PALÆONTOGRAPHICAL SOCIETY.

VOL. XXII.

SUPPLEMENT

TO THE

FOSSIL CORALS.

PART II, No. 1.

CRETACEOUS.

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PART III.

ISSUED FOR 1868.

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VOLUME XXII.

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ISSUED FOR 1868.

FEBRUARY, 1869.

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A CLASSIFIED LIST OF THE MONOGRAPHS COMPLETED, IN COURSE OF PUBLICATION AND IN PREPARATION, WITH THE NAMES OF THEIR RESPECTIVE AUTHORS;

THE DATES OF ISSUE OF THE ANNUAL VOLUMES;

A GENERAL SUMMARY, SHOWING THE NUMBER OF THE PAGES, PLATES, FIGURES, AND SPECIES IN EACH MONOGRAPH;

AND A STRATIGRAPHICAL LIST OF THE BRITISH FOSSILS TO BE FOUND IN THE YEARLY VOLUMES.

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Vol. XVIII. Issued for the Year	1864	The Fossil Echinodermata, Vol. II, Part II (Liassic Ophiuroidea), by Dr. Wright, 6 plates. The Trilobites of the Silurian, Devonian, &c., Formations, Part III, by Mr. J. W. Salter, 11 plates. The Belemnitidæ, Part II, Liassic Belemnites, by Prof. Phillips, 7 plates. The Pleistocene Mammalia, Part I, Introduction, Felis spelæa, by Messrs. W. Boyd Dawkins and W. A. Sanford, 5 plates. Title-pages, &c., to the Monographs on the Reptilia of the London Clay, Cretaceous, and Wealden Formations.
,, XIX. ,,	1865	The Crag Foraminifera, Part I, No. 1, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady, 4 plates. Supplement to the Fossil Corals, Part I, Tertiary, by Dr. Duncan, 10 plates. The Fossil Merostomata, Part I, Pterygotus, by Mr. H. Woodward, 9 plates. The Fossil Brachiopoda, Part VII, No. 1, Silurian, by Mr. Davidson, 12 plates.
,, XX. ,,	1866	Supplement to the Fossil Corals, Part IV, No. 1, Liassic, by Dr. Duncan, 11 plates. The Trilobites of the Silurian, Devonian, &c., Formations, Part IV (Silurian), by Mr. J. W. Salter, 6 plates. The Fossil Brachiopoda, Part VII, No. 2, Silurian, by Mr. Davidson, 10 plates. The Belemnitidæ, Part III, Liassic Belemnites, by Prof. Phillips, 13 plates.
,, XXI. ,,	1867	Flora of Carboniferous Strata, Part I, by Mr. E. W. Binney, 6 plates. Supplement to the Fossil Corals, Part IV, No. 2, Liassic, by Dr. Duncan, 6 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part II, by Dr. Wright, 14 plates. The Fishes of the Old Red Sandstone, Part I, by Messrs. J. Powrie and E. Ray Lankester, 5 plates. The Pleistocene Mammalia, Part II, Felis spelæa, continued, by Messrs. W. Boyd Dawkins and W. A. Sanford, 14 plates.
,, XXII. ,,	1868	Supplement to the Fossil Corals, Part II, No. 1, Cretaceous, by Dr. Duncan, 9 plates. The Fossil Merostomata, Part II, Pterygotus, by Mr. H. Woodward, 6 plates. The Fossil Brachiopoda, Part VII, No. 3, Silurian, by Mr. Davidson, 15 plates. The Belemnitidæ, Part IV, Liassic and Oolitic Belemnites, by Prof. Phillips, 7 plates. The Reptilia of the Kimmeridge Clay, No. 3, by Prof. Owen, 4 plates. The Pleistocene Mammalia, Part III, Felis spelæa, continued, with F. Lynx, by Messrs. W. Boyd Dawkins and W. A. Sanford, 6 plates.

LIST OF MONOGRAPHS

Completed, in course of Publication, and in Preparation.

MONOGRAPHS which have been COMPLETED :—

The Tertiary, Cretaceous, Oolitic, Devonian, and Silurian Corals, by MM. Milne-Edwards and J. Haime.
The Polyzoa of the Crag, by Mr. G. Busk.
The Tertiary Echinodermata, by Professor Forbes.
The Fossil Cirripedes, by Mr. C. Darwin.
The Tertiary Entomostraca, by Prof. T. Rupert Jones.
The Cretaceous Entomostraca, by Prof. T. Rupert Jones.
The Fossil Estheriæ, by Prof. T. Rupert Jones.
The Tertiary, Cretaceous, Oolitic, Liassic, Permian, Carboniferous, and Devonian Brachiopoda, by Mr. T. Davidson.
The Mollusca of the Crag, by Mr. S. V. Wood.
The Great Oolite Mollusca, by Professor Morris and Mr. J. Lycett.
The Cretaceous (Upper) Cephalopoda, by Mr. D. Sharpe.
The Fossils of the Permian Formation, by Professor King.
The Reptilia of the London Clay (and of the Bracklesham and other Tertiary Beds), by Professors Owen and Bell.
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The Flora of the Carboniferous Formation, by Mr. E. W. Binney.
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The Echinodermata of the Oolitic and Cretaceous Formations, by Dr. Wright.
The Fossil Merostomata, by Mr. H. Woodward.

* Members having specimens which might assist the authors in preparing their respective Monographs are requested to communicate in the first instance with the Honorary Secretary.

MONOGRAPHS in course of Publication—*Continued.*

The Trilobites of the Mountain-Limestone, Devonian, and Silurian Formations, by Mr. J. W. Salter.
The Malacostracous Crustacea, by Professor Bell.
The Eocene Mollusca, by Messrs. F. E. Edwards and S. V. Wood.
The Silurian Brachiopoda, by Mr. Davidson.
The Belemnites, by Professor Phillips.
The Fishes of the Old Red Sandstone, by Messrs. J. Powrie and E. Ray Lankester.
The Reptilia of the Kimmeridge Clay, by Professor Owen.
The Reptilia of the Liassic Formations, by Professor Owen.
The Pleistocene Mammalia, by Messrs. Boyd Dawkins and W. A. Sanford.

MONOGRAPHS which are in course of Preparation :*—

The Flora of the Tertiary Formation, by Mr. W. S. Mitchell.
The Cretaceous Foraminifera, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady.
The Foraminifera of the Lias, by Mr. H. B. Brady.
The Graptolites, by Professor Wyville Thomson.
The Polyzoa of the Chalk Formation, by Mr. G. Busk.
The Crinoidea, by Professor Wyville Thomson.
The Post-Tertiary Entomostraca, by the Rev. H. W. Crosskey and Messrs. G. S. Brady and D. Robertson.
The Wealden, Purbeck, and Jurassic Entomostraca, by Messrs. T. Rupert Jones and G. S. Brady.
The Bivalve Entomostraca of the Carboniferous Formations, by Messrs. T. Rupert Jones and J. W. Kirkby.
The Phyllopoda of the Palæozoic Rocks, by Mr. J. W. Salter.
The Post-Tertiary Mollusca, by Mr. J. Gwyn Jeffreys.
The Cretaceous Mollusca (exclusive of the Brachiopoda), by the Rev. T. Wiltshire.
The Purbeck Mollusca, by Mr. R. Etheridge.
The Inferior Oolite Mollusca, by Mr. R. Etheridge.
The Rhætic Mollusca, by Mr. R. Etheridge.
The Liassic Gasteropoda, by Mr. Ralph Tate.
The Ammonites of the Lias, by Dr. Wright.
The Cetacea of the Crag, by Professor Owen.

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* Members having specimens which might assist the authors in preparing their respective Monographs are requested to communicate in the first instance with the Honorary Secretary.

Dates of the Issue of the Yearly Volumes of the Palæontographical Society.

The Volume for	1847	was issued	to the	Members,	March, 1848.
,,	1848	,,	,,	,,	July, 1849.
,,	1849	,,	,,	,,	August, 1850.
,,	1850	,,	,,	,,	June, 1851.
,,	1851	,,	,,	,,	June, 1851.
,,	1852	,,	,,	,,	August, 1852.
,,	1853	,,	,,	,,	December, 1853.
,,	1854	,,	,,	,,	May, 1855.
,,	1855	,,	,,	,,	February, 1857.
,,	1856	,,	,,	,,	April, 1858.
,,	1857	,,	,,	,,	November, 1859.
,,	1858	,,	,,	,,	March, 1861.
,,	1859	,,	,,	,,	December, 1861.
,,	1860	,,	,,	,,	May, 1863.
,,	1861	,,	,,	,,	May, 1863.
,,	1862	,,	,,	,,	August, 1864.
,,	1863	,,	,,	,,	June, 1865.
,,	1864	,,	,,	,,	April, 1866.
,,	1865	,,	,,	,,	December, 1866.
,,	1866	,,	,,	,,	June, 1867.
,,	1867	,,	,,	,,	June, 1868.
,,	1868	,,	,,	,,	February, 1869.

be complete, or in the course *of* completion; *in the* SECOND *column, the yearly volumes which contain each particular Monograph (as a guide to binding the same); and in the* THIRD *and following columns, the number of pages, plates, figures, and species described in the different Monographs.*

I. SUBJECT OF MONOGRAPH.	II. Dates of the Years *for which* the Volume containing the Monograph was issued.	III *m.* Dates of the Years of Publication on the title-page of each part.	IV *n.* Dates of the Years *in which* the Monograph was published.	III. No. of Pages of Letterpress in each Monograph.	IV. No. of Plates in each Monograph.	V. No. of Lithographed Figures and of Woodcuts.	VI. No. of Species described in the Text.
The Flora of the Carboniferous Strata, by Mr. E. W. Binney, in course of completion	1867	1868	1868	32	6	32	2
The Crag Foraminifera, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady, in course of completion	1865	1866	1866	78	4	211	43
Tertiary, Cretaceous, Oolitic, Devonian, and Silurian Corals, by MM. Milne-Edwards and J. Haime, *complete* (*k*)	1849, 1851, 1852, 1853, 1854	1850, 1851, 1852, 1853, 1854	1850, 1851, 1852, 1853, 1855	406	72	800	319*g*
Supplement to the Fossil Corals, by Dr. Duncan, in course of completion	1865, 1866, 1867, 1868	1866, 1867, 1868, 1869	1866, 1867, 1868, 1869	170	36	623	112
The Polyzoa of the Crag, by Mr. G. Busk, *complete*	1857	1859	1859	145	22	641	122
The Tertiary Echinodermata, by Prof. Forbes, *complete*	1852	1852	1852	39	4	144	44
The Oolitic Echinodermata, by Dr. Wright. Vol. I, *complete*	1855, 1856, 1857, 1858	1855, 1856, 1859, 1860	1857, 1558, 1859, 1861	474	43	724	109*h*
" " Vol. II, in course of completion	1861, 1864	1862, 1866	1863, 1866	154	19	218	29
The Cretaceous Echinodermata, by Dr. Wright. Vol. I, in course of completion	1862, 1867	1864, 1868	1864, 1868	112	25	382	28
The Fossil Cirripedes, by Mr. C. Darwin, *complete*	1851, 1854, 1858*a*	1851, 1854 *	1851, 1855, 1861	137	7	320	54
The Fossil Merostomata, by Mr. H. Woodward, in course of completion	1865, 1868	1866, 1869	1866, 1869	70	15	91	2
The Tertiary Entomostraca, by Prof. Rupert Jones, *complete*	1855	1856	1857	74	6	233	56
The Cretaceous Entomostraca, by Prof. Rupert Jones, *complete*	1849	1849	1850	41	7	176	27
The Fossil Estheriæ, by Prof. Rupert Jones, *complete*	1860	1862	1863	139	5	158	19*i*
The Trilobites of the Mountain-limestone, Devonian, Silurian, and other Formations, by Mr. J. W. Salter, in course of completion	1862, 1863, 1864, 1866	1864, 1865, 1866, 1867	1864, 1865, 1866, 1867	216	31	703	114
The Malacostracous Crustacea (comprising those of the London Clay, Gault, and Greensands), by Prof. T. Bell, in course of completion	1856, 1860	1857, 1862	1858, 1863	88	22	215	50
Fossil Brachiopoda, Vol. I. The Tertiary, Cretaceous Oolitic, and Liassic Brachiopoda, by Mr. T. Davidson, *complete*	1850, 1852, 1853, 1854	1851, 1852, 1853, 1854	1851, 1852, 1853, 1855	409	42	1855	160
" " Vol. II. The Permian and Carboniferous Brachiopoda, *complete*	1856*d*, 1857, 1858, 1859, 1860	1857, 1858, 1860, 1861 †	1858, 1859, 1861, 1861, 1863	331	59	1909	157
" " Vol. III. The Devonian and Silurian Brachiopoda, in course of completion	1862, 1863, 1865, 1866, 1868	1864, 1865, 1866, 1867, 1869	1864, 1865, 1866, 1867, 1869	379	57	2215	216
The Mollusca of the Crag, by Mr. S. V. Wood:—							
Vol. I. (Univalves), *complete*	1847, 1855*b*	1848	1848, 1857	216	21	581	244
Vol. II. (Bivalves), *complete*	1850, 1853, 1855, 1858*c*	1850, 1853, 1856, 1860	1851, 1853, 1857, 1861	344	31	691	253
The Eocene Mollusca, Cephalopoda and Univalves, by Mr. F. E. Edwards, in course of completion	1848, 1852, 1854, 1855, 1858	1849, 1852, 1854, 1856, 1860	1849, 1852, 1855, 1857, 1861	332	33	578	161
The Eocene Mollusca, Bivalves, by Mr. S. V. Wood, in course of completion	1859, 1862	1861, 1864	1861, 1864	136	20	396	146
The Great Oolite Mollusca, by Prof. Morris and Mr. J. Lycett, *complete*	1850, 1853, 1854	1850, 1853, 1854	1850, 1853, 1855	282	30	816	419
" " " Supplement by Dr. Lycett, *complete*	1861	1863	1863	129	15	337	194
The Belemnites, by Prof. Phillips, in course of completion	1863, 1864, 1866, 1868	1865, 1866, 1867, 1869	1865, 1866, 1867, 1869	108	27	495	61
The Upper Cretaceous Cephalopoda, by Mr. D. Sharpe, *complete*	1853, 1854, 1855	1853, 1854, 1856	1853, 1855, 1857	67	27	319	79
The Fossils of the Permian Formation, by Prof. King, *complete*	1849, 1854*e*	1850 *	1850, 1855	287	29	511	138
The Fishes of the Old Red Sandstone, by Messrs. J. Powrie and E. Ray Lankester, in course of completion	1867	1868	1868	33	5	72	9
The Reptilia of the London Clay [and of the Bracklesham and other Tertiary Beds], by Profs. Owen and Bell, *complete*‡	1848, 1849, 1856*f*	1849, 1850 *	1849, 1850, 1859	150	58	304	39
The Reptilia of the Cretaceous Formations, by Prof. Owen, *complete*‡	1851, 1857, 1858, 1862	1851, 1859, 1860, 1864	1851, 1859, 1861, 1864	184	59	519	26
The Reptilia of the Wealden and Purbeck Formations, by Prof. Owen, *complete*‡	1853, 1854, 1855, 1856, 1857, 1858, 1862	1853, 1854, 1856, 1857, 1859, 1860, 1864	1853, 1855, 1857, 1858, 1859, 1861, 1864	155	62	251	17
The Reptilia of the Kimmeridge Clay Formation, by Prof. Owen, in course of completion	1859, 1860, 1868	1861, 1862, 1869	1861, 1863, 1869	16	6	23	3
The Reptilia of the Liassic Formations, by Prof. Owen, in course of completion	1859,‖ 1860,‖ 1863	1861, 1862, 1865	1861, 1863, 1865	80	33	142	7
The Pleistocene Mammalia, by Messrs. W. Boyd Dawkins and Mr. W. A. Sanford, in course of completion	1864, 1867, 1868	1866, 1868, 1869	1866, 1868, 1869	218	25	213	2
			TOTAL	6,231	963	17,958	3,191

a Index. *b* Title-page to Univalves. *c* Note to Crag Mollusca. *d* Contains the Permian, which is complete. *e* Two corrections of Plates. *f* Supplement.
g Many of the species are described, but not figured. *h* British species only reckoned. *i* British species only reckoned. *k* A Supplement is now in course of publication.
l Wants Index. *m* Useful in binding up the parts. *n* Useful for establishing the dates of new species. * Dates not given. † Marked 1857—1862.
‡ Title-pages and Index will be found in the 1864 Volume, or may be had separately. ‖ Marked on outside label 'Reptilia of Oolitic Formations.'

Stratigraphical Table *exhibiting the* British Fossils *already figured and described in the* Annual Volumes (1847—1868) *of the* Palæontographical Society.

	PLANTS.	PROTOZOA.		RADIATA.		ARTICULATA.						MOLLUSCA.				VERTEBRATA.		
		Sponges.	Foraminifera.	Corals.	Echinodermata.	Cirripedes.	Cypridæ, Cytherinæ, &c.	Estheriæ.	Merostomata.	Trilobites.	Malacostracous Crustacea.	Polyzoa.	Brachiopoda.	Monomyaria, Dimyaria, and Gasteropoda.	Cephalopoda.	Fishes.	Reptiles.	Mammalia.
Pleistocene ...	...	...	...	...	......	......	...	...	......	......	...	...	......	......	...	...	......	1864, 1867, 1868
Crag	...	...	1865	1849	1852	1851, 1854	...	...	......	......	...	1857	1852	1847, 1850, 1853, 1855				
Eocene	...	...	...	1849, 1865	1852	1851, 1854	1855	...	......	......	1856	...	1852	1852, 1854, 1855, 1858, 1859, 1862	1848	...	1848, 1849, 1856	
Cretaceous ...	...	...	...	1849, 1858	1862, 1867	1851, 1854	1849	...	......	......	1860	...	1852, 1854	......	1853, 1854, 1855	...	1851, 1857, 1858, 1862	
Wealden	...	...	...	...	......	......	...	1860	......	......	...	...	......	......	...	...	1853, 1854, 1855, 1856, 1857, 1862	
Oolitic	...	...	...	1851	1855, 1856, 1857, 1858, 1861	1851	...	1860	......	......	...	...	1850, 1852	1850, 1853, 1854	1850, 1861	...	(Purbeck) 1853, 1858 (Kim. Clay), 1859, 1860, 1868	
Liassic	...	...	...	1851, 1866, 1867	1855, 1856, 1858, 1861, 1864	......	...	...	......	......	...	...	1850, 1852	......	1863, 1864, 1866	...	1859, 1860, 1863	
Triassic	...	...	...	...	......	......	...	1860	......			...						
Permian	1849	1849	1849	1849, 1852	1849	......	1849	1860	......	......	...	1849	1849, 1856	1849	1849	1849	1849	
Carboniferous	1867	...	...	1852	......	......	...	1860	......	......	...	...	1856, 1857, 1858, 1859, 1860					
Devonian	...	...	...	1853	......	......	...	1860	1865, 1868	1862	...	...	1862, 1863	......	...	1867		
Silurian	...	...	...	1854	......	......	...	...	......	1862, 1863, 1864, 1866		...	1865, 1866, 1868					
Cambrian......	...	...	...	...	......	......	...	...	......	1864		...						

Note.—The numbers in the above List refer to the Volumes issued for those Dates.

THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

VOLUME FOR 1868.

LONDON:

MDCCCLXIX.

A MONOGRAPH

OF THE

BRITISH FOSSIL CORALS.

SECOND SERIES.

BY

P. MARTIN DUNCAN, M.B. LOND., F.R.S.,

FELLOW OF, AND SECRETARY TO, THE GEOLOGICAL SOCIETY.

Being a Supplement to the

'Monograph of the British Fossil Corals,' by MM. MILNE-EDWARDS *and* JULES HAIME.

PART II, No. 1.

CORALS FROM THE WHITE CHALK, THE UPPER GREENSAND, AND THE RED CHALK OF HUNSTANTON.

Pages 1—26; Plates I—IX.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1869.

PRINTED BY
J. E. ADLARD, BARTHOLOMEW CLOSE.

CONTENTS.

A MONOGRAPH

OF THE

BRITISH FOSSIL CORALS.

(SECOND SERIES.)

PART II.—No. 1.

CORALS FROM THE CRETACEOUS FORMATIONS.

INTRODUCTION.

NOTWITHSTANDING several years have elapsed since MM. Milne-Edwards and Jules Haime wrote their description of the Corals of the British Cretaceous series, and vast additions have been lately made to the faunæ of the Chalk, Upper Greensand, Gault, and Lower Greensand, very few new *Madreporaria* have been discovered in these Upper Secondary deposits.

A few species which had been described by Mr. Lonsdale before MM. Milne-Edwards and Jules Haime wrote their Monograph for the Palæontographical Society, but which those authors did not consider sufficiently distinguished, appear, from the study of new specimens and the examination of the original types, to be worthy of re-publication. These species, with some others known in Continental Cretaceous deposits, but not hitherto noticed in Great Britain, and several new species, are described and illustrated in this Part.

Some important varieties of the species described by MM. Milne-Edwards and Jules Haime and by Mr. Lonsdale have been studied and described, and some illustrations of the specific forms themselves have been added in consequence of the reception of fine specimens.

Corals from the Upper and Lower White Chalk.[1]

MM. Milne-Edwards and Jules Haime noticed and described nine species from these formations. One of these species had been previously described by Mantell and another by Reuss, so that seven species were added to our British fauna through the industry of the great French Zoophytologists.

During the last few months I have thoroughly examined the specimens offered to me and those which had been studied by Milne-Edwards and Jules Haime, Lonsdale, and Mantell. I can add ten new species to the list of the Corals from the White Chalk, and five good varieties of formerly known species. It is necessary, also, to admit a species of Mr. Lonsdale's, and to suppress one of MM. Milne-Edwards and Jules Haime's.

Section—*APOROSA.*

Family—TURBINOLIDÆ.

Division—Caryophyllaceæ.

Genus—Caryophyllia.

MM. Milne-Edwards and Jules Haime adopted for a Coral from the Upper Chalk the name *Cyathina lævigata.* They published this name in their "Monog. des Turbinolides" ('Ann. des Sciences Nat.,' 3me série, vol. ix, p. 290, 1848), and in their 'Monograph of the Corals of the Upper Chalk' (Pal. Soc., 1850). Lonsdale named the same coral *Monocarya centralis,* Dixon (' Geol. of Sussex,' 1850), and probably *Monocarya cultrata* also.

In 1850 D'Orbigny ('Prodr. de Paléont.,' t. ii, p. 275, 1850) gave the Coral the specific name *cylindracea,* it having become evident that Reuss was the primary discoverer of the species in 1846. In his 'Kreideformation,' p. 61, pl. xiv, figs. 23—30, Reuss gave the name *Anthophyllum cylindraceum.* The genus of the Coral is evidently *Caryophyllia* in the sense adopted by Charles Stokes in 1828.

[1] The following authors have written upon this subject:

Parkinson, 'Organic Remains of a Former World,' &c., 1811.
Mantell, 'Geol. of Sussex,' 1822; and 'Trans. Geol. Soc.,' 2nd series, vol. iii, 1829.
Fleming, 'British Animals,' 1828.
Phillips, 'Illust. Geol. York,' part i, 1829.
S. Woodward, 'Syn. Table of Brit. Org. Remains,' 1830.
R. C. Taylor, in 'Mag. Nat. Hist.,' vol. iii, p. 271, 1830.
MM. Milne-Edwards and Jules Haime, op. cit.
Lonsdale, in Dixon's 'Geol. Sussex,' 1850.

MM. Milne-Edwards and Jules Haime, having all this information before them, very properly admit the generic and specific names to be *Caryophyllia cylindracea,* Reuss, sp. ('Hist. Nat. des Corall.,' vol. ii, p. 18).

This species is very polymorphic, and the pali of some specimens are very like the outer terminations of the columellary structures in some *Parasmiliæ.* Very frequently it is hardly possible to determine in *Caryophyllia cylindracea* which are pali and which the ends of the columellary fasciculi. Moreover, in some specimens the base is small and the costæ reach low down, whilst in others the base is normal and large, the costæ being abnormal from their length.

There is a new species of this genus in the Dunstable Chalk and another in the Chalk of Sussex. There are thus three species of *Caryophyllia* in the Upper Chalk of England:

1. *Caryophyllia cylindracea,* Reuss, sp.
2. ,, *Lonsdalei,* Duncan.
3. ,, *Tennanti* ,,

1. Caryophyllia cylindracea, *Reuss,* sp. Pl. I, figs. 7—12.

In the British Museum, Dixon Collection.

2. Caryophyllia Lonsdalei, *Duncan.* Pl. I, figs. 1—3.

The corallum has a large and encrusting base, and the stem is cylindro-conical and straight. There is a slight curve near the base.

The calice is circular, small, not very open, and moderately deep.

The columella is small, and is terminated by rod-shaped processes.

The septa are slightly exsert, the primary especially. There are three complete cycles, and the septa of the higher orders of the fourth cycle are not developed in every system. The primary, secondary, and tertiary septa are very alike. They have a wavy inner edge, and are granular.

The pali are situated before the tertiary septa, and are knob-shaped and rather flat from side to side.

The costæ are nearly equal at the calicular margin, and pass downwards as flat, band-like prominences, separated by shallow intercostal grooves. They are continued to the base, but are hidden midway by an epithecal growth.

Height of the corallum, $\frac{5}{6}$ths inch. Breadth of the calice, $\frac{1}{3}$rd inch.

Locality. Dunstable. In the Collection of the Rev. T. Wiltshire, F.G.S.

This species is readily distinguished by its costæ, and is more closely allied to *C. cylindracea* than to any other form.

3. Caryophyllia Tennanti, *Duncan.* Pl. I, figs. 4—6.

The corallum has a large base, a curved cylindrical stem, and an inclined elliptical calice. It is short in relation to its broad base.

The calice is open and shallow.

The columella is small, and terminates in twelve knob-shaped endings to the fasciculi.

The septa are unequal, and there are five incomplete cycles.

The laminæ are marked with curved lines of granules, are wavy and unequal.

The pali are higher than the columellary processes, are wavy, flattened, and curved.

The costæ are sub-equal in the upper third, but are not seen below.

Height, $1\frac{1}{3}$rd inch. Length of calice, $\frac{3}{6}$ths inch.

Locality. Sussex; Upper Chalk. In the Collection of Professor Tennant, F.G.S.

This species connects the Cretaceous *Caryophylliæ* with those of the Tertiary and Recent systems.

Family—TURBINOLIDÆ.

Division—Turbinoliaceæ.

Genus nov.—Onchotrochus.

The corallum is simple, tall, slender, rather hook-shaped or clavate, and presents evidences of irregular growth.

There is no endotheca.

The costæ are rudimentary, and there is no columella.

The septa are few in number.

The epitheca is pellicular and striated.

The genus is somewhat allied to *Smilotrochus, Stylotrochus,* and very distantly to *Flabellum.*

... Onchotrochus serpentinus, *Duncan.* Pl. VI, figs. 1—4.

The corallum is tubulate, curved superiorly, and straight and tapering inferiorly. A sudden diminution in the diameter of the upper part of the corallum exists.

The costæ are quite rudimentary.

The epitheca is marked with fine transverse striations.

The septa are continuous with what appear to be rudimentary intercostal spaces.

The laminæ are twelve in number; they project into the circular calice, but are not exsert. A section proves that they are very stout, even low down in the corallum.

Length of the corallum, 1 inch. Diameter of the calice, $\frac{1}{8}$th inch.

Locality. Charlton, Kent. In the Collection of the Rev. T. Wiltshire, F.G.S.

This species is mimetic of *Parasmilia serpentina*, Ed. and H., from the same geological horizon, just as *Trochosmilia cylindrica* is mimetic of *Parasmilia cylindrica*. The *Stylotrochi* of the Cambridge Upper Greensand are closely allied to this species, which is found in the Grey Chalk and Lower White Chalk.

Family—ASTRÆIDÆ.

Genus—Trochosmilia.

Sub-genus—Cœlosmilia.

It is a great question whether *Cœlosmilia* can stand as a genus. It is impossible to separate its species from those of *Trochosmilia* by an external examination, and sections prove that there is no columella and a very scanty endotheca. Still there is an endotheca, and the visceral cavity of the Coral was not open from top to bottom, as in the *Turbinolidæ*. It is true that there is a facies common to the *Cœlosmiliæ*, and that they are a natural group; but, in fact, they do not differ from a *Trochosmilia* with scanty endotheca. On studying the genus *Trochosmilia* it will be noticed that many of its species have never been described with reference to their endotheca. Many were determined from one or two specimens, and sections of the majority have not been made. Now, *Trochosmilia sulcata*, Ed. and H., has very little endotheca; it is a species from the Gault, and the *Cœlosmiliæ* are all from the Cretaceous, Eocene, and recent Coral-faunæ. In placing *Cœlosmilia* as a sub-genus, but included in *Trochosmilia*, it must be admitted that the classification becomes simpler and more natural. Since MM. Milne-Edwards and Jules Haime published their 'Hist. Nat. des Coralliaires,' some new species of *Cœlosmilia* have been published or described.

The following species have been described:

1. *Cœlosmilia poculum*, Ed. & H., recent.
2. „ *Faujasi*, „ White Chalk, Ciply.
3. „ *punctata*, „ „
4. „ *laxa*, „ Norwich Chalk.
5. „ *Edwardsi*, D'Orb., Sezanne.
6. „ *Atlantica*, Martin, sp., Timber Creek, New Jersey.
7. „ *excavata*, Hagenow, sp., Chalk of Rugen.
8. „ *radicata*, Quenstedt, Nattheim.

The new species are—

9.	*Cœlosmilia*	*elliptica*,	Reuss,	Castel Gomberto.
10.	,,	*Javana*,	Duncan, MS.,	Java.
11.	,,	*cornucopiæ*	,,	Trimmingham Chalk.
12.	,,	*Wiltshiri*	,,	Norwich Chalk.
13.	,,	*Woodwardi*	,,	White Chalk, England.
14.	,,	*granulata*,	,,	,,
15.	,,	*cylindrica*,	,,	,,

The species *cornucopiæ*, *Wiltshiri*, *Woodwardi*, *granulata*, and *cylindrica* are new to British palæontology, and are very characteristic of the Upper Chalk.

There are in the Upper Chalk three well-marked varieties of *Cœlosmilia laxa*, Ed. & H.

An analysis of the species produces the following results.

1. The species *Atlantica*, *punctata*, *Edwardsi*, *excavata*, and *radicata*, either pertain to other species or are really indeterminable.

2. The species whose septal arrangement shows more cycles than four or which have some septa of the fifth cycle are—

Cœlosmilia poculum.
,, *Faujasi.*
,, *Javana.*
,, *cornucopiæ.*
,, *Wiltshiri.*
,, *Woodwardi.*
,, *elliptica.*

3. The species whose septal arrangement shows three cycles or four cycles, or some septa of the fourth cycle, are—

Cœlosmilia granulata.
,, *cylindrica.*
,, *laxa.*

4. The species with large bases and with more than four cycles are—

Cœlosmilia poculum.
,, *elliptica.*

5. The species with a large base and with more than three cycles of septa, but not more than four, is—

Cœlosmilia cylindrica.

TROCHOSMILIÆ. *Sub-genus*—CŒLOSMILIA (having scanty endotheca).

With wide bases; the costæ	hardly prominent, replaced inferiorly by granules; five cycles; corallum straight	*Trochosmilia* (*C.*) *poculum*, Ed. & H., sp.
	cristiform superiorly, with intermediate costæ; five cycles; corallum curved	„ (*C.*) *elliptica*, Reuss, sp.
	very distinct, flat, wide; intercostal spaces linear; four cycles; corallum cylindrical	„ (*C.*) *cylindrica*, Duncan.
With pedicel or a small trace of a former attachment; five cycles; the costæ	throughout indistinct, plane and subequal	„ (*C.*) *Faujasi*, Ed. & H., sp.
	alternately large and small; subcristiform above, crossed by ornamentation	„ (*C.*) *Javana*, Duncan.
	subcristiform throughout; subequal above	„ (*C.*) *cornucopiæ*, „
	very distant, distinct and subcristiform, smaller much ornamented	„ (*C.*) *Wiltshiri*, „
	long, the principal cristiform, many smaller between them; corallum long and cornuted	„ (*C.*) *Woodwardi*, „
Four cycles (or part of); the costæ	well marked, distant, very granular; intercostal spaces very granular and strongly marked; corallum curved	„ (*C.*) *granulata*, „
	distant, distinct, and cross-marked in intercostal spaces	„ (*C.*) *laxa*, Ed. & H., sp.

Genus—Trochosmilia.

Sub-genus—Cœlosmilia.

1. Trochosmilia (Cœlosmilia) laxa, *Ed. & H.* Pl. III, figs. 11—17; Pl. IV, figs. 9—12.

In examining good specimens of this species I found the fourth cycle of septa to be present. Its laminæ are small, but decidedly visible. Consequently the calice as drawn by MM. Milne-Edwards and Jules Haime ('Monog. Brit. Foss. Corals,' P. I, Pl. VIII, fig. 4 *c*) is incorrect. The following description will apply to three varieties of the species.

Variety 1.—The corallum is conico-cylindrical and straight.

The costæ are intensely granular inferiorly, and two large costæ are separated by three smaller. Near the calice the larger costæ have a wavy cristiform ridge upon them, the intermediate costæ being very granular, with chevron patterns, or they may be moniliform. At the calicular margin the costæ are nearly flat and granular. The fourth cycle of septa is distinct.

Variety 2.—Inferiorly in structure as variety 1. Superiorly the principal costæ are very cristiform, and well marked with a secondary ridge. The chevron markings of the intermediate costæ are very distinct.

Variety 3.—Costæ inferiorly wavy and sparely granular. Superiorly the costæ are subcristiform and plain, the continuity of the crests being defective. The intermediate costæ are broken and moniliform, and here and there chevroned.

Localities.—Norwich Chalk; Wiltshire Chalk. In the British Museum and in the Salisbury Museum.

2. Trochosmilia (Cœlosmilia) cornucopiæ, *Duncan.* Pl. III, figs. 6—10.

The corallum is strongly curved in the plane of the smaller axis, and it is compressed superiorly, and is finely pedunculate. The growth rings and swellings are moderately developed.

The costæ are subequal above, and cristate and unequal inferiorly.

The septa are numerous and very unequal. There are five cycles of septa and six systems. The primary septa are very exsert, and the secondary are less so. The septa of the fifth cycle are very small.

The calice is elliptical, and the fossa very deep, the larger septa joining those opposite at its bottom.

There are traces of epitheca.

Height, 1 inch. Breadth of calice $\frac{5}{6}$ths inch; length of calice, 1 inch. Depth of fossa $\frac{3}{6}$ths inch.

Locality. Trimmingham; Upper Chalk. In the Collection of the Rev. T. Wiltshire, F.G.S.

3. Trochosmilia (Cœlosmilia) Wiltshiri, *Duncan*. Pl. III, figs. 1—5.

The corallum is tall, curved, finely pedicillate, and is not compressed.

The growth-rings are distinct.

The costæ are very distinct and unequal, and they reach from base to calice. The smaller intermediate costæ are ornamented with chevrons and horizontal lines. The larger costæ have a secondary crest upon their free surface.

The septa are unequal, slender, and not crowded.

The calice is circular.

There are five cycles of septa, but the fifth is incomplete in some systems. The primary septa are large, slightly exsert, and extend far inwards.

The calicular margin is very thin, and the fossa is deep.

Height, $1\frac{2}{3}$rds inch. Diameter of the calice, $\frac{2}{3}$rds inch.

Locality. Norwich; Upper Chalk. In the Collection of the Rev. T. Wiltshire, F.G.S.

4. Trochosmilia (Cœlosmilia) Woodwardi, *Duncan*. Pl. IV, figs. 5—8.

The corallum is tall, cornute, slightly pedicillate, and narrow.

The growth-markings are distinct.

The costæ are distinct from base to calice. Two large subcristiform and very distinct costæ bound three intermediate small and more or less moniliform costæ. Sets of these costæ occur around the corallum.

The septa are crowded, wavy, and unequal. Many unite laterally, and the largest reach far into the axial space.

The calice is circular, and the wall is very thin.

Height, 2 inches. Breadth of the calice, $\frac{5}{6}$ths inch.

Locality. Chalk of South of England. In the British Museum (Dixon Collection).

5. Trochosmilia (Cœlosmilia) granulata, *Duncan*. Pl. IV, figs. 1—4; Pl. VI, fig. 9.

The corallum is tall and slightly curved, and it has a long pedicel, with a very distinct base.

The corallum is slightly compressed, and bulges here and there.

The costæ are well marked, distant, subequal, and intensely granular. The larger costæ are more distinct inferiorly and midway than close to the calicular margin; they are cristiform in some places, notched by chevron-shaped ornamentation in others, and occasionally sharply pointed or absent. The spaces between the larger costæ are wide, faintly convex, and are marked longitudinally by small costæ, and transversely by wavy or chevroned ornamentation.

The whole external surface of the corallum is very granular.

The calicular wall is very thin, and the calice is elliptical.

There are three perfect cycles of septa, and some orders of the fourth cycle in some of the systems. The septa are wide apart, slightly exsert, unequal, and slender. They do not reach far inwards at once, but dip downwards with a gentle curve.

In a section the inner margin of the larger septa is wavy.

The endotheca is scanty.

Height, $1\frac{2}{3}$rds inch. Length of calice, $\frac{5}{6}$ths inch; breadth, $\frac{2}{3}$rds inch.

Locality. Norwich, and Chalk of south of England. In the British Museum (Dixon Collection).

6. Trochosmilia (Cœlosmilia) cylindrica, *Duncan*. Pl. V, figs. 1—3.

The corallum is tall, cylindrical, and very slightly bent. The calicular opening is smaller in diameter than the rest of the corallum.

The costæ are nearly equal, broad, slightly rounded, and are separated by shallow, narrow, and undulating intercostal grooves. The costæ are profusely ornamented with transverse ridges, straight, curved, or angular, and with large granules.

The calicular edge is very thin, and the broad convex costæ are continuous with slender, unequal septa.

There are four cycles of septa. The primary are exsert, and the laminæ of the higher orders are very small.

There is no columella, the larger septa are united by a few short attachments from their inner margins.

The endotheca is scanty.

Height, several inches. Breadth of the calice, $\frac{5}{6}$ths inch.

Locality. Norwich, Upper Chalk. In the Collection of the Rev. T. Wiltshire, F.G.S.

The sub-genus *Cœlosmilia* is represented in the British Chalk by one species formerly known, by three varieties of it, and by five new species.

1.	*Trochosmilia*	(*Cœlosmilia*)	*laxa*,	Ed. & H.	
	,,	,,	,,	Varieties 1, 2, 3, Duncan.	
2.	,,	,,	,,	*cornucopiæ*,	Duncan.
3.	,,	,,	,,	*Wiltshiri*,	,,
4.	,,	,,	,,	*Woodwardi*,	,,
5.	,,	,,	,,	*granulata*,	,,
6.	,,	,,	,,	*cylindrica*,	,,

These *Trochosmiliæ*, with a slight amount of endotheca—what there is of it is generally low down—are very characteristic of the Upper Chalk, and their presence suggests that the Upper Chalk of Norwich and Trimmingham is, from the evidence of its Corals, as well as from the proofs already asserted from its Mollusca, on a higher horizon than the Upper Chalk, usually so called, in the south-east district. The Coral evidence brings the Norfolk Chalk closer in relation with the Faxoe, Rugen, and Ciply deposits.

The affinity between *Trochosmilia* (*C.*) *cornucopiæ* and *Cœlosmilia excavata*, Hagenow, sp. (a doubtful form, but well drawn by Quenstedt), is evident. It is from Rugen. *Trochosmilia Wiltshiri* and *T. Faujasi* from Ciply are closely allied.

The depth of the space between the calicular margin and the top of the upper dissepiment in these species indicates that the corals had great mesenteric, ovarian, perigastric, and water systems. They were probably very rapid growers. The wall is merged into the costal system, which is strengthened by a most unusual cross-bar and cristiform ornamentation; and this development, which is almost epithecal, is complementary to the defective endotheca.

Family—ASTRÆIDÆ.

Division—Trochosmiliaceæ.

Genus—Parasmilia.

MM. Milne-Edwards and Jules Haime described five species of this genus from the Upper Chalk, viz.—

1.	*Parasmilia*	*centralis*,	Mantell, sp.
2.	,,	*Mantelli*,	Ed. and H.
3.	,,	*cylindrica*,	,,
4.	,,	*Fittoni*,	,,
5.	,,	*serpentina*,	,,

Parasmilia cylindrica and *Parasmilia serpentina* are readily distinguished by their external shape; but, owing to the polymorphic character of *Parasmilia centralis,* it is by no means easy to separate it from *Parasmilia Mantelli* and *Parasmilia Fittoni.*

Parasmilia Mantelli, Ed. and H., was determined from one specimen alone, and it is clearly united to *Parasmilia centralis* by *Parasmilia Gravesana,* Ed. and H., of the White Chalk of Châlons-sur-Marne and Beauvais (Oise). This species has been found in England. Having found many specimens of *Parasmilia centralis* with costæ like those of *P. Mantelli* in some parts of the corallum, and found normal costæ in others, I consider *P. Mantelli* a variety of *P. Gravesana,* and that this last species is a variety and good sub-species of *P. centralis. Parasmilia Fittoni,* Ed. and H., has a large columella and a definite structural distinction in its tertiary costæ from *P. centralis.*

The following is a list of the British *Parasmiliæ:*

1. *Parasmilia centralis,* Mantell, sp.
   ,, ,, variety *Mantelli.*
   ,, ,, sub-species *Gravesana,* Ed. and H.
2. ,, *Fittoni,* Ed. and H.
3. ,, *cylindrica,* ,,
4. ,, *serpentina,* ,,
5. ,, *monilis,* Duncan.
6. ,, *granulata,* ,,

1. Parasmilia centralis, *Mantell,* sp.; sub-species *Gravesana,* Ed. and H. Pl. VI, figs. 14—17; pl. V, figs. 8, 9.

MM. Milne-Edwards and Jules Haime notice that *P. Gravesana* is "très voisine de la *P. centralis;* elle s'en distingue seulement par ses côtes."—'Hist. Nat. des Coral.,' vol. iii, p. 173. Pl. V, figs. 10—15.

In the British Museum.

2. Parasmilia monilis, *Duncan.* Pl. V, figs. 4—7.

The corallum is long, much curved, and distorted. It is more or less cylindrical above, and contracted here and there. Inferiorly it is pedunculate, the peduncle being small, curved, and long.

The costæ are nearly equal on the peduncle; and there they are rather subcristiform, a secondary crest being found on each costa. In the intercostal spaces there is either a faint ridge, or a moniliform series of granules. On the body of the Coral the principal costæ are sharp, wavy, granular, and keeled. They have several smaller and less prominent granular costæ between them, and in the intercostal space there is a series of moniliform granules.

The calice is often smaller than the body, and the wall is very thin.

The septa are small, and there are four cycles, the last cycle being rudimentary.

The columella is small.

The height varies from $\frac{1}{4}$ inch to 2 inches, and the diameter from $\frac{1}{2}$ to $\frac{2}{3}$rds inch.

Locality. Gravesend. In the Collection of the Rev. T. Wiltshire, F.G.S.

3. Parasmilia granulata, *Duncan.* Pl. VI, figs. 5—8.

The corallum is tall, nearly straight, finely pedunculate, and cylindro-conical.

The calice is very large, widely open, deep, and has a thin margin.

The columella is well developed.

The septa are barely exsert, reach but slightly inwards, and pass downwards at once. They are very unequal, and alternately large and small, and there are four complete cycles and part of the fifth.

The costæ are subequal near the calice, and the broadest are continuous with the smallest septa. On the body the costæ are subcristiform and in sets of four. On the pedicel they are very granular and very distinct.

Height, 1$\frac{1}{3}$rd inch. Breadth of calice, $\frac{1}{2}$ inch. In the British Museum (Dixon Collection).

This species was included by Lonsdale in his genus *Monocarya*, and was termed *M. centralis*. *Parasmilia* has the priority as a genus, and the species is evidently not *P. centralis*.

The position of the genus *Parasmilia* is somewhat like that of *Cœlosmilia*, but MM. Milne-Edwards and Jules Haime have created the genus *Cylicosmilia* for *Parasmiliæ* with abundant endotheca. Now, in careful sections (pl. VI, figs. 12, 13) I find that *P. centralis* and its varieties have endothecal dissepiments reaching close to the calicular fossa. The genus must, therefore, absorb *Cylicosmilia;* and *C. Altavillensis*, Defrance, sp., of the Eocene of Hauteville, must become *Parasmilia Altavillensis*, Defrance, sp.

Reuss has described an Eocene *Parasmilia* from Monte Grumi which is closely allied to the *Parasmilia centralis* series.

Order—*ZOANTHARIA APOROSA.*

Family—OCULINIDÆ.

Genus—Diblasus, *Lonsdale.*

This genus was established by Lonsdale in Dixon's 'Geol. of Sussex,' 1850, pp. 248—254, pl. xviii, figs. 14—28), and was described by the learned zoophytologist with all that critical acumen which characterises him. MM. Milne-Edwards and Jules Haime, whilst they acknowledge the genus to be "voisin des *Synhelia*" ('Hist. Nat. des Corall.,' pl. 2, p. 115), do not give it a place in their classification. I have, therefore, carefully studied and drawn the specimens from the Dixon Collection in the British Museum, and have great pleasure in doing justice to Mr. Lonsdale by inserting his genus with slight alterations, to meet the terminology of the day.

Genus—Diblasus, *Lonsdale* (amended).

The corallum is encrusting, and very irregular in shape.

The calices are wide apart, and projecting.

The intercalicular tissue is costulate.

The septa are unequal.

There are no pali.

The columella is formed by the junction of the larger septa, and does not exist as a separate structure.

Gemmation marginal and intercalicinal.

The genus is clearly not closely allied to *Synhelia*, for it has no palular or true columellary structures. It approaches the genus *Astrohelia*, which is a transition genus, bringing the *Oculinidæ* in relation with the *Astræinæ* through the *Cladangiæ* (Milne-Edwards and Jules Haime, 'Hist. Nat. des Corall.,' vol. ii, p. 111).

1. Diblasus Gravensis, *Lonsdale.* Pl. II, figs. 1—11.

The corallum is very irregular in shape and size.

The calices project, and are irregular in their projection and size.

The costæ are granular, equal, subequal, and unequal in different parts of the same corallum.

There are three cycles of septa, and sometimes some of the fourth cycle are seen.

Some primary septa nearly reach those opposite to them, and form a rudimentary columella. They are dentate, crowded, and are granular laterally.

Diameter of usual-sized calices, $\frac{1}{6}$th inch.

Locality. Gravesend Chalk. In the British Museum (Dixon Collection).

The condition in which the specimens of this species are found is very remarkable. The inside of nearly every calice has been worn away, so that the mural edges of the septa are all that remain. The perfect calices appear to have shrunk from the surrounding cœnenchyma, and in many places the costæ have been worn off.

A large Calice magnified.

There are several specimens of Corals from the Lower Chalk, which cannot, however, be identified, on account of their fragmentary condition. Most probably, *Onchotrochus serpentinus,* Duncan, is a Lower as well as an Upper Chalk form.

The following is a complete list of the Fossil Corals from the Upper and Lower White Chalk of Great Britain :

III.—List of New Species.

1. *Caryophyllia Lonsdalei,* Duncan.
2. ,, *Tennanti,* ,,
3. *Onchotrochus serpentinus,* ,,
4. *Trochosmilia* (*Cœlosmilia*) *cornucopiæ,* Duncan.
5. ,, ,, *Wiltshiri,* ,,
6. ,, ,, *Woodwardi,* ,,
7. ,, ,, *granulata,* ,,
8. ,, ,, *cylindracea,* ,,
9. *Parasmilia monilis,* Duncan.
10. ,, *granulata,* ,,
11. *Diblasus Gravensis,* Lonsdale.

IV.—List of the Corals from the Upper and Lower White Chalk.

1. *Caryophyllia cylindracea*, Reuss, sp.[1]
2. „ *Lonsdalei*, Duncan.
3. *Caryophyllia Tennanti*, Duncan.
4. *Onchotrochus serpentinus*, „[2]
5. *Trochosmilia laxa*, Ed. and H., sp., and varieties 1, 2, 3.[3]
6. „ *cornucopiæ*, Duncan.
7. *Trochosmilia Wiltshiri*, „
8. „ *Woodwardi*, Duncan.
9. „ *granulata*, „
10. „ *cylindracea*, „
11. *Parasmilia centralis*, Mantell, sp., varieties 1, 2.[4]
12. „ *cylindrica*, Ed. and H.
13. „ *Fittoni*,[5] „
14. „ *serpentina*, „
15. „ *monilis*, Duncan.
16. „ *granulata* „
17. *Diblasus Gravensis*, Lonsdale.
18. *Synhelia Sharpeana*, Ed. and H. } [6]
19. *Stephanophyllia Bowerbanki*, Ed. and H. }

The list of species presents a remarkable assemblage of forms. The *Caryophylliæ* are represented in existing seas, from low spring-tide level to 80 or 200 fathoms. The West Indian, the Mediterranean, the south-west and the north-east British seas, are favourite localities. With one exception, the *Caryophyllia Smithi*, they are always deep water forms; and this Coral is evidently a littoral variety of *C. borealis*. The *Oculinidæ* of the present day are usually found under the same conditions as the *Caryophylliæ*, and doubtless the *Parasmiliæ* and *Trochosmiliæ* were dwellers in from 10 to 200 fathoms.[7]

There are no forms which indicate shallow waters, or anything like a reef. The Coral fauna was a deep-sea one.

[1] Synonym, *Cyathina lævigata*.

[2] Lower Chalk.

[3] Varieties or sub-species not hitherto described.

[4] Varieties or sub-species not hitherto described.

[5] See the remarks upon the propriety of absorbing *P. Mantelli*. M. de Fromentel has described *Caryophyllia decemeris* from Southfleet. Much experience in these species inclines me to believe that the decemeral arrangement is a monstrosity. There has only been one specimen of this species found.

[6] Lower Chalk.

[7] Dr. W. Carpenter, F.R.S., dredged up living *Oculinidæ* from the great depth of 530 fathoms, in the autumn of 1868.

NOTE.—CORALS IN FLINTS.

The flints of the Upper Chalk often contain Corals. Usually the destructive silicification has produced such loss of structures as to render the specific and often the generic diagnosis impossible. No new species have been distinguished in the flints.

The flint pebbles of the Woolwich series and the basement bed of the London Clay were derived from the Upper Chalk principally. In breaking up a series of the pebbles Mr. J. Flower, F.G.S., discovered several Corals. A cast of a Trochosmilian (Cœlosmilia, sp. —?) is represented below.

Cast of a Coral from a pebble.

Several young simple Corals were noticed by Mr. Flower, but their structures are very badly preserved.

Section of simple Corals in flint.

The most interesting fossil of the series is a perforate Coral, with a most delicate lace-like structure of its cœnenchyma. Within this Coral is an aporose form, probably a *Caryophyllia.*

Sections of Coral in flint.

The perforate structure resembles that of the Alveoporæ.

The only example of an aporose Coral which is invariably surrounded by another structure is in Cryptangia, a genus whose species are always immersed in Celleporæ. It is possible that this Caryophyllia of the Chalk was, like *Cryptangia parasita,* always immersed in a mass of cellular Alveopora.

V.—Corals from the Upper Greensand.[1]

The scanty Coral-fauna of the Upper Greensand was described by MM. Milne-Edwards and Jules Haime; and although some years have elapsed since the publication of the first part of the 'British Fossil Corals,' Pal. Soc., and the beds have been well searched, very few additions can be made to the list of the *Madreporaria*. The following is the list of the published species (1850):

1. *Peplosmilia Austeni*, Ed. and H.
2. *Trochosmilia tuberosa*, ,,
3. *Parastræa stricta*, ,,
4. *Micrabacia coronula*, Goldfuss, sp.

In their 'Hist. Nat. des Corall.,' vol. ii, MM. Milne-Edwards and Jules Haime make some alterations in the synonyms of the genera, and add a species to the list. They do not give any further information respecting some doubtful species noticed by Mr. Godwin-Austen and Prof. Morris. Their amended list is as follows:

1. *Peplosmilia Austeni*, Ed. and H.
2. *Smilotrochus tuberosus*, ,,
3. ,, *Austeni*, ,,
4. *Favia stricta*, Ed. and H.
5. *Micrabacia coronula*, Goldfuss, sp.

Family—TURBINOLIDÆ.

Division—Turbinoliaceæ.

Genus—Smilotrochus.

Trochosmilia tuberosa, Ed. and H., has no endotheca, and therefore is of necessity included amongst the *Turbinolidæ*. The genus *Smilotrochus* was determined in order to receive the species.

[1] The following authors have written on this subject:
W. Smith, 'Strata Identified by Organic Fossils,' 1816.
Godwin-Austen, 'Trans. Geol. Soc.,' 2nd series, vol. vi, p. 452, 1842.
Morris, 'Cat. of British Fossils,' p. 46, 1843.
MM. Milne-Edwards and Jules Haime, op. cit.

Genus—Smilotrochus, *Ed. and H.*

The corallum is simple, straight, cuneiform, free, and without a trace of former adhesion. There is no columella.

The wall is naked and costulate.

There is no epitheca.

The simple costæ are distinct from the base to the calice.

This is the simplest form of *Aporose Zoantharia*, and its structures only comprise a wall, septa, and costæ. *Flabellum* has an epitheca in addition, and *Stylotrochus* of De Fromentel is a *Smilotrochus* with a styliform columella, the septa uniting also by their thickened internal margins. *Onchotrochus*, nobis, has a pellicular epitheca, no columella; but, like *Stylotrochus*, the septa are united internally.

1. Smilotrochus tuberosus, *Ed. and H.*

> Trochosmilia tuberosa, *Ed. and H.*
> Turbinolia compressa (?), *Morris.*

This species, with five cycles of septa, was described in the 'Monograph of the Brit. Foss. Corals, Upper Greensand,' Milne-Edwards and Jules Haime.

2. Smilotrochus Austeni, *Ed. and H.* Pl. VII, fig. 12.

This species is thus described in the 'Hist. Nat. des Corall.,' vol. ii, p. 71 :

The corallum is regularly cuneiform, very much compressed below, and slightly elongate.

The calice is elliptical; the summit of the larger axis is rounded.

Forty-eight costæ, subequal, straight, fine, and granular.

Height of the corallum, about ⅓rd inch.

Locality. Farringdon.

MM. Milne-Edwards and Jules Haime do not mention where the specimen is deposited.

3. Smilotrochus elongatus, *Duncan.* Pl. VII, figs. 1—6.

The corallum is tall, straight, and nearly cylindrical.

The columellary space is large.

The septa are fine and unequal, especially in length. There are four cycles of septa.

Height, about an inch.

Locality. Upper Greensand of Cambridgeshire. In the Collection of James Carter, Esq.

4. Smilotrochus angulatus, *Duncan.* Pl. VII, figs. 7, 8.

The corallum is conical, hexagonal, and slightly curved at its very fine inferior extremity. It is broad superiorly, has six prominent angles, and is slightly compressed.

The septa are fine, unequal, and each plane between the angles has a system of four cycles.

The columellary space is large.

Height, $\frac{3}{4}$ths to 1 inch. Breadth, $\frac{1}{2}$ inch.

Locality. Upper Greensand, Cambridge. In the Collection of James Carter, Esq.

Genus—Onchotrochus.

Onchotrochus Carteri, *Duncan.* Pl. VIII, figs. 1—14.

In the young corallum there is a flat and rounded expansion at the base, by which it was attached to foreign substances, but this is lost as growth proceeds.

The corallum is either straight or slightly curved, is tall, very slender, cylindro-conical, clavate, and enlarged here and there.

The worn specimens are more or less angular in transverse outline.

The costæ are angular projections, which extend from base to calice; they are subequal, wide apart, and are connected and covered with a fine, striate, pellicular epitheca, which readily disappears.

The growth-markings are very common.

The calice is circular and shallow.

The septa are stout at the walls and wedge-shaped; they are rounded superiorly, and do not extend far inwards. There are twelve septa, and they are subequal. The septa in sections often appear to be equal, and their inner ends are joined, and the axial space is filled up by a deposit of coral structure; but the reverse is the case occasionally, and the irregularity of the septa may often be well seen. The septa are continuous with the costæ.

Height, $\frac{1}{3}$rd—$\frac{2}{3}$rds—1 inch. Diameter of costæ, $\frac{1}{12}$th—$\frac{1}{10}$th inch.

Locality. Cambridge Greensand. In the Collections of James Carter and Rev. T. Wiltshire, F.G.S.

The species has great resemblance to the lower part of *Onchotrochus serpentinus*, nobis. Very careful examination of sections and calices proves that there is no columella, that the inner ends of the septa produce a false one, and that the styloid appearance is due to fossilization.

The discovery of better specimens may, perhaps, lead M. de Fromentel to consider his *Stylotrochus*, which resembles this form, to be of the same genus.

Family—ASTRÆIDÆ.

Division—Stylinaceæ.

Genus—Cyathophora, *Michelin.*

This genus has the usual characters of compound *Astræinæ*, but the dissepiments act as tabulæ, and shut in the calice below, just as in some of the Liassic *Isastrææ*. There is no columella. The curved dissepiments are not noticed, and the family of the genus must remain unsettled, for the minute structure is clearly tabulate. The genus flourished in the Lower and Middle Oolites, and the only Cretaceous species is that under consideration, and which has been described by D'Orbigny from the Craie tuffeau of Martigues.

1. Cyathophora monticularia, *D'Orb.*, sp. Pl. VIII, figs. 15—18.

The septa are rather thick.

There are three cycles, but the third is often deficient in one or two systems.

Locality. Haldon. In the Collection of the Geological Society.

Division—Faviaceæ.

Genus—Favia, *Ehrenberg.*

This genus has absorbed the *Parastræaceæ*, so that the old *Parastræa stricta*, Ed. and H., is now named *Favia stricta*, Ed. and H.

1. Favia minutissima, *Duncan*. Pl. VII, figs. 9—11.

The corallum is encrusting, gibbous, and small.

The calices are very small, close, and with very scanty intercorallite tissue.

There are twelve septa.

The costæ are continuous.

Diameter of the calices, under $\frac{1}{12}$th inch.

Locality. Haldon. In the Collection of the Geological Society.

This is the smallest of the *Faviæ*.

Division—Astræaceæ.

Genus—Thamnastræa.

Thamnastræa superposita, *Michelin*, sp. Pl. VII, figs. 13—17.

MM. Milne-Edwards and Jules Haime thus notice this species ('Hist. Nat. de Corall.,' vol. ii, p. 559):

"M. Michelin's specimen is very young; it is encircled by a strongly folded epitheca, which is formed of two layers.

"No columella is distinguishable.

"The septa are tolerably strong and unequal.

"There are three cycles, with the rudiments of a fourth in one or two systems."

The superposition of the calices is remarkable, and I cannot but place a Coral found in the Irish Upper Greensand by Ralph Tate, Esq., F.G.S., in this species.

Locality. Ireland; Upper Greensand. In the Collection of R. Tate, Esq., F.G.S.

VI.—List of Species from the Upper Greensand.

1. *Onchotrochus Carteri*, Duncan.
2. *Smilotrochus tuberosus*, Ed. and H.
3. ,, *Austeni*, ,,
4. ,, *elongatus*, Duncan.
5. ,, *angulatus*, ,,
6. *Peplosmilia Austeni*, Ed. and H.
7. *Cyathophora monticularia*, D'Orbigny.
8. *Favia stricta*, Ed. and H.
9. ,, *minutissima*, Duncan.
10. *Thamnastræa superposita*, Michelin.
11. *Micrabacia coronula*, Goldfuss, sp.

VII.—Corals from the Red Chalk of Hunstanton, Norfolk.

The Red Chalk of Hunstanton contains several forms of *Madreporaria*. The small fauna has this peculiarity—its species belong to the group of the *Fungidæ* without exception. The specimens are small, usually much worn at the calicular end, and are readily distinguished by their mammiliform appearance and white colour. There are no compound *Fungidæ* in the Red Rock, but only such small simple forms as would now characterise the presence of physical conditions unfavorable for Coral life. The recent simple *Fungidæ* are found at all depths. Vast numbers of fossil specimens are to be collected in the Lower Chalk of Gosau, a few exist in the Upper Greensand and in the Neocomian formations. In the existing Coral-fauna no simple *Fungidæ* are found in the West Indian Seas, whilst the Red Sea, Pacific, and Indian Oceans, abound with them. It is probable that peculiar conditions are necessary for their development.[1]

List of the Species of Corals in the Red Chalk of Hunstanton.

1. *Micrabacia coronula*, Goldfuss, sp.
   ,, ,, variety, major.
2. *Cyclolites polymorpha*, Goldfuss, sp.
3. *Podoseris mammiliformis*, Duncan.
4. ,, *elongata*, Duncan.

[1] For a notice of the geology of the Red Chalk, see Rev. T. Wiltshire's communication to the Geol. Soc., Feb., 1869.

Family—FUNGIDÆ.

Sub-Family—Funginæ.

Genus—Micrabacia.

There are specimens of a small form of *Micrabacia coronula,* Goldf., sp., and of a large variety, in the Red Rock (pl. IX, fig. 1). The species is well known in the Upper Greensand of England and in the Chalk of Essen. There is another species, which is hardly distinguishable from *M. coronula* in the Neocomian of Caussols (Var.).

The variety of the species found in the Red Rock rather resembles the Neocomian species in its diameter and flatness. The genus had a very short vertical range, and was represented in later times by the *Stephanophylliæ.*

Sub-Family—LOPHOSERINÆ.

Genus—Cyclolites.

This genus almost characterises the geological horizon of the Craie tuffeau; Gosau, Ile d'Aix, les Martigues, Vaucluse, Corbières, Uchaux, &c., having deposits in which numerous species have been found. A few species are found in the White Chalk, and in the Eocene and Miocene deposits. There are some doubtful Neocomian species, and the genus is extinct.

Cyclolites polymorpha, *Goldfuss,* sp. Pl. IX, fig. 18.

The corallum is very irregular in shape, generally sub-elliptical, and not very tall.

The highest point of the calice is not central, and the central fossula is very variable in its place.

The septa are very numerous, thin, close, flexuous, crenulate, and occur in series of fours.

The solitary specimen of this form is small, but the fossula and the septa are tolerably distinct.

Locality. Hunstanton. In the Collection of the Rev. T. Wiltshire, F.G.S.

SUB-FAMILY—LOPHOSERINÆ.

Genus nov.—PODOSERIS, *Duncan.*

The corallum has a large concave base, by which it is attached to foreign bodies.

The epitheca commences at the basal margin, and is stout and reaches the calicular margin.

The height of the corallum varies.

The calice is generally smaller than the base, and is convex.

The septa are numerous and unequal, the largest reaching a rudimentary columella.

The central fossula is circular and small.

The costæ are seen when the epitheca is worn; they are distinct, connected by synapticulæ, and are straight.

The genus has been created to admit *Micrabaciæ* with adherent bases and more or less of a peduncle.

1. PODOSERIS MAMMILIFORMIS, *Duncan.* Pl. IX, figs. 2—15.

The corallum is short, straight, and broad. The base is concave, and is either larger than the calice or there is a constriction immediately above it, and it is slightly smaller than the calice.

The calice is round, convex, depressed in the centre, and is bounded by the epitheca.

The laminæ are stout, unequal, curved superiorly, and often join.

There are five cycles in six systems, the last cycle being very rudimentary.

The synapticulæ are numerous.

The costæ are straight and subequal, and are smaller than the septa.

The ornamentation of the septo-costal apparatus varies, and there may be an almost moniliform series of enlargements on the septa, or they may be plain.

The columella is formed principally by the ends of the longest septa.

The height of the corallum appears to be determined by the growth of the body between the base and the calice.

Height of the corallum, $\frac{1}{4}$ inch. Breadth at the calicular margin $\frac{1}{3}$rd inch.
" " " $\frac{1}{6}$th " " " " $\frac{1}{4}$ "
" " " $\frac{1}{2}$ " " " " $\frac{11}{30}$ths "

Monstrosities are often found amongst specimens of this species.

Locality. Hunstanton. In the Collection of the Rev. T. Wiltshire, F.G.S.

2. PODOSERIS ELONGATA, *Duncan*. Pl. IX, figs. 16, 17.

The corallum is tall, with a broad, circular, and slightly concave base, a long, conico-cylindrical stem; and a small calice, much narrower than the base.

The epitheca is in bands.

The costæ are alternately large and very small, somewhat distant, wavy, and united by synapticulæ, many of which are oblique.

The septa frequently unite by their axial ends. There appear to be five cycles of septa.

The base of the corallum has a cellular tissue, probably from the fossilization of some body to which it was adherent.

Height $\frac{5}{6}$ inch. Breadth of base $\frac{1}{2}$ inch. Calice $\frac{1}{4}$ inch.

The shape of this species is most unusual.

Locality. Hunstanton. In the Collection of the Rev. T. Wiltshire, F.G.S.

PLATE I.

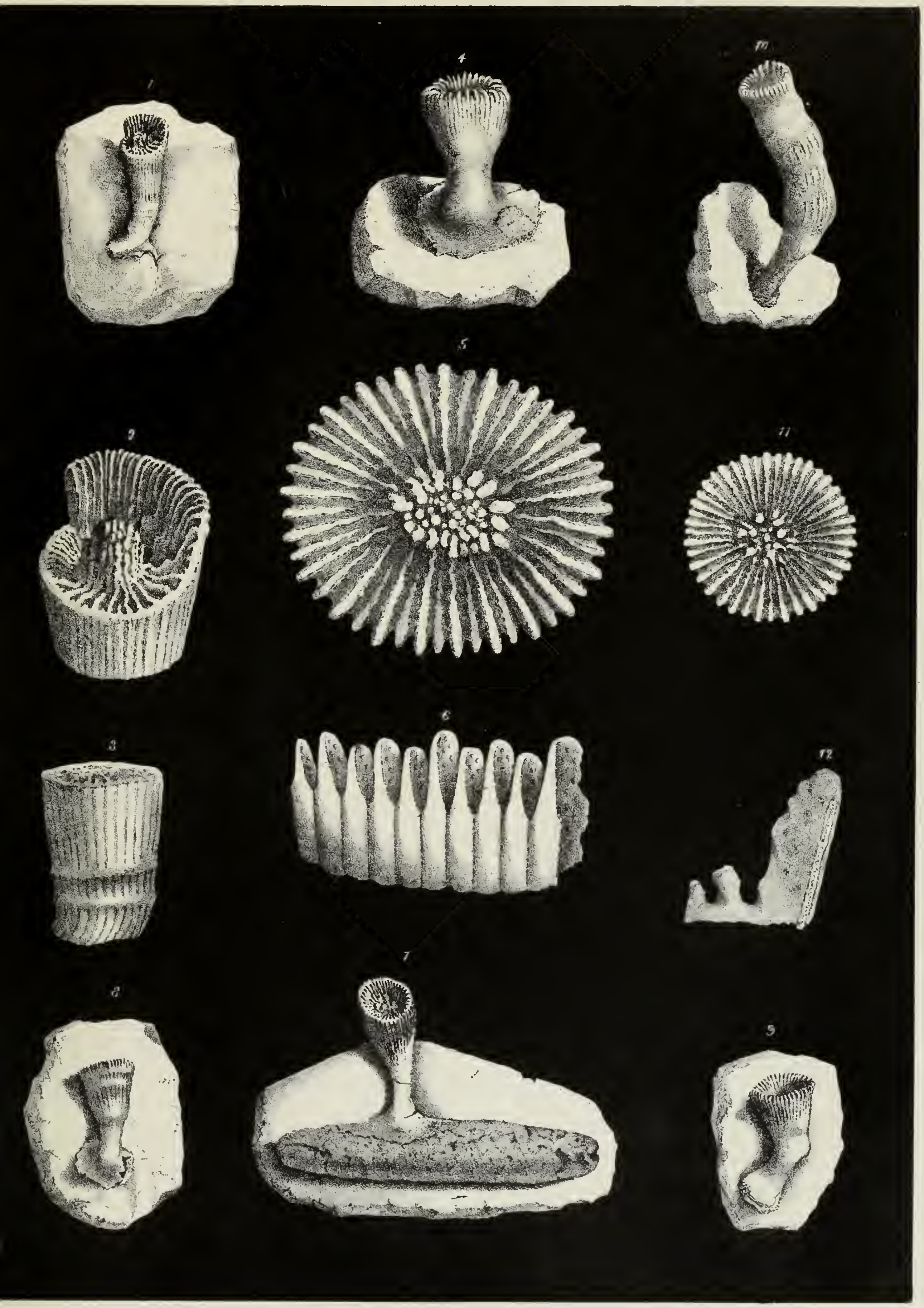
CORALS FROM THE CHALK.

Fig.

1. The corallum of *Caryophyllia Lonsdalei*, Duncan. (P. 3.)
2. The calice and columella, magnified.
3. The costæ, magnified.
4. The corallum of *Caryophyllia Tennanti*, Duncan. (P. 4.)
5. The calice, magnified.
6. The costæ, magnified.
7. *Caryophyllia cylindracea*, Reuss, sp. (P. 3.) On a Belemnite.

8., 9., 10. Unusual shapes of this species.

11. A calice, magnified, showing the small pali noticed in many specimens.
12. A septum, its dentation, and a portion of one of the pali, magnified.



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CORALS FROM THE CHALK

PLATE II.

CORALS FROM THE CHALK.

Fig.

1.
2.
3.
7.
10.
11. Various shapes of the corallum of *Diblasus Gravensis*, Lonsdale. (P. 14.)

4.
6.
9. The costæ, magnified.

5. The peculiar appearance of tolerably well preserved calices, induced by fossilization, magnified.

8. The method of gemmation, and the appearance of a large calice with the septa worn out of it, magnified.

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CORALS FROM THE CHALK.

PLATE III.

CORALS FROM THE CHALK.

Fig.

1. The corallum of *Trochosmilia* (*Cœlosmilia*) *Wiltshiri*, Duncan. (P. 9.)
2. A portion of the calice, magnified.
3. A side view of one of the septa, magnified.

4., 5. Magnified views of the costæ.

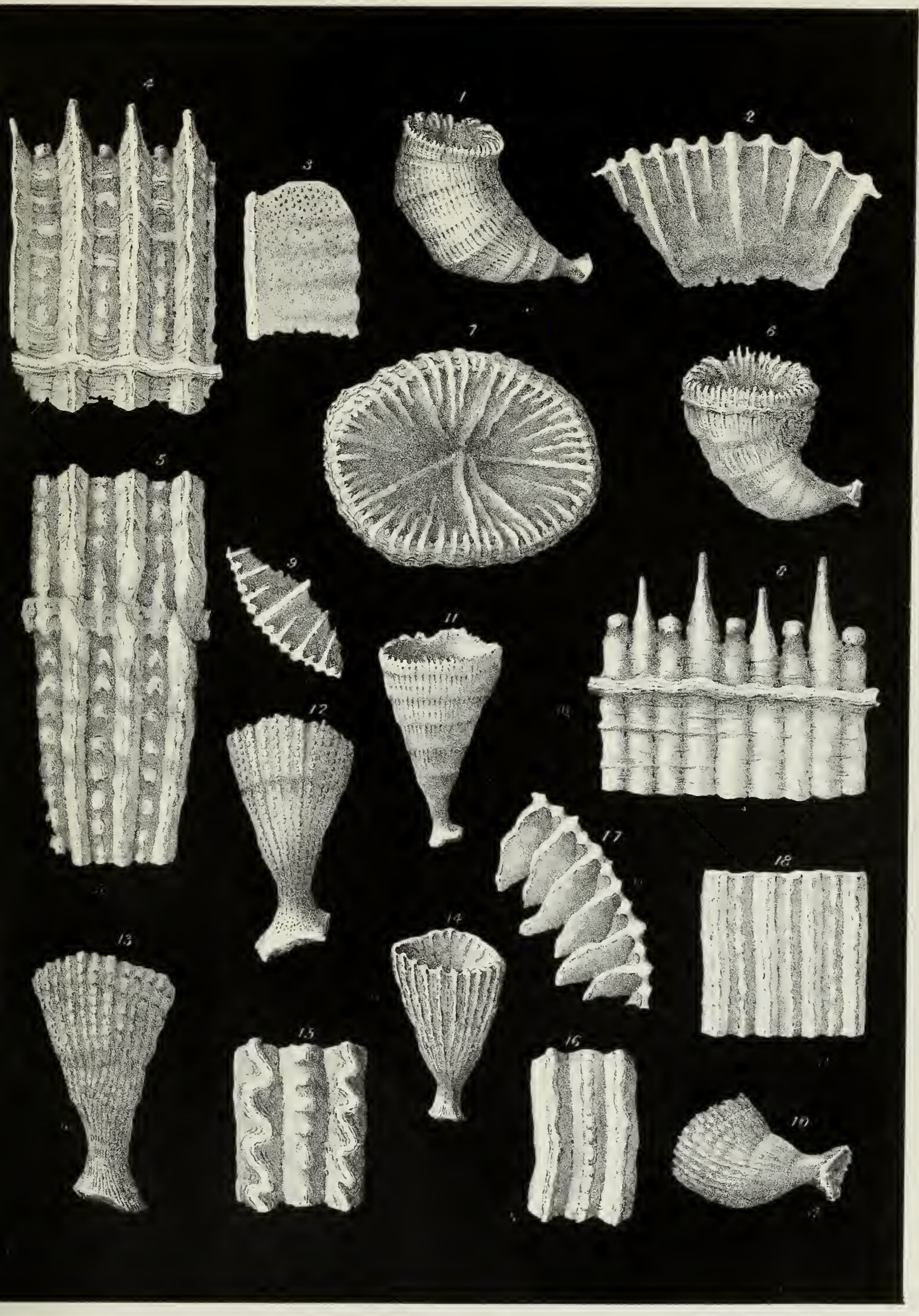
6. The corallum of *Trochosmilia* (*Cœlosmilia*) *cornucopiæ*, Duncan. (P. 8.)
7. The calice, magnified.
8. The costæ near the calicular margin, magnified.
9. The arrangement of the septa as regards their size (a diagram).
10. The peduncle, magnified.

11., 14. Specimens of *Trochosmilia* (*Cœlosmilia*) *laxa*, Ed. and H., varieties. (P. 8.)

12., 13. Magnified portions.

15., 16., 18. Costæ, magnified.

17. A diagram of the septal arrangement.



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CORALS FROM THE CHALK.

PLATE IV.

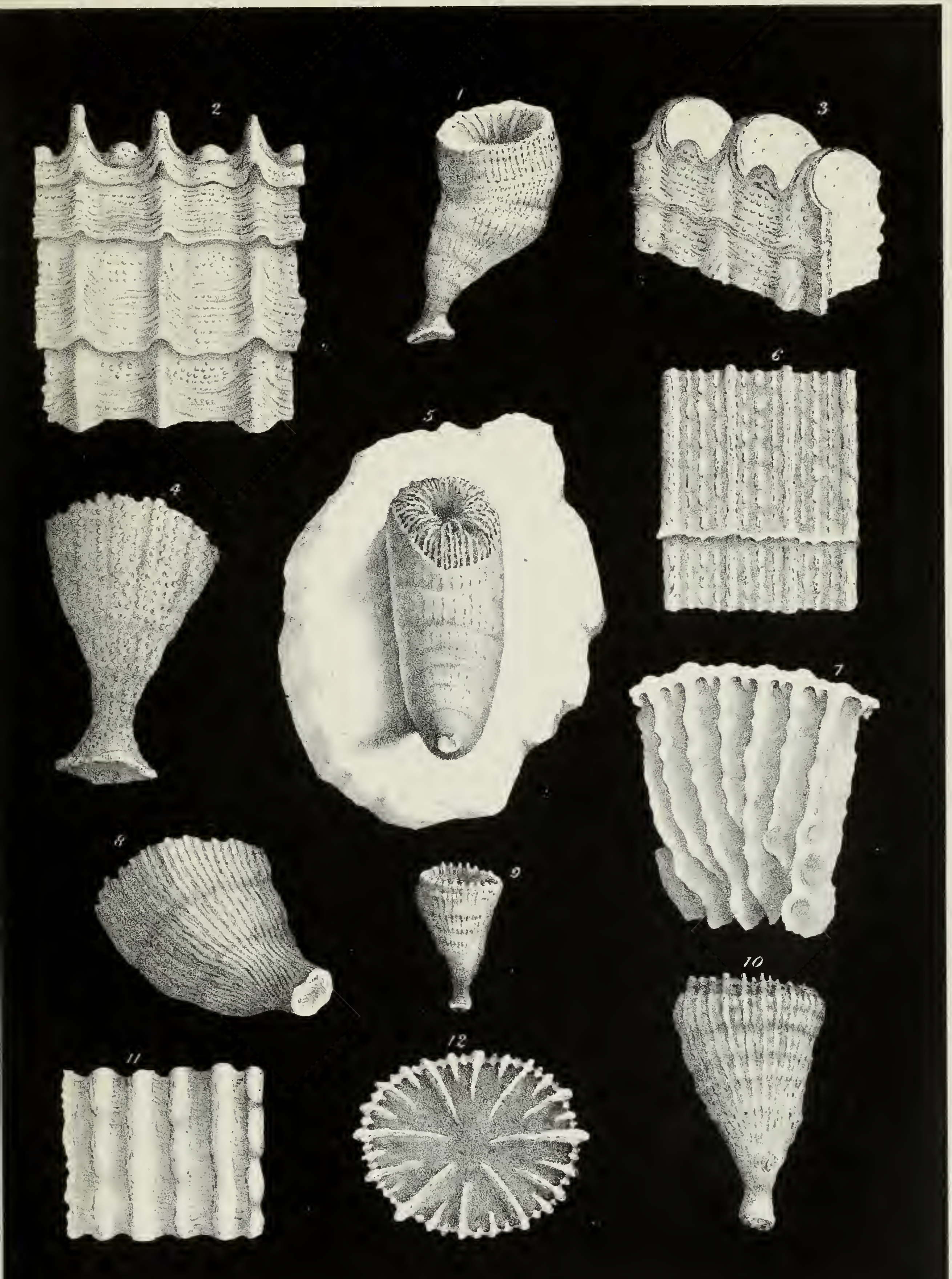
CORALS FROM THE CHALK.

Fig.

1. The corallum of *Trochosmilia* (*Cœlosmilia*) *granulata*, Duncan. (P. 10.)
2. The costæ, magnified.
3. The cellular margin, magnified.
4. The peduncle, magnified.
5. The corallum of *Trochosmilia* (*Cœlosmilia*) *Woodwardi*, Duncan. (P. 9.)
6. The costæ, magnified.
7. The septa, magnified.
8. The peduncle, magnified.

9.
10. } The corallum (nat. size and enlarged) of a variety of *Trochosmilia* (*Cœlosmilia*) *laxa*, Ed. and H. (P. 8.)

11. The costæ, magnified.
12. The calice, magnified, showing the septa of the fourth cycle.



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CORALS FROM THE CHALK.

PLATE V.

CORALS FROM THE CHALK.

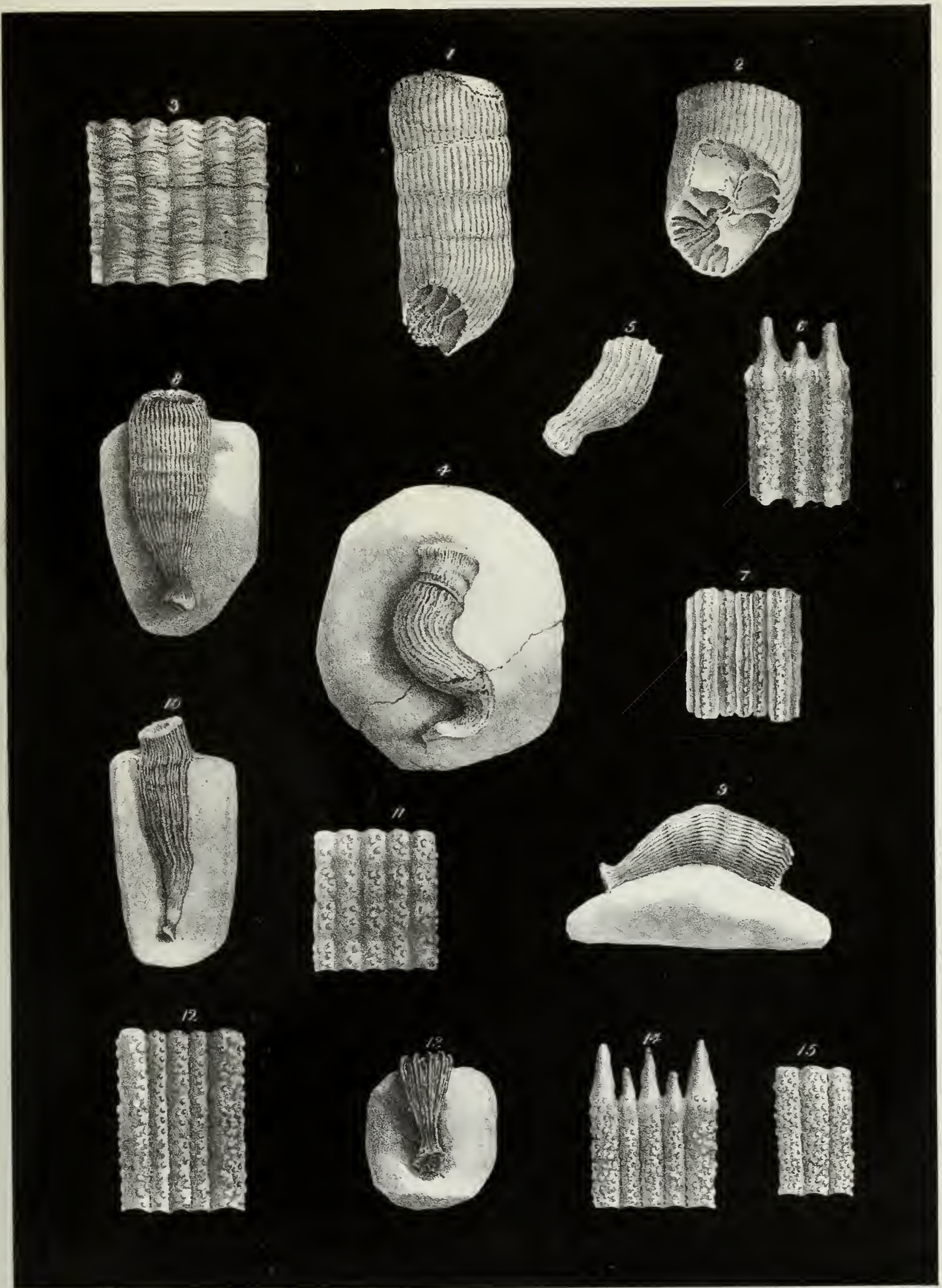
Fig.

1. The corallum of *Trochosmilia* (*Cœlosmilia*) *cylindrica*, Duncan. (P. 10.)
2. A fractured portion of the corallum, showing the endothecal dissepiments and the septa.
3. Costæ, magnified.
4. The corallum of *Parasmilia monilis*, Duncan. (P. 12.)
5. A magnified view of the costæ on the peduncle.
6. A magnified view of the costæ high up.
7. The costæ on the body of the corallum, magnified.

8., 9. The corallum of *Parasmilia centralis*, Ed. and H., sub-species *Gravesana*. (P. 12.)

10., 13. The corallum of *Parasmilia centralis*, showing the typical costal arrangement.

11., 12., 14., 15. The costæ of the corallum, magnified.



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CORALS FROM THE CHALK

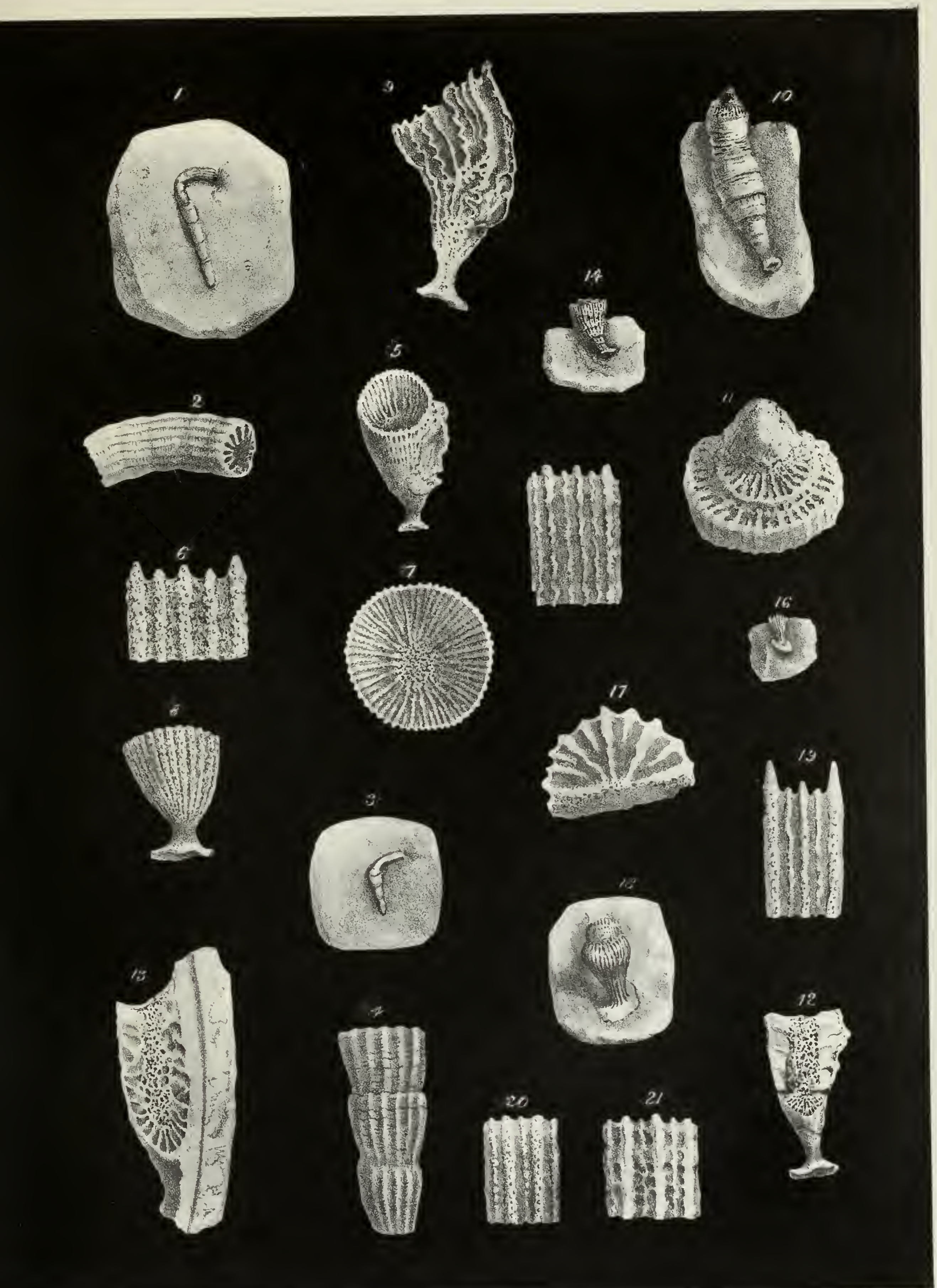
PLATE VI.

CORALS FROM THE CHALK.

FIG.

1. The corallum of *Onchotrochus serpentinus*, Duncan. (P. 4.)
2. The calicular end of the corallum, magnified.
3. The corallum of a small specimen.
4. The costæ, magnified.
5. The corallum of *Parasmilia granulata*, Duncan. (P. 13.)
6. The costæ, magnified.
7. The calice, magnified.
8. The peduncle and its costæ, magnified.
9. A longitudinal section of the corallum of *Trochosmilia* (*cœlosmilia*) *granulata*, Duncan, showing the wavy inner ends of the septa, and the scanty endotheca.
10. The corallum of a *Caryophyllia*, showing irregular growth.
11. The calice, magnified, showing a distorted arrangement of the septa.
12. } Longitudinal sections of *Parasmilia centralis*, showing the large columella and the
13. } scanty endotheca.

14. A corallum of a young *Parasmilia centralis*, variety *Mantelli*. (P. 12.)
16. A younger specimen.
15. The costæ, magnified.
17. A portion of the calice, magnified.
18. A distorted corallum of *Parasmilia centralis*.
19. }
20. } Its costæ, magnified.
21. }



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CORALS FROM THE CHALK.

PLATE VII.

CORALS FROM THE UPPER GREENSAND.

Fig.

1. 2. 3. Various shapes of the corallum of *Smilotrochus elongatus*, Duncan. (P. 19.) The specimens are worn, and the corallites are in the form of casts. Small portions of the original hard parts still remain.

4. A transverse section of a corallum, slightly magnified.

5. 6. The casts of the intercostal spaces simulating costæ, slightly magnified.

7. The corallum of *Smilotrochus angulatus*, Duncan. (P. 20.)

8. The transverse section, slightly magnified. (The specimens are in the form of casts.)

9. The corallum of *Favia minutissima*, Duncan. (P. 22.)

10. A portion, magnified.

11. Endothecal structures of the corallum, magnified.

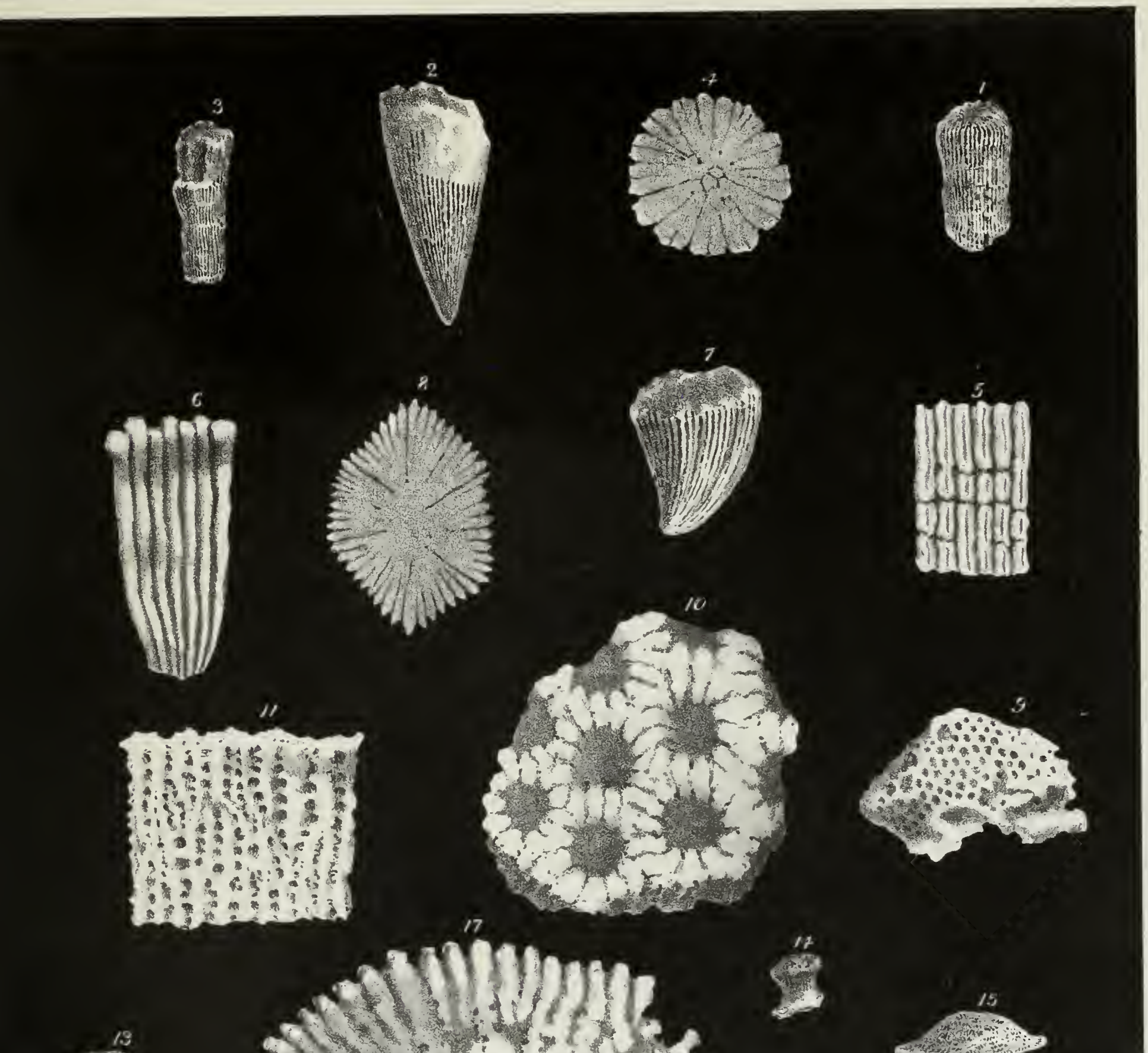
12. The corallum of *Smilotrochus Austeni*, Edwards and Haime. (P. 19.) Copied from the 'Hist. Nat. des Coralliaires.'

13. The corallum of *Thamnastræa superposita*, Michelin, sp. (P. 22.

14. 15. Specimens from the French Upper Greensand.

16. A corallum, magnified.

17. A calice, close to the edge of the corallum, magnified and drawn with the camera lucida. The continuous costæ are to be observed inferiorly.



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CORALS FROM THE UPPER GREENSAND

PLATE VIII.

ORALS FROM THE UPPER GREENSAND.

Fig.

1. 2. 3. 4. 5. 11. 13. Corallites of *Onchotrocus Carteri*, Duncan. (P. 20.)

6. A worn calice, magnified. Fossilization has produced a false union of the septa, and a central space.

7. 8. Sections of the same specimen. The central tissue is due to fossilization.

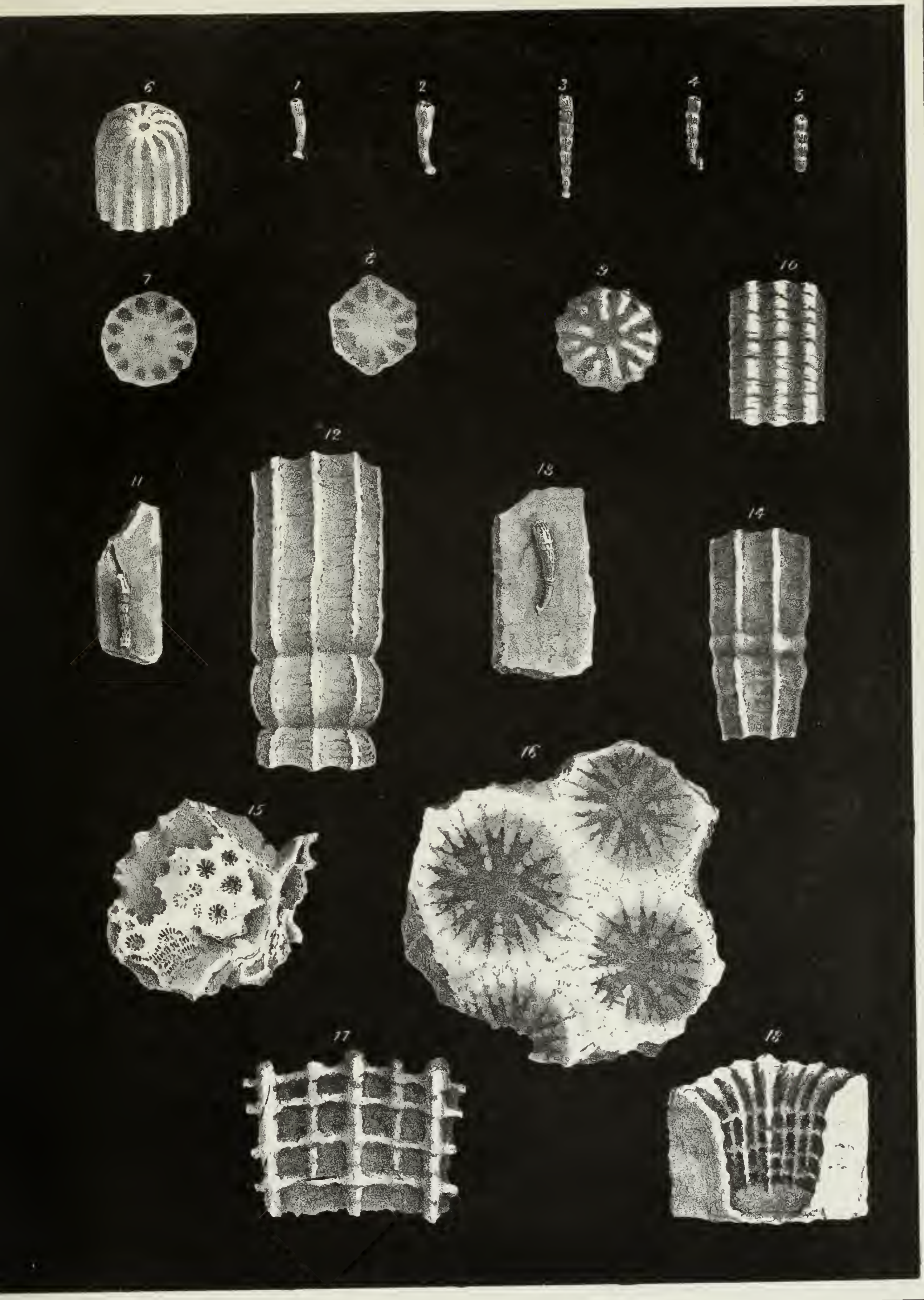
9. A normal calice, magnified.

10. 12. 14. The costal and epithecal structures of three different specimens.

15. The corallum of *Cyathophora monticularia*, D'Orb., sp. (P. 21.)

16. A portion, magnified.

17. 18. Sections magnified, showing the endotheca, and in fig. 18 one of the tabulæ.



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M & N Hanhart imp

CORALS FROM THE UPPER GREENSAND

PLATE IX.

CORALS FROM THE RED CHALK OF HUNSTANTON.

Fig.

1. A variety of *Microbacia coronata*, Goldfuss. Natural size. (P. 24.)

2. The usual appearance presented by the worn specimens of *Podoseris mammiliformis*, Duncan. (P. 25.)

3. } 5. } The calice, magnified.

6. A specimen with a large base.

4. A natural section (longitudinal) showing the synapticulæ, magnified.

7. A specimen showing a convex calice, the costæ and synapticulæ, magnified.

10. A specimen with epitheca, magnified.

11. } 12. } Natural size.

13. An irregularly shaped corallum.

14. Its base, magnified.

9. The side view, magnified.

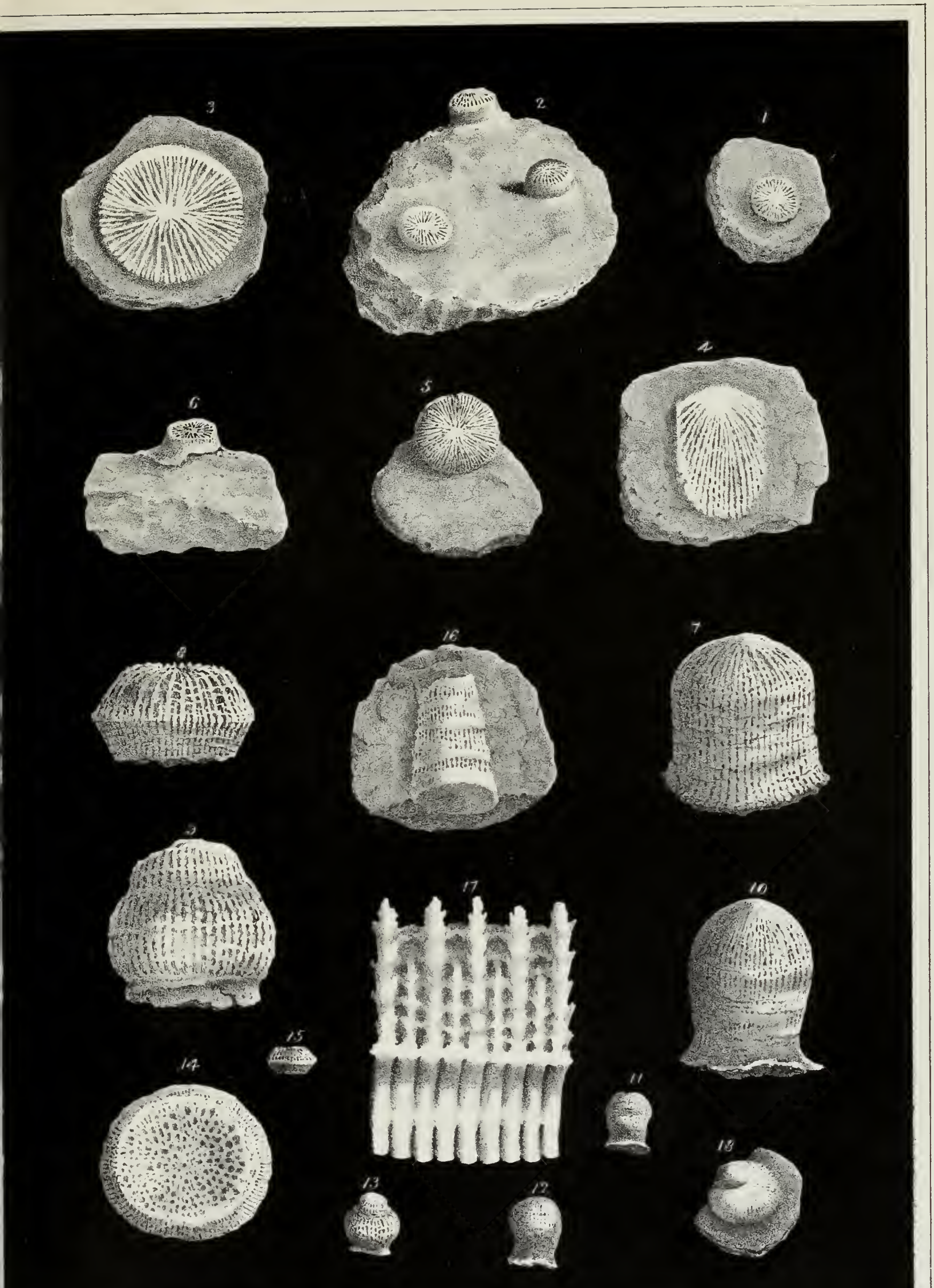
15. A short specimen.

8. A magnified view of it, showing the synapticulæ.

16. The corallum of *Podoseris elongata*, Duncan. (P. 26.)

17. Its costæ, magnified.

18. The corallum of *Cyclolites polymorpha*, Goldfuss. (P. 24.)



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CORALS FROM THE RED CHALK.

THE

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MDCCCLXIX.

A MONOGRAPH

OF THE

BRITISH FOSSIL CRUSTACEA,

BELONGING TO THE

ORDER MEROSTOMATA.

PART II.

[PTERYGOTUS BILOBUS, *Salter.*]

PAGES 45—70.; PLATES X—XV.

BY

HENRY WOODWARD, F.G.S., F.Z.S.,

OF THE BRITISH MUSEUM.

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A MONOGRAPH

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BRITISH FOSSIL CRUSTACEA

OF THE

ORDER MEROSTOMATA.

PART II.

INTRODUCTION.

GEOLOGY OF LESMAHAGO, LANARKSHIRE.

As this and the succeeding part of the Monograph will be mainly occupied with the description of species of *Pterygoti* obtained from one locality, namely, the parish of Lesmahago, in Lanarkshire, I have thought it not out of place here to prefix a short description of the district by Sir Roderick I. Murchison, Bart., who, with Prof. Ramsay, visited Lesmahago in 1855, accompanied by Mr. Robert Slimon, for the purpose of studying the geology of this locality.

This account, although written some years since, is in the main confirmed by an examination subsequently made by Mr. A. Geikie, F.R.S. (now Director of the Geological Survey of Scotland), who, in an admirable paper[1] (published in the 'Quart. Journ. Geol. Soc., Lond.,' 1860, vol. xvi, p. 312), traces out the connection of these extreme northern Silurian deposits with those of the Pentland Hills in Edinburghshire.[2] (See also 'Siluria,' 4th edition, 1867, pp. 159—162.)

I think this description the more necessary inasmuch as the name of the district has now become so familiar to all collectors of palæozoic fossils, by reason of the vast number of specimens (chiefly of *Crustacea*) obtained by Mr. Robert Slimon and his sons, and now distributed through the museums and private collections, not only of this country, but also of Europe and America.

[1] One of Mr. Geikie's sections illustrates this Introduction. See page 51.

[2] The officers of the Geological Survey and subsequently Mr. G. C. Haswell, of Edinburgh, have discovered remains of *Pterygotus* and *Slimonia* in the Upper Silurian rocks of the Pentland Hills.

On the Discovery, by Mr. Robert Slimon, of Fossils in the uppermost Silurian Rocks, near Lesmahago, in Scotland, with Observations on the Relations of the Palæozoic Strata in that part of Lanarkshire. By Sir Roderick Impey Murchison, d.c.l., f.r.s., v.p.g.s., and Director-General of the Geological Survey.

(Reprinted, by permission, from the 'Quarterly Journal of the Geological Society of London' for 1856, vol. xii, pp. 15—19.)

"*Introduction.*—At the last meeting of the British Association [in 1855], Mr. Robert Slimon brought to Glasgow two remarkable collections of fossils from the extensive parish of Lesmahago, in which he practises as a surgeon. One of these collections was derived from the bands of Carboniferous Limestone, which there alternate with Coal, and are characterised by a great abundance of fine specimens of *Producti*, *Encrinites*, Corals, and other remains peculiar to deposits of that age. The other consisted of specimens of Crustaceans in dark-coloured schist or flag, and to two or three specimens of which my attention, as President of the Geological Section, was fortunately called by Mr. David Page. The magnificent collection of Mr. R. Slimon had, in fact, remained almost unobserved, in a hall which few geologists visited.

"The moment I cast my eye over these remarkable Crustaceans, which much resembled *Pterygoti*, and saw the matrix in which they were imbedded, it occurred to me that they probably pertained to the Uppermost Silurian zone. It became, therefore, necessary to visit the locality in question, chiefly for the purpose of ascertaining the physical relations of the dark schist with large Crustaceans to the Old Red Sandstone. For, as I was aware that the genus *Pterygotus* had been found as low in the Silurian rocks as the Upper Caradoc band, it might prove that there was the same great hiatus near Lesmahago as had up to this time been supposed to prevail all over Scotland, and that no representative of the Uppermost Silurian existed. On the other hand, the band in question might prove to be that which I shall endeavour to show it is, viz. the true representative of the highest Silurian zone, as developed in Herefordshire, Shropshire, and Westmoreland in England, in Russia on the Continent of Europe, and also in North America.

"Having requested Prof. Ramsay to accompany me, we visited Lesmahago together, and there found, to our gratification, that the worthy and modest Mr. Slimon had not only a much richer collection of the fossils in question than he brought to Glasgow, but had also an accurate acquaintance with many of the prominent and detailed features of the tract. Guided by him to the best natural sections, and particularly to the spot on 'Logan Water,' hitherto famous only in Scottish song, where he had found the Crustacean fossils, we afterwards endeavoured to obtain a general notion of the relations of all the rock-masses of the district.' * * * * *

" *General Relations of the Rocks of the Lesmahago District.*—In a former communication I invited attention to the general direction of the great masses of the Silurian rocks of the South of Scotland, which have been described by various authors under that name, since the discovery in them of many well-known Silurian fossils.[1] I then suggested that, judging from some of those organic remains, as found in the environs of Girvan, there were indications, in that parallel, of an ascending order from the Lower Silurian rocks (which unquestionably form the great mass of the South-Scottish Greywacke) to the Upper Silurians. At the same time it was noticed that the strike of the Girvan strata would carry them nearly to the Silurian rocks of the Pentland Hills, south of Edinburgh, which have the same general direction, *i. e.* nearly from north-east to south-west. Now, if a line be drawn from the rocks north of Girvan to the northern face of the Pentland Hills, it is seen to pass over an intervening tract, throughout which basins of Carboniferous rocks, surrounded by girdles of Old Red Sandstone and diversified by a great abundance of igneous rocks (porphyry, greenstone, &c.), are represented in all the published geological maps. The discovery made by Mr. Slimon of fossils which prove to be of Upper Silurian age, over a considerable area in the extensive parish of Lesmahago (for this Scottish parish has a length of twenty-five miles), has advanced, therefore, the northern frontier of the Silurian or slaty rocks ; some of the localities in question being not less than twenty miles to the north-west of their previously defined boundary. The extent to which the Lesmahago Silurians may be hereafter shown to be connected upon the surface with those of the tracts around the Lead Hills, and other parts of Ayrshire and Dumfriesshire, on the south and south-east, must be a work of future labour. That work will demonstrate whether these Lesmahago rocks constitute an advanced Silurian promontory or headland, or whether, as is most probable, they form an outlier of that age.

" The large parish of Lesmahago is pre-eminently distinguished in its western part by dome-shaped hills, which rise to the south-west of the River Clyde, and on the left bank of that river, where it forms the well-known beautiful Falls of Bonnington and Stonebyres, near the town of Lanark. The rock over which the Clyde cascades is the Old Red Sandstone, which formation, extending to the west and south-west to the village and parish of Lesmahago, is overlain on the north and south by Carboniferous Limestones and Coal, whilst on the south-west it is underlain by the dark and schistose rocks to which attention is now specially invited.

" *Upper Silurian Rocks.*—The relations of these dark grey, schistose strata of clay-slate

[1] 'Quart. Journ. Geol. Soc.,' 1851, vol. vii, p. 137.

to the Old Red Sandstone are seen on the banks of the Nethan River, and also on those of other tributaries of the Clyde, particularly the Logan Water, on each of which rivers Mr. Slimon has marked the junction between the grey Silurian and the Old Red rocks. The Silurian beds rise up into several hills of considerable altitude, one of which (Nutberry, 1715 feet above the sea) we ascended. Judging from the outline of the country, and the extensive range of similar high moorlands, I am disposed to think that these rocks may be found to spread north and westward over the hills of Dunside and Middlefield, 1300 to 1500 feet high, and may even range to Cairn Table on the south, the summit of which, according to the Trigonometrical Surveyors, is 1944 feet above the sea. Advancing eastwards from the range of hills on the flank of Nutberry, in one part of which Mr. Slimon discovered an Orthoceratite, and descending the Logan Water to about a mile below the farmhouse of Dunside, you reach the uppermost band of the grey strata in which were discovered those remarkable Crustaceans which have been above referred to.

"The lowest portions of the Silurian rocks which fell under the inspection of Prof. Ramsay and myself are those which are traversed by the Nethan River as it flows from Priest Hill and Nutberry Hill to Cumberland. Several dislocations and convolutions which are seen on that line among Silurian strata, as well as in the contiguous Old Red, are well explained by the frequent protrusion of porphyry (usually a red quartziferous porphyry). On the whole, however, it was manifest to both Prof. Ramsay and myself that in receding from the Old Red boundary, and in ascending to the higher hills by the course of the Nethan, we made a gathering, descending section, because the strata, succeeding to each other with a prevalent dip to the north-east or east-north-east, consisted successively of differently constituted materials. Thus, whilst the uppermost strata were dark grey and schistose, other layers of lighter colours were more siliceous and formed stonebands. These are followed by other courses of shale and schists, in which are nodular concretions, occasionally calcareous, in which we looked in vain to find a few fossils which could have led us to suppose them (what they might very well prove to be from mineral aspect) the representatives of the Wenlock formation. It is from one of these strata that Mr. Slimon procured the Orthoceratite above alluded to, but which is too imperfect to be specifically determined. With some undulations and several breaks, particularly in the proximity of the intrusive porphyry, all these Silurian strata are inclined towards the east-north-east and north-east, and at angles varying from 12° and 15° to verticality where they roll over in flexures.

"The inferior beds exposed in the section of the Nethan are here and there mineralized, and specially so where trap-rocks, chiefly greenstone, have penetrated the strata, veins of lead-ore and much sulphate of barytes being there apparent on the surface.

"The section, however, which best exhibits the relations of the Silurian rocks to the Old Red Sandstone is seen on the banks of Logan Water, between the farms of Dunside and Ach Robert. The last of the decidedly dark grey and schistose beds observable in descending from the flanks of the Silurian hills (Nutberry, &c.), are those in which all the fossils described by Mr. Salter[1] were found by Mr. Slimon. These dark fossiliferous rocks, the clay-slate of mineralogists, are immediately overlain by and pass up into Red Sandstone, in which there are several alternations of more or less greyish or greenish-grey bands, the whole, like the beds in the Nethan, dipping to the east-north-east or north-east.

" *Old Red Sandstone.*—In the traverse along the Logan Water I did not observe any unconformity between the grey beds with Crustaceans and other fossils and the overlying red sandstones, the lowest courses of which are marked upon Mr. Slimon's unpublished map as 'Red Silurians.' For my own part, however, I would rather consider these red strata as constituting the base of the Old Red Sandstone, because they graduate up into, and alternate with, the pebbly conglomerates which are largely developed near Ach Robert and Waterside.

" Some of the porphyries which are associated with the red rock in this part of the series seemed to be interstratified and of age contemporaneous with the sandstones with which they dip symmetrically, and like which they are jointed and exhibit the way-boards of sedimentary deposits. In mineral characters and in their interstratification with red sediments, these rocks, though of much older date, present much the aspect of some of the porphyries of the Rothe-todte-liegende of the Permian age in Germany.

" The conglomerates of the Old Red of this tract differ strikingly from those of the same age in the North Highlands, where the so-called lower conglomerate is usually a very coarse breccia, the huge fragments of which are more or less angular, whilst here they are all worn and rounded pebbles, the largest of which scarcely ever reaches a foot in its greatest diameter.

" Most of the pebbles consist of grey and pink quartz-rock, but these are mixed with other varieties of crystalline and some igneous rocks. This conglomerate zone, which is fairly interstratified in red sandstone, and ranges from north to south (as laid down on Mr. Slimon's map), is much nearer to the dark grey Silurian on the Nethan River than it is to the same rock on the Logan Water; whilst on the Kype Water the two rocks are still further removed from each other. Time and detailed examination will determine whether this deviation of outline be due to breaks and unconformable arrangements, or simply to changes in the degree of inclination of the strata. By comparing the only watercourses which we examined, I am led to think that the difference of the angle of dip may sufficiently explain these diversities of superficial area, because on the Logan Water we found the inclination varying from 7° to 12° only on an average; the red beds with imbedded porphyries and conglomerates, as well as the inferior grey beds, sloping off to the north-east or east-north-east at these low angles, except where they rolled over bosses of porphyry. On the Nethan banks, on the contrary, the beds are more highly inclined.

[1] 'Quart. Journ. Geol. Soc.,' 1856, vol. xii, p. 26.

"In ascending order the Old Red Sandstone, including all that portion of it which lies above the conglomerate, and extends by Lesmahago to the Clyde and Lanark, is usually of a lighter colour and freer quality than the subjacent beds, and occupies a very varied outline in reference to the Carboniferous Limestone and Coal-fields on either side of it, and under which it is seen to dip. On the banks of the Nethan Water, where we examined them, the junctions are much broken, and, on the whole, it would appear that the older rocks have been so convoluted as to form the southern edge of the great central Scottish Coal-field, or the complete girdle of the Douglas Coal-basin, the south-west side of which is flanked by the Old Red of the Hawkshaw Hills, and also, according to Mr. Slimon, by the Silurian rock of Bremerside Hill."*

The following short account of the relation of the *Pterygotus*-bearing shales of Lesmahago was communicated in a letter to the Author by Mr. Slimon in 1867 :

"Commencing in an ascending order with what we consider to be the lowest Silurian beds of this area, we find them to be of great thickness, composed of coarse, hard, stony bands, separated by thin clayey beds of shale. The *Ceratiocaris* is the principal fossil in these lowest beds; it is very abundant, but of small size, and is associated with some shells.

"*Ceratiocaris* recurs in the higher beds, but the specimens are far larger. A fault, caused by the intrusion of a dyke of hornblende-porphyry, called the Nutberry Hill Dyke, occurs here, and is followed by a rock containing an *Orthoceras*, but ill preserved. This bed is succeeded by *Ceratiocaris*-shales splitting up into slaty laminæ, often as thin as paper. Here the *Ceratiocaris* attains its maximum development, both in size and numbers, becoming rarer in the higher beds, and disappearing altogether in the highest Silurian. In these slaty beds *Slimonia acuminata* first appears, but very small in size; as it increases in development in the higher beds, *Eurypterus lanceolatus* and *Pterygotus bilobus* (var. *a*) make their appearance, both small in size and few in numbers in the lower beds, but gradually increasing in importance in the higher; var. *a*, *inornatus*, being replaced by var. γ, *perornatus* (attaining a length of from 2 to 3 feet). *E. lanceolatus* in the lowest beds is not an inch in length, but in the highest it is of considerable size.

"*Eurypterus scorpioides* and *Stylonurus Logani* first appear in these upper slaty beds (here much disturbed by intrusive hornblende-porphyry). They are more rarely met with than other species, but appear to follow the same law as regards their gradual development and decline. I have portions from higher beds attesting their continued increase in size upwards.

"The Upper Silurian beds here described occur along the Logan Water in a distance

* The description of the Lower Carboniferous and Igneous Rocks of the tract is here omitted.

(traversed on the dip) of about four miles; the uppermost bed containing *Lingula cornea*, *Platyschisma helicites*, *Beyrichia*, &c.

"*Dictyocaris Slimoni* also occurs in these beds, but is never obtained entire. Fragments of Trilobites (?), a few small shells, and some supposed vegetable remains, complete the list of fossils.

"In many of the beds seen in this section no fossils of any kind are found.

"These grey shaly and slaty beds dip beneath and are conformable with a series of red and grey shales of a more sandy nature than the foregoing (but unfossiliferous), extending for a mile and half; I have called them "Red Silurian," but Sir Roderick Murchison considers they should form the base of the Old Red Sandstone series. In one bed only fragments of a *Stylonurus* have been found, and one small specimen, thought to be part of a *Slimonia acuminata*, but the evidence is too fragmentary to rely on. All the strata are very much disturbed, owing to intrusions of felspar- and hornblende-porphyry, causing many of the beds to be repeated and faulted."

It is, however, to these very disturbances that we are, no doubt, indebted for the exposure of the *Pterygotus*-bearing shales of Logan Water.

The subjoined section is copied from one which accompanies Mr. Geikie's paper published in the 'Quarterly Journal of the Geological Society,' 1860, vol. xvi, pl. xviii, Section 1, and exhibits the *Pterygotus*-bearing shales as they appear in the anticlinal of the bed of the Logan Water, and the succeeding Lower Old Red Sandstone and Carboniferous deposits.

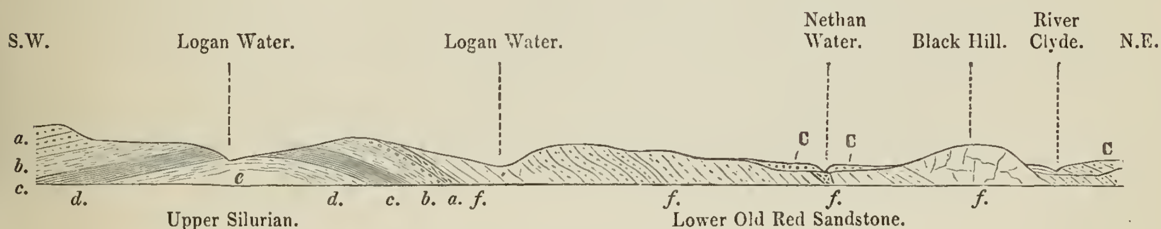


Fig. 7.—Section of the Upper Silurian and other strata near Lesmahago.

a, a. Purplish-grey Sandstones. *b, b.* Red shales, Sandstone bands, and Conglomerate. *c, c.* Olive shales. *d, d.* Hard flaggy shales (*Pterygotus*). *e.* Hard shales and stone bands. *f, f, f.* Felstone. *C, C, C.* Carboniferous strata (unconformable to Old Red).

Mr. Archibald Geikie, F.R.S., the Director of the Geological Survey of Scotland, has most obligingly furnished me with the following descriptive section, in descending order, of the deposits of the Lesmahago district, taken from the joint observations of his colleague Mr. B. N. Peach and himself.

Section of Strata below the base of the Old Red Sandstone in the District of Lesmahagow.

Basement Beds of Lower Old Red Sandstone.

a. Coarse conglomerate, chiefly of well-rounded fragments of liver-coloured quartz-rock. This is a very persistent band through the whole district.

b. Red mudstones and shales, with ripple-marks and sun-cracks. 60 to 70 feet.

c. Grey and green flaggy shales, with hard stone-partings, like portions of the Silurian series. 140 feet.

d. Red mudstones and shales, like those (*b*) below the quartzite conglomerate. 500 feet.

e. Red sandstones and fine quartz-conglomerates. 300 feet.

Upper Silurian.

f. Sandy, flaggy, green stone-bands and shales, with partings of grey and red mudstone passing conformably upwards into *e*. About 130 feet.

g. Blue, grey, and green shales, sandy mudstones and sandstone bands, becoming more sandy towards the top, and more shaly and flaggy towards the bottom. 200 feet. These are the *Trochus* beds; they contain *Platyschisma helicites*, three species of *Lingula*, *Beyrichia*, and some undetermined shells.

h. Hard blue and grey flaggy shales, with occasional bands of calcareous nodules. 350 feet. These are the *Pterygotus* beds.

i. Hard grey flagstones and bands of hard greywacke. About 500 feet.

k. Grey, blue, and olive shales, becoming more and more interbedded with hard stone-bands towards the base. About 300 feet. In some of these beds *Beyrichia* is very abundant; others contain *Ceratiocaris*, two or three species of *Lingula*, some shells not yet determined, *Platyschisma helicites*, &c.

l. Hard bands of greywacke, with shale partings. These form the lowest portion of the Silurian series visible in this district. They must be at least 2000 feet thick. Fossils are scarce, but an *Orthoceras* occurs along with plant-like markings and *Ceratiocaris*.

The total thickness of Upper Silurian strata in the neighbourhood of Lesmahago cannot be less than 3500 feet, and, as the base of the series is nowhere seen, the depth may be much more.

Although the *Pterygoti* occurring in the dark clay-slates of the Upper Silurian of Logan Water and the Nethan River are far inferior in size to the gigantic *Pt. anglicus* from the Lower Old Red Sandstone of Forfarshire and Perthshire, yet for wonderful perfection of preservation they can scarcely be rivalled, and certainly not surpassed, by similar remains from any other formation. Since the preceding description of *Pt. anglicus* was written, however, I have had the good fortune to visit the Museum of the Natural History Society at Montrose (September, 1867), and inspect the magnificent specimen of *Pterygotus anglicus* there preserved, from Lord Panmure's Quarries at Carmyllie. This unique example measures about 3 feet 6 inches in length, 13 inches across the widest segment, and is by far the most perfect remain of this species yet met with, having the head united to the complete series of body-rings, including the 'telson' or terminal segment; the body-rings themselves lifting out from the matrix and presenting both the dorsal and the ventral aspect. The thoracic plate is also seen *in situ*, the great swimming-feet (or ectognaths) attached to the head, on the centre of which last are seen the larval eye-spots (ocelli), and the great compound marginal eyes, with their facets as beautifully preserved as if it were a living Crustacean and not a remnant of a Palæozoic age. The friable condition of the fossil alone has prevented the possibility of obtaining the loan of it for delineation, but I hope to be able before the completion of this present Monograph to offer to the Society a fitting representation of this truly wonderful *Pterygotus*.

Genus 1.—PTERYGOTUS, *Agassiz.—Continued.*

Species 2.—PTERYGOTUS BILOBUS:—Salter. 1859.

1. var. α, *inornatus.*	3. var. γ, *perornatus.*
2. var. β, *crassus.*	4. var. δ, *acidens.*

The species about to be considered was first described by Mr. Salter, under the generic name *Himantopterus,* in the 'Quarterly Journal of the Geological Society' for 1855, vol. xii, pp. 27 and 28, where a figure is also given (reproduced in 'Siluria,' last edition, 1867, p. 162).

Of the species of *Himantopterus,* described in the paper above alluded to, two only at present call for consideration, namely, *H. bilobus* and *H. perornatus.* Mr. Salter subsequently referred these to *Pterygotus* (see 'Mem. Geol. Surv.,' Monograph 1, 1859, p. 39).

At the time of the publication of the above Monograph comparatively but few entire remains of *Pterygotus bilobus* had been obtained, whilst *Pt. perornatus* was even less perfectly known from parts of specimens.

It is probable that Mr. Slimon has obtained not fewer than several hundred specimens, more or less perfect, of *Pt. bilobus* alone, since the commencement of his labours in the shales of Lesmahago, but *Pt. perornatus* continues an extremely rare form.

If a comparison be instituted between the figures in the first plate of the Geological Survey Monograph on *Pterygotus* (published in 1859) and the six plates which accompany the present part of this Monograph, some idea may be formed of the progress which has been made in the discovery of new materials, during the past nine years, for the more complete elucidation of this remarkable genus.[1]

[1] This progress will be still further illustrated by the genera *Slimonia, Eurypterus,* and *Stylonurus,* the descriptions of which will follow the present part.

VAR. 1.—I. PTERYGOTUS BILOBUS, var. *a*, *inornatus*. Pl. X, figs. 1—3.

HIMANTOPTERUS BILOBUS,	*Salter*.	Quart. Journ. Geol. Soc., 1856, vol. xii, p. 29, fig. 1.
——	——	'Siluria,' 2nd edit., 1859, p. 155, foss. 21.
——	——	'Page's Advanced Text-book,' 1856, p. 135, fig. 1.
PTERYGOTUS	——	*Salter*. Mem. Geol. Surv., Mon. I, 1859, p. 39, pl. i, figs. 1—12.

Pterygotus bilobus[1] (var. *a*, *inornatus*), the original *Pt. bilobus* of Mr. Salter, is usually 5 to 6 inches in length, and somewhat less than 2 inches in its greatest breadth; the general form is elongate-oval in front, and attenuated behind (resembling the outline of a *Palæoniscus*).

In this variety the thorax is not easily distinguished from the abdomen, into which it is attenuated, the greatest width being about the fourth and fifth segment; its anterior segments are wide transversely, the posterior ones becoming less and less so, till the twelfth (19) is nearly equilateral; the telson is oblong and emarginate, and narrower than any of the somites; the antennæ are long, slender, and chelate at their extremities; the palpi (endognaths) are filiform; the swimming-feet moderately broad. These are the general characters.

Figs. 1—3, Pl. X, represent three examples of this species, the variation observable being due, to some extent, to the crumpling up, or squeezing out, which all these specimens have undergone since their original entombment.

⁂ Before proceeding further it is necessary to explain that the little numbers along the margin of the segments of each figure in the accompanying Plates correspond with the Roman numerals on the segments of the restored figures of *Pterygotus anglicus*, Pl. VIII, which appeared in the First Part of this Monograph. They are intended to remind the student that, theoretically, the head is composed of the first seven segments of the animal coalesced together to form the carapace, and that thus there are seven cephalic, seven thoracic, and five or six abdominal somites or segments (according to whether the 'telson' be reckoned as a segment or not; see Introduction, p. 5).

The head-shield is about $1\frac{1}{4}$ to $1\frac{1}{2}$ inch in breadth by an inch or $1\frac{1}{8}$ inch in length; the anterior contour is semicircular, the posterior border is straight. The compound eyes (*o*, *o*) are placed upon the latero-anterior border. They are broadly crescentic and convex, placed half below and half above the margin of the head, their extreme length being about 7 lines.[2] No lenses can be seen with the naked eye; but, when magnified, the appearance is that given in the annexed woodcut. They appear to be somewhat larger, in

[1] In the description of the species of *Pterygotus* we shall (wherever it is possible) continue to avail ourselves of Mr. Salter's diagnoses, merely altering such parts as a more complete acquaintance with the details of their structure enables us to do so with advantage.

[2] A line is always here used to signify $\frac{1}{12}$th of an inch.

proportion, in this species than in the great *Pt. anglicus* (Part I, Pl. VIII). The larval eye-spots (ocelli) occupy the centre of the head-shield (see Pl. X, Fig. 3, *le*).

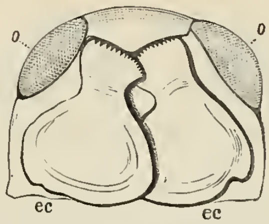


FIG. 8.

FIG. 8 *a*.

Fig. 8. Cast of the under side of the head of *Pt. bilobus*,[1] with the basal joints of the ectognaths (*ec*) in place; the large eyes (*o, o*) are also seen; Fig. 8 *a* represents a portion of one of the eyes greatly magnified.

The Body-segments.—The body, in well-preserved individuals, is barrel-shaped in front, the seven anterior or thoracic segments (8—14), taken together, measuring about $1\frac{3}{4}$ inch in length by $1\frac{3}{4}$ in greatest breadth. The thoracic somites in one specimen (Pl. X, fig. 3) measure $2\frac{1}{4}$ inches in length, but the length of the segments in this example are certainly above the average.

The anterior segments are extremely narrow in proportion to their breadth, being about five times as broad as they are long. When not crushed or distorted they are gently arched forward in the centre, whilst at the sides the anterior angles are produced forward into blunt lobes, the outer margins being oblique, and their posterior angles a little produced backward, particularly in the seventh thoracic segment (14). This general form of the thoracic segment will be observed in all the species of *Pterygotus* (see Pls. VIII, X, XI, XII, and XV).

The following five segments (15—19)—which are called abdominal—present a marked change from the preceding, becoming gradually narrower and longer; the first (15) being three or (at most) four times as wide as long; the fourth (18) hardly twice as wide as long; the fifth (19), or penultimate, is nearly equilateral, being only a very little wider than long; both the fourth and fifth somites are a little contracted in front, and have their lateral borders slightly curved and the posterior angles produced; the fifth somite (19) is carinated on its upper side, but only for its lower two thirds. The 'telson' or terminal segment (20) is 11 lines in length by 8 lines in breadth; it is carinated for a short distance at its upper end, whilst at its lower border it is deeply emarginated.

The outer margins of the body-segments and telson appear to be quite smooth, not serrated or crenated, as in several other species.

We are unable to give direct evidence of the thickness of the body-segments, as we did in the case of *Pt. anglicus* (see Part I, pp. 41 and 42); but there is little doubt that it was about the same in relative proportion to its bulk.

[1] Copied from pl. i, fig. 4, of 'Geol. Surv. Memoir,' Mon. I, on the *Eurypteridæ*.

At first sight it would appear that the body of *Pt. bilobus*, var. *a*, was destitute of the characteristic markings discernible upon the larger examples of this genus; but such is really not the case, for although not always readily seen, they can, with the aid of a good pocket-lens, usually be detected upon some part of the body-segments. It consists in this, as in the larger, species of numerous small semicircular plicæ (the curve opening forwards, see Woodcut), which probably covered the anterior half of each segment, leaving the posterior destitute of ornament (see Pl. XIII, fig. 1 *g*).

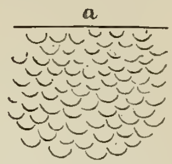


Fig. 9. Ornament on the segments of *Pt. bilobus*. *a*. Anterior border.

The head in this as in the other species is destitute of sculpture on its surface.

We must now proceed to the examination of the under side of the head and the appendages.

Numerous specimens belonging to this species can now be seen and studied, both in the Museum of Practical Geology, Jermyn Street, and in the British Museum, in which many of the appendages still remain *in situ*; whilst in other examples they are found displaced, but preserved upon the same slab with the entire body; from which it is evident they have become detached by the quiet dissolution of the softer muscular tissues of the animal.

In the accompanying Woodcut (p. 58) I have delineated, of the natural size, the oral appendages belonging to the entire specimen of *Pterygotus bilobus*, var. *a*, drawn upon Pl. X, fig. 3. These (by some slight movement in the fine, soft, clayey sediment in which the animal was enveloped) must have become separated from the rest of the body before decomposition had proceeded very far; for, although fractured and imperfect in detail (by reason of the present indurated character of the matrix), they still clearly prove that the entire buccal apparatus—held together by its integument—has thus been preserved to us.

The separate organs are represented as they lie upon the surface of the same slab of shale in which the entire body (Pl. X, fig. 3) is preserved. Their correct order and position may be readily understood by turning to Part I, Pl. VIII, fig. 1, where I have given a restored figure of the under side of the great *Pt. anglicus*, with its oral appendages in place. The *antennæ* (Woodcut, fig. 10, I, I; Pl. X, figs. 1, 2, *a*, *a*) are about $2\frac{1}{4}$ inches in length by $\frac{1}{4}$ inch in breadth at the base of the chelæ, the moveable ramus being about 8 lines long. Both the fixed and the moveable rami of the chelæ are slender; the former is slightly shorter than the latter; their points are sharply incurved; the inner borders are armed with minute teeth, which, like that of the larger species, vary in size, being at intervals marked by one much larger than the rest.

There appear to be five joints in the antennæ of this species, but it is seldom that their true line of articulation can be readily distinguished. Five are clearly to be seen in one of the antennæ figured in the accompanying woodcut, fig. 10.

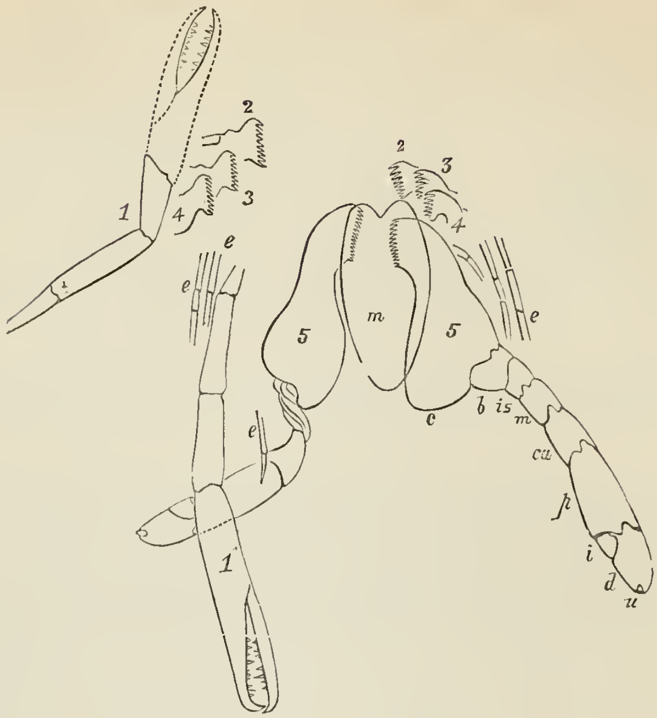


Fig. 10. Detached organs from the head of *Pterygotus bilobus* (var. *a*), figured in Pl. X, fig. 3.
1, 1. The chelate antennæ.
2, 2. The basal joints of the 1st pair of endognaths.
3, 3. " " 2nd " "
4, 4. " " 3rd " "
5, 5. The ectognaths, or maxillipeds.
m. The metastoma, or post-oral plate.
e, e, e. Portions of the filiform appendages of the endognaths.
The letters to the joints of the ectognath correspond with the articuli as enumerated in Part I, p. 6.
(The organs are here represented of the natural size.)

The first joint is 3 lines in length by 1 line at its proximal and 2 lines at its distal end in breadth; the second and third are each 6 lines in length and 2 lines in breadth; the fourth is 6 lines to the base of the articulation of the moveable ramus, the rami being 7 lines in length; the fifth joint is the moveable ramus already described.

The antennæ appear to have been epistomial organs like the inner antennæ of *Limulus* (see Part I, Pl. IX, fig. 1, 2); we have no evidence of their having been furnished with a mandible at their proximal end, as is the case with the succeeding four pairs of oral appendages, the endognaths and ectognaths. We shall, therefore, continue to consider their point of attachment to be anterior to the mouth, as represented in Part I, Pl. VIII, fig. 1, 2.

The Endognaths (which may be considered as equivalent to the mandibles and the first and second maxillæ of the higher Crustacea) are the next three pairs of oral appendages.

They present no marked variation in the size of their basal joints, although the length of the articuli of their palpi, no doubt, varies according to their anterior or posterior position in the series. The subjoined Woodcut (fig. 11) conveys a correct idea of the general form

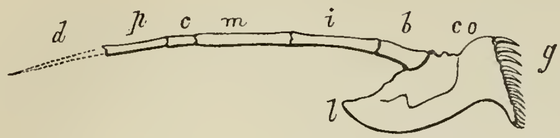


FIG. 11. Endognath of *Pterygotus bilobus.*

which they present. It is drawn from a detached specimen preserved in the British Museum.

Two other and more perfect detached examples (preserved in the Museum of Practical Geology, Jermyn Street) are represented in Pl. XIV, fig. 3.

In general form they closely agree with the far larger endognaths of *Pt. anglicus* (see Part I, Pl. VII, figs. 5, 6, 7). The coxal joint (*co*) has a broad tongue-shaped lamina (*l*), for its attachment to the head, and is furnished along its inner free border with a row of about nine or ten sharp, curved teeth (*g*), which are longest in front and have the appearance of being articulated at their base to the border of the coxal joint; the palpus is articulated to the mandible on its upper border by a short joint (*b*), succeeded by two nearly linear joints of about equal length (*i* and *m*); the carpus (*c*), a very small articulation, is followed by the penultimate joint (*p*), corresponding nearly in length with the third and fourth articuli; to this is articulated the slender, tapering terminal joint (*d*). The length of the palpi varies; the longer of the two figured at Pl. XIV, fig. 3, measures 1 inch 7 lines from its articulation with the coxal joint to its distal extremity; the shorter measures 1 inch 4 lines, whilst that figured in our Woodcut (fig. 11) is 1 inch 9 lines long; the endognath (*e*) lying across the swimming-foot of the entire *Pterygotus* in Pl. X, fig. 1, measures 1 inch, 8 lines. Two endognaths—one *in sitû* on the left side of the head (*e*), and the other lying across the three anterior thoracic segments on the right side—are seen with the *Pterygotus bilotus*, Pl. X, fig. 2; whilst the basal joints of all three pairs of endognaths, and portions of their palpi, are seen associated together in the specimen figured in our Woodcut, fig. 10, on page 58.

The Ectognaths in all the species of this order represent (so far as we are acquainted with their appendages) the principal organs of locomotion and manducation.[1] They may be considered to be homologous with the first pair of maxillipeds in the higher Crustacea, and also to correspond with the last pair of appendages in *Limulus* (Pl. IX, fig. 1, 7). In

[1] *Stylonurus* is the only genus in which we find *two pairs* of elongated swimming appendages. See 'Geol. Mag.,' 1864, vol. i, pl. x, fig. 1, p. 197; and 'Quart. Journ. Geol. Soc.,' 1865, vol. xxi, pl. xiii, p. 482.

the larval Decapod we find locomotion effected by the enlargement of two pairs of the maxillipeds, the true thoracic limbs being undeveloped, the abdomen being also destitute of appendages, thus affording another illustration among recent Crustacea of this palæozoic type of structure (see Pl. IX, fig. 7).

The ectognaths in *Pterygotus bilobus*, var. *a*, differ but little in general form from those of the great *Pt. anglicus* described in Part I of this Monograph; they can be seen *in sitû* in figs. 1 and 2, Pl. X, and in the detailed drawing of the detached appendages of fig. 3 given in the Woodcut at page 58 (fig. 10).

The following is an enumeration of the several joints of this appendage:

1. Basal joint (*coxa*).—The great lower lobe is wide and of a spherico-triangular shape, the inner margins, as well as the outer and base, being all convex. The neck is suddenly contracted and short, and the serrated terminal lobe transverse or oblong, greatly oblique, and overlapping (in many specimens) the opposite edge.

Its toothed margin is curved and set with about thirteen small teeth.

The succeeding joints (which together make up the swimming-foot) are articulated to the posterior outer angle of the great lower lobe of the coxal joint.

2. *Basos*, short and broad linear.

3. *Ischium*, narrow, longest on the inner margin.

4. *Meros*, longest on the outer margin; lower border indented, forming an articulation for the—

5. *Carpus*, somewhat triangular in form, having its outer and longest border convex, and its upper edge produced so as to form a process by which it is more strongly articulated with the fourth joint.

6. *Propodos*.—With the exception of the great basal joint, this is the largest of any, being equal in length to the four preceding articuli. It is oblong, but contracted slightly at the upper end, so as to give a curved outline to its outer border; the upper or proximal end is doubly curved where it is articulated with the fifth joint; the inner lateral margin is nearly straight; the distal end is pretty deeply indented, so as to form a rounded notch for the reception of the terminal joint.

Between this joint and the terminal one there is what Prof. Hall has called [1] an intercalated triangular plate (see Woodcut, p. 58, fig. 10, 5, *i*), united to the border of the penultimate joint, and overlapping the oval terminal palette (see *antè*, Part I, p. 35).

Dactylos.—A regularly ovate palette, as broad as the penultimate joint, and nearly as long; it fits into the bilobed extremity of the sixth joint, and is held fast by its articulation with it, and by the overlapping of the intercalated triangular plate (*i*) already referred to.

This ovate palette is seen to be indented at its distal end, and into the indentation

[1] See 'Nat. Hist. of New York, Palæontology,' vol. iii, 1859, pp. 397 and 400, on *Eurypterus*, pl. 80 and nine following plates.

is inserted a minute plate (*u*) which Prof. Hall calls a 'terminal palette;' this cannot, however, be considered of greater importance than a spine or claw affixed to the distal extremity of the joint, like that seen on the tip of the modified antennule of the male *Limulus* (see Pl. IX, fig. 1 a), or on the extremity of the terminal oval palette of the swimming-foot of the recent *Scylla serrata.*

The Metastoma, or Post-oral Plate.—This cordate plate is found with all the species. Its position is naturally behind the oral aperture, enclosing, with its anterior bilobed portion, the inner mandibular borders of the great coxal joints of the ectognaths (see Pl. VIII, fig. 1 *m*; and Pl. X, fig. 2 *m*). It also remains associated with the detached oral appendages figured in our Woodcut, p. 58, fig. 10 *m*. Its impression can be faintly seen through the head-shield of fig. 1 in Pl. VIII. Its length varies from 9 to 11 lines, and its breadth is usually about 5 to 6 lines. The anterior portion of the metastoma sometimes displays upon its surface the characteristic semicircular plicæ seen so readily in all the larger forms (Pl. III, fig. 1; Pl. XIII, fig. 1 *e*; Pl. XV, fig. 3). This plate was, no doubt, attached to the head by its posterior border, which, in some specimens, is seen to be distinctly truncated at its lower end.

The Thoracic Plate, or Operculum.—The normal position of this plate is upon the ventral surface of the body, covering the under surface of the first two thoracic somites; it was attached along its anterior border to the posterior margin of the head; the rest of the plate was, no doubt, free, as in the recent *Limulus.*

I have somewhat fully described this plate in Part I, p. 39, and I shall have occasion to refer to it again when treating of *Pt. perornatus*, &c., so I will now only briefly describe its form in *Pt. bilobus.*

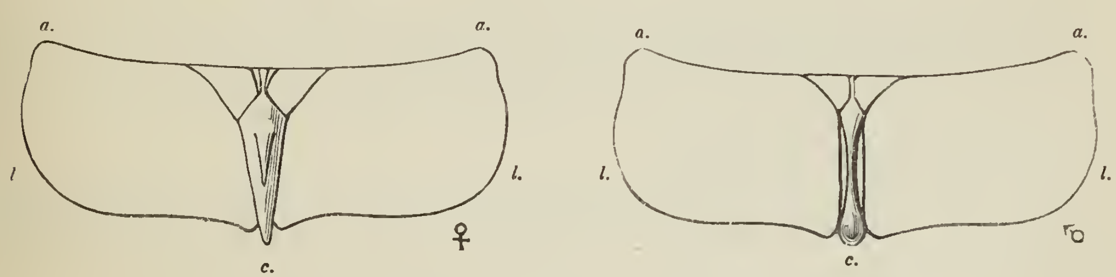


Fig. 12. Operculum of *Pt. bilobus*, var. *a*. (Two forms seen.)
a, a. Line of attachment to head. *l, l.* Lateral alæ. *c.* Central appendage.

It consists in this, as in all the other forms, of a median appendage and two lateral alæ. These alæ, which are sculptured upon their outer and under side, are equal in length to the first two thoracic segments, and in breadth correspond exactly with the segments which they overlie. They are united in the median line by a narrow central lobe (*rounded* at its distal free end in Pl. X, fig. 1 *c*, but *pointed* in Pl. X, fig. 2), hastate at its proximal end, which is directed forwards.

I have drawn these two forms of plates on the accompanying Woodcut (fig. 12), in order that they may be more clearly seen.

Probably these differences in form may be of sexual value, especially as the same portion of this plate is modified in the male and female of *Limulus* (see Pl. IX, figs. 1 and 1 *c*). I do not think them of specific importance.

Some excellent figures of *Pterygotus bilobus* will be found in pl. i, 'Memoirs of the Geol. Surv.,' Monograph I, 1859. In this plate are represented two entire examples, parts of three others, and several detached appendages belonging to *Pt. bilobus*, var. α (figs. 1—12). In pl. xv of the same work a diagrammatical restoration is given of this species, which, however, now needs to be corrected in accordance with the present more complete knowledge of its structure. Another segment should be added to the thoracic series, and between the chelate antennæ and the great ectognaths or maxillipeds, there should be three pairs of endognaths with simple palpi.

The true position of the thoracic plate or operculum has also since been satisfactorily made out.[1] (See Part I of this Monograph, Pl. VIII, fig. 1, &c.)

In pl. i, figs. 8 and 8 *a* (*op. cit.*), a very perfect swimming-foot of one of the ectognaths is represented having a long stylet (*t*) attached to the lower and inner border of the 4th joint (*meros*). This is evidently the palpus of one of the endognaths detached from its place and lying upon the surface of the swimming-foot of the ectognath, a very likely thing to happen when the appendages become detached from the head.

The other remains figured in this plate (except fig. 17, *Eurypterus lanceolatus*) belong to *Pterygotus bilobus* (var. γ, *perornatus*), to be presently described.

Var. 2.—Pterygotus bilobus, var. β, *crassus*. Pl. XI, fig. 1.

The specimen upon which this variety is founded is distinguished from var. α by the greater transverse breadth of the body-segments in proportion to their length, whilst the penultimate segment (19) and the telson (20) are as long and as well developed as in the preceding variety of this species.

Nor does it appear that any of the segments save the last thoracic (14) and the first abdominal (15) have been abnormally overlapped one above another by longitudinal compression after death.

[1] These same corrections may be made in the first figure ever given by Mr. Salter, in Nov. 1855, 'Quart. Journ. Geol. Soc.,' 1856, vol. xii, p. 28 ; and in 'Siluria,' 4th edition, 1867, p. 162.

The following are the measurements of the body:

	Head,		1 inch 3 lines long,		and 1 inch 7 lines broad.
Thoracic.	Segment	(8)	2	,,	1 ,, 9 ,,
	,,	(9)	3	,,	2 inches broad.
	,,	(10)	3	,,	2 ,,
	,,	(11)	2	,,	2 ,, 1 line broad.
	,,	(12)	2	,,	2 ,, 1 ,,
	,,	(13)	2½	,,	2 ,, ... ,,
	,,	(14)	3	,,	1 inch 8 lines broad.
Abdominal.	,,	(15)	3	,,	1 ,, 2 ,,
	,,	(16)	2	,,	1 ,, 1 line broad.
	,,	(17)	2	,,	1 ,, ... ,,
	,,	(18)	3	,,	... 11 lines ,,
	,,	(19)	7	,,	... 10 ,, ,,
	Telson	(20)	11	,,	... 9 ,, ,,

In the example figured (Pl. XI, fig. 1) the ectognaths or swimming-feet (*ec*), are both *in sitû,* and the impressions of their great serrated basal joints (*s*) can be seen through the overlying head-shield. The thoracic plate, or operculum, with its pointed median lobe, can likewise be seen impressed through the anterior thoracic somites. One of the endognaths (*e*) and one of the chelate antennæ (*a*) are also seen detached from the head and lying on the left side of the body. The large compound eyes (*o*, *o*) can also be seen on the anterior border of the head-shield.

The dilated form of this specimen appeared to me so very extreme as compared with the great series of *Pt. bilobus*, var. *a*, which I have had the opportunity to examine, both in the British Museum and the Museum of Practical Geology, Jermyn Street, that I have thought it at least entitled to a passing notice.[1]

VAR. 3.—PTERYGOTUS BILOBUS, var. γ, *perornatus*. Pl. XI, fig. 2, and Pls. XIII—XV.

HIMANTOPTERUS PERORNATUS, *Salter*. Quart. Journ. Geol. Soc., 1856, vol. xii, p. 31, and p. 28, fig. 6.

PTERYGOTUS PERORNATUS, *Salter*. Mem. Geol. Surv., Mon. I, 1859, p. 45, pl. i, figs. 13—15; pl. xv, fig. 2.

— — var. *plicatissimus*. Ib., pl. i, fig. 16.

In my report to the British Association for the Advancement of Science (read before

[1] In the 'Quarterly Journ. Geol. Soc.,' vol. xxiv, 1868, p. 295, I only spoke of three varieties of *bilobus*, viz. var. *inornatus*, *perornatus*, and *crassus*; it has since been found necessary to name a fourth variety, δ, *acidens*. (See also 'Report British Association,' Dundee, 1867, p. 44.)

Section C, at Dundee) in 1867, and printed in the volume for that year, p. 44, and also in the 'Quarterly Journal of the Geological Society' for 1868, vol. xxiv, p. 294, I pointed out the necessity of reconsidering the species of *Pt. bilobus* and *Pt. perornatus.*

Previously to 1865 *Pterygotus bilobus* had been found by Mr. Slimon in a nearly perfect state, being the first British species figured entire.

It obtained its specific name from the bilobed character of the telson; but at that time no complete example of *Pterygotus perornatus* had been met with.[1]

Since then *Pt. perornatus* has also been obtained whole, and is likewise furnished with a bilobed telson.

Difference in size cannot be relied upon as a means of separating these two, nor can the ornamentation be made use of as a specific distinction; the appendages are alike in both.

The thoracic plate or operculum is valuable, no doubt, as a means of separating such forms, but, unfortunately, it cannot often be seen.

I have therefore concluded to retain the name *bilobus* as the specific designation for all four forms described in this part, treating them as varieties only, until we can obtain more positive evidence of their specific distinctness than we at present possess.

That event arising, the specific name *bilobus* should be abolished, and the varietal appellations retained as of specific value. I do not, however, apprehend that such a necessity is likely to occur, the present tendency among naturalists being rather to diminish than to increase the number of species.

This is the largest form of *Pterygotus* found at Lesmahago, the almost entire example—figured in Pl. XIII, of one half of the natural size—being not less than $11\frac{1}{2}$ to 12 inches in length and $3\frac{1}{4}$ inches in greatest breadth.

Figs. 1 and 2 in Pl. XV were parts of two individuals equally large, whilst the detached head and swimming-feet figured of the natural size on Pl. XIV would represent an animal 18 inches in length by 5 inches in breadth. If the detached chela (Pl. XI, fig. 3) belonged to this species, we have evidence of a form not less than 2 feet in length and probably longer.

Making a careful measurement of the body of *Pt. perornatus* figured in Pl. XIII, and aided by figs. 1 and 2 of Pl. XV, we get the following proportions for an individual about 12 inches in length:

[1] The head and first six thoracic segments of a specimen as large as that figured on our Pl. XV are drawn by Mr Bone in pl. i of the 'Geological Survey Memoirs, Monograph I.'

	Head (1—7)	=	2 inches long	by 3 inches broad.	
Thoracic.	Segment (8)	=	4 lines	,, 3 ,,	2 lines broad.
	,, (9)	=	8 ,,	,, 3 ,,	3 ,,
	,, (10)	=	9 ,,	,, 3 ,,	4 ,,
	,, (11)	=	9 ,,	,, 3 ,,	2 ,,
	,, (12)	=	9 ,,	,, 3 ,,	2 ,,
	,, (13)	=	9 ,,	,, 3 ,,	2 ,,
	,, (14)	=	8 ,,	,, 2 ,,	6 ,,
Abdominal.	,, (15)	=	8 ,,	,, 2 ,,	2 ,,
	,, (16)	=	9 ,,	,, 2 ,,	0 ,,
	,, (17)	=	9 ,,	,, 1 ,,	10 ,,
	,, (18)	=	10 ,,	,, 1 ,,	6 ,,
	,, (19)	=	1 inch	,, 1 ,,	5 ,,
	Telson (20)	=	1 ,, 9 lines	,, 1 ,,	5 ,,

The head is nearly one third broader than long, semicircular in front, the large compound eyes forming prominent projections on the latero-anterior border about 10 lines in length. The facetted corneæ of the eyes in Pl. XIII, and of the detached head figured on Pl. XIV, 1 *b*, 1 *c*, can be distinctly seen with a good pocket-glass.

The larval eye-spots, or ocelli, are also clearly seen in the centre of the carapace of all the specimens figured.

The surface of the carapace is destitute of squamate markings or any other kind of ornamentation whatsoever; but the surfaces of the coxal joints of the ectognath (Pl. XIV, fig. 1 *c*) and the cordiform metastoma, or post-oral plate, are both highly ornamented with squamate markings (Pl. XV, fig. 3).

The chelate antennæ belonging to the specimen figured in Pl. XIII are 4½ inches in length, and the chelæ are 5 lines broad. The length of the movable ramus of the chela is 1 inch; the inner border of both rami are closely planted with large and small sharply pointed teeth. They closely resemble in form the antennæ of var. *a* already noticed.

The endognaths agree in form with the previously described organs of var. *a*. The woodcut figure of a detached endognath given at page 59 (fig. 11) probably belongs to this variety, with which its size well agrees.

The metastoma or post-oral plate (Pl. XIII, figs. 1 *a*, *m*, and 1 *c*; Pl. XIV, fig. 2;[1] and Pl. XV, fig. 3) is oblong oval, deeply bilobed in front, and slightly truncated along its posterior border. It is closely covered, especially upon its anterior and bilobed portion, with minute squamate markings. The detached lip-plate (fig. 3, Pl. XV) is 2 inches 4 lines long and 1¼ inch in breadth near the centre, representing an individual not less than 18 inches long.

Although the thoracic plate or operculum is discernible in the specimen figured in

[1] This lip-plate belongs to the specimen figured in Pl. XIII, which was thus figured twice by mistake.

Pl. XIII, where the anterior thoracic segments are displaced, yet its exact contour cannot very well be represented.

The anterior body-segments are much arched forward in the centre; the lateral area is recurved as in the other species; and the anterior border appears to have projected under and formed an articulation with the preceding segment (see Pl. XV, fig. 1, segments 9 and 10).

The sculpture of the body-rings (Pl. XIII, fig. 1 *g*) extends over less than half their surface.

The plicæ are open forwards, very small, often almost linear on the front margin, and the remainder are less than semicircles. The anterior border of the segments is rounded off and smooth. A transverse faintly impressed line separates the anterior sculptured half from the posterior smooth portion; but this is not always seen. The lateral borders of the segments are not crenated.

The telson (Pl. XV, fig. 2, 20), is bilobed in form like the preceding varieties α and β; and the penultimate segment has its anterior border contracted, its sides curved, and its posterior angles produced in a similar manner.

On the Branchiæ in Pterygotus.—The determination by Dr. James Hall, in America, of the true position of the thoracic plate or operculum in *Eurypterus*,[1] having since been fully confirmed with regard to the British species of *Pterygotus*,[2] *Slimonia*,[3] and *Eurypterus*,[4] and also its homology with the operculum in *Limulus* (Pl. IX, fig. 1, 1 *a*)—beneath which are placed the respiratory organs—it was reasonable to expect to find evidence of branchiæ in *Pterygotus* also, considering the wonderful state of perfection in which many of the remains of this genus have been preserved.

But it was not until 1867 that I obtained satisfactory evidence of their existence. I first drew attention to them in my 'Third Report to the British Association on the Structure and Classification of the Fossil Crustacea,' at Dundee, in September of that year, and I have since published figures of some detached leaflets in a paper read before the Geological Society in March last.[5]

I first detected them associated with the specimen figured in Pl. XII, figs. 1 *a* (*br*) and 1 *d*; next in that in Pl. XIII, figs. 1 *a* and 1 *h*. When at Dundee (in 1867), I obtained from Mr. Slimon a portion of shale having several detached leaf-like organs preserved upon it,[6] corresponding in form and surface-markings with those referred to above, and which occur with specimens of entire *Pterygoti* and lying in such a position upon the slabs as to leave little doubt that their normal place of attachment would be under the thoracic plate or operculum, as in the recent *Limulus*.

[1] Hall, 1859, 'Geol. Surv. New York,' "Palæontology," vol. iii, pp. 392—413.

[2] H. Woodward, 1867, 'Quart. Journ. Geol. Soc.,' vol. xxiii, pp. 28—37, pls. 1 and 2.

[3] Ditto, 'Intellectual Observer,' 1863, vol. iv, pp. 229—237.

[4] Ditto, 'Geol. Mag.,' 1864, vol. i, pp. 107—111, pl. v, fig. 8.

[5] 'Quart. Journ. Geol. Soc.,' 1868, vol. xxiv, p. 294, pl. x, figs. 3 *a*, 3 *b*.

[6] The same which are figured in the 'Quart. Journ.' above referred to.

But there is yet another specimen, which seems to complete the evidence of the position of these branchial plates in *Pterygotus*.

I allude to a specimen described in the 'Memoirs of the Geol. Survey,' Monograph I, p. 49, under the name of *Pt. perornatus*, var. *plicatissimus*. One of the body-rings is there figured, *loc. cit.*; and the anterior portion of the specimen is represented in pl. i, fig. 16, of that work. We have figured the whole of the same specimen of the natural size in Pl. XI, fig. 2 *a*, and the anterior portion enlarged twice the natural size in fig. 2 *b*.

Mr. Salter writes as follows:—"The carapace[1] is much compressed longitudinally, but the true form would probably be a full semioval; the position of the eyes is obscurely marked. The surface is covered with semicircular plicæ,[2] the curves of which open backwards (contrary to the usual position over the rest of the body). In front is seen the impression of the large ovate median lobe of the epistoma,[3] shaped as usual, and behind are two radiated muscular impressions[4] placed low down on the carapace and towards the median line, which impressions are probably the attachments of the great swimming-feet."

In another place (p. 45) in the same description he observes:—"The head (carapace) was formerly described by me as smooth, but in better specimens it is closely and fully sculptured, the plicæ convex *forwards*." It is evident that Mr. Salter here refers to this same specimen (Pl. XI, fig. 2); for although I have carefully examined all the heads of *Pterygotus perornatus* within my reach, I have been unable to detect any sculpture on the head-shield, nor, indeed, does it exist upon the carapace of this or of any other species of this genus. The fact, then, of the portion here referred to (fig. 2 *b*) being sculptured precludes us from considering it as the head-shield. With regard to the direction of the squamate markings having their "plicæ convex *forwards*," and the curves open backwards, as this would be obviously contrary to every other known specimen of *Pterygotus* showing sculpture, we are at once enabled to perceive that this portion belonged to the under side of the body of fig. 2 *a*, and has been squeezed forwards as well as much compressed. This explains the difficulty of the reversed direction of the squamæ.

Mr. Salter has called the central appendage (figs. 2 *a* and 2 *b* (*c*, *c*)) "the large ovate median lobe of the epistoma, shaped as usual." This most satisfactorily settles the question of the nature of this anterior displaced organ of figs. 2 *a*, 2 *b*. The plate at that time (1859) described as the epistoma, or conjoined epistoma and labrum, is now known as the thoracic plate or operculum; *c* is its central appendage, and *op*, *op* are the two broad lateral wings, closely covered with squamæ.

But that which is of the greatest interest to us in this specimen (as bearing upon the question of the position of the branchiæ), is that between the curved and squeezed-up

[1] The portion so called is seen in our enlarged figure, Pl. XI, fig. 2 *b*.

[2] See the lateral portions of fig. 2 *b*.

[3] Pl. XI, figs. 2 *a* and 2 *b*, letter *c*.

[4] Ibid., letters *br*, *br*.

operculum and the anterior border of the foremost body-segment there are preserved undoubted remains of branchial plates, figs. 2 *a* and 2 *b*, *br*, *br*, presenting the same delicate leaf-like vascular appearance as is seen in the specimens figured in Pls. XII and XIII.

These delicate membranous plates in *Pterygotus* differ in form from the corresponding organs in *Limulus;* but there is no doubt they occupied the same relative position. In *Limulus* the vascular striæ are parallel to the circumference of the lamellæ; in *Pterygotus* they appear to have branched and subdivided from the centre to the margin of the plate, becoming finer and more numerous towards the border.

As I shall have occasion to refer again to the branchiæ in the genus *Slimonia,* I do not propose to enter more fully upon their description here, especially as I hope shortly to have executed some carefully prepared figures of the respiratory organs of *Limulus* and other recent lamellibranchiate Crustacea for illustration and comparison.

In the details of the ornamentation and in the form of the body-segments this specimen (Pl. XI, fig. 2 *a*) agrees with that figured in Pl. XIII, fig. 1 *a*.

Var. 4.—Pterygotus bilobus, var. δ, *acidens*. Pl. XII.

This specimen, to which we have had occasion already to refer when speaking of the branchiæ of *Pterygotus,* is full of interest. It is preserved in the Museum of Practical Geology, Jermyn Street.

We see the head, with its great compound eyes (*o*, *o*), and its lateral eye-spots (*l e*), its chelate antenna (*a*), its great ectognaths or swimming-jaw-feet (*ec*), its metastoma or post-oral plate (*m*); the thoracic plate or operculum (*op*), with its branchiæ (*br*); and all the segments present (save 15 and 16, which are indicated with a lighter shading), including the broad bilobed telson (20).

The general outline of the body is globose, probably more so in proportion to its size than any example of var. *perornatus*. The dimensions are as follows :—

			long.		broad.			
	Head	(1—7)	15 lines	by	2 inches.			
	Body-segment	(8)	4	,,	2	,,		
Thoracic.	,,	(9)	6	,,	2	,,	2 lines.	
	,,	(10)	7	,,	2	,,	4 ,,	
	,,	(11)	6	,,	2	,,	6 ,,	
	,,	(12)	5	,,	2	,,	6 ,,	
	,,	(13)	5	,,	2	,,	5 ,,	
	,,	(14)	4	,,	2	,,	2 ,,	
Abdominal.	,,	(15)	6 ?	,,	1	,,	9 ,,	?
	,,	(16)	6 ?	,,	1	,,	7 ,,	?
	,,	(17)	6	,,	1	,,	4 ,,	
	,,	(18)	6	,,	1	,,	4 ,,	
	,,	(19)	9	,,	1	,,	... ...	
	Telson	(20)	15	,,	1	,,	1 line.	

The surface of the head is not ornamented in any way, but the bases of the jaw-feet, the thoracic plate (see Woodcut, fig. 13), and the anterior third of the body-segments, are closely covered with minute plicæ.

The portion of magnified scale-markings drawn by Mr. Hollick in Pl. XII, fig. 1 *c*, are from the body-segment (10); the squamæ are so close together that they actually present the appearance represented, but there is no real overlapping of scales, only a mimetic resemblance to it. Along the anterior border the scale-markings are very fine, closely packed, and but little arched; lower down they become more acute and considerably larger; whilst on the lateral borders they are extremely minute and packed very close together. The edges of all the segments are very minutely serrated, as in the larger Devonian species. The thoracic plate, which is very well preserved, is about 2 inches in breadth by about 10 lines in length.

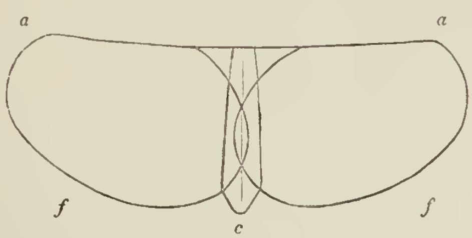


Fig. 13. Thoracic plate or operculum of *Pt. bilobus*, var. δ.[1]
a, a. Line of attachment to posterior border of head-shield. *f.f.* Free border. *c.* Central appendage.

[1] The representation of the operculum in Pl. XII, fig. 1 *e*, is not quite correct. This Woodcut conveys a better idea of its form.

There is little doubt but that we have in this species evidence of a second and more membranous thoracic plate lying within the outer one, but its border is but ill defined in our plate.

The branchiæ are more distinct in this than in any specimen I have seen.

The largest leaflet is 8 lines in length by 4 lines in breadth ; the smaller are 4 lines in length and 2 lines wide.

The chelate antennules in var. δ (Pl. XII, fig. 1 *b*) are distinguished from the ordinary form of *bilobus* by the more regular denticulation of the chelæ, and by the larger size of the terminal joint.

Length 1 inch 7 lines, breadth 4 lines; length of moveable ramus of chelæ 13 lines.

The metastoma, or post-oral plate, does not appear to be truncated posteriorly, as in var. *perornatus*, and is somewhat more oval and less elongated; and the emargination of the anterior border is much more slight.

Length 15 lines, breadth 10 lines.

Both ectognaths are preserved entire, and the serrated edges of their great basal joints are seen pressing through the head-shield, just in front of the larval eye-spots. The free swimming-foot attached to the coxal joint measures $1\frac{1}{2}$ inch in length, and the penultimate joint (which is the widest) is $4\frac{1}{2}$ lines in breadth.

It exhibits the same small intercalated triangular plate at the point of attachment of the dactylos with the propodos, and the former has at its distal extremity the same minute terminal palette, or unguis, common to the other species of *Pterygotus*.

This, together with all the foregoing varieties described in this Part, are from the Uppermost Silurian of Lesmahago, Lanarkshire.

PLATE X.

UPPER SILURIAN CRUSTACEA.

Order—MEROSTOMATA.

Sub-Order—EURYPTERIDA.

FIG.

1—3. *Pterygotus bilobus*, Salter, var. α, *inornatus*.

1. Represents an almost entire example, having several of its appendages preserved.

   a, a. The chelate antennæ, displaced (the stars indicate the proximal ends).

   o, o. The large compound eyes.

   s, s. The serrated mandibular borders of the basal joints of the maxillipeds or ectognaths (their general outline is seen through the carapace).

   ec, ec. The ectognaths, with their broad, oar-like extremities.

   e. One of the small endognaths, preserved entire, but lying on the slab detached from the head.

   c. The narrow median lobe of the thoracic plate (the impression seen through the overlying somites).

2. An almost equally well-preserved specimen. The antennæ (*a, a*) are still attached in their normal position to the anterior border of the head-shield. One of the endognaths (*e*) and an ectognath (*ec*) are still *in sitû;* the metastoma or post-oral plate (*m*) is clearly seen.

3. Exhibits well the large compound eyes (*o, o*) and the larval eye-spots or *ocelli* (*le*). All the appendages have been detached from this specimen, and lie at a little distance from it upon the same slab (they are represented in the Woodcut, p. 58).

N.B.—The small figures placed against the body-segments in all these plates correspond throughout with the small Roman numerals placed against the segments of the restored figures of *Pt. anglicus*, given in Part I, Pl. VIII, of this Monograph.

From the Uppermost Silurian formation of Lesmahago, Lanarkshire.

Drawn, of the natural size, from specimens in the British Museum.

Holbck, Del et lith   F Waller Imp

PTERYGOTUS BILOBUS, *Salter (var a)*

Uppermost Silurian Rocks of Lanarkshire

PLATE XI.

UPPER SILURIAN CRUSTACEA.

Order—MEROSTOMATA.

Sub-Order—EURYPTERIDA.

FIG.

1\. *Pterygotus bilobus*, var. β, *crassus*.

o, o. The compound eyes.

s. The serrated mandibular border of one of the ectognaths.

ec, ec. The ectognaths, preserved *in sitû*.

e. One of the endognaths, displaced.

a. A chelate antenna; the claw or pincer hidden beneath the telson.

2 *a*. Seven of the anterior segments of *Pt. bilobus* var. γ, *perornatus* (= var. *plicatissimus*, Salter).

op. The opercular plate, squeezed forward and much distorted.

c. The central appendage of same.

br. The branchiæ exposed to view, protruding from beneath the upper and originally attached border of the operculum.

2 *b*. The above described portion of 2 *a*, magnified twice (the letters are the same as in fig. 2 *a*, above). [The direction of the plicæ upon the operculum indicates that the *lower* edge in our Plate was that by which it was originally attached to the posterior border of the under side of the head. The head, and probably the first two body-segments, are wanting.]

3\. Detached antennæ of a very large *Pterygotus* (probably *Pt. bilobus*, var. γ).

ch. The moveable chela, with its large teeth, resembling those of *Pt. anglicus* (see Part I, Pl. VII, figs. 1—3).

The surface at B is covered with the valves of *Beyrichia Klœdeni* or *gibba* (a small bivalved Entomostracan), a pair of which are enlarged and figured at B 1.

Figs. 1, 2 *a*, and 3, are drawn of the natural size; fig. 2 *b* magnified twice; fig. B 1 magnified six times.

From Uppermost Silurian of Lesmahago, Lanarkshire.

Figs. 1 and 3 are in the British Museum. Fig. 2 is in the Museum of Practical Geology, Jermyn Street.

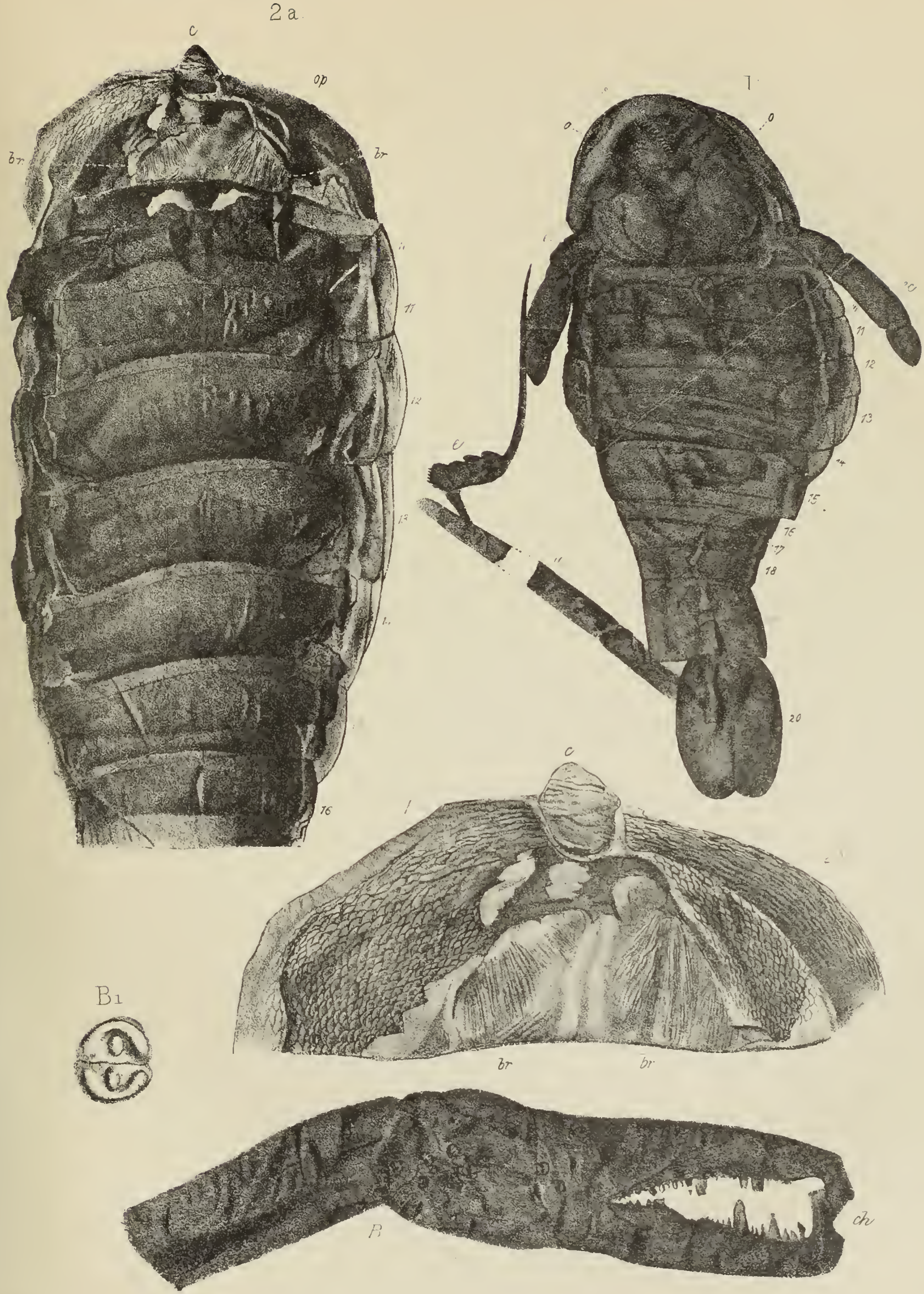


Fig. 1. PTERYGOTUS BILOBUS, *Salter (var. β.)* *Fig. 2 (var. γ.)*

Fig. 3. Detached chelate Antenna of Pterygotus

PLATE XII.

UPPER SILURIAN CRUSTACEA.

Order—Merostomata.

Sub-Order—Eurypterida.

Pterygotus bilobus, var. δ, *acidens*.

Fig.

1 *a*. Represents an individual of the natural size.

le. The larval eye-spots.

o, *o*. The compound eyes.

a. One of the antennæ.

m. The metastoma, or post-oral plate.

ec. One of the ectognaths.

op. The operculum (*c*, its central portion).

br. Some of the branchiæ.

The segments marked 15 and 16 are absent in the specimen.

1 *b*. Antenna, magnified twice the natural size; *m*, moveable ramus of chela.

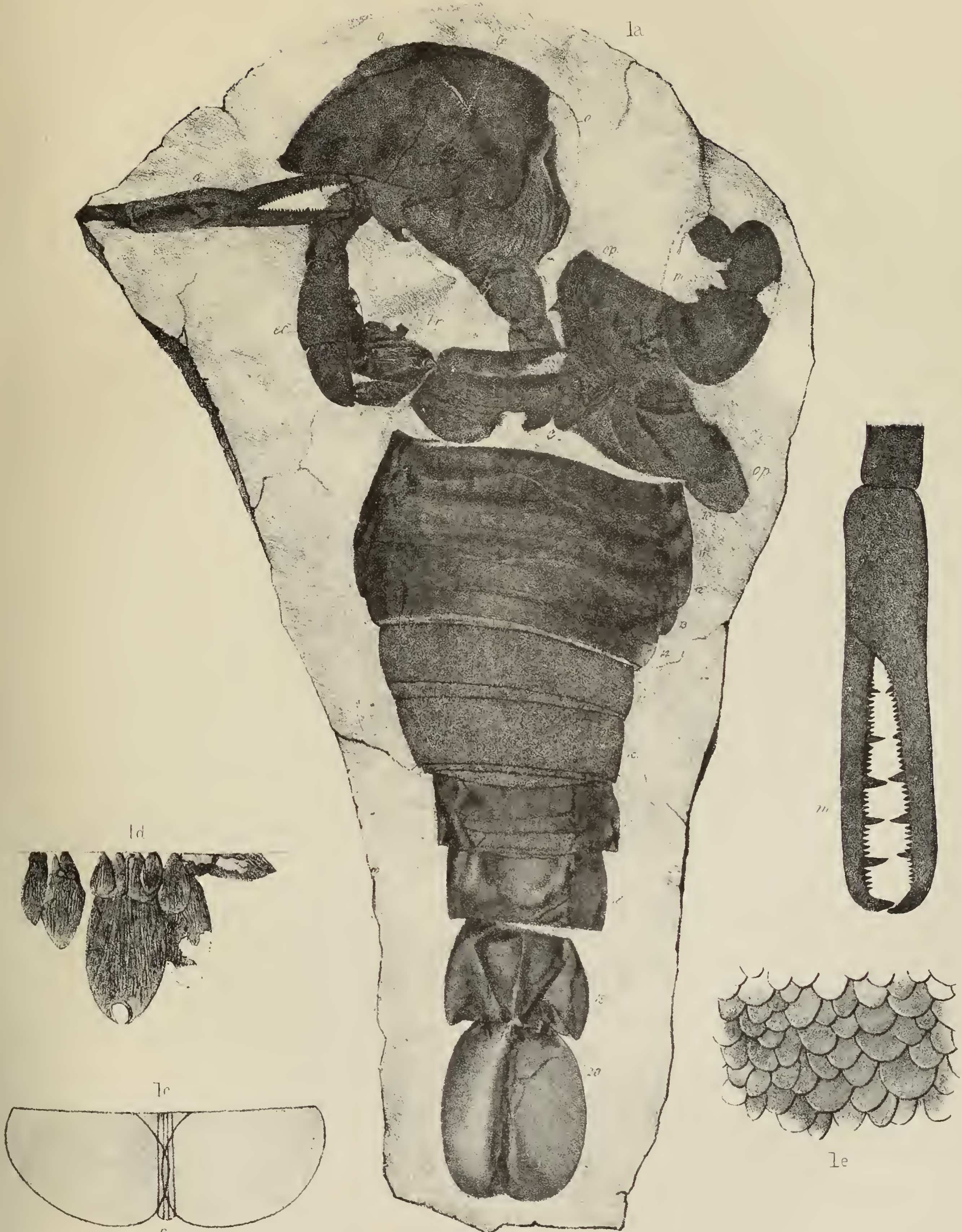
1 *c*. Some of the scale-like markings upon the surface of the thorax, greatly magnified.

1 *d*. Some of the branchiæ, enlarged twice the natural size.

1 *e*. Thoracic plate restored (natural size).

From the Uppermost Silurian of Lesmahago, Lanarkshire.

Drawn from a specimen in the Museum of Practical Geology, Jermyn Street.



A.T. Hollick, Del et lith

F Waller Imp

PTERYGOTUS BILOBUS *Salter (var. δ)*

U. Silurian of Lanarkshire

PLATE XIII.

UPPER SILURIAN CRUSTACEA.

Order—Merostomata.

Sub-Order—Eurypterida.

Pterygotus bilobus, var. γ, *perornatus*.

Fig.

1 *a*. An almost entire example, reduced to one half the natural size.

a, *a*. The antennæ, detached and displaced (the points of attachment to the head are marked by stars).

o, *o*. The eyes; and (*le*) the larval eye-spots or ocelli.

e. An endognath and part of another, displaced.

ec. The ectognaths, or swimming-feet; their great basal joints (*c*, *c*) are detached, and lie in front of the head.

m. The metastoma or post-oral plate.

The telson (20) is restored.

1 *b*. The larval eyes, magnified three times.

1 *c*. One of the large compound eyes, magnified three times.

1 *d*. A portion of same, magnified fifteen times.

1 *e*. The metastoma, of the natural size.

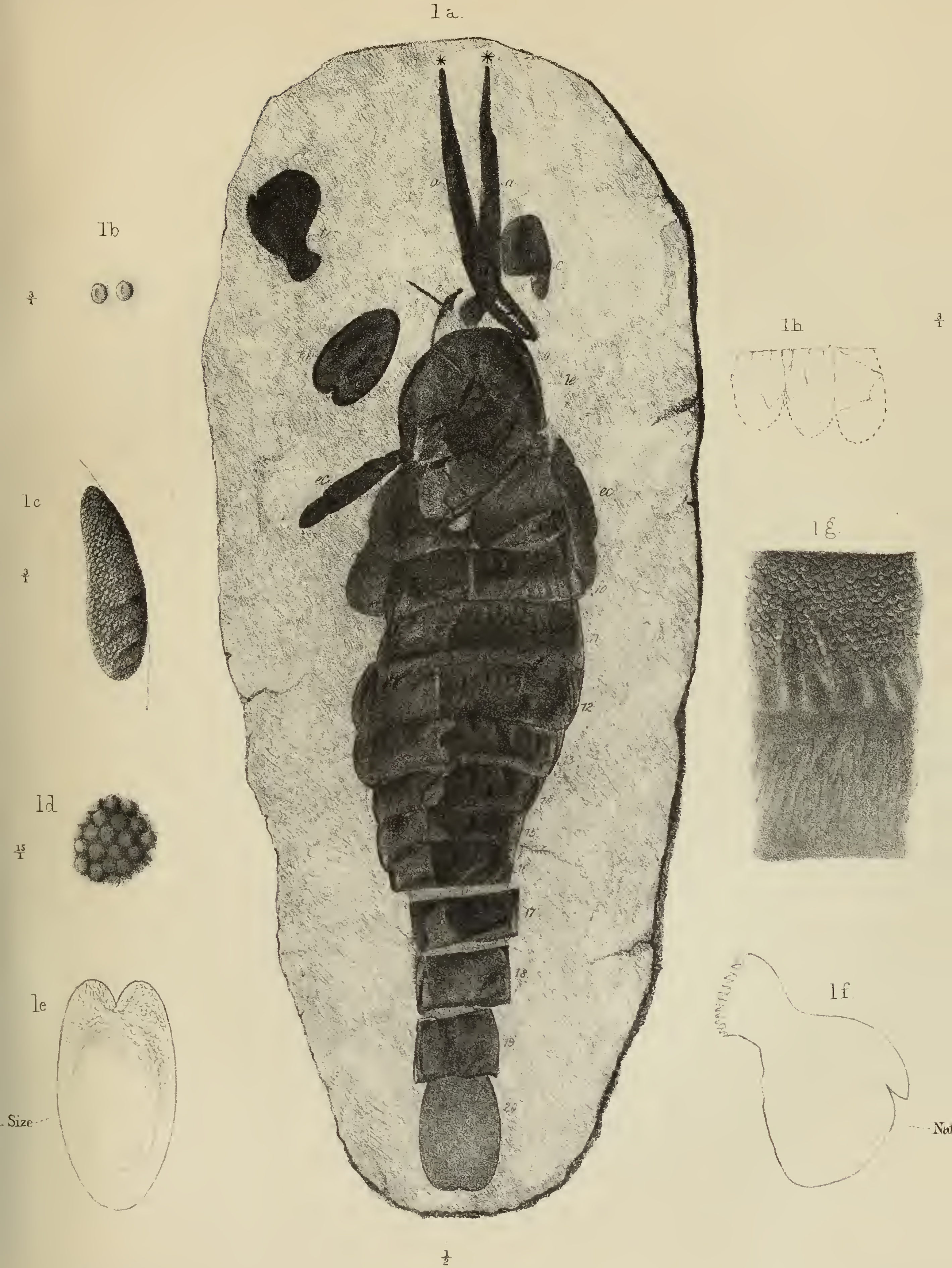
1 *f*. The coxal joint of one of the ectognaths, natural size.

1 *g*. Part of a thoracic segment, magnified three times, to show the scale-like markings on its upper part.

1 *h*. Three of the branchiæ, magnified three times, seen in this specimen where a portion of a thoracic segment has been removed.

From the Uppermost Silurian of Lesmahago, Lanarkshire.

Drawn from a specimen in the Museum of Practical Geology, Jermyn Street.



A. T. Hollick, Del. et lith.

F. Waller Imp.

PTERYGOTUS BILOBUS, *Salter* (*var γ.*)

U. Silurian of Lanarkshire

PLATE XIV.

UPPER SILURIAN CRUSTACEA.

Order—Merostomata.

Sub-Order—Eurypterida.

Fig.

1. *Pterygotus bilobus*, var. γ, *perornatus*.

1 *a*. Head, with the great maxillipeds or ectognaths still attached, but displaced outwards on either side.

The form of the head-shield, the compound facetted eyes (*o*, *o*), and the larval eyes (*le*) are well seen. The joints of the ectognaths are lettered to correspond with the names given to the articuli (see page 6, Part I).

1 *b*. Facets of eye, magnified ten times.

1 *c*. Facets of eye, magnified six times.

(The form is evidently altered by compression.)

1 *d*. Scale-like markings from the right coxal joint, magnified four times.

(The upper portion of the left coxal joint is restored.)

2. A detached lip-plate, showing the lower edge (near the figure 2) to be truncated. (See also Pl. XV, fig. 3.)

3. Two beautifully preserved endognaths, found detached (the joints are lettered as in fig. 1).

From the Uppermost Silurian of Lesmahago, Lanarkshire.

Figs. 1 *a*, 2, and 3 are drawn, of the natural size, from specimens preserved in the Museum of Practical Geology, Jermyn Street.

E Fielding Del et Lith

F.Waller. Imp

PTERYGOTUS BILOBUS, (var. γ) PERORNATUS, &c.

Uppermost Silurian of Lanarkshire

PLATE XV.

UPPER SILURIAN CRUSTACEA.

Order—MEROSTOMATA.

Sub-Order—EURYPTERIDA.

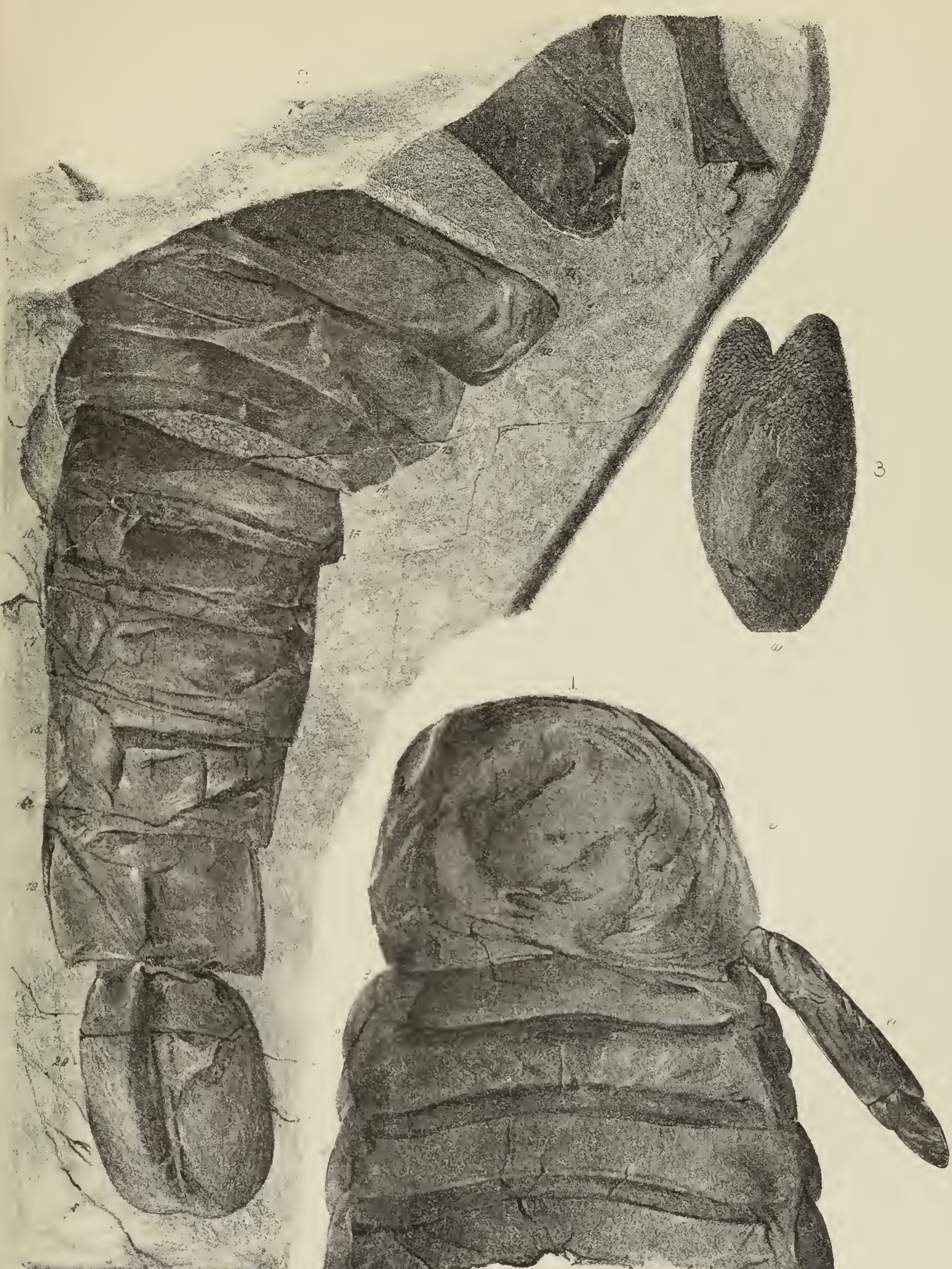
Pterygotus bilobus, var. γ, *perornatus*.

FIG.

1. Head and four anterior segments of body of *Pt. bilobus*, var. γ, showing the larval eyes (*le*), the compound eyes (*o*, *o*), and the right swimming-foot (ectognath), still attached *in sitû*.
2. The greater part of the body of another specimen, having portions of the thoracic and the entire series of abdominal somites preserved.
3. A very beautifully preserved detached lip-plate of *Pt. bilobus*, var. γ, showing the truncated posterior border (*a*), by which it was attached to the head. The surface is beautifully squamate.

From the Uppermost Silurian of Lesmahago, Lanarkshire.

Drawn, of the natural size, from specimens preserved in the British Museum.



J. Fending Del et Lith

F. Haner imp

PTERYGOTUS BILOBUS, (var γ) PERORNATUS

U Silurian of Lanarkshire

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A MONOGRAPH

OF THE

BRITISH FOSSIL BRACHIOPODA.

PART VII. NO. III.

CONTAINING

PAGES 169—248; PLATES XXIII—XXXVII.

THE SILURIAN BRACHIOPODA.

BY

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breviori, lacunosa, apice quadridentata. Mus. Tess., tab. v, fig. 6; Lister, 'Angl.,' 249, tab. ix, fig. 57; Grew, 'Mus.,' tab. xix, fig. 6: fossilis." This description is obscure, for many species of Rhynchonella have their shell roundish, with numerous grooves, and the remainder of the diagnosis cannot be easily understood. Linné, however, gives us three references for figures; but these in no way assist us in clearing up the difficulty, for it is certain that these three figures refer to totally different species! The first reference is to pl. v, fig. 6, of the 'Musæum Tessinianum;' and although it would be difficult to positively identify any species from such unsatisfactory drawings (see our Pl. XXIII, fig. 15 A, B), it would be still more difficult to refer to it the shell under description. The description in the 'Musæum Tessinianum' is, however, somewhat more explicit,[1] but by no means implies that the shell we now term *Rhynchonella Wilsoni* was Linné's *Anomia lacunosa.*[2] The second reference to pl. ix, fig. 57, of Lister's 'Historiæ Animalium Angliæ' (1678) is quite a mistake, as any tyro would at once perceive by a glance at the figure we have also reproduced from that work (Pl. XXIII, fig. 17). This last, according to Lister, would be a Carboniferous shell, and is stated to occur near Gunnerley, in Lincolnshire, and in the lead-bearing rock of Derbyshire and Yorkshire. The reference to Grew's curious old book, 'Musæum Regalis Societatis,' published in 1681, is stranger still, for the *Rhynchonella* therein figured (see our Pl. XXIII, fig. 16) is as different from that of Lister as it is from Linnæus's own represented in the 'Musæum Tessinianum.' It is therefore not surprising that James Sowerby, in 1816, did not recognise the Linnean species while describing his *Terebratula Wilsoni;* and as no other person could possibly have done so, who had not been able to consult the Tessinian collection where the type of *A. lacunosa* is preserved, it naturally follows that Sowerby was justified in giving the name *Wilsoni* to his well described and figured species. It will also be seen from a glance at the list of synonyms and references that, with the exception of Wahlenberg, Hisinger, and Dalman, almost every palæontologist has made use of the Sowerbyan designation of *Wilsoni.* In 1821, it is true, Wahlenberg describes *Anomites lacunosus* by the following few words:—"*plicatus globosus, in sola Gothlandia lectus;*" and Dalman, in 1827, described at some length, and gave recognisable figures (see our Pl. XXIII, fig. 18) of Sowerby's *T. Wilsoni,* as the *Anomia lacunosa* of Wahlenberg; but strangely he does not refer to Linné, though he mentions *T. Wilsoni* of Sowerby as being a synonym! Hisinger, in 1837, reproduces Dalman's views; and, as I stated above, it is very possible that *A. lacunosa* of Linné and *T. Wilsoni* may be synonymous, but of this there is not positive proof. At p. 128 of his 'Ipsa Linnæi Conchylia,' however, Mr. Hanley informs us that in the Linnean

[1] 'Musæum Tessinianum,' p. 88:—*a.* "*Anomia subglobosa,* postice dupliciter striata, tab. v, fig. 6:—Testa versus umbones striis 16, antice vero 8. Valvula superior antice valde emarginata dentibus duobus, ad latere vero utrinque dentibus duobus. Valvula inferior tribus, ad latere vero utrinque dentibus duobus."

[2] Prof. M'Coy and some other palæontologists would, however, refer quite another species, namely, the *T. borealis* of Schlotheim and von Buch, to the *A. lacunosa* of Linnæus.

Collection he found the box of *Anomia lacunosa* containing four specimens which would agree with *Terebratula Wilsoni*.

I need not refer to Schlotheim's interpretation of *T. lacunosa* ('Die Petrefact.,' p. 267, 1820), further than to say that he unites under that denomination a strange mixture of different species. In 1834 Von Buch ('Ueber Ter.,' p. 47) adopts Sowerby's *T. Wilsoni*, placing at the same time Wahlenberg and Dalman's *A. lacunosa* among its synonyms; he also mentions that the *Ter. lacunosa* of Zeiten and of Schlotheim is a distinct species from that of Linnæus; and adds, "It is sufficiently evident, from the figure of Fabio Colonna,[1] and his description, that in his *Anomia triloba lacunosa* he has wished to refer specially to this (Jurassic) Terebratula, and that Langé and Scheuchzer have confounded no other shell with this one; that in all likelihood Linné wished to reunite under the name of *lacunosa* all the *Terebratulæ* of which the dorsal (ventral) sinus is distinguished by an upper plaited surface; and that, consequently, when the Swedish naturalists wish to reduce this denomination to the *T. Wilsoni*, they have not the right to invoke for this the authority of Linné." I cannot, however, entirely coincide with the baron's view, although the various references to the figures given by Linné for his *A. lacunosa* might lead to that inference; for it must also be remembered that Linné describes other Anomias referable to other species of *Rhynchonella*. Bronn, in his 'Index Palæontologicus,' adopts Sowerby's *T. Wilsoni*, adding *A. lacunosa* of Linné, Wahlenberg, Dalman, and Hisinger, among its synonyms. Lindström also, in the 'Proceedings of the Royal Academy of Stockholm,' adopts the term *Wilsoni* in preference to that of *lacunosa;* so also MM. de Verneuil and Keyserling, at p. 87 of their work 'On the Geol. of Russia;' and d'Eichwald and many other palæontologists have taken the same view. The designation *Wilsoni* must therefore be adopted for the shell under description, and that of *lacunosa* placed amongst those *incertæ sedis*, or with a point of interrogation among the synonyms of *Wilsoni;* for no palæontologist can in justice claim any species as his own whose description and figures are as obscure and doubtful as are those of the so-termed *Anomia lacunosa* of Linnæus.

Rhynchonella Wilsoni is variable in its shape, but especially in the degree of convexity or depth of its valves; the ribs are also smaller and more numerous in some specimens than in others; and although these last in the greater number of specimens become divided by an indented line (fig. 6*c*) in their proximity of the margin, this character is not observable in every specimen. It has also appeared to me that those extremely gibbous specimens, whose depth so greatly exceeds that of their length or width, occur principally in the Aymestry Limestone; the Llandovery and Wenlock examples being larger, but comparatively less deep or ventricose. *Ter. pentagona*, Sow., from the Upper Ludlow of Delbury, Shropshire, is a young shell of *Rh. Wilsoni*. Mr. Salter informs me that the *Hemithyris pentagona*, M'Coy ('Brit. Pal. Foss.,' p. 205), is

[1] 'De Purpura,' p. 35, 1675.

also a young *Rh. Wilsoni;* and that he has likewise examined the original figure and described specimen of *Hem. sphæroidalis*, M'Coy ('Brit. Pal. Foss.'), in the Cambridge Museum, and found it to be a small variety of *R. Wilsoni;* the specimen being from the Aymestry Limestone of Botville. *T. crebricosta*, Sow., from the Llandovery of Tynewydd (figured in the 'Silurian System'), is evidently a crushed specimen of *Rh. Wilsoni*, as any one can see by a glance at the original specimen preserved in the Museum of the Geological Society. *Rhynchonella* (*Hemithyris*) *Davidsoni* of M'Coy appears, both to Mr. Salter and myself, to be only a variety of *Rh. Wilsoni*, with fewer and larger ribs. I will describe it separately, but as a named variety of the last-mentioned species.[1]

Position and Locality. Although Viscount d'Archiac, M. de Verneuil, and some few other palæontologists, have given the range of this species from the Upper Silurian to the Devonian inclusive, it may be here stated that its range has not, I think, been hitherto satisfactorily ascertained beyond the Llandovery, Wenlock, and Ludlow periods. In his paper on the 'Parallelisme des depôts Paléozoiques de l'Amérique Septentrionale avec ceux de l'Europe,'[2] M. de Verneuil states that *T. Wilsoni* in general belongs to the *Upper Silurian*, and that it is represented in the *Devonian* system by a species with finer and more numerous ribs. At p. 392 of the same author's 'Description of the Fossils of the Rhenish Provinces,'[3] as well as at p. 88 of the second vol. of the 'Geol. of Russia,' *Rh. Wilsoni* is said to occur in the Devonian Limestone of Néhou, in Normandy; and it cannot be denied that externally the Néhou specimens very much resemble externally some varieties of the Silurian shell; but I ascertained that their interiors presented constant modifications, which warranted Alcide d'Orbigny in giving to the Devonian form the designation of *sub-Wilsoni*. In vol. ix, pl. xiii, of the second series of the 'Annals and Mag. of Nat. History,' for May, 1852, I carefully represented the interiors of both forms, from specimens collected by myself in England and the Continent.

It occurs in the *Upper Ludlow* at Brockton and Burton; Delbury, Salop; Dafaddfa-Uchaf, south-west of Hazle, Woolhope; Hales End and Brock Hill section, near Malvern; in various places in the Woolhope district, Usk; New Hall, Builth, etc.

In the *Aymestry* Limestone, at Sedgley; Botville; Church Stretton, Aymestry, Ankerdine Hill, Abberley; Llanbadoc, &c., in the Usk district.

In the *Lower Ludlow*, St. Ishmael's Church, Dale, Callow Farm, Hill End,

[1] At p. 87 of the 'Geology of Russia' M. de Verneuil observes—"La forme remarquablement gibbeuse de la *T. Wilsoni*, par suite de laquelle les plis des deux valves tombent presque perpendiculairement les uns sur les autres et rendent les bords très obtus et à peine angulaux, la font facilement reconnaitre au milieu de ses analogues, qui, au reste, ne sont pas nombreuses. La plus voisine, saus contredit, est celle que Mr. Sowerby a décrite sous le nom de *Atrypa sphærica* (*Rh. Davidsoni*), et qu'il nous parait même impossible de distinguer par aucun bon caractère."

[2] 'Bull. Soc. Géol. de France,' 2nd ser., vol. iv, 1847.

[3] 'Transactions of the Geol. Soc. of London,' 2nd ser., vol. vi, 1841.

Abberley, Leintwardine; Dowlas, near Usk; Cwm-Craig-ddu and Erw Gilfach, Builth district.

In the *Wenlock Limestone* and *Shale*, west of Rock Farm, May Hill, Dudley; near Walsall; east of Ledbury; Eastnor Gravel Pit; Witfield, Tortworth; Comb Hill, Malvern; Clincher's Mill; Scar Lime-works, Onibury. Bryn-Mawr; Mynydd-Tryfan; and Capel-y-rhiw, North Wales (in beds above the Denbighshire Grit).

In the *Woolhope Limestone* at Little Hope Woolhope, Bogmine Shelve, and in the Llandovery at Tynewydd, Llandovery.

In Scotland it occurs in the Wenlock Shale of the Pentland Hills, and in the same formation at Clogher Head, Kerry.

Abroad it is abundant in the Island of Gothland; at Moustel-Pank, and at St. Johannis in the Island of Oesel, and in Russia; in the neighbourhood of Christiania, Norway. In America it is stated by M. de Verneuil to occur in the States of Tennessee and of the Ohio, where it is completely identical with the European specimens.

RHYNCHONELLA WILSONI, var. DAVIDSONI, *M'Coy*. Pl. XXIII, figs. 11—14.

> TEREBRATULA SPHÆRICA, *Dav.* Bull. Soc. Géol. de France, 2nd ser., vol. v, p. 328, pl. iii, fig. 36, 1848 (of Géol. Trans., not of Sil. Syst.)
>
> HEMITHYRIS DAVIDSONI, *M'Coy.* Annals and Mag. of Nat. Hist., vol. viii, 2nd ser., p. 392, 1851; and British Palæozoic Fossils, p. 200, 1852.

This variety differs from the typical forms of *Rh. Wilsoni* in having fewer and stronger ribs; in other respects the general form is about the same, being subcuboidal, and usually slightly longer than wide, some examples having attained 13 lines in length, 12 in width, and 10 in depth; and of these a fine series, belonging to Mr. Fletcher's collection, may be seen in the Woodwardian Museum, Cambridge. Prof. M'Coy is, however, mistaken when he asserts that the ribs are not divided by a median sulcus, as in *Rh. Wilsoni;* for I have now before me several specimens in which the ribs are, in the proximity of the margin, divided by a median groove (see Pl. XXIII, figs. 12*a* and 12*c*.) It is true that in some examples (as is the case with typical *Rh. Wilsoni*), the longitudinal grooves are not clearly observable, and may be entirely absent. The number of ribs varies also in different individuals, so that from three to six ribs may be counted on the slightly raised mesial fold, as well as on the shallow sinus; when the ribs are more numerous the form gradually merges into true *Rh. Wilsoni*. In 1848 I had referrred this form to the *Terebratula sphærica*, Sow., so named by that author in Murchison's and Sedgwick's memoir "On the Physical Structure and Old Stratified Deposits of Devonshire" ('Trans. Geol. Society,' vol. v, pl. lvii, fig. 3, 1840), but I had overlooked the fact that the same author had previously, in the 'Silurian System,' applied that name to a slightly varied form of *Rhynchonella deflexa:* it will therefore be better to adopt M'Coy's term *Davidsoni* as a varietal designation for the modification of *Rh. Wilsoni* under description. Prof. M'Coy, in his work on 'British Palæozoic Fossils,' refers to the figure given by myself in the 'Bulletin de la Société Géologique de France,' vol. v, pl. iii, fig. 36, as the type of his *Hem. Davidsoni.* I mention this because in the Woodwardian Museum some very uncertain examples had been so named by Prof. M'Coy.

The variety *Davidsoni* occurs in the Wenlock Limestone at Dudley, Walsall, and Falfield. Prof. M'Coy states it to be very rare in the Upper Ludlow rock of Burton and Brockton, near Wenlock.

RHYNCHONELLA WILSONI, var. SPHÆROIDALIS, *M'Coy.* Pl. XXIII, fig. 10.

HEMITHYRIS SPHÆROIDALIS, *M'Coy.* Annals and Mag. of Nat. Hist., vol. viii, 2nd ser., p. 393, 1851; and Brit. Pal. Foss., p. 206, pl. i L, fig. 4, 1852.

As already stated, judging from the description and figure published by Prof. M'Coy, *Hemithyris sphæroidalis* can be nothing more than a small variety or young form of *Rhynchonella Wilsoni.* It occurs in the Wenlock Limestone of Dudley, and in the Aymestry Limestone of Sedgley and of Botville.

RHYNCHONELLA NASUTA, *M'Coy.* Pl. XXIII, fig. 19.

HEMITHYRIS NASUTA, *M'Coy.* Annals and Mag. of Nat. Hist., vol. viii, 2nd ser., p. 393, 1851; and British Pal. Foss., p. 203, pl. i L, ii, fig. 5, 1852.

Spec. Char. Longitudinally oval, either longer than wide or about as wide as long; sides rounded; the front in old specimens is produced into a flat tongue-shaped lobe. Valves almost equally convex, the dorsal one slightly the deepest. In the ventral valve the sinus commences close to the extremity of the beak, and gradually widens as it nears the front; beak moderately produced, and so much incurved as to almost touch the umbonal beak of the opposite valve. Dorsal valve uniformly convex at the umbone, but gradually a wide obtusely rounded mesial fold is produced, so that the valve becomes trilobed anteriorly. Surface ornamented with from twenty to twenty-six simple, close, slightly produced, rounded, radiating ribs, of which six or seven, rather stronger than the rest, occupy the fold and sinus. Interior not known. Two specimens measured—

Length 14, width 12, depth 8 lines.
,, 12, ,, 12 lines.

Obs. Of this species I have seen but two or three examples, and consequently it is not possible to say much with reference to the modifications it may assume. It does not appear, however, to be very rare in the Caradoc Limestone of Craig Head, near Girvan, in Ayrshire, from whence Prof. M'Coy's original specimen was derived, but it is difficult to obtain out of that rock a perfect specimen. One, however, of which the dorsal valve was almost entire, did not present so elongated a form as is presented by the typical specimen in the Cambridge Museum. It would consequently be desirable that more specimens of this shell should be collected by those who may have occasion to visit the Craig Head Quarry. Prof. M'Coy informs us that this species much resembles the *Terebratula promontorium* of Kutorga, from the Lower Silurian limestones of Pulkowa (see 'Verhandlungen der Russ. Kais. Min. Gesellschaft zu St.-Petersburg,' for 1845, pl. vi, fig. 3), but is distinguished by its ribbed surface.

RHYNCHONELLA BOREALIS, *Schloth.* Pl. XXI, figs. 14—27.

? ANOMITES PLICATELLA, *Wahlenberg.* Nov. Act. Upsal., p. 67 (Linn., Mus. Tessin., p. 88, pl. v, fig. 5 ?), 1821.
TEREBRATULA — *Dalman.* Vet. Akad. Handl., p. 140, pl. vi, fig. 2, 1828 (synonymia exclusa).
— DIODONTA, *Id.* Ib., pl. vi, fig. 4, 1828.
— BOREALIS, *Id.* Schlotheim, Systematisches Verzeichniss der Pet. Sammlung, p. 68, No. 88, 1832.
— — *V. Buch.* Ueber Tereb., Akad. Berlin, p. 67, 1834; and Mém. Soc. Géol. de France, vol. iii, p. 171, pl. xvi, fig. 15, 1838.
— PLICATELLA, *Hisinger.* Lethæa Suecica, p. 80, tab. xxiii, fig. 4, 1837.
— BOREALIS, *Angelin.* Mus. Pal. Suecicum, No. 48, 1838.
— LACUNOSA (= *T. borealis*, Schloth., Buch), *J. de C. Sowerby.* Sil. Syst., pl. xii, fig. 10, 1839.
— BIDENTATA, *Sow.* Ib., pl. xii, fig. 13*a*.
— PLICATELLA, *De Verneuil.* Geol. of Russia, vol. ii, p. 84, 1845.
— — *Id.* Bull. Soc. Géol. de France, vol. v, 2nd ser., p. 346, 1848.
— CRISPATA, *Dav.* Ib., p. 329 (non *T. crispata*, Sow.)
HYPOTHYRIS BOREALIS, *Phillips* and *Salter.* Memoirs Geol. Survey, vol. ii, p. 383, pl. xxviii, figs. 9—14, 1848.
TEREBRATULA — *Bronn.* Index Pal., p. 1231, 1848.
HEMITHYRIS — *D'Orbigny.* Prodrome, voi. i, p. 37, 1849.
RHYNCHONELLA — *Morris.* Cat. of British Fossils, p. 146, 1854.
HEMITHYRIS LACUNOSA, *M'Coy.* Brit. Pal. Foss., p. 201, 1852.
RHYNCHONELLA — *Schmidt.* Sil.-Form. Ehstland, &c., Archiv. Nat. Liv.- Ehst- und Kurland, vol. ii, p. 211, 1858.
— PLICATELLA, *D'Eichwald.* Lethæa Rossica, vol. i, p. 758, 1859.

RHYNCHONELLA DIODONTA, *D'Eichwald.* Lethæa Rossica, p. 759, 1859.
— BOREALIS, *Salter.* Siluria, 2nd ed., p. 544, pl. xxii, fig. 4, var. fig. 5, 1859.
— — var. DIODONTA, *Id.* Ib., pl. xxii, fig. 5.
— — *Lindström.* Proceed. Royal Acad. of Stockholm, p. 365, 1860.

Spec. Char. Subtrigonal, wider than long. Valves more or less gibbous, dorsal valve always most gibbous. Beak of ventral valve moderately produced and incurved, foramen clearly exposed, and situated beneath the angular extremity of the beak; it extends to the hinge-line, and is margined on either side by narrow deltidial plates; sinus broad, deep, and extending from the extremity of the beak to the front. In the dorsal valve the fold is abruptly raised, with wide smooth walls, but flattened along the middle, and varying in breadth in different specimens. Surface of valves ornamented with from ten to twenty angular ribs, of which from two to six compose the fold, while from one to five occupy the sinus. The ribs are usually simple, but sometimes, as an exception, one or two dichotomise, the whole being crossed by fine transverse striæ. On either side of the beak, between the beak-ridges and hinge-line, a concave smooth space occurs, while the lateral spaces on either side of the beak are moderately wide; the margin of the ventral valve indenting by a convex curve the corresponding edge of the dorsal valve. Interior not known. Three specimens measured—

Length 14, width 17, depth 12 lines.
„ 11, „ 13, „ 7 „
„ 10, „ 11, „ 9 „

Obs. This species varies greatly in shape, according to age and individual, and especially so from the number of ribs which occur on the fold and sinus ; and this has tempted Dalman and others to distinguish some of these varieties by the separate specific denominations of *diodonta* and *bidentata.* Mr. Salter observes, when describing *Rh. borealis,* that the shell is conspicuous, even in its young state, by the two raised dorsal ribs and the deep furrow in the ventral valve with its single rib; that, if this number is retained, it becomes *T. diodonta,* Dalman, and that perhaps even *T. bidentata,* id., may be the young of it; but that with respect to the former, he is quite sure it is only a variety, and that Dalman himself has hinted at the probability of this, the *T. bidentata* of the 'Sil. System' being a synonym of *T. diodonta,* &c. Having assembled a large number of specimens of *Rh. borealis* from the Wenlock Limestone of Dudley, where the shell is abundant, I found that in some young examples the two ribs of the small variety *diodonta* were also present in large adult individuals of *Rh. borealis,* such as in figs. 16 and 18, while in other specimens there are three, four, and more, on the fold, as in figs. 14, 15, and 24 ; but in other young examples of *Rh. borealis* three, four, and even five ribs are present on the fold; and these are persistent into the adult state, so that it seems impossible to know where to draw a definite line of demarcation among these many varieties, or rather modifications in shape, of this single most variable species. In some specimens the transverse striæ are finer and closer than in other examples; while in some specimens of the variety *diodonta*, these last, such as in fig. 23, are wide apart, prominent, or scale-like. I am not, however, certain whether *T. bidentata* of Dalman (not of Sowerby) may be a distinct species or not, and therefore I must leave this an open question.

The next point to determine is the name the shell should retain, for some confusion and uncertainty seems to have prevailed upon the subject. In 1767 Linné briefly described his *Anomia plicatella*, but gave no reference to figures, and consequently it was not possible to be certain what was the shell intended for that species, and a *Spirifer* was subsequently by some palæontologists, myself included, rightly or wrongly referred to the Linnean species. In 1821 (at p. 67 of the 8th vol. of the 'Nova Acta Soc. Upsaliensis') Wahlenberg described a *Rhynchonella* by the designation of *Anomites plicatella*, and referred for its figure to Linnæus's 'Mus. Tessinianum,' p. 88, pl. v, fig. 5; but Wahlenberg seems to have overlooked the fact that Linné had himself, in the 12th ed. of his 'Systema Naturæ,' referred that figure to his *Anomia reticularis;* and in Turton's translation of the last-named work (vol. iv, p. 282, 1802) the same reference is so reproduced. It is quite possible, and even probable, that in giving that reference of figure to *A. reticularis*, Linné committed a mistake, and some naturalists have even considered the Linnean *A. lacunosa* to be referable to the species under description, whilst others have applied that name to the shell now known as *Rh. Wilsoni*. We therefore have no positive evidence that the species here described by the name of *Rh. borealis* was the *Anomia plicatella* of Linnæus.

In September, 1825, James Sowerby, in his 'Mineral Conchology' (vol. v, p. 167, pl. 503, fig. 1), correctly described and illustrated a large Jurassic *Rhynchonella*, under the designation of *plicatella*, which name will have to be preserved; and consequently, whatever subsequent naturalists may have supposed to have been the *A. plicatella* of Linnæus, we cannot adopt their view, as the name had for the first time been given to a well-defined species by Sowerby. It is quite true that, in 1828, Dalman, and after him Hisinger, described and figured the shell here described under the designation of *T. plicatella;* but that name cannot, as I have said, claim precedence over that of Sowerby. At page 67 of his 'Ueber Terebrateln,' Von Buch describes a Silurian shell under the designation of *Terebratula borealis*, Schlotheim, and refers us for a figure to Schlotheim's 'Nachträge,' 1, pl. xx, fig. 6 (there erroneously named *T. lacunosa*), and since then Bronn and several other palæontologists have adopted the term *borealis* for the shell under description; and this name I think should be retained, as it puts an end to the confusion created by the uncertainty relating to Linnæus's species. I may here mention that the name *borealis* was first published in the catalogue of Schlotheim's collection, and without any further reference (in 1822), and would have remained simply a useless catalogue name had not Von Buch fully described the species in 1834 under the same designation. M. D'Eichwald considers *Rh. diodonta* to be distinct from the species under description, as well as from *Rh. bidentata;* but in Russia, as well as in Sweden and in Great Britain, *Rh. diodonta* and *Rh. borealis* occur in the same localities, and merge by every gradation of form one into the other.

Position and Locality. In Great Britain *Rh. borealis,* and its varieties *diodonta* and *bidentata,* range from the Lower Llandovery to the Upper Ludlow, but are most abundant in the Wenlock Limestone. We find it in the *Upper Ludlow* at Hope End, Frith Pound; Mathon, Malvern district; Hazle, Wonder, Pilliard's Barn, Stoke Edith, Shucknall, Woolhope district; west of Rock Farm, May Hill district (Phillips and Salter).

Aymestry Limestone, Russell's Farm.

Wenlock Limestone, near Walsall, Dudley, Benthall and Wenlock Edge. East of Canwood and Dormington Wood, Woolhope; Hobbs; Longhope; Abberley, Chirbury Malverns, Falfield, &c.

Woolhope beds, Little Hope Woolhope.

Upper Llandovery. Fron, Coldbrook, Llandovery (var. like fig. 22, Pl. XXI). East of Merchlin and Bogmine, near Shelve, North Wales (Survey).

Lower Llandovery. Priory Mill (Survey).

In Ireland it has been found in the Wenlock Shales, at Ferriter's Cove, Dingle, County Kerry. Some other localities have also been named by Prof. M'Coy and General Portlock; but not being quite satisfied as to the correctness of the identification, I need not refer to them in this place. It is also probable, though not yet perfectly certain, that this species occurs in the Wenlock Shales of the Pentland Hills in Scotland.

Abroad *Rhynchonella borealis,* as well as its variety *diodonta,* occur plentifully in the Wenlock beds of the Island of Gothland, these specimens being identical with our own. According to D'Eichwald, it would occur in the Coral Limestone of the Island of Oesel, at Hohenheim, Ficht, also in the north of the Ural. It has likewise been found in rocks of the Llandovery age in the neighbourhood of Christiania, in Norway.

RHYNCHONELLA DECEMPLICATA, *Sow.* Pl. XXIII, figs. 20—24.

TEREBRATULA DECEMPLICATA, *J. de C. Sow.* Silurian System, pl. xxi, fig. 17, 1839.
HYPOTHYRIS — *Phillips* and *Salter.* Memoirs of the Geol. Survey of Great Britain, vol. ii, p. 280, 1848.
RHYNCHONELLA — *Salter.* Siluria, 2nd ed., p. 544, pl. ix, fig. 15, 1859.
— — *Id.* Mem. Geol. Survey of Great Britain, vol. iii, p. 278, 1866.

Spec. Char. Shell small, globose, or slightly transversely oval. Valves moderately convex or gibbous. Ventral valve rather deeper than the dorsal one; beak small, incurved; sinus wide, deep, with a small median rib; ribs on each of the lateral portions of the valve varying in number from five to seven. Dorsal valve divided by a wide, moderately elevated, biplicated fold, while from five to seven ribs ornament each of the lateral portions of the valve. Surface of both valves crossed by concentric lines of growth. Two specimens measured—

Length 7, width 7, depth 6 lines.
,, 5, ,, 6, ,, 3 ,,

Obs. This species is easily recognisable on account of its wide biplicated fold and sinus, and small simple lateral ribs; but it is a mistake to suppose that, as its name would imply, not more than ten ribs ornament the surface of each valve, for I have counted from ten to fifteen in different examples. It varies also much in size, but rarely exceeds the dimensions above given, and is often smaller. The form to which it most approaches is *Rhynchonella borealis*, var. *diodonta*, but it is distinguished by its more numerous and smaller lateral ribs.

Position and Locality. Although mentioned in 'Siluria' as having been found in the Wenlock, I have not seen specimens derived from that formation. It is peculiar, as far as I know, to the *Upper Llandovery* (May Hill group of Sedgwick). One example, however, which I cannot distinguish from the species under description, was sent to me by Mr. Davies from the Bala Limestone of Allt-y-gader, Llanfyllin, in North Wales (fig. 24).

The following localities have been quoted, all in Upper Llandovery:—Mwdwl, Eithin, Plas Madoc, North Wales; also Presteign, Malverns; Minton, Chirbury, Norbury. In Wales and Shropshire fine examples occur at the Obelisk, Eastnor Park. Phillips and Salter mention also, besides the above-named localities, under Worcester Beacon; Wych; Cowley Park, Malvern; Ankerdine Hill, Abberley district; Lampeter Hill, Haverfordwest district, and Marloes Bay in the Marloes district, &c.

I am not acquainted with the shell from either Scotland or Ireland, and have not seen any foreign specimen.

RHYNCHONELLA DEFLEXA, *Sow.* Pl. XXII, figs. 24—27.

TEREBRATULA DEFLEXA, *J. de C. Sow.* Sil. Syst., pl, xii, fig. 14, 1839.
— BREVIROSTRIS, *Id.* Ib., pl. xiii, fig. 15.
— SPHÆRICA, *Id.* Ib., pl. xiii, fig. 17.
— INTERPLICATA, *Id.* Ib., pl. xiii, fig. 23.
— DEFLEXA, *Barrande.* Brachiopoda of Bohemia, Naturwissens. Abhandl., pl. xx, fig. 15, 1847.
— DEFLEXA et SPHÆRICA, *Dav.* Bull. Soc. Géol. France, 2nd ser., vol. v, p. 328, 1848.
— — *De Verneuil.* Ib., p. 346, 1848.

HYPOTHYRIS DEFLEXA et BREVIROSTRIS, *Phillips* and *Salter*. Memoirs of the Geol. Survey, vol. ii, p. 280, 1848.
ATRYPA INTERPLICATA, *J. Hall*. Palæont. New York, vol. ii, p. 275, pl. lvii, figs. 2 *a—g*, 1852.
RHYNCHONELLA DEFLEXA, *Salter*. Siluria, p. 544, pl. xxii, fig. 10, 1859.
— — *Lindström*. Gottlands Brach., p. 366, 1860.

Spec. Char. Transversely oval or subovate, wider than long. Dorsal valve ventricose, especially at the middle and umbone, which last is higher, much incurved, and projecting beyond the small closely incurved beak of the ventral valve. Mesial fold broad, but scarcely rising above the general convexity of the valve. Surface ornamented with from twelve to thirty angular ribs, of which from three to nine occupy the fold. Ventral valve most convex at the beak, which is small. Mesial sinus wide and deep, commencing at a short distance from the extremity of the beak, and gradually widening till it reaches the front. Surface of valves ornamented with from eleven to twenty-nine angular ribs, of which from two to eight occupy the sinus. Some of the ribs are also due to interpolation, and the whole surface of both valves is closely crossed by numerous fine, concentric, slightly projecting lines of growth. Proportions variable; two specimens measured—

Length 9, width 8, depth 6 lines.
„ 6, „ 6, „ 6 „

Obs. In 1848 I had made out that *T. brevirostris* and *T. sphærica* of the 'Silurian System,' were synonyms of *T. deflexa;* and Mr. Salter subsequently added *T. interplicata* of the same author and work to the synonyms of the species under description. They are all simple modifications in shape and age of a single well-characterised species; indeed, its short closely incurved beaks and ventricose dorsal valve might at first sight lead one to imagine that the ventral valve was the dorsal one, but such is certainly not the case. It varies also in the number and strength of its ribs, as may be seen by the figures in our plate. We are not acquainted with the interior.

Position and Locality. The vertical range of this species is not very great, for we know it only from the Woolhope Limestone and the Wenlock Limestone and Shale. It is common in two last-named rocks at Dudley, Benthall Edge, Wenlock Edge; Lincoln Hill, near Walsall, &c. Phillips and Salter mention its presence under Worcester Beacon and Croft in the Malvern district, east of Hill End in the Abberley district, Checkley Common, Dormington Wood, and Woolhope, Woolhope district. Between Rock and Dursley Cross, May Hill district; Pwll-Calch, Llandeilo district, and at Ballard's Quarry in the Woolhope beds.

In Ireland it has been found by the Geological Survey at Cahirconree, west side, County Kerry, in rocks of the Wenlock age. It has not yet been found in Scotland.

Abroad it occurs in the Island of Gothland; in Bohemia; and at Lockport, New York State, America; all in beds corresponding with our Wenlock Limestone and Shale.

Rhynchonella Lewisii, *Dav.* Pl. XXIII, figs. 25—28.

Terebratula Lewisii, *Dav.* Bull. Soc. Géol. France, 2nd ser., vol. v, p. 330, pl. iii, fig. 30, 1848.
Hemithyris — *M'Coy.* British Pal. Foss., p. 203, 1852.
Rhynchonella — *Salter,* Siluria, 2nd ed., p. 250, fig. 57, 2, 1859.
— — *Lindström.* Gottlands Brachiopod., p. 366, 1860.

Spec. Char. Subrhomboidal or transversely oval; ventral valve rather less convex than the dorsal one; beak small, acute, much incurved; sinus rather deep, of moderate breadth, sides almost perpendicular; dorsal valve more or less convex, sometimes gibbous, evenly tumid near the beaks, mesial fold rather narrow, prominent, and rounded, rising abruptly from the lateral portions of the shell, so that it presents a somewhat pinched appearance. Surface of each valve ornamented with from twenty to twenty-six simple radiating ribs, of which from two to five occupy the fold, and from one to four the sinus; the surface is also crossed by many projecting, scale-like, concentric ridges, which become larger and more numerous as they approach the margin of the shell. Two specimens measured—

Length 8, width 10, depth 5 lines.
„ 8, „ 10, „ 7 „

Obs. This species is easily distinguished from other British Silurian *Rhynchonellæ* by its shape and the scale-like concentric laminæ which ornament its surface; the mesial fold has also often a peculiarly pinched-in appearance, which is best seen from the front, as represented in fig. 25*a*. Like all its congeners, it varies considerably in the number and strength of its ribs. When quite young it is much compressed, the fold and sinus being scarcely developed. As correctly remarked by Prof. M'Coy, *Rh. Lewisii* is quite distinct from *Rh.* (*Atrypa*) *increbescens*, Hall, although some depressed varieties of the last-named species bear a certain resemblance to the shell under description. Some incomplete interiors may be seen in the Woodwardian Museum, Cambridge; and Prof. M'Coy states that casts show in the ventral valve two short, slightly diverging slits of dental lamellæ, between which are three or four diverging ridges in the rostral portion; and that the dorsal valve shows a wide mesial slit of the thick septa, and impressions of two short cardinal teeth just within the ends of the dental lamellæ of the opposite valve.

Position and Locality. In 'Siluria' (p. 545) the range of this species is said to be in the Llandovery and Wenlock. I am, however, acquainted with the shell only from the last-named formation, in which at some localities it is exceedingly abundant. I found it at

Dudley, and near Walsall, also at Benthall Edge, and it is stated to occur at Rock Farm, May Hill. Prof. M'Coy mentions the shell as occurring in the black calcareous flags of Mathyrafal, south of Meifod, Montgomeryshire. I am not acquainted with it from either Scotland or Ireland. Dr. Lindström has obtained this shell at Gothland.

RHYNCHONELLA NUCULA, *Sow.* (sp.). Pl. XXIV, figs. 1—7.

TEREBRATULA NUCULA, *J. de C. Sow.* Silurian System, pl. v, fig. 20, 1839.
— PUSILLA, *Sow.* Ib., pl. xxi, fig. 18, 1839.
— NEGLECTA, *Id.* Ib., pl. xxi, fig. 14, 1839.
— PULCHRA, *Id.* Ib., pl. v, fig. 21, 1839.
— POMELII, *Dav.* Bull. Soc. Géol. Fr., 2nd ser., vol. v, p. 330, pl. iii, fig. 28, 1848.
— SEMISULCATA, *Salter* and *Sow.* Quarterly Journal Geol. Soc., vol. i, p. 21, 1843.
HYPOTHYRIS — *Phillips* and *Salter.* Memoirs of the Geol. Survey, vol. ii, p. 382, pl. xxviii, figs. 1—8, 1848 = *T. neglecta,* Sow., Sil. Syst., pl. xxi, fig. 14.
— NUCULA, *Id.* Ib., p. 281.
HEMITHYRIS — *M'Coy.* Brit. Pal. Foss., p. 204, 1852.
RHYNCHONELLA — *Morris.* Cat. of British Fossils, p. 147, 1854.
— — *Lindström.* Gottlands Brachiopod., p. 366, 1860.
— — *Salter.* Memoirs Geol. Survey, vol. iii, p. 278, 279, and 368, 1866.
ATRYPA — *M'Coy.* Synopsis of the Silurian Fossils of Ireland, p. 40, 1846.
RHYNCHONELLA — *Salter.* Siluria, 2nd ed., pl. xxii, fig. 1, and p. 250, fig. 57, 1, 1859.
— OBTUSIPLICATA, *Id.* Ib., 2nd ed., p. 545, 1859.

Spec. Char. Shell small, subpentagonal, with rounded angles, more or less globose. Ventral valve less convex than the opposite one; beak small, pointed, and incurved; sinus wide, moderately deep, commencing about the middle of the shell, and extending to the front. Dorsal valve convex and often gibbous, mesial fold about as wide as a third of the breadth of the shell, much raised close to the front. Surface of each valve ornamented by from sixteen to twenty angular ribs, of which usually four occupy the fold, and three the sinus. Two specimens measured—

Length 5, width 6, depth 4 lines.
„ 6, „ 6, „ 5 „

Obs. This troublesome little shell has misled more than one palæontologist, and several names have been given to apparently simple modifications in shape of the Sowerbyan species. It seems to have been for the first time named, described, and figured, by J. de C. Sowerby, in the 'Silurian System;" but the figures are incomplete and unsatisfactory; and this may partly account for the uncertainty, confusion, and difference in opinion which have existed about the subject. Sowerby, however, states his shell to be "Globose, obscurely three-lobed, plaited; plaits sharp, about fifteen, three or four of which are prominent, and elevated in the middle of the front; beak small, adpressed; lower valve slightly flattened. Length 5 lines, width the same. *Loc.* Ludlow, Presteign, Ledbury, Bagbarrow Hill, and west of Malvern Hills; Bradnor Hill, Kington; Trewerne Hills, Radnorshire; Aram, near Newnham;" and in Pl. XXIV, fig. 1, I have reproduced the original figure. In 1848, from my not understanding Sowerby's species, I described under the name of *T. Pomelii* some similar shells which I had found in the Aymestry Limestone at Sedgley and the Wenlock Limestone of Dudley. In the same year Phillips and Salter again described *Rh. nucula* under the designation of *Hypothyris semisulcata*, Dalman. But I am not aware that Dalman ever gave that name to any Silurian species; it is certainly not to be found in his "Memoir on the Brachiopoda of Sweden," published in the 'Transactions of the Royal Academy of Stockholm.'[1] Since then, however, both Mr. Salter and Prof. M'Coy have placed *H. semisulcata* among the synonyms of *Rh. nucula*. In their description Prof. Phillips and Mr. Salter observe—"The above specific character, though long, is necessary to distinguish this common shell from other Silurian species, and especially from *T. lacunosa*, with which Mr. Sowerby had cautiously united it. It is, however, a much smaller and more delicate shell, never has the strong ventral and dorsal sinus in the young state, and the middle does not rise abruptly and bring its plaits to a level as in *T. lacunosa* [they mean *T. borealis*], but has them on the sides, as well as top of the curved elevation; the sinus is very deep on the front margin, but it is more by suppression of the central ribs than by their elevation, a very frequent character of *Terebratulæ*. The name is adopted from a Swedish specimen so labelled, but from what work of Dalman's it is adopted we do not know. We recognise *T. neglecta*, from the Lower Silurian rocks of Llandovery, for this species; it occurs at other places in Lower Silurian rocks." Now, with reference to *T. neglecta*, Sow., it may or may not possibly be a synonym of *Rh. nucula*. It was observed and described by Mr. J. de C. Sowerby on a single incomplete or distorted fragment from Mandinam, Llandovery (Upper Llandovery), and is said to be "orbicular, convex, plaited; plaits 17, acute; beak small; a fragment." In Pl. XXIV, fig. 17, will be found a figure drawn from the original specimen; and as I really do not know what to make of the shell, it may at least for the present be allowed to remain where Prof. Phillips and Mr. Salter have placed it.

In 1852 Prof. M'Coy, while describing *Rh. nucula*, observes—"Having carefully examined a large number of specimens, I think with Prof. Bronn that the *T. pulchra* and *T. nucula* of Sowerby should be united, the very trifling differences in form and number of lateral plaits not coexisting, sometimes the one, and sometimes both, being observable in the contiguous specimens, which are clustered in great numbers in the

[1] The name appears first in a paper by Salter and Sowerby, in vol. i, p. 21, of the 'Quarterly Journal of the Geol. Soc. of London,' 1843.

Upper Ludlow rocks; and the obtuse-looking examples (*nucula*) often prove, on counting, to have the same number of ridges, and to have the same proportions as the sharply marked ones (*pulchra*)." *T. pulchra* is therefore added to the synonyms by Prof. M'Coy, and where it may also for the present be allowed to remain, and especially so since it is entirely ignored in 'Siluria.' Again, Mr. Salter informed me, when I met him last in Cambridge, that *T. pusilla*, Sow., from the Lower Llandovery rocks of Cefn Rhyddan, was nothing more than a small specimen of *Rh. nucula;* and I must confess that the inspection of the crushed valve on which Sowerby founded this so-termed species would lead me to agree with Mr. Salter. It is stated to be "nearly globose, plaited, plaits about 14, sharp, 4 of them elevated in the front; length and width nearly 4 lines," a description which will well suit *Rh. nucula.* Lastly, in page 545 of the 2nd ed. of 'Siluria' we find a *Rhynchonella* from Worcester Beacon, Upper Llandovery, identified by Mr. Salter as the *Rh. obtusiplicata* of Hall ('Pal. New York,' vol. ii, p. 279); but upon examining the imperfect specimen or specimens upon which this identification is founded, and which is preserved in the Museum of Practical Geology, I am strongly impressed with the idea that it also must be referred to *Rh. nucula;* its ribs are angular, not rounded, and of the fourteen ribs which may be counted on the dorsal valve four occupy the fold. A figure of this specimen will also be found in Pl. XXIV, fig. 7.

Although the usual number of ribs in the fold of *Rh. nucula* is four, sometimes there are but three, and some specimens have presented as many as five.

Position and Locality. If all the shells here referred to *Rh. nucula* do in reality belong to the species, its range would be considerable, for we should have it in the *Lower Llandovery, Upper Llandovery, Woolhope Limestone, Wenlock Limestone* and *Shales, Lower* and *Upper Ludlow*, and *Aymestry Limestone.* A vast number of localities have been named in various works, but I cannot answer as to the correctness of them all, any more than of some of those I have transcribed from different works relative to the other species described in this work. The larger number of those I am about to name are taken from vols. ii and iii of the 'Memoirs of the Geol. Survey,' as well as from the lists in the possession of the Geol. Survey. Many more could be given, but those here recorded may, I think, suffice.

Upper Ludlow—Overley, Hope End Park, Malvern district; west of Rock Farm, May Hill district; Usk; Aberedw and Cwm Craig ddu, Builth district; north-east of Pillard's Barn, Woolhope; Nun Hill, Cleobury, Kington, Hereford; Frith Farm, and Horeb Chapel; Burton and Brokton, near Wenlock; Collinfield and Benson Knot, Westmoreland; Downton Castle, Aymestry, Herefordshire; Woolhope, &c.

Aymestry Limestone—Rilbury, Malvern district; Backbury Camp, Woolhope district; Llanbadock and Ty-Newydd, Usk district; Shucknall Hill, Woolhope district; Sedgley, near Wenlock, &c.

Lower Ludlow—South of Putley, Woolhope district; Pyrton Passage; Leintwardine, Shropshire, &c.

Wenlock Limestone—Eastnor Castle; Botvyle and Malvern; north of Canwood, Woolhope district; Rock, May Hill district; Wenlock Edge, Dudley; Rock Farm, Longhope; Mwdwl-Eithin; Moel Seissog; east of Merchlin, Plas Madoc, North Wales, &c.

Woolhope Limestone—Woolhope, Bogmine Shelve.

Upper Llandovery—Worcester Beacon (in conglomerate), Marloes Bay; May Hill; Damory Bridge.

Lower Llandovery—Cefn Rhyddan, &c.

In Scotland it occurs in the Wenlock Shales of the Pentland Hills; and, according to Prof. M'Coy, at Braes, one mile and a half east of Girvan, in Ayrshire.

In Ireland it is stated by Prof. M'Coy to be not uncommon in the slates at Doonquin, Dingle, County Kerry, and in the slates at Foylathurrig, Dingle.

Abroad it was found by Dr. Lindström in the Island of Gothland.

RHYNCHONELLA LLANDOVERIANA, *Dav.* Pl. XXIV, fig. 8—13.

ATRYPA SERRATA, *M'Coy.* Synopsis of the Silurian Fossils of Ireland, p. 41, pl. iii, fig. 29, 1846.
TEREBRATULA SERRATA, *Salter.* Quarterly Journal Geol. Soc., vol. vii, p. 172, 1851.
RHYNCHONELLA — *Morris.* Catal. of British Fossils, p. 147, 1854.
— — *Salter.* Siluria, 2nd ed., p. 230, fig. 48, 1, 1859.
— LLANDOVERIANA (*Dav.*), *Murchison.* Siluria, 3rd ed., p. 527, 1867.

Spec. Char. Transversely rhomboidal, wider than long. Ventral valve moderately convex; beak small, incurved; sinus broad, rather shallow, and extending to not more than half way to the beak. Dorsal valve gently convex; fold wide, and very little elevated above the general convexity of the valve, and commencing likewise at about half way from the umbonal beak. Surface ornamented with about thirty-five small, obtuse, radiating ribs, of which seven or eight occupy the fold and sinus. Two specimens measured—

Length 7, width 9 lines (M'Coy's type specimen).
,, 6, ,, 7, depth 3 lines.

Obs. The name *serrata* cannot be adopted for this species, since it has already been applied by Mr. J. de C. Sowerby to a beautiful Liassic species ('Min. Con.,' pl. 503, fig. 2, September, 1825). I have therefore proposed that of *Llandoveriana*, and the name has been adopted by Murchison in his third edition of 'Siluria.' Prof. M'Coy remarks that his species is principally remarkable for the great number of its simple radiating ribs, which, together with the depression of the valves, gives a sharp serrated appearance to the edge. The ribs vary somewhat in number and strength in different specimens, the shell much resembling in its external form and appearance certain Jurassic and Cretaceous species.

Position and Locality. *Rh. Llandoveriana* appears to be a characteristic fossil of the Llandovery period, and occurs abundantly in many Irish localities. I have seen it from Lettershanbally, Leenane, Ardaun, Boocaun, County Galway. Prof. M'Coy mentions likewise that it is common in grey quartzites at Blackwater Bridge, in the sandstone of Cong, slates of Cappacorcogne, Glencraff, &c., all in the County of Galway.

In Scotland it occurs in sandstone at Saugh Hill, near Girvan, in Ayrshire, and was so identified by Mr. Salter, who observed at the same time that the Saugh Hill sandstone resembles that of Cong, in Ireland, and that they possess several of the same fossils. In England it occurs also in the Upper Llandovery at Damory Bridge, Tortworth (Survey Collection).

Rhynchonella Weaveri, *Salter*, MS. Pl. XXIV, fig. 14.

Spec. Char. Triangularly ovate, longer than wide, broadest anteriorly. Valves moderately and almost equally convex; fold in the dorsal valve of small elevation, and confined to the anterior half of the valve; beak small, incurved. Sinus in the ventral valve shallow, and visible only close to the front. Surface of each valve ornamented by some thirty-three small radiating ribs, of which from five to six occupy the fold and sinus.

Length $5\frac{1}{2}$, width 5, depth $3\frac{1}{2}$ lines.

Obs. Of this small species I have seen two specimens only; and these differed from *Rh. Llandoveriana* in being longer than wide. More examples will, however, require to be found and carefully examined before we can feel perfectly certain that the shell may not be a variation in form or variety of *Rh. Llandoveriana*. In the collection of the Geological Society we found a specimen, on the label of which Mr. Salter had written the name *Weaveri*, and which we have figured and described.

Position and Locality. Upper Llandovery, Long's Quarry, Tortworth; also at May Hill, in the same formation.

Rhynchonella tripartita, *J. de C. Sow.* (sp.) Pl. XXIV, figs. 15—16.

Terebratula tripartita, *J. de C. Sow.* Sil. Syst., pl. xxi, fig. 15, 1839; and Siluria 2nd ed., p. 545, pl. ix, fig. 10, 1859.

Spec. Char. Transversely pentagonal, much wider than long. Valves moderately convex. In the dorsal valve the fold is wide and convex, while in the ventral valve the sinus extends from the extremity of the beak to the front. Surface of valves ornamented by about twenty-four angular bifurcating ribs, which are crossed by concentric lines of growth.

Length 8, width 13 lines.

Obs. Of this species I have never been able to examine more than two imperfect specimens, those figured by J. de C. Sowerby in the 'Silurian System,' and preserved in the Museum of the Geological Society of London. One of these is the internal cast of a ventral valve, while the other is a cast or impression of the exterior of the same valve; and on such scanty and incomplete material it is impossible to completely describe the species, or to say much with reference to its specific value. It differs, however, sufficiently in shape from other British species of the genus with which we are acquainted, and especially so from those that occur in the Llandovery rocks, as to lead us to retain it, at least provisionally, as a distinct species.

Position and Locality. Lower Llandovery beds; Goleugoed, Llandovery.

RHYNCHONELLA THOMSONI, sp. nov. Pl. XXIV, fig. 18.

TEREBRATULA, sp., *Salter.* Quarterly Journal Geol. Soc., vol. vii, p. 117, pl. viii, fig. 3, 1851.

Spec. Char. Shell small, somewhat trigonal and compressed, longer than wide, broadest anteriorly, tapering at the beaks; front straight. Valves moderately and uniformly convex; smooth to within a short distance from the margin, where in the dorsal valve, close to the front, there exists a wide flattened or slightly concave mesial fold of small elevation. One or two short ribs occur also on the lateral portions of the shell. In the ventral valve one or two short ribs are also present near the front. Sinus wide, short, and very shallow. Beak small, moderately incurved, with a small aperture under its angular extremity.

Length 5, width 4, depth 2 lines.

Obs. In 1851 this small shell was well figured by Mr. Salter, but without description or specific designation. When quite young no fold, sinus, or ribs, are observable, while in more aged examples they exist only close to the frontal margin. I have named it in honour of Mr. J. Thomson, of Glasgow, to whom we are indebted for the discovery of several important Ayrshire Silurian species.

Position and Locality. Rh. Thomsoni is not exceedingly rare in the Caradoc Limestone at Craig's Head Quarry, near Girvan, in Ayrshire. It is said to have been found also at Penwhapple Glen.

Rhynchonella Pentlandica, *Haswell*. Pl. XXII, figs. 9 to 19.

Rhynchonella, sp., *Salter*. Memoirs of the Geological Survey of Great Britain, Scotland (32), p. 138, pl. ii, figs. 7, 7_a, 1861.
— Pentlandicus, *Haswell*. On the Silurian Formation of the Pentland Hills, p. 31, pl. iii, figs. 9, 10, 1865.
— — *Dav.* Trans. Geol. Soc. Glasgow, pl. i, figs. 22—27, 1868.

Spec. Char. Shell small, oblong oval, ovate; sometimes almost circular or transversely oval, rounded or truncated, and slightly indented in front; broadest across the middle. Ventral valve convex, a little deeper than the opposite one, and longitudinally divided along the middle by an angular groove or depression, which, commencing close to the extremity of the beak, extends to the front, dividing the valve into two equal lobes; beak small, incurved. Dorsal valve moderately convex, with a slight flatness or longitudinal depression along the middle of the umbone. Surface of valves closely covered with numerous fine radiating striæ or small ribs, which increase in number as they near the margins by the means of many interpolated striæ. In the interior of the ventral valve a deep trilobed muscular scar is visible in the posterior portion of the valve, while in the dorsal valve a short small mesial ridge separates each pair of the adductor quadruple muscular impressions. Two specimens measured—

Length 6, width 5, depth 3 lines.
,, 5, ,, $5\frac{1}{2}$, ,, $3\frac{1}{2}$,,

Obs. This small species is exceedingly variable on account of the modifications in shape it assumes, being either elongated or transversely oval, while both extremes are connected by intermediate shapes, the elongated oval being, however, the most common form it presents. It occurs in great abundance under the condition of external and internal casts, no specimen with the shell preserved having been hitherto discovered. In 1861 Mr. Salter recognised it as a distinct and probably new species; but though figuring it, he refrained from applying to it a distinctive specific denomination, "from its being too imperfect to identify with published forms." It was subsequently named *Rh. Pentlandicus* by Mr. G. Haswell, who gave a description and figures of two of its principal modifications in shape. In Pl. XXII will be found a series of figures illustrating several of the variations in form assumed by this species, as well as carefully enlarged illustrations of its internal characters, selected from a very extensive series of specimens collected by Messrs. Haswell, Brown, and Henderson; Mr. Salter's two figures have been likewise reproduced. By means of softened gutta-percha we have reproduced the perfect shell (fig. 14), while fig. 19 is taken from the specimen described by Mr. Haswell as a distinct variety.

Position and Locality. Rh. Pentlandica occurs by thousands in the Ludlow Shales of the escarpments bordering the North Esk River, not very far from the Bevelaw Reservoir in the Pentland Hills, where also it was discovered by Mr. A. Geikie. We are not at present acquainted with any other British or foreign locality.

RHYNCHONELLA SALTERI, sp. nov. Pl. XXIV, figs. 19—20.

Spec. Char. Shell small, pentagonal, slightly wider than long, front line straight, tapering at the beaks. Valves moderately convex, smooth to about half their posterior length; fold in the dorsal valve wide, and formed of three ribs, while the lateral portions of each valve are either smooth or with one or two short ribs in the contiguity of the margin. In the ventral valve two ribs occupy the sinus; beak short and incurved.

Length 4, width $4\frac{1}{2}$, depth $2\frac{1}{2}$ lines.

Position and Locality.—It occurs in the Caradoc at Penwhapple Glen, near Girvan, in Ayrshire, and at Boduan, in Carnarvonshire, both the figured specimens are preserved in the Museum of the Geological Survey.

RHYNCHONELLA ? ÆMULA, *Salter*, MS. Pl. XXIV, fig. 21.

RHYNCHONELLA ÆMULA, *Salter*. Catalogue of the Collection of Fossils in the Museum of Practical Geology, p. 7, 1865.

Spec. Char. Subpentagonal, slightly wider than long. Ventral valve uniformly convex and smooth to about half its length from the beak; mesial sinus moderately concave, commencing at the front margin and extending to rather more than one third of the length of the valve, with a wide central rounded rib; there are two or three short ribs also close to the margin on each of the lateral portions of the valve; beak short, closely incurved down to the umbone of the opposite valve. Dorsal valve convex, with a rather wide, much elevated mesial fold, which, commencing at about half the length of the valve, becomes biplicated as it reaches the front; two short rounded ribs also exist on each of the lateral portions of the valve, but are confined to the contiguity of the margin.

Length 4, width 5, depth 3 lines.

Obs. This small species is easily distinguished by its shape from our other Silurian forms. One can perceive, also, through the transparency of the shell, a straight line extending from the extremity of the beak and umbone to about half the length of the valves, and indicating the presence in the interior of the valves of short septa or ridges. It also bears resemblance to some varieties of *Camarophoria globulina;* and it is with much uncertainty that we provisionally place it under *Rhynchonella.*

Position and Locality. It occurs in the Caradoc at the Chair of Kildare, in Ireland, and specimens may be seen in the Museum of the Geological Survey. At page 7 of the

'Catalogue of the Fossils in the Museum of Practical Geology,' published in 1865, other localities are recorded, as follow:—Craig Head, Girvan; Cerrig-y-Druidion; Desertcreight, Tyrone; and Harnage Park, Cressage; all in the Caradoc or Bala formation.

RHYNCHONELLA ? BELTIANA, sp. nov. Pl. XXIV, fig. 22.

Spec. Char. Almost circular, nearly as wide as long. Dorsal valve convex; mesial fold wide, more or less elevated and flattened along the middle; commencing at the frontal margin, it extends to rather more than half the length of the valve. Ventral valve convex, but much less deep than the opposite one; sinus concave, of greater or lesser depth, forming in front a convex curve or wave rising abruptly on either of the lateral sides; beak small, closely incurved. Surface smooth.

Length 5, width 6, depth 4 lines.

Some examples, however, attained nearly the double of the above dimensions.

Obs. When quite young the shell is much flattened or very slightly convex, with hardly any definable fold and sinus; these, however, become developed with age, as seen in the figure. In external shape it somewhat resembles one or two Bohemian Silurian forms figured by Barrande; but from these our shell differs in several details. I name it after Mr. Thomas Belt, to whom science is indebted for valuable researches among the Lower Silurian and Cambrian rocks.

Position and Locality. Rh. Beltiana occurs in rocks of Wenlock or of May Hill age, at Cahireconree, County Kerry, Ireland; and a fine series of specimens may be seen in the Museum of the Geological Survey of Ireland.

RHYNCHONELLA ? PORTLOCKIANA, sp. nov. Pl. XXIV, figs. 23—25.

Spec. Char. Ovate, or nearly circular, usually longer than wide. Dorsal valve convex, divided into three longitudinal convex lobes, of which the central one forms the mesial fold; it is narrow at its commencement close to the umbone, and continues so for some distance, but afterwards gradually increases in width and elevation as it nears the front. Ventral valve convex, and deeper than the opposite one; sinus concave, turning in abruptly on either side; beak small, incurved. Surface smooth, feebly marked by concentric lines of growth. Two specimens measured—

Length 3, width $2\frac{1}{2}$, depth 2 lines.
,, 3, ,, 3 ,, 2 ,,

Obs. This small shell is remarkable on account of the trilobed shape of its ventral valve, as well as from the form of its mesial fold. This last feature easily distinguishes it from the larger *Rh. ? Beltiana.* When quite young the dorsal valve is almost flat, the fold being scarcely defined. From not having been able to obtain an insight into the interior of this and the preceding species, it is not possible to feel quite certain that they really belong to the genus *Rhynchonella*.

Position and Locality. *Rh. Portlockiana* occurs in the Caradoc at the Chair of Kildare, in Ireland. Specimens may be seen in the Museum in Jermyn Street.

Rhynchonella ? Edgelliana, sp. nov. Pl. XXIV, figs. 27—28.

Spec. Char. Transversely oval, valves moderately convex. Dorsal valve divided into three almost equal parts, of which the central one forms the mesial fold. Ventral valve convex, with a deep concave mesial fold. Surface smooth.

Length 5, width 6 lines.

Obs. Of this species (?) Mr. Wyatt-Edgell found two incomplete specimens or valves only; and consequently, from such scanty material, it is not possible to offer a complete or satisfactory description. I am likewise very uncertain with reference to the genus to which it should be referred, but have provisionally left it with *Rhynchonella*. It might perhaps belong to *Meristella?* I have, however, considered it desirable to describe and figure the shell as far as practicable, on account of its having been obtained from rocks of the Llandeilo age, near Ffairfack. The specimens are in the late Mr. Wyatt-Edgell's collection.

Rhynchonella ? navicula, *Sow.* (sp.) Pl. XXII, figs. 20—23.

Terebratula	navicula,	*J. de C. Sow.* Silurian System, pl. v, fig. 17, 1839.
Atrypa	—	*M'Coy*. A Synopsis of the Silurian Fossils of Ireland, p. 40, 1846.
Terebratula	—	*Barrande*. Silurische Brachiopoden aus Böhmen, pl. xv, fig. 4, 1847.
—	—	*Dav*. Bull. Soc. Géol. de France, 2nd series, vol. v, p. 328, 1848.
Hypothyris	—	*Phillips*. Memoirs of the Geol. Survey of Great Britain, p. 281, 1848.
Atrypa	—	*D'Orbigny*. Prodrome, vol. i, p. 40, 1849.
Hemithyris	—	*M'Coy*. Brit. Pal. Foss., p. 204, 1852.
Rhynchonella	—	*Salter*. Siluria, 2nd ed., p. 545, pl. xxii, fig. 12, 1859.
—	? —	*Lindström*. Gotlands Brachiopoder, p. 381, 1860.
—	—	*Salter*. Memoirs of the Geological Survey of Great Britain vol. iii, p. 279, 1866.

Spec. Char. Shell rather small, ovate or boat-shaped, widest and most rounded posteriorly, gradually narrowing anteriorly, slightly convex in front. Ventral valve very convex and arched, obscurely keeled along the middle, the lateral margins forming a broad convex curve; beak closely incurved over the umbone of the opposite valve. Dorsal valve concave, but slightly convex in the contiguity of the hinge-line and sides. Surface of both valves smooth, marked only by a few fine lines of growth. In the inner surface of the dorsal valve a slightly raised mesial ridge extends from under the hinge-plates to about half the length of the valve, and on either side are two scars formed by the adductor muscle, while in the internal cast the place occupied by the mesial ridge forms a longitudinal groove, the muscular impressions being slightly in relief on either side. The sockets are widely separate. In the interior of the ventral valve a mesial groove extends from the extremity of the beak to about the middle of the shell; and on either side, running parallel with the hinge-line, are two rather broad, rounded projections, at the outer extremity of which is situated the articulating tooth; under these are two obliquely placed or chevron-like, elongated, oval-shaped muscular scars, considerably raised from the bottom of the valve (these projecting parts forming corresponding depressions on the internal cast).

Length 6, width $4\frac{1}{2}$, depth 4 lines.

Obs. Surely this shell differs much, both by its external as well as its internal characters, from those peculiar to the genus *Rhynchonella;* so much so that it may hereafter be found desirable to propose for it and similarly characterised shells a separate generic or sub-generic designation. Not being, however, quite satisfied as to the shape and means by which its oral arms were supported, I have preferred to follow the greater number of palæontologists, leaving it provisionally with *Rhynchonella.* Prof. M'Coy justly observes that "the peculiar chevron mark on the cast of the greater valve is very remarkable, and makes the cast very easily recognisable; that it forms the anterior boundary apparently of two great prominent muscular impressions, which are marked by radiating striæ from the beak:" and, as Mr. J. de C. Sowerby observes, its "boat-shape" is very peculiar. The shell does not seem to have much exceeded the proportions above given.

Position and Locality. *Rhynchonella ? navicula* appears confined to the Wenlock and Ludlow formations, and is more abundant in the last mentioned. In the *Upper Ludlow* it occurs near Ludlow, at Usk Castle; Hale's End and Overley, in the Malvern district; Pyrton Passage, Tortworth district; Cwm-Craig-ddu, in the Builth district. Mr. J. de C. Sowerby mentions the following localities:—Ludlow Promontory; Clyro Hill, Radnorshire; Brecon Anticlinal, viz. Corn-y-Tan, Alltfawr, and Rhiwannest. In the *Aymestry Limestone* it is common at Sedgley, near Wolverhampton, also at Llanbadoc, in the Usk district, &c. In the *Lower Ludlow* at Cefn Ila. In the *Wenlock Shale* near Builth (Siluria). Mr. Salter mentions Cefn Barog; Moel-Todig; Dinas Bran; Welshpool, Mynydd-y-Gaer; Llanefydd, in North Wales. Other localities are enumerated by Profs. M'Coy and Phillips; but from these I have not seen specimens.

In Ireland it occurs in the Ludlow and Wenlock Shales at Doonquin and Ferriter's Cove, Dingle, County Kerry, &c. It has not yet been recorded as a Scottish fossil.

Abroad it is found in the Island of Gothland; in Bohemia, &c.

Rhynchonella ? nana, *Salter*, MS. Pl. XXIV, fig. 26.

Spec. Char. Shell small, obscurely pentagonal, broadest near the beaks, gradually narrowing anteriorly, slightly indented in front. Ventral valve very convex, and keeled along the middle, but divided by a small longitudinal groove or sinus, most apparent near the front; lateral portions of the valve slightly concave, beak incurved. Dorsal valve slightly convex, divided into two lobes by a deep mesial furrow extending along the middle. External surface not known.

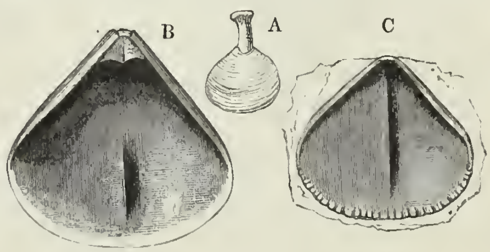
Length 4, width 4, depth 3 lines.

Obs. Of this small species I have seen but one internal cast, which was found by the late Mr. Wyatt-Edgell in the Caradoc at Tyrone, in Ireland. It somewhat resembles *Rh. ? navicula*, but is quite distinct, and surely does not belong to the genus *Rhynchonella*, where it is provisionally located. The description must necessarily be very incomplete, since we are not acquainted with the shell itself, or with its exterior characters; but it was in all probability smooth. The original specimen forms part of the collection of the late Mr. Wyatt-Edgell, and to the tablet Mr. Salter had appended the specific designation here reproduced.

Genus—Eichwaldia, *Billings*, 1858.

Report of the Geological Survey of Canada for 1857, published in 1858.

The characters appertaining to this genus have not yet been completely defined, I am therefore somewhat uncertain as to the place it should occupy in the classification of the Brachiopoda, and also whether it be really represented in our British Silurian deposits. Mr. Billings diagnoses his genus as follows:—"Large valve perforated on the umbo for the passage of the peduncle; the place of the foramen beneath the beak occupied by an imperforate concave plate, the interior divided by an obscure medio-longitudinal ridge; interior of smaller valve divided throughout from the beak to the front by a very prominent medio-longitudinal ridge; no hinge, teeth, sockets, or other articulating apparatus, in either valve." Mr. Billings has kindly sent me one example of his *Eichwaldia subtrigonalis*, as



Eichwaldia subtrigonalis, Billings.

well as three drawings, of which I here append woodcuts. It is certain that the genus or species last named was provided with a tolerably long peduncle, for Mr. Billings found a silicified specimen (fig. A) at Paquette Rapids, on the Ottawa River, in the Black-River Limestone, in which this appendage had been wonderfully preserved. The fig. A represents the ventral valve, and the pedicle seems to issue from the back of the beak, as described above, although the inspection of the specimen kindly sent me by Mr. Billings would tend to leave some uncertainty in my mind how the pedicle could have found space sufficient to protrude from under the concave plate above described and seen in fig. B, which represents an enlarged view of the interior of the ventral valve, while in fig. C we have that of the dorsal one. From these figures the shell would appear to be destitute of teeth and sockets for the articulation of the valves, nor would there appear to exist any processes for the attachment of any appendage such as spiral arms, although I feel convinced that the shell was provided with them under some form at present quite unknown to us. Mr. Billings writes me that it seems to be allied to *Lingula* and *Obolus;* but upon that point I would not venture, with the scanty material before me, to offer any decided opinion. No traces of muscular scars could be made out.

EICHWALDIA ? CAPEWELLI, *Dav.* Pl. XXV, figs. 12—15.

TEREBRATULA CAPEWELLI,	*Davidson.*	Bull. Soc. Géol. France, 2nd series, vol. v, p. 327, pl iii, fig. 34, 1848.
ATRYPA —	*D'Orb.*	Prodrome, vol. i, p. 40, 1849.
PORAMONITES —	*Morris.*	Catalogue of British Fossils, p. 143, 1854.
RHYNCHONELLA —	*Salter.*	Siluria, 2nd ed., p. 250, 1859.
PORAMBONITES —	*Id.*	Ib., p. 544.
— —	*Lindström.*	Gotlands Brachiopoder, Öfv. K. Akad. Förhandl., p. 364, 1860.
— —	*Murchison.*	Siluria, 3rd ed., p. 527, 1867.

Spec. Char. Subrhomboidal, transversely oval, broadest anteriorly. Dorsal valve moderately convex; mesial fold wide, rounded, and of small elevation; commencing at a little distance from the umbone, it extends to the front. Ventral valve convex, rather less deep than the opposite one; sinus broad, concave, and shallow; originating at the extremity of the beak, it extends to the front; beak small, closely incurved over the umbo of the dorsal valve. Surface of both valves closely covered with raised, thread-like ridges, forming all over the shell a network of more or less regular six-sided cells, the bottom of the cells being flat, and margined by slightly raised hexagonal ridges. In the interior of the dorsal valve there exists a mesial ridge, and a concave plate is present under the beak. In the dorsal valve a mesial septum extends from under the umbonal beak to about half the length of the valve; and on either side of this, on the bottom of the shell, are situated two muscular (adductor) impressions.

Length 8, width 9, depth 4 lines.

Obs. This beautifully sculptured shell was discovered by Mr. Capewell in 1847, and I shortly afterwards published a figure and description of the species from specimens I had picked up at Hay Head, near Walsall at about the same time. The sculptured surface is very peculiar, and nearly resembles that seen on *Discina* (*Trematis*) *punctata.* The cells (not punctures or perforations) vary much both in size and shape, are small at the umbone and on the beak, but gradually become larger as they near the middle of the shell, becoming again smaller as they approach the frontal and lateral margins. When there has been an interruption in the growth of the shell, and which is indicated by a sharp concentric line, the cells often begin again by being smaller. They also assume a greater or lesser degree of regularity in their shape, some being almost triangular, lozenge-shaped, or more or less regularly five- or six-sided. On the valve of one specimen, measuring five lines in length by some six in breadth, I counted nearly three thousand of these cells. In some examples the mesial fold is hardly produced above the regular convexity of the valve, while in other examples it is sharply defined. No very satisfactory specimen showing the interior of this shell has been found; but an internal cast from Malvern, in the Museum of the Geol. Survey (fig. 15), exhibits some of its characters, and Prof. Hall assures me that the species is, without doubt, referable to the genus *Eichwaldia.* While I was describing our British shell in 1848 M. de Verneuil showed me some specimens he had found in the Niagara group at Lockport, in America, which at the time appeared to me as well as to him to be identical with our *E. Capewelli.* This American shell was afterwards described and figured by Prof. Hall in vol. ii of his magnificent work on the 'Palæontology of New York' (p. 281, pl. lvii, fig. 5, 1852), under the designation of *Atrypa corallifera.* A full description of this last-named species is to be found in the 'Report of the State Cabinet for the Year 1865;' and in Pl. XXV, fig. 13*a*, will be seen a section of the American shell, taken from Prof. Hall's figure.

Position and Locality. This species appears to be confined to the Woolhope and Wenlock formations. It occurs in the Wenlock Shale at Hay Head and Linley's Lime-Works, north-east of Walsall; also at Dormington Wood and Dudley. It has also been found near the road between Alfrick and Crews Hill, Malvern, in beds of the Woolhope age. I am not acquainted with the shell from either Scotland or Ireland, but it has been found in the Island of Gothland by Dr. Lindström.

Genus—Porambonites, *Pander*, 1830.

I much regret not to be yet in possession of satisfactory information with reference to the internal characters belonging to this genus; all we know upon the subject has been already recorded at p. 99 of my "General Introduction," and we must look to the Russian palæontologists for a complete description of the interior of a shell that occurs so plentifully in the Lower Silurian rocks of the north of Russia.

Porambonites intercedens, *Pander; var. filosa, M'Coy*. Pl. XXV, figs. 16; 17—19 (?); Pl. XXVI, figs. 1, 2, 3 (?).

Porambonites intercedens, *Pander*. Beitr. zur Geog. des Russischen Reiches, p. 2, fig. 2, 1830.
Spirifer porambonites, *Von Buch*. Beitr. zur Geb. Russl., p. 13, pl. ii, figs. 4—7, 1840.
— — *De Verneuil* et *De Keyserling*. Geol. of Russia, vol. ii, p. 131, 1845.
Atrypa filosa, *M'Coy*. A Synopsis of the Silurian Fossils of Ireland, p. 39, pl. iii, fig. 28, 1846.
Porambonites intercedens ? *M'Coy*. British Pal. Foss., p. 212, 1852.
— — *Salter*. Siluria, 2nd ed., p. 544, 1859.
— æquirostris, *D'Eichwald*. Lethæa Rossica, Ancienne Période, vol. i, p. 794, 1859 (not *P. æquirostris*, Schlotheim, sp.).

Spec. Char. Subpentagonal, nearly circular, and either a little longer or shorter than wide; greatest breadth about the middle; sides rounded; hinge-line straight, less than half the width of the shell, and forming an obtuse angle with the lateral margins. Both valves are very convex, the dorsal one being the deepest. Dorsal valve posteriorly uniformly convex to about half the length of the shell; the fold, which is moderately broad, is slightly rounded, and of small elevation; it occurs on the anterior half of the valve; area rudimentary. Ventral valve with a concave sinus, which extends from the front to about half the length of the shell; beak incurved, area small, triangular, with a fissure in the middle. Surface of both valves marked by numerous thread-like radiating striæ, some of which being closer than others, increase in number as they near the margin by the interpolation of shorter ones. These striæ are chiefly formed by rows of small rounded or oval cells, close to one another, and separated only by narrow ridges; the free interspaces between each longitudinal row of pits or cells are smooth, and of smaller or greater width.

Length 16, width 17, depth 12 lines.

Obs. M. de Verneuil has justly observed, in his description of *Spirifer porambonites* (the name he adopts for the shell under description), that it is very variable in shape, and that to some of its modifications or varieties Pander had applied the distinctive specific designations of *Porambonites intercedens*, *P. alta*, *P. elevata*, *P. pentagona*, *P. lata*, *P. plana*, *P. trigona*, *P. subrecta*, *P. latissima*, *P. parva*, and *P. rotunda*. I cannot help expressing surprise that so distinguished a palæontologist as Dr. C. H. Pander should not have himself perceived that there would be no limit to the number of so-termed species, if to every slight modification of shape or size observable in different specimens of every species it should be necessary to apply a separate specific denomination. At page 794 of his 'Lethæa Rossica' M. E. d'Eichwald would add to the list of synonyms that of *P. æquirostris*, Schlotheim, which last name he proposes to adopt as the designation under which the species should be recognised; but Schlotheim's species, which was briefly described, but not figured, at p. 282 of his 'Petref. Gothæ' (1820), is evidently distinct from *P. intercedens* by its shape and characters, and is justly maintained by M. de Verneuil and other palæontologists as a separate species. In 1846 Prof. M'Coy described under the designation of *Atrypa filosa* an Irish shell, which seems to me referable to *T. intercedens* or to one of its varieties; and on carefully examining the surface of some well-preserved specimens kindly lent to me by the Director of the Geological Survey of Ireland, I found that it was covered with radiating rows of pits placed along the bottom of fine sunken striæ, exactly in a similar manner to those which M. de Verneuil has represented in pl. ii, fig. 4*f*, of the second volume of the 'Geology of Russia.' In 1822 Prof. M'Coy describes also (but does not figure), under the name of *Porambonites intercedens*, some doubtful Scottish specimens which had been obtained at Wrae Quarry, in Peebleshire (Pl. XXV, figs. 17—19), and are preserved in the Woodwardian Museum at Cambridge; but neither Mr. Salter nor myself, who have carefully examined the specimens so referred, could feel entirely satisfied as to the correctness of this identification. In his description of these last-named specimens Prof. M'Coy observes that he has adopted for the species the first specific name out of the synonyms used by Pander in his descriptions, although it is rather with the large depressed varieties, named by him *C. pentagona*, that the specimens have the most analogy.

As I have already stated, our Irish specimens agree very nearly in shape with the Russian ones, but the striæ are somewhat more strongly marked in the former. Of the interior I have represented two fine internal casts (Pl. XXVI, figs. 1, 2), which, I believe, belong to the species of which we have given the perfect exterior, but of this I am not perfectly certain.

Position and Locality. *P. intercedens* occurs in the Caradoc at Dunabrattin, Knockmahon, Tramore, County Waterford, in Ireland; and from these localities a fine series of specimens may be seen in the Museums of the Geol. Survey at London and Dublin.

No English examples have as yet turned up; but the species, according to Prof. M'Coy, occurs also in Scotland.

Abroad M. de Verneuil states it to be one of the most characteristic fossils of the Lower Silurian rocks of the north of Russia; that the variety *rotunda* occurs in Norway, from whence it has been quoted by M. d'Eichwald; and that Mr. Bunbury brought the shell from the neighbourhood of Christiania, in whose collection M. de Verneuil saw a specimen. *P. intercedens* and its varieties are abundant at Pavlosk, Popova, Poulkova, Reval, &c., in Russia.

Genus—Triplesia,[1] *Hall*, 1859.

The characters belonging to this genus have not been as yet completely made out. Prof. Hall describes it as follows:

"Shells transverse or elongate, trilobed or subtrilobate, ventral valve being marked by a broad deep sinuosity, and the dorsal valve by a corresponding fold. Hinge-line straight; area small, foramen triangular. External surface concentrically striated, and with fine, obscure or obsolete, radiating striæ; internal structure not determined. Types—*Atrypa extans*, *A. cuspidata*, and *A. nucleata*."

In a paper "On some Rocks and Fossils occurring near Phillipsburgh," published in August, 1861, Mr. Billings considers *Triplesia*, Hall, to be a synonym of his own genus *Camerella*, described in the 'Canadian Naturalist and Geologist,' vol. iv, p. 301, August, 1859; but I doubt much, as does Prof. Hall, that the two can be synonymous, and certainly *C. longirostra* and *C. varians*, Billings, do not belong to the same group or genus as *Triplesia extans*, or to the species I am about to describe. Moreover, Mr. Billings observes, at p. 8 of the paper above named, that "The genus *Camerella* appears to belong to the family *Rhynchonellidæ*, the species differing from the ordinary forms of *Rhynchonella* by having the surface in general either not ribbed at all, or with only a few obscure plications, not extending to the beak. The interior differs in having the dental plates of the ventral valve converging so as to form a small triangular or oval chamber of variable dimensions, as in *Pentamerus*." I have considered it necessary to refer to these details to show that *Triplesia*, Hall, cannot be the same as *Camerella*, for in *Triplesia* we have a straight hinge-line, area, deltidium, and foramen at its extremity, none of which characters belong to *Camerella*. Unfortunately, the internal arrangements of *Triplesia* do not appear to have been hitherto discovered; and I have no material which would enable me to throw light upon the subject. The genus must, consequently, be provisionally received; and it would be very desirable that good internal casts of *T. extans* and *T. Grayiæ* should

[1] 'Twelfth Report on State Cabinet of New York,' p. 44, 1859. Gr. τριπλασιος, triplex, in reference to the trilobed character of several of the species.

be sought for, by which some of the internal generic and family characters might be determined.

Triplesia Grayiæ, sp. nov. Pl. XXIV, figs. 31—32; and Pl. XXV, figs. 9, 10, 11.

Spec. Char. Subrhomboidal or obscurely lozenge-shaped; longer than wide, greatest breadth lower than the middle of the shell or at the anterior half. Dorsal valve gibbous, divided into three lobes of almost equal width, the central one forming a prominent angular fold, which, rising gradually at a short distance from the extremity of the umbone, becomes most elevated shortly before reaching the front, while its sides slope rapidly in the manner of a roof. The lateral portions, or ears, close to the hinge-line are flattened, while the umbone remains convex. Ventral valve much less deep than the opposite one; sinus deep, angular, extending from the extremity of the beak to the front, and defined by subangular margins. Beak nearly straight, much produced, usually large and tapering, but truncated at its extremity by a small circular aperture. Area triangular, sometimes equilateral, but more often the length is somewhat less than that of the width at the hinge-line. Deltidium rather broad, and occupying about one third of the area space; triangular, and most elevated along the middle. Surface of both valves marked by numerous thread-like, radiating striæ, which are crossed here and there by concentric lines of growth. Two specimens measured—

Length 6, width $5\frac{1}{2}$, depth 5 lines.

Obs. In external shape and size the dorsal valve somewhat resembles that of *Atrypa extans*, Conrad and Hall, as represented in pl. xxxiii, fig. 1*a*, *b*, of the first vol. of the 'Palæontology of New York,' but differs from it entirely by its fine thread-like, radiating striæ, as well as by the great extension of the area in its ventral valve. Having sent drawings of our shell to Prof. Hall, he remarked that it is generically identical with *Triplesia extans*, but does not belong to the American species. The several Ayrshire specimens I have seen seem to denote that in the perfect shell there existed a small foramen at the extremity of the beak for the passage of a pedicle, but, owing to the difficulty of obtaining specimens in good condition, it is rarely seen. Its angular fold is also very remarkable, reminding us of that occurring in *Rhynchonella acuta*. Its combined characters make it easily distinguishable from all our other British Silurian Brachiopoda.

I have named this shell in honour of Mrs. E. Gray, of Glasgow, to whom science is indebted for the discovery of several new species of Ayrshire Silurian fossils.

Position and Locality. This species belongs to the Caradoc or Bala division. Several bivalve examples were found by Mrs. Gray in the limestone at Craig Head Quarry, near Girvan, in Ayrshire, and dorsal valves had been collected by Mr. J. Thomson in a green brecchia in Penwhapple Glen, at about one hundred yards below

Penwhapple Bridge on the Barr road, three miles and a half from Old Daily church, Girvan, Ayrshire.

In England it was found by Mr. Lightbody in the Caradoc of Llandeilo (Birds Hill); and in the Museum of Practical Geology of London may be seen specimens from Pistyll Deroi, Llandeilo. I am not acquainted with the shell from any other locality or country.

Although the foregoing is the only British Silurian species which is, perhaps, properly located in the genus *Triplesia,* I have provisionally ventured to add those that now follow, not knowing to what other genus they can be allotted.

TRIPLESIA? MACCOYANA, sp. nov. Pl. XXIV, fig. 29.

HEMITHYRIS DEPRESSA, *M'Coy.* Brit. Pal. Foss., p. 201, 1852 (not *Atrypa depressa,* Sow.).

Spec. Char. Shell small, transversely oval, greatest breadth at about the middle; ventral valve slightly convex at its rostral portion, depressed towards the lateral margins, while a triangular sinus of moderate depth commences at a short distance from the extremity of the beak and extends to the front. Hinge-line short, area triangular and narrow, a small aperture existing under its small, prominent, pointed beak. Dorsal valve convex, sometimes much so, and strongly arched when viewed in profile. Mesial fold rising gradually, and chiefly confined to the anterior half of the shell. Surfaces of both valves smooth or marked by concentric lines of growth.

Length 5, width $5\frac{1}{2}$, depth 3 lines.

Obs. My attention was first drawn to this shell by Mr. Salter while on a visit to Cambridge. That experienced palæontologist at once perceived that it was not the *Atrypa depressa* of Sowerby, as erroneously supposed and described by M'Coy, but that it was, perhaps, a new species of *Triplesia.* I regret, however, that from want of time (while in Cambridge) I was not able to study the shell as carefully as I desired, but I clearly saw the small area which exists between the extremity of the beak and hinge-line, but of which no mention is made by M'Coy. Eight specimens from the Bala Limestone of Brynbedwog Quarry, near Bala, Merionethshire, are preserved in the Woodwardian Museum. This Brachiopod is here provisionally classed with *Triplesia,* as it is the genus to which it appears to bear most resemblance. I have also named it after Prof. M'Coy, to whom science is indebted for many excellent works.

Triplesia ? monilifera, *M'Coy* (sp.). Pl. XXV, figs. 3—5.

Producta monilifera, *M'Coy*. A Synopsis of the Silurian Fossils of Ireland, p. 25, pl. iii, fig. 3, 1846.
Orthis monilifera, *Etheridge*. Catalogue of the Collection of Fossils in the Mus. of Practical Geology, p. 8, 1865.

Spec. Char. Shell small, sometimes irregular, transversely oval, wider than long, broadest at about the middle of its length. Valves almost equally convex and deep. In the ventral valve a wide, deepish sinus commences at the front and disappears as it nears the beak, which is convex, pointed, and slightly incurved; hinge-line straight and either slightly shorter or longer than the width of the shell; area triangular, of small elevation, with a narrow convex pseudo-deltidium along its middle. Dorsal valve divided into three lobes by a wide convex mesial fold. Surface of both valves ornamented by eight or nine almost parallel rows of continuous concentric ridges, each row being formed of continuous, bead-like, elevated tubercles. Between each row is a wide, slightly concave space. Interior unknown.

Length 3, width 4, depth 2 lines.

Obs. A single ventral valve of this curious little shell was, in 1846, figured and described by Prof. M'Coy under the designation of *Producta monilifera,* and stated to be a miniature of *P. pustulosus*, Phillips. I admit that the aspect of this specimen, partly imbedded in the matrix, might naturally have led the distinguished Irlsh palæontologist to such an interpretation. Since that period, however, many perfect examples having turned up, it became easy to describe its external shape, and to show that it had nothing in common with *Productus*, although, being unacquainted with its internal arrangements, we cannot determine to what genus it should be referred. It is, however, probable or possible that my so termed *Triplesia Grayiæ*[1] and the shell under description may belong to the same genus, for which Prof. Hall thinks a new name should be proposed. For the present, however, I prefer leaving the species with *Triplesia,* as I am averse to propose a new genus for a shell of whose internal character I am completely ignorant. *T.? monilifera* has also, like *T. Grayiæ*, been found to vary much in shape on account of the twisted appearance the fold and sinus sometimes assume, and of these malformations a specimen is represented by fig. 5 of our plate. The concentric bead-like ridges are also strongly marked in some examples, while in others they are simply rows of unconnected elevated tubercles. I have not been able to clearly ascertain

[1] Prof. Hall writes, March, 1867—"Your little *T. Grayiæ*, on cutting down, seems to me to show a slender, closely coiled spire, somewhat as in *Cœlospira* or *Atrypa,* but there is only a single specimen showing it, and the condition of the others is not good."

whether there existed or not a small foramen at the extremity of the beak of the ventral valve.

Position and Locality. *T. ? monilifera* is known from the Caradoc or Bala Limestone only. In England it was found by Prof. Harkness at Keisley, Dufton, in Westmoreland. In Ireland it was obtained by Prof. M'Coy and others at the Chair of Kildare, County Kildare. It is not known to me from any other locality, British or foreign.

Before describing the numerous species composing the genus *Orthis*, it may be desirable to make known four which we cannot at present refer with certainty to any genus as yet established. The family, also, to which they belong, as well as that of *Eichwaldia Capewelli, Triplesia Grayiæ, T. ? Maccoyana, and T. ? monilifera,* described in the preceding pages, will require to be hereafter determined. It is to be hoped that the discovery of specimens exhibiting internal characters will before long enable palæontologists to assign to these doubtful forms their true place in the classification.

CYRTIA ? NASUTA, *Lindström* (sp.). Pl. XXV, figs. 1, 2.

STROPHOMENA NASUTA, *Lindström.* Öfv. K. Akad. Förhandl. Stockholm, 1860, p. 371, pl. xiii, fig. 15.

Spec. Char. Shell small, somewhat obscurely pentagonal or transversely oval, not always very regular in shape, slightly broader than long, greatest width anteriorly, tapering at the beak; hinge-line straight, shorter than the width of the shell. Ventral valve convex, beak nearly straight, and truncated at its extremity by a minute circular foramen; area triangular, about one fourth as high as long; deltidium very narrow and convex. Sinus deep, angular, and becoming obsolete as it nears the beak; three or four short, not very regular, or equally wide, or straight ribs occur on each of the lateral portions of the valve, but do not extend to much more than half the length of the valve from the margin. Dorsal valve convex, rather less deep than the opposite one, and divided along the middle, more or less regularly, by a prominent angular fold, which, commencing at a short distance from the umbone, extends to the front; three or four short ribs are also present on the lateral portions of this valve, and the surface of both valves is crossed by numerous more or less strongly marked concentric or scabrose ridges of growth. Interior unknown.

Length 3, width $3\frac{1}{2}$, depth 2 lines.

Obs. Of this curious little Spirifer-shaped shell, I have seen four British and two or three Swedish examples. They were all more or less irregular in the shape and position of their fold, sinus, and ribs, which is chiefly to be accounted for by the fold and sinus being twisted more to one side than to the other. They all, however, possess the same essential characters of area, deltidium, and apicial foramen, as well as the same general shape and character. The beak and umbone are also smooth, the ribs not extending over those portions of the shell. Dr. Lindström places this species in the genus *Strophomena* on account of a slight resemblance he considers it to bear with *Strophomena Loveni*, but it must also be remembered that in the last-named shell the dorsal valve is essentially concave, although there may exist a small elevation in its middle and towards the front, but in *C. nasuta* this same valve is entirely convex, and much resembles that of many Spirifers. The name *nasuta* had also been given by Conrad and Emmons to a shell which Prof. Hall believes to be a synonym of *Strophomena alternata*;[1] but as the species under description cannot, I think, be considered as belonging to that genus, wherein the valves are always more or less concavo-convex, the name *nasuta* need not be changed. The shape of the area, deltidium, and apicial foramen is, I admit, very similar to what we find in certain species of *Strophomena;* but it must also be remembered that in some species of *Cyrtia* there also exists a small circular foramen at the extremity of the deltidium, close to the extremity of the beak, as I have represented elsewhere in some Chinese examples of *Cyrtia Murchisoniana.* I do not, however, positively assert the place of this Spirifer-like shell to be that of the genus *Cyrtia*, but from its shape it was possibly provided with spirally coiled lamellæ (as perhaps in Spirifer) for the support of the oral arms, an opinion also entertained by Prof. Hall. For the present, therefore, its family and generic position must be considered an open question, to be determined hereafter, when we are in possession of specimens exhibiting its internal arrangements.

Position and Locality. *Cyrtia nasuta* occurs in the Wenlock Limestone of Dudley and of Benthall Edge, where it was collected by Mr. J. Gray and the Rev. H. Day: Mr. Gray's specimens are now in the British Museum. Abroad it was first discovered by Dr. Lindström at Wisby and Färo, in Gothland.

ATRYPA? APICULATA, *Salter* and *Forbes*, (sp.), MS. Pl. XXV, fig. 6.

RHYNCHONELLA APICULATA, *Etheridge.* A Catalogue of the Fossils in the Museum of Practical Geology, p. 7, 1865.

Spec. Char. Shell small, obtusely triangular or somewhat pear-shaped, about as long as wide, broadest anteriorly, tapering posteriorly into a pointed beak; hinge-line straight, less than half the width of the shell; sides rounded, front margin straight; dorsal valve moderately convex, almost gibbous at the umbone; sinus wide, square, and shallow, commencing at the front and extending to about half the length of the valve. Ventral valve convex, deeper than the opposite one; beak produced, nearly straight, with a minute terminal foramen (?). Area triangular, about one third as high as long; deltidium wide and flattened. A wide mesial rounded fold, commencing at a short distance from the extremity

[1] Conrad, 'Journ. Acad. Nat. Sciences,' vol. viii, p. 260; also J. Hall, 'Pal. New York,' vol. i, p. 102.

of the beak, extends to the front. Surface of both valves smooth, but marked by a few faint concentric lines of growth.

Length 3, width 3, depth 2 lines.

Obs. This interesting little species had some years ago received from Messrs. Forbes and Salter the MS. name of *Rhynchonella apiculata*, and this has been transcribed in the printed catalogue of the fossils in the Museum of Practical Geology. It is not, however, a *Rhynchonella*, and Mr. Salter would now refer it to *Atrypa;* but I am sadly at a loss to know where it should be placed, while Prof. Hall would suggest the proposing of a new genus for its reception. Unfortunately, all my endeavours to discover its internal arrangements have proved unavailing, and consequently I have provisionally left it with *Atrypa*, to which, in all probability, it does not belong.

Position and Locality. This small shell occurs in the Caradoc or Bala Limestone, at the Chair of Kildare, County Kildare, Ireland; and some good examples may be seen in the Museum of Practical Geology.

Atrypa ? incerta, sp. nov. Pl. XXIV, fig. 30; and Pl. XXV, figs. 7, 8.

Spec. Char. Obtusely pentagonal, about as broad as long, greatest width posteriorly or at about one third of the length of the shell from the beak; hinge-line straight, a little shorter than the width of the shell. Ventral valve either uniformly convex and gibbous, or with a broad slightly elevated fold close to the front; beak tapering to a point, with a minute apical foramen (?); area triangular, about one third as high as long; deltidium very wide and flat, with either a narrow longitudinal ridge or line along its centre. Dorsal valve not known. Surface smooth.

Length 10, width 10 lines.

Obs. Whether this be a distinct species or simply a large variety of *Atrypa apiculata* I am not at present able to determine. Four or five ventral valves only having been discovered, it is not possible to offer a complete description of the shell. It differs, however, in several particulars from *A. ? apiculata;* it is a much larger shell, its hinge-line is proportionately longer, and the area and deltidium somewhat different. Under these circumstances, and from its being found in a different formation, I have been induced to apply to it a distinct specific designation.

The same difficulty relating to its genus as in the preceding species here prevails; I will consequently leave it provisionally with *Atrypa.* I am still uncertain whether it was provided with an apicial foramen.

Position and Locality. This species occurs in the Upper Llandovery rocks at Penkill, near Girvan, in Ayrshire, where it was discovered for the first time by Mrs. E. Gray, of Glasgow.

MERISTA ? CYMBULA, sp. nov. Pl. XXII, figs. 28, 29.

Spec. Char. Shell very small, elongated, oval, or subrhomboidal, greatest breadth a little below the middle. Ventral valve evenly convex, forming a nearly regular arch from the beak to the frontal margin, slightly subcarinate; beak small, strongly incurved over the umbone of the dorsal valve. Dorsal valve concave, slightly convex at the umbone and lateral edges. Surface of both valves smooth. In the interior of the ventral valve a triangular arched plate, with a projecting ridge along the middle, commences under the extremity of the incurved beak and extends to about half the length of the valve; on either side of the beak a strong tooth is supported by a curved dental plate. Interior of dorsal valve not known.

Length 2, width $1\frac{1}{2}$, depth 1 line.

Obs. The genus to which this curious little shell should be referred cannot yet be determined, for we know nothing of the internal arrangements of its smaller valve. It resembles much, in its external appearance, a shell described and figured by Mr. Billings in the 'Canadian Journal' for May, 1861, under the designation of *Centronella glans-fagea*, Hall;[1] but this last differs from ours by its much larger dimensions and more prominent beak. While describing his *Rhynch. glans-fagea*, Professor Hall remarks that it differs so widely from any other species hitherto found in his (American) rocks as to be at once recognised merely by its form, and that he has placed it provisionally in the genus *Rhynchonella;* not having had an opportunity of seeing its internal characters. In 1859 Mr. Billings mentioned this species as the type of his new genus *Centronella*, and he considered it to be intermediate to *Terebratula* and *Waldheimia* on account of its simple loop, which extends to about half the length of the valve before being reflected backwards towards the beak. Not knowing what are the characters of the interior of the dorsal valve of our shell, I cannot surmise whether or not it possessed a loop; and as Mr. Billings does not mention the presence of an arch-shaped plate in the ventral valve of *C. glans-fagea*, it is probable that our British shell does not belong to the same genus. The arch-shaped plate of *M. ? cymbula* resembles somewhat that figured by Prof. Hall in his *Camarium typum* or that of some species of *Merista*. We will, therefore, for the present, leave it under the last-named genus.

Position and Locality. This little shell was found in the Caradoc-Bala formation at Hendre wen (Cerrig-y-druidion); and I believe it occurs also at the Chair of Kildare, in Ireland, in the same formation.

[1] *Rhynchonella ? glans-fagea*, Hall. 'Tenth Annual Report of the Regents of the University of the State of New York,' p. 85, 1857.

Family—ORTHIDÆ.

Genus—Orthis, *Dalman*, 1827.

See "General Introduction," p. 101.

Orthis is one of the most important genera that occur in the Silurian rocks of this and other countries; it will consequently be necessary to devote to it very careful study. It varies considerably in shape, as do the species of every great genus; and it is probable that, when completely understood or worked out, it may be necessary to subdivide it into several minor groups, distinguished by certain internal and external characters and features. It is also one of the earliest genera with which we are at present acquainted, for one species has been found in the Lower Lingula-flags, or Menevian group; and the genus has continued to prevail throughout the entire series of Palæozoic rocks.

Before describing the many species that occur in Great Britain, it may be as well to briefly notice a few of the most prominent features in the interior of each valve. These details differ, however, somewhat in certain forms, but the same general character appears to be pretty constant in by far the larger number.

Fig. 1.

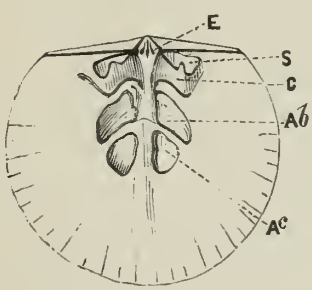
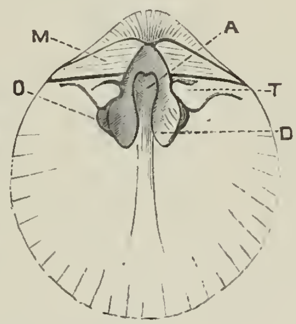


Fig. 2.



Orthis elegantula, Dalman.

Fig. 1.—Interior of the *dorsal* valve:—*E.* Cardinal process. *C.* Brachial processes. *S.* Dental sockets, usually surrounded by a raised ridge, which we will designate as the socket-walls. A^b. Posterior adductor or occlusor muscular impression; of these there are two, separated by a ridge of greater or lesser width; under these are another pair of muscular scars, A^c, similarly separated, which have been referred to the anterior adductor or occlusor muscle. The form of these four scars varies in some species.

Fig. 2.—Interior of the *ventral* valve:—*M.* Area. *T.* Teeth, at times supported by strong plates, termed dental plates. *A.* Adductor or occlusor muscular impression, usually situated on either side of a slightly elevated ridge. *D.* Divaricator muscular impressions. *O.* Ventral adjustor muscular impression. These three kinds of scars are usually enclosed in a saucer-shaped depression or cavity, more or less distinctly surrounded by a prominent ridge, which is sometimes formed by a prolongation of the dental plates.

Orthis biloba, *Linné* (sp.). Pl. XXVI, figs. 10 to 15.

Anomia biloba, *Linné.* Systema Naturæ, ed. xii, vol. i, pars 2, p. 1154, 1767.
Terebratula sinuata, *J. Sow.* Trans. Linn. Soc., vol. xii, p. 516, pl. xxviii, figs. 5, 6, 1815.
— cardiospermiformis, *Hisinger.* Anteck., Act. R. Soc. Holm., pl. vii, fig. 6, 1826.
Delthyris — *Dalman.* Vet. Akad. Handl., p. 124, pl. iii, fig. 7, 1827.
— — *Hisinger.* Bidrag till Sveriges Geognosi, vol. iv, p. 220, pl. vii, fig. 6, 1828.
Spirifer — *Von Buch.* Ueber Spirifer und Orthis, Berlin Acad. Trans., p. 49, pl. i, fig. 7, 1837; and Mem. Soc. Géol. France, 1 ser., vol. iv, p. 196, pl. x, fig. 23, 1840.
Delthyris — *His.* Lethæa Suecica, p. 74, tab. xxi, fig. 9, 1837.
Terebratula (Delthyris ?) cardiospermiformis, *Angelin.* Mus. Palæont. Svecicum, 1838.
Spirifer sinuatus, *Sow.* Silurian System, p. 630, pl. xiii, fig. 10, 1839.
Delthyris — *J. Hall.* Geol. Rep. 4th District New York, p. 105, fig. 8, 1843.
Spirifer ? biloba, *Sharpe.* Quart. Journal Geol. Soc., p. 161, 1847.
— bilobus, *De Vern.* Bull. Soc. Géol. France, 2nd ser., vol. iv, 1847.
Orthis biloba, *Dav.* Bull. Soc. Géol. France, 2nd ser., vol. v, p. 321, t. 3, fig. 18, 1848.
— — *De Verneuil.* Ibid., p. 343, pl. iv, fig. 10, 1848.
— — *Phillips* and *Salter.* Mem. Geol. Survey, vol. ii, p. 287, 1848.
Spirifer bilobus, *Bronn.* Index Pal., p. 1173, 1848.
Orthis biloba, *D'Orb.* Prodrome, vol. i, p. 36, 1849.
Dicœlosia biloba, *King.* Monog. Permian Fossils (Pal. Soc.), p. 106, 1850.
Orthis — *M'Coy.* Brit. Pal. Foss., p. 213, 1852.
— cardiospermiformis, *Quenstedt.* Handbuch der Petref., pl. xxxix, fig. 3, 1851.
Spirifer bilobus, *Hall.* Pal. of New York, vol. ii, p. 260, pl. liv, fig. 1, 1852.
Orthis biloba, *Morris.* Cat. of Brit. Foss., p. 139, 1854.
Anomia — *Hanley.* Ipsa Linnæi Conchylia, p. 134, 1855.
Delthyris varica, *Conrad.* Journ. Ac. Phil., vol. viii, tab. xiv, fig. 20.
Orthis biloba, *Salter.* Siluria, 2nd ed., p. 543, pl. ix, fig. 20, and pl. xx, fig. 14, 1859.
— — *Lindström.* Gotl. Brach., Öfv. K. Akad. Förhandl., p. 370, 1860.
— — *Ramsay* and *Salter.* Mem. Geol. Survey, vol. iii, pp. 267, 361, 1866.
— varica, *Dana.* Manual of Geology, p. 254, 1866.
— biloba, *Dav.* Trans. Geol. Soc. Glasgow, Pal. Series, vol. i, pl. ii, fig. 11, 1868.

Spec. Char. Shell small, more or less deeply bilobed or forked, obcordate, subtrigonal, constricted medio-longitudinally, deeply sinuate in front, widest anteriorly; hinge-line straight, shorter than the width of shell. Dorsal valve moderately convex, umbone slightly gibbous, ears rectangular, flattened close to the cardinal extremities, front divided into two rounded convex lobes, diverging more or less, and divided posteriorly or during part of their length by a deep median sinus or groove; hinge-area narrow. Ventral valve deeper or more convex than the opposite one, flattened at the cardinal angles, and divided longitudinally into two convex lobes by a deep sinus; beak more or less incurved; area triangular, of moderate height; fissure open, triangular; surface of both valves marked by longitudinal striæ, which radiate from the umbone or beak to the margin of each lobe, one or two smaller or shorter ribs being interpolated between each two of the principal ones; surface concentrically marked by fine striæ; shell structure punctate. In the interior of dorsal valve a small divided cardinal process is situated between two rather widely separate, small, curved brachial processes, on the outer side of which, close to the hinge-line, are the sockets. A mesial ridge extends from under the cardinal process to the front. Adductor or occlusor scars quadruple; one pair on the bottom of the valve on each side, close to the mesial ridge, but very faintly marked. In the ventral valve a prominent tooth on each side at the base of the fissure; dental plates curving inwards on each side so as to enclose a small saucer-shaped cavity, longitudinally divided by a somewhat flattened mesial ridge. This cavity is occupied by the adductor or occlusor muscular scar (in the middle or on the mesial ridge) and laterally by the divaricator and ventral adjustor. A wide, flattened, inwardly dentated band margins the interior of each valve.

Length 7, width 5, depth 2 lines, but more often smaller.

Obs. This remarkable little shell has been frequently described and illustrated, but its true generic position had not been ascertained prior to 1847, when the study of some well-preserved interiors of both valves enabled me to demonstrate that its true place and affinities were with *Orthis*, and not with *Spirifer*, *Delthyris*, *Terebratula*, or *Dicœlosia*, where it had been located by various palæontologists. In 1767 Linnæus describes his shell as follows:—"*Anomia biloba. A. testa biloba æquali striata. Hab. . . . . . a. D. Pennant fossilis*;" but he does not mention any locality or give any reference to a figure. In 1847 Messrs. Sharpe, Salter, and myself ascertained that the Linnean collection contains the shell under description so labelled by Linnæus himself;[1] but, singularly enough, the Swedes Hisinger and Dalman appear not to have known the shell so named by Linnæus, since they give to it the new designation of *cardiospermiformis*. In 1815 the species was well figured by James Sowerby, under the new name *Terebratula sinuata*; and it subsequently received that of *varica* from Conrad. In 1850 Prof. King proposed for its reception a new genus, *Dicœlosia*, but did not give any valid reasons for so doing. As I have shown, all its interior characters are those of *Orthis*, and as such it has been recognised by almost every palæontologist subsequent to 1848.

Orthis biloba varies very much in shape, and chiefly so by the greater or lesser extension and divergence of the free portion of its lobes, the frontal indentation being very small in some examples and very deep in others. M. de Verneuil and Dr. Lindström

[1] See Hanley, 'Ipsa Linnæi Conchylia,' p. 134, 1855.

have recognised in Gothland two varieties of this shell, but all those hitherto found in our British Silurian rocks belong to one of these only. In his description of *Orthis biloba*, or *Spirifer cardiospermiformis* (as he terms it), Baron von Buch compares the diverging free lobes with what we find in some specimens of *Terebratula diphya;* but the last-named shell is a true *Terebratula*, provided with a short loop, somewhat similar in shape to what we see in *Tereb. vitrea* or *T. carnea;* still, a similar cause may, in both cases, easily have occasioned the deviation of the lobes, although both species and genera are distinct.

Position and Locality. *Orthis biloba* seems to have enjoyed a somewhat extended geological vertical range, for we find it in the Caradoc-Bala, Lower and Upper Llandovery, Woolhope, Wenlock, and Lower Ludlow formations. In the *Lower Ludlow* it occurs at Ledbury. In the *Wenlock Limestone* and *Shales* at Buildwas; Wenlock Edge; Lincoln Hill; Rock Farm; May Hill; Hay Head, near Walsall, Dudley, Worcester Beacon, &c. In the *Woolhope beds* at Storridge, in the Malvern district. In the *Lower Llandovery* at Mwmffre, Llandovery. In the *Caradoc-Bala* at Cefn Rhyddan; Glyn Ceiriog, Denbighshire, &c. &c.

In Scotland it is not rare in the Wenlock Shales of the Pentland Hills. I am not acquainted with any Irish specimens.

Abroad it abounds in the Silurian rocks of the Island of Gothland, and is also found in Norway; but it is not known to me from Russia. It abounds in the Niagara group at Wolcott and Rochester, more rarely at Lockport, in the State of New York, &c.

Orthis Lewisii, *Dav.* Pl. XXVI, figs. 4 to 9.

Orthis Lewisii, *Dav.* Bull. Soc. Géol. France, 2nd ser., vol. v, p. 323, pl. iii, fig. 19, 1848.
— — *Morris.* Catalogue of British Fossils, p. 140, 1854.
— — *Salter.* Siluria, 2nd ed., p. 544, 1859.
— — *Lindström.* Gotlands Brachiopoder, Öfv. K. Akad. Förhandl., p. 370, 1860.
— — *Dav.* Trans. Geol. Soc. of Glasgow, Pal. Series, vol. i, pl. ii, figs. 5, 6, 7, 1868.

Spec. Char. Shell small, somewhat pentagonal, about as wide as long, tapering at the beak, slightly indented in front, rounded laterally. Hinge-line straight, usually slightly shorter than the width of the shell. Dorsal valve semicircular, moderately convex, divided into two lobes by a median longitudinal depression or sinus; hinge-area triangular, narrow. Ventral valve convex, deeper than the opposite one, somewhat raised or keeled along the middle; beak produced, angular, slightly incurved; area large, triangular, fissure open. Surface of valves marked by about twenty-eight thread-like radiating ribs, with interspaces of about equal width. The ribs are either simple, bifurcated, or due to the interpolation of a shorter rib between each two of the longer ones. In the interior of the dorsal valve an elevated, thin, triangular, mesial septum extends from under the extremity of the umbonal beak to within a short distance of the front. The two curved brachial processes are connected with the upper edge of the septum by the means of two concave plates; on the outer side of the brachial processes, close to the hinge-line, are situated the sockets, while a pair of muscular scars occupy the bottom of the valve on either side close to the mesial septum. In the interior of the ventral valve a prominent tooth is situated at the base of the fissure; while the dental plates converge on either side, and enclose a small saucer-shaped cavity, longitudinally divided by a mesial ridge.

Length $3\frac{1}{2}$, width $3\frac{1}{2}$, depth 3 lines.

Obs. This pretty little *Orthis* differs much from its congeners by the internal arrangements of its smaller valve, and is the only British species with which I am acquainted presenting in the interior of its dorsal valve an elevated triangular septum with two concave plates connecting the brachial processes with the upper edge of the septum. In the Devonian rocks of Ferques, in France, we find another small *Orthis* (*O. Deshayesii*, Bouchard, MS.) possessing a similarly shaped septum, but without the curved plates which in *O. Lewisii* connect the brachial processes with the mesial septum. In *O. Lewisii* there does not appear to exist any prominent cardinal process. The interior of the ventral valve does not, however, appear to differ in any marked peculiarity from what we find in the generality of species of which the genus is composed.

Position and Locality. *O. Lewisii* occurs in the Wenlock Limestone at Dudley and at Hay Head, near Walsall.

In Scotland it is found in beds of a similar age in the Pentland Hills. In this last-named locality well-preserved internal casts are often procured.

Abroad it was found by Dr. Lindström in the Island of Gothland.

ORTHIS BOUCHARDII, *Dav.* Pl. XXVI, figs. 16—23.

ORTHIS BOUCHARDII, *Dav.* London Geol. Journal, p. 64, pl. xiii, figs. 5—8, Feb., 1847.
— — *Dav.* Bull. Soc. Géol. de France, 2nd ser., vol. v, p. 322, pl. iii, fig. 20, 1848.
— — *Morris.* Catalogue of British Fossils, p. 139, 1854.
— — *Salter.* Siluria, 2nd ed., p. 251, fig. 1, 1859.
— — *Lindström.* Gotlands Brachiopoder, p. 371, 1860.

Spec. Char. Somewhat pentagonal or quadrate, thick, rather wider than long, straight or slightly indented in front, tapering at the beak, moderately rounded or arched laterally;

broadest anteriorly. Hinge-line shorter than the width of shell; valves convex, becoming attenuated at the margin. Dorsal valve moderately convex, slightly gibbous near the umbo, with a mesial depression extending to the front; hinge-area narrow. Ventral valve slightly deeper than the opposite one, somewhat depressed longitudinally along the middle; beak produced, acutely angular, very slightly incurved; area large, triangular; fissure linguate, open. Surface of each valve marked by a variable number of strong obtusely angular ribs, which increase in number with age, one or two shorter and smaller ribs becoming interpolated between each pair of larger ones, while sometimes some of the principal ribs become bifurcated. The surface of each valve is also strongly imbricated or crossed by prominent, equidistant, scale-like, concentric ridges. In the interior of the dorsal valve a small prominent cardinal process is situated between two curved brachial processes. Under the cardinal process commences a prominent convex ridge, which separates each pair of the quadruple muscular scars. In the interior of the ventral valve a prominent tooth is situated at each extremity of the base of fissure, while the dental plates curve inwards and enclose a saucer-shaped muscular cavity, divided along the middle by a widish, slightly raised mesial ridge, which is itself longitudinally depressed along its middle. Shell-structure punctate.

Length $6\frac{1}{2}$, width 7, depth 4 lines.

Obs. This is a rather small but very distinct and interesting little species, well characterised by the arrangement of the costæ and their strongly imbricated surface. It is also a very thick shell. As will be seen by a glance at the figures in our plate, the number of ribs increase rapidly with age, and show much regularity or symmetry in their arrangement in the same specimen. When quite young, as in fig. 16, six or eight simple ribs only are present on each valve; in fig. 17 they become more numerous, chiefly from interpolations, and still more so in the adult examples, fig. 18. Although the shell is generally smaller than that of the proportions above given, some few specimens have slightly exceeded them.

Position and Locality. The true geological position of this species is the Wenlock Limestone, and in which formation at Benthall Edge I found the first example in 1846. In 'Siluria' it is quoted from the Llandovery rocks, while the Museum of Practical Geology of London possesses a well-preserved ventral valve (fig. 23), which is stated to have been found in the Lower Llandovery or the Caradoc at Penwhapple Glen, near Girvan, in Ayrshire.

Abroad it has been collected by Dr. Lindström in the Upper Silurian rocks of the Island of Gothland.

ORTHIS ELEGANTULA, *Dalman*. Pl. XXVII, figs. 1—9; and Woodcuts, figs. 1 & 2, p. 205.

ORTHIS ELEGANTULA, *Dalman*. Vet. Akad. Handl., p. 117, pl. ii, fig. 6, 1828.
GONAMBONITES OBLONGUS, *Pander*. Beitr., pl. xxv, fig. 5, 1830.
ORTHIS ELEGANTULA, *Hisinger*. Lethæa Suecica, p. 71, pl. xx, fig. 13, 1837.
— — *V. Buch*. Ueber Delthyris und Orthis, Akad. Berlin, p. 36, pl. ii, figs. 3, 4, 5, 1837; and Mém. Soc. Géol. France, vol. iv, p. 207, pl. xi, fig. 4, 1840.
— CANALIS, *J. de C. Sow*. Silurian System, pl. xiii, fig. 12*a*, 1839.
— — *Hall*. Geol. Rep. 4th District N. York, p. 105, fig. 6; p. 107, 1843.
— ELEGANTULA, *De Verneuil*. Geol. of Russia, vol. ii, pl. xiii, fig. 5, 1845.
— — *M'Coy*. Synopsis Sil. Foss. of Ireland, p. 29, 1846.
— — *De Verneuil*. Bull Soc. Géol. France, 2nd ser., vol. iv, 1847; and vol. v, p. 347, 1848.
— — *Dav*. London Geol. Journal, pl. xiii, figs. 9—11, 1847; and Bull Soc. Géol. France, 2nd ser., vol. v, p. 321, pl. iii, fig. 23, 1848.
— — *Phillips* and *Salter*. Mem. Geol. Survey, vol. ii, p. 287, 1848.
— — *Barrande*. Sil. Brachiop. Böhmen; Naturw. Abhandl., vol. ii, p. 44, pl. xx, fig. 4, 1848.
— — *Bronn*. Index Pal., vol. ii, p. 854, 1848.
— — *Salter*. Quarterly Journal Geol. Soc., vol. vii, p. 170, 1851.
— — *J. Hall*. Pal. New York, vol. ii, p. 252, pl. lii, fig. 3, 1852.
— — *M'Coy*. Brit. Pal. Foss., p. 216, 1852.
— — *F. Schmidt*. Silurische Format. von Ehstlands, &c.; Archiv Nat. Liv- Ehst- und Kurlands, p. 213, 1858.
— — *Salter*. Siluria, 2nd ed., pl. ix, fig. 19, and pl. xx, fig. 12, 1859.
— — *Lindström*. Gotlands Brachiopoder, p. 366, 1860.
— — *Salter*. Mem. Geol. Survey Edinburgh (32), p. 134, 1861.
— — et O. PARVA, *M'Coy*. Brit. Pal. Foss., pp. 216 and 221, 1852.
— — (including O. PARVA), *Salter*. Mem. Geol. Survey, vol. iii, pp. 268, 276, 277, 279, 361, 1866.
— — *Haswell*. Sil. Form. Pentland Hills, p. 34, pl. ii, fig. 19, 1865.
— — *Dav*. Trans. Geol. Soc. of Glasgow, Pal. Series, vol. i, pl. ii, figs. 8, 9, 1868.

Spec. Char. Longitudinally oval or ovate, broadest posteriorly or at a short distance from the hinge-line, sides rounded, converging anteriorly, rounded in front; hinge-line shorter than the width of shell. Ventral valve uniformly convex and arched, without sinus; beak moderately produced and incurved; area triangular, about one fifth as high as long, fissure open. Dorsal valve nearly flat or gently convex laterally, with a slight, shallow, longitudinal depression or sinus commencing at the umbone, and gradually widening as it nears the front; a small longitudinal fold sometimes occupies the centre of the depression; hinge-area narrow. Surface marked by numerous thread-like radiating striæ, not always very regular in thickness, on account of the interpolation of one, two, or three smaller ribs between the principal ones. Some ribs also bifurcate. In the interior of the ventral valve a prominent tooth exists on either side of the base of fissure, supported by strong dental plates. The muscular saucer-shaped depression is divided longitudinally by a raised, wide, flattened ridge. In the interior of ventral valve a small bilobed cardinal process is situated between the prominent, diverging, curved brachial processes, on the outer side of which, close to the hinge-line, lies the deep-margined socket, while a widish rounded mesial ridge extends from under the cardinal process to about half the length of the valve, and separates into two pairs—the muscular (adductor) impressions.

Length 9, width 8, depth 5 lines.

Obs. This well-known and widely spread species varies slightly in its form, and it is, therefore, possible that one or two of the so-called species which will follow may be merely modifications or varieties of the species under description; but as palæontologists have maintained them as distinct, it will be preferable that for the present we should follow them in this particular. *O. canalis* of Sowerby is, however, an undoubted synomym, and it may be questionable whether the British specimens referred to *O. parva* are anything else than slight modifications in shape of Dalman's species. At page 188 of the 2nd vol. of the 'Geol. of Russia,' M. de Verneuil informs us that *O. parva* is easily distinguished from *O. basalis,* Dal., and *O. orbicularis,* J. Sow., by the strong incurvature of its beak. *O. hybrida,* of which the valves are subequal, and in which the front does not present any convex sinuosity towards the dorsal valve, cannot either be confounded with it. It is not, however, the same with *O. elegantula,* Dal.; the Russian species is so near to it that they have been united by Von Buch and D'Eichwald. Thus, *O. elegantula* has not its ribs fasciculated, nor are they angular, as are those of *O. parva,* &c. M. de Verneuil is, however, disposed to maintain them as distinct, on account of a supposed difference in the formation in which they occur, as well as on account of certain differences in the characters of the shell. I have not, however, met with any true examples of *O. parva* in our British Silurian rocks; but, on the contrary, have found well-characterised examples of *O. elegantula* in rocks of both Lower and Upper Silurian age; and Mr. Salter informs me that the specimens in the Woodwardian Museum described and attributed by Prof. M'Coy to *O. parva* are only slight modifications of *O. elegantula.*

Position and Locality. O. elegantula occurs in the Llandeilo, Caradoc-Bala, Llandovery, Wenlock, and Ludlow formations. The localities in which it has been found are very numerous; we will enumerate some of the principal only. In the *Ludlow* north of Bringwood Chase, near Ludlow; Bodenham, Shucknall Hill, and in various places in the Woolhope, Usk, Builth, and Abberley districts; at Freshwater East, Pembrokeshire, &c. &c. In the *Wenlock Limestone* and *Shale* at Dudley; near Walsall; Benthall Edge, Lincoln Hill, Wenlock Edge, Buildwas (Shropshire). The Geological Surveyors found it at Craig-hir; Mwdwl Eithin; Moel Seisiog; east of Merchlin; Plas Madoc, North Wales; also in beds above the Denbighshire Grits at Bryn-mawr; Capel-y-rhiw;

Moel Fodig; Fridd-y-fedwen; Mynydd Tryfan; Cefn Barog; Fron-fawr; River Dee, south of Llangollen; Myndd-y-gaer. It has also been met with at May Hill, Usk, Rock Farm, Longhope; east of Cotwood, Whitfield, Tortworth, &c. In the *Upper Llandovery* at Llandovery; Presteign; Chirbury; Wooltack; Bogmine; Norbury, Malverns, Huntley Hill, May Hill, Church Stretton, &c. &c. In the *Lower Llandovery* at Ridge behind Penrock, at Cefn-Rhyddan, Mathyrafal and Pen-y-Craig, North Wales. In the *Caradoc* at Llanfyllin, Moelydd, near Llansaintfraid, Oswestry; Llyn Idwal; Moel Siabod; Carnedd Dafydd, Bettws-y-coed, Dolwyddelan, Madryn Park (Carnarvonshire); Llanfwrog, near Ruthin (M'Coy), Denbighshire, North of Llangedwyn; Meifod, Llanfyllin; Welshpool, Llanwddyn (Montgomeryshire). South of Llangollen, south and south-east of Cerrig-y-Druidion, Corwen; Llanrhaiaden; north of Tremadoc (Salter). Gretton, Shropshire, &c. &c. In the *Upper Llandeilo* at Tyn-Twr, four miles south of Llangefui, &c.

In Scotland it occurs in the Wenlock Shales in the Pentland Hills near Edinburgh. In the Llandovery rocks at Mullock above Dalquorrhan, and in the Caradoc Limestone at Craig Head Quarry, Girvan, Ayrshire.

In Ireland it has been found in many Upper and Lower Silurian localities in the Counties of Galway, Kildare, Kerry, Mayo, Wexford, Waterford, Wicklow. It has been obtained at the Chair of Kildare, Kilbride, Cong, Egool, Ballaghaderreen, Tramore, Blackwater, Leenane; Holyford, County Tipperary, &c.

Abroad it is very common in the Island of Gothland; has also been found in the Silurian rocks of Russia, Bohemia, United States, &c. &c.

ORTHIS CRASSA, *Lindström*. Pl. XXVII, figs. 17—19.

ORTHIS CRASSA, *Lindström*. Gotlands Brachiopoder, p. 369, 1860.

Spec. Char. Shell almost circular, sometimes transversely oval, widest about the middle; hinge-line shorter than width of shell; both valves convex, sometimes gibbous, the ventral one always most so, while a mesial depression extends from the umbone to the front in the dorsal one. In the ventral valve the beak is small and much incurved, so that the beaks of both valves are often very approximate; areas narrow; surface of both valves covered with numerous small radiating ribs, which increase in number by bifurcation as well as by the interpolation of small ribs near the margin. The valves are also marked by concentric lines of growth. Two specimens measured—

Length 6, width 6, depth 5 lines.
,, 7, ,, 8, ,, 5 ,,

Obs. Dr. Lindström informs me that this species differs from *O. elegantula*, to which it most approaches, by being nearly circular, and sometimes almost globular, both of its valves being often very convex; the area is also curved, and not rectilinear, as in the last-named species; the muscular impressions, cardinal and bracial processes, are also said to be slightly different. I must, however, confess that at times I find some difficulty in clearly discriminating certain minute differences which are said to occur in certain very closely related forms, and which are, perhaps, rather of varietal than specific value.

Position and Locality. In England *O. crassa* occurs in the Wenlock Limestone of the Malverns; at Garcoed, near Usk; and in the Lower Ludlow near Martley, on the road to Clifton, Abberley. Abroad it was found by Dr. Lindström in the "Middle Gothland" group in the Island of Gothland.

Orthis hybrida, *Sow.* Pl. XXVII. figs. 15, 16.

Orthis hybrida, *Sow.* Sil. Syst., pl. xiii, fig. 11, 1839.
— — *Portlock.* Report on the Geol. of Londonderry, &c., p. 451, 1843.
— — *J. Hall.* Geol. Rep. 4th District, p. 107, fig. 7, 1843.
— — *M'Coy.* Synopsis Sil. Foss., Ireland, p. 31, 1846.
— — *Dav.* London Geol. Journal, pl. xiii, figs. 13, 14, 1847.
— — *De Verneuil.* Bull. Soc. Géol. France, 2nd ser., vol. iv, p. 703, 1847.
— — *Dav.* et *De Verneuil.* Bull. Soc. Géol. de France, 2nd ser., vol. v, pp. 321 and 347, pl. iii, fig. 22, 1848.
— — *Phillips* and *Salter.* Mem. Geol. Survey, vol. ii, p. 289, 1848.
— — *Bronn.* Index Pal., p. 855, 1848.
— — *Barrande.* Sil. Brach. of Bohemia; Naturw. Abhandl., vol. ii, p. 45, pl. xix., fig. 9, 1848.
— — *Hall.* Pal. New York, vol. ii, p. 253, pl. lii, fig. 4, 1852.
— — *M'Coy.* Brit. Pal. Foss., p. 220, 1852.
— — *F. Schmidt.* Silurische Form. von Ehstland, &c.; Archiv Nat. Liv- Ehst- und Kurlands, p. 213, 1858.
— — *Salter.* Siluria, 2nd ed., pl. xx, fig. 13, 1859.
— — *Lindström.* Gotlands Brachiopoder, p. 369, 1860.
— — *Salter.* Mem. Geol. Survey, vol. iii, pp. 276, 279, 1866.

Spec. Char. Rotundato-trigonal or lenticular, slightly wider than long, broadest posteriorly, straight or slightly indented in front; valves almost equally convex, most so near the beaks, flattened anteriorly. In the dorsal valve a slight depression extends sometimes all the way from the umbonal beak to the front; hinge-line very short, beaks approximate, areas small; surface of both valves closely covered with very fine, thread-like, radiating striæ, increasing in number towards the margins from numerous interpolations, the valves being likewise crossed by concentric lines of growth. In the interior of the dorsal valve a small but prominent cardinal process is situated between two curved, very prominent, brachial processes, while a mesial ridge extends from under the cardinal process to about half the length of the valve, and thus separates the two pair of muscular impressions; in the interior of the ventral valve the prolongation of the dental plates circumscribes a small muscular disc, with a mesial ridge along the centre.

Length 5, width $5\frac{1}{2}$, depth $3\frac{1}{2}$ lines.

Obs. This species would be very variable in its shapes if certain large specimens occasionally found in England and in Gothland were really referable to it. The typical form of *O. hybrida*, which occurs so abundantly in our Wenlock Shale and Limestone, is pretty constant, however, in its shapes, from the size of less than a pin's head to that of about five lines and a half in length, and agrees in all essential particulars with figs. 15 and 16 of our plate. Dr. Lindström informs me that he has procured in the Island of Gothland specimens of an *Orthis* which he seems disposed to refer to the one under description; it measured fully one inch in length by one inch two lines in breadth, and this would nearly agree with some similarly proportioned specimens (fig. 20) found near Walsall; but I am very uncertain whether either the Swedish or British examples in question do really belong to the same species as the small *O. hybrida* which is so abundant and characteristic a species in our Upper Silurian rocks.

Position and Locality. At page 526 of the third edition of 'Siluria' *O. hybrida* is stated to occur in the Caradoc, Llandovery, and Wenlock formations; and the Survey Museum is said to possess specimens from the Lower Ludlow of Hillend, Martley, Abberley, and some other places; but the Wenlock is the horizon where the shell is best known to me, and where, at any rate, it is the most abundant. In the Wenlock Limestone and its shales it occurs at Dudley, Hay Head, near Walsall, Buildwas, near Wenlock, &c.; also, according to Messrs. Phillips and Salter, in various localities in the Malvern, Abberley, Woolhope, May Hill, and Usk districts; and again by Prof. Ramsay and Mr. Salter at Mathyrafal and Pen-y-Craig in the Lower Llandovery of North Wales. I have never met with any specimens in the Caradoc, nor am I acquainted with any examples from either Scotland or from Ireland, although it is said by Prof. M'Coy to have been found in the last-named portion of the British Isles.

ORTHIS LUNATA, *Sow.* Pl. XXVIII, figs. 1—5.

ORTHIS LUNATA, *Sow.* Sil. Syst., pl. v, fig. 15, 1839.
— ORBICULARIS, *Sow.* Ibid., fig. 16.
— LUNATA et O. ORBICULARIS, *M'Coy.* Synopsis Sil. Foss. of Ireland, p. 32, 1846.
— — — *Phillips* and *Salter.* Mem. Geol. Survey, vol. ii, p. 290, 1848.
— ORBICULARIS, *F. Schmidt.* Silurische Format. von Ehstland, &c., p. 213, 1858.
— LUNATA, *Salter.* Siluria, 2nd ed., p. 20, fig. 11, 1859.
— — *M'Coy.* Brit. Pal. Foss., p. 220, 1852.

Spec. Char. Shell nearly orbicular or rotundato-quadrate, wider than long, greatest width anteriorly; hinge-line straight, a little less than the width of the shell. Ventral valve very moderately and uniformly convex; beak small, area about one seventh as wide as long. Dorsal valve very gently convex, with a shallow longitudinal mesial depression along the middle, widest towards the front; hinge-area linear; surface of both valves covered with numerous thread-like radiating striæ, which increase in number at various distances from the beaks by the interpolation of shorter ribs. In the interior of the dorsal valve a small cardinal process is situated between two slightly projecting brachial processes or plates, which, however, extend along the bottom of the valve to some little distance along the posterior half of the muscular disc; a small central ridge proceeds likewise from the base of the cardinal process to about one third of the length of the valve, while on either side is situated an elongated muscular area, laterally margined by a slightly projecting ridge. In the interior of the ventral valve there exists a moderately sized saucer-shaped muscular depression, surrounded by a raised margin, while along the middle is situated a small pear-shaped scar, due to the occlusor or adductor muscle. In the internal casts the hollows above described are represented by corresponding elevations, &c.

Length 4, width 6, depth 2 lines.

Obs. As justly remarked by Prof. M'Coy, the great depression and near equality of the valves, much finer striæ, and singular elongated narrow form of the elongated muscular impressions, and, I might add, prolongation of the brachial processes or lamellæ in the posterior portion of the muscular disc, easily distinguish this species from *O. basalis* and some other nearly allied forms. This last-named feature is well seen in the internal cast fig. 3, and in the enlarged view of the interior of the same valve fig. 3, *a*.

Position and Locality. This species occurs abundantly in the Upper Ludlow at Whitecliff, and in several other localities near Ludlow in Shropshire; at Wonder, Woolhope, &c. Messrs. Phillips and Salter record its presence in rocks of a similar age in various localities in the Malvern, Abberley, Woolhope, Usk, Builth, and Llandeilo districts. It does not yet seem to have been found in Scotland, and I am not really certain whether it really occurs in Ireland, although General Portlock mentions it from Desertcreight, Tyrone, with a mark of doubt.

Orthis Girvaniensis, sp. nov. Pl. XXVIII, fig. 10.

Spec. Char. Almost circular, about as wide as long, both valves very convex, without fold or sinus, the dorsal one at times almost gibbous; hinge-line slightly exceeding half the width of the shell, slightly truncated in front. In the ventral valve the beak is angular, the area small, triangular, with open fissure. In the dorsal valve it assumes a lesser size and height. Surface of both valves covered with numerous thread-like striæ, which increase in number by many interpolations, while the whole surface is crossed at intervals by concentric lines of growth. Interior not known.

Length 5, width 5, depth $3\frac{1}{2}$ lines.

Obs. This small species seems distinguished from its congeners by its circular form, the great and regular convexity of its dorsal valve, and apparent total absence of either fold or sinus. It was found by Mrs. Gray, of Glasgow, in the Caradoc Limestone of Craig Head Quarry, Girvan, Ayrshire. I am not acquainted with the shell from any other locality.

ORTHIS BASALIS, *Dalman* (?). Pl. XXVII, figs. 10, 11.

ORTHIS BASALIS, *Dalman.* Vet. Akad. Handl., p. 116, pl. ii, fig. 5, 1827.
— — *Hisinger.* Lethæa Suecica, p. 71, pl. xx, fig. 12, 1837.
— ? — *Von Buch.* Ueber Delthyris, p. 60, 1837.
— ELEGANTULA, *Dav.* London Geol. Journal, p. 62, pl. xiii, figs. 10, 11, 1847.
— — *Lindström.* Gotlands Brachiopoder, p. 367, 1860.

Spec. Char. Almost circular, slightly longer than wide, broadest posteriorly, sides rounded, gently converging anteriorly towards the front; hinge-line a little less than the greatest width of shell; dorsal valve very slightly convex, or almost flat, with a shallow median depression, which, commencing close to the umbone, extends to the front. Ventral valve moderately convex, somewhat longitudinally keeled along the middle; area triangular, of moderate height, fissure open; beak very small, incurved, projecting but little above the area. Surface of valves marked by numerous small, radiating, bifurcated and interpolated, raised striæ, crossed by concentric lines of growth. In the interior of the dorsal valve a small bilobed cardinal process is situated between two small, curved, deviating, projecting brachial processes, while a moderately wide, rounded mesial ridge separates the two pair of adductor muscular impressions.

Length 8, width 9, depth 3 lines.

Obs. The Swedish types of this species have not been hitherto properly or sufficiently illustrated, so that it is difficult to be perfectly certain as to its occurrence in Britain. Dr. Lindström, to whom I had sent specimens of the shell figured in our plate, assured me that it was referable to Dalman's *O. basalis;* and we are informed by Baron von Buch, as well as by Dr. Lindström, that Dalman's species does not always present the heart-shaped form given to it by the last-named naturalist; but I would at the same time observe that I doubt greatly that the shell figured by Von Buch as *O. basalis* does really belong to that species.

Dalman states, in his description, that this species is nearly allied to *O. elegantula,* but distinct, being less gibbous, and manifestly broader anteriorly; the beak less prominently erect and very little incurved, so that the area of the larger valve is well exposed. In 1847 I confounded the shell under description with *O. elegantula;* but, although then unacquainted with *O. basalis*, I did not fail to remark that the Benthall Edge and the Falfield specimens seemed to differ materially from each other, and that it would not be improbable that *O. orbicularis*, Sow., might be one of the varieties of *O. elegantula*. This Falfield shell was consequently afterwards referred to *O. orbicularis* by myself and others; but this is a mistake, as the last-named shell is now affirmed to be the same as *O. lunata*, which differs in several particulars from *O. basalis*, as will be found detailed under *O. lunata*. I am not yet quite satisfied that Dr. Lindström's *O. canaliculata* is well distinguished from *O. basalis;* at least our English Aymestry Limestone specimens of Lindström's shell differ in little besides size from the shell found at Falfield, which is referred by Lindström to Dalman's species. I will, however, provisionally retain them both as distinct, not having been able to compare with them a sufficient number of Swedish specimens. In fact, all these so termed species are so closely connected that it is hardly possible at times to feel quite certain to which should be referred some of the intermediate or less typical forms, and it may, perhaps, be found desirable hereafter to dispense with one or two of them.

Position and Locality. The Wenlock Shale, Falfield, near Tortworth. It may occur in other localities, but they are unknown to me. Abroad it has been found in Gothland, Sweden.

ORTHIS CANALICULATA, *Lindström*. Pl. XXVII, figs. 12, 13.

ORTHIS CANALICULATA, *Lindström*. Gotlands Brach., Öfv. K. Akad. Förhandl., p. 369, pl. xiii, fig. 10, 1860.

— ORBICULARIS, *F. Schmidt*. Beitrag zur Geologie der Insel Gotland, p. 44.

Spec. Char. Transversely oval, broader than long, greatest breadth near the middle, slightly indented in front, broadly rounded laterally; hinge-line shorter than breadth of shell. Dorsal valve semicircular, gently convex, most so at the umbone, flattened laterally close to hinge-line and cardinal extremities; divided longitudinally by a moderately deep angular depression or sinus; hinge-area narrow. Ventral valve moderately convex, most so near the beak, which is small and incurved; area triangular, about one third as high as long. Surface of valves marked by numerous small, radiating, bifurcating, and interpolating ribs. In the interior of the dorsal valve the cardinal process is small, rhombic, undivided; situated in the middle of the area, below the brachial processes are small but broad laminæ, converging towards the cardinal process, while the quadruple muscular impressions are divided by a broadish, rounded mesial ridge. Length 6, width 7, depth 3 lines.

Obs. Dr. Lindström considers this shell to be distinguishable from *O. elegantula* by its general shape, the valves not converging or tapering anteriorly, as in the last-named species; also by the deepish angular sinus which divides the dorsal valve into two distinct parts or lobes. The cardinal and brachial processes are also smaller and slightly different in detail from those observable in *O. elegantula.*

Position and Locality. In 1846 I found this shell in the Aymestry Limestone of Sedgley, near Wolverhampton, and Dr. Lindström assures me that my English specimens entirely agree with those that were found by himself in the Island of Gothland.

ORTHIS POLYGRAMMA, *Sow.* (sp.), var. PENTLANDICA. Pl. XXIX, figs. 1—10.

ATRYPA POLYGRAMMA, *Sow.* Sil. Syst., pl. xxi, fig. 4 *a*, 1839.
ORTHIS, sp., *Salter.* Memoirs of the Geol. Survey, 32, Scotland, p. 138, 1861.
— MICHELINI vel REVERSA, *Haswell.* On the Silurian Formation of the Pentland Hills, p. 34, pl. iii, fig. 8, 1865.
— POLYGRAMMA, *Murchison.* Siluria, 3rd edit., p. 526, 1867.
— — *Dav.* Trans. Geol. Soc. of Glasgow, Palæont. Series, vol. i, pl. ii, figs. 12 to 16, 1868.

Spec. Char. Transversely oval, or about as wide as long, more often broadest anteriorly, front gently arched or slightly indented, sides moderately rounded, beak very obtusely angular; hinge-line about half the breadth of the shell. Ventral valve convex, most so at the beak, while a wide shallow depression or sinus extends from the front to about one third of the length of the valve; beak very slightly produced, incurved; area triangular, narrow, fissure open. Dorsal valve rather deeper than the opposite one, uniformly convex, without fold. Surface of both valves marked by numerous thread-like radiating striæ, augmenting in number, as the shell acquires age, by bifurcation or by numerous interpolated shorter striæ. In the interior of the ventral valve a strong tooth is situated at each basal extremity of the fissure, while the curved dental plates enclose a large saucer-shaped muscular depression, longitudinally divided in the middle by a slightly raised mesial ridge. In the interior of the dorsal valve a small cardinal process is situated between two curved brachial processes, while the quadruple impressions of the adductor or occlusor muscle are longitudinally divided by a mesial convex ridge. Two specimens measured—

Length 11, width 13, depth 7 lines.
„ 12, „ 12, „ 8 „

Obs. This shell varies slightly in shape in different specimens, as may be seen by a glance at the forms illustrated in our plate. These modifications are chiefly due to some specimens being more regularly transversely oval than are others, and in the degree of convexity of the valves; thus, for example, in two individuals measuring about one inch in length, the one was four lines in depth while the other assumed almost double that proportion; again, the greatest breadth generally occurs at the anterior half of the shell, while in other specimens it is situated about the middle. The beaks of both valves also come so near together in some examples that the areas are hardly apparent. The identification of this species has occasioned me some trouble, and is still somewhat uncertain. While studying Sir R. Murchison's original specimens of *Atrypa polygramma* (figs. 1, 2, of our plate), in the Museum of the Geological Society, I at once perceived that the shell so named belonged to the genus *Orthis*, and bore great resemblance to similarly shaped shells which occur in the Wenlock Shales of the Pentland Hills. These latter Mr. Salter had already alluded to, in the Appendix to Mr. Geikie's memoir on the Silurian rocks of the Pentland Hills, as at first appearance bearing much resemblance to *O. resupinata*, and as looking like a magnified *O. reversa*, but hardly belonging to that species. Murchison's specimens of *A. polygramma* agree entirely as to size, shape, and sculpture, with others found in the Pentland Hills, and, as was justly observed, bear much resemblance to some forms of *O. resupinata* and *O. Michelini*, but the Silurian shell is easily distinguished from those two Carboniferous forms by the total absence of those slender spines which rise from the striæ in the two species above named. It is, however, possible that the Irish type of *O. reversa* may be a smaller variety of *O. polygramma;* but in that case I question whether the Scottish shell from the Ayrshire beds, which has likewise been referred to Salter's Irish species, is really the same thing. All reference to *O. polygramma* was omitted in the second edition of 'Siluria,' but has been added to the third, published in 1867.

Position and Locality. I am uncertain with reference to the age of the rock formation from which Murchison's two examples of *A. polygramma* were obtained. In the 'Silurian System' the rock is stated to be Caradoc, and the locality Powis Castle Park; but since 1839 a portion of the Caradoc has been transferred to the Llandovery, and it is, therefore, possible that *O. polygramma* may belong to the last-named group. In Scotland the shell occurs in the Wenlock Shales of the Pentland Hills, where it is common, but mostly in the condition of well-preserved internal casts.

ORTHIS REVERSA, *Salter*. Pl. XXIX, figs. 11, 12, 13.

ORTHIS REVERSA, *Salter*. Addenda to the Synopsis of the Silurian Fossils of Ireland, p. 72, pl. v, fig. 2, 1846.

Spec. Char. Round, about as wide as long, or slightly transverse with age. Hinge-line usually very short. Ventral valve moderately and evenly convex. Dorsal valve convex, with a shallow depression or sinus near the front; front edge slightly raised; beak small, incurved; area very narrow. Surface of both valves marked by numerous thread-like, radiating striæ. In the interior of the dorsal valve a small cardinal process is situated between two deviating curved brachial processes; quadruple muscular scars feebly marked, and divided longitudinally by a narrow ridge. In the interior of the ventral valve the saucer-shaped muscular depression occupies about a sixth of the inner surface of the valve, while the centre is occupied by a rather large adductor muscular impression, divided by a small narrow ridge, the remaining portions of the depression being filled up by the divaricator muscular scars. Two specimens measured—

Length 9, width 9 lines.
10, „ 12 „

Obs. It was in 1846 that Mr. Salter named, described, and illustrated his *O. reversa*, and he tells us distinctly that his shell was round when young, more transverse when old, the dorsal valve uniformly convex, while a shallow depression is present near the front in the opposite one; and that his shell was described and figured from abundant internal and external casts in the sandstone of Galway, which specimens form part of Sir R. Griffith's collection. He also adds that there are species much resembling this in similar strata in Ayrshire. Now, it must be observed that, with reference to these Ayrshire specimens, Mr. Salter did not positively identify them in 1846 with his Galway types, but simply observed that they much resemble them. Having obtained, through the kind medium of Sir R. Griffith, the loan of the original specimens described by Mr. Salter,[1] and compared them with the Ayrshire specimens so named, I cannot help considering these last, if not a distinct species, at any rate as a well-marked variety, which I will consequently describe separately. I must also observe that Mr. Salter had, at the time, the circular form so much in view as the type of his species (figs. 11 and 12 of our plate), that in the explanation of his plate he distinctly intimates the transverse specimens to be a "supposed variety, deeply depressed in front."

Position and Locality. The Lower Llandovery (?) at Egool, Ballaghaderreen, County Mayo; Cappacorcogue, Cong, &c., County Galway, Ireland. Also Lower Llandovery, Mandinam, near Llandovery.

ORTHIS REVERSA, *Salt.*, var. MULLOCKIENSIS, *Dav.* Pl. XXIX, figs. 14—18.

ORTHIS REVERSA, *Salter.* Quart. Journ. Geol. Soc., vol. vii, p. 171, pl. ix, fig. 13, 1857.
— — *M'Coy.* Brit. Pal. Foss., p. 225, 1852 (not of Synopsis Sil. Foss. Ireland).
— — *Salter.* Siluria, 2nd ed., p. 230, fig. 48, 3, 1859.

Transversely oval, or slightly quadrate, broadest about the middle. Obtusely angular posteriorly, slightly indented anteriorly, rounded laterally. Hinge-line usually very short.

[1] These are drawn in our plate.

Ventral valve convex, with a rather deep depression or sinus extending from the frontal margin to a short distance from the extremity of the beak. Area narrow and small; fissure open, triangular. Dorsal valve moderately convex, with a rather wide, moderately elevated mesial fold commencing at a short distance from the umbone, and extending to the front. Surface marked by numerous thread-like radiating striæ, which increase in number as the shell acquires age and size by means of numerous interpolations. In the interior of the ventral valve the saucer-shaped muscular depression is considerably bilobed or forked, while in the dorsal valve the small cardinal process is situated between two deviating, small, curved, projecting brachial processes; the quadruple muscular scars are deep, and longitudinally divided by a rather wide, rounded, mesial ridge. Two specimens measured—

Length 8, width 10 lines.
,, 7, ,, 8, depth 3 lines.

Obs. A glance at figures 11 and 12 of our plate, which illustrate the typical form of Salter's *O. reversa*, and at the Ayrshire specimen, fig. 17, will, I think, convince the student as to the desirability of maintaining this last as at least a well-marked variety of the first. The presence of a mesial fold in the ventral valve, the general shape of the shell, and form of the muscular scars in the ventral valve, will warrant our conclusion. While describing this shell at p. 261 of his work on British Fossil Brachiopoda, Prof. M'Coy further observes that "the striation of this species is minutely granular under the lens, as in the *O. elegantula*, with which imperfect specimens might very readily be confounded; but the striæ are coarser, much more equal, obtuse, and close together, and in that species dichotomise, and do not present the subalternate character of the finer striation of this species, which is narrower, and very easily distinguished by the broad, flat, mesial depression in the receiving (ventral) valve, when that part is seen. Some of the specimens show the hinge-line more extended, and the mesial ridge in the entering (dorsal) valve defined, leading to the belief that *O. fallax* (Salter) may be an extreme variety of the present species, mainly distinguished by a coarser striation."

Position and Locality. At p. 230 of the 2nd ed. of 'Siluria' Mr. Salter mentions this shell as a characteristic fossil of the Lower Llandovery rocks. In Scotland it occurs at Mulloch Quarry, Dalquorhan, and other localities in the Girvan valley, Ayrshire. In England it was found in the Woolhope Limestone of Sandbanks, Presteign,—at least a very good specimen (fig. 18 of our plate) is so labelled by Mr. Salter in the Museum of Practical Geology; it is also stated to occur in the Lower Llandovery at Cefnmyddan, and in the Upper Llandovery at Charfield Green, Tortworth.

ORTHIS FALLAX, *Salter*. Pl. XXXI, figs. 9—11.

ORTHIS FALLAX, *Salter*. Addenda to Synopsis of Sil. Foss. of Ireland, p. 72, pl. v, fig. 3, 1846.
— — *Ibid.* Siluria, 2nd ed., p. 544, 1859.

Spec. Char. Transversely oval, wider than long; hinge-line slightly shorter than the width of shell. Dorsal valve semicircular, moderately convex, fold wide, raised in front. Ventral valve moderately convex, most so at the beak; a wide depression or sinus commences at a short distance from the extremity of the beak, and extends to the front. Area narrow, fissure open, beak slightly incurved. Surface of both valves marked by numerous radiating thread-like striæ, increasing in number towards the margin by means of numerous interpolations. In the interior of dorsal valve a small cardinal process is situated between two small, curved, brachial processes. In the interior of ventral valve the muscular depression is elongate-oval, rather small, and divided longitudinally by a narrow median ridge.

Length 7, width 8 lines.

Obs. Of this species (?) I have not been able to obtain sufficient or quite satisfactory material, but, thanks to the kindness of Sir R. Griffith, I have been able to examine and figure the specimens from which Mr. Salter described and illustrated his species. These consist of two or three internal casts and external impressions, no complete example having been hitherto discovered. Consequently I am not quite certain whether this is a good distinct species, or a variation in shape of the preceding one, as has been supposed by Prof. M'Coy. The hinge-line is, however, much longer than what we find in either *O. reversa* or the var. (?) *Mullockiensis;* the ribs are likewise rather coarser, and the muscular impressions smaller and somewhat different in shape.

Position and Locality. In 'Siluria' Mr. Salter refers *O. fallax* to the Llandovery period. In Ireland it occurs at Killey, Pomeroy, County Tyrone; it has also been found in the Caradoc at Desertcreat, Tyrone (Survey Mus.). Mr. Salter informs me that internal and external casts abound in a sandstone of the Llandovery age in Galway, and that a species much resembling it also occurs in Ayrshire.

ORTHIS BAILYANA, sp. nov. Pl. XXIX, figs. 19—20.

Spec. Char. Shell thick, round, slightly wider than long; valves moderately convex; hinge-line shorter than the width of shell; areas small, fissure in both valves open and large. Exterior surface marked by numerous fine, thread-like, radiating striæ, here and there crossed by concentric lines of growth. In the interior of ventral valve a prominent tooth on each side of fissure. The dental plates enclose an elongated muscular depression of about six lines in length by some four in breadth, somewhat elevated and angular at its anterior extremity. The raised margin which surrounds the muscular cavity is continued to within a short distance of the front in the shape of a narrow mesial ridge, while a broad parallel vascular trunk follows on either side the outer margin of the muscular cavity as well as of the mesial ridge, where, turning outwards and backwards, it encloses wide ovarian spaces. In the interior of the dorsal valve a large wide fissure encloses a concave cavity, longitudinally divided along the middle by a narrow mesial ridge; the brachial processes are very small, while a convex mesial longitudinal ridge separates into two pairs the quadruple impression formed by the adductor or occlusor muscle; the upper or posterior pair are transversely oval, while the anterior pair are obliquely placed, and deeply indented or forked laterally.

Length 12, depth 13 lines.

Obs. This is a very distinctive and singularly marked species. Externally it is finely striated, as in *O. reversa*, but is especially remarkable on account of the shape of its muscular impressions in the dorsal valve, and in the absence of a prominent cardinal process, as well as by the smallness of its brachial processes. It has hitherto been found only in the condition of internal casts and impressions.

Position and Locality. *O. Bailyana* occurs at the Townland of Ballybro, one mile north of Tagoate, County of Wexford, in Ireland, the rock being a coarse grit of the Caradoc or Bala age (?). Together with it *O. calligramma* occurs in plenty, as well as *O. biforata*, *Leptæna sericea*, and *Favosites fibrosus*.

I have named it in honour of Mr. W. H. Baily, Palæontologist to the Geological Survey of Ireland, to whom science is indebted for several valuable discoveries.

ORTHIS REDUX, *Barrande*. Pl. XXVIII, figs. 6—9.

ORTHIS REDUX, *Barr.* Silurische Brachiopoden aus Böhmen; Naturw. Abhandl., vol. ii, p. 49, pl. xviii, fig. 7, 1848.

— — *Salter.* Quarterly Journal Geol. Soc., vol. xx, p. 294, pl. xvii, fig. 7, 1863.

Spec. Char. Almost circular, slightly wider than long; hinge-line less than the width of shell; ventral valve very moderately and uniformly convex; beak small, area narrow. Dorsal valve almost flat, with a longitudinal depression along the middle, and small well-defined hinge-area; surface of both valves closely covered with numerous thread-like striæ, which increase in number towards the margin from the interpolation of one or two smaller striæ between each of the principal ribs. In the interior of the ventral valve the muscular area is large and margined by a gently prominent ridge. In the interior of the dorsal valve the cardinal process is moderately large, and situated at the posterior extremity of a rounded ridge, which extends to nearly half the length of the valve, while the brachial processes are formed of two short prominent laminæ. The quadruple muscular impressions are arranged in two pairs, and longitudinally divided by a widish mesial ridge.

Length about 5, width 6, depth 2 lines.

Obs. Mr. Salter has identified this small species with the Bohemian *O. redux,* and I am of opinion that, although the Budleigh-Salterton shell is smaller than the one so named by Barrande, the resemblance is sufficiently close to warrant the supposed identity. It seems likewise, as stated by Mr. Salter, to bear a resemblance to the shell described by M. de Verneuil, in the 'Bulletin Soc. Géol. de France' (2nd ser., vol. x, p. 993, pl. xxvi, fig. 9, 1855), under the designation of *O. testudinaria,* Dal.; but in this instance, as in that of Barrande, internal casts alone are figured, so that it is hardly possible to feel entirely satisfied with an identification based upon such incomplete material. Fortunately with us the species is exceedingly abundant, occurring as sharply preserved external impressions as well as internal casts of both valves, so that by the aid of gutta-percha the perfect interior and exterior of both valves can be reproduced.

Position and Locality. *Orthis redux* was discovered, for the first time in England, as one of the most abundant of the numerous species of fossils that occur in the red and whitish sandstone and quartzite pebble-bed at Budleigh-Salterton, in Devonshire; but these pebbles were derived from beds not found *in situ* in the locality, and it is still impossible to say from whence they have been drifted. Mr. Salter seems to consider the age of the rock from which the pebbles were derived to be that of the Lowest Llandeilo or the Arenig group, while by some other geologists it has been referred to the Caradoc.

Orthis redux has also been found by the Rev. P. B. Brodie in erratic boulders, similar to those that occur at Budleigh-Salterton, in the Drift near Warwick.[1] On the Continent it is abundant in the quartzites at May, near Caen, in Normandy, where it has been known for many years;[2] also in the Lower Silurian of Bohemia.

[1] 'Geological Magazine,' vol. ii, p 566, 1865.

[2] It occurs at May in company with *Homalonotus Brongniarti, Conularia undulata,* &c. See Deslongchamp's "Notes pour servir à la Géologie du Calvados," 'Bulletin de la Soc. Linn. de Normandie,' vol. viii. The quartzite sandstone of May is referred to the Caradoc group. It is this May district to which Mr. Salter points as the origin of the Budleigh-Salterton fossiliferous pebbles.

ORTHIS TESTUDINARIA, *Dalman*. Pl. XXVIII, figs. 13—24.

ORTHIS TESTUDINARIA, *Dal.* Vet. Akad. Handl., p. 115, pl. ii, fig. 4, 1827.
— — *Hisinger.* Pet. Suecica, p. 71, tab. xx, fig. 11, 1837.
— — *Sow.* Silurian System, pl. xx, figs. 9, 10, 1839.
— — *Conrad.* Ann. Geol. Report, p. 63, 1839, &c.
— STRIATULA, *Conrad,* in MS., &c. Emmons, Geol. Report, p. 394, illust. 105, fig. 3, 1842.
— TESTUDINARIA, *M'Coy.* Synopsis Sil. Foss. Ireland, p. 35, 1846.
— — *Hall.* Pal. N. York, vol. i, p. 117, pl. xxxii, fig. 1, 1847.
— — *Phillips* and *Salter.* Mem. Geol. Survey, vol. ii, p. 373, 1848.
— — *M'Coy.* Brit. Pal. Foss., p. 228, 1852.
— — *Meneghini.* Paléont. Sardaigne, p. 28, pl. A, fig. 6, 1857.
— STRIATULA, *Salter.* Quarterly Journal Geol. Soc., vol. xv, p. 380, pl. xiii, figs. 14, 16, 1868.
— — *Salter.* Siluria, 2nd ed., p.74, fig. 12, 6, pl. v, fig. 1, 1859.
— — *Salter.* Mem. Geol. Survey, vol. iii, p. 340, pl. xiii, figs. 10—14, 1866.

Spec. Char. Suborbicular or truncato-orbicular, usually wider than long, rounded or slightly emarginated in front; hinge-line straight, shorter than the width of the shell. Ventral valve moderately convex, sometimes slightly longitudinal, elevated along the middle; beak small, incurved, area narrow. Dorsal valve very slightly convex, at times almost flat, with a longitudinal depression along the middle; hinge-area narrow. Surface of both valves covered with numerous radiating thread-like ribs, which increase in number at various distances from the beaks by the means of bifurcation or by one or two smaller striæ being interpolated between each pair of the larger ones; the valves are also crossed by concentric lines of growth. In the interior of the dorsal valve the cardinal process is situated between two small projecting, deviating, brachial laminæ, while the quadruple muscular impressions are small and divided into pairs by a rather wide mesial ridge. In the ventral valve the muscular area is moderately developed, elongated, and forked in front. Two specimens measured—

Length 7, width 7, depth 3 lines.
„ 11, „ 12 lines.

Obs. Although I have never had the advantage of being able to procure a Swedish example of Dalman's *Orthis testudinaria*, I am inclined to believe (after a study of the Swedish author's figure and description[1]) that our British specimens above described

[1] "O. testa confertissime striata, costis sub-alternis elevatioribus: valva minori subplana semiorbiculari; majori basi gibba, nate prominula nutante. Locus. Ostrogothia ad Borenshult, in calce cinerea. Longit. 15 mm., latit. testæ 15, lat. valvæ minoris ad basin 12 mm., crass. 7 mm.

"Species quasi media inter *O. elegantulam* et *O. basalem*, ad utraque distincta ambitu magis orbiculari, minime ad cordatum tendente, præsertim vero costarum radiantium ratione, quæ enim duplicis sunt generis, are referable to that species. Messrs. Phillips and Salter, in 1848, had arrived at a similar conclusion; but at a later period (1866) the last-named author referred the British specimens to *Orthis striatula* of Conrad, a name that cannot, however, be retained for the shell under description, since Schlotheim had already applied it in 1813 to another species.[1] Prof. M'Coy also identifies our British shell with *O. testudinaria* of Dalman, at p. 228 of his large work on 'Brit. Pal. Fossils.' As may be seen from the specimens selected for illustration, this species varies a good deal in shape and size, according to age and specimen. Fig. 13, however, agrees most nearly with Dalman's illustration. Prof. M'Coy observes that "the slight convexity of the receiving (ventral) valve, the wide and very low cardinal area, and the very much coarser, more separated, angular, and less equal ridging of the valves, easily separate the species from the *O. elegantula*; and the greater size and depression of the valves, as well as the less number of striæ at a small distance from the beak, separate it from the *O. parva*. Gothland specimens agree in general form, proportional measurements, and in the remarkably low cardinal area; but seem to have the entering (dorsal) valve more obtuse, and the ribbing slightly more regular; but the observed varieties of the Gothland specimens show these to be inconstant, and only irregular peculiarities of a few specimens." I cannot, however, agree with Prof. Phillips and Mr. Salter that *Atrypa polygramma*, Sow., is a large variety of *O. testudinaria*; both shells being quite distinct.

Position and Locality. This species is said to have been found in the Llandeilo, Caradoc, and Lower Llandovery formations; but it is most prevalent in the first two. In the Lower Llandeilo it occurs at Pont-brennaraeth, Llandeilo, and Narbeth, also at Pont-dwfn, Haverfordwest; at Shelve, in the upper beds of the Llandeilo; also at Great Peraver and Gorrans, Cornwall, in quartzites attributed to the age of the Llandeilo Flags. In the Caradoc it is stated to occur at Grüg, Llandeilo; Sholes Hook, Haverfordwest, Cheney Longville, Hollies Farm, Horderley; Meifod, and Church Stretton in Shropshire; and a number of other localities are recorded by Prof. M'Coy in his work on 'Brit. Pal. Foss.' From the Lower Llandovery it is stated to have been obtained at Cefn Rhyddan, near Llandovery, &c.

In Scotland it was found at Durness, Sutherlandshire, in Lower Silurian.

In Ireland it is stated by Prof. M'Coy to be common in the slates at Ballygarvan Bridge, and in other localities in the counties of Wexford, Kildare, Wicklow, &c.

videlicet; *elevatiores* (circiter 30), testæ basin fere attingentes; et *humiliores* plus minus abbreviatæ, quarum 2—3, inter par priorum.

"Valva minor subplana, 1, in medio longitudinaliter sub-impressa; suborbicularis, basi truncata, apice vero rotundato, minime prominulo. Linea cardinalis quam valvæ longitudo manifeste brevior. Valva major basi gibba, nate prominula, modice curva, valvæ minoris convexitatem minime attingente. Sub nate areola triangularis impresso-plana, foramine deltoideo brevi.

"*Obs.*—Rostrum quam in *O. elegantula* minus sed quam in *O. basali* magis curvatum; margo cardinalis quam in utraque specie brevior.—Specimina plura consului similia."

[1] 'Min. Taschenbuch,' pl. i, fig. 6, 1813. This is a shell closely resembling *O. resupinata*, Martin.

Abroad it has been found in Ostrogothia, Sweden, and, according to Méneghini, in the Island of Sardinia. It occurs also in the Trenton Limestone in the State of New York, and, according to Mr. Salter, at Allumette Island, in Canada, &c.

Orthis Edgelliana, *Salter*, MS. Pl. XXXII, figs. 1—4.

Spec. Char. Marginally almost circular, rather wider than long, greatest width about the middle; hinge-line shorter than the breadth of the shell. Ventral valve moderately and uniformly convex, without any fold or sinus; beak small, slightly produced and incurved; area triangular, about one fourth as broad as long, fissure narrow. Dorsal valve semicircular, not quite as deep as the opposite one, gently convex, most so at the umbone, but divided longitudinally into two lobes by a mesial depression or sulcus; hinge-area narrow. Surface of both valves ornamented by the means of numerous strongish ribs, which radiate from the extremity of the beaks to the margin, while between each two of the principal costæ are interpolated one, two, or three smaller ones, so that the ribs appear as if arranged in clusters, the largest one in the middle being the most elevated. A few concentric lines, more or less deeply indented, intersect the radiating riblets. Shell distinctly punctated. Two specimens measured—

Length 10, width 12, depth 5 lines.
„ 10, „ 11, „ 6 „

Obs. This species does not appear to have ever much exceeded one inch in length: the ribs are much smaller and closer in some specimens than in others: some examples also have their valves more convex than others. The interior presents the general features of the genus *Orthis*, as will be seen by a glance at figs. 3 and 4 of Pl. XXXII.

Position and Locality. *O. Edgelliana* was discovered for the first time by Mr. Wyatt-Edgell in the Upper Wenlock beds at Garcoed, near Usk, where it appears to be tolerably abundant. It received from Mr. Salter the MS. name by which it is here recorded.

Orthis Menapiæ, *Hicks*, MS. Pl. XXXIII, figs. 8—12.

Orthis Menapiæ, *Dav.* Geol. Mag., vol. v, p. 314, pl. xvi, figs. 24—28, 1868.

Spec. Char. Truncato-orbicular, rather wider than long; hinge-line a little shorter than the greatest width of shell. Dorsal valve semicircular, somewhat indented in front, slightly convex, with a longitudinal depression or sulcus along the middle; area narrow and divided by a triangular fissure. Ventral valve rather deeper than the opposite one, with a rounded longitudinal ridge or elevation commencing at the extremity of the small incurved beak, and gradually widening as it nears the front; hinge-area very narrow. Surface of both valves ornamented with numerous fine, angular, thread-like, bifurcating striæ.

Length about 7, width 8 or 9, depth 2 lines.

Obs. Orthis Menapiæ is a small well-marked species, but is rarely found possessing its normal form, or its shell, nearly every specimen being more or less distorted from the effects of cleavage and fossilization, as is well exhibited in fig. 9. No very complete examples, or rather internal casts, having as yet been obtained, I have not attempted to describe its interior, but in figs. 11 and 12 will be seen the little we are at present acquainted with.

Position and Locality. This species was discovered for the first time by Mr. Hicks at the base of the Arenig group, or Lowest Llandeilo, at Tremanhire, and subsequently at Llanveran, Ramsey Island, and Whitesand Bay, all near St. David's; and the designation *Menapiæ* was assigned to it by Mr. Hicks, from the classical name of the earliest city mentioned in the St. David's district. It occurs in company with *Orthis Carausii* (Salter), but is easily distinguished from it by its shape as well as by the number and strength of its striæ. I am not acquainted with the species from any other British or foreign locality.

ORTHIS CARAUSII, *Salter*, MS. Pl. XXXIII, figs. 1—7.

ORTHIS CARAUSII, *Dav.* Geol. Mag., vol. v, p. 315, pl. xvi, fig. 23, July, 1868.

Spec. Char. Suborbicular, rather wider than long; hinge-line as long as or a little less than the width of the shell; slightly indented in front. Dorsal valve very gently convex, with a longitudinal depression along the middle. Ventral valve deeper than the opposite one; beak small, incurved; area rather narrow. Surface of valves covered with about sixteen simple rounded ribs, and concave interspaces of about equal breadth. In the interior of the ventral valve the muscular area is small, and laterally margined by a prolongation of the dental plates. In the interior of the dorsal valve the cardinal process is very small, while a projecting ridge extends from its base to about half the length of the valve; muscular impressions very slightly marked; brachial processes small.

Length 7, width 8, depth 3 lines.

Obs. This important species was discovered in the Lower Arenig or Lower Llandeilo rocks of St. David's by Mr. Hicks about the year 1864. The shell occurs in vast abundance in the condition of internal casts and external impressions, mostly with their natural shape, in yellow sandstone at Tremanhire; and in an extraordinary state of distortion in darker shales at Llanveran, Whitesand Bay, and Ramsey Island, St. David's, Pembrokeshire. Indeed, so great is the state of distortion from the effects of cleavage that one example found by Mr. Homfray at Llanveran measured five lines in length by twenty-seven in width, while the width of the shell before fossilization could not have exceeded seven or eight. In other cases the shell was similarly elongated or twisted to one or other side in the most irregular manner. I am not acquainted with any other localities than those above recorded.

Orthis Hicksii, *Salter*, MS. Pl. XXXIII, figs. 13—16.

Orthis Hicksii, *Dav.* Geol. Mag., vol. v, p. 314, pl. xvi, fig. 17—19, July, 1868.

Spec. Char. Shell small, transversely oval; hinge-line shorter than the greatest breadth of the shell; cardinal angles rounded. Dorsal valve semicircular, moderately convex, slightly longitudinally depressed along the middle. Ventral valve convex, deeper than the opposite one. Area triangular, moderately wide; surface of valves ornamented by about ten principal, narrow, radiating ribs, with wide interspaces between each pair, in the middle of which is situated a shorter rib.

Length about 4, width 5 lines.

Obs. *Orthis Hicksii* is a scarce fossil, and very rarely found even in a passably complete condition. It was discovered by Mr. Hicks in the middle (sandstone) beds of the Menevian group at Ninewells and Porth-y-rhaw, near St. David's, and is the oldest species of the genus on record. It has not been hitherto found in North Wales, nor, to my knowledge, in any other locality.

Orthis lenticularis, *Wahlenberg* (sp.)? Pl. XXXIII, figs. 22—28.

? Anomites lenticularis,		*Wahlenberg.* Nova Acta Upsal., vol. viii, p. 66, 1821.
? Atrypa	? —	*Dalman.* Kongl. Vetenskaps Acad. Hand., p. 132, 1827.
? Spirifer	—	*Von Buch.* Berl. Akad., 1834, p. 48, pl. i, figs. 13, 14.
Orthis	—	*Salter.* Mem. of the Geol. Survey, vol. iii, p. 339, pl. iv, figs. 8—10, 1866.
—	—	*Dav.* Geol. Mag., vol. v, pl. xvi, figs. 20—22, July, 1868.

Spec. Char. Shell small, transversely oval, nearly straight or slightly indented in front, wider than long; hinge-line nearly as long as the breadth of the shell. Dorsal valve moderately convex, with a broad longitudinal depression, commencing at the umbone, and, gradually widening as it nears the front, is bounded by two rather prominent ribs, the sinus being occupied by two or three smaller ones. On each of the lateral portions are three or four principal ribs, with a shorter one occupying the centre of the wide interspace left between each of the larger ribs. Ventral valve convex, deeper than the opposite one, with a slightly prominent fold or rounded elevation corresponding with the sinus in the opposite valve; beak small, area narrow, fissure triangular. Surface ornamented as in the dorsal valve, while both valves are likewise crossed by strong concentric lines of growth. Three specimens measured—

Length 2, width 3 lines (usual size).
„ 3, „ 4 „ } compressed, unusually large example.
„ 6, „ 6 „ }

Obs. Although this shell occurs by millions in certain rocks, it is exceeding rare to meet with a tolerably complete example. The shell is found under the conditions of casts and impressions which are so much distorted from the effects of pressure that it is often impossible to make out the real shape and character. Mr. Salter observes that it is a very well-marked and pretty species, that the length is less than the breadth in the proportion of seven to nine; the number of ribs varying greatly, but not in a manner to make him believe we have more than one species. Although usually small, some examples appear to have attained nearly half an inch in length and breadth; for after a close examination of some hundred examples of all sizes, varying from two to nearly six lines in length, I could perceive no other differences than that in some examples the ribs were a little more numerous and closer than in others, and that the very large examples have been to some extent extended by pressure. There can, therefore, exist no doubt as to the value of this little species, so characteristic of the Upper Lingula-flags of both North and South Wales; but the application of the name here given is still attended by some uncertainty.

In 1821 Wahlenberg described, but did not figure, his *Anomites lenticularis* in the following words:—"Suborbicularis utrinque convexiusculus radiatim undulatus. In lapide suillo strati schisti aluminaris per plures provincias passim copiose sedet, in quo lapide nulla alia testacea unquam lecta sunt. Magnitudine et situ Entomostraciten pisiformem in eodem lapide provenientem aliquanto refert. Utraque valvula pari convexitate gaudet, adeo ut conjunctæ semina lentis proxime æquent. Valvulæ substantia sua tenuissimæ fuisse videntur." Subsequently both Dalman and Hisinger redescribed Wahlenberg's species, without figuring it, under the designation of *Atrypa? lenticularis.* Von Buch makes of it a *Spirifer,* and Salter an *Orthis.* In 1865 Kjerulf[1] both describes and figures what he takes to be the *Atrypa? lenticularis* of Dalman, adding *Orthis vaticina,* Salter as a synonym, and *Atrypa micula,* Dal., as a closely allied species. In his description of *O. lenticularis* Mr. Salter observes that he does not see in the Scandinavian specimens from Kinnekulle, in West Gothland, sufficient differences to warrant him in separating it from the British examples, and that he has but little doubt that the shell under description is Dalman's species from Egeberg, though the specimens in the Survey Collection have less prominent ribs, and a generally smoother appearance; but that

[1] "Veiviser ved geologiske excursioner i Christiania Omegn.," 1865.

there is no essential difference. Mr. Salter also has authorised me to state that *O. vaticina* was the name he gave to the shell before he found that *O. lenticularis* was nothing else.

On the 3rd of January, 1867, Mr. Plant enclosed me a natural-sized photograph of a large specimen (Pl. XXXIII, fig. 27), which he had procured from near the top of Murchison's 'Lingula-flags,' at Rhiw Felyn, in North Wales, and which he considered to be distinct from *O. lenticularis;* and in this opinion at one time I felt almost disposed to concur; but since then the discovery of several intermediate-sized examples by Mr. Homfray at Ogof-ddu, Criccieth, near Portmadoc, and by Mr. Belt at Penmain Pool, west of Dolgelly, has induced me to look upon the larger and smaller specimens as mere modifications of form, age, and state of fossilization of a single species; the shell found by Mr. Plant being likewise flattened out and distorted by pressure. It is quite possible, as was stated to Dr. Lindström by Prof. Angelin, that several species may have been confounded with Wahlenberg and Dalman's unfigured *Anomites lenticularis;* but there appears to be much probability that Mr. Salter is correct in his identification of our English specimens with those found in Sweden.

Position and Locality. Orthis lenticularis seems to be confined to the Upper Lingula-flags (Dolgelly groups of Belt, or upper portion of the Ffestiniog group of Sedgwick), and occurs at Penmorfa Church, near Tremadoc; near Criccieth, at Ogof-ddu Cliff, Gwerny-y-Barcud, Rhiwfelyn, and in several other Welsh localities.

The foreign localities have already been mentioned. Baron von Buch observes that the individuals of this species are assembled by millions, without shell, piled one upon another over a great thickness of strata (just as we find them to occur in North Wales), and of themselves compose the aluminiferous schists of Andrarum in Scania. Dalman mentions that these beds extend over all West Gothland, and over certain other provinces of Sweden, which he does not name. It occurs also in Norway.

Orthis alata, *J. de C. Sow.* (sp.). Pl. XXXIII, figs. 17—21.

Spirifer ? alatus, *J. de C. Sow.* Silurian System, pl. xxii, fig. 7, 1839.
Orthis alata, *Salter.* Siluria, 2nd ed., p. 55, fig. 15; and pl. v, fig. 6, 1849.
— —? *Id.* Memoirs of the Geol. Survey, vol. iii, p. 337, 1866.

Spec. Char. Semicircular, with expanded angular extremities, wider than long, slightly indented in front; hinge-line straight, and as long as the greatest breadth of shell. Dorsal valve very slightly convex, flattened laterally near the cardinal line and extremities; a longitudinal depression, commencing likewise at the centre of the umbone, gradually deepens and widens as it nears the front; hinge-area very narrow. Ventral valve moderately convex, and flattened near the cardinal extremities; area narrow, fissure small.

Surface of valves ornamented with from eighteen to thirty simple rounded ribs, with deep concave interspaces between each pair of ribs of equal or slightly greater breadth, the whole surface being likewise marked or finely imbricated by minute, radiating, longitudinal striæ, crossed by very fine, equidistant, concentric lines. Interior not known. A large specimen measured—

Length 6, width 10 lines.

Obs. This species was originally described by Mr. J. de C. Sowerby as a *Spirifer;* but its true place in the genus *Orthis* was subsequently assigned to it by Mr. Salter. It varies very much in shape, on account of a greater or lesser prolongation of its cardinal extremities or "expanded cuspidate sides," as described by Mr. Sowerby. The specimens figured in the 'Silurian System' are also somewhat out of shape, the shell not being usually quite as transverse as therein represented.

Position and Locality. *Orthis alata* occurs low down in the Llandeilo formation at Perkins Beech and Lords Hill, Shelve, where it is tolerably abundant in the condition of external casts and impressions, the shell itself not having been obtained. Sowerby's examples are stated to have been found at Pensarn and Mount Pleasant, Caermarthen, also in the Lower Llandeilo, to which stage the shell seems to be apparently restricted, at least so far as we are at present aware.

Orthis Berthoisi, *Rouault* (?), var. erratica, *Dav.* Pl. XXXII, figs. 21—28.

? Orthis Berthoisi, *Rouault.* Bull. Soc. Géol. de France, 2nd ser., vol. vi, p. 68, pl. ii, figs. 4, 4*a*, *b*, *c*, 1848.
? — — *Sharpe.* Quarterly Journal Geol. Soc., vol. ix, p. 154, pl. viii, fig. 4, 1853.

Spec. Char. Shell ovate, or slightly transversely oval, rather wider than long, broadest about the middle; hinge-line short, not more than half, and often less than half, the width of shell. Ventral valve very moderately convex, with or without a slight mesial depression, commencing at about the middle of the valve and widening as it nears the front. Area narrow and small. Dorsal valve slightly convex, with sometimes a shallow median depression, which, beginning at the umbo, dies out before reaching the middle of the shell; both valves are covered with numerous thread-like bifurcating striæ, which divide several times before reaching the margin; the valves are likewise crossed at irregular intervals by strong concentric lines of growth. In the interior of the dorsal valve there is a large elongated, oval-shaped, prominent, cardinal process between two triangular brachial processes or plates, on the upper outer side of which, and close under the small hinge-area, are situated the sockets, while a thickened rounded ridge extends from under the cardinal process to about half the length of the bottom of the valve, and on either side of this are the concave adductor muscular oval-shaped impressions. (These projections and indentations produce corresponding depressions and elevations on the internal casts of both valves.) In the interior of the ventral valve the muscular area is rather large, and margined by a slightly projecting ridge, while a widish ridge extends longitudinally along the centre.

Length 11, width 12 lines.

Obs. I do not feel certain that the shell above described is really identical with the *Orthis Berthoisi* of Rouault, and consequently have given to it the varietal designation of *erratica*, which can be hereafter retained as a specific denomination should a comparison with Rouault's type prove the two to be distinct. The shell figured by the French palæontologist assumes much larger proportions than any specimen I have yet seen of the shell under description from Budleigh-Salterton. The specimen of *O. Berthoisi* found by M. Rouault at Couyère, in Brittany, were much distorted from the effects of cleavage; but one example, with apparently its natural shape, measured about 19 lines in length by about the same in breadth, while the hinge-line and area were also smaller than in any of the British examples provisionally referred to it.[1]

In 1853 Mr. D. Sharpe figured and described under the designation of *O. Berthoisi*, Rouault, a shell much more resembling our Budleigh-Salterton examples, and which he stated to be abundant in the upper division of the Lower Silurian formation at the Porto di Santa Anna, in the Serra de Bussaco, in Portugal. Mr. Sharpe observes[2] that "In general form and external markings this shell closely resembles the common Carboniferous species, *Orthis Michelini* of Leveillé (*O. filiaria*, Phill.), the only obvious distinction being the slight depression near the umbo of the deeper valve, but the form of the muscular impressions in the dorsal valve affords a sufficient distinction;" also that "the specimens figured by M. Rouault are much distorted, and only show the exterior, for which reason the species is refigured here. It is interesting as a connecting link with the Lower Silurian strata of Brittany, and should teach us caution in assigning an age to

[1] At p. 68 of his memoir M. Rouault describes his *O. Berthoisi* in the following words:—"J'appelle particulièrement l'attention des savants sur ce fossile tant à cause de la rareté de ces Mollusques dans ces Schistes (de Couyère en Bretagne) que des caractères qu'il va nous offrir. C'est une grand coquille du groupe des *Arcuato-striatæ* de M. de Verneuil; elle est peu épaisse et sa valve dorsale seule est sensiblement renflée et munie d'un crochet peu saillant; ses deux valves sont couvertes de stries fines, très nombreuses, et de lignes d'accroissement très marquées; mais le caractère le plus saillant et en même temps le plus difficile à préciser dans une description specifique nous est fourni par les nombreuses deformations qu'elle a subies. Ces déformations sont telles que sur soixante échantillons il ne m'a pas été possible d'en rencontrér deux de formes semblables, bien qu'ils appartiennent à une espèce dont la forme symétrique est bien reconnue."

[2] Mr. Sharpe's description of *O. Berthoisi* is as follows:—"Shell ovate, with a very short hinge-line; dorsal valve slightly convex; ventral valve more convex than the dorsal, with a slight mesial depression, which, beginning at the umbo, dies out before reaching the middle of the valve; both valves are covered with very numerous fine bifurcating ribs, which divide many times before they reach the margin, and are crossed at irregular distances by strong concentric lines; lateral ribs curved. Length 1 inch, greatest breadth below the middle $\frac{4}{5}$th of an inch."

unknown strata from the general form of a shell without strict attention to specific differences; as, had this species been found alone, most palæontologists would have referred it to the Carboniferous period." The only difference I can see between the Portuguese specimens and those found at Budleigh-Salterton is that in the first the shell is broadest anteriorly, whilst in the last it is more uniformly transversely oval; and, indeed, if the English and Portuguese specimens belong to the same species as that described from Brittany we would certainly have three distinct varieties, one of which would be peculiar to each of the three localities above named.

Position and Locality. Of the shell under description I have examined a number of internal casts and external impressions, collected by Messrs. Vicary, Valpy, and Winwood, from the "Pebble-bed" of Budleigh-Salterton, in Devonshire. The pebbles and boulders are erratic, and seem in that locality to have been derived from rocks of two distinct periods. Those, however, containing the *O. Berthoisi* are quartzites, or compact reddish sandstones of perhaps the Llandeilo age, but no rock *in situ* hitherto discovered in Great Britain has furnished us with the species. The foreign localities of this species have been already recorded.

ORTHIS VALPYANA, sp. nov. Pl. XXXII, figs. 29—33.

Spec. Char. Semicircular, or transversely oval, wider than long; hinge-line a little shorter than width of shell. Ventral valve evenly and moderately convex; beak small, incurved; area narrow; fissure triangular, open. Dorsal valve slightly convex, area linear. Surface of both valves covered with numerous small radiating ribs, each principal one bifurcating two or three times before attaining the margin, so as to form small clusters of striæ. In the interior of the dorsal valve a small bifid cardinal process, forming the posterior extremity of a small longitudinal ridge, is situated between two very small brachial processes. In the interior of ventral valve the muscular area is small.

Length 8, width 10 lines.

Obs. The festooned appearance of the ribs in many specimens of this species easily distinguishes it from *O. intercostata*, Portlock. The muscular impressions are very faintly marked.

Position and Locality. Several internal casts and external impressions of this shell were found by Messrs. Vicary and Valpy at Budleigh-Salterton, in boulders which are supposed to be of the same age as those containing *Orthis Berthoisi*.

Orthis intercostata, *Portlock*. Pl. XXXVIII, figs. 1—3.

Orthis intercostata, *Portlock*. Report on the Geology of the County of Londonderry, &c., p. 454, pl. xxxvii, fig. 3, 1843.
— — *M'Coy*. Synopsis Sil. Foss. Ireland, p. 31, 1846.
— — *Salter*. Siluria, 2nd ed., p. 543, 1859.

Spec. Char. Nearly semicircular, a little wider than long; hinge-line slightly shorter than width of shell. Ventral valve very moderately and uniformly convex; area narrow and small. Dorsal valve and interior not known. Surface marked by fine thread-like, longitudinal, radiating striæ, with wide interspaces between each pair, in the centre of which is situated a smaller rib, which, commencing at various distances from the beak, extends to the front.

Length 7, width 8 lines.

Obs. Of this species only three or four ventral valves have come under my notice, notwithstanding that Prof. M'Coy states it to be not uncommon in the sandy slates (Caradoc) of Bardahessiagh, Pomeroy, County Tyrone, as well as in the sandstone of Killey, Pomeroy, County Tyrone. Portlock mentions Desertcreat, Tyrone, as the locality from whence his specimen was derived. More material in connection with this species should be sought for.

Orthis vespertilio, *J. de C. Sow.* Pl. XXX, figs. 11—21.

Orthis bilobata, *J. de C. Sow.* Silurian System, pl. xix, fig. 7, 1839.
— vespertilio, *Id.* Ib., pl. xx, fig. 11.
— bilobata et vespertilio, *Portlock*. Geol. Rep. of the County of Londonderry, &c., p. 453 and table, 1843.
— vespertilio, *M'Coy*. Synopsis Sil. Foss. Ireland, p. 36, 1846.
— — including O. bilobata, *Phillips* and *Salter*. Mem. Geol. Survey, vol. ii, p. 291, 1848.
— — *M'Coy*. Brit. Pal. Foss., p. 230, 1852.
— — *F. Schmidt*. Sil. Form. von Ehstland, &c.; Archiv Nat. Liv.-Ehst.-und Kurlands, vol. ii, p. 214, 1858.
— — *Salter*. Siluria, 2nd edit., p. 74, fig. 7; and pl. vi, figs. 1—3, 1859.

Spec. Char. Rotundato-quadrate, greatest breadth usually at the hinge-line, sometimes near the middle of the shell; sides slightly concave prior to being rounded at their cardinal extremities. In some individuals these extremities form small mucronate wings or angular prolongations; front indented by a concave curve. Dorsal valve convex, longitudinally divided into two lobes by a deep, obtusely angular median sinus; the lateral portions of the valve close to the extremities of the hinge-line are flattened; hinge-area narrow. Ventral valve convex at the beak, but becoming slightly concave towards the front and margins, while a strong prominent mesial fold or sharply angular ridge extends from the extremity of the beak to the front; area triangular, fissure open. Surface of valves marked with numerous small angular radiating striæ, often dichotomising or increasing in number by the interpolation of additional ribs, which are at times arranged in clusters of four or five of unequal length and breadth. In the interior of the dorsal valve a projecting cardinal process is situated between two smallish deviating brachial laminæ. In the interior of the ventral valve the saucer-shaped muscular area is margined by a slightly raised ridge.

Length 15, width 19, depth 5 lines.

Obs. As justly observed by Prof. M'Coy, "This species varies prodigiously in the amount of gibbosity of the bilobed dorsal valve, ranging by imperceptible gradation from almost hemispherical to nearly flat; the ventral valve also varies, but to a less extent; it is always approximately flat at the sides, but varies from convex to concave." Much difference is likewise observable in the respective width of the shell in different individuals. The larger number of specimens are widest at the hinge-line, while others are widest at about half the length of the shell. In 1848 Messrs. Phillips and Salter correctly united *O. vespertilio* and *O. bilobata* into a single species.

Position and Locality. *O. vespertilio* is abundant, and may be said to be characteristic of the Caradoc or Bala formation, for the fossil has been but sparingly found in the Lower Llandovery. In England it was first discovered by Sir R. Murchison in the Caradoc Sandstone of Shropshire, at Acton Scott, &c.; it is common at Harnage, south-east of Shrewsbury; Gretton, near Cardington, &c. According to Messrs. Ramsay and Salter it is plentiful at Dolwyddelan; Penmachno, Caernarvonshire; south of Llangollen; south-east of Cerrig-y-Druidion, Denbighshire; Meifod; Welshpool; north of Llangedwyn; Llanwddyn; Llanfyllin, Montgomeryshire; east, west, and south-east of Bala Lake; near Corwen; Hirnant Ridge, Merionethshire. It has also been met with in the Malvern, May Hill, Llandeilo and Haverfordwest districts, by Prof. Phillips. Prof. Harkness has sent me specimens from the Bala Limestone of Keisley, as well as from the Lower Bala series or black shales at Pusgill, near Dufton, in Westmoreland. It is also said to be a common species at Coniston.

From the Lower Llandovery I have seen specimens, found by Mr. Hughes one mile south of Cwmrhyddan.

In Scotland it is a very common shell in the Caradoc Limestone at Craighead Quarry, near Girvan, in Ayrshire.

In Ireland it has been found in a number of Caradoc localities, such as at Portrane, County Dublin; Desertcreat, Killey, Pomeroy, County Tyrone, &c.

It is also stated to occur in Russia.

ORTHIS RUSTICA, *J. de C. Sow.* Pl. XXXIV, figs. 13—17; var. *rigida*, figs. 18, 19; var. *Wallsalliensis*, figs. 20—22.

ORTHIS RUSTICA, *J. de C. Sow.* Silurian System, pl. xii, fig. 9, 1839.
— — *M'Coy.* Synopsis Sil. Foss. Ireland, p. 34, 1846.
— — *Dav.* London Geol. Journal, p. 64, pl. xiii, figs. 1—4, 1847.
— RIGIDA, *Id.* Ib., p. 63, pl. xiii, figs. 16, 17, 1847.
— RUSTICA et var. RIGIDA, *Dav.* Bull. Soc. Géol. Fr., 2nd ser., vol. v, p. 322, pl. iii, fig. 15, 1848.
— WALSALLII, *Id.* Ib., p. 339, pl. iv, fig. 7, 1848.
— CALLIGRAMMA, var. RUSTICA, *Phillips* and *Salter.* Memoirs Geol. Survey, vol. ii, p. 376, 1848.
— — var. RIGIDA, *Id.* Ib., p. 376.
— — ,, WALSALLIENSIS, *Id.* Ib., p. 376.
— RUSTICA et var. RIGIDA, *D'Orb.* Prodrome, vol. i, p. 36, 1849.
— OSILIENSIS, *Schrenk.* Schmidt's Sil. Form. von Ehstland, &c.; Archiv Nat. Liv.- Ehst.- und Kurlands, vol. ii, p. 213, 1858.
— RUSTICA, *Salter.* Siluria, 2nd ed., p. 544, pl. xx, fig. 10, 1859.
— RUSTICA et O. RIGIDA, *M'Coy.* Brit. Pal. Foss., p. 226, 1852.
— RUSTICA, *Lindström.* Gotlands Brachiopoder, p. 370, 1860.
— CALLIGRAMMA, var. RUSTICA et RIGIDA, *Salter.* Mem. Geol. Survey, vol. iii, p. 337, 1866.
— — var. WALSALLIENSIS ?, *Id.* Ib., (not *O. Walsalliensis*, Dav.)

Spec. Char. Somewhat rotundato-quadrate or semicircular, broadest about the middle; hinge-line straight, slightly less than the width of the shell; sides rounded; cardinal extremities sometimes rounded, more often angular from the lateral portions of the valves becoming slightly concave as they near the extremities of the hinge-line; front slightly indented. Dorsal valve more or less convex, with sometimes a slight median longitudinal depression, but the front usually presents a small elevated curve; area well defined, but not quite as wide as that of the other valve. Ventral valve not so deep as the dorsal one, most convex at the beak, slightly depressed longitudinally towards the front; area triangular, of moderate width, fissure large and open; beak very small, scarcely produced beyond the apex of the area. Surface of valves covered with from fifty to one hundred and twenty small rounded ribs, of which two fifths or more are shorter than the others and interpolated between those that extend uninterruptedly from the beak to the margin. The surface of valves are also concentrically crossed by small equidistant raised lines or ridges. In the interior of the dorsal valve, between two widely deviating brachial laminæ, is situated a projecting cardinal process or boss, which is divided by a small longitudinal slit at its summit, while the posterior portion is narrow, the anterior is thickened. Under the cardinal process a short rounded ridge separates the small oval concave dendritic muscular scar. In the interior of the ventral valve, on either side of the wide triangular fissure, is situated a strong tooth, while the dental plates partly encircle the saucer-shaped muscular cavity. On the outer side of these, and extending further down, are the large well-defined and margined ovarian spaces. The vascular trunks are also sometimes apparent. A large specimen measured—

Length 16, width 19, depth 7 lines.

Obs. In 1839 Mr. J. de C. Sowerby described his *Orthis rustica* as being "Transversely oblong, rather square, depressed, uneven, with many rounded radii, which become more numerous towards the margin; front straight or slightly elevated. Length 1 inch 1 line, width 1½ inches. The hinge-area is triangular and rather large; radii between 40 and 50. Loc. Wenlock; Valley of Woolhope." To this description was added the figure of a ventral valve only. I was, however, subsequently (in 1847) enabled to describe and fully illustrate the exterior and interior of this remarkable species from a magnificent series of perfectly preserved examples obtained by Mr. Lewis and myself near Walsall, during the excavation of the new Rushall Canal. I also picked up some very perfect valves, showing the interior, during my researches at Benthall Edge and Lincoln Hill. I must now again remind the student that one of the chief characters of *Orthis rustica* consists in its generally having a small interpolated rib between each two of the longer ones, or between those which extend directly from the extremity of the beaks to the margin; the number of ribs varying according to the age of the individual. It was from having overlooked this important circumstance that I was in 1847 and 1848 tempted to separate, under the designations of *rigida* and *Walsalliensis*, two variations in form presented by this species, the first with fewer, the latter with smaller and more numerous ribs. Full-grown individuals of the typical *O. rustica* present about fifty-six ribs on each valve, while a full-grown example of *O. Walsalliensis* would have upwards of 120 on each valve; and as the shape of the shell, though usually smaller, is similar to that of *O. rustica*, and the interior is likewise identical, we are reduced to consider it as nothing more than a variety of Sowerby's species,—a conclusion I had arrived at soon after the publication of my paper in the 'Bulletin de la Société Géol. de France' (1848). In the same year and subsequently Mr. Salter considered *O. rustica*, *O. rigida*, and *O. Walsalliensis* as distinct varieties of *O. calligramma*, Dalm.; but he added at the same time that he feared few students of Silurian fossils would feel disposed to go with him in uniting all the above-mentioned forms (and others, of which he gives a list) with *O. calligramma*. I regret to say that, although I entertain the highest possible opinion of Mr. Salter's views relating to Silurian fossils, I cannot concur with him in the opinion above expressed, for were I to admit *O. rustica* and its var. *Walsalliensis* as varieties of Dalman's species, I might find equal reason for admitting into it a far larger number of forms than Mr. Salter would like to see numbered among the varieties of *O. calligramma*. The last-named shell has, in my humble opinion, been correctly considered by the generality of palæontologists as distinct from *O. rustica*, both on account of its more oval shape as well as from the character of its ribs, which in Dalman's species are fewer, straight, and simple. At p. 207 of the 2nd vol. of the 'Geology of Russia,' M. de Verneuil distinctly states, while describing *O. calligramma*—"La surface des valves est ornée de plis simples et droits, qui, comptés avec soin sur plus de cinquante individus, nous ont offert tous les nombres depuis quinze jusqu'à quarante, mais se maintiennent le plus souvent entre vingt à vingt-cinq. Ces plis, arrondis comme les sillions qui les séparent, naissent successivement le long du bord cardinal, et ne se réunissent pas tous au crochet. Dans les intervalles, on decouvre à la loupe, sur les échantillons d'une parfaite conversation deux à trois stries longitudinales extrêmement fines." I may also observe that the Lower Silurian shell attributed by Mr. Salter, with a point of doubt, to my *O. Walsalliensis*, belongs to another species.

Besides the differences already recorded with reference to the shape and ribs in *O. calligramma* and *O. rustica*, I may mention that in Dalman's shell the ventral valve is uniformly convex, and much more so than the dorsal, while in *O. rustica* the latter is usually the deepest and most convex; the ventral valve showing also a marked longitudinal depression from about the middle to the front.

Having some years ago received, through the kindness of Prof. F. Schmidt, of St. Petersburg, a perfectly preserved example of Schrenk's *O. Osiliensis*, I was able to satisfy myself as to its identity with Sowerby's *O. rustica*. Therefore, in Pl. XXXIV, figs. 13—17 represent Sowerby's true *O. rustica*, figs. 18, 19 the var. *rigida*, and figs. 20—22 the var. *Walsalliensis*.

Position and Locality. *O. rustica* appears to be a characteristic fossil of the Wenlock period; is most abundant near Walsall, occurring also at Benthall Edge, Lincoln Hill; in Wenlock Shales opposite the ruins of Buildwas Abbey, near Wenlock, in Shropshire; at Abberley and Callow Farm in the Abberley district; Dormington Wood, Woolhope district.

No Scottish specimen has hitherto been discovered; but in Ireland it occurs at Ferriter's Cove, Dingle, County Kerry; and it is also mentioned by M'Coy from Foylathurrig, in the same county.

Abroad it occurs in the Island of Gothland, in Sweden, and at Erras, in Esthonia.

Orthis calligramma, *Dalman*. Pl. XXXV, fig. 1—17; var. *Davidsoni*, figs. 18, 19; var. *Scotica*, figs. 20—22; var. *virgata*, figs. 23, 24., and Pl. XXXVII, fig. 2.

Orthis calligramma, *Dal.* Kon. Vet. Handl., p. 114, pl. ii, fig. 3, 1827.

Orthambonites crassicosta, eminens, *Pander*. Beitr. zur Geogn. Russl., p. 81, pl. xxi, figs. 1, 2, 1830.

Orthis calligramma, *Hisinger*. Lethæa Suecica, p. 74, pl. xx, fig. 10, 1837.

— transversa, semicircularis, tetragona, rotundata, rotunda, æqualis, [illegible]ata, plana, *Pander*. Id., pl. xxii, figs. 1—8.

ORTHIS OVATA, *Pander*. Beitr. zur Geogn. Russl., p. 83, pl. xvi A, fig. 9, 1830.
— CALLIGRAMMA, *Von Buch*. Ueber Delthyris und Orthis, Berlin Trans., p. 58, 1837; and Mém. Soc. Géol. de France, vol. iv, p. 206, pl. xi, fig. 2, 1840.—O. OVATA, *Von Buch*, Berlin Trans., p. 59; and O. ORTHAMBONITES, p. 66, 1837.
— CALLACTIS, *Sow*. Silurian System, pl. xix, fig. 5, 1839.
— VIRGATA, *Id*. Ib., pl. xx, fig. 15.
— ORTHAMBONITES, *Von Buch*. Beitr. zur Geb. Russl., p. 18, 1840.
— — *D'Eichwald*. Sil. Syst. in Esthl., p. 150, 1840.
— FLABELLULUM, *J. Hall* (not of *Sow*.). Rep. 4th Geol. Dist. New York, p. 105, fig. 5, and p. 107, 1843.
— — *De Castelnau* (not of *Sow*.). Terrains Sil. de l'Amérique du Nord, p. 37, 1843.
— CALLIGRAMMA, *De Verneuil*. Geol. of Russia, vol. ii, p. 207, pl. xiii, figs. 7—9, 1845.
— — *Dav*. London Geol. Journal, p. 65, 1847.
— DAVIDSONI, *De Verneuil*. Bull. Soc. Géol. de France, 2nd ser., vol. v, p. 341, pl. iv, fig. 9, 1848.
— CALLIGRAMMA (pars), *Phillips* and *Salter*. Mem. Geol. Survey, vol. ii, p. 374, 1848.
— — *Quenstedt*. Handbuch, p. 485, pl. xxxviii, fig. 41, 1851.
— — *M'Coy* (including O. VIRGATA). Brit. Pal. Foss., p. 214, 1852.
— — var. VIRGATA, *Salter*. Quarterly Journal Geol. Soc., vol. vii, p. 171, 1851.
— FLABELLULUM, *J. Hall* (not of *Sow*.). Geol. New York, vol. ii, p. 254, pl. lii, fig. 6, 1852.
ORTHISINA SCOTICA, *M'Coy*. Annals Nat. Hist., 2nd series, vol. viii, p. 400, 1851; and Brit. Pal. Foss., p. 232, pl. i H, fig. 29, 1852.
ORTHIS CALLIGRAMMA, *F. Schmidt*. Sil. Format. Ehstland; Archiv. Nat. Liv.- Ehst.- und Kurlands, vol. ii, p. 212, 1858.
— — *Salter*. Siluria, 2nd ed., pl. v, figs. 8, 9, 1859.
— — *D'Eichwald*. Lethæa Rossica, Periode Ancienne, p. 827, 1859.
— — *Dav*. General Introduction, pl. vii, fig. 127, 1853.
— DAVIDSONI, *Lindström*. Gotlands Brachiopoder, p. 370, 1860.
— CALLIGRAMMA, var. PROAVA, *Salter*. Mem. Geol. Survey, vol. iii, p. 22, fig. 1, 1866.
— — var. CALLIPTYCHA, *Id*. Ib., fig. 2.
— — „ VIRGATA, *Id*. Ib., fig. 3.
— — „ SIMPLEX, *Id*. (not *M'Coy*). Ib., fig. 4.

Spec. Char. Transversely semicircular, usually wider than long, broadest about the middle; sides and front rounded; hinge-line slightly less than the width of shell. Ventral valve uniformly convex; beak small, incurved, not always protruding above the apex of the area. Area moderately wide; fissure triangular, open. Dorsal valve usually much less deep than the opposite one, most convex at the umbone, sometimes slightly depressed towards the front; hinge-area narrow. Surface of valves marked with from sixteen to fifty simple, straight, radiating, rounded riblets, with concave interspaces, of variable width, between each pair of ribs; two or three very fine longitudinal lines may, by the aid of the lens, be seen in the interspaces left between the ribs, and these also are crossed by very fine concentric equidistant lines. In the interior of the dorsal valve a small cardinal process fills the centre of the triangular fissure; while a wide longitudinal ridge separates into two pairs the oval scars left by the adductor muscle: the diverging brachial processes or laminæ are small. In the interior of the ventral valve the saucer-shaped muscular depression is of moderate size. Two specimens measured—

Length 10, width 10, depth 4 lines.
" 13, " 15, " 6 "

Obs. In 1827 Dalman described and figured his *Orthis calligramma* so as not to be misunderstood,[1] and he distinctly intimates that the ribs are straight and simple; the shell was subsequently (in 1845) correctly described by M. de Verneuil, who had occasion to compare together a great number of Russian examples. No doubt it is variable, both in shape and in the lesser or greater number of simple ribs which ornament the surface of its valves in different specimens; it may therefore be convenient, perhaps, to maintain distinct varietal denominations for such forms as *O. Davidsoni*, Vern., *O. virgata*, Sow., *O. Scotica*, M'Coy, &c., for these shells present slight variations in their detail, while still preserving the essential character of the original or typical form; but I do not consider that we should be justified in uniting to it, as varieties, such shells as *O. rustica*, *O. Walsalliensis*, and others that are characterised, not only by a difference in general shape, but likewise by the presence of the numerous interpolated ribs, which do not exist in *O. calligramma*. The shell has also been well described by Prof. M'Coy, in his work on British Palæozoic Fossils; and he justly observes therein, that "it is well distinguished from the old *O. flabellulum* of Sowerby (with which it has been sometimes confounded) " by its more regular definite ribbing, and the fine longitudinal striæ in the interspaces, without short irregular ribs, the sharp extension of the ribs more nearly to the beak on the casts, the greater inclination of the large cardinal area, and its being situated in the most convex instead of the flat valve." In many of the Russian specimens

[1] "O. testa margine compressa, basi utrinque angulata, radiatim multisulcata et concinne striata, costis indivisis: valvæ majoris nate prominula subincurva. Locus: In calce cinerea Ostrogothiæ, ad Skarpäsen rarius, Dom. Olivecrona, Mus. Ac. Sc. Holmiensis.

"Longit. 22 mm., latit. 24 mm., valvæ minoris basis latit. 21 mm.; testa 13 mm. crassa.

"Facie accedit ad *Orth. elegantulam, basalem* et *testudinariam*, sed major, costis omnibus indivisis, et una cum sulcis longitudinaliter striatis. Ab. *O. callacti* facillime distinguitur costis multoties numerosioribus (circiter 32—34), itaque magis approximatis. Valva minor basi convexa, versus marginem applanata, ambitu plus quam semicirculari, basi rectilinea lataque, angulis lateralibus fere rectangulis. Valva major convexior, nate parum prominula sub-incurva, et ab ipsa basi parum remota. Margo cardinalis latus, sed brevis, lævis, cum foraminis deltoidei brevisque vestigio. Sutura valvarum non nisi leviter undulata."

of *O. calligramma* the small incurved beak appears slightly above the highest point of the area, as may be seen in fig. 7 *a,* pl. xiii, of the 'Geol. of Russia;' but in fig. 7 *e* of the same plate the small incurved beak is no longer visible. This is also observable in many of our British specimens from the Caradoc of Moelydd, near Oswestry, and where the shell most resembling the Russian type is found. M. de Verneuil informs us that *O. orthambonites* is a variety of *O. calligramma* which exists only in Russia, unless we unite to it certain individuals of the Swedish *O. callactis,* Dalman. I am still uncertain, however, whether Dalman's *O. callactis* is more than a variety of the shell under description, although M'Coy describes it at p. 214 of his work on British Palæozoic Fossils as a distinct species. We may assert that the *O. callactis* of the 'Silurian System' is no more than a variety of *O. calligramma.* The fine longitudinal striæ which cover the surface of the interspaces between the ribs, as well as the fine concentric equidistant lines observable on well-preserved specimens, are rarely seen on any of our Lower Silurian specimens, on account of their indifferent state of preservation; but they have been noticed both by De Verneuil, D'Eichwald, and myself, on Russian Lower Silurian specimens, and are well exposed in some of our Upper Silurian examples of the variety *Davidsoni.* Thus, while describing the var. *orthambonites,* M. de Verneuil writes—" Dans cette variété, les sillons ne sont pas finement striés dans le sens de la longueur, mais ils sont, ainsi que les plis eux-mêmes, recouverts de fines stries transverses. Cette différence, souvent très difficile à apercevoir, est la seule que nous ayons pu observer entre les *O. calligramma* et *orthambonites,* et encore est-il permi de croire qu'elle est plus apparente que réelle, et dépend des divers degrés de conservation de la coquille: en effet, presque tous nos échantillons paraissent plus ou moins altérés, la plupart ont les plis tout-à-fait lisses, les uns prennent graduellement des stries longitudinales, d'autres des stries transverses, et enfin un échantillon plus complet nous a offert quelques stries longitudinales recouvertes et presque cachées par des stries transverses. Ces différences ont échappé à M. Pander, dont les espèces ne sont établies que sur des rapports de longueur et de largeur, sur le nombre des plis ou sur les dimensions de l'area, qui sont ce qu'il y a de plus variable. Elles ont au contraire été observées par M. Eichwald, qui a appelé *O. orthambonites* la variété à stries transverses, et *O. callactis* celle à stries longitudinales. Nous avons préféré adopter pour cette dernière le nom *O. calligramma,* en nous fondant sur les caractères que lui a reconnus M. Hisinger."

I know but little of the var. *virgata* (Pl. XXXV, figs. 23, 24, and Pl. XXXVII, fig. 2). Mr. Salter states—" We have but one valve of this species, and Mr. Sowerby only figured the same valve in the 'Silurian System.' It agrees in shape pretty well with *O. plana,* or *O. lata,* Pander, having the hinge-line somewhat shorter than the width of the shell. But it is of larger form, and has numerous, thirty-six or more, ribs, very regular and equal in size." It occurs in the Caradoc, at Cwm-gwynen-uchaf, Montgomeryshire. Mr. Salter considers M'Coy's *O. simplex* (see Pl. XXXII, figs. 10, 11) to be also a variety of *O. calligramma;* but this, I think, can hardly be the case, since the interior of M'Coy's species presents some well-marked differences, as may be seen in the figures above mentioned. *O. plicata*, Sow., has likewise been considered to be a variety of *O. calligramma;* but as the ribs are numerous, and shorter ones are here and there interpolated between the longer ones, we will follow Prof. M'Coy in retaining it, at least provisionally, as distinct. The variety *Davidsoni* (Pl. XXXV, figs. 18, 19) was discovered for the first time in the Wenlock Shales near Walsall, by Mr. A. Lewis, and was by myself in 1847 referred to Dalman's *O. calligramma*. In 1848, however, M. de Verneuil separated it completely from the form under description, adding, "This species has been confounded in certain collections with the *O. calligramma* from the Lower Silurian, from which it is distinguished by the development and small curvature of its area. In *O. calligramma* the beak, instead of inclining backwards, as in *O. Davidsoni*, is incurved, so as to place itself nearly in the plane of the longitudinal axis of the shell. We find in the United States, in the Trenton Limestone, which forms part of the Lower Silurian formation, a species, *O. tricinaria*, Conrad, which is very close to ours, and from which it is distinguished by a larger number of ribs, and by the absence of a hinge-area in the ventral valve." Mr. Salter, however, I think, correctly considers *O. Davidsoni* to be a simple variety of Dalman's species, and so does D'Eichwald at p. 827 of the 2nd vol. of his 'Lethæa Rossica.' In the variety *Davidsoni* the ribs seem to vary from sixteen to nineteen in number, and the concentric equidistant striæ are very apparent. It was found also in the Woolhope beds at Hope Quay, Minsterly, and in the Island of Gothland.

Orthis Scotica (*Orthisina Scotica*, M'Coy) (Pl. XXXV, figs. 20—22) seems to me to be also a variety of *O. calligramma*, and most certainly does not belong to the genus *Orthisina*, with which it has been erroneously classed by M'Coy. It is somewhat more subquadrate than are the ordinary forms of *calligramma*, with from twenty-four to twenty-eight simple ribs, and interspaces of about equal width. In the dorsal valve there exists a slight median depression; but this is also observable in some specimens of *O. calligramma*. Prof. M'Coy states that in form it is intermediate between the *O. inflexa* and *O. plana* (Pander, sp.), but is more depressed. The fissure is, however, triangular and open, as in *Orthis;* and when one can examine several specimens of this so-termed species, its passages into the common shapes of *O. calligramma* become quite apparent. It occurs with the ordinary forms of *O. calligramma* in the Caradoc Limestone at Craig Head Quarry, near Girvan, in Ayrshire; and also, according to Prof. M'Coy, in the calcareous shales of Colmonel on the Stinchar.

Before concluding our account of the many modifications presented by Dalman's species, we must refer to a large variety (Pl. XXXV, fig. 8) which occurs in the Lower Llandovery rocks at Mulloch Hill Quarry, near Girvan, in Ayrshire, as well as at Cong, County Galway, in Ireland. This variety seems to have exceeded in size all the others, and to have presented very wide interspaces between its ribs. *Orthis Thakel*, var. *convexa*, of Salter, figured in Strachey's 'Pal. of the Niti,' from the Northern Himalaya

(p. 28, pl. iv, fig. 8), bears also much resemblance to certain varieties of *O. calligramma*.

Position and Locality. This remarkable species seems to have had a very extended vertical as well as geographical range, for we find it in the *Llandeilo, Caradoc, Llandovery,* and *Wenlock* formations.

In the *Llandeilo* it occurs at the west of Stiper Stones; at Tan-y-Craig, Builth; one mile north-west of Llanerchymedd; Treiorwerth; Tyn-twr, four miles south of Llangefni (Salter), &c.

In the *Caradoc,* at Moelydd, near Oswestry; Carneddan, Builth; Bettws-y-Coed; Dolwyddelan; Yspytty Evan, Caernarvonshire; south of Llangollen; south-east of Cerrig-y-Druidion, Denbighshire; Llanfyllin; Meifod; Llanwyddyn; Welshpool, Montgomeryshire; and east of Bala Lake (Salter). Eithen Ridge, east of Berwyn Hills; at Horderley, Glyn Ceriog, and in several localities, such as at Helm Gill Dent, in the Coniston Limestone of the Lake district, &c.

In the *Llandovery* at Huntley Hill, May Hill, Presteign; Longwind; Chirbury, &c.

For its occurrence in the *Woolhope* and *Wenlock* Limestones localities have been already given.

In Scotland it occurs in several places near Girvan, in Ayrshire.

In Ireland it has been found in many localities, as Desertcreat, Tyrone, Grangegeeth, &c., County Meath; Knock-Mahon, Tramore, County Waterford, &c.

Abroad it has been found in Russia, Sweden, America, &c., and Mr. Billings mentions the var. *Davidsoni* as being abundant at the Jumpers and in other localities in the Island of Anticosti.

ORTHIS PLICATA, *J. de C. Sow.* (sp.). Pl. XXXV, figs. 25, 26; and Pl. XXXVII, fig. 1.

SPIRIFER ? PLICATUS, *J. de C. Sow.* Sil. Syst., pl. xxi, fig. 6, 1839.
ORTHIS CALLIGRAMMA, var. PLICATA, *Salter.* Mem. Geol. Survey, p. 376, 1848.
— PLICATA, *M'Coy.* Brit. Pal. Foss., p. 222, 1852.
— CALLIGRAMMA, var. PLICATA. *Salter.* Siluria, 2nd ed., pl. v, fig. 7, 1859; and Mem. Geol. Survey, vol. iii, p. 336, pl. xxii, fig. 5, 1866.

Spec. Char. Semicircular or sub-quadrate; hinge-line straight, exceeding the width of the shell; cardinal extremities forming slightly mucronate wings; lateral and frontal margins rounded. Ventral valve evenly and moderately convex; beak not projecting; area triangular, flat, at times large; fissure narrow. Dorsal valve less deep or convex than the opposite one; area narrow. Surface of both valves marked with from forty to fifty or more small, sub-equal, radiating angular ribs, of which a certain number are due to interpolations, the ribs being separated from each other by concave interspaces of lesser width; the whole are crossed by fine concentric lines of growth. Two specimens measured—

Length 11, width 17 lines (Sowerby's figured type.)
„ 12, „ 13

Obs. With the very scanty and incomplete material at my command, I feel quite uncertain whether Mr. Salter was correct or not in considering *O. plicata* as a variety of *O. calligramma.* I therefore prefer following Messrs. Sowerby and M'Coy in provisionally keeping the two under separate designations. One reason for this is the marked external difference in shape existing between Sowerby's figure of *O. plicata* and that of Dalman's *O. calligramma;* for while in the first (Pl. XXXVII, fig. 1) the hinge-line greatly exceeds the width of the shell, the reverse is the prevalent character in Dalman's form. Then, again, the much larger number of ribs in *O. plicata,* of which a portion are due to interpolation, if the shell so labelled by Salter in the Museum of Practical Geology (Pl. XXXVII, fig. 26) does really belong to the form under description. While describing *O. plicata,* M'Coy remarks, at p. 222 of his work already named, that the outline varies considerably, as well as the degree of acuteness of the cardinal angles; and Mr. Salter tells us that "in the var. *plicata* the ribs are numerous, and, though regular and rounded, are frequently interlined; that they are at least twice as numerous as in any of the previously described varieties of *O. calligramma,* viz. *parva, calliptycha, virgata,* and *simplex,* and that they show the cross striæ, and frequently a longitudinal stria in the hollow between the ribs;" but what somewhat puzzles me is that while Mr. Salter retains *O. virgata* and *O. plicata* as distinct varieties of *O. calligramma,* he should state, at p. 287 of the 2nd vol. of the 'Memoirs of the Geological Survey,' that "*O. virgata* and *Sp.? plicatus,* 'Sil. Syst.,' are opposite valves of the same species." Whether, therefore, *O. virgata* should be considered as a synonym (or variety) of the form under description, or of *O. calligramma,* seems to be a question still open to some uncertainty; but as its external form approaches most nearly to some varieties (with small and numerous ribs) of Dalman's species, and as Mr. Salter informs us that its ribs are very regular and equal in size, we have provisionally, at any rate, allowed it to remain where placed by Salter, namely, among the varieties of *calligramma.* It would, however, be necessary, in order to be able to settle the question at issue, to seek for casts of the exterior of the so termed varieties *virgata* and *plicata,* for it is not possible to correctly judge as to the specific value of a new species from the mere inspection of the internal cast of one valve only, and this is all Sowerby was able to offer us in the present case.

Position and Locality. O. plicata is said to be not a very rare shell in the Caradoc-Bala formation, and has been met with at Bryn-gwyn, and in several other places near Bala. Mr. Sowerby mentions also Goleugoed, Llandovery; it was found also by Prof. Sedgwick in the Bala schists of Llansantfraid, Glyn Ceiriog, at Meifod, Mathyrafal, &c.

Orthis Sowerbyiana, sp. nov. Pl. XXXV, figs. 27—31.

Orthis calligramma, var. Walsalliensis, *Salter* (not *O. Walsalliensis*, Dav.). Mem. Geol. Survey, vol. iii, p. 337, pl. xxii, figs. 6, 7.

Spec. Char. Semicircular, longer than wide; hinge-line straight, slightly exceeding the width of shell; cardinal extremities rounded; dorsal valve evenly convex, but flattened at the ears. Surface of valve marked with upwards of fifty small radiating ribs, the larger number of which extend from the beak to the front, with a wide interspace between each two, in the centre of which is another smaller and shorter rib, the whole being crossed by fine concentric lines of growth.

Length 9, width 13 lines.

Obs. Of this species (?) I am acquainted with the exterior and interior of the dorsal valve only, and consequently can offer but a very incomplete description of its form and character. Mr. Salter described it (with a mark of interrogation) as *O. calligramma*, var. *Walsalliensis* (?), Dav., but I am quite certain that it is neither the one nor the other; by its shape and interpolated ribs it is at once removed from *O. calligramma*, and it has not the shape of *O. Walsalliensis*, which last is no more than a variety of *O. rustica*, Sow., as has been already explained. I also found, after a careful examination of the original specimen, that the ribs had not been quite correctly expressed in pl. xxii, fig. 6 *a*, of the 3rd vol. of the 'Memoirs of the Geological Survey.' Mr. Salter, however, states in his description—"This might be described as an extreme form of var. *plicata*, for its shape agrees well. But there are the following differences, which bring it nearer to the var. *Walsalliensis* of the Upper Silurian (ours is a Lower Llandovery variety). The dorsal valve is more convex than in *O. plicata*, and the ribs, instead of being numerous and slightly interlined, divide into bundles of twos and threes from very near their origin, and again, sometimes branching at half-way down, form fascicles of four or five ribs. There is an approach, in the very numerous ribs, to the *O. rustica*, Sow., which I regard also as a variety. That shell and *O. rigida* are, however, square and depressed, the latter furrowed down the middle. The shell here figured is in any case an extreme form, and yet the general aspect of the ribs, their rod-like form, cross striæ, and regular intervals, above all the form and size of the interior tooth (cardinal process) of the upper (dorsal) valve, decide me in referring all these varieties to a single species." I have already explained why I must dissent from this view.

Position and Locality. Lower Llandovery, Gas-works, Haverfordwest; Caradoc of Cefn Llwydlo, Brecknockshire (Salter).

ORTHIS FLABELLULUM, *J. de C. Sow.* Pl. XXXIV, figs. 1—12 *a.*

ORTHIS FLABELLULUM, *J. de C. Sowerby.* Sil. Syst., pl. xix, fig. 8, and pl. xxi, fig. 8, 1839.
— CALLIGRAMMA (pars), *De Verneuil* (not of *Dalman*). Geol. of Russia, vol. ii, p. 207, 1845.
— FLABELLULUM, *M'Coy.* Synopsis Sil. Foss. Ireland, p. 30, 1846.
— — *Salter.* Mem. Geol. Survey, vol. ii, p. 289, 1848, and vol. iii, p. 338, pl. xxi, figs. 9—16, 1866.
— — *J. Hall.* Pal. of New York, vol. ii, p. 254, pl. lii, fig. 6, 1851.
— — *M'Coy* Brit. Pal. Foss., p. 218, 1852.
— — *Salter.* Siluria, 2nd ed., p. 543, pl. v, fig. 12, 1859.

Spec. Char. Transversely semi-oval or slightly sub-quadrate, wider than long, broadest anteriorly; sides and front rounded; hinge-line less than the width of shell. Ventral valve nearly flat, or slightly convex at the beak, widely depressed longitudinally between the beak and frontal margin; area rather narrow, often inclining backwards, with a triangular open fissure in the middle. Dorsal valve uniformly convex; hinge-area narrow. Surface of valves covered by a variable number of radiating ribs, simple for some distance from the beaks, with concave interspaces of about equal width, but augmenting in number from the margin by the interpolation of a smaller rib between each two of the longer ones, or by the bifurcation of some of the original ones, the whole surface being likewise marked by numerous small, equidistant, projecting, concentric lines of growth. In the interior of the dorsal valve the cardinal process is small, and situated between two moderately sized diverging cardinal plates; muscular scars separated into pairs by a wide, flattened, mesial ridge. In the ventral valve the muscular area is square, of moderate size, and with a deep indentation in front. In the ventral valve the external branches of the vascular trunks are turned outwards and backwards, sending off at intervals longitudinal branches, which become divided several times as they near the margin.

Length 12, breadth 15, depth 5 lines.

Obs. Although my distinguished friend M. de Verneuil and some others have been tempted to regard Sowerby's excellent species as a variety of *O. calligramma*, no two forms, when well understood, could be more clearly separate. In *O. calligramma* the ventral valve is regularly convex, in *O. flabellulum* it is flat or concavo-convex. In the first species the dorsal valve is less deep than the ventral, the reverse is the rule with that of Sowerby. Then the general shape of both shells is different, as well as that of their ribbing; and there is also some modification of details in the interior of the valves of both forms. Prof. M'Coy justly observes, "that the width of the ribs as well as the size, presence or absence, of the intermediary short ribs, varies much in different parts of

PLATE XXIII.

SILURIAN SPECIES.

FIG.

1—9. *Rhynchonella Wilsoni*, Sow. 1. Upper Ludlow; S. W. of Hazle, Woolhope. 2. After Sowerby's figure in 'Siluria:' Aymestry Limestone; Aymestry. 3, 4. Internal cast from the Aymestry Limestone; Sedgley. 5, 6, 7. Two large specimens from Wenlock Limestone; Dudley. 8. Variety (*Terebratula crebricosta*, Sow.); from the original specimen; Tynewydd, Llandovery. 9. Variety (*Terebratula pentagona*, Sow.); from the original specimen; Upper Ludlow; Delbury, Shropshire.

10. „ „ var. *sphæroidalis*, M'Coy. After the figure in 'Brit. Pal. Foss.,' pl. i L, fig. 4.

11—14. „ „ var. *Davidsoni*, M'Coy. A series of specimens from the Wenlock Limestone of Dudley.

15. „ „ ? *Anomia lacunosa*, Linné. From the figures in the 'Musæum Tessinianum.'

16. „ „ ? A figure taken from Grew's work; referred by Linnæus to his *Anomia lacunosa*.

17. „ „ ? A figure taken from Martin Lister's 'Historia Animalium;' likewise referred by Linnæus to his *A. lacunosa*.

These figures are here introduced to show how difficult it is to feel certain what was the type form considered by Linné as his *A. lacunosa*.

18. „ „ Dalman's figure of his *Anomia lacunosa*.

19. *Rhynchonella nasuta*, M'Coy. From the original specimen in the Woodwardian Museum, Cambridge. Caradoc; Craigh Head Quarry, Girvan, Ayrshire.

20—24. „ *decemplicata*, Sow. 20. May Hill Sandstone; Eastnor Obelisk, Eastnor Park; Dr. Holl's Collection. 21. May Hill Sandstone; Eastnor; Museum Pract. Geol. 23. After Sowerby's original figures, Llandovery rock; Malvern. 24. Bala Beds; Allt-y-gader, Llanfyllin, North Wales.

25—28. „ *Lewisii*, Dav. From the Wenlock Limestone of Dudley.

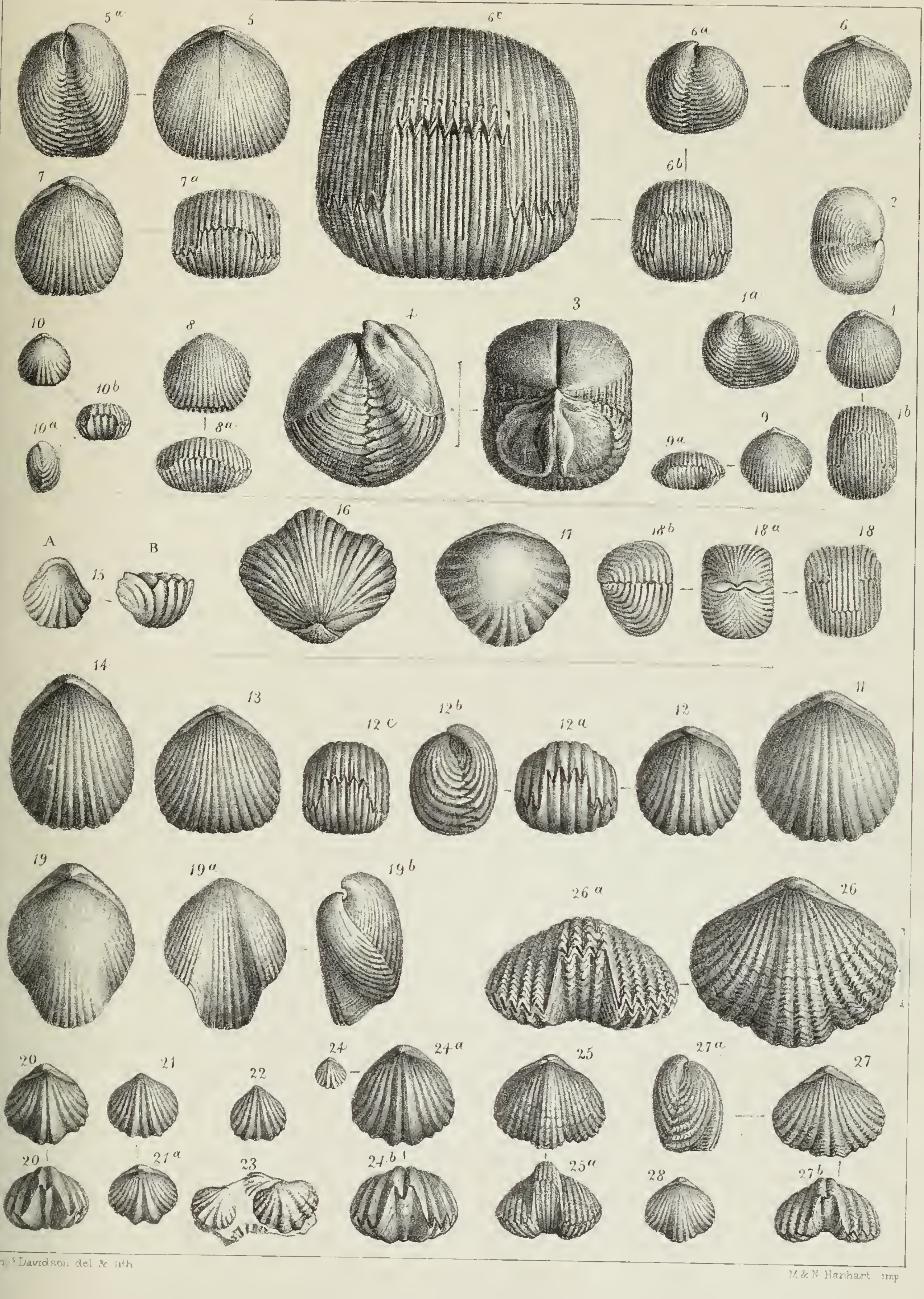


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PLATE XXIV.

SILURIAN SPECIES.

FIG.

1—7. *Rhynchonella nucula*, Sow. 1. After the original figure in the 'Silurian System:' Upper Ludlow; Radnorshire. 2. After the original specimen of *Terebratula pusilla*, Sow.; Lower Llandovery; Cefn-Rhyddan. 3. After Salter's figure in 'Siluria,' 2nd ed., p. 250. 4. Cast; Upper Llandovery; May Hill. 5. Davidson's *Terebratula Pomelii;* Dudley. 6. After Mr. Salter's figures of *Rhyn. semisulcata.* 7. The specimen named *Rh. obtusiplicata* by Salter in the Geological Survey Museum; Upper Llandovery; Worcester Beacon.

8—13. ,, *Llandoveriana*, Dav., = *serrata*, M'Coy. 8. After M'Coy's original figure; Boocaun, Cong, Ireland. 9. From Lettershanbally. 10. Internal cast of ventral valve; from Outerard; 10 *a*. Enlarged. 11. From Shanballymore. 12. Upper Llandovery; Damory Bridge, Tortworth. 13. From Lettershanbally.

14. ,, *Weareri*, Salter, MS. Upper Llandovery; Long's Quarry, Tortworth. Museum of the Geological Society.

15, 16. ,, *tripartita*, Sow. 15. After Sowerby's original figure. 16. From a gutta-percha impression of the same specimen. Golengoed, in Lower Llandovery. Mus. Geol. Soc.

17. ,, *neglecta*, Sow. After the original specimen. Upper Llandovery; Llandovery. Mus. Geol. Soc. According to Messrs. Phillips and Salter, this is the same as *Rh. nucula*.

18. ,, *Thomsoni*, Dav. 18. Natural size. 18 *a*, *b*, *c*. Enlarged. Caradoc; Craig Head Quarry, Girvan, Ayrshire.

19, 20. ,, *Salteri*, Dav. 19. Caradoc; Penwhapple Burn, Girvan, Ayrshire. 20. Boduan, Caernarvonshire. Mus. Geol. Survey.

21. ,, ? *æmula*, Salter, MS. Caradoc; Chair of Kildare. Mus. Geol. Survey.

22. ,, ? *Beltiana*, Dav. Upper Silurian; Cahireconree. Mus. Geol. Survey of Ireland.

23—25. ,, ? *Portlockiana*, Dav. Caradoc; Chair of Kildare. 24. Mus. Geol. Survey.

26. ,, ? *nana*, Salter, MS. Caradoc; Tyrone. Coll. of the late Mr. Wyatt-Edgell.

27, 28. ,, ? *Edgelliana*. Near Fairfack, Llandeilo, Wales. Coll. of the late Mr. Wyatt-Edgell.

29. *Triplesia*? *Maccoyana*, Dav. Brynbedwog Quarry, near Bala; in Bala Limestone. = *Hemithyris depressa*, M'Coy, not of Sow. Woodwardian Museum, Cambridge.

30. *Atrypa*? *incerta*, Dav. Upper Llandovery; Penhill, Ayrshire. Hunterian Museum, Glasgow.

31, 32. *Triplesia Grayiæ*, Dav. Caradoc; Craig Head Quarry, Girvan, Ayrshire. 31. In the Hunterian Museum, Glasgow.

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PLATE XXV.

SILURIAN SPECIES.

Fig.		
1—2.	*Cyrtia? nasuta*, Lindström, sp.	Wenlock Limestone; Dudley. 1. In the British Museum. 2. In the Rev. H. G. Day's Collection.
3—5.	*Triplesia? monilifera*, M'Coy, sp.	Caradoc; Chair of Kildare, Ireland. 4 and 5. Mus. Geol. Survey.
6.	*Atrypa? apiculata*, Salter, MS.	Caradoc; Chair of Kildare. Mus. Geol. Survey.
7, 8.	*Atrypa? incerta*, Dav.	Upper Llandovery; Penhill, Ayrshire.
9, 10, 11.	*Triplesia Grayiæ*, Dav.	9, 10. Penwhapple Glen, Ayrshire. 11. Pistyll Deroi, Llandeilo. Mus. Geol. Survey.
12—15.	*Eichwaldia Capewelli*, Dav.	12—14. Wenlock Limestone; Dudley. 12 *a*. Specimen enlarged. 12 *b*. Sculpture, greatly magnified. 13 *a*. Section of an American specimen (*Eichwaldia corallifera*, Hall), after Prof. J. Hall. 15. Internal cast, enlarged. Woolhope Limestone; between Alfrick and Crews Hill. Mus. Geol. Survey.
16.	*Porambonites intercedens*, Pander, var. *filosa*, M'Coy.	Caradoc; Dunabrallin, Waterford. Mus. Geol. Survey.
17—19.	,, ,,	? Caradoc; Wrae Quarry, Peebleshire. Woodwardian Museum, Cambridge. Specimens so named by Prof. M'Coy.

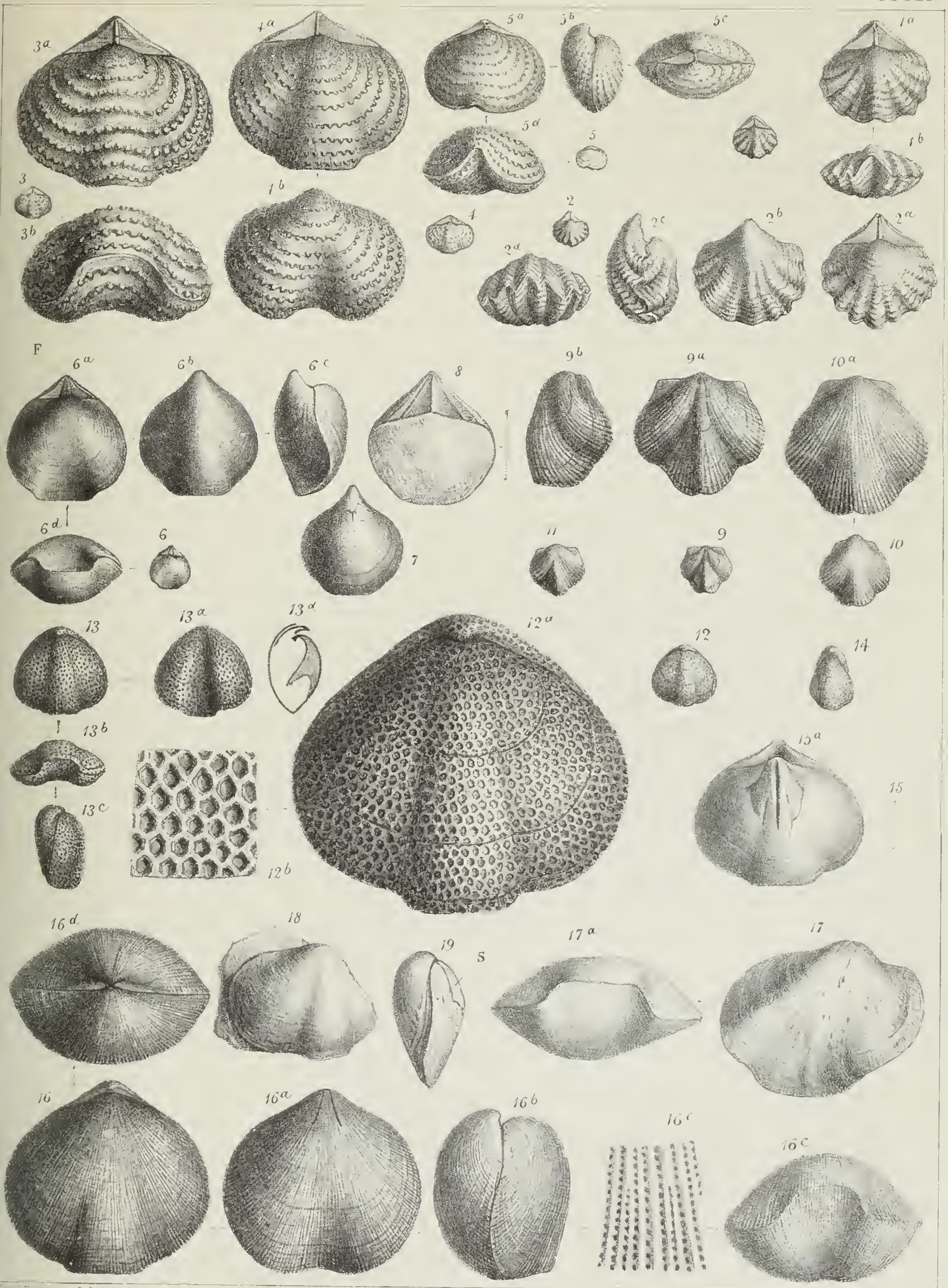

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PLATE XXVI.

SILURIAN SPECIES.

Fig.		
1, 2.	*Porambonites*? *intercedens*, var. *filosa*?	Caradoc; Dunabrattin, Waterford. Mus. Geol. Survey, Ireland.
3.	,, ,,	Wrae Quarry, Peebleshire. Woodwardian Museum, Cambridge.
4—9.	*Orthis Lewisii*, Dav.	6—8. Wenlock Limestone; near Dudley. 8 *a*. Interior of ventral, and 8 *b*, of dorsal valve, enlarged. 9. Internal cast of dorsal valve, from Wenlock Shale; Pentland Hills, Scotland.
10—15.	,, *biloba*, Linné, sp.	A series of variations in shape and age. Wenlock Limestone; Walsall, Dudley, Buildwas, Pentland Hills, &c. 12. Caradoc; Cefn-Rhyddan. Mus. Geol. Survey.
16—23.	,, *Bouchardii*, Dav.	16—22. Several variations in shape and age, from the Wenlock Limestone of Benthall Edge. 22. Interior of dorsal, 22 *a*, interior of ventral valve, enlarged. 23. A specimen from Penwhapple Glen, Ayrshire, in Mus. Geol. Survey, supposed to be from the Llandovery beds.

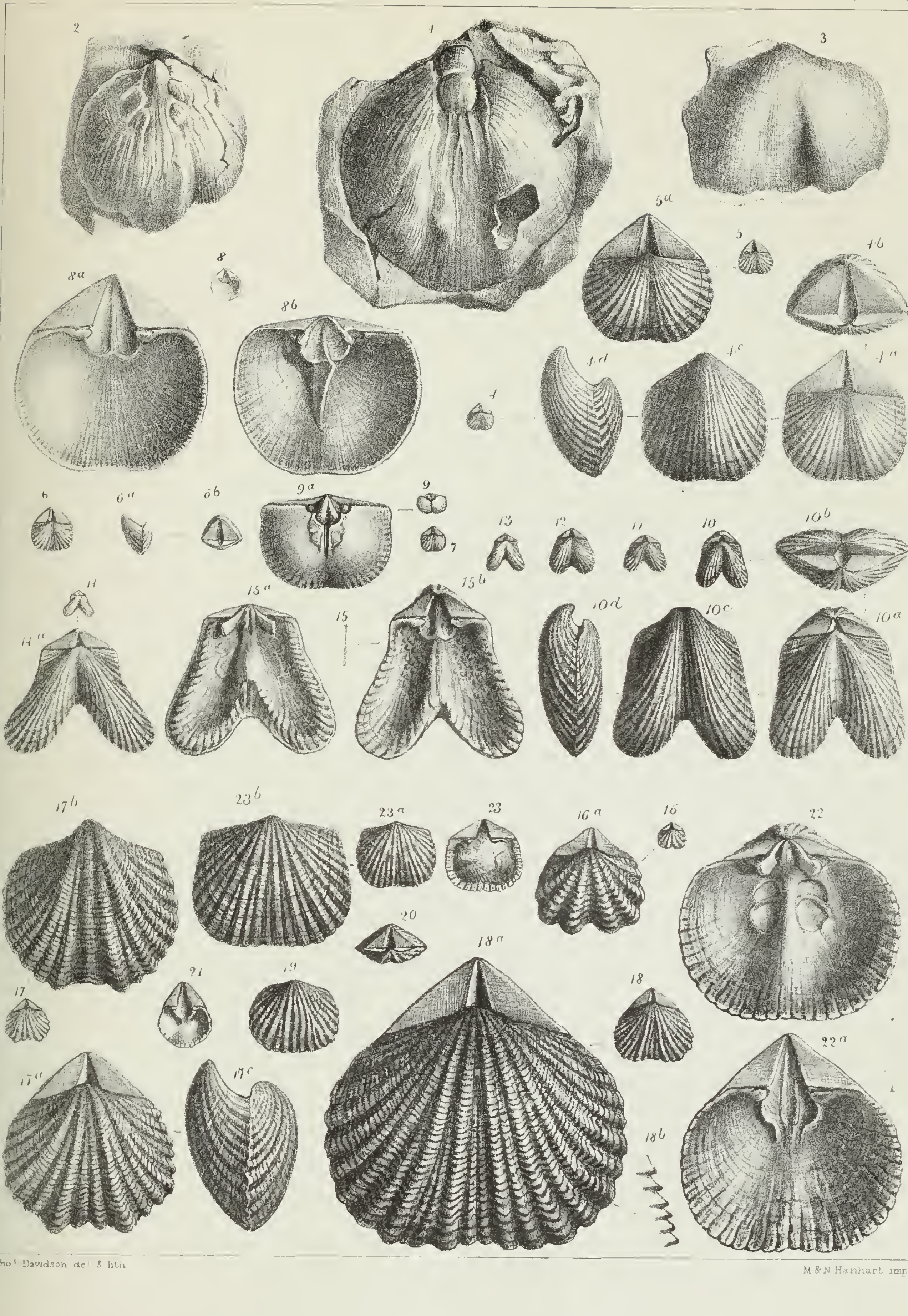

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PLATE XXVII.

SILURIAN SPECIES.

Fig.

1—9. *Orthis elegantula*, Dalman. 1—6. Different forms, from the Wenlock Limestone of Dudley and near Walsall. 7 *a*. Interior of the ventral valve, enlarged. 7 *b*. Interior of dorsal valve. 8. Interior of dorsal valve seen from the hinge-line, showing the projecting cardinal plates and process. 9 and 9 *a*. Internal casts, enlarged; from Wenlock Shale; Slate Mill, Pembrokeshire. Mus. Geol. Survey.

10—11. ,, *basalis*, Dalman (according to Lindström). Wenlock Shale; Falfield, near Tortworth.

12—13. ,, *canaliculata*, Lindström. Aymestry Limestone; Sedgley, near Wolverhampton.

14. ,, *elegantula*, var.? Bala Limestone; Blaeny Crom, Denbighshire. Mr. Davies' Collection.

15—16. ,, *hybrida*, Sow. Wenlock Limestone; Dudley. 16. Interior of dorsal valve, enlarged. 16 *a*. Interior of ventral valve, enlarged.

17—19 *a*. ,, *crassa*, Lindström. 17. Wenlock Limestone; Garcoed, near Usk. 18. Wenlock Limestone, Malverns. 19. Interior of dorsal valve, enlarged; Lower Ludlow; near Martley. 18 and 19. In Coll. Geol. Survey.

20. ,, ? ,, Species not determined; supposed to be a very large var. of *O. hybrida*; from Wenlock Limestone; near Walsall.

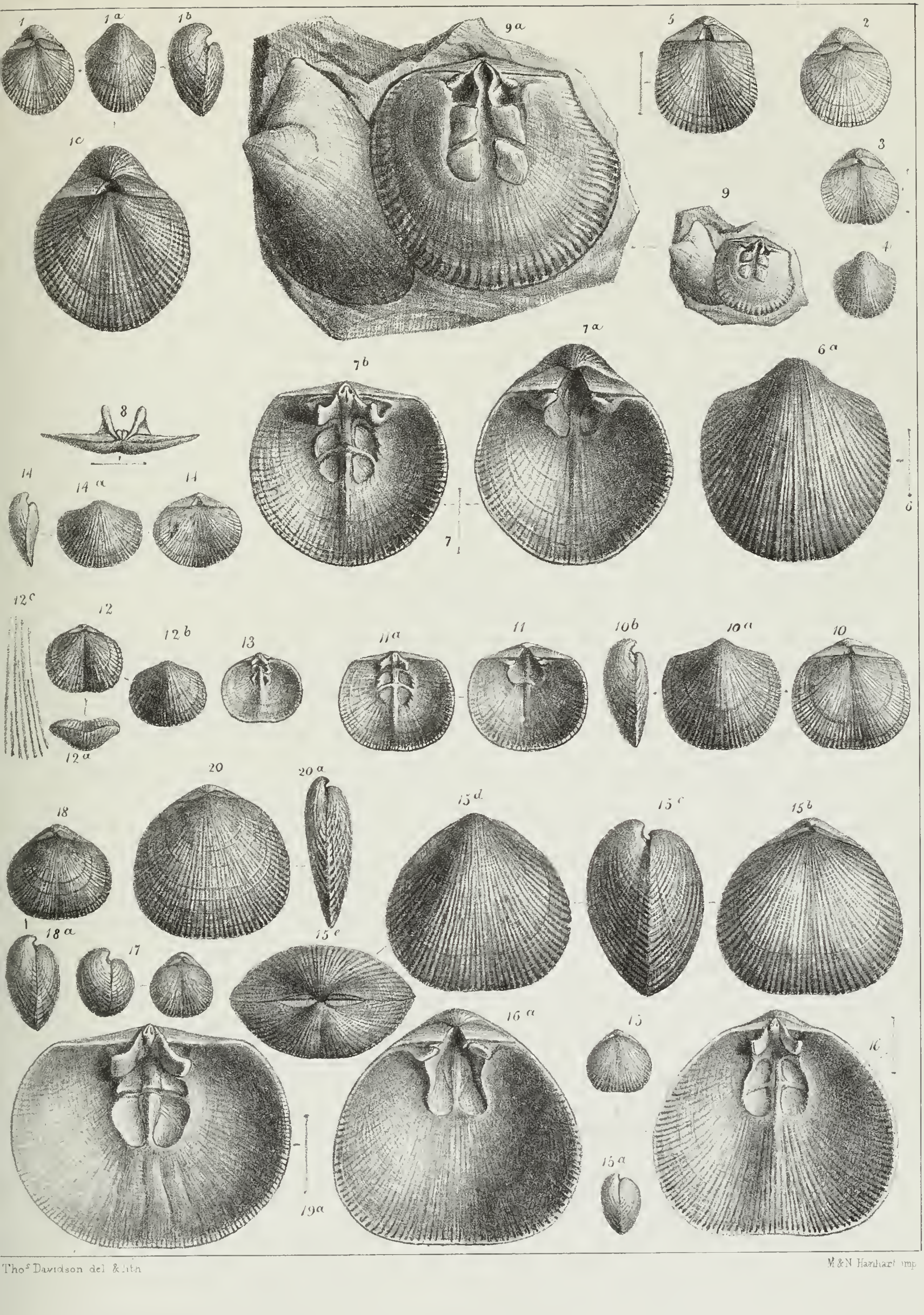

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PLATE XXVIII.

SILURIAN SPECIES.

FIG.

1—5. *Orthis lunata*, Sow. 1. Upper Ludlow; Wonder, Woolhope. 2. Internal and external casts. Upper Ludlow; Whitecliffe, near Ludlow. 3. Internal cast of dorsal valve, enlarged. 3 *a*. A gutta-percha impression, taken from the same cast, and enlarged. Upper Ludlow; Wonder, Woolhope. Coll. of Geol. Survey. 4. Mould in gutta-percha, from an internal cast (4 *a*) of the ventral valve; both enlarged. Coll. of Geol. Surv. 5. Interior of ventral valve. Ludlow.

6—9. ,, *redux*, Barrande? Lower Silurian; Budleigh Salterton, Devonshire. 6. Complete form, taken with gutta-percha from an external cast. 7. Internal casts. 8. Interior of ventral valve; 8 *a*, of dorsal valve. 9. Internal cast of dorsal valve. These last three figures are enlarged.

10. ,, *Girvaniensis*, Dav. Caradoc; Craig Head Quarry, Girvan, Ayrshire.

11. ,, *elegantula*, Dal. (*O. canalis*, M'Coy). From moulds in gutta-percha, taken from internal casts. Kilbride, Cong. In the Collection of Sir R. Griffith.

12. ,, *parva*, Pander? According to M'Coy. From Egool, Ballaghaderreen. Sir R. Griffith's Collection.

13—24. ,, *testudinaria*, Dalman. 13. Caradoc; Grug, Llandeilo. 14—19. Different specimens figured by Mr. Salter in vols. ii and iii of the 'Memoirs of the Geol. Survey,' from the Caradoc of Cheney Longville; Cefn Rhyddan, &c. 20. Internal cast of ventral valve, enlarged. Caradoc; Narberth. 21. Interior of the same valve. Llandeilo Flags; Pantdwfn, Carmarthenshire. 21 *a*. Interior of dorsal valve, enlarged. 22. Internal cast of ventral valve, from Gorrans, Cornwall (Llandeilo Flags). 23, 24. After Mr. Salter's figures. From Durness, Sutherlandshire; in Llandeilo Flags. All these specimens are in the Museum of the Geological Survey.

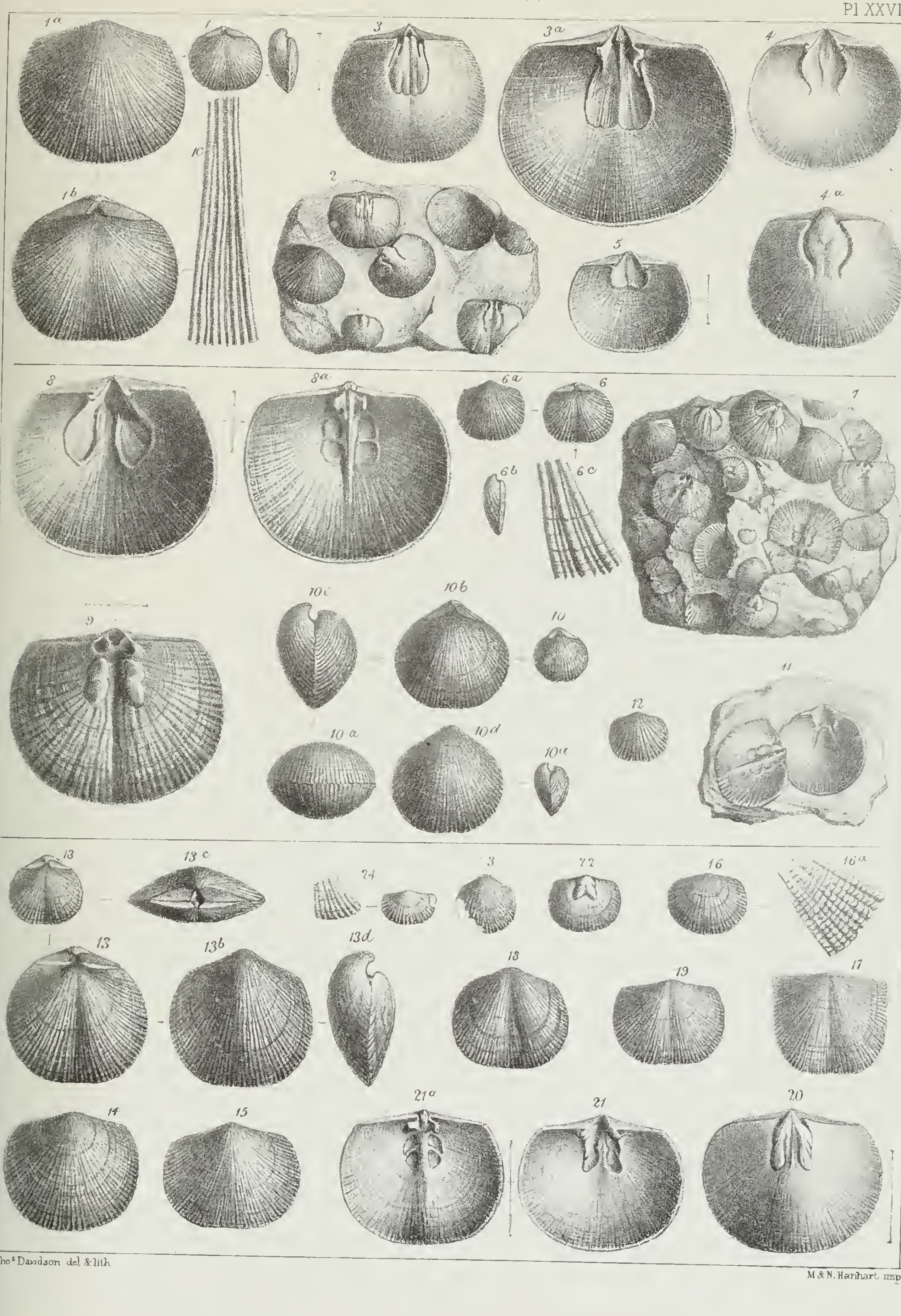

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PLATE XXIX.

SILURIAN SPECIES.

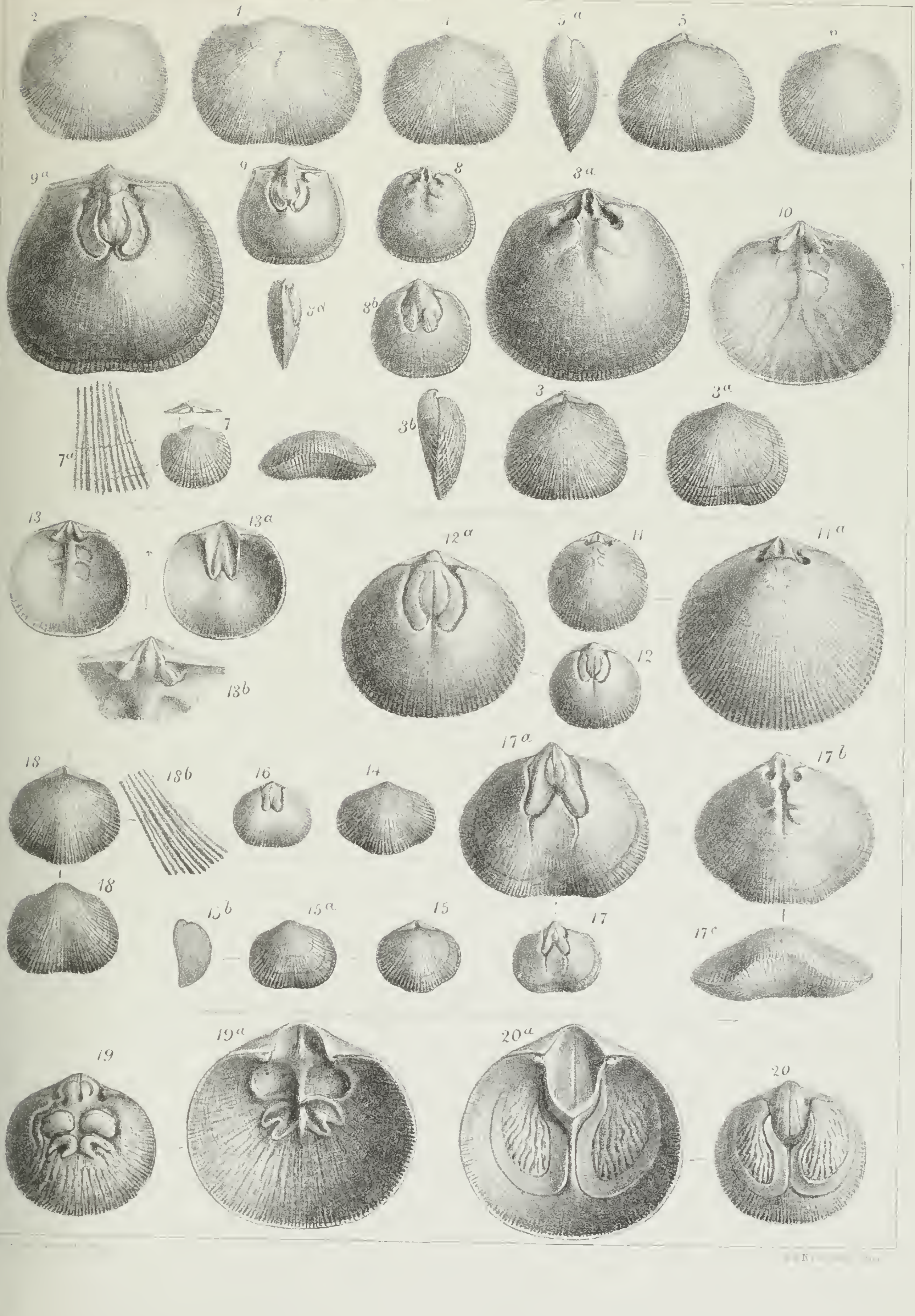
FIG.

1—10. *Orthis polygramma,* Sow. 1, 2. The two original specimens figured in 'Silurian System.' Powis Castle Park. Mus. Geol. Society. 3. Lower Llandovery; Gorlwyn. Mus. Geol. Soc. 4—7. Wenlock Shales; near the North Esk Reservoir, Pentland Hills. 4 and 5 are in the Mus. Geol. Survey. 8, 8 *a*. Internal cast of dorsal valve. 8 *b*, 8 *c*. Internal cast of ventral valve. 9. Internal cast of ventral valve. 10. Interior of dorsal valve; taken in gutta-percha from an internal cast, from the Pentland Hills. Mus. Geol. Survey.

11—13. ,, *reversa,* Salter. 11. Internal cast of dorsal valve; 12, of ventral valve. 11 *a* and 12 *a*. Magnified. The original specimen figured in the 'Synopsis Sil. Foss. of Ireland,' from Egool, Ballaghderra, and Cappacorcogue, Cong. Sir R. Griffith's Coll. 13. Lower Llandovery; Mandinam, near Llandovery. Mus. Geol. Survey.

14—18. ,, ,, var. *Mullochiensis.* 14, 15. Llandovery rock; Mulloch Quarry, Dalquorhan, Ayrshire. 16, 17. Internal cast of both valves. Same locality. 18. Woolhope Limestone; Sandbanks, Presteign. Mus. Geol. Survey.

19—20. ,, *Bailyana,* Dav. Caradoc beds; Townland of Ballybro, one mile north of Tagot, County Wexford. Mus. Geol. Survey of Ireland. 19. Internal cast of dorsal valve. 19 *a*. Interior of the same valve, taken from a cast, enlarged. 20. Internal cast of ventral valve. 20 *a*. Interior of ventral valve, taken from a cast, enlarged.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12 a
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18 b
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17 a
17 b
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15 b
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17 c
19 a
20 a
19
20

PLATE XXX.

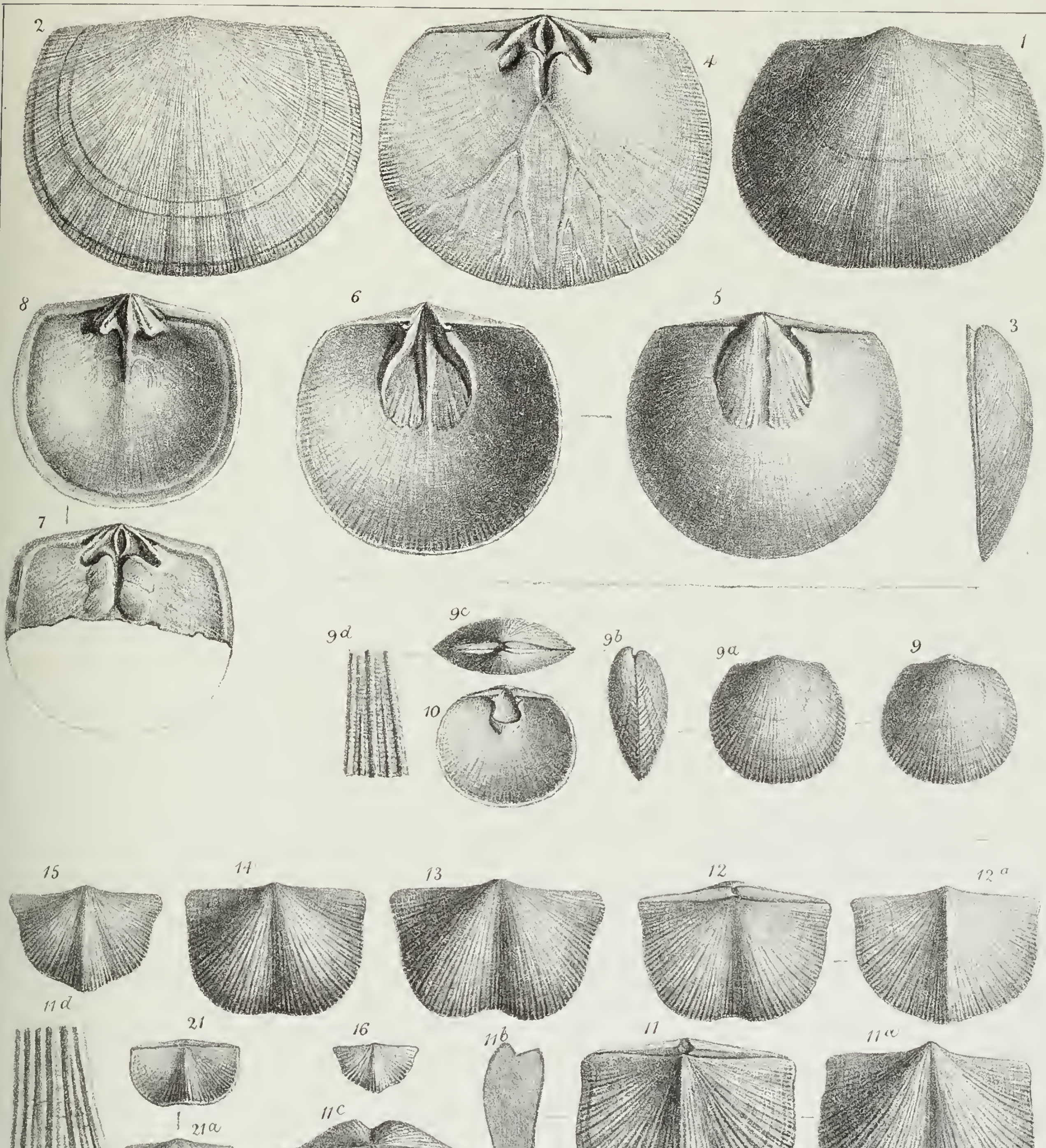
SILURIAN SPECIES.

FIG.

1—8. *Orthis patera*, Salter, MS. 1. Exterior of ventral valve. 2. Exterior of dorsal valve. 3. Profile of the two valves. 4. Internal cast of dorsal valve; 5, of ventral valve. 6. Interior of ventral valve, taken in gutta-percha from a cast. 7. Internal cast of dorsal valve. 8. Interior of the same valve. All from Caradoc; Corston Farm; Hopesay. Museum Geol. Survey.

9, 10. ,, *æquivalvis*, Dav. Wenlock Shale; near Walsall. 10. Interior of ventral valve.

11—21. ,, *vespertilio*, Sow. 11. From the original specimen figured in the 'Silurian System.' Caradoc; Acton Scott. 11*d*. Portion of shell, magnified. Mus. Geol. Soc. 12. Caradoc; Craig Head Quarry, Girvan, Ayrshire. 13. Portrane, County Dublin. 14—16. Caradoc; Harnage, south-east of Shrewsbury. 17. Internal cast of dorsal valve. Caradoc; Acton Scott. Mus. Geol. Soc. (Original specimen figured in 'Silurian System,' pl. xix, fig. 7.) 18. Interior of the same, taken in gutta-percha from a cast. 19. Internal cast of ventral valve; near Bala. 20. Interior of ventral valve, taken in gutta-percha from an internal cast. Gretton. 21. From Rathdrum, Wicklow. Mus. Geol. Survey of Ireland.



Thos Davidson del & lith.

M & N Hanhart imp

PLATE XXXI.

SILURIAN SPECIES.

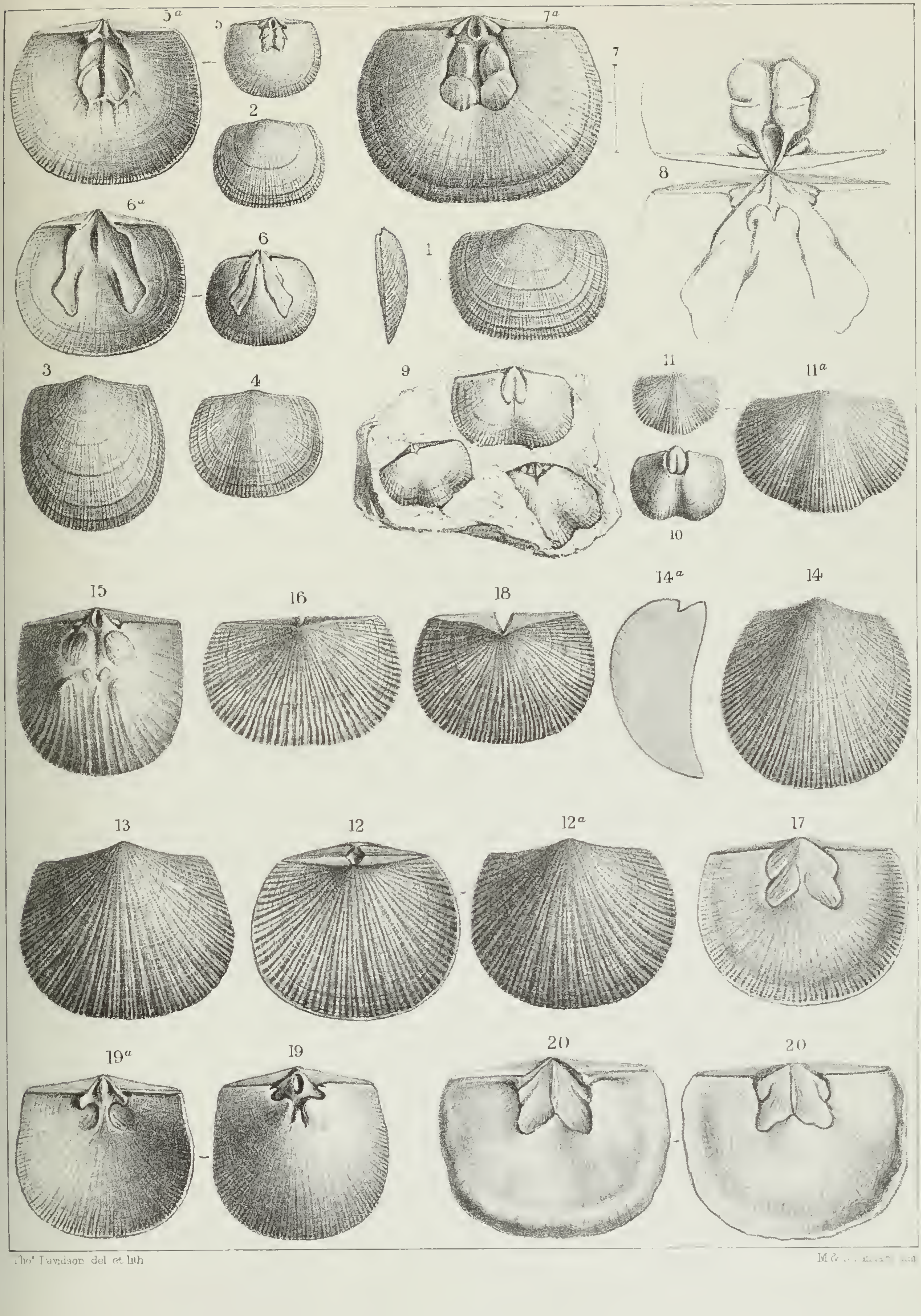
Fig.

1—8. *Orthis alternata*, Sow. 1, 2, 3. Caradoc; Pentre, Llymru, Llanfyllin. Mus. Geol. Survey. 4. Caradoc; Eglways Anne, north of Bala. Same Museum. 5. Internal cast of dorsal valve. 5 *a.* Interior of dorsal valve; from a gutta-percha mould taken from the cast and enlarged. 6. Internal cast of ventral valve. Caradoc; Ketch, Llanfyllin. 6 *a.* Interior of valve, taken in gutta-percha from internal cast and enlarged. 7. Internal cast of dorsal valve, enlarged. From Cheney Longville. Mus. Geol. Survey. 8. Figure taken from an unpublished plate prepared by the Geol. Survey. The figure is enlarged, and shows the internal cast of both valves.

9—11. ,, *fallax*, Salter. 9. After the original figure in the 'Synopsis Sil. Foss. of Ireland.' Caradoc; Desertcreat, Tyrone. Coll. of Sir R. Griffith. 11. From Killey, Pomeroy. Same Collection. 10. Internal cast of ventral valve. Desertcreat. Mus. Geol. Survey.

12—20. ,, *porcata*, M'Coy. 12. Coniston Limestone; Coniston. Mus. Geol. Soc. 13. Portraine, County Dublin. Mus. Geol. Survey of Ireland. 14. Moelydd, near Bala. 15. Internal cast of dorsal valve, after a figure by M'Coy, in 'Brit. Pal. Foss.' Coniston. 16. Another figure, from the same work and the same locality. 17. Var. *grandis*, Portlock. Internal cast of ventral valve. 18. Var. *inflata*, Salter. Coniston Limestone; Westmoreland. 19. Internal cast of dorsal valve. = *O. grandis*, Pollock (not Sow.). Desertcreat, Tyrone. 19 *a.* Interior of the same valve, from a gutta-percha impression taken from the cast. 20. Internal cast of ventral valve. Same locality. 20 *a.* Interior, taken from the cast. Portlock's original specimens in the Museum of the Geol. Survey.

SILURIAN.

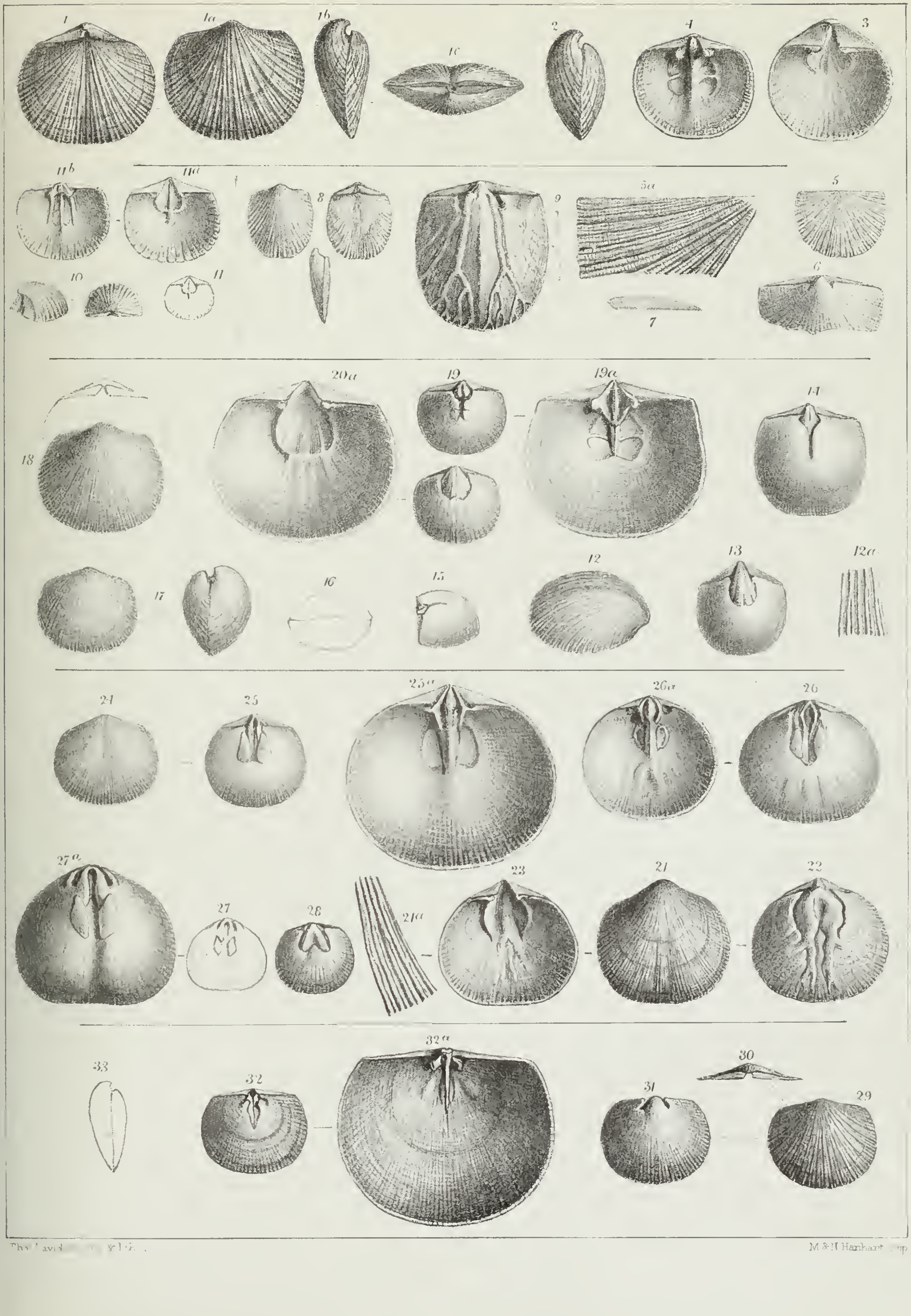


Thos Davidson del et lith
M & ... imp

PLATE XXXII.

SILURIAN SPECIES.

Fig.		
1—4.	*Orthis Edgelliana*,	Salter, MS. Upper Wenlock; Garcoed, near Usk. Coll. of the late Mr. Wyatt-Edgell. 3. Interior of ventral valve. 4. Interior of dorsal valve.
5—9.	,, *Hirnantensis*,	M'Coy. 5, 6, 7. After Prof. M'Coy's original figures. Bala Limestone; Aber Hirnant. 8. A small complete specimen from the same locality. 9. Internal cast of dorsal valve, enlarged. Hirnant.
10, 11.	,, *simplex*,	M'Coy. 10. After the original figure in the 'Synops. Silur. Foss. Ireland.' Carrickadaggan, County Wexford. 11. Interior of ventral valve; 11 *a*, enlarged. 11 *b*. Interior of dorsal valve, enlarged. Caradoc; Chair of Kildare. Mus. Geol. Survey.
12—20.	,, *turgida*,	M'Coy. 12—16. After Prof. M'Coy's original figures. Lower Llandovery Limestone; Llandeilo. 17. Caradoc; Penllech, Ysputty Evan. 18. Penhill, Ayrshire. 19. Internal cast of ventral valve. 19 *a*. Interior of the same valve, enlarged; from a gutta-percha mould taken from the cast. 20. Internal cast of ventral valve. 20 *a*. Interior of same valve, made from the cast, enlarged. Penllech, Ysputty Evan.
21—28.	,, *Berthoisi*,	Rouault, var. *erratica*. From pebbles of quartzite of Llandeilo (?) age, Budleigh-Salterton, Devonshire. 25, 26, 27. Interior of dorsal valve. 22, 23, 28. Interior of ventral valve. From the Collections of Messrs. Vicary and Valpy.
29—33.	,, *Valpyana*,	Dav. Budleigh-Salterton. Coll. of Mr. Vicary. 32 *a*. Interior of dorsal valve.



M & N Hanhart imp.

PLATE XXXIII.

SILURIAN SPECIES.

Fig.		
1—7.	*Orthis Carausii*, Salter, MS.	1—4. Complete form, drawn from gutta-percha moulds taken from external casts. Lower Llandeilo or Arenig rocks; Tremanhire, near St. David's. 5. Internal and external casts, showing their natural shape in a yellow sandstone; from Tremanhire. 6. Distorted internal casts; from Ramsey Island, near St. David's. 7 *a*. Interior of ventral; 7 *b*, of dorsal valve.
8—12.	,, *Menapiæ*, Hicks, MS.	From the Lower Llandeilo or Arenig group of Ramsey Island. 8. Perfect form, from gutta-percha moulds made from external casts. 9. Distorted internal and external casts. 10. Profile view of both valves. 11. Internal cast of dorsal valve; 12, of ventral valve.
13—16.	,, *Hicksii*, Salter, MS.	From the Middle (sandstone) beds of the Menevian group or Lower Lingula-flags of Ninewells and Porth-y-rhaw, near St. David's. 13, 14, 15. Complete form, taken by the means of gutta-purcha from external casts. 16. Internal cast of ventral valve.
17—21.	,, *alata*, Sow.	17. After the figure in the 'Silurian System.' Llandeilo Flags; Pensarn, Caermarthenshire. 18, 19. Complete forms, taken from external casts by means of gutta-percha; 18 *a*, enlarged. 20. Internal cast. 21. Portion of the shell, enlarged.
22—29.	,, *lenticularis*, Wahlenberg, sp.?	From the Upper Lingula-flags. 22—25. After figures by Salter, in vol. iii, pl. iv, of the 'Memoirs of the Geol. Survey.' Penmorfa Church, Tremadoc. 26. Complete form, drawn from gutta-percha moulds taken from external casts. Ogof-ddu Cliff, North Wales. 27. A very large flattened specimen from Rhiw Felyn. Mr. Plant's Collection. 28, 29. Gwerny-y-Barcud ("Dolgelly group" of Belt).

Thos Davidson del & lith. M & N Hanhart imp

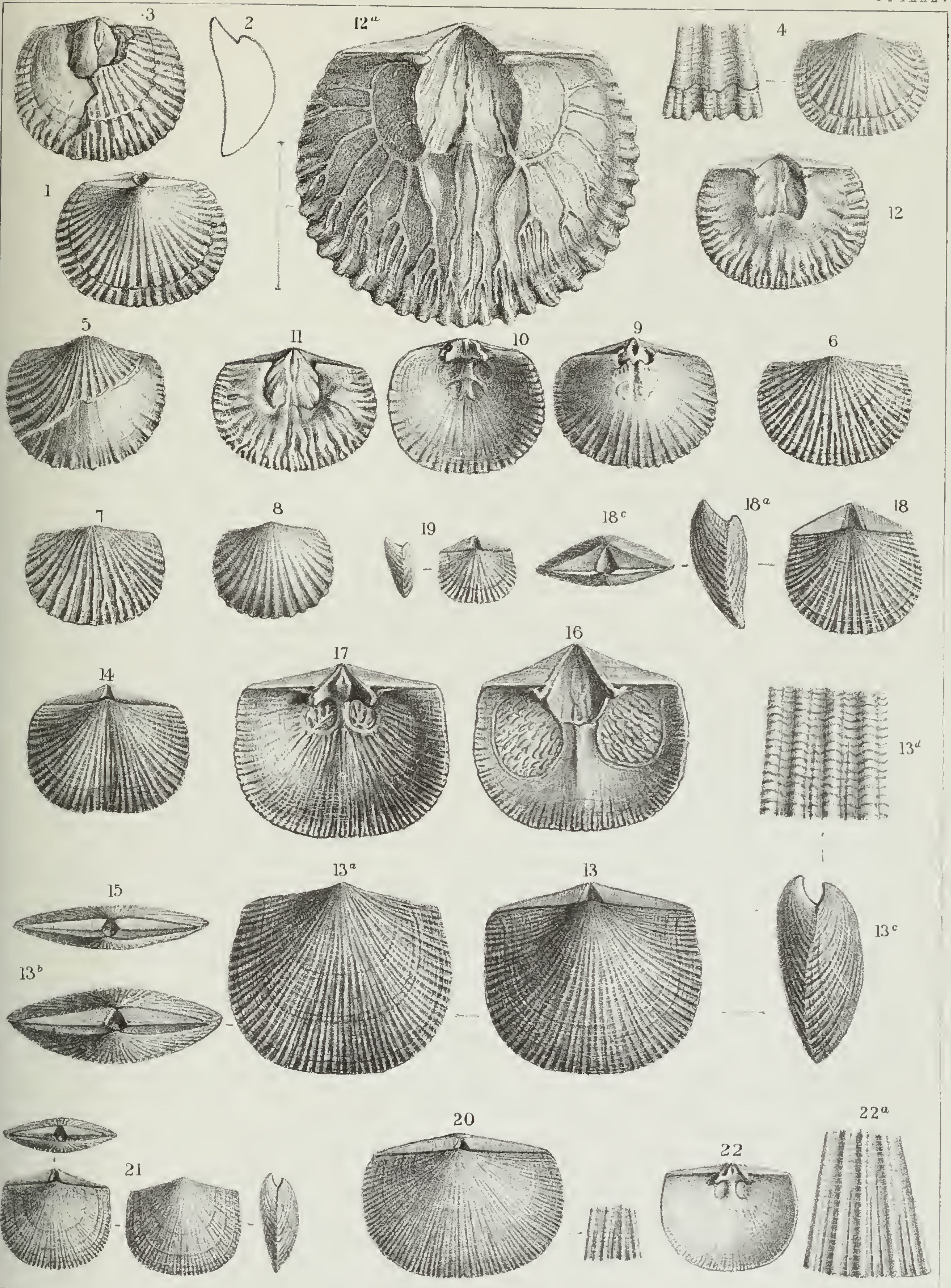
PLATE XXXIV.

SILURIAN SPECIES.

FIG.

1—12 *a*. *Orthis flabellulum*, Sow. 1. Perfect specimen. 2. Profile view of both valves. 3. Ventral valve, with part of the internal cast seen. 4. Dorsal valve, showing the bifurcation (and even trifurcation) of the ribs near the margin. 5. Dorsal valve. 6. Ventral valve, with ribs bifurcated. 7. Var. *multifida*, Salter. 8. Dorsal valve. 9. Internal cast of dorsal valve. 10. Interior of the same valve. 11, 12. Internal casts of ventral valve. 12 *a*. Interior of the ventral valve, enlarged, showing well the muscular and vascular impressions. All these specimens are from the Caradoc Sandstone of Boduan, Carnarvonshire, and are drawn mostly from specimens in the Museum of the Geological Survey, and of which a few had also been previously figured by Salter in 2nd vol. of the 'Memoirs Geol. Survey.' 12 *a* is from a fine internal cast in the Woodwardian Museum, Cambridge.

13—22. ,, *rustica*, Sow. 12, 14, 15. Wenlock Limestone; Rushall Canal, near Walsall. 16. Interior of ventral; 17, of dorsal valve. Same locality. 18, 19. Var. *rigida*, Dav. Benthall Edge. 20—22. Var. *Walsalliensis*, Dav. 20. From Rushall Canal. 21. From Buildwas, near Wenlock. 22. Interior of dorsal valve. 22 *a*. A portion of the shell, enlarged.



Thos Davidson del et lith

M & N Hanhart imp

PLATE XXXV.

SILURIAN SPECIES.

Fig.			
1—3.	*Orthis calligramma*, Dalman.		Caradoc; Moelydd, near Bala.
4.	,,	,,	Caradoc; Craig Head, Girvan, Ayrshire.
5.	,,	,,	Caradoc; Grangegeeth, County Meath. Mus. Geol. Survey of Ireland.
6.	,,	,,	Caradoc; var. with numerous small ribs. Craig Head, Girvan. Coll. of Mr. J. Thomson.
7.	,,	,,	Caradoc; Lamby, Ireland.
8.	,,	,,	Large Lower Llandovery variety; Cong, Galway. Mus. Geol. Survey.
9.	,,	,,	Interior of dorsal valve. Caradoc; Desertcreat, Tyrone. Same Museum.
10, 11.	,,	,,	Internal casts of dorsal and ventral valves. Grangegeeth, Ireland.
12.	,,	,,	Very fine internal cast of ventral valve. From the Caradoc of Das Eithen Ridge, east of the Berwyn Hills.
13, 14, 15.	,,	,,	Var. *proava*, Salter. After figures in vol. iii, 'Mem. Geol. Survey.' Upper Llandeilo rocks; Llanerchymedd, Anglesea.
16.	,,	,,	Var. *calliptycha* (Sow.), Salter. Id. Caradoc slates; Pembrokeshire. (This strongly resembles *O. Davidsoni.*)
17.	,,	,,	(*O. callactis*, Sow.) After the figure in 'Sil. System.'
18, 19.	,,	,,	Var. *Davidsoni*, De Verneuil. Wenlock Limestone; Rushall Canal, near Walsall. Mus. Geol. Survey.
20—22.	,,	,,	Var. *Scotica*, M'Coy (*Orthisina Scotica*, M'Coy). Caradoc; Craig Head Quarry, near Girwan. 20. After M'Coy's figure.
23, 24.	,,	,,	Var. *virgata* (according to Mr. Salter). 23 and 24 *a* are from figures in vol. iii, 'Mem. Geol. Survey.' Caradoc; Cwm-Gwynen-Uchaf, Montgomeryshire. Mus. Geol. Survey.
25, 26.	,,	*plicata*, Sow.	*O. calligramma*, var. *plicata*, Salter. 25. Internal cast of dorsal valve, after Salter's figure in vol. iii, 'Mem. Geol. Surv.' Caradoc; Bala. 26. Caradoc; south-west of Bryn, Bedwog. Mus. Geol. Survey.
27—31.	,,	*Sowerbyana*, Dav.	*O. calligramma*, var. *Walsalliensis*, Salter (not of Davidson). 27, 29, 30. From Mr. Salter's figures, 'Mem. Geol. Survey,' vol. iii. Lower Llandovery; Gas Works, Haverfordwest; and Caradoc of Cefn Llwydlo, Brecknockshire. 28 and 31. Specimens from same locality.

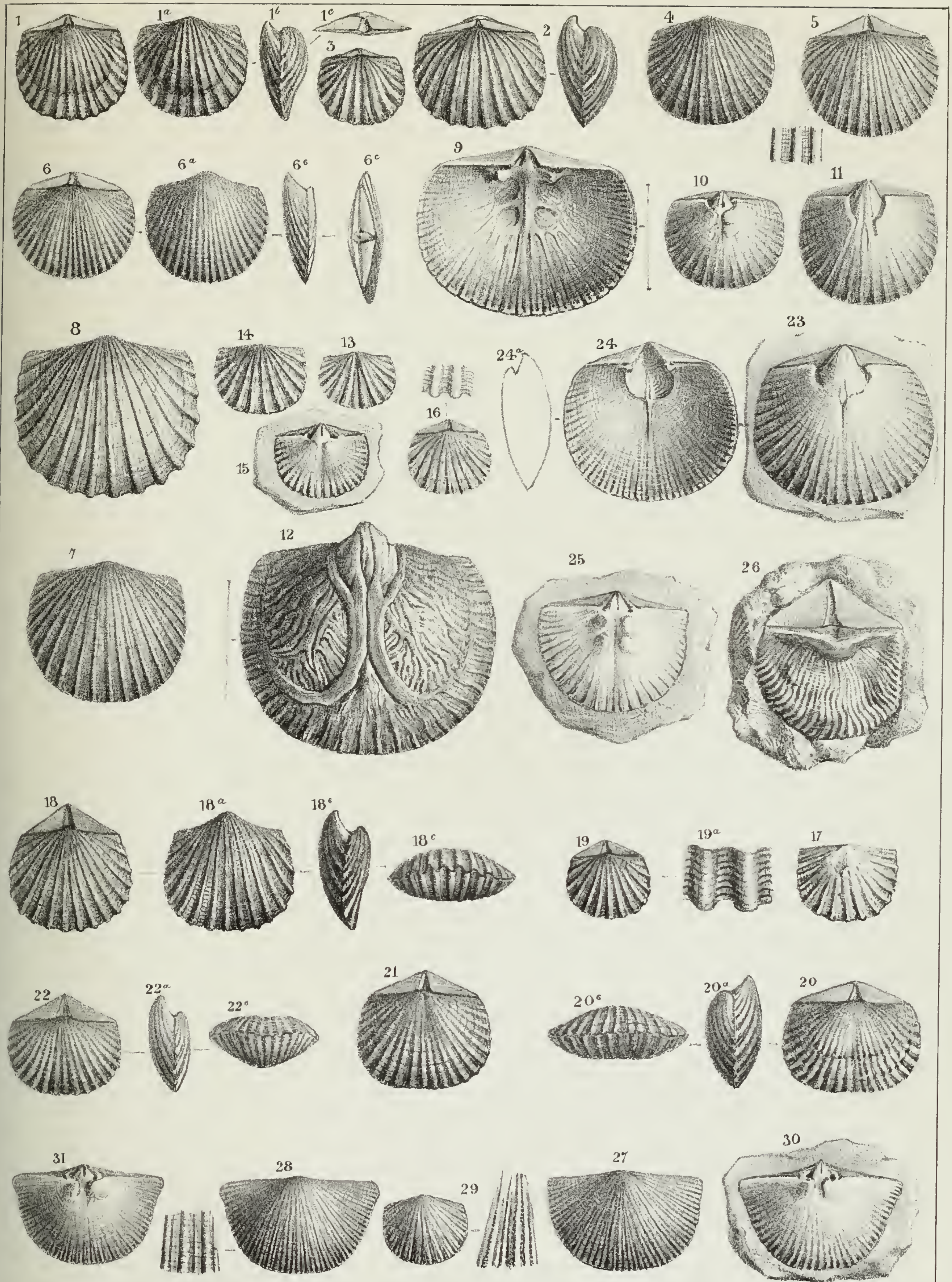


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PLATE XXXVI.

SILURIAN SPECIES.

Fig.		
1—4.	*Orthis confinis*, Salter.	1. From the original figures, 'Quart. Journ. Geol. Soc.,' vol. vii. Llandeilo beds; Bogang, Knochdolian, Ayrshire. 2. Stincher River, Ayrshire. 3. Bogang. Mus. Geol. Survey. 4. Internal cast of dorsal valve. Mullock Hill, Ayrshire.
5—17.	,, *Actoniæ*, Sow.	5. Caradoc; Bryn Bedwog, near Bala. Geol. Survey Mus. 6. Moelydd. 7. Robeston, Pembrokeshire. Geol. Survey Mus. 8, 9, 10, 11, 13, 14. After Salter's figures in 'Mem. Geol. Survey,' vol. iii. South Wales, in Caradoc; also from Lower Llandovery specimens in Mus. Geol. Survey. 12. Llandeilo Flags; Garn Arenigs. Geol. Survey Mus. 15. Interior of ventral valve, enlarged; taken with gutta-percha from an internal cast. Caradoc; Bryn Bedwog, near Bala. Geol. Survey Mus. 16. Internal cast of ventral valve, enlarged. Caradoc; Chair of Kildare, Ireland. 17. Interior of dorsal valve. Caradoc; Gas Works, Haverfordwest.
18—23.	,, *sagittifera*, M'Coy.	18—20. After figures in 'Brit. Pal. Foss.,' pl. i H. From the Caradoc schists of Aber Hirnant. Woodwardian Museum, Cambridge. 20, 21. Two large internal casts of dorsal and ventral valves. From the same locality and collection. 22. Interior of dorsal; 23, interior of ventral valve. Caradoc; Cwm-yr-acttinen, Bala.
24—30.	,, *protensa*, Sow.	24, 25, 26. After Sowerby's figures of *O. lata* in 'Sil. Syst.' Lower Llandovery; Llandovery. 27. Internal cast of ventral valve. 28. Internal cast of dorsal valve. Lower Llandovery; Golengoed, Llandovery. 29. Internal cast of dorsal valve, enlarged. Lower Llandovery; Troutbeck. Coll. of late Mr. Wyatt-Edgell. 30. Interior of ventral valve, enlarged; taken from an internal cast with gutta-percha. Golengoed. Mus. Geol. Soc.
31—34	,, *Salteri*, Dav.	31, 32. Internal cast of ventral valve. 33. Internal cast of dorsal valve. 33. The same, enlarged. 34. Interior of the same valve, enlarged; taken with gutta-percha from an internal cast. Caradoc; Horderly, Salop. Coll. of late Mr. Wyatt-Edgell.
35—38.	,, *sarmentosa*, M'Coy.	After figures in 'Brit. Pal. Foss.' Schists of Llyn Ogwen. Woodwardian Museum, Cambridge.
39—42.	,, *retrorstriata*, M'Coy.	After figures in 'Brit. Pal. Foss.' Cerrig-y-Druidion. Woodwardian Museum, Cambridge.

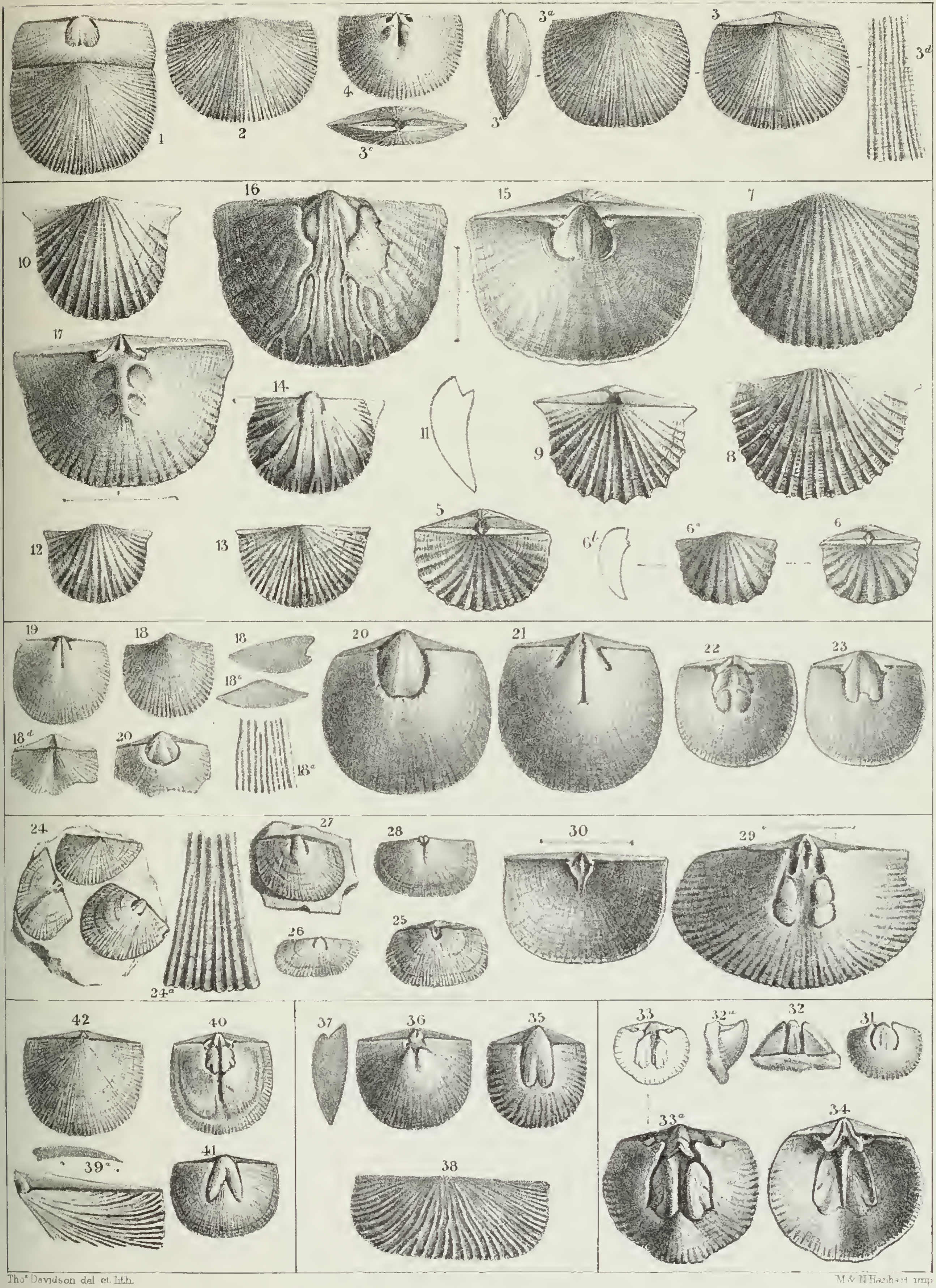

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PLATE XXXVII.

SILURIAN SPECIES.

Fig.

1. *Orthis plicata*, Sow. After the original figure in 'Silurian System,' pl. xxi, fig. 6.

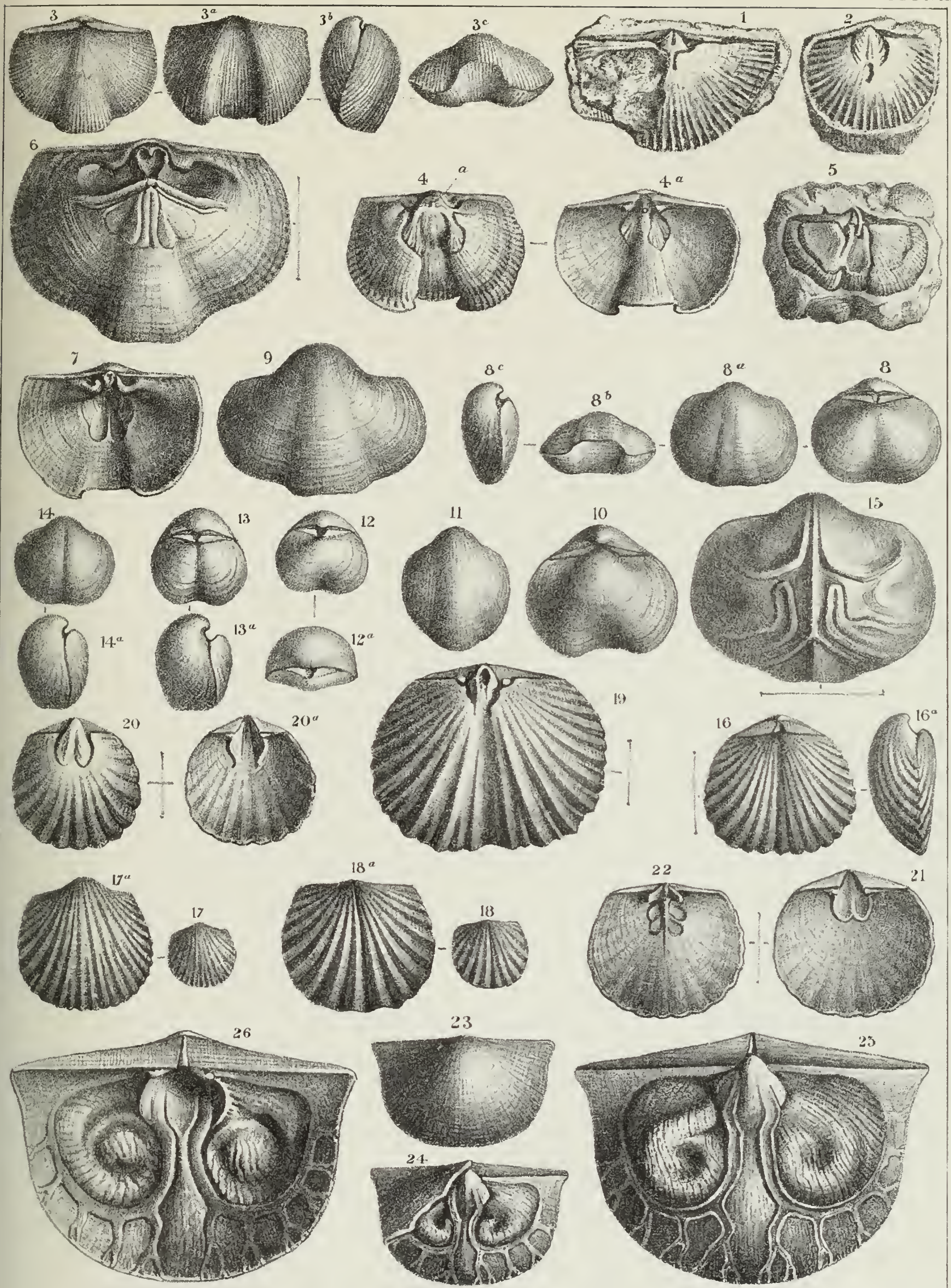
2. „ *virgata*, Sow. Id., pl. xx, fig. 15.

3—7. „ ? *spiriferoides*, M'Coy. 3. Caradoc; Llanfyllin. Mus. Geol. Survey. 4. Internal cast of ventral valve; *a*, a little projection due to the tube. Same locality. 4 *a*. Interior of the same valve, taken from the cast by the means of gutta-percha. 5. Internal cast, in which the cast of the tube is preserved; from Bala Limestone, $1\frac{1}{2}$ mile east of Bala. Sharpe's Coll., Mus. Geol. Soc. 6. Internal cast of dorsal valve, enlarged. Bala Limestone; Garnedd Quarry, near Bala. 7. Interior of dorsal valve, taken with gutta-percha from an internal cast. Llanfyllin.

8—15. „ *insularis*, Eichwald. 8, 14. Caradoc; Chair of Kildare. Mus. Geol. Survey. 9. A large specimen. Portrane. Mus. Geol. Survey, Ireland. 10, 11. Llandovery beds; Mandinam, Llandovery. 12, 13. Caradoc; Chair of Kildare. 15. Internal cast of dorsal valve, enlarged. Lower Llandovery; River Sevin, Llellyrhyddod, Llandovery.

16—22. „ *unguis*, Sow. 16. Complete form, taken from external cast by means of gutta-percha. Caradoc; Gretton. 17. Caradoc; Acton Scott. 17 *a*. Enlarged. 18. Caradoc; Cheney Longville. 18 *a*. Enlarged. Both in Mus. Geol. Survey. 19. Internal cast of dorsal valve, enlarged. From Caradoc; Gretton. Coll. of Mr. Lightbody. 20. Internal cast of ventral valve. Caradoc; Horderley. An enlarged figure of Murchison's original specimen, figured in 'Silurian System.' 20 *a*. Interior, taken from the cast with gutta-percha and enlarged. Mus. Geol. Soc.

23—26. *Strophomena Jukesii*, Dav. Caradoc; Grangegeeth, County Meath. Mus. Geol. Survey of Ireland. 23. Exterior of ventral valve. 24. Specimen showing part of internal cast of ventral valve. 25. Internal cast of ventral valve, much enlarged. 26. Interior of same valve, taken from the internal cast with gutta-percha.



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THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

VOLUME FOR 1868.

LONDON:

MDCCCLXIX.

A MONOGRAPH

OF

BRITISH BELEMNITIDÆ.

BY

JOHN PHILLIPS,

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PART IV,

CONTAINING

PAGES 87—108; PLATES XXI—XXVII.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1869.

PRINTED BY
J. E. ADLARD, BARTHOLOMEW CLOSE.

Proportions. The diameter (*v d*) being taken at 100, the ventral radius is 40, the dorsal 60, the cross diameter 100, the axis 420.

PHRAGMOCONE. Nearly straight, with a nearly circular section; the angle $m = 25°$.

Locality. In the lower part of the Upper Lias at Saltwick (*Phillips*); at Robin Hood's Bay (*Cullen*); in ironstone layers at Kettleness (*Simpson*); in the shale under the Jet-bed, plentifully; and in ironstone layers at Staithes and Rosedale (*Phillips*); in the Marlstone series below the ironstone.

Observations. The agreement of this Belemnite with that long known as *B. paxillosus* is obvious and intimate, and the resemblance of particular selected specimens is almost complete, the principal observable difference being a greater proportionate length of axis and a longer tapering to a less obtuse apex in the Yorkshire specimens.

For comparison, a specimen from Ilminster, in Mr. Moore's Cabinet, is represented fig. 52, *Ml.*

Recurvation of the apex occurs in several of the specimens of *B. paxillosus*, especially in those from Ilminster; in several of the specimens of *B. cylindricus* from Rosedale, near Staithes, it is so pronounced as to approach the form of *B. aduncatus.*

On the whole, I can hardly doubt that the Yorkshire specimens agree with *B. paxillosus amalthei* of Quenstedt ('Cephal.,' pl. xxv, fig. 5); the state of conservation seldom allows of the striation of the apex to be perfectly seen, as in our representation of *B. paxillosus* (Pl. XX, fig. 52, *Ml*).

B. elongatus, *B. apicicurvatus*, *B. paxillosus*, and *B. cylindricus*, taken together, compose a natural group of generally cylindrical or cylindroid forms, with dorso-lateral grooves at the apex, and plaits or striæ on the ventral and dorsal aspects (exceptionally, a deeper stria on the ventral and also on the dorsal face). They are unknown in Lower Lias, but extend from the base of the Middle Lias to the lower part of the Upper Lias, and are found in Dorsetshire, Gloucestershire, Northamptonshire, Lincolnshire, and Yorkshire.

BELEMNITES OXYCONUS, *Quenstedt.* (Diagram, No. 23, p. 88.)

Reference. *Belemnites* (*tripartitus*) *oxyconus*, Quenstedt, 'Cephalop.,' p. 419, pl. xxvi, figs. 19, 20, 1849.

GUARD. Compressed, conoidal or conical, ending in a produced, pointed, somewhat reclined apex; lateral grooves extend over the alveolar region.

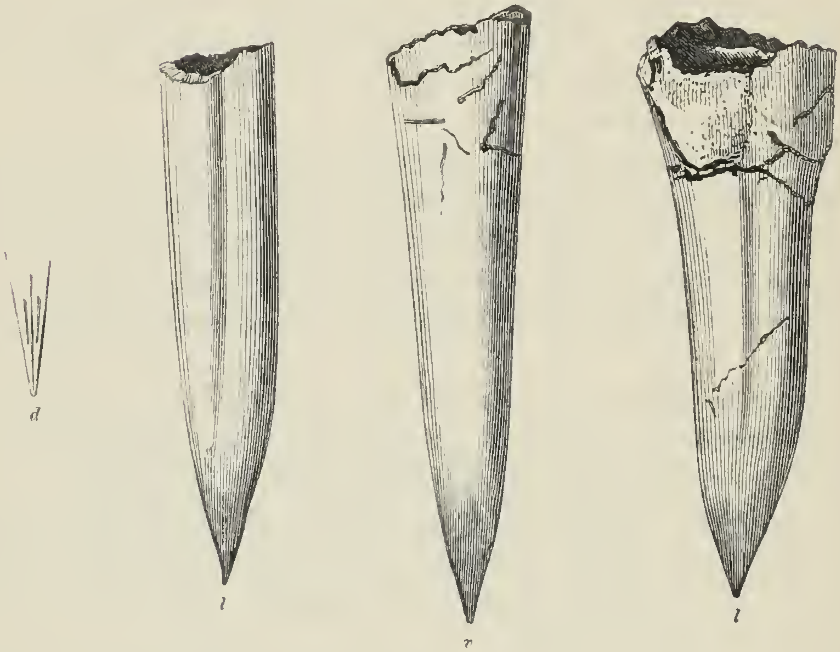
Transverse section oval, the ventral region broadest.

Locality. Cheltenham, in the Belemnite-bed of the Lower Lias (*Buckman*).

The fossil here represented, from Mr. Buckman's Collection, is from the "Belemnite-bed" of the Lower Lias of Cheltenham. It corresponds to all appearance with the species

DIAGRAM 23.

Belemnites oxyconus.



referred to by Quenstedt, and I find it also to be much allied to *B. elegans* of Simpson (p. 84; and Pl. XX, fig. 50); but it is not striated about the point, as that species seems always to be; its axis is shorter, and the figure is more oblique. It seems allied to *B. acutus* of Miller, and may be the old form of that species.

DIAGRAM 24.

v'. Longest individual. v''. Smaller. v'''. Minute specimen.

In Mr. Charles Moore's very interesting collection from the Upper Lias of Ilminster are specimens of an extremely small, short Belemnite, which may possibly be the young of such a species as *B. Voltzii.* It merits, however, a careful description, as all the very young Belemnites do.

Belemnites minutus, n. s. (Diagram, No. 24, *v′*, *v″*, *v‴*.)

Guard. Short conical, straight, acute, with two faint latero-dorsal grooves, and an obscure trace of ventral depression towards the apex.

Dimensions. From $\frac{1}{8}$ to $\frac{1}{4}$ and (apparently the same species) $\frac{3}{4}$ inch long.

Locality. Upper Lias, Ilminster.

Remarks. It is possible that, by further research, older forms may be identified with these almost microscopical specimens of Mr. Moore's acuteness and industry. They cannot be the young of *B. Ilminstrensis*, but rather should be referred to a form such as *B. Voltzii.*

In the same collection are specimens from the Upper Lias of Ilminster of a slender Belemnite, agreeing in general with *B. quadricanaliculatus,* but differing in the striation and some other points of interest, as will appear by the following description, in which it is regarded as a variety. Specimens of the ordinary type occur with it.*

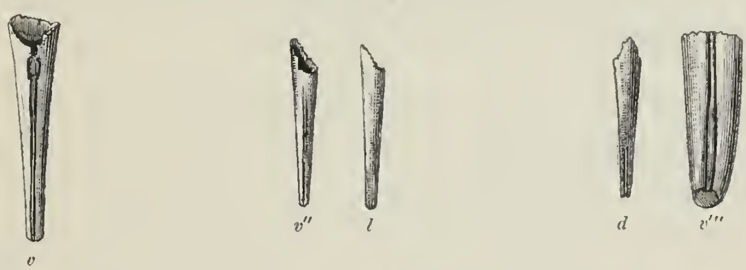
Belemnites quadricanaliculatus, var. obsoletus. (Diagram, No. 25, *v′*, *v″*, *v‴*, *l*, *d*.)

Guard. Long slender conical, often a little bent, marked by a conspicuous double-striated ventral groove, extending over part of the alveolar region; striæ and traces of dorsal grooves near the apex, which is always found truncated.

Dimensions. Under 1 inch in length.

Locality. Upper Lias, Ilminster.

DIAGRAM 25.



v′. Ventral face, full size. *v″*. The same, smaller. *v‴*. Magnified view of the ventral striæ. *l*. Lateral, *d*. dorsal.

* In the description of *B. quadricanaliculatus*, p. 68, the dorsal groove is said to be sometimes double. I find, also, the ventral groove double in several examples.

In the preceding pages I have endeavoured to describe all the forms of Liassic Belemnites of which I have been enabled to study sufficient examples. Under very favorable circumstances a few characteristic forms have been traced completely from very young to quite mature specimens—for example, *B. Ilminstrensis* (Pl. XII). Some have been collected in such great numbers as to leave no doubt of their possessing a real relationship—*e. g. B. lævis* (Pl. X); others possess such peculiarities of form and structure, amid many variations, as to allow of their being quoted without fear from very distant localities—*e. g. B. clavatus* (Pl. III).

Some cases have occurred of forms which, if not really very rare, have not yet been collected in sufficient number to allow of giving more than the description fitting to a particular age of the animal, as *B. excavatus*, *B. calcar*, *B. dens*, on Pl. II. In handling these curious species I have been guided by the experience acquired in examining the other more favorable cases, and I hope the results will be found trustworthy in the main. But I am most anxious to be furnished with more, many more, examples of Belemnites of various magnitudes, from the largest to the least, which may be collected from *one limited band of Lias*, at one definite place. For instance, in the greatly reduced band of Upper Lias clays in the Vale of Gloucester, near Dursley and Wotton-under-Edge, Belemnites occur with *Ammonites bifrons*, as well as others in the Marlstone below, and in the sands and Cephalopodal bed above. If any one to whom this may reach would devote a few days to extract a few dozens of Belemnites of all magnitudes from each of the beds named, taken separately, preserving carefully the fragments which belong to each specimen, and would send them to me for study, the conclusions to which I shall soon request attention as to the geological succession of Liassic life, and the changes of form which accompany the transition from Liassic to Oolitic sediments, might acquire a considerable augmentation of value. I did once make such a collection (1843), and was in hopes that it might have been preserved in a museum which contains very many palæontological data gathered under my direction, but ill-fortune befell them after they left my hands.

The reader will doubtless remark that of the Liassic species mentioned by previous English authors the following are not described by me:

B. aduncatus of Miller, said to be from Weymouth and Lyme, pp. 5 and 8.
B. trifidus, Voltz, Whitby, p. 8.
B. brevirostris, D'Orbigny, Cheltenham, p. 11.

Of the first I possess a specimen—Liassic. It appears to me an exaggerated variety of *B. elongatus*.

Many Liassic Belemnites exhibit a tendency to recurvation of the apex, the ventral portion being more or less curved upwards or towards the back. Even when both the ventral and dorsal outlines curve to meet, or towards meeting, the ventral curve is often most decided, and carries off the apex towards the dorsal line, so as to make it project in that direction. In old specimens of *B. vulgaris* at Whitby, *B. cylindricus* at Staithes, and *B. paxillosus* at Ilminster, this is very obvious. Thus, in a series of twenty-four specimens of *B. cylindricus* collected by myself near Staithes, about half are positively recurved, the rest slightly so or not at all. When the recurvation is very decided it is often accompanied by ventro-planation. Two specimens of *B. elongatus* from Cheltenham in my collection, which were presented to me by my friend the late H. E. Strickland, Esq., show this variation strongly; it seems to be not at all an anomaly, but the usual structure. The recurvation, where regular, increases with age, and thus augments the tendency to bluntness which appears in many old specimens.

The variation here alluded to under the title of recurvation is so far normal that it is always an upward curve.

The one specimen on which *B. trifidus* was quoted was from Upper Lias, Whitby. It is not distinct from *B. tripartitus*. Of *B. brevirostris*, D'Orb., quoted by Professor Morris from Cheltenham, I have seen no specimens.

I am aware that in the collections preserved at Whitby several interesting specimens occur to which Mr. Simpson has assigned names in his treatise on the Yorkshire Lias, and I have made drawings and careful observations of many of them; but the difficulty, to which reference has been made above, of deciding upon claims to specific distinction from single, perhaps exceptional, specimens, deters me from doing more at present than expressing my hope that the diligent Curator of the Whitby Museum will persevere in the useful labour of amassing very many examples of the species which occur in each bed of the Lias which he knows so well. For thus, I believe, he will have just grounds for reducing the number of his specific names, and of augmenting the notices of variety under each form.

One of these interesting fossils I must, however, mention expressly, as it occurs in the Marlstone of the coast very frequently, but seldom in so good a condition as to admit of sufficient definition. It is that called *Belemnites inæqualis* by Mr. Simpson, belonging to the group of bisulcate Belemnites allied to *B. apicicurvatus*, *paxillosus*, &c.. It appears to be identical with specimens of *B. paxillosus numismalis*, of Quenstedt ('Cephalop.,' t. 23, fig. 21), which I have lately examined at Stutgardt. It is included in the Table, p. 94.

Oppel, in his work entitled 'Jura-Formation' (1856—1859), mentions *B. Whitbiensis*, from the lower part of the Upper Lias. I am convinced this must be a synonym of *B. vulgaris*, one of the forms of Belemnites from this zone already named and described by Mr. Simpson in 1855. This zone is called by Mayer, Toarcian I, *a—c*.

He also names a species from Bridport, as accompanying *Ammonites torulosus* in the lowest part of the Inferior Oolite, *B. Dorsetensis*. From inspection of the Munich Collection I infer this to be a synonym of *B. quadricanaliculatus*. The beds thus designated are included by Mayer among the Upper Lias beds, and called Toarcian III.

Mayer, in his "Systematic List of Jurassic Belemnites" ('Journal de Conchyliologie,' 1863), quotes Oppel for a species named *B. Wrightii* after the eminent palæontologist of Cheltenham, and assigns it to the upper part of the Upper Lias, viz. Toarcian I, *d.* I have not been fortunate enough to obtain a specimen. He also gives a new name (*B. neglectus*) to a specimen said by Oppel to be from the Belemnite bed of Lyme Regis, which is figured by (Quenstedt, 'Jura,' pl. xlii, fig. 20) as from the lowest bed of Inferior Oolite. If it be "*unicanaliculate*," as Mayer says, it is probably of an Oolitic type, or from the Bridport Sands.

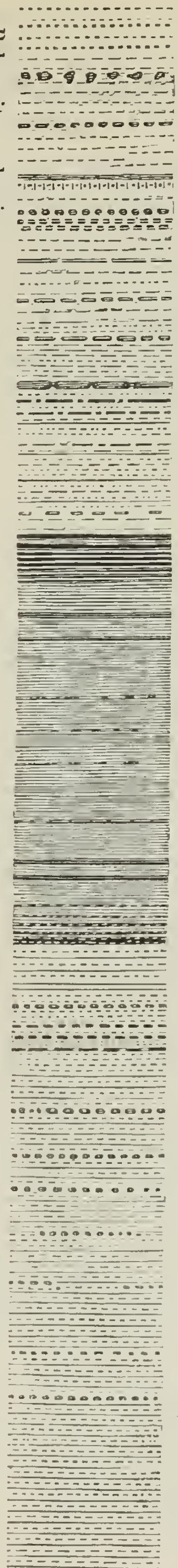
It will be requisite, no doubt, hereafter to construct a Supplement to these pages, and my own collection contains a few specimens worthy of notice if more, and more illustrative, specimens, can be obtained.

Meantime it appears to me useful to present a summary of the distribution of well-recognised forms in the Yorkshire Lias, every bed of which between Saltburn and Saltwick I have in late years carefully examined and for the most part exactly measured, and searched many times for Belemnites and other fossils. The general result of this labour appears in the Tabular View,* p. 93, which is reduced from a larger drawing, beginning with Gryphitic beds above the Lima beds and *Ammonites Bucklandi,* and ending below the Dogger, and is not meant to include the transition sandy beds, if they may be so termed, at Blue Wick.

My friend Mr. Simpson has already composed a similar and more minute description of the beds between Saltwick and the Peak, so that the two may be compared, and the reference of every fossil on the Lias Cliffs of the Yorkshire coast to its real repository become by degrees quite complete. Far clearer on this magnificent coast than even on that of Dorset is the distribution of the fossils in the Middle and Upper Lias, and capable of often-repeated proof; but in respect of the lowest Lias, it is not in the Yorkshire cliffs that it must be studied. Nor do I know of more than one example of Rhætic beds in the county, and that is now concealed under the grassy surface of a deep cutting at Barton, on the North-Eastern Railway. It was exposed, many years since, in an anticlinal resting on the Keuper Marls, and I examined it well, but found few fossils in it.

* In the Table, p. 93, nodules are marked by interrupted bands. Two Belemnite-beds are marked by 'β. β.'

Lias of the Yorkshire Coast between Saltwick and Saltburn.



	Belemnites	Voltzii.	
Leda ovum.	Belemnites	subaduncatus.	Amm. bifrons.
	Belemnites vulgaris.		
	50		
	Belemnites	β. β. striolatus.	Amm. communis.
	Belemnites	β. β. subtenuis.	
	100		
	Belemnites	dorsalis.	
	Belemnites	tubularis.	Amm Mulgravius (serpentinus).
	Belemnites	lævis.	
	Belemnites	tripartitus.	
	150		
Posidonomya.	Belemnites	cylindricus.	Amm. annulatus.
	200		
	Belemnites	acuminatus.	
Pecten æquivalvis.	Belemnites	paxillosus.	Amm. Hawskerensis (spinatus).
	Belemnites	breviformis.	
Avicula cygnipes.	Belemnites	rudis.	
	250		
Cardium truncatum.	300	numismalis	Amm. Clevelandicus (margaritaceus).
Gryphæa depressa.			
	350		
Avicula inæquivalvis.			
Modiola scalprum.	Belemnites	pollex.	Amm. maculatus.
	400		
	450		
Pholadomya ambigua.	Belemnites	elegans.	
	Belemnites	clavatus.	
	500		
	550		
	600		
	Belemnites	dens.	
Gryphæa Maccullochii.	Belemnites	acutus.	Amm. obtusus.
	650 feet		

In the Table of Distribution of Belemnites given at p. 93, I have introduced the names of several well-known and definitely characterised Ammonites in their ordinary places in the strata. This might have been done to a greater extent, and thus a more minute comparison have been made with the similar and equally well-known Ammonitic zones on the Dorsetshire coast. But this subject will come under a more full examination hereafter, when the Belemnitic beds above that which is so famous at the foot of Golden Cliff shall have been as fully explored as have been the contemporaneous parts of the Yorkshire section. Mr. Day and Mr. Etheridge have already made good progress in this work, which is not so easy on the Dorsetshire as on the northern coast.

I now present, in a diagram, a classification of Yorkshire Lias, according to natural divisions of the series, adopting as few groups as possible; and in this scale of time I have written the species of Belemnites already described from the cliffs of Saltburn, Staithes, Whitby, and Robin Hood's Bay.

Distribution of certain species of Belemnites in the strata of the Yorkshire coast.	B. acutus.	B. dens.	B. penicillatus.	B. elegans.	B. scabrosus.	B. pollex.	B. inæqualis.	B. rudis.	B. paxillosus. cylindricus.	B. acuminatus.	B. breviformis.	B. tripartitus.	B. lævis.	B. tubularis.	B. striolatus.	B. subtenuis.	B. dorsalis.	B. vulgaris.	B. Voltzii.	B. subaduncatus.
Alum Shale. Leda Beds	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	*	*
Upper Ironstones, &c.	...	...	...	...	...	...	...	...	...	...	...	...	*	*	*	*	*	*	...	...
Jet Series	...	...	...	...	...	...	...	...	*	...	...	*	...	...	...	...	...	...	...	...
Mid. Ironstone Series	...	...	...	...	...	...	...	*	*	*	*	...	...	...	...	...	...	...	...	...
Marlstone	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...
Lower Ironstone Series	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Lower Lias Shale ...	*	*	*	*	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Lias Limestones	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	..
Rhætic beds...........	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

LIAS—OOLITE.

A complete passage by continuous change from the Upper Lias to the Inferior Oolite, from an argillaceous shale or clay to an Oolitic limestone, is not to be looked for; but there are a few localities in England where beds are interposed which mark one or more stages in the change of sediments, and are themselves marked as much by change of the forms of life as by mineral variation. My attention was attracted to this subject during frequent examinations of the Yorkshire coast on several occasions previous to the publication of the first volume of my work on the strata and fossils of that coast, in 1829. Generally speaking, the Oolitic series terminates below in a variable sandy, irony, or calcareous rock, sometimes almost full of shells, at other places not yielding one. The Lias on which this rests is in general strongly contrasted with it in colour, structure, composition, and fossils; but in one locality on the coast, at Blue Wick, under the Peak of Robin Hood's Bay, the series of strata, including Lias below and Oolitic rocks above, admits of subdivisions which soften the change from Lias to Oolite, and exhibit a pretty full series of fossils for illustration of the life forms of the transition period.

In my account of these beds ('Illust. of Geol. Yorkshire,' vol. i, p. 91, first edition) they are all classed as a conchiferous (*Dogger*) series analogous to the Inferior Oolite of Bath, which at that time was universally allowed to include the sandy beds below, so well known and described at Bath and Yeovil. The description given of these beds at Blue Wick shows that they were regarded by me as "gradually changing in the lower beds" to the Alum-shale.

In 1859 the further researches of Dr. Wright ('Geol. Journal,' vol. xvi, p. 1) convinced him that these passage-beds were the equivalent of the "Cephalopodal bed" and sands which cap the Lias of Gloucestershire and Dorsetshire; and by the valuable evidence of the Ammonitidæ they have been of late years pretty generally associated with the Lias, as the uppermost member of that formation. Of the few Belemnites which occur in these beds I have noticed the most conspicuous, viz. *B. irregularis* (Pl. XV, fig. 37), at Frocester Hill; *B. inornatus* (Pl. XVIII, fig. 46), at Blue Wick; *B. sulci-stylus*, (Pl. XIX, fig. 49), at Nailsworth.

Having lately on several occasions examined many times with great care these sands at Bridport, where they are capped by the Oolite, and again at Yeovil under similar conditions, I am able to add to the list of species four other forms, viz.—

Bel. Voltzii. Upper part of the Yeovil Sands, only 15 or 20 feet below the Oolite.
Bel. tricanaliculatus, Quenstedt, 'Cephal.,' t. 25, figs. 13—15. Bridport Sands.
Bel. quadricanaliculatus, Quenstedt, 'Jura.,' t. xli, f. 17.

Bel. unisulcatus, Blainville, 'Mém. sur les Bel.,' pl. v, fig. 21; D'Orbigny, 'Ter. Jur.,' pl. viii, figs. 1—5. Bridport and Bradford Abbas.

I regard these as all truly Liassic forms, to whatever extent they may hereafter be found continued into the Oolitic strata.

BELEMNITES OF THE OOLITIC SYSTEM.

Regarded from the most general point of view, the Belemnites of the Oolitic limestones, sands, and clays present themselves in five natural groups, which may be thus typified:

1. Group of *Belemnites giganteus,* Blainville. Large compressed species, with a nearly regular elliptical or oval section; no ventral groove.
2. Group of *Belemnites canaliculatus,* Schlotheim (*sulcatus,* Miller). More or less depressed; the ventral surface conspicuously grooved in the middle part of the guard.
3. Group of *Belemnites hastatus,* Blainville, whose remarkable elongation, hastate shape, and deep ventral groove, mark them distinctly.
4. Group of *Belemnites tornatilis,* Phillips (*Owenii,* Pratt; *Pusozianus,* D'Orbigny). Long subcylindrical Belemnites, with a groove on the ventral aspect towards the apex of the guard.
5. Group of *Belemnites abbreviatus,* Miller (*excentricus,* Blainville). Large short Long Belemnites, plane or broadly grooved on the sides, flattened or slightly grooved near the apex on the ventral aspect.

I propose to describe these groups in the order set down; and have only now to remark, by way of introduction, that the first group may be regarded as continued from the Upper Lias into the Bath Oolite series, where apparently it grows to the utmost magnitude, and then ends. The second group begins in the lowest of the Oolites and ascends to the Oxford Clay, not, I believe, to the uppermost part of that deposit. The third group, notwithstanding its seeming resemblance to *Belemnites clavatus* of the Lias, is really more allied to the second here noted; it begins in the Bath Oolite series, but not, I believe, at the base of it, and extends into the Kimmeridge Clay. Its relation to *B. jaculum* of the Speeton Clay and *B. pistilliformis* of the Neocomian beds, and the small Belemnites of the Folkestone Gault, will be considered hereafter. The fourth group extends from the Kelloway Rock to the Kimmeridge Clay. The fifth begins in the Oxford Clay, not, I believe, at the base, and extends upwards into the Kimmeridge Clay of Oxfordshire, the Speeton Clay of Yorkshire, and the congeneric bed of Lincolnshire called Tealby Stone.

On the Group of large compressed Belemnites in the Inferior Oolite (Pls. XXI to XXIV).

Belemnites ellipticus (Pl. XXI) is the name given by Miller to a fine, straight, compressed species, which occurs in the Oolite of Dundry, and in the country near Yeovil and Bridport.

Sowerby (in 'Min. Conch.,' pl. 590, fig. 4) figures under the name of *B. compressus* of Blainville one of the several forms of large Belemnites which are frequent in the "Grey Limestone," a part of the Bath Oolite series, of Gristhorpe and other places near Scarborough. Some of these fossils agree exactly with *B. quinquesulcatus* of Blainville as to the termination, others correspond with *B. Aalensis* of Voltz in general figure, while examples may be selected which seem to be identical with *B. gladius* of Blainville and *B. giganteus* of Schlotheim. They do not occur in the strata above.

In the south of England such forms are not frequent. I have, however, been favoured with the sight of two fine examples from the collection of Mr. Read, of Salisbury, obtained from near Sherborne; and another has been sent me from Leckhampton by Mr. Buckman.

In considering how to deal with these fossils, I remark, in the first place, that *B. ellipticus* of Miller, from Dundry, is not exactly to be matched in form and structure by any specimens from Yorkshire, unless a single specimen from the grey Dogger-beds of Blue Wick be referred to it. Next, that in specimens from Yorkshire two distinguishable variations appear—1, analogous to *B. giganteus*, *B. gladius*, and *B. Aalensis*; 2, analogous to *B. quinquesulcatus* and *B. compressus* of Blainville. And these same forms occur in the south of England, so that we have three species or remarkable varieties in this group of large Belemnites to be considered. Those who regard them as varieties will still find it useful to preserve the distinctive names, though all may be spoken of as *Belemnites giganteus*, Auctorum. I begin with *Belemnites ellipticus* of Miller.

Belemnites ellipticus, *Miller*. Pl. XXI, fig. 53.

Reference. *B. ellipticus*, Miller, 'Geol. Trans.,' 2nd series, vol. ii, p. 60, pl. viii, figs. 4—16, 1826.

Guard. Straight, elongate, very much compressed, gradually and uniformly tapering, with an almost uniformly oval section (the ventral face widest), smooth, without furrows except near the summit, where two or more faint lateral facettes break the regularity of the surface.

The transverse sections of the sheath are almost uniformly oval, the ventral face being rather wider than the dorsal, and the axes measuring 72 and 100. At the apex of the alveolus the inner layers have a somewhat less oval figure than the exterior; and very near the axis they become undulated by the latero-dorsal facettes, but never show the deep grooving of *B. Aalensis*, *B. quinquesulcatus*, &c. Miller says the inner layers give a nearly circular section, but this is not the case in either of my specimens. Substance light-coloured, finely fibrous.

Greatest length of axis $7\frac{1}{2}$ inches in a specimen $12\frac{1}{2}$ inches long; the diameters at the apex of the alveolus being under 1 inch from back to front, and above $\frac{5}{8}$ths from side to side.

Proportions. The diameter, from front to back, at the apex of the alveolus being 100, that from side to side is 72; the ventral radius 36, the dorsal 64.

PHRAGMOCONE. Incompletely known, but presenting in fragments remarkable characters; oblique, with straight sides inclined at angles of 16° and 20° nearly. Section compressed elliptical, with axes as 88 to 100 near the apex, and as 83 to 100 near the aperture, the excentricity increasing with age. The septa are oblique, with slightly waved edges, siphon oval, submarginal, in a slight degree removed from the conjugate axis towards the right side of the animal.

Depth of the largest chamber = one seventh of the diameter.

Locality. In the Inferior Oolite of Dundry Hill. *Miller's* Collection in the Bristol Museum. In *Mr. W. Sanders's* Collection and *Prof. Phillips'* Collection.

Observations. Miller's figures are very unsatisfactory, and his reference of fig. 17 in his essay to this species is a mistake. Many additional specimens are needed, especially young examples, but I think the main characters are clear for adults. The surface of some specimens is much worn and eroded; Serpulæ adhere to others. *Belemnites longus* of Voltz (Pl. III, fig. 1) is similar, but its apicial line is uniformly less excentric, and shorter in proportion; it is from the Oolite of Buxweiler. *Belemnites gladius* of Blainville, from the Oolite of Bayeux, and from Rabenstein, is analogous if not identical.

BELEMNITES AALENSIS, *Voltz.* Pl. XXII, fig. 54; Pl. XXIII, fig. 55.

Reference. *Belemnites giganteus*, Schlotheim, 'Petref.,' p. 45 (probably), 1820.
B. gigas, Blainville, 'Bélemn.,' p. 91, pl. v, fig. 20 (probably), 1827.
B. Aalensis, Voltz, 'Obs. sur les Bélemn.,' p. 60, pl. iv, pl. vii, fig. 1, 1830.
B. Aalensis, Phillips, 'Geol. of Yorkshire,' p. 166, 1835.

GUARD. Sheath large, very much compressed, smooth. Anterior region unknown. Alveolar region cylindroid, often a little contracted in the middle. Apicial region (frequently) much contracted at a small distance from the alveolus, and thence extending into a long, compressed (often slightly bent or undulated) conical figure, terminated obtusely, obscurely striated lengthwise, and marked by six or seven furrows, viz. two latero-dorsal, very deep, much longer than the others, extending nearly the whole length of the attenuated part of the apicial region; four latero-ventral, of unequal length, the shortest and faintest being near the ventral line; and one medio-dorsal, always faint, and sometimes absent.

The sections of the sheath vary according to the distance from the apex. The apicial line is straight. At the alveolar apex the external layer is oval, with diameters as 81 to 100, the dorsal part being widest; nearer the apex the figure is formed by two unequal, nearly semicircular curves, the ventral one being largest; at the apex it is extremely compressed, with six or seven grooves. These grooves show in the central portions of every section of the sheath, and on breaking the specimens across a central prominence occasionally appears, but less distinctly than in the next species. The substance is compact and light-coloured, breaking nearly at right angles to the axis.

Phragmocone. Oblique, with straight sides inclined at angles of 23°, the back and front inclined at 27°. Section elliptico-compressed, with diameters as 91 to 100.

Greatest length observed 20 inches, of which the apicial line is 12. Greatest diameter on the middle alveolar region 2 inches.

Proportions. The diameter, *v d*, at the alveolar apex being 100, the lateral diameter is 81, the ventral radius is 40, the dorsal 60.

Varieties. In most specimens the apicial region contracts remarkably at about one third of its length behind the alveolar apex, while before that line the alveolar region is nearly cylindroid; in others the whole figure more nearly approaches to a cone; the lateral profile of some is bent in a gentle arch, in others undulated.

Locality. In the Lower Oolite formation (upper part) of Yorkshire, especially on the Scars at White Nab, south of Scarborough. (At Aalen in Wurtemburg, in the Lower Oolite formation, lower part, *Voltz*). In *Mr. Bean's* Collection, Yorkshire Museum, Scarborough Museum, and in the *Author's* Cabinet. In the Lower Oolite of Sherborne (*Mr. Reed*); and in the Lower Oolite of Leckhampton (*Mr. Buckman*).

Observations. On specimens from White Nab, thin Oyster shells are found attached, and accommodated to the curved surface of the alveolar region of the sheath. In the alveolar cavity of another are crystals of sulphide of zinc.

Belemnites quinquesulcatus. Pl. XXIII, fig. 56; Pl. XXIV, fig. 57.

Reference. *Belemnites quinquesulcatus*, Blainville, 'Mém. sur Bélemn.,' p. 83, pl. ii, fig. 8, 1827.

B. compressus, Sowerby, 'Min. Conch.,' pl. 590, fig. 4, 1828.

Guard. Sheath large, conical, compressed, smooth. Anterior region unknown. Alveolar region conoid. Apicial region rapidly tapering to an obtuse compressed summit, and grooved with four, five, or six furrows, viz. two latero-dorsal extending over about one third of the apicial region, two latero-ventral of about half that length, one medio-dorsal, and one medio-ventral of variable length and distinctness.

The sections of the sheath vary according to situation. At the alveolar apex the contour is nearly elliptical, with diameters as 90 to 100; within the border the layers are oval (the ventral region broadest), while nearer the centre the layers show inflexions corresponding to the grooves of the summit, though still nearer the axis these are again lost. Nearer the summit the contour consists of two unequal subcircular curves, and the plan of the summit is a compressed pentagonal or hexagonal figure, with four, five, or six deep notches. When the sheath is broken across the central layers sometimes separate from the rest, so as to appear in a fluted prominence, and the same thing happens in old specimens from decay. Substance light-brown or grey.

Greatest length observed 8 inches, with a diameter not exceeding 2 inches.

Proportions. The ventro-dorsal diameter at the alveolar apex being 100, the ventral radius is 43, the dorsal 57; the transverse diameter is 87.

Phragmocone. Oblique, deeply inserted, with straight sides inclined at angles of 23° and 27°. Section compressed elliptical in the ratio of 87 to 100. The ventral region occupies about half the circumference. The septa are very oblique, advancing dorsally, not waved on the edge nor undulated by the siphon. Irregular striæ are seen parallel to the ventral line, crossing others parallel to the edges of the septa. On the dorsal aspect are arched shades of colour crossing the contrary curvatures of the striæ of growth. The ventral aspect is often black.

Proportions. Diameters as 100 to 87. Depth of chambers one eighth of the diameter.

Varieties. The degree in which the figure approaches to a cone varies a little, and the apicial furrows are rather inconstant. Some specimens show hardly any medio-ventral or medio-dorsal grooves, in others these are distinct or even duplicate, and the intervening spaces are striated.

Localities. In the Lower Oolite formation of Yorkshire, at White Nab, Cloughton Wyke, Carlton Husthwaite. (Also near Mezières, *Blainville.*) At Sherborne, in Dorset

(*Mr. Read*). Specimens occur in the Yorkshire Museum, Museums of Whitby, the Scarborough Phil. Soc., &c.

Observations. Oyster shells adhere frequently to the apicial region of the sheath, which is always more or less incomplete and eroded. This short form is conjectured by D'Orbigny to be the female of *B. giganteus* (*B. Aalensis*, Voltz). The two forms must be regarded as closely allied.

On the Canaliculated Belemnites of the Inferior Oolite (Pl. XXV).

Miller, in his account of *Belemnites sulcatus* ('Geol. Trans.,' 2nd ser., vol. ii, pl. viii figs. 3, 4, 5), gives for localities, "Dundry, near Oxford, Inferior Oolite." His fig. appears to represent *B. apiciconus* of Blainville, which occurs frequently in the Inferior Oolite, but has not yet been found near Oxford. Fig. 5 I have always supposed to represent a fossil from the Oxford Clay. It seems to be copied or modelled from specimens which still exist in the Bristol Museum, and are marked "*B. sulcatus*," Inferior Oolite.

In the lowest beds of the Inferior Oolite of the south of England, generally, among the most frequent Belemnites are those of the type of *B. apiciconus*, Blainville. To judge from examples collected by Mr. Buckman near Sherborne, and by myself near Yeovil, there are two other distinguishable forms, of a slenderer figure, one canaliculated to the apex or very near it, the other not carrying its groove so far backward. To these there may be added the fossil called in my work on the Yorkshire Coast *B. anomalus*, and there quoted from the Kelloways Rock. It belongs really, I believe, to the Grey Limestone of Gristhorpe. None of these, so far as I yet know, have the fusiform or hastate shape in any period of their growth; but I have not met with very young forms of any one of them. They are all distinct from the canaliculated Belemnites of Stonesfield, and never exhibit much of that depression in the post-alveolar region which always belongs to the allies of *B. fusiformis* of Miller.

Belemnites apiciconus, *Blainville*. Pl. XXV, fig. 58.

Reference. *Belemnites apiciconus*, Blainv., 'Mém. sur les Bélemnites,' p. 69, pl. ii, fig. 2, 1827.
B. canaliculatus, Quenstedt, 'Der Jura,' p. 411, pl. lvi, fig. 6, 1858; 'Cephalop.,' p. 439, pl. xxix, fig. 6, 1849.

Guard. Cylindrical in the middle, tapering in a curve to a pointed apex. Ventral surface marked by a deep narrow groove, which is continuous for the whole length, except toward the apex, where a portion in length about equal to half the axis is free from any groove or depression.

Transverse section nearly circular; axis subcentral.

Dimensions of an ordinary specimen $2\frac{1}{2}$ inches, of which $1\frac{1}{2}$ belong to the axis. Diameter at apex of alveolus 0·46.

Proportion of axis to diameter at apex of alveolus 325 to 100.

PHRAGMOCONE. Unknown to me.

Locality. Yeovil, in Inferior Oolite (*Oxford Museum*).

Observations. D'Orbigny quotes *Bel. sulcatus* as the prior equivalent of this species, and gives figures ('Terr. Jur.,' pl. xii, figs. 1—8) of the young and old, with several cross sections, and one longitudinal section. It is very doubtful whether these all belong to one species. The fusiform young is marked by an almost continuous furrow, like the Stonesfield fossils; the longitudinal section belongs to a remarkably short type; the mature individual has a peculiarity in the expanding posterior ending of the canal.

In the Museum of the Garden of Plants is a large series of '*B. apiciconus*,' jun. from Croiselles, in Normandy.

Bel. canaliculatus of Schlotheim is too variously interpreted to be safely quoted, except in the definite shape given to it by Quenstedt, in the work quoted. In his 'Cephalopoda,' *B. canaliculatus* is made to include *B. sulcatus* of Miller, *B. Altdorfensis* and its Russian analogue, and the Stonesfield fossil, of which a young example is given, 'Cephalopoda,' pl. xxix, fig. 7.

BELEMNITES BLAINVILLII, *Voltz.* Pl. XXV, figs. 59, 60.

Reference. *Belemnites acutus*, Blainville, 'Mém. sur les Bélem.,' p. 69, pl. ii, fig. 3 (medium size), 1827.

B. Blainvillii, Voltz, 'Obs. Bélemn.,' p. 37, pl. i, fig. 9 (full-sized), 1830.

„ D'Orb., 'Terr. Jur.,' p. 107, pl. xii, figs. 9—16 (young), 1842.

GUARD. Elongate, uniformly tapering to a smooth, rather blunt apex. Ventral face marked by a distinct narrow groove extending from very near the apex to the beginning or over a part of the alveolar cavity, and then ceasing gradually.

Transverse sections nearly circular, or a little oblong, with a nearly central axis.

Dimensions. Largest specimen which I have measured $4\frac{1}{2}$ inches long, of which the axis is $3\frac{1}{4}$ inches, the diameter at the alveolar apex being 0·43 from back to front and 0·41 across. In smaller specimens length 3 inches, diameter 0·36. Young specimens, such as figured by Voltz, I have not seen.

Proportions. The axis of the guard measures 600 to 750, the diameter being 100.

PHRAGMOCONE. Indistinctly seen.

Locality. Inferior Oolite, at Bradford Abbas (*Buckman*), Sherborne (*Oxford Museum*).

BELEMNITES CANALICULATUS, *Schlotheim.* Pl. XXV, fig. 61.

Reference. *Belemnites canaliculatus*, Schlotheim, 'Petref.,' p. 49, No. 7, 1820.
,, D'Orb., 'Terr. Jur.,' p. 108, pl. xiii, figs. 1—5, 1842.

GUARD. Cylindro-conical, tapering uniformly to a somewhat sharp point. Ventral surface marked by a narrow deep groove along the whole length, so that even the point is hardly free from groove.

Transverse section nearly circular, in var. α through the whole length, in var. β depressed in the post-alveolar region.

Dimensions. Large specimen 2 inches and $\frac{3}{10}$ths, of which the axis occupies $1\frac{1}{9}$ inch, the diameter at the apex of alveolus being 0·4.

Proportions. Axis 300, the diameter being 100.

Locality. This fossil occurs in the lowest beds of Inferior Oolite at Bridport and Yeovil (*Phillips*), at Dundry (*Sanders*), Wotton-under-Edge (*Phillips*), and Leckhampton Hill (*Buckman*). How much further north it is to be found I cannot say. It has not yet been seen at Stonesfield, or in the Oolites north of Oxford (which are mostly of the Great Oolite), nor have I seen it in Yorkshire.

Observations. The specimens represented in Pl. XXV agree with the figure and description of D'Orbigny, except that they are not at all depressed in the post-alveolar region. Thus two marked varieties arise. They are much shorter in proportion than *B. Blainvillii,* and by the continuity of the ventral sulcus are easily separated from *B. apiciconus.*

BELEMNITES TERMINALIS, n. s. Pl. XXV, fig. 62.

GUARD. Elongate, lanceolate, or very slightly subhastate, depressed, tapering to an acute point; ventral face grooved over the alveolar region, and over the post-alveolar tract to near the apex; groove deep, narrow.

Transverse section at the alveolar apex wider than long; still wider in proportion towards the apex; axis nearer to the ventral face.

Proportion of axis of guard to the ventro-dorsal diameter at the alveolar apex 550 to 100.

PHRAGMOCONE. Unknown.

Locality. Yeovil, Inferior Oolite; specimen in the Oxford Museum.

Observations. This fossil differs from *B. apiciconus* chiefly by its general depression and smaller diameter when specimens of the same length are compared. It agrees in general figure with *B. Bessinus,* as given by D'Orbigny, and as represented at Stonesfield, but the groove does not reach so far backward. It may be supposed to be the connecting link between the two species named.

Belemnites anomalus, *Phillips.* (Diagram No. 26.)

DIAGRAM 26.

Reference. *Belemnites anomalus,* Phillips. 'Geology of Yorkshire,' vol. i, p. 166 (2nd edition, 1835).

Guard. Elongate cylindrical in the post-alveolar region, tapering to a long conical point. Ventral surface grooved in the alveolar and post-alveolar, but not in the apicial region, towards which the groove, previously narrow, grows shallower and wider.

Transverse section somewhat elliptical in the alveolar region, by reason of the ventral thickening of the guard; nearly circular in the post-alveolar region.

Greatest length observed 2·75 inches, of which the apicial line is 2·0; the greatest diameter 0·34.

Locality. White Nab, near Scarborough, in the Grey Limestone. Specimens in the Cabinets of *Mr. James Cook, Mr. Bean,* and the *Author.*

Observations. The greater proportionate length of the axis of the guard is the most marked differential character when this is compared with *B. apiciconus.*

On the Belemnites of Stonesfield, Pl. XXVI.

Lhwyd, in the 'Lithophylacium Britannicum,' 1699, refers to "Stonesfield" for three specimens of Belemnites, all marked by a ventral furrow.

"1677. Belemnites major canaliculatus, sive aqualiculo per mediam longitudinem insignitus. È fodinis Stunsfieldiensibus.

"1705. Belemnites ari-pistillum referens, canaliculatus. È lapidicinâ Stunsfieldiensi" (figured in Lhwyd, tab. 25, fig. 1705, and copied in Diagram 27, below).

DIAGRAM 27.

"1720. Belemnites (cylindraceus) formæ compressioris, fissurâ altero latere donata, è fodinis Stunsfeldiensibus."

The specimens thus referred to by numbers cannot now be recognised in the Oxford ("Ashmolean") Museum.

Platt, in 1764, illustrates his sensible account of the 'Origin and Formation of the Extraneous Fossil called the Belemnite' by instructive figures of fusiform specimens from "Stonsfield" and Piddington, the latter being found in Oxford Clay. On his pl. iv, fig. 3 represents the Piddington fossil, with a groove not reaching to the alveolar region, while fig. 2 shows the completely grooved surface of the Stonesfield fossil, as may be seen by the diagram below, which is copied from Platt.

DIAGRAM 28.

Parkinson's 'Organic Remains of a Former World' presents to us the fusiform Belemnite of Stonesfield, in vol. iii, pl. 8, fig. 13; the lateral and retral expansion of the guard being greater than usual.

Miller, in the 'Geol. Trans.,' 2nd ser., vol. ii, pl. viii, fig. 22, gives a figure of the same unusual proportions, but with the peculiarity that the ventral groove does not extend over any part of the alveolar cavity, a circumstance never yet observed by me among upwards of twenty specimens from Stonesfield.

Morris and Lycett, in the 'Monographs of the Palæontographical Society,' give figures and descriptions of the Belemnites of Stonesfield, under the names of *B. Bessinus* (adopted from D'Orbigny) and *B. fusiformis* (vol. for 1850, pl. i, figs. 5 to 8). The figs. 5 and 7 for *B. Bessinus* differ scarcely in anything from figs. 6 and 8 for *B. fusiformis*, except that these latter are slightly swollen in the middle part of the post-alveolar region. These authors regard *B. fusiformis* as the equivalent of *B. Fleuriausus* of D'Orbigny. But the author of the 'Paléontologie Française' was of a different opinion, and placed *B. fusiformis* of Miller among the many synonyms which he quotes with *B. hastatus* of Blainville. In Pl. XXVI all the different forms of Stonesfield Belemnites as yet discovered are represented; they all possess a depressed post-alveolar region, and a ventral sulcus reaching far toward the apex, and extending considerably in the alveolar region.

Belemnites Bessinus, *D'Orb.* Pl. XXVI, fig. 63.

Reference. *B. Bessinus*, D'Orb., 'Pal. Franç. Ter. Jur.,' p. 110, pl. xiii, figs. 7—13, 1842.
B. canaliculatus, Quenst., 'Ceph.,' p. 438, pl. xxix, fig. 7, 1849.

Guard. Elongate, gently and equally tapering till near the apex, which is subacute; depressed in all the post-alveolar and part of the alveolar region, nearly circular in the advanced part of the alveolar region; ventral surface marked by a deep distinct groove reaching from near the apex to about the last or most advanced of the septa in the phragmocone.

Transverse section nearly circular at the alveolar apex, much depressed in all the region behind it.

Dimensions. Greatest length observed $6\frac{1}{10}$ inches (specimen in Oxford Museum); the alveolar cavity occupies $1\frac{1}{4}$ inch. Diameter at alveolar apex 0·6 inch.

Proportions. Taking the diameter *v d* at the alveolar apex = 100, that from side to side = 105; the axis is excentric and = 500; near the apex the diameter from side to side is to that from back to front as 135 : 100.

Phragmocone. In several specimens this part of the Belemnite shell is seen; in one of my examples it is very well seen. The angle is from 18° to 29°; the sides are straight; the back and front very slightly curved; the apex is a spherule; the septa are at the ordinary distance—about one sixth of the diameter; the axis of the chambered part visible is half the length of the axis of the guard; the diameter of the largest septum (crushed) $\frac{1}{2}$ inch. But single septa occur in the Stonesfield strata which measure 1 inch across, and are very nearly circular.

Locality. Stonesfield, Oxfordshire, in the lowest fissile beds of the Great Oolite.

Observations. The specimens which are represented in Pl. XXVI under the name of *B. Bessinus*, agree very fairly with D'Orbigny's figure already referred to, except that no trace of contraction in breadth appears about the alveolar apex, as in his example, giving a slightly subhastate figure to the guard. But a specimen in the Oxford Collection, of the same size as the largest of our figures, exhibits this peculiar outline in a very slight degree; it also shows, but not very clearly, the double shallow stria which is mentioned at the retral extremity of the deep, well-defined ventral groove (D'Orb., pl. xiii, fig. 7). If to these points of agreement we add the conformity of the angle of the phragmocone (20° in each), there will be little reason to doubt the agreement of the species. D'Orbigny obtained his specimen from the Inferior Oolite of Port-en-Bessin (Calvados).

Belemnites aripistillum, *Llwyd*. Pl. XXVI, fig. 64.

Reference. *Belemnites aripistillum referens*, Llwyd, 'Lithophylacium Britannicum,' No. 1705, pl. xxv, fig. 1705, 1699.

Fusiform Belemnite, Platt, 'Phil. Trans.,' pl. iv, fig. 2, 1764.

B. fusiformis, Parkinson, 'Org. Rem.,' p. 127, vol. iii, pl. viii, fig. 13, 1813.

B. fusiformis, Miller, 'Geol. Trans.,' p. 61, vol. ii, pl. viii, fig. 22; pl. ix, figs. 5, 7, 1826.

B. fusiformis, Morris and Lycett, 'Great Oolite Mollusca,' Part. I, p. 8, pl. i, figs. 6 and 8, 1851.

Guard. Elongate, fusiform, anteriorly circular, posteriorly depressed, with a deep well-defined furrow on the ventral surface, extending over the alveolus, and reaching to the apex, or near to it.

The young and old agree in general form.

Transverse sections show the outline to be reniform in all the post-alveolar region, the longest diameter being from side to side; in the most advanced part of the alveolar region the section is nearly circular; the axis is excentric and straight.

The longest specimen of the guard, including its expansion over the alveolus, measures $3\frac{1}{4}$ inches; the alveolar portion being $\frac{3}{4}$ inch. Diameter from side to side at the alveolar apex ·21, at the expanded part ·36.

Proportions. Taking the diameter from back to front at the alveolar apex at 100, that from side to side is 120, the axis 1000.

Phragmocone. Partially observed in several specimens, in none completely.

Locality. Stonesfield, Oxfordshire (*Phillips*) and Eyeford, Gloucestershire (*Buckman*); in the lowest fissile beds of the Great Oolite.

Observations. Morris and Lycett ('Pal. Soc. Monog.') and Morris ('Catalogue of British Fossils') give for a synonym *B. Fleuriausus* of D'Orbigny, 'Terrains Jurassiques Céphalop.,' pl. xiii, figs. 14—18. D'Orbigny himself treats *B. fusiformis* as identical with *B. hastatus*—remarking of this species the unusual distance between the septa, the apex submucronate and free from groove for one third of the apicial length, and the small angle of the phragmocone (11° to 18°). "It is," he says, "without contradiction, the most characteristic species of the lower Oxford Clay, where it constitutes a positive and certain zone." If we take the drawings and descriptions of D'Orbigny for guide, and compare with them the fossils of British localities, we shall find in the Oxford Clay of Cowley near Oxford, close analogies to *B. hastatus*, and in the fossils of Stonesfield equal resemblance to *B. Fleuriausus*, which is quoted from "Great Oolite" at Luçon (Vendée).

BELEMNITES PARALLELUS, n. s. Pl. XXVII, figs. 65, 66.

Reference.—Belemnites canaliculatus Quenstedt., 'Cephalop.,' pl. xix, fig. 4, from beds below *Ammonites macrocephalus;* and *B. fusiformis* of the same author pl. xxix, fig. 40, from the Great Oolite of Lahr, in the Rheinthal, may probably be of his species. 1849.

GUARD. Elongate, depressed, except in the advanced alveolar region; fusiform when young, then becoming hastate or subhastate (old specimens unknown at present). Ventral surface marked by a distinct groove, extended forward over the alveolar cavity and backward toward the very acute apex, but terminating in that direction so as to leave free from groove a length equal to one third of the axis of the guard.

Transverse sections circular across the forward part of the alveolar cavity, depressed and reniform in all the post-alveolar part, except toward the apex, where they pass from elliptical to circular.

Dimensions. From $\frac{1}{2}$ inch to $3\frac{4}{10}$ inches, of which the axis is about 2 inches and $\frac{8}{10}$ths.

Proportions. In the oldest example yet observed, the axis is seven times as long as the greatest post-alveolar breadth, ten times as long as the breadth at the alveolar apex, and between eleven and twelve times as long as the ventro-dorsal diameter there. Axis, therefore, 1150; the ventro-dorsal diameter being taken at 100.

PHRAGMOCONE. In one specimen 24 septa are counted in a quarter of an inch from the apex, which is terminated by rather a large spherule. The angle of the phragmocone is about 28°.

In young fusiform specimens, resembling an oat-grain, the alveolar part is rarely traceable, the pearly laminæ of the guard having perished, or fracture having occurred. In older specimens these white laminæ are covered over by darker and more solid layers.

Locality. In Clay coloured on the Ordnance Map as the "Fuller's Earth," between Great and Inferior Oolite, at Whistle Bridge, near Yeovil (*Ibbotson, Buckman, Wood*); and Misterton, near Sherborne (*Buckman*). In the Museum at Strasburg a specimen marked from the "Fuller's Earth at Oerschingen," above 5 inches long, much resembles our specimens from Dorsetshire. In the Oxford Collection are specimens from the Oxford Clay at Long Marston, near Oxford, which cannot be distinguished from those of Dorset.

EXPLANATION OF PLATE XXI.

FIG.

53. BELEMNITES ELLIPTICUS.

- *l'*. Lateral view of specimen in the Bristol Institution, from Dundry.
- *v'*. Ventral aspect of the same, showing the greatly compressed shape.
- *l''*. Lateral view, showing rugose extremity, and trace of lateral groove.
- *l'''*. Lateral view, showing worn surface, and groove near the apex.
- *v'''*. Outline of the ventral aspect.
- *s'''*. Cross section of the same.
- s'. View of a septum with the siphuncle, showing its unusually elliptical outline.
- ϕ'. Side view of two septa.
- ϕ''. Side view of phragmocone, with the conothecal laminæ.
- σ. Striation on the conotheca; s'', one of the septa of ϕ''; s''', another septum.

P. Lackerbauer lith.

Imp. Becquet à Paris.

EXPLANATION OF PLATE XXII.

FIG.

54. BELEMNITES AALENSIS.

l'. Lateral view of a specimen from White Nab, Scarborough.

d'. Dorsal aspect of the same.

l''. Lateral view of another specimen, showing plainly the lateral groove.

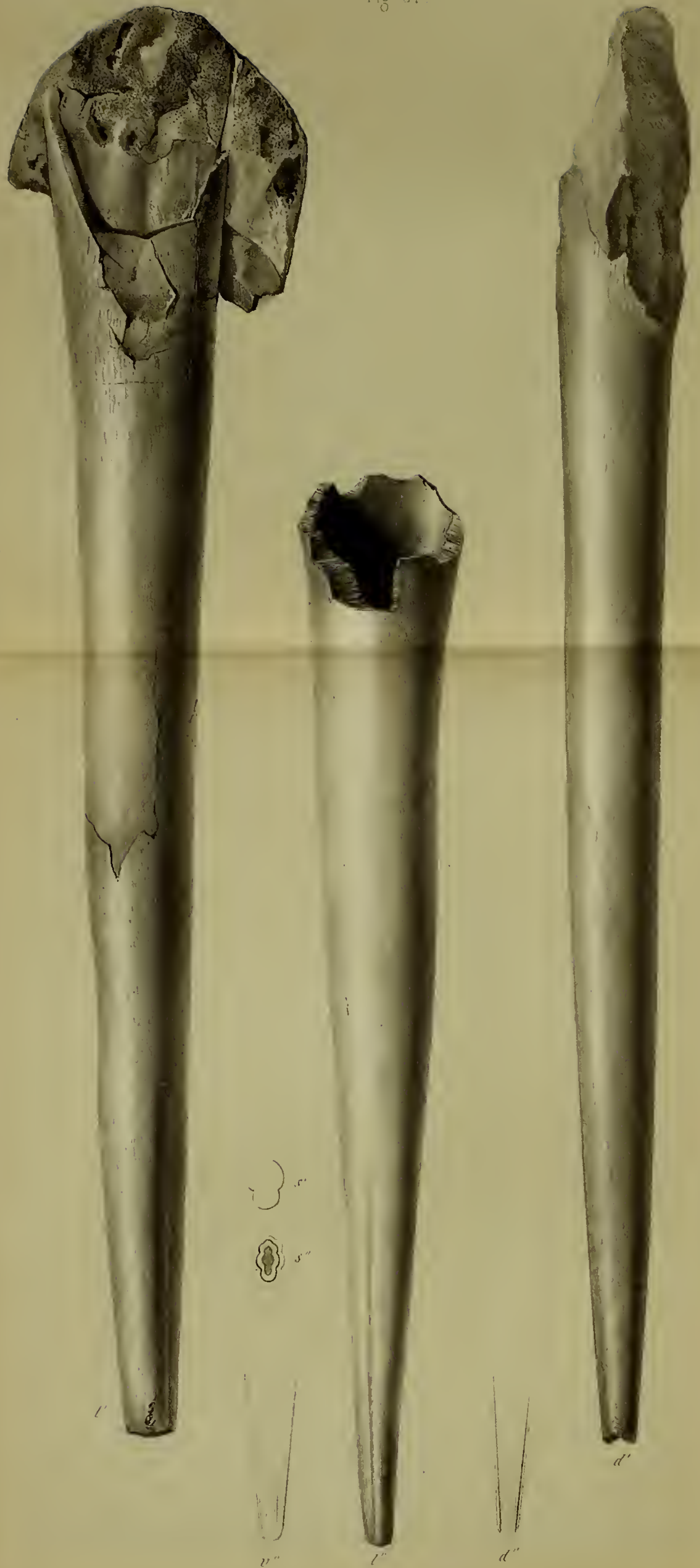
v''. Ventral aspect, somewhat striated.

d''. Dorsal aspect, also striated, and showing the two grooves.

s'. Cross section not far from the end.

s''. Cross section, showing the internal parts to be marked with several short grooves.

Fig. 54.



J. Lackerbauer lith.

Imp. Becquet à Paris

EXPLANATION OF PLATE XXIII.

FIG.

55 BELEMNITES GIGANTEUS.

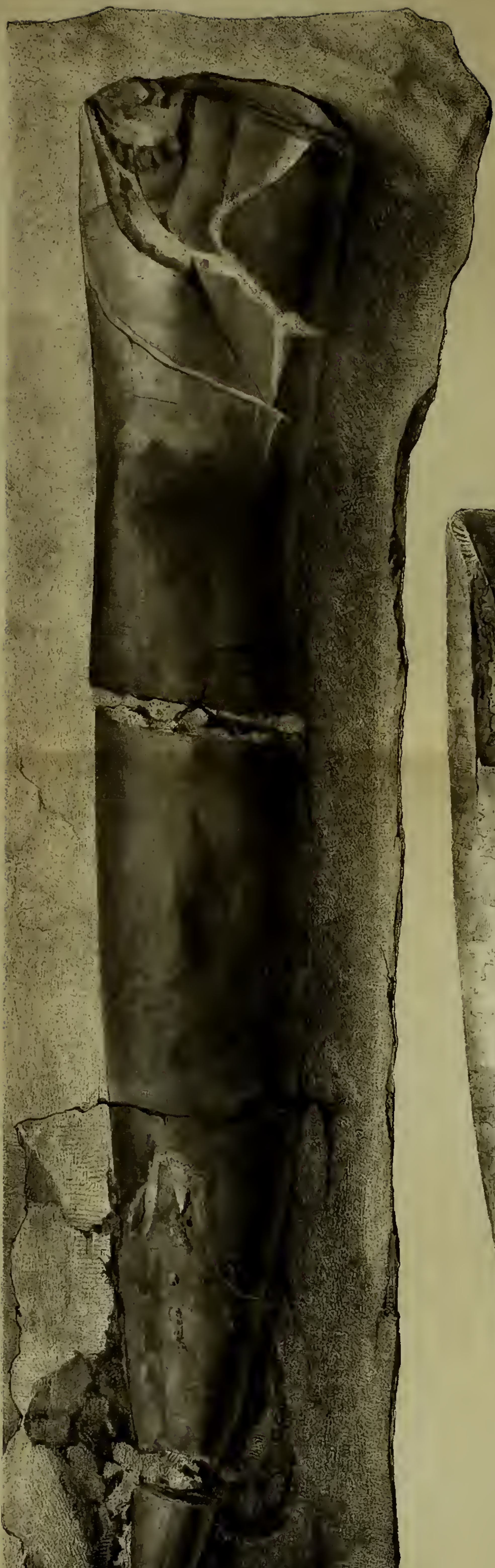
l'. Lateral aspect. (From the Inferior Oolite, near Sherborne, Dorsetshire.) In the Collection of Mr. Reed, Salisbury.

The specimen was cracked and displaced after being enclosed in the rock.

56 BELEMNITES QUINQUESULCATUS.

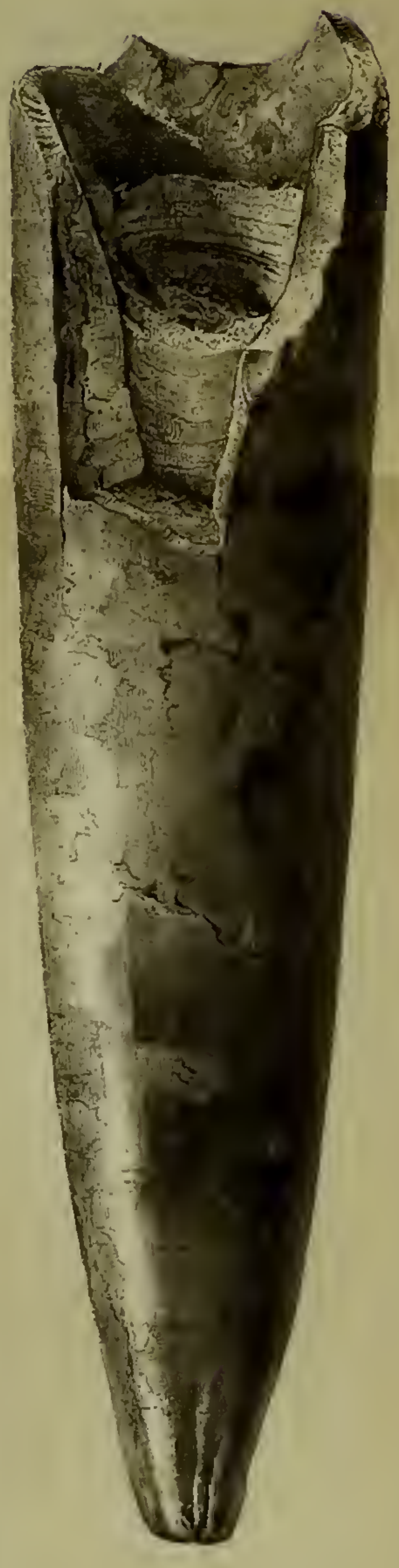
l''. Lateral aspect, with six-channelled apex (From near Sherborne.) In the Collection of Mr. Reed.

Fig. 55.



1'

Fig. 56.



1''

P. Lackerbauer lith.

Imp. Becquet à Paris

EXPLANATION OF PLATE XXIV.

Fig.

57 Belemnites quinquesulcatus.

l'. Lateral aspect. (From the Grey Limestone of White Nab, Scarborough.) By erosion at the point the grooves appear.

v'. Ventral aspect, striato-sulcate.

d'. Dorsal aspect, showing the two lateral and one short dorsal groove.

l''. Lateral aspect, with grooved apex, and the phragmocone *in situ.*

d''. A specimen, seen dorsally, to show the lateral grooves, and on the phragmocone the hyperbolic dorsal arcs.

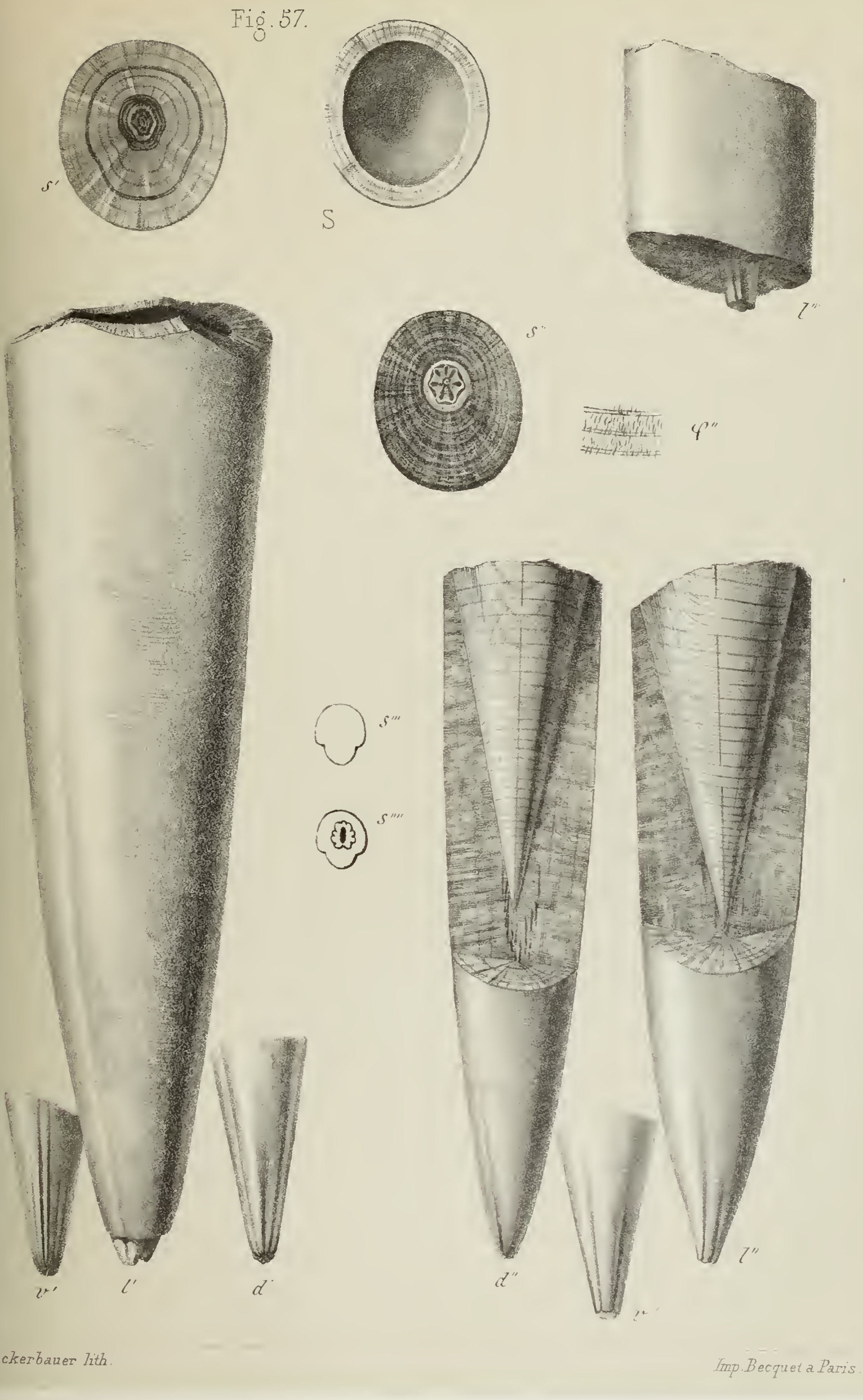
ϕ''. Striation on the conotheca.

l'''. Fragment seen laterally, showing by accidental fracture the interior apicial grooves.

s. Cross section in the alveolar region.

s', s'', s''', s^{iv}. Cross sections of the sheath. In s', the interior laminæ show lateral grooves: in s'', the terminal grooves are marked by seven tinted radial parts: in s^{iv}, several grooves appear.

Fig. 57.



P. Lackerbauer lith.

Imp. Becquet a Paris.

EXPLANATION OF PLATE XXV.

FIG.

58. BELEMNITES APICICONUS. (From Yeovil.)

v. Ventral aspect, showing an unusually definite posterior ending to the groove, and its continuity over the alveolar cavity. Specimen in the Oxford Museum, from Inferior Oolite, Yeovil.

l. Lateral view of the same : s, section across the alveolar cavity ; *v'*, frustum seen vertically to show the distinctness of the groove.

59. BELEMNITES BLAINVILLII. Long variety. (From Sherborne.)

v'. Ventral aspect, showing the groove reaching nearly to the apex, and dying out on the alveolar cavity.

v''. Another example, showing the groove certainly extending over a part of the alveolar space.

l. A side view.

s. Section across the alveolar cavity; *s*, section across the guard at the alveolar apex.

60. BELEMNITES BLAINVILLII. Shorter variety. (From Sherborne.)

v'. Ventral aspect, the groove reaching to the phragmocone.

s'. Cross section.

v''. Another specimen, showing the groove extended further forward.

s''. Cross section of the same ; *l''*, lateral view.

v'''. Ventral aspect of a specimen, where the groove does not quite reach the alveolar cavity ; s''', cross section of the alveolar cavity.

61. BELEMNITES CANALICULATUS.

v' Ventral aspect } of a small specimen from Dundry.
l'. Lateral aspect }

v''. Ventral aspect of a larger specimen, a little bent, from Dundry.

s''. Cross section of the sheath ; s'', section across the alveolar cavity.

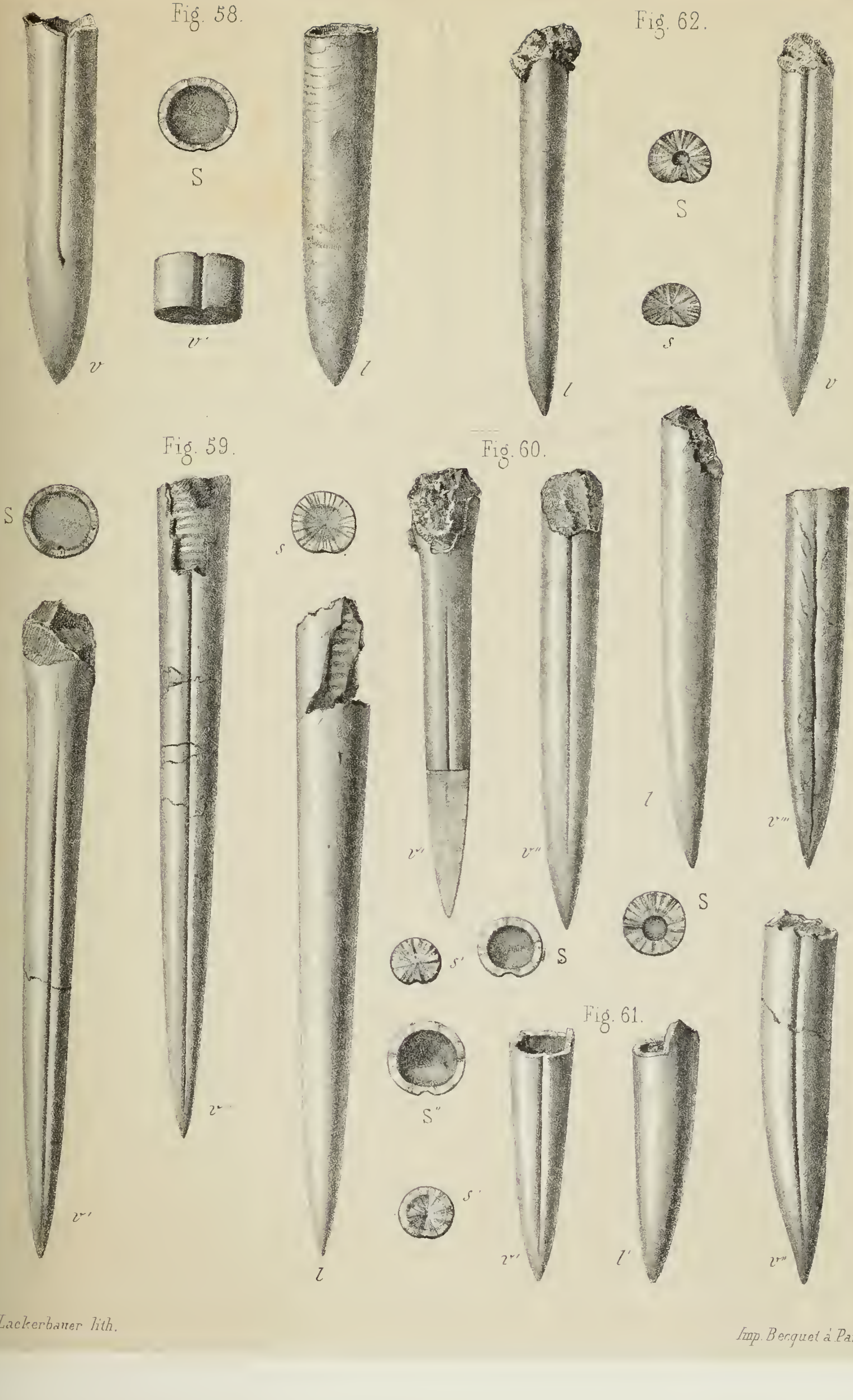
62. BELEMNITES TERMINALIS, n. s.

l. Lateral view.

v. Ventral aspect.

s. Section across the alveolar chamber.

s. Section across the guard.



P. Lackerbauer lith.

Imp. Becquet à Paris.

EXPLANATION OF PLATE XXVI.

FIG.

63. BELEMNITES BESSINUS. (From Stonesfield.)

v'. Ventral aspect of a specimen, showing the phragmocone *in sitû*, and the groove continued over it.

s', s''. Cross sections of the sheath.

v''. Ventral aspect of a large specimen in the Oxford Museum.

v'''. Similar view of a small specimen.

v^{iv}. Another specimen of intermediate size.

l^{iv}. Lateral view of the same.

s^{iv}. Cross section of the alveolar chamber.

64. BELEMNITES ARI-PISTILLUM. (From Stonesfield.)

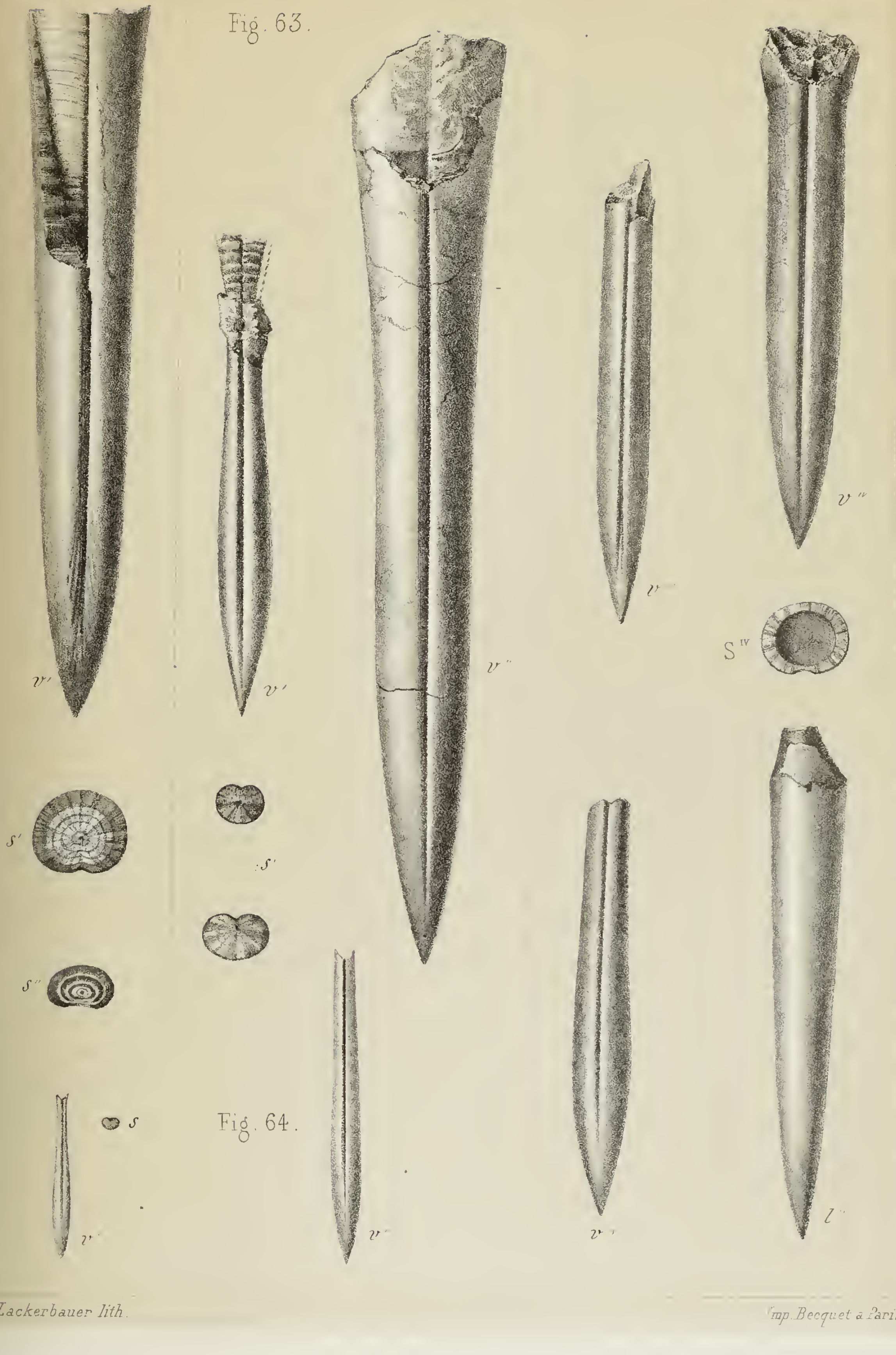
v'. Ventral aspect with phragmocone, *in sitû*.

s'. Sections across the guard.

v''. Small specimen; s'', its cross section.

v'''. Specimen of one somewhat larger.

v^{iv} Largest example which has been observed by the author. In Mr. J. Parker's Collection.



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EXPLANATION OF PLATE XXVII.

FIG.

65. BELEMNITES PARALLELUS, n. s. (Upper series on the Plate.)

- v'. Ventral aspect of a fragment, showing the alveolar cavity, and an abnormal expansion of the groove: from Misterton, near Sherborne.
- l'. Lateral aspect of a fragment from Misterton.
- l''. Lateral view of the largest individual from Misterton.
- v''. Ventral aspect of the same.
- s$''$. Sections across the alveolar cavity.
- s''. Sections across the sheath.

66. Lower series on the Plate.

- l^{iv}. Lateral views of specimens from Whistle Bridge, near Yeovil.
- d^{iv}. Dorsal view, and v^{iv} ventral view of the same.
- s^{iv}. Sections of the guard of the same.
- l^{v}, d^{v}, v^{v}. Young specimens.
- v'''. Shows the relation of the young to the larger figures.
- ϕ''. Restoration of the phragmocone.
- ϕ'''. Longitudinal section (by splitting), showing the phragmocone.
- s$'''$. Cross sections of the alveolar cavity.

Fig. 65.

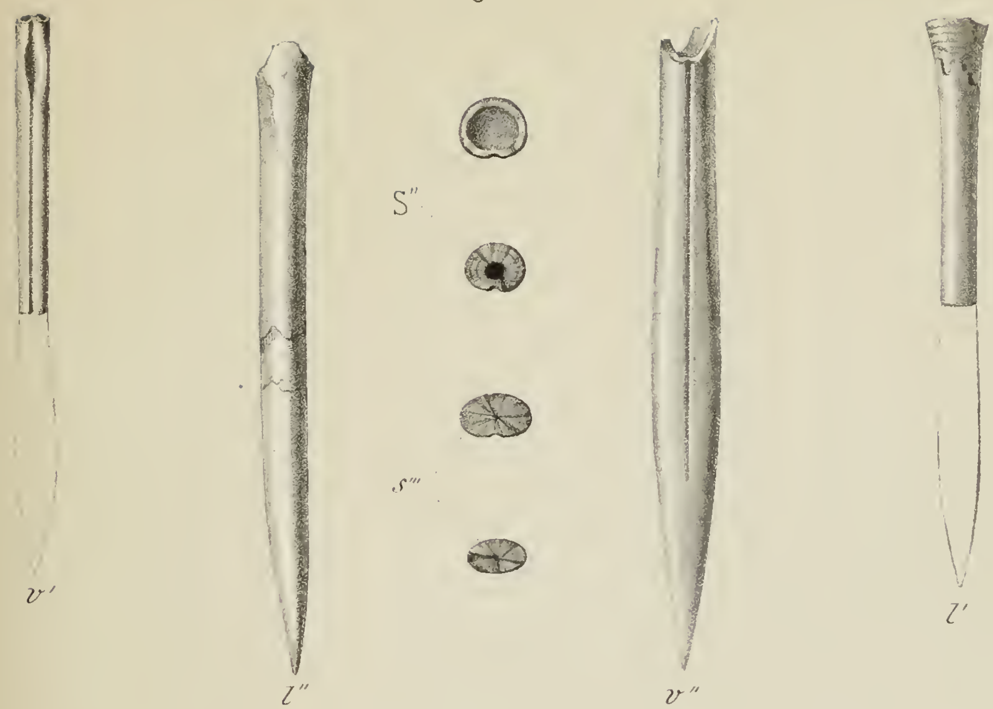
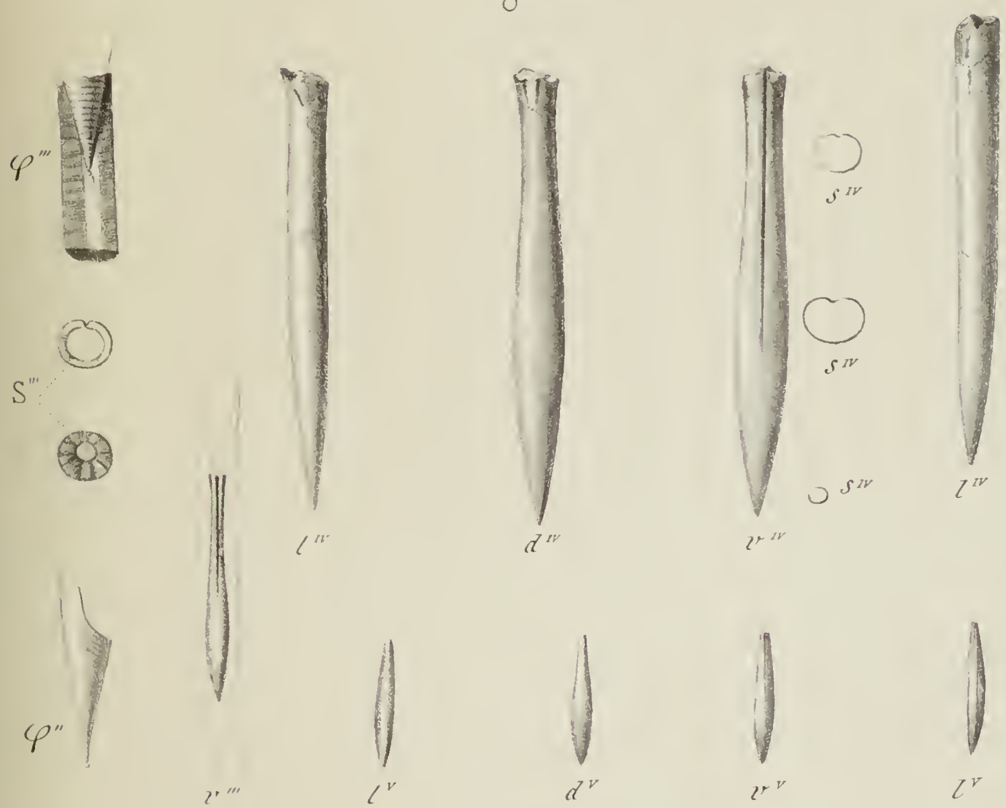


Fig. 66.



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THE

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MONOGRAPHS

ON THE

BRITISH FOSSIL

REPTILIA

FROM

THE KIMMERIDGE CLAY.

BY

RICHARD OWEN, F.R.S., D.C.L.,

FOREIGN ASSOCIATE OF THE INSTITUTE OF FRANCE, ETC., ETC.

No. III,

CONTAINING

PLIOSAURUS GRANDIS, PL. TROCHANTERIUS, AND PL. PORTLANDICUS.

Pages 1—12; Plates I—IV.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1869.

PRINTED BY
J. E. ADLARD, BARTHOLOMEW CLOSE.

MONOGRAPH (No. III)

OF

THE FOSSIL REPTILIA

OF THE

KIMMERIDGE CLAY.

Order—SAUROPTERYGIA, *Owen.*

Genus—Pliosaurus, *Owen.*

The first* and second† Monographs relating to the *Reptilia* of the Kimmeridge Clay were mainly expository of the dental characters of *Pliosaurus,* and indicative of the gigantic size attained by some individuals of the genus. In the present Monograph I propose to treat of this genus more at large, and submit the evidences that I have obtained of its specific modifications.

The generic characters of the teeth, in regard to shape and structure, have been sufficiently exemplified in the first two Monographs: those of the skeleton are chiefly shown by vertebræ from the region of the neck. These resemble, at first sight, the vertebræ of the genus *Ichthyosaurus* in their extreme shortness as compared with their breadth and depth. A cervical vertebra of a *Pliosaurus,* from the Kimmeridge Clay of Foxcombe Hill, near Oxford, measures, for example, in breadth, six inches; in depth, or vertical diameter, five inches; while in length, or the diameter corresponding with the axis of the animal's body, or of its vertebral column, it measures only an inch and a half. Nevertheless, with these ichthyosaurian proportions is associated an essentially plesiosaurian type of structure. The lower surface of the cervical centrums show the pair of vascular foramina: the terminal articular surfaces are flat, not concave: the cervical rib was ligamentously tied, in some species, to two processes, the di- and par-apophyses,—occupying two thirds of the fore-and-aft extent of the side of the

* Vol. of Pal. Soc. for the year 1859; Monogr. of the 'Reptilia of the Kim. Clay,' pp. 15, 16, Pl. VII, 1861.

† Vol. of Pal. Soc. for the year 1860; Monogr. of the 'Reptilia of the Kim. Clay,' pp. 27, 28, Pl. XII, 1863 (1862 on the cover).

centrum, slightly projecting beyond the surface, and divided by a deep linear fissure. I have rarely seen an instance in which the neurapophyses were anchylosed to the centrum, and never one with the pleurapophyses so attached. In a specimen of *Pliosaurus* from the Kimmeridge Clay of Market-Downham, in the collection of C. B. Rose, Esq., F.G.S. (at Yarmouth), there are twenty of these short cervical vertebræ, at the trunk end of which series the costal processes begin to climb, as in *Plesiosaurus,* upon the neurapophysis,—the diapophysis growing at the expense of the parapophysis, until the rib becomes supported, in the dorsal region, upon a single strong and prominent process: this is subdepressed, with an oval transverse section, which is rather sharp at the anterior margin. The vertebral centrums begin to gain in length as the costal processes rise in position, and those of the dorsal region have attained to quite plesiosaurian proportions. Throughout the rest of the column the vertebræ closely repeat the plesiosaurian characters on a large scale. The sides, or non-articular surface of the centrum, are rugous near the articular ends, elsewhere smooth, and in the dorsal region longitudinally concave. In the caudal vertebræ the costal process is undivided, prominent, with a vertically elliptical section, continuous with the neurapophysial surface at the base of the tail: the lower surface of the centrum is square-shaped and nearly flat: its angles are marked by the hypapophysial surfaces, of which the anterior pair is usually the largest..

The generic character derived from the organs of locomotion is the apparent absence of the antibrachial and cnemial bones, which seem to be represented by a proximal row of three large "carpal" and "tarsal" ossicles. On the homology of these I shall offer remarks in the sequel.

As to the history of the present genus, I may briefly state that in a 'Report on British Fossil Reptiles,' communicated to the Meeting of the British Association for the Advancement of Sciences, held in 1839, and printed in the volume of 'Reports' for that year,* I described certain fossils, from which were deduced the two species of *Plesiosaurus,* called "*grandis,*" p. 83, and "*trochanterius,*" p. 85. In my second Report on the same class of fossils communicated to the Association in 1841, I pointed out (p. 60) the characters by which those two species departed so far from the type-characters of *Plesiosaurus* as to merit being placed in a distinct genus or subgenus, for which I proposed the name of *Pliosaurus;* admitting at the same time in reference to the two species, that "subsequent discoveries and observations were needed to supply distinct and recognisable characters for them"—"the two forms of femora, on which they were founded, not having then been found so associated with vertebræ and other bones as to aid in their definition."†

I propose in the present Monograph to describe and figure the specimens, among those that have subsequently come under my notice, which afford good grounds for the acceptance of the two species, and for the addition of a third to the genus *Pliosaurus.* It may seem strange that jaws which have lost all their teeth should yield new characters derivable from the number, proportions, and disposition of such organs; but herein a

* 'Report of Brit. Assoc.,' 8vo, pp. 83, 86, 1839.

† Ib. (Second Report), p. 54, 1841.

Palæontologist's mode of work is like that of Antiquaries of another order, who read inscriptions on Roman buildings by the nail-marks when the letters themselves have been wrenched off for the sake of the metal.

Species—PLIOSAURUS GRANDIS, *Owen.* Plates I and II.

PLESIOSAURUS GRANDIS, *Ow.* Report on British Fossil Reptiles, 8vo, p. 83, 1839.
PLEIOSAURUS BRACHYDEIRUS, *Ow.* Odontography, 4to, p. 283 (?), 1840.

The most complete example of the skull of a Pliosaur which has come under my observation was disinterred from the Kimmeridge Clay, at Kimmeridge, Dorsetshire, under the superintendence of J. C. Mansel, Esq., F.G.S., of Longthorne, in that county. This skull is also the largest of such specimens hitherto found'; and, since the matrix has been removed, it has yielded the most instructive characters of cranial structure and dentition. Originally sent to me by Mr. Mansel for determination and description, the specimen has since been presented by its discoverer to the British Museum. The same liberal donor has subsequently enriched the National Collection by a lower jaw and part of the cranium, with evidence of the locomotive organs of the *Pliosaurus trochanterius.* I shall premise to the descriptions some of the dimensions of both specimens.

TABLE OF ADMEASUREMENTS.

	Pliosaurus grandis.			*Pliosaurus trochanterius.*		
	Feet.	Inches.	Lines.	Feet.	Inches.	Lines.
Length of the mandible in a straight line from the fore end of the symphysis to the angle of the jaw . .	5	8	—	4	4	—
Ib., following the curve on the outer side of the ramus	5	11	—	4	5	6
Length of the alveolar series following the curve . .	3	7	—	1	9	6
Length of the "symphysis mandibulæ" . . .	1	1	6	1	4	6
Greatest breadth of ditto	—	7	3	—	7	4
Breadth at posterior part of ditto	—	6	9	—	7	4
Depth of, at the same part	—	5	6	—	3	9
Depth of ramus anterior to articular surface . .	—	4	3	—	4	9
Breadth of mandible at the hind end of the alveolar series	1	11	—	—	8	8
Length of cranium from the occipital condyle to the end of muzzle*	4	9	—	—	—	—
Greatest breadth of premaxillaries, viz., across the fourth pair of alveoli	—	6	9	—	—	—
Breadth behind the fifth pair of alveoli . . .	—	5	6	—	—	—
Breadth of cranium behind the alveolar series . .	2	1	—	—	—	—
Length of palato-nares	—	5	—	—	—	—
Breadth of ditto	—	1	8	—	—	—
Distance from their back part to end of occipital condyle	—	6	5	—	—	—

* The tympanic articulations for the lower jaw, which extend the cranium beyond the condyle, are broken off.

In *Pliosaurus grandis* the number of alveoli on each side of the upper jaw is twenty-seven or twenty-eight. The first pair (Pl. II, $_a$) are terminal and approximate; the outlet of each measures 1 inch 3 lines in long diameter, which lies in the axis of the jaw: the second alveolus (*b*), with an outlet 1 inch 9 lines in long diameter, which is transverse to the jaw's axis, is divided by a partition (*a'*) of 4 lines breadth from the first: the third socket ($_c$) is divided by a partition (*b'*), half an inch in breadth, from the second; its outlet is circular, and 2 inches in diameter: the fourth socket (*d*) is of similar size, and at rather less distance from the third: the fifth socket ($_e$) is less in transverse diameter than the third, but is equal in fore-and-aft diameter to the fourth, from which it stands 9 lines apart. These five pairs of alveoli are in the premaxillary bones, and occupy the whole of their alveolar extent. An interval of rather more than 2 inches intervenes between the last premaxillary and the first maxillary alveolus, which is the sixth of the series; and this interval is traversed obliquely by the maxillo-premaxillary suture (Pl. I, 22). The maxillary alveoli have partition walls of about 4 lines in thickness at their free border; but these become thinner as the teeth decrease in size in the hinder third part of the series. The alveoli increase in size from the first to the fourth maxillary tooth (ninth of the dental series); the longest diameter of the aperture of this socket is 3 inches: thence the alveoli gradually decrease in size to a diameter of half an inch. The form of the alveolar aperture is, for the most part, a full oval, nearly circular, with the long diameter inclining more or less transversely.

The margins of the larger maxillary alveoli are the most prominent. The entire alveolar series describes longitudinally and horizontally a gently undulated course (Pl. I, fig. 1), the premaxillary series forming a slight convexity, and the larger maxillary alveoli a similar convexity, outward. Longitudinally and vertically (Pl. I, fig. 2) the alveolar border is almost straight as far as the seventeenth tooth, and then gently bends upward to the end of the series. A groove, deepening into fossæ answering in number to the alveoli, extends along the inner side of each premaxillary series (Pl. II, $_{nn}$). This groove is interrupted at the diastema between the premaxillary and maxillary alveoli: it recommences at the inner side of the maxillary series (Pl. II, $_n$), also deepening into pits opposite the inner and back part of the alveoli, and continues, though feebly indicated, along the hinder third of the alveolar series.

The bony palate is entire, save at the palato-nares (Pl. II, $_r$, $_r$); but on the inner side of the twelfth socket, counting backward, on each side, there is a nervo-vascular foramen terminating a canal in the upper jaw, directed obliquely downward and forward: the foramen is elliptical, an inch in diameter; a shallow channel extends a few inches in advance of its outlet, and three or four similar but smaller foramina succeed each other anteriorly near the inner wall of the internal alveolar groove, leading to a linear channel 7 inches long, which, with its fellow on the opposite side, defines the base of a median longitudinal ridge of the bony palate between the first three pairs of maxillary alveoli, which ridge (fig. 1, 21) is transversely convex, and about an inch in breadth. As the bony palate expands in breadth, behind the nervo-vascular foramina, it presents transversely a broader median convexity, bounded by lateral shallow concavities. On the transverse line, between the sixteenth pair of alveoli, are the anterior ends of the palatine bones, which are divided by a median suture (Pl. I, 20, 20). The major part of the palato-nares are bounded by the pterygoids (ib., 24, 24), which extend backward to the base of the occipital condyle (ib., 1), underlapping the basi-sphenoid and basi-occipital, developing ridges which project below the level of the lateral parts of the fossa, and converge to meet behind the area, including the posterior nostrils. External to these ridges the pterygoids diverge to abut against the tympanic pedicles. The mesial border of an ectopterygoid is preserved at 25, fig. 1.

The number of alveoli in each ramus of the mandible (Pl. I, fig. 3) is twenty-five or twenty-six. The five alveoli corresponding with the premaxillary sockets in the upper jaw are the largest. They are separated by similar intervals. Between the fifth and the sixth alveolus is a diastema of about 8 lines; the long diameter of the sixth alveolus is 1 inch 10 lines. An interval of 5 lines divides it from the seventh socket. The succeeding ones are closer together: they gradually increase in size to the twelfth or thirteenth, but do not obtain the size of those opposed to them above; they then gradually decrease in size and depth to a diameter of about half an inch.

The summits of crowns of successional teeth protrude from fossæ at the inner and back part of the anterior alveoli. The crown of a more advanced successional tooth projects into the bottom of the socket of the third and fifth of the symphysial series: these teeth show the characters of the genus *Pliosaurus*.

The inter-alveolar part of the "symphysis mandibulæ" forms a median longitudinal rising, less convex or ridge-like than the one on the palate above. Fossæ are discernible on the inner side of the mandibular alveoli, but less marked in the upper jaw. The apex of a successional tooth appears in two of these pits. On the inner side of the posterior third of the mandibular ramus there is a wide and deep channel between the surangular (29) and angular (30) elements; and this groove is continued forward indicative of the upper border of the splenial (31) which extends along the inner side of the lower half of the dentary nearly to the symphysis. The articular surface of the mandible (29), 7 inches in transverse, and 5 inches in antero-posterior extent, is slightly concave transversely at the inner three fourths of its extent, and then gently convex at the outer fourth; it is more concave from before backwards in the major part of its extent, but the peripheral boundary is not entire.

The plesiosaurian affinities, as contradistinguished from the ichthyosaurian, are exemplified in the more complete and separate sockets of all the teeth, and in the smaller proportion contributed by the premaxillaries to their support and to the formation of the upper jaw.

The palato-nares of *Pliosaurus* are more linear and approximate than the species of *Plesiosaurus* (*Pl. Hawkinsii*, Pl. XVI;* and *Pl. rostratus*, Pl. XIII,* ib.), in which they have been observed.

* Vol. of Pal. Soc. for the year 1863; Monogr. of the 'Reptilia of the Liassic Formations,' 1865.

Species—Pliosaurus brachydeirus, *Owen* (?).

In the Museum of Geology at Oxford are considerable proportions of the upper and lower jaws of a *Pliosaurus* from the Kimmeridge Clay at Market-Raisin.* The teeth, in number, proportions, and arrangement, correspond so closely with those in the specimen above described as to induce me to believe them to belong to the same species. The following are the differences which I have noted between them: the widest diastema divides the fourth upper tooth from the fifth in the Oxford specimen, not the fifth from the sixth: the maxillo-premaxillary suture with the lateral compression at this interval, as in the British Museum specimen. If the pair of small anterior sockets and teeth are wanting, either through age or accident, in the Oxford specimen the difference noted would be accounted for. It may be remarked that the number of alveoli—twenty-six—on the least imperfect side of the upper jaw is the same in both skulls, and in both a small part of the series is wanting posteriorly. In both the premaxillary part of the jaw containing four pairs of large teeth is slightly expanded. In the maxillary part of the Oxford specimen the teeth increase in size to the sixth; in the British Museum specimen to the fifth; beyond which they gradually diminish. The length of the best-preserved alveolar series is 3 feet in the Oxford specimen, and 3 feet 7 inches in that in the British Museum.

In the mandible from Market-Raisin there are thirty-five sockets in each side; in that from Kimmeridge there are only thirty: but as neither specimens have the alveolar series quite complete, I do not feel that there is sufficient ground to reject the hypothesis of individual variety. In all the essential characters, including length of symphysis mandibulæ, the Market-Raisin skull agrees with that in the Kimmeridge example of *Pliosaurus grandis,* and differs from that of *Pliosaurus trochanterius,* about to be described. If, however, the minor differences which have been noted between the Oxford specimen and that figured in Pls. I and II, should prove to be constant, the specific name "*brachydeirus,*" by which I originally indicated Dr. Buckland's magnificent specimen† from Market-Raisin, might be retained for it.

* 'Second Report on British Fossil Reptiles,' "Report of British Association," p. 61, 1841.

† 'Odontography,' p. 283.

Species—Pliosaurus trochanterius, *Owen*. Plate III.

Plesiosaurus trochanterius, *Ow.* Report on British Fossil Reptiles, 8vo, p. 85, 1839.

In the work above cited the specific character of the fossil Reptile in question was indicated by modifications of the femur; but the chief distinction between *Pliosaurus trochanterius* and *Pl. grandis* is conspicuous in the greater relative extent of the symphysis mandibulæ in the former, and in the greater proportion of the dental series lodged in that part of the lower jaw. This character is exemplified in the fourth admeasurement in the "Table," p. 3, and in Pl. III, fig. 3, as compared with Pl. I, fig. 3.

The surangular developes in *Pliosaurus trochanterius* [Pl. III, fig. 4, 29′] a low but well-marked angular coronoid process. Anterior to this the upper border of the mandible becomes thick and transversely convex; and, an inch below the border, the outer side of the ramus is impressed by a wide and deep longitudinal groove. So much of the articular surface as is preserved agrees in structure and form with that in *Pliosaurus grandis;* and the extent of the angular projection behind the articular cavity to the same.

The fore part of the symphysis, including the first three pairs of teeth, has been subject to such violent horizontal force as to be crushed in that direction, and broken across both the upper and the under surfaces of the rest of the mandible, without having been detached from the intervening structure or tissue of the bone. The bottoms of the sockets only of the included teeth are preserved, with parts of the partitions which, here, are only from 2 to 3 lines thick. These sockets increase in size to the third. The diameter of the outlet of the fifth socket, which is the first entire one, measures 1 inch 9 lines across; it is rather less longitudinally. The outlets of most of the alveoli are subcircular, with a tendency to a subquadrate section, with intervals not exceeding 2 lines, and they retain a uniformity of size to within four or five sockets at the end of the series, which progressively decrease in size.

The total number of teeth, as shown by sockets, in each mandibular ramus is fourteen; of which ten occupy the symphysial part of the jaw (Pl. III, fig. 3).

The upper surface of the symphysis between the first six teeth is flush with the alveolar outlets, is smooth, and slightly convex transversely. Beyond the sixth pair of teeth the intervening surface rises above the inner borders of the alveoli as high as half an inch between the ninth—eleventh pairs of sockets; the upper surface of the hinder part of the symphysis becomes slightly convex transversely, and the pointed anterior ends of the splenials (31) enter into its composition.*

No part of the upper jaws of this skull of *Pliosaurus trochanterius* has been preserved;

* Some of the matrix retained in the interval appears to prolong, in the figure, the symphysis beyond its true posterior limit.

but the quarrymen extracted the hind part of the cranium (Pl. III, fig. 1). It shows a hemispheroid condyle (1) 2 inches 8 lines in basal diameter. The foramen magnum is a full transverse ellipse, 1 inch 3 lines across. The broad and low occipital surface includes the thick horizontal backwardly projecting paroccipital ridges, below which extend still more backward and somewhat downward the short and broad tympanics, terminated each by a condyle convex in its outer two thirds, concave transversely at the inner third: the breadth of this condyle (28) is 5 inches.

The upper transverse ridge of the occiput is broken away. The parietal region (7) is formed by a lofty median vertical wall of bone, slightly expanding below to form the side walls of a miserably small cerebral cavity.

I have neither respect nor inclination for undue multiplication of genera; but the degree of difference in the number of mandibular teeth and extent of the symphysis tempts to a view of the present evidence of *Pliosaurus trochanterius* as testifying to something more than specific distinction from the *Pliosaurus grandis*. I leave, however, the opening for a "name" to any labourer in gattungsmackery who may yield to the temptation.

The *Pliosaurus grandis* retains more similarity with the type Sauropterygians (*Pl. dolichodeirus*, e. g.) in the proportions of the symphysis and of the number of symphysially located teeth. Nevertheless, modifications in these particulars are presented, though in a minor degree, by species of true *Plesiosauri* [compare, in the 'Monograph of the Fossil Reptilia of the Liassic Formations,'* Pl. III, fig. 2 (*Plesiosaurus dolichoderius*), with Pl. XVI, fig. 2 (*Plesiosaurus Hawkinsii*)].

The specimen figured in Pl. III, fig. 2, includes the part of the maxillary bones, with eight or nine pairs of alveoli at or very near to the hind end of the series, of a smaller individual of the *Pliosaurus trochanterius* than that to which the lower jaw, figs. 3, 4, 5, belongs. The transverse section above the figure shows the medial (20) and inner alveolar (21) palatal ridges; also the prominent longitudinal medial ridge on the upper surface (here turned down) of that part of the skull; a similar rising occurs in *Plesiosaurus* (comp. Monogr. cited,* Pl. III, fig. 1, *Ples. dolichodeirus*, Pl. VI, *Ples. homalospondylus*, Pl. XVI, fig. 1, *Ples. Hawkinsii*).

This fragment measures 11 inches in length, and 6 inches in greatest breadth. It is from the same locality and formation as the larger skull, viz., the Kimmeridge Clay of Kimmeridge. Both specimens have been liberally presented to the British Museum by the discoverer, J. C. Mansel, Esq., F.G.S.

PLIOSAURUS PORTLANDICUS, *Owen*. Plate IV, figs. 1, 2, 3.

The true and sufficient generic distinction from *Plesiosaurus* indicated by the term *Pliosaurus*, and suggested by modifications of the shape of the teeth and proportions of

* Vol. of Pal. Soc. for the year 1863, published 1865.

the cervical vertebræ, is confirmed by the structure of the bony framework of the paddles. The modification in question, like the fore-and-aft compression or shortness of the cervical centrums, exemplifies the nearer resemblance, I will not say affinity, of *Pliosaurus* to *Ichthyosaurus;* the segment of the natatory limb which answers to the antibrachium and the cnemion in the higher Vertebrates being scarcely more marked or differentiated in the present genus of huge *Sauropterygia* than in *Ichythyopterygia.*

The first indication of the modification in question was given by a specimen in which only the proximal halves of the two bones, or two chief bones, succeeding the femur were preserved along with that bone.

The inference which I drew from close inspection and comparison of the preserved portions of the two cnemial bones was subsequently confirmed or strengthened by the condition of the same segment of the fin-bones in the magnificent specimen of those bones restored by Mr. Mansel, probably from the bones of the skeleton of the *Pliosaurus grandis* to which the above described skull belonged, and of which fin-bones a cast is exhibited in the Palæontological Gallery of the British Museum.

Nevertheless, with the close general affinities illustrated by most of the framework and dentition of *Plio-* to *Plesio-saurus,* I waited in hopes of an opportunity of acquiring certainty as to the structure of the middle segments of the limb before committing myself to a publication of what I am now able to positively state to be a generic character of *Pliosaurus.*

The wished-for evidence reached me this year in the form of a block of Portland stone, in which were imbedded the femur, cnemion, tarsus, and part of the metatarsus and digits of a right hind-limb, referable by the character about to be described to the genus *Pliosaurus.* The specimen, moreover, had the additional interest of being the first evidence of that genus from the Upper Oolite of Portland Island. It is figured rather less than half the natural size in Pl. IV.

The femur (Pl. IV, figs. 1 and 2, 65) presents the usual plesiosauroid proportions and characters, the pliosaurian affinity being faintly indicated, as usual, by the greater extent of the tract (above 67′) external to the fibular division (above 67) of the distal articular extremity: the tuberosity (fig. 2, *tr*) and contiguous rough surfaces for the attachment of muscles, at and near to the proximal end, are also a little more strongly marked, as in the *Pliosaurus grandis,* but the tuberosity is less distinctly prominent than in *Pliosaurus trochanterius.* The head of the femur (fig. 3, nat. size), subconvex and oblong, is slightly nipped in, as it were, near its outer third part from side to side; the long axis of this surface is at right angles to the plane of the expanded and compressed distal end of the bone. A few of the crateriform elevations on the rough articular surface are preserved. The inner side of the bone is exposed in the block of matrix. The roughness for ligamentous or tendinal attachment ceases about one third of the way down the shaft. This part, gradually contracting, assumes first a circular transverse section, then becomes compressed from without inwards instead

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of from side to side, increasing in breadth and diminishing in thickness to the distal articular end. The surfaces for tibia (66) and fibula (67) are indicated by, or meet at, a widely open angle. The projecting part of the femur beyond the tibial surface is rounded off; that beyond the fibula is, as above remarked, of greater extent, and may have terminated more angularly, but the extreme end has been broken away (fig. 2, 65). The representatives of tibia and fibula appear in size and shape, as in *Ichthyosaurus*, to be a first series of tarsal ossicles; they, however, markedly exceed in size the ossicles of the two succeeding rows, properly constituting the tarsal segment of the fin. The bone (66) answering to the tibia in *Plesiosaurus* (fig. 4, 66) is an irregular oval or oblong flat plate, the margin adapted to the femur being longest and least convex. The breadth of this bone exceeds its length, and the inner or tibial, and the outer or fibular, margins are rounded or strongly convex; the distal margin is more even or straight at its middle part. The length of the bone (in the axis of the femur) is 2 inches; the breadth of the bone is 2 inches 9 lines: an interval of 5 lines between it and the femur indicates most probably the thickness of ligamentous matter which dissolved away after the carcase of the Reptile had sunk into the fine sand or sandy mud now hardened into Portland stone.

The fibula (67) is less than the tibia, measuring 1 inch 9 lines in length, and 2 inches 8 lines in breadth: the margin towards the femur is almost straight; the outer and inner margins convex; the distal one is produced into a low rounded angle opposite the interspace between the tarsal bones *a* and *cl′*, and this slight modification is interesting because the homologous bone in *Plesiosaurus* (fig. 4, 67) shows a similar angular production between the same tarsal ossicles, whilst the distal end of the tibia is truncate.

Another character which would seem to show that a tarsal structure or arrangement immediately followed the femur is evidenced by a depression in the matrix indicative of a third bone, smaller than either fibula or tibia, and of an oval form with the long axis parallel with that of the fin and the small end of the oval produced towards the femur. This ossicle I regard as the homologue of the fabella (67′), which is present in some *Plesiosauri* (*Pl. rugosus*, for example, fig. 4, 67′), where its homotype in the fore-limb is represented by a detached olecranal process of the ulna. But the bone (67′) in *Pliosaurus portlandicus* is relatively larger and less triangular in shape than in *Plesiosaurus rugosus*.

The thickness of these tarsal-like representatives of tibia and fibula is about 4 lines.

The three bones of the proximal tarsal row are more uniform in size and shape than in most *Plesiosauri*, the innermost or scaphoid (*s*) is, however, the smallest: it is transversely elliptical in shape, 1 inch 9 lines in breath, 1 inch 2 lines in length; the original ligamentous interspace between it and the tibia is 3 lines. The astragalus (*a*) has a produced part of its proximal margin directed toward the interspace between the tibia and fibula. This modification somewhat interferes with the regularity of its elliptical contour. Its length is 1 inch 4 lines; its breadth 1 inch 11 lines. The interspace between it and the scaphoid is reduced to 2 lines; that between it and the cnemial bones is from 4 to 5 lines. The calcaneum (*cl′*) is the largest of this row; its proximal margin is straight and parallel with the outer distal margin of the fibula (67), with which it was connected by ligamentous matter from 3 to 4 lines in thickness. A short straight facet toward the astragalus is divided by a low angle from a longer straight facet opposite the ecto-cuneiforme (*ce*): the rest of the margin of the calcaneum is strongly rounded or convex; it appears to have been closely connected with the fabella (67′), which fits into the interspace between the fibula and calcaneum, and whether to regard the ossicle marked 67′ as the apophysial lever of fibula or as the calcaneum may be a question.

The distal tarsal row consists of three bones. The innermost or ento-cuneiform (*ci*) has its free inner or tibial margin straight or slightly concave, joining at a marked angle the proximal and distal margins; these pass into the outer margin by a regular convex line. The length of the ento-cuneiform is 1 inch 2 lines, its breadth 1 inch 6 lines. The meso-cuneiform (*cm*) is transversely elliptical, but with the margin towards the astragalus (*a*) rather straight: with the same length as the preceding ossicle its breadth is 1 inch 8 lines: the middle of its distal convexity is opposite the interspace between the second and third metatarsals. The ecto-cuneiform (*ce*) is larger than the other two bones, as it is in *Plesiosaurus*, and of a subquadrate form, one angle extending into the interspace between astragalus and calcaneum; the margin toward the astragalus and meso-cuneiform is simply convex; the distal margin which supported the fourth metatarsal is straight, as is that part of the outer margin which probably articulated with the proximally advanced head of the fifth metatarsal.

The first, second, and third metatarsals here preserved nearly in their natural relative positions, progressively increase in length as in *Plesiosaurus*, but are by no means so long in proportion to their breadth, herein retaining somewhat of the Ichthyosaurian character; each, however, as in *Plesiosaurus*, is more convex at its proximal than at its distal end.

The first or innermost metatarsal (I) is 1 inch 3 lines long, and 1 inch broad proximally. The second, 1 inch 6 lines in length, has a proximal breadth of 1 inch 2 lines. The third, 1 inch 10 lines in length, is 1 inch 2 lines across its proximal end, 10 lines across its distal end, and 8 lines across its mid part.

It is probable that before this paddle was finally or safely covered up its extremities had been fed upon, or nibbled at, by some predatory fishes or other aquatic animals of the period. The proximal phalanx of the second digit (II) has been pulled nearly an inch away from its metatarsal bone: it is 2 inches in length and 1 inch in breadth proximally, where the surface is less convex than in the metatarsals. The rest of the fin-bones were lost in detaching the block of stone, two or three being feebly indicated by depressions of the matrix.

The length of the femur is 1 foot 7 lines: the longest diameter of the proximal end is 3 inches 4 lines: the breadth of the middle of the shaft is 2 inches 4 lines, that of the distal end is 6 inches.

The breadth of the cnemion, including the fabella, is 6 inches 9 lines.

The length of the paddle, from the head of the femur to the tarsus inclusive, is 1 foot 5 inches 6 lines.

If these dimensions are of the fin of a full-grown Pliosaur, the Portland species is inferior in size to the grand Pliosaurs of the Kimmeridge Clay. Vertebræ* and teeth of *Pliosaurus portlandicus* are still desiderata, and well worth careful looking after by collectors of fossils from that interesting formation.

* Since this was penned fragments of the skeleton of the same individual have been transmitted to the British Museum, including an entire caudal vertebra, with the characters described at p. 2; also portions of ribs, which have a subcircular transverse section and compact structure, as in *Sauropterygia* generally. Should materials reach me, I hope to be able to show modifications of cervical and other vertebræ of specific value, and to refer them to their respective kinds of Pliosaur.

PLATE I.

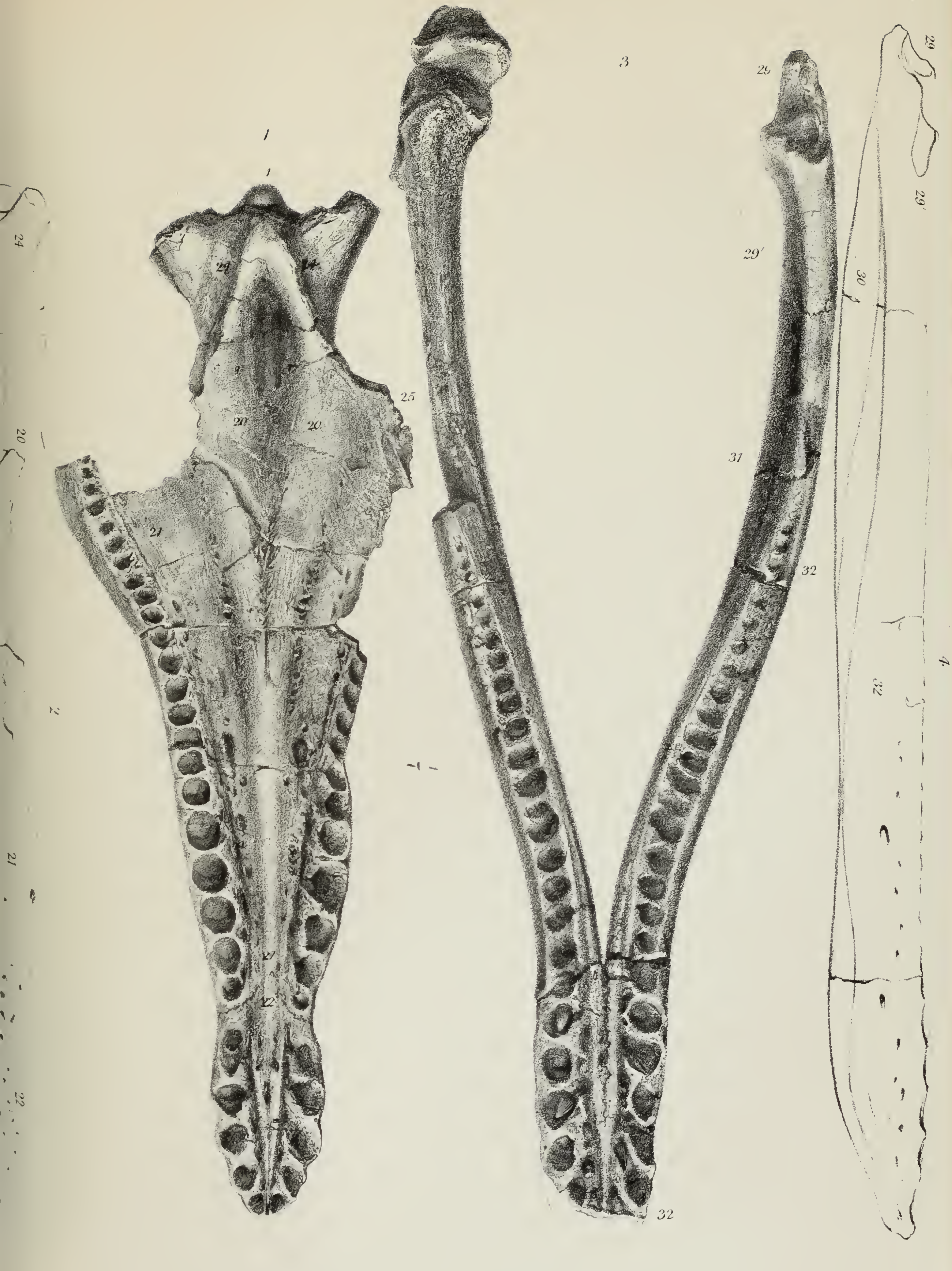
Pliosaurus grandis.

Fig.

1. Under or palatal surface of skull.
2. Profile or side view of ditto.
3. Upper surface of lower jaw.
4. Side view of ditto.

About 1-7th nat. size; figs. 3 and 4 not reduced quite to the same proportions as fig. 1.

From the Kimmeridge Clay of Kimmeridge, Dorsetshire. In the British Museum.



PLIOSAURUS GRANDIS

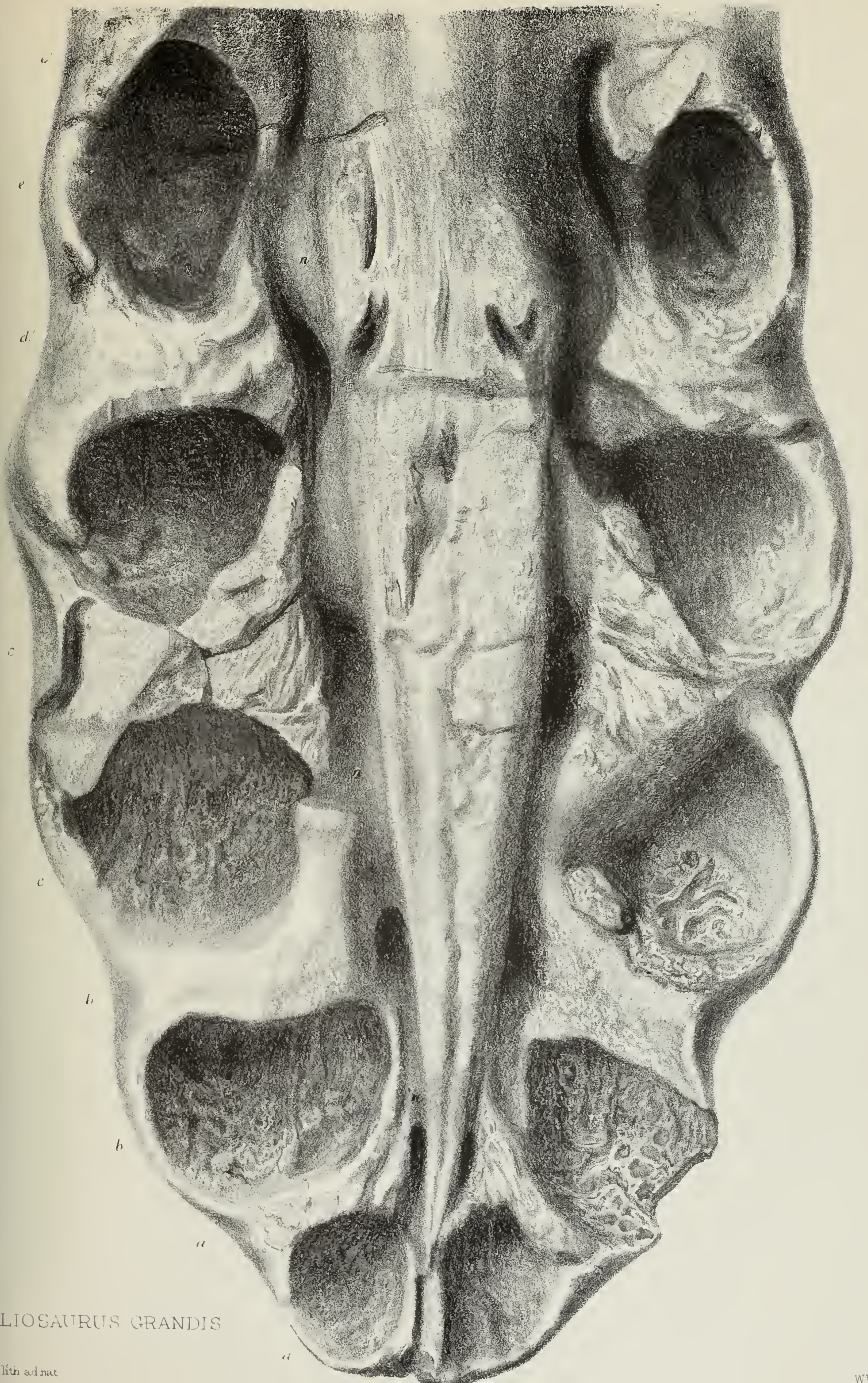
W West imp.

PLATE II.

Pliosaurus grandis.

Palatal surface of alveolar part of premaxillary bones, nat. size.

From the Kimmeridge Clay of Kimmeridge, Dorsetshire. In the British Museum.



PLIOSAURUS GRANDIS

…el lith ad nat

W West imp.

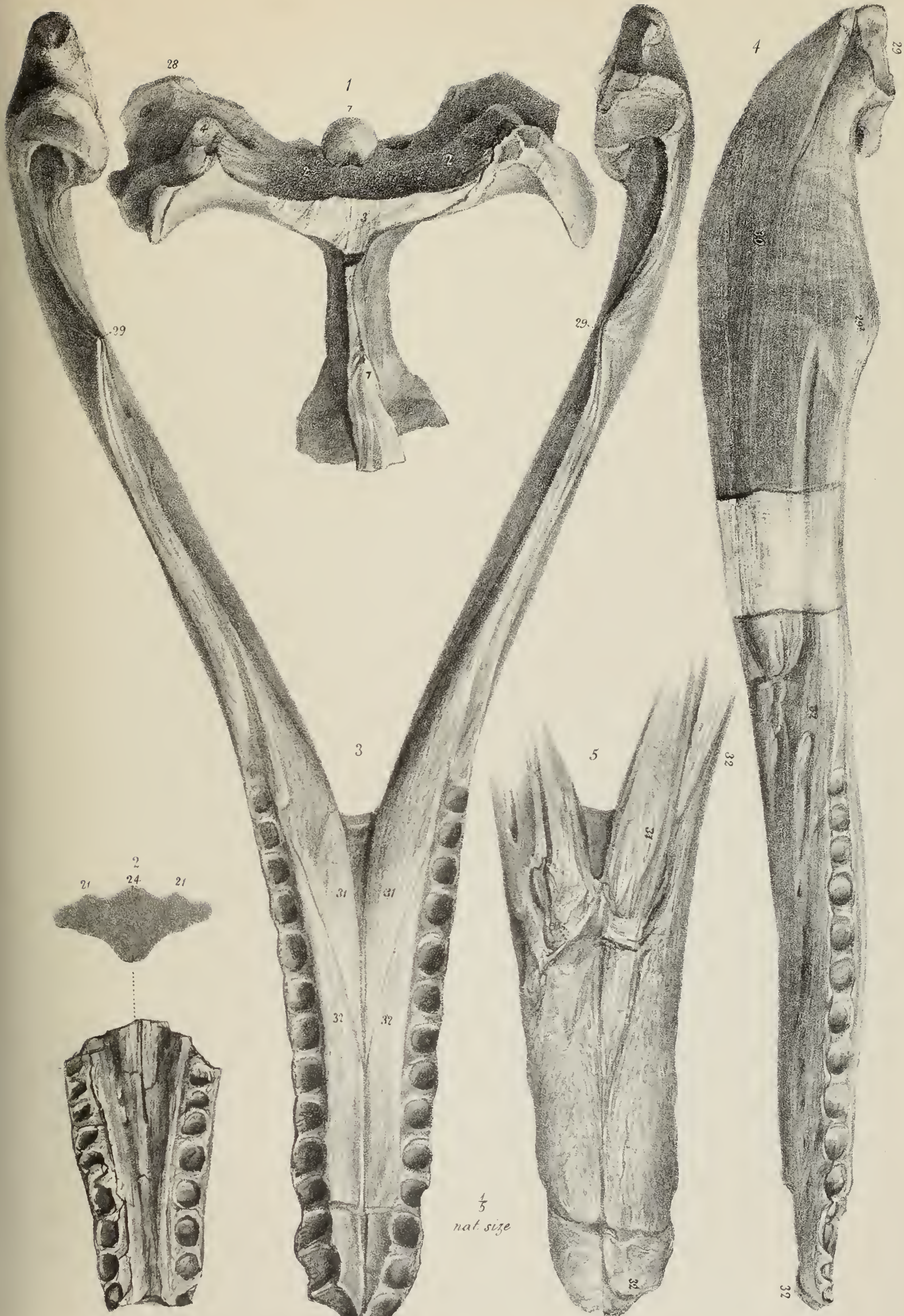
PLATE III.

Pliosaurus trochanterius.

Fig.

1. Upper view of hind part of cranium.
2. Under view of part of upper jaw.
3. Upper view of lower jaw.
4. Side view of ditto.
5. Under view of symphysis of ditto, 1-5th nat. size.

From the Kimmeridge Clay of Kimmeridge, Dorsetshire. In the British Museum.



From nat. & on Stone by J. Erxleben

M. & N. Hanhart imp.

PLIOSAURUS TROCHANTERIUS.

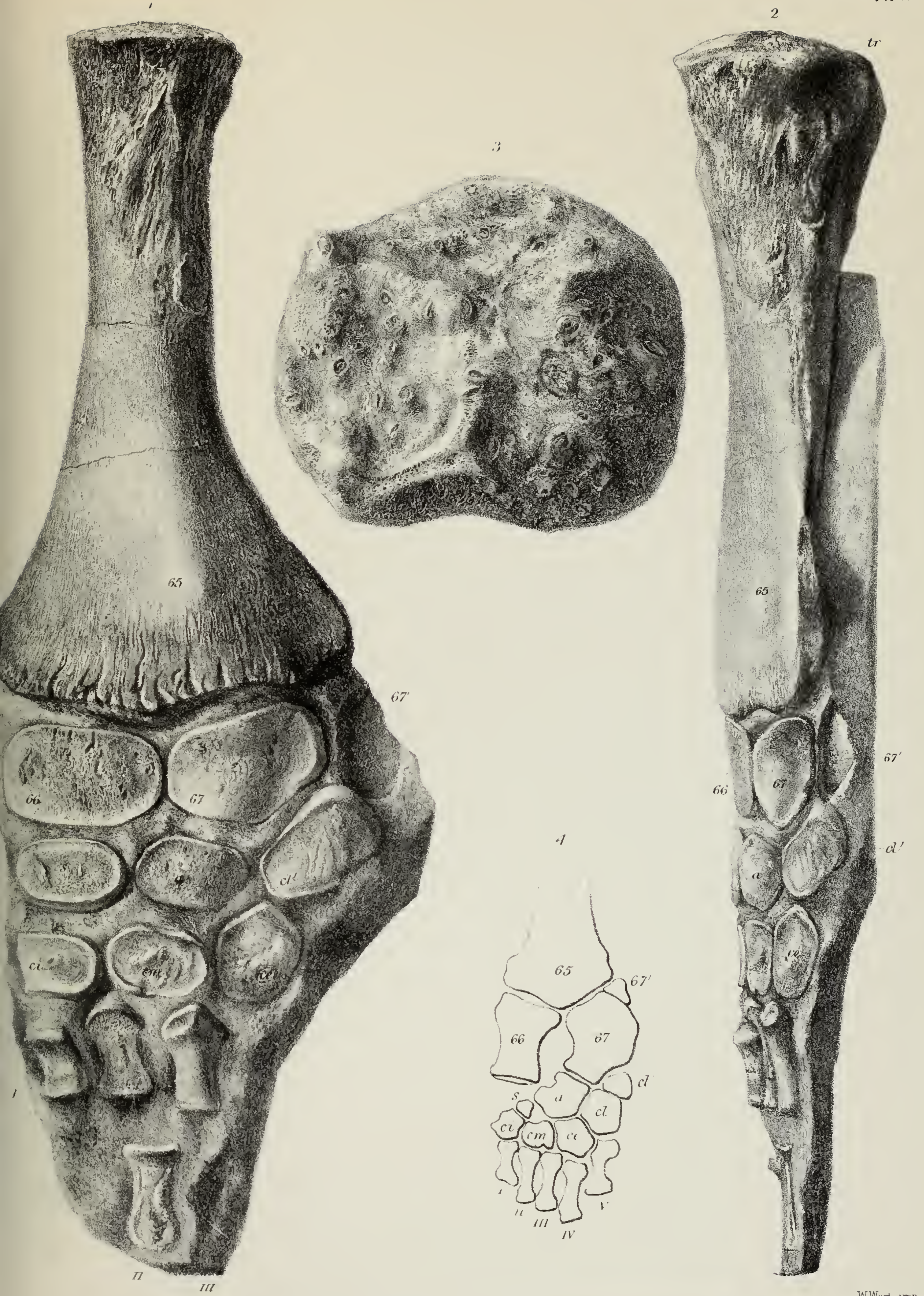
PLATE IV.

Pliosaurus portlandicus.

Fig.

1. Inner side view of the bones of the right-hand paddle, 3-8ths nat. size.
2. Posterior or edge view of ditto, ditto.
3. Head of the femur, nat. size.
4. Outline of bones of leg, tarsus, and metatarsus, of *Plesiosaurus rugosus*, 1-6th nat. size.

The *Pliosaurus portlandicus* is from the Portland Oolite, Isle of Portland, Dorsetshire. In the British Museum.



del

W West imp.

Figs 1, 2, 3, PLIOSAURUS PORTLANDICUS   Fig. 4, PLESIOSAURUS RUGOSUS.

THE

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THE

BRITISH

PLEISTOCENE MAMMALIA.

BY

W. BOYD DAWKINS, M.A., F.R.S., G.S.,

AND

W. AYSHFORD SANFORD, F.G.S.

PART III.

BRITISH PLEISTOCENE FELIDÆ.

FELIS SPELÆA, Goldfuss. *FELIS LYNX*, Linnæus.

(Pages 125—176; Plates XX—XXII, XXIIa, XXIIb, XXIII.)

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1869.

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J. E. ADLARD, BARTHOLOMEW CLOSE.

§ 1 γ. *Definition from other Pleistocene tibiæ.*—The tibia may be distinguished from all other bones associated with it in Pleistocene deposits, by the following points :—From any of the Deer or Ox tribe, by the oblique direction of the astragaline facets ; from the Horse, by the slenderness of the shaft. It approaches that of the Hyæna very closely, but in the latter animal the crest is longer, both proximally and distally, so that the head is flatter and the whole shaft more decidedly prismatic. Its size, also, would at once stamp its character. In the Bear the shaft is decidedly prismatic throughout, the distal articulation is much wider, and the astragaline depressions shallower. The internal malleolus does not descend so far, while the whole epiphysis extends much further externally. The crest also is much smaller, as well as the patellar tubercle ; the extero-anterior tuberosity is much lower, and the depression for the adipose ligament does not cut off the internal facet from the patellar tubercle, but passes down straight over the latter ; the semilunar facets are flatter, and the posterior attachments for the muscles are far more distinctly marked.

We know of no figures of any fossil tibiæ of *Felis spelæa.*

§ 2. *Fibula* (Pl. XIX, figs. 3, 4).—We have met with fragments only of the fibula of *Felis spelæa*, one of which consists of the shaft, and the other of a perfect distal end ; both were obtained from Bleadon Cave, and are figured in Pl. XIX, figs. 3, 4.

§ 2 α. *Description.*—As we have never met with the proximal end of the bone that afforded origin to the soleus muscle, we omit all notice of it ; analogy would show that it was identical in form with that of the living Lion. The shaft of the bone (fig. 3) at the proximal end is triangular in section, and its posterior surface is shown in the figure (*a*). The roughened surface affords point of origin to the peronæus longus. The shorter of the remaining two sides or the anterior is the fibular origin of tibialis posticus, which is attached to this bone in Felis. Below, the shaft becomes cylindrical, having a sharp high ridge (*b*) on the internal surface, which is the line of attachment for the fibulo-tibial interosseous membrane. On the posterior side of this ridge, about the middle of the bone, is the origin of the flexor longus pollicis, and lower down that of the flexor longus digitorum. It curves forward near the distal end and forms a sharp wedge-like tubercle, on the outer side of which (fig. 3, *e*) is the origin of the peronæus tertius. At the inner angle of the distal end there is a roughened surface, which is developed in the adult into a second sharp ridge, that also runs spirally backwards half round the bone, so as to form the posterior distal edge. On the outer side of this, a little below the middle, is the origin of the peronæus brevis (fig. 3, *d*). The two ridges above described are opposite to each other at the distal end, and form a flat blade-like expansion, on the inner side of which is a slight polished elevation, which is the distal articulation with the tibia.

The extensor communis digitorum or cnemodactylus of Riolan is not attached to the proximal end of the tibia in Felis, but passes upwards to the external face of the condyle of the femur.

In fig. 4 we have represented the distal end of a left fibula which resembles in every respect, save that of size, the corresponding portion of the leonine or tigrine bone. It presents externally a deep groove between two tuberosities, which, in the living animal, is converted by a ligament into a canal for the tendon of the peronæus longus (fig. 4, *a*). The posterior tuberosity forms the external malleolus, behind which is a second groove (fig. 4, *c*), deep and narrow, for the tendons of the peronæi brevis and tertius. Internally we find a small concave articulation close to the epiphysial division, by which the bone is attached laterally to the tibia, and below this is a flat surface which articulates with the outer side of the astragalus, and behind this, again, is a depression for one of the ligaments which bind the fibula to the tarsus.

From the immature state of the shaft we have been unable to institute a rigid comparison between it and those of the recent Feles.

Dr. Schmerling[1] gives a rough and slight figure of a portion of a fibula, and states in the text that the upper portion is broken away; his figure, therefore, must be that of the external and posterior aspect of the distal end, together with about two thirds of the shaft; with this exception, we have met with no figure of the bone.

§ 2 β. *Measurements.*—In the following table the superior massiveness of the spelæan fibula is shown over those of the Lion and Tiger.

COMPARATIVE MEASUREMENTS.

	Felis spelæa.		*Felis leo.*		*F. tigris.*
	Taunton Museum.				
	Figured shaft. Sandford Hill.	Figured distal articulation. Sandford Hill.	W. A. S.	112 K, British Museum.	114 L, British Museum.
1. Maximum length	...	...	11·15	11·55	10·0
2. Minimum circumference	1·25	...	0·85	1·12	1·10
3. Transverse measurement of proximal articulation	...	...	0·35	0·75	0·45
4. Vertical ditto	...	...	1·30	1·30	1·05
5. Transverse measurement of proximal articulation	...	0·65	0·60	0·57	1·50
6. Distal ditto	...	1·23	1·10	1·26	0·45

[1] 'Oss. Foss. de Liége,' vol. ii, pl. xvi, fig. 4, p. 80.

§ 3 *a*. *Patella* (Pl. XIX, figs. 5, 5′).—The patella of *Felis spelæa*, of which many specimens are preserved in the Taunton Museum from the caves of Sandford Hill and Bleadon, exactly resembles that of the Lion and Tiger in form, but surpasses them in size. As in the recent Feles, it varies considerably in size and proportion. In shape it resembles a flattened pear, the small end being that to which the great ligament is attached which unites the bone to the anterior crest of the tibia. Many anatomists consider that in this bone we have the analogue, in the hind limb, of the olecranon of the ulna, a point that will be found fully discussed in the 'Cyclopædia of Anatomy and Physiology.'[1] The outer or anterior surface (Pl. XIX, fig. 5′) is roughened for the attachment of the tendons of the muscles, which we have elsewhere pointed out as the extensors of the leg and the flexors of the thigh, including the "paracural" of Straus-Durckheim, which has no analogue in man. The upper part of the proximal or posterior surface (fig. 5) is entirely occupied by the slightly convex articulation which fits the intercondylian or anterior facet of the femur; its edges slightly extend beyond the body of the bone.

The only patella liable to be confounded with that of *Felis spelæa* is that of the Bear; it may, however, be easily distinguished by its more oval form, and by the greater comparative extent of its femoral articulation.

§ 3 *β*. *Measurements*.—The variation in size is seen in the following table of measurements of the patella in *Felis spelæa*, *F. leo*, and *F. tigris*:—

	Felis spelæa.				*Felis leo.*			*F. tigris.*
	Taunton Museum.							
	Bleadon Cave. Figured specimen.	Bleadon Cave.	Bleadon Cave.	Bleadon Cave.	W. A. S.	629, Coll. Surg.	626, Coll. Surg.	101, Coll. Surg.
Maximum length	2·90	3·00	2·80	2·50	2·40	2·42	1·85	1·94
Maximum circumference	4·73	5·00	4·58	4·37	4·00	4·1	3·7	3·4
Transverse measurement of proximal articulation	1·85	2·00	1·80	1·70	1·55	1·58	1·4	1·3
Vertical ditto	1·90	1·95	1·95	1·85	1·50	1·25	1·1	1·33

[1] Article "Skeleton," p. 664 et seq.

CHAPTER XIII.

Carpus, Pl. XX, figs. 1, 1′, 2, 3, 4, 5, 5′.

CONTENTS.

In describing the bones of the carpus we shall consider the anterior or dorsal surface as that which is naturally so in all quadrupeds; the palmar and inferior or posterior as synonyms denoting the same portion of the bone.

The carpus in the genus Felis is composed of seven bones, besides the small one which has no independent existence in human anatomy, called by Straus-Durckheim the 'phacoid.' The scaphoido-lunare, the cuneiform, and pisiform, compose the upper or proximal row; the trapezoid, the trapezium, the magnum, and unciform, the lower or distal. Of these we have only met with the scaphoido-lunare, the unciform, and pisiform, in *Felis spelæa*.

1. *Scaphoido-lunare* (Pl. XX, figs. 1, 1′, 2).—1 α. *Description.*—The scaphoido-lunare is by far the largest and most important bone in the carpus; it extends throughout the whole width of the joint, and forms almost the sole means of attachment between the fore paw and the forearm. It is very massive and is roughly quadrangular in plan, with a large and strong tubercle projecting from the postero-internal angle (fig. 1′, *e*); it is broader than long, and much thicker externally than internally. The proximal or radial articulation (figs. 1, 2, *a*, *b*), which covers the whole of that surface of the bone with the exception of that portion which is opposite the tubercle is convex, traversed intero-posteriorly by a depression (figs. 1, 2, *b*) running from behind forwards and inwards. On its external edge is a very small articulation for the upper edge of the pisiform, which just touches it at that point (figs. 1, 2, *c*).

The tubercle (fig. 1′ *e*) is a somewhat pyramidal or conical mass, projecting diagonally inwards from the intero-posterior angle of the bone. It presents on its antero-internal surface a round flat articulation (fig. 1′, *e*) for the phacoid bone, to which is attached the adductor pollicis muscle instead of to the tubercle itself, as in man. It affords attachment to a large number of ligaments, the principal of which is the annular or armillary, which is attached by some of its lower fibres. It would serve but little purpose were we to enumerate them all, for they are extremely difficult to separate; they have been reckoned and described to the number of twenty-six by Straus-Durckheim.[1] They bind the radius to the carpus, and the bones of the carpus the one to the other.

The distal surface of the bone is entirely articular, and is divided by well-marked ridges into three well-defined articulations, the internal being a slightly concave parallelogram (figs. 1, 1′, 2, *f*) set diagonally outwards and downwards for the head of the unciform; the second (figs. 1, 1′, 2, *g*), being more concave than the preceding and wider posteriorly than anteriorly for the reception of the head of the magnum; and the third, (figs. 1, 1′, 2, *h*), being triangular and divided by a broad diagonal elevation into two slightly concave surfaces for the reception of the heads of the trapezium and trapezoid.

We have met with no scaphoido-lunare of Lion or Tiger which equals in size several of those in the Taunton Museum belonging to *Felis spelæa*, but we have figured one from Bleadon Cave (Pl. XX, fig. 2), which in no respect differs from those of either of the above animals. The larger spelæan specimens are somewhat thicker proportionally than the smaller, as well as the leonine and tigrine. That figured from Sandford Hill Cave, (Pl. XX, fig. 1), apparently belongs to the individual that has furnished us with a great many of the originals of our plates.

§ 1 β. *Measurements.*—The following table shows the variation in size between the leonine, tigrine, and spelæan scaphoido-lunaria.

Comparative Measurements.

	Felis spelæa. Taunton Museum. Largest. Bleadon Cave.	*Felis spelæa.* Taunton Museum. Figured specimen. Sandford Hill Cave.	*Felis spelæa.* Taunton Museum. Figured specimen. Smallest. Bleadon Cave.	*F. leo.* W. A. S.	*F. tigris.* Coll. Surg.
1. Maximum length	1·75	1·33	1·12	1·12	1·12
2. Minimum circumference	6·80	6·75	5·75	5·20	...
3. Transverse measurement of proximal articulation	2·30	2·10	1·87	1·80	1·8
4. Vertical ditto	1·40	1·60	1·13	1·45	1·2
5. Transverse measurement of distal articulation...	2·08	1·96	1·65	1·64	1·42
6. Vertical ditto	1·53	1·41	1·30	1·10	0·93

[1] Op. cit., vol. ii, p. 84 et seq.

§ 1 γ. *Definition from that of Ursus.*—The scaphoido-lunare of the Bear may be distinguished at a glance from that of *Felis spelæa,* the tubercle being much larger, cylindrical and projecting directly backwards, and the articulation for the magnum being parallel to the side of the bone instead of running diagonally across it, as in the latter animal.

§ 2. *Pisiform* (figs. 3, 4), α. *Description.*—The pisiform of *Felis spelæa* strongly resembles in plan that of all the other Feles we have examined, those of the different species being only distinguishable by their size. Even in the same species it presents small variations of shape and proportion. It may be considered, generally speaking, as a long three-sided pyramid, bevelled off proximally and distally for articulation, with the cuneiform and the styloid process of the ulna, the apex swelling into a tuberosity (figs. 3, 4, *b*), for the attachments of the tendon of the ulnaris muscle, of those for the bending of the fifth digit, of the common flexor of all the digits, and of the transverse adductor of the first. It is firmly attached to its fellow carpals, to the metacarpals, and forearm, by a large number of ligaments, and thus it forms a powerful *point d'appui* for the motions of the fore foot, analogous to the shaft of the calcaneum in the hind foot. The articulations may be distinguished as the proximal or ulnar (fig. 4, *a*), which is known by its semilunar form, and the distal or cuneiform, which presents the plan of a rectangular parallelogram with rounded angles (fig. 3, *c*). Both are nearly flat, and unite in a sharp and nearly straight edge.

It may be known from the corresponding bone of the Bear by the possession of the following points :—By its greater length, by the flatness of the ulnar articulation as contrasted with the concavity of that of the Bear, and by the straightness of the edge separating the articulations, which is concave in the latter.

We have met with several specimens from the caves of Bleadon and Sandford Hill, some of which are but little larger than the living Lion and Tiger, while others (see fig. 4) are much larger than those of any of the living Feles. The original of fig. 4 probably belonged to the same skeleton as the large scaphoido-lunare figured in the same plate.

§ 2 β. *Measurements.*—The variations in the size of the pisiform in *Felis spelæa, F. leo,* and *F. tigris* are shown in the following table :—

Comparative Measurements.

	Felis spelæa. Taunton Museum. Bleadon Cave. Figured.	*Felis spelæa.* Taunton Museum. Sandford Hill Cave. Figured.	*Felis spelæa.* Taunton Museum. Bleadon Cave.	*Felis spelæa.* Taunton Museum. Bleadon Cave.	*Felis leo.* British Museum.	*Felis leo.* W. A. S.	*F. tigris.* British Museum.
1. Maximum length	1·95	1·92	1·80	1·77	1·29	1·52	1·55
2. Minimum circumference	2·10	2·10	2·00	1·90	1·35	1·50	1·35
3. Transverse measurement of proximal articulation	1·05	0·95	0·96	0·93	...	0·95	...
4. Vertical ditto	0·50	0·53	0·50	0·43	...	0·46	...
5. Transverse measurement of distal articulation	1·00	1·00	0·82	0·74	0·75	0·80	0·75
6. Vertical ditto	0·75	0·75	0·76	0·50	0·35	0·43	0·44

§ 3. *Unciform* (figs. 5, 5′,) *a. Description.*—The unciform of *Felis spelæa* is a small, somewhat wedge-shaped bone, not distinguishable from that of the recent Lion and Tiger except by its massiveness. The head of the wedge occupies the anterior or dorsal aspect of the bone, and a very slight tuberosity is the only trace of the claw-like process which gives the name to the bone in man.

The proximal or scaphoidal articulation (fig. 5, *a*) is much narrower than the distal, the sides being nearly parallel. It is much longer from front to back than broad; convex anteriorly and slightly concave posteriorly, it ends on the palmar surface in a semicircular boundary. The distal or metacarpal articulation (figs. 5, 5′, *b*) partakes of the wedge-shape of the bone. It is deeply concave, and receives the heads of the fourth and fifth metacarpals. The inner articulation (figs. 5, 5′, *c*) for the magnum is shaped something like the letter L, placed so that the stem coincides with the anterior edge of the bone. It is nearly flat. The remaining articulation, or the cuneiform (figs. 5, 5′, *d*), is for the most part slightly convex, and occupies the anterior part of the external surface. The anterior or dorsal surface assumes the form of an irregular pentagon (fig. 5), roughened and indented between the lateral articulations for the attachment of several interosseous ligaments. The thin end of the wedge, occupying the palmar surface, is a tubercle (fig. 5′, *e*) for the attachment of the adductor of the fifth digit; the opponens of the same digit not being attached, as in man, to this bone, but to the magnum.

This bone strongly resembles that of the Bear, but is easily distinguished by the greater squareness of the latter, as well as by the flatter distal articulation. We know of no other bone with which it can be compared.

§ 3. β. *Measurements.*—The variations in size of the unciform in *Felis spelæa*, *F. leo*, and *F. tigris* are shown in the following table:

COMPARATIVE MEASUREMENTS.

	Felis spelæa. Taunton Museum. Bleadon Cave.	*Felis spelæa.* Taunton Museum. Bleadon Cave.	*Felis spelæa.* Taunton Museum. Sandford Hill Cave. Figured.	*F. leo.* British Museum.	*F. tigris.* British Museum.
1. Maximum length	1·40	1·32	1·14	0·92	1·07
2. Minimum circumference	3·03	3·04	3·47	2·18	2·60
3. Transverse measurement of proximal articulation	0·64	0·62	0·50	0·41	0·30
4. Vertical ditto	1·29	1·13	1·22	0·76	0·94
5. Transverse measurement of distal articulation...	1·03	0·90	0·88	0·62	0·64
6. Vertical ditto	1·20	1·10	1·20	0·80	0·98

CHAPTER XIV.

METACARPALS. Pls. XIX, fig. 6; XX, 6, 7; XXI, 1—5.
PHALANGES. Pl. XXI, figs. 6—14.

CONTENTS.

§ 1. *Metacarpals.* α. *Introduction.*—As metacarpal bones of the genus Felis have to perform very much the same functions in all the species, they present but few characters of value in classification, the variation in the proportions observable in different individuals of the same being frequently as great as in the closely allied species. For the most part, however, the metacarpals of *Felis spelæa,* from the bone-caverns, are stouter and stronger than those of the living Lion and Tiger; but, on the other hand, some of them are even smaller in every dimension than the average-sized bones of the two latter animals; the large series also from the caves of Somerset proves that there is a gradual passage from the most massive to the most slender spelæan form; size cannot, therefore, be considered of specific value. We are fortunate in being able to give figures of a complete set from the cavern of Sandford Hill (Pl. XXI, figs. 1, 2, 3, 4, 5), which belonged to an individual in the prime of life. They are remarkable for their straightness and stoutness, and the fourth presents a variation which we shall describe in its due place. We have also figured the proximal end of a fourth metacarpal of the small form from Bleadon Cave (Pl. XX, fig. 6), and a remarkably small fifth from the hyæna-den of Wookey Hole (Pl. XX, fig. 7). A gigantic second metacarpal from the lower brickearths of Crayford is also figured (Pl. XIX, fig. 6).

The metacarpals when united form a compact transverse arch, the convexity being dorsal, and the concavity palmar; the latter transmits the tendons of the flexor and adductor muscles to their points of insertion in the phalanges.

§ 1. β. *First Metacarpal* (Pl. XXI, fig. 1).—The first metacarpal for the hallux or thumb, in its shortness and the obliquity of its articulations, differs from all the rest of its fellows. The proximal articulation with the trapezium occupies the end of the bone, and extends diagonally outwards and downwards on the dorsal surface, forming a shallow, pulley-shaped joint by which the thumb is freely moved in a transverse direction. On the internal edge there is a very small facet (*b*), which is in apposition with the phacoid bone in the recent Felidæ. Externally also there is a small facet, which rests on the internal edge of the second metacarpal. The united action of these articulations and of the ligaments which bind this bone to the carpus, prevent any rotatory action; and thus the thumb cannot be opposed, as in man, to the other digits. The shaft is short, stout, and slightly bent towards the outside, and traversed on its dorsal aspect by a groove running from the extero-inferior edge of the proximal articulation diagonally outwards and forwards, and receiving the tendons proper to the bone for the common extensor digitorum. The palmar surface is concave, and much roughened for the attachment of a large number of ligaments. The distal articulation (*d*) is very oblique, and faces inwards and downwards, so that the action of the phalange is still more transverse than it otherwise would be, and its tearing and grasping power is much increased. Immediately above it in the middle of the palmar surface is a small well-marked tubercle which affords attachment to the ligament, uniting the bone to the first phalange of the second digit, and to the adductor brevis pollicis muscle. The majority of the tendons of the muscles that regulate the motion of this joint are attached, not to the bone itself, but to a large internal sesamoid, occupying the intero-inferior angle (*e*) of the bone.

§ 1. γ. *Second, Third, Fourth, Fifth Metacarpals* (Pls. XIX, fig. 6; XX, figs. 6, 7; XXI, figs. 2, 3, 4, 5). The proximal end of the second metacarpal forms a wedge-like mass slightly shifted, as it were, outwards for a quarter of its width. In front it is rectangular; behind, on the palmar surface, it throws out a small tubercle which is the thin end of the wedge. The proximal or trapezoidal articulation (Pls. XIX, fig. 6; XXI, fig. 2, *a*) is triangular in outline; concave transversely, and nearly flat vertically. On the upper and outer edge of the palmar tubercle is a small flat surface (Pl. XXI, fig. 2, *b*), which articulates with the postero-internal facet of the os magnum, and immediately above is the somewhat triangular surface set at right angles to the trapezoidal articulation which is in contact with the antero-internal facet of the same bone. At the antero-internal angle of the trapezoidal articulation is a small concave surface (fig. 2, *c*), which receives the convex external facet of the trapezium, and, extending from it backwards as far as the palmar tubercle, is a broad slightly concave surface for contact with the first metacarpal. Immediately under the articulations for the os magnum are two concave surfaces, the anterior being the larger and deeper (fig. 2, *d*), which overlap corresponding surfaces on the inner side of the third metacarpal. Between them is a large ligamentary cavity. On the dorsal or anterior surface of the proximal end runs diagonally a shallow groove (Pl. XXI, fig. 2, *e*), to the upper part of which is attached the trapezoidal ligament. The whole of the head of the bone is roughened for the reception of the ligaments binding the bone to the carpus and its fellow metacarpals. The shaft presents a triangular section proximally, and is nearly circular in the middle and distally. At the point where it joins the distal articulation it is flattened in front, and develops a slight palmar ridge behind.

The distal articulation of the four outer metacarpals (Pls. XIX, fig. 6; XX, fig. 7; XXI, figs. 2, 3, 4, 5, *f*) bear a strong resemblance to each other; like those of the metatarsals they are bulb-shaped, and divided from the epiphysial line of the shaft by deep dorsal and lateral depressions (*g*); on the palmar or inferior surface they develop a short ridge in the median line (Pl. XX, fig. 7), which fits into the palmar notch of the first phalanges. On either side of it lies a sesamoid bone to which are fixed nearly all the tendons of the adductor and flexor muscles, for the movement of the metacarpals. At the point where the shaft joins the distal end is a tuberosity (Pl. XXI, figs. 2, 3, 4, 5, *i*) which catches the sides of the phalangeal articulations, and prevents these bones from bending backwards beyond an angle of about 60°, and thus forms a firm fulcrum for the support of the weight of the body.

The distal terminations of the metacarpals may easily be distinguished from each other by the positions of the tuberosities, and by the form of the distal articulations. The distal articulation of the fifth is, as it were, cut off on the outer side (Pl. XXI, fig. 5, *f*), while that of the second (fig. 2 *f*) is cut off on the inner side: the third and fourth are symmetrical, the former having the inner, and the latter the outer, tuberosity larger, and set lower on the bone. These articulations are epiphysial.

The proximal articulation of the third metacarpal (fig. 3) is set nearly at right angles to the end of the shaft, the dorsal face expanding considerably more than the posterior; it is vertically convex, transversely concavo-convex. On its inner side is a broad oval surface (fig. 3, *a*) set on a tuberosity for articulation with the overhanging portion of the second metacarpal (fig. 2, *d*); these two articular surfaces are divided from each other by a well-marked ridge (*c*). On the external side are two concave surfaces (fig. 3, *e*), which overhang and articulate with the fourth metacarpal: they are not so deeply concave, and are more confluent than those of the second. The proximal dorsal surface of the fourth (fig. 4) strongly resembles that of the third, but it is rounder and less excavated; the articulation also is altogether different, the facet for the unciform (fig. 4 *d*) being simply convex vertically and flat transversely, while that for the third metacarpal and the os magnum forms a continuous surface (fig. 4 *a*), partially interrupted on the inner side by a ligamentary notch (Pl. XX, fig. 6). It is slightly convex both vertically and transversely, and usually forms one curvilinear surface with the unciform articulation, being divided from it by a slight ridge. This form from Bleadon is shown in Pl. XX, fig. 6. In that figured in Pl. XXI, fig. 4, these surfaces (*d*, *a*) are set at a considerable angle to each other; these two bones represent the extreme variation in the form of the proximal articulation. In the recent Felidæ also a similar amount of variation may be observed. The articulation for the fifth metacarpal (fig. 4 *e*) is much less concave than those of the second and third; the proximal edge is much thickened and flattened, the palmar is small. The form of the third and fourth metacarpals is much stouter than that of the others, and the arch-like curvature is less and the dorsal surface is more flattened.

The fifth metacarpals of the Carnivora resemble each other so closely that it requires some attention to distinguish between forms of nearly the same size. In the Feles generally, they have a tendency to be triangular in section, to be more tapering, and to arch more decidedly in a palmar and outward direction than any of the others. The proximal articulation for the unciform (Pl. XX, fig. 7 *a;* XXI, fig. 5 *a*) forms a continuous surface with that of the fourth metacarpal, and like it is convex only in a vertical direction; it covers the whole of the end of the bone. The inter-metacarpal articulation (Pls. XXI, fig. 5 *b;* XX, fig. 7 *b*) is a flattened surface, segmental in form, set at right angles to that for the unciform, and interrupted inferiorly by a large ligamentary notch (Pl. XX, fig. 7 *e*), in front of which rises an articular eminence (Pls. XX, fig. 7 *d;* XXI. fig. 5 *d*), which fits into a corresponding hollow in the fourth metacarpal. Externally the head presents a large tuberosity (Pl. XXI, fig. 5 *e*), which affords attachment to the strong ligaments that bind the bone to the unciform, cuneiform, and pisiform. On the palmar surface also there is a large tuberosity (Pl. XX, fig. 7 *f*).

Nearly all the ridges on the metacarpals are for the attachment of ligaments; the only direct muscular attachments being those for the very small muscles connected with the flexion of the digits.

We have not attempted a more detailed description of these bones because of the great variation in the form of their articular surfaces, which renders it almost impossible to lay hold of characteristics common to a large series. The few points of difference that we have given are constant in all those of *Felis spelæa* and Lion which we have examined.

§ 1. δ. *Measurements.*—In the following table of measurements we have given the extreme variations of size and proportion in *Felis spelæa* as compared with corresponding bones of lion and tiger. The gigantic size of the second metacarpal from Crayford (Pl. XIX, fig. 6) is visible also in the metatarsal, fig. 7 of the same plate, and in an upper canine which was discovered after our plates were engraved. All these probably belonged to the same individual, and are far larger than any other remains of the animal that have yet been found.

Measurements of Metacarpals.

First Metacarpal.	*Felis spelæa.*					*Felis leo.*		*F. tigris.*
	Bleadon. Figured specimen.	Bleadon Cave.	Bleadon Cave.	Bleadon Cave.	Bleadon Cave.	British Museum.	W. A. S.	British Museum.
1. Maximum length	1·89	1·20	2·05	1·78	1·95	1·33	1·65	1·61
2. Minimum circumference	2·40	2·15	2·44	2·38	2·38	2·08	1·90	1·78
3. Transverse measurement of proximal articulation	0·80	0·70	0·90	0·80	0·88	0·56	0·65	0·70
4. Vertical	1·25	0·90	1·12	1·00	1·03	0·53	0·75	0·92
5. Transverse measurement of distal articulation	0·90	0·80	0·87	...	0·84	0·64	0·75	0·75
6. Vertical	1·20	0·86	0·96	0·87	...	1·20	1·20	0·65

Second Metacarpal.	*Felis spelæa.*							*Felis leo.*		*F. tigris.*
	Sandford Hill Cave. Figured specimen.	Bleadon Cave.	Bleadon Cave.	Bleadon Cave.	Bleadon Cave.	Ilford Brickearth.	Crayford Brickearth.	British Museum.	W. A. S.	British Museum.
1. Maximum length	4·22	4·58	...	...	...	4·20	5·9	3·55	4·00	3·84
2. Minimum circumference	2·20	2·25	2·24	2·33	...	1·90	2·2	1·35	1·54	1·58
3. Transverse measurement of proximal articulation	0·98	0·84	...	1·08	1·15	0·81	0·8	0·72	0·78	0·80
4. Vertical	1·20	...	1·31	1·45	...	1·12	1·1	0·95	1·00	1·09
5. Transverse measurement of distal articulation	1·10	...	...	...	...	0·78	1·0	0·62	0·75	0·75
6. Vertical	1·95	...	...	...	...	1·50	2·0	1·30	1·54	1·60

Measurements of Metacarpals—*continued.*

Third Metacarpal.	*Felis spelæa.*		*Felis leo.*		*F. tigris.*
	Sandford Hill Cave.	Bleadon Cave.	British Museum.	W. A. S.	British Museum.
1. Maximum length	4·90	5·03	4·00	4·45	4·35
2. Minimum circumference	2·20	2·50	1·28	1·57	1·61
3. Transverse measurement of proximal articulation	1·50	1·29	0·70	1·30	0·80
4. Vertical	1·20	1·44	0·80	1·20	0·91
5. Transverse measurement of distal articulation...	1·25	1·11	0·85	0·90	0·80
6. Vertical	2·10	2·30	1·30	1·60	0·39

Fourth Metacarpal.	*Felis spelæa.*					*F. leo.*
	Sandford Hill Cave.	Bleadon Cave.	Bleadon Cave.	Bleadon Cave.	Bleadon Cave.	W. A. S.
1. Maximum length	4·83	5·50	...	...	...	4·40
2. Minimum circumference	2·08	2·12	2·28	2·00	...	1·55
3. Transverse measurement of proximal articulation	1·20	0·96	1·08	0·93	...	0·85
4. Vertical	1·40	1·96	2·02	...	...	1·40
5. Transverse measurement of distal articulation...	1·20	1·02	...	...	1·05	0·80
6. Vertical	1·95	1·95	...	...	1·95	1·65

Fifth Metacarpal.	*Felis spelæa.*					*Felis leo.*		*F. tigris.*
	Sandford Hill Cave.	Bleadon Cave.	Bleadon Cave.	Bleadon Cave.	Bleadon Cave.	British Museum.	W. A. S.	British Museum.
1. Maximum length	3·98	4·12	4·00	...	...	3·21	3·70	3·24
2. Minimum circumference	1·95	1·90	1·77	1·75	2·18	1·35	1·60	1·50
3. Transverse measurement of proximal articulation	0·60	0·63	0·60	0·63	0·60	0·49	0·43	0·49
4. Vertical	1·80	0·90	1·77	1·75	2·13	1·30	1·30	1·49
5. Transverse measurement of distal articulation	1·12	0·85	0·74	0·87	...	0·65	0·81	0·75
6. Vertical	1·90	1·68	1·62	...	...	1·31	1·60	1·46

§ 2. *Phalanges. a. First Phalanges.*—The first phalange, or phalangiole, of the first digit, or thumb, is very short and of greater width than depth. The proximal articulation (Pl. XXI, fig. 6, *a*) is set obliquely to the dorsal face of the bone, so that the internal descends lower than the external edge. By this arrangement the first can be opposed to the other digits as in the Quadrumana, though the first metacarpal has no movement whatever of revolution. The palmar edge of the articulation is notched (fig. 6, *b*) to receive the elevation on the same surface of the metacarpal, so that it gives but little hindrance to the action of the flexor muscles. On each side of this are two small eminences for the adductor and abductor medii, the flexor brevis pollicis not being differentiated in the genus Felis. The extensor longus is attached by an intermediate cartilage to a similar eminence on the dorsal surface, the tendon also passing on to the claw phalange. The distal articulation is terminal, and sits evenly on the bone; it is convex vertically, and slightly so transversely, so that a slight movement of rotation is allowed to the claw phalange; it is much wider on the palmar than on the dorsal surface: immediately above the palmar edge is a deep depression for the reception of the flexor tuberosity of the claw phalange when the flexor muscles are in action. The small lateral expansion of this articulation prevents the retraction of the claw so completely in this digit as in the others, but as it is raised from the ground it is in no danger of being blunted by accidental contact; its position also on the inner side would prevent its being in the way of the animal. We have met with four specimens of this bone from Sandford Hill and Bleadon Caves; they vary in size from that of the ordinary Lion to that of the same proportions as the other large bones we have described.

The first phalanges of the remaining digits (figs. 7, 8, 9, 10) are very similar in their general character; the shafts being nearly cylindrical and slightly arched, and much smaller than the wide proximal articulations (*a*); the latter are deeply notched on the palmar edge (*b*) to receive the palmar ridge of the metacarpal. The palmar surface also is furnished with small eminences for the insertion of abductor and adductor muscles and bear on either side two well-marked tuberosities to which are attached the ends of a strong ligament, the infra-phalangiole annular, through which, as through a pulley, pass the tendons of the flexor profundus and the flexor sublimis on their way to the claw phalange: the distal articulation is shaped like a pulley, and extends higher up on the palmar than on the dorsal surface, and bears a depression on the dorsal edge for the tuberosity of the second phalange.

The first phalange of the third and fourth digits (figs. 8 and 9) resemble each other so closely that it would be impossible to determine to which of these two digits an isolated bone belonged; that of the second digit is very much the stouter, and slightly the shorter, and is curved outwards, while that of the fifth is very much more slender, and is bent considerably inwards. All are easily distinguished from those of the hind paw by their greater slenderness and by their cylindrical section. The large size of the proximal articulation and the tapering form of the bone in the Bear, and the small size of those in the

Hyæna, are points by which the first phalanges of those animals may be separated from those of *Felis spelæa*. We know of no others that can be confounded with them.

§ 2 β. *Second Phalanges.*—The second phalanges of all the Feles are characterised by their triangular section, and by the outward projection of their distal articulation; the latter allows the claw phalange when retracted to fall back outside the axis of the bone, so as to raise the point of the claw over the articulation, and thus protect it from injury. Those of *Felis spelæa* (Pl. XXI, 11, 12, 13, 14) closely resemble their homologues of the hind limb, but are longer and more bent externally. The proximal articulation (*a*), which, following the section of the shaft, is triangular, is composed of two slight concavities divided by a median ridge; it is deeply excavated on the palmar ridge by a notch and pit, in which is inserted the tendon of the flexor sublimis muscle. On its dorsal edge is a small flattened tuberosity (*b*), forming the apex of the triangle for the attachment of the tendon of the extensor communis. The bone tapers gradually down to the distal end of the shaft. The distal end is a somewhat rectangular mass, of nearly double the width of the shaft and projecting outwards (*d*) from the axis of the shaft, and giving the whole bone a curved outline. The articulation closely resembles that on the first phalange of the thumb, which performs similar functions. It affords a means of differentiating the digits of the same paw, that of the second phalange of the second digit forming an obtuse angle with the inner edge of the bone, that belonging to the third a nearly right angle, that belonging to the fourth being slightly acute, while that belonging to the fifth is more acute and very much shorter in its transverse diameter. Like the first phalanges these bones are much longer and more slender than those of the hind paw.

We have been unable to detect any difference of form between the phalanges of Lion, Tiger, and *Felis spelæa*. We have met with no British specimens of the third phalanges sufficiently perfect to describe, with the exception of Pl. V, fig. 14: they only differ from each other in size, those of the fore being in the main larger than those of the hind paw.

§ 2 γ. *Measurements.*—The following table of measurements shows that the superiority of size observable in the other bones of *Felis spelæa* as compared with those of Tiger and Lion is carried out in every bone of the fore paw.

Measurements of Phalanges.

	First Phalanges.			Second Phalanges.		
	Felis spelæa.	*F. leo.*	*F. tigris.*	*Felis spelæa.*	*F. leo.*	*F. tigris.*
First digit.	Sandford Hill.	W. A. S.	British Museum.	Bleadon.	W. A. S.	British Museum.
1. Maximum length	1·42	1·25	1·15	...	...	...
2. Minimum circumference	2·60	2·00	1·6	...	...	...
3. Transverse measurement of proximal articulation	0·92	0·80	0·7	...	...	...
4. Vertical	0·70	0·55	0·4	...	...	...
5. Transverse measurement of distal articulation	0·90	0·65	0·48	...	...	...
6. Vertical	1·00	0·90	0·8	...	...	...
Second digit.						
1. Maximum length	2·04	1·78	1·9	1·52	1·25	1·5
2. Minimum circumference	2·00	1·70	1·5	1·60	1·50	1·2
3. Transverse measurement of proximal articulation	0·95	0·72	0·7	0·72	0·60	0·6
4. Vertical	0·60	0·50	0·5	0·50	0·50	0·4
5. Transverse measurement of distal articulation	0·70	0·60	0·5	0·80	0·63	0·6
6. Vertical	0·72	0·80	0·8	0·63	0·60	0·7
Third digit.						
1. Maximum length	2·42	2·00	2·2	2·00	1·30	1·6
2. Minimum circumference	2·00	1·80	...	1·80	1·35	...
3. Transverse measurement of proximal articulation	1·00	0·85	0·88	0·82	0·64	0·65
4. Vertical	0·70	0·55	0·45	0·70	0·45	0·4
5. Transverse measurement of distal articulation	0·70	0·65	0·55	0·80	0·54	0·55
6. Vertical	0·80	0·90	0·8	0·70	0·50	0·8
Fourth digit.				Sandford Hill.		
1. Minimum length	2·20	1·85	2·05	1·75	1·30	1·5
2. Minimum circumference	2·00	1·74	1·6	1·70	1·25	1·2
3. Transverse measurement of proximal articulation	0·98	0·85	0·75	0·84	0·60	0·75
4. Vertical	0·69	0·45	0·4	0·61	0·45	0·35
5. Transverse measurement of distal articulation	0·70	0·60	0·43	0·70	0·50	0·5
6. Vertical	0·70	0·65	0·6	0·55	0·50	0·5

MEASUREMENTS OF PHALANGES—*continued.*

Fifth digit.	First Phalanges.			Second Phalanges.		
	Felis spelæa.	*F. leo.*	*F. tigris.*	*Felis spelæa.*	*F. leo.*	*F. tigris.*
	Sandford Hill.	W. A. S.	British Museum.	Bleadon.	W. A. S.	British Museum.
1. Maximum length	1·97	1·75	1·65	1·70	1·10	1·22
2. Minimum circumference	1·60	1·50	1·4	1·70	1·25	1·2
3. Transverse measurement of proximal articulation	0·75	0·75	0·6	0·70	0·60	0·6
4. Vertical	0·55	0·50	0·42	0·55	0·40	0·5
5. Transverse measurement of distal articulation	0·60	0·60	0·5	0·65	0·50	0·5
6. Vertical	0·70	0·65	0·5	0·55	0·50	0·5

CHAPTER XV.

LIMB BONES OF THE WHELP. Pl. XXII.

CONTENTS.

§ 1. *Description.*—M. Gervais, in his 'Zoologie et Paléontologie Française,'[1] states that M. de Serres and his coadjutors in the work[2] on the fossil mammals of Lunel Viel have figured and described bones as leonine, which he considers to belong to young *Felis spelæa,* "before it had lost its milk teeth," and that Dr. Schmerling had indicated the presence of lion in the Belgian caves "without giving more certain proof of its existence." The bones from Lunel Viel (exclusive of the head) consist of the sacrum, the proximal half of a femur, both of which are figured, and an ulna that is only described; while those from Belgium consist of a nearly entire pelvis, and a perfect radius and ulna. All these, however, seem to be of by no means so young an age as M. Gervais supposed. In the figures given by M. de Serres[2] and Dr. Schmerling,[3] there is no trace of lines of separation between the sacral vertebræ; while in a third sacral that passed through our hands, and is now in the Taunton Museum, and which had belonged to an animal very much larger than the average-sized Lion, the anchylosis was not yet completed. It is clear, therefore, that the former must have belonged to older animals than the latter. In our figures also of the radius and tibia (Pls. II, fig. 1, XIX, 1, 1'), the anchylosis is imperfect, so that the proximal epiphysis is lost in each case, although the full size and proportions have been reached. The limb bones from Belgium and Lunel Viel present epiphyses firmly anchylosed to the shaft, and strongly marked muscular ridges, and they therefore belonged to not merely full grown but to tolerably aged animals.

In Britain we have met with several bones of the spelæan whelp from the caves of

[1] Edition 1859, p. 227.

[2] 'Oss. Foss. de Lunel Viel,' pl. viii, figs. 15, 16, p. 107.

[3] 'Oss. Foss. de Liége,' tom. ii, pl. xix, figs. 1, 2, p. 90.

Bleadon, Hutton, and Sandford Hill. An ulna from the latter cave must from its extreme shortness have belonged to a very young animal. In Mr. Beard's collection, now in the Taunton Museum, are two right fibulæ, the larger of which we figure (Pl. XXII, fig. 9), with some doubt as to its correct determination. Its ridges, which are slightly developed, and the distal lateral articulations for the tibia, are of the same form as in the older Lion. So far as we can tell, from the limited means at our disposal, it is of the size of a Lion's whelp six weeks old. In the same collection there are both ends of a left radius which correspond exactly with those of a young Lion of three months. They most probably were obtained in Hutton Cave, which has furnished two young humeri, one of which is figured (Pl. XXII, fig. 1), a large portion of a right scapula, both ulnæ (one figured, figs. 2, 3), both femora (figs. 7, 8), a left tibia, calcaneum (fig. 10), a fifth metacarpal (fig. 4), and some first and second phalanges (figs. 5, 6), including a part of the first digit of the fore paw. All these bones in size and proportions agree with those of a Lion's whelp of three months. From Hutton also were obtained the maxillary and lower jaw, which have already been figured (Pl. XIII, figs. 1, 3), and described. The whole of them most probably belonged to one individual. The calcaneum and some phalanges of an older animal from Bleadon are also preserved in the Taunton Museum. All these bones coincide with those of the adult which we have figured and described in the course of this Monograph. They are, however, much more cylindrical, and present fainter muscular impressions, and are considerably shorter.

§ 2. *Measurements.*—The following measurements are all that the condition of the bones would admit of being taken. Humerus: minimum circumference, 3·05; do., 3·04. Ulna: minimum circumference, 2·20; length of humeral articulation, 2·00; length of radial articulation, 1·15; depth of radial articulation, 0·40. A second specimen agrees with the preceding while in a third the minimum circumference is 2·20, and the length of the humeral articulation, 1·70. Radius: minimum circumference, 1·40. Femur: minimum circumference, 2·78; do., 277. Tibia: minimum circumference, 2·60. Fibula: minimum circumference, 0·50; do., 0·60.

Table showing the variations in the size of calcanea of Felis spelæa, from youth to old age.

	Adult. Pl. IV, fig. 2.	Young. Pl. XXII, fig. 10.	Young.
1. Total length	5·60	...	...
2. Minimum circumference	4·73	3·00	...
3. Maximum vertical measurement	2·36	1·40	1·08
4. ,, transverse ,,	2·38	1·50	0·68
5. From inner articulation to outer end of bone, articulation included	3·95	...	...
6. Transverse measurement of sigmoidal articulation	0·92	0·50	0·36
7. Transverse measurement of cuboidal articulation	1·32	1·00	...
8. Vertical ditto	1·17	1·00	...
9. Transverse measurement of inner astragaline articulation	0·81	0·60	0·50
10. Vertical ditto	0·74	0·60	0·50

The minimum circumference of the phalange of the first digit is 1·85; of the rest, 1·10, 1·42, 1·30, 1·46; and of the second phalange, 1·29.

CHAPTER XVI.

Felis spelæa, Goldfuss, specifically identical with Felis leo, Linnæus.

CONTENTS.

§ 1. *Introduction.*—In the preceding chapters we have analysed the differences observable in skeletons of Lion, Tiger, and *Felis spelæa,* not founding our comparison on one skeleton merely of either of the former animals, but comparing and noting the variations in the form and proportion of the bones of all the individuals preserved in the museums of London and Oxford. One fertile source of error in the work of previous observers has been avoided—the use of the bones of animals kept in menageries, which are invariably affected in direct proportion to the length of the confinement of their possessors, and to the extent to which the natural habits have been restrained and curbed by domestication. They are so deformed, and, if the cub has been born in captivity, so small and puny, that they are absolutely useless as a means of comparison. Before we proceed to sum up the bearing of the evidence on the recent affinities of *Felis spelæa,* we intend to quote the opinions of the naturalists in chronological order, following to a certain extent the method of M. de Blainville and Baron Cuvier.

§ 2. *Various opinions held by naturalists.*—The first evidence of the discovery of *Felis spelæa* is afforded by a figure[1] of an unequal phalange, appended to a paper on the Dragons of the Carpathians, written by Dr. John Hain in 1672. It is most important, because it brings the range of the fossil animal into the Hungarian Basin of the Danube. Leibnitz, in 1749,[2] figured a fragment of skull obtained from the cavern of Schartzfeldt. The plate contains four rudely executed figures, of which the upper may represent the

[1] Recognised by Cuvier ('Oss. Foss.,' t. iv, p. 449, 2nd edit., 1822), and ascribed by him to Dr. Vollgnad ('Ephém. Nat. Cur.,' an. iv, dec. 1, obs. clxx, p. 227). The latter, however, merely gives an outline of a paper published in the preceding year by Dr. Hain ('Miscell. Nat. Cur. Medico-Physic. Germ.,' An. III, Obs. CXXXIX. "De Draconibus Carpathicis").

[2] 'Protogæa,' pl. xi, fig, 1, p. 62.

parietals and part of the occipitals of a Lion, while those underneath may be the fore part of the upper and lower jaws, of the same animal; but it is very possible that the originals may have belonged to the Bear. The whole are referred to in the text as "vera elephantium ossa," the upper part of the head being taken for the "tibia" of the Elephant. The fragment of skull is compared by Soemmerring[1] with the skulls of Lion and *Ursus spelæus.* He considers that it differs in no respect from the former animal; but he adds that in most of the points relied upon it resembles other species of the genus Felis. He gives a more exact figure than that of Leibnitz.

In 1774 Esper[2] published an account of the mammals found in the Margraviat of Bareith, in which he figures an upper jaw from Gailenreuth. He obtained also detached teeth and bones. He believes them to belong to an unknown animal, more closely allied to the Lion than any other species. Rosenmüller,[3] in 1804, states that he is about to publish a work on an unknown fossil animal of the genus Felis, and he adds that its bones differ in some respects from the Lion. Dr. Goldfuss[4] published, in 1810, a small work on the environs of Muggendorf, in which a nearly perfect skull from the cave of Gailenreuth was figured and described under the name of *Felis spelæa,* which was adopted by Cuvier, and became the recognised specific name of the animal. In 1821[5] he republished his determination of the species, and gave a full-sized figure of the skull, which he considered to belong to an extinct species, more closely allied to the Panther than to Lion or Tiger.

Drs. Pander and D'Alton[6] state, in 1822, that *Felis spelæa* differs specifically from *Felis leo,* and refer to their figures in support of this conclusion. The figures, which are those of a skull and lower jaw, exhibit no sutures. The second premolar of the upper jaw is bifanged, as in the skull from Sandford Hill Cave (Pl. XI, fig. 1). There are no measurements of the skull given in the text, nor is any information afforded as to the museum in which it is preserved.

Baron Cuvier, in the second edition of the 'Ossemens Fossiles,'[7] published in 1823, does not pronounce a decided opinion on the relation of *Felis spelæa* to the large existing members of the genus, because he was unable to make a personal inspection of the type specimens described by Dr. Goldfuss; but he states his belief that the real affinities of the animal are neither with the Lion nor the Tiger, but with the Jaguar (*Felis onca*), giving as his principal reasons the gentle curve of the profile and the form of the lower jaw.[8]

[1] 'Magasin pour l'Histoire Nat. de l'Homme' de M. C. Grosse,' t. iii, cah. 1, No. 3, p. 60; Cuvier, op. cit. We cannot verify this reference.

[2] 'Description des Zoolithes, &c., dans la Margraviat de Bareith,' folio, Nuremburg,' 1774, tab. ix, xii, p. 53.

[3] 'Abbildungen und Beschreibung der fossilen Knochen des Höhlenbären,' folio; fig. 1, pp. 11, 19; Weimar, 1804.

[4] 'Die Umgebungen von Muggendorf,' Erlangen, 1810.

[5] 'Nova Acta Physico-Medica Acad. Cæs.-Leop. Cur.,' tom. x, p. 489, tab. 45, 1821.

[6] 'Die Skelete der Raubthiere,' tab. viii, *a, b, c, d,* 1822.

[7] Tom. iv, pp. 451—455.

[8] See '*Felis spelæa,*' cap. i; cap. vi, § 20.

Our great cave-explorer, Dr. Buckland,[1] in 1823, was the first to ascribe the spelæan remains to the fossil Tiger, without, however, giving any reasons for his conclusion.

His rival, Dr. Schmerling, in 1833, in his *résumé* of the species of Felis in the caverns of Liége,[2] considers that *Felis spelæa*, was allied to the Lion, but of a distinct species. He figures, however, bones from the same locality as belonging to the existing Lion; but confuses them with those of the *Felis antiqua* of Cuvier, which was not a Lion, but a Panther (*F. Pardus*).

MM. Marcel de Serres, Dubreuil, and Jeanjean,[3] writing in 1839, insist on the specific distinctness of *Felis spelæa* from the recent Lion, assigning as the principal difference the shortness of the muzzle. Like Dr. Schmerling, they identify a second species with the latter animal.

M. de Blainville, in 1841,[4] rejects the view advanced by Marcel de Serres and Dr. Schmerling, that the smaller bones ascribed to the Lion belong to a species differing from *Felis spelæa*, on the ground that they were probably not those of an adult. He, however, offers no opinion on the exact affinities of *Felis spelæa*.

M. Pictet,[5] in 1844, uses nearly the same words as Marcel de Serres and his fellow-workers in his notice on *Felis spelæa*. He does not recognise the smaller remains as those of *Felis leo*.

M. Gervais,[6] in the first edition of his 'Paléontologie,' published in 1848, regards the animal as a Lion (*Felis leo major*), without assigning any reasons for his conclusion.

Professor Owen,[7] 1842, adopted Dr. Buckland's opinion, and terms the animal a "spelæan Tiger," although he recognises the want of evidence sufficient to put the question of its species beyond dispute. He reproduced his views in 1846, in the 'British Fossil Mammals.'[8] In 1859, however, he published, in the 'Philosophical Transactions,'[9] a figure of a skull with the nasal processes restored as in the Lion. It is clear, therefore, that he recognises the leonine nature of the animal, for his figure shows that characteristic which is of specific value in determining Lion from Tiger.

Dr. Falconer is quoted by the eminent French palæontologist M. Lartet,[10] in 1864, as holding the view that *Felis spelæa* was identical in species with the Tiger inhabiting the north of China and the region of the Altai, and that it was driven out of Europe "par le développement progressif des sociétés humaines." In 1858[11] he enumerated "Cave Lion" among the remains from Kent's Hole.

[1] 'Reliquiæ Diluvianæ,' p. 261, 1823.
[2] 'Oss. Foss. de Liége,' tom. ii, p. 93, 1833.
[3] 'Oss. Foss. de Lunel-Viel,' p. 101, 1839.
[4] 'Ostéographie,' article "Felis," p. 115, 1841.
[5] 'Paléontologie,' vol. i, p. 186, 1st ed., 1844; vol. i, p. 228, 2nd ed., 1853.
[6] 'Zoologie et Paléontologie Françaises,' vol. i, p. 123, 1st ed., 1848; vol. i, p. 227, 2nd ed., 1859.
[7] 'Report of British Association,' 1842.
[8] 'British Foss. Mam.,' 1846.
[9] 'Philosophical Trans.,' pl. xii, "Memoir on Thylacoleo," 1859.
[10] 'Revue Archéologique Cavernes du Périgord,' p. 21, 1864.
[11] 'Palæontological Memoirs,' vol. ii, p. 457, 1868.

§ 3. *Conclusion.*—This diversity of opinion as to the actual affinities of *Felis spelæa* flows from two causes—the imperfection of the fossil remains, and the fact that the variations in the form and size of living feline species were not recognised. In the present Monograph we have attempted to arrive at the truth by a strict analysis of the evidence afforded by the Mendip Caves, which has never been submitted to the judgment of other naturalists. In assigning a specific value to differences between Lion and Tiger, we have realised the great amount of variation in size and form within the limits of a species, insisted upon by our great philosophic naturalist, Mr. Charles Darwin. Our labours have resulted in our being unable to admit that any other differences than the following are constant in the Lion and Tiger.

In the Lion the frontal processes (*i*, Pls. VII—X) of the maxillaries extend as far back as a transverse line passing through the naso-frontal suture; their apices are pointed. The inner bounding line of the nasal aperture, viewed in front, forms an even curve. The frontal ends of the nasal bones are flat. In the frontal bones the inter-orbital space is flatter and wider than in the Tiger. The temporal length of the frontals is smaller, and consequently the post-orbital process is placed further back, and the extension of the sagittal crest on the bone is less in the adult skulls. The comparatively shorter space between the posterior palatal foramen (Pl. VIII, *j*) and the orbital edge of the palate relative to the basal length of the skull is also to be reckoned characteristic. In the lower jaw (Pl. I, *a*) the ramal process is invariably present.

In the Tiger the frontal processes of the maxillary bones never extend so far back as a transverse line passing through the naso-frontal suture; their apices are truncated; the internal bounding line of the nasal aperture, when viewed in front, presents a double curvature. The frontal portions of the nasals are bent downwards, so as to form a median depression at their symphysis. The post-orbital processes have a larger frontal development (see page 56), and cause the inter-orbital surface to be more concave and narrower than in the Lion. The greater temporal length of the frontals causes the long-waisted appearance of the skull, and the greater development of the sagittal crest on the frontals of the adult. The posterior palatal foramen is further removed from the orbital edge of the palate relatively to the basal length of the skull. The ramal process is invariably absent from the lower jaw. These are the only points of difference that we find constant in the large series of leonine and tigrine skeletons in Oxford and London. The bones of the trunk and the extremities presenting such variations in size and form that we are unable to recognise any to be constant.

What, then, is the position of *Felis spelæa* in relation to these two animals, for the form of the lower jaw and of the skull forbid its comparison with the Jaguar?[1] The result of a minute comparison of its skeleton with those of the two former animals leads us to the following conclusions:—First, that *Felis spelæa* is more leonine in character than the recent Lion, and more divergent from the tigrine form. If the remains of the

[1] See Chapters I—VI.

three animals were placed in serial order, *Felis leo* would occupy the middle place, the points of difference between Lion and Tiger being exaggerated in *Felis spelæa*. Secondly, that while it is undoubtedly true that *Felis spelæa* was on the whole a larger and stouter animal than the existing Lion, some individuals are even smaller than some of the larger Lions of the present day, the series of spelæan remains not presenting greater contrasts in size than those of the recent Lion. And lastly, that there is not one character by which the animal can be distinguished from the living Lion. It must therefore be admitted that *Felis spelæa* is specifically identical with the Lion now living on the face of the earth. And this being the case, it becomes a serious question as to whether the term *Felis spelæa* should not be struck out of palæontological catalogues. Since, however, it has occupied a space in scientific nomenclature for more than fifty years, it is perhaps more convenient to term the animal *Felis leo*, var. *spelæa*, thus indicating that variety of the Lion that inhabited the caves of Northern and Western Europe during the Post-glacial epoch. Its range in Britain, and the causes of its extermination in Western Europe, will be considered in the next two chapters, and evidence will be adduced that will bring the sojourn of the animal in Europe down to a time not far distant from the Christian era.

CHAPTER XVII.

Range of Felis leo, var. *a*, spelæa.

CONTENTS.

§ 1. *Distribution in Britain.*—In the previous chapters we have proved that *Felis spelæa* is specifically identical with the existing Lion. We have now to show the distribution of its remains in Great Britain, so that we may approximately arrive at its relative numbers in various districts during the Post-glacial period. It is undoubtedly true that there is no direct evidence on this point, for the remains that have been found are merely those that have survived a series of accidents. Those in the brickearths and gravel-pits owe their preservation to the chance, first of all, of the animals being drowned, of their bodies having escaped the all-devouring jaws of the Hyæna, of their having been deposited in the ancient river-bed, and not having been swept out seaward, to be devoured by the fishes. To these must be added the chance of the gravel-pit or brickfield being formed in that precise spot, of their being discovered, and, lastly, of their not being destroyed by the ignorant workmen. Those also that have been found in the caves have had to run the gauntlet of a similar series of accidents. The absence, therefore, of its remains does not prove that the animal did not dwell in any particular district, but merely that it does not happen to have been discovered. But, nevertheless, the chances of preservation being equal over the whole British area, the relative numbers of the animal that dwelt in its various parts can be fairly estimated by the varying numbers of the remains found. In undertaking this task we fully recognise the imperfection of the geological record. We will begin with North Britain, and work our way southwards.

The Cave Lion is conspicuous by its absence from the whole of Scotland, Northumberland, Cumberland, and Westmoreland. In the North Riding of Yorkshire its teeth have been obtained from the bone-cave of Kirby-Moorside,[1] along with the remains of the Cave Hyæna and Wolf. Two canines and a metacarpal also were found by Dr. Buckland in the Hyæna-den of Kirkdale,[2] as well as a calcaneum that is now in the York Museum, associated with relics of the leptorhine Rhinoceros of Owen, the Mammoth, Bison, Reindeer, and others. In the river-deposit also of Bielbecks a very fine series of animals, consisting of Ursus, Bison, Wolf, and Cave Lion, were disinterred by the Rev. W. Vernon, F.R.S., in 1829, the leonine remains being a fragment of maxillary, both rami of the lower jaw, the ulna, radius, femur, and metatarsals, all of which belong to one individual.[3] The numerous caves in the Mountain-limestone of Lancashire and Derbyshire, strange to say, have not furnished a single fragment that can be attributed to the Lion, although they have been diligently explored by various observers; nor have the Midland Counties furnished the least trace of its existence as far south as the meridian of Oxford.

In the Eastern Counties it is very rare. The Post-glacial gravels of Barnwell have yielded a lower jaw that is preserved in the Natural History Collection at Cambridge, and a femur that is now in the British Museum. In Suffolk its remains have been found in the gravel-bed pierced by the tunnel at Ipswich, along with those of the Roedeer, Bison, Irish Elk, tichorhine Rhinoceros, Mammoth, Grizzly Bear, and others.[4] In North Essex the energetic collector Mr. John Brown, of Stanway, obtained a humerus from Clacton, now in the British Museum, and some other remains which Professor Owen quotes from Walton.[5]

The River-deposits of the great valley of the Thames have furnished its remains in comparative abundance. Its teeth occur at Hurley Bottom,[6] in Berkshire, along with the bones of the tichorhine Rhinoceros and *Hippopotamus major*. The great sheet of gravel, also, on which London stands, has yielded several isolated teeth to various collectors. From the great brick-pit at Ilford, on the north side of the Thames, one metacarpal has been obtained by Dr. Cotton, and two rami respectively by Mr. Antonio Brady and Mr. R. D. Darbishire, along with the remains of *Elephas antiquus*, Mammoth, Red-deer, Beaver, and other mammals. In the corresponding sheet of brickearth on the opposite side of the river, extending from Erith to Crayford, a lower jaw and an os innominatum[7] (Pl. III, fig. 1) were found by Mr. Swayne; a canine, two lower jaws (Pl. I, fig. 3), a humerus, metacarpal, metatarsal, and a phalange, by Dr. Spurrell; a gigantic canine by Professor Morris; and a lower jaw by Mr. Grantham. In the same county

[1] Museum of College of Surgeons.

[2] British Museum.

[3] All these remains are preserved in the York Museum.

[4] In the collection of R. Fitch, Esq., F.G.S., of Norwich.

[5] 'Brit. Foss. Mam.,' p. 152. We have been unable to find out where these remains are preserved.

[6] Oxford Museum.

[7] Now in the British Museum.

the Post-glacial brickearth of Otterham, near Sittingbourne, has furnished upper premolar 3 and a large upper sectorial to Mr. Hughes, F.G.S.; and a similar deposit near Hartlip, in the same neighbourhood, a femur to Mr. Bland.[1] A very careful search throughout South Kent and the whole of Sussex has not revealed a trace of the former existence of the Lion in the heart of the dense Wealden Forest, that from the nature of the ground must have overshadowed those districts during the Post-glacial epoch. In going westward we meet with the animal again in the low-level river-deposits of Fisherton, in a lower jaw, found by Dr. Blackmore, and now in the Salisbury Museum. The low-level gravels also of Loxbrook, in the valley of the Avon, near Bath, have furnished a remarkably fine humerus (Pl. XVIII, fig. 2) to the energy of the Rev. H. H. Winwood, F.G.S. In the collection of the Right Hon. Earl of Enniskillen, at Florence Court, is a canine from the cave on Durdham Down, near Bristol, explored by Mr. Stutchbury. Remains of the leptorhine Rhinoceros of Owen and *Hippopotamus major* from the same cave are preserved in the Bristol Museum.

But the district that, of all others, has furnished the most enormous quantity of the remains of the Cave Lion, and is entitled, therefore, to rank as its metropolis in Britain, is the western half of the Mendip range of hills in Somerset. Throughout the area extending from the ancient city of Wells westward to the new watering-place of Weston-super-Mare the Mountain-limestone is traversed by numerous caves that have afforded most valuable evidence as to the character of the ancient Post-glacial Fauna in the west of England to the Rev. D. Williams, Mr. Beard, and ourselves. Among the animals the Cave Lion stands out the most prominently.

We found in Wookeyhole Hyæna-den twelve teeth (Pl. XI, fig. 9; Pl. XII, figs. 9, 13, 15), an ulna (Pl. II, fig. 9), astragalus, and metacarpal (Pl. XX, fig. 7). Dr. Boyd also obtained a magnificent upper canine (Pl, XI, fig. 6).[2] All the remains were more or less gnawed, and bore indisputable traces of the animals to which they belonged having fallen a prey to the Hyænas.

The Feline remains from Bleadon, Sandford Hill, and Hutton Caves, explored by Messrs. Williams and Beard, are preserved in the Taunton Museum, where they constitute, perhaps, the most magnificent series in the world. They are as follows, in various conditions, some being perfect, others fragmentary.

[1] Both these are in the Museum of the Geological Society of London.

[2] In the Oxford and Taunton Museums, and in the collections of Mr. James Parker, Mr. Sanford, and Mr. Willett.

Bleadon Cave.

Adult.

	Numbers.
Maxillaries	10
Squamosal (Pl. IX, figs. 2, 3)	1
Lower jaws	12
Vertebræ (Pl. XIV, fig. 3; and Pl. XVI, figs. 1, 2, 4, 5, 6, 7, 8, 9, 10)	50
Sternebers (Pl. XVI, fig. 10)	5
Scapula	1
Humeri (Pl. XVIII, fig. 1)	8
Ulnæ (Pl. II, fig. 5)	14
Radii (Pl. II, fig. 4)	8
Carpals (Pl. XX, figs. 2, 3)	8
Metacarpals (Pl. XX, fig. 6; and Pl. XXI, fig. 1)	61
Phalanges	38
Ilium	1
Femora (Pl. XVIII, fig. 4)	6
Tibiæ	9

Adult.

	Numbers.
Fibula (Pl. XIX, fig. 4)	1
Tarsals (Pl. IV)	39
Metatarsals (Pl. V, fig. 1)	18
Phalanges	59
Sesamoids	2
Permanent teeth (Pl. XI, figs. 4, 8, 10, 11, 12, 13, 14; and Pl. XII, figs. 4, 6, 7, 8, 10, 11, 12, 14)	95

Whelp.

Maxillaries (Pl. XIII, fig. 2)	2
Lower jaws	8
Metacarpal	1
Phalanges (Pl. XXII, fig. 6)	2
Calcaneum	1
Fibulæ (Pl. XXII, fig. 9)	2
Milk-teeth (Pl. XIII, fig. 8)	12

Sandford Hill Cave.

The following bones probably belong to one adult individual:

Skull (Pl. X, fig. 1).
Lower jaws (Pl. I, figs. 1, 2).
Atlas (Pl. XIV, fig. 1).
Sixth cervical vertebra (Pl. XIV, fig. 2).
Second dorsal vertebra (Pl. XV).
Second lumbar vertebra (Pl. XVI, fig. 3).
Third sacral vertebra.
Both scapulæ (Pl. XVII).
Left humerus.
Both ulnæ (Pl. II, fig. 8).
Both radii (Pl. II, fig. 1).
Right scaphoido-lunare (Pl. XX, fig. 1).
Left pisiform (Pl. XX, fig. 4).
Metacarpals 2, 3, 4, 5, of right paw (Pl. XXI, figs. 2, 3, 4, 5).
Metacarpals 2, 3, 4, of left paw.
First phalanges of right paw (Pl. XXI, figs. 6—10).
Ossa innominata.
Patella (Pl. XIX, fig. 5).
Both tibiæ (Pl. XIX, figs. 1, 2).
Right fibula (Pl. XIX, fig. 3).
Both astragali.
Scaphoid.
Both calcanea.
Left cuneiform.
Metatarsals 2, 4, 5, of right paw (Pl. V, figs. 2, 4, 5).
Metatarsals 3 (Pl. V, fig. 3), 4, of left paw.
First phalange of the fifth digit of left paw.

Other Adult Bones.

	Numbers.
Maxillaries and intermaxillaries (Pl. XI, fig. 1). Lower jaws corresponding with the above.	
Vertebræ	6
Humeri	2
Ulnæ corresponding with humeri	2
Carpal	1
Os pubis	1
Tarsal	1
Permanent teeth (Pl. XII, fig. 5)	3

Remains of Whelp.

Maxillary bones	3
Lower jaws (Pl. XIII, fig. 4)	2
Milk-teeth (Pl. XIII, figs. 5, 6, 7)	4

Hutton Cave.

Bones of Whelp.

	Numbers.		Numbers.
Maxillary (Pl. XIII, fig. 1)	1	Sterneber	1
Lower jaws, a pair of (Pl. XIII, fig. 3)	2	A pair of femora (Pl. XXII, figs. 7, 8)	2
Scapula	1	Tibia	1
A pair of humeri (Pl. XXII, fig. 1)	2	Calcaneum (Pl. XXII, fig. 10).	
A pair of ulnæ (Pl. XXII, fig. 2)	2		

The skull and lower jaws, Pls. VI, VII, VIII, IX, were obtained either from Sandford Hill or Hutton Caves.

The accumulation of so enormous a quantity of the remains of the Lion in the caves of so small an area may be accounted for by the peculiar position of the Mendip Hills, that command fertile valleys on the north, and look out towards the south and west over a plain which, in Post-glacial times, occupied a large portion of the Bristol Channel. Around them were the feeding-grounds of incalculable numbers of the Reindeer, Bison, and Horse, of the Mammoth and tichorhine Rhinoceros, and, therefore, we might expect to find the carnivora present in very great abundance. There is evidence, indeed, that a larger number, not only of Lions, but also of Bears and Hyænas, existed in the district than have yet been proved to have lived in a similar area at any time in the past history of the earth.

To the south of this district no leonine remains have been discovered as far as the outcrop of the Devonian Limestones on the shores of Torquay and Plymouth. In the Brixham Cave two phalanges[1] were found along with flint flakes and the remains of the Hyæna, Bear, and other animals; in that of Kent's Hole, explored by the Rev. J. McEnery, an upper jaw, four teeth, and an ulna;[2] and in that of Oreston, near Plymouth, explored by Mr. Whidby, three canines, one humerus (Pl. XVIII, fig. 1), one metacarpal, and two metatarsals.[3]

Nor were they less rare on the opposite side of the Bristol Channel in South Wales. The researches of Col. Wood and Dr. Falconer have resulted only in the discovery of an upper jaw and five teeth (Pl. XI, figs. 1, 2, 5) in the Cave of Ravenscliff, three canines and a fragment of skull in that of North Hill Tor,[4] and a few fragmentary remains from those of Spritsail Tor and Long Hole;[5] from a cave on Caldy Island also a carnassial has been obtained by the Rev. F. Smith. In North Wales, a cave at Cefn, in Denbighshire, is quoted by Dr. Falconer as containing the remains of *Felis spelæa*, but we have been unable to submit them to a personal examination.

These are all the cases of the occurrence of the animal in Great Britain revealed by a careful search in every public and private museum and collection of note in the kingdom. The absence, therefore, of the animal from certain districts cannot be accounted for on

[1] In the possession of the Royal Society.

[2] In the British Museum, that of the College of Surgeons, and of the Geological Society, and in the possession of the Earl of Enniskillen.

[3] In the British Museum, that of Leeds, and that of the Geological Survey of England.

[4] 'Palæontological Memoirs of the late Dr. Falconer,' vol. ii, p. 458. [5] Op. cit., p. 525.

the supposition that the animal remains have not been examined; and consequently the range of the animal through Britain, so far as extant evidence goes, is fairly represented, although, of course, it may be modified from time to time by future discoveries. Its metropolis was West Somerset, where it was incredibly numerous; thence it ranged throughout England as far as the North Riding of Yorkshire, being very rare in proportion to the other animals living at the time. Its absence from Scotland, Cumberland, and Westmoreland, and its extreme rarity in North Wales, may be accounted for by the fact that the mountains in those districts were crowned by glaciers during the Post-glacial epoch, which would necessarily involve a climate unfitted for the great development of the Herbivora in regions much broken up into hill and valley, and the consequent absence of the Carnivores. In Scotland, at least, there is no other hypothesis that will account for the absence of every animal that can be ascribed to the Post-glacial group, excepting the Mammoth, which has been found in a few places, and which has been proved by the Siberian discoveries to have been capable of existing in the zone of vegetation represented by the Scotch Fir. If it be objected to this view that the Reindeer flourished in countless herds in a Siberian and North-American climate at least as severe as that of the Post-glacial winter in Britain, it may be answered that in Siberia and North America, where animal life is so abundant, the country consists of plains elevated but little above the sea-level, and capable of affording good pasturage in the short arctic summer, while in Scotland, Wales, Westmoreland, and Cumberland, the broken nature of the ground could not ever have admitted of the growth of feed for a large body of Herbivores.

The animal also has not been found in Ireland, most probably because only one of the numerous caves of that country has been properly explored, the energies of collectors being directed towards the acquisition of prehistoric remains from the turbaries and alluvia.

§ 2. *Mammals associated with the Cave Lion in Britain.*—In the following table we have given a list of all the fossil animals associated with the Cave Lion in the bone-caves and river-deposits of Great Britain. The varieties *Cervus Bucklandi* of Professor Owen and *Cervus Guettardi* of Baron Cuvier are included under the general specific name of *Cervus tarandus;* and *Strongyloceros spelæus* of the former under *Cervus elaphus*. *Equus fossilis* is also intended to include *Equus asinus*, which, up to the present time, has not been proved to have lived in North-Western Europe during the Post-glacial epoch. *Elephas antiquus* also is intended to include *Elephas priscus*, a name which the author of the species, Dr. Falconer, gave up during the last years of his life.[1] The *Rhinoceros leptorhinus* of Owen is used as the exact equivalent of the *Rhinoceros hemitœchus* of Dr. Falconer, and of what M. Lartet[2] takes to be represented by the *R. Merckii* of Dr. Kaup. With the exception of the lists of animals from Long Hole, Northhill Tor, Spritsail Tor, and Cefn Caves, for which we are indebted to Dr. Falconer, all the species have been determined by a personal examination of the remains.

[1] 'Palæontological Memoirs,' 8vo, vol. ii, pp. 251, 592, 1868.

[2] 'Ann. des Sc. Nat.,' 5e sér. Zool. et Paléont., tom. viii, p. 157, et seq.

Species associated with *Felis leo* (*var. spelæa*) in Britain.

	Post-glacial Caves.														Post-glacial River Deposits.							Riv. Deposits.		
	Bleadon Cave.	Brixham Cave.	Caswell Bay.	Cefn.	Durdham Down.	Hutton.	Kent's Hole.	Kirby. Moorside.	Kirkdale.	Long Hole.	Oreston.	Sandford Hill.	Spritsail Tor. Northhill Tor.	Wookey Hole.	Barnwell.	Bielbecks.	Fisherton.	Hartlip. Otterham.	Ipswich.	Loxbrook	Walton-on-the-Naze.	Clacton.	Crayford. Erith.	Ilford.
Homo, L.		×					×							×										
Rhinolophus ferrum-equinum, Leach							×																	
Vespertilio noctula, Schreb.																								
Ursus arctos, L.	×	×			×		×		×		×	×	×	×									×	×
U. spelæus, Gold.	×	×		×		×	×		×	×	×	×	×	×							×	×?	×	
U. ferox, L.		×		×			×		×					×									×	×
Gulo luscus, Fab.	×																							
Meles taxus, L.							×			×			×	×										
Mustela erminea, L.							×		×															
M. putorius, L.										×			×											
M. martes, L.	×																							
Lutra vulgaris, Erxl.	×				×		×			×														
Canis vulpes, L.	×	×	×			×	×		×	×	×	×	×	×			×						×	
C. lupus, L.	×	×		×		×	×		×	×	×	×	×	×					×				×	
Hyæna spelæa. Gold.	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×		×			×			
Felis catus, L.	×									×													×	
F. antiqua, Cuv. (=*F. pardus*)	×					×																		
F. spelæa, Gold.	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Machairodus latidens, Owen							×																	
Megaceros Hibernicus, Owen	×	×		×		×	×		×	×			×	×	×				×	×	×	×	×	×
Cervus Brownii, Dawkins																						×		
C. tarandus, L.	×	×	×	×		×	×		×	×	×		×	×	×		×			×				
C. capreolus, L.	×	×											×				×		×					?
C. elaphus, L.	×	×	×	×			×		×	×			×	×	×	×					×		×	×
Ovibos moschatus, Desm.																							×	
Bos primigenius, Boj	×	×	?				×				×	×		×		×	×		×		×	×	×	×
Bison priscus, Owen	×		?			×	?		×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Hippopotamus major, Desm.				×	×		×		×												×			
Sus scrofa, L.	×						×			×			×				×						×	
Equus fossilis, Owen	×	×	×	×	×	×	×		×	×	×	×	×	×		×	×	×	×	×	×	×	×	×
Rhinoceros megarhinus, Christ.											?												×	×
Rh. leptorhinus, Owen				×	×				×	×				×		×					×	×	×	×
Rh. tichorhinus, Cuv.		×	×	×			×			×	×	×	×	×	×		×	×	×	×			×	×
Elephas antiquus, Falc.	×			×	×				×	×			×								×	×	×	×
E. primigenius, Blum.	×	×			×	×	×			×		×	×	×	×	×	×	×	×	×	×		×	×
Lemmus sp., Link.	×																×							
Lepus cuniculus, Pall.		×					×		×	×														
L. timidus, Erxl.	×	×					×		×	×			×				×							
Lagomys spelæus, Owen	×	×					×																	
Spermophilus erythrogenoides, Falc.	?											?												
Sp. citillus, Pall.																	×							
Arvicola pratensis, Bell							×																	
A. agrestis, Flem.							×		×															
A. amphibia, Desm.							×		×	×			×	×									×	×
Mus musculus, L.									×															
Castor fiber, L.								×																×

§ 3. *Range in Time in Britain.*—We have now to discuss the palæontological value of the remains of the animal in determining the age of the deposits in which they are found. On a reference to the foregoing Table it will be seen that the animal occurs more or less abundantly in Bone-caves and River-deposits that are beyond all doubt of Post-glacial age, that is to say, which contain the remains of the arctic group of animals that invaded Western Europe during the great refrigeration of temperature at the close of the Pliocene epoch, such as the Mammoth, Musk-sheep, and Reindeer, and that spread over the area that had been occupied by the Glacial sea as the land gradually rose again above the waves. There are, however, in Britain certain deposits which contain the remains of Post-glacial mammals associated with those which have been considered characteristic of the Pliocenes of France, Germany, and Italy, and which, therefore, stand intermediate in the geological scale between Pre- and Post-glacial deposits properly so called. In two of these the Cave Lion has been found, in the ancient river-bed at Clacton, and in the Lower Brick-earths of the Thames Valley, at Ilford in Essex, and Crayford in Kent. We will, therefore, sum up the whole of the palæontological evidence as to their place in the geological scale.

The occurrence at Clacton of *Rhinoceros leptorhinus* of Owen (*R. hemitœchus* of Falconer), of *Elephas antiquus, Hippopotamus major*, Irish Elk, Horse, and of Urus, may be accounted for equally well by the assumption of its Pre- or Post-glacial age, for these Pliocene animals dwelt side by side in the same area with the arctic group of mammalia during the Post-glacial epoch. A new species of Deer, *Cervus Brownii*, is closely allied to the Fallow Deer, that is now found wild only in the districts adjacent to the shores of the Mediterranean. The Bison is the only animal that points in the Post-glacial direction, and this even will very probably be proved by future investigations on the Continent to have lived in France, Germany, and Italy during the Pliocene period. With its exception, therefore, there is nothing to forbid the supposition of the Pliocene age of the deposit; but, nevertheless, as the characteristic mammals of the Pliocene, so abundant in the Forest-bed of Norfolk and Suffolk, are absent, it would be hazardous to ascribe it to that age. And in the same way, since the Reindeer, Mammoth, tichorhine Rhinoceros, and other equally common and characteristic Post-glacial mammals, are also absent, it cannot be said to belong to the class of deposits containing their remains. We are, therefore, justified in assuming that it represents, in point of geological time, an epoch during which some of the more hardy Pliocene species lived under a temperature too severe for the more delicate of their congeners, and not cold enough for the invasion of the Reindeer and the allied arctic mammals.

The Lower Brickearths of the Thames Valley at Ilford and Crayford contain the remains of *Rhinoceros megarhinus*, which has not yet been found in France, Germany, or Italy in any strata later than the Pliocene age, and are therefore brought into more intimate relation with that epoch than any other of the deposits undoubtedly Post-glacial. Nevertheless, strange to say, since the Essay on the "Lower Brickearths"[1] was written,

[1] 'Quart. Geol. Journ.,' May, 1867, "On the Age of the Lower Brickearths of the Thames Valley," by W. Boyd Dawkins, M.A., F.G.S.

its author discovered the skull of a Musk-sheep at Crayford, which of all the arctic mammals now alive rejoices the most in a severe climate. How the remains of the megarhine or southern species of Rhinoceros, could lie side by side with those of the most northern in habit of the herbivora, in the same river-bed, is a problem very hard to solve. Could the two animals have coexisted under the same climate in the same area? So far as we know of the former range of the one and of the habits of its living analogue,[1] and of the habits of the other, it would have been impossible. There is, however, one view which has the merit of explaining this conflict of evidence, and which therefore is probably true. During the depression of North Germany and the greater portion of Britain, those portions of the Pliocene Continent now represented by France and the south of England were not submerged, for in that case they would present some traces of the deposit of the icebergs that were so numerous in the North Sea of the period; it is hardly within reason to suppose that all proof of submergence beneath the Glacial sea should have been removed by subaërial denudation from so large an area, while to the north of the Thames and in North Germany it is so abundant and so ample: it is, therefore, probable that the Thames Valley roughly marks the ancient coast-line of the Glacial sea in Britain, and that to the south the Pliocene land extended through France into Italy, while to the north the look-out was over a dreary expanse of sea, burdened with icebergs, like that off the coast of Newfoundland. The temperate Pliocene climate must of course have been lowered by the presence of so much melting ice as is implied by the presence of the boulder-clay, and especially in the neighbourhood of its coast-line, independently of any great change flowing from some other unknown and cosmical cause. This climatal change must have banished to a certain extent the Pliocene mammalia from the area over which it was felt; but, nevertheless, it is highly consistent with what we know of the migration of the herbivores to suppose that now and then some of the Pliocene mammals, such as *Rh. megarhinus*, may have ventured northwards as far as the shores of the great glacial sea. Again, M. Lartet[2] has proved that the Quaternary mammals invaded Europe from their ancient home in Siberia, where they dwelt during the Pliocene epoch, at the commencement of the European Quaternary period; the change in the Pliocene temperature coupled very possibly with the depression of land in North Siberia causing the animals inhabiting that area to advance westwards and to occupy the feeding grounds till then belonging to the Pliocene Fauna. This immigration very probably began at the time that North-Eastern Europe was *being depressed* beneath the waves during the Boulder-clay epoch. If this be admitted there is nothing improbable in the hypothesis that the arctic immigrants would gradually creep round the shores of the glacial sea, and here and there occupy in the winter the same pastures that afforded food to Pliocene mammals in the summer. Thus, the remains of mammals indisputably Pliocene may have been commingled in the deposits of the same stream. In this way the

[1] See 'Nat. Hist. Rev.,' No. xix, p. 339, 1865.

[2] 'Comptes Rendus,' p. 409, et seq., 1858.

presence of the Musk-sheep, the only arctic mammal found, the Mammoth, and tichorhine Rhinoceros may be accounted for in the midst of the hardiest portion of the Pliocene mammalia, the Red Deer, Horse, Urus, and others, and even with *Rh. megarhinus*, in the brickpits of Crayford.

On the whole, therefore, there is a high probability that the fresh-water deposit at Clacton and the Brickearths of the Thames Valley form the first terms of the Post-glacial series, that is to say, of a series characterised by the invasion of Western and Central Europe by the arctic group of mammals; that they are of a higher antiquity than the majority of British fluviatile deposits; and that they bridge over that interval between the Pliocene and Post-glacial or Quaternary epochs, which is sharply marked in Britain by Glacial phenomena, but which, in France and Italy, is not sharply defined. Such is the nature of the evidence on which we have founded our belief that these two deposits are more ancient than the ordinary Post-glacial brickearths and gravels, and that they consequently present the most ancient traces of the Cave Lion in Britain.

The Cave Lion has also been found in association with the Pliocene Machairodus in Kent's Hole, but the occurrence of that animal does not stamp the Pliocene age of the cave, because of the enormous number of Reindeer, Cave Hyænas, Mammoths, tichorhine Rhinoceroses, and other characteristic post-glacial mammals that were also found. Its presence can only be accounted for on the supposition that it strayed up northwards from its southern habitat very much in the same way as its congener the Tiger does now in Northern Asia. There is, indeed, nothing more improbable in the idea that the Machairodus of Kent's Hole preyed upon the Reindeer of the neighbourhood than that a Tiger specifically the same with that of India should at times prey upon the same animal in Siberia at the present day. It proves, however, one important fact, that while the Post-glacial fauna were in full possession of the British area, the Pliocene fauna, of which it is a member, occupied a zoological province further to the south.

What, then, is the range of the Cave Lion in time in Great Britain? It is found neither in the Forest-bed nor in the ancient land-surface underlying the marine Crag of Norfolk and Suffolk, whence the water-worn remains of terrestrial Mammalia were ultimately derived. It first occurs at Clacton, Ilford, and Crayford, and it subsequently lived in incredible numbers in the South of England during the occupation of the country by the arctic group of Mammals. At the close of the Post-glacial or Quaternary period it disappeared utterly, no trace of it having yet been found in any prehistoric deposit.

§ 4. *Continental range.*—Nor on the mainland of Europe has the Cave Lion been proved to have existed during the Pliocene epoch. In France it has been found in the caverns of Echenoz and Fovent (in Haut-Saône), of Gondenaus (Doubs), of Lunelviel (Hérault), of Pondres and St. Julien d'Ecosse (Garde);[1] and in that of Aurignac described

[1] Gervais, 'Paléontologie Française,' p. 123.

by M. Lartet.[1] It has also been discovered in the caves of Bruniquel and Les Eyzies and in the Rock-shelter of the Madelaine under circumstances which prove that it inhabited France while the stone-using primeval hunters lived in the country, and engraved the objects of their chase on fragments of Reindeer antler, and tusks of Mammoth. In the extreme south it is quoted by Baron Cuvier from the bone-breccia of Nice. It occurs also in the river-deposits of Tour de Boulade (Puy de Dôme), of Abbeville (Somme), of Paris (Seine), of Soute by Pons (Charénte Inférieure), and other localities. Throughout Belgium and Germany it occurs more or less abundantly, and especially in the caves, such as those of Liége, Goffontaine, Gailenreuth, Schartzfeldt, Altenstein, and Sundwig. The first case on record of its discovery is that by Dr. John Hain in the Carpathians in 1672, which is also very valuable because it is the most southern point in central Europe in which its remains have been found.

Up to the present time the animal has not been found in Spain, most probably because so few bone-caves have been explored in that country. In Italy it is proved by the discoveries of M. Ceselli[2] to have been living in the neighbourhood of Rome, while the volcanos of that district were active. In Sicily, the labours of Dr. Falconer[3] in the Grotto of Maccagnone have resulted in the proof that it inhabited the island along with Man, the Hyæna, Hippopotamus, and *Elephas antiquus.*

Thus there is proof that the animal ranged throughout France and Germany, as far south as the basin of the Upper Danube, and throughout Italy as far as the extreme point of Sicily. It has not, up to the present time, been discovered in Scandinavia, Denmark, or Prussia.

There is no reason to believe that any of the deposits in which it occurs throughout this great area are of other than Post-glacial or Quaternary date. Nevertheless, it would be rash in the present state of our knowledge of the Pliocene Felidæ of those countries to affirm that the Cave Lion was not an inhabitant of Europe during the Pliocene epoch.

§ 5. *Identity with* Felis atrox (*Leidy*), *of North America.*—In 1852,[4] Dr. Leidy figured and described a left mandible from the neighbourhood of Natchez, in Mississippi, without angle or coronoid process, and enveloped in a coating of peroxide of iron which could not be removed. Sufficient of it, however, was shown to enable Dr. Leidy to recognise its leonine affinities, and to convince him that it belonged to an animal specifically distinct from *Felis leo*, *F. tigris*, or *F. leo*, var. *a spelæa*. The two points that seemed to us in our examination of the figure to separate it from that of the Cave

[1] 'Ann. des Sc. Nat.,' 1861, p. 177.

[2] 'Correspondance de Rome du 4 Mai,' 1867.

[3] Falconer, 'Palæontological Memoirs,' vol. ii, p. 550, 1868.

[4] "Description of an Extinct Species of American Lion," 'Trans. American Philos. Soc.,' Philadelphia, n. s., vol. x, pp. 319—321, pl. 34.

Lion were the enormous depth of the ramus, and the forward position of the ramal process underneath Premolar 4, as compared with our type specimens of the mandibles of the latter animal.[1] In all other respects it was identical in form, those minor differences brought forward by Dr. Leidy vanishing away at the comparison of the large series of leonine jaws in the Taunton Museum. The subsequent discovery, however, of a lower jaw[2] of the Cave Lion in Mr. Beard's Collection from Bleadon Cave has caused us to reconsider our conclusion, since it presents exactly those characters by which we believed *Felis atrox* to differ from the Cave Lion, its ramal process occupying precisely the same abnormal forward position, and the depth of its ramus measuring 2·77 inches beneath Premolar 4, as compared with a corresponding measurement of 2·5 inches of Dr. Leidy's figure. In the latter, moreover, the thickness of the coat of peroxide of iron is not taken into account. We are, therefore, compelled to admit that specific difference has not yet been proved to exist between the American and the Cave Lion, and to believe, on the evidence before us, that the jaw in question really belongs to the latter animal. Contrary to what might have been expected, it differs more from that of the great South-American Felis, the Jaguar, in the enormous development of the ramal process, than does that of the existing Lion of the Old World.

The associated remains found at Natchez belong to Ursus, Bison, Equus, and Mastodon, as well as to representatives (now extinct) of the South American Fauna of the time, Megalonyx and Mylodon.

There is nothing *à priori* unreasonable in the idea that a geographical variety of the Cave Lion should have lived in North America during the Post-glacial or Quaternary period of that area, when we recollect that the Mammoth, Bison, and Horse, which have not yet been proved to differ specifically from those found in the Europæo-Asiatic Post-glacial series, have a similar range. There is no doubt of the specific identity of the American with the European Mammoth. *Bison Americanus* has been found in the fossil state at Big-bone Lick, Kentucky. The Bison associated with the American Lion at Natchez is considered by Dr. Leidy ('Smithsonian Contrib. to Knowledge,' 1852, vol. v, art. iii) to belong to a new species, *Bison latifrons*, Leidy; but since we cannot lay hold of even one point of difference between it and the enormous Bisons of Post-glacial Europe, we cannot think with him that Baron Cuvier was wrong in ascribing the remains to the Aurochs ('Oss. Foss.,' 4to, t. iv, p. 50, pl. iii, fig. 2). We cannot detect a specific difference in the comparison of *Equus Americanus* with the many forms of *Equus fossilis* in Europe.

So far, then, as we have any evidence at all, the animal, is a link in the chain that binds the Post-glacial Fauna of North America with that of Europe and Northern Asia, and we may fairly argue that the American Lion bore the same relation to that of the European Caves as the Waipiti to the Red Deer, the American to the European

[1] See 'Brit. Pleist. Mam.,' article "Felidæ," pl. i, figs. 1, 2 *a*.

[2] 'Cat. Taunt. Mus.,' No. 1. Felis, No. 16 and p. 7.

Bison, or the Canadian Elk to that of the Old World. Its occurrence in America is not more startling than that of the Musk-sheep in the South of France. But it extends the ancient range of the Cave Lion eastwards through Russia and the vast steppes of Northern Asia, across Bhering's Straits into the great treeless barren grounds of North America, and thence southwards into the zone of the woods, and over the great prairies of the Bison, down to the almost tropical region of the Gulf of Mexico. Subsequent investigation will, doubtless, prove its former existence in the intermediate area just as in the parallel case of the Mammoth. What we know of the living Carnivores, such as the Wolf, Fox, and Tiger, would naturally lead us to expect those found in a fossil state to have a far wider range than any of the Herbivora.[1]

[1] See 'Introduction,' p. xlix.

CHAPTER XVIII.

THE RETREAT OF THE LION FROM EUROPE.

§ 1. *Introduction.*
§ 2. *Evidence derived from History.*
§ 3. *Evidence derived from Myths.*
§ 4. *Cause of Disappearance.*
§ 5. *Conclusion.*

§ 1. *Introduction.* In the last two chapters the specific identity of the Cave Lion with that living at the present day has been summed up, and its distribution over Post-glacial Europe and America unfolded so far as the materials at our commands would allow. In conclusion, we propose to discuss its retreat from Europe. It vanished away, as we have seen, from Britain, France, Germany, and Italy before the dawn of the Prehistoric epoch, or the epoch characterised by the introduction of the Dog, Goat, *Bos longifrons*, and Sheep into Europe, as well as by the appearance of the Neolithic and bronze-using races of men.[1] It is, however, extremely probable that while those animals and peoples were spreading through Europe northwards and westwards, the Lion was retreating to the south and to the east; at all events, there is ample proof that it was living in Thrace at the commencement of the Historical period in Greece, and it is not unreasonable to suppose that its retreat from North-eastern and Central Europe was gradually brought about.

The documentary evidence on which the former existence of the Lion in Europe is based is of two distinct kinds; first, that which is indisputably true, since it presents the same grounds for being accepted as any other fact recorded in history; and secondly, that which is afforded by myths which we may expect *à priori* to have been based upon some foundation of truth that we are able to arrive at by using history on the one hand and palæontology on the other, as our analytical tests.

[1] The Prehistoric Period is defined in the Introduction to the British Pleistocene Mammalia (§§ 1, 2, 3, 4, 5), and in an essay on The Prehistoric Mammals of Great Britain ('International Congress of Prehistoric Archæology,' Norwich, 1868).

§ 2. *Evidence derived from history.* We have seen that the first mention of the Cave Lion is that recorded by Dr. Hain from the Hungarian basin of the Upper Danube. Strange to say, the very first historical notice that we possess of the animal is that incidentally recorded of its attacks on the baggage Camels of Xerxes, in an area but a short distance to the south of this, in the mountainous district of Thrace, between Acanthus and the city of Thessalonica. The following exact account is given by Herodotus of an incident in Xerxes' march through Southern Thrace and Macedonia before the battle of Thermopylæ :—" And Xerxes[1] and the army marched from Acanthus, striking inland, wishing to come to Therma (Thessalonica), and he marched through the Pæonian and Crestonian districts to the River Echeidorus, which rises in the Crestonian district, and flows through the Mygdonian country, and opens near by the marsh that is close to the River Axius. And while he was on the march in this direction Lions fell upon the baggage Camels. For the Lions, coming down by night and leaving their usual haunts, touched nothing else, neither beast of burden nor man, but killed the Camels only. And I wonder what on earth could have been the cause that made the Lions abstain from the other animals and attack the Camels only, beasts that they had never seen before nor tasted. Now, there are in these districts *many Lions,* and wild Oxen with very large horns that are objects of barter to the Greeks. Now, the boundary of the district inhabited by the Lions is the River Nestus, that flows through Abdera, and the Acheloüs, that flows through Acharnania. For neither to the east of the Nestus is there a Lion anywhere in the whole of Europe, nor to the west of the Acheloüs in the rest of the continent, but its habitat is the district between these rivers." We undoubtedly owe the knowledge that Lions dwelt in this district in the year 480 B.C. to the wonder at their strange choice of prey. The story was still fresh in the memory of the hunters of Chalcidice when it was chosen by Herodotus, in his travels some twenty-five years afterwards, to light up his wonderful narrative. The animal at that time ranged through the country south of the Balkans, through Roumania to the west of the River Carasu, and

[1] Herodotus ; book vii, cap. 124-6.

Ξέρξης δὲ καὶ ὁ πεζος στράτος ἐπορέυετο ἐκ τῆς 'Ακάνθου, τὴν μεσόγαιαν τάμνων τῆς ὁδοῦ, βουλόμενος ἐς τὴν Θέρμην ἀπικέσθαι· ἐπορέυετο δὲ διὰ τῆς Παιονικῆς καὶ Κρηστωνικῆς ἐπὶ ποταμὸν 'Εχείδωρον, ὃς ἐκ Κρηστωνάιων ἀρξάμενος, ῥέει διὰ Μυγδονίης χώρης, καὶ ἐζίει παρὰ τὸ ἕλος τὸ ἐπ 'Αξιῳ ποταμῷ.

Πορευομένῳ δὲ τάυτῃ λέοντες οἱ ἐπιθήκαντο τῇσι σιτοφόροισι καμήλοισι· καταφοιτέοντες γὰρ οἱ λέοντες τὰς νύκτας, καὶ λείποντες τὰ σφέτερα ἤθεα, ἄλλου μὲν ὀυδένος ἅπτοντο οὔτε ὑποζυγιου, οὔτε ἀνθρώπου, οἱ δὲ τας καμηλους ἐκεραΐζον μόυνας. Θωΰμαζω δὲ τὸ αἴτιον ὅ,τί κοτε ἦν, τῶν ἄλλων τὸ ἀναγκάζον ἀπεχομένους τοὺς λέοντας τῇσι καμήλοισι ἐπιτιθεσθαι· τὸ μήτε πρότερον ὀπώπεσαν θήριον μήτ ἐπεπειρέατο αὐτοῦ. 'Εισὶ δὲ κατὰ ταῦτα τὰ χωρία καὶ λεόντες πολλοὶ, καὶ βόες ἄγριοι, τῶν τὰ κέρεα ὑπερμεγάθεα ἐστι, τὰ ἐς τοὺς Ἕλληνας φοιτέοντα. Οὖρος δὲ τοῖσι λέουσί ἐστιν ὅ,τε δί 'Αβδήρων ῥέων πόταμος Νέστος, καὶ ὁ δι 'Ακαρνανίης ῥέων 'Αχελῷος· οὔτε γὰρ τὸ πρὸς τὴν ἠῶ τοῦ Νέστου οὐδαμοθι πάσης τῆς ἔμπροσθεν Εὐρώπης ἴδοι τὶς ἂν λέοντα, οὔτε πρὸς Εσπέρης τοῦ Αχελῴου ἐν τῇ ὑπολόιπῳ ἠπείρῳ, ἀλλ' ἐν τῇ μεταξὺ τουτέων τῶν ποτάμων γίνονται.

through Thessaly as far south as the Gulf of Lepanto and the Isthmus of Corinth, having as its western boundary the River Potamo and the Pindus Mountains.

The next mention of the European Lion we find in Xenophon's 'Treatise on Hunting,' which he composed on his banishment from Athens, after he had exchanged the court and the camp for the pleasures of gardening and hunting, in his splendid retreat in Lacedæmon, about the year 380 B.C.[1]—"Now, Lions, Pardaleis, Lynxes, Panthers, Bears, and the like beasts, are caught in foreign countries in the neighbourhood of Mount Pangæum and Mount Cissus, which is beyond Macedonia, and in the Mysian Olympus, and in Pindus, and in Nyse that is above Syria, and in other mountains that are able to support such animals." Mount Pangæum is situated near the sources of the Nestus, not far from the range of Rhodope (of the Balkans), Cissus is close to Thessalonica, and therefore this passage corroborates strongly the statement given by Herodotus as to the range of the animal, the only difference being that Xenophon states that it inhabited the Despoto Dagh Mountains of Roumelia, the eastern watershed of the Nestus, instead of its being restricted to the western bank of that river. Baron Cuvier,[2] indeed, and the late Right-Honorable Sir George Cornewall Lewis[3] agree in refusing historical value to this passage, because other localities in Asia are mentioned, believing that all these animals were not found in any one of these localities. But the fact that the Lion lived in that area, both before and after Xenophon's time, coupled with the fact that the Panther, Lynx, and Bear ranged through Europe in company in Post-glacial times, renders it very probable that he was scientifically accurate when he advised their capture in that district, by placing poisoned food near their drinking places. The Lynx and Bear still live in the same neighbourhood, and the Panther still remains in Asia Minor, bereft of his congener the Lion.

The historical value of the account of the range of the Lion in Europe given by Herodotus and Xenophon is corroborated by the testimony of the great father of natural history, Aristotle, who flourished some fifty years after the time of the latter writer, and who, being a native of Stagira, lived in the very district said to have been inhabited by the Lion. He describes its European range very nearly in the same words as those used by Herodotus; but in the hundred and fifty years that elapsed between their dates the hunter and the husbandman had made great inroads on the last foothold of the Lion in Europe. The "πολλοὶ λέοντες," "the many Lions," spoken of by the one had dwindled

[1] Ξενοφῶντος Κυνηγετικός. Cap. xi, 1. Λέοντες δὲ, παρδάλεις, λύγκες, πάνθηρες, ἄρκτοι καὶ τἄλλα ὅσσα ἐστι τοιᾶυτα θήρια ἁλίσκεται ἐν ξενᾶις χωρᾶις περὶ τὸ Παγγᾶιον ὄρος καὶ τὸν Κίττον τὸ ὑπερ τῆς Μακεδονίας, τάδ' ἐν τῷ 'Ολύμπῳ τῷ Μυσίῳ καὶ ἐν Πίνδῳ, τὰ δ' ἐν τῇ Νύσῇ τῇ ὑπὲρ τῆς Συρίας καὶ πρὸς τοῖς ἀλλοις ὄρεσι, ὅσα οἷα τ' ἐστι τρέφειν τοιαῦτα.

[2] 'Oss. Foss.,' 3e édit., 4to., t. iv, p. 425.

[3] 'Notes and Queries,' second series, viii, 1895, "Lions in Greece." We are indebted for several of the references to classical works to the learning of this eminent critic.

down into the "*σπάνιον γένος*," "the rare animal" of the other; he adds also that the wild beasts of Europe are more courageous than those of Asia or Africa.[1]

We have no mention of the animal in Europe from this time recorded by any writer down to the year A.D. 80 or 100, when it is mentioned by Dio Chrysostom Rhetor[2] in his 'Essay on Beauty.' "The honorable," he writes, "have vanished away in time, as they say the Lions have done which formerly dwelt in Europe, for there are no longer any more; but formerly they dwelt in the district of Macedonia and in other places.[3] Philostratus, also, writing in his 'Lives of the Sophists,' about the year 220 A.D., relates that Agathion, the athlete, who lived in the time of Herodes Atticus, 104—180, A.D., complained that he could not rival Hercules because there were no Lions in Acarnania. It is therefore clear that the Lion had deserted Europe before the end of the first century after Christ; or, in other words, that the "rare animal" of Aristotle had become extinct during the four hundred years that followed his time. It is, of course, impossible to fix the exact date, just as in the parallel case of the Brown Bear in Scotland or the Beaver in South Wales.

In the literature of Rome there is nothing that would lead to the supposition that the Lion lived in Italy during the Historic period.

> "At rabidæ tigres absunt et sæva leonum
> Semina."—Georg. ii, 151.

According to the high authority of Sir Cornewall Lewis, it is not even alluded to in Italian mythology.[4]

§ 3. *Evidence afforded by Myths.* In bringing Mythology to bear upon the question of the former existence of the Lion in countries where it was extinct before the Historical Period, we are justified only by the high probability of its truth, afforded by the fossil remains on the one hand and by history on the other. The evidence, indeed, afforded by the myths is so strong that Sir G. C. Lewis has admitted its value without knowing of the corroborative witness of the fossil remains. That eminent critic sagaciously inferred

[1] Aristotle, 'Nat. Hist.,' edit. Schneider, lib. vi, 28, 1:

Σπάνιον γὰρ τὸ γένος τὸ τῶν λεόντων ἐστι, καὶ οὐκ ἐν πολλῷ γίγνεται τόπῳ, ἀλλὰ τῆς Εὐρώπης ἁπάσης ἐν τῷ μεταζὺ τοῦ Ἀχελώου καὶ τοῦ Νέσσου ποταμοῦ.

Lib. viii, 27, 6.—*Ἔτι δὲ λέοντες μὲν ἐν τῇ Ευρώπῃ μᾶλλον, καὶ τῆς Ευρώπης ἐν τῷ μεταζὺ τόπῳ τοῦ Ἀχελώου καὶ τοῦ Νέσσου. Παρδάλεις δὲ έν τῇ Ἀσίᾳ· ἐν δὲ τῇ Ἐυρώπῃ οὐ γίνονται. Ὅλως δὲ τὰ μὲν ἄγρια ἀγριώτερα ἐν τῇ Ἀσίᾳ, άνδρειότερα δὲ παντα τὰ ἐν τῇ Ευρώπῃ, πολυμορφότατα δὲ τὰ ἐν Λιβύῃ· καὶ λέγεταί τις παροιμία, ὅτι ἀεὶ φέρει τι Λιβύη καινόν.*

[2] 'Orationes,' edit. J. J. Reiske, Orat. 21, Περὶ Καλλοῦς, sec. 269:

Εκλελόιπασι τῷ χρόνῳ οῖ καλοὶ, ὄιον δὴ φᾶσι τοὺς λέοντας πάθειν τοὺς ἐν τῇ Ευρώπῃ· ὀυ γὰρ ἔτι ἀυτῶν εἶναι τὸ γένος, πρότερον δ' ἦσαν, καὶ περὶ Μακεδονίαν καὶ ἐν ἀλλοῖς τόποις.

[3] 'Vit. Apoll.,' lib. i, cap. xv.

[4] 'Notes and Queries,' second series, vols. viii, ix, "Lions in Greece."

the former existence of the animal in the Peloponnesus before the dawn of history from the following incidental notices that have been woven into the myths:

"The Nemean Lion inhabited a cave with two mouths on Mount Treton, between Mycenæ and Nemea. Its destruction was one of the twelve labours of Hercules (Paus. ii, 15, 2; Apollod. ii, 5, 1; Diod. iv, 11), who is related to have accomplished this feat by the unaided strength of his arms, and without the aid of any weapon (Eur. Herc. Fur. 15, 3; Noom. xxv, 176). Admetus, King of Pheræ, loved Alcestis, the daughter of Pelias; her father promised to give her to the man who should harness Lions and Wild Boars to the same chariot. Apollo enabled Admetus to fulfil this condition, and Admetus married Alcestis (Apollod. i, 9, 15). Adrastus, King of Argos, in obedience to an oracle which ordered him to marry his daughters to a Wild Boar and a Lion, gave Deipyle to Tydeus, and Argea to Polynices, because they bore respectively the images of those animals on their shields."[1]

The Roman writer Ælian was probably right in his supposition that the Lion had been expelled from the Peloponnesus before the days of Homer.[2]

We have already seen that the existence of the Lions has been proved historically in Thrace, Macedonia, and Thessaly. It is attested also by the voice of tradition. King Caranus,[3] the mythical founder of the Macedonian dynasty, is reported to have celebrated his victory over Ciseus, a neighbouring king, by a trophy that was overturned by a Lion that descended from Mount Olympus; and therefore, according to Pausanias, the Macedonians, deterred by the omen, never erected trophies afterwards. Lysimachus also, according to the same author,[4] a Macedonian, and one of Alexander's body-guards, was thrown into a Lion's den by the command of his master, and conquered the beast. Polydamus[5] also, the athlete, killed a great and strong Lion, without arms of any kind, on Mount Olympus. A Lioness, sent by Diana,[6] killed Phayllus, the tyrant of Ambracia, and therefore was reverenced by the Ambraciots as their deliverer. It is worthy of note that Ambracia lies to the west of the River Acheloüs, and outside the boundary laid down by Herodotus.

[1] 'Notes and Queries,' vol. ix, p. 57.

[2] Ælian, 'De Nat. Anim.,' Schneider, lib. iii, cap. i, 27.

[3] Pausanias, lib. ix, cap. xl, 4.

[4] Pausanias, lib. i, cap. ix, 5:

Ὁ δὲ Λυσίμαχος οὗτος γένος τε ἦν Μακεδὼν, καὶ Ἀγεξάνδρου δορύφορος· ὃν Ἀλέξανδρός πότε ὑπ ὀργῆς λέοντι ὁμοῶ καθείρζας ἐς οἴκημα κεκρατηκότα εὗρε τοῦ θηρίου.

[5] Pausanias, lib. vi, cap. v, 3.

Οὗτοι πολλάκις οἱ λέοντες καὶ ἐς τὴν περὶ τοὺ Ὄλυμπον πλανῶνται χωρὰν· τούτου δὲ τοῦ ὄρους ἡ μὲν ἐς Μακεδονίαν πλευρὰ, ἡ δὲ ἐπι Θεσσάλους καὶ τὸν ποταμὸν τέτραπται τὸν Πηνεῖον. Ἐνταῦθα ὁ Πουλύδαμας λέοντα ἐν τῳ Ὄλύμπῳ μέγαν καὶ ἄλκιμον θήριον κατειργάσατο οὔδενι ἐσκευάσμενος ὅπλῳ.

[6] Ælian, 'De Nat. Anim.,' Schneider, lib. xii, cap. xl:

Ἀμπρακίωται δὲ, ἐπεὶ τὸν τύραννον αὐτῶν Φαΐλλον διεσπάσατο λέαινα, τιμῶσι τὸ ζῷον αἴτιον αὐτõις ἐλευθερίας γεγεννήμενον.

The scene of one of the prettiest stories recorded by Ælian is laid in Mount Pangæum, the very mountain quoted by Xenophon as the haunt of Lions some five hundred years before :[1]—"Eudemus tells the tale that in Pangæum, in Thrace, a Bear attacked the lair of a Lion while it was unguarded, and killed the cubs that were small and too weak to defend themselves, and when the father and mother came home from hunting somewhere, and saw their children lying dead, they were very much aggrieved, and attacked the Bear; and she was afraid and climbed up into a tree as quickly as she could, and settled herself down, trying to avoid the attack. Now, when they saw that they could not avenge themselves on her, the Lioness did not cease to watch the tree, but sat down in ambush at the foot, eying the bear, that was covered with blood. But the Lion, as it were, without purpose and distraught with grief, after the manner of a man, rushed off to the mountains, and chanced to light on a woodcutter, who in terror let fall his axe; but the Lion fawned upon him, and reaching up saluted him as well as he could, and licked his face with his tongue. And the man took courage. And the Lion encircled him with his tail, and led him, and did not suffer him to leave his axe behind, but pointed with his foot for it to be taken up. And when the man did not understand he took it up in his mouth and reached it to him. And he followed while the Lion led him to his den. And when the Lioness saw him she came and made signs, looking at the pitiable spectacle, and then up at the Bear. Then the man perceived and understood that the Lion has suffered cruel wrong from the Bear, and cut down the tree with might and main. And the tree fell, and the Lions tore the Bear in pieces; but the man the Lion led back again, safe and sound, to the place where he lighted on him, and returned him to the very tree he had been cutting."

This simple story, tested by the light of history, implies that the Lions some time dwelt in the neighbourhood of Pangæum. It is a very fair example of the valuable evidence that may be obtained from the analysis of myths, its historical corroboration being a mere accident. To the same class belong the story of the slaughter of the Nemean Lion, the conditions of marriage imposed on Admetus by Pelias, and those imposed on Tydeus and Polynices, that we have already quoted. They respectively imply that the Lion formerly lived in Nemea, and in company with the Wild Boar in the forests of Pheræ and Argos. The mythical evidence is most important in this particular, that it proves that the range of the Lion was becoming more and more restricted before the Historic Period commenced in Greece. If we add to this the geological testimony that the animal spread through the greater part of North-western and Central Europe during the Post-glacial epoch, and that of History as to its limited range, we are enabled to realise that the animal *gradually* retreated from Europe, step by step, until at last it became extinct some time between the days of Aristotle, B.C. 340, and those of Dio Chrysostom Rhetor, A.D. 80 to 100.

[1] Lib. iii, cap. xxi.

The Lion is also mentioned in the 'Niebelungen Lied' as having afforded sport to Sir Siegfried in the famous hunt in the Forest of Worms:[1]

961.

"With that an aged huntsman a watchful limehound took,
And shortly brought the champion into a shady nook,
Where store of beasts were couching; as each sprang from his lair,
The warriors, like good hunters, fell on and caught them there.

962.

"All that the limehound started, anon with mighty hand
Were slain by noble Siegfried, the chief of Netherland.
No beast could there outrun him, so swift his steed could race:
He won from all high praises for mastery in the chase.

963.

"Whatever he attempted, he went the best before.
The first beast he encounter'd was a fierce half-bred boar.
Him with a mighty death-stroke he stretched upon the ground;
Just after in a thicket a lion huge he found.

964.

"Him the limehound started; his bow Sir Siegfried drew;
With a keen-headed arrow he shot the lion through,
But three faint bounds thereafter the dying monster made.
His wondering fellow-huntsmen thanks to Sir Siegfried paid."

This passage, however, does not prove that the Lion dwelt in Bohemia at the time it was written (A.D. 900—1300?), because the whole story, according to the high authority of Prof. Max Muller,[2] is simply the ancient myth of Hercules appearing in a Gothic dress. It is, moreover, unsupported by collateral evidence of any kind, and therefore cannot be considered of historical value.

§ 4. *Cause of disappearance.* The cause of the disappearance of the Lion from Europe is very clear. The Leonine remains found in the ancient dwelling-places of Aurignac and La Madelaine testify to the warfare carried on by the Reindeer folk in France with the Post-glacial Lion, just as the story of the Nemean Lion, and the like, testify to the struggle carried on by the ancient Greek with the same animal in Peloponnese. Man cannot dwell at peace with the larger Carnivores. In exact proportion to his increase in numbers they decrease, being driven out of the field in the struggle for life. It would be almost possible to infer the want of civilisation and the small number of any people inhabiting a district fitted for the support of the large ruminants, by the amount of the carnivorous fauna. The fact, for example, that the Wolf lingered in Ireland as late as the

[1] 'The Fall of the Nibelungers,' by W. Lettsom, 1850, p. 161.

[2] 'Chips from a German Workshop,' vol. ii.

year 1710 is evidence of the sparse population and the uncivilised habits of the people in that island.

To this incessant warfare with man the retreat of the Lion from Europe may be attributed, and not to any want of food or to any climatal change. The winter cold of Mount Pindus and of the Balkans could not have been much less severe than that of the Pyrenees, the Vosges, or the Mendips; and the herds of Bison, Uri, and Elks that dwelt in the great Hercynian Forest that overshadowed the greater part of Germany in Prehistoric and Historic times were at least as well suited to become the prey of the Lions as any to be met with in the mountains of Thessaly or Macedonia.

§ 5. *Conclusion.* We have now briefly to sum up the results of our labours. Up to the present time *Felis spelæa* has been considered by various naturalists an extinct animal allied to the Lion, Tiger, or Jaguar. By a careful comparison of the remains of the animal, bone by bone, with those of the larger living Felidæ, we have arrived at the fact that it is specially identical with the Lion of Africa and Asia. Its range, both in space and time, has been determined so far as the materials at our command would allow; and lastly, the approximate date of its disappearance from Europe has been fixed by an appeal to the literature of Greece and Rome.

CHAPTER XIX.

FAMILY—FELIDÆ.

Genus—FELIS.

Species—FELIS LYNX, *Linnæus*.

Pl. XXIII.

§ 1. *Gisement.*
§ 2. *Description.*
§ 3. *Determination.*
§ 4. *Measurements.*
§ 5. *Conclusion.*

§ 1. *Gisement.* We are indebted to Dr. Ransom for the discovery of the remains of a Carnivore hitherto unknown in Britain, in a fissure that penetrates the Permian Limestone in Pleasley Vale, in Derbyshire, termed the Yew Tree Cave. The conditions under which the discovery was made are as follows :—"The cave is entered by a narrow opening, large enough for one person to creep through ; the descent is a series of inclines and sudden falls, which require the help of a rope and a long pole. The total depth is 70 feet, and the length about 100 feet (of the part explored). It is everywhere narrow, and in some places so much so that only a person of moderate obesity can pass. I was obliged to move sideways. The mud which fills the insterstices between the angular blocks at the floor of the cave is red loam, interspersed with small fragments of the stalagmite. No rolled stones were found, and no transported ones. Here and there the mud was hardened with infiltration of carbonate of lime ; this was particularly the case with that which lay upon the projecting ledges of the walls. The osseous remains found were imbedded in the red loam, and were best preserved when it was infiltrated with carbonate of lime. In some parts the bones were very friable, and fell to pieces on the slightest attempt to remove them. The number of fragments of bones in parts was so great as to form a large proportion of the mud. The bones were not found rolled or worn ; they were much broken in some parts of the cave, not in others—on the whole, not more so than might easily be accounted for by the falling of stones, by which means, also, the stalagmite was much broken. Only one bone was found which appeared to show marks of teeth. . . . A number of jaws of Wolf, and one which I take to be that of a Fox, were found ; also numerous long bones and jaws of Roedeer, part of the skull and lower jaws of a Pig, several jaws of the Watervole, and a still larger number which I have not yet determined. . . . How the bones got there it is not easy to say, there were few or no indications of the cave having been a den of wild animals, although it is possible that the expanded portion near the mouth may have been so used at some time. In that case, the bones found in the deeper parts must have been those which had been washed or fallen down, or of animals which had run down in the ardour of the chase, as the steep part of the fissure could not, I feel sure, be ascended by any animal which had once gone down. This was illustrated by our finding the almost entire skeleton of a Dog in the deepest part of the cave, so recent that the pupa-cases of the flesh-fly were still found perfect; and similarly in the new cave, which is shaped so as to form a capital live trap, I found great numbers of rabbits' bones and hares' bones in each cave, clustered and lying together as the animals died. No confident opinion founded on the position of the bones in the floor of the cave could be formed as to their relative ages, as the dribbling of water through the loose stones of the floor carries away and displaces the mud and objects imbedded in it."[1]

It is clear, from this precise account given by Dr. Ransom, that the geological age of the remains in the cave cannot be determined with absolute certainty. So far as the internal evidence goes, they may be of Prehistoric, or even Historic, date with as great probability as Postglacial; but, nevertheless, there are two circumstances which render the latter hypothesis the most tenable. In the first place, in a cave in the neighbourhood, the tichorhine Rhinoceros, Mammoth, and Bison have been found; and in the second place, the Carnivore in question must have crossed over into Derbyshire while Britain formed part of the mainland of Europe, or, in other words, during the Postglacial epoch, or very possibly before; for it is impossible to suppose that it could have invaded our island from France or Germany during Prehistoric times, and that it should have been brought over by the care of man is most improbable. Its Postglacial age, therefore, may be assumed with a very high degree of probability, although not with absolute certainty.

§ 2. *Description.* The remains (Pl. XXIII) consist of a fragment of skull and a lower jaw that most probably belonged to the same individual. The former presents the occipital bone in a perfect state of preservation, together with the basisphenoid, tympanics, the zygomatic portion of the temporal, and fragments of the parietals. The latter is a right ramus perfect with the exception of a small portion of the coronoid process and the tip of the angle, and with all the teeth *in sitû*, except the incisors. The unworn condition of the teeth implies that the animal was an adult just coming into its full prime.

[1] Brit. Assoc., Nottingham, 1866, Paper read before Section C.

§ 3. *Determination.* These remains were submitted to Prof. Owen shortly after their discovery, and were pronounced by that high authority to belong to *Felis cervaria,* the Lynx of Northern Asia. A careful comparison, however, with the Lynx in the British and Oxford Museums, and that of the Royal College of Surgeons, proves that they may be referred with equal justice to the Lynx of Norway and Sweden, *Felis borealis* (Temminck). It is foreign to the plan of this work to analyse all the variations presented by the European and North-Asiatic Lynxes; but we cannot detect any osteological difference of specific value between the Norwegian Lynx and the North-Asiatic *Felis cervaria.* The variations also in size presented by the various European Lynxes seem to be of no more importance in classification than those of the African Panther (*Leopardus varius*).

Among the smaller Felines there are only the Lynxes which are capable of being compared with our fossil on account of their peculiarly formed teeth. It is differentiated from the Canadian Lynx by the presence of a small cusp *c* (Pl. XXIII, figs. 3, 4, 5) on the lower true molar, which is invariably absent from the corresponding tooth of the latter animal. It is allied most closely with the Norwegian Lynx and the *Felis cervaria.* We will compare the remains *seriatim.*

The basi-occipital in the fossil is remarkable for its intertympanic squareness, fig. 2, as in the Norwegian Lynx. In *Felis cervaria* the planes bounding it on either side next the tympanics are inclined at a much greater angle to each other. The occipital foramen, fig. 1, is slightly more roof-shaped above than in either of these two Lynxes. The sur-occipital encroaches somewhat further upon the superior surface of the head than in *Felis cervaria,* as is shown by the measurements; there are no other differences observable between the fossil skull and those of these two animals. The relatively small mastoid differentiates the fossil from the Panther of Africa, the large size of the paramastoids from the Caracal, in which animal they are reduced to a small lamina embracing the tympanic bulla. The same point also differentiates it from *Leopardus pardina*, and from the Peshoo or Canadian Lynx.

The lower jaw (figs. 3, 4, 5, 6) differs in no respect from that of *Felis borealis* and *F. cervaria,* excepting in the strength of the muscular impressions. The alveolar border is nearly parallel to the inferior, without any tapering; the anterior portion is very much thickened; the ramal process *a* (fig. 3) is developed, and causes the convexity of the lower contour. The exterior of the crown of the canine bears two sillons (figs. 3 and 7), of which the inner is the smaller. In *Felis cervaria* the latter is very faint; but it is very strongly marked in *Felis borealis.* The inner side of the crown also is traversed by one sillon, that bounds the flattened slightly convex internal area.

The crown of premolar 3 consists of three cusps, of which the anterior, or the smaller, *b* (figs. 3, 4, 5), is not mapped off from the primary, *a,* by a cleft, but springs from a cingulum that is well defined on the inner side; *a* is very large and triangular, and separated from the secondary, *c,* by a deep cleft; *c* is defined from the cingulum. In *F. borealis* the cusp, *b,* is more clearly defined.

Premolar 4 repeats all the characters of the preceding tooth, but the secondary cusps, *b* and *c*, are increased in size, and the former defined from the primary, *a*, by a cleft; and from the cingulum by a notch; *a* also is more trenchant and broader in the antero-posterior direction.

The sectorial molar presents absolutely no points of difference when compared with that of *F. borealis* and *F. cervaria*, but, as before mentioned, it is differentiated from that of the Canadian Lynx by the presence of the small accessory cusp, *c*, which is adherent to the posterior base of the posterior blade, *a*. In the latter animal, moreover, the anterior blade, *b*, is shorter as compared with the posterior, *a*.

§ 4. *Measurements.* In the following tables we have arranged the measurements, in inches and tenths, of the skulls and lower jaws most closely allied to our fossil. The differences in size and proportions can be seen at a glance. In the last column of the measurements of the lower jaw we have inserted those of the teeth, from a jaw marked and found by Senhor Delgado[1] in the Casa da Moura, a cave in the Jurassic Limestone of Cesareda, in Portugal, that had been inhabited by a tribe of cannibals, probably of the Bronze Age. They agree exactly with those of our fossil, and therefore, although the jaw to which they belong is smaller in every dimension than the fossil from Derbyshire, both probably belong to the same species. The difference of size is not greater than that existing between two skulls of Norwegian Lynxes in the British Museum.

Measurements of Skull.	*F. lynx*, Pl. XXIII.	*F. lynx* (*borealis*), Brit. Mus., 1230 A.	*F. lynx* (*cervaria*), Brit. Mus., 1156 A.	*F. lynx* (*cervaria*), Coll. Surg., 4587.	*F. Lynx* (*Canada*), Oxford Museum.
Maximum height of occiput	1·81	1·6	1·62	1·45	1·35
" " occipital foramen	·86	·65	·68	·6	·55
" " exoccipitals	1·05	...	...	·85	·8
Transverse extent of occiput	2·02	2·0	2·0	2·17	2·2
Transverse measurement of occipital foramen	·79	·7	·66	·65	·6
Antero-posterior extent of condyles	·57	·55	·57	·5	·55
" " basi-occipital	1·05	1·08	1·02	1·02	·85
" " zygomatic articulation	·42	·4	·42	·35	·28
Transverse " " "	·98	1·0	·78	·78	·9
Meatus auditorius to meatus auditorius	2·0	1·99	2·0	1·89	1·6
Glenoid articulation to glenoid articulation	1·88	1·82	1·86	1·62	1·6
Intertympanic space	·85	·7	·64	·46	·52
Antero-posterior extent of tympanic bulla	·92	·95	·96	1·05	·95
Encroachment of sur-occipital on parietal surface	·35	·3	·26	·2	...

[1] Commissão Geologica de Portugal. Estudos Geologicos. Da Existencia do Homem no nosso solo em Tempos mui remotos provado pelo estudos das cavernas. Primeiro opusculo. Noticia ácerca das Grutas da Cesarada. Par J. F. W. Delgado. Com a versao em Francez, par M. Dalhunty. This jaw is alluded to in the text as belonging to species *a*, and is figured in pl. ii, fig. 1. See also Bone Caves in Portugal, 'Quart. Geol. Journ.,' No. 94, Translations and Notices, p. 9.

Measurements of Lower Jaw.	*F. lynx*, Pl. XXIII.	*F. lynx* (*borealis*), Brit. Mus., 1230 A.	*F. lynx* (*cervaria*), Brit. Mus., 1156 A.	*F. lynx* (*cervaria*), Coll. Surg., 4587.	*F. lynx* (*Canada*), Oxford Museum.	*F. lynx*, Casa da Moura.
Maximum length	4·2	4·0	4·0	3·5	3·4	...
Maximum height	1·68	1·8	1·8	1·6	1·66	...
Circumference behind $\overline{M1}$	2·2	2·0	2·0	1·7	1·6	...
„ before PM3	2·4	2·0	2·0	1·5	1·4	...
Diastema	·3	·3	·25	...	...	·35
Length of inferior border	3·3+	3·5	3·2	2·9	2·8	...
Height of articulation above angle	·85	·7	·75	·8	·78	...
Length of molar series	1·54	1·55	1·5	1·2	1·16	1·4
Antero-posterior extent of $\overline{M1}$	·65	·65	·63	·42	·46	·65
Antero-transverse „ „	·26	·26	·25	·2	·2	...
Postero-transverse „ „	·24	·26	·23	·2	·18	...
Height of crown	·35	·39	·35	·28	·32	...
Antero-posterior extent of PM4	·49	·50	·46	·45	·42	·5
Antero-transverse „ „	·19	·2	·19	·17	·16	...
Postero-transverse „ „	·27	·25	·23	·2	·18	...
Height of crown	·35	·32	·35	·39	·31	...
Antero-posterior extent of PM3	·4	·4	·4	·34	·31	·35
Antero-transverse „ „	·15	·16	·13	·13	·11	...
Postero-transverse „ „	·23	·2	·22	·16	·16	...
Height of crown	·29	·28	...	·21	·24	...
Length of canine	1·85	...	...	1·4	...	...
Length of crown of canine	·75	·8	·8	·5	·55	...
Symphysial length	1·25	1·1	1·2	·9	·7	...
Symphysial breadth	·5	·55	·5	·4	·48	...
Condylar length	·9	...	...	·8	·7	...
Condylar breadth	·5	...	...	·4	·2	...

§ 5. *Conclusion.* In fine, there is sufficient evidence afforded by these two fragments to prove that the animal to which they belonged was specifically identical with the *Felis* (*lynx*) *borealis* of Norway, or with the variety *F.* (*lynx*) *cervaria* of Sibéria. It was one of the larger Lynxes which in ancient times spread over the whole of the mainland of Europe, and still maintain their ground, in the wilder and more desolate parts, in Scandinavia, Russia, France, Germany, Spain, Italy, and the south. Its addition to the Fauna anciently dwelling in Great Britain is the more remarkable because it was predicted in the First Part of our Monograph written in 1865.

PLATE XX.

Felis spelæa, Goldfuss.

CARPUS. METACARPALS.

(Natural size.)

Fig.

1. Scaphoido-lunare, anterior or dorsal aspect. Sandford Hill Cave. Taunton Museum.

1′. Distal aspect of same.

2. Scaphoido-lunare of the small form, anterior or dorsal aspect. Bleadon Cave. Taunton Museum.

3. Distal aspect of pisiform. Bleadon Cave. Taunton Museum.

4. Proximal or ulnar aspect of pisiform. Sandford Hill Cave. Taunton Museum.

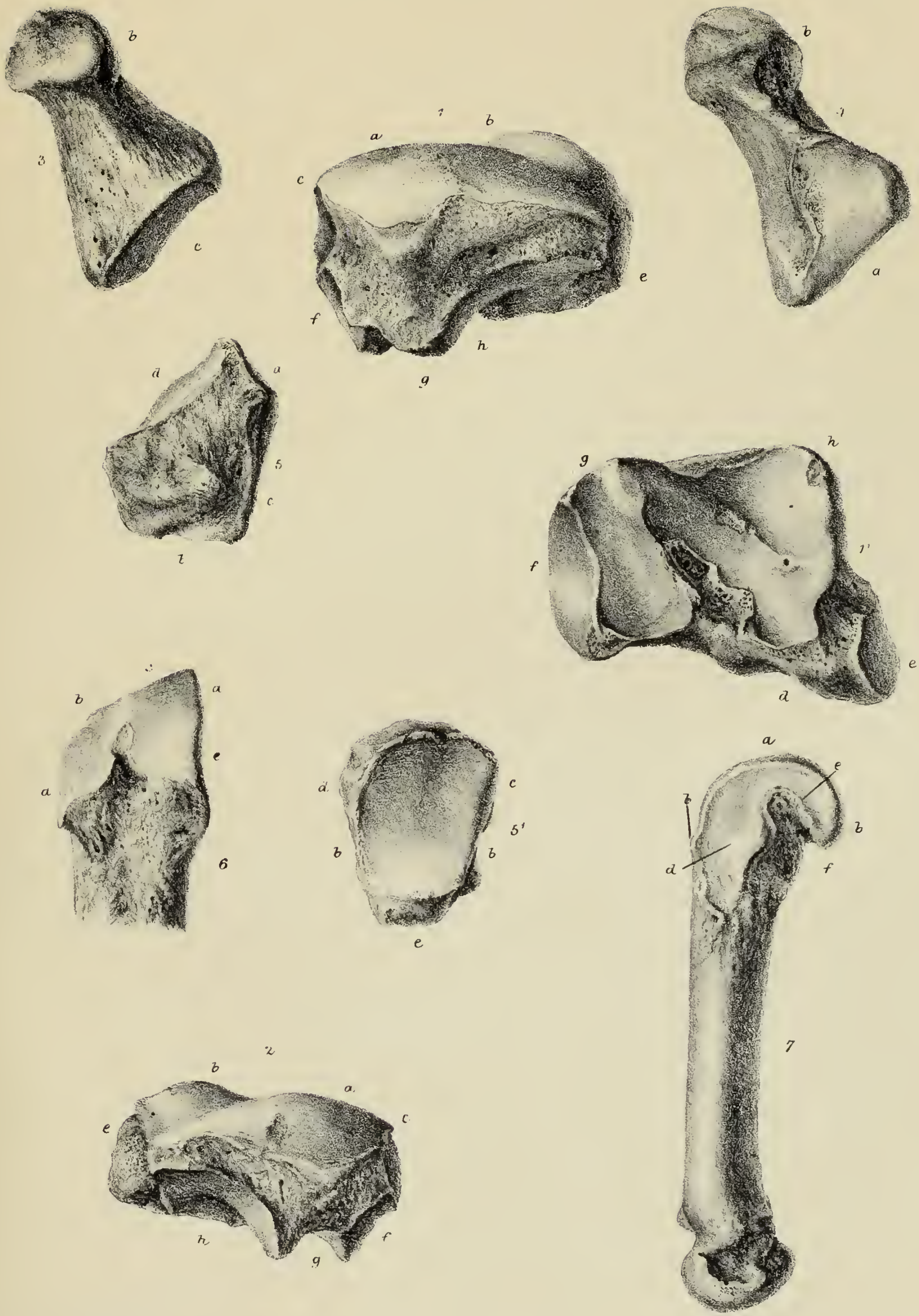
5. Anterior or dorsal aspect of unciform, right side. Sandford Hill Cave. Taunton Museum.

5′. Distal or metacarpal aspect of same bone.

6. Proximal end of fourth metacarpal of the ordinary form and size. Bleadon Cave. Taunton Museum.

7. Fifth metacarpal internal aspect. Wookey Hyæna-den. Mr. Boyd Dawkins' Collection.

FELIS SPELÆA.



W A Sanford del W^m Bidgood lith

CARPUS.

W West imp

PLATE XXI.

Felis spelæa, Goldfuss.

RIGHT FORE PAW.

(Natural size.)

FIG.

1. First metacarpal. Bleadon Cave.

2.
3.
4.
5. Remaining metacarpals from the same individual. Sandford Hill Cave.

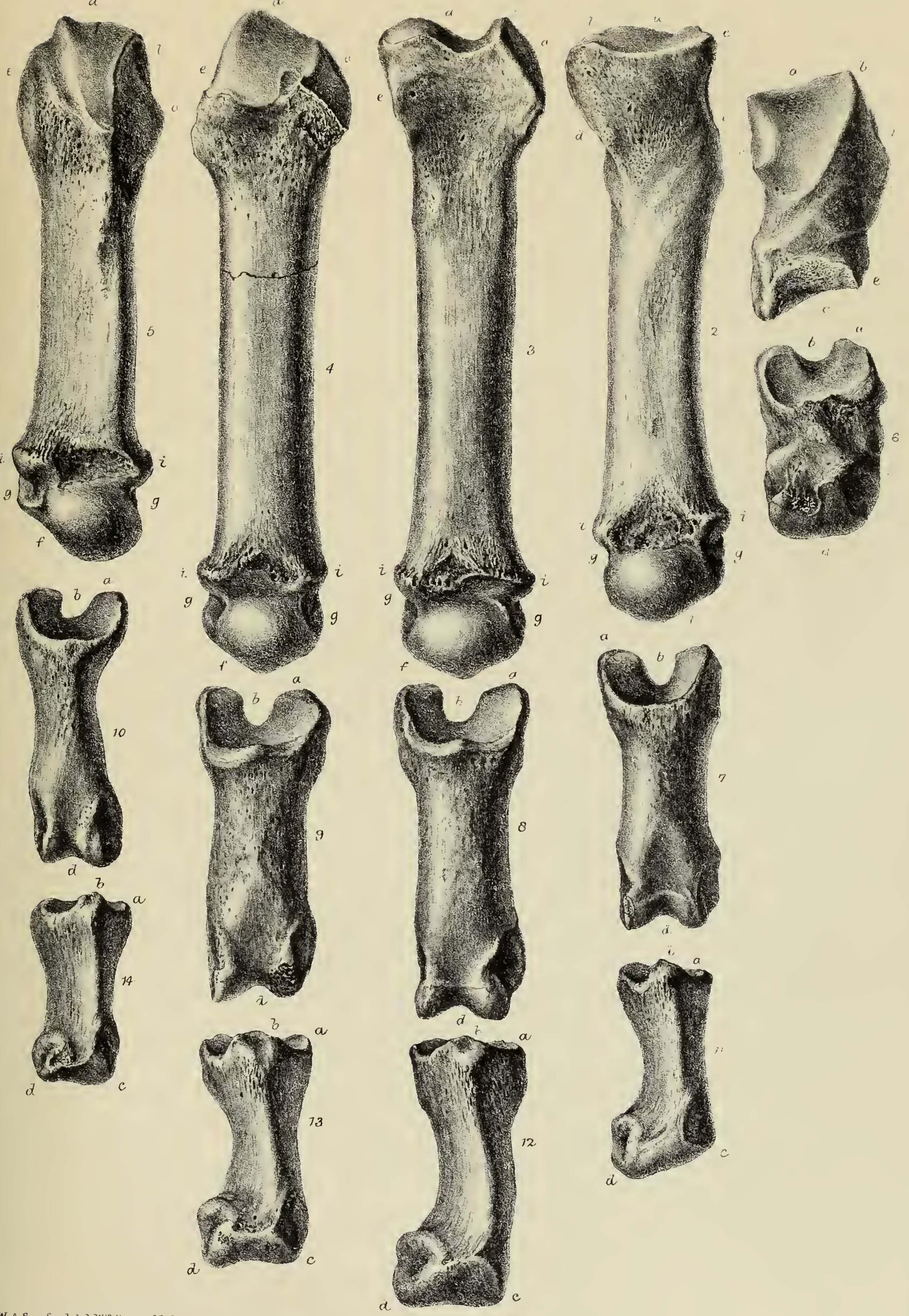
6.
7.
8.
9.
10. The first phalanges, apparently belonging to the individual as the last.

11. Second phalange of second digit. Bleadon Cave.
12. Second phalange of third digit. Bleadon Cave.
13. Second phalange of fourth digit, apparently belonging to the same individual as the set of metacarpals and first phalanges.
14. Second phalange of fifth digit (reversed), from left paw. Bleadon Cave.

All these were found by Mr. Beard, and are now preserved in the Taunton Museum.

FELIS SPELÆA.

PLATE XXI



W A Sanford del W^m Bidgood lith

FORE–PAW

PLATE XXII.

Felis spelæa, Goldfuss.

Bones of Whelp.

(Natural size.)

1. Left humerus, posterior aspect.
2. Right ulna, external aspect.
3. The same, internal aspect.
4. Left fifth metacarpal, dorsal aspect.
5. First phalange of one (second or fifth) of the outer digits of the hind paw.
6. Second phalange, dorsal aspect.
7. Right femur, posterior aspect.
8. Left femur, front aspect.
9. Shaft of left fibula, tibial aspect.
10. Left calcaneum, external aspect.

These bones, with the exception of 6 and 9, were found in Hutton Cave by Messrs. Beard and Williams, and probably belonged to one animal. The two exceptions were found in Bleadon Cave. All are now in the collection of cave-mammals in the Taunton Museum.

W A S del. J Dinkel lith

BONES OF WHELP.

W West imp

PLATE XXII A.

Felis spelæa. Goldfuss.

ULNA. RADIUS. TIBIA. FIBULA. PATELLA.

(Natural size.)

FIG.

1. Internal or ulnar aspect of right radius, represented in Pl. II, figs. 1, 2, 3, described at pp. 8, 9. Sandford Hill Cave.
2. Internal aspect of proximal half of right ulna represented in Pl. II, fig. 8, described at pp. 6, 7. Sandford Hill Cave.
3. Composite figure of external aspect of right tibia. The proximal portion is represented in Pl. XIX, figs. 2, 2′, the shaft and distal end in Pl. XIX, fig. 1 *a*. Both are described at pp. 122—4. Sandford Hill Cave.
4. External or tibial aspect of shaft of right fibula, represented in Pl. XIX, fig. 3, described at pp. 125—6. Sandford Hill Cave.
5. Internal aspect of distal end of right fibula, represented in Pl. XIX, fig. 4, described at pp. 125—6. Bleadon Cave.
6. Lateral aspect of patella, described at p. 127. Bleadon Cave.

We have added this and the following supplementary Plate XXII B in consequence of the desire, which has been expressed, that all the plates should be of life size. In no case has the same aspect of the same bone been repeated.

FELIS SPELÆA

Wm. Bidgood del. et lith.

BONES OF THE LIMBS, nat. size

W. West imp.

PLATE XXII B.

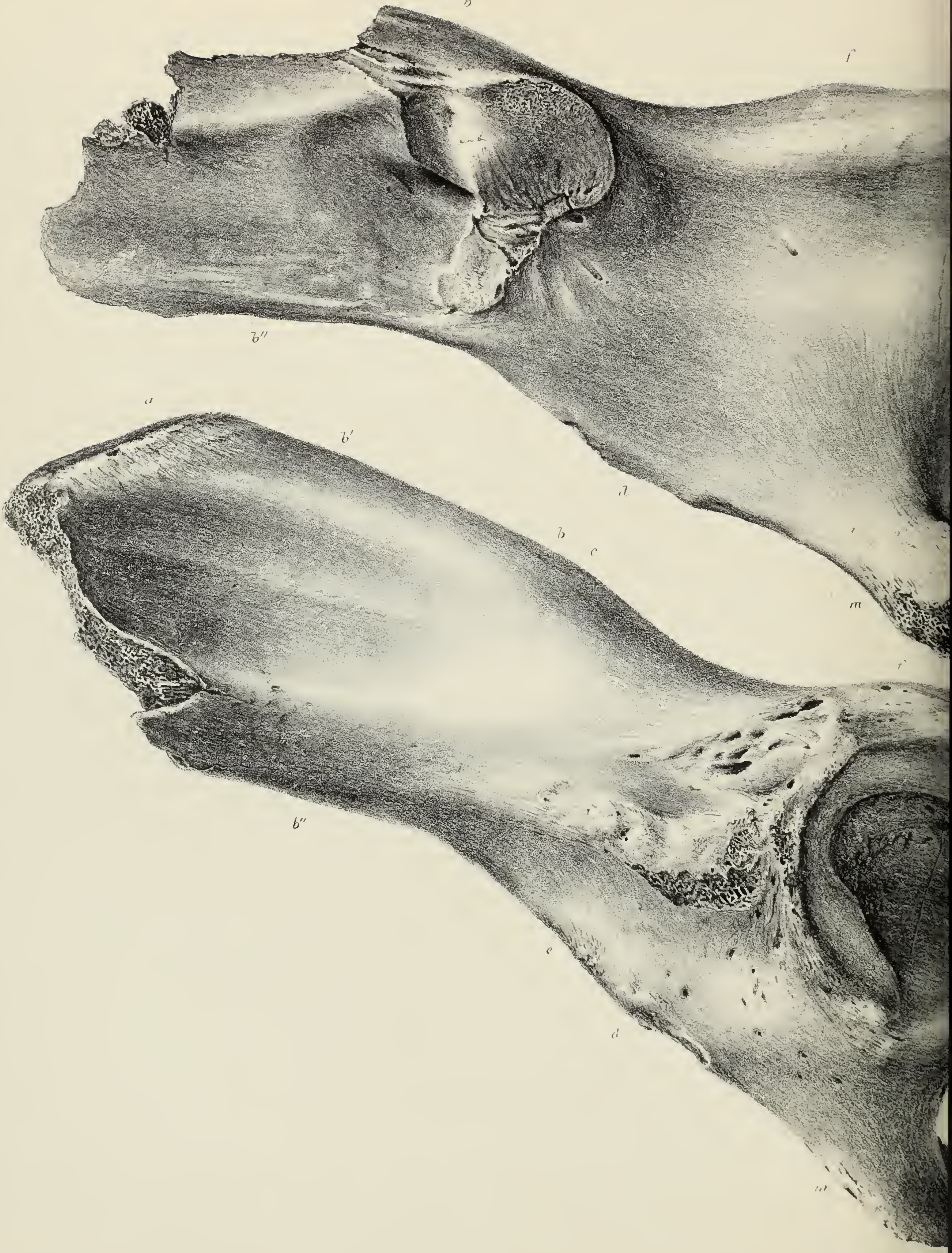
Felis spelæa, Goldfuss.

OS INNOMINATUM. VERTEBRA.

(Natural size.)

Fig.

1. External aspect of right os innominatum. Sandford Hill Cave.
2. Internal aspect of left os innominatum. This pair probably belonged to a Lioness, on account of the slenderness and curvature of the os pubis. The texture of the bone closely resembles that of the sacral vertebra, fig. 4, and several other young bones from the same locality. The animal, therefore, to which it belonged, though of full size, was probably young at the time of its death. Sandford Hill Cave.
3. Os pubis of very large animal, much stouter and less curved than that of fig. 2. Sandford Hill Cave.
4. Third sacral vertebra, with portion of the second (see p. 96). Sandford Hill Cave.



Bidgood del et lith

PELVIC

nal size

W West imp

PLATE XXIII.

Felis Lynx, Linnæus.

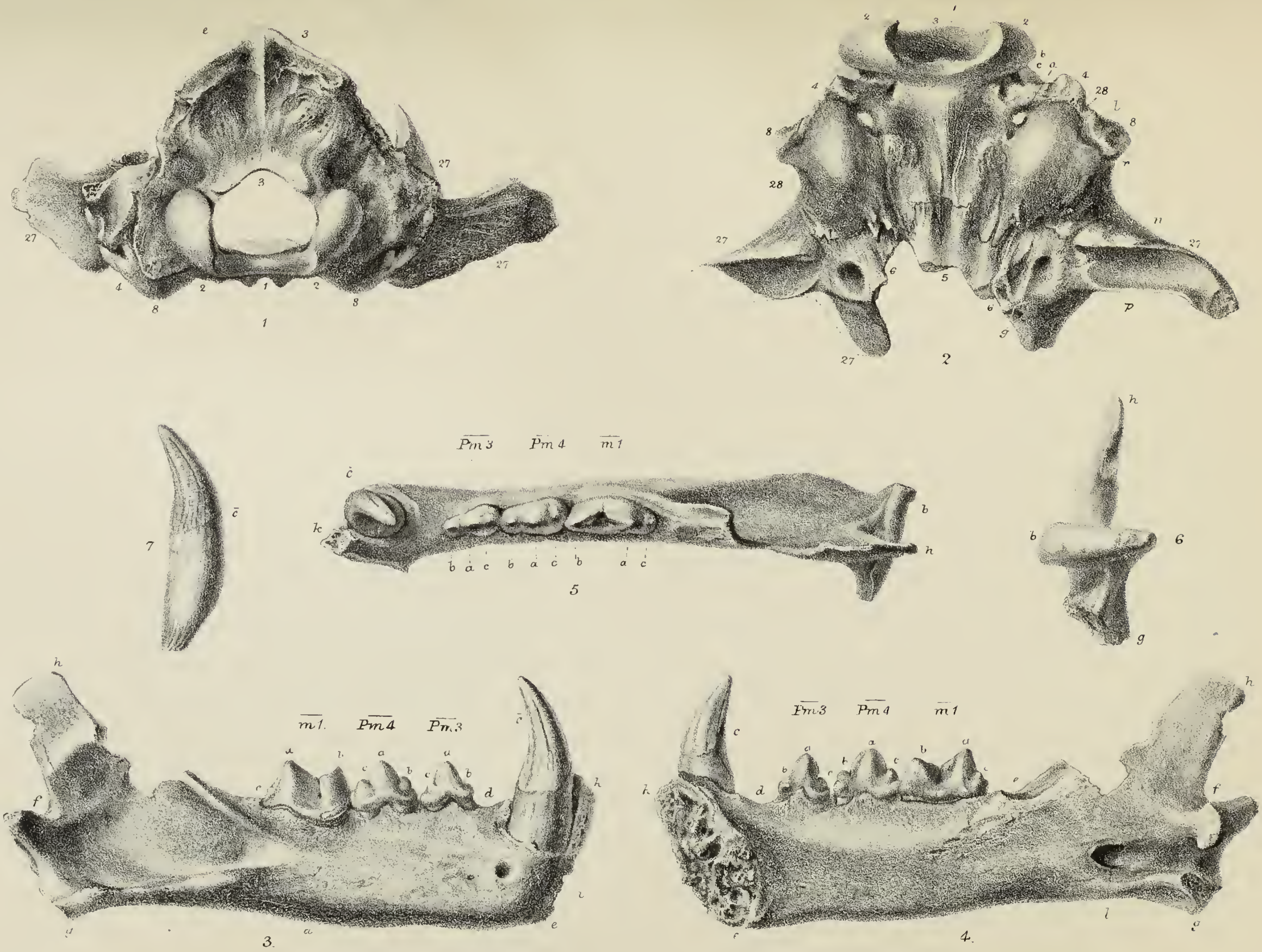
SKULL AND LOWER JAW.

(Natural size.)

Fig.

1. Occipital aspect of skull. Yew Tree Cave. Dr. Ransom's Collection.
2. Basal aspect of fig. 1.
3. External aspect of right lower jaw. Yew Tree Cave. Dr. Ransom's Collection.
4. Internal aspect of fig. 3.
5. Superior ditto.
6. Posterior ditto.
7. Exterior aspect of right lower canine, taken from the lower jaw.

FELIS LYNX.



SKULL AND LOWER JAW.

J Dinkel, del et lith

W West imp