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ISSUED FOR 1871.

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VOLUME XXV.

CONTAINING

ISSUED FOR 1871.

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THE DATES OF ISSUE OF THE ANNUAL VOLUMES;

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

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„ XVIII.	„	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.

* These Volumes are issued in two forms of binding, first, with all the Monographs stitched together and enclosed in one cover; secondly, with each of the Monographs separate, and the whole of the separate parts placed in an envelope. The previous volumes are not in separate parts.

CATALOGUE OF WORKS—Continued.

Vol. XXII.* Issued for the Year	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, concluded, with F. lynx, by Messrs. W. Boyd Dawkins and W. A. Sanford, 6 plates.
„ XXIII.* „	1869	Supplement to the Fossil Corals, Part II, No. 2, Cretaceous, by Dr. Duncan, 6 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part III, by Dr. Wright, 10 plates. The Belemnitidæ, Part V, Oxford Clay, &c., Belemnites, by Prof. Phillips, 9 plates. The Fishes of the Old Red Sandstone, Part I (concluded), by Messrs. J. Powrie and E. Ray Lankester, 9 plates. The Reptilia of the Liassic Formations, Part II, by Prof. Owen, 4 plates. The Crag Cetacea, No. 1, by Prof. Owen, 5 plates.
„ XXIV.* „	1870	The Flora of the Carboniferous Strata, Part II, by Mr. E. W. Binney, 6 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part IV, by Dr. Wright, 10 plates. The Fossil Brachiopoda, Part VII, No. 4, Silurian, by Mr. Davidson, 13 plates. The Eocene Mollusca, Part IV, No. 3, Bivalves, by Mr. S. V. Wood, 5 plates. The Fossil Mammalia of the Mesozoic Formations, by Professor Owen, 4 plates.
„ XXV.* „	1871	The Flora of the Carboniferous Strata, Part III, by Mr. E. W. Binney, 6 plates. The Fossil Merostomata, Part III, Pterygotus and Slimonia, by Mr. H. Woodward, 5 plates. Supplement to the Crag Mollusca, Part I (Univalves), by Mr. S. V. Wood, with an Introduction on the Crag District, by Messrs. S. V. Wood, jun., and F. W. Harmer, 7 plates and map. Supplement to the Reptilia of the Wealden (Iguanodon), No. IV, by Prof. Owen, 3 plates The Pleistocene Mammalia, Part IV, Felis pardus, &c., by Messrs W. Boyd Dawkins and W. A. Sanford, 2 plates. The Pleistocene Mammalia, Part V, Ovibos moschatus, by Mr. W. Boyd Dawkins, 5 plates.

* These Volumes are issued in two forms of binding, first, with all the Monographs stitched together and enclosed in one cover; secondly, with each of the Monographs separate, and the whole of the separate parts placed in an envelope. The previous volumes are not in separate parts.

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, Devonian, and Silurian 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.
The Reptilia of the Cretaceous, Wealden, and Purbeck Formations, by Professor Owen.
The Fossil Mammalia of the Mesozoic Formations, by Professor Owen.

MONOGRAPHS in course of PUBLICATION:*—

The Flora of the Carboniferous Formation, by Mr. E. W. Binney.
The Crag Foraminifera, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady.
Supplement to the Fossil Corals, by Dr. Duncan.
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.
Supplement to the Crag Mollusca, by Mr. S. V. Wood.
The Eocene Mollusca, by Mr. S. V. Wood.
The Belemnites, by Professor Phillips.
The Fishes of the Old Red Sandstone, by Messrs. J. Powrie and E. Ray Lankester, and Professor Traquair.
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.
The Cetacea of the Crag, by Professor Owen.

* Unfinished through the death of the Author, but will be continued by Mr. H. Woodward.

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 Palæozoic Polyzoa, by Dr. Duncan.
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 Trigoniæ, by Dr. Lycett.
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.

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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.
,,	1869	,,	,,	,,	January, 1870.
,,	1870	,,	,,	,,	January, 1871.
,,	1871	,,	,,	,,	June, 1872.

Summary of the Monographs issued to the Members (*up to* JUNE, 1872): *showing in the* first *column whether each Monograph hitherto published 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* fourth *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 *in which* the Monograph was published.	IV. No. of Pages of Letterpress in each Monograph.	V. No. of Plates in each Monograph.	VI. No. of Lithographed Figures and of Woodcuts.	VII. No. of Species described in the Text.
The Flora of the Carboniferous Strata, by Mr. E. W. Binney, in course of completion	1867, 1870, 1871	1868, 1871, 1872	96	18	110	15
The Crag Foraminifera, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady, in course of completion	1865	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, 1855	406	72	800	319*g*
Supplement to the Fossil Corals, by Dr. Duncan, in course of completion	1865, 1866, 1867, 1868, 1869	1866, 1867, 1868, 1869, 1870	190	42	710	129
The Polyzoa of the Crag, by Mr. G. Busk, *complete*	1857	1859	145	22	641	122
The Tertiary Echinodermata, by Prof. Forbes, *complete*	1852	1852	39	4	144	44
The Oolitic Echinodermata, by Dr. Wright. Vol. I, *complete* (*l*)	1855, 1856, 1857, 1858	1857, 1558, 1859, 1861	474	43	724	109*h*
" " Vol. II, in course of completion	1861, 1864	1863, 1866	154	19	218	29
The Cretaceous Echinodermata, by Dr. Wright. Vol. I, in course of completion	1862, 1867, 1869, 1870	1864, 1868, 1870, 1871	160	45	603	46
The Fossil Cirripedes, by Mr. C. Darwin, *complete*	1851, 1854, 1858*a*	1851, 1855, 1861	137	7	320	54
The Fossil Merostomata, by Mr. H. Woodward, in course of completion	1865, 1868, 1871	1866, 1869, 1872	120	20	143	11
The Tertiary Entomostraca, by Prof. Rupert Jones, *complete*	1855	1857	74	6	233	56
The Cretaceous Entomostraca, by Prof. Rupert Jones, *complete*	1849	1850	41	7	176	27
The Fossil Estheriæ, by Prof. Rupert Jones, *complete*	1860	1863	139	5	158	19*i*
The Trilobites of the Mountain-limestone, Devonian, Silurian, and other Formations, by Mr. J. W. Salter (incomplete through the Author's death)	1862, 1863, 1864, 1866	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	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, 1855	409	42	1855	160
" " Vol. II. The Permian and Carboniferous Brachiopoda, *complete*	1856*d*, 1857, 1858, 1859, 1860	1858, 1859, 1861, 1861, 1863	331	59	1909	157
" " Vol. III. The Devonian and Silurian Brachiopoda, *complete*	1862, 1863, 1865, 1866, 1868, 1870	1864, 1865, 1866, 1867, 1869, 1871	528	70	2766	321
The Mollusca of the Crag, by Mr. S. V. Wood:—						
Vol. I. (Univalves), *complete*	1847, 1855*b*	1848, 1857	216	21	581	244
Vol. II. (Bivalves), *complete*	1850, 1853, 1855, 1858*c*	1851, 1853, 1857, 1861	344	31	691	253
Supplement to the Crag Mollusca, by Mr. S. V. Wood	1871	1872	130	7	221	111
The Eocene Mollusca, Cephalopoda and Univalves, by Mr. F. E. Edwards, in course of completion	1848, 1852, 1854, 1855, 1858	1849, 1852, 1855, 1857, 1861	332	33	578	161
The Eocene Mollusca, Bivalves, by Mr. S. V. Wood, in course of completion	1859, 1862, 1870	1861, 1864, 1871	182	25	531	194
The Great Oolite Mollusca, by Prof. Morris and Dr. Lycett, *complete*	1850, 1853, 1854	1850, 1853, 1855	282	30	846	419
" " " Supplement by Dr. Lycett, *complete*	1861	1863	129	15	337	194
The Belemnites, by Prof. Phillips, in course of completion	1863, 1864, 1866, 1868, 1869	1865, 1866, 1867, 1869, 1870	128	36	622	69
The Upper Cretaceous Cephalopoda, by Mr. D. Sharpe, *complete*	1853, 1854, 1855	1853, 1855, 1857	67	27	319	79
The Fossils of the Permian Formation, by Prof. King, *complete*	1849, 1854*e*	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, 1869	1868, 1870	62	14	195	21
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, 1859	150	58	304	39
The Reptilia of the Cretaceous Formations, by Prof. Owen, *complete* ‡	1851, 1857, 1858, 1862	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, 1871	1853, 1855, 1857, 1858, 1859, 1861, 1864, 1872	170	65	260	17
The Reptilia of the Kimmeridge Clay Formation, by Prof. Owen, in course of completion	1859, 1860, 1868	1861, 1863, 1869	16	6	23	3
The Reptilia of the Liassic Formations, by Prof. Owen, in course of completion	1859,‖ 1860,‖ 1863, 1869	1861, 1863, 1865, 1870	121	37	177	8
The Crag Cetacea, by Prof. Owen, in course of completion	1869	1870	40	5	43	7
The Pleistocene Mammalia, by Messrs. W. Boyd Dawkins and Mr. W. A. Sanford, in course of completion	1864, 1867, 1868, 1871	1866, 1868, 1869, 1872	266	32	250	7
The Fossil Mammalia of the Mesozoic Formations, by Prof. Owen, *complete*	1870	1871	115	4	247	30
		Total	7,016	1,072	19,894	3,845

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 for establishing the dates of new species.
‡ 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—1871) *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, 1871
Crag	...	...	1865	1849	1852	1851, 1854	...	...	......	......	...	1857	1852	1847, 1850, 1853, 1855, 1871	...	...	.....	1869
Eocene	...	...	...	1849, 1865	1852	1851, 1854	1855	...	......	......	1856	...	1852	1852, 1854, 1855, 1858, 1859, 1862, 1870	1848	...	1848, 1849, 1856	
Cretaceous ...	...	...	...	1849, 1868, 1869	1862, 1867, 1869, 1870	1851, 1854	1849	...	......	......	1860	...	1852, 1854	......	1853, 1854, 1855	...	1851, 1857, 1858, 1862	
Wealden	...	...	...	...	......	......	...	1860	......	......	...	...	......	......	...	...	1853, 1854, 1855, 1856, 1857, 1862, 1871	
Oolitic	...	...	...	1851	1855, 1856, 1857, 1858, 1861	1851	...	1860	......	......	...	...	1850, 1852	1850, 1853, 1854	1850, 1861, 1868, 1869	...	(Purbeck) 1853, 1858 (Kim. Clay), 1859, 1860, 1868	1870
Liassic	...	...	...	1851, 1866, 1867	1855, 1856, 1858, 1861, 1864	......	...	...	......	......	...	...	1850, 1852	......	1863, 1864, 1866, 1868	...	1859, 1860, 1863, 1869	
Triassic	...	...	...	...	......	......	...	1860	......	......	...	...	......	......	......	......	......	1870
Permian	1849	1849	1849	1849, 1852	1849	......	1849	1860	......	......	...	1849	1849, 1856	1849	1849	1849	1849	
Carboniferous	1867, 1870, 1871	...	...	1852	......	......	...	1860	......	......	...	...	1856, 1857, 1858, 1859, 1860					
Devonian	...	...	...	1853	......	......	...	1860	1865, 1868	1862	...	...	1862, 1863	......	...	1867, 1869		
Silurian	...	...	...	1854	......	......	...	...	1868, 1871	1862, 1863, 1864, 1866	...	...	1865, 1866, 1868, 1870					
Cambrian	...	...	...	...	......	......	...	...	......	1864								

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

THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

VOLUME FOR 1871.

LONDON:

MDCCCLXXII.

OBSERVATIONS

ON THE

STRUCTURE OF FOSSIL PLANTS

FOUND IN THE

CARBONIFEROUS STRATA.

BY

E. W. BINNEY, F.R.S., F.G.S.

PART III.

LEPIDODENDRON.

PAGES 63—96; PLATES XIII—XVIII.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1872.

PRINTED BY

J. E. ADLARD, BARTHOLOMEW CLOSE.

CONTENTS.

PART III.

I. Introductory Remarks.

In the Part last published of this Monograph a deviation was made from the plan first proposed, in considering some of the Organs of Fructification of Fossil Plants, and leaving the treatment of the structure of the Stems for a time. I will now, therefore, return to the original intention of describing the internal structure of several specimens of Fossil Woods from my own cabinet and that of Mr. J. S. Dawes. These are in a good state of preservation, and will afford some additional information on the genus Lepidodendron.

After the investigations of Witham, Lindley and Hutton, Brongniart, Hooker, and others, nearly every portion of the structure of the stem had been made out, with the exception of the medulla. It was more inferred than proved that the structure of this part consisted of cellular tissue in the Rev. C. G. W. Harcourt's specimen found at Hesley Heath. Mr. Dawes' specimen, however, figured in Plate VII, and described in Part II of this Monograph, clearly proves that the above-named authors were in the main right in stating that the medulla of *Lepidodendron* was composed of a cellular tissue which was not ordinary parenchyma, like such as is found immediately outside the vascular cylinder; for it consisted of large rectilinear cells, arranged in vertical series, something like bricks upon their ends, as first noticed by Mr. Dawes to occur in *Halonia*. This beautiful *Lepidodendron*, probably the most perfect in its state of preservation of any with which we are acquainted, will be described in detail before I proceed to consider the genus *Halonia*, and to show the relation of that fossil to *Lepidodendron*. Some remarkable instances of the division of the vascular axes of *Lepidodendron*, *Halonia*, and *Sigillaria vascularis*, just before the stems of those plants dichotomize, will be given. These fully confirm Brongniart's views, as stated in his admirable memoir on *Les Lycopodiacées*, in the second volume of his 'Histoire des Végétaux fossiles.'

I shall then restate the chief part of what has been published on the structure of *Halonia*. Next a description of Mr. Dawes' and my own specimens will be given in detail. In conclusion, it is intended to show the connection of *Halonia* with *Lepidodendron*, so far as their structure is concerned.

The *Halonia regularis* of Lindley and Hutton is the only species that will be now described, as the other species, although similar in structure, vary very much in their external characters from that species.

II. Bibliographical History of Lepidodendron.

§ 1. At page 34 of Part II of this Monograph reference is made to some of the authors who had written on *Lepidodendron;* but since the time of the publication of M. Adolphe Brongniart's memoir on *Lycopodiacées*[1] probably little has been done to increase our knowledge of the structure of the stem of *Lepidodendron.* The restored figure in his plate xxi is nearly similar in structure to that of the specimen now about to be described, with the exception of the medulla or pith and the tissue enclosing the vascular bundles, which in the specimen from Hesley Heath were not very well preserved, and therefore not altogether correctly shown. To those who desire to obtain a knowledge of the structure of *Lepidodendron* and its relation to recent *Lycopodiaceæ*, a reference to the work itself is necessary. For the present probably it will be sufficient for my purpose to quote the author's views, as expressed at page 45 of his work.

" Si, après avoir ainsi cherché à determiner les rapports de position des divers tissus qui entrent dans la composition de ce rameau de Lépidodendron, nous examinons la structure même de chacun de ces tissus, et surtout de quelques-uns d'entre eux, nous verrions que la nature des fibres vasculaires qui composent soit le cylindre central, soit les faisceaux qui se portent dans les feuilles, confirme tout à-fait l'analogie des ces plantes avec les Lycopodiacées. Ainsi, le cylindre vasculaire qui entoure le tissu cellulaire central, et qui occupe presque le centre de la tige est uniformément composé du même tissu; il n'y a pas mélange de fibres et de vaisseaux de diverses sortes, comme dans les faisceaux fibro-vasculaires de Phanérogames; il est, au contraire, entièrment formé d'élémens identiques par leur structure, et qui ne diffèrent que par leur volume et la déformation que la compression leur a donnée, disposition tout-à-fait semblable à celle qu'on observe dans les faisceaux vasculaires aplatis des Lycopodiacées et dans ceux des Fougères. Enfin, ces fibres ont cette structure toute particulière, si habituelle dans les végétaux de cette classe naturelle, qu'on a désignée sous le nom de vaisseaux rayés, vaisseaux fendus, vaisseaux scalariformes (treppengange), et qui paraissent former un des caractères essentiels de ces végétaux. Le volume beaucoup moindre de ces vaisseaux dans la partie extérieure du cylindre vasculaire et dans les faisceaux qui s'en séparent pour se porter dans les feuilles, est encore un caractère qu'on observe généralement dans

[1] 'Histoire des Végétaux fossiles,' Tome Deuxième (published in 1837).

les Lycopodiacées, et particulièrement dans celles dont les feuilles très nombreuses, sont en rapport avec un nombre proportionnel de faisceaux vasculaires entourant l'axe central. (Voyez la coupe de la tige du *Lycopodium verticillatum*, pl. x, fig. 1.)

"Enfin, la délicatesse du tissu cellulaire qui environne extérieurement ce cylindre vasculaire, et qui le sépare du tissu cellulaire plus dense qui forme la zone résistante extérieure de la tige, la destruction facile de ce tissu, la position excentrique de l'axe vasculaire dans l'espèce de cavité cylindrique qui résulte de la destruction plus ou moins complète de ce tissu cellulaire, sont des caractères ou des dispositions accidentelles qu'on recontre très fréquemment sur les tiges sèches des Lycopodiacées conservées dans nos herbiers.

"Ainsi, par la structure intérieure de leurs tiges, comme par leur forme extérieure, leur mode de ramification et la disposition de leurs feuilles, les Lépidodendrons s'accordent presque complètement avec les Lycopodiacées, et ne seraient autre chose que des Lycopodiacées arborescentes."

§ 2. *Carruthers.*—This author, in his paper published in vol. xiii, pp. 2 to 9, 'Journ. Botany,' says "*Lepidodendron* was a branching tree of considerable size. It is separated from the other genera of coal plants by the form and arrangements of the leaf-scars upon its stem. More than forty species have been recorded; but, as the scars present different appearances on different portions of the same plant, no doubt more species have been established than the materials fairly warrant. But that they were numerous in species, and very numerous in individuals, any one who has even cursorily examined a coal-pit, or the fossils in any public museum, must be convinced. They certainly contributed largely to the formation of coal.

"The researches of Witham, Lindley and Hutton, Brongniart, and Binney have made us acquainted with the stem."

Mr. Carruthers, in a note referring to my papers on *Sigillaria vascularis*, published in the 'Quarterly Journal of the Geological Society,' and in the 'Phil. Transactions,' speaking of myself, says, "He refers them to the genus *Sigillaria*, because of their agreement in internal structure with Brongniart's *Sigillaria elegans;* but he cannot separate them by their external markings from *Lepidodendron selaginoides*, Lindl. and Hutt.; and, as the only characters by which the two genera are distinguished are derived from the markings of the stem, we must consider *Sigillaria vascularis* as a true *Lepidodendron.* I am the more satisfied as to this because I believe no essential difference exists, as has been hitherto maintained, between the stems of *Sigillaria* and *Lepidodendron*, or any of the other lepidodendroid plants of the coal period. I cannot enter into this question here, but I shall take an early opportunity of publishing my views and the reasons for maintaining them."

Mr. Carruthers then goes on to state, "These published observations, together with the examination of some beautiful specimens in the collection of Robert Brown, now in the Botanical Department of the British Museum, and of Mr. Alexander Bryson, enable me to give a somewhat complete description of its singular structure.

"The axis of the stem cannot be considered as a true medulla or pith, inasmuch as it is composed, not of simple cells, but of elongated utricles, of various sizes, irregularly arranged, and having their walls marked with scalariform bars (pl. lvi, fig. 2). These utricles indeed differ from the vascular tissue of the woody cylinder which surrounds them, only by their length. The tissue of the woody cylinder consists of long scalariform vessels, which increase in size from the inner margin to the outer; this increase being sufficient to meet the requirements of the enlarged circumference, with the help of only a few additional series of vessels. As there is no true medullary cellular tissue in the axis, so there are no medullary rays passing through this cylinder. In radial sections an appearance is seen singularly resembling, to the naked eye, the silver grain produced in dicotyledonous woods by the medullary rays, but this arises from a very different cause. The diameter of the vessels is so great that, on a polished surface, only the scalariform wall of the vessel that lies on or near the surface is exhibited; and when the upper wall of a vessel is cut away, the lower wall is often so deeply buried in the opaque substance that the peculiar structure is obscured. In the case of sections prepared for microscopic examination, both surfaces of some vessels are often removed, and the scalariform markings on the lateral walls, or on any horizontal walls which by chance occupy a medial position between the polished surfaces, only are seen. This absence of the scalariform bars gives at first sight the appearance produced by medullary rays.

"The continuous cylinder of scalariform vascular tissue appears to be penetrated by the vascular bundles which ultimately supply the leaves. These bundles apparently originate either in the scalariform tissue of the axis or on the inner surface of the woody cylinder. They have been mistaken for, or misnamed, medullary rays.

"The woody cylinder is surrounded by a great thickness of cellular tissue, which extends to the exterior of the stem, and is composed of three distinct and separate zones. The inner zone has never, so far as I know, been perfectly preserved in any specimen, yet traces of it sometimes may be seen, and it is rightly restored in Brongniart's drawing of *Lepidodendron Harcourtii*, in the 'Archives du Muséum,' vol. i, pl. xxxi. Its absence in fossils is owing to its extremely delicate structure. The cells of the middle zone have thicker walls, and they have consequently frequently resisted decomposition before fossilization made them permanent. In the outer zones the cells are very much lengthened, and have a smaller diameter. They nearly resemble true vascular tissue; but the progress of lengthening may easily be traced from the interior outwards, and no distinction can be drawn between the true cells and the long and slender ones of the outer circumference. The cell-walls of all the three zones are without markings of any kind.

"These three cellular zones are traversed by the vascular bundles which rise from the outside of the interior woody cylinder, if they do not actually pass through it, and pass to the leaves and branches. These bundles separate from the woody cylinder a long way below the point where they pass off into the leaf. At first their direction is almost parallel with the cylinders, slightly inclining outwards; they then incline more outwards; and as they approach the circumference of the stem, they resume their nearly ascending direction for some distance, until they finally pass out to the leaves which they support. Each bundle consists of scalariform vessels, very much finer than those of the woody cylinder, surrounded by elongated cells, like those of the outer zones, and probably still further enclosed by a delicate parenchyma, which disappeared before it could be fossilized. The only evidence I have of the existence of this cellular tissue is that the bundles never fill the cavities in the parenchyma of the stem through which they pass. The bundles terminate in the points seen on the areolas of the stem, which are the scars of the leaves.

"The woody cylinder is of different thicknesses in different stems, and appears to have increased with the growth of the tree. There is, however, no indication of interruption in the growth, or of seasonal layers. Yet it cannot be conceived that the whole vascular cylinder arose and was developed at the same time. It is very probable that the zone of slender and consequently of rarely preserved cellular tissue, which surrounds the woody cylinder, was analogous in its functions to the cambium layer of phanerogamous stems, like the similar layers in recent *Lycopodiaceæ,* described by Spring in his 'Monographie de la Famille des Lycopodiacées' (p. 294).

"If we separate the different structures we have described in the axis into two series, the one series axial, and the other epidermal, we shall have the axis composed of scalariform utricles, the woody cylinder and the vascular bundles passing to the leaves belonging to the first series, and the two external zones of the vascular tissue to the second. The inner zone of cellular tissue, like the cambium layer, was most probably common to both series, the cells of the outer circumference being developed into the parenchyma of the epidermal series, while the vessels of the woody axis were produced from the cells of the inner series."

Here come in the paragraphs on the Strobilus of *Lepidodendron* and its stigmarioid roots, quoted by me at length in pages 37 and 38 of Part II of this Monograph. Then the author proceeds, "In speculating upon the conditions under which the forests of *Lepidodendron* flourished, it is most important to observe whatever is peculiar in those organs by which the plants were connected with the physical conditions around them. Geologists have too much overlooked such considerations in their deductions as to the physical phenomena of a period from the plants and animals that then existed. They have often taken for granted that the known conditions of the living species of a genus are true also of the fossil members of the same genus. In the want of other evidence such an assumption may be cautiously employed; but, unless its true value be accurately estimated, the greatest errors may arise, as they have in the past. For example, the systematic position of the *Elephas primigenius* having been clearly established, the inference was thought legitimate that, as the modern representatives of the genus were confined to tropical or subtropical countries, the boreal regions must have enjoyed a similar climate when they were inhabited by these ancient elephants. It was, however, discovered that their skin was clothed with wool and long hair, and that consequently they were adapted to endure a cold climate. In plants the structure of the fruit would, in most cases, teach nothing as to the temperature and humidity of the atmosphere in which, or the kind of soil upon which, the organism grew, though it would be of the first importance in determining the systematic position. On the other hand, the root, the leaves, and the tissues of the plant would be of only secondary importance in regard to systematic position, but of the highest value in determining physical condition. In regard to *Lepidodendron*, its singular roots would seem to imply that it derived a large amount of moisture through them from a moist soil, and so far differed from most living Cryptogamia which obtain it mostly from the atmosphere. The roots of this genus presented in their crowded and long rootlets an immense surface for the absorption of moisture; and, in their great abundance of lax cellular tissue, possessed the means of containing this moisture and transmitting it to the foliage.

"The leaves of *Lepidodendron* were simple, lanceolate, acute, and sessile. They had a single medial nerve. The younger branches were densely crowded with leaves; and the scars left on the trunk, after they perished, give the numerous beautiful markings by which the species have been distinguished. The leaves, when found separated from the branches, are called *Lepidophylla*. . . . .

. . . "The structure of the arboreal stem of *Lepidodendron* is much more complex than that of any known cryptogam. The central axis of the irregularly arranged vascular tissue in *Lycopodium* is suited to the low stature of the plants of that genus; but in the giant *Lepidodendron* there is a complexity which approaches the structure of some dicotyledonous stems. The general arrangement of the tissues, resembling what exists in some *Cycadeæ* and *Cactaceæ*, has caused this fossil plant to be referred sometimes to the one and sometimes to the other of these Orders; but the resemblance is only one of analogy and not of affinity. The presence of scalariform tissue, of which the woody portion is entirely composed, and the absence of medullary rays, would, even if the fruit were unknown, be sufficient to establish the cryptogamic nature of the plant. A comparison with the Cycadean stem may help us, by the resemblances and differences which will appear, better to understand the stem of *Lepidodendron*. The Cycads have all a large medulla, composed of large-sized parenchyma, in some genera traversed by numerous vascular bundles, as in *Encephalartus*, and in others entirely cellular, as in *Cycas* and *Zamia*. This is surrounded by a single woody cylinder, or several, everywhere penetrated with medullary rays. Beyond this there is a considerable thickness of parenchyma, composed in their inner portion of cells whose length exceeds only slightly their breadth; these gradually lengthen, until they assume an appearance very like the external portion of *Lepidodendron*. This cortical parenchyma is traversed by the vascular bundles which supply the leaves. The two stems are evidently built upon the same plan; and were we to substitute scalariform tissue for the gymnospermatous woody tissue, and scalariform utricles for true medullary parenchyma, and finally exclude the medullary rays, the description of the Cycadean stem would apply to that of *Lepidodendron*. And it deserves special notice, that the surface of the Cycadean trunk is composed of the bases of the old leaves, together with the scales which in some species are interspersed among them or alternate with them. The leaves do not disarticulate at the circumference of the stem, but at some distance from it, leaving a small portion of the base persistent. The scars of the outer surface of the stem give a different impression from those presented when the persistent bases of the leaf-stalks are removed. Whoever is even a little familiar with coal fossils is aware that there are two sets of scars on the stems of *Lepidodendron*—one superficial and the other internal. The fossils that present the first set are generally said to be 'corticated' stems, and those exhibiting the others 'decorticated.' The 'bark' is generally converted into a compact structureless coal, the outer surface of which has the one set of scars, and the inner surface the other. I believe this coal is produced by the external of the two epidermal series, and that the outer scars were truly superficial, while the inner were produced by the vessels which passed to the bases of the leaves. The two sets of scars in Cycadean stems are analogous structures; but in *Lepidodendron* the layer which bears the scars on its two surfaces is a compact cylinder; while in *Cycadeæ* there is no connecting tissue uniting the bases of the leaves; they are closely packed together, but quite free from each other. It is evident that in many respects the fossil stem had a striking analogy in the arrangement of its parts to that of the recent Cycads, while it was a true Cryptogam; and if we now examine the slender stem of *Lycopodium*, we shall find, I believe, that *Lepidodendron*, though more highly developed, does not differ essentially from it.

"Spring, in his 'Monographie des Lycopodiacées' (p. 293), describes the stem of this Order as composed of five parts:—1st, the woody axis; 2nd, a layer of delicate cells; 3rd, the liber; 4th, the herbaceous envelope; and, 5th, the epidermis.

"The axis is composed of bundles of scalariform vessels, scattered through a very delicate cellular tissue, in a regular figure, which varies in the different species. This axis is surrounded by a layer of lax, delicate, cellular tissue, which Spring considers to be the channel through which the sap circulates, and the seat of growth in the stem, the inner portion being developed into wood vessels, and the outer into 'liber.' The 'liber' is composed of elongated cells, with thickened walls. Spring gives to it this name because of its analogy to the liber in dicotyledons. This layer is often so thin that it is difficult to detect. It is surrounded by a thick greenish layer, composed of large elongated cells with thin walls; and this is covered with an epidermis, consisting of small cells with thick walls. The vascular bundles pass through the various layers of cellular tissue from the axis to the circumference.

"The great difference between the stem of *Lepidodendron* and *Lycopodium* is the existence of a pseudo-medulla and the arrangement of the vascular tissue as a solid cylinder in the fossil genus, compared with the central position and loose structure of the vascular tissue in the recent plant. In both the recent and fossil stems the vascular tissues are surrounded by a zone of thin-walled cells, which has disappeared in all the dried specimens of *Lycopodium* I have examined, having the axis free, and which, as we have seen, is very rarely preserved in *Lepidodendron*."

§ 3. *Schimper*. Professor Schimper[1] describes his Family of *Lepidodrendeæ* as follows:—*Plantæ arborescentes, foliis homomorphis, lanceolatis et linearibus, plano-carinatis, integerrimis, spiraliter dispositis, deciduis, cicatricesque regulares relinquentes; trunci fasciculis vascularibus in cylindrum continuum conjunctis solum parenchyma medullare continente vel parenchyma vasis intermixtum; fructificatione strobiliformi, sporangia elongata bractearum basi horizontali adfixa lateraliter dehiscentia gerente.*

"Les feuilles articulées caduques laissant des cicatrices régulières persistantes pendant tout la durée de la plante, le cylindre vasculaire continu ne refermant que du parenchyme médullaire ou formé entièrment par un tissu fibro-vasculaire, les strobiles caducs portant des sporanges allongés placés horizontalement sur la base des bractées, sont des caractères distinctifs qui paraissent autoriser l'établissement d'une famille spéciale pour ce groupe de végétaux fossiles formé de plusieurs genres distincts.

"Toutes le Lepidodendrées paraissent avoir été arborescentes. On en a trouvé des troncs qui avaient une longueur de plus de 100 pieds et un diamètre de 10 à 12 pieds. Le tronc était simple jusqu'à hauteur considérable; la ramification se faisait par dichotomie régulière; les feuilles persistaient assez longtemps sur les rameaux, comme dans nos Conifères; et leurs cicatrices, quoique changées à la suite du développement de la plante, conservaient cependant une forme très-régulière, même sur les troncs les plus âgés."

The same author, after describing the outside appearance of *Lepidodendron*, Sternb., *Sagenaria*, Brong., at p. 16, says, "M. Brongniart compare la structure interne du tronc des Lépidodendrons à celle de la tige des *Psilotum* et des *Tmesipteris*. Le cylindre vasculaire de l'espèce examinée par ce savant, du *Lep. Harcourtii*, est en effet, comme dans ces deux genres, simple et sans lacunes médullaires il est formé intérieurement de larges vaisseaux scalariformes, et extérieurement d'étroits vaisseaux rayés (spiralés ?), d'où partent des faisceaux composés de fibres ou de vaisseaux tout-à-fait semblables à ces dernièrs, pour se rendre dans les feuilles en décrivant un arc qui se rapproche de l'horizontale vers son extrémité. Le cylindre lui-même est renfermé dans une gaîne épaisse d'un tissu parenchymateux très-solide qui est suivi du parenchyme cortical, également épais, mais d'une texture plus lâche. Dans ce dernier tissu, on remarque deux zones d'un aspect un peu différent, et dans lesquelles Corda a cru distinguer le liber et le parenchyme cortical des Phanérogames. Un tissu superficiel, enfin, composé de cellules très-étroites et allongées constitue l'epiderme. Les Lycopodes vivants montrent du reste exactement les mêmes

[1] 'Traité de Paléontologie végétale,' Tome second, Première Partie, p. 13, 1870.

differences dans les diverses couches du tissu parenchymateux qui se suivent depuis la surface du cylindre vasculaire jusqu'à l'épiderme inclusivement.

"Il est à noter cependant que ce qui a été dit sur la structure interne ne se rapporte qu'à une seule espèce, le *Lep. Harcourtii*, prise pour type, et il n'est pas du tout certain que tous les fossiles qui, à la suite de leur organisation extérieure, se trouvent réunis dans ce genre, aient aussi la même organisation intérieure; cela est même peu probable. M. Binney, dans son mémoire cité plus haut (*Sigillaria and Lepidodendron*, printed in the 'Proceedings of the Geological Soc. of London,' Jan., 1862), parle de deux plantes dont le cicatrices foliaires coincident parfaitement avec celles des *Lepidodendron*, et dont l'une, le *Sigillaria vascularis*, offre la structure des Sigillaires, tandis que l'autre, le *Lepidodendron vasculare*, a son axe central entièrement composé de gros vaisseaux scalariformes et de fins vaisseaux rayés, au lieu d'offrir un cylindre vasculaire occupé intérieurement par un parenchyme médullaire, comme dans le *L. Harcourtii*. Ce type se rapprocherait donc davantage des Lycopodes, et le dernier des *Psilotum* et *Tmesipteris*."

§ 4. *Williamson.*—Professor W. C. Williamson, F.R.S., in a paper read before the Royal Society, June 15, 1871,[1] "On the Organisation of the Fossil Plants of the Coal-Measures, Part 2, *Lepidodendron* and *Sigillaria*," says, "The *Lepidodendron selaginoides* described by Mr. Binney, and still more recently by Mr. Carruthers, is taken as the standard of comparison for numerous other forms. It consists of a central medullary axis composed of a combination of transversely barred vessels with similarly barred cells; the vessels are arranged without any special linear order. The tissue is closely surrounded by a second and narrower ring, also of barred vessels, but of smaller size, and arranged in vertical laminæ which radiate from within outwards. These laminæ are separated by short vertical piles of cells, believed to be medullary rays. In the transverse section the intersected mouths of the vessels form radiating lines, and the whole structure is regarded as an early type of an exogenous cylinder; it is from this cylinder alone that the vascular bundles going to the leaves are given off. This woody zone is surrounded by a very thick cortical layer, which is parenchymatous at its inner part, the cells being without definite order; but externally they become prosenchymatous, and are arranged in radiating lines, which latter tendency is observed to manifest itself whenever the bark-cells assume the prosenchymatous type. Outside the bark is an epidermal layer separated from the rest of the bark by a thin bast-layer of prosenchyma, the cells of which are developed into a tubular and almost vascular form; but the vessels are never barred, being essentially of the fibrous type. Externally to this bast-layer is a more superficial epiderm of parenchyma supporting the bases of the leaves, which consist of similar parenchymatous tissue. Tangential sections of these outer cortical tissues show that the so-called 'decorticated' specimens of *Lepidodendron*, and of other allied plants, are merely examples

[1] 'Proceed. Roy. Soc.,' vol. xix, p. 500, &c.; 'Nature,' No. 87, vol. iv, p. 173, June 29th, 1871.

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that have lost their epidermal layer, or had it converted into coal; this layer, strengthened by the bast-tissue of its inner surface, having remained as a hollow cylinder, when all the more internal structures had been destroyed or removed.

"From this type the author proceeds upwards, through a series of examples in which the *vessels* of the medulla become separated from its central *cellular* portions and retreat towards its periphery, forming an outer cylinder of medullary vessels, arranged without order, and enclose a defined cellular axis; at the same time the encircling ligneous zone of radiating vessels becomes yet more developed, both in the number of its vessels and in the diameter of the cylinder relatively to that of the entire stem. As these changes are produced, the medullary rays separating the laminæ of the woody wedges become more definite, some of them assuming a more composite structure, and the entire organization gradually assuming a more exogenous type. At the same time the cortical portions retain all the essential features of the Lepidodendroid plants.

"We are thus brought by the evidence of internal organisation to the conclusion that the plants which Brongniart has divided into two distinct groups, one of which he has placed amongst the Vascular Cryptogams, and the other amongst the Gymnospermous Exogens, constitute one great natural family. . . . . . .

"*Stigmaria* is shown to have been much misunderstood, so far as the details of its structure are concerned, especially of late years. In his memoir on *Sigillaria elegans*, published in 1839, M. Brongniart gave a description of it, which, though limited to a small portion of its structure, was as far as it went a remarkably correct one. The plant, now well known to be a root of *Sigillaria*, possessed a cellular pith without any trace of a distinct outer zone of medullary vessels, such as is universal amongst the *Lepidodendra*. The pith is immediately surrounded by a thick and well-developed ligneous cylinder, which contains two distinct sets of primary and secondary medullary rays. The primary ones are of large size, and are arranged in regular quincuncial order; they are composed of thick masses of mural cellular tissue. A tangential section of each ray exhibits a lenticular outline, the long axis of which corresponds with that of the stem; these rays pass directly outwards from pith to bark, and separate the larger woody wedges, which constitute so distinct a feature in all transverse sections of this zone, and each of which consists of aggregated laminæ of barred vessels, disposed in a very regular radiating series. The smaller rays consist of vertical piles of cells arranged in single rows, and often consisting of but one, two, or three cells in each vertical series; these latter are very numerous, and intervene between all the numerous radiating laminæ of vessels that constitute the larger wedges of woody tissue. The vessels going to the rootlets are not given off from the pith, as Goeppert supposed, but from the sides of the woody wedges bounding the *upper* part of the several large lenticular medullary rays; those of the *lower* portion of the ray taking no part in the constitution of the vascular bundles. The vessels of the region in question descend vertically, and parallel to each other, until they come in contact with the medullary ray, when they are suddenly deflected, in large numbers, in an outward direction, and nearly at right angles to their previous course, to reach the rootlets. But only a small number reach their destination, the great majority of the deflected vessels terminating in the woody zone. A very thick bark surrounds the woody zone. Immediately in contact with the latter it consists of a thin layer of delicate, vertically elongated, cellular tissue, in which the mural tissues of the outer extremities of the medullary rays become merged. Externally to this structure is a thick parenchyma, which quickly assumes a more or less prosenchymatous form, and becomes arranged in thin radiating laminæ as it extends outwards. The epidermal layer consists of cellular parenchyma, with vertically elongated cells at its inner surface, which feebly represents the bast-layer of the other forms of Lepidodendroid plants. The rootlets consist of an outer layer of parenchyma, derived from the epidermal parenchyma. Within this is a cylindrical space, the tissue of which has always disappeared. In the centre is a bundle of vessels surrounded by a cylinder of very delicate cellular tissue, prolonged either from one of the medullary rays, or from the delicate innermost layer of the bark, because it always accompanies the vessels in their progress through the middle and outer barks.

"The facts of which the preceding is a summary lead to the conclusion that all the forms of plants described are but modifications of the Lepidodendroid type. The leaf-scars of the specimens so common in the coal-shales represent tangential sections of the petioles of leaves when such sections are made close to the epidermal layer. The thin film of coal of which these leaf-scars consist, in specimens found both in sandstone and in shale, does not represent the entire bark as generally thought, and as is implied in the term 'decorticated' usually applied to them, but it is derived from the epidermal layer. In such specimens all the more central axial structures, viz., the medulla, the wood, and the thick layer of true bark, have disappeared through decay, having been either destroyed, or in some instances detached and floated out; the bast-layer of the epiderm has arrested the destruction of the entire cylinder, and formed the mould into which inorganic materials have been introduced. On the other hand, the woody cylinder is the part most frequently preserved in *Stigmaria;* doubtless because, being subterranean, it was protected against the atmospheric action which destroyed so much of the stem.

"It is evident that all these Lepidodendroid and Sigillarian plants must be included in one common family, and that the separation of the latter from the former as a group of Gymnosperms, as suggested by M. Brongniart, must be abandoned. The remarkable development of exogenous woody structures in most members of the entire family indicates the necessity of ceasing to apply either to them or to their living representatives the term Acrogenous. Hence the author proposes a division of the vascular cryptogams into an Exogenous group, containing *Lycopodiaceæ, Equiseticeæ,* and the fossil *Calamitaceæ,* and an Endogenous group, containing the Ferns,—the former uniting the Cryptogams with the Exogens through the *Cycadeæ* and the other Gymnosperms, and the latter linking them with the Endogens through the *Palmaceæ.*"

III. General Observations on Lepidodendron, Stigmaria, and Halonia.

The genus *Lepidodendron,* as shown by the Hesley Heath and Dudley specimens, although they are very similar in their external characters with small specimens of *Sigillaria vascularis,* differs much from them in its internal structure. The first-named plant shows no trace of a radiating cylinder of barred tubes arranged in wedge-shaped masses, or anything like medullary rays, whereas the last-named affords evidence of both these important characters, and in those parts it is identical in structure with *Stigmaria.* The specimens figured and described by me in the 'Quarterly Journal of the Geological Society,' and in the 'Philosophical Transactions,' amply prove that *Sigillaria* was an exogenous tree, and had an internal vascular cylinder arranged in wedge-shaped masses, and penetrated by medullary rays, as well as an external zone arranged in radiating series of strong vascular-like tubes, or utricles, without any appearance of bars or discs, and penetrated by large vascular bundles. Both the large and small specimens were the same in internal structure; and the one could be shown to pass gradually into the other, the rhomboidal scars of the former giving place to the irregular ribs and furrows of the latter.

Professor Williamson has had in his possession for many years a specimen of *Stigmaria,* figured and described by me in 1849,[1] which, although the medulla is absent, distinctly shows in the inside of the cylinder, as left, the medullary rays traversing that portion of the stem. Several specimens in my cabinet also distinctly prove the existence of these vessels in *Stigmaria.*

Sir William Logan, myself, and others have alluded to the occurrence of *Stigmaria* in the floors of coal-seams. The specimens of this root there found are almost always in a very indistinct and distorted condition, and the only characters generally to be seen are the impressions or casts of some circular areolæ and the traces of rootlets in the fire-clay. Yet from these imperfect characters the whole of *Stigmariæ* in this country have been generally included in the species *ficoides.* It has long been my opinion that the external characters of this root are common to several other genera of aquatic plants besides *Sigillaria,* and that such roots would have a great similarity in appearance from their former soft and muddy *habitats.* Now, all the specimens of *Stigmaria* which I have seen, and whose connection I have traced with upright stems of *Sigillaria,* have always been of a comparatively large size, seldom if ever less than from two to three inches in diameter. The *Sigillaria* at its base divides into four main roots, each of which bifurcates into two secondary roots, which in their turn again dichotomize into two tertiary roots. Each of these last present on their surface an irregularly ribbed and furrowed, or, more correctly speaking, a gnarled appearance for a considerable distance outwards; and this gradually

[1] 'Quart. Journ. Geol. Soc.,' vol. vi, p. 17.

disappears, and is succeeded at first by indistinct holes of a circular form, or projecting circular knobs, which soon pass into distinct areolæ with an elevated point in their centre, and radicles radiating from the root in all directions. When this state of the root is attained, the gradual decrease in bulk, which has gone on from the base of the *Sigillaria* to this point, ceases, and the *Stigmaria* root runs to the length of twenty feet and upwards with about the same size. Its absolute termination is not often seen; but, from specimens found, it is generally believed to have an obtuse club-shaped end. Certainly I have never seen it dichotomize into smaller roots, although other observers may have been more fortunate.

Professor Williamson, in his 'Observations' previously quoted, when speaking of the structure of the medulla of *Stigmaria*, says that it possessed "a cellular pith without any trace of a distinct outer zone of medullary vessels, such as is universal amongst the *Lepidodendra*." I have no doubt that he has found in numerous small stems, obtained from the "Upper Foot Coal" near Oldham (a locality which I first observed and pointed out to others, but from which time I have never been able to obtain any more specimens for myself), evidence of the cellular pith he alludes to. This cellular tissue is not the ordinary parenchyma usually forming piths, but the "orthosenchymatous" tissue common as a medulla to *Lepidodendron, Halonia*, and *Calamodendron* (?). This structure (in the locality above named) is found to prevail in many stems possessing radiating woody cylinders of barred tubes, penetrated by medullary rays, and varying in diameter from one twentieth of an inch to two inches. All these specimens, from the similarity of their structure, might be taken to be *Stigmaria;* but we seldom find their external characters so well preserved as to recognise them as identical with the large roots found connected with *Sigillaria* stems. From specimens in my possession it is almost certain that there are fossil roots, having all the outward characters of *Stigmaria*, some of which have their medulla composed of the cellular tissue alluded to by Professor Williamson; whilst others have a medulla composed of a combination of transversely barred vessels and cellular tissues, or what I have ventured to term "orthosenchymatous" tissue, as shown in my specimens of *Sigillaria vascularis* and the *Stigmaria* figured and described by Professor Geoppert. It is also probable that these roots may have belonged to distinct, but allied, trees. These two different kinds of medulla appear to have existed in Lepidodendroid trees; the former in *Lepidodendron Harcourtii*, and the latter in my *Lepidodendron vasculare*.

It is scarcely necessary here to allude to the great number of genera and species of fossil plants which have been erected on imperfect and ill-preserved specimens, only exhibiting some of their external characters; but even amongst these, few persons could determine a compressed *Stigmaria ficoides* from a *Halonia regularis*, except where the latter was observed to dichotomize. When we examine the structure of the vascular bundles traversing the stem from the central woody axis to the leaves or rootlets, we have difficulty in distinguishing those which belong to *Sigillaria* and *Lepidodendron* from those of *Stigmaria* and *Halonia*, only the latter are considerably larger. In fact the *Stigmaria*, from the structure of its rootlet, might be supposed to be a stem (as originally entertained) rather than a root, as it has undoubtedly been proved to be by actual connection of the one with the other.

When we come to examine more carefully the specimens of plants found in coal-floors, it is probable that we shall find the remains of the roots of many different plants besides those of *Sigillaria*. The greatest difficulty we have to encounter in our investigation is the wretched condition in which the fossils are found, being usually very much compressed and distorted; and seldom in my own experience, except in the case of "Gannister" floors, has it been possible to obtain any trace of the internal structure of the plants.

It must always be borne in mind that the specimens of fossil woods showing structure in a perfect condition are generally of a very small size; those of *Calamodendron commune*, and the small *Stigmaria*-like plant from the Upper Foot Coal, often being only from one twentieth to one thirtieth of an inch in diameter. In such small spaces every cell of the medulla, as well as those in the radiating woody cylinder, is preserved in as perfect a condition as it existed in the living plant. But *Sigillaria vascularis*, *Lepidodendron*, and *Halonia* are seldom, in my own experience, found of less size than one third of an inch in diameter, which, is a large size when compared with the minute specimens of *Calamodendron* and *Stigmaria*-like plants above alluded to.

It may be asserted with confidence that up to the present time we do not know of any specimen of *Lepidodendron* exceeding three inches in diameter, or any specimen of *Sigillaria* one foot in diameter, that affords evidence of its internal structure in anything like a perfect condition.

Assuming *Stigmaria* and *Halonia* to be roots, they have this marked difference, namely, the former, having attained its usual characters, is not found to bifurcate, whilst the latter appears to continue to bifurcate as far as it has been possible to trace it.

Great caution is required in attempting to connect the different, though allied, fossil plants by a series of gradations from one to another, taking a little from each, and then joining those parts together, more especially if the describer be an accomplished draughtsman; for his pencil is often too apt to be directed by his preconceived ideas rather than by the simple and true delineation of the specimen itself. I have endeavoured, as much as possible, to represent truly the appearance of the structures as seen in the specimens; and in order to do that I have had the advantage of securing the services of so correct an artist as Mr. J. N. Fitch, who gives exact delineations of the specimens as they appear to his unbiassed eyes, and not according to any preconceived opinions of my own. The endeavour has been to describe correctly the specimens without attempting to generalize, or to bind up into a whole scattered and fragmentary specimens, which may or may not have been formerly connected with different plants.

The opinions of various authors on the subject, up to the present time, are given in their own words; but the facts observed by me are left to speak for or against such views, without specially combating or supporting them.

IV. Description of the Specimens.

§ 1. The Specimen (*Lepidodendron Harcourtii*), No. 31. Plate XIII (and No. 18, p. 48, Plate VII, fig. 6).

For this beautiful fossil (Pl. XIII, figs. 1—6) I am indebted to the kindness of my friend Mr. J. S. Dawes, who discovered it in the clay-ironstone of the Coal-measures near Dudley. The original specimen, however, from which the slices were made has unfortunately been lost or mislaid; but, from what we can learn, we understand that it exhibited all the external characters of rhomboidal scars, and other appearances, which generally distinguish *L. Harcourtii.*

The transverse section of the specimen, magnified three and three quarters diameters, in fig. 1, is irregularly oval, measuring one and a half inches across its major, and one inch across its minor axis. The medulla is nearly circular, and measures two eighths of an inch in diameter. For about one tenth of an inch within the circumference of the specimen there appears, for the greater part of the distance, a line of division, as if there had been originally some change of structure there.

The central axis is eccentric, as is generally found to be the case with specimens of *Lepidodendron* affording evidence of the former existence of a medulla. It has been considered that such displacement has arisen from the destruction of the cellular tissue surrounding it; but in this instance nearly the whole of the structure, from the centre to the circumference, has been beautifully preserved; and therefore the displacement of the central axis in this instance can scarcely be attributed to that cause.

The celebrated Hesley Heath specimen, so fully illustrated and described by Witham, Lindley and Hutton, and Brongniart, and from which nearly the whole of our knowledge of the structure of *Lepidodendron* has been obtained, was by no means in a good state of preservation, so far as its medulla was concerned. This was assumed to consist of common parenchymatous tissue, like that constituting the greater portion of the stem exterior to the vascular cylinder. In the specimen now under description we shall find that the medulla, as represented on a large scale in Plate VII, fig. 6, of Part II of this Monograph, shows in a distinct manner every cell; but these are not those of cellular tissue, such as is usually found to constitute ordinary pith, but large oblong cells, arranged in vertical series, exactly resembling those first described by Mr. Dawes as composing the medulla of *Halonia*. In my description of *Sigillaria vascularis*,[1] many years

[1] 'Quart. Journ. Geol. Soc. London,' for May, 1862, vol. xviii, p. 106, pl. iv.

ago, some of this structure was noticed in the medulla of that plant, intermixed with the scalariform tissue forming the bulk of the central axis; and a somewhat similar structure is mentioned as composing the medulla of *Calamodendron commune*, in Specimens Nos. 3 and 4, at page 23 of Part I of this Monograph. I have also observed it in the medulla of a small stem which would pass for a *Stigmaria;* and it has been there sometimes mistaken for common parenchymatous tissue. For the sake of convenience, and in order to distinguish it from ordinary parenchyma and prosenchyma, I purpose to term it "orthosenchyma," and "orthosenchymatous tissue," in the following descriptions.[1]

The medulla of orthosenchymatous tissue is surrounded by a zone of scalariform vascular tissue, of large dimensions in the interior, and gradually diminishing in size as it approaches and enters the dark corrugated line on the exterior. From this part originate the vascular bundles which communicate with the leaves. They appear to come from the concave spaces forming the outer edge of the dark line. Succeeding the vascular cylinder, which is quite destitute of any traces of medullary rays, is a dark shaded zone, of about twice the diameter of the internal woody cylinder previously described, composed chiefly of the mouths of the vascular bundles, but also exhibiting a series of round masses of large cells, of a light colour, which are only slightly shown in the plate (fig. 1). Next comes the great mass of fine parenchymatous tissue, traversed by vascular bundles; but this in the Hesley Heath and most other specimens has for the most part disappeared, having been replaced by mineral matter. This zone of tissue increases in size and strength as it approaches the broken and irregular line seen near to the exterior of the specimen. Outside this line the tissue gradually enlarges into long utricles, or tubes, arranged in a radiating series. This is covered by a thick epidermis, now converted into bright coal, showing no traces of structure.

Fig. 2 is a longitudinal section of a portion of the stem (magnified four diameters), extending from the inside of the woody cylinder (*b*), through the zone of fine vascular tissue (*c*), whence arise the vascular bundles (*d*), which traverse the mass of parenchymatous tissue (*e*) out to the leaves. These bundles at first run nearly parallel to the woody cylinder, then gradually curve outwards, until they become nearly level, when they again curve upwards, and reach the outside of the stem, and communicate with the leaves.

Fig. 3 is another longitudinal section of the inner portion of the stem (magnified seven diameters), showing the orthosenchymatous tissue (*a*) of a part of the medulla, the zones of coarse and fine vascular tissue (*b* and *c*), and the vascular bundles of scalariform tissue (*d*), surrounded by a zone of fine orthosenchymatous tissue similar in structure (but finer

[1] Probably some may object to the coining of a new term, and think that orthosenchyma is merely muriform tissue set upon its end; but that is scarcely so; for the short cross lines are not placed at right angles to the long ones, as is generally the case in the latter structure, but at different angles; and it cannot well be termed cubical cellular tissue.

in texture) to that of the medulla traversing the great mass of parenchyma (*e*), which forms the chief portion of the stem.

Fig. 4 shows a longitudinal section of an outer portion of the stem (magnified twelve diameters), in which are displayed the coarse parenchymatous tissue (*e*), passing into elongated utricles and tubes (*f*), that nearly resemble true vascular tissue, but show no markings on their walls, and the epidermis (*g*), converted into coal, about twice the thickness of the radiating zone.

Fig. 5 (magnified twenty-four diameters) is a partly transverse section of one of the vascular bundles, taken near the outside of the stem. In structure, whether we consider the vascular bundle of scalariform tubes, the orthosenchymatous tissue so often wanting, the light-coloured zone of fine parenchyma, and the outside of coarse parenchyma, it very much resembles a transverse section of a rootlet of *Stigmaria,* as figured and described by me in the 'Quart. Journ. Geol. Soc.,' vol. vi, pp. 18, 19. This structure had long previously been made out by Professor Goeppert.[1]

Fig. 6 (magnified five diameters) is a section of a portion of the outside of the stem, showing the coarse parenchymatous tissue, passing into the elongated utricles (or tubes), arranged in radiating series, together with a portion of the epidermis, and one of the outer bundles near to its passage into a leaf.

If we separate the various structures already described into two series, the one axial and the other epidermal, we have (1) an axis, composed of orthosenchymatous tissue, (2) a woody cylinder, formed of an inner zone of coarse vascular tissue and an outer one of finer vascular tissue, from the latter of which originate (3) the vascular bundles, passing to the leaves, belonging to the first, and (4) the zones of fine and coarse parenchyma, the latter passing into (5) elongated utricles or tubes, resembling those found in *Sigillaria vascularis, Stigmaria,* and *Halonia,* and (6) the outer bark, belonging to the second.

This specimen, to a great extent, confirms the views of Brongniart on the structure of the stem of *Lepidodendron Harcourtii,* as restored by him from the Hesley Heath specimen; but the medulla is in a much better state of preservation than it was in the Rev. Mr. Harcourt's fossil. The vascular bundles are shown to be enveloped in a zone of orthosenchymatous tissue, which Brongniart, it appears, did not notice. The line of demarcation betwixt the inner and finer parenchyma and the coarser and outer zone is found to be nearly imperceptible, and not so well defined as he represented it. The outer radiating series, moreover, is composed of much longer utricles (or tubes) than those he restored. Altogether the characters of Mr. Dawes' specimen, though in a better state of preservation than that of Hesley Heath, do not, in my opinion, vary sufficiently from that plant to be made the basis of a new species; therefore it has been considered desirable to class this specimen under *Lepidodendron Harcourtii.*

[1] 'Genera Plant. Foss.' (Stigmaria), p. 29.

Before leaving the subject of the structure of the stem of *Lepidodendron*, it will be as well very briefly to consider the dichotomization of the stem of this plant. This appears to have been of the same character in *Lepidodendron, Sigillaria vascularis, Halonia,* and probably other similar plants. It is like that which prevails in Lycopodiaceæ as described by Brongniart[1] as follows :—" Ce mode de ramification me paraît extrêmement rare parmi les plantes appartenant à d'autres classes du règne végétal, car toutes les plantes phanérogames qui offrent des tiges dichotomes doivent cette apparence ou à un rameau réellement latéral et secondaire, qui a pris un accroissement égal au rameau principal, ou à deux rameaux latéraux, opposés ou alternes et rapprochés, qui se sont seuls developpés tandis que la tige principale s'est transformée en un simple pédoncle floral, ou bien a subi un avortement complet.

" Dans ces divers cas un des rameaux ou même tous les deux sont d'un ordre différent de la tige à laquelle ils font suite, et ils naissent de l'aisselle d'une feuille insérée sur cette tige. Dans les Lycopodiacées, ou contraire, le développement est continu, et la tige tout entière se divise en deux faisceaux, comme on le voit quelquefois parmi les plantes phanérogames, dans les tiges monstrueuses, dites fasciédes, qui seules me paraissent offrir un mode de division analogue, malgré son irrégularité, à celui des Lycopodiacées." This mode of division in the stem has not to my knowledge been hitherto noticed, although collectors must have observed instances of it.

§ 2. The Specimen (*Lepidodendron Harcourtii*), No. 32. Plate XIV, figs. 1, 2, 3.

Specimen No. 32 (Plate XIV, fig. 1, natural size) is the transverse section of a stem of *Lepidodendron Harcourtii,* found by me in the Black-shale-ironstone in the lower part of the Middle Coal-measures at Hady, near Chesterfield. It is of an oval form, and measures three inches across its major and one and a half inches across its minor axis. The outside is marked with prominent rhomboidal scales, measuring three eighths of an inch one way and two eighths of an inch the other. The fossil, composed of clay-ironstone of a black colour, is enveloped in a coating of bright coal, and shows no trace of structure except in the two horseshoe-shaped bodies in the inside. At the first glance these might have been considered to have been accidentally introduced after the interior of the stem had been decomposed and removed; but the occurrence of similar axes in the stems of *Sigillaria vascularis* and *Halonia regularis,* hereinafter described, shows that this is very improbable, if not impossible. The two axial bodies occur in about the middle of the specimen, and at about equal distances from the sides, each measuring two eighths of an

[1] 'Histoire des Végétaux fossiles,' Tome ii, pp. 3, 4.

inch across. There is no doubt that we have here the stem of a *Lepidodendron* cut across where the woody cylinder has commenced to divide, but lower down than where the whole stem dichotomizes into two, as is so generally seen in *Lycopodiaceæ*.

Figs. 2 and 3 (magnified three and a half diameters) represent the two vascular axes. Their outer portions show structure, in the large scalariform tubes generally found constituting the woody cylinder of *Lepidodendron*. There is no trace of anything resembling medullary rays. The whole of the medulla has been replaced by white carbonate of lime. Fig. 2 represents the lower and fig. 3 the upper of the bodies seen in fig. 1.

§ 3. The Specimen (*Sigillaria vascularis*) No. 33. Plate XIV, figs. 4, 5, 6.

Specimen No. 33 (Plate XIV, fig. 4, magnified three and a half diameters) is a transverse section of *Sigillaria vascularis*, found by me in the "Bullion" seam of coal (marked ** in the section of the Lancashire Coal-measures, p. 12) at Spa Clough near Burnley. It is of an elongate-oval form, and measures one and six eighths of an inch across its major, and seven eighths of an inch across its minor axis. The specimen is enclosed in its matrix of carbonate of lime. The two apple-shaped vascular axes, parted by some fine orthosenchymatous tissue, and surrounded by a radiating cylinder of vascular tissue of a wedge-shape, containing medullary rays, appear to have been enclosed in a zone of delicate parenchyma, which, having partially disappeared, has been more or less replaced by carbonate of lime. This is succeeded by a zone of strong parenchyma, which gradually passes into long utricles or tubes, arranged in radiating series; and throughout all pass the vascular bundles, leading from near the central cylinder to the leaves. The external covering appears to have consisted of an outer bark, now converted into coal.

Figs. 5 and 6 (magnified ten diameters) represent the right and left apple-shaped bodies free from the stem. Their axes are seen to be composed of large scalariform utricles or tubes, and of fine orthosenchymatous tissue near the notches in the outer lines. They are surrounded by a cylinder of radiating vascular tissue, and a portion of the zone of fine parenchyma envelopes it.

A similar example of dichotomization of the stem of *Halonia regularis*, hereinafter described, also shows the division of the vascular axis of the stem into two, like those of *Lepidodendron* and *Sigillaria*.

Brongniart, in speaking of the stems of *Lycopodiaceæ*,[1] says, "Parmi ces dernières [Lycopodiacées] ce mode de ramification tient à leur développement entièrement terminal,

[1] 'Histoire des Végétaux fossiles,' Tome ii, p. 4.

mode de développement que cette famille partage avec les Fougères, et probablement avec quelques autres familles voisines, et qui devrait faire réserver à ce groupe de végétaux le nom très-juste d'Acrogènes, appliqué par M. Lindley à toutes les Cryptogames et Agames."

This no doubt is true with regard to *Lycopodiaceæ;* but with respect to *Lepidodendron, Halonia,* and *Sigillaria,* the two first-named genera exhibiting no traces of medullary rays, whilst the latter possesses them, are very like Acrogens; but most assuredly the last-named genus, and probably the other two, were exogenous plants, as the specimens formerly described by me distinctly prove.[1]

V. Bibliographical History of Halonia.

Having thus concluded my description of the internal structure of the stem of *Lepidodendron* and its mode of dichotomization, I will now proceed to describe some specimens of *Halonia regularis.* First, however, it is desirable to give a short sketch of the present state of our knowledge of this fossil plant.

Several authors have distinctly stated that *Lepidodendron* had roots resembling those of *Stigmaria;* and Mr. Dawes, who possessed in 1848 by far the most perfect specimens then known, hinted that *Halonia* might prove to be the root of *Lepidodendron.*

§ 1. *Lindley and Hutton.*

a. "*Halonia? tortuosa.*[2]—In sandstone in a quarry near South Shields, from a specimen furnished by Isaac Cookson, Esq.

"Whatever this may have been, it is evidently very distinct from anything hitherto described. Probably the present specimen has been jammed and distorted so much as to have lost, in a great measure, its original character; but enough remains to convey some idea of its external structure.

"It seems to have been a plant of small dimensions, the surface of whose stem was completely covered with little processes, which, in falling away, left minute quincuncial ill-defined spots, that rapidly became separated and obliterated as the stem advanced in age. Among these spots, at intervals of three fourths of an inch every way, were arranged little projections, the apex of which was terminated by some appendage now lost. The ramification appears to have been dichotomous, but this is extremely uncertain.

[1] 'Quart. Journ. Geol. Soc.' for May, 1862, vol. xviii; and 'Phil. Trans.,' volume for 1865, p. 576.

[2] Lindley and Hutton's 'Fossil Flora,' vol. ii, p. 85, 1833—5.

"The principal questions to answer are, first—What were the processes? And, second, What were the projections? If the processes were leaves, as it appears probable, then the projections will have been either the bases of old or the points of rudimentary branches; and in that case the affinity of the fossil will be nearest with *Halonia.* (See the next article.) But if we suppose the processes to have been analogous to the ramenta of Ferns, then the projections may be considered to be of the same nature as those we find in *Stigmaria,* where they are plainly the bases of leaves. A great objection to this view is, that the arrangement of the spots left by the processes is too regular for ramenta.

"The only branch that is seen in the specimen will not enable a botanist to say whether the mode of ramification was dichotomous or alternate. If the projections are the bases of leaves, it may have been dichotomous; but, if they are rudimentary branches, it must have been alternate.

"Under these cirumstances we are forced to leave the specimen in a state of uncertainty, which is unfortunately too common in this science."

b. "*Halonia gracilis* (page 86).—From the Coal-measures of Low Moor in Yorkshire.

"At first sight one would be disposed to consider this a *Lepidodendron,* to which its rhomboidal scars give it strong resemblance. But if we consider *Lepidodendron* as an extinct form of *Lycopodiaceæ,* we must limit it to those fossils in which the mode of branching was dichotomous, for no other kind of ramification is met with in recent *Lycopodiaceæ.*

"Here, however, it is plain, from numerous scars of branches, that they were arranged in an alternate manner round a common elongating axis, after the plan as now obtains in the Spruce Fir. In fact, if we compare this to a vigorous branch of a Spruce Fir, one year old, we shall find the resemblance very striking even in the scars of the leaves. For this reason, and for the sake of rendering our notions of the extinct *Flora* as definite as we can, the genus *Halonia* is proposed, to comprehend all those fossils in which the surface of *Lepidodendron* is added, with the mode of branching of certain *Coniferæ,* and which, it is therefore to be inferred, were of a nature analogous to the latter."

c. "*Halonia regularis* (vol. iii, p. 228).—Fig. 1, from Halliwell Stone Quarry, near Bolton. Fig. 2, from Peel Stone Quarry, near Bolton, both communicated by Mr. Dawes, of Bolton.

"These are most remarkable specimens of this curious genus. They are quite distinct, both in dimensions and in the regularity with which their tubercles are arranged, from either of the species previously figured."

§ 2. Mr. Richard Brown, in a description of an upright *Lepidodendron* with *Stigmaria* roots, in the roof of the Sydney Main-coal, in the Island of Cape Breton, states,[1] "Since I forwarded to the Society a description of the Sydney *Sigillaria,* about twelve

[1] 'Quart. Journ. Geol. Soc. of London,' vol. iv, p. 46, 1847.

months ago, I have discovered several upright trees in the coal-measures, evidently *not Sigillariæ,* with roots of *Stigmaria* united to them. These trees exhibited so many of the characters of *Lepidodendron* that I at once concluded they belonged to that genus; but, having never seen it hinted that *Lepidodendron* possessed *Stigmaria* roots, and distrusting my own skill in fossil botany, I determined to wait till I could collect more decisive evidence in confirmation of my opinion. This evidence I have now obtained in another example, fortunately most complete in all its parts, a description of which I hasten to lay before the Society, accompanied with sketches, which I hope will clearly prove that the stem in question is a genuine *Lepidodendron* united to roots of *Stigmaria.*"

§ 3. Unger, in 1847, in his 'Chloris Protogæa,' under his Order XX, *Lepidodendreæ,* 98, *Halonia,* Lindl. and Hutt. says:

"Trunci arborei cylindrici decorticati? cicatricibus minoribus punctiformibus vel rhomboideis spiraliter dispositis, majoribus tuberculatis remotis instructi."

"Lindl. and Hutt., 'Foss. Flora,' ii, p. 12.

"1. *Halonia tuberculata,* 'Brong. Hist. Végét. Foss.,' ii, pl. xxviii, figs. 1, 2, 3.

"*Halonia tortuosa,* Lindl. and Hutt., Foss. Flo., South Shields, vol. ii, pl. lxxxv, p. 11.

"2. *Halonia gracilis,* Lindl. and Hutt., Low Moor.

"3. *Halonia Beinertiana,* Göpp., p. 203, Charlottenbrun, Silesia."

§ 4. Mr. J. S. Dawes, in some remarks on the internal structure of *Halonia,*[1] states that "it was proposed by the authors of the 'Fossil Flora' that the genus *Halonia* should comprehend all those plants combining the surface of the *Lepidodendra* with the mode of branching of the *Coniferæ,* to which latter order they considered these fossils to be analogous. The discovery, however, of better preserved specimens has clearly shown that the supposed remains of alternate branches, noticed more particularly in the species *H. gracilis,* must have been merely impressions of the protuberances which characterize these fossils, and that they are, in fact, like the *Lepidodendra,* dichotomous. A still further proof of cryptogamic affinity is now afforded by sections of a specimen from the neighbourhood of Birmingham, in which traces of the vegetable structure have been preserved. By reference to the drawing, fig. 1, it will be seen that this stem is composed of a central medullary column (*a*), surrounded by a series of scalariform vessels (*b*); these being succeeded by a compact cellular tissue (*c*), which becomes more lax between this central part and the cortical zone, the latter (*d*) being composed of a thick-membraned, very regular tissue, and bearing a large proportion to the rest of the stem, equal in some specimens to one third of the diameter. There are no concentric rings, or, strictly speaking, medullary rays, neither any ligneous fibre, or indeed any indications whatever of affinity with the *Coniferæ,* or even with that division of the Dicotyledons, except that some

[1] Vol. iv, pp. 289—291, of the 'Quart. Journ. Geol. Soc.,' 1848.

similarity exists in the character of the striated tubes which surround the medullary column, and the pseudo-vascular bundles of certain *Zamiæ*. Neither are these plants to be referred to that class which includes the *Sigillaria*, *Anabathra*, &c.; for, although the structure in some important respects may correspond, the arrangement of the tubes of the vascular system is altogether reversed; consequently, the curved scalariform bundles, which traverse the stem from its axis to the periphery, do not emerge from the tissues immediately in connection with the medullary column, but are thrown off from the outer portion of the sheath. These leaf-cords, which appear somewhat to resemble the stem in miniature, take a direction for some distance nearly horizontal, so that different portions of the tissues of several neighbouring bundles are usually cut through, giving to the transverse section some appearance of a radiated structure. I should observe, that these fasciculi differ in size, the smaller ones having a direction towards the spirally arranged scars which cover the surface of the stem; the larger ones being connected with the processes that occur upon it at certain intervals, each of these projections exhibiting a roundish cicatrix at its apex, as though some leaf-like appendage had been supported upon it, and having some resemblance to the well-known tubercles of *Stigmaria*. These few observations will be sufficient to show that the fossil in question belonged to the vascular *Cryptogamiæ;* and that, when compared with the other plants of the Coal-measures, the nearest affinity is with *Lepidodendron*. We might, in fact, considering their tortuous root-like appearauce, and on other accounts, be tempted to speculate as to the relationship they bear to this fossil; but possibly some other specimens in my possession, not yet sufficiently examined, may throw further light upon the subject.

"Since the above remarks were forwarded to the Society, I have been fortunate enough to obtain some very good sections of another specimen of this fossil, and am now enabled to mention a peculiarity in the structure which had previously escaped notice, viz., that a narrow ring of very regular, compact, elongated tissue exists on the outer portion of the cortical zone (*e*), similar to the prosenchymatous arrangement mentioned as occurring in the corresponding part of the *Lepidodendron*. Having, however, had an opportunity to look through many specimens of this latter fossil, I may venture to say that the descriptions hitherto given of it do not in this and some other respects correctly represent its structure. Such discrepancies have probably arisen from the inferior state of the specimen first met with by the Rev. C. G. Vernon Harcourt, and also in consequence of Mr. Witham having originally figured from portions of two distinct fossils, apparently mistaking in one instance an imperfect fragment of *Halonia* for a piece of *Lepidodendron* (see 'Transactions of the Natural History Society of Newcastle,' 1832, and 'Internal Structure of Fossil Vegetables,' Edinburgh, 1833, pl. xii, fig. 3; pl. xiii, fig. 1). Brongniart indeed admits being unable to detect this exterior tissue; but nevertheless describes it both in his 'Histoire des Végétaux Fossiles' and in the 'Archives du Muséum d'Histoire Naturelle' upon English authority; he has, however, discovered a very similar tissue, although differently placed, in the cortical zone of the *Sigillaria elegans*.

"There are some other points connected with, and in the constitution of, these fossils that I hope to refer to on a future occasion; and may perhaps now observe that the medullary column does not, either in the *Lepidodendron* or *Halonia*, consist of the usual parenchymatous tissue, but seems to be composed of large quadrangular cells arranged in perpendicular series, and presenting an appearance as though each minute column was confined within a slight membrane or tube. I believe that no such structure has been found to exist in recent vegetation, the nearest approach to it being probably in *Psilotum*, one of the Lycopod family, and of course incompatible with the idea of this central portion being a true medulla; these plants must therefore be still further removed from any supposed phanerogamic alliances."

§ 5. Dr. Hooker, in writing of *Lepidodendron*,[1] states, "Of the stem, branches, leaves, and fructification, we have thus a satisfactory knowledge, but the nature of their roots is not ascertained. Mr. Dawes, of West Bromwich, to whom I am indebted for much information regarding the structural character of coal fossils, is inclined to regard the species of *Halonia* as roots of *Lepidodendron*, on which opinion I have no remarks to offer." Again, on the same page, he observes, "*Halonia*, another genus of *Lepidodendreæ*, is composed of three species, possibly the roots of these or others of the same genus."

§ 6. Brongniart, in treating of *Halonia*, writes,[2]

"Halonia, *Lind. et Hutt.*

"Les tiges, assez rares et mal connues, qui forment ce genre, offrent, sur les parties qui sont bien conservées, une écorce, marquée de cicatrices foliaires, disposées comme dans les *Lepidodendron;* mais la tige présente en outre de gros tubercules coniques disposés en quinconce, et sur lesquels s'étend uniformémént l'écorce générale et les feuilles qu'elle supportait.

"La disposition quinconciale des mamelons ou tubercules qui font saillie sur la tige et la continuitié de leur base avec le reste de l'écorce de la tige distingue complètement ce genre des précédents. Ici les gros mamelons ne paraissent pas des cicatrices, mais des saillies sous-corticales comme celles qui seraient produites par des racines non sorties de dessous l'écorce."[2]

[1] "On the Vegetation of the Carboniferous Period," 'Memoirs of the Geological Survey of Great Britain,' vol. ii, Part II, p. 422, 1848.

[2] 'Tableau des Genres de Végétaux Fossiles,' p. 43, 1849.

At page 96 he gives the following classification:

"LYCOPODIACÉES.

Lépidodendrées.

Lepidodendron.
Lepidostrobus.
Lepidophyllum.
Ulodendron.
Megaphyton.
Halonia.
Lepidophloios.
Knorria."

§ 7. GOLDENBERG, in writing on *Lepidodendron*, appears to consider that *Halonia* is a genus allied to that plant, if not even a species of the same genus.[1]

VIII. *Genus* HALONIA.

"LEPIDODENDRON.—The stem of these plants is cylindrical; and on the bark of well-preserved specimens the points of attachment of the leaves may be seen, which resemble in all points those of *Lepidodendron*. But in addition to these the stem also bears conical protuberances, arranged quincuncially, which are evenly covered by the bark with its leaf-scars, so that it seems as if these protuberances were due to branches not yet come through.

"If the form and dimensions of the parts where the leaves were attached suggest that some species of *Lepidodendron* is represented by *Halonia*, it is still more confirmed by our often having met with specimens of *Halonia* exhibiting the same ramification as *Lepidodendron*.

"The specimen represented and described by us shows that the protuberances appeared on the outer branches only, there being no traces of such swellings below the bifurcation; and, lastly, in favour of this view is the fact that all the stems of *Haloniæ* have a proportionally small circumference.

"39. *Halonia dichotoma*, pl. iii, fig. 12.

"This three-inch stem is branched dichotomously, and bears spirally arranged papillæ on each arm of the bifurcation, whereas the stem never bears these growths below the bifurcation.

"The bark is covered with rhomboidal leaf-scars, resembling in shape and arrangement the leaf-attachments of *Lepidodendron*.

[1] 'Flora Saraepontana fossilis,' part i, p. 20, 1855. For this translation I am indebted to the kindness of my friend, Mr. Charles Bailey, the indefatigable Librarian of the Literary and Philosophical Society of Manchester.

"Our specimen was found in the railway-cutting at Friedrichsthal. Here also are found

"40. *Halonia tuberculata*, Brong., 'Hist. Vég. fos.,' ii, p. 28, figs. 1, 2, 3. Auerswaldflotz, near Gerweiler.

"41. *Halonia regularis*, Lind. and Hutt., 'Foss. Flor.,' iii, p. 179, pl. 228. From the Carboniferous Sandstone at Duttweile.

"§ 8. *Binney.*—In a paper of my own on *Sigillaria* and its roots,[1] a full account is given of specimens observed, and the date of their publication. It is there stated, "My specimens here mentioned beyond doubt prove that *Stigmaria* is the root of *Sigillaria*. It will probably be found that this character of root was common to several other genera of aquatic plants besides *Sigillaria*, but this point requires carefully to be examined and proved."

§ 9. Dr. Schimper describes *Halonia* in the following words:[2]—"Trunci dichotome ramosi, ramis patentibus, mediocriter crassi, corticati rhombeo-cicatricosi, tuberculati; decorticati breviter quincunciatim papillosi, tuberculis apice perforatis basi vel totâ superficie papillis brevibus (pulvinulis foliorum subcorticalibus) tectis, spiraliter dispositis. Cylindrus centralis medulla impletus.

"Type végétal très-bizarre, dont le mode de ramification, la forme et la disposition des cicatrices foliaires rappellent bien les *Lepidodendron*, mais qui se distingue de ce genre par un système de tubercules obtus-coniques disposés en quinconce, qui recouvre la tige et dont la signification morphologique n'a point encore été déterminée. M. d'Eichwald y voit les points d'attache des feuilles, et dans les petites cicatrices rhomboidales celles d'écailles qui auraient recouvert la tige. Cette manière de voir est évidemment erronée. M. Goldenberg croit voir dans ces bourrelets, qui, dans les échantillons bien conservés, sont couverts de cicatrices foliaires comme le reste du tronc ou du rameau, des rameaux à l'état latent non arrivés à leur développement normal. Si ces proéminences sont percées d'une ouverture vasculaire à leur sommet, comme M. d'Eichwald les représente (voy. notre planche) il est naturel d'admettre, ce me semble, que c'étaient là les points d'attache des fruits.

"Le genre *Halonia* est limité au terrain houiller, où il est représenté par un très petit nombre d'espèces, si toutefois il y en a plusieurs, et par peu d'individus.

"3. *Halonia regularis*, Lindl. et Hutt. Tuberculis 6-seriatis foliorum cicatricibus (vasorum cicatriculis) subcorticalibus punctiformibus. Lind. et Hutt., *op. c.* iii, p. 179, pl. 208.

1 'Transactions of the Manchester Geological Society,' vol. iii, p. 110, May, 1861.

2 'Traité de Paléontologie végétale, ou la Flore du monde primitif,' &c. Tome seconde, Première Partie, p. 53.

"Dans le grès houiller de Halliwell et Peel, près de Bolton (Angleterre), près de Duttweiler, pays de Saarbrucken."

Dr. Schimper, in a supplementary note of the same work, at p. 117, states that, after his general considerations on *Stigmaria* had been printed off, he heard of the discovery (in the quarries of the grauwacke, near Thun) of a trunk furnished with roots. This trunk has been obtained by Doctor Faudel for the Museum of Colmar; and when he (Dr. Schimper) examined the specimen, it completely confirmed his opinion previously expressed that *Stigmaria* might have belonged to other trees besides *Sigillaria.* He found, in fact, that the trunk in question furnished with a Stigmarioid root was indeed a trunk of *Knorria longifolia,* whose base agreed with *Ancistrophyllum,* while its middle portion corresponded with *Didymophyllum Schottini,* Gœpp.

VI. Description of the Specimens.

§ 1. Specimen No. 34, *Halonia regularis.* Pl. XV, figs. 1—4.

For this instructive specimen (Pl. XV, fig. 1, magnified three and one fifth diameters) I am also indebted to Mr. Dawes, who discovered it in the clay-ironstone of the Coal-measures near Dudley. The original fossil from which the slices were made is not now to be found, so I cannot describe, from my own knowledge, what were its external characters; but, from Mr. Dawes' description, it no doubt belonged to the genus *Halonia;* and, from its identity in structure with other specimens of my own, intended to be hereinafter described, it most probably belonged to the species *regularis.*

The transverse section of the specimen, as shown in fig. 1, is irregularly oval, flattened on one side, and measures one and five eighths inches across its major, and one and three eighths inches across its minor axis. The central axis is near the middle of the specimen. The medulla in this section appears to be much disarranged and destroyed, so that we cannot tell whether it consisted of orthosenchymatous tissue, like that in *Lepidodendron,* or not. The woody cylinder, enclosing the medulla, is also considerably disarranged; but there is sufficient evidence to show that it was composed of barred tubes or utricles. The mouths of some of these appear to be filled with a very fine orthosenchymatous tissue, of a bright wine colour, probably a portion of the medulla squeezed into them during the process of mineralization. The outside of the woody cylinder is bordered by an irregular band, dark in colour, as drawn in the plate; but, when viewed by transmitted light, it is seen to be of a bright wine colour. From near this zone proceed the large vascular bundles, which go outwards through the parenchyma to the leaves or roots (whichever of those appendages they may prove to be). The portion of the stem from the woody cylinder to the irregular light-coloured line near the outside of the specimen consists of fine parenchyma, on which are dotted numerous mouths of vascular bundles, enveloped in orthosenchyma, similar to those found in *Lepidodendron* previously described. Outside of the above-named line, where the parenchyma appears stronger, and its cell-walls thicker, it seems gradually to pass into elongated utricles (or tubes), and to assume at the edge a radiating appearance. In the specimen there appears to be only a little coaly matter near the upper part on the right hand side of the finger, the other portion probably having been removed. The transverse section, on the whole, is like that of *Lepidodendron;* and the great value of the specimen is the perfect preservation of the delicate parenchymatous tissue surrounding the woody cylinder, and so generally absent in woods of this description. It supplies a part wanting in a valuable specimen (No. 35), to be hereinafter described.

Fig. 2 (magnified four diameters) represents a longitudinal section of a portion of the same specimen, showing the medulla (*a*), composed of orthosenchymatous tissue, in a beautiful state of preservation; the woody cylinder, formed of scalariform utricles or tubes (*b*), the fine scalariform tubes or utricles (*c*), from which proceed the large vascular bundles (*d*), composed of scalariform tubes, enveloped in a zone of fine orthosenchymatous tissue, traversing the parenchyma (*e*), and leading to the rootlets. Two of these bundles are seen going down from the woody cylinder on the left hand side, and one on the right hand side. The woody cylinder has been displaced, in this specimen, from its original position, and now appears sloping instead of vertical. On the extreme edge of the fossil there is evidence of some traces of the elongated utricles or tubes (*f*), the occurrence of which has been previously alluded to in the description of the transverse section.

Fig. 3 (magnified eight diameters) exhibits a longitudinal section of a portion of the medulla (*a*), the woody cylinder (*b*), and the darker zone (*c*), whence the vascular bundles (*d*) appear to originate, all in a most beautiful state of preservation.

Fig. 4 (magnified twenty-five diameters) gives a transverse section (nearly at a right angle) of one of the vascular bundles, enveloped in a zone of orthosenchyma near the outside of the specimen. This, in all its parts, is scarcely to be distinguished from the vascular bundle taken from the same part of *Lepidodendron*, and hereinbefore described and figured in page 79, Pl. XIII, fig. 5, or from a similar vascular bundle in *Stigmaria*.

§ 2. Specimen No. 35, *Halonia regularis*. Plate XVI, figs. 1—5.

Specimen No. 35 (Pl. XVI, fig. 1, natural size) represents an example of *Halonia regularis*, from the Upper Brooksbottom seam of coal in Lancashire, marked * in the section of strata previously given at page 12 of this Monograph. It is imbedded in a matrix of limestone, and has only a part of one side exposed. The specimen is one and three eighths of an inch long; and its section is irregularly oval, measuring one and one eighth of an inch across the major, and six eighths of an inch across the minor axis. The outside shows numerous small superficial papillæ, and four circular tubercles, each having a depressed areola, with a small projection in the centre. The medulla and vascular cylinder are in a most perfect state of preservation; but the zone of fine parenchymatous tissue, so well preserved in Specimen No. 34, is for the most part wanting, having been replaced by carbonate of lime. In this mineralized portion is seen a vascular bundle, showing structure. Next comes a zone of parenchyma, increasing in the strength of its cells until it gradually passes into elongated utricles (or tubes), arranged in radiating series, constituting the outside next the bark.

Fig. 2 (magnified five diameters) represents a transverse section of the specimen, showing the medulla composed of orthosenchyma, and a woody cylinder, formed of large scalariform utricles (or tubes) in the interior of the circle, and smaller ones next the outside, ftom which proceed the vascular bundles. One of the last is seen considerably distorted in appearance, but showing the structure in the central part. The thick zone of parenchyma gradually increases in strength, until it passes into the outer zone of elongated utricles or tubes. It may be objected that the vascular bundle has been introduced into the interior of the stem after the decomposition of the delicate parenchyma surrounding the woody cylinder; but this argument, if good for anything, would prove that the latter had also been introduced. The position of this woody cylinder, however, and of the vascular bundle, occupying their original places, is clearly shown in the specimen, No. 34, last described, where those parts are seen imbedded in the parenchyma as when growing. No doubt the structure of this vascular bundle is much the same as that found in *Stigmaria*, and might easily be mistaken for it; but it seems more reasonable to suppose that this vascular bundle belongs to the stem in which it is now found than to another that is not even seen near it. In other specimens in my cabinet there is abundant evidence to prove that *Halonia regularis* was furnished with vascular bundles proceeding from the woody cylinder to the outside, in all respects like those found in *Lepidodendron* and *Stigmaria*, and previously described in this Monograph.

Fig. 3 is a longitudinal section of a portion of the whole root (magnified ten diameters), showing the medulla (*a*), composed of orthosenchymatous tissue, the large scalariform tubes forming the inside of the woody cylinder (*b*), and the smaller ones, composing the exterior (*c*), the fine parenchyma (*e*), and the elongated utricles or tubes, forming the outer radiating cylinder (*f*). This section does not very distinctly show any vascular bundles proceeding from the woody cylinder, except a trace of one on the right hand side in the specimen; but this is not more than might have been expected, for the section is only one quarter of an inch in length, and the tubercles or rootlets on the outside of *Halonia* are very few in number, when compared with the leaves on *Lepidodendron* and the vascular bundles seen in that plant.

Fig. 4 (magnified ten diameters) is a transverse section of the medulla, composed of orthosenchyma, surrounded by a woody cylinder of scalariform tubes or utricles, all in a most beautiful state of preservation, with scarcely a cell wanting, and nearly as perfect as when they grew.

Fig. 5 (magnified forty diameters) represents a nearly right-angled transverse section of the vascular bundle in the middle of the root. This we take for one of those which proceeded from the outside of the woody cylinder to the rootlets. It consists of an axis of scalariform tissue, composed of two different sizes of tubes, the one being much larger than the other, and formerly imbedded in a zone of orthosenchyma, which has disappeared in the specimen. This is succeeded by a zone of regular parenchyma.

On comparing this section with a similar one of *Stigmaria,* figured and described by me many years since, scarcely any difference can be detected.[1]

§ 3. Specimen No. 36, *Halonia regularis.* Plate XVII, figs. 1, 2, 3.

Specimen No. 36 (Plate XVII, fig. 1, natural size) is another example of *Halonia regularis* from the Upper Brooksbottom seam of coal. It is imbedded in a nodule of limestone, and only shows a portion of one side of the fossil. Its transverse section is irregularly oval, measuring one and a half inches across its major and three quarters of an inch across its minor axis. The length of the specimen is two and one quarter inches. So far as it is exposed, no one would be able to distinguish it from a small specimen of *Stigmaria ficoides.* Unlike No. 35, it presents no appearance of tubercles; but in their places are depressed areolæ of a circular form, having a raised ball in the centre, and arranged in quincuncial order. From its external characters the most experienced judge of Carboniferous fossils would not be able to distinguish it from a *Stigmaria;* but when we proceed to examine its internal structure, we find that it is exactly the same as that of *Halonia regularis,* and very different from that of *Stigmaria ficoides.*

Fig. 2 (magnified five diameters) represents a transverse section of the same specimen, which displays a medulla composed of orthosenchyma and a woody cylinder, formed of large scalariform tubes in the interior of the circle, and smaller ones next the inside, whence proceed the vascular bundles; a trace of one of these is seen. A portion of the delicate parenchyma, next to the woody cylinder, has been destroyed, and replaced with mineral matter; but the greater part of it is preserved, and shows it to increase in strength as it approaches the circumference, assuming a prosenchymatous structure and a radiating appearance. Outside of this is a dark line, succeeded by an epidermal layer whose structure is apparently destroyed. It is upon the surface of the latter, however, that the Stigmarioid areolæ occur; and, if it were carefully removed, we should most probably find the tubercles generally seen, as in specimens Nos. 35 and 38, and other common forms of *Halonia regularis,* in the place of the areolæ in this specimen.

[1] 'Quart. Journ. Geolog. Soc.,' vol. vi, pp. 18, 19.

Fig. 3 (magnified twenty diameters) represents the centre of one of the areolæ, showing the vascular bundles in the middle, with a zone of orthosenchyma, which has for the most part disappeared, as is generally the case, and a regular zone of parenchyma very similar to that exhibited in fig. 5 of Plate XVI, as occurring in specimen No. 35.

§ 4. Specimen No. 37, *Halonia regularis*. Plate XVII, figs. 4, 5, 6.

Specimen No. 37 (fig. 4, natural size) is another example of *Halonia regularis*, also from the Upper Brooksbottom seam of coal. Like the last described specimen, it is partly imbedded in a matrix of limestone. The portion exposed shows the main stem, or rather *root*, immediately before it dichotomizes, and parts of the forking branches. The transverse section of the former is irregularly oval, measuring one eighth of an inch across its major and rather more than half an inch across its minor axis. The two portions of the fork are nearly circular, and each measures about five eighths of an inch in diameter. The depressed areolæ, so well shown in specimen No. 36, are not equally displayed in this, but there is sufficient evidence to prove that it belongs to *Halonia regularis*.

Fig. 5 (magnified five diameters) is a transverse section of the specimen, showing the medulla composed of orthosenchyma, and a woody cylinder composed of large scalariform tubes in the interior of the broken circle, and lesser utricles or cells next the exterior. The division of the woody cylinder might at first sight have been taken for an accidental disruption before the specimen was fossilized; but, as it occurs just before the root dichotomizes, and is not the only example of the kind in my possession, I am led to believe that it is the first commencement of the division of the woody cylinder into two, as previously described at length in specimens No. 32 and No. 33. Outside the woody cylinder the delicate parenchyma has, for the most part, disappeared; but evidence of four vascular bundles, partly showing structure, is seen in the mineralized portion; and, where the parenchyma becomes stronger and passes into prosenchyma, indications of more bundles are seen.

The exterior presents a thick epidermis, similar to that described in the last specimen (No. 36); and the two are so much alike in structure that it is impossible to distinguish the one from the other.

I am aware that the vascular bundles last named, as well as those in Nos. 35 and 36, have been generally described as intruding rootlets of *Stigmaria* which have penetrated the stem. No doubt they do appear larger, especially on their outsides, than we should expect to find in such a root; but the delicate tissues of those parts have nearly always been much distended, whilst the vascular bundles in the centre remain generally of the same size. Whether they be taken for the vascular bundles of the root, in which they are now found, or intruding rootlets of *Stigmaria*, their structure is no doubt the same, and therefore we cannot absolutely decide the question; but still it appears to me that it is under the circumstances more reasonable to believe that they are vascular bundles belonging to the body in which they are now found than similar organs belonging to another plant.

Fig. 6 (magnified 10 diameters) represents the woody axis, exhibiting structure throughout, except in the unshaded portion in the figure, which is composed of crystalline carbonate of lime, and which appears as if the medulla and woody cylinder had been disrupted prior to the mineralization of the specimen, and would no doubt have been taken as such did it not occur immediately before the dichotomizing of the root, and had not specimens Nos. 32 and 33, as well as others in our cabinet, been brought to our notice.

§ 5. Specimen No. 38 (*Halonia regularis*). Plate XVIII.

This is another specimen of *Halonia regularis*. It was found by Mr. Higson, one of Her Majesty's Inspectors of Coal-mines, and presented by him to the Manchester Museum. For permission to figure it I am indebted to the kindness of the Commissioners of that Institution. It is from the sandstone quarry of Peel, near Bolton-le-Moors, a locality noted for the beautiful specimens of Coal Plants which have been found there. The specimen shows no traces of internal structure, being simply a cast in a very fine-grained sandstone, with its thick epidermis converted into coal. The tubercles project from the stem about a quarter of an inch, and show how the spaces intervening between them had been once covered by a similar thick mass of coal. Where the outside matrix of the coal has been removed, the tubercles are seen covered by the coaly envelope, and only exposing a depressed areola, like that shown in specimen No. 36, and the areolæ so generally seen on the outside of *Stigmaria*. In fact, when seen with its epidermis preserved, it is a *Stigmaria* in outside appearance; but without that part of the plant it is a *Halonia regularis*. The exterior of the root, when deprived of its coaly envelope, is seen to be covered with numerous papillæ as well as the tubercles previously described. The length of the fossil is $9\frac{1}{2}$ inches, and its diameter 2 inches, and its form is nearly as cylindrical as it originally grew, apparently having been subjected to little or no pressure.

In specimen No. 34 the structure of *Halonia regularis* is beautifully shown, but nothing of its external character. In No. 35 the internal structure and the tubercles are given. In specimen No. 36 are exhibited the internal structure and the areolæ. In specimen No. 37 we have evidence of the dichotomization of the plant, and its internal structure. Lastly, in No. 38, although it affords no evidence of internal structure, there is a most perfect representation of all the external characters of the plant, without its being compressed, and before it was mineralized. The conditions in which these fossils often occur clearly show that when deprived of its epidermis the plant has generally been taken for *Halonia regularis;* but, when clothed with its epidermis, it clearly resembled, and might be taken for, a *Stigmaria.*

VII. Concluding Remarks.

Those portions of the Hesley Heath specimen in which the structure of the stem had been destroyed have fortunately been preserved in the Dudley specimen described in this Monograph, so that it may be now considered that we possess a knowledge of the structure of the whole of the stem of *Lepidodendron Harcourtii.*

In addition to the reasons given at page 37 for believing that *Sigillaria* and *Lepidodendron* were different, though allied, plants, I consider that the Dudley specimen of *Lepidodendron Harcourtii* clearly proves that it had a medulla of orthosenchyma, whilst the *Sigillaria vascularis* and *Lepidodendron vasculare* had, in the place of such tissue, large scalariform tubes, sometimes but not always mixed with orthosenchyma. Moreover, the central woody axis of *Sigillaria vascularis* was arranged in wedge-shaped masses, and penetrated by medullary rays, thus differing altogether from the entirely vascular zone constituting the woody axis of *Lepidodendron,* either *Harcourtii* or *vasculare.* The vascular bundles proceeding from the outside of the woody cylinder to the leaves, the zone of lax parenchyma gradually increasing in strength, and afterwards passing into elongated utricles or tubes, and having a radiating arrangement at its outside, as well as the epidermis, all appear to have been much the same in structure in both *Lepidodendron* and *Sigillaria.*

It appears from my specimens, hereinbefore described, that *Lepidodendron Harcourtii, Sigillaria vascularis,* and *Halonia regularis,* had all a similar mode of dichotomizing, and that the division of the pith and woody axis was much the same in these three plants. The facts are given as they appear from an examination of the specimens, and are left for the consideration of the physiological botanist, who is much abler than myself to investigate the system of dichotomization of ancient plants by the phenomena observed in living *Lycopodiaceæ.*

I have always had a doubt that *Lepidodendron* had the *Stigmaria ficoides* for its root, such as was proved to be the case with large, ribbed, and furrowed *Sigillariæ;* but I saw the probability of Mr. Dawes' view, that *Halonia regularis* might prove to be the root of *Lepidodendron,* both on account of its frequent bifurcations and on account of other characters, quite independent of the similarity in structure of the two plants.

The researches of Mr. Richard Brown and Professor Schimper led me to expect that *Lepidodendron,* as well as *Knorria,* had a Stigmarioid root. My own observations, and the specimens here described, lead me to conclude that *Halonia regularis* is the root of *Lepidodendron Harcourtii,* but not the root of *Sigillaria,* that being, as was before stated, *Stigmaria ficoides.* It is seen in the description of the specimens in this Monograph how much *Stigmaria* resembles *Halonia* in its external appearance, with the exception of its tendency to bifurcate, which *Stigmaria* does not do after it has assumed its ordinary characters, and that it is very difficult, if not impossible, to distinguish an imperfect specimen of one of these roots from the other, although their internal structure differs as much as that of *Lepidodendron Harcourtii* does from *Sigillaria vascularis*. In short, it must be considered that *Halonia regularis* is merely a *Stigmaria* with its epidermis removed.

Now, when we compare the internal structure of *Halonia regularis* with that of *Lepidodendron Harcourtii*, we find they are the same in every particular. The medulla, composed of orthosenchyma, is the same in both plants; so also the interior and exterior of the woody cylinder, composed of larger and smaller barred vessels—the vascular bundles leading to the leaves—the lax and delicate parenchyma gradually increasing in strength until it passes into elongated utricles (prosenchyma), arranged in radiating series —and the epidermis forming the exterior, are all alike in *Halonia* and *Lepidodendron;* therefore, as to identity of structure, and so far as that is of any value, we are led to conclude that *Halonia regularis* is the root of *Lepidodendron Harcourtii*. Up to this time, however, I have not heard of their having been found absolutely united to each other, as was the case with *Stigmaria* and *Sigillaria*.

In my examination of the Lancashire Coal-measures I have generally found *Halonia regularis* associated with *Lepidodendron*. This is the case in the Peel Quarry, where both these fossil plants are found in about the same relative proportions. A similar result is obtained in the Upper Foot seam of Oldham and the Bullion Coal of Burnley and its vicinity; but in the Upper Brooksbottom seam *Halonia* occurs more frequently than *Lepidodendron*, so far as my experience in collecting the fossil plants in this seam of coal has extended. In many districts, no doubt, *Lepidodendron* is found in great abundance, with few or no traces of *Halonia regularis;* but in such cases we always meet with numerous ill-preserved specimens of *Stigmaria*. In my own experience well-defined specimens of *Halonia regularis*, showing the quincuncially arranged tubercles, are seldom found except in sandstones, and when the epidermis of the plant has been removed. The reason why they have not been recognized in shales and "binds" is, that they are there compressed with their epidermis on, and have been generally taken for remains of *Stigmaria*.

PLATE XIII.

Lepidodendron Harcourtii.

Fig. 1 (No. 31). A transverse section of a stem from the Coal-measures near Dudley. Magnified 3¾ diameters.

Fig 2. A longitudinal section (from the centre to the circumference) of the stem. Magnified 4 diameters.

In this and the following plates the same parts of the specimens figured are indicated by the same letters, as follow :—

a. The middle part, showing the central axis or pith, composed of orthosenchyma.

b. The large scalariform tubes forming the inner portion of the woody cylinder.

c. The smaller scalariform tubes forming the outer portion of the woody cylinder, from which the vascular bundles communicating with the leaves or rootlets proceed.

d. The vascular bundles, proceeding from the woody cylinder and extending to the leaves or rootlets.

e. The mass of parenchymatous tissue, at first (near to the woody axis) of a fine and lax character, but increasing in size and strength as it proceeds outwards, until it becomes prosenchymatous.

f. The elongated utricles or tubes, arranged in radiating series, forming the outer zone next the epidermis.

g. The epidermis, converted into coal.

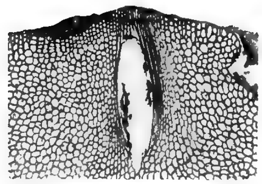
Fig. 3. A longitudinal section of a portion of the stem, showing part of the pith, the inner and outer portions of the woody cylinder, the origin and structure of the vascular bundles, and the delicate parenchyma traversed by them. Magnified 7 diameters.

Fig. 4. A longitudinal section of a portion of the outer part of the stem, exhibiting the coarse parenchymatous tissue, gradually passing into prosenchyma, and thence into elongated utricles or tubes; and the epidermis. Magnified 12 diameters.

Fig. 5. A nearly right-angled transverse section of one of the vascular bundles, near the outside of the stem, displaying the vascular axis, surrounded by a zone of orthosenchymatous tissue, then a regular circle of fine parenchyma, and the mass of coarse parenchyma in which the whole is imbedded. Magnified 24 diameters.

Fig. 6. A transverse section of a part of the stem near the outside, showing the coarse parenchyma traversed by a vascular bundle, and a portion of the outer radiating cylinder, and the epidermis. Magnified 5 diameters.

Fig 6



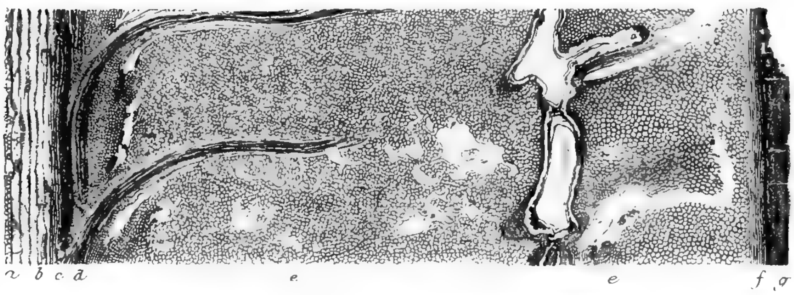


Fig 2

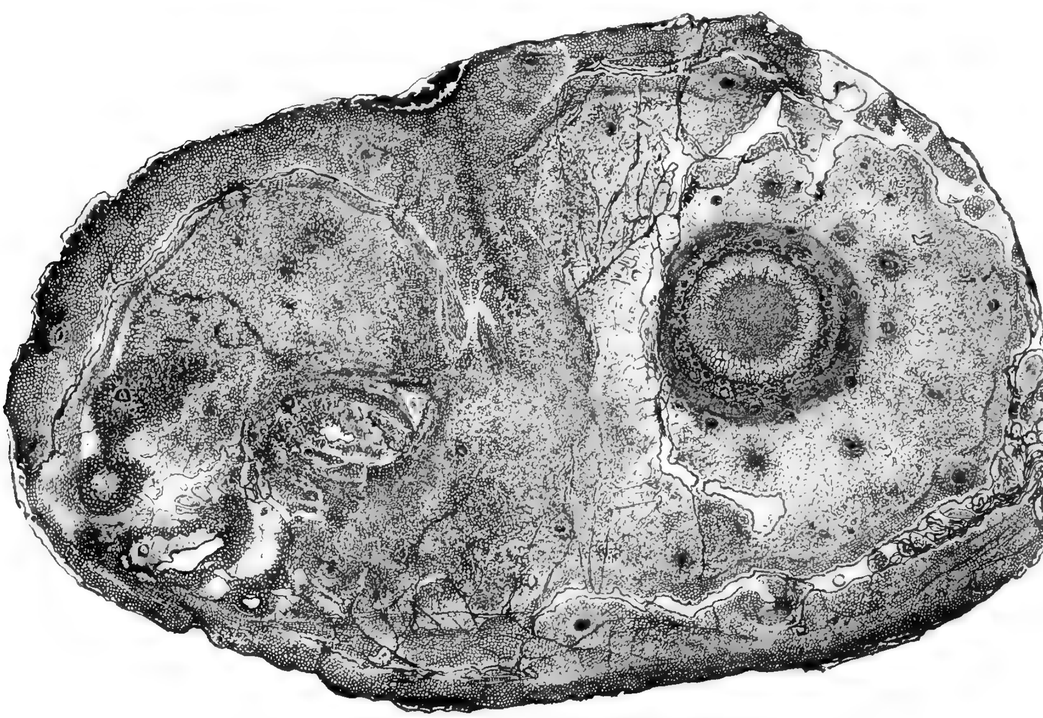


Fig 1

No. 31

Fig. 5

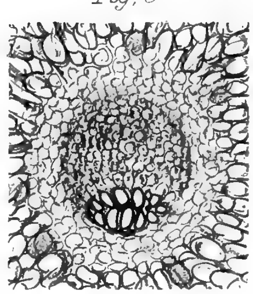
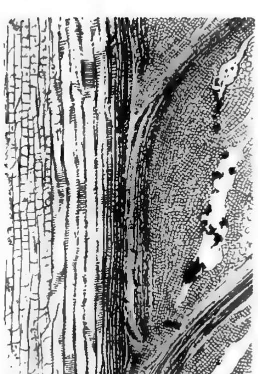


Fig 3



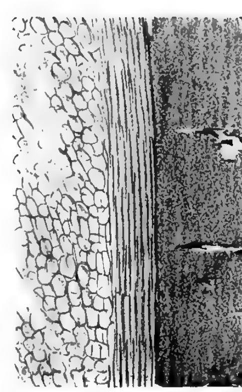


Fig 4

J. N. Fitch del. et Lith

F. Fitch, imp

PLATE XIV.

Lepidodendron Harcourtii.

Fig. 1 (No. 32). A portion of a stem cut transversely, showing the rhomboidal scars and the leaf-attachments on the outside, and the two vascular axes of a horseshoe shape in the inside. This stem is cut across, probably at a point just before it commenced to divide in two. Natural size.

Fig. 2. One of the horseshoe-shaped bodies, showing vascular scalariform structure on its outside margin. Magnified $3\frac{1}{2}$ diameters.

Fig. 3. The other. Magnified $3\frac{1}{2}$ diameters.

Fig. 4 (No. 33). *Sigillaria vascularis.* A transverse section of the stem, showing two woody cylinders, with an apple-shape section, cut across at a point before the stem began to dichotomize. From the Bullion seam of Coal at Spa Clough, near Burnley. Magnified $3\frac{1}{2}$ diameters.

Fig. 5. Section of one of the central bodies, showing large detached (scalariform) vessels in fine orthosenchymatous tissue in the middle, and a woody cylinder of (scalariform) tubes or utricles, gradually diminishing in size as it goes outwards towards a radiating cylinder of barred tubes in wedge-shaped masses. Magnified 10 diameters.

Fig. 6. The other. Magnified 10 diameters.

Fig 1.

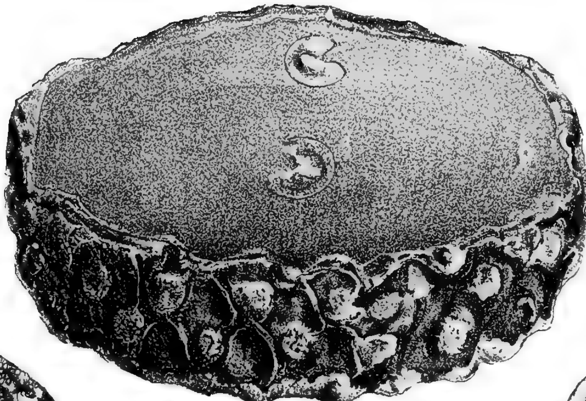
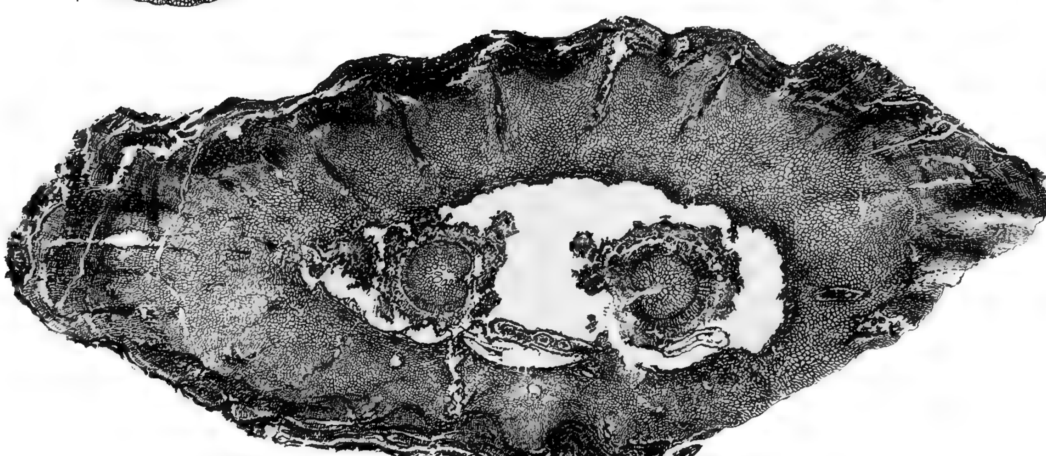


Fig 2

No. 32.

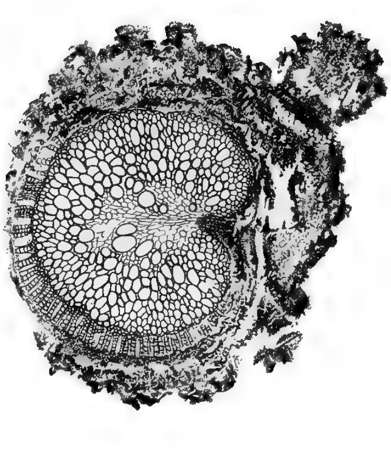
Fig 3

Fig 4



No. 33.

Fig 5



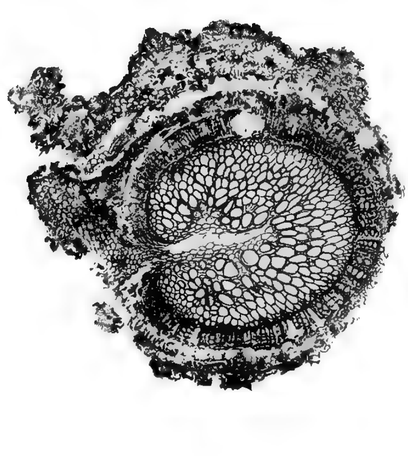


Fig 6

J N Fitch del et Lith

[illegible] imp

PLATE XV.

Halonia regularis.

Fig. 1 (No. 34) represents a transverse section of a root, exhibiting a disarranged woody cylinder and the mouths of numerous vascular bundles traversing the parenchymatous tissue, of which it was chiefly composed. From the Coal-measures near Dudley. Magnified $3\frac{1}{5}$ diameters.

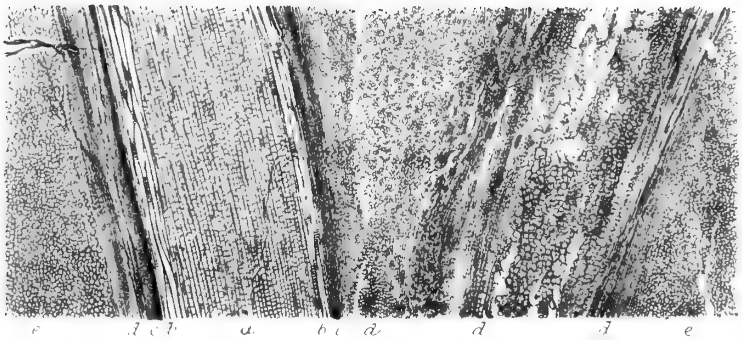
Fig. 2. A longitudinal section of a portion, showing the medulla, composed of orthosenchyma, surrounded by a woody cylinder of scalariform tubes, from which proceed vascular bundles (several of them being displayed). Magnified 4 diameters.[1]

Fig. 3. A longitudinal section of a portion of the centre of the root, showing the medulla and the woody cylinder. Magnified 8 diameters.

Fig. 4. A transverse section (at nearly right angles) of one of the vascular bundles, near the outside of the root. Magnified 25 diameters.

[1] The artist has represented in fig. 2 the specimen as a stem, and not as a root, as we believe it to be. In order, therefore, to show the true direction of the vascular bundles leading to the rootlets, the figure should be reversed.

Fig 2



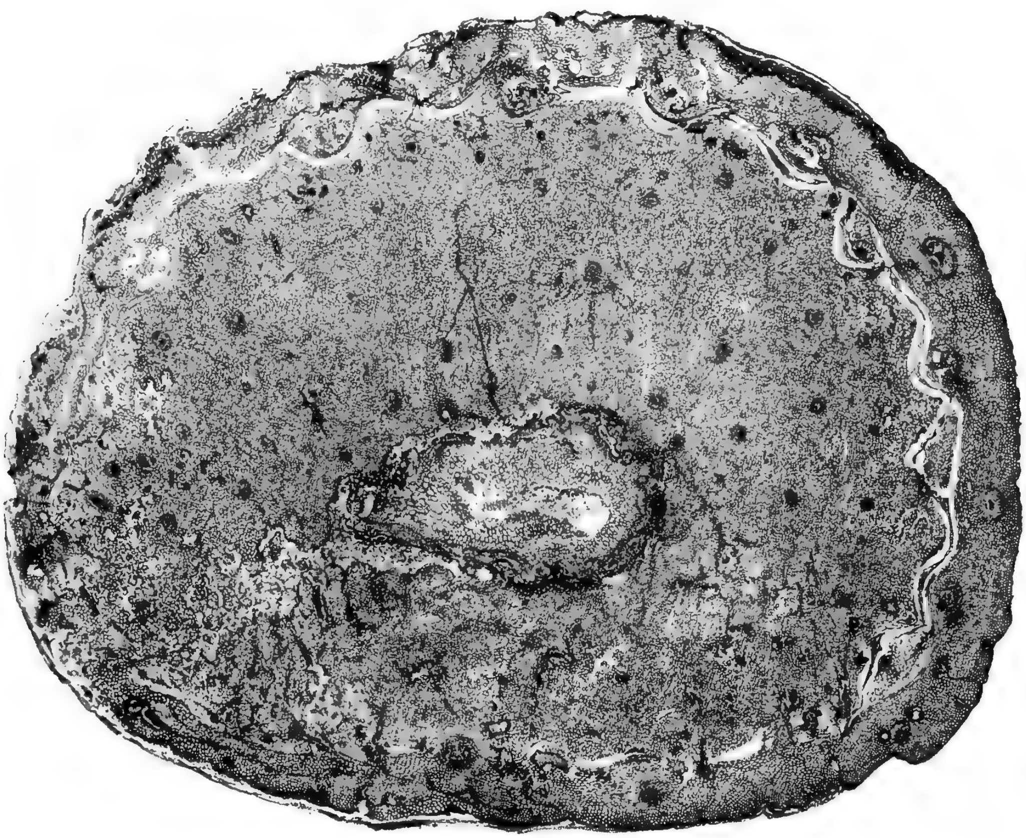
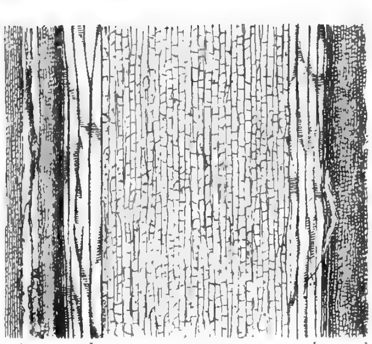


Fig 1

N° 84

Fig 3



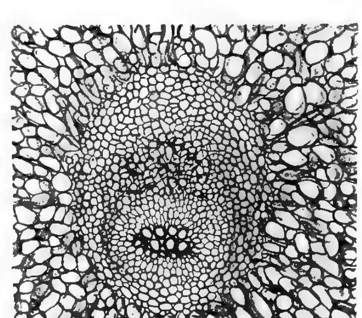


Fig 4

J N Fitch del et Lith

F Fitch imp

PLATE XVI.

Halonia regularis.

Fig. 1 (No. 35) represents a portion of a root, showing the tubercles, having a raised central pimple, and the woody axis in the inside of the root. From the Upper Brooksbottom seam of Coal, Lancashire. Natural size.

Fig 2. A transverse section of the root, showing the medulla, woody cylinder, a vascular bundle, portions of the parenchyma, and the outer radiating cylinder. Magnified 5 diameters.

Fig. 3. A longitudinal section of the root, representing the medulla, vascular cylinder, parenchymatous tissue, and outer radiating zone. Magnified 10 diameters.

Fig. 4. A transverse section of the medulla and woody cylinder. Magnified 10 diameters.

Fig. 5. A transverse section (nearly at right angles) of one of the vascular bundles in the inside of the root. Magnified 40 diameters.

Fig 1

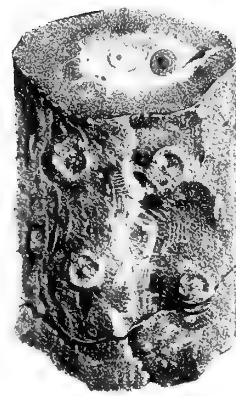


Fig 4

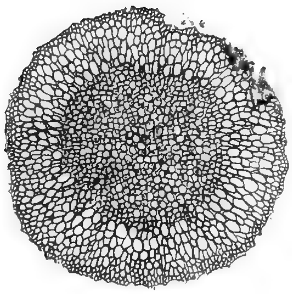


Fig 5

No. 35

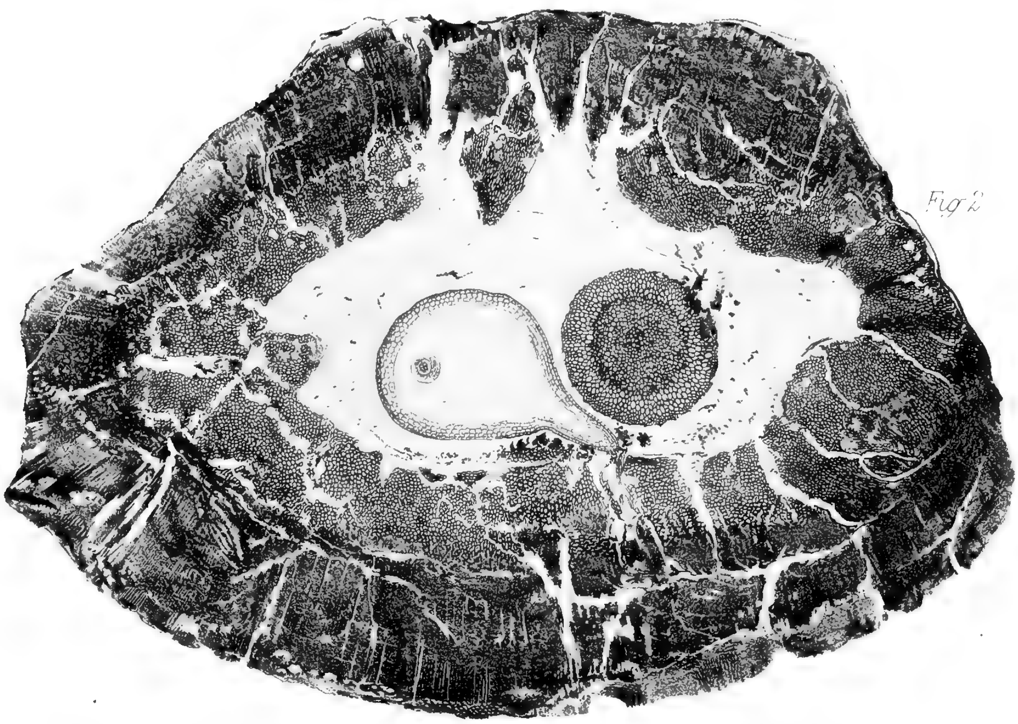
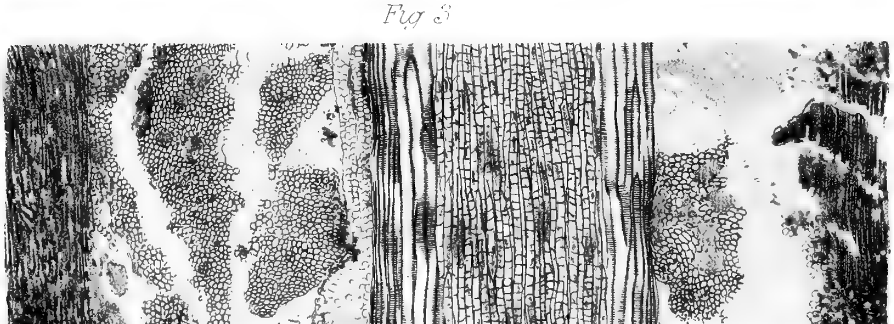


Fig 2

Fig 3



Fitch del. et Lith [illegible] imp

PLATE XVII.

Halonia regularis.

Fig. 1 (No. 36). A portion of a root, showing the depressed areolæ with a central raised pimple. From the Upper Brooksbottom seam of Coal, Lancashire. Natural size.

Fig. 2. A transverse section of the same root, showing the medullary axis, the woody cylinder, the parenchyma (passing gradually into prosenchyma), and the epidermis. Magnified 5 diameters.

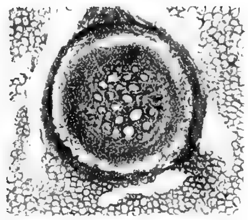
Fig. 3. A transverse section of one of the raised papillæ in the areolæ, showing the vascular tubes surrounded by a space formerly occupied by orthosenchymatous tissue, and succeeded by a zone of fine parenchyma. Magnified 20 diameters.

Fig. 4 (No. 37). A forking portion of a root, from the Upper Brooksbottom seam of Coal, Lancashire. Natural size.

Fig. 5 is a transverse section of the root, showing the medulla and vascular cylinder divided across, surrounded by the parenchymatous tissue, with the outer zone and the thick epidermis. Magnified 5 diameters.

Fig. 6 is a transverse section of the medulla and the woody cylinder; the unshaded portion indicates their division. Magnified 10 diameters.

Fig 3



Fig

Nº 37

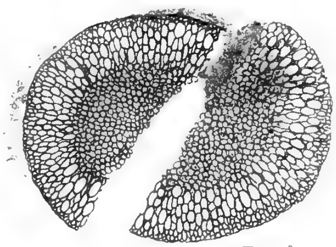
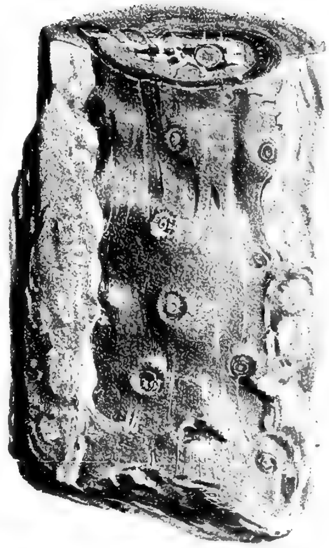


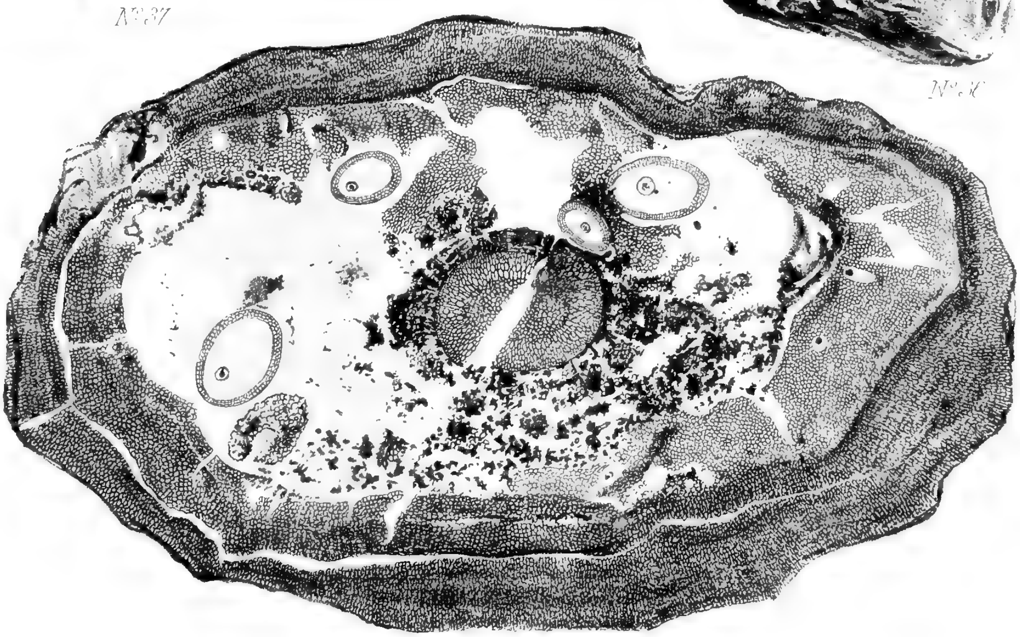
Fig 6

Fig



Nº 36

Fig 1



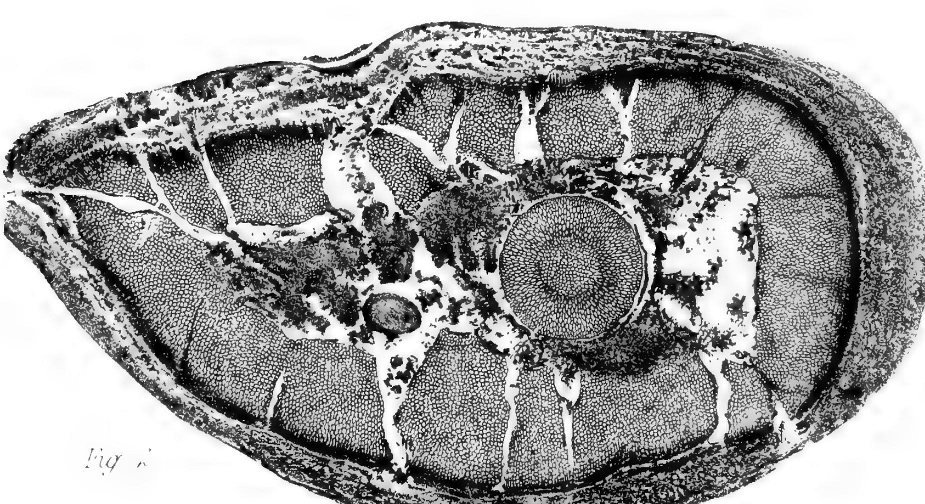


Fig 2

J H Fitch del et Lith

W Fitch imp

PLATE XVIII.

Halonia regularis (No. 38).

This drawing represents the outside of a specimen, partly coated with its epidermis (converted into coal), and partly bared. Thus are seen both the areolæ and the tubercles, according to the condition in which the outside of the specimen is exposed. From the Peel Delph, near Bolton-le-Moors. Natural size.

Plate XVIII

No. 38

W. H. Fitch del et Lith

B. Fitch imp

THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

VOLUME FOR 1871.

LONDON:
MDCCCLXXII.

A MONOGRAPH

OF THE

BRITISH FOSSIL CRUSTACEA,

BELONGING TO THE

ORDER MEROSTOMATA.

PART III.

[PTERYGOTUS AND SLIMONIA.]

PAGES 71—120; PLATES XVI—XX.

BY

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

OF THE BRITISH MUSEUM.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1872.

PRINTED BY

J. E. ADLARD, BARTHOLOMEW CLOSE.

A MONOGRAPH

OF THE

BRITISH FOSSIL CRUSTACEA

OF THE

ORDER MEROSTOMATA.

PART III.

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

Species 3.—PTERYGOTUS RANICEPS:—H. Woodward. 1868. Pl. XVI, fig. 1.

PTERYGOTUS RANICEPS, *H. Woodward.* Quart. Journ. Geol. Soc., 1868, vol. xxiv, p. 294, pl. ix, fig. 3.

OUR knowledge of this species is confined to a single specimen obtained, like the preceding one, by Mr. Robert Slimon from the hard flaggy shales (Upper Silurian) of Logan Water, near Lesmahagow, Lanarkshire (see pages 46—52).

Head-shield obtusely triangular. Eyes prominent, marginal. Breadth of posterior border of carapace 6 lines; greatest length 4½ lines, from posterior border to eyes 3 lines; breadth of carapace at eyes 3½ lines; diameter of eye 1 line.[1] A small depression marks the centre of the carapace between the eyes, and a small elevation may be seen slightly posterior to them, also on the median line. Larval eye-spots not visible. Length of the six segments 7½ lines, greatest breadth 9 lines; no ornamentation is preserved upon any part of the integument.

The specimen here described and figured is preserved in the British Museum.

REMAINS OF PTERYGOTUS FROM THE WEST OF ENGLAND.

The following *seven* species[2] are given upon the authority of Mr. J. W. Salter, the late eminent Palæontologist to the Geological Survey, who had devoted many years to the investigation of this group; namely:

[1] This tubercle probably marks the position of the ocelli.

[2] An eighth species, *Pterygotus punctatus*, Salter, has, since its publication, been determined to belong to the genus *Eurypterus* (see 'Quart. Journ. Geol. Soc.,' 1868, paper by H. Woodward, "On some New Species of Crustacea," &c., vol. xxiv, p. 290, plates ix and x).

PTERYGOTUS BANKSII, *Salter*. U. Ludlow Rock and Passage-Beds, Ludlow, Whitcliffe, &c.
— TAURINUS, *Salter*. U. Silurian, Ewyas-Harold, Herefordshire.
— LUDENSIS, *Salter*. Old Red Sandstone, Ludlow, Trimpley, &c.
— GIGAS, *Salter*. Downton Sandstone and Passage Beds, Kington, Hereford.
— PROBLEMATICUS, *Salter*. U. Ludlow Rock, and Passage Beds, Whitcliffe, Ludlow Cornstones, Old Red Sandstone, &c.
— ARCUATUS, *Salter*. L. Ludlow Rock, Church Hill, Leintwardine.
— STYLOPS, *Salter*. U. Silurian, Kington.

With the exception of *Pterygotus Banksii*, they are founded upon well-marked fragments only—which, however decisive as to their specific distinctness, need further confirmation by the discovery of more perfect remains.

Save in a few instances, therefore, it has not been thought desirable to redraw these detached portions, but rather to refer the reader to the large series of remains figured in the Geological Survey Monograph by Messrs. Huxley and Salter, and to reprint the descriptions of species as given by the latter,[1] merely correcting any obvious errors and making such few additions as we are enabled to do with confidence by our increased acquaintance with the more complete examples from other localities.

Should more perfect remains be discovered, as there is every encouragement to hope may be the case, we may yet, at some future day, figure as entire examples of these West of England *Pterygoti* as we have been enabled to do of those from beds of the same age in Scotland.

Species 4.—PTERYGOTUS BANKSII:—Salter. 1859. Pl. XVI, figs. 2—6.

HIMANTOPTERUS BANKSII, *Salter*. Quart. Journ. Geol. Soc., 1856, vol. xii, p. 32 and p. 99, pl. ii, fig. 5.
— — Siluria, 2nd ed., 1856, p. 266, foss. 66, fig. 1.
PTERYGOTUS BANKSII, *Salter*. Mem. Geol. Surv., Mon. I, 1859, p. 51, pl. xii, figs. 22—46.
— — Siluria, 3rd edit., 1859, p. 540.
— — Ibid., 4th edit., 1867, p. 239.

Named in honour of Richard Banks, Esq., of Kington, Hereford, who has made rich collections of the *Pterygoti* of that locality.

This small neat species, of which there are many specimens, both in the British Museum and in that of the Museum of Practical Geology, occurs with *Pterygotus gigas*, and spines both of Crustacea and fish, in the yellow tilestones[2] (Downton Sandstone) beds

[1] If we omit *Eurypterus* (*Pterygotus*) *punctatus* (which occupies nearly two folio plates, and has twenty-eight figures devoted to its illustration), and *Pt. taurinus* (which was not published until 1868), the six remaining species occupy four folio plates and are illustrated by ninety-seven figures; all are in a very imperfect state of preservation, and consist only of detached plates and appendages.—H. W.

[2] Referring to this term the Rev. W. S. Symonds, M.A., F.G.S., Rector of Pendock, near Tewkesbury (who has paid especial attention to the geology of this district), writes as follows:—" The word ' tilestones'

of Kington, Herefordshire. It is associated with the *Platyschisma helicites* and *Lingula cornea* (Sil. Syst.). These are the two species of shells which accompany the fossils of Lesmahagow above described; a good argument, therefore, even without other evidence, for regarding these Lesmahagow beds as the uppermost portions of the Ludlow rocks.[1]

The full size must have been from four to five inches long, but the specimens usually met with would probably not be above three or four inches. One or two show the connection of the body-rings with the head (Pl. XVI, fig. 5) and appendages, or with the tail joints (fig. 4). None are quite complete, and though we have nearly all the parts they are usually disjointed.

The carapace (Pl. XVI, figs. 2 and 3) is a broad semioval; its length is as six to seven, except when lengthened or shortened by pressure. It is regularly convex, a little produced in front, smooth, and bears the small oval eyes rather more than half way up the head. They are much smaller than in *Pterygotus bilobus*, being not above one fourth the length of the carapace, and very convex.

The body is at first wider than the head, and then tapers backwards (Pl. XVI, fig. 5). The first ring is very narrow; the second twice as broad, and with the usual dilated extremities; the third, fourth, and fifth somites strap-shaped, arched in the middle, and direct on the sides, so that the segment appears much bent. The ends are truncate, in the anterior rings widest behind, and in the posterior ones tapering backwards.

The hinder rings (Pl. XVI, fig. 4) become gradually less transverse, the eleventh only two and a half times wider than long, and the twelfth above once and three quarters its own length.

The caudal joint (telson) differs, in its expanded form, materially from that of *Pterygotus bilobus*. It is about three fourths as long as wide; narrow at the base, with two short ridges running down from either angle; then expanded with somewhat convex sides towards the wide subtruncate apex; the outer angles are rounded off, the terminal notch shallow, and a short median keel continued from it one third up the segment.

The sculpture of the head is not known. On the body-rings a transverse lineation, running into open plicæ on the sides, occupies the front margin for not quite half the segment; a few plicæ are intermixed with the lines.[2]

(now happily abandoned by Sir R. I. Murchison) is altogether inappropriate as applied to the Ledbury rocks. There is not a stone capable of being formed into a *tile*, from the Downton sandstone to the Cornstones of Wall Hills; but there are thin muddy marls over the Downton beds, which would have been tilestones had they sufficiently hardened, and which are doubtless the equivalents of the true tilestones. I consider, therefore the term 'passage-rocks,' as used by Sir R. Murchison in the last edition of 'Siluria' to be the more appropriate appellation for these transition beds, and one which allows to the palæontologist as well as the physical geologist, a broad margin for the line of demar ation between the two great epochs of the Silurian and the Old Red." ('Quart. Journ. Geol. Soc.,' Lond., 1860, vol. xvi, pp. 193—197.)

[1] 'Quart. Journ. Geol.,' vol. xii, 1856, p. 32. See also Part II of this Monograph, pp. 46—52.

[2] On a caudal joint (pl. xii, fig. 46, Mem. Geol. Surv., Mon. I) a lineation, parallel to the outer border,

The *Antennæ* (Geol. Surv. Mem., Mon. I, pl. xii, figs. 30 and 40) are remarkably slender and straight; the base is large and broad, suddenly attenuated into the shaft, which is only a tenth of an inch wide, and three quarters of an inch long, beset with close small teeth, and furnished with three larger conical ones nearly straight; the central one as long as the width of the shaft. In the fragment of an antenna figured by Mr. Salter (Mon. I, pl. xii, fig. 40) from the Ludlow Rocks, the intermediate teeth are a little longer in proportion.

Ectognaths.—The basal joints are flask-shaped, much more elongate in the neck than those of *P. bilobus,* and less swelled at the base. [It is possible, Mr. Salter adds, they may not belong to this species at all, but to *Eurypterus linearis,* a species which occurs in the same beds; we do not yet know this joint in *Eurypterus.*[1]] The base is subquadrate, quite rectangular on the outer upper margin; the notch for attachment of the other joints is immediately beneath this angle, and tapering into the long neck, which has a sharp ridge posteriorly, and, together with the terminal lobes, equals the length of the basal portion. The teeth are minute.

The *Swimming-foot* (Pl. XVI, fig. 5) has a characteristic shape; the upper joints (fourth and fifth) are rather narrow; and the penultimate (*p*), instead of being simply conical, as in *Pt. bilobus,* is ovate, with the outer border especially convex. It is notched above to receive the fifth joint, and below divided into very unequal lobes. The terminal palette (*d*) is true oval, rather blunt at its origin, and more pointed at the extremity. It is nearly equal to the penultimate joint in length, but considerably narrower.

The *Post-oral plate* (Pl. XVI, fig. 6) differs a little in shape, but not specifically, unless the greater amount of ornament in some specimens be considered sufficient to separate it. The shape is elongate oval, the greatest width is at the upper third, the base is subtruncate, the apex has a shallow obtuse notch. At the lower fourth there is evidently a tubercle of attachment, and such as occurs in a more linear shape in other species. [It is desirable to find out the post-oral plate of *Eurypterus,* which is probably very similar.]

The sculpture is very conspicuous over the upper half; it consists of nearly straight or very slightly curved plicæ arranged in arched lines, and ending abruptly against the outer margin. In the sandstone specimens the sculpture does not extend so far down, but it is identical in structure.

Localities.—Upper Ludlow Rock, Ludlow Lane, Whitcliffe (and Batchcot?), Parlan, exterior slope of the Woolhope Valley (Mus. P. G.), Kington, Herefordshire (Mr. R. Banks' cabinet), Passage Beds, Ludlow Railway cuttings (cabinets of Messrs. Lightbody and Marston, Ludlow Museum, British Museum, and Museum of Practical Geology, Jermyn Street.)

is distinct, but it is uncertain if this specimen be of the same species; it has a strong median groove down the under side, and is less expanded in form than *P. Banksii.*

[1] Several of these minute detached basal joints are figured by Mr. Salter (see Mem. Geol. Surv., Mon. I, pl. xii, figs. 29 and 29*a*), but as they present no character of importance, and as their connection with *Pt. Banksii* seems doubtful, we have not thought it needful to reproduce them here.—H. W.

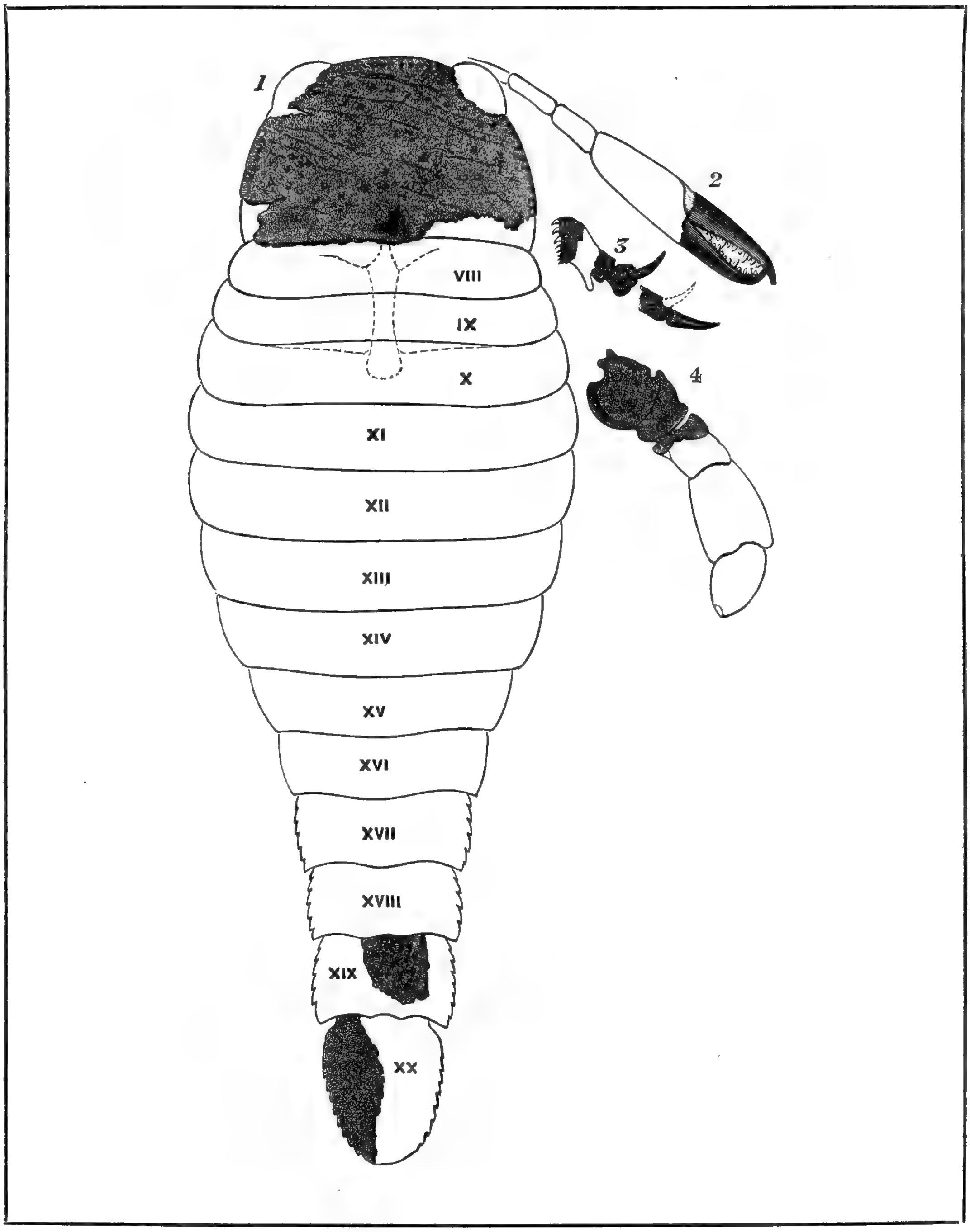


FIG. 14.—*Pterygotus taurinus*, Salter. Ledbury series, Ewyas Harold, Herefordshire. After a sketch by Mr. J. W. Salter, F.G.S. (For description see page 76.)

The shaded parts, namely, 1. the head-shield; 2, the chelate antenna; 3, the endognath; 4, the ectognath, or swimming-foot; and parts referred by Mr. Salter to the penultimate segment (XIX); and the last segment or "telson" (XX); are alone preserved.—H. W.

Species 5.—PTERYGOTUS TAURINUS:—Salter. 1868. Woodcut, Fig. 14, p. 75.

PTERYGOTUS TAURINUS, *Salter*. Report Brit. Assoc., Norwich Meeting, 1868. Trans. of Sections, p. 78.

This new species was obtained from the lowest Old Red, or Ledbury Shales formation. It is a very large one, and must have measured 7 feet in length when perfect. Its head is very square; the base of the swimming-foot small in proportion to that of other species. The chelate antennæ have the apices very greatly hooked and the teeth close. Only fragments of the body-rings have been found. The tail-joint appears to have been oval. The specimens were found at Ewyas Harold, and are in the cabinet of Dr. McCullough, of Abergavenny.

The Woodcut, given on page 75, is reproduced from an original sketch by the late Mr. J. W. Salter, drawn at the time his note was written. The parts known only are shaded; the outline was intended by Mr. Salter to convey an idea of the general form.

Measurements given by Mr. Salter:—

1. Head a foot wide.
2. Portion of chelate antennæ preserved, 6 inches long.
3. Portions of two palpi, 4 inches.
4. Basal portion of swimming-foot, 5 inches.

Species 6.—PTERYGOTUS LUDENSIS:—Salter. 1859. Pl. XVI, figs. 7—9.

PTERYGOTUS LUDENSIS, *Salter*. Mem. Geol. Surv., Mon. I, 1859, p. 79, pl. xiv, figs. 1—13; pl. ix, fig. 18?; pl. xii, figs. 1—5 (and 6?).
— — *Salter*. Siluria, 4th edit., 1867, p. 140, and p. 238.

Under this name Mr. Salter describes, with but little doubt of its specific distinctness, the fragments of a fine species very abundant indeed in the transition beds of Ludlow, shown as they are in the railway cutting near that town. All the specimens are in the cabinets of Mr. Lightbody and his son. The same species is found at Trimpley, near Kidderminster, and we are indebted to the late Mr. G. E. Roberts for the means of illustrating some points not clear in the specimens at Ludlow.

The materials consist of several body-rings[1] of a large size (Pl. XVI, figs. 7 and 8); a fragment of the caudal joint;[2] a specimen showing nearly all the body-joints and telson in position, but a good deal obliterated; the serrate basis of the swimming-feet, mandibles with palpi, antennæ; and to these must be added the post-oral plate, the bilobed

[1] Mem. Geol. Surv., Mon. I, pl. xiv, figs. 2, 3, 4, 11: these are all fragments merely.—H. W.

[2] Ibid., fig. 12; only a fragment.

" (abdominal ? appendages,"[1] and possibly a portion of a swimming-foot, together with an imperfect caudal joint. (Mem. Geol. Surv., Mon. I, pl. xii, figs. 4—6.)

The two last may, however, belong to *P. gigas,* a species very nearly allied, and to which (says Mr. Salter) for some time I believed the whole of the specimens referable. Again, there is so much resemblance in certain points to the Scotch species, *P. anglicus,* that it requires nice discrimination to separate the three forms. The characters of the antennæ, and also of the caudal joint, will, I think, be sufficient. And if subsequent observation should tend to show that this "Tilestone" species is the opposite sex of the *P. gigas,* it will still have been worth while provisionally to separate them.

Body-joints.—The complete specimen (Pl. XVI, fig. 7) shows that the body was not greatly elongated, the segments being all rather widely transverse, the eighth, for instance, being fully four and a half times as wide as long; the ninth and tenth are gradually narrower, but the eleventh still shows a width two and a half times greater than the length, while in *P. anglicus* the corresponding joint appears to have been no more than one and a half times the length.

The penultimate joint is squareish, or rather inversely conical, not much expanded below. It is about one fourth wider than long, as in *P. anglicus,* and this at the hinder part only. A strong central keel runs down its whole length, covered with large squamæ, and the margins are similarly ornamented. (See Pl. XVI, fig. 8.) If the caudal joint (Mem. Geol. Sur., Mon. I, pl. ix, fig. 18) be of this species, it has lost the terminal apiculus. It is nearly elliptical, the base truncated. It is fully four inches long.

The sculpture of the body-rings consist of open semicircular squamæ, flattened along the anterior border and more convex behind, occupying the anterior half of the segment in the front rings, and more in the hinder ones, till, in the ninth and tenth, they nearly cover the segment. On the sides they are more elongated, and, as in other species (*P. gigas,* for instance), those on the upper side are more elongate and pointed than those on the lower. All the plicæ are prominent and sharp-edged. There are very few intermediate ones, but the surface of the cuticle is generally roughened between the plicæ. Some segments show the plicæ very large, and must have been at least fourteen inches broad. Other specimens in the Ludlow Museum show four or five rings overlapping, and some are subcylindrical, and with sharp edges. The caudal joint is broad-oval and shortly apiculated, less abruptly so than in *P. anglicus,* which, too, has a less regularly oval form, the greatest breadth being below the middle. It is marked all the way down dorsally by a strong carina covered with broad squamæ, and the edges are also squamate in two or three rows. In the specimen from Trimpley, the sides are marked by oblique radiating interrupted lines.

The *Thoracic plate* ("Epistoma and Labrum," Salter) is as large as that of *Pt. anglicus,* and nearly like it in all its parts.

[1] These are still undeterminable; they may be cephalic, or thoracic appendages, they are clearly *not* abdominal; they probably do not belong to this genus at all: see figures 25—27, page 91.—H. W.

Antennæ.—These resemble in general form those of *P. anglicus,* but have a more slender shaft, tapering more quickly and narrower and with more conical teeth. The teeth are intermediate in form between the species above mentioned and *P. problematicus,* the central one being long-lanceolate, and the secondaries narrow, conical, and with coarse striæ. The base of the fixed claw is furnished with a set of stiff spines, as in *P. problematicus,* but the whole chela is proportionably much shorter.

Endognaths.—Of these there seem to be *three* pairs, as in *P. anglicus,* and of very similar shape. The joints of the palpus, like those of *P. gigas,* have a squamose ridge, along each side, and the ends of the joints are bilobed. The second joint is three and a quarter times as long as broad. This is nearly the proportion in *P. anglicus,* where it is three times the breadth. (See Woodcut, below, Fig. 16.)

The other pairs of jaws have their anterior margin more curved, and the teeth set on a more convex edge than in *P. anglicus.* The first tooth is set more backward, thick, and curved at the base, and all are more curved than in the Scotch species.

The *Post-oral plate* may belong either to this or to *P. gigas* (see Woodcut, Fig. 18, p. 84).

Base of Swimming-foot (Pl. XVI, fig. 9).—These portions are very characteristic in all the species. In this the shape most nearly resembles that of *P. gigas,* and the teeth are short and blunt, as in that species, but the neck is shorter. From *P. anglicus,* the shorter form, the short neck, blunt teeth, and convex upper lobe overhanging the teeth distinguish it; but the sculpture raised into thick, prominent, boss-like plicæ is almost identical. The lower edge is tuberculate, and even spinous; our figure does not show this part. A little comparison of this specimen with *P. anglicus* will show that both in the upper or front edge and on the lower or hinder edge the terminal lobe is more prominent in *P. ludensis.*

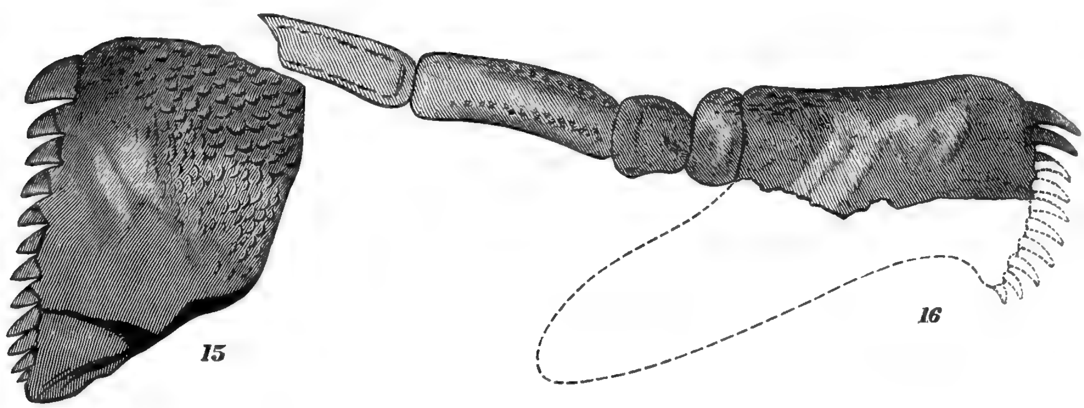


Fig. 15.—Mandibular border of ectognath of *Pterygotus ludensis,* Salter, from Mr. Lightbody's Cabinet.
,, 16.—An endognath of *Pt. ludensis,* with its palpus. Museum Pract. Geology. Both specimens from the Basement-beds of the Old Red Sandstone, Ludlow Railway, Ludlow.

Thoracic Appendages[1] (?) (Mem. Geol. Surv., Mon. I, pl. xii, figs. 4 and 5).—The nature of these is not understood, nor do these specimens show the characteristic irregular base. But they differ specifically both from the similar appendages referred to *P. problematicus* and *P. arcuatus*, by their deep terminal notch. The outer edges are thickened, and the substance of the whole appendage is thick. The lateral plicæ run down in oblique rows on the inner (?) surface becoming more and more linear, till they become straight lines, like the pennæ of a feather, and on the outer side; impressed distant converging striæ cut up, as it were, the whole surface into narrow bands, the termination of these bands being serrated projections in *P. problematicus,* but in this species they come to an even edge on the notched border.

Ovisacs (?).—The egg-packets (*Parka*), found in plenty with this species at Trimpley, show the membranous veil in several cases. The ova of considerable size, generally oval, and placed a little apart in the younger packets, but they become hexagonal or polygonal, from mutual pressure, in the older ones (see Pl. XVI, figs. 10 and 11).

Localities.—Base of the Old Red Sandstone, at Ludlow Railway Station (abundant); at Trimpley, north of Bewdley, associated with *Pteraspis Banksii.*

Species 7.—PTERYGOTUS GIGAS :—Salter. 1859.

PTERYGOTUS GIGAS, *Salter.* Mem. Geol. Surv., 1859, Mon. I, p. 83, pls. viii and ix.
— PROBLEMATICUS, *Banks.* Quart. Journ. Geol. Soc., vol. xii, 1856, p. 93, &c.

Although there are very strong grounds for considering the remains referred to this species to be only English representatives of the great Scotch *Pterygotus anglicus,* figured in Part I of this Monograph, we have not treated it here as synonymous because we have no new or more perfect materials to offer than those heretofore described in the 'Geological Survey Monograph.' Therefore, in deference to Mr. Salter's determination, we retain the species, giving his diagnosis, with only a few additional notes where needed.

For some years a large *Pterygotus* has been known in the beds of Downton Sandstone (Uppermost Ludlow Rock), worked for building purposes at Kington, Herefordshire, and a description of many of its parts was given by Mr. R. Banks, of Ridgbourne, in the 'Quarterly Journal of the Geological Society' for 1856. Since his description was written he has continued to labour assiduously to collect the fragments, and has been fortunate enough to discover nearly all the parts of this fine species. He has generously placed these fragile specimens in our hands, and presented a series of excellent drawings which were formerly exhibited at the Geological Society. In the paper quoted above the

[1] I am at present quite unable to decide the true position of these fragments. (See Woodcut, Figs. 25—27, p. 91.)—H. W.

fragments were all considered to belong to the *P. problematicus* of Agassiz, a species for which there is unfortunately very scanty material, but which, as originally described, is a Ludlow Rock species identical with one of the Kington fossils, but not apparently with the principal and largest of them, here described, and which in many respects is very like *P. anglicus*.

P. gigas has, in common with the latter species, the open scale-like sculpture on the body-rings, and the thick tubercular scales on their margin ; the shape of the *epistome*[1] and head is very similar, but the latter is rounded, and not truncate in front.[2] The penultimate body-ring is wider and has a short keel on the upper surface only (while *P. anglicus* has one on both sides above and below),[3] and the tail-joint or telson appears to be emarginate instead of pointed. But if this character should be deceptive, there can be no doubt of the specific difference, since this joint is furnished with a most remarkable elevated crest or ridge, nearly half an inch high, which is quite absent in the Scotch species.[4]

As the fragments indicate a species of the largest size, the above specific name will not be inappropriate. The size of the chelate antennæ exceeds that of any known species.

There are two species in the Kington beds, *P. gigas* and *P. problematicus*, and it was, of course, possible that some of the parts assigned to the former might belong to the latter species. The subsequent discovery of nearly all the parts of *P. problematicus* shows that in this instance the fragments have been rightly collocated.

Head or *Carapace* (pl. viii, fig. 1, Mem. Geol. Surv., Mon. I).—Nearly semi-oval, convex, the width three inches and three quarters at the broad base, probably greater than the length. The specimen being imperfect behind, the true length is not known, but the portion preserved is three inches and a quarter long. The eyes are very large, three quarters of an inch long, oval, and prominent beyond the margin. They are placed very near the anterior end, and the space between them on the margin is about an inch and three quarters, while between the convex inner edges of the eyes it is about an inch and a half. The anterior border is arched and very slightly angular in front, with a crenulate edge. The sides are convex, their margin not visible. (See Woodcut, fig. 17, p. 81.)

In the centre of the carapace, and forming an equilateral triangle with the eyes, is an elongate tubercle. The general surface appears somewhat rugose (see Woodcut, fig. 17).

[1] Thoracic plate, not epistome.—H. W.

[2] The head in *Pterygotus anglicus*, Ag., is now known to be rounded in front, not trapezoidal, as was believed to be the case in 1859, when the above description was penned (see *antè*, Part I, p. 36, Pls. I and II).—H. W.

[3] This appears to be an error. In *Pt. anglicus* the penultimate segment is only keeled upon the dorsal surface (see *antè*, Part I, p. 42, fig. 6, Pl. III, fig. 2, and Pl. VIII).—H. W.

[4] The Scotch species is proved to have a well-marked keel to the telson (see Part I, p. 42, Pl. II, fig. 1, and Pl. VI). In Pl. II, fig. 1, the young and perfect Pterygotus there drawn has a high ridge to the telson, which is clearly seen folded down towards the right side of the tail-plate. In Pl. VI it is erect and thickened into a strong keel by reason of the greater age of the individual.—H. W.

Thoracic Plate (formerly called the *Epistoma*, pl. viii, fig. 2, Mem. Geol. Surv., Mon. I).—The proportions of this plate and its sculpture are very like those of *P. anglicus*, and specimens figured indicate this part to be quite as large as in that species. The plicæ on the upper or front portion are crowded, and but slightly curved; those further back are semicircular or even semi-oval, while those near the apex of the side lobes are narrower and pointed as in the cognate species. Similar but smaller plicæ occur down the centre lobe, which does not appear to have prominent elongate scales, nor is it convex as it is in *P. anglicus*. Its base is broad and spear-shaped.

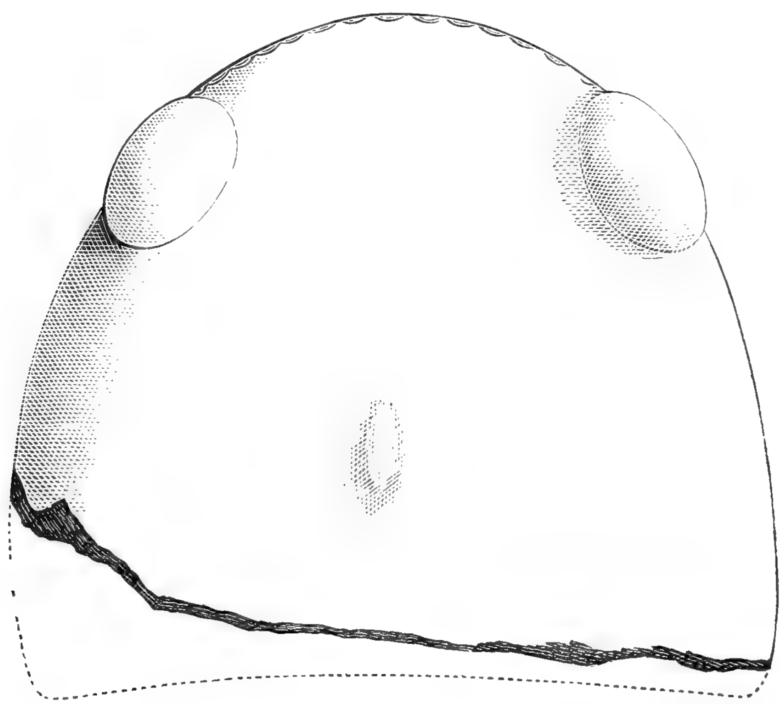


FIG. 17.—Head of *Pterygotus gigas*, Salter. From the Downton Sandstone of Kington, Herefordshire; in the Cabinet of R. Banks, Esq.

Body-rings.—The anterior body-rings (Mem. Geol. Surv., Mon. I, pl. viii, fig. 3), bear the squamæ only on their front half, and these are less curved and less crowded than in the corresponding segments of *P. anglicus*. The edge of the plicæ is thickened. Figs. 4 and 5 (op. cit.) must represent large segments from a portion of the body further back than fig. 3, for the squamæ cover the whole lower surface of the segment (fig. 5), and the greater part of the upper side (fig. 4). They are greatly more convex than in the Scotch species, the posterior ones especially being parabolic or even pointed in form, frequently three tenths of an inch long and equally broad. Fig. 5 (op. cit.) shows the closely squamate lateral edges of the segment, which are convex and rounded in the forward portion and sharply keeled behind. The front margin in both of these segments is contracted, for articulation with the previous joint, and has a broad groove running along its whole length. The hinder angles are a little produced.

Penultimate Segment (figs. 6 to 9, and pl. ix, fig. 15, Mem. Geol. Surv., Mon. I).—This joint is much wider than long, in the proportion of four inches and a half to two inches and a half; some specimens must have been fully five inches long, and, therefore, nine or ten broad. The segment is widest and flattest at the hinder end, the margins are compressed and keeled, except at the thickened and contracted base, and the angle (fig. 9) pointed and produced. The upper surface (fig. 7) is gently convex, but without any ridge, while the lower (?) (fig. 6) has a short thick keel extending half way up. It terminates on the hinder margin of the segment, which is rather deeply notched at this point. The surface is thickly covered with plicæ, both above and below, but they are much more prominent on the lower (keeled) surface[1] than on the other, where they are mere surface markings and often obliterated. They cover the whole of the segment, but are less thickly placed towards the hinder margin, at least on the under side (fig. 6). The margin itself is tubercular.

The squamate keeled lateral borders are ornamented with several (about four or five) rows of oblique thick plicæ, more prominent and larger on the lower side; these are continued from about the anterior fourth of the segment, where the keel commences, to the pointed hinder angle. Similar, but still larger, plicæ cover the central keel, and numerous shallow folds run obliquely backwards from the sides to the keel.

Telson or Tail-joint (pl. ix, figs. 16, 17, Mem. Geol. Surv., Mon. I).—The dimensions of this joint give the best indication of the size to which the species grew; its length was full 5 inches, and the width $4\frac{1}{2}$. The largest specimens of this part in *P. anglicus* (pl. v, fig. 5, op. cit.) are rather longer, but narrower. The general shape was that of a broad and pretty regular oval, but truncated at the base and emarginate at the apex. The under side is flat, except at the origin of the joint, while it is somewhat convex; the median line is even concave. Oblique folds or lines, like those on the penultimate segment, occur on the forward half. The upper side is also flattened, but furnished along its whole length with a great central keel, rather thick at its origin, but becoming narrower and more elevated (six tenths of an inch high in the centre), and then decreasing towards the tip.

Sculpture as in the preceding segment. The blunt ridge of the central keel is covered with small squamate plates, and the margins have four or five rows of oblique elongate ones. The general surface is bare of plicæ, except near the base, where they are numerous and prominent both on the upper and under side.

Appendages.—Chelate Antennæ (pl. ix, figs. 1, 3, Mem. Geol. Surv., Mon. I).—Frag-

[1] We have already stated, in a footnote, p. 80, that in *Pterygotus* there is no keel or ridge to the ventral surface of any segment of the body; Mr. Salter's description, given above, must therefore be reversed, and his fig. 7, pl. viii, op. cit., must be regarded as the *under* side of the penultimate segment, and fig. 6 as the *upper* or dorsal surface of the body.—H. W.

ments only are yet found; the large base of the fixed claw is about five inches long to the first tooth (in the largest *P. anglicus* it is not more than three inches and a quarter), and one inch ten lines broad (nearly of equal breadth throughout). The articulating edge is long and oblique, the joint narrowing considerably into the serrate claw. Of this portion there is but little preserved, but it shows the chela to have had broad (probably subovate) cutting teeth, as well as numerous close-set smaller ones. These last are short, conical near the base of the fixed claw, and coarsely striated parallel to their sides, the striæ branching from above downwards. Further out (as shown in the specimen, fig. 2, op. cit., which may be the free claw), the smaller teeth are lanceolate and narrow, and the striæ parallel. These striæ are very closely set, much more so than in any other species. The teeth appear to have been irregular in size, and much crowded; a third specimen (fig. 3) shows three kinds, a small lanceolate one, larger subovate secondary ones, and one a great striate tooth, apparently the median one (see pl. vi, fig. 5, op. cit.), which is coarsely ribbed, and is, besides, serrated on the inner edge.

The *endognath* has somewhat broader and shorter teeth than that figured in pl. vii (op. cit.), and the second maxillary piece is more curved anteriorly. Both specimens are preserved in Mr. Banks' cabinet.

Of the palpi (pl. ix, figs. 5—7, Mem. Geol. Surv., Mon. I) only fragments are left. Fig. 5 shows four joints connected, but all compressed in a direction perpendicular to their length. Their diameter is half an inch, and their proportions may be compared with those shown in pl. vii, fig. 4 (op. cit.). The second joint is rather longer, and the third not quite so long as in *P. anglicus*. The other figured fragments are less distorted; fig. 6 shows the fourth joint fully one inch and a half long, with the tip expanded and bilobed. In fig. 7 one of the lobes bears a fringe of spines. All the joints show elongate squamæ on their outer side.

Swimming-foot (pl. ix, figs. 4—9, Mem. Geol. Surv., Mon. I). The great basal joint (fig. 8), with its serrated tip, closely resembles in form and sculpture that figured in pl. vii, 'Geol. Surv. Mon.,' the chief difference being the greater width of the foliaceous base, and the more backward position of the notch at the point of attachment for the succeeding joints. The serrate terminal lobe (figs. 4 and 9) has broad stout teeth, as usual, thirteen in number, slightly curved, the uppermost broader and shorter than the rest, the lowest a rounded lobe as broad as the two preceding teeth taken together. The teeth are shorter than in *P. anglicus*, especially the upper ones, so that the outline of the serrate edge is more curved. The perfect specimen is only three inches and a half long by two inches and three quarters broad, but fragments indicate a size equal to the largest specimens of the Scotch species.

Of the other joints of the swimming-foot only two or three specimens (pl ix, figs. 10—12, Mem. Geol. Surv., Mon. I) have occurred. Fig. 10 shows the upper surface of the right-hand swimming-foot, with two complete joints; the fourth and fifth, with a portion of the great penultimate joint. The latter joint is better shown in another fragment (fig. 10), which is in close juxtaposition, and has a fragment of the fifth joint attached to it.

The fourth and fifth joints closely resemble those in *P. anglicus* (see pl. vi, op. cit.), but the form of the penultimate or propodite is, as usual, characteristic. It is oblong, two inches and a half in length by one and a half broad, and is but little broader at one end than the other. The upper or proximal end is deeply bilobed, as in *P.* (now *Eurypterus*) *punctatus*, the lobes being apparently equally prominent, and the distal or outer end is trilobed; this is partly seen in fig. 10, but much better in fig. 11, where the outer lobe is pointed and prominent, the middle one rounded and shallow, and the inner truncate; the last forms nearly a straight line, ending in a sharp angle against the straight inner margin.

Both outer and inner margins of the penultimate joint are serrate, with elongate appressed squamæ, and the surface of the preceding joints (the fourth especially) has close and rather elongate plicæ.

Of the terminal palette there is no trace; its probable shape is given in the dotted outline (by Mr. Salter, in pl. ix, fig. 10, op. cit.).

Only the *metastoma* (pl. ix, fig. 13, Mem. Geol. Surv., Mon. I) remains to be described. It is greatly like that of *P. anglicus* (pl. vi, op. cit.), and chiefly differs in the more contracted base and large open plicæ of the surface. The notch is somewhat deeper. It may have been smooth over the hinder portion (as in pl. xii, fig. 3, op. cit.), which is the same or a closely allied species, and may be noticed here, though possibly it belongs to *P. ludensis,* above described. (See Woodcut below, Fig. 18.)

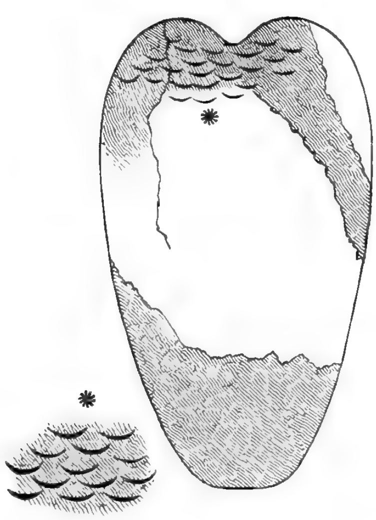


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FIG. 18.—Metastoma, or post-oral plate, belonging either to *Pt. ludensis*, or to *Pt. gigas*, from the "Passage-beds" at Ludlow.

* A part of the sculpture magnified.

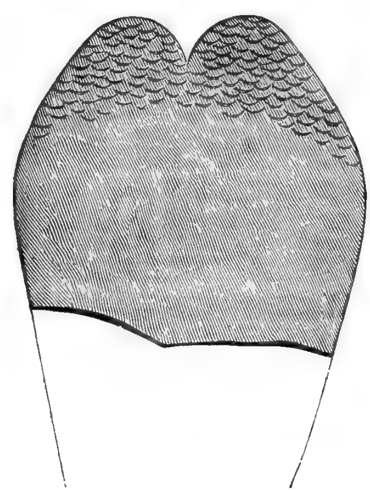

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FIG. 19.—Imperfectly preserved Metastoma referred to *Pt. problematicus*, Upper Ludlow Rock, Ludlow.

This post-oral plate, in its anterior portion, a good deal resembles the fragment figured in pl. ix (op. cit.), the notch being a little less deep only. The shape is much more elongate than in *P. anglicus,* the length being as seven to four; the width is greatest at the anterior third, and the general shape ovate. The plicæ are large and open, and are confined to the anterior portion about the notch.

The basal joint of the swimming-foot (fig. 8), found at the same locality, is in almost every respect like that of *P. gigas,* having the teeth broad and short.

Locality.—Downton Sandstone (Uppermost Ludlow Rock) of Kington, Herefordshire. (Cabinet of Mr. R. Banks, of that place.) Some specimens, presented by that gentleman, are in the Museum of Pract. Geology; as are also specimens collected by Mr. A. Marston, of Ludlow. They were found at the Ludlow Railway Bridge, in the passage beds at the base of the Old Red Sandstone.

Species 8.—PTERYGOTUS PROBLEMATICUS:—Salter.

PTERYGOTUS PROBLEMATICUS, *Agassiz.* In Sil. Syst., 1839, p. 606, pl. iv, figs. 4 and 5 (and 6, tooth of *Sphagodus pristodontus,* Ag., tooth only).

— — *Strickland* and *Salter.* Quart. Journ. Geol. Soc., 1852, vol. viii, pl. xxi, figs. 1, 2, p. 386.

— — Siluria, 2nd edit., 1856, pl. xix, figs. 4—6.

— — „ 3rd ed., 1859, „ p. 265.

— — „ 4th ed., 1867, „ p. 237.

— — *Salter.* Mem. Geol. Surv., 1859, Mon. I, p. 89, pl. xii, figs. 7—16, 20, 21; and pl. xiv, figs. 16—18.

As this is the principal, if not the only, species in the true Upper Ludlow Rock which has the usual semicircular ornamental plicæ, it is to this that the name *problematicus* should be given; and fortunately, on one of the minute original fragments figured in the 'Silurian System,' the small intermediate plicæ are to be seen marking the species more definitely.

The large chela, figured as above under this name, by the late Mr. Strickland and myself, proves to be really an appendage of this same species, at least it is always associated with it in the same bed. Again, the antennary portions, fragments of body-rings, bases of the swimming-feet, post-oral plate, &c. (pl. xii, Mem. Geol. Surv., Mon. I), are all found in the Whitcliffe, Ludlow, or other localities of the Upper Ludlow Rock, and clearly differ from the corresponding parts in *P.* (now *Eurypterus*) *punctatus,* the only other large species occurring with them, as well as from those just described which are characteristic of the beds of passage above the top of the Ludlow series. *P. problematicus* may now, therefore, be considered an established species, and the cabinets of our Ludlow friends, Messrs. Cocking and Marston, have furnished many of the materials. It occurs, too, in plenty, as Mr. Lightbody's researches show, in the transition beds beneath the Old Red Sandstone (pl. xiv, op. cit.); and Mr. J. Harley, to whom we are indebted for much valuable help, has been fortunate enough to detect its fragments far up in the Cornstones of the Old Red itself, a higher limit than the genus had been known before to attain.

[If the large fragments from the transition beds above quoted, and figured on pl. xiv, Mem. Geol. Surv., Mon. I, be of the same species as the sculpture indicates, the body-segments attained a very large size, nearly three inches from back to front. As it is possible these may belong to a different species, I will describe these portions first.

Carapace (?) (pl. xiv, fig. 16, Mem. Geol. Surv., Mon. I).—A fragment, three inches by two and a half, has the surface sculptured, unlike the body-rings, *i. e.* much more finely marked, and without the regular increase in size and curve of the plicæ backwards. The anterior ones are nearly as much bent as the hinder ones, though smaller; all are but slightly prominent, and are covered by numerous smaller plicæ.

Body-rings (pl. xiv, fig. 17, op. cit.).—One of the broad abdominal rings, two inches and three quarters from back to front; the articulating front margin is rather deeply concave, and its edge is obscurely striated longitudinally. The plicæ are very numerous and close-set, not so large as in *P. anglicus*, or so straight on the forward edge, where, however, they are very closely packed. They are more open posteriorly, and cover more than half the segment, interspersed with very numerous minute semicircular plaits.

Another piece (fig. 14, op. cit.) is here considered as belonging to this species, but it only shows the interspersed plicæ over part of the surface, and it quite possibly belongs to *P. ludensis*, or even to a new species.

Penultimate Joint (pl. xiv, fig. 18, op. cit.) — Of this we have only the lower surface; and as the plicæ are restricted to the upper portions, and only a few small ones are interspersed, it is possibly not *P. problematicus*, but of the same species as the one (fig. 15) mentioned above. The width is greater than that of the same joint in *P. anglicus* or *P. ludensis*, being three inches and a half, while the length is only two and a quarter (or as fourteen to nine), which is about the proportion in *P. gigas*. The joint is not expanded posteriorly, as in that species, and the plicæ are semicircular, not pointed, on the lower side.]

In the true Ludlow Rock but few body-joints have been met with; the two best are figured from Mr. J. Harley's collection, viz. pl. xii, fig. 20, op. cit., must be one of the thoracic rings, and fig. 21 probably the tenth or last but two of the segments. Both show the minute interspersed plicæ very clearly, and these small plicæ extend over nearly all the segment, while the larger ones are confined to the anterior half.

Telson as yet unknown, as also is the thoracic plate.

Antennæ (pl. xii, figs. 7—10, Mem. Geol. Surv., Mon. I).—Fig. 10 is most probably part of the stem, and shows the large and small plicæ in perfection. Figs. 7 to 9 show the large characteristic chelæ, which can scarcely be confounded with those of any other species, the teeth being so much elongated. Fig. 7 is the fixed claw, with a widely expanded and largely dentate base. The shaft is parallel-sided (not tapering as in *P. ludensis*), and the teeth long-lanceolate, the large one being much longer than the diameter of the shaft (in fig. 7, fully three quarters of an inch long); the secondaries, three or four on each side of it, with small teeth interspersed, all linear-lanceolate, erect and remote, not crowded at their bases. In the fixed ramus they are either erect or (fig. 8) point forward a very little.

The striæ on the teeth are very fine and close; somewhat oblique on the great tooth, and more direct in the smaller ones. In *P. gigas* and *P. ludensis* they are coarser, and the teeth broad. The great terminal mucro is as broad and long as the primary tooth, or even longer, and is bent at right angles to the shaft.

Swimming-feet: Basal Joint (pl. xii, figs. 11—14, op. cit.). — Several fragments have been found of the great basal joint, and one tolerably perfect from the Whitcliffe, Ludlow (fig. 11). It shows a wide-expanded basal lobe, and the whole extent of the serrate tip, with the usual number of teeth (thirteen, or rather twelve in this specimen), in fig. 14 the upper tooth being obsolete. Fig. 13 *a*, from Ludlow, shows the full number.

The lobe in front of the teeth is arched and thickened in all the specimens (a character in which this species differs widely from *P. anglicus*), and the second tooth is more than twice the breadth of any of the others, conical, and but little curved; the remaining teeth are long, straight, narrow, and separated by about their width from each other in large specimens. These elongate teeth are very distinctive of the species. I believe I am not mistaken in referring Agassiz's figure of the *Sphagodus* tooth to this portion.

Metastoma (pl. xii, fig. 15, op. cit.) is cordate-ovate, narrower at the bilobed end, and has its greatest width below the middle, becoming angulated at that point. The notch is deep, the lobes rounded (the base is broken off); surface marked with open squamæ, but only near the upper end and about the notch. This post-oral plate is the broadest of any species known.

Fig. 16 is a plate of the same nature as those found with *P. ludensis*, and is possibly a thoracic or abdominal appendage, though, as no species are known with any such attached, its nature is quite doubtful. The entire form is better seen at p. 91 (Woodcut, Fig. 25), viz. a lobed broad emarginate plate (*d*), in the wide notch of which is attached the truncated sub-oval plate, *b*.

Localities.—Upper Ludlow Rock, Whitcliffe, and many places near Ludlow (Ludlow Museum and Museum of Practical Geology, Cabinets of Messrs. Lightbody, Cocking, J. Harley, and A. Marston). Kendal, Westmoreland (Museum of Practical Geology). Ludlow Bone-bed, Ludlow; Downton Sandstone of Bradnor Hill, Kington (Mr. R.

Banks's Cabinet). Base of Old Red Sandstone, Ludlow Railway Station (Museum of Practical Geology). Cornstones of Hopton Gate (Cabinet of Mr. J. Harley).

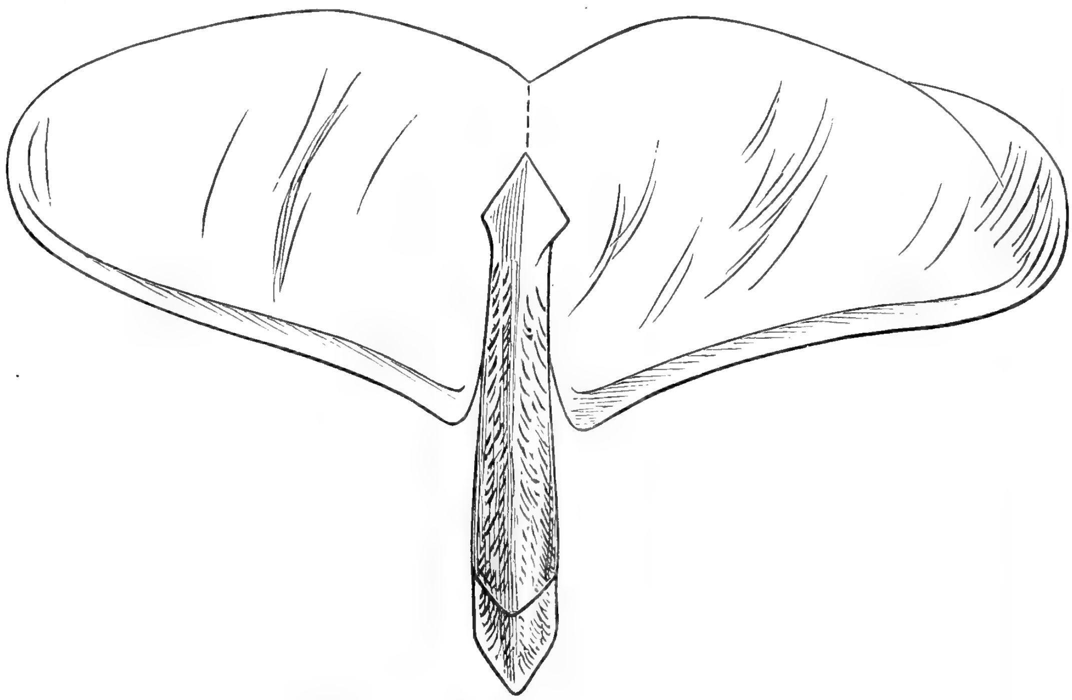

FIG. 20.—Thoracic plate, copied from an unpublished sketch by Mr. J. W. Salter, and referred by him to *Pterygotus problematicus*, Ag. Locality of specimen unknown.

One of the most widely spread species; it is probably this which occurs in the Upper Llandovery Rock or "May Hill Sandstone" of the Obelisk, Eastnor Park.

Several fragments, probably belonging to this species, have been obtained from the Wenlock Shale and Limestone (together with other remains referable to *Eurypterus punctatus*), from Dudley and Malvern, and are preserved in the British Museum, and in the Cabinet of John Gray, Esq., of Hagley, and in those of Messrs. Henry Johnson, E. Hollier, and C. Ketley, of Dudley.

Species 9.—PTERYGOTUS ARCUATUS:—Salter. 1859.

PTERYGOTUS ARCUATUS, *Salter*. Mem. Geol. Surv., 1859, Mon. I, p. 95, pl. xiii, figs. 8, 12, 13, 15, and 16.

This name is applied to a large and fine species, of which several fragments occur in the Lower Ludlow Rock of Leintwardine, with the more common *P.* (now *Eurypterus*) *punctatus*. It is clearly distinct from that species; but, except for the total absence of any minute interspersed plicæ, the body-segments might be easily mistaken for those of

P. problematicus, to which it is closely allied; and with it, in the same beds of Lower Ludlow Rock, occur antennæ, the obscure appendages (figured in our Woodcut, Fig. 25, p. 91), swimming-feet, maxillæ, and other oral apparatus, differing specifically from those of *P. problematicus,* and yet more distinctly separated from the portions of *P.* (now *Eurypterus*) *punctatus* found in the same beds. Of these fragments the body-segment must receive the name, the other pieces being only provisionally arranged with it. They all resemble the corresponding parts in the Upper Ludlow species.

Body-segments (pl. xiii, fig. 12, Mem. Geol. Surv., Mon. I).—This specimen is clearly, from its shape, the second body-segment, seven inches broad and more than one inch and a half deep. It is curved, and more oblique laterally than in *P. anglicus,* the sides forming an angle of 65° with the base. The anterior edge is much more sinuated than the posterior, owing to the deep excavation to receive the first segment; but the central part is strongly arched forward on both margins. The lateral anterior process is broken off, but enough remains to show it was prominent. The sides are oblique, inclined forward at an angle of 80° from the posterior angle, which is rounded off. The margin is crenulated, the prominent minute sculpture confined to the anterior third, but continued more faintly over a large part of the rest of the segment.

A specimen, crushed longitudinally, shows that the species was rotund in section, as in *P.* (now *Eurypterus*) *punctatus* and others.

Antennæ.—In all probability, pl. xiii, fig. 8, Mem. Geol. Surv., Mon. I, represents the antenna of this species. Its resemblance to those of *P. problematicus* is very close. The shaft is linear, the long end turned abruptly up, and the teeth straight, narrow, and remote, as in that species; but the chela is much more slender, three inches and a half to four inches long, and the larger central tooth is scarcely longer than the diameter of the shaft itself, while the secondary teeth, some of them at least, approach it more nearly in size. The tooth at the base of the large terminal mucro is appressed against it, and the mucro itself (pl. xi, fig. 3, op. cit.) is sometimes oblique. All the teeth are finely striate, the striæ tending obliquely backward on the principal teeth. There are numerous sharp, conical, minute teeth between the secondaries.

21

FIG. 21.—The basal joint of an endognath of *Pt. arcuatus,* Salter.

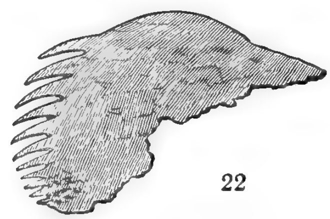

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FIG. 22.—Mandibular border of one of the endognaths of *Pt. arcuatus?*

Both specimens from the Lower Ludlow Rock, Leintwardine, Shropshire.

Endognaths.—Most probably, pl. xiii, fig. 15, Mem. Geol. Surv., Mon. I, represents the first or second pair of these organs; and it is pretty clearly referable to *P. arcuatus*, and not to *P.* (now *Eurypterus*) *punctatus*, which has much shorter and blunter mandibles (pl. xi, fig. 6, op. cit.). It is elongate, or even falcate, the upper lobe greatly convex, the posterior portion drawn out laterally instead of backwards; the surface closely sculptured all over. The teeth are not oblique, straight, and conical, as in *P.* (now *Eurypterus*) *punctatus*, but lanceolate and curved, and directed outwards. About ten or eleven are free, the rest confused, either in a horny plate or mixed with setæ. In this particular and in the production of the lower lobe it resembles *P.* (now *Eurypterus*) *punctatus*, but the great curvature and elongation of the plate distinguish it.

Base of Swimming-foot (pl. xi, fig. 10, Mem. Geol. Surv., Mon. I).—Most probably, from the very convex form of the anterior edge, and the greatly elongate teeth, this belongs rather to the present species than to *P.* (now *Eurypterus*) *punctatus*.

Post-oral Plate (pl. xv, fig. 5, Mem. Geol. Surv., Mon. I).—Found at Leintwardine by Mr. Alfred Marston. It differs from the corresponding plate in all the species; having the lobes of the apex narrow, and nearly their own width apart, the sinus between them being very wide and shallow, instead of a simple deep notch. The plate is cordato-lanceolate; for the upper two thirds it is oval, the greatest width being rather below the upper third; the base is rather suddenly contracted, and tongue-shaped.

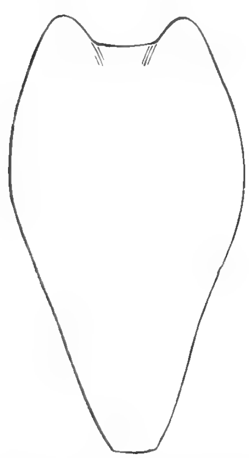


FIG. 23.—Post-oral plate, or metastoma, of *P. arcuatus*, Salt. (Natural size.)

Thoracic (?) *Appendage* (pl. xiii, fig. 16, Mem. Geol. Surv., Mon. I).—This is more perfect than any other specimen, though only the impression of one side. The large ovate terminal plate (*b*) shows well the gradation between the ordinary plicæ and the long lateral plaits; the middle line is bare of any ornament. At the apex are seen two or three of those impressed lines which are so much more conspicuous on the opposite surface, and which seem to divide the plate into laciniæ (*a*). The plate is indented at its basal end, corresponding to the central depression (ridge in the cast) of the preceding joint. This joint is very irregular in shape, the lobes on one side being single, on the opposed side double. Both are marked with minute plicæ near the edges. (See Woodcuts, page 91, Figs. 25—27.)

Locality.—The above-mentioned fragments have all successively come to light during the active researches of the Ludlow geologists in the quarries of Lower Ludlow Rock at Leintwardine, particularly in one at Church Hill. There are many new Crustacea to be described from the same quarry.

Species 10.—PTERYGOTUS (?) STYLOPS :—Salter. 1859.

PTERYGOTUS STYLOPS, *Salter.* **Mem. Geol. Survey. Mon. I, 1859, p. 55, pl. xii, fig. 47. (Reproduced in our Woodcut, Fig. 24.)**

This remarkable small carapace has occurred to the assiduous search of Mr. R. Banks, of Kington.

Only the anterior part is preserved, and even of this the frontal portion between the eyes is broken off; it was, perhaps, less prominent than the dotted line indicates. The forward position and round form of the great eyes very much assimilate the species to *Sl. acuminata;* but without doubt it belongs to the true *Pterygotus* (near, perhaps, to *Pt. raniceps,* from Lanarkshire, see p. 71).

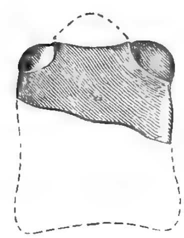
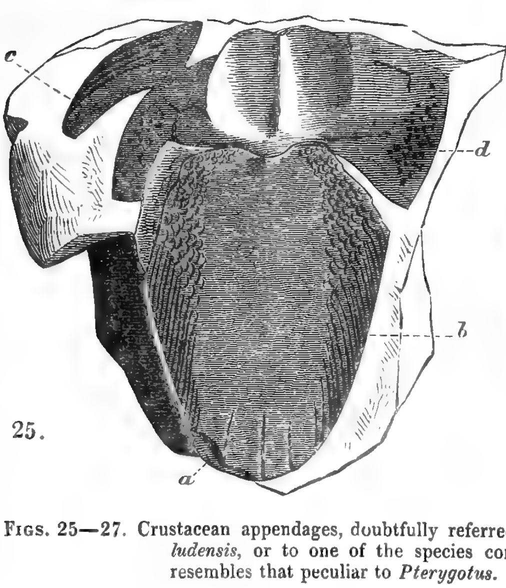


FIG. 24.—Head of *Pterygotus stylops,* Salter.

The eyes are remarkably prominent and turgid, a slightly raised fold of the carapace encircling them. A small tubercle, like that on the same part in *Pterygotus gigas,* occurs on the median line of the head, and rather nearer to each eye than their distance from one another (probably indicating the position of the ocelli). As only a single broken specimen has occurred, it is useless to describe it further. There can be no doubt of the distinctness of the species.

Locality.—Kington, Herefordshire. Collection of Mr. R. Banks, of Kington.



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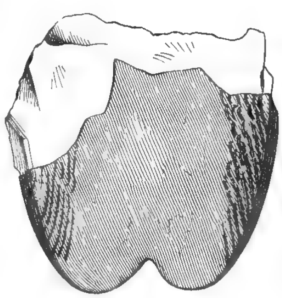

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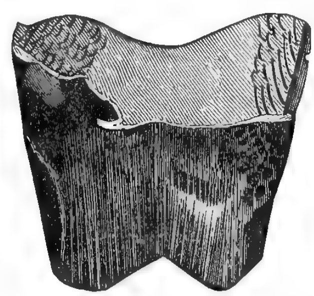


27.

FIGS. 25—27. Crustacean appendages, doubtfully referred by Mr. J. W. Salter to *Pterygotus problematicus, Pt. arcuatus, Pt. ludensis,* or to one of the species common to the Ludlow Rocks. The ornamentation, when preserved, resembles that peculiar to *Pterygotus.* Lower Ludlow Rock, Leintwardine.

NOTES ON SILURIAN LOCALITIES IN THE WEST OF ENGLAND WHERE FOSSIL CRUSTACEA BELONGING TO THE ORDER MEROSTOMATA HAVE BEEN DISCOVERED.

BY THE REV. W. S. SYMONDS, M.A., F.G.S., OF PENDOCK.

(Written to accompany Mr. HENRY WOODWARD'S 'Monograph on British Fossil Crustacea.')

1.—*Pterygotus* OF THE UPPER LLANDOVERY SANDSTONE.

Having been requested by my friend Mr. Henry Woodward, of the British Museum, to give a short description of the principal localities in which those remarkable Crustacea, the *Pterygoti, Stylonuri,* and *Eurypteri,* are found in the region of Siluria, I cannot do better than allude, in the first place, to the oldest known form of *Pterygotus*, discovered some years ago by Mr.John Burrow, of Great Malvern, and figured in the 'Memoirs of Hugh Edwin Strickland,' by Sir Wm. Jardine, Bart., under the title of "*Pterygotus problematicus.*" It is the jaw-foot only that is preserved. The strata in which the relic was discovered belong to the upper series of the Upper Llandovery beds, where they support the Obelisk in Eastnor Park, near Ledbury, Herefordshire. The common fossils of these strata are the *Nucula Eastnori,* with *Pentameri* and *Stricklandiniæ.* The author of these notes was present with the Malvern Field Club when this oldest known evidence of the existence of *Pterygotus* was discovered.

2.—WENLOCK LIMESTONE AND SHALE.

Although I am tolerably conversant with the *fossils* as well as the physical geology of the Wenlock rock series, it was not until lately that I became acquainted with the fact that remains of *Pterygotus* had been found therein. Mr. Woodward, however, has directed my attention to the occurrence of portions of the body of this Crustacean in a slab of Dudley Limestone in the British Museum. The rock in which these relics occur is undoubtedly the well-known Wenlock Limestone, so celebrated for its Trilobites and Crinoids. The remains occur not only imprinted upon shale attached to the limestone, but, in several instances, in the limestone itself.

The first of these remains, consisting of small fragments only, covered with the characteristic scale-markings, were obtained by Mr. John Gray, of Hagley, and are now in the British Museum.

In the National Collection are also a jaw-foot and several united body-segments of *Pterygotus*,[1] obtained by Mr. Charles Ketley, of Smethwick. Other remains of the same genus are, Mr. Woodward informs me, to be seen in the cabinets of Mr. E. Hollier and Mr. Henry Johnson, of Dudley.

Some of these specimens may be referable to *Pterygotus problematicus*, giving to this species a very wide range in time, as we find its remains in the Upper Llandovery Sandstone, the Wenlock series, the Ludlow rock, and possibly in the Passage-beds.

3.—Aymestry Rock.

The next oldest rock bearing evidence of the existence of *Pterygotus*, that I am aware of, is indicated by the discovery of a "jaw-foot" of *Pterygotus* by myself in the Aymestry rock of Gorstley, near Newent, many years ago. This specimen was forwarded to Sir Roderick Murchison, and is now in the Museum at the College, Great Malvern. This rock is quarried to some extent at Gorstley, and is somewhat remarkable for containing nests of beautiful spicules of the sulphuret of nickel. I have seen the internal casts of *Rhynchonella Wilsoni* filled with these spicules.

4.—Lower Ludlow Rocks.

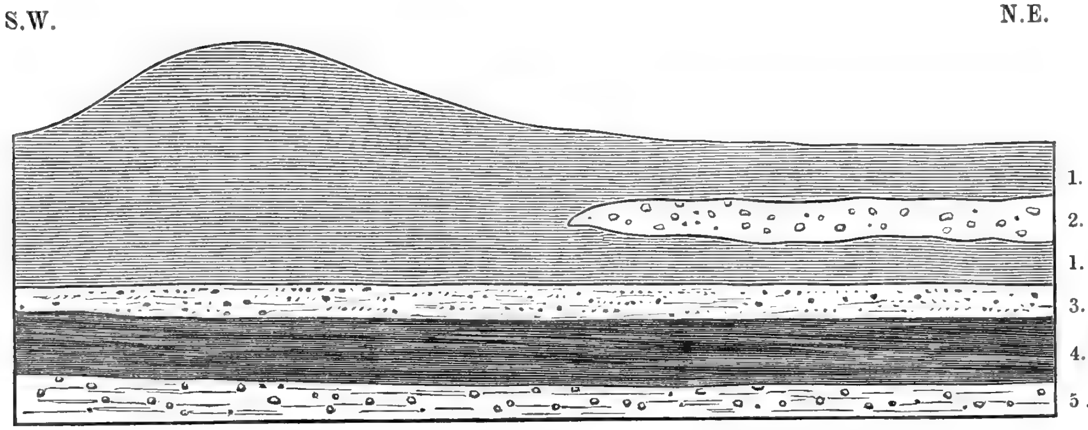
The next stratified rocks in which we find remains of *Pterygotus*, and also of *Eurypterus*, are the Lower Ludlow beds of Church Hill, Leintwardine. They are shaly beds, which occupy the uppermost strata of this formation, and have furnished the beautiful series of fossil Star-fishes and Crustaceans found by Mr. Lightbody, Mr. Marston, and other geologists. In these strata also was discovered the *Scaphaspis ludensis*, by Mr. John Edward Lee, of Caerleon. This Fish is at present the oldest known form of vertebrate life. We have visited this quarry in company with Mr. Lightbody and Mr. Marston more than once. The section is now nearly destroyed, as the quarry is almost filled up. The remains of *Pterygoti* have been found all through the beds; and in 1865 a new species of *Eurypterus* from them was described by Mr. Henry Woodward.

We were conducted by Mr. Marston to a quarry in a lane called "The Old Road," near to Leintwardine, where the shale is found between masses of the *Pentamerus Knightii* limestone, and where also *Pterygoti* have been found. This *Pentamerus Knightii* limestone is more or less associated at Leintwardine with the uppermost layers of the Lower Ludlow Rock, and is not altogether on the same horizon as the so-called "Aymestry" or

[1] The ornamentation upon these and other portions resembles that figured and described by Mr. Salter as *Pterygotus* (now *Eurypterus*) *punctatus*.—H. W.

Upper Ludlow Limestone of Ledbury and Woolhope. I agree with Mr. Lightbody and Mr. Marston that it should not be considered as a distinct formation, as it is intercalated at different horizons in the Ludlow rocks, both upper and lower.

FIG. 28.—SECTION OF OLD ROAD QUARRY (FROM A SKETCH BY MR. MARSTON) AT CHURCH HILL, LEINTWARDINE, SHROPSHIRE.



1. Shale like Lower Ludlow Shale.
2. Intercalated mass of nodular limestone, with *Pentamerus.*
3. *Pentamerus* bed, about 18 inches in thickness.
4. Shaly bed (about 3 feet thick), with Star-fishes, *Pterygotus*, and *Eurypterus.*
5. Thick bed, with *Pentamerus Knightii.*

5.—UPPER LUDLOW ROCK.

The name of "Seraphim" was given to certain winged-looking bodies (*Pterygotus,* Agassiz) by the Scotch quarrymen who first found them in the Lower Old Red Sandstone of Scotland. In pl. iv, figs. 4, 5, of Murchison's 'Silurian System,' a fragment of the carapace of *Pterygotus* is figured by Agassiz, and he then came to the conclusion that the animal it belonged to must be referred to the class of Fishes, while Hugh Miller, in his 8th chapter of the 'Old Red Sandstone,' gives a graphic account of the after-judgment of Agassiz, and how, in the presence of himself, Sir R. Murchison, and others, "his eye brightened," as he looked upon better specimens of "the huge Crustacean of Balruddery," and he said, turning to the company, "I will tell you what these are,—the remains of a huge lobster!"

It was of the merest fragments of this "Seraphim" from the Upper Ludlow rocks, in the collections of the Rev. T. T. Lewis and Dr. Lloyd, that Agassiz declares, in the 'Silurian System' (chap. xlv, p. 606), these remains belong undoubtedly to the same animal as the "Seraphim" of the Old Red Sandstone of Scotland.

Mr. Hugh Strickland read a paper[1] before the Geological Society in June, 1852, on the occurrence at Hagley, four miles north-east of Hereford, of the Ludlow Bone-bed, "a stratum interesting, not only for its wide extension, as contrasted with its very slight vertical thickness, but also as presenting nearly, if not quite, the earliest known indication of vertebrate life on the surface of our planet."[2] The writer of these notes accompanied Mr. Strickland and Mr. Scobie on the original discovery of this protruded mass of Upper Ludlow rock, which is in close proximity to a trap-dyke at Bartestree, there seen to traverse and alter the Lower Old Red Sandstone. The following is the section, taken from our measurements made on the spot:

	Feet.	Inches.
Old Red Sandstone.—Red clays and marls	12	0
Brownish beds	2	0
Flaggy beds, micaceous	2	0
Downton Beds.—Yellowish sandstones, with carbonized Plants	2	0
Clay	0	6
Micaceous yellow beds, with Plants	4	0
Bone-bed, with teeth and spines of Fish, and *Pterygotus*	0	1
Upper Ludlow Beds.—Numerous fossils and *Pterygotus* claw, in the Strickland Collection at Jardine Hall	4	0

The chelæ of a *Pterygotus* were afterwards discovered by Mr. Scobie in the Upper Ludlow rock at Hagley, and forwarded by him to London, where it was examined by Mr. Salter, and described by him[3] as being especially interesting, and exhibiting the limbs of a Silurian fossil not hitherto discovered. These he connected satisfactorily with the species so fully figured by Agassiz, which was obtained from the basement beds of the Old Red Sandstone of Forfarshire.

On the same slab with it are specimens of *Orthis lunata* and *Orbicula rugata,* fossils of the Upper Ludlow Rock, and not found in the higher, yellow, Downton Sandstones. This *Pterygotus* claw is in the cabinet of Mrs. Hugh Strickland, at Jardine Hall, Dumfriesshire, and is figured, 'Quart. Journ. Geol. Soc.,' vol. viii, pl. xxi, under the name of *Pterygotus problematicus.* The pit at Hagley, though still open, has not been worked for some years; but I well remember having seen fragments of the carapace of *Pterygotus* in the yellow Downton Sandstones which overlie the "Bone-bed." The "Bone-bed," too, of Hagley Quarry is especially rich in Crustacean and Ichthyic remains.

The line of junction between the Passage-rocks of the Old Red Sandstone with the Upper Ludlow rocks strikes in a north-east direction from the Painscastle Hills to Kington, and thence flanks the hills which run by Shobdon and Richards Castle to Ludlow. The Upper Ludlow rock is seen well filled with fossils along Hergest Ridge, and thence by Gladestry to Painscastle, where it is overlain by ridges of the lowest Old Red Sandstone.

[1] 'Quart. Journ. Geol. Soc.,' vol. viii, p. 381.

[2] Op. cit., vol. ix, p. 8. [3] Op. cit., vol. viii, p. 386.

These strata furnish occasionally the remains of the carapace of *Pterygotus*, which I have myself seen there in the same slabs with *Platyschisma helicites*, and the characteristic *Chonetes lata*.

At Bradnor Hill, near Kington, the lane which leads to the hill from Newton exposes what I consider to be the summit of the Upper Ludlow rock, and the Bone-bed associated with its upper layers. These beds contain true Upper Ludlow fossils, as *Cornulites serpularius*, *Platyschisma helicites*, *Chonetes lata*, *Rhynchonella nucula*, *Orbicula rugata*, and *Orthoceratites* of two or three species, and which are not found in the overlying Passage-beds proper. Remains of *Pterygotus* also occur in these strata.

6.—Passage-beds.

The transition- or "Passage-beds" between two great formations often furnish a series of fossils of the highest value to the palæontologist, and the Passage-rocks between the Upper Silurians and the Lower Old Red Sandstone are no exception to this rule. The occurrence of large Crustacea other than *Trilobites* in the older rocks was hardly known until about the year 1855, when discoveries were made in Scotland and Siluria of several new forms of fine Crustacea, which have been described by Salter, Huxley, and more lately by Woodward. In many localities these remains of Crustaceans are accompanied by the relics of Fishes, such as *Pteraspis* (the oldest form of which has been found in the Lower Ludlow beds, below the Aymestry Limestone), *Cephalaspis, Auchenaspis*, and *Onchus*, two of which forms, *Pteraspis* and *Onchus*, range from Silurian deposits into the Middle Old Red, for remains of both these genera have been detected in rocks above the "Cornstones." As, however, the characteristic Silurian shells do not appear in any quantity above the "Bone-bed," for convenience sake I place the base of the "Passage-beds" at the "Bone-bed," inclusive. I include in the "Passage-beds" all the strata from the summit of the Upper Ludlow Rock proper to the micaceous flags and red marls which herald in the Old Red proper, and which contain traces of *Cephalaspis Lyellii* and *Scaphaspis Lloydii*, two Fishes abundant in the overlying Cornstones.

It was in 1854 or the commencement of 1855 that my friend Mr. Richard Banks, of Ridgebourne, Kington, first directed my attention to the remarkable collection of fossils he had obtained from several localities in that neighbourhood. I acquainted Sir R. Murchison with the fact of their discovery, and papers were subsequently published in the Journal of the Geological Society and in the 'Edin. New Phil. Jour.,' by Mr. Banks, Sir P. Egerton, Sir R. Murchison, Mr. Salter, and myself, with descriptions of the fossils and their position in the strata in which they were discovered. (See 'Edin. New Phil. Jour.,' April, 1855, and Oct., 1856. Also 'Quart. Journ. Geol. Soc.,' May, 1856; and March 25, 1857, &c.)

In addition to the discovery of some new forms of Fish, Mr. Banks found the relics of several Crustaceans, such as *Pterygotus* and *Eurypterus*; but on visiting the localities in which the fossils were found on several occasions, I am satisfied that the sites from which they were obtained are all *below* the Upper Ludlow Rock in stratigraphical position.

In strata that are intermediate between the Upper Ludlow Rock and the Yellow Downton Sandstone, Mr. Banks found *Pterygotus* remains associated with *Platyschisma helicites* and a small *Lingula;* this was between Newton and Bradnor Hill. The overlying strata also contain remains of *Pterygotus* with the *Lingula cornea* of the Downton Sandstones.

At Ivy Chimney is a sandstone quarry low down on Bradnor Hill, which furnished to Dr. Melville, Mr. Lightbody, and myself on one occasion the head of *Eurypterus*. These beds are apparently lower in position than the Downton Sandstone. The Downton Sandstone on Bradnor yields throughout remains of *Pterygotus, Eurypterus,* and *Cyathaspis Banksii,* with *Lingula cornea.* Again, these crustacean remains are found in a quarry at the Lodge Farm, Huntington. New Radnor church is built of Downton Sandstone, from a quarry between New Radnor and Harley, in an interesting outlier of Downton Rock; crustacean remains, with *Lingulæ,* occur in the *débris* which is strewn around.

7.—Passage-beds at Ludlow.

The lowest of the Passage-beds in the section on the Shrewsbury and Hereford Railway, near the Ludlow Tunnel, are beds which are believed to be the equivalents of the Upper Downton Sandstone. The same history attaches to the "Tin Mill Beds," near Downton. *Pterygotus gigas, Pterygotus Banksii,* and *Lingula cornea,* with *Eurypterus linearis,* have been found in these strata. The lower Bone-bed occurs on the right bank of the Teme, near Ludlow; but, owing to a fault or overlap, I believe it has not been found on the left bank near the Ludlow Tunnel. Indeed the Ludlow section will not bear comparison with the Ledbury section (to which we shall allude bye and bye) as regards the perfect continuity of rock-succession. The different beds are much obscured, and their relation to each other was difficult to determine. There is a grey sandstone between Onibury and Norton, and at the Tin Mills near Downton, which I believe to be the equivalent of certain grey grits at Ledbury, and this contains *Cephalaspis Murchisonii* and a *Lingula* at both places, with many carbonaceous remains of Plants.

The Olive Shales described by Mr. Marston ('Geol. Mag.,' 1870, vol. vii, p. 408) overlie these grey micaceous sandstones.

The Olive Shales were excavated on the line of the Shrewsbury and Hereford Railway; and when I visited this locality in company with my friends, Messrs. Lightbody, Salwey, and Marston, they were yielding a rich harvest of organic remains. Mr. Lightbody's cabinet and the Museum at Ludlow are both enriched with rare fossils from these shales. In the middle of these beds was a deposit, termed by my friends an "upper bone-bed,"

Localities.		*Formations.*	*Fossil Contents.*
Near Ludlow, at Boulden, Whitbaitch, and Oakley Park.	Old Red Sandstone.	Lower Cornstones.	*Pteraspis, Scaphaspis, Cephalaspis Lyellii, Zenaspis Salweyi.*
		Micaceous soft red marl beds.	*Pteraspis, Scaphaspis,* and *Cephalaspis.*
		Hard stone.	
Paper Mills.	Passage-beds.	Hard micaceous beds.	
		Olive Shales.	*Cephalaspis Murchisonii, Pterygotus Banksii, Eurypterus* (3 species).
Overbury Ludlow Railway.		Hard micaceous beds.	
		Different coloured thin beds.	*Auchenaspis, Scaphaspis.*
		Red beds.	
Bull Ring, Ludlow.	Upper Silurian.	Greenish-grey micaceous beds with nodules of soft perishable mudstone.	
Onibury, &c.		Downton Sandstone.	*Pterygotus* (scarce). *Eurypterus.* *Pterygotus, Eurypterus.*
Forge Bridge.		Dark-olive stone.	
		Shales.	Bone-bed.
		Upper Ludlow beds.[1]	

[1] From a section by Mr. Marston, with the exception of placing the demarcation of the Upper Ludlow at the Lower Bone-bed.

which yielded to their hammers no less than three species of fossil Fishes, *Cephalaspis Murchisonii*, *C. ornatus*, and *Auchenaspis Egertoni*, which Sir P. Egerton informs me is a different species of *Auchenaspis* to that found at the Ledbury section outside the Tunnel. At the Tin Mills, in this olive shale, no less than three species of *Eurypterus* were found, together with the *Pterygotus Banksii* of the Kington beds.

Purple grits full of mica succeed these shales at the Tin Mills, and they contain a large *Lingula*.

Over these again rests a grey micaceous sandstone, with *Lingulæ* and carbonaceous markings. These strata are upon nearly the same horizon as the grey *Auchenaspis* grits of Ledbury.

8.—Passage-beds at Ledbury, Herefordshire.

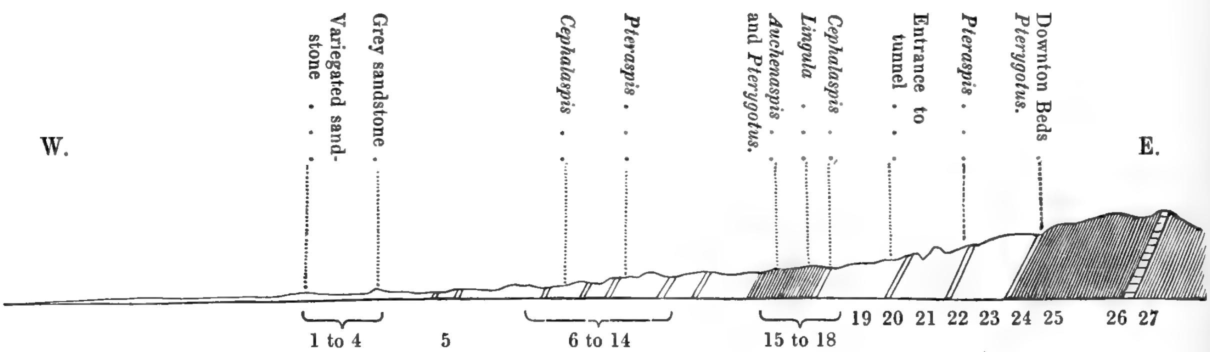
In my paper on these rocks as displayed on the line of railway between Malvern and Ledbury, in and outside the Ledbury tunnel, the following passage occurs:[1]—"In my communication on 'The Old Red Sandstone of Herefordshire,' published in the 'Edinburgh New Phil. Journ.' (April 1, 1859, p. 232), I expressed my opinion that the Ludlow sections on the horizon of the Passage-beds above the Downton Sandstone are broken by faults, and that the true succession is therefore destroyed. I had come to this determination long before the beds now developed in the railroad-cutting at Ledbury were exposed to view; and, having again visited Ludlow, and compared the Passage-rocks of that district with those of Ledbury, I am convinced that nowhere perhaps in the world is there such an exhibition of Passage-beds presented to the eye of the geologist as at the Ledbury Tunnel on the Worcester and Hereford Railway."

I have visited Ludlow on more than one occasion since writing these words, and as I have no reason for altering my opinion, I do not hesitate to reproduce the Ledbury section, marking more especially the beds in which the remains of Crustaceans occurred. It will be sufficient to say here that the section was entire throughout, not being interfered with by any break or obscurity, and was carefully measured off yard by yard and inch by inch. The Aymestry rock, with *Pentamerus Knightii*, was cut through in the Tunnel, and was apparently higher in the Ludlow series than the *Pentamerus Knightii* rock of Leintwardine. Thus we had—1. Aymestry rock (ten feet); 2. Upper Ludlow beds with *Chonetes lata*, &c. (140 feet; Ludlow Bone-bed not detected); 3. Downton sandstone (nine feet), with *Lingulæ* and fragments of carapace of *Pterygotus*; 4. Red and mottled marls and thin sandstones (210 feet), with *Lingulæ* and remains of *Pteraspis*; 5. Grey shales and grits at the tunnel's mouth (eight feet), with *Pterygotus* and *Cephalaspis Murchisonii*; 6. Purple shales and thin sandy beds (thirty-four feet), with a few remains of *Lingulæ*; 7. Grey marl, passing into red and grey marl and bluish-grey rocks (*Auche-*

[1] 'Quart. Journ. Geol. Soc.,' vol. xvi, p. 193.

naspis grits, twenty feet), with *Auchenaspis Salteri*, *Pterygotus*, *Cephalaspis* (two species), and *Lingulæ*. These strata pass conformably into red marly beds with white and reddish sandstones which yielded fragments of *Pterygotus*, also remains of a *Pteraspis* now in Lord Enniskillen's collection, and a *Cephalaspis*.

FIG. 29.—SECTION AT THE RAILWAY TUNNEL, NEAR LEDBURY, HEREFORDSHIRE.[1]



Explanation of Section.

1. Marl with some bands of sandstone.
2. Grey rock.
3. Marl.
4. Grey rock.
5. Marl.
6. Grey rock.
7. Marly rock with *Cephalaspis*.
8. Grey rock.
9. Marly rock.
10. Grey rock.
11. Marly rock with *Pteraspis*, some of the hard bands finely laminated.
12. Grey rock.
13. Marl.
14. Grey rock.
15. Marl.
16. Grey marl and Grey rock. { Red and blue marls. Yellowish-grey sandstone, 18 inches. Greenish shale, 6 inches. Dark grey sandstone, 8 inches. Deep red micaceous shale.
17. Purple sandstone.
18. Purple marls and shales.
19. Grey shale.
20. Red marl.
21. Red sandstone.
22. Red marl with *Pteraspis*.
23. Mottled marls.
24. Red marls with grey spots.
25. Downton sandstone with red, grey, and yellow marls.
26. Upper Ludlow rocks, about 140 feet.
27. Aymestry rocks, about 10 feet thick.

9.—THE PASSAGE-BEDS OF THE WOOLHOPE DISTRICT.

These strata have been well described quite recently by my friend the Rev. P. B. Brodie, in the 'Quart. Journ. Geol. Soc.,' Aug. 1, 1871. The sections nevertheless are poor compared with that at *Ledbury*; and the only one of them worth consideration is that at *Perton*, where we see only 16 feet 11 inches of rock in stratigraphical succession. Mr. Brodie,

[1] This section was given to illustrate my paper in 'Quart. Journ. Geol. Soc.,' 1860, vol. xvi, p. 194; but unfortunately the engraver did not reverse the drawing, so that the engraving is there reversed. See also 'Quart. Journ. Geol. Soc.,' vol. xvii, p. 154.

however, was very successful in finding fossils. In "Olive shales" at the base of the quarry he found *Pterygotus Banksii,* and three species of *Eurypterus,* determined by Mr. Woodward. He also discovered a nearly entire specimen of a new species of *Eurypterus,* named by Mr. Woodward *E. Brodiei,* and described by him before the British Association at Liverpool, 1870.[1] I may here state that these Perton beds rest on the Downton Sandstone proper. I obtained a specimen of the carapace of a *Pterygotus* from yellow sandstone, lying underneath the "olive shales" of Mr. Brodie, and not now exposed. The Perton beds also contain many remains of carbonized Plants, and the seed-vessels regarded by Dr. Hooker[2] as Lycopodiaceous have been found therein. It may interest our readers to state, that the original specimens from which these seeds of land-plants were determined, were found years ago by Mr. Strickland and the writer of these notes, at Gamage Ford,[3] on the south side of the Woolhope anticlinal. The "Bone-bed" is found near Gamage Ford; and from shales closely connected therewith I obtained some beautiful specimens of the shields of *Scaphaspis,* which appear to be the same as *Scaphaspis ludensis* of the Lower Ludlow Rock of Leintwardine. With these two occurred fish-spines and portions of the carapace of *Pterygotus.* The ichthyodorulites are in the cabinet of the Earl of Enniskillen.

10.—Passage-beds at Linley, Salop.

The most northerly extension of the Passage-beds in the Silurian region is probably at Linley, Salop, which I visited in company with the late Mr. George Roberts, who, in conjunction with Mr. John Randall, published a paper thereon in the 'Quarterly Journal of the Geological Society' (1863, vol. xix, p. 229, &c.). Sections along the Linley Brook, four miles north of Bridgenorth, show the positions of the beds. The Coal-measures there rest upon a denuded surface of red Passage-clays, the relics of the denudation of the Old Red Sandstone; and below these we have twenty feet of light-coloured grits, with remains of Plants and fragments of Crustaceans. The whole section through the Old Red clays down to a limestone in the Upper Ludlow is about eighty feet. *Lingula cornea* ranges from the red Passage-beds through the Downton beds down to some shales, with remains of Fishes, Crustaceans, and *Lingulæ,* which I believe to be the representative of the Ludlow Bone-bed. Flaggy beds with *Serpulites longissimus* represent here the Upper Ludlow Shales, which pass into limestone (Aymestry Limestone?). I do not think that any beds at Linley can be correlated with those of Trimpley, near Kidderminster, as was supposed, which are, I believe, higher in the Lower Cornstone series of the Old Red Sandstone, and are not Passage-beds.

[1] Since figured and described in the 'Quart. Journ. Geol. Soc.' 1871, vol. xxvii, p. 261, with a woodcut. See also Trans. Woolhope Club, 1870, p. 276. Hereford, 1871.

[2] 'Quart. Journ. Geol. Soc.,' vol. ix, p. 12, and vol. xvii, p. 162.

[3] Ibid., vol. ix, p. 9.

11.—Old Red Sandstone (Lower Cornstones), Trimpley, near Kidderminster.

Some years ago I accompanied Mr. George Roberts on an examination of the strata exposed at Trimpley, two miles north-west of Kidderminster. I am not inclined to rank these strata as Passage-beds, as some suppose them to be, but as true Lower Old Red Cornstones. The lowest beds are seen at a place called Little Gayne. They are micaceous shales, and Mr. Roberts showed me a collection of plant remains from these, associated with the egg-packets of the *Pterygotus* (*Parka decipiens*). Portions of the carapace of this Crustacean I saw myself in these flaggy shales. Above these strata there come on, opposite the Church, a series of impure Cornstones, interstratified with greyish flagstones exactly like the beds at Leyster's Pole, near Leominster, and those on the Bromyard Road, north-west of the great Cradley Quarries, near Malvern, which have yielded so many fish-remains to myself and others. These strata at Trimpley afforded numerous remains of *Pterygotus, Leptocheles, Cephalaspis Lyellii, Pteraspis rostratus,* and abundant plant remains. The egg-packets of *Pterygotus* were more numerous than I ever saw them in any other locality.

12.—Old Red Sandstone (Lower Cornstones), near Cradley, Malvern.

I have walked some hundreds of miles in my lifetime in endeavouring to discover a section showing a good passage into these strata, but have not yet succeeded. The ground is always more or less broken by faults, with a brook running on the line of fault, or obscured more or less on the point of junction. I have, however, little doubt that the beds at Trimpley, Leyster's Pole, near Leominster, and on the Bromyard Road near Cradley, are on the same general horizon, that they lie considerably above the Passage-beds proper, and are part and parcel of the Old Red Sandstone, whatever may be the fossils which they and their allied Passage-beds have yielded.

There are, or were, some years ago, two small quarries worked, one on the right and the other on the left of the Bromyard Road (about a mile north-west of the great Cradley quarry, on the summit of the hill, known as 'Cradley quarries'). These quarries are worthy of note. The quarry on the right, or East, which is a little higher in the series than that on the left, or West, has, on several occasions, yielded the remains of *Pterygotus.* The mineral character of this rock is that of greyish flags with impure cornstone concretions. Vegetable remains are nearly as abundant as they are at Trimpley, the beds also contained '*Parka decipiens.*' *Pteraspis, Scaphaspis,* and *Cephalaspis* are found here, and it was from this quarry that Mr. Ray Lankester obtained the specimen of

Pteraspis with scales attached, an account of which was communicated by him to the Geological Society in March, 1864 (see Quart. Journ. Geol. Soc., vol. xx, p. 194, &c.).

The quarry West of the road, and opposite the Old Farm House near the East quarry, is lower in the series by a few feet than the other, and the flags and Cornstones therein are full of remains of *Pteraspis*, *Cephalaspis*, and here and there traces of Crustacean chelæ and portions of carapaces. Specimens of these remains may be seen at the Museum at Worcester, and at the College at Malvern, also in Dr. Grindrod's collection at Townshend House, Malvern.

It is almost impossible to distinguish these beds, as far as carbonaceous markings and mineral aspect goes, from similar beds at Rowlestone, and Cusop, Hay, which are higher in the series of the Old Red Rocks.

13.—Old Red Sandstone (Lower Cornstones), Pontrilas, and Monmouth Cap, Herefordshire.

The Cornstone beds of the Old Red Sandstone commence nearly at the base of that formation, as seen near the railway-cutting at Wall Hills near Ledbury, where their position, as regards the Passage-rocks and Upper Silurians, may be studied. But even here there is a fault across the Passage-beds on the line of the River Leddon, and we have the consequent denudation and obscurity. Ascending upwards we find higher Cornstone groups, interbedded with marls, sandstones, and flagstones.

With no Silurian base to give us a starting point within many miles, we have only fossils to guide us as to the position of the strata exhibited near the Station at Pontrilas on the Hereford and Abergavenny Railway. Years ago, when the railway arch was building at Pontrilas, I saw a portion of a Fish, either *Pteraspis* or *Cephalaspis*, built into the wall; and afterwards my friend Mr. Thackwell and myself obtained fragments and plates of these Fishes and portions of the carapaces of Crustaceans from the loose *débris* in the quarry. Plant remains occur here; and it was from the equivalent beds near Ewyas Harold Castle, I believe, that Dr. McCullough and Mr. Salter obtained the remains of a gigantic *Pterygotus*.[1]

The sections here are difficult to follow out, owing to the lanes, &c., being so much obscured; but a walk from the quarry at Pontrilas Station by the Common of Ewyas Harold will lead the geologist to a Cornstone quarry yielding remains of *Cephalaspis* and *Pteraspis*. When the position of this quarry is compared with that of others on the opposite side of the River Munnow, above Monmouth Cap, and near Grosmont, the geologist will have little doubt that these Cornstone beds overlie the *Pterygotus*- and plant-bearing rocks of the Pontrilas Station.

[1] *Pterygotus taurinus*, Salter, see pp. 75 and 76 of this Monograph.—H. W.

14.—Rowlestone Section, and Cusop Beds near Hay. Flagstones overlying the Lower Cornstones.

The geologist who wishes to study the correlation of these strata should first visit the town of Hay in Breconshire.

In that interesting district the Old Red Sandstone is denuded into lofty hills, with the Wye flowing on the line of denudation between them and the Radnorshire Silurians, upcast on the north and north-east.

Descending downwards from the upper crests of the "Brownstones" of the Black Mountains, and where portions of Old Red conglomerate still linger, we pass from Brownstones into thin Cornstones (Upper Cornstones), in which, only last summer, in company with Mr. Thomas, of Hay, I detected a portion of the dermal plate of a *Scaphaspis*. These Cornstones overlie and pass downwards into greenish and grey sandstones, with beds filled with layers of carbonaceous matter. Years ago speculations were entered into for sinking for coal on the east side of the ravine above Cusop, two miles south of Hay, and much money was sunk in these equivalents of the Rowlestone beds.

Below these flaggy beds (Cusop carbonaceous beds) there are other Cornstones, as seen in the section between Hay and Mouse Castle, and from these Cornstones came the large Fish spine exhibited by myself at the late meeting of the British Association at Edinburgh (1871), and named *Onchus major* by Mr. Etheridge, as being the largest known spine from the Lower Old Red yet discovered.[1] To the north-west of the town of Hay the lower beds of the Old Red with greyish sandstones and carbonaceous remains pass into the Upper Silurians of Radnorshire.

Now, he who examines the Rowlestone district near Pontrilas and Abergavenny, and observes how, as near Hay, Cornstones pass upwards and are overlain by flaggy beds with carbonaceous remains, these flaggy beds always occupying a particular horizon, will have little doubt in correlating the Rowlestone and Cusop flags as belonging to the same rock series, and in concluding that they belong to an upper Cornstone series and not to the lowest. In short, they form a line of demarcation between the Lower Cornstones and the Upper thin Cornstones and Brownstones which are so unfossiliferous throughout all the region of the Old Red of the West of England. On the summit and flanks of Rowlestone Hill, south of Ewyas Harold, Herefordshire, these grey flags have been quarried. They furnished a new species of *Stylonurus* (*St. Symondsii*), which is not unlike *St. Powriei* of the Devonian of Forfarshire, besides other remains of Crustaceans found by Dr. McCullough of Abergavenny, such as *Præarcturus gigas*, Woodward, &c. I have seen Fish remains in strata overlying these Rowlestone Rocks among the Black Mountains, and on the Darren, but the above are the newest relics of Crustaceans in the Old Red proper of which the writer is aware.—W. S. S.

[1] While staying at Penzance I have seen, in the Geological Museum of the Institute, portions of Fish-spines from the Cornish Polperro beds which are associated with numerous remains of *Scaphaspis* and *Pteraspis*, like *Onchus major* in structure.—W. S. S.

Genus 2.—Slimonia, *Page*. 1856.

Species 1.—SLIMONIA ACUMINATA :—Salter, sp., 1855. Plates XVII—XX.

Himantopterus acuminatus, *Salter*. Quart. Journ. Geol. Soc. 1855, vol. xii, p. 29, fig. 4.
—— maximus, *Ib.* Id., p. 28, fig. 3.
Slimonia acuminata, *D. Page*. Advanced Text-book, 1856, p. 135, fig. 3.
Himantopterus acuminatus, *Ib.* Id., 2nd edition, 1859, p. 163, figs. a. b.
—— —— *Ib.* —— p. 159, fig. 2.
Pterygotus acuminatus, *Salter*. Mem. Geol. Surv., Mon. I., 1859, p. 57, plates ii, xiii, figs. 1—4, xv, fig. 1.
Slimonia acuminata, *H. Woodward*, 1863. Intellectual Observer, vol. iv, p. 229, plate and woodcuts.

Slimonia acuminata is the largest species found at Logan Water; and its generic name has been justly given to it in honour of Mr. Robert Slimon, who has, for more than twenty years, laboured most assiduously, at Lesmahago, to perfect our knowledge of this ancient and interesting order of Crustacea.

If we compare the figures of specimens given on Plates XVII to XIX, accompanying this Monograph, with those published in 1859 by Messrs. Huxley and Salter, we shall the better be able to understand and appreciate the vast amount of additional information which we now possess, the result of Mr. Slimon's energetic labours.

Plate XVII represents the most perfect example known; and will serve to convey a very correct idea of the relative proportions and structure of *Slimonia* as compared with the preceding genus *Pterygotus*.

The specimen in this plate has its *ventral* aspect exposed, and, therefore, we do not see the large trapezoidal carapace with its prominent marginal eyes (figured in Plates XVIII and XIX); but we notice the elongated heart-shaped lip-plate or metastoma (*m*) in the centre, covering the buccal cavity; the pair of minute and simple antennæ (2, 2, and detached fig. 3), which in this genus seem to take the place of the great chelate antennæ seen in *Pterygotus* (figured repeatedly in the plates which illustrate Parts I and II of this Monograph); the three pairs of simple many-jointed and spinose endognaths (3, 4, 5, and detached fig. 4); and the great swimming-feet or ectognaths (6, 6) with their broad basal joints serving evidently as powerful jaws; also the thoracic plate or operculum with its tongue-shaped median plate (7, *c*) *in sitû*, covering the first and second thoracic rings. The six broad thoracic segments, followed by six narrow abdominal somites, the last four of which are almost quadrangular in form, and terminated by a finely pointed spear-shaped tail-plate or telson, contrast markedly with the more robust and compact body in *Pterygotus*, with its rounded head-shield and great chelate antennæ.

The Head-shield (Pl. XVIII, fig. 2; Pl. XIX, fig. 1) in general form is oblong, the sides slightly swelling for about two thirds of the length, and contracting about the anterior third to again expand slightly at the anterior angles, where the prominent oval eyes are placed (*o*, *o*); the front border is somewhat rounded and, as well as the sides, crenated, or rather tuberculated along the edge.

The posterior border is incurved, and the lateral angles rounded. A kind of double tuberculate border is conspicuous down the sides of the head, the tubercles being elongated, while on the arched front border there are three or four rows. Two short minute keels, one on either side of and close to the median line, mark the hinder border of the head, and are also repeated on the posterior edge of each of the first six body-segments.

The Ocelli.—The two larval eye-spots (ocelli, *l*) are distinctly to be seen near the centre of the head-shield, and about one third of its length from the front border.

The Compound Eyes.—The facets composing the great compound marginal eyes can be not unfrequently clearly seen with a hand magnifying-glass.

Mr. Erxleben has endeavoured to give on Pl. XIX, fig. 2, a representation of the compound eye in *Slimonia*, magnified four times, but the facets are drawn upon rather too large a scale. They measure with the micrometer one tenth of a millimètre each.

Head-shields of *Slimonia* are very numerous both in the British Museum collection and in the Museum of Practical Geology, Jermyn Street.

That on Pl. XIX, fig. 1, measures 5¾ inches in greatest breadth and 6¾ inches in greatest length. That on Pl. XVIII, fig. 2, is 2¾ inches in breadth and 3¼ inches in length.

The head of *Slimonia* was very well known to Mr. Salter at the time of the publication of the 'Geological Survey Monograph,' as appears from the figures given on pl. ii accompanying his description, and from a woodcut in the text at p. 63. Mr. Salter gives an outline of a head measuring 6¼ inches in breadth and 7½ inches in length from the anterior to the posterior border. He does not notice the larval eye-spots on any of the Eurypterida; they have, however, been observed in *Eurypterus remipes* by Professor James Hall, in America.[1]

No ornamentation of any kind has been detected upon the general surface of the head-shield.

[1] 'Nat. Hist.,' New York, Part iv; 'Palæontology,' vol. iii, plates 80—84, pp. 382—419.

The Body-rings are twelve in number, exclusive of the telson, or tail-plate. Of these the first, or anterior, six are reckoned, as in *Pterygotus* (see Parts I & II), as thoracic, and the remaining six as abdominal somites.[1]

Thoracic Segments.—In these somites the breadth greatly exceeds the length, the fourth segment being nearly six times as broad as it is long.

In the large and very perfect specimens figured on Pl. XVII the proportions of the thoracic segments are as follows:—

	No.	Breadth.		Length.	
1st Segment	(8)[1]	5 inches	by	7	lines.
2nd "	(9)	5½ "	"	10	"
3rd "	(10)	5¾ "	"	11	"
4th "	(11)	6 "	"	13	"
5th "	(12)	5½ "	"	12	"
6th "	(13)	4½ "	"	12	"

The posterior margin of the six anterior segments is ornamented, like the hinder border of the head, with two small keels or ridges upon their dorsal surfaces,[2] one on either side

[1] These figures *in brackets* will be found to agree with the figures placed against each segment in the plates of this Monograph, and also with the Roman numerals placed upon each segment in the restored figures in Plates VIII and XX.

They are intended to remind the student that the head-shield is not a *simple segment,* but is composed in the Eurypterida of *at least seven* coalesced segments, each represented by a pair of appendages.

The hindmost of these seven coalesced segments, however, bears the opercular plate, as in the modern *Limulus,* and is considered to be equivalent to the first thoracic somite, as in the Xiphosures.

There are then only six *true cephalic somites* remaining in the head-shield of *Pterygotus,* whilst in *Limulus* there are clearly seven. This is explained by assuming that the somite bearing the antennules in *Limulus* is wanting or aborted in *Pterygotus.* (See ante, p. 43.)

Following out this assumption that the antennules were aborted, we have everywhere spoken of the first pair of appendages as the *antennæ.* (See p. 43.) [See also 'Quart. Journ. Geol. Soc.,' 1866, vol. xxiii, p. 33.] The figures and Roman numerals, therefore, express the *actual number* of segments present, which are represented by paired appendages, not the theoretical seven cephalic, and seven thoracic, and seven abdominal segments = twenty-one. (See Introduction, Part I, pp. 4—6.)

The absence of a number corresponding to this assumed aborted segment has inadvertently led to two errata. Thus in the explanation to Plate VIII the segment marked XIV is erroneously classed as thoracic instead of abdominal, and the error is repeated in Part II, pp. 63 and 65, the segment (14) being there also bracketed as thoracic.

In Part I, p. 63, I have said that "in this case" [that is, if we assume that the first thoracic somite is coalesced with the head—then] "only the first six anterior somites will be counted as thoracic, the posterior six will be reckoned as abdominal, and the 'telson' will make up the twenty-one segments."

[2] They are seen as impressions—through the compression of the segments—in the specimen figured in Pl. XVII, which exhibits a *ventral* aspect of *Sl. acuminata;* but these carinæ are strictly confined to the *dorsal* surface of the segments.

of the median line, each composed of from three to four tubercles arranged in a line, with their blunt points directed backwards. The sides of the anterior segments are rounded and the hinder border but slightly incurved, like the posterior border of the head. A line is usually seen crossing each segment parallel with its anterior border, and indicating the portion of each body-ring inserted beneath that of the preceding segment. At first sight there does not appear to be any trace of the squamate ornamentation, covering the surface of the segments, so characteristic of other members of this sub-order; but, although

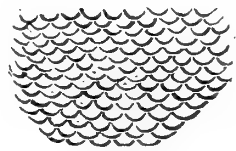


FIG. 30.—Plicæ, greatly magnified, from an abdominal ring in *Slimonia acuminata*, Salter, sp.

rarely seen, it may occasionally be detected upon the anterior border of the somites; the plicæ are, however, very minute, and not at all conspicuous as in *Pterygotus anglicus*.

The foregoing measurements do not represent by any means the largest-sized body known. A detached body, in which the first six somites (thoracic) are conjoined, preserved in the British Museum, gives the following measurements:—

	No.	Breadth.		Length.
1st Segment	(8)	$8\frac{1}{2}$ inches	by	1 inch.
2nd ,,	(9)	$8\frac{1}{2}$,,	,,	$1\frac{1}{4}$,,
3rd ,,	(10)	$8\frac{3}{4}$,,	,,	$1\frac{1}{2}$,,
4th ,,	(11)	8 ,,	,,	$1\frac{1}{2}$,,
5th ,,	(12)	$7\frac{1}{4}$,,	,,	$1\frac{1}{4}$,,
6th ,,	(13)	6 ,,	,,	$1\frac{1}{4}$,,

Abdominal Segments.—These commence with the fourteenth somite, and, in the specimen figured in Pl. XVII, measure as follows:—

	No.	Breadth.		Length.
7th Segment	(14)[1]	$3\frac{1}{2}$ inches	by	1 inch.
8th ,,	(15)	$2\frac{3}{4}$,,	,,	$1\frac{1}{2}$,,
9th ,,	(16)	2 ,,	,,	$1\frac{1}{2}$,,
10th ,,	(17)	2 ,,	,,	$1\frac{3}{4}$,,
11th ,,	(18)	$1\frac{3}{4}$,,	,,	2 ,,
12th ,,	(19)	$1\frac{3}{4}$,,	,,	$2\frac{1}{4}$,,

The sides of these posterior segments are nearly straight; they have no keel-markings, as is the case with the thoracic segments, nor are their borders produced at all.

[1] See foot-note [1], *ante*, page 107.

The surface of all the segments is much crumpled and creased, clearly indicating that the covering of the body was far less robust than in *Pterygotus anglicus*, Agassiz.

The *Telson* or tail-plate (20) is a large, somewhat oval plate, terminated by a long slender finely pointed spine, often nearly as long as the telson itself. The length without the spine, in fig. 1, Pl. XVII, is three inches, and, including the spine, $5\frac{3}{4}$ inches. The greatest breadth is $2\frac{1}{4}$ inches; the breadth at its articulation with the last segment $1\frac{1}{4}$ inch. The lower side of the telson is somewhat hollowed, whilst upon the dorsal surface it is marked by a strong median keel which is continued down the centre of the tail-spine to its extremity.

The margin of this tail-joint is ornamented with a serrate or tuberculate ornamentation near the base (like that on the margin of the head), which is often seen to be continued down the sides of the terminal spine.

We have already referred to the ocelli and compound eyes which occupy the dorsal aspect of the head-shield; and must now describe those appendages which are grouped around the mouth on the ventral aspect of the body.

The Antennæ (Pl. XVII, figs. 1, 2, 2, and 3; Pl. XVIII, figs. 1, 2, 2). This pair of appendages is very small; and, from the fact of their always lying closely folded down on either side of the mouth, they had remained unnoticed by previous observers until pointed out by me in an account of this genus published in 1863.[1]

The subjoined woodcut (fig. 31) shows the usual position in which they are found. In

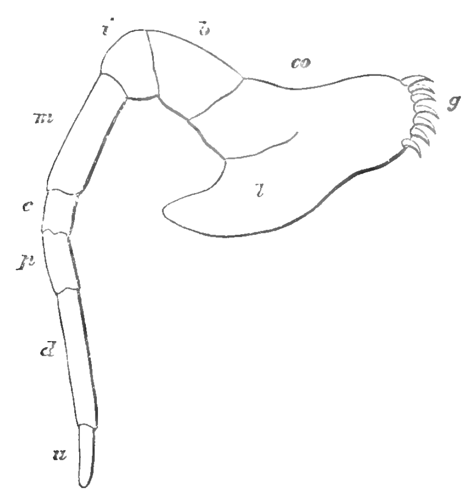


FIG. 31.—Antenna of *Slimonia acuminata*, Salter, sp. (Natural size).

Pl. XVII, fig. 3, the palpus is turned in the opposite direction with regard to its basal or attached portion (endognath) to that in which it usually occurs.

[1] See 'Intellectual Observer,' vol. iv, 1863, pp. 229—237; woodcut K, p. 235.

The first or coxal joint (*co*) is the largest, measuring 9 lines in its greatest length and 9 lines in its greatest breadth. The tongue-shaped extension (*l*) unites it to the head and to the muscles by which the palpus (*b*—*u*) and the endognath (*g*) are moved.

The mandibular portion (*g*) is armed with from 7 to 8 sharp and recurved teeth about 1 line in length. From the upper side of the endognath the palpus takes its rise: (*b*) the *basos* measures 6 lines in length and four lines in breadth: (*i*) the *ischium* commences 4 lines in breadth, but contracts to 2 lines at its distal end; it is 3 lines in length: the four succeeding joints are nearly cylindrical in form: (*m*) the *meros* is 8 lines in length and 2 lines in breadth: (*c*) the *carpus* is 3 lines in length and 2 broad: (*p*) the *propodos* is 4 lines long and 1½ broad: (*d*) the *dactylus* is 9 lines long and 1 line broad: (*u*) the *unguis* or terminal joint is 4 lines long and 1 line broad.

The structure of this pair of appendages differs widely from the antennæ in the preceding genus (see Parts I & II), and seems to indicate a close affinity with *Eurypterus* (to be presently described).

Instead of the powerful chelate appendages with which the front of the head in *Pterygotus* was armed, we find in *Slimonia* only this pair of minute and simple eight-jointed antennæ which could merely have served as feelers (and accessory endognaths), not as organs of prehension.

Another essential point of difference to be noted in these organs as compared with those of *Pterygotus* is in the fact that the chelate organs in *Pterygotus* do not perform the functions of manducation with their basal joint, but only subserve the purposes of prehension, and to convey food to the mouth, being placed in front of the buccal orifice.

In *Slimonia* the small slender antennæ are expanded at their base so as to form an additional pair of jaws (endognaths), and are, therefore, directly in relation with the buccal orifice.

These distinctions are of the highest importance in considering which of the two pairs of antennary organs has been suppressed in the Eurypterida.

If we take *Pterygotus* by itself, the fact of its antennæ not being furnished with a mandibular basal joint would lead to the inference that these great chelate organs of prehension were equivalent to the *antennules* in *Limulus*, and that the antennæ were suppressed.

If, on the contrary, we take *Slimonia* by itself, the fact of its antennæ being furnished with maxillated basal joints would favour the inference that they were equivalent to the *antennæ* in *Limulus*, and that the antennules were suppressed.

But we so frequently find the same pair of organs in closely allied families, and even genera, of living Crustacea so greatly modified as to present scarcely a character in common save their corresponding position, that we may well suppose the differences of form and office above described to be due, not to a difference in the organs, but to diversity of habits in the genera; suggesting the more actively predacious character of *Pterygotus* as compared with *Slimonia*, and probably that the food of the former consisted of quick-swimming fishes and cephalopods, whilst the latter preyed upon minute or sedentary animals, or was possibly a carrion-feeder, like so many of its representatives at the present day.

If we really knew such to be the actual function required to be performed in each case, the organs in question could hardly be better adapted for their respective tasks.

Endognaths (= Mandibles and Maxillæ) (Pl. XVII, figs. 1, 3, 4, 5, fig. 4; and Pl. XVIII, figs. 1, 3, 4, 5).—Following next after the antennæ we find three pairs of endognaths, with a pair of eight-jointed palpi to each. There is a very good woodcut (fig. 7) of one of these on p. 62 of the Survey Memoir on *Pterygotus*, and upon p. 63 of the same work is a woodcut of a head with parts of two of the palpi preserved nearly *in sitú*.

We figure a large detached endognath on Pl. XVII, fig. 4, the palpus of which measures four inches in length.

The *coxa* or basal joint (*co*) is roughly quadrangular in outline, and is 1½ inches in both length and breadth; the inner border (*g*) is 8 lines broad and is armed with about fourteen sharp and curved teeth, which at the upper end are nearly 2 lines in length, but diminish rapidly to the lower part of the mandible, where they are little more than bristles (as in the endognath of *Limulus*); the lower border (*b*) is nearly square, but half an inch narrower than the upper border; by it the appendage was attached to the head; a few scattered scale-markings are disposed over the upper free border.

The *palpus* (*b-u*) in this specimen seems to be turned the reverse way; it lies with its spiny border downwards and its point directed outwards; usually its upper border is spinose and the recurved terminal spine is directed inwards, as in the accompanying woodcut, fig. 32, p. 112.

The *basos* (*b*) is an oblong joint one inch in length and three quarters of an inch broad; it has a few scale-markings on its upper border.

The *ischium* (*i*) measures one inch along its longest border, but only half an inch along its spinose upper border, being sharply bent upwards; it is three quarters of an inch broad.

The *meros* (*m*) is three quarters of an inch long and the same broad; its distal end and that of the four succeeding articulations is fringed with spines.

The *carpus* (*c*) is three quarters of an inch long and seven lines broad.

The *propodos* (*p*) is five lines long and six broad.

The *dactylus* (*d*) is three lines long and four broad.

Between this joint and the terminal claw (*u*) there is a small joint (*t*) two lines long and four broad (seen also in the woodcut, fig. 32, p. 112); the claw (*u*) is half an inch long, and strongly recurved.

The accompanying woodcut (fig. 32, p. 112) represents the largest endognathary palpus with which I am acquainted. It measures seven inches in length and two inches in greatest breadth. The five distal joints appear to have been fringed with spines at their lower and outer borders, which are more sharply pointed near the extremity. The form and proportion of the five distal joints agree very closely with those in the palpus drawn on Pl. XVII, fig. 4; but the *ischium* and *basos* differ considerably, and appear to be squeezed together. The same squamate markings are seen on the surface. (See Woodcut, fig. 32.)

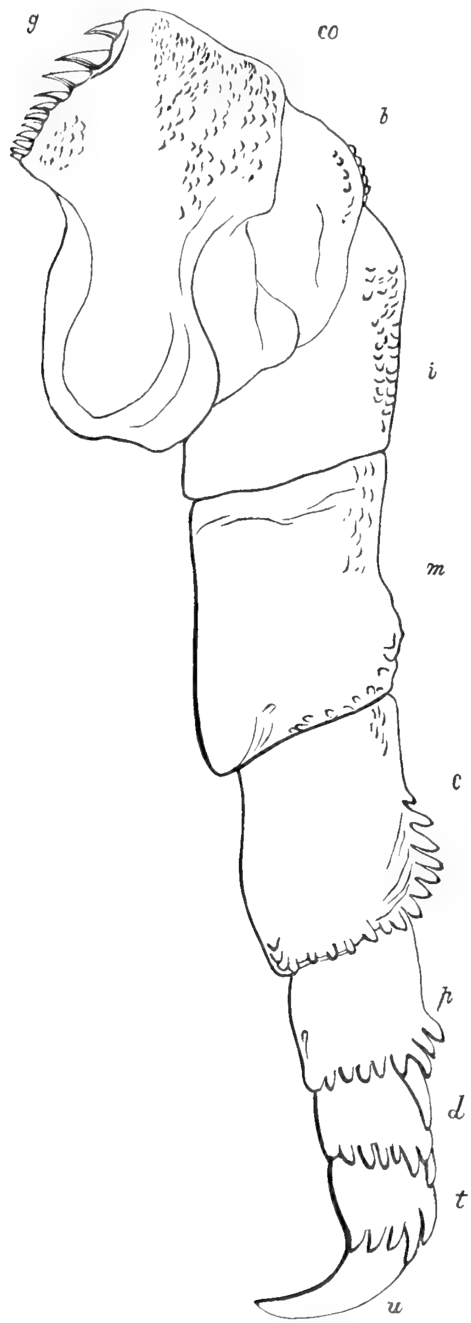


FIG. 32.—Endognathary palpus of *Slimonia* (natural size), U. Silurian, Lesmahagow, Lanarkshire. Original specimen in the Britisih Museum.

These mouth-appendages appear to be much more robust than in *Pterygotus,* and must have served, not only as powerful jaws, but also to retain and bring within reach of the mandibles the living or dead substances to be devoured.

Swimming-feet (Ectognaths) (Pl. XVII, figs. 1, 6, 6, and Pl. XVIII, figs. 1, 6, 6).—The largest swimming-foot of this species with which I am acquainted is a detached example in the British Museum. This specimen measures ten inches from the crest of the maxilla to the terminal palette, the swimming-foot itself measuring six inches in length. The position and form of these organs are well seen, *in sitû,* in Pl. XVII, fig. 1, and in the detached appendages figured on Pl. XVIII, fig. 1.

Coxa.—This joint in form may be roughly compared to a right-angled triangle, the inner or mandibular border and the base forming the rectangle. The base measures $2\frac{1}{2}$ inches in breadth, to the outer angle of which the great swimming-foot is seen to be attached, the outer and longest side of the triangle measuring $4\frac{1}{2}$ inches; the upper end, which forms the mandible, is contracted three inches from the base, where it measures only ten lines in breadth; the mandibular border is $1\frac{1}{4}$ lines broad, and beset with 14 nearly equal-sized teeth one line in length. Some minute squamæ are observable upon the surface of this joint.

Basos.—This is a small segment, four lines only in length, inserted at its proximal end into the external angle of the coxal joint, where it is nine lines broad and expanding laterally at its distal end to $1\frac{1}{4}$ inches, so as to embrace in its cup-shaped and rounded lower border the conjoined *ischium* and *meros*.

The *Ischium* and *Meros* resemble an oblong square divided diagonally, the *ischium* having its upper and proximal border 11 lines broad, and its lower end cut off by the distal termination of the meros, which is one inch broad, whilst the proximal end of the meros is in like manner cut off by its union with the *ischium*.

The *ischium* along its inner longitudinal free border measures one inch; the *meros* along its outer rounded free border measures $1\frac{1}{2}$ inches; the conjoined border measures 16 lines in length.

The *carpus* resembles the *basos* in form; it is ten lines broad at the upper and five lines long and slightly expanded at the lower border, which is curved so as to afford a better articulation to the *propodos*.

The *propodos* is two inches long and ten lines broad, and its sides are nearly parallel; it is excavated at the lower extremity, so as to admit the insertion of the *dactylus*.

Between these two on the inner side is a small triangular plate intercalated, four lines in length and three in breadth; a similar plate is known to exist in *Eurypterus* and other forms.

The *dactylus* is $1\frac{1}{2}$ inches long and half an inch broad; near its termination a minute plate (*unguis*) is inserted; a similar terminal plate is noticed by Professor Hall in *Eurypterus*. The border of these joints is sometimes seen to be slightly crenated.

Post-oral Plate or *Metastoma* (Pl. XVII, fig. 1, *m*; Pl. XVIII, fig. 1, *m*).—This plate is seen *in situ* in Pls. XVII and XVIII; the largest lip-plate of *Slimonia* known is that figured in the subjoined woodcut (fig. 33) of the natural size. It measures $5\frac{1}{2}$ inches in length and $1\frac{3}{4}$ inches in greatest breadth, the lower part being only ten lines broad. Its greater length as compared to its breadth distinguishes it at once from the metastoma of *Pterogotus*, with the remains of which *Slimonia* is commonly found associated.

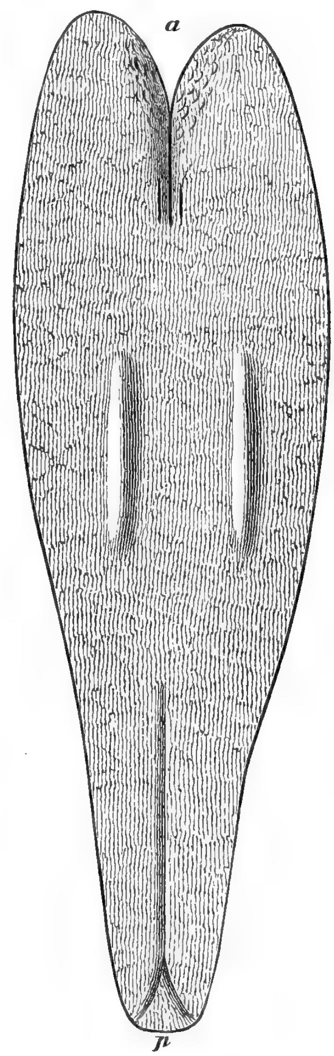


Fig. 33.—Largest lip-plate of *Slimonia acuminata* known, from Upper Ludlow Rock, Lesmahagow. Original preserved in the British Museum.

The upper end (*a*) is deeply bilobed, the lobes elliptical and the notch very narrow; its greatest breadth ($1\frac{3}{4}$ in.) is in the centre of the upper two thirds; the lower third is very narrow and has a raised keel down the centre, two inches long, which bifurcates at the hinder border. Near the centre of the widest part are two subcentral parallel ridges about 1½ inches long. A few scale-like markings are seen near the upper notched end of the lip-plate. This plate was, no doubt, attached along the line of the posterior median ridge and by its hinder border (*p*). It overlapped the inner borders of the great basal ectognaths, and served as a *mentum,* or lower lip, being attached behind, not in front of the buccal orifice, as is the hypostome in the Trilobita.

The Thoracic Plate or Operculum (Pl. XVII, fig. 1, 7, *c*, and fig. 2; and Pl. XX, figs. 2, 3, & 4).—The displacement of this plate in the description of this species by Mr. Salter ('Geol. Surv. Mem.,' Mon. I, p. 59), where, as in the descriptions of *Pterygotus,* it is called "the conjoined epistoma and labrum," has already been referred to under *Pterygotus.* (See restoration after Mr. Salter, Part I of this Monograph, p. 27 and p. 39.) It is only necessary to point out that fig. 5, p. 59, of Mr. Salter's description (op. cit.) is identical in form with the plate seen *in sitû* on our Pl. XVII, fig. 1, 7, *c*; and that figured on p. 60, fig. 6 (op. cit.) is the tricuspid median appendage of a plate identical in form with that figured on our Pl. XVII, fig. 2, and is known to occupy the same relative position in the body of *Slimonia* as that seen *in sitû* (7, *c*) on the same plate in fig. 1. It is, in fact, homologous with the *operculum* of *Limulus* (Part I, Pl. IX, fig. 1, 8, and fig. 1, *c*), and is composed, as in *Limulus,* of the modified appendages belonging to the first thoracic somite, which in both *Limulus* and *Slimonia* is coalesced with the cephalon.

The thoracic plate seen *in sitû* in fig. 1, Pl. XVII, measures five inches from border to border, and is 1½ inches in length; it is divided into two lateral oblong pieces by a median lobe (*c*), which is 2¼ inches long and projects considerably below the rest of the lower free border of the plate. This median lobe in fig. 1 is broadest at its lower rounded extremity, where it is eight lines wide, contracting to six lines where it unites with the two oblong lateral pieces of the *operculum;* at its upper end it forms a small triangle, four lines long and four broad, from the apex of which a narrow double line extends to the upper attached border. Two diagonal lines take their rise from the upper triangular end of the median lobe (*c*), uniting with the upper border of the operculum one inch on either side of its central line.

The specimen figured on Pl. XVII, fig. 2, measures eight inches in breadth and 1¾ inches in length; the median lobe is 3½ inches long; its termination (*c*), instead of being rounded, as in fig. 1, is tricuspid, measuring one inch across the side cusps; the centre of the median lobe is ridged; the margins are slightly curved, and unite in a lanceolate termination half an inch from the anterior attached border. Instead of the two diagonal lines seen in fig. 1, three lateral lines are given off from near the lanceolate upper end of the median lobe, which, expanding on either side, reunite with each other, and so with the upper and inner attached border of the operculum one inch on either side the median line. A slight double border two lines broad surrounds the free margin of the lateral lobes of the operculum.

There is good reason to believe that both these forms of opercular plates not only belong to *Slimonia*, but to one species, namely, *Slimonia acuminata.*

How, then, can we explain the diversity in the form of the median appendage in the two opercula figured on Plate XVII?

If we refer again to its living analogue, *Limulus*, we shall find that in the Moluccan and American king-crabs the same parts are modified in the males of both species, namely, the antennæ and the median articulated appendages of the thoracic plate or operculum (see Pl. IX and Woodcuts, I, II, fig. 34), corresponding to the coalesced median appendage in *Slimonia*.[1]

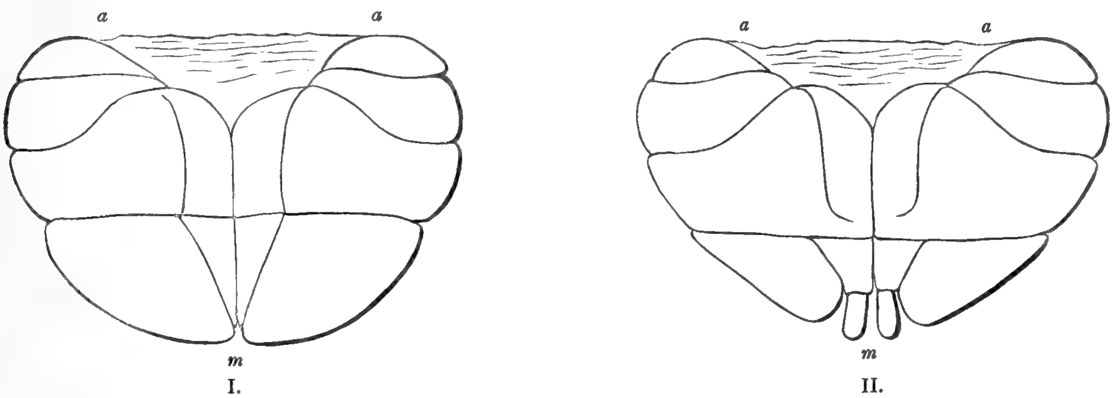


FIG. 34.—Operculum or thoracic plate of *Limulus polyphemus*, Linn. (living). I. Male. II. Female. *a, a.* Anterior attached border: *m* = median appendage.

At present we only know one form of antennæ in *Slimonia*, but the discovery of the two forms of thoracic plate (Pl. XVII, fig. 1, 7 *c*, and fig. 2; and Pl. XX, figs. 3 and 4) affords strong grounds for assuming that we have here evidence of the male and female of this fossil type.

The Branchiæ (Pl. XIX, figs. 3, 4).—In my account of *Pterygotus bilobus*, Salter, in Part II of this Monograph (pp. 66—68, Pl. XI, fig. 2; Pl. XII, figs. 1 *a*, 1 *d*; Pl. XIII, fig. 1 *h*) I have figured and described the branchial plates belonging to that species. Similar leaf-like organs of a larger size have been obtained at Lesmahagow, associated with *Slimonia*, some of which I figure on Pl. XIX, figs. 3, 4, of the natural size. They

[1] This median lobe is even more readily identified with *Limulus* if we take *Eurypterus* instead of *Slimonia* for comparison. In *Eurypterus* the division of the median lobe into two detached articulated appendages remains clearly visible, whereas in the other fossil genera these are coalesced.

This coalesced median appendage, with its broad lateral alæ, forming together the operculum, is really only the modified pair of appendages belonging to the first thoracic somite, the median pair of appendages (or coalesced lobe, as the case may be) corresponding to the endopodites, and the external alæ to the exopodites of an ordinary pair of Crustacean limbs.

This singularly modified pair of thoracic appendages perform the same office in *Limulus* as do the antepenultimate thoracic legs in the female lobster, or the last thoracic limb on each side in the male; in the former bearing the *oviducts*, in the latter the *vas deferens.*

appear to be arranged in linear series, and were attached in single or double rows to the under surface of the body by their upper end, whilst their lateral and lower rounded leaf-like borders were freely bathed in the fluid medium in order to oxygenate the blood.

These leaf-like appendages are highly vascular; they are about two inches in length and three fourths of an inch broad, but they vary in size, having probably been largest near the centre of the body, becoming smaller as they approached the sides.

In the adult living *Limulus* we find the operculum, or thoracic plate, takes its rise from, and is attached to, the posterior margin of the head-shield.[1] This plate bears on its upper and inner surface the reproductive organs, or ovaries, and is succeeded by five

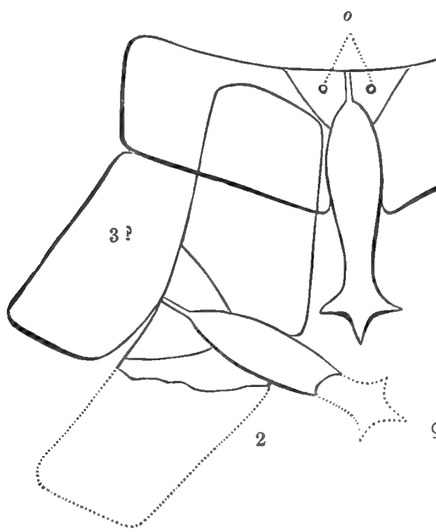


Fig. 35.—Opercula or thoracic plates of *Slimonia acuminata*, Salter, sp., found associated together.
1. The outer or *true operculum*, bearing the ovaries (*o*). 2. First branchigerous plate underlying 1, but now displaced.
3 ? Part of a third plate ?
Mr. Slimon considered this tricuspid form of plate to belong to the *female* of *Slimonia* because he has several times found it associated with masses of the eggs (called by Dr. Fleming *Parka decipiens*).

similar but more membranous plates bearing the branchiæ upon their inner surfaces. These five branchial plates are nearly hidden beneath the operculum when closely compressed. Each plate, however, represents the modified pair of appendages belonging to a corresponding thoracic somite.

In *Pterygotus* and *Slimonia* we find the thoracic plate, or operculum, occupying the same position as in *Limulus*, and attached to the hinder border of the head. But as the segments in the Eurypteridæ are not coalesced as in the modern *Limulus*, but are well developed, the thoracic plate can therefore only cover and conceal the two first thoracic somites.

Supposing each of these (marked viii and ix in Pl. XX) to have borne a single or

[1] With which the first thoracic segment is coalesced. This is also the case in *Pterygotus*, *Slimonia*, &c.

double row of branchiæ supported on two similar but more membranous plates, they might easily have lain concealed beneath the outer operculum.

This latter point seems established on the evidence of specimens both in the Museum of Practical Geology and in the British Museum, showing *two* (or three?) opercular plates of the same shape associated together, and evidently belonging to the same individual.[1]

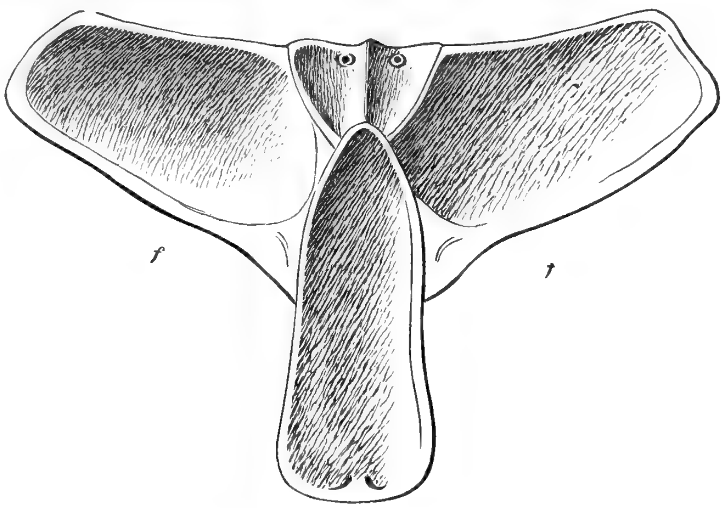


Fig. 36.—View of the inner side of an opercular plate of *Slimonia acuminata*, from Lesmahagow, Lanarkshire, in which the two reproductive openings are seen near the centre of the upper attached border (*a, a*) of the plate.

Two of these plates, moreover, exhibit two small rounded prominences, which, there can be little doubt, were ovarian openings. (See Woodcuts, figs. 35 and 36.)

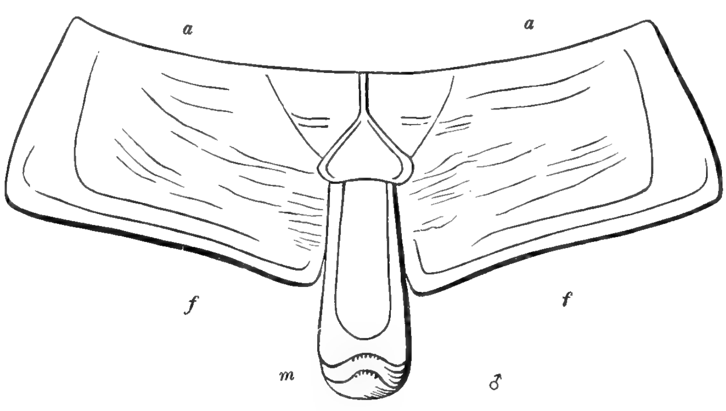


Fig. 37.—Thoracic plate or operculum of *Slimonia* ——— sp. ?, giving indication of the presence of branchigerous plates concealed beneath. *a, a.* Attached border. *f, f.* Free border. *m.* Median appendage.

This paucity in the number of pairs of appendages to the body-rings is a truly larval character, reminding one of the condition of the larval Decapod (see Part I, Plate IX,

[1] See 'Quart. Journ. Geol. Soc.,' 1867, vol. xxiii, p. 31. H. Woodward, "On the Structure of the Xiphosura and their Relationship with the Eurypteridæ."

figs. 6 & 7), and of the still nearer larval *Limulus,* which, in its earlier stage, has appendages only to three of the thoracic somites.[1]

In the two annexed diagram-figures of specimens preserved in the Museum of Practical Geology (figs. 37 and 38) the thoracic plate differs somewhat in form from that usually

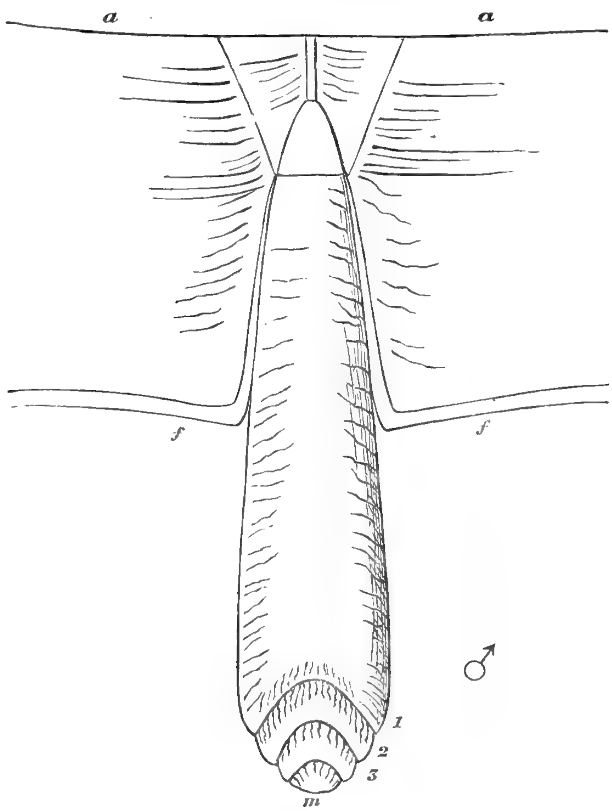


Fig. 38.—Thoracic plate or operculum—part of an almost entire specimen—of *Slimonia acuminata* (only the centre of operculum drawn), showing apparently three plates overlying each other. Length of alæ, 3 inches. Length of median appendage, 5 inches.

associated with *Slimonia acuminata;* they deserve to be recorded, therefore, on that account; but they also appear to give evidence that they conceal beneath them one or more branchigerous plates, the edges of which are seen at *m,* and along the lower border of the lateral alæ of the operculum (*f, f*).

[1] See 'Quart. Journ. Geol. Soc.,' 1867, vol. xxiii, p. 34. Also 'Sur le développement des *Limules,*' par H. Milne-Edwards, Société Philomathique, Nov. 10th, 1838. On "The Horsefoot Crab," by the Rev. S. Lockwood, Ph.D., in 'American Naturalist,' vol. iv, 1870, p. 257. Also Dr. A. S. Packard, junr., 'On the Development of the "King Crab," *Limulus polyphemus,*' read before American Association for the Advancement of Science, 1870, 'Geol. Mag.,' 1870, vol. vii, p. 491. 'Untersuchungen über Bau und Entwickelung der Arthropoden zur Embryologie und Morphologie des *Limulus polyphemus,*' von Dr. Anton Dohrn. Abdruck aus der 'Jenaischen Zeitschrift,' Band vi, Heft 4. (Received 30th September, 1871.—H. W.) And "Further Remarks on the Relationship of the Xiphosura to the Eurypterida and to the Trilobita," by H. Woodward, 'Quart. Journ. Geol. Soc.,' 1872, Part I, vol. xxviii, p. 46.

One other point which may be mentioned as favouring the conclusion we have arrived at, namely, that there were *at least two* thoracic plates, the one attached to the first thoracic segment coalesced with the cephalon, and bearing the reproductive organs; the other attached to the second (first *free*) thoracic somite and bearing the branchiæ[1]—is that some of these thoracic plates are closely covered with fine squamate markings, whilst others are entirely destitute of any kind of ornamentation upon their surface.

I do not think that this is due merely to the condition of preservation of the individual specimen; for if markings were present we should, from the fine-grained nature of the matrix, certainly find them either upon the intaglio or relievo side of the slabs, the specimens being nearly always obtained thus impressed, *in duplicate* as it were, in the matrix.

On the contrary, I am inclined to consider the presence of scale-markings in the one plate and their absence in the other to be due to the circumstance that the scale-marked plate is the outer or first thoracic plate (bearing the ovaries), whilst the smooth plate is the inner or second thoracic plate (the gill-bearing plate), which, like the inner plates to *Limulus* is thinner and more membranaceous than the external operculum.

Judging from the large series of detached portions of this species, preserved in the British Museum, and in the Museum of Practical Geology, Jermyn Street, the largest specimen of *Slimonia acuminata* known could not have exceeded four feet in length; and by far the greater number of individuals were less than three feet long. They cannot therefore be said to equal in size the largest species of the genus *Pterygotus,* which, no doubt, attained a length of at least five feet.

Besides the almost perfect specimen, figured on Plate XVII, which is about $26\frac{1}{2}$ inches in length, there are three small and nearly entire examples of *Slimonia*, measuring respectively: $7\frac{1}{4}$ inches, 7 inches, and $5\frac{3}{4}$ inches in length, and $1\frac{1}{2}$ inch, $1\frac{1}{4}$ inch, and 1 inch in breadth.

The hinder border of the head and each of the six anterior segments is marked in these young individuals with two small subcentral keels or ridges upon their dorsal surfaces.

The integument appears to have been extremely thin; no scale-markings are discernible, and the whole surface is much crumpled up.

Except that at this early stage the young of *Slimonia* seem to be much narrower in proportion to their length, the restored figures on Plate XX might serve to represent one of these small specimens. Portions preserved in section in the British Museum, and in the Museum of Practical Geology, indicate that the anterior segments in *Slimonia* were even more robust than in *Pterygotus* (see Part I, p. 41), whilst the posterior segments were nearly if not quite cylindrical.

Only one species of this singular genus is known, and its remains are, at present, confined to one locality, namely, the Banks of Logan Water, near Lesmahagow, Lanarkshire.

[1] It is quite possible there may have been a third plate, also branchigerous.

The series of forms, already figured and described, and included in the genera *Pterygotus* and *Slimonia*, although differing among themselves in many important points of structure, have one common distinctive character, namely, the position of the large compound eyes.

In the genera *Stylonurus* and *Eurypterus*, and in the XIPHOSURA (to be described in Part IV), these organs occupy a more or less *sub-central* position upon the dorsal surface of the carapace, as is the case also in the TRILOBITA. In *Pterygotus* and *Slimonia*, on the contrary, the eyes are *marginal*, being placed upon the latero-anterior border of the head. The only form which, from the position of the eyes, can be compared with *Slimonia* and *Pterygotus*, is Hall's *Dolichopterus*,[1] an American form, in which the large compound eyes approach very near the latero-anterior angles of the carapace; but, nevertheless, they are *not marginal* eyes, but are really placed upon the dorsal surface of the head, as in *Eurypterus* proper, of which, indeed, Hall makes his *Dolichopterus macrocheirus* a sub-generic form.

For the greater convenience of the palæontological student, the diagnostic characters of each genus of the MEROSTOMATA will be given in a condensed form at the conclusion of Part IV.

[1] 'Geological Survey of New York, Palæontology,' by James Hall, vol. iii, p. 414*, pl. lxxxiii, Albany, U.S., 1859.

PLATE XVI.

UPPER SILURIAN AND DEVONIAN CRUSTACEA.

Order—Merostomata.

Sub-Order—Eurypterida.

Fig.

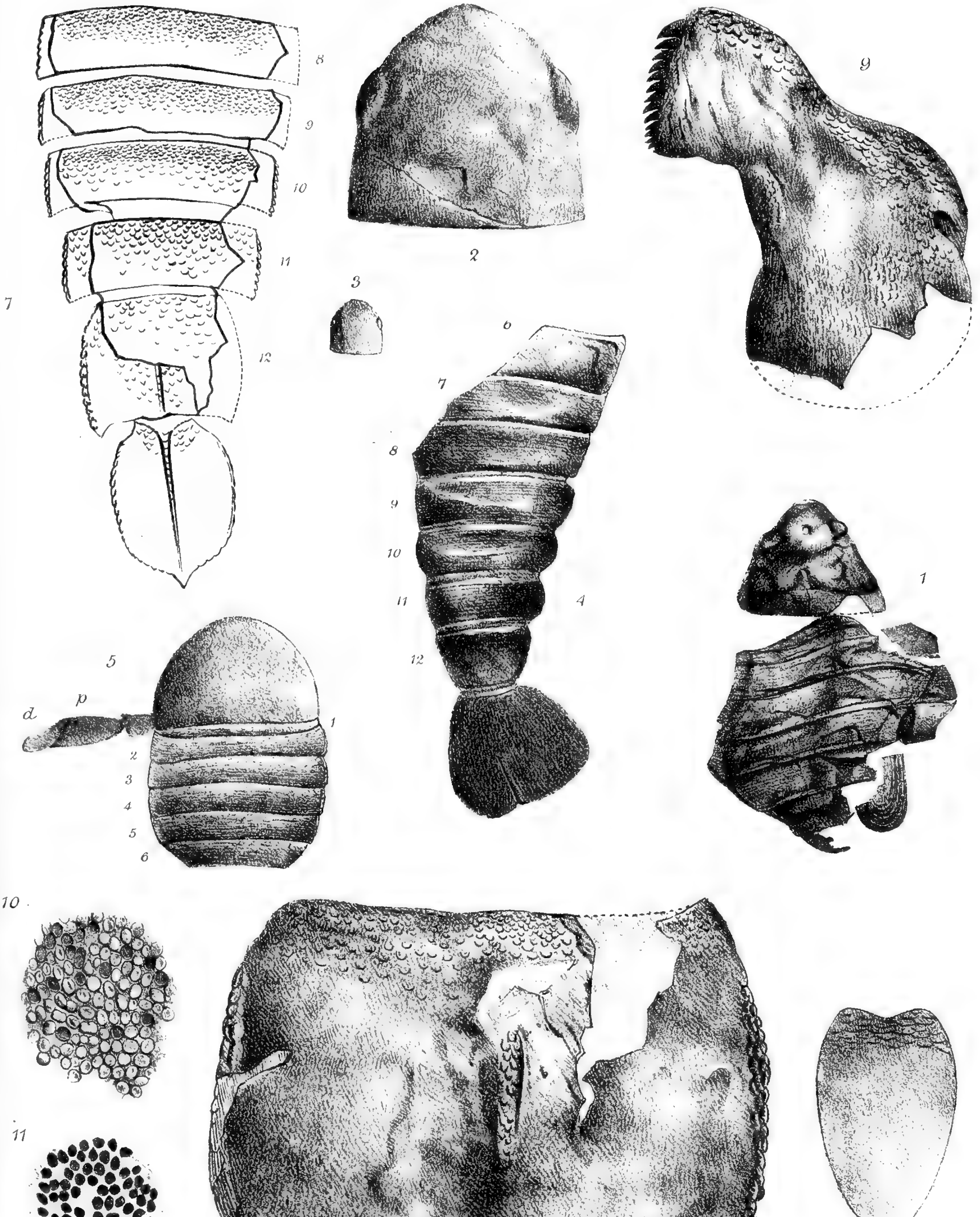
1. *Pterygotus raniceps*, H. Woodw. U. Ludlow Rock, Lesmahagow, Lanarkshire. (Drawn from the original specimen in the British Museum.) P. 71.
2. *Pterygotus Banksii*, Salter. The carapace from the Passage Beds at the Ludlow Railway Station. (In Mr. Lightbody's Cabinet.) Pp. 72—74.
3. *Pterygotus Banksii*, head of a very young individual. Downton Sandstone, Kington. (Mr. Banks's Cabinet.)
4. *Pterygotus Banksii*. The posterior segments of the body, with the telson. Passage Beds, Railway Station, Ludlow. (From Mr. Lightbody's Cabinet.)
5. *Pterygotus Banksii*. The anterior half of the body, exhibiting the carapace, six thoracic segments, and the left ectognath or swimming-foot. Upper Ludlow Rock. (Mr. Lightbody's Cabinet.)
6. A metastoma or post-oral plate. Upper Ludlow Rock. (Mr. Lightbody's Cabinet.)
7. *Pterygotus ludensis*, Salter. Posterior portion of body, reduced to two thirds. P. 76.
8. *Pterygotus problematicus?* A penultimate body-segment, showing the short *dorsal* ridge—not *sternal*, as supposed by Mr. Salter.—H. W. (From Mr. Lightbody's Cabinet.) P. 77.

   Mr. Salter remarks: "Perhaps this represents only a variety of *P. ludensis.*"
9. *Pterygotus ludensis*, Salter. Basal joint of an ectognath, with short serrations. (Mr. Lightbody's Cabinet.)
10. *Parka decipiens*, Fleming. *Ova* of *Pterygotus*. P. 79.
11. This specimen shows the eggs in section, as black carbonaceous spots, whereas in Fig. 10 the external surface and rounded form of many are well preserved.

    If these eggs were enclosed, like those of the modern *Limulus*, in a hard and horny exchorion, and deposited in the sand in the same manner, we have at once a simple explanation furnished us of their abundance in certain beds.

Figs. 10 & 11 are drawn from specimens obtained by the late Mr. Baugh, and preserved in the British Museum, from the base of the Old Red Sandstone at Trimpley, north of Bewdley.

With the exception of Figs. 1, 10, and 11, these are all re-drawn from Mr. C. R. Bone's excellent figures in plates xii and xiv of Messrs. Huxley and Salter's Monograph on the Eurypteridæ. ('Mem. Geol. Surv.,' Mon. I, 1859.)



A.T. Hollick, del et lith. W West imp.

Remains of PTERYGOTUS *Raniceps, P. Banksii, P. Ludensis &c.*

PLATE XVII.

UPPER SILURIAN CRUSTACEA.

Order—Merostomata.

Sub-Order—Eurypterida.

Figs. 1—4.—*Slimonia acuminata*, Salter, sp. P. 105.

Fig.

1. This is by no means the largest, but it is one of the most perfect, specimens met with by Mr. Robert Slimon at Lesmahagow. Both the intaglio and relievo are now preserved in the British Museum.

   The specimen exhibits its ventral aspect.

   The small letters and figures refer to the same parts and organs as indicated in Parts I & II of this Monograph.

2. A detached thoracic plate, exhibiting the tricuspid termination of the median lobe (*c*). From a specimen in the British Museum. P. 114.

3. One of the antennæ, with its serrated basal joint, and also that of the opposing maxilla. P. 109.

4. One of the endognaths. The mandible in this specimen is turned the reverse way. P. 111.

All drawn of the natural size from specimens in the British Museum.

Formation.—Uppermost Ludlow Rock.

Locality.—Lesmahagow, Lanarkshire.

From nat. on stone by J. Erxleben.

W. West imp.

SLIMONIA ACUMINATA, *Salter sp.*

PLATE XVIII.

UPPER SILURIAN CRUSTACEA.

Order—MEROSTOMATA.

Sub-Order—EURYPTERIDA.

Figs. 1, 2.—*Slimonia acuminata,* Salter, sp. P. 105.

FIG.

1. The appendages detached from the head, but otherwise found entire, as represented.

   The lip-plate, the great swimming-feet, the endognaths, and even the antennæ, are preserved.

   The specimen is drawn two thirds the natural size.

2. A detached head-shield belonging to a young individual. P. 106.

   The large compound eyes (*o, o*) and the larval eye-spots (*l e*) are well seen.

   Drawn of the natural size. From specimens in the British Museum.

   Formation.—Uppermost Ludlow Rock.

   Locality.—Lesmahagow, Lanarkshire.

1.

2.

From nat. on stone by J. Erxleben

W. West imp.

SLIMONIA ACUMINATA *Salter sp.*

PLATE XIX.

UPPER SILURIAN CRUSTACEA.

Order—MEROSTOMATA.

Sub-Order—EURYPTERIDA.

Figs. 1—4.—*Slimonia acuminata*, Salter, sp. P. 106.

FIG.

1. The largest perfect head-shield known.

    (*o*, *o*), the compound eyes.

    (*l*, *e*), larval eye-spots.

    Drawn the natural size.

2. One of the compound eyes of a small individual, enlarged four times in order to show the facets.

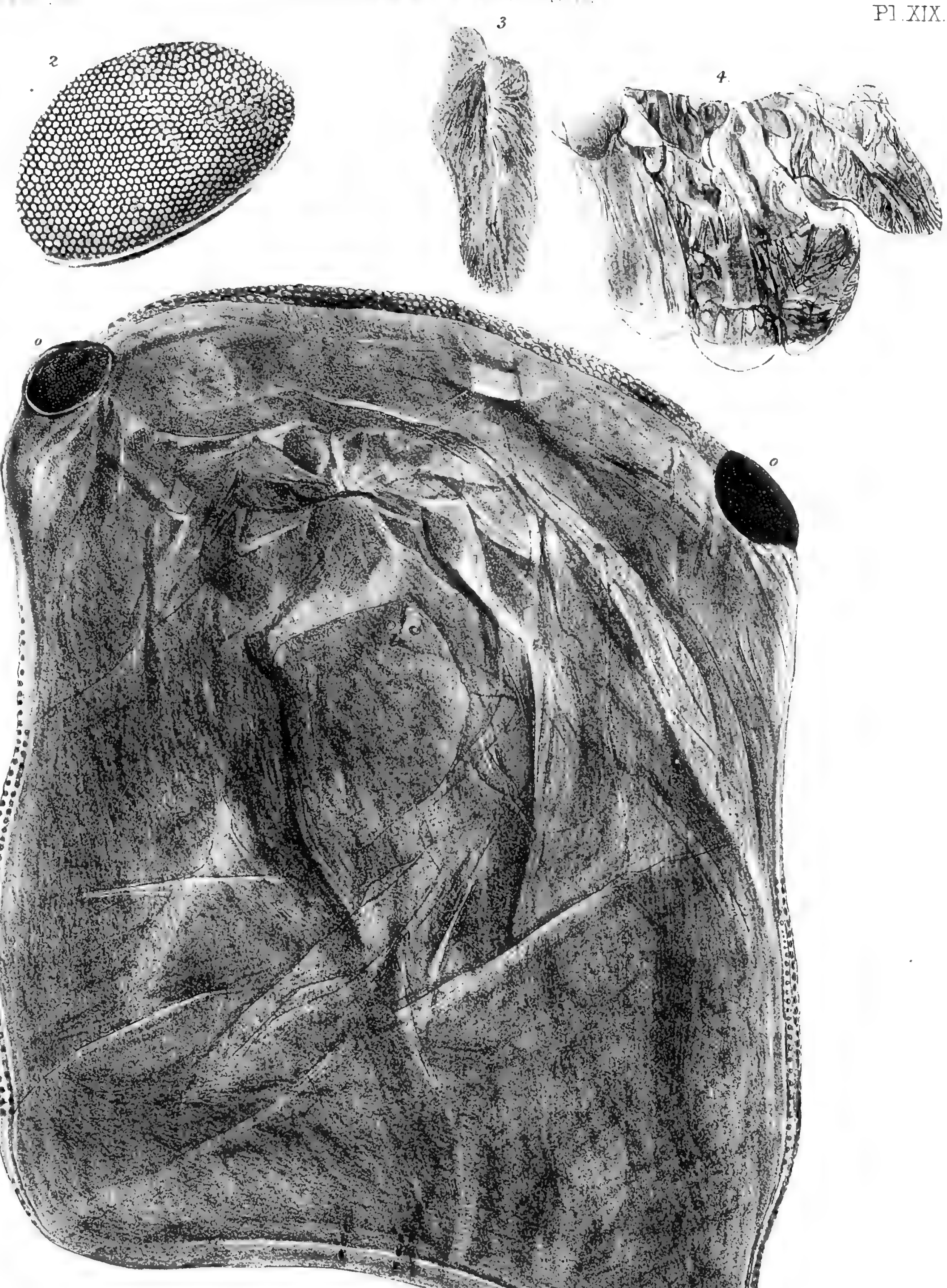
3. A detached leaflet from the branchiæ of the natural size. P. 115.

4. A series of branchiæ preserved united. Drawn of the natural size. P. 115.

    From specimens in the British Museum.

    Formation.—Uppermost Ludlow Rock.

    Locality.—Lesmahagow, Lanarkshire.



F^d nat. on stone by J. Erxleben W. West imp.

SLIMONIA ACUMINATA *Salter* sp.

PLATE XX.

UPPER SILURIAN CRUSTACEA.

Order—MEROSTOMATA.

Sub-Order—EURYPTERIDA.

Figs. 1—4.—*Slimonia acuminata*, Salter, sp. P. 105.

FIG.

1. Upper side. Restored.
2. Under side. ,,
3. Median appendage of thoracic plate or operculum (male ?).
4. Ditto (female ?).

Segments I—VI. Cephalic.[1]

,, VII—XIII. Thoracic.[2]

,, XIV—XX. Abdominal.[3]

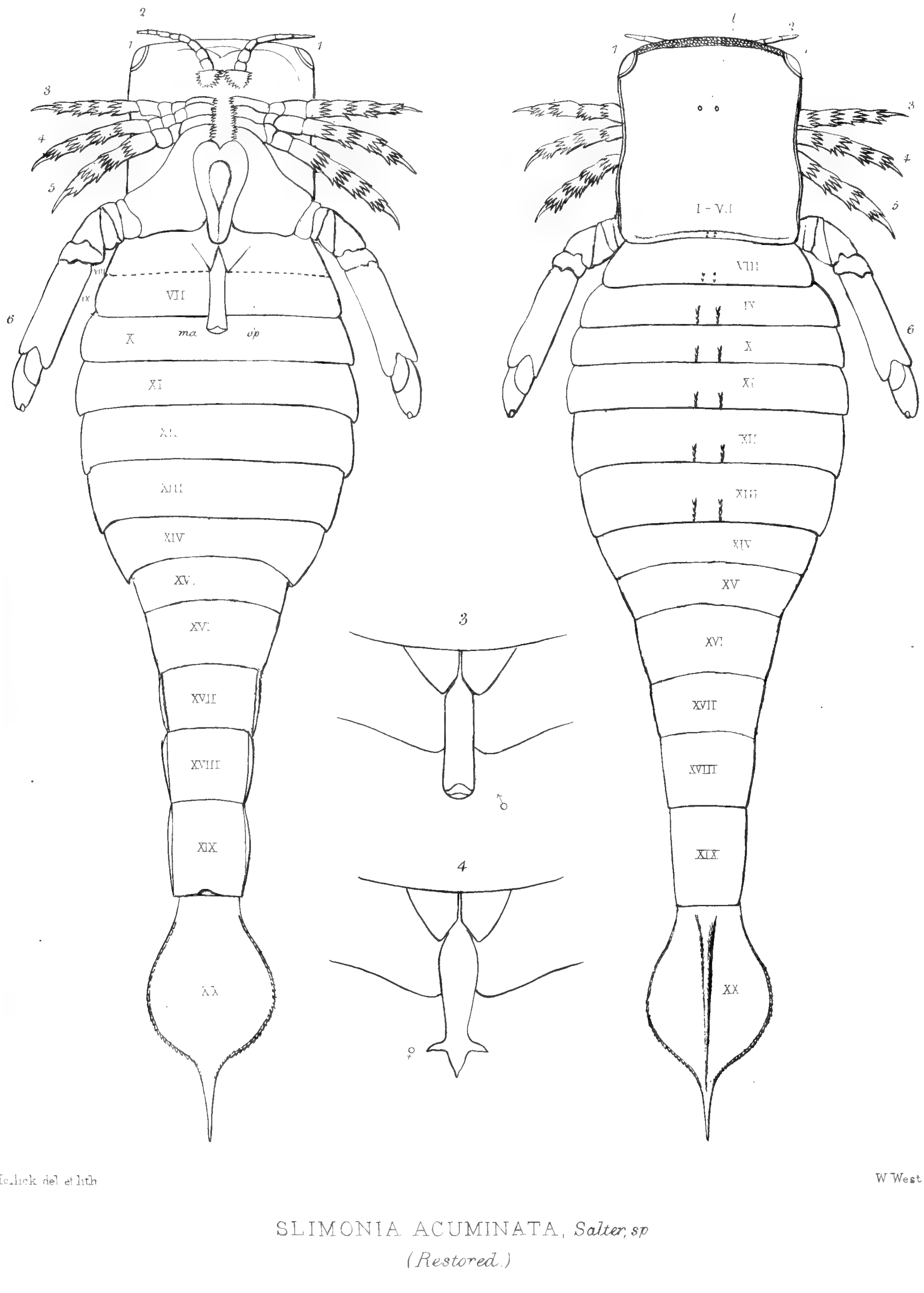
[1] One cephalic segment (that bearing the antennules) is suppressed in the Eurypteridæ.

[2] The first thoracic segment bearing the thoracic plate or operculum is coalesced with the head-shield both in *Limulus* and in *Pterygotus*, &c.

[3] In the explanation to Plate VIII, the 14th Segment is included as thoracic; this is an error, and should be corrected.

U. SILURIAN CRUSTACEA

2



A.T. Hollick del et lith

W West imp

SLIMONIA ACUMINATA, *Salter, sp*

(Restored.)

THE

PALÆONTOGRAPHICAL SOCIETY.

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LONDON:

MDCCCLXXII.

SUPPLEMENT

TO THE

CRAG MOLLUSCA,

COMPRISING

TESTACEA FROM THE UPPER TERTIARIES OF THE EAST OF ENGLAND.

BY

SEARLES V. WOOD, F.G.S.

PART I.

UNIVALVES.

WITH

AN INTRODUCTORY OUTLINE OF THE GEOLOGY OF THE SAME DISTRICT, AND MAP.

BY

S. V. WOOD, Jun., F.G.S., and F. W. HARMER, F.G.S.

Pages i—xxxi; 1—99; Plates I—VII.

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INTRODUCTION.

WHEN the 'Crag Mollusca' was passing through the press, during the years from 1846 to 1856, our knowledge of the Upper Tertiaries was not only very restricted, but some erroneous ideas existed as to the identity of beds now found to be very different in age. Geologists had begun to consider the Clyde beds as newer than the Crag; but the Bridlington deposit was regarded as coeval with the Norwich Crag, while the relation of this Crag to the Red was but vaguely ascertained. Moreover, the thick beds of sand which overlie the Red Crag, but which are now found to have no connexion with it, were then regarded as the "unproductive sands of the Crag," while the Glacial beds were known but dimly under the term "Northern Drift," or as the "Boulder Clay," under which term two very different deposits, the Boulder Till of the Cromer Cliff and the wide-spread Boulder Clay of the East Anglian uplands, were confounded together. Further, the Post-glacial freshwater beds of Clacton, Ilford, Grays, Stutton, and other places, were thought at this time by many, myself included, to belong to the age of the Crag, which, indeed, so far as any light their freshwater testaceous remains would throw on the question, there was every reason to suppose was the case.

The advance of geology during the years that have since elapsed has thrown new light on the relations borne by these various newer tertiary beds to each other, and I have been able in consequence to refer the species noticed in the present work to the formations in which they occur, according to what I believe to be their true geological sequence, and accordingly several new formations and localities are referred to throughout the Supplement that are not to be found in the original work.

Under these circumstances I have thought it desirable to confine this Supplement to fossils from that portion of England in which the succession of the various beds has been systematically worked out, and to avail myself of the labours of my son and his coadjutor, Mr. F. W. Harmer, of Norwich, who have for several years past occupied themselves in studying these formations in the field, and in regularly mapping them on the one-inch scale Ordnance maps. The area over which they have carried, and now very nearly completed this mapping, is that which extends from the Norfolk coast, as far west as the Wash, to the River Thames, comprising nearly all of the three counties, Essex, Suffolk, and Norfolk; so that they have had the opportunity of tracing the beds over a wide area, and of thus guarding themselves against the not unlikely error of regarding as separate formations, beds that differ only from local peculiarities, but are in fact identical in age and continuity.

From the map so constructed by them, the lithographic map which accompanies this Supplement, and which, although it embraces the entire Crag area, comprises only a portion of that embraced by the original, has been taken by reduction to the scale of one fourth (linear) of the original; and the sections which accompany it (and without which it would be difficult to understand either the structure of the country or the sequence of the deposits) have been carefully prepared by them for its illustration. All the formations quoted for Mollusca in my work will be found in this map, with the following exceptions; viz. the Bridlington bed, which is on the Yorkshire coast; the Kelsea Hill gravel, which is near the same coast; the gravel of Hunstanton, which is at the north-western extremity of the Norfolk Coast; the Brick-earth of the Nar, which is in the same neighbourhood; and the gravel of March, which is in the midst of the great fen district of Cambridgeshire.

The geological position of the beds thus beyond the limit of the map will, however, be explained in the following outline of the geology of the Upper Tertiaries of East Anglia, which has been written by my son and Mr. Harmer as embodying their views of the subject. The actual area from which the Mollusca described or referred to in my Supplement were obtained, is that which lies east of a line drawn from London to Bridlington, and including the latter place.

I defer some remarks which I propose to make on the fauna of the several Upper Tertiaries embraced in this Supplement, until the remaining part of it, which will contain the Bivalvia; and I propose then to give a tabular list of the species.

S. V. Wood.

AN OUTLINE OF THE GEOLOGY OF THE UPPER TERTIARIES OF EAST ANGLIA.

By S. V. Wood, junior, F.G.S., and F. W. Harmer, F.G.S.

The Coralline Crag.

The oldest of the Upper Tertiaries of East Anglia—the Coralline Crag—is but a fragment of the once continuous deposit that must have spread at least from Tattingstone on the south-west, to Aldborough on the north, nearly the whole of the formation having undergone destruction prior to the accumulation of the Red Crag. It is not improbable that under the highlands formed of Glacial beds other isolated masses of the Coralline Crag may be concealed, but the only fragments which offer themselves to our investigation are a very small one at Tattingstone (see the south-western end of Section A), another at Pettistree Hall, Sutton (see also Section A), another at Ramsholt Cliff (on the Deben River, near Sutton), and the main mass which occupies the parishes of Orford, Sudbourn, Iken, and Aldborough. To these may be added a trace (not shown in the map) at Trimley, where it was observed in the digging of a ditch by the late Mr. Acton.

The Cor. Crag has long been known to consist of two main portions, and a third subordinate bed. The first and lowest of these, (3′ of Section XXII,) consists of a series of calcareous sands, in some places more or less marly, which are rich in Molluscan remains. The second, 3″, consists of a solid bed formed of Molluscan remains, agglutinated with the fronds and fragments of various species of Polyzoa into a rock, so hard as to have been formerly quarried for building. The third and uppermost, 3‴, is a thin subsidiary bed, consisting of a few feet of the abraded material of the rock, reconstructed evidently in very shoal water, probably, indeed, between tide marks, as it is very obliquely bedded.

From the outliers at Tattingstone and Ramsholt this rock bed is absent, but over the Sutton outlier a small cap of it remains. Over the main mass, however, it spreads continuously, and either from a slight northerly dip of the whole formation, or else from a displacement of the underlying shelly sands, this rock bed descends to the sea level at the northern extremity of the area. The thickness of the formation has been estimated at between eighty and ninety feet, but this seems to us to be much in excess of the fact. The place to test the true thickness of the formation is clearly that where it is in the greatest state of preservation. This is the neighbourhood of Sudbourn, at the southern extremity of the main mass. The London clay, upon which it rests, comes out along the Butley Creek Marshes, and the shelly beds in their full force appear along the slope which fringes those marshes on the eastern side of the creek, where they are exposed in several pits, known as the Gedgrave, the Gomer, the Broom, and the Hall pits, from which the Mollusca of that neighbourhood are obtained. Higher up this slope comes the rock bed, which forms the upper part of the low hills, and this is exposed in numerous pits, that stretch away from those eminences to the northern extremity of the formation. The outcrop of the shelly beds (3′) along this slope is shown in Section XXII. Now, it is clear, as it seems to us, that, the whole formation being thus present in the complete state, we have only to take the elevation of the highest points attained by the Cor. rock bed, 3″, and its overlying reconstructed bed, 3‴, in these parts, above the elevation at which the London clay thus crops out at its base, and the difference, after making allowance for any slight dip there may be, will be the thickness of the entire mass. Estimated in this way, it will be difficult to make out the thickness of the Cor. Crag as exceeding sixty feet.

Mr. Prestwich has attempted to divide the shelly sands, 3′, into constant and determinable horizons, which he thinks might by investigation be identified by special groups of fossils. We doubt the constancy or determinability of such horizons; and, so far from their being characterised by special groups of fossils, the author of the 'Crag Mollusca' in his long researches has mainly confined himself to one pit at Sutton, affording a vertical range of but a very few feet, and yet from this spot he has obtained specimens of nearly the whole known species of the Cor. Crag, many of these being known to collectors as occurring only at the pits near Orford. Not only this, but so inconstant is the Molluscan facies at any one place, that many species which once occurred at this spot (and some of them abundantly) have not been noticed there for many years. An attempt under such circumstances to group these shelly beds in any order of Molluscan succession would thus evidently be illusory. At this spot, moreover, Foraminifera were once abundant, and from it Mr. Wood collected all the species obtained by him from the Cor. Crag which are described in the Monograph of Messrs. Jones and Parker. No Foraminifera, however, have been found by him there for many years, although very many tons of the Crag from the same spot have been sifted by him for Mollusca during that period.

The depth of water under which this Crag was accumulated has been estimated by Mr. Prestwich at "possibly from 500 to 1000 feet." Against this view there are, it seems to us, objections. A depth of 1000 feet would have carried the Crag sea over the whole of East Anglia, and, indeed, across England,[1] and it is unlikely that all traces of such a sea should have been so completely removed as to present the blank which now exists. At elevations of about 350 feet (*i. e.* fifty-eight fathoms), some pebble beds occur through Southern Essex, which might represent the shingle of the southern shore of a sea having a depth of about sixty fathoms over Suffolk, and these might belong to the age of the Coralline Crag, but these seem better to associate themselves with the Bagshot beds on which they rest than to any later formation.[2] The author of the 'Crag Mollusca' considers that nothing among the forms of Mollusca yet obtained from the Crag, points to the existence of any greater depth of water for their habitat than thirty-five or forty fathoms; so that, coupling the physical difficulties with the exigences of the Molluscan evidence, we may, we think, regard the depth of the Cor. Crag sea of Suffolk as under 300 or even 250 feet, rather than as approaching 1000.[3]

[1] Some traces occur on the North Downs of Kent of beds supposed by some to belong to the oldest Crag, or Diestien formation. These are by the Geological Survey assigned to sands beneath the London Clay; but if they be of Crag age, there has, we contend, been a great upheaval in this part of England in Post-glacial times, which has quite changed the relative levels of the Crag period.

[2] See 'Quart. Journ. Geo. Soc.,' vol. xxiv, p. 464, and also the forthcoming new edition of the Memoir of the Geological Survey on sheets 1 and 7, in which the view of their Bagshot age is adopted.

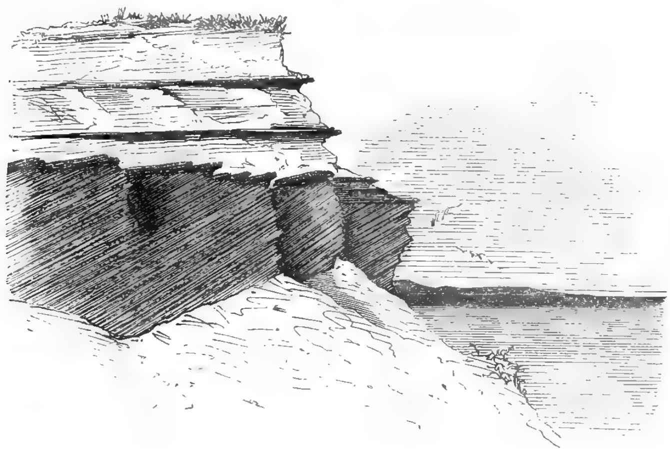
[3] The line of 600 feet is now distant between 350 and 600 miles from the Suffolk coast. The deepest parts of the North Sea between Suffolk and the Dutch coast are but 180 feet, while the depth of the chief part of that sea ranges between tide marks and 150 feet. Messrs. Jones and Parker, in the introduction to their Monograph (p. 3), say, in reference to the Coralline Crag Foraminifera, that they are best represented by dredgings between 300 and 420 feet south of the Scilly Isles, and from the Mediterranean at 126 feet. This small depth in the Mediterranean is significant, as it is with the Mediterranean that the Molluscan Fauna of the Coralline Crag has its chief affinity.

The *Entomostraca* throw no light on the subject, as Mr. Rupert Jones, according to the revision of the Monograph of himself, Mr. Parker, and Mr. Brady, made by him in the 'Geol. Magazine' (vol. vii, p. 155),

The Red Crag.

1. *Its structure.*—The physical structure of the Red Crag is unlike that of any other formation known to us, ancient or modern. The more considerable portion of it is formed of a succession of beds, varying from two or three, to nearly twenty feet in thickness, each of which consists of laminæ of sand and shells, inclined at a high degree to the horizon. The laminæ planes of each bed form an angle with those of the other beds above and beneath them; and at the base of each bed they change into a slight curl.[1] This structure is altogether different from the well known one of false bedding, which also exists in some parts of the Red Crag, especially in that under which the phosphatic nodules are worked, and the two forms of bedding pass more or less into each other. This oblique lamination may be traced (as, for instance, in Bawdsey Cliff) for a consider-

OBLIQUE RED CRAG IN BAWDSEY CLIFF.



The oblique bedded crag appearing above the Talus is nearly twenty feet in thickness.

able distance in a constant manner, without shading off into horizontal stratification or passing into false bedding. If we examine a section of any beach or foreshore (at right angles to the line of the shore) we shall find it presents exactly this

describes eighteen species, of which only five are recognised as living, viz. *Cythere punctata*, *C. sublacunosa*, *C. trachypora*, *Cythereis ceratoptera*, and *C. tamarindus;* the first and fourth of which are species of the British coasts, the third and fourth of the Norwegian coast, and the fifth an Atlantic form. Of the Polyzoa their describer Mr. Busk says, in a letter to the author of the 'Crag Mollusca,' "Judging from the habits of existing forms, those of the Crag may have lived at any depth from the surface downwards," to which we may add that the rock bed made up of the remains of Polyzoa is very false-bedded, which is indicative of the reverse of deep water.

[1] Something approaching this oblique lamination may be seen in the Great Oolite of the Great Northern Railway cuttings near Grantham, and on the Yorkshire coast south of Scarborough.

feature. The pebble heaps of the London Clay basement bed about Bickley, in Kent, not unfrequently exhibit this, while the Lower Glacial pebble beds (to be spoken of hereafter) in the neighbourhood of Halesworth and Henham exhibit it yet more distinctly; their oblique bedding, which is constant and parallel throughout sections between twenty and thirty feet in depth, contrasting with the horizontal bedding of equally deep sections of the same pebbles at other localities—the one case representing the accumulations of a foreshore subaërially heaped up under the action of tide and surge, and the other the same accumulations spread out under a shallow sea. This beach or foreshore character pertains to a large part of the Red Crag, and well agrees with some of its other features; as, *e.g.*, the intercalation occasionally of land and fresh-water shells in a truly marine deposit, which presents none of those intermediate features that occur in a fluvio-marine one;[1] the presence of beds of *Cardium* double, as they lived among the tossed-about heaps of other shells; and the bedding up of the deposit against and around a low cliff of Coralline Crag (as at Sutton) which is perforated by lithodomous mollusca. The Red Crag thus presents itself as the remains of an extensive series of banks that were more or less dry at every tide, and that were from time to time partially swept away and reaccumulated; every bed (of which three or four are often to be seen resting on one another) representing some of this destruction and reaccumulation, since the top of every preceding bed is planed off evenly to form a floor for the next above, in the base of which small pebbles and small rolled phosphatic nodules often abound, in some cases forming thin bands. In the channels which permeated these banks there seems to have been accumulated those portions of the Red Crag which exhibit the true features, often very extreme, of false bedding. If we examine any long section of this beached-up Crag where its base is exposed, such as in the cliff at Bawdsey, we do not find beneath it that bed, several inches thick, of phosphatic nodules which occurs in the various pits worked for nodule extraction, nor any of those large angular flints and masses of Septaria so abundant at the base of the Crag, where it is thus worked; while in these pits we find an absence (at least in the beds immediately over the nodule bed) of those foreshore features just described, and in their stead true and often very fantastic false bedding. An inference seems to follow from this that where these flint erratics and Septaria masses occur we have the bottoms of the channels permeating the banks, up which there drove floating ice freighted with flints from some chalk shore; and that these channels afterwards silted up and became part of the banks, for it is very remarkable that none of these erratics occur in the body of the Crag itself. If the main mass of the Crag had been deposited under water, we should naturally expect to find the large flints and masses of Septaria, so abundantly present in places at its base, distributed through the entire mass of the formation.

[1] Mr. Bell, in vol. viii of the 'Geol. Mag.,' p. 451, gives a section at Butley, where a bed of land and fresh-water shells is intercalated between two of these beached-up beds of Red Crag.

2. *The age of the different portions of the Red Crag.*—The physical structure of the Red Crag just discussed assists, we think, in the elimination of the age of its different portions, as indicated by their organic remains. The author of the 'Crag Mollusca' very long ago, and again in 1866,[1] pointed out an affinity between the organic contents of the Walton Naze bed and the Coralline Crag, which distinguished the former from the rest of the Red Crag. In this he was guided both by the predominance at Walton of certain species characteristic of the Coralline, and by the absence of others specially characteristic of the rest of the Red Crag. Thus, it is doubtful whether there has ever occurred at Walton any of the three species of *Tellina*, *T. obliqua*, *T. prætenuis*, and *T. lata*, the individuals of which make up the principal part of the shells of the Butley[2] and Scrobicularia Crags, and of the Fluvio-marine and Chillesford beds; nor has there occurred there the several species of the genus *Leda*, so common in the Crag of Butley; and particularly is there absent from Walton the shell so highly characteristic of the newer part of the Red Crag, of the Fluvio-marine and Chillesford beds, and of the Lower, Middle, and Upper Glacial formations, *Nucula Cobboldiæ;* while the dextral form of *Trophon antiquus*, which abounds in the rest of the Red Crag,[3] is unknown at Walton, the sinistral or older form[4] alone occurring there.

In testing the age of the different portions of the Red Crag, we must reverse those rules which make negative evidence of so little value, and positive evidence of so much; for it is the negative, and not the positive upon which we must rely in this case. Great stress has been laid upon the leavening of the Red Crag fauna by shells derived from the Coralline, but the inclination of modern research is to attach less importance to Coralline Crag derivation than formerly. It is, however, Red Crag derivation that seems to us to be the complicating element. It is obvious that where banks of sand full of shells are swept away and reaccumulated, the dead shells of these banks must be undistinguishably mixed up with those that have but just parted with the living animal; so that if, as probably was the case, a very material change in the denizens of the Crag sea was taking place between the earliest and latest parts of the Red Crag formation, by the disappearance of certain old forms and the incoming of some new ones, we should get no clear record of it in the beds of Crag formed during this time; because the existing fauna would in these contemporary accumulations be largely leavened by heaps of semi-fossilized shells of the antecedent period, derived from the destruction of the older banks, such as the Walton bed.[5]

[1] 'Quart. Journ. Geol. Soc.,' vol. xxii, p. 538.

[2] *T. lata* is rare in the newer beds of the Red Crag, but profuse in the Fluvio-marine and Chillesford beds. *T. obliqua* is a Cor. Crag. shell.

[3] Except in that of Bentley, the Crag of which presents a nearer approach to that of Walton than any other, although it has a decidedly newer facies.

[4] See the remarks as to this shell, p. 19 of the 'Supplement to the Crag Mollusca.'

[5] Collectors often clear out from their boxes,in order to make room for other specimens which they value more, shells obtained at other localities. These thrown away specimens may be found by the next comer, and spurious localities thus arise for shells. We anticipate that much confusion will arise from this, and

In this way it is almost impossible to separate the Red Crag into those chronological divisions of it that probably exist; but there are two, besides that of Walton, which may be clearly indicated. The first of these is the Red Crag of Butley, in which the northern forms of Mollusca predominate, and in which *Nucula Cobboldiæ* and the species of *Leda* become very common, and of which the whole fauna, both in individuals and in species, makes a great approach to that of the Fluvio-marine Crag, offering in this respect a great contrast to the Crag of Walton. This approach to the one and contrast with the other would, we are convinced, be greatly enhanced could we eliminate from the evidence those false witnesses, the intermixed shells derived from older banks swept away. The second of these beds needs no special palæontological test for its distinction, as it rests on the Red Crag of Butley, in the section under Chillesford Church (see Section XVII). It consists of Crag, gradually losing both the red colour and the oblique bedding as we ascend in the section, becoming horizontal in the upper layers. This Crag is poor in species, being largely made up of *Tellina prætenuis* and *T. obliqua;* but in it appears *Scrobicularia plana* in some abundance, a shell unknown in the other parts of the Red, but occurring in the Fluvio-marine Crag of Bramerton. Valves of *Mya truncata* also, which are unknown to the Walton bed, and almost so to the Crag of the Deben region, but which become common in the Butley Crag, are very abundant in these Scrobicularia beds, where exposed over the Coralline Crag at Sudbourn in Section XVIII.

Although there is doubtless an intermingling of more than one stage of the Red Crag in that region which is cut by the rivers Orwell and Deben, it would be impracticable to distinguish them further here; and, accordingly, in the sections all this Crag has been grouped under the same symbol as the Crag of Butley, viz. as 4″, although it is probably all, or most of it, older than the Butley bed; the still older bed of Walton being distinguished by the symbol 4′, and the newest, or Scrobicularia Crag, by 4‴.

The Chillesford Beds, and the Correlation of the Red and Fluvio-marine Crags.

Although for the most part they seem to have been swept off the Red Crag region, yet we find this Crag capped in a few places by some beds that remain more complete over the Fluvio-marine Crag area. These consist of a micaceous sand (5′) in which occurs, though not constantly, the shelly bed *x*. This sand passes up without break into a bed of laminated micaceous clay (5″), which, in some localities, yields a few shells, or their casts. This bed varies from a dark blue tenacious laminated clay, as at Aldeby and

geologists must be on their guard against it. A specimen of *Tellina obliqua* obtained by H. Norton, Esq., of Norwich, at Walton, probably got there in this way. In Mr. Wood's collection in the British Museum is a specimen of *T. prætenuis* labelled Walton, which he thinks must have originally come from some other locality.

Easton Cliff, to a loamy micaceous sand, more or less interbedded with seams of laminated clay, as on the immediate west of Beccles and on the south of Norwich, but it is easily recognisable everywhere.

These beds 5′ and 5″ were first recognised[1] in the pit behind Chillesford Church (see Section XVII), where they occur immediately over the Scrobicularia Crag. Their fauna differs but slightly from that of the Fluvio-marine Crag, and as little, except in its greater richness, from that of the Scrobicularia Crag beneath them. In the well-known pit at Bramerton Common the Chillesford shell bed (x), with true marine facies, and its overlying laminated clay, are exposed, as well as the Fluvio-marine Crag itself, which rests on the Chalk (see Section XVI). The bed x is there divided from the Fluvio-marine Crag, $\overline{4}$, by about twelve feet of unfossiliferous sand (not distinguished in the section by any symbol), which exactly take the place of the Scrobicularia Crag of the Chillesford section. *Scrobicularia plana* occurs in the Fluvio-marine Crag of Section XVI, though rarely; but in another pit, about a quarter of a mile east of that represented in Section XVI, and known to the Norwich collectors as the Scrobicularia pit, a deep section of sand, interspersed with shelly beds, is exposed, part of which answers in position to the sands thus intervening in Section XVI, between $\overline{4}$ and x, and in this pit the shell is common. Comparing thus the section at Bramerton with that at Chillesford, the inference arises that the Fluvio-marine Crag in the former is the equivalent of the Marine Red Crag of Butley in the latter; and that the sands without symbol, separating the Fluvio-marine Crag from the bed x, are represented by the Scrobicularia Crag of the Chillesford section. Or we may even confine our correlation with the Fluvio-marine Crag to the base of the Scrobicularia Crag itself.

We might thus, without much hesitation, arrive at the conclusion that the Fluvio-marine Crag of Bramerton was coeval with the newest parts of the Red, were it not for one conflicting feature, which we have endeavoured to bring out by making Section XVII partly hypothetical. This section represents what we conceive would be presented by an excavation made at right angles to the pit under the Church (Stackyard pit), back to the Chillesford beds pit behind the Church. The section afforded by the Stackyard pit is truly represented by the extreme right of Section XVII; and there we have the Scrobicularia Crag overlaid by a few feet of sand marked *?*. This sand is divided from the Scrobicularia Crag by a well-marked line of erosion, which descends in potholes into the latter. In this sand no organic remains have been detected, while that under the Chillesford clay, in the pit behind the Church, has yielded a series of fossils in high preservation. Holes sunk in the bottom of this pit disclosed the upper beds of the Scrobicularia Crag, which are exposed in the Stackyard pit below, but without any signs of such a line of erosion as that appearing on the face of the Stackyard pit. It is obvious that if the unfossiliferous sand marked *?*, separated by this line of erosion from the Scorbicularia Crag,

[1] By a party of geologists headed by Mr. Prestwich; see 'Quart. Journ. Geo. Soc.,' vol. v, p. 345.

be the same as the sand 5′ of the pit behind the church, containing the fossiliferous bed *x*, the identity of the Chillesford with the Bramerton section fails; and the idea forces itself that the Fluvio-marine Crag of the Bramerton section, and its overlying sands, which pass so uninteruptedly up into the Chillesford beds, are newer than even the Scrobicularia Crag itself.

It, however, appears to us the more probable alternative, that the sands marked *?* are not the Chillesford sands of the pit behind the church, but some later deposit; probably the Middle Glacial sand (8), which, in a pit only a furlong north of the church, occurs under the Boulder clay (9). Figure XVII accordingly represents the section on this hypothesis, and on the assumption that if a clear section were carried down from the Chillesford clay of the pit behind the church into the Red Crag, it would disclose that uninterrupted passage of the formations into each other which is represented on the left side of the figure; the sands marked *?* lying somewhat in the way suggested by the broken line.

It is important to observe that while this probable conformity exists at Chillesford, the Red Crag of Walton is clearly unconformable to the Chillesford beds which overlie it; the sands of those beds (5′) lying on a very irregular surface of the Red Crag and filling up the depressions in it (see Section XXI); while both these sands and the laminated clay (5″) above them overlap the Crag on the south side, and rest there on the London clay (see Section Q).[1] Nothing, therefore, can be clearer, we think, than that the Walton Crag, so distinguishable by its fauna from the newer Red Crag beds 4″ and 4‴, had been denuded before the Chillesford beds overspread it, and is quite disconnected from them.

If the hypothesis presented in Section XVII is true, we see that the northern part of the Red Crag area continued to receive accumulations up to and during the time when the Fluvio-marine Crag was deposited; and that from a depression which then set in, the Fluvio-marine Crag gave place, through the sands shown in the Bramerton section without symbol, to the marine deposit, *x*, of that place; while the sandbank deposit, 4″, of the Chillesford section gave place through the beds 4‴ to the same overlying bed *x*; the submergence carrying the sands 5′, in which this bed *x* occurs, over the Walton Crag.

The other instances which exist of the Chillesford beds over the Red Crag area, such as those on the eastern side of the Deben, opposite Woodbridge, do not afford any section which would show their conformability, or the reverse, to the underlying Red Crag; but the appearances, as far as they go, all point there to an unconformability. How far the sands which, in some of the excavations for phosphatic nodule working, seem to pass down into the Red Crag by thin seams of comminuted shell in their lower part may belong to the Crag, it is difficult to say. They are not, we think, the Chillesford

[1] In Section Q this overlap is represented as existing at the northern end also; but as the face of the cliff is there obscured, this is uncertain.

The bed *x* can be detected in Walton Cliff, but the shells are in too decayed a state for extraction or even recognition.

sands, for they neither contain the shell bed *x*, nor, though sometimes twenty feet thick, do they present any traces of the Chillesford clay over them. It is not improbable that while the upper part of these sands belong to the Glacial formation, the lower with shell seams belong to the Crag, being the result of the silting up of those channels between the banks, at the bottom of which it is that the great chalk flints and other erratics occur. Accordingly, in the map we have, as the safer course, nowhere over the Red Crag area shown the Chillesford beds unless we could detect the Chillesford clay in the neighbourhood.[1]

The Fluvio-marine Condition of the Chillesford Beds.

In the Sections XVI and XVII first discussed, and in that at Aldeby (No. XIV), the Chillesford bed is marine; but in all the other sections of the beds, such as those shown in Sections VII, IX, X, XI, XII, and XIV, the bed 5′ is more or less Fluvio-marine in character, and in the cases of Nos. IX, X, and XI, as much so as is the Fluvio-marine Crag of Bramerton itself; and, accordingly, the beds shown in the last-mentioned sections have always been regarded by collectors as the Fluvio-marine Crag. The sands, however (5′), which in these sections underlie the laminated clay (5″), and contain the shelly seam, *x*, are but very few feet in thickness. The more likely view seems to us to be that the sites of Sections IX, X, and XI, which were land during the formation of the Red and Fluvio-marine Crag, became, by the depression which at Bramerton caused the Fluvio-marine conditions to disappear, and the marine bed *x* to occur, covered by the estuary, and received a Fluvio-marine fauna; the clay 5″ eventually spreading over all. In some places in the valley of the Tese, near Saxlingham, the bed 5′ is in the condition of compact pebbles overlain by the clay 5″, which is somewhat thin (see Section XII). This pebbly condition of the bed 5′ seems to have extended across from the Tese valley to Bungay; for at Ditchingham, near that place, a patch of it full of shells occurs at the edge of the Waveney, in the garden of a house a mile north of the line of Section J. It is too small to be shown in the map, and is overlain by the Middle Glacial sand. This line of pebbles doubtless marked part of the south-western shore of the estuary portion of the Upper Crag sea.

[1] While this introduction is passing through the press, the Fluvio-marine Crag has been discovered by Mr. W. M. Crowfoot at the base of Dunwich Cliff, having been cleared of the talus covering by the storms of the winter of 1871-2; and various Crag shells, inclusive of *Cyrena fluminalis*, have been obtained by him from it. The Crag here consists of a deep red bed with shells, overlain by micaceous sands with threads or thin seams of clay. These sands seem to be those intervening between the Fluvio-marine Crag and the Chillesford beds, and they have accordingly been represented in the section of this cliff (R) under the same shading as the Crag $\overline{4}$. This shading should have been continued in the section to near the southern end of the cliff. An irregular line of denudation parts these micaceous sands from the red (or orange) sand marked *b?* As to the capping beds (10) of this cliff, see note, page xxix.

The limits of the Chillesford clay were extensive, for we find what seems to be this deposit as far north-west as Needham Market,[1] showing that the valley of the Gipping had come into existence prior to the Crag period; while well-preserved remnants of it extend northwards to near Burgh and Oxnead, on the Bure, and to Barton Turf on the Ant.

The Mammalian Remains of the Crag.

Before leaving the subject of the Upper Crag, the bed of rough flints which occurs, not only at the base of the Fluvio-marine Crag, but also at that of the Chillesford sands, where these rest on the Chalk, should be noticed. The mammalian remains (chiefly molar teeth) which have come from this bed have been regarded by some as belonging to the fauna of the Upper Crag period; while by others this bed is regarded as an old land surface, in which the remains of animals that lived upon it are imbedded. From both these views, however, we dissent. Land surfaces are not to be looked for in a bed of rough flints, without any traces of a peat or soil covering, but in such beds as those of the forest series presently to be described; while it is not in pure land surfaces that the remains of the mammalia that lived on it are preserved (for in these the bones perish into dust by atmospheric agencies), but in the sediment of the pools, lakes, swamps, and rivers of the time; and even in these we find the remains in a more connected form than that of bouldered teeth, and portions of the more solid parts of the bones, such as have come from this bed of rough flints. On the other hand, these are just the remains which, when an anterior deposit yields to cliff waste, escape destruction from the waves, and are preserved in the estuarine and coast deposits of the subsequent period. Accordingly, we believe the origin of all the mammalian remains found in this bed to be derivative equally with the rough flints themselves; and we may add that marine Mollusca sometimes occur in the bed, though we never heard of a land shell having been found in it.

With the exception of the connected cetacean vertebræ which occurred a few years since in the Chillesford clay at Chillesford, it therefore seems to us open to much question whether any of the mammalian remains obtained from the Fluvio-marine Crag, or from the Chillesford beds, belonged to individuals which lived during the accumulation of these deposits. In the case of the Red Crag we venture to affirm that all such remains (even those of the Ziphioid Cetaceans, notwithstanding their occurrence at Antwerp) are derivative; since, independently of their consisting only of isolated fragments, more or less bouldered and perforated by lithodomous Mollusca, they do not occur in the body of the Red Crag itself, but only in the nodule bed at its base, which is, *par excellence*, a bed of erratics of all sorts. Of derivative origin also, are, as it seems to us, the mammalian remains occurring at the base of the Coralline Crag.

[1] In a pit on the north of the town by the Windmill. One side of the section shows the laminated clay forced up into a vertical position, apparently by the pressure of land ice during the subsequent Glacial period. There is a pit of micaceous sand three furlongs north-west of Easton Church (six miles north of Woodbridge) that may belong to these Chillesford beds, but we have not ventured to show it as such in the map.

The fact that no trace of the mastodon has yet occurred among the abundant elephantine remains from the Hasboro' Forest bed and the other beds of that series, of itself raises the doubt whether that animal lived during the age of the Upper Crag; since the Hasboro' Forest bed, if it be not actually coeval with the Upper Crag beds containing mastodon remains, is evidently separated from the latest [1] of them by an interval of time too slight (and accompanied apparently by no change of climate) satisfactorily to account for the disappearance of this great proboscidean genus. The Mastodon teeth found in the Red and Fluvio-marine Crags, and in the Chillesford beds, have, we think, been derived from destroyed freshwater deposits intermediate between the Coralline Crag and the Red;[2] while the Cetacean remains in the Red Crag have, as the author of the 'Crag Mollusca' long since suggested, been probably derived from the destroyed Coralline Crag itself.

The Forest Beds.

The several deposits of this series have been distinguished in the sections by the letters A, B, C, D, and E.

The Green clay of Bacton (A) occurs upon the beach about half a mile south of that place. It was described by the Rev. Chas. Green in 1842,[3] and consists of a greenish sandy mud, which has yielded numerous mammalian remains and freshwater Mollusca, as well as leaves and fragments of wood. It is associated with some blue and brown clay, but, like the other deposits of this series, is too much obscured by the shingle of the beach and the cliff talus to exhibit any section.

The Forest bed of Hasboro' (B) occurs at the base of the cliff, and on the beach. It consists of a ferruginous gravel indurated into a pan, which is associated with a bed of blue clay. In and on this occur the remains of a forest growth. This bed has also yielded abundantly mammalian remains, fir cones, and land and freshwater shells.

Beds A and B may not improbably be identical, while the traces of this old forest growth are said to occur at the following other places along the beach, but they are usually so covered by the modern beach shingle that it is only at rare intervals they are exposed. These places are three quarters of a mile south of Overstrand Gap, at Mundesley,[4] at Trimingham, and at Cromer.[5]

[1] A mastodon tooth was obtained by the late Col. Alexander from the Chillesford beds of Easton Cliff.

[2] If *Mastodon arvernensis* really has occurred at the base of the Coralline Crag, then the beds from which the remains of this animal have got into the Red and Fluvio-marine Crags may not improbably have been even anterior to the Coralline Crag.

[3] 'Hist. Antiq. and Geol. of Bacton,' Norwich, 1842.

[4] There is a freshwater Post-glacial bed at Mundesley (11) shown in section W, known as the insect bed, which might be confounded with the Pre-glacial beds of the Forest series, owing to the peculiar way it (like several other instances of Post-glacial beds) undercuts the Glacial beds, and is, so to speak, wedged into them.

[5] These localities are given from information furnished by the Rev. John Gunn to the author of the

The bed C is better exposed, and forms the base of the cliff at Woman Hythe (see Sections W and III). It consists of a dense black sandy clay, thickly packed with freshwater Mollusca, chiefly *Paludina contecta*, and is overlain by the Lower Glacial pebbly sands (6). These three beds A, B, and C, occur on the north Norfolk coast, while beds D and E are on the Suffolk coast, at the base of Kessingland Cliff (see Sections T and V). The base of this cliff is usually covered with talus, which obscures the section, but for a few years past the part shown in Section V has been very clear.

Bed D consists of a mottled clay, unstratified, its upper surface being full of small concretions and penetrated with roots. It extends from near the Lighthouse ravine almost to the southern extremity of Kessingland Cliff, and it has yielded Mr. W. M. Crowfoot, of Beccles, some mammalian remains.

Resting in a hollow of D, occurs bed E, which is a laminated clay, underlaid by prostrate trees, amongst which is a small colony of freshwater Mollusca. Most of the Mammalian remains obtained from Kessingland and Pakefield have, we believe, been found on the shore, doubtless washed out of beds D or E.

The relation of all these beds A, B, C, D, and E, to the Crag has been, and is likely to remain, a matter of uncertainty. As concerns A, B, and C, since there is, in our opinion, no marine bed exposed along the coast section between Eccles and Weybourn which is so old[1] as the Chillesford clay, by which to test their relative age, they may be coeval with the Upper Crag, or they may be posterior, or even anterior to it. The Chillesford clay may once have spread over that part of Norfolk, and been denuded prior to the formation of beds A, B, and C; in which case they are posterior. On the other hand, they may have accumulated on what was a land surface at the time when the Fluvio-marine Crag spread over East Norfolk and Suffolk, and the Red Crag over East Suffolk, as well as later, when these parts underwent the depression that gave rise to the Chillesford beds. Seeing how the Fluvio-marine and Red Crag deposits are confined to the more southern part of the area, and how much more thin the Chillesford clay is in the parts nearest to the Cromer coast, than it is further south, about Surlingham, Beccles, Easton Cliff, and Halesworth, and over the Coralline Crag of Aldboro', Sudbourn, &c., this latter alternative is far from improbable. Whichever way, however, we look at the question, the mammalian remains of beds A and B do, we think, more nearly represent the terrestrial fauna of the Upper Crag period than any others known to us; since, if

'Crag Mollusca,' in 1844. The indefatigable researches of Mr. Gunn in the Forest bed, and the costly collection made from it, and presented by him to the Norwich Museum, are so well known and highly appreciated, as to need no remark from us.

[1] We say this after repeated and most careful examination. What may be concealed below the beach between Weybourn and Mundesley at those places where the chalk does not rise to the beach line, or between Mundesley and Eccles where these occasional appearances of the chalk cease to occur, is another thing altogether.

not actually coeval with the Upper Crag beds themselves, they must have followed directly upon the elevation of the Chillesford clay into land.

With respect to beds D and E a different case presents itself. There occurs at the foot of the lighthouse ravine of Kessingland Cliff, a bed of micaceous clayey sand, which is marked in Section T as *5?*. So far as occasional clearances of the talus after storms has permitted Mr. Crowfoot (who has watched the section for some years) to see, the root-indented mottled clay D, with the freshwater bed E in its hollow, appears to lie up to this micaceous clayey sand, in the way shown in Section T. If this be so, and the bed *5?* be the Chillesford clay, then these beds, D and E, are posterior to the Crag. Even then, however, it by no means follows that D and E are coeval with A, B, and C, because, while the latter are overlain by the pebbly sand (6) and the other beds of the Lower Glacial series, the Middle Glacial (8) alone, as far as the talus allows us to see, rests upon D and E in the Kessingland section. As, therefore, the Lower Glacial beds are proved by outliers still remaining to the south (those of the pebbly sands being extensive) to have once overspread Kessingland, we cannot resist the conclusion that beds D and E, if coeval with A, B, and C, must have been covered by these Lower Glacial beds; and these, latter, to have been so *exactly* denuded prior to the Middle Glacial sands, as to have left the root-penetrated surface of the clay D intact, (as it may now be seen to exist, along a section of near a mile in extent) and yet have cleared away every trace of the Lower Glacial beds. All, therefore, that can safely be averred of beds A, B, and C is, that they are anterior to the Lower Glacial; and of beds D and E, that they are anterior to the Middle Glacial, and probably posterior to the Crag.

The Lower Glacial Series (Nos. 6 and 7).

The beds of this series (6, 6*a*, and 7) are shown in Sections C, D, E, F, G, H, J, K, L, M, N, O, R, S, U, and W. The lowest, the pebbly sands, 6,[1] consist of sands, mostly of a

[1] These sands were first brought to the notice of geologists by one of us under the name of "Bure Valley beds," and their range from the Bure Valley past Norwich to the neighbourhood of Southwold, as well as their inferiority to the contorted drift, and their superiority to the Chillesford clay, was shown by diagram and numerous vertical sections. This was in 1866 (see 'Quart. Jour. Geol. Soc.,' vol. xxii, p. 546). Their position, and that of the formations Nos. 1, $\overline{4}$, 5, 7, 8, 9, and 10, both above and below Norwich, will be found again represented in sections in the journal for the same year by the other of us, precisely as they are in that neighbourhood in the present sections (see vol. xxiii, p. 89). In 1868 the structure of Norfolk and Suffolk, illustrated by map and copious sections, was laid by us before the British Association in the same way in which it is represented in the present map and sections, with the exception that the identity of the pebbly sand of Weybourn which underlies the Cromer Till along the North Norfolk coast, with the Bure Valley beds, was expressly left open for further investigation; it being pointed out that the Weybourn sand and the overlying Cromer Till (with the base of which it is interbedded) occupied, relatively to the contorted drift, the same position as did the Bure Valley beds; so that they might either be the equivalent of these Bure Valley beds, or be a formation subsequent to them, and intervening between

deep orange colour, more or less interbedded with seams of rolled pebbles. The pebbles in some places so predominate as to form masses of shingle, while near their southern extremity, in the immediate neighbourhood of Halesworth (Section G) and of Henham (see northern end of Section C), they appear in the form of true beaches, as already mentioned at page vi. These sands and pebble beds contain shell fragments occasionally, but recognisable fossils only at Crostwick, Rackheath, Spixworth, Wroxham, and Belaugh inland, and along the coast at Weybourn, between that place and Runton, and about Trimmingham. They form the base of the whole Glacial series, and indicate the first setting in of the great Glacial subsidence. While their pebbles and shingle thus indicate shore conditions, their fauna is as truly Fluvio-marine as the beds $\bar{4}$ and 5′; and while in some parts, as in Sections D, E (at Ingate), O (at Hartford Bridges), S, VIII, IX, X, XI, XII, and XV, they rest on and more or less indent the Chillesford clay; in others, as in Section G, they occupy its place, lying *in the beached form* up against foreshores of this clay.[1]

Their fauna has been investigated with some perseverance, but it is well worth further research. So far as yet known, it differs from that of the Fluvio-marine Crag and Chillesford beds in the disappearance, or in the increasing rarity of certain forms, rather than in the introduction of new ones. Of the three specially common species of *Tellina* characteristic of the Chillesford beds, *T. obliqua*, *T. lata*, and *T. prætenuis*, the latter is, in these

them and the contorted drift. (See abridgment of the paper in 'Geological Magazine,' vol. v, p. 452.) Having, soon after this, satisfied ourselves that they actually were such equivalent, we took the opportunity of laying a section disclosed by the Norwich Sewer Works before the Geological Society, in April, 1869, to assert this; and at page 446 of vol. xxv of their journal the succession of the beds about Norwich is once more shown in section; and the pebbly sands (Bure Valley beds), which in that section are shown as succeeding the Chillesford clay, are expressly stated to "expand northwards into the Weybourn sand and Boulder Till of the Cromer Cliff section, to be unconformable to the Crag and Chillesford beds, to be palæontologically distinct from them, and to be characterised by the first appearance in England of *Tellina Balthica*." In the 'Geological Magazine' for January, 1870 (pp. 19, 20, and 21), this position of the pebbly sands and Cromer Till was again pointed out very distinctly, and the character of the fauna which had been obtained by us from those sands at Belaugh, Rackheath, Weybourn, and Runton (Woman Hythe), explained. Lastly, in the same magazine for September, 1871, a woodcut of the coast section from Cromer to Woman Hythe is given exactly as in the present Section W. Subsequently to all this Mr. Prestwich, in the 'Quarterly Journal of the Geological Society' for November, 1871, brings forward this pebbly sand as something new, assigning to it the name of "Westleton Shingle"; and, apparently overlooking much of what had been thus brought forward by us, altogether misrepresents our views as thus matured, basing them apparently on the paper of 1866. Hence the above explanation. We have, under these circumstances, here refrained from assigning any other name to these sands than that of "pebbly" to denote their character; but if a local name be desirable, none can be so proper as that of "Bure Valley beds," both by reason of its priority, and of the fact that their greatest exposure, and their principal fossiliferous localities, occur in the valleys of the Bure and its tributaries.

[1] Some of the patches of Chillesford beds shown underlying the pebbly sands in Sections N and O are, of course, merely hypothetical, and are inserted under the mass of newer beds only to show the patchy way in which they remain wherever the chalk floor is exposed.

sands, extremely rare, and as we get no trace of it in later beds it was evidently then dying out.

There is one species, however, which comes in with these beds that is wholly unknown in any older ones, and is especially characteristic of every Glacial and Post Glacial deposit, viz. *Tellina Balthica* (*Psammobia solidula*). It has been objected that the occurrence of this shell at Weybourn is due to geographical causes, and that notwithstanding its presence there, some part of the Crag is comprised in the section at that place (No. IV); but apart from the fact that there is nothing at Weybourn answering physically to the Chillesford clay,[1] the Glacial, and non-Crag age, of this shell is proved by its absence from every exposure of sand (and they are many) that can be proved to belong to the Crag series by having the Chillesford clay over it; industriously as these beds have, many of them for half a century, been searched by collectors. Such Crag beds range up to within twelve miles of the Weybourn Cliff, occurring at Coltishall, Horstead, and Burgh, (see Sections IX, X, and XI) and in the neighbourhood of Coltishall and Horstead they are in the immediate contiguity of the pebbly sands with *Tellina Balthica.* Thus while, in every bed of this neighbourhood which can be proved to belong to the Crag by having the Chillesford clay over it, not a trace occurs of this shell, several fossiliferous sections of the Lower Glacial sands resting direct on the chalk are to be found in the immediate neighbourhood of such proved Crag beds; and these swarm with *Tellina Balthica.* Pits of the sands thus swarming with this shell occur at Belaugh (see Section N), only eight and eleven furlongs respectively from the well-known pit at Coltishall (No. X), and about three furlongs further from the equally well-known pit at Horstead (No. XI), in both of which the sands 5′, full of shells, are exposed with the Chillesford clay over them, but in which sands no trace of this shell, as before observed, has been detected. No impartial observer can, we think, doubt that such *Tellina Balthica* sands are those of the Lower Glacial formation, resting direct on the chalk in spaces from which the Chillesford beds have been previously denuded. It is only near the chalk floor that Mollusca usually occur in these beds, though where they overlie the freshwater bed C at Woman Hythe (Sections W and III) there occurs in them high up, where they are interbedded with the Till, a colony of *Mya truncata* double, and with siphonal ends uppermost, as they lived. We took from these sands at Weybourn part of a mammalian humerus.

Where these sands pass into shingle masses, we evidently approach the shore of the sea of their period, while where they are obliquely bedded in deep sections, we find its actual beach line. Tracing them from these parts towards the north Norfolk coast, and observing the way they are overlain by the contorted drift, where the Cromer Till is not present, as well as the the special characters of that drift, we find the Till (6*a*) to be merely the deeper water deposit of this early Glacial estuary, in which these shingle

[1] A few inches, or sometimes a foot, or little more, of gray clay over the large flints which rest on the chalk, and among which shells are interbedded, can, we think, never be mistaken for so well-defined a formation as the Chillesford.

masses accumulated; and that the Fauna of this Till, a glacier-fed deposit nearly destitute of Molluscan remains, is represented by the shells occurring in the sands of Crostwick, Rackheath, Belaugh, &c. If we follow the coast section (W) we see that this stratified formation, the Till, is lenticularly developed; that is, it attenuates greatly towards either extremity of the Cliff section, being in its greatest thickness about Trimingham and Sidestrand. Not only so, but we see throughout the Coast section, *that the pebbly sands are interbedded with the Till*, and that where this is thickest these pebbly sands begin to change their character, becoming very silty and interstratified with bands of ash-coloured Till, full of chalk débris, while the pebble seams are thin and intermittent.[1] The Till is found in well sinkings for a few miles inland of the North Norfolk coast, but it does not come to the surface, and it is not present where the pebbly sands come out along the valleys of the Bure and of its tributary rivulets (see Section N).

This clay, 6*a*, often strongly stratified, which was once supposed to be identical with the great Boulder clay (No. 9), thus turns out to be a mere estuary deposit, rapidly attenuating in every direction from its centre. Part of the shores of this estuary we can define with approach to accuracy by the shingle masses and pebble beaches which lined them, while the abundance of rolled chalk lumps, and especially the great sheets of chalk several feet thick (VI of Section W) that are interstratified in the Till, prove that one side of this estuary must have been fed by a glacier, some part of which, at least, was in contact with the chalk district.

At the Hasboro' or Eastern extremity of the Coast section, there exists an unconformity between the Till and the overlying contorted drift, which is here uncontorted and finely stratified; but, so far as the churning up of the two formations at the other, or Western extremity of the Coast section allows of observation, the Till there seems to pass into the contorted drift without interruption. Probably the unconformity of the Till at the Hasboro' extremity was due merely to some current, as we find the base of the contorted drift itself filling up, in the form of sand, hollows in the Till, and this sand unconformably overlain by the main stratified mass of that drift, as shown in Sections I and II.

The Contorted Drift.—The most extensive deposit of the Lower Glacial series is the contorted drift of Sir Charles Lyell (No. 7). This bed along the Norfolk coast changes its aspect materially. In the Western part of the section it becomes more chalky, by an intermixture of fine chalk débris and chalky silt with the red mud of which the Eastern half is mainly composed; and in this Western portion, masses, sometimes of enormous size, of marl, or reconstructed chalk (VII of Section W), are enveloped in it. A study of these masses shows clearly that the agency by which they were introduced was that to which the contortions were due, since masses of this material are usually

[1] They are here also much charged with lignite and peat débris, as is the Till itself in some places. This lignite and peat were doubtless swept off the old forest-covered surface by the land ice, then beginning to gather, and carried into this estuary.

present with the contortions; and as these masses cease eastwards, so do the contortions, the drift becoming, save for the presence of sandgalls, uncontorted; and about Bacton and Hasboro' putting on the stratified condition shown in Sections I and II, wherein bands of fine mud and sand alternate with chalky silt, and bands of clay more or less intermixed with chalk débris. Some of this interstratified material is scarcely distinguishable from the material of the great chalky clay No. 9; while more of it is identical with the marl of which the masses, No. VII, are composed. These masses, again, are identical with a formation that covers much of North-west Norfolk, and occurs also in the South-west, consisting of soft chalk finely ground up by the enveloping land ice sheet of the period, and spread out from its seaward termination into a deposit that frequently shows stratification (sometimes very fine), and in which great sandgalls, like those so abundant in the red mud portion of it, occur.[1] It is in the district where this reconstructed soft chalk of North-west Norfolk changes horizontally into the red mud or brick-earth that the included masses of marl, such as the Coast section presents, become frequent; being sometimes acres in extent, and worked for Marl pits, or for limekilns. The mass supplying one of these limekilns shows itself enveloped in the red mud in the Cliff section on the south side of Cromer Town, and another, west of Woman Hythe, which is some 300 yards long, has sunk down to the chalk, squeezing out the Till on either side. This reddish-brown mud is easily followed from the Cromer coast southward to Norwich in a continuous deposit; but the Marl masses in it cease a few miles north and north-west of that city. About Norwich it is worked as brick-earth in numerous sections, but, as the contortions and Marl masses are absent from it here,[2] it has been regarded by the Norfolk Geologists as "the Lower Boulder clay." There can be no question that in these contortions and Marl masses we have evidence of the grounding in the red mud of icebergs detached from the sea foot of the land glacier occupying the Chalk country, which were laden at their bottoms with masses of the same degraded chalk which was extruded from the glacier foot, and spread out under the sea over North-west Norfolk. South of Norwich the deposit becomes very intermittent, and often very thin, its thinness being apparently due principally to intra-glacial denudation.

[1] Even in this district it will suddenly change into a sandy stratified silt, or into compact yellow brick earth. Sections of either of these conditions of this drift occur with the clay No. 9 over it (beyond the limits of the map) near Guist, in the Wensum valley; that valley having been excavated out of the contorted drift, in the interval between this drift and the Middle Glacial No. 8, which, with the clay No. 9, occurs in the valley, and in some places *in the bottom of it.*

[2] It is contorted in a pit four furlongs north-north-west of Thorpe Asylum, but that, we think, is not a contortion of the period of this drift, but due to the intraglacial excavation of the valley here, which causes the later Glacial beds to plunge into the valley. The pit three furlongs north-west of Upton Church (near the eastern end of section O), shows in the most striking manner the contorted drift in its red mud form, contorted, and containing sandgalls, just as it is about Cromer, overlain by the great chalky clay No. 9. Section II represents a spot in Hasboro' Cliff, where a tongue-like piece of the contorted drift (finely stratified with chalky silt and clay with chalk débris) has been lifted during the accumulation of the overlying sand, 8, which has found its way under the piece without its becoming detached.

In tracing this drift from the East coast at Hopton, and from the numerous inland sections of the extreme North of Suffolk and East of Norfolk, towards the Cromer coast, we see it in a fine section at West Somerton, overlain by the sand, No. 8, which is again close at hand overlain by the clay, No. 9 (see Section M), and we then lose it by the intervention of several miles of marsh. On the cliff beginning to rise at Eccles the drift appears again in the identical form of reddish-brown brick-earth possessed by it at Somerton, but overlain by a thin bed of stony clay (No. XI), to be presently noticed. From this place westwards it can be seen to assume gradually the finely stratified appearance it possesses at Hasboro', and then to change still further west into its original red Brick-earth condition.

This deposit must once have spread far to the southward, for what appear to be outliers of it occur at Kesgrave (five miles south-west of Woodbridge), and at Blaxhall, half a mile east-north-east of the church (seven miles north-east of Woodbridge); while beyond the limits of the map we have found it in the south-west of Suffolk, near Boxford, and probably at Sudbury. The Blaxhall outlier contains marl masses similar to those in the North Norfolk coast section.

The breaking off of this deposit into outliers southward is evidently due to a great denudation of the Lower Glacial formation prior to the accumulation of the Middle Glacial sands, which occupy to a great extent troughs or valleys in the Lower Glacial beds; and it is quite possible that outliers of it may be concealed under the tablelands of Middle Glacial sand which separate the East Anglian valleys from each other in Section A. It is clear that the valley system of East Anglia had its inception in this denudation, though it would be beyond the scope of the present outline to show this further than appears from the sections accompanying the map.[1]

The Contorted Drift has yielded no fauna as yet worth mentioning; but *Tellina Balthica* and fragments of *Cardium edule*, *Cyprina islandica*, and *Mactra ovalis*, and of a *Mya*, are not unfrequent in it. We took from it at Elsing (twelve miles west-north-west of Norwich) the femur of a small mammal.

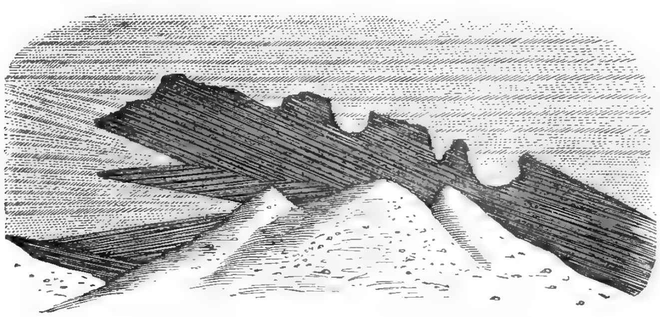
The Middle Glacial (No. 8).

This formation is principally composed of sand within the limits of the map, though gravel is more or less intermixed in places; but southwards, towards and over Essex, the formation consists mainly of gravel. These sands have their greatest thickness over the Red Crag region, and were long confounded with that formation, under the term "unproductive sands of the Crag." Although the sands over the Crag are treated by us as all

[1] We should explain, however, that it is to this intraglacial erosion that the chalky clay (No. 9) owes its abnormal position in the bottoms of valleys cut through the older Glacial beds—a position which, before we had discovered the true explanation of it, led us to suppose (as suggested in vol. xxiii of the 'Quarterly Journal of the Geological Society,' p. 89) that the clay in the valley bottoms was a different Boulder clay of subsequent origin to the clay No. 9.

belonging to the Middle Glacial formation, it is not impossible that the lower part of them, which is sometimes very red, may belong to the pebbly sand, No. 6; but no means occur to us by which that could be determined, the whole sand mass presenting no line of division, and being unfossiliferous alike. It is easy, however, to see that they have no connection with the Red Crag, for along the north side of the Stour and south side of the Orwell, this Crag occurs only in places under them, the sands there resting for the most part on the London clay. Moreover did any part of the sands covering the Crag belong to that formation, it would be to the Chillesford beds, which overlie the Red Crag to the north at Chillesford, and to the south at Walton. Over the greater part of the Red Crag area, however, no trace of the Chillesford clay appears in the numerous deep sections of sand with this Crag at their base, which there occur. The Red Crag has, evidently prior to the Middle Glacial, been denuded of some of its upper part, even over the country east of the Deben, since the Scrobicularia beds, which, by losing upwards their oblique stratification, indicate an increased depth of water which must have carried them over the Crags of Butley, Capel, Boyton, &c., do not occur south or west of Chillesford. Between the Deben and the Orwell this denudation has been greater, for at one point, north-west of Nacton, the Middle Glacial has for an interval of three miles no Crag under it; while between the Orwell and the Stour, and across the Stour towards Harwich and Walton, only small patches of Crag occur at intervals under the Middle Glacial, that formation for the most part resting direct on the London clay; and sometimes, as at Wrabness, only the phosphatic nodule bed has escaped. As the Chillesford beds, which must once have spread from Walton Cliff northwards over the Red Crag, have for the most part[1] gone with it, this denudation must have been posterior to them, and most probably was the same as that which intervened between the contorted drift and the Middle Glacial in Norfolk, as the two (apparent) outliers of the

RUGGED SURFACE OF OBLIQUE RED CRAG ENVELOPED IN MIDDLE GLACIAL SAND IN A PIT A QUARTER OF A MILE S.W. OF MELTON CHURCH, NEAR WOODBRIDGE.



The dark oblique bedded mass is the Crag.

[1] There may of course be patches of these beds over the Red Crag between the Stour and the Alde, which, for want of sections, are not shown on the map, and are lost in the expanse of Middle Glacial sand.

contorted drift at Blaxhall, and Kesgrave, lie just within the limits of the Red Crag area. The foregoing figure shows the manner in which these Middle Glacial sands along the Deben region rest on and envelope rugged surfaces of the Red Crag.

Over the greater part of their range these sands are unfossiliferous, and it is only in the neighbourhood of Yarmouth that they have yielded a fauna.[1] This fauna is a very interesting and important one, but it requires great patience to obtain, owing to the sparse occurrence and fragmentary condition of the specimens. The two principal places from which it has been procured, are Billockby, eight miles north-west of Yarmouth, and Hopton Cliff. At the latter place (see Section U) the sands are underlain by the contorted drift, No. 7, and overlain by the chalky clay, No. 9. At Billockby they are overlain by the clay No. 9, while No. 7 comes out along the lower ground. No question can thus arise as to the position of the sands from which this fauna has been obtained. The specimens come from a thin shelly seam at the top of the formation some four or five feet below the clay, No. 9. This fauna is specially interesting, not only as showing a much older aspect than that of any of the Glacial beds of Scotland, and even of Bridlington, but also in its approaching that of the Coralline Crag by the presence of such species as *Turritella incrassata, Nassa granulata, Chemnitzia internodula, Dentalium dentalis, Limopsis pygmæa, Cytherea rudis, Cardita scalaris, C. corbis, Woodia digitaria, Astarte Burtinii, A. Omalii,* and *Erycinella ovalis,* the three last of which are not known living, *Cardita scalaris* being a Pacific shell, and the rest Mediterranean and Atlantic species, not ranging so far north as Britain. On the other hand, its affinity with the Red and Fluvio-marine Crags and with the Chillesford bed is shown by the presence of *Cerithium tricinctum, Tellina obliqua,* and *Nucula Cobboldiæ*—species not known as living—as well as by that of several other Red Crag forms which are now living in the Mediterranean and range into British seas, but which are unknown further north.[2] In this respect the Middle Glacial fauna presents a contrast (which no difference of latitude will explain) not merely to the Post-glacial beds of Kelsea, March, Hunstanton, and the Nar valley, but also to the fossiliferous so-called Glacial beds of the Severn valley, of Wales, of the North-west of England, and of Scotland. Messrs. Crosskey and Robertson, to whom some of the sand was submitted, found on a cursory examination that the Foraminifera occurring in it were, like the shells, much worn, and that they presented an arctic character, varied by the presence of one or two Tertiary forms. The peculiarity of this fauna naturally prompts a suspicion that it may be derivative from the Crag, and it is necessary therefore to examine that question.

[1] We have observed fragments of shells in the Middle Glacial, however, at other places, viz. at Wisset, two miles north-west of Halesworth; at the Brick kiln on the North of Stowmarket (where the sand is overlain by a Post-glacial Brick clay); and at Helmingstone, six miles north of Ipswich.

[2] This Fauna, as well as that of the Lower Glacial, will be given by the author of the 'Crag Mollusca' in the tabular list to appear in the concluding part of his 'Supplement.' In the meantime see, as to the Middle Glacial Fauna (latest results), 'Geol. Mag.' vol. viii, p. 410; and as to the Lower Glacial Fauna, 'Quart. Journ. Geol. Soc.,' vol. xxvi, p. 92.

Premising that the general condition of the specimens justifies the assumption that if any of the species be derivative, the whole are so, since, the most remarkable species are quite as well preserved as such forms as *Purpura lapillus*, *Trophon antiquus*, and *Tellina Balthica* (whose genuineness would be doubted by none), the following reasons for the genuineness of the entire fauna offer themselves:

1. So far as the Crag fauna is known, it would require in order to furnish by derivation the Middle Glacial shells, the Coralline, Red, and Fluvio-marine Crags, as well as some other bed for four of them which do not occur in the Crag, viz. *Tellina Balthica*, *Venus fluctuosa*, *Loripes lactea*, and the not unfrequent *Trophon mediglacialis*, which is the characteristic shell of the formation. 2. Not a trace or fragment of most of the common strong shells of the Coralline and Red Crags has occurred. 3. The sinistral form of *Trophon antiquus*,[1] which is profuse throughout the Red and Fluvio-marine Crags, and frequent in the Chillesford and Lower Glacial sands, is absent; while specimens of the dextral form, and especially fragments of the columella and mouth showing the dextral turn, are abundant. No derivation from the Red Crag, in which myriads of these strong sinistral Trophons occur, could have taken place without their fragments being present abundantly. 4. The specimens of *Pectunculus glycimeris* which make up so large a part of the Red Crag are large shells, whereas this species though abundant in the Middle Glacial is mostly in the condition of very small individuals and fry, the largest specimen or fragment not nearly equalling the average size of the Crag shells. Any derivation from the Red Crag would have brought an abundance of these large specimens, or of their fragments, into the Middle Glacial sand. 5. Some of the species, such as *Venus fasciata*, are, although greatly worn, and mostly consisting merely of the hinge portions of the shell, perhaps fifty times as abundant as in any known Crag bed.

These five reasons, to which others might be added, seem to justify our regarding the Middle Glacial fauna as contemporaneous and not derivative; but although contemporaneous, it is evidently one which did not live on the spot where it is found, since not only are all the specimens, with the exception of the *Anomiæ*, more or less rolled, but the limited extent of the fossiliferous area suggests that it was only here that a current bringing the shelly sand from some other part of the sea bottom impinged. Interspersed with these rolled and worn Molluscan remains there occur in great numbers small and perfect valves, always single, of the tender papyraceous *Anomia ephippium*. These are all young shells from one eighth to one quarter of an inch in diameter; and their occurrence among such a rolled accumulation suggests the idea that they adhered to floating bodies which were brought to the spot by the same current that swept the shelly sand along the bottom; their tender valves having sunk as these floating bodies decayed, and become intermixed with the worn bottom-travelled Mollusca.

[1] See, as to the history in time of this shell, which is an indirect confirmation of the above argument, p. 19 of the 'Supplement.'

The Great Chalky Clay, or Upper Glacial (No. 9).

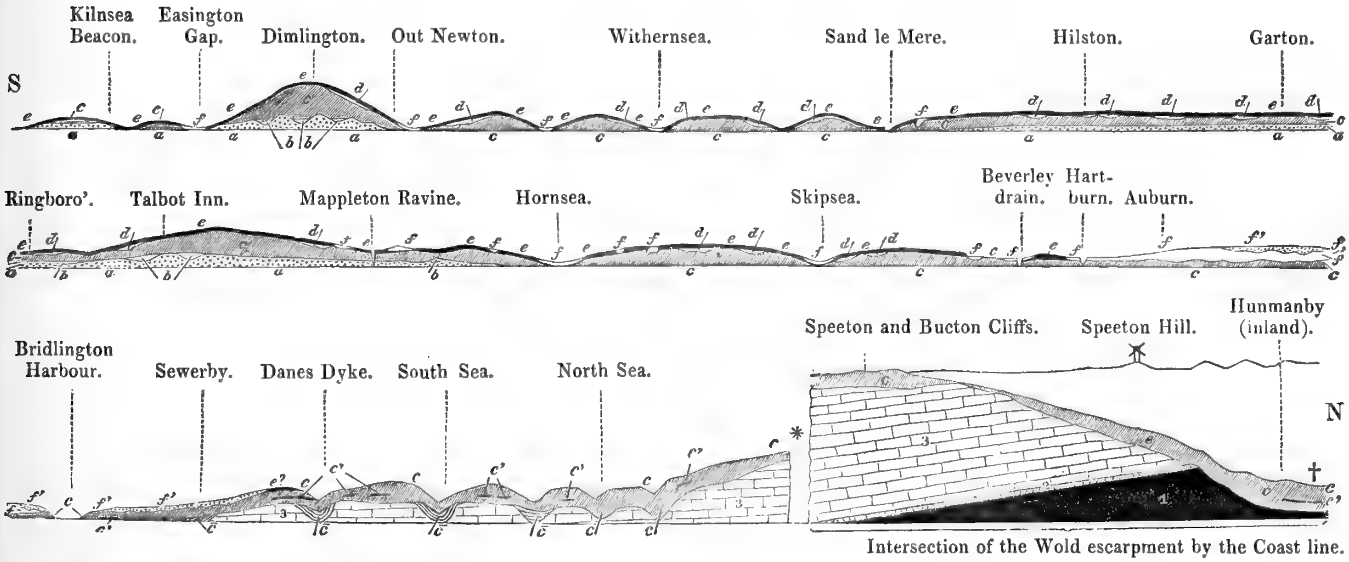
This wide-spread unstratified deposit extends over the eastern and the east central counties, and is there wholly unfossiliferous. In the parts traversed by the sections it is mostly of no great thickness, owing apparently to denudation; but further from the coast, and away from the main valleys, its thickness is more considerable, amounting in the west of Suffolk to as much as 120 feet,[1] and in Cambridgeshire to still more. Where it does not descend, as it often does, in a plunge, but rests evenly on the Middle Glacial sand, as around Woodbridge and in Sections T and U, this clay not unfrequently passes down into that sand by a passage bed consisting of a few feet of the clay which becomes more sandy downwards, until it shades off into the subjacent sand. In other places it lies evenly upon the sand in a conformable manner without any such passage bed; and there can be little question that the succession was effected by tranquil deposition, uninterrupted by any change of conditions other than those which produced a new kind of sediment. This clay all may admit to be the result of the degradation of the Cretaceous, Oolitic, and Liassic districts by land ice—the *moraine profonde* of the great enveloping ice sheet of the Upper Glacial period; but no one can look at the even way in which it overlies the sand in Kessingland and Hopton Cliffs (Sections T and U) without being convinced that it could not have been *so placed* by the action of land ice, since this could not have failed to crumple up and distort those sands, just as the intruding bergs bringing the marl masses churned up the contorted drift. Section P shows what an ice plough of the period of the clay No. 9 would accomplish. The Crag and the overlying sand, S, of this section appear on one side of the cutting at the East Suffolk Railway Junction; but in the short space of the width of the cutting they are cut off so entirely, that the opposite side presents nothing but a churn up of sand and London clay; while a piece of the Red Crag thus ploughed out has been left two miles off, at a high level, in a mass of gravel about the junction of the Middle Glacial sand with the chalky clay, and is exposed in a pit south of the "Sparrows nest." If this be the result of the grounding of an ice island, as we cannot doubt it was, how much of the sand of Hopton and Kessingland Cliffs would have been left under the pressure of the land-ice sheet itself? Nevertheless this clay, not only in these cliffs, but all over East Anglia, is quite as unstratified as is that of Scotland and the north of England, and it is everywhere, except on the Yorkshire coast, quite as destitute of organic remains.

The species given in the Crag Mollusca and its Supplement from the Upper Glacial formation are from the Bridlington bed, the age of which appears to us to be posterior to that of the great chalky clay of East Anglia (No. 9); the bed occurring in a continuation of

[1] This was the total thickness in the cutting and contractor's well beneath it at Horseheath on the borders of Cambridgeshire and Suffolk. The cutting and well at Old North Road Station of the Cambridge and Oxford Railway showed this clay there to be about 160 feet in thickness.

that clay, which is absent from the country south of Yorkshire and the north-east of Lincolnshire.

THE YORKSHIRE COAST SECTION FROM THE MOUTH OF THE HUMBER TO SPEETON (50 miles).[1]



Vertical scale, 500 feet to the inch. Horizontal scale of the part between Kilnsea and Bridlington, $2\frac{1}{2}$ miles to the inch; of the part between Bridlington and the break in the section, 2 miles to the inch; and of the Wold intersection, 2 inches to the mile. 1. Oolitic formations. 2. The Red Chalk. 3. The Chalk. *a.* Blue clay, principally composed of Oolitic and chalk *débris* (No. 9 of the Norfolk and Suffolk map and sections). *b.* Occasional thin beds of sand and gravel, and bands of clay intermediate between *a* and *c*. *c.* The purple clay with chalk *débris* in its lower part. This clay occurs as far south as Cleethorpes in Lincolnshire (where it is capped by *e*), but it then becomes lost under the great marsh of East Lincolnshire. *c'* Sand and gravel beds in *c*, from one of which at the beach line immediately north of Bridlington Harbour the Bridlington shells referred to in the 'Crag Mollusca' and its 'Supplement' have been obtained. $\overline{c}$. Moraines of rolled chalk lumps under *c*, which are probably terrestrial equivalents of the lowest portion of the Marine Glacial Clay, *c*, in the southern part of the section. *d.* The Hessle sand and gravel (Kelsea Hill Gravel). *e.* The Hessle clay with boulders. *f.* Sands and gravels posterior to *e*, and which at Hornsea contain fresh-water mollusca. *f'*. Still later gravel, principally composed of chalk fragments. The recent Cyclas marls omitted. The asterisk marks an interval omitted of four miles. † marks the source of the Hertford river, which, rising near the cliff, flows away from it inland. The lowest part of *c*, or that with the chalk *débris* in greatest abundance, dies out some way south of Bridlington, near which, its place becomes occupied by the chalk moraines, $\overline{c}$.

Along the South Yorkshire coast the unstratified chalky clay (No. 9) of East Anglia occurs in the lower part of the cliff, beneath which, judging from adjacent borings inland, it descends near the Humber end, about 100 feet, being in some of the borings underlain

[1] Taken from a paper by S. V. Wood, jun., and J. L. Rome on the "Glacial and Post-glacial structure of South Yorkshire and North Lincolnshire" in 'Quart. Journ. Geol. Soc.,' vol. xxiv, p. 146. The cut is reproduced here by the kind permission of the Council of the Geological Society.

by a few feet of sand. This thickness, added to what appears above the beach line, does not differ much from the maximum thickness of the clay in Suffolk. Over this clay, and separated from it in places by the beds *b*, there appears another clay, *c*, differing from it in colour (being of a purplish brown), but more particularly differing from it in its contents; for while in the clay, *a*, chalk débris is the principal, and débris of beds older than the chalk the subordinate ingredient, in the overlying purple clay, *c*, these proportions are reversed. Further, the purple clay, *c*, is not only less abundantly supplied with chalk, but this ingredient diminishes so much upwards, that where the uppermost part of the clay remains undenuded, in the highest cliffs, such as those of Dimlington and the "Talbot," it is wholly absent; showing the gradual release of the chalk country from those degrading agencies which supplied its débris so profusely to the earlier and underlying East Anglian clay, *a*. North of Hornsea no trace of *a* occurs above the beach line, and where the chalk floor comes to the surface about a mile north of the Bridlington shell bed [1] (which is at the beach line immediately on the north side of the harbour), nothing like the chalky clay *a* appears over it; but instead, the purple clay *c* is seen resting direct on the chalk, underlain occasionally by some moraines of rolled chalk, *c̄*, that are probably coeval with the lowest part of *c* further south. The position of the Bridlington bed seems therefore to be about the middle part of the purple clay, *c*, where there is some chalk intermixture; and though posterior to the great chalky clay of East Anglia, the bed was evidently succeeded by all that part of the Upper Glacial period in which the rest of the purple clay, both with and without chalk, accumulated. Although the Bridlington fauna does not present nearly such Crag affinities as that of either the Lower or Middle Glacial, and is much more arctic than either, it is nevertheless distinguishable from that of every Scotch, north of England, and Welsh bed, by the presence of those special Upper Crag forms *Tellina obliqua*, and *Nucula Cobboldiæ*, shells not now living, and whose nearest living affinities occur in the Pacific; while all the species of the Scotch, Welsh, and north of England beds are to be found on one side or other of the Atlantic, or in the Arctic seas connected with it.[2]

The Plateau gravel (No. 10).

This gravel is everywhere unfossiliferous, and is composed almost entirely of flint. It is difficult in some cases to form an opinion whether it is of Glacial or Post-glacial age. Most of that which is shown in the sections under the number 10 is doubtless

[1] The bed was always so covered by the shingle as to be exposed only at rare intervals, and it is now, we believe, buried under the artificial works of an esplanade. Borings in the harbour showed it to be underlain by twenty-eight feet of the clay *c*, under which were fifteen feet of gravel, and then the chalk.

[2] At Dimlington Cliff, a little below the beds *b*, Sir Charles Lyell and Mr. Thomas McK. Hughes found a thin band of sand intercalated in *a* which contained Mollusca, some, as Mr. Hughes informs us, having their valves united. The species they found have not been communicated to us.

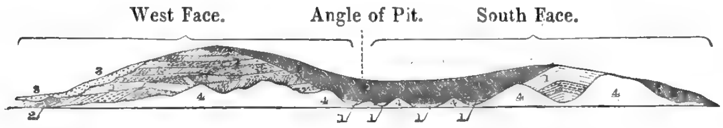
Post-glacial, but with respect to that which caps Mousehold Heath (see Section O), and that which caps the high land of Poringland and Strumpshaw (see Section L), it seems the same as the gravel which has an extensive spread in West Norfolk (beyond the limits of the map); since, like it, the gravel of these places, especially that of Monsehold, contains beds of very large flints more or less rolled. These gravels of West Norfolk set in almost along the same line as that about which the Middle Glacial sand ceases, *i. e.* along a line extending from Hingham in the south, to Wells in the north. This West Norfolk gravel is also composed almost entirely of large flints, which are mostly so rolled as to resemble cannon shot. These cannon-shot gravels sometimes contain masses of sand formed of chalk grains; and as they are never overlain by the chalky clay (9), but in a few instances have this clay, under them, it may be that, if not of Post-glacial age, they are a local modification of such clay due to the action of some powerful current over this part of Norfolk, which dissolved all the soluble part of the morainic material forming that clay, and rolled the flints into the cannon-shot form. The absence of these thick gravels over all the southern part of East Anglia is a peculiar feature, but some thick beds of gravel, which occur on the Chalk Wold of Yorkshire about Speeton and Bucton, seem to bear a relation to the purple clay (*c*) capping the Wold at those places, similar to that which the plateau gravels of Norfolk bear to the clay, No. 9. These Wold gravels, moreover, seem absent over the clay, *c*, where it occurs further south, viz. over Holderness.

The Post-glacial formations (No. 11).

Several localities for shells from marine beds of this age are given in the 'Supplement to the Crag Mollusca,' viz., Kelsea Hill, Paull Cliff, March, Hunstanton, and the Nar Brickearth.

The Kelsea Hill bed is in Yorkshire, adjoining the railway from Hull to Withernsea, one mile east of the Burstwick station. It consists of sand and gravel, rich in individuals of shells, all more or less rolled, and is specially notable for an abundant admixture of the river shell, *Cyrena fluminalis*, with the marine Mollusca; pointing presumptively to the inference that the bed was accumulated after the glacial submergence had given place to emergence, so that a river flowed not far distant from this spot. The deposit was described many years ago in Prof. Phillips' 'Geology of Yorkshire,' and more particularly again by Mr. Prestwich in vol. xvii of the 'Quarterly Journal of the Geological Society,' wherein a more copious list of Mollusca than our researches have afforded is given by Mr. Gwyn Jeffreys. The whole of these consist of species still living, and with three or four exceptions that are Scandinavian they are British. The geological position of this deposit will be found fully examined in the paper from which the preceding section of the Yorkshire Coast is taken; and by the permission of the Council of the Geological Society the accompanying cut from that paper of the section afforded by Kelsea Hill in 1867 is given.

KELSEA HILL BALLAST PIT IN 1867 (Extreme height of section, 35 feet).



1. Sand and gravel with Marine shells and *Cyrena fluminalis* (*d* of the Yorkshire coast section). 2. The Hessle Clay (*e* of the coast section). 3. Newer Gravel (*f* of the coast section). N.B.—The Clay, No. 2 at the extreme left of the section, is probably only a subaërial wash down of No. 2, which is *in sitû* in the centre of the section. 4. Talus.

The Kelsea gravel is overlain by a clay containing some stones and boulders (mostly small), which, from its identity with that of the well-known Hessle section, has been termed "the Hessle clay." This clay is shown in the preceding coast section under the letter *e*, and there wraps the whole of the denuded edges of the purple clay to which the Bridlington bed belongs like a cloth, and is underlain irregularly by beds of sand and gravel called "the Hessle sand" (*d*) that are presumably identical with the gravel and sand of Kelsea Hill. This presumption accords with the molluscan contents of the gravel when contrasted with those of the Bridlington bed; for at Kelsea there is not only an absence of the specially arctic and American forms which characterise the Bridlington bed, but also of those characteristic crag forms *Tellina obliqua* and *Nucula Cobboldiæ*.

Paull Cliff is on the Humber; but it has been nearly destroyed in making the battery at that place. The sand and gravel of Paull, there can be little question, belongs to the Hessle sand (*d*), as it has yielded similar shells to the Kelsea gravel, Mr. Prestwich finding in it the *Cyrena;* and it rests on either *a* or *c*.

The Hunstanton gravel resembles in its palæontological aspects the Kelsea Hill bed in consisting entirely of living species, and none but those inhabiting British seas have yet been obtained by us from it.[1] It is not, however, overlain by anything answering to the Hessle clay, which caps the Kelsea gravel, that clay not having been traced further

[1] This gravel and that at March was first described by Mr. Seeley in the 'Quarterly Journal of the Geological Society,' vol. xxii, p. 470, but two shells that he names from Hunstanton, *Nassa reticosa* and *Tellina obliqua*, have not been found by others, and are believed to be *Nassa reticulata*, and the large, rounded form of *T. Balthica*, both of which occur there. The shell also, called by him *Astarte crebricostata*, from March, is most probably *A. borealis*, which occurs plentifully there, and which is a somewhat abnormal form of this shell, and approaching *A. crebricostata*. We have not yet been able to find *Tellina proxima* given by him from March, nor to recognise anything like the Glacial clay there, the clay with some minute fragments of chalk, which underlies and seems connected with the gravel, being, we consider, of Post-glacial age.

south than Steeping, in Lincolnshire, on the opposite side of the Wash, and about 20 miles west of Hunstanton; neither does the *Cyrena* occur in it.[1]

The March gravel occurs around March railway station, and in pits in the town itself. It is in the midst of the Cambridgeshire Fen,[2] and there are no means of testing geologically its position, as it forms but small islands rising out of the recent peat and alluvium of the great level of the Fen. It is very rich in individuals of Mollusca, which are in good preservation, and its fauna, so far as yet known, resembles that of Kelsea and Hunstanton in consisting entirely of species now living, and which, with two exceptions, still inhabit British seas. In all these gravels, as well as in the Nar Brick-earth, *Ostrea edulis,* which is absent from all the East Anglian, and, indeed, from all the English glacial beds,[3] is abundant; and there can be little doubt that the four are synchronous and belong to the earlier, or *Cyrena fluminalis* part of the Post-glacial period.

The fifth fossiliferous marine Post-glacial formation referred to, is that of the Brick-earth of the Nar Valley, in north-west Norfolk, which occurs at East Winch, Bilney, Pentney, East Walton, Tottenhill, and other places. Our knowledge of the Mollusca of this formation is wholly due to the late Mr. C. B. Rose.[4] Its fauna, like that of the gravels of Kelsea Hill, Hunstanton, and March, consists entirely of species still living, and which, with one exception, occur in British Seas. The shells of this formation are in fine preservation; and there can be little doubt of the deposit being one of an estuary connected with that sea, which a Post-glacial depression, shown by the Hessle beds, caused to overflow the lower elevations of the eastern side of England.

The clay XI, shown in Sections I and II as capping Hasboro' Cliff, is a deposit of not more than four or five feet in thickness and is unfossiliferous. It seems destitute of chalk, but is full of small stones, chiefly flint; and rising from the sea level at Eccles Cliff, it dies out at an elevation of about fifty feet along the coast between Bacton and Mundesley. It is not improbable that it may be synchronous with the Hessle clay, although, at present, we are without the means for a satisfactory comparison.[5]

1 *Cyrena fluminalis,* however, occurs in the fluviatile deposit of Barnewell, in Cambridgeshire, which we regard as coeval with the March and Hunstanton marine beds.

2 Similar fossiliferous gravel occurs at other places in the Fen, such as Whittlesey, Wimblington, and elsewhere.

3 In some earlier papers by us this shell was given from the Middle Glacial, but it was a mistake.

4 See 'Geol. Mag.,' vol. ii, p. 8, and the prior papers there recited. A list of the Mollusca is there given by Mr. Rose, to which should be added *Nassa pygmæa*.

5 This clay obscures the surface of the low country for some miles south-east of Hasboro' so as to render the mapping of that part uncertain. Whether it has been mistaken on the Hasboro' Cliff for the Great Chalky clay, No. 9, we know not; but we do not recognise this latter clay either at Hasboro' or anywhere else along the North Norfolk coast section, though it occurs on the East Norfolk coast from Caistor to Winterton. On the top of Dunwich Cliff (Section R) there occurs a Post-glacial bed, from three to seven feet in thickness, consisting of a loam which in places contains some fragments of the clay, No. 9. This may, perhaps, be the same as the capping clay, XI, of Hasboro'. It is shown in Section R under the same

The rest of the Post-glacial formations shown in the map and sections under the number 11, are with some exceptions, (among which must be included beds wherein *Cyrena fluminalis* occurs, such as those at Stutton on the Stour estuary, and at Gedgrave near Orford, regarded by us as belonging to the older part of this period,) probably newer than these marine gravels, and belong to the later part of the Post-glacial period. In the preceding Yorkshire Coast section the earlier Post-glacial series, the Hessle sand and clay (*d* and *e*), are excavated or removed to give place to numerous later beds (*f*) of sand and gravel, which are of considerable thickness, and some of which contain freshwater Mollusca. It is clear from this coast section, therefore, that extensive beds, especially river gravels, accumulated over the north-east of England after the land had emerged from the Hessle clay re-depression; and to these we consider the principal part of the East Anglian Post-glacial Valley beds, which are shown in the map, under the number 11, belong.[1]

The recent alluvium, shown in the map under the figure (that of a crow flying) which has been adopted in their maps by the Geological Survey to distinguish these deposits, is mainly due to that considerable depression anterior to historical times, which buried so much forest ground all round the English coasts. This last depression brought the sea water into valleys which during the preceding (later Post-glacial) period were dry and forest-covered; and filling them, has given rise to the Broads of East Norfolk. The same depression has produced the wide flats of alluvium which fill so much of the valleys of the Waveney, Ant, and Yare, in East Norfolk, by silting up the lower parts of these valleys with modern estuarine mud, which was found at Yarmouth, in a well boring, to be 170 feet in thickness.[2]

The rest of the recent deposits consist of shingle, such as the great bank which shuts in the Alde from the sea at Orford, or of blown sand, which at Lowestoft has buried the sea cliff, and with some deserted foreshore has produced new land called the Denes.

S. V. Wood, Jun.
F. W. Harmer.
February, 1872.

N.B.—The lithographic map having been reduced to one fourth the original scale, from a survey made on the one inch Ordnance sheets, those who may have occasion to use it for field purposes will find it convenient to employ these sheets, (which are of very

shading and number as the Post-glacial gravel (10), but it, in fact, passes over that gravel where the cliff is highest (under the Ruins), and where a small portion of the clay No. 9 remains *in sitû*, but the two patches, numbered 10, capping the southern half of the section, consist entirely of this loam.

[1] Sections of the Crag and Glacial beds along valley sides often show a Post-Glacial gravel over them, as, *e. g.*, Sections IX, X, XI, and XIV. It would, however, be scarcely possible to map all these patches, and if done their representation would obscure that of the older beds.

[2] See Prestwich in 'Quart. Journ. Geol. Soc.,' vol. xvi, p. 449.

small cost) and to measure off on them from the lithographic map all distances multiplied four times. In this way, by measuring from the parish church of any place, the site of which is shown by a cross, or from any bend of a stream, a greater approach to accuracy will be obtained, as well as the advantage of the contour surface furnished by the Ordnance sheet. The names of a few places (Norwich among them), where the shading is close and intricate, have been omitted, or they would have obscured the Geology. As, however, the site of the churches of all these is shown by the crosses, they can be readily identified on the Ordnance sheet. Wherever the lines of section traverse pits affording sections which exhibit the beds clearly, they are indicated by indentations in the surface line, and their position is written over them. Thorpe and Sizewell Cliff is run down and grassed. From Section T, northward to Lowestoft, the cliff is much obscured by talus, but traces of a boss of the pebbles, No. 6, appear at one part. From Lowestoft to near the southern end of Section U, the cliff is obscured by being buried in blown sand. The cliff by Caistor, Ormesby, Scratby, and Winterton, is similarly obscured, but in places, at the top, No. 9 is exposed. None of these portions of the East Anglian Cliff are, therefore, represented in the sections, but the map shows of what the uppermost part of those portions of the cliff consists. Many names of places have been wrongly spelt by the lithographer in the map, but they can easily be recognised.

Reference to Sections A to W 1 The Chalk 2 The London clay 3 The Coralline Crag 4 The Red Crag. 4̄ The fluvio-marine Crag 5 The Chillesford beds 6 The Pebbly sand and Pebble beds 6ᵃ The Cromer Till 7 The Contorted Drift 8 The Middle Glacial 9 The Upper Glacial 10 Plateau Gravel 11 Post Glacial valley beds ⌣ Recent A The Mammaliferous clay of Bacton Beach B Forest bed and Gravel pan of Cromer & Hasbro' C. Freshwater peaty clay of Woman Hythe D The Mammaliferous clay of Kessingland with forest bed over it E Freshwater bed in hollow of D with tree trunks under it VI Sheets of Chalk interbedded in 6ᵃ VII masses of reconstructed Chalk (or marl) in 7 Reference to Sect.ˢ I to XXII A,B,C,D & E 1, 2, 4̄, 6, 6ᵃ 7, 8, 9, 10 & 11 as before 3' The Shelly Sands of the Coralline Crag. 3'' The Bryozoon Rock bed of the Coralline Crag 3''' Bed reconstructed out of 3' comminuted 4' The Walton Red Crag 4'' The Deben Orwell and Butley Red Crag 4''' The Scrobicularia Crag 5' The Chillesford sand with Shell bed X 5'' The Chillesford clay. XI The Capping Stony clay of Hasboro' Cliff Longitudinal Scale of Sections A to P. one inch to the Mile & of Sect.ˢ Q to W two inches to the Mile The Vertical Scales, are in feet above the sea level and approximate only

SUPPLEMENT

TO THE

MOLLUSCA FROM THE CRAG;

BEING

DESCRIPTIONS OF ADDITIONAL SPECIES,

AND

REMARKS ON SPECIES PREVIOUSLY DESCRIBED.

CEPHALOPODA.

In the first part of the 'Crag Mollusca' it was observed that no remains of an animal belonging to this class had been detected in any section of the Upper Tertiaries, or what was there called the periods of the Crag deposits. I am equally unable now to introduce the name of any Cephalopod which may be presumed to have lived during the time of the Crag or any of the succeeding periods, although I have searched zealously in the hope of obtaining the terminal portion of the bone of the "Cuttle Fish." This bone is in some places left in great numbers on our own shores, and is an organic remain we might expect to find, but as yet I have not seen a vestige of such a fossil in the Upper Tertiaries of the East of England. The mucro of *Belosepia,* presumed to be similar to that of *Sepia,* is by no means rare in the sandy beds of Bracklesham or of Grignon.

GASTEROPODA.

Pulmonata.

Helix Suttonensis, *S. Wood.* Tab. I, fig. 2, *a—c.*

Spec. Char. H. Testâ apertè umbilicatâ, orbiculatâ, supra convexiusculâ, costulato-transversè striatâ, subtùs convexâ, lævigatâ; anfractibus septem subcarinatis, versus peripheriam inconspicue subangulatis; aperturâ angustato-lunulatâ; peristomate reflexo? umbilico parvo.

Diameter, $\frac{1}{4}$ of an inch.

Locality. Coralline Crag, Sutton.

A single specimen rewarded my researches in 1867, and this is the first instance, so far as I know, of a land animal having been observed in the truly marine deposit of the Coralline Crag. This deposit I have always imagined to have been quite out of the reach of fresh-water streams, and the only way I can account for the presence of this *Helix* at Sutton is that it was probably carried out to sea upon a piece of drift wood, which, in its decay, left it among the marine Mollusca.

This is an elegant little shell, and symmetrical in its form. It has seven volutions, the first of which is perfectly smooth, but the others are beautifully ornamented with thickened and rounded, but not imbricated, ridges, or thickened lines of increase; about eighty on the outer volution, and the suture or juncture between the whorls is deep and very distinct, the edge of the succeeding volution being slightly elevated. The under surface of the shell is quite smooth, the umbilicus small, and broadly funnel-shaped.

On comparing my fossil with existing species I find it most nearly related to *Helix calathus* and *H. bifrons,* but to neither of them can it be strictly referred; the spire is less elevated than in the first, but more so than in the second, and there is a difference in the ornamental ridges of both; in one they are fewer and larger, and in the other smaller. In my shell the umbilicus is more funnel-shaped, and as my specimen was probably a full grown individual, judging from a slightly reflected margin to the aperture, it is not so large as either of the recent species; it bears rather a closer resemblance to *bifrons,* but a specimen of that species of corresponding size to the Crag shell has only six volutions. I have therefore given to it the above name to commemorate a locality that has yielded me so many Crag species.

The near relationship of the shell to Madeira species is not without its significance on the subject of the climate of the Coralline Crag period in Britain, for though a suite of land Mollusca would be necessary before any just inference could be drawn on this point, yet this solitary form harmonises with what I and Messrs. Forbes and Hanley (in opposition to the author of the 'Brit. Conch.') hold to be the general facies of the Cor. Crag Fauna, viz. that it is more southern than British.

Helix rysa, 'Crag Moll.,' vol. i, p. 4, Tab. I, fig. 1, must for the present retain that name. I have not been able to find an existing species to which it can be referred. The specimen I figured was then unique. Mr. Canham has obtained from the "diggers" at Waldringfield a second individual, which, he says, came out of the Red Crag at that locality.

Pupa muscorum, *Müller*. Supplement, Tab. I, fig. 7, *a*, *b*.

Localities. Red Crag, Butley. Fluvio-marine Crag, Bramerton. Post-glacial, Clacton and Stutton.

A specimen of this species has recently been found in the Red Crag at Butley by Mr. A. Bell, which I have had figured, and another by Mr. Harmer at Bramerton; each of these shows a tooth in the aperture. My specimens from Clacton and Stutton are nearly all endentulous. I have given to this shell the above name, having previously used it in my former 'Catalogue.' The confusion respecting the true *muscorum* of Linné still exists, and perhaps may never be cleared up, but the *muscorum* of Müller appears to be admitted, and this name is entitled to precedence before that of *marginata*, Mont.

Limnæa Pingelii ? *Möller*. Supplement, Tab. IV, fig. 4.

Lymnæa Pingelii (Lymnophysa Pingelii, *Beck*) in Möller, Ind. Moll. Groenl., p. 5.

"*Testâ ovato-elongata; spira conica, acutiuscula; anfr.* 5*; sutura profundiori; apertura dimidio testæ longitudinis breviori; rima umbilicali angustiori. L.* 6, 5'''."—Möller.

Locality. Red Crag, Butley.

This specimen was found in the Red Crag at Butley by Mr. A. Bell, and I have assigned it, though with doubt, to the above-named species; it is shorter and more inflated than any of our British species. This specimen is in the cabinet of Mr. Reed, of York, Fig. 8, *b*, Tab. I, 'Crag Moll.,' vol. i, may, perhaps, be referred to the same species, and fig. 8, *a*, of the same plate may be what Möller described as *L. Holböllii*, which is more elongated, and it has a larger umbilicus. I have several specimens of this from Butley. These appear to represent the existing northern forms of this genus.

Melampus fusiformis, *S. Wood.* Crag Moll., vol. i, p 12, Tab. I, fig. 14 (as *Conovulus myosotis*), and Supplement, Tab. I, fig. 1.

Melampus fusiformis, *A. Bell.* Ann. and Mag. Nat. Hist., 1870.

Axis, ½ an inch.

Localities. Red Crag, Sutton. Fluvio-marine Crag, Thorpe, in Suffolk, and Bramerton.

The specimen figured in Supplement, Tab. I, was found by Mr. A. Bell at Thorpe, in Suffolk, and in the 'Crag Moll.,' vol. i, Tab. I, figs. 14 and 15, are represented some specimens from the Red Crag of Sutton, which are there called *Conovulus myosotis* (with a doubt). These, I think, may be united with the shell figured in Supplement, Tab. I, although they have no denticles on the inside of the outer lip. A similar, but smaller, specimen has been found at Thorpe, in Suffolk, by Mr. E. Cavell, in which the outer lip has also indications of denticles. This shell is much larger and more fusiform than the existing *myosotis*, has a more pointed base, and is a thicker shell.

Mr. Bell, in the 'Geol. Mag.,' vol. vi, p. 41, gives *Limnæa peregra* and *L. truncatula* as species from the Red Crag of Butley. I have also found *Planorbis complanatus* and *Pl. spirorbis* at the same locality.

These two or three fresh-water shells thus occurring in the Red Crag do not appear to me to indicate estuarine conditions, as they may have been introduced into the Red Crag sea down those rills of fresh water that we see on every beach between tide marks, coming from the land and meandering over the shore to the brink of the waves. The principal part of the Red Crag, including the Crag at Butley, from which these shells were obtained, being a beach or foreshore deposit, *i. e.* one formed between high and low water marks, land and fresh-water shells so carried down would become incorporated with the purely marine deposit, and thus impart a different aspect to a formation from that of a fluvio-marine one, which is produced by the gradual intermingling in an estuary of a fresh-water river with the salt water of the sea. It is clear from the position of the Red Crag at Butley relatively to the Coralline Rock bank against which it abuts, that the shore was immediately contiguous to the places from which these fresh-water shells were derived. Even those parts of the Red Crag which appear to have been formed actually under water, such as that under which the phosphatic nodules are worked, were in the immediate contiguity of the foreshore deposits with which they are associated, and may easily have received introductions of land and fresh-water shells in a similar way.

PECTINIBRANCHIATA.

Marine.

Ovula Leathesii, *Sowerby*. Crag Moll., vol. i, p. 14, Tab. II, fig. 1, *a*, *b*.

Localities. Cor. Crag, Sutton and near Orford. Red Crag, Walton Naze and Butley.

Two varieties of this Crag fossil were figured as above referred to, both of which were considered there as referable to *Bulla spelta*, Linné.

At fig. 23, Tab. VII, of this Supplement I have given a front view of the short variety, the back of which was represented in 'Crag Moll.,' Tab. II, fig. 1, *b*, from the Red Crag.

This somewhat resembles *O. Adriatica*, Sow., but I believe it is only a short variety of *O. spelta*, which I will here call var. *brevior*. Specimens from the Cor. Crag in Mr. Cavell's collection exhibit also the same differences. Mr. Bell gives the name of *O. Adriatica* ('Ann. and Mag. Nat. Hist.,' May, 1871, p. 9) as a Crag species, which I imagine to be the short variety. This thickened margin, the presumed indication of the adult, may be seen on specimens of various sizes, like the variations in *Cypræa Europæa*. I have obtained the shell from Butley, where it is smaller than in the Walton bed. I am informed by Mr. Charlesworth that the specimen, upon the authority of which this species was introduced by Dr. Woodward into his Norwich Crag list, is most probably spurious as a Norwich Crag shell.

Ovulum obtusum from China, Sow., 'Thesaur. Conch.,' vol. ii, p. 474, pl. c, figs. 22, 23, can scarcely be distinguished from our Crag shells.

CYPRÆA EUROPÆA, *Mont.* Crag Moll., vol. i, p. 17, Tab. II, fig. 6, and Supplement, Tab. V, fig. 24.

Localities. Cor. Crag, Sutton, and near Orford. Red Crag passim. Middle Glacial, Billockby.

The figure in Supplement, Tab. V, represents a very globose form from the Red Crag of Sutton, which I believe is merely a variety of *C. Europæa*, although it is more spherical and less elongated than the generality of specimens, and it has rather more numerous ridges. In Mr. Bell's paper on "Some new or little-known Shells of the Crag" ('Ann. and Mag. Nat. Hist.,' September, 1870) is the name of *Cypræa Dertonensis*, Mich., but I do not know the shell he alludes to. If it be the present Crag shell I cannot acquiesce in the reference. The shell figured and described by Michelotti ('Desc. des Foss. Terr. Mioc. de l'Ital.,' p. 331, pl. xiv, fig. 10) appears to me to be a different species. I have not seen Mr. Bell's specimen.

Fragments of *C. Europæa* have occurred in the Middle Glacial sand of Hopton Cliff. I am informed by Mr. Charlesworth that the specimen upon the authority of which *Cypræa Europæa* was introduced into Dr. Woodward's Norwich Crag list is probably spurious as a Norwich Crag shell.

ROSTELLARIA LUCIDA? *J. Sowerby.* Supplement, Tab. II, fig. 14.

Locality. Red Crag, Sutton.

In my 'Catalogue,' as also in the 'Crag Mollusca,' vol. i, p. 24, mention is made of a shell found in the Red Crag at Sutton, to which I gave the name of *R. plurimacosta*, and then stated it as greatly resembling the London Clay species (*R. lucida*). The specimens found by me are all more or less in a mutilated condition, and I regret to say that my knowledge is not improved by the sight of any better than I then possessed. I am induced to have it figured because the specimens have the lithological character of the Red Crag shells; and although it is a species probably derived from an older deposit than the one in which it was found, it has not the appearance of the *known* derivative fossils from the older tertiaries, and I think it is just possible to have lived in the Coralline Crag sea and been derived from that Crag. My specimens differ slightly from the Highgate fossil; the costæ upon the Crag shell are rather closer, thicker, and more obtuse, and the volutions not quite so convex, with the intermediate striæ closer and not so fine, but the Crag specimens will not admit of fair comparison. Our shell seems to agree rather better with the figure and description given by M. Deshayes ('An. sans Vert. du Bass. de Par.,' t. iii, p. 461, pl. 92, figs. 4—7), which is more slender, and the costæ a little larger, with the striæ closer; the long rostrum there shown has not been preserved in any of our British fossils. The figure given by Sowerby of the Bracklesham shell (Dixon, 'Geol. of Sussex,' p. 187, tab. v, fig. 21) much resembles the Crag specimens.

ANCILLARIA GLANDIFORMIS ? *Lam.* Supplement, Tab. V, fig. 7.

Locality. Red Crag, Waldringfield.

Another shell, most probably derived from some anterior deposit, has been obligingly presented to me by Mr. Charlesworth, who obtained it from the nodule pits in the Red Crag at Waldringfield. It is in a very mutilated condition, but I think it may be referred to *Ancillaria glandiformis*, Lamarck, 'Ann. du Mus.,' tab. xvi, p. 305. It seems to correspond with fig. 7, *a*, *b*, tab. vi, 'Foss. Moll. des Wien. Beck,' vol. i, where Dr. Hörnes has figured several varieties of the species. My specimen is in a similar condition to most of the Red Crag shells in respect to lithological character.

VOLUTA NODOSA ? *J. Sowerby.* Supplement, Tab. V, fig. 6, *a*, *b*.

VOLUTA NODOSA, *J. Sow.* Min. Conch., tab. 399, fig. 2.

Locality. Red Crag, Waldringfield.

A single specimen, which I have referred as above, has been obtained by the Rev. Mr. Canham from the nodule diggers in the Red Crag at Waldringfield; it is in all probability a specimen derived from some anterior formation, perhaps from the same bed which has supplied to the Crag the specimens of *Rostellaria lucida.*

Our specimen has undergone considerable water action, as most of the exterior ornament is obliterated. Mr. Edwards speaks of this older Tertiary species being very variable, and has represented several different forms ('Eocene Moll.,' p. 141, Tab. XIX, fig. 1); he gives it as a species from the London Clay at Highgate, and also from the Bracklesham beds.

VOLUTA LUCTATRIX, *Solander*. Supplement, Tab. VI, fig. 14.

Locality. Red Crag, Waldringfield.

Another extraneous specimen has been obtained by Mr. Canham from the same place, which I have referred to the young state of *Voluta luctatrix*. Our shell corresponds with fig. 3, *d*, *e*, Tab. XIX, of 'Eocene Mollusca;' it is rather less in size, but I have no doubt of its identity; the specimen has undergone a good deal of rough treatment by its removal into the bed of the Red Crag. This species (*luctatrix*) is very abundant at Barton, where specimens of all ages and sizes may be found, from $4\frac{1}{2}$ inches down to $\frac{3}{8}$ths of an inch, and the young species vary much in shape, being comparatively more elongated than when full grown. Perfect specimens have a small apex or pullus, and two or three of the upper volutions are smooth, or free from ornament of any kind, like the pullus of true *Voluta*, with its very obtuse apex. Swainson proposed for these Eocene fossils with a small apex the term *Volutilites*, but this is a name of hybrid composition, and does not appear to be generally adopted. This Eocene form of Volute has nearly died out. One shell of this character has been obtained from the Aguilhas Bank, and named *V. abyssicola*, which is probably a true descendant of ne of our Eocene species.

VOLUTA LAMBERTI, *J. Sowerby*. Crag Moll., vol. i, p. 20, Tab. II, fig. 3.

Localities. Cor. Crag passim. Red Crag passim. Fluvio-marine Crag, Yarn Hill, near Southwold.

In the 'Crag Mollusca' I regarded the presence of this shell in the Red Crag as due to derivation from the Coralline, but there can, I think, be now no reason for doubting that the shell was a denizen of the Red Crag sea, because it was lately found by Mr. Charlesworth and Mr. V. Colchester in association with *Pecten princeps* in the pit at Yarn Hill, near Potter's Bridge, Southwold, which belongs either to the Fluvio-marine Crag or the Chillesford bed (though to which it is hard to say). There can, therefore, be no doubt that it lived through the Red and Fluvio-marine Crag period. There is no known living shell with which it can in my opinion be identified.

MITRA EBENUS? var. UNIPLICATUS, *S. Wood*. Supplement, Tab. III, fig. 6.

Locality. Coralline Crag, Orford. Red Crag, Waldringfield (*A. Bell*).

When I first obtained the above represented specimen, I had it figured under an impression that it was a distinct species (or even genus), having but one fold or ridge upon the columella, but I have since seen two or three more specimens in Mr. Bell's possession resembling it in every respect, with the exception of the columella, which in his specimens had three, and in one instance four folds, denoting it to be a true *Mitra*. I have, therefore, retained for it the above name. It much resembles, and probably may be the same as, *Voluta pyramidella* of Brocchi, p. 318, Tab. IV, fig. 5; my shell has an obtuse apex, the volutions much flattened, a very slight shoulder, and a deep suture. Mr. Bell gives *M. ebenus* as a Red Crag shell from Waldringfield, but I have not seen the specimen.

MITRA FUSIFORMIS, *Brocchi*. Supplement, Tab. V, fig. 3, *a*, *b*.

VOLUTA FUSIFORMIS, *Broc.* Conch. Foss. Subapen., vol. ii, p. 315, 1814.
MITRA — *Grat.* Conch. Foss. du Bas. de l'Ad., t. 37, figs. 6, 7.
— — *Bellardi.* Mon. della Mitr. Foss. del Piem., p. 5, t. 1, figs. 6—10.
— — *Hörnes.* Foss. Vien. Bas., p. 98, t. 10, figs. 4—7.

Spec. Char. *M.* "*Testâ fusiformi-elongata, lævi; anfractibus convexiusculis, postice subangulatis; apertura elongata; columella recta* 4—6 *plicata; spira elata.*" (Bellardi.)

Length, 2 inches, nearly."

Locality. Red Crag, Waldringfield.

A single specimen of a shell, which I have with very little doubt referred to a common Continental fossil species, has been obtained from the nodule workings by the Rev. Mr. Canham. This specimen has, like many of its associates in the Red Crag at Waldringfield, undergone some rough treatment. Most of its outer coating has been removed. It is a very elongated specimen, but I believe where it is abundant the same form may be observed. Our specimen has only four folds upon the columella; the first is the most prominent, diminishing towards the base, but these plaits or folds are said to vary in number from four to six. This is probably a derived specimen.

In vol. ii, 'Moll. Sic.,' Phillippi refers *M. fusiformis* to *M. zonata*, Swainson and Risso. Weinkauff gives this name to Marryat. This latter name seems to have been imposed on the existing shell from the coloured band on the exterior. I have retained Brocchi's name, which seems to be generally adopted for this fossil. It is a variable species, and Bellardi assigns as synonyms *M. plicatella*, Lam., *M. pyramidella*, and *M. incognita*, Grateloup.

TEREBRA CANALIS, *S. Wood*. Supplement, Tab. IV, fig. 1.

Length, $1\frac{1}{8}$th inch.

Localities. Coralline Crag near Orford. Red Crag, Waldringfield (*Bell* and *Canham*).

When describing this shell in the 'Crag Moll.' I had only a few fragments to assist in the determination of the species. Since then I have obtained some better specimens, and have here given an additional figure.

This may possibly hereafter be referred to *T. fuscata*, Broc., which is said to be very variable, but it differs considerably from the typical form of that species. The Crag shell has a longer and more inflected canal, with a more obtuse apex, and the spiral band is narrower and less distinctly marked, with the longitudinal lines less prominent. Specimens of *fuscata* from the Vienna and Bordeaux beds attain to the length of three inches and upwards. The Crag shell seems somewhat to resemble a variety figured by Dr. Speyer, 'Ober. Oligoc.,' &c., p. 13, tab. i, figs. 7, 8, *a*, *b*. M. Nyst considers it as a dextral variety of *T. inversa* (Catal. in 'Bull. de l'Acad. Roy. des Sci., Lettr., et des Beaux Arts de Belgique,' chap. xvii, p. 420). I have for the present retained my original name. The shell referred to by Mr. Bell in 'Ann. and Mag. Nat. Hist.' for May, 1871, under the name *T. exilis*, Bell, I have seen, and regard as a variety only of *canalis*.

COLUMBELLA? HOLBÖLLII, *Möller*. Supplement, Tab. VI, fig. 21.

FUSUS HOLBÖLLII, *Möll.* Ind. Moll. Groenl., p. 15

"*Testa fusiformi, elongata, alba, lævi, epidermide cornea, fusco-lutea, solidiore obtecta; anfr.* 9 *sensim crescentibus, planulatis; spira acuminata. Long.* 2, 4‴."—Möll.

Locality. Upper Glacial, Bridlington.

A specimen of this species is in the British Museum among the Bridlington fossils, and it is enumerated by the late Dr. S. P. Woodward in his list of Bridlington fossils in the 'Geol. Mag.,' vol. i, p. 53. This species is also found fossil in the Belfast deposit, where I believe it is by no means uncommon. It is found living in the Spitzbergen and Greenland seas.

COLUMBELLA? SULCATA, *J. Sowerby*. Crag Moll., vol. i, p. 23, Tab. II, fig. 2. Supplement, Tab. II, fig. 16.

Localities. Cor. Crag, Sutton. Red Crag, Walton and Sutton. Fluvio-marine Crag, Bramerton? Middle Glacial, Hopton?

The figure in Supplement, Tab. II, represents a specimen found by G. Gibson, Esq., of Saffron Walden, in the Red Crag at Walton-on-the-Naze. It is nearly double the size of any specimen of this species previously obtained by myself.

In the 'Crag Moll.,' vol. i, p. 23, the character given to this species is "apex acute." This is an error, for although in some of the specimens the spire is much elevated and elongately tapering, the apex is always more or less obtuse or mammillated. The species of this genus from Turin and Astigiana are represented by Bellardi as being very acutely pointed. This species has been obtained from the Coralline Crag by Mr. Bell, as well as a fragment of it by myself.

It is a very aberrant form of *Columbella.* The young state of the Crag shell much resembles *Buc. minus,* Phil.; it has then a sharp and plain outer lip and a longer canal (see 'Crag Moll.,' Tab. II, fig. 2, *d*). A fragment, consisting of the outer lip with its denticulations, and a little of the exterior of the shell on which the striated markings are visible, obtained from the Middle Glacial of Hopton, seems referable to this species. It is given in Dr. Woodward's Norwich Crag list as a Bramerton shell, but I have not seen it myself from there.

Pyrula reticulata, *Lamarck.* Crag Moll., vol. i, p. 42, Tab. II, fig. 12.

Localities. Cor. Crag, Ramsholt. Red Crag, Waldringfield, Walton Naze.

In the Appendix, p. 311, vol. ii, I stated that I thought the cast of *Pyrula* figured (Tab. XXXI, fig. 6) was the same as the one previously figured from the Coralline Crag, and the specific name *reticulata* was in consequence proposed to be altered. I now think they belong to two different species, and I here restore to the Cor. Crag shell the name *reticulata* originally given to it, and the Sandstone cast, which is of a different age from that of the Crag, may retain the name of *acclinis* until it can be better determined. This Cor. Crag shell has been referred to *P. condita,* Brongn., by M. Nyst, and to *P. cancellata,* Grateloup, by Mr. A. Bell, and to *P. subintermedia,* Bronn, by Mr. Jeffreys. Two or three specimens of what appear to be *P. reticulata* of the Cor. Crag have been obtained from the Red Crag. Mr. Bell gives it from Waldringfield. It is probably derivative in the Red Crag. Hörnes gives eight synonyms to *P. reticulata.*

Cassis Saburon, *Bruguière.* Supplement, Tab. VI, fig. 2, *a, b.*

Le Saburon, *Adanson.* Senegal, p. 112, pl. vii, fig. 8, 1758.
Cassidea Saburon, *Brug.* Ency., p. 420.

Locality. Red Crag, Waldringfield.

This has been obtained from the diggers in the Red Crag at Waldringfield by Mr. Canham. It is probably an extraneous fossil, and derived from some anterior formation. The shell has undergone a good deal of water action, and I cannot perceive a trace of striation upon the surface; still, it so appears to correspond in all other respects with the species to which I have referred it, that I imagine the striæ have been rubbed off, or the outer surface has decorticated away, as it is quite smooth; it is also a little disfigured by the loss of a portion of its canal, but this was probably done in the lifetime of the animal and clumsily repaired.

This is a living species, with an extensive geographical range, being found on the coast of Spain, Portugal, and Algiers. It is a fossil of the Bordeaux beds and the Vienna basin, and M. Nyst gives it from the "Crag gris" of Belgium, and it may possibly have lived in the Coralline Crag Sea.

Cassidaria bicatenata, *J. Sow.* Crag Moll., vol. i, p. 27, Tab. IV, fig. 5.

Localities. Cor. Crag, Ramsholt and near Orford. Red Crag, Sutton, Bawdsey, Felixstowe, and Waldringfield. Fluvio-marine Crag, near Norwich?

Var. ecatenata. Supplement, Tab. VI, fig. 1, *a.*

Locality. Cor. Crag, near Orford.

The figure represents a specimen of *Cassidaria* from Mr. Cavell's cabinet, with a more elongated form than what I have had previously figured as *bicatenata,* and it is free from the double chain-like ornament upon the upper part of the volution. It approaches very near to *C. Tyrrhena,* Chemn., but it is, I believe, specifically distinct. It is from the Coralline Crag at Orford. I have also found the general form of *bicatenata* with its two rows of nodules or catenæ in the Cor. Crag at Ramsholt. Our present specimen differs also in the ornamentation, not having the small intermediate line between the ridges.

Fig. 1, *b*, Tab. VI, represents a small specimen in Mr. Canham's cabinet of *Cassidaria bicatenata* from the Red Crag at Waldringfield, which I have had figured to show that the thickened margin to the outer lip was in this case formed before the shell had attained to half of its usual size. The present specimen having had its aperture and anterior termination enveloped, may perhaps have had its natural growth checked and so became adult, though of so small a size; but this does not necessarily follow, because the thickening of the lip in this group of Mollusca is by no means an indication of the adult condition, for in the recent forms of *Cassis* this thickening of the lip may sometimes be seen to have occurred two or three times in the growth of the animal. This species is included in the list of shells from the neighbourhood of Norwich obtained by Sir C. Lyell in 1838, and identified for him by the late Mr. G. Sowerby and myself ('Mag. Nat. Hist.,' n. s., vol. iii, p. 329). I can therefore scarcely doubt its being a genuine Norwich Crag shell, though it does not appear to have been found of late years in the neighbourhood of Norwich.

Nassa granifera, *Dujardin.* Supplement, Tab. VI, fig. 11.

Buccinum graniferum, *Dujard.* Geol. Tr. France, vol. ii, pt. 2, pl. 20, figs. 11, 12.
Nassa granifera, *A. Bell.* Ann. and Mag. Nat. Hist., May, 1871.

Axis, $\frac{5}{16}$ths of an inch, nearly.

Localities. Coralline Crag, Gedgrave (*A. Bell*), Sutton (*S. Wood*). Red Crag, Sutton (*S. Wood*).

The specimen figured was lent to me by Mr. Bell, who obtained it from a dealer at Orford. I have a second, but less perfect, specimen from the Cor. Crag of Sutton. I have also found one in the Red Crag of Sutton, which I consider may be referred to the same species. In the 'Crag Moll.,' vol. i, p. 30, this was considered as specifically different from *N. granulata*, and the differences are there pointed out.

N. granulata, 'Nyst. Foss. Belg.,' p. 575, pl. xliii, fig. 11, appears to belong to this species.

NASSA PYGMÆA, *Lam.* Crag Moll., Appendix, p. 315, Tab. XXXI, fig. 5; Supplement, Tab. VI, fig. 6.

Localities. Cor. Crag, Sutton? Red Crag, Butley (*Bell*)? Post-glacial, Nar Brick-earth (*Rose*).

The condition of the specimen fig. 5 of Tab. XXXI renders it doubtful whether this species has occurred in the Cor. Crag. It is given by Mr. Bell ('Ann. and Mag. Nat. Hist.,' May, 1871) as from the Red Crag of Butley, but I have not seen the specimen. The shell figured in Supplement, Tab. VI, fig. 6, is one of a suite in excellent preservation obtained by Mr. Rose from the Nar Brick-earth, and on the tablet was the name of *Nassa pygmæa*, by Mr. Jeffreys.

NASSA GRANULATA, *J. Sowerby.* Crag Moll., vol. i, p. 29, Tab. III, fig. 3.

Localities. Cor. Crag passim. Red Crag passim. Middle Glacial, Billockby and Hopton.

Several specimens of this species, most of them very imperfect, but with their distinctive characters well preserved, have been obtained from the Middle Glacial sands at Billockby and at Hopton Cliff.

NASSA INCRASSATA, *Müller.* Crag Moll., vol. i, p. 29, Tab. III, fig. 4.

Localities. Cor. Crag, Sutton. Red Crag, Sutton and Butley. Fluvio-marine Crag, Bramerton. Middle Glacial, Billockby. Post-glacial, Nar Valley.

I have seen this shell from the Fluvio-marine Crag of the Bramerton Pit. The body-whorl and mouth of this shell have also been obtained from the Middle Glacial sands of Billockby. Several specimens in fine preservation have also been obtained by Mr. Rose from the brick-earth of the Nar Valley.

Nassa densecostata, *A. Bell.* Supplement, Tab. VI, fig. 8.

Nassa densecostata, *A. Bell.* Ann. and Mag. Nat. Hist., May, 1871.

Locality. Cor. Crag, near Orford.

A single specimen, not perfect, has been put into my hands for figuring. This came, Mr. A. Bell informs me, from the Coralline Crag, near Orford. Its nearest resemblance is to *N. limata*, Ch. (*B. prismaticum*, Broc.), but is much more slender and more numerously costated, as pointed out by Mr. Bell. I have seen only this specimen, and its specific distinction will require some further evidence for its confirmation.

Nassa propinqua, *J. Sowerby.* Crag Moll., vol. i, p. 30, Tab. III, fig. 2.

Localities. Red Crag, Walton Naze, and Sutton; Chillesford bed, Easton Bavent.

This shell Mr. Bell gives ('Ann. and Mag. Nat. Hist.,' September, 1870) from the Chillesford shell-bed of Easton Bavent Cliff, but I have not seen the specimen. He says it is the same as *N. trivittata*, Say., *Buc. trivittatum*, Gould (1st ed., 'Inv. Massach.,' p. 309, fig. 211, and in 2nd ed., p. 364, fig. 632), neither of which figures well represent the Crag shell, but the recent species is said to be very variable. This name (*N. propinqua*) was given to me in MS. by S. P. Woodward as from the Cor. Crag (in Mr. Wigham's collection), but I have not been able to find the specimen. Sowerby's name has, I believe, priority over that of *trivittata*.

Nassa pulchella, *Andrzejowski.* Supplement, Tab. VI, fig. 7.

Nassa pulchella, *Andrz.* Coq. Foss. Volh. Bull. Mosc., vi, p. 438, t. 2, fig. 2, 1833.
Buccinum reticulatum, *Dubois.* Coq. Foss. Wolh-Pod., p. 27, pl. 1, figs. 28, 29.
— — *Hörnes.* Vienna Foss., p. 151, t. 12, fig. 18, 1856.

Spec. Char. *N. Testâ mediocre, ovato-conicâ, longitudinaliter plicatâ, striis transversis distantibus decussatâ, subgranulosâ; anfractibus planiusculis; aperturâ magnâ ovatâ, labro intus, dentato.*

Axis, $\frac{1}{2}$ an inch.

Localities. Coralline Crag, near Orford. Red Crag, Waldringfield (*Bell*).

The specimen figured was obtained by Mr. Bell from the Cor. Crag, near Orford, and it was put into my hands with the name of *N. pulchella*, and it is the shell described under that name in the 'Ann. and Mag. Nat. Hist.,' May, 1871, as *N. pulchella*, A. Bell, n. s., but I believe it to be referable to the Russian fossil. Mr. Miller, of Ipswich, has obtained from the same locality a second specimen, and Mr. Harmer has very recently sent me another. It somewhat resembles a dwarf variety of *N. reticulata,* but it is, I believe, a full-grown shell and specifically distinct, as described by Mr. Bell. The accidental coincidence in the adoption of the name is curious. Mr. Bell also gives it (loc. cit.) from the Red Crag of Waldringfield.

NASSA PUSILLINA, *S. Wood.* Supplement, Tab. II, fig. 7.

Spec. Char. N. Testá parvá, elongato-conoideá, longitudinaliter costatá; costis 5—6, *spiraliter striatá; striis paucis, magnis, elevatis; anfractibus planiusculis aperturá ovatá; labro extus varicoso, intus dentato.*

Axis, $\frac{3}{8}$ths of an inch.

Localities. Fluvio-marine Crag, Bramerton. Red Crag, Butley. Middle Glacial, Billockby.

In Dr. S. P. Woodward's list of Norwich Crag fossils this is inserted as "*Nassa* ——, sp. (slender pointed), Norwich; examples in all collections;" from which remark, I presume, it is not rare near Norwich. The varices are rounded, with a considerable space between each; the suture is well defined, and the ribs slightly oblique, but the artist has made them rather too much inclined. It is very unlike all the other Crag *Nassas,* coming nearest to *N. consociata,* but quite distinct; it is identical in all respects with a shell in the Museum of the Geological Society presented by the late Jas. Smith, of Jordan Hill, but which is without a name, marked "Raised Beach, Gibraltar." It may, therefore, probably some day be found living in the Mediterranean area. It is by no means rare at Billockby.

It is the shell referred to as *N. pusio* in the paper by S. V. Wood, jun., and F. W. Harmer, in 'Brit. Assoc. Reports' for 1870, but I find the name *pusio* has been previously occupied.

NASSA RETICULATA, *Linné.* Supplement, Tab. VI, fig. 5.

BUCCINUM RETICULATUM, *Linn.* Syst. Nat., edit. xii, p. 1205.

Locality. Post-glacial, Kelsey Hill and Hunstanton.

This shell is very common at Kelsey Hill, but I do not know it from any Glacial or Pre-glacial formation in Britain. The specimen figured was found by my son at Kelsey. It has a great range in the recent state. The shell figured under this name from Bordeaux is, I believe, distinct. A fragment of *N. reticulata,* obtained from the beds of the Severn Valley, was sent me for inspection by Mr. G. Maw.

Nassa reticosa, *J. Sowerby.* Crag Moll., vol. i, p. 33, Tab. III, fig. 10; Supplement, Tab. IV, fig. 3, and Tab. VII, fig. 15.

Localities. Red Crag passim; Chillesford bed, Easton Bavent (*Bell*).

This, as before shown, is a very variable shell, and I have here introduced two more forms which I think may be referred to the same species. Fig. 3, Tab. IV, of the present Supplement represents a small specimen obtained by Mr. Bell from the Red Crag of Butley, which has a perfectly cancellated exterior without any thickened ribs or varices, which might be called var. *simplex*, and fig. 15, Tab. VII, is a shell I found in the Red Crag of Sutton which has an angulated shoulder to the volution, and belongs, I believe, to this species, and I will call it var. *scalarina.*

Mr. Bell informs me that he has obtained *N. reticosa* from the Chillesford bed of Easton Bavent Cliff, but I have not seen the specimen. Some fragments of spires from the Middle Glacial sand of Billockby seem to belong to the *costata* variety of this shell, but they are too doubtful to justify an identification.

Nassa conglobata, *Broc.* ('Crag. Moll.,' vol. i, p. 32, Tab. III, fig. 9), is possibly *Buccinum* (*Desmoulea*) *abbreviatum,* Chemn., a shell living on the coast of Senegal, but the shell is so rare in the Crag that I am not certain the fossil and recent shells are absolutely identical.

Nassa Monensis, Forbes, and N. Pliocena, Strickland, are still uncertain species. These two shells, originally described by Strickland, are not to be found. Mr. Etheridge, of the Geol. Survey, kindly endeavoured with much trouble to find them, but without success. My own shell (Tab. III, fig. 5, 'Crag Moll.') is possibly a var. of *reticosa.* I have not been able to find another like it.

Nassa labiosa, *J. Sow.* Crag. Moll., vol. i, p. 28, Tab. VII, fig. 22.

This shell was by E. Forbes referred to *Buc. semistriatum,* Broc. ('Mem. Geol. Surv.,' 1846, p. 428), and lately by Mr. Jeffreys, 'Geol. Journ.,' vol. xxvii, p. 144. I still think the two shells specifically distinct for the reasons stated at the above reference.

Buccinum Dalei, *J. Sowerby.* Crag. Moll., vol. i, p. 34, Tab. III, fig. 10. Supplement, Tab. II, fig. 9.

Localities. Cor. Crag, Ramsholt, Sutton, and near Orford. Red Crag passim. Fluvio-marine Crag, Bramerton; Chillesford bed, Easton Bavent.

The figure in Supplement represents a specimen of *Buccinum Dalei* found in the Red Crag at Walton-on-the-Naze by the Rev. T. Wiltshire, who has obligingly presented it to me. This specimen has the volutions in a reversed direction, that is to say from right to left. The late Dr. S. P. Woodward told me in 1864 that he had also found the fragment of a specimen of this species in the Coralline Crag with a sinistral volution, and as this shell had not been previously known in that reversed condition, I thought it deserving of a special representation. Mr. Robert Bell has very recently showed me a similar specimen from the Red Crag of Waldringfield. The circumstance that these specimens should have been discovered within a short period would seem rather to indicate a slight tendency in this species to vary its mode of volution, and perhaps if a few individuals of this form congregated together a progeny possessing a sinistral volution might have been produced.

The form of this species resembles in its general contour that of *Buc. undatum,* but it has a more distinct plait or tooth at the base of the columella, like that of *Nassa,* and Mr. Hancock pointed out that the animal had a different kind of "lingual ribbon" from *B. undatum.* In consequence of this character, and of possessing a different form of operculum, Dr. W. Stimpson, in an elaborate paper published in the 'Canadian Naturalist,' 1865, vol. ii (wherein he describes fifteen recent species in the genus *Buccinum*), has, at p. 366, proposed for it the generic name of *Liomesus* "with *Buc. Dalei* as the type." Mr. Jeffreys ('Brit. Conch.,' vol. iv, p. 297, 1867) has given to this shell the name of *Buccinopsis.*[1] Dr. Gray in 1859 proposed a genus under the name of *Cominella,* to receive species resembling *Buccinum,* having an operculum like that of the *Murices* and *Fusi,* in which the nucleus is terminal at the inner base of the mouth, increasing by semi-elliptical layers.

If the form of the operculum be sufficient of itself to consitute a generic character, I think our species will have to be referred to *Cominella,* should that be of prior establishment. With this uncertainty, and being unable to ascertain the date of priority for these different names, I have left our Crag species in its original position of *Buccinum.* A specimen of *B. Dalei* is in the Norwich Museum from the Fluvio-marine Crag, and

[1] This has no generic connection with *Buccinanops,* a word of similar meaning proposed by D'Orbigny, 1839, of which Herrmannsen says "Etym. vocabulum hybridum non admittendum;" neither is it generically related to two Eocene species figured by Deshayes with the name *Buccinopsis* ('An. sans Vert. du Bas de Par.,' t. xi, pl. xciii, figs. 21—23 and 29—32), afterwards described as *Truncaria,* Adams.

Mr. A. Bell gives this species from the Chillesford Bed of Easton Bavent Cliff, in 'Ann. and Mag. Nat. Hist.' for Sept., 1870.

Buccinum pseudo-Dalei, *S. Wood.* Supplement, Tab. V, fig. 4; Tab. VI, fig. 9.

Locality. Cor. Crag, near Orford.

Tab. V, fig. 4, represents a specimen lately obtained by Mr. A. Bell from the Coralline Crag near Orford, which, though resembling *B. Dalei*, departs from that shell sufficiently to entitle it, I think, to a distinct specific name, and I propose to call it *pseudo-Dalei*. The exterior of the specimen is not quite perfect, but it appears to have been covered with fine striæ, smaller and finer than I have seen upon any specimens of *B. Dalei*. The form of the aperture is also different, being more expanded at the base, and the columella is more twisted. The apex of this specimen is obscured. There is also a general angularity of aspect presented by the shell, in which it contrasts with *B. Dalei*.

Tab. VII, fig. 9, represents the fragment of a shell now in the British Museum found in the Coralline Crag at Orford by Henry Woodward, Esq.; it is marked as the apex of *B. Dalei*, which I believe it is, or even more probably of the above *pseudo-Dalei*. It seems from its depression and from the early expansion of the volutions to have belonged to the present species, which in the perfect shell has unfortunately this part hidden. Several fragments of *B. Dalei* in my cabinet from the Cor. Crag of Sutton have the first two or three volutions filled with calcareous matter.

Buccinum glaciale, *Linné.* Supplement, Tab. II, fig. 1.

Buccinum glaciale, *Linn.* Syst. Nat., 12th ed., No. 474, p. 1204.
— — *Chemn.* Conch. Cab., vol. x, p. 180, t. 152, figs. 1446, 1447.
Tritonium — *Fabr.* Faun. Groenl., No. 397, 1780.

Length, 2 inches.

Locality. Red Crag, Sutton? and Walton Naze.

The figure of this species here given is from a recent shell in the British Museum, but I have seen a perfect specimen that was, I believe, obtained by the late Mr. Edward Acton from some of the nodule diggers in the parish of Sutton, undoubtedly belonging to this species. This I should have preferred to figure, but I was not able to obtain it for that purpose. There can be no doubt that it came from the Crag, and I have myself found a fragment of what I believe belongs to this species at Walton-on-the-Naze.

Buccinum undatum, *Linné.* Crag Moll., vol. i, p. 35, Tab. III, fig. 12. Supplement, Tab. II.

Localities. Red Crag, Sutton. Upper Glacial, Bridlington? Post-glacial, Kelseahill gravel (*Jeffreys*), and Nar brick-earth (*Rose*).

Localities of var. *tenerum.*—Red Crag passim. Fluvio-marine Crag, Bramerton and Thorpe; Chillesford bed, Bramerton and Horstead. Middle Glacial, Billockby and Hopton. Post-glacial, The March gravel.

In the 'Crag Mollusca' I have figured three different forms under the specific name of *undatum,* and I have here introduced three more.

Fig. 2, Tab. II, Supplement, appears to resemble what has been called *B. Grœnlandicum.* Fig. 3 of the same plate is an extreme variety as to its ornamentation, which I will call *Buc. undatum,* var. *clathratum. Buc. tenerum* of 'Min. Conch.,' t. 486, figs. 3, 4, which the late Dr. S. P. Woodward in his list of Norwich Crag shells refers to *cyaneum?* may possibly be distinct. Fragments of *tenerum* (principally of the columella) occur in the Middle Glacial sands of Billockby and Hopton Cliff, while perfect specimens of it exactly resembling those of the Red Crag and of all ages abound in the Post-glacial Fen gravel of March. The constant features maintained by *tenerum* in the Crag, when found to recur in so modern a formation as the Fen gravel, impress me with the belief that this is a distinct species. *Buc. undatum* ('Crag Moll.,' Tab. III, fig. 12, *c*) is very rare in the Crag, while the form *tenerum* swarms in it. In the numerous specimens sent to me from March by Mr. Harmer I have not seen the true form of *B. undatum,* and as this Post-glacial gravel of March presents a more Arctic character than the present British seas I am disposed to believe *B. tenerum* may be *B. cyaneum.*

Supplement, Tab. II, fig. 5, represents a specimen from the Red Crag of Butley which has much perplexed me. There is an angularity in the upper part of the volution, below which it is contracted. The upper part of the volution is slightly striated, and there are some striæ on the base or lower part of the body-whorl, with very faint indications of undulations upon the spire, like those of *undatum,* with reflected imbrications upon the columella. The spire is much depressed, but it looks like a distortion, and I have considered it as such for the present. I will call it *B. undatum,* var. *ovulum.* The axis of the shell is $\frac{9}{16}$ths of an inch.

Purpura lapillus, *Linné.* Crag. Moll., vol. i, p. 36, Tab. IV, fig. 6.

Localities. Red Crag passim. Fluvio-marine Crag, Bramerton and Thorpe. Lower Glacial, Belaugh, Rackheath, and Weybourne. Middle Glacial, Billockby and Hopton. Post-glacial, Kelsey Hill and March.

The variety *crispata* occurs in the Chillesford bed at most of its localities and in the Lower and Middle Glacial sands. In the Middle Glacial the form *incrassata* is in association with *crispata*. I am disposed to think that *incrassata* is entitled to specific value; it much resembles *Fusus decemcostatus*, Gould. The common living British form, *crispata*, occurs in the fen gravels, and is said to be abundant at Kelsea Hill. *P. incrassata* is given in Woodward's list as from Thorpe, but rare.

TROPHON[1] ANTIQUUS, var. STRIATUS. Crag. Moll., vol. i, p. 44, Tab. V, fig. 1, *c*, *d*.

Localities. Red Crag passim, except Walton and Bentley. Fluvio-marine Crag passim; Chil. bed, Horstead, Coltishall, Aldeby, and Easton Bavent. Lower Glacial, Belaugh, Rackheath, and Weybourne. Middle Glacial, Hopton and Billockby.

TROPHON ANTIQUUS, var. STRIATUS CONTRARIUS. Id. Tab., fig. 1, *d, e, f, g, i, j*.

Localities. Red Crag passim. Fluvio-marine Crag passim; Chillesford bed, Horstead, Coltishall, Aldeby, and Easton Bavent. Lower Glacial, Belaugh, Rackheath, and Weybourne. Middle Glacial, Billockby?

TROPHON ANTIQUUS, var. CARINATUS. Id. Tab., fig. 1, *a*, *b*.

Localities. Red Crag, Sutton and Butley. Fluvio-marine Crag, Bramerton? Upper Glacial, Bridlington (*Woodward*).

TROPHON ANTIQUUS, var. CARINATUS CONTRARIUS. Id. Tab., fig. 1, *k*. Supplement, Tab. I, fig. 10, *a*, *b*, *c*.

Localities. Red Crag, Newbourn. Fluvio-marine Crag, Bramerton? Upper Glacial, Bridlington.

Some few years since, I found at Newbourn a specimen of this sinistral shell, which exhibits three ridges of carinæ upon the upper volution, and these are continued over the body-whorl, a form of sculpture I had not before seen upon any Crag specimens from Suffolk or Essex, and I have also had figured, by the obliging permission of the Committee of the Norwich Museum, a specimen of this reversed form which has the same carinæ, even more prominent (fig. 10, *a*); this latter shell was presented to the Museum

[1] *Neptunea*, Bolten, 1798, has been proposed by Messrs. H. and A. Adams as a generic name for this shell. *Tritonium*, O. Fabr., was adopted by Loven, and this has precedence; but it is difficult now to say what species was intended as the type of that genus. The name of *Trophon** has been previously given to my Crag shells, and as the differences between these are merely artificial or conventional, I have here retained the one I employed in the 'Crag Mollusca.'

* *Trophon* appears to be masculine, being, according to Mr. Jeffreys, a contraction of *Trophonius*.

by the late Col. Alexander, but, unfortunately, it has no special locality attached. It is undoubtedly a Crag shell, and from its appearance it looks like one of the Fluvio-marine specimens of Bramerton. The sinistral form of *T. antiquus,* occasionally found at the present day in the British seas, is simply striated, and not carinated, corresponding in that respect with the shell so abundant at Walton-on-the-Naze.

In the 'Crag Mollusca,' vol. i, p. 45, I have expressed an opinion that this left-handed striated whelk was, in British seas, probably the original form, in opposition to the general statement of conchologists that it is merely a variety, in consequence of the difference displayed from the common right-handed shell of the present day.

The great majority of shelled univalved Mollusca have the volutions turned in a dextral direction, that is, from left to right, but whether the original inflexion was given to the right or to the left we do not know, or why they should have taken the one in preference to the other. Among the Cephalopoda, the oldest known form is the straight one, as in *Orthoceras.* The bend from this seems to have been first in a vertical direction, such as *Phragmoceras* or *Toxoceras.* The deviation from that vertical direction was, I conjecture, due to the partial atrophy of the organs on one side, from a slightly altered position of the heart, until the highly oblique growth of the *Turrilite* was reached.

Fusus sinistrorsus, Lam., is now an inhabitant of the Mediterranean Sea, and it is also a fossil in the newer Tertiaries of Sicily, and this may be a descendant of the older form of the Walton Crag sea. I can perceive no difference sufficient to constitute the Mediterranean shell a different species from the Crag fossil. It is, therefore, somewhat remarkable that in *Trophon antiquus* this sinistral form should be the only one found in the Crag of Belgium, appearing there in the middle and upper beds, both dextral and sinistral forms being unknown in the lower, as they are also in the Cor. Crag of this country, thus apparently showing that the dextral form of this shell was of more modern origin than the sinistral, and that it had not appeared during the earlier part of the Red Crag. The left-handed "Almond Whelk" is the only form of this variable species which is found in the Red Crag of Walton-on-the-Naze (the whole fauna of which locality is, in my opinion, clearly older than that of any other part of the Red Crag); for while I have seen thousands of the sinistral shell from this locality, I have never met with one of the dextral form there, or seen a specimen of it in the possession of any collector from this place. In the rest of the Red Crag the dextral and sinistral forms of the striated shell seem present in about equal proportions, and the same thing occurs in the Fluvio-marine Crag, in the Chillesford bed passim, and in the Lower Glacial sands of Belaugh, Rackheath, and Weybourne. In the Middle Glacial sands, however, the only trace of the sinistral form that has occurred is the pullus of some sinistral *Trophon,* which is probably *contrarius;* while several perfect young specimens, and one full grown, as well as numerous fragments of the columella of the dextral shell, have occurred. It would thus seem that the life of this species, so far as the seas of Britain and Belgium reveal it, exhibits the curious feature of having begun exclusively left-handed, then to have varied by the birth of dextral individuals, and so progressed through the various subsequent formations until, by the decrease of the sinistral and increase of the dextral individuals, the species has attained in these seas to its present condition, wherein millions of dextral individuals occur to one sinistral. The late Edward Forbes mentions the occurrence in the Irish Drift of the sinistral form, and if it be the case that *Nucula Cobboldiæ* occurs in that Drift in association with it, as has been said, that occurrence would be in accordance with the antiquity of both these shells in the seas of Britain.

TROPHON BERNICIENSIS? *King.* Supplement, Tab. I, fig. 8, *a, b.*

FUSUS BERNICIENSIS, *King.* Ann. and Mag. Nat. Hist., vol. xviii, p. 246.

Locality. Fluvio-marine Crag, near Norwich.

The above (fig. *b*) represents a specimen which was sent to me by the late Dr. S. P. Woodward for examination; it was accompanied by the following note:—"I have compared my new *Fusus* from the Norwich Crag with the figure of *T. Spitzbergensis,* and find them agree very well in the character of the spiral striæ; but the recent shell has a more contracted canal." The very young condition of the "Norwich Crag" shell is much like *Spitzbergensis,* but the resemblance is less so when it is full grown. I think it more resembles the British shell *T. Berniciensis,* King, although with this it has not a perfect identity. Another specimen (fig. 8 *a*) has been more recently obtained from the same neighbourhood which appears to belong to the same species. This was found by Mr. John King, of St. Andrew's, Norwich, who has obligingly permitted me to have it figured. I have given to it provisionally the above name with a doubt, but if from future discoveries it should prove to be a new species I would suggest that it be called *T. Woodwardii.*

TROPHON NORVEGICUS, *Chemn.* Supplement, Tab. V, fig. 14.

In the 'Crag Moll.,' vol. ii, Tab. XXXI, fig. 1, is represented a specimen of what I then believed to be the species here referred to, and I have now another very nearly perfect from the cabinet of Mr. Canham, who has obligingly permitted me the use of it. It came from the nodule pits of the Red Crag at Waldringfield. This shows a more elongated form than the living shell, with a comparatively smaller aperture and more recurved canal. The outer lip is not quite perfect, but if it were, it would rather help to diminish the smaller proportions of the aperture.

TROPHON VENTRICOSUS? *Gray.* Supplement, Tab. III, fig. 4.

FUSUS VENTRICOSUS, *Gray.* In Beechey's Voyage, p. 117.
— — *Gould.* Inv. Massachusetts, p. 285, fig. 200.

Locality. Upper Glacial, Bridlington.

The specimen figured was sent to me by Mr. Leckenby; it is not perfect, and unfit for fair description, but I have doubtfully referred it as above. Dr. S. P. Woodward introduced this name in his list of Bridlington species, depending for so doing upon the above-mentioned specimen, as I have done.

TROPHON TURTONI, *Bean.* Crag Moll., Appendix, p. 312, Tab. XXXI, fig. 2. Supplement, Tab. I, fig. 11, *a, b.*

Locality. Red Crag, Butley and Waldringfield.

In the 'Crag Moll.,' vol. ii, p. 312, I was able to indicate the presence of this species in the Red Crag, but my specimen there illustrated (Tab. XXXI, fig. 2) was so fragmentary that it could not be depended upon, and although the specimen I have had figured is not quite perfect it is sufficiently so to justify me in referring it to the species above named. Since my specimen was engraved I have seen, in the collection of the Rev. Mr. Canham, an individual of this species obtained from the nodule pit in the Red Crag at Waldringfield, rather larger than my own, with the aperture more perfect, as also another by Mr. Bell, from Butley; one of these I should have preferred to have had figured had I been previously aware of their existence.

TROPHON ELEGANS, *Charlesworth.* Crag Moll., vol. i, p. 46, Tab. V, fig. 2.

In Mr. Canham's rich collection of Crag fossils is a fine specimen of what has been figured under the name of *Trophon elegans,* Charlesworth. The locality was not then known, and it is somewhat singular that this second individual should also have been picked up on the beach at Felixstow. Fig. 6, *a, b,* Tab. II, represents a shell found in the Red Crag at Butley by Mr. A. Bell, which, when first shown to me, I thought was a new species, but as it may possibly be the immature form of *T. elegans* I hesitate to give it a new name.

Trophon Sabini, *Hancock.* Supplement, Tab. II, fig. 15.

Locality. Upper Glacial, Bridlington.

A species is introduced into Dr. Woodward's list of Bridlington fossils under this name, but to which no authority is attached. I presume the shell belonging to Mr. Leckenby figured here was the one intended. It is given as a distinct species by Dr. Woodward, and I have followed him. This is the shell, I suppose, referred to by E. Forbes in 'Mem. Geol. Surv.,' p. 426, No. 119, 1846, from the Irish Drift, as well as from Bridlington, but he has given to his fossil the name of *T. Sabini*, Gray. *Buc. Sabinii*, Gray, is another species. The present shell seems more slender than *T. Islandicus*, with rather a deeper suture and a smaller apex, and it is, I imagine, the same as a shell figured by Gould, 'Invert. Massach.,' p. 284, fig. 199, called *F. Islandicus*, var. *pygmæus*.

Trophon altus, *S. Wood.* Crag. Moll., vol. i, p. 47, Tab. VI, fig. 13; and Supplement, Tab. II, fig. 17, *a*, *b*.

Localities. Red Crag, Butley. Fluvio-marine Crag, Bramerton.

I have here given representations of two specimens which, I believe, belong to the fossil I previously figured and described, with the above name, in 'Crag Moll.' One is an elongated variety, with obsolete costæ, which I found in the Red Crag at Butley; the other is a shorter and more inflated shell, without ribs or striæ, found by Mr. A. Bell also at Butley. The nearest approach to this species, as pointed out by Mr. A. Bell, is a specimen in the British Museum from Newfoundland, named *F. cretaceus*, Reeve, and Mr. Bell has sent to me for examination some fossil specimens he has received from Dr. Dawson with the locality of "Rivière du Loup," which appear to be identical with the Crag shell, differing from *F. cretaceus*, in having an obtuse or mammillated apex, and attached to them is the name of *Buccinofusus Kroyeri*. This Canadian fossil is, I think, the same as the Crag shell, and it appears to present the same difference from *cretaceus* of Reeve (the one having an obtuse apex, while the other is pointed) as is considered specifically to distinguish *F. Islandicus* from *F. propinquus*. I think the Canadian fossil is not the *Kroyeri* of Möller.

This Crag fossil was originally called *Murex pullus* by S. Woodward, and I would have adopted the specific name, but it is neither the *pullus* of Linné nor the *pullus* of Pennant, and, in order to avoid confusion, I have thought it best to give it a new name.

Trophon propinquus, *Alder.* Crag Moll., Appendix, p. 313, Tab. XXXI, fig. 3. Supplement, Tab. II, fig. 15, *a*, *b*; Supplement, Tab. II, fig. 15.

Localities. Cor. Crag, near Orford. Red Crag, Sutton and Butley. Upper Glacial, Bridlington.

In the 'British Conchology,' vol. iv, pp. 333—341, are described four species under the respective names of *Fusus Islandicus, F. gracilis, F. propinquus,* and *F. buccinatus* (or *Jeffreysianus,* Fisch.); not one of these is there admitted by the author to have been an inhabitant of the Crag sea, either of the Coralline or of the Red, and he says (p. 336) "I do not consider the Crag specimens which have been referred to this species (*gracilis*) by Searles Wood, Woodward, and Nyst, identical with the above. These last agree with the North American form, which is smaller and more tumid and has a short spire. If such should prove to be distinct it might be called *curtus*."[1]

Having expressed my dissent to Mr. Jeffreys, he obligingly sent me some of his recent specimens for examination, but this has not altered my previously formed opinion. I still consider *gracilis, propinquus,* and *buccinatus* (or *Jeffreysianus*) as Crag species. The shell called *Islandicus* has a mammillated apex, and is probably distinct. This latter I have not yet seen from the Crag, either the Red or Coralline.

Supplement, Tab. II, fig. 15, *a*, represents a specimen with a very straight canal, obtained by Mr. A. Bell from the Red Crag, Butley, and this I consider merely as an abnormal form of *F. propinquus;* and fig. 15, *b*, is that of a distorted variety of the same species found by myself in the Red Crag of Sutton. Fig. 21 of Supplement, Tab. VII, is a reversed form obtained by Mr. Robert Bell at Waldringfield.

Trophon Leckenbyi, *S. Wood.* Supplement, Tab. VII, fig. 1.

Locality. Upper Glacial, Bridlington.

The specimen figured has been in my possession for several years, but is, unfortunately, imperfect, and must, I think, have been given me by Mr. Leckenby, of Scarborough, to whom we are much indebted for obtaining the authentic fauna of the Bridlington bed.[2]

Though resembling *gracilis, Islandicus, propinquus,* and *Jeffreysianus,* it differs

[1] *Fusus curtus,* James Smith, a Clyde fossil ('Trans. Geol. Soc.,' 2nd ser., vol. vi, p. 156, No. 26), is probably *Mangelia Trevelyana,* Forb. and Hanl., and *F. curtus* of James Sowerby is a London Clay shell from Highgate, M. C. T. 199, fig. 5, and is quite distinct.

[2] I am sorry to say that spurious shells have been put on the scientific market as from Bridlington. Amongst them one that Mr. Leckenby detected, and sent me to look at, was an Eocene shell from a bed whose fossils are of similar colour to those from Bridlington.

from them all in two respects—one in that it is much less tapering, and the other in the shallowness of the suture. It is strongly marked with spiral striæ. Mr. Jeffreys sent me for comparison a shell obtained by him in the Porcupine dredgings, and which he intended to call *turgidulus*, which resembles our shell, but is much thinner and less strongly striated than ours. I have named the present shell after Mr. Leckenby.

Trophon Actoni, *S. Wood.* Supplement, Tab. II, fig. 13.

Locality. Red Crag, Butley.

In this figure I have represented a specimen found by myself at Butley, which I am unable to refer to any known species. Its principal distinction is a slight shoulder to the volution or obtuse angularity at the upper part. The outer lip is a little sinuated, like many northern species of this genus.

If this should prove (by the discovery of better specimens) a new species, I propose to call it *Tr. Actoni*, in commemoration of the late Edward Acton, surgeon, of Grundisburgh, a zealous collector of Crag fossils, and a liberal distributor of his specimens where he thought they would contribute to disseminate information.

A specimen very recently sent to me for examination by Mr. James Reeve, from the Fluvio-marine Crag of Bramerton, seems to belong to the same species, but the specimen, like my own, is imperfect, and unfit for correct determination.

Trophon Sarsii, *Jeffreys.* Supplement, Tab. I, fig, 9.

Length, $1\frac{5}{8}$ths inch.

Localities. Red Crag, Waldringfield (*Bell*), and Butley.

A specimen represented as above referred to was obtained by myself in 1868, from Butley, and since the figure was engraved Mr. A. Bell has shown me a similar specimen from the nodule pit at Waldringfield.

In the paper called 'Nature,' December 9th, 1869, Mr. Jeffreys has, in his report on the deep-sea dredgings, given to a shell there obtained, which he says is the same as my Crag fossil, the name of *Fusus Sarsii*, in compliment to the late Prof. Sars, who had obtained the same shell living near the Laffoden Isles; I have, therefore, adopted the name for my Crag shell.

Trophon craticulatus, *Fabricius.* Supplement, Tab. III, fig. 1, *a, b.*

Locality. Upper Glacial, Bridlington.

Mr. Leckenby has obligingly sent to me for description a fossil from Bridlington which he tells me has been determined by Mr. Jeffreys to belong to the above-named species; the label accompanying the specimen says, "once marked *Gunneri* by S. P. W." In the Appendix to the 'Crag Mollusca,' p. 313, Tab. XXXI, fig. 4, is described a shell from the neighbourhood of Wexford which had been previously considered by E. Forbes ('Mem. Geol. Surv.,' 1846, p. 425) as *Trophon Fabricii*, Möller, with the name of *craticulatus*, Fab., given by Möller as a synonym. The shell I have here figured is probably the same species, but it is different in some of its characters, and I have in consequence had it represented as a variety. The exterior is ribbed and decussated by two or more raised spiral ridges, but it has not the upper part of the volution projecting and fimbriated. I believe in the assignment, and have adopted the above name as being the older one, on the authority of Möller. This name must, therefore, be given to the figure in the 'App. to Crag Moll.' *Fusus craticulatus*, Broc., is a very different shell.

TROPHON BAMFFIUS, *Donovan*. Supplement, Tab. III, fig. 2.

MUREX BAMFFIUS, *Don.* Brit. Shells, vol. v, p. 169, fig. 1.

Localities. Post Glacial, March and Kelsea Hill.

The figure of this shell was taken from a specimen from the Clyde beds, and was introduced in order to show the difference from the next species (figs. 10 *a* and *b*), but since the plate was engraved I have seen a suite of specimens from the post-glacial gravel of March; so that this species is an East Anglian fossil. The March specimens are rather larger than any that I have seen from the Clyde beds, and approach slightly nearer to *scalariformis*. A specimen of *Bamffius* was sent me for examination by Mr. G. Maw, from the Severn Valley beds. I have not met with this species from the Crag or any East Anglian glacial bed. It is given under the name *clathratus* by Mr. Jeffreys from Kelsea Hill.

TROPHON SCALARIFORMIS, *Gould.* Crag Moll., vol. i, p. 48, Tab. VI, fig. 7. Supplement, Tab. III, fig. 10 *a*, *b*.

Localities. Red Crag, Sutton, Bawdsey, Butley. Fluvio-marine Crag, Bramerton. Middle Glacial, Billockby and Hopton. Upper Glacial, Bridlington. Post-glacial, Kelsea Hill.

The figure is taken from a Bridlington shell belonging to Mr. Leckenby, which seems to have been the authority for the occurrence of *Bamffius* at Bridlington. The shell, however, seems to me not to belong to that species, but to be the young of the much larger Crag shell, *scalariformis* ('Crag Moll.,' Tab. VI, fig. 7), which (identical in size and in all other respects with the Crag shell) is common at Bridlington.

The costæ of *scalariformis* are much fewer than those of *Bamffius*, and the shell is of more than double the linear dimensions of *Bamffius*. *Scalariformis* occurs in the Fluvio-marine Crag of Bramerton, but is very rare in it, and a specimen has been obtained from the Middle Glacial sand of Billockby, and another from that of Hopton, both of which fell to pieces, but their fragments exhibit clearly all the characters which distinguish this shell from *Bamffius*. I have not met with it from any of the localities of the Chillesford bed or from the Lower Glacial. It is given by Mr. Jeffreys as from Kelsea Hill.

TROPHON BARVICENSIS, *Johnson*. Supplement, Tab. VI, fig. 20.

FUSUS BARVICENSIS, *Johnson*. Edinb. Phil. Journ., vol. xiii, p. 221.
TROPHON — *Forb.* et *Hanl.* Brit. Moll., vol. iii, p. 442, pl. cxi, figs. 5, 6.

Localities. Red Crag, Walton, and Shottisham (*Bell*), Waldringfield.

Mr. Canham has sent to me a specimen he has obtained from the Red Crag at Waldringfield, which I have referred and represented as above. The fossil has been rubbed and its more prominent portions worn down, but it seems to correspond in all other respects. The periodical reflections of the outer lip called ribs or costæ are about ten in number upon the last remaining whorl; these are decussated by four or five spiral lines or ridges, and it has an angular or projecting shoulder a little below the suture. The specimen measures half an inch in length. Mr. Bell gives the species as from Walton and Shottisham ('Ann. and Mag. Nat. Hist.,' May, 1871), but I have not seen the specimens.

TROPHON GUNNERI, *Lovén*. Supplement, Tab. III, fig. 18 *a, b*.

TRITONIUM GUNNERI, *Lovén*. Ind. Moll. Scand., p. 12, No. 84.

Localities. Upper Glacial, Bridlington. Post Glacial, Kelsea Hill.

My figure represents a specimen in the British Museum from Bridlington, and the late Dr. S. P. Woodward has introduced the name into his list of Norwich Crag shells, but with a mark of doubt. I have not, however, seen it from the Crag of either Suffolk or Norfolk. This much resembles *scalariformis*, but the fimbriæ are furnished with projecting fronds. Mr. Jeffreys has ('Quart. Journ. Geol. Soc.,' vol. xvii, p. 450) identified the shell as a Kelsea Hill species.

TROPHON PAULULUS, Crag Moll., vol. i, Tab. VI, fig. 6, is, according to Mr. Jeffreys, the young of his *Defrancia teres*, 'Brit. Conch.,' vol. v, p. 219. In this I think he is correct. The peculiar ornamentation of the upper volutions is spoken of in the 'Brit. Moll.,' as also in 'Brit. Conch.,' but it has never been represented.

TROPHON MURICATUS. Crag Moll., vol. i, Tab. VI, fig. 5.

A perfect specimen has occurred in the Middle Glacial sand of Billockby, but I have not met with it from the Fluvio-marine Crag, the Chillesford bed, or from the Lower Glacial sands.

TROPHON MEDIGLACIALIS, *S. Wood.* Supplement, Tab. VII, fig. 12, *a, b.*

Spec. Char. *T. Testâ elongato-fusiformi, anfractibus rotundatis, longitudinaliter costatâ, costis* (8—10) *elevatis obtusis; spiraliter lineatâ, lineis paucis elevatis; aperturâ ovatâ; caudâ elongatâ.*

Locality. Middle Glacial, Billockby, and Hopton.

Length, half an inch nearly.

About a dozen specimens of this shell have occurred in the Middle Glacial sand of Billockby, and five in that of Hopton, and as they do not vary greatly in size, I infer that the specimen figured is a full-grown shell, or nearly so. Like almost all the fossils from this formation, the specimens are in a more or less injured condition; but the one figured has suffered but little, as the spiral striæ are preserved on it. The upper part of the whorls do not show any spiral striation, and this appears, not only in the specimen figured, but on such others as retain the external markings. As all the specmens, however, are more or less worn, this absence of striata on the upper part of the whorl may possibly be due to erosion. The costæ appear to be nearly equal in number on all the volutions. None of the specimens indicate any less tapering form than that figured, while some are slightly more tapering and slender.

This species being unknown to me from any other formation than the Middle Glacial sand of East Anglia, while it is somewhat numerous there, it appears to be characteristic of that formation; I have therefore assigned to it the specific name of *mediglacialis.*

TROPHON? BILLOCKBIENSIS, *S. Wood.* Supplement, Tab. VII, fig. 13.

Locality. Middle Glacial, Billockby.

Length, $\frac{1}{4}$ of an inch.

A unique specimen in good preservation from Billockby, shown in fig. 13, is the foundation for this species, but whether it be a young specimen or a full-grown shell, there are no means of judging. It differs from *mediglacialis* in its less tapering form, the length of the shell being hardly twice its breadth; while in *mediglacialis* it is very nearly three times. It also differs from all the specimens of *mediglacialis* in the spiral striation, which is equally distributed over the whorls. I have never seen any but full-grown forms or nearly so of *Purpura tetragona,* and it is not impossible that the shell in question may be the young of that species. In this uncertainty I have provisionally given it the above name.

Fusus crispus ? *Borson.* Supplement, Tab. 11, fig. 10.

Fusus crispus, *Borson* (fide *Mich.*). Oritt. Piemont., p. 317, No. 17.
— — *Michelotti.* Desc. des Foss. Mioc. de l'Ital., September, p. 272, t. ix, figs. 17, 18.

Spec. Char. "*F. Testa elongato-fusoidea, solida ; anfractibus convexis, longitudinaliter costatis ; costis crassis, rotundatis, transversim plicatis, plicis super costas lamellosis, in interstitiis filiformibus, apertura subovata, canali elongatiusculo, aperto, cylindraceo ; labro intus profunde sulcato ; columella lævigata.*"—Mich.

Locality. Red Crag, Sutton.

The specimen figured was obtained by Mr. Whincopp from the workmen at the nodule excavations in the Red Crag, and he has kindly permitted me to figure it, and though much worn it retains some of the outer coating with its ornaments. I have also obtained from the Red Crag at Sutton a specimen which appears to belong to the same species, but in a more worn condition. This is probably a derived species.

Fusus abrasus, *S. Wood.* Supplement, Tab. II, fig. 8.

Locality. Red Crag, near Woodbridge.

This represents another specimen from the collection of Mr. Whincopp. It appears to be a fossil extraneous to the Red Crag, and it has been much altered, and the outer coating apparently removed. It has somewhat the form and ornaments of *F. rugosus* or *F. costiferus,* but the ribs incline too much to the right, and it is too elongated. It is a very much abraded shell, and as I am unable to refer it to any species known to myself, I have given to it provisionally the above name.

Fusus imperspicuus (*T. imperspicuum*). Crag Moll., vol. i, p. 50, Tab. VI, fig. 12.

The late Dr. S. P. Woodward (*in Lit.*) suggested this might be *F. latericeus.* I have carefully again compared my shell with that species, and I think they are specifically different. I have given another view of the Crag shell, showing the opening, Supplement, Tab. II, fig. 4.

Fusus Forbesii, Strickland. *F. cinereus*, Say., *Buc. plicosum*, Gould, is mentioned at p. 314, 'Append. Crag Moll.' I have not seen this as a fossil from the Upper Tertiaries of the *East* of England.

TRITON HEPTAGONUS. Crag Moll., vol. i, p. 41, Tab. IV, fig. 8.

The specimen figured, as above referred to, is, I regret to say, the only one I have seen. Mr. Jeffreys, in 'Brit. Conch.,' vol. v, p. 218, refers this Crag shell to *T. cutaceus*. I do not coincide in that opinion; at the same time it does not strictly accord with the Subapennine fossil; neither can I find a published species with which it can be identified. I propose to call it *Triton connectens*.

MUREX CORALLINUS, *Scacchi*. Supplement, Tab. II, fig. 12 *a*, *b*.

MUREX CORALLINUS, *Scac.* Faun. del. Nap., p. 11, fig. 15.
— INCONSPICUA, *G. B. Sow.* Conch. Illust. Murex, fig. 81.
— BADIUS, *Reeve.* Conch. Icon. Murex, pl. 32, fig. 159?
— ACICULATUS, *Jeffreys.* Brit. Conch., vol. iv, p. 310.
FUSUS LAVATUS, *Phil.* En Moll. Sic., vol. i, p. 203.
— CORALLINUS, *Id.* En Moll. Sic., vol. ii, p. 178, t. 25, fig. 29.

Spec. Char. *M. Testâ elongato-fusiformi; anfractibus* 6—7, *rotundatis; longitudinaliter plicatâ; spiraliter striatâ, striis vel lineis elevatis scabris, subæqualibus, labro incrassato intus plicato; caudâ brevi, fistulosâ.*

Length, $\frac{5}{8}$ths of an inch.

Locality. Cor. Crag, Gedgrave.

A single specimen (the only one known to me) was obtained by the late Dr. S. P. Woodward, and Mr. Horace Woodward has obligingly permitted me to have it figured. The only difference that I can detect between the recent shell and our fossil is that the latter is a trifle the longer, and, although it appears to be a full-grown specimen, the canal is not closed, as in the recent species.

MUREX CANHAMI, *S. Wood*. Supplement, Tab. VII, fig. 14.

Spec. Char. *Testâ oblongo-ovatâ, fusiformi, valde striatâ; anfractibus superne depressis, carinatis, scalariæformibus, septem fariam varicosis, varicibus lamellosis, in angulum protractis; superne squamato crenulatis; aperturâ ovatâ; canali brevi.*

Length, $\frac{9}{16}$ths of an inch.

Locality. Red Crag, Waldringfield.

The specimen figured has been obligingly sent to me by Mr. Canham. It is in good preservation, deeply coloured with Red Crag, and it appears to me not to be a derivative. I have a fragment from the Coralline Crag near Orford that may probably be the same species.

The shell to which it appears to approach the nearest (judging from figure and description) is *Murex Haidingeri*, Hörnes, 'Vienna Foss.,' vol. i, p. 228, tab. xxiii, fig. 12; but I think it is distinct. It differs from *M. tortuosus*, the well-known Crag species, in having all its ridges frondiculated, and I have named it after the discoverer, the Rev. H. Canham.

Murex erinaceus, *Linné*. Supplement, Tab. II, fig. 11.

Murex decussatus, *Broc.* Conch. Foss. Subapen., p. 391, pl. vii, fig. 11.

Locality. Red Crag, Harwich? Butley. Fluvio-marine Crag, Bramerton? Post Glacial, Kelsea Hill.

At page 39, vol. i, of the 'Crag Mollusca,' is introduced a notice of this species as having been found in the Fluvio-marine Crag at Bramerton. This was sent to Sir Charles Lyell for examination, in whose possession I saw it. We were both of opinion that it was a genuine Crag shell, but a short time previous to the publication of my first volume it was unfortunately lost, and I was unable to have it figured. I have, therefore, now, in order to complete the Crag Mollusca, given the representation of a recent specimen, and since the Plate has been engraved, Mr. A. Bell has found a fragment of this species in the Red Crag at Butley.

In a paper by the late Mr. Webster, in the 'Trans. of the Geol. Soc.,' vol. ii, p. 220, 1814, is a List of Shells from Harwich (which, I presume, were intended as Crag species), and in this is the name of *Murex erinaceus*; but where these specimens are I cannot ascertain. There are two or three in that List it would be desirable to examine (viz. *Trochus alligatus*, *Venus gallina*, and *Pecten infirmatus*), to learn what shells were intended to be determined by those names.

Mr. Jeffreys identifies a fragment of *Murex erinaceus* from the Kelsea Hill Gravel.

Pleurotoma.

The genus *Pleurotoma*, as originally instituted by Lamarck, was intended for those fusiform shells possessing a slit in the outer lip for the excurrent canal. There is, however, a large group of this kind of shell in which the outlet varies from a deep and narrow incision, such as in *Pl. Babylonia*, through a broad and sloping sinus, until it vanishes in the genus *Fusus*. These have been divided into many genera, such as *Mangilia, Bela, Defrancia, Clavatula, Rhaphitoma*, and several more. The impossibility of drawing a satisfactory line between these genera seems to have induced M. Hörnes, in his work 'On the Vienna Fossils,' to group them all under the generic name of *Pleurotoma*, and in this Supplement I have followed his example.

Pleurotoma coronata? *Bellardi*. Supplement, Tab. VI, fig. 4, *a, b*.

Pleurotoma coronata, *Bellardi*. Mon. Pleurot. Foss., p. 47, t. iii, fig. 5, 1847.

Locality. Red Crag, Waldringfield.

A single specimen from the nodule pit in the Red Crag at Waldringfield has been put into my hands for examination by the Rev. H. Canham. This shell has a smaller and shorter aperture than is shown in *Bellardi's* figure of this species; but the Crag specimen is unique, and I have given to it the above name provisionally. There is a distinct ridge on the lower part of the volution just above the suture; the knobs are on a somewhat angular whorl, and the sinus is not very distinct. It is probably a derived specimen.

Pleurotoma intorta, *Brocchi*. Crag Moll., vol. i, Tab. VI, fig. 4.

Although some more specimens have been turned out of the nodule pits, this species may, I think, be still classed among the extraneous fossils of the Red Crag. I have not yet seen it from the Coralline Crag. It much resembles *Pl. callosa*, Kiener, from the Gaboon River.

Pleurotoma interrupta, *Brocchi*. Supplement, Tab. V, fig. 1.

Murex interruptus, *Broc.* Conch. Foss. Subapen, t. ix, fig. 21, 1814.
Pleurotoma interrupta, *Bellardi*. Mon. Pleurot. Foss., p. 31, t. i, fig. 16, 1845.
— turris, *Lam.* Hist. des An. sans Vert., vol. vii, p. 97.

Locality. Red Crag, Waldringfield.

This is another shell for the notice of which I am indebted to Mr. Canham. It is from the Red Crag at Waldringfield. It is probably a derived specimen, and has been much rubbed and water-worn, but there is enough of it left, I think, to justify the reference. It is the only specimen I have seen.

Pleurotoma turrifera, *Nyst.* Crag Moll., vol. i, p. 53, Tab. VI, fig. 1 (as *P. turricula,* Brocch.).

Localities. As in 'Crag Moll.'

This, so far as I know, is confined to the Red Crag. The specimens I found were not restricted to the "Coprolite" bed, but were obtained from various parts of the Red Crag. They are all more or less rubbed and worn, and are probably derived specimens. I have seen nothing more perfect than those previously figured. This is quite distinct from *Murex turricula,* Mont., and as this latter has precedence in date, our present shell must have its name changed. M. Nyst proposed to call the present shell *Pleurotoma turrifera,* and I have adopted his proposition.

Pleurotoma nodifera, ? *Lamarck.* Supplement, Tab. VII, fig. 6.

Pleurotoma nodifera, *Lam.* Hist. des An. sans Vert., 2nd edit., t. ix, p. 353.

Locality. Red Crag, Waldringfield.

The specimen figured is from the nodule workings at Waldringfield, and is in a mutilated condition, its true character being obscured. It is probably an extraneous fossil, but it has the colour of the true shell of the Red Crag. The nearest species I can compare it with is the above, but it is very doubtful, and I am unwilling in its present state to consider it a new species. The specimen has one row of prominent nodules (fourteen in the last remaining volution), between which and the suture is a shallow and curving sinus, as shown by lines of growth. *Pl. nodosa,* Bellardi, has a similar row of nodules, but the form of that shell is different. The specimen is from the cabinet of Mr. Canham.

Pleurotoma inermis, *Partsch.* Crag Moll., vol. i, p. 55, Tab. VII, fig. 1, as *P. porrecta.* Supplement, Tab. III, fig. 2 *a, b.*

Pleurotoma inermis, *Partsch,* 1842, fide *Hörnes.*
— — *Hörnes.* Foss. Moll., Vienna, vol. i, p. 349, t. xxxviii, fig. 10, 1856.
— nivale ? *Lovén.* Ind. Moll. Scand., p. 14, 1846.

PLEUROTOMA GASTALDII, *Sismonda.* Syn. Method. Pied. Foss., p. 33, 1847.
— — *Bellardi.* Mon. Pleurot. Foss. Pied., p. 44, t. xi, fig. 19, 1848.
— NIVALIS ? *Jeffreys.* Brit. Moll., vol. iv, p. 388, pl. xci, fig. 4, 1867.

Localities. Cor. Crag, near Orford, and Ramsholt.

I have given two fresh views of this species of specimens from the Cor. Crag, near Orford, as they are variable in ornament; one is nearly smooth and the other shows a row of prominent nodules in the middle, formed by the thickened margin of the back of the sinus. The specimen previously figured, 'Crag Moll.,' vol. i, Tab. VII, fig. 1, is of an intermediate character.

M. Bellardi (p. 44, as above) has given the date of 1842 to the name of *Gastaldii.* I am not able to determine the right to priority. My copy of 'Syn. Meth. Pied. Foss.,' referred to, is dated 1847.

PLEUROTOMA TARENTINI, ? *Philippi.* Supplement, Tab. III, fig. 5.

PLEUROTOMA TARENTINI, *Phil.* En. Moll. Sic., vol. ii, p. 175, t. xxvi, fig. 26.

Locality. Cor. Crag, near Orford and Sutton.

The specimen figured was sent to me by the late Dr. S. P. Woodward some years since, as having been found in the Coralline Crag, near Orford, and with it was the name of *Pleurotoma Renieri,* Phil. Some fragments of the same species have been long in my cabinet, but I had imagined them to be the young state of *Pl. turricula,* Broc. (*P. turrifera*). Mr. A. Bell has sent to me, since my figure was engraved, a specimen in better condition, accompanied by the name of *Pl. Tarentini,* while I have myself obtained another, and as I think it corresponds with that species rather than with *Pl. Renieri,* I have so referred it, although probably the two species may be united. It is ornamented with spiral ridges, the two upper ones being larger and further apart than the others; these ridges are continued over the base of the volution, but the upper part is not carinated. The sinus appears to be broad and shallow, curving towards the suture; the apex of the shell is obtuse, and the two first volutions smooth.

PLEUROTOMA MODIOLA, *Jan.* Crag Moll., vol. i, p. 54, Tab. VI, fig. 2 (as *P. carinata*).

FUSUS MODIOLUS, *Jan.* Catal., p. 10, No. 17, 1832, fide *Hörnes.*
PLEUROTOMA MODIOLA, *Bellardi.* Mon. Pleurot. Foss. Pied., p. 68, t. iii, fig. 9, 1841.
— — *Hörnes.* Foss. Moll., Vienna, vol. i, p. 366, t. xxxix, fig. 12, 1856.

Localities. As in Crag Moll.

My Crag shell was referred to *Pl. carinata,* Phil., which, being subsequent in date to the above, I have here adopted the older one. I have not been able to find a specimen since the one previously figured. Dr. Hörnes represents the lip as deeply sinuated above the keel.

Pleurotoma crispata, *Jan.* Supplement, Tab. VI, fig. 13.

Pleurotoma crispata, *Jan.* Catal., p. 9, No. 25, fide *Bellardi.*
— — *Bellardi.* Mon. Pleur. Foss. Pied., p. 69, Tab. IV, fig. 2, var. *A. papillosa.*
— — *Hörnes.* Foss. Moll., Vien., vol. i, p. 367, t. xxxix, fig. 13.

Locality. Cor. Crag, Ramsholt.

Spec. Char. Pl. " *Testa turrita, spira elata, anfractibus convexis medio carinatis, postice concavis, longitudinaliter arcuatim striatis, antice convexis, transversim grosse striatis subcostatis; striis æquidistantibus in primis* 1 *vel* 2 *in ultimo perplurimis usque ad canalem regulariter decressentibus, carina simplici; sutures marginatis, margini simplici, filiformi; canali brevi, contorto, apertura, ovata.*"—Bellardi.

This shell was found by myself some years ago in the Coralline Crag, at Ramsholt, and as it has a sub-nodulous keel upon the upper whorls, it was (with other forms which I have now separated) regarded as a variety of the shell figured under the name of *P. semicolon* in 'Crag Moll.,' vol. i, p. 54. I now think it is specifically distinct, and have referred it to Bellardi's var. *carina nodulosa* of *P. crispata*, Jan. The sinus, as shown by the lines of growth, is broad, and curving from the keel to the suture, below which is a small ridge. The apex of my shell is obtuse and smooth, and the aperture is rather shorter comparatively than the species to which it is referred.

Pleurotoma Icenorum, *S. Wood.* Crag Moll., vol. i, p. 54, Tab. VI, fig. 3 *a* (as *Pl. semicolon*).

Locality. Coralline Crag, Orford and Sutton.

In the 'Crag Moll.' this shell was doubtfully referred as var. *a* of *Pl. semicolon*, a Lower Tertiary species. Since then I have seen and found more and better specimens, which satisfy me that the Crag shell is quite distinct from *semicolon*; a view shared by Mr. Edwards in his 'Eocene Mollusca Univalves' (p. 244). I should have been inclined, from Basterot's figure of *Pl. denticula*, to refer the Crag shell to his species of that name; but another widely spread Eocene shell is described by Mr. Edwards under the name *Pl. denticula* ('Eocene Moll. Univalves,' p. 286), and considered by him to be identical with Basterot's species. As the Crag shell is clearly distinct from the shell thus identified by Mr. Edwards with *Pl. denticula*, Bast., there seems no alternative than to assign it another name as a new species, which I have accordingly done as *Pl. Icenorum.* It appears to be intermediate between *denticula* and *galerita.*

PLEUROTOMA BIPUNCTULA, *S. Wood.* Crag Moll., vol. i, p. 54, Tab. VI, fig. 3 *b* (as *P. semicolon*).

This shell, which I also doubtfully referred as var. *b* of *Pl. semicolon*, J. Sow, is, I am now satisfied, distinct from that species. It differs from the preceding *Pl. Icenorum* in several points, viz. in its ornament, in its more fusiform shape, and in the position of the sinus of the outer lip, which in this is more central, as indicated by the knobs left on the volution. It somewhat resembles *Pl. bicatena*, Grat., but I believe it is different, and it differs from the Eocene *Pl. denticula.*

Mr. Bell, in the 'Ann. and Mag. Nat. Hist.,' 1871, gives the name of *Pleur. pannum* to my shell. It possibly may be so, but I have not been able to see a specimen of that Bordeaux species. The description given by Basterot is insufficient, so that I could not venture to refer my shell in reliance on that, and the figure of this species by Bellardi, 'Piedm. Foss.,' Tab. II, fig. 2, is so inadequate, that it does not represent the position of the sinus, neither does his description (p. 27) supply the deficiency. I have therefore given to it a new name.

PLEUROTOMA LINEARIS. Crag Moll., vol. i, p. 56, Tab. VII, fig. 2.

Localities. Cor. Crag, Sutton. Red Crag, Sutton and Butley. Chillesford Bed, Aldeby (*Crowfoot* and *Dowson*). Middle Glacial, Billockby.

The red crag form of this shell figured in the 'Crag Mollusca' as the recent *linearis*, possesses the same number of ribs and the same sculpture as on the recent shell, but a specimen from the Middle Glacial sand of Billockby, in a state of preservation unusually perfect for that formation, departs from the recent form in respect that it possesses fourteen ribs on the body whorl and twelve on the next, or two beyond the respective numbers on these whorls possessed by recent shells. I have not, however, thought it necessary to figure the Middle Glacial shell, or to assign it as a new species, which, however, it may possibly be, as it approaches *perpulchra* in the character of its ribs and of its striation, though not identical with that species.

PLEUROTOMA ELEGANTULA, *A. Bell.* Supplement, Tab. III, fig. 8.

PLEUROTOMA ELEGANTULA, *A. Bell.* Ann. and Mag. Nat. Hist., p. 8, May, 1871.

Spec. Char. Pl. "*Shell stoutly fusiform; whorls* 7—9 *convex, ornamented with close-set ribs* 10—12 *on the second whorl* (*penultimate?*)*; suture deep; mouth and canal open; pillar lip reflected; notch sinuated rather deeply.*"—A. Bell.

Length, $\frac{7}{10}$ths of an inch.

Localities. Cor. Crag, Gedgrave, and Ramsholt.

The specimen figured was found by myself at Ramsholt, and since the engraving was made Mr. A. Bell has shown me some similar and rather better specimens which he has obtained from a dealer at Orford. In the 'Ann. and Mag. Nat. Hist.' for May, 1871, Mr. Bell has described three species under the respective names of *Pleurotoma elegantula*, *Pl. volvula*, and *Pl. notata.* These specimens I have seen, and although there is some slight variation among them, there did not appear to me sufficient differences for specific variation. I have here adopted one of the names he has published, but I think from what I saw the others can be considered only as varieties. A large series of these is desirable to determine their correct claim to specific isolation. Our present shell has 7—8 volutions, the two first are smooth and the third has numerous riblets, while the rest of the shell has prominent obtuse costæ, with fine spiral striæ, which are visible only in places.

Pleurotoma crassa, *A. Bell.* Supplement, Tab. VII, fig. 10.

Conopleura crassa, *A. Bell.* Ann. and Mag. Nat. Hist., p. 8, May, 1871.

Spec. Char. "*Shell thick, shortly conical, smooth, polished; spire occupying about half the length of the shell; apex pointed; whorls* 8—10 *slightly convex at bottom, constricted towards the top; suture slight, forming a channel on the top of the whorl; ribs stout, but hardly raised above the surface; mouth short, open; canal short and broad; pillar lip straight, reflected with the callus, massed into a pad at the top, which forms one side of the labial notch; notch very large, broad, and deep; outer lip spreading.*"—A. Bell.

Length, $\frac{7}{16}$ths of an inch.

Locality. Coralline Crag, Gedgrave.

Two specimens of this species have been obtained by Mr. Bell and sent to me with the MS. name of *Conopleura crassa* attached. This specific name I have therefore retained for the present, but the generic one, I think, is not required. This shell appears to be closely allied, and perhaps when more specimens are examined it may be referred to *sigmoidea*, Bronn, figured and described by Bellardi, 'Mon. della Pleur. Foss.,' p. 109, as *Raphitoma, sigmoidea*, Tab. IV, fig. 29; that shell, however, is described as "*Anfractibus ventricosis,*" and finely striated. The Crag specimens appear to be free from striæ (judging from the two specimens I have seen) with rather flattened volutions. The apex is small, but obtuse, and the two first volutions are without ridges.

Pleurotoma attenuata, *Montagu.* Supplement, Tab. III, fig. 7.

Murex attenuatus, *Mont.* Test. Brit., p. 266, pl. ix, fig. 6, 1803.
Pleurotoma attenuata, *Jeffreys.* Brit. Conch., vol. iv, p. 377, pl. xc, fig. 2.

Locality. Coralline Crag, Orford and Sutton.

A few specimens in my Collection appear to correspond with Montague's figure and expressive description, as well as with those of Forbes, and Hanley, and Mr. Jeffreys, although my specimens, being fossil, do not exhibit the spirally-coloured lines of the living shell. The outer lip of my specimens is not quite perfect, but the lines of growth show an elegant curve with a moderately sized sinuation from the projecting portion up to the suture. Fig. 6 *a*, Tab. VII, of 'Crag Moll.,' may, I think, be a form of this species; and so far as I have seen, I doubt if the shell called *Pl. gracilior,* A. Bell, 'Ann. and Mag. Nat. Hist.,' May, 1871, can be specifically separated from it.

Pleurotoma septangularis, *Montagu.* Supplement, Tab. VI, fig. 16.

Murex septangularis, *Mont.* Test. Brit., p. 268, Tab. IX, fig. 5.
Pleurotoma heptagona, *Scacchi.* Notiz., p. 42, t. i, fig. 9.
— septangulare, *Phil.* En. Moll. Sic.,' vol. ii, p. 169.

Locality. Post-glacial, Nar Brickearth, Pentney (*Rose*).

Two specimens belonging undoubtedly to this well-known species are in Mr. Rose's cabinet, and I give them without hesitation; moreover, they are attested in Mr. Jeffreys' handwriting. Mr. Rose has kindly permitted me the use of them for illustration.

This is one of the existing British species which I have not seen or heard of from any Tertiary deposit in this country older than the Post-glacial.

Pleurotoma elegantior, *S. Wood.* Supplement, Tab. III, fig. 15.

Spec. Char. Pl. Testa fusiformi, tereti; anfractibus 7, juxta suturam costulata obsolete angulatis, longitudinaliter subtilissime striatis, transversim costulatis; spira acuminata.

Length, ½ an inch.

Locality. Upper Glacial, Bridlington.

The specimen figured was, among some Bridlington fossils, obligingly sent to me for examination by Mr. Leckenby. It comes near to, but does not seem identical with, *M. elegans* of Möller. The costæ are prominent, terminating at the upper angle of the volution, between which and the suture is the sinuation curving backwards. Considering it different, I have given to it the above specific name.

Pleurotoma scalaris? *Möller.* Supplement, Tab. III, fig. 12

Defrancia scalaris, *Möll.* Ind. Moll. Groenl., p. 12, 1842.

Locality. Upper Glacial, Bridlington.

This was also sent to me by Mr. Leckenby, and with the specimen is a label on which is written, "considered by J. G. J. to be a large example of *Mang. pyramidalis.*" It seems to correspond with the description given by Möller of his species *scalaris,* and I have ventured, with a doubt, to refer it accordingly.

Mangelia cinerea, Möller, is given in Woodward's List as a species from Bridlington, which I have not been able to find. The nearest approach to *cinerea* is a shell represented in 'Crag Moll.,' vol. i, p. 64, Tab. VII, fig. 15, as *Clavatula plicifera.*

Defrancia cinerea, Möll., in British Museum, is probably an elongated var. of *scalaris.* These forms all depart from *turricula* in the absence of the prominent shoulder of that species.

Pleurotoma Dowsoni, *S. Wood.* Supplement, Tab. III, figs. 13 and 14.

Spec. Char. Pl. Testa ovato-fusiformi, clathrata; anfractibus convexis, tumidiusculis, juxta suturam angulatis, longitudinaliter lineis eminentibus cinctis, transversim plicatis; spira breviore.

Length, $\frac{9}{10}$ths.

Localities. Chillesford bed, Aldeby. Middle Glacial, Billockby, and Hopton? Upper Glacial, Bridlington.

One specimen was sent to me as from Bridlington, fig. 14, by Mr. Leckenby, and another, fig. 13, from Aldeby, was found by Messrs. Crowfoot and Dowson. They approach the recent *exarata* of Möller, but are shorter and much more tumid. These two specimens are in excellent preservation. About a dozen specimens of a shell from the Middle Glacial of Hopton and Billockby appear to belong to this species, but they are too much mutilated to enable me to refer them to it without a note of interrogation. They agree in the tumid form, and in so much of the sculpture as is preserved, their ribs being fewer than those of *proxima.* I have named the shell after Mr. E. T. Dowson, of Geldeston, to whose industry, in association with Mr. W. M. Crowfoot, of Beccles, we are indebted for so complete a fauna of the Aldeby deposit.

PLEUROTOMA ROBUSTA, *S. Wood.* Supplement, Tab. III, fig. 16.

Spec. Char. Pl. Testa ovato-fusiformi; anfractibus 6, *juxta suturam subangulatis, longitudinaliter costulata, obsoletè clathrata.*

Length, $\frac{3}{4}$ths inch.

Locality. Upper Glacial, Bridlington.

From a specimen in my own possession, given to me some years ago by Mr. Leckenby. This is the largest species of that section of this genus, to which the generic name of *Mangelia* has been applied, that I have met with. The shell differs altogether from *turricula* in its more robust form, in its greater size, and in the indistinctness of the shoulder angle.

PLEUROTOMA TURRICULA, *Mont.* Crag Moll., vol. i, p. 62, Tab. VII, fig. 13; Supplement, Tab. VII, fig. 8.

Localities. Red Crag, Walton, Sutton, and Butley. Fluvio-marine Crag, Bramerton. Chillesford Bed, Aldeby. Middle Glacial, Hopton. Upper Glacial, Bridlington (*Woodward*). Post-glacial, March and Kelsea Hill.

Several specimens of this well-marked and common British shell have occurred in the Middle Glacial Sand of Billockby and Hopton, and I have a good suite of them from the March gravel. It is rare in the Fluvio-marine Crag, and has occurred in the Chillesford bed at Aldeby, and it is given as common at Kelsea Hill by Mr. Jeffreys.

The specimen in Supplement, Tab. VII, fig. 8, is from the Middle Glacial Sand of Hopton Cliff. It differs from the typical form of *turricula* (of which several individuals have been obtained from the same sand) in the relatively greater proportion of the body whorl, which is fully two thirds the length of the whole shell. As this, however, seems to me only such a modification as might be expected to occur to a chance individual, I have only ventured to regard it as a variety of *Pl. turricula.*

PLEUROTOMA ASSIMILIS, *S. Wood.* Supplement, Tab. VI, fig. 18.

Localities. Red Crag, Butley. Middle Glacial, Billockby and Hopton.

Spec. Char. Pl. Testa ovato-fusiformi, obsoletè clathrata; longitudinaliter costulata anfractibus sex, juxta suturam rotundato-angulatis; spira acuminata.

Length, $\frac{9}{16}$ths of an inch.

The specimen figured is from the Middle Glacial Sand at Billockby, and another has occurred at Hopton. I have also found in the Red Crag of Butley a specimen of it quite perfect, and of similar size to that figured, which, so far as I know, is unique in the Crag.

I have given the name *assimilis* from its close similarity, in all other respects than size, to the large Bridlington shell *robusta*. The uniformity in size between the Crag specimen and the two Middle Glacial ones, renders it probable that the specimen figured is full grown; I have, therefore, considered this species as distinct from *robusta*, and assigned to it a separate name. It is, however, possible that, as some existing shells assume gigantic proportions under certain arctic conditions, the shell thus appearing in the Red Crag before the Glacial conditions had actually fallen upon Britain, and occurring in similar size in the Middle Glacial Sand by virtue of those causes, whatever they may be, to which the presence of so many southern species in these sands is due, became inflated by the truly arctic conditions under which the Bridlington shells lived, to the gigantic dimensions possessed by the species I have figured under the name of *robusta*. The shell differs from *Trevelyana* in the greater length of the body whorl relatively to the spire, and in having a less prominence of shoulder: also in its greater size.

PLEUROTOMA HYSTRIX, *Jan.* Supplement, Tab. VI, fig. 3, *a*, *b*.

PLEUROTOMA HISTRIX, *Jan.* Catal., p. 10, No. 59, 1832, fide *Bellardi*.
RHAPHITOMA HISTRIX, *Bellardi.* Mon. delle Pleur. Foss., p. 85, t. iv, fig. 14, 1847.
DEFRANCIA HISTRIX, *A. Bell.* Ann. and Mag. Nat. Hist., September, 1870.

Spec. Char. " *Testa subfusiformi, elongatâ, angusta, costis longitudinalibus et transversalibus exilissimis, lamellosis clathrata; in earum intersecatione papillis acutis, erectis hirsuta; anfractibus planiusculis, elongatis, posticé lævibus; spira elata, apertura ovato-elongata; labro intus sulcato; canali longinsculo.*"—Bellardi.

Length, $\frac{13}{16}$ths of an inch.

Localities. Cor. Crag, Sutton (*Bell*). Red Crag, Walton-on-the-Naze.

The specimen figured was obtained by myself from Walton, from which place another has since been obtained by Mr. Bell. It much resembles *Fusus cancellatus*, J. Sow., *Clavatula cancellata*, 'Crag Moll.,' but the present shell is more elongated, and there is a broad sinus adjoining the suture; this leaves a blank or naked depressed space at the top of the volution, or at least shows only lines of growth of the sinuated aperture. The shell is elegantly cancellated, and the outer lip is somewhat thickened and denticulated on the inside. This is not *Murex hystrix*, Linn. Mr. Bell gives the species as from the Cor. Crag. ('Ann. and Mag. Nat. Hist.,' May, 1871), but I have not seen the specimen.

PLEUROTOMA TENUISTRIATA, *A. Bell.* Crag Moll., vol. i, p. 62, Tab. VII, fig. 12 (as *Clavatula lævigata*).

PLEUROTOMA TENUISTRIATA, *A. Bell* Ann. and Mag. Nat. Hist. for May, 1871.

Locality. As in 'Crag Moll.'

In the 'Crag Mollusca' I referred this shell doubtfully to *Pleurotoma lævigatum* of Philippi, but the specimen there figured was not quite perfect. Mr. Bell has lately found one or two in better preservation, to which he has given the name of *Pl. tenuistriata.* As I am satisfied that this shell is distinct from *P. lævigata,* I have given it here under Mr. Bell's name.

PLEUROTOMA LÆVIGATA, *Phil.* Supplement, Tab. VI, fig. 15.

Localities. Red Crag, Walton and Butley.

The above figure represents a specimen of what I believe to be the true form of *lævigata,* found by myself in the Red Crag of Butley. Mr. Bell gives it also from Walton Naze.

PLEUROTOMA CYLINDRACEA ? *Möller.*

DEFRANCIA CYLINDRACEA, *Möller.* Ind. Moll. Grœnl., p. 13, 1842.
MANGELIA CYLINDRACEA, *Woodward.* Geol. Mag., vol. i, p. 53, 1864.

Locality. Upper Glacial, Bridlington?

This is given in Dr. Woodward's Bridlington list with a query, but I cannot find a shell among the Bridlington fossils that will correspond with Möller's description.

PLEUROTOMA SENILIS, *S. Wood.* Supplement, Tab. V, fig. 5.

Locality. Red Crag, Waldringfield.

The specimen figured was obtained by Mr. Canham from the Nodule pit at Waldringfield. It is much rubbed and worn, and the striæ are nearly obliterated. The costæ on the body whorl are, however, sinuated, from which I imagine it possessed a sinuated outer lip. Not being able to give it a correct diagnosis, I have called it provisionally *Pl. senilis.* It is probably a derived specimen.

PLEUROTOMA HISPIDULA, *Jan.* Supplement, Tab. III, fig. 3.

RHAPHITOMA HISPIDULA, *Jan.*, fide *Bellardi.* Mon. Foss. Pied., p. 92, t. iv, fig. 17.
PLEUROTOMA DECUSSATUM, *Phil.* En. Moll. Sic., vol. ii, p. 174, t. xxvi, fig. 23.
— — *A. Bell.* Ann. and Mag. Nat. Hist., May, 1871.

Spec. Char. "*Testa fusiformi, plicis tenuibus longitudinalibus, lineisque transversis elevatis distantibus reticulata; anfractibus æque et parum convexis; apertura oblonga, spiram æquante.*"—Philippi.

Length, $\frac{3}{4}$ths of an inch.

Locality. Coralline Crag, near Orford.

The specimen figured was found by myself, and Mr. Bell has very recently obtained several more from the same place. There is a considerable difference among the specimens, some being more elongated than others; the shorter are strongly ribbed on the body whorl, while on the longer the ribs become nearly obsolete. On the last volution the whorls are very slightly shouldered, and the sinus is broad and shallow. *Clavatula concinnata*, 'Crag. Moll.,' vol. i, p. 61, Tab. VII, fig. 11, *a*, *b*, are probably varieties of this species. This is quite distinct from *Pl. decussata*, Lam., as also from *Pl. decussata* of Couthouy. *Rhaphitoma plicatella*, Jan., is closely allied, but seems to have fewer ribs.

Pleurotoma pyramidalis, *Ström*. Supplement, Tab. III, fig. 9, *a*, *b*, Tab. VII, fig. 22.

Localities. Red Crag, Butley. Fluvio-marine Crag, Thorpe, in Suffolk (*Bell*). Upper Glacial, Bridlington. Post-glacial, March and Kelsea Hill.

The specimen of this well-known northern shell represented in fig. 9 of Tab. III is one found by Mr. Bell in the Red Crag of Butley; and that in the fig. 22 of Tab. VII is one of a suite from March found by Mr. Harmer. They differ slightly, but may both, I think, be referred to this species. The Crag shell has the body whorl smooth, but there are indications of longitudinal riblets on the upper volutions. I cannot see any spiral striæ, but these may be obliterated by attrition. Some of the March specimens are perfectly smooth without appearing to have undergone much wear, but in others faint traces of riblets on the lower whorl are apparent. A specimen from Bridlington is in the British Museum, and it is given from Kelsea Hill by Mr. Jeffreys. The species is given from Thorpe in Suffolk by Mr. Bell in 'Ann. and Mag. of Nat. Hist.' for September, 1870.

Pleurotoma bicarinata? *Couth*. Supplement, Tab. VI, fig. 17.

Locality. Red Crag, Butley.

The specimen figured was found by myself at Butley. It very much resembles *P. violacea* of Meig. and Ad., but seems still closer to *bicarinata*, Couth., as there are two very distinct carinæ on the whorls.

Many of the forms of *Pleurotomæ*, both those in the Crag and those living in British and Northern seas, run so much into each other, and are, withal, so inconstant in their characters, even among a group of individuals of apparently the same species, that I feel the greatest difficulty in assigning specific names, and I have therefore placed a note of interrogation against the name of this species.

Pleurotoma equalis, *S. Wood.* Supplement, Tab. III, fig. 17.

Spec. Char. Pl. Testa elongato-fusiformi lævi, anfractibus 6, *convexiusculis; obsolete angulatis; suturis distinctis, sub-depressis, spira brevi, apice obtuso, apertura dimidiam æquante; canali longuiscula, labro simplici acuto.*

Locality. Red Crag, Butley.

Length, half an inch.

The specimen figured is the only one that I have seen, and was obtained by myself from Butley.

It is perfectly smooth and polished; it resembles in form *Pl. violacea,* Migh. and Ad., but my shell has no sculpture, and it appears too perfect to have been abraded; moreover, that shell is stated to measure $\frac{3}{10}$ths only of an inch in length, whereas my shell is at least $\frac{5}{10}$ths of an inch. I therefore presume it to be distinct, and have given to it a new name.

Pleurotoma rufa, *Mont.* Supplement, Tab. VII, fig. 17.

Localities. Red Crag, Butley? Fluvio-marine Crag, Thorpe? Post-glacial, March.

The specimen figured of this well-known British shell is one of two found by Mr. Harmer in the March Gravel. The species is given by Mr. Bell from the Red Crag of Butley ('Ann. and Mag. Nat. Hist.,' September, 1870), and in Dr. Woodward's 'Norwich Crag List' (in 'White's Directory'), from Thorpe, but I have not seen the specimens for either of those occurrences.

Pleurotoma quadricincta, *S. Wood.* Supplement, Tab. VII, fig. 11.

Spec. Char. Pl. Testa turrita, sub-fusiformi, costata, costis sub-erectis, anfractibus 6—7, *convexis transversim stratis, striis paucis; apertura ovata; labro intus lævi.*

Locality. Red Crag, Butley.

Length, $\frac{5}{8}$ths of an inch.

The above represents one of two specimens in good preservation which I found in the Red Crag at Butley. The shell somewhat resembles *Murex harpula,* Broc., but in the description of that species it is distinctly stated as "interstitiis lævigatis." The ornamentation upon the Crag shell is peculiar; there are four strong, large, spiral lines upon the lower half of the volution (especially visible between the ribs), and the upper portion is covered with very fine spiral striæ. My shell has seven volutions, including the apical one, which is smooth; the costæ are prominent, 10—12, and the striæ are carried over the ribs when the surface has not been rubbed and worn.

Pleurotoma nebulosa, *S. Wood.* Crag Moll., vol. i, p. 60, Tab. VII, fig. 10, as *Clavatula nebula.*

Localities. Red Crag, Sutton and Butley.

Mr. Jeffreys, 'Brit. Conch.,' vol. iv, p. 386, observes that this Crag shell does not agree with the living species *nebula* of Montague. In this I am disposed to agree with him, and, not being able to identify it with any other known shell, I have assigned to it the above name.

Pleurotoma nebula, *Mont.* Supplement, Tab. VII, fig. 7.

Locality. Coralline Crag, Sutton.

The above figure represents a specimen in my cabinet from the Coralline Crag of Sutton, of what, I believe, may be truly referred to the existing species of this name, agreeing with the Mediterranean variety of it.

Fig. 9, Tab. VI, of this Supplement represents the fragment of a shell which Mr. Canham had obtained from the Red Crag of Waldringfield. I felt induced to have it figured in order to call attention to its existence, and to leave nothing unnoticed up to the present time that has been found in the Upper Tertiaries of the East of England. This fragment has been named and published in the 'Ann. and Mag. Nat. Hist.,' 1871, by Mr. Bell, under the name of *Pl. violacea* var. *gigantea* — *Pl. arctica,* Adams. There were two specimens, but both unfortunately in the same mutilated condition, with nothing but the last volution remaining, and this is entirely destitute of sculpture, showing only that it possessed a sinuation at the upper part of the outer lip. The reference of these fragments to *violacea* by Mr. Bell does not quite meet with my approval, as the shell to which they belonged must have exceeded an inch in length, while the longitudinal dimensions of *violacea,* as given by the American authors, are only $\frac{3}{10}$ths of an inch; and there is no ornament on our present shell to assist in its determination. There is a fragment of a shell in my cabinet from the Cor. Crag (which much resembles our Red Crag shell), and this has distant and obsolete costæ, and covered with fine spiral striæ, which might have been upon the Red Crag shell. As Mr. Bell has given to this the name of *arctica,* I have not thought it necessary to alter it, still I think it might be called *ambigua.* I doubt its specific connection with *violacea.*

Pleurotoma rugulosa, *Philippi.*

Pleurotoma rugulosa, *Phil.* En. Moll. Sic., vol. ii, p. 169, t. xxvi, fig. 8.
— — *Jeffreys.* Brit. Conch., vol. iv, p. 381, pl. xc, fig. 4.

Locality. Coralline Crag, Sutton.

Very recently I have found two or three specimens which I believe may be fairly referred to the above-named species. They were obtained too late to be represented in my plate.

Pleurotoma striolata, *Philippi.*

Pleurotoma striolatum (Scacchi), *Phil.* En. Moll. Sic., vol. ii, p. 168, Tab. xxvi, fig. 7.

Locality. Coralline Crag, near Orford.

Since my plates were engraved for this work, Mr. Robert Bell has shown me a specimen from near Orford with the above name, which I believe is correctly referred, and more recently I have obtained a similar one from the same locality.

Cancellaria contorta? *Basterot.* Supplement, Tab. VI, fig. 19.

Cancellaria contorta, *Bast.* Foss. Env. de Bord., p. 47, pl. ii, fig. 3, 1825.
— — *Hörnes.* Vienna Foss., vol. i, p. 311, t. xxxiv, figs. 7, 8.
— — *Bellardi.* Foss. Tert. de Pied., p. 29, t. iii, figs. 7—10.

Locality. Coralline Crag, Gedgrave.

Two specimens of this species have been obtained by Mr. A. Bell and sent to me with the above name. They differ slightly from the general form of *contorta* in being rather more elongated, corresponding with what Dr. Hörnes has considered a variety (fig. 8 of his plate), which has comparatively a smaller and shorter aperture, that is less than the length of the spire. It has about sixteen longitudinal ridges, crossed by spiral striæ, alternating large and small, and the outer lip is strongly denticulated. It is an elegantly formed shell, and not at all appropriately named. Having had no other means of identifying this than figures, I have given the reference with doubt.

Cancellaria gracilenta, *S. Wood.* Supplement, Tab. III, fig. 23.

Spec. Char. C. Testa minuta ovato-acuta, extremitate utraque acuta anfractibus *convexis longitudinaliter creberrime costulatis, transversim vel spiraliter striatis, suturis profundis; apertura ovata; labro acuto, columella triplicata.*

Length, $\frac{3}{8}$ths of an inch.

Localities. Coralline Crag, Sutton, and near Orford.

When describing *C. costellifera* ('Crag Moll.,' vol. i, p. 66) I considered the above represented specimen merely as a variety of that shell; but I now believe it to be distinct. Mr. Bell has lately sent to me a specimen from near Orford, which may be referred to it; and with this was the name of *C. Bonellii*, var. *Dertonensis;* but I think my shell differs sufficiently to be specifically removed from that species; it is more elongated, has finer sculpture and a deeper suture, with more convex volutions; the upper two of which are free from ornament.

CANCELLARIA SUBANGULOSA, *S. Wood.* Crag Moll., vol. i, p. 66, Tab. VII, fig. 20.
Supplement, Tab. III, fig. 27.

ADMETE REEDII, *A. Bell.* Ann. and Mag. Nat. Hist., September, 1870.

Localities. Cor. Crag, Sutton, and near Orford.

Mr. Bell placed in my hands the specimen figured in Tab. III, fig. 27, of this Supplement, and he has since described it under the name of *Admete Reedii,* as above, but except in point of size I cannot distinguish between it and a numerous suite of specimens in my possession of *subangulosa,* all small, but varying much in size, which, like this larger shell *Reedii,* possess no fold on the columella. This fold is shown on the specimen figured in the 'Crag Mollusca,' Tab. VII, fig. 20, but it does not appear to be a constant character. Specimens of *subangulosa* were given by me to Dr. Koenen, who recognised it as a German Oligocene species ('Unter Oligoc. Fauna' von Helmstädt, S. 473), and Dr. O. Speyer has, in his 'Conchology of the Cassel Tertiaries' (Cassel, 1867), figured several forms which he groups together as this shell. In some the shoulder is almost obsolete, as it is in *gracilenta,* and the folds on the columella faint and double, and others where the fold is very distinct and treble.

It would seem, therefore, that this is a very variable shell, and that the folds on the columella are not a reliable character in it. Mr. Bell's large shell *Reedii* shows six whorls, while those specimens of mine, that are identical with it in all respects save size, show but four. This strengthens my view that my *subangulosa* is only the young of *Reedii;* but why the full-grown shell should be so rare I am unable to suggest. One of Dr. Speyer's figures shows six whorls.

CANCELLARIA BELLARDI? *Mich.* Supplement, Tab. III, fig. 25.

CANCELLARIA BELLARDII. Descrip. des Foss. Misc. de l'Italie Septent., p. 225.
— EVULSA, *Sow.* Bellardi, Descript. d. Cancell. foss. du Piemont, p. 25.

Locality. Red Crag, Sutton.

At page 67, 'Crag Moll.,' vol. i, two specimens are spoken of as having been found in the Red Crag of Sutton, and considered as worn individuals of *Cancellaria læviuscula*, Sow. One of these is represented in the above figure. It resembles a shell obligingly sent to me by M. Bosquet with the name *C. Bellardi* attached, and I have referred my specimen to it. It is doubtless a derivative in the Red Crag.

CANCELLARIA BONELLII? *Bellardi.* Supplement, Tab. III, fig. 26.

CANCELLARIA BONELLII, *Bellardi.* Desc. d. Cancell. foss. Piemont, p. 24.

Locality. Red Crag, Sutton.

The other of these specimens is represented in the above figure, and I have referred it with doubt to Bellardi's species *Bonellii.* This also is doubtless a derivative form in the Red Crag.

CANCELLARIA? CHARLESWORTHII, *S. Wood.* Supplement, Tab. III, fig. 22, *a*, *b*.

Locality. Red Crag, Waldringfield.

The shell represented in this figure was given to me by Mr. Charlesworth, who obtained it from the diggers at Waldringfield. It is not in a condition for fair comparison; a portion of the outer shell remains, and this shows a few large costæ somewhat resembling *C. crassicosta*, Bellardi (Pl. IX, figs. 7, 8), or to *C. inermis*, Hörnes (Tab. XXXIV, fig. 10), but to neither can it, I think, be referred. I have called it provisionally *C. Charlesworthii.* This also is doubtless a derivative form in the Red Crag.

CANCELLARIA CANCELLATA? *Linné.* Supplement, Tab. III, fig. 24.

VOLUTA CANCELLATA, *Linné.* Sys. Nat., 12th ed., p. 91.

Localities. Cor. Crag, Ramsholt, Sutton. Living, Mediterranean.

In my Catalogue, 1842, is inserted the name of *Cancellaria granulata;* an imperfect specimen only was found by myself, and am I sorry to say that I have seen nothing better. This specimen, now in the British Museum, is represented in the above figure, and I believe it to belong to *C. cancellata*, Linné. Another, but smaller, fragment I have since found in the Cor. Crag of Sutton. In consequence of the imperfect state of the specimens, I have placed a note of interrogation against the name.

CANCELLARIA SPINULOSA? *Broc.* Supplement, Tab. VI, fig. 10.

VOLUTA SPINULOSA, *Broc.* Conch. foss. sub-app., tab. iii, fig. 15.

Locality. Cor. Crag, Sutton.

The specimen figured was found by myself, and though not in perfect condition, appears to belong to Brocchi's species *spinulosa*. It is, however, destitute of the spinous volutions of that species as represented by Brocchi; but these may have been rubbed off. I have, however, considered it a variety under the name of *subspinulosa*. The form of my shell much resembles an older tertiary genus called *Mesostoma*, by Deshayes, but that has no fold upon the colummella; still I think the two are nearly related.

APORRHAIS PESPELICANI, *Linn.* Crag Moll., vol. i, p. 25, Tab. II, fig. 4 *a b*.

Localities. Cor. Crag., Ramsholt, Gedgrave, and Sutton. Red Crag, Sutton, Newbourn, Brightwell, Bawdsey. Fluvio-marine Crag, Thorpe in Suffolk (Bell). Post-glacial, March Gravel, Nar Brick-earth (Rose).

The shell figured, as above referred to, was from the Red Crag at Brightwell, and it corresponds precisely with the common form of the British shell of that name. This so-called *pespelicani* has been lately found in considerable numbers in the Cor. Crag at Gedgrave; but the specimens there found differ somewhat in being more elongated and more delicately marked than those from the Red Crag, representing an intermediate form between it and *A. McAndreæ*, Jeffreys (*A. pescarbonis*, Forb and Hanl).

Our Coralline Crag variety is a slender shell, and the nodules smaller than upon the common British form (in some specimens as many as twenty on the last volution), and in that respect it closely approaches *Chenopus Serresianus* (Phil. "En. Moll. Sic.," vol. ii, p. 185, Tab. XXVI, fig. *b*.), which probably is the same species.

The Crag shell appears to me to be the connecting link between *Ap. pespelicani*, and *Rostellaria pescarbonis*, Brongniart. Several of these finely marked specimens have lately come into my possession, but after my plates were finished, or I would have had one represented.

I do not know the *Aporrhais* in any newer formation than the Red and Fluvio-marine Crag of Suffolk, until we come to Post-glacial beds of the Nar Valley, where, I believe, it is not rare; the specimens from there being of the large and coarse form, like those of the Red Crag. A fragment has been found in the March Gravel by Mr. Harmer, and Mr. Bell gives it from Thorpe, Suffolk.

CERITHIUM ? ABERRANS, *S. Wood.* Supplement, Tab. III, fig. 20.

Length, ½ an inch.

Locality. Coralline Crag, near Orford.

The figure above referred to is the representation of a specimen I picked out of a tray of shells which Mr. Henry Woodward obligingly showed to me; and who said that they had been found by his late brother, Dr. S. P. Woodward, and, he believed, all in the Coralline Crag. There was no special locality attached to any one of the specimens, but they had the aspect of the shells from Orford; and as the late Dr. Woodward had collected from the Cor. Crag only in that neighbourhood, there can be little doubt of its being from that locality. Neither do I think that there is any doubt as to this shell being a genuine fossil of the Coralline Crag. It appears to be destitute of nodules or thickenings in the lines of growth, which is the general character of the genus *Cerithium.* In the form of the aperture it is like a shell called *Bittium filosum*, from Neeah Bay, but that is more elongated. I have given to my shell provisionally the above name.

N.B.—Since the engraving was made (some years since), and before the figure could be compared, I regret to say the fossil was lost or mislaid, and has not since been found. This is unfortunate, as it was put into the hands of the engraver before the shell had undergone a thorough examination, trusting to future opportunity for comparison.

CERITHIUM PERPULCHRUM, *S. Wood.* Crag Moll., vol. i, p. 72, Tab. VIII, fig. 10.

This may perhaps be referred to *C. mamillatum*, Riso. See Phil. "En. Moll. Sic.," vol. i, p. 194, Tab. XI, figs. 11, 12.

M. Nyst gives from the Belgian Crag, *Cerithium trilineatum*, Phil. var. *inversum.* I have not seen this variety from the English Crag.

CERITHIUM RETICULATUM, *Da Costa.* Supplement, Tab. V, fig. 22.

STROMBIFORMIS RETICULATUS, *Da Costa.* Brit. Conch., p. 117, pl. viii, fig. 13, 1778.

Locality. Red Crag, Walton-Naze (Bell)? Post Glacial, Nar Brick-earth.

Several specimens of this species have been found by Mr. Rose in the Nar Brick-earth at West Bilney, and he has permitted me to have one of them figured.

It was one of the Nar specimens, I am informed, that constituted the authority under which the species was introduced into Dr. Woodward's list of Norwich Crag shells. This species, though somewhat resembling the Red Crag, *C. variculosum* ('Crag Moll.,' Tab. VIII, fig. 3), is, I consider, quite distinct: the form of the whorls separately, as well as that which they give to the complete shell being very different. Mr. A. Bell gives *C. reticulatum* from the Red Crag of Walton ('Ann. and Mag.,' September, 1870), but I have not seen the specimen, and imagine that it may probably be the *variculosum* of that locality.

CERITHIUM TRICINCTUM, *Broc.* Crag Moll., p. 69, Tab. VIII, fig. 1, *a* and *b*. Supplement, Tab. III, fig. 19.

Locality. Cor. Crag, Sutton, and near Orford. Red Crag *passim*. Fluvio-marine Crag, Bramerton. Chillesford Bed, Bramerton and Horstead. Middle Glacial, Hopton.

The above figure, 19, was made from a fragment of this species, which I had obtained from the Cor. Crag of Sutton, and it was inserted in order to justify its admission among the shells of that formation. Since the plate was engraved, however, I am glad to say that I have obtained three other specimens from the Coralline Crag of the neighbourhood of Orford (Gomer pit), one of which is nearly perfect, and would be exactly represented by the old figure 1*a*, of Tab. VIII, of the 'Crag Mollusca.' This species is common in the Red Crag and in the Fluvio-marine Crag at Bramerton, as well as in the Chillesford Bed at that place. It occurs also, but rarely, in what I consider to be its Fluvio-marine representative—the Crag of Horstead, but I have not seen it from the other localities of that bed. I have not met with it from the Lower Glacial sands; but one specimen, which fig. 19, of Tab. III, would well represent, has occurred in the Middle Glacial sand of Hopton. I do not know it living.

Mr. Charlesworth has also given me a specimen, too mutilated for figuring of a species of this genus, but the characters are not sufficiently distinct for specific determination. In this the volutions are more close and numerous than those of *C. tricinctum*, as were remarked to me by Mr. Charlesworth; it is, I believe, distinct. He obtained it from the nodule bed at Waldringfield, and is probably a derivative in the Red Crag.

Fig. 21, of Tab. III, of this 'Supplement,' represents an imperfect specimen obtained by myself from the Post Glacial Freshwater Deposit at Grays. Mutilated specimens of *Melania inquinata*, and another species of *Melania*, have got into this deposit at Grays, from the Eocene Woolwich sands, and the specimen produced may therefore be of similar origin, as it resembles *Cerithium* (*Potamides*) *intermedium*, of Sowerby, from those sands ('Min. Cor.,' Tab. CXLVII, fig. 3.) I was induced to figure its form, from the difference between the character and composition of this specimen, and that of these older tertiary derivatives; the *Melaniæ* being strong shells, much abraded, while the specimen figured was so fragile that it fell to pieces, leaving only the fragment figured, and disclosed that it was filled with the material of the Grays Deposit, and not that of the Eocene one, which at first induced me to suppose that it might have been a living denizen of the waters of the Grays deposit. I have figured it simply as a shell found in the Grays Bed, without venturing to express a positive opinion about it.

CERITHIOPSIS LACTEA ? *Möller.* Supplement, Tab. IV, fig. 16.

TURRITELLA LACTEA, *Möll.* Ind. Moll. Groenl., p. 9, 1842.
— RETICULATA, *Mighels* and *Adams.* Bost. Journ., iv, p. 50, pl. iv, fig. 19.
— — *Binney.* Gould's Inv. Massach., 2nd ed., p. 318, fig. 586.

Locality. Coralline Crag, Sutton.

I have found a single specimen only, which is here referred to the above-named species, although with some doubt. The aperture of my shell is not quite perfect; the figure is represented as rather too conical.

CERITHIOPSIS TUBERCULARIS, *Mont.* Crag Moll., vol i, Tab. VIII, fig. 5 (as *Cerithium*).

Localities. Cor. Crag, Sutton, and near Orford. Red Crag, Shottisham (Bell). Fluvio-marine Crag, Bramerton. Middle Glacial, Billockby.

Specimens of this shell are abundant in the Coralline Crag at Sutton, exhibiting great variation, as I have shown in 'Crag Moll.,' Tab. VIII, some being much elongated, while others are short and tumid; but I have not met with a specimen having only two rows of tubercles, like that which has been called *C. Clarkei* ('Brit. Moll.,' vol. iii, p. 368, Tab. CIII, fig. 6). This appears to be merely the absence of the middle row, a character common in *C. perversum,* where most of the upper volutions have only two. *C. Barleei* I do not know. One imperfect specimen of *C. tubercularis* has been found by Mr. Reeve, and fragments by others, in the Fluvio-marine Crag of Bramerton; and an imperfect specimen has occurred in the Middle Glacial of Billockby. It is given from the Red Crag, Shottisham, by Mr. Bell ('Ann. and Mag. Nat. Hist.,' May, 1871). It has not been yet met with in the Chillesford Bed anywhere, or in the Lower Glacial Sands, to my knowledge.

TURRITELLA INCRASSATA, *J. Sow.* Crag Moll., vol. i, p. 75, Tab. IX, fig. 7.

Localities. Coralline, Red, and Fluvio-marine Crags *passim,* Chillesford Bed, Bramerton. Middle Glacial, Billockby and Hopton.

The above name was employed by me from a belief that it was prior to the one used by Brocchi (*T. triplicata*), which I still believe is the case. There is a date upon the plate in 'Min. Conch.' of April 1, 1814. This species is very abundant in the Cor. Crag., and is very variable in ornamentation. The apex is very seldom preserved, except in very young individuals which have a slender form, tapering up to a point which is smooth and obtuse.

Though common in the Red and Fluvio-marine Crags, it becomes rare in the Chillesford bed, and I have not met with it in the Lower Glacial Sands. It is an extremely abundant shell in the Middle Glacial Sands, especially at Billockby, at which place I have never met with the allied form *terebra.* The form in these sands is the var. *triplicata.* fig. 7*a,* and 7*c* of Tab. IX of 'Crag Moll.'

TURRITELLA TEREBRA, *Linné.* Crag Moll., vol. i, p. 74, Tab. IX, fig. 9.

Localities. Fluvio-marine Crag, Bramerton. Chillesford Bed *passim.* Middle Glacial, Clippesby, and Hopton. Upper Glacial, Bridlington. Post-glacial, March and Kelsey Hill, Nar Brick-earth (Rose).

This species is common in the Fluvio-marine Crag of Bramerton, but I have not met with it in the Cor. Crag, nor with a clear example of it in the Red Crag. It occurs, but is not very common, in the Chillesford bed at all its localities; while at Clippesby (only a mile from Billockby where we find the form *incrassata* alone), *terebra* exclusively occurs. Compared with *incrassata* it is rare in the Middle Glacial, but specimens are not unfrequent. I have not seen it from the Lower Glacial. It is common in the Post-glacial gravel of March, and occurs at Kelsey Hill. Specimens of it sent to me by Mr. Maw from the Severn Valley beds, as well as those from March, shew a tendency in occasional individuals to approach the form *incrassata,* but there is no difficulty in distinguishing a group of the one form from a group of the other. Mr. Rose obtained it from the Nar Brick-earth, at West Bilney, and East Winch.

TURRITELLA EROSA, *Couthouy.* Crag Moll., vol. 1, p. 76, Tab. IX, fig. 8.

TURRITELLA EROSA, *Couthouy.* Boston Jour. Nat. Hist., 2, p. 103, Tab. III, fig. 1.
— CLATHRATULA, *S. Wood.* Crag Moll., vol. i, p. 76, Tab. IX, fig. 8.

Locality. Upper Glacial, Bridlington.

The shell, from Bridlington, was in the 'Crag Mollusca' assigned by me as a new species (*clathratula*). I am now satisfied that it is identical with Couthouy's North American shell *erosa* (*polaris* of Beck), which is given by Möller as a Greenland shell. The statement at p. 83, of vol. iv, of 'Brit. Conch.,' that this shell has been found by me in the Cor. Crag of Sutton is an error. I know it from no older East Anglian bed than that of Bridlington.

TURRITELLA? PENEPOLARIS, *S. Wood.* Supplement, Tab. IV, fig. 20.

Locality. Cor. Crag, near Orford and Sutton.

A fragment of a shell from the Cor. Crag of Sutton, that I was unable to refer to any existing species, has long been in my possession, but it was too imperfect for determination. The late Dr. S. P. Woodward obtained a somewhat corresponding specimen from the Cor. Crag of the Orford neighbourhood, which has the aperture rather more perfect than my own; and I am now enabled with the two fragments to give a probable representation for a species. Dr. Woodward's specimen was accompanied with the name of *Mesalia polaris*. I have carefully compared these fragments with that species, and I think that they are quite distinct from it. The sculpture of *polaris* shows four or five broad threads in a spiral direction, with corresponding spaces between them, whereas the Cor. Crag shell is covered with numerous fine threads and narrow depressions. I have placed it provisionally in the above-named genus, which I think it more nearly resembles than that of *Mesalia*; the shells of this latter genus have a somewhat emarginate base, or rather a reflexion of the lower part of the inner lip, which the Crag shell does not appear to possess.

TURRITELLA PLANISPIRA, *S. Wood.* Crag Moll., vol. i, p. 76. Tab. IX, fig. 11.

M. Mayer in 'Journ. de Conch.,' vol. xiv, p. 173, Pl. III, fig. 2, has described a species of *Turritella*, with the specific name of *Sandbergeri*, and to this he has given as a synonym, *T. planispira*, S. Wood, non Nyst. All the Coralline Crag forms of this genus possess a wide range of variation in the external ornament, but I believe my species *T. planispira* forms a group as well defined and constant as any.

It has been identified with *subangulata* of Brocchi by Mr. Jeffreys ('Quart. Journ. Geol. Soc.,' vol. xxvii, p. 146), but I think it is not that shell, as it agrees with it neither in the form of the whorls (which are invariably flat, and not subangular), nor in the external sculpturing. The figure of it in Tab. IX of 'Crag Moll.,' shows only six or seven spiral threads, but it has always eight, and more frequently nine, all of equal size. In some individuals the central thread thickens, and so produces a faint subangulation, which is scarcely perceptible without a magnifier. This shell, and that called *T. incrassata* var. *bicincta* (fig. 7*d* of Tab. IX of 'Crag. Moll.'), appear to me to constitute the most marked forms of this genus that lived in the Cor. Crag sea; but inasmuch as a series may be selected, showing a gradation of all the forms into each other, I doubt whether the whole of the Coralline Crag varieties and species, *triplicata*, *vermicularis*, *bicincta*, and *planispira*, are not merely individual and inconstant variations of the one species *incrassata*; and the same remark might be applied to Brocchi's species, *duplicata*, *bicarinata*, *subangulata*, *marginata*, and *replicata*.

Before dismissing the genus Turritella, I may mention that Mr. Busk in his beautiful 'Monograph of the Crag Polyzoa,' at p. 59, gives *Cellepora edax*, "habitat Cor. Crag, S. Wood, on a specimen of Natica and Turritella."

The living analogue found by the Rev. Mr. Hinks on the coast of Devonshire, was attached to a *Turritella*, but the late Mr. Alder told me he had a specimen of *C. edax* upon

Trochus exiguus. I believe the shell which the Crag Polyzoon (*C. edax*) has selected for its support is a species of *Turritella;* at least in all the numerous specimens I have seen. The form it has assumed is unlike that of a turriculated shell, but I think the burden imposed upon the animal in its growth, by the *Cellepora* occupying the base, has compelled the Mollusc to expand while the shell was increasing, so as to be deflected from its proper angle of volution, and depressed into a turbinated form. Mr. Busk has very justly pointed out in the case of *Alysidota catena,* as in that of other adherent Polyzoa, that the animal has the power of eroding the surface of the shell upon which it lived, though by what means this is effected is not said.

I am however inclined to think that the destroyer of the *Turritella* was not the Polyzoon, but that the shell has been absorbed or removed by the Mollusc itself in order to lighten its heavy and inconvenient incumbrance, for whenever a portion of the shell is visible, it has retained its exterior ornament without any apparent abrasion, and in all the instances that I have seen, the shell has been a *Turritella.*

I have figured a specimen partially uncovered, obligingly lent to me for that purpose by the directors of the Museum at Norwich, which shows a deflection from the normal angle of volution (*Turritella incrassata,* Supplement, Tab. V, fig. 25 *b*), and another of my own, fig. 25 *a*, wholly enveloped, but distorted. Fig. 3, Pl. XXII, of Mr. Busk's work is, I believe, a *Turritella.*

ALVANIA SUPRANITIDA, *S. Wood.* Crag Moll., vol. i, p. 99, Tab. XII, fig. 11 *a b.* (as *A. ascaris*).

ALVANIA SUPRANITIDA,		*S. Wood.*	Ann. and Mag. Nat. Hist., vol. ix, p. 534, tab. 5.
ACLIS	—	*Loven.*	Ind. Moll. Scan., p. 17, 1846.
—	—	*Forbes and Hanl.*	Brit. Mol., vol. iii, p. 320, tab. 90, figs. 2 & 3.
—	—	*Jeffreys.*	Brit. Conch., vol. 4, p. 103.

Localities. Cor. Crag, Sutton.

This species was described by me as *supranitida* in my catalogue in the 'Ann. and Mag. of Nat. Hist.,' of 1842, but in the 'Crag Mollusca,' I (as there stated), in deference to the opinion of the late Mr. Alder, referred it to *A. ascaris,* Turt. The shell *supranitida* has, however, been recognised by Loven, Forbes and Hanley, and Jeffreys as a living species distinct from *ascaris,* and I have accordingly restored the name.

Mr. Jeffreys in 'Brit. Conc.,' vol. iv, p. 103, mentions *ascaris* from the Cor. Crag as being in the collection I gave to the British Museum, mixed with *supranitida,* but I do not recognise it there, nor have I, though it is inserted in the list of Gasteropoda of Mr. Prestwich's Cor. Crag paper, seen it anywhere from the Crag.

Alvania albella, *Leach,* M.S. Crag Moll., vol. i, p. 99. Tab. XII, fig. 11*c*.

> Alvania albella, *S. Wood.* Annals and Mag. of Nat. Hist., vol. ix, p. 534, 1842.
> Aclis Walleri, *Jeffreys.* Brit. Conch., vol. iv, p. 105, pl. lxxii, fig. 4, 1867.

Locality. Cor. Crag, Sutton.

This species was given by me in my catalogue in the 'Annals and Mag. of Nat. Hist.,' for 1842, under the name *albella,* a manuscript name of Dr. Leach for the recent shell since called *Walleri,* which, as stated at p. 99 of the 'Crag Moll.,' I found on a tablet in the Brit. Museum, with the name in Dr. Leach's handwriting attached. This tablet, I regret to say, cannot now be found, and some confusion has arisen in consequence, as Mr. Jeffreys appears to think ('Brit. Conc.,' vol. iv, p. 104) that *albella* of Leach was *ascaris* of Turt. Mr. Jeffreys recognises *Walleri* in a single specimen in my collection in the British Museum, but there are twenty-six specimens there on a separate tablet which appear to me identical in all respects with some specimens of his recent *Walleri* which he kindly gave me. I fell into the mistake in the 'Crag Moll.' of supposing this to be an eroded form of the shell *there* described as *ascaris* (*supranitida*), but I have now reverted to my more correct views of 1842. Since my collection went to the British Museum, both this shell and *supranitida* have become extremely rare in the Crag.

Some Conchologists have adopted the name of *Aclis* for this genus, and it may require a remark from me in explanation for not following the same plan. In the first place I used the name of *Alvania* in 1842, when the Crag shell was fully described, and this was previous to the name of *Aclis,* proposed by Dr. Lovén in 1846. In the second place I merely employed a name that had been given by Leach, and attached by him to a specimen in the Brit. Mus.; and in the third place the shells included under the name of *Alvania,* by Weinkauff and others, have no characters by which they could be distinguished generically from those called *Rissoa.*

MENESTHO, *Möller,* 1842.

Diagn. Gen. "*Animal pede elongato, angusto, ore simplici, membrana linguali destituto; tentaculis brevioribus, crassiusculis, oculos perparvos ad basin internum ferentibus. Operculo pauco-spirato. Testa conica turrita.*"—(*Möll.*)

The above is a description of this proposed genus, and the author has referred to *Turbo albulus* of the Fauna Greenlandica, as his intended type, the shell of which presents a different form of aperture from either *Rissoa* or *Turritella,* and approaches nearest to *Pasithea,* Lea.; but we do not know the species intended as the type of this latter genus in which several very different forms have been included.

MENESTHO LÆVIGATA, *S. Wood.* Supplement, Tab. IV, fig. 19.

Spec. Char. Testa elongata turrita, lævigata, apice obtusiusculo; anfractibus (8—9) *planulatis, apertura ovata posterius angulata quinquepartem teste æquante; columella incurva, labro simplice, acuto.*

Length, ½ an inch.

Locality. Coralline Crag, Sutton.

A few imperfect specimens, and one perfect, were found by myself in the Cor. Crag of Sutton. The perfect one figured was destroyed while in the hands of the engraver (1866). Some years after that Mr. Bell sent to me a very perfect individual of what possibly may be the same species, but with the name of *M. Britannica.* Mr. Bell's shell was found at Sutton. The shell figured had about eight volutions, the upper three or four more conical than the lower, which were nearly cylindrical; the apex was obtuse and glossy, and the rest of the shell free from striæ or sculpture of any kind; the volutions slightly convex, the upper part being a little contracted; it had a distinct and rather depressed suture; the aperture ovate, acuminated at the junction of the whorl, and it was an elegantly formed shell. It much resembles *Pyramis striatula,* Couthouy ('Boston Journ. Nat. Hist.,' vol. ii, p. 101, Pl. I, fig. 6, described also by Gould, 'Inv. Mass.,' p. 269, fig. 174, but that shell is said to be covered "with revolving lines," and is probably the same as *Menestho albula;* my shell is smooth.

PYRAMIDELLA LÆVIUSCULA, *S. Wood.* Crag Moll., vol. i, p. 77, Tab. IX, fig. 2.

Localities. Cor. Crag, Sutton, and near Orford. Red Crag, Walton Naze.

Pyramidella læviuscula of the Crag has, according to Mr. Jeffreys, been obtained recent in the Mediterranean. It is also a fossil in the Belgian Crag, and in the Vienna beds, figured by Hörnes, vol. i, p. 492, Tab. XLIV, fig. 20, and there referred to *P. plicosa,* Bronn. M. Nyst figured it as *P. terebellata.* It is probably *terebellata,* Broc., but not of Lamarck. Whether this be the *unisulcata,* Dujardin, I do not know. There are two or three species in the Bordeaux beds of nearly the same size; *Pyramidella mitrula,* 'Bast. Bord. Foss.,' Pl. I, fig. 5, is probably another species. I must refer to M. Deshayes, 'Par. Foss.,' vol. ii, p. 583, who has given full particulars of these fossil *Pyramidellæ.* I have obtained a specimen from the Cor. Crag, near Orford, of this species, which is more elongated than any of my Sutton specimens, and I obtained the shell from the Red Crag of Walton very soon after the publication of the 'Crag Mollusca.' This shell has been found abundantly in the Coralline Crag at Sutton.

Scalaria Turtoni, *Turton*. Supplement, Tab. IV, fig. 7.

> Turbo Turtonis, *Turt.* Conch. Dict., p. 208, fig. 97, 1819.
> Scalaria Turtonis, *Forb.* and *Hanl.* Brit. Moll., vol. iii, p. 204, pl. lxx, figs. 1, 2.

Localities. Chillesford Bed, Sudbourn Church Walks, and Beccles Waterworks.

The above figure represents a specimen obtained by Mr. A. Bell from Sudbourn Church Walks, and I have very recently found another specimen at the same locality. M. Weinkauff ('Conch. des Mittel,' vol. ii, p. 234) gives two varieties of this species. One he calls *gracillissima*. Our fossil is the less elongated one, and corresponds with the variety from the Irish seas; it has a deep suture, and the whorls are nearly circular. *Scalaria trinacria,* Phil., vol. ii, p. 145, looks like, and is probably a short variety of this species. Mr. Crowfoot sent me a fragment obtained from the Waterworks Well at Beccles, which pierced probably the Chillesford bed; and this fragment I think may be referred to the above-named species. Fig. 5, Tab. IV, represents the portion of a shell also obtained by Mr. Bell from the bed at Sudbourn Church Walks, which I believe is a variety of the above species. It has a faint spiral ridge at the base of the volution, similar to that upon *Sc. pseudo-scalaris,* Risso. I have therefore called it var. *pseudo-Turtoni.* In the 'Ann. and Nat. Mag. Hist.,' September, 1870, Mr. Bell gives the name of *Sc. pseudo-scalaris* from the same deposit. I have not seen that species as a British fossil; probably the specimen I have figured as var. *pseudo-Turtoni* may be that on which he has made this reference. *Scalaria fimbriosa* is given in the list of Mr. Prestwich's paper as from the Red Crag of Woodbridge. This is probably through some mistake. *Scalaria communis* is also there given from Waldringfield, but I have seen nothing answering to this species or I would have had it figured.

Scalaria Trevelyana, *Leach*. Crag Moll., vol. i, p. 94, Tab. VIII, fig. 20, and Supplement Tab. IV, fig. 6.

Localities. Red Crag, Sutton. Fluvio-marine Crag, Bramerton. Chillesford Bed, Aldeby. Middle Glacial, Hopton and Billockby.

I have here given a large representation of a small specimen from Aldeby, found by Messrs. Crowfoot and Dowson. This young specimen has the three upper volutions free from ribs of any kind. The specimen I previously figured has lost the upper half in which this character is shown. I have not met with this species from any other locality of the Chillesford bed, and it is rare in the Fluvio-marine Crag. A fragment consisting of a single whorl has occurred in the Middle Glacial of Hopton, and another rather more complete at Billockby.

SCALARIA CANCELLATA, *Broc.* Crag Moll., vol. i, p. 95, Tab. VIII, fig. 2, and Supplement, Tab. IV, fig. 2.

Locality. Cor. Crag, near Orford.

A fine specimen of this species having been obtained from the Cor. Crag at Orford, and obligingly given to me by Mr. H. B. Woodward, I have been induced to have it represented in Tab. IV, fig. 2, and I think from this specimen the shell may safely be referred to Brocchi's species.

I regret not having been able to find a better specimen of what I called *Scalaria obtusicostata,* 'Crag Moll,' vol. i, p. 95, Tab. VIII, fig. 21.

SCALARIA GROENLANDICA, *Chemn.* Crag Moll., vol. i, p. 90, Tab. VIII, fig. 11.

Localities. Red Crag, Sutton. Fluvio-marine Crag, Bramerton. Chillesford Bed, *passim.* Lower Glacial, Belaugh. Middle Glacial, Hopton. Upper Glacial, Bridlington.

This shell is not uncommon in the Fluvio-marine Crag, and in some of the localities of the Chillesford bed, and in the Lower Glacial Sand at Belaugh. Two fragments have occurred in the Middle Glacial of Hopton.

In our long list of Crag *Scalariæ* there are several that I have not been able to refer to existing analogues. *Scalaria soluta,* Tiberi, 'Journ. de Conch.,' vol. xi, p. 159, Pl. VI, fig. 3, is probably the young state, and figs. 3, 4, Pl. V of the same Journal, vol. xvi, possibly the full-grown condition of *Scalaria frondosa,* J. Sow., from the Coralline Crag. *Scalaria exima,* Pecchioli, may perhaps be also referred to *frondosa.* The Crag shell is variable, some specimens being more elongated than others, and the spinous fronds more or less produced. This Crag species I have found at Gedgrave.

Scalaria frondicula somewhat resembles *Sc. Algeriana,* Weinkauff, but that Mediterranean shell is said to be covered with spiral striæ; but my Crag shell is quite smooth between the reflected costæ.

CHEMNITZIA CLATHRATA? *Jeffreys.* Supplement, Tab. VII, fig. 18.

ODOSTOMIA CLATHRATA, *Jef.* Ann. and Mag. Nat. Hist., 2nd ser., vol. ii, p. 345, 1848.
CHEMNITZIA — *Forb.* and *Hanl.* Brit. Moll., vol. iii, p. 258, pl. xciv, fig. 4.

Locality. Coralline Crag, Sutton.

A single specimen has lately rewarded my researches, which seems to correspond with a recent British shell described by Mr. Jeffreys as a distinct species. Messrs. Forbes and Hanley gave it under the above name, but with a ?, considering it probably a var. of *indistincta* (*curvicostata* of 'Crag Moll.'); it appears to me to differ from that species in being somewhat less cylindrical, and in the ornamentation; the ribs being less curved, and the spiral striæ on the lower part of the volution more prominent or distinct. The outer lip of my specimen is unfortunately not quite perfect.

CHEMNITZIA FILOSA. Crag Moll., vol. i, p. 82, Tab. X, fig. 7.

This is probably the same as *Parthenia varicosa*, Forbes, from the Ægean, but that specific name having been employed by Basterot for a different shell, apparently of this genus, I have retained the name *filosa* originally given in my catalogue.

CHEMNITZIA ELEGANTIOR, *S. Wood.* Crag Moll., vol. i, p. 81, Tab. X, fig. 5 (as *Ch. elegantissima*).

Locality. Cor. Crag, Sutton. Red Crag, Walton.

This shell was referred to *Chemnitzia elegantissima*, Mont., in the 'Crag Mollusca,' but the ribs are straight, though inclined, but not curved or flexuous, such as those upon *elegantissima*. I think therefore that it must be treated as distinct, and I propose to call it *Ch. elegantior*. Mr. Bell has shown me a portion of a specimen from the Red Crag of Walton (see *Odostomia lactea* in Bell's list 'Ann. and Mag.,' May, 1871), which appears to be specifically the same as my own from the Coralline Crag. I am unable to say whether the *elegantissima* of Woodward's Norwich Crag list be this shell or Montague's *elegantissima*.

CHEMNITZIA INTERNODULA, *S. Wood.* Crag Moll., vol. i, p. 81, Tab. X, fig. 6.

Localities. Cor. Crag, Sutton. Red Crag, Sutton, and Walton, and Butley (Bell). Fluvio-marine Crag, Bramerton. Middle Glacial, Hopton and Billockby.

This shell has occurred, but very rarely, in the Fluvio-marine Crag at Bramerton, and several imperfect specimens of it have occurred in the Middle Glacial of Billockby and Hopton. I have not met with it from any of the localities of the Chillesford bed or Lower Glacial Sands. I understand that it has been found living in the Mediterranean, but have not seen the shell.

CHEMNITZIA RUFA, *Philippi.* Crag Moll., vol. i, p. 79, Tab. X, fig. 2.

The author of 'Brit. Conch.' (vol. iv, p. 163) seems to doubt the correctness of my assignment, and I have in consequence again examined my specimens. I still believe my Coralline Crag shell to be identical with the recent British species of that name. I have also a specimen from the same formation (at Sutton) of *Ch. fulvocincta*, Forb. and Hanl., which Mr. Jeffreys considers only as a variety of *rufa;* the difference between these two consisting in one having rather more convex volutions than the other. The figure in 'Crag Moll.' has the costæ rather too numerous, and they are not sufficiently erect.

Chemnitzia rugulosa, *S. Wood.* Supplement, Tab. IV, fig. 15.

Locality. Red Crag, Walton Naze. Fluvio-marine Crag, Yarn Hill?

Two somewhat imperfect specimens, presumedly belonging to this genus, were found by myself many years since, one of which is represented in the above figure. They were not described in the 'Crag Mollusca,' in the hope that something more perfect or capable of better determination might be discovered, but in this I have been disappointed. These are unfortunately much rubbed and their true markings partially obliterated. The volutions are convex on the lower part and flattened above, where there are some obsolete riblets, and there is an indistinct fold upon an upright columella—the characteristic distinction of this genus. The shell it most resembles is *Ch. speciosa*, dredged by Mr. McAndrew in Vigo Bay, but I am not able to say they are the same. Mr. Crowfoot has recently sent me two still more imperfect specimens from the Fluvio-marine deposit at Yarn Hill, which, I think, may be referred to the same species. I have given the name provisionally.

Chemnitzia plicatula? *Brocchi.* Supplement, Tab. VII, fig. 3.

Turbo plicatulus, *Broc.* Conch. Foss. Sub-ap., vol. ii, p. 376, t. vii, fig. 5, 1814.
Turbonilla plicatula, *Hörnes.* Conch. Foss. Wien., vol. i, p. 503, tab. xliii, fig. 33, 1856.

Localities. Red Crag, Butley, Walton Naze (*Bell*). Chillesford Bed, Beccles Waterworks.

A single, but very imperfect specimen (the one figured from Butley) has been put into my hands by Mr. A. Bell, to which the name above was attached. It is too imperfect for diagnosis, and I have referred it as above, though with doubt. The fragment shows about three fifths of what probably was its original size. The plications and ribs are straight and numerous, and the volutions are nearly flat. It differs from the one I have previously called *rugulosa*, in which the volutions are convex on the lower part.

Mr. Crowfoot has recently sent to me two small fragments, which appear to belong to the same species. These, he tells me, were obtained in sinking the Beccles Waterworks well, which, it is to be presumed, pierced the same bed as that not far away at Aldeby, though it has a Fluvio-marine aspect. All these fragments have had their surface more or less decorticated or altered in some degree, and the above reference is not satisfactory.

Mr. Bell ('Ann. and Mag. Nat. Hist.,' May, 1871) gives this also from Walton, but I have not seen that specimen.

ODOSTOMIA INSCULPTA, *Montagu*. Supplement, Tab. IV, fig. 18.

TURBO INSCULPTUS, *Mont.* Test. Brit., Supplement, p. 129, 1808.
ODOSTOMIA INSCULPTA, *Forb.* and *Hanl.* Brit. Moll., vol. iii, p. 289, pl. xcvi, fig. 6.
— — *Jeffreys.* Brit. Conch., vol. iv, p. 139, pl. lxxiv, fig. 4.

Locality. Coralline Crag, Sutton.

An imperfect specimen of this species has recently been obtained by myself from Sutton. It has lost its obtuse apex and a part of the spire, but may, I think, be distinguished by its peculiar ornament. It is the only specimen I have seen.

ODOSTOMIA? GULSONÆ, *Clark.* Supplement, Tab. IV, fig. 26.

CHEMNITZIA GULSONÆ, *Clark.* Ann. and Mag. Nat. Hist., 3rd ser., vol. vi, p. 459.
ODOSTOMIA? — *Forb.* and *Hanl.* Brit. Moll., vol. iv, p. 281, pl. cxxxii, fig. 6.
JEFFREYSIA? — *Jeffreys.* Ann. and Mag. Nat. Hist., Jan., 1859, p. 17.
ACTIS — *Id.* Brit. Conch., vol. iv, p. 106, pl. lxxii, fig. 5.

Locality. Coralline Crag, Sutton.

A single specimen was found by myself a few years since which I then considered as a new species, and had given to it the name of *O. mitis.* Upon showing the shell to Mr. Jeffreys he considered it as an identity with a British species which he had figured and described under the name of *Odostomia minima* ('Ann. and Mag. Nat Hist.,' 1858, p. 9, Pl. XI, fig. 3); and my shell passed under that name in a report by him upon the dredgings of the Shetland seas ('Brit. Assoc.,' 1863). He has not, however, in 'Brit. Conch.' identified *Od. minima* with any Crag shell, but speaks (vol. iv, p. 107) of *Aclis Gulsonæ* having been found by me in the Coralline Crag at Clacton (corrected to Sutton in vol. v, p. 210). I presume that the shell thus referred to is the single specimen of which I have been speaking, and I have accordingly adopted the specific name for it. The figure above referred to is a copy from a figure of a recent shell, my specimen (which, I believe, is the only one that has been found) having been destroyed while in the hands of the engraver.

Odostomia conoidea, *Brocchi.* Crag Moll., vol. i, p. 85, Tab. IX, fig. 3 *a* (as *O. plicata*).

Odostomia conoidea, *Broc.* Conch. Foss. Sub-ap., p. 660, c. 16, fig. 2.

Localities. Cor. Crag, Sutton, Ramsholt, and near Orford. Red Crag, Walton? Fluvio-marine Crag, Bramerton? Middle Glacial, Billockby?

This shell was in the 'Crag Moll.' referred by me to *O. plicata* of Mont. with *O. conoidea*, Broc., as a synonym. The two, however, appear to be, as stated p. 317 of Appendix, distinct. *O. conoidea* is given by Mr. Bell from Walton in 'Ann. and Mag. Nat. Hist.,' September, 1870, but I have not seen the specimen. This is the only Red Crag occurrence of it of which I am aware. An imperfect specimen obtained by Mr. Reeve from the Fluvio-marine Crag of Bramerton, and another by my son from the Middle Glacial sand of Billockby, appear to belong to this species, but they are not sufficiently perfect for certain identification.

Odostomia plicata, *Mont.* Supplement, Tab. IV, fig. 22.

Turbo plicatus, *Mont.* Test. Brit., p. 325, tab. xxi, fig. 2.

Localities. Cor. Crag, Sutton. Red Crag.

A single specimen of this shell, which has been obtained by me from the Coralline Crag at Sutton, and is represented in the above figure, enables me to retain the name of Montagu's species as a Cor. Crag shell, as mentioned p. 317 (*Od. plicata*) of Appendix. I had it from the Red Crag, but the name of the locality has not been preserved.

Odostomia conspicua ? *Alder.* Crag. Moll., vol. i, p. 85, Tab. IX, fig. 3 (as *O. plicata*, var.).

Odostomia conspicua, *Alder.* Trans. Tynes Nat. Field Club, i, 359.

Locality. Cor. Crag, Sutton.

The shell figured in 'Crag Moll.' as variety *b* of *O. plicata*, Mont. seems to me now more to resemble the above shell *conspicua;* that species and *conoidea* being the only two recent British species which, like our Crag shells, are denticulated on the inner side of the outer lip. I have assigned it to *conspicua* with doubt, as it may not improbably be some foreign species unknown to me.

ODOSTOMIA UNIDENTATA, *Montagu.* Appendix, p. 317, Tab. XXXI, fig. 11.

Localities. Red Crag, Walton. Middle Glacial, Billockby?

In addition to the solitary specimen from Walton, mentioned p. 317 of Appendix, a specimen has occurred in the Middle Glacial sand at Billockby that seems referable to this species, but it is not sufficiently perfect to be free from doubt.

ODOSTOMIA OBLIQUA? *Alder.* Supplement, Tab. IV, fig. 24.

ODOSTOMIA OBLIQUA, *Alder.* Ann. and Mag. Nat. Hist., vol. xiii, p. 327, pl. viii, fig. 12.

Locality. Cor. Crag, Sutton.

A single specimen, obtained by me from the Cor. Crag of Sutton, is represented in the above figure, and referred with doubt to the above species; it is, I believe, a young individual, and the form not very well shown. Mr. A. Bell has since my engraving was made found a full-grown specimen, which I would rather have figured.

ODOSTOMIA? ORNATA, *S. Wood.* Crag. Moll., vol. i, p. 87, Tab. IX, fig. 6 (as *O. similima*).

This shell is, I now believe, quite distinct from *O. simillima* of Montague, to which I assigned it with doubt in the 'Crag Moll.' I am unable to refer the Crag shell to any species known to myself, either British or European. In my 'Catalogue of Crag Mollusca,' 1842, it was called *Rissoa? costellata*, but as the name *costellata* is already appropriated to another shell, I propose to call it *ornata.* It is so aberrant a form of *Odostomia* that I had intended to erect a new genus for it, but I have thought it better to leave that task to some future author, when some allied forms that can be grouped with it may have been discovered.

ODOSTOMIA ALBELLA, *Lovén.*

Since the figures for this Supplement were engraved Mr. Robert Bell has sent me from the Coralline Crag of Sutton a specimen with the name *albella* attached, but I have not yet had the opportunity of comparing it with Lovén's shell.

Genus.—EULIMENE.

In the 'Crag Mollusca,' vol. i, p. 109, two Red Crag shells are referred to the genus *Paludestrina*, viz. *P. pendula* and *P. terrebellata.* The first of these was described in my Catalogue of 1842 as *Eulima pendula.* In external shape both these shells resemble some of the forms of the genus *Niso*, but are distinguishable from them by the absence of the large open umbilicus. They also approach some forms of the genus *Eulima*, but, unlike that genus, the labium (or left lip) is extended over the umbilicus.

Feeling the impropriety of keeping these shells in the genus *Paludestrina*, and pressed by the difficulty of finding a genus suitable to their reception, I propose the above name *Eulimene* (one of the Nereids) for their reception.

Eulimene pendula, *S. Wood.* Crag Moll., vol. i, p. 109, Tab. XII, fig. 6 (as *Paludestrina pendula*).

Eulima pendula, *S. Wood.* Catalogue, 1842.

Locality. Walton Naze.

Eulimene terebellata, *Nyst.* Crag Moll., vol. i, p. 109, Tab. XII, fig. 7 (as *Paludestrina terebellata*).

Melania terrebellata, *Nyst.* Coq. Foss. de Belg., p. 413, pl. xxxviii, fig. 12, 1844.

Localities. Red Crag, Sutton, and Walton Naze.

Fig 21, *a*, *b*, Supplement Tab. IV, represents a specimen lately found by myself in the Cor. Crag of Sutton, which, from its imperfect state, I do not feel justified in referring to any particular name. The presence, however, of an open umbilicus shown in the figure, coupled with its tapering form, suggests some affinity with the genus *Niso*.

Eulima stenostoma, *Jeffreys.* Supplement, Tab. IV, fig. 25.

Eulima stenostoma, *Jeffreys.* Ann. and Mag. Nat. Hist., 3rd ser., ii, p. 128, pl. v, fig. 7.

Locality. Cor. Crag, Sutton.

A single specimen shown in the above figure has been found by me at Sutton, which, I think, may be referred to this species. The artist has not been very successful in its representation.

Eulima similis ? *D'Orbigny*, 1847. Supplement, Tab. VII, fig. 16.

Melania distorta, *Phil.* En. Mol. Sic., vol. i, p. 158, t. ix, fig. 10, 1836.
— — *Grateloup.* Pl. i, No. 4, fig. 14, 1847.
Eulima — *Forb.* and *Hanl.* Brit. Moll., vol. iii, p. 232, pl. xcii, figs. 4—6.
— Philippii, *Weinkauff.* Conch. des Mittelm., vol. ii, p. 228, 1868.

Length, $\frac{1}{4}$ of an inch.

Locality. Red Crag, Walton-on-the-Naze (*A. Bell*).

This specimen was put into my hands as *Eulima distorta* by Mr. Bell. The aperture appears to me to be too short for the recent species so called, and resembles a young specimen of *polita*. I therefore assign it to the above species with a note of interrogation.

The Paris basin shell first called *E. distorta* is, I think, with D'Orbigny and Weinkauff, distinct from the existing shell of that name, and I have therefore adopted D'Orbigny's name of *similis*, which has priority to that of *Philippii*, proposed for it by Weinkauff. The older tertiary fossil differs in size, as also in the proportions of the aperture, to the length of the shell. The flexure in the spire is present in the young of *E. polita*.

EULIMA SUBULATA, *Donovan*. Crag Moll., vol. i, p. 97, Tab. XIX, fig. 3.

Localities. Cor. Crag, Sutton, Ramsholt, and near Orford.

In 'Brit. Conch.,' vol. iv, p. 209, Mr. Jeffreys observes, in reference to the recent *subulata*, "This is not the *Eulima subulata* of Searles Wood nor that of Nyst;" and in the list to the Cor. Crag paper of Mr. Prestwich he repeats this, but at the same time gives the shell as a living West European abysmal form. I am, however, still unable to perceive any difference between the Crag shell and the living British shell *subulata*, and I have therefore retained the Crag shell under the name I originally assigned to it.

EULIMA BILINEATA ? *Alder*.

EULIMA BILINEATA, *Ald*. Forbes and Han., vol. iii, p. 238, t. xcii, fig. 9—10.

Locality. Cor. Crag, Sutton. Recent, Britain.

A specimen of *Eulima* in my collection, $\frac{1}{6}$th of an inch in length, retains the colouring matter on it, but is not otherwise distinguishable from *subulata*. This colouring matter forms a broad, fulvous spiral band, occupying the centre of the two lower whorls with traces of another narrow band at the upper and lower part of the same whorls. Mr. Alder in his description of this species says (Forbes and Han., vol. iii, p. 138) that "it has two bands placed close together in the centre of the body whorl, with occasionally a faint indication of another on the upper or lower margin." If by the obscuration due to the fossilization of my shell the two bands placed close together in the centre of the body whorl have coalesced into apparently one broad band, then the colouring of the recent and fossil shell agrees, but if not, the fossil may be a new species, for which I would propose the name of *E. dubia*. As the sole apparent difference between this and *subulata* consists in this coloration, I have not thought it necessary to figure the specimen.

EULIMA INTERMEDIA, *Cantraine?* Crag Moll., vol. i, p. 96, Tab. XIX, fig. 1 *a* (as var. *vulgaris* of *E. polita*).

Localities. Cor. Crag, Sutton. Red Crag, Walton Naze.

The shell figured 1 *a*, in Tab. XIX, of 'Crag Mollusca,' was there referred to *Eulima polita*, but Mr. Jeffreys, (Brit. Conch., vol. iv, p. 204,) considers the Crag shell to be *Eulima intermedia*, Cantraine, a distinct species. I have therefore upon this authority inserted the species here. Fig. 1 *b* of the same table represents the species to which it was there assigned, viz. *E. polita*, which occurs in the Cor. Crag, at Sutton, and in the Red Crag, at Walton.

EULIMA GLABELLA, *S. Wood.* Crag Moll., vol. i, p. 98, Tab. XIX, fig. 2, and Supplement, Tab. VII, fig. 4, *a*, *b*.

Locality. Cor. Crag, Sutton.

The shell figured and described by myself under this name is, I believe, quite distinct. The previous figure of my shell does not sufficiently represent the sinuosity in the outer lip, the lower portion having considerable projection; the contraction above causes a slight indentation in the whorl all up the volutions, such as is not possessed by any other British species of this genus. My shell much resembles *Eul. auriculata*, Von Koenen, 'Mittel Oligoc.,' p. 104, Tab. VII, fig. 3, *a—c*, judging from the figure, in having a deeply sinuated outer lip. This Crag shell has a rounded or obtuse apex, unlike the generality of species in this genus, some of which are occasionally decollated, but my shell does not appear to have been mutilated in that way. I have therefore given a fresh view of the mouth and lip of my shell.

EULIMELLA ACICULA, *Phil.* Crag Moll., vol. i, p. 84, Tab. X, fig. 11, *b*, *c* (as var. *lævigata* of *Chemnitzia similis*).

MELANIA ACICULA, *Phil.* En. Moll. Sic., vol. ii, p. 134, t. ix, fig. 6.

Localities. Cor. Crag, Sutton. Red Crag, Walton (*Bell*). Fluvio-marine Crag, Yarn Hill.

This shell I now consider is no variety of *Chemnitzia similis*, as supposed by me in the 'Crag Mollusca,' but the above *Eulimella* (*Melania*) *acicula* of Philippi.

It has been sent to me by Messrs. Crowfoot and Dowson from the Fluvio-marine deposit of Yarn Hill, near Potter's Bridge, Southwold, and Mr. Bell gives it from the Red Crag of Walton ('Ann. and Mag.,' September, 1870).

PALUDINA ? GLACIALIS, *S. Wood.* Supplement, Tab. IV, fig. 14, *a*, *b*., Tab. VII, fig. 25.

Localities. Chillesford Bed, Coltishall. Lower Glacial, Belaugh and Rackheath. Middle Glacial, Hopton.

Several specimens of this shell have occurred in the pebbly sands of Belaugh and Rackheath, and recently another was put into my hands by H. Norton, Esq., of Norwich, from the shell bed beneath the Chillesford Clay, at Coltishall.

The volutions in this shell, which I have referred to the genus *Paludina*, are flat, or rather inclined to be concave externally; the mouth is subcircular, and the inner lip slightly extends over a small umbilicus; the shell is by no means thin, and the apex is very much flattened. The lower glacial sands in which this shell has occurred, as well as the Chillesford Sand at Coltishall, are of Fluvio-marine origin; and in them, in actual association with this *Paludina glacialis*, specimens of *P. vivipara* occur, none of them presenting any sign of departure from their normal form; and I have seen nothing which by connecting this shell with *P. vivipara* would justify the idea that it was a variety of that shell. Moreover, it is difficult to conceive that any species of *Paludina* could thus assume so very distinct a form (which is shown to be common to several individuals) while living in association with the unaltered normal form of that shell.

The Middle Glacial specimen in Tab. VII differs in being more flattened, and it is from a formation which has not only afforded no indication of Fluvio-marine conditions, but whose physical relations indicate it to have been accumulated under several hundred feet of sea depth. The presence however, in abundance of *Littorinæ* in the Middle Glacial sands, renders it probable that some at least of the shells of those sands lived near a shore, and were transported by currents to the place where we now find them, so that the shell may in this way have been a denizen of an estuary or of a river, which was carried into a purely marine and deep-water area. Assuming this, and that it is really the young of *glacialis*, the shell must have undergone a change from its original form in the interval between the commencement of the Lower Glacial formation, where we get the shell at Belaugh and Rackheath, and the accumulation of the Middle Glacial deposit. It is quite possible, however, that the shell may be no *Paludina* at all, and I have assigned its name provisionally, and with doubt.

Paludina media, *Woodward.* Crag Moll., vol. i, p. 110, Tab. XII, fig. 1.

> Paludina media, *S. Woodward.* Geol. of Norfolk, pl. iii, figs. 5 and 6.
> — — *S. P. Woodward.* In Gunn's article on Geology of Norfolk in, White's Hist. and Directory of Norfolk Sheffield, 1864.

Locality. Fluvio-marine Crag, Bramerton and Thorpe.

The *Paludina* from Bramerton and Thorpe described in 'Crag Mollusca,' vol. i, p. 110, Tab. XII, fig. 16, was referred to *P. lenta* and *P. unicolor*, but which in vol. ii I changed to *P. parilis.* This Fluvio-marine shell of Bramerton I now think ought to have been called *P. media,* the name the late Dr. S. P. Woodward restored to it, and from his so doing I presume he also considered it a distinct species. This name was rejected by myself because there were two shells figured by S. Woodward, sen., in the 'Geology of Norfolk,' called *media* and *rotundata,* and I did not know which was to be considered the type.

Paludina Clactonensis, *S. Wood.* Supplement, Tab. I, fig. 4, *a. b.*

Locality. Post-glacial, Clacton.

The specimens figured were obtained at Clacton, by the Rev. O. Fisher. They were found by him in the marly portion of the deposit at that locality, in association with *Corbicula fluminalis,* and where I have also found some estuarine species *Mytilus edulis, Scrobicularia plana,* and *Tellina Balthica.*[1] Under these circumstances the peculiar thickened and somewhat angular form which it possesses, like *glacialis,* suggests the idea whether both it and *glacialis* are not distortions of some known species of *Paludina,* due to their living either in salt or brackish water. I have, however, given it provisionally the specific name of *Clactonensis.*

A shell from the diluvium at Templehof, near Berlin, called *P. diluviana,* Kunth ('Zeitschrift f. Geolog. Geschellschaft,' Berlin, 1865, Tab. VII, fig. 8), very much resembles *Clactonensis,* and may be identical with it.

Paludina contecta, *Millet.* Supplement, Tab. I, fig. 6.

> Cyclostoma contectum, *Millet.* Mollusca of Maine-et-Loire, 1813, p. 5.
> Paludina Listeri, *Forbes* and *Hanley.* Brit. Moll., vol. iii, p. 8, pl. lxxi, fig. 16.

Locality. Pre-glacial Forest Formation, Woman Hythe, Runton.

The above figure represents a shell from the purely freshwater deposit at Woman

[1] These three marine species may very possibly, however, not belong to the Post-glacial deposit at all, but be modern shells washed into it; the deposit where these shells occurred being on the present beach.

Hythe. This I have referred to *Paludina contecta* of Millet. The volutions are very convex, with a deep sutural line, and the apex is very acute.

PALUDINA VIVIPARA, *Linné*. Supplement, Tab. I, fig. 5.

HELIX VIVIPARA, *Linné*. Syst. Nat., 12th ed., p. 1247.
PALUDINA VIVIPARA, *Forbes* and *Hanley*. Vol. iii, p. 11, t. lxxi, f. 14, 15.

Localities. Chillesford bed, Easton Bavent Cliff. Lower Glacial, Rackheath.

The specimen figured is that of a small individual from Rackheath, but since it was engraved a full-grown specimen has been obtained by Mr. Cavell from Easton Cliff.

All these fossil forms differ so materially from each other, that I have placed them under separate names. They have in all probability descended from a common ancestor, and most likely *P. lenta* stood in that position, but altered circumstances materially altered their forms, so as to make them permanent varieties, which it is difficult not to call species.

I therefore refer my figured specimens in the following manner:—

Paludina media. Crag Moll., vol. i, Tab. XII, fig. 1.
— *Clactonensis* (*P. diluviana*, Kunth ?). Supplement, Tab. I, fig. 4, *a*, *b*.
— *glacialis*. Supplement, Tab. IV, fig. 14, *a*, *b*.
— *vivipara*. Supplement, Tab. I, fig. 5.
— *contecta*, id. Tab. I, fig. 6, *a*, *b*.

The species of the genus *Paludina* are of difficult determination, and naturalists are far from being in accord respecting their specific limitations. M. Deshayes says ('Hist. des An. sans Vert.,' vol. ii, p. 483): "Nous devons affirmer n'avoir jamais vu une espèce vivante quelconque, absolument identique avec l'espèce fossil d'Angleterre ou de France;" speaking of the Older Tertiaries. When I applied to Mr. Jeffreys for his opinion respecting the Clacton shell, he replied in letter, March, 1865, (with permission to quote his opinion), "I could find no difference between those (the *Clactonensis*) and crag specimens. I consider the *P. lenta* from the so-called upper Eocene Beds and your *P. parilis* or *P. lenta* of the Crag as the same species, and that this species (including each fossil form) is distinct from *P. unicolor* of the Nile." In the discussion on one of Mr. Prestwich's papers upon the Crag ('Quart. Journ. Geol. Soc.,' vol. xxvi, p. 282), Mr. Jeffreys, however, calls the Crag species *Paludina unicolor;* from which it would seem that this opinion of 1865 has been modified. It must be admitted that the specific determination of the various forms of this genus is in an unsatisfactory state.

HYDROBIA ULVÆ, *Pennant.* Supplement, Tab. IV, fig. 23. Crag Moll., vol. i, p. 109 (as *Paludestrina ulvæ*).

TURBO ULVÆ, *Penn.* Brit. Zool., 4th ed., vol. iv, p. 132, pl. lxxxvi, fig. 120.

Localities. Red Crag, Walton (Bell)? Fluvio-marine Crag, Yarn Hill, near Southwold. Chillesford bed, Aldeby. Post-glacial, Gedgrave.

This species I have not seen as fossil from either of those purely marine formations, the Coralline and Red Crags. The specimen figured is from a formation at Gedgrave, mentioned in vol. i, p. 109, which is, I believe, a post-glacial bed, where land and freshwater shells of an old post-glacial period are intermixed with a re-deposit of Coralline Crag derivatives. It has been found by Mr. Reeve in the Fluvio-marine Crag at Bramerton, and by Messrs. Dowson and Crowfoot at Yarn Hill and Aldeby. This species is given by Mr. Bell from Walton (' Ann. and Mag. Nat. Hist.,' Sept., 1870), but I have not seen the shell.

HYDROBIA SUBUMBILICATA, *Mont.* Crag Moll., vol. i, p. 108, Tab. XI, fig. 2 (as *Paludestrina subumbilicata*).

Localities. Fluvio-marine Crag, Bramerton. Chillesford bed, Bramerton.

This species, so very common in the Fluvio-marine Crag at Bramerton, is, I am informed, very rare in the Marine Chillesford bed at that place, and I have not met with it in the Chillesford bed elsewhere, nor in the Lower or Middle Glacial Sands. I agree in the distinction drawn by Montagu between this shell and its congeners *ulvæ* and *ventrosa;* and distinct from all these is, in my opinion, *Hydrobia thermalis* (*Helix octona*?, Linn.), Crag Moll., vol. ii, p. 319, Tab. XXXI, fig. 12, to which I have referred the shells found in the freshwater (older post-glacial) deposits of Clacton and Grays.

RISSOA PROXIMA, *Alder.* Supplement, Tab. IV, fig. 17.

RISSOA PROXIMA, *Alder MS.* Thompson, An. Nat. Hist., vol. xx, p. 174.

Locality. Coralline Crag, Sutton.

In deference to the British conchologists, I have separated two specimens which I had considered as varieties of *R. vitrea.* They were pointed out to me by Mr. Jeffreys as specifically distinct. The striæ with which they are covered (which are not very visible in my fossils) appear to be the only character by which they can be distinguished.

Rissoa eximia? *Jeffreys.* Supplement, Tab. VII, fig. 5.

> Rissoa eximia, *Jeff.* Ann. and Mag. Nat. Hist., n. s., vol. iv, p. 299, 1849.
> Chemnitzia eximia, *Forb.* and *Hanl.* Brit. Moll., vol. iv, p. 278, pl. xc, fig. 1, as *Rissoa eximia.*
> Odostomia eximia, *Jeff.* Brit. Conch., vol. iv, p. 155, pl. lxxv, fig. 4.

Localities. Coralline Crag, Sutton. Living, Shetland Seas.

The single specimen of this shell, which is represented in the figure as above, is all that I have yet met with, and was found by myself in the Coralline Crag of Sutton. It is strongly ribbed, and has three somewhat broad spiral striæ on the lower part of the whorl, in which respect there is a slight inaccuracy in the figure which shows but two such striæ. These striæ crossing the ribs give rise to two rows of depressions or cavities between them. The specimen is slightly worn.

Rissoa semicostata, *Woodward* (non *Mont.*). Crag Moll., vol. i, p. 102, Tab. XI, fig. 10, and also fig. 9 (as *R. pulchella*).

Localities. Red Crag, Butley, Sutton, and Kesgrave. Middle Glacial, Billockby.

This shell was described by Woodward in his 'Geology of Norfolk' (1833) under the name of *Turbo semicostatus*, auctorum, but the authors of the 'British Mollusca' and the author of the 'British Conchology' agree that Montagu's *Turbo semicostatus* is identical with *R. striata* of Adams. As, however, I consider the Crag fossil to be distinct from any known recent species, I have retained it under the name of *semicostata*, Woodward, that name being unoccupied now that Adams' older name of *striata* is applied to the other (Montagu's) shell; the synonym *Turbo semicostatus*, Mont., given at page 102 of 'Crag Moll.,' being an error. His son, Dr. Woodward, in the list of Norwich Crag shells in White's Directory of Norfolk, refers this species to *inconspicua*, Alder; but the Crag forms invariably have the outer lip thickened and dentated within, which the recent *inconspicua* has not; and if this be a specific character, the two shells must be distinct.

My identification of the shell shown in fig. 9, of Tab. XI, of Crag Moll., with *pulchella*, Phil., has been dissented from; and in such dissent I agree, as I now believe it to be the same as *semicostata*, Woodward; I therefore unite these species under the name of *semicostata*. Since the publication of the 'Crag Moll.' I have obtained three specimens of the original *semicostata*, Woodward (fig. 10 of Tab. XI), from the Red Crag of Butley, which may be synchronous with the Fluvio-marine Crag of Bramerton, from which the shell shown in fig. 10 came. Those figured as *pulchella* (fig. 9, *a*, *b*) were, from what I consider to be, an older portion of the Red Crag, viz. that at Kesgrave and Sutton. Possibly in the interval the shell may have undergone a slight change. Both forms of the shell, with the denticulations well shown, are not uncommon in the Middle Glacial of Billockby, but I have not seen it from either the Chillesford bed or the Lower Glacial sand.

Rissoa senecta, *S. Wood.* Supplement, Tab. V, fig. 15.

Locality. Cor. Crag, Sutton.

Length, $\frac{1}{10}$th of an inch.

A single specimen of this genus, shown in the figure above referred to, has lately been found by myself, which I cannot refer to a known species, and I have therefore given to it provisionally the above name. The volutions (about five) are nearly flat; the costæ few (ten or eleven), large, coarse, and wrinkled; suture distinct, but not deep; spiral striæ large and distant; body whorl two thirds the length of the shell; aperture large and ovate.

Rissoa reticulata? *Mont.* Crag Moll., vol. i, p. 103, Tab. XI, fig. 5.

In the 'Crag Mollusca' I referred this shell to *R. reticulata,* Mont., with a doubt.

Dr. Hörnes makes this Crag shell identical with *R. Montagui,* Payr., and in the list in Mr. Prestwich's Coralline Crag paper Mr. Jeffreys refers the Crag shell to "*R. calathus,* F. and H., not *R. reticulata,* Mont.," while in his 'Brit. Conch.,' vol. iv, p. 12, he says *calathus* is but a very doubtful species, and in his view only a variety of *R. reticulata;* and then adds (p. 13) that S. Wood's Crag shell called *reticulata* more resembles *calathus* than *reticulata,* and may be an intermediate variety. In this chaos of opinion I have thought it wisest to retain my shell under the designation given to it in the 'Crag Mollusca,' and with the same doubt.

Rissoa Stefanisi, *Jeffreys.* Crag Moll., vol. i, p. 106, Tab. XI, fig. 12 (as *R. costulata,* S. Wood).

Rissoa Stefanisi, *Jeff.* Brit. Conch., vol. iv, p. 36.

This shell was described by me in the 'Crag Mollusca' as a new species in ignorance that the name was preoccupied for other shells, as has been pointed out by Mr. Jeffreys in vol. iv, p. 36, of 'Brit. Conch.,' who there proposed for it the name *Stefanisi.* This name I have therefore adopted.

Natica proxima, *S. Wood.* Crag Moll., vol. i, p. 143, Tab. XVI, fig. 4; Supplement, Tab. IV, fig. 12.

Localities. Cor. Crag, Ramsholt. Red Crag, Butley.

This shell has been described as living in British and Mediterranean seas under the name *N. sordida* of Philippi, by Forbes and Hanley ('Brit. Mol.,' vol. iii, p. 334), and by Jeffreys ('Brit. Conch.,' vol. iv, p. 219). As, however, Philippi's name was two years subsequent to that (*proxima*) given by me in my 'Catalogue' of 1842, I have retained it under my own name. I have now obtained a specimen from the Red Crag, Butley, which is represented in Supplement, Tab. IV. *N. proxima,* S. Wood, is referred by Weinkauff to *N. fusca*, De Blain, to which species the author of 'Brit. Conch.,' in vol. v, p. 215, also refers *sordida.*

Natica helicina? *Brocchi.* Supplement, Tab. IV, fig. 8, *a*, *b*.

Nerita helicina, *Broc.* Foss. subap., p, 279, t. i, fig. 10, 1814.
Natica — *Hörnes.* Foss. Moll. des Wien. Beck., vol. i, p. 525, t. xlvii, figs. 6, 7.

Localities. Cor. Crag, Sutton. Red Crag, Walton Naze, Essex. Bentley, Suffolk.

A few specimens of what I imagine to be the species above referred to have recently been found by myself at both the above localities.

Natica Alderi, *Forbes.* Supplement, Tab. VII, fig. 27.

Natica Alderi, *Forbes.* Malac. Monen., p. 31, pl. ii, figs. 6, 7.
— nitida, *Forb.* and *Hanl.* Brit. Moll., vol. iii, p. 330, pl. c, figs. 2—4.
— — *Rose.* Geol. Mag., vol. ii, p. 11.

Localities. Cor. Crag, Gedgrave. Fluvio-marine Crag, Yarn Hill. Middle Glacial, Hopton and Billockby. Post-glacial, March and Kelsea Hill gravels and Nar. Brick-earth, at West Bilney, and East Winch (*Rose*).

Five specimens belonging undoubtedly to this species have been found by Mr. Rose in the Nar. Brick-earth, one of which is figured as above. These shells have the exterior quite perfect, smooth, and glossy, but I am not able to see the remains of any coloured markings, and they most probably belonged to the white variety. Some specimens of this shell (but none full grown) have occurred in the Middle Glacial sand of Hopton and Billockby. I am inclined to think that the shell described in 'Crag Moll.' (vol. i. p, 142, Tab. XVI, fig. 1) from the Red Crag, as *N. Guillemini* belongs to the present species, or it may be the young of *N. catenoides.*

N. Alderi has been found at Yarn Hill by Mr. Crowfoot. I have seen a fine specimen found by Mr. Harmer at March, and it is given (under the name *nitida*) by Mr. Jeffreys from Kelsea Hill. Since my plate has been engraved I have found a specimen of this species in the Coralline Crag of Gedgrave.

Natica clausa. Crag Moll., vol. i, p. 147, Tab. XVI, fig. 2.

Localities. Red Crag, Sutton and Butley. Fluvio-marine Crag, Bramerton. Chillesford bed, Aldeby, and Horsted. Lower Glacial, Rackheath. Middle Glacial, Hopton, and Billockby. Upper Glacial, Bridlington. Post Glacial, Kelsea Hill.

Specimens of this species have been now obtained from all the above formations. It is not uncommon in the Middle Glacial, but the specimens are all young shells. It seems the reverse of common in all the formations prior to the Middle Glacial. It is given from Kelsea Hill by Mr. Jeffreys.

Natica Grœnlandica, *Beck.* Crag Moll., vol. i, p. 146, Tab. XII, fig. 5.

Localities. Red Crag, Butley. Fluvio-marine Crag, Bramerton, and Thorpe in Suffolk. Chillesford bed, Chillesford. Upper Glacial, Bridlington. Post Glacial, Kelsea Hill.

Since the publication of the 'Crag Moll.,' I have myself found this shell at Butley and Chillesford. It has been found by Mr. Reeve in the Fluvio-marine Crag, Bramerton, and is given by Mr. A. Bell from that of Thorpe in Suffolk.

Mr. Jeffreys gives it from Kelsea Hill. It appears to me that the *N. borealis* of Mr. A. Bell's list in the 'Ann. and Mag. Nat. Hist.' for May, 1871, is *N. Grœnlandica*, Beck.

Natica hemiclausa, *Sow.* Crag Moll., vol. i, p. 144, Tab. XIV, fig. 5.

Localities. Red Crag, Walton, Sutton, and Butley. Chillesford bed, Easton ?

In my Monograph I gave this shell from Walton and Sutton, and I have since found it at Butley. Mr. A. Bell informed me that he had observed it at Easton Cliff, but he has not so given it in either of his lists in the 'Ann. and Mag. of Nat. Hist.' Dr. Woodward gives it in his list (in 'White's Directory') as common at Norwich, but I have not met with an instance of its occurrence in that neighbourhood.

NATICA CIRRIFORMIS, *Sow.* Crag Moll., vol. i, p. 145, Tab. XVI, fig. 7.

I only know this shell as a Cor. Crag species. It is given, however, by Mr. Bell ('Ann. and Mag. Nat. Hist.,' September, 1870) from the Red Crag of Sutton, and of Waldringfield, but I have not seen the specimens.

NATICA MULTIPUNCTATA, *S. Wood.* Crag Moll., vol. i, p. 148, Tab. XVI, fig. 9.

This shell Mr. Bell informed me he had obtained from the Chillesford bed of Easton Cliff, but I have not seen the specimen, nor does he give it in either of his lists in the 'Ann. and Mag. of Nat. Hist.;' personally I only know the species from the Red Crag of Walton, Sutton, and Butley, and from the Cor. Crag.

NATICA OCCLUSA, *S. Wood.* Crag Moll., vol. i, p. 146, Tab. XII, fig. 4, Supplement, Tab. IV, fig. 11.

Localities. Red Crag, Butley. Chillesford bed, Easton Bavent? Upper Glacial, Bridlington.

This species was proposed by me for the Bridlington shell, figured in 'Crag Moll.' Since then I have obtained the specimen represented in fig. 11 of 'Supplement,' Tab. IV, from the Red Crag at Butley, which appears to resemble *N. occlusa* from Bridlington very closely, though the spire is not quite so much elevated, but more so than that in *N. clausa.* I have therefore referred it to the Bridlington species; Mr. Bell gives it from Easton Bavent, but I have not seen the specimen.

NATICA CATENA, *Da Costa.* Crag Moll., vol. i, p. 142, Tab. XVI, fig. 8.

Localities. Red Crag, Sutton and Butley. Fluvio-marine Crag, Bramerton. Chillesford bed, Horstead and Coltishall. Lower Glacial Sand, Belaugh. Middle Glacial, Billockby and Hopton. Upper Glacial, Bridlington.

In none of the fossil specimens of this shell that I have seen are there any remains of the marks resembling those upon the recent shell. In 'Brit. Conch.,' vol. iv, p. 222, is the following observation, "The coloured markings of this species (*catena*) are not exhibited in the Crag shells so named by Mr. Wood, although they are retained in his *N. millepunctata*"—a remark that seems to imply a doubt as to the correctness of my reference of *catena.* The cause of this difference I imagine is that the *red* spots of the one are more durable than the *brown* chain-like markings of the other, as in the dead or beach laid specimens they are generally invisible. *Red* spots appear to be permanent upon some of the Older Tertiary *Pleurotomæ,* and I believe that colour is preserved upon some of the older Secondary Fossils. So far as the uncertainty which always attaches from the resemblance to this species which other species, when fossil, may from decortication put on, will allow me to say, *N. catena* seems common in the Fluvio-marine Crag of Bramerton, and in the Chillesford bed at Horstead and Coltishall, but rare in the Lower Glacial sands, and is common in the young state in the Middle Glacial of Hopton Billockby. I have not seen it from the Post-Glacial beds of East Anglia.

NATICA PUSILLA? *Say.* Supplement, Tab. IV, fig. 9.

NATICA PUSILLA, *Say.* Journ. Acad. Nat. Sci. Phil., ii, p. 257, 1822.
— — *Binney.* Gould. Inv. Massach., 2nd ed., p. 344, fig. 613, 1870.

Locality. Coralline Crag, near Orford.

The above represents a shell I have lately obtained, but, like the generality of specimens of the Crag *Naticæ,* the glossiness of the exterior is gone. I have given it the above name with doubt, as my shell differs in some respects from the existing one. On comparing my specimen, it seems to have rather more convex volutions than the recent *pusilla,* and the pad over the umbilicus larger and more extended in the Crag shell. It resembles somewhat *Nat. occulta,* Desh., 'Des. An. sans Vert.,' Pl. LXVIII, figs. 11—13, and it appears intermediate between the two, as if the Crag one descended from the Paris basin shell with alteration, and the recent species from the Crag one with still further alteration. I feel much disposed to consider it specifically distinct, and to call it *N. occultata,* but having only two or three specimens, and those with the exterior not perfect, I have preferred giving it the above name.

NATICA CATENOIDES, *S. Wood.* Crag Moll., vol. i, p. 141, Tab. XVI, fig. 16, Supplement, Tab. IV, fig. 13 *a, b.*

Localities. Red Crag, Waldringfield, Sutton, and Walton. Chillesford bed, Easton Bavent. ?

The shell represented in fig. 13 of Supplement, Tab. IV, was obtained at Waldringfield by Mr. Canham, which being much larger than the one represented in 'Crag Moll.,' I thought it desirable that it should be figured; especially as considerable uncertainty has existed, and, indeed, still exists, respecting the correct appropriation of this Red Crag shell. The late Edward Forbes considered it identical with *N. glaucina* (*catena*), 'Mem. of the Geol. Survey,' 1846, p. 430; while in the 'Brit. Moll.,' vol. iii, p. 306, 1853, the authors refer this Crag shell to *Nat. sordida.* Again, M. Thuden has still more recently placed it as a doubtful synonym with *Nat. nitida* ('Om. de J. Bohus. Postplioc. eller. glac. format.,' p. 56, 1866). I cannot say that I agree with any of these references; the shell more resembling *Nat. heros,* Say, to which Mr. Jeffreys refers it. I believe however that it is distinct, as that shell has a deeper suture. I have found some imperfect specimens in the Cor. Crag of Sutton which may possibly belong to *catenoides* but more probably to *N. helicina,* Broc. *N. catenoides* is given also by Mr. Bell from Easton Cliff, ('Ann. and Mag. Nat. Hist.,' September, 1870) but I have not seen the specimen.

Natica Montacuti, *Forbes.* Supplement, Tab. IV, fig. 10.

Natica Montacuti, *Forb.* Malac. *Monen.*, p. 32, pl. ii, figs. 3, 4.

Locality. Upper Glacial, Bridlington.

My figure represents a specimen in the British Museum, among the Bridlington Fossils, to which the above name is attached, and this I think may be fairly referred as above. This name is introduced by the late Dr. S. P. Woodward in his list of Bridlington Shells, 'Geol. Mag.,' vol. i, p. 53.

Natica helicoides, *Johnston.* Crag Moll., vol. i, p. 145, Tab. XVI, fig. 3.

Localities. Red Crag, Sutton and Butley. Fluvio-marine Crag, Bramerton. Chillesford bed, Horstead, Coltishall, and Aldeby. Lower Glacial, Belaugh. Middle Glacial, Hopton. Upper Glacial, Bridlington. Post Glacial, March and Kelsea Hill.

This shell appears to be rare in the Red and Fluvio-marine Crags, but common in the Chillesford bed at certain localities. It is rare in the Lower Glacial, and a single young specimen only has occurred in the Middle. It is very abundant and of large size in the March gravel. Mr. Jeffreys gives it as rare at Kelsea Hill.

Three small specimens were found by myself in the Coralline Crag of Sutton, which I once thought belonged to the genus *Natica*, and I called them *Natica depressula* ('Crag Moll.,' vol. i, p. 149), but which I afterwards described in vol. ii, p. 319, as *Jeffreysia patula.* I am sorry to say no other specimen resembling them has since come into my possession. Mr. Jeffreys says they are the fry of *Velutina virgata.* They are probably the fry of some species, but I think not of *virgata,* as my Crag specimens of that species have a larger and more obtuse apex.

Amaura candida, *Möller.* Supplement, Tab. I, fig. 3 *a, b.*

Amaura candida, *Möll.* Ind. Moll. Groenl., p. 7, 1842.
— — *H.* and *A. Adams.* Genera, vol. i, p. 214, pl. xxii, fig. 9, 1858.
— — *A. Bell.* Ann. and Mag. Nat. Hist., September, 1870.

Locality. Red Crag, Butley.

This was found by Mr. Bell, to whom I am indebted for the use of the specimen for the above figure; it is the only one I have seen from the Crag.

LITTORINA RUDIS, *Maton*. Supplement, Tab. V, figs. 9 and 10 *a*, *b*.

In my Monograph, vol. i, p. 118, Tab. X, fig. 14, *a—k*, I have given figures and descriptions of a variety of forms of shells belonging to the genus *Littorina*, from the Fluvio-marine Crag of Norfolk and Suffolk, which I had considered as all belonging to one species, *littorea*, and I have here had figured two or three more to show the extraordinary range in variation to which they had been subject. The British Conchologists, although they have kept separate several forms of this genus, have no accordance respecting specific division.

I have obtained a very large number of specimens of *Littorinæ* from the Fluvio-marine Chillesford bed, at Horstead and Coltishall, and from the Lower Glacial sand at Belaugh, and these correspond principally with the form usually seen in our markets. With these, as might be supposed, are small or young specimens strongly marked with spiral striæ and with a well-defined suture, while the large or full-grown specimens are nearly smooth. Two or three of the distorted figures of *Littorina*, 'Crag Mol.,' vol. i, Tab. X, fig. 14, may probably be referred to what is called *rudis*. Mr. Jeffreys says (vol. iii, p. 367) that *rudis* is viviparous, and *littorea* oviparous. If this be so, that distinction might entitle them to be considered as more than specifically distinct; but as far as their testaceous covering goes there seems so much intermingling of character between *rudis* and *littorea*, not to speak of the numerous other forms treated as species or varieties, that I confess to the greatest uncertainty in assigning shells to these respective species separately; what seems to be *L. rudis* from Bramerton is shown in Tab. V, fig. 9; and a distortion of the same species from the same place, put into my hands by Mr. Horace Woodward, is shown in fig. 10. *L. littorea* occurs also in the Middle Glacial at Hopton and Billockby, in the Upper Glacial at Bridlington, and in the Post-Glacial Gravels of March, Hunstanton, and Kelsea Hill, and in the Nar Brickearth.

LACUNA RETICULATA, *S. Wood*. Crag Moll., vol. i, p. 122, Tab. XII, fig. 10.

MACROMPHALUS RETICULATUS, *S. Wood*. (Catalogue of shells from the Crag.) Ann. Nat. Hist., 1842, p. 537.

This shell is excessively rare to my researches, and I am unable to give to it any additional particulars; it does not strictly conform to the characters of the genus as generally described, but it has a broad and flattened pillar lip or elongated umbilicus; it nearly resembles *Lacuna elegans*, Deshayes, 'An. sans Vert. du Bas. de Par.,' vol. ii, p. 371, Pl. XVII, figs. 4—6, but it is probably distinct. Another species, somewhat resembling it, is placed in the same genus by Dr. von Koenen, 'Mittel Olig. Norddeutschlands,'

Tab. VII, fig. 10, called *L. striatula*, which, however, I think is also different from the Crag shell. *Lacuna cliona*, Raincourt and Munier, 'Journ. de Conch.,' vol. xi, p. 201, Pl. VII, fig. 1, is a similar Eocene fossil with a reticulated surface; this group might, I think, be separated from *Lacuna*, the only resemblance to which is the elongated umbilicus. Fig. 23 of Supplement Tab. V was engraved under an impression I had that it might be *Lacuna quadrifasciata*. It, however, differs so little from some of the least elongated forms of *Littorina suboperta*, that it may be an immature form of that shell.

LACUNA VINCTA, *Mont.* Crag Moll., Appendix, p. 316, Tab. XXXI, fig. 13.

Localities. Fluvio-marine Crag, Bramerton. Post Glacial, March, and Kelsea Hill.

This shell seems to be confined to the Fluvio-marine Crag (where, according to Mr. Reeve, it is rare) and not to have occurred in any other Crag, or East Anglian Glacial bed. It is abundant and in good preservation in the March Gravel, and is given by Mr. Jeffreys as abundant at Kelsea Hill.

LACUNA CRASSIOR, *Mont.* ?

This shell is given as occurring at Kelsea Hill, by Mr. Jeffreys, in 'Quart. Jour. Geol. Soc.,' vol. xvii, p. 450, but he is silent as to it in his 'Brit. Conch.' I insert it, therefore, with doubt as an East Anglian fossil.

TROCHUS TURGIDULUS ? *Brocchi.* Supplement, Tab. V, fig. 8.

TROCHUS TURGIDULUS, *Broc.* Conch. foss. Subap., vol. ii, p. 353, t. v, fig. 16, 1814.

Alt. $\frac{1}{4}$ of an inch.

Locality. Coralline Crag, Sutton.

Two small specimens found by myself are here referred with doubt to the above-named species; they differ from *T. Montacuti* in having a sharper angle to the lower part of the volution, and they have been somewhat abraded, by which a great part of the outer coating has been removed, obliterating some of its character. They are smaller than the representation by Brocchi, but they may not be full grown; they resemble the figure by Dubois, 'Coq. Foss. Volh. Pod.,' Pl. II, figs. 29, 30, but are less strongly striated. It is, however, an unsatisfactory identification.

TROCHUS TUMIDUS, *Mont.* Crag Moll., vol. i, p. 130, Tab. XIV, fig. 2.

Localities. Red Crag, Sutton. Fluvio-marine Crag, Bramerton. Chillesford bed, Bramerton, and Aldeby.

This shell has been found by Mr. Reeve in the Chillesford bed at Bramerton, as well as in the Fluvio-marine Crag below, and by Messrs. Crowfoot and Dowson at Aldeby.

TROCHUS ZIZYPHINUS, *Linné.* Crag Moll., vol. i, p. 124, Tab. XIII, fig. 9.

Localities. Cor. Crag, Sutton, Ramsholt, and near Orford. Red Crag, Sutton. Fluvio-marine Crag, Bramerton. Middle Glacial, Hopton?

This species is given in Dr. Woodward's Nor. Crag list in 'White's Directory,' but I have not myself seen it from that Crag. Fragments of a large, finely striated Trochus are common in the Middle Glacial sand of Hopton, which, there can be little doubt, are of this species.

TROCHUS CINERARIUS, *Linné.* Crag Moll., vol. i, p. 131, Tab. XIV, fig. 7.

Localities. Red Crag, Walton and Sutton. Middle Glacial, Hopton. Post Glacial, March.

I have not met with any certain trace of this shell in the Fluvio-marine Crag or at any of the localities of the Chillesford bed, at which I am somewhat surprised. One tolerably perfect specimen and several imperfect have occurred in the Middle Glacial sand of Hopton, and I have it from the March Gravel. Some very injured apices of a Trochus sent me from Bramerton may not improbably belong to this shell, but they are not sufficient to justify my inserting it from that locality.

TROCHUS NODULIFERENS, *S. Wood.* Crag. Moll., vol. i, p. 126, Tab. XIII, fig. 6 (as *T. papillosus*); and Supplement, Tab. V, fig. 14.

TROCHUS GRANOSUS, *S. Wood.* Catalogue, 1842.
— PAPILLOSUS, *Da Costa.* Crag. Mollusca, vol. i, p. 126.

Localities. As in 'Crag Moll.' and Fluvio-marine Crag, Bramerton and Thorpe? Middle Glacial, Hopton?

In speaking of this shell in the 'Crag Mollusca' I pointed out the differences which existed between it and the recent *papillosus*, Da Costa (*granulatus*, Born), but I did not consider that they justified my referring it to a distinct species. The author of the 'Brit.

Conchology,' however, insists that this Crag shell is distinct from the living *papillosus* (*granulatus*).

In 'Supplement,' Tab. V, fig. 14, I have shown a specimen from Walton Naze, which represents another of the various forms of this shell, and which in its granulations seems undistinguishable from the recent *papillosus*, but is much flatter, and without any convexity in the whorls. Under these circumstances I have thought it best provisionally to place the shell shown in the above figure, and in figures 6, *a*, *b*, *c*, of Tab. XIII of 'Crag Mollusca,' as a new species under the name *noduliferens*.

Whether *T. granulatus*, from Walton Naze, in Mr. Bell's list ('Annals and Mag. Nat. Hist.,' September, 1870), presents any nearer approach to the living shell I know not, as I have not seen the specimen.

Dr. Woodward gives *Trochus granulatus*, Born (*similis* Sby.), in his list of Norwich Crag shells in 'White's Directory,' as from Bramerton and Thorpe, on more than one authority. But whether the recent *granulatus*, or the above shell now called *noduliferens* is meant I am unable to say.

Fragments of a granulated Trochus occur in the Middle Glacial of Hopton that may belong either to this shell or to *papillosus* (*granulatus*).

TROCHUS BULLATUS, *Phil.?* Crag Moll., vol. i, p. 124, Tab. XIII, fig. 4 (as *T. zizyphinus*, var. *monstrosa*); Suppl., Tab. VII, fig. 20.

TROCHUS BULLATUS, *Philippi*. Moll. Sic., p. 226, vol. ii, t. xxviii, fig. 8.

Localities. Cor. Crag, Sutton and near Orford. Red Crag, Walton Naze.

The specimen figured in 'Suppl.,' Tab. VII, was obtained by me some years ago from the Reg Crag of Walton. It differs altogether from *zizyphinus* in the tumidity of the whorls and in the presence on them of faint granulations (which, however, rather resemble diagonal sculpturing than granulations), and in these particulars the shell seems identical with the figure and description of Philippi's species *bullatus*. I have also a half-grown specimen from the same locality. The shell figured in 'Crag Mollusca,' Tab. XIII, fig. 4, as *zizyphinus* var. *monstrosa*, from the Coralline Crag, Sutton, appears to be the same species, and Mr. Bell observes 'Ann. and Mag. Nat. Hist.,' May, 1871, that "he has obtained two specimens, one decorticated (similar to the shell figured in the 'Mon. Crag Moll.,' Tab. XIII, fig. 4), from the Cor. Crag, Gedgrave, and that Prof. Sequenza had sent him a series of Philippi's *T. bullatus* in all stages of growth and preservation, and a close comparison of their sculpture and form enabled him to correlate the Italian and Crag shells." Mr. Bell showed me the series thus obtained, and, as it seemed to bear out the view thus expressed, I have inserted the species from both the Coralline and Red Crag.

Margarita Groenlandica, *Chemnitz.* Supplement, Tab. V, figs. 11, *a, b.*

Trochus Groenlandicus, *Chemn.* Conch. Cab., vol. v, p. 108, t. clxxi, fig. 1671.
Margarita undulata, *Gould.* Invert. Massach., p. 254, fig. 172.*
— — *S. P. Woodward.* Norwich Crag Shells, p. 5, 1864.

Diameter, $\frac{1}{4}$ of an inch.

Locality. Fluvio-marine Crag ?, near Norwich. Middle Glacial, Hopton.

A specimen of this species has been obligingly forwarded to me by Mr. Bayfield, of Norwich, and he thinks it was found either at Thorpe or Postwick, but he is not able to say whether it is from the upper or lower bed. The present specimen is not a full-grown individual, as it possesses little more than three volutions. G. B. Sowerby describes this shell (*M. undulata*) as having four, Messrs. Forbes and Hanley describe it as having five, and Mr. Jeffreys as having six, volutions.

Three varieties of this species are given by Mr. Jeffreys, and our present shell seems to correspond with the one he has named *lævior*, which is said to be smooth. The Crag shell has visible lines of growth with one or two nearly obsolete spiral ridges, but there are no nndulations upon the upper part of the volution.

The pullus of this species, as well as those of *M. maculata* and *M. trochoidea*, are free from striæ or ornament of any kind.

Several small specimens, more or less imperfect, of a *Margarita* have occurred in the Middle Glacial sand of Hopton. Their rubbed condition will not allow one to say positively that they belong to this species, but there can be little doubt of their belonging to one of the varieties of it.

Margarita maculata, *S. Wood.* Crag. Moll., vol. i, p. 135, Tab. XV, fig. 3.

Localities. As in 'Crag. Moll.'

This elegant species would be a shell of some importance if the one found fossil in America and also recent upon the Coast of California should be identical with it. I have not been able to see the fossil from Williamsburg, spoken of by Sir Charles Lyell "*Solarium,* nearly allied to *Solariella maculata,*" 'Proc. Geol. Soc.,' 1845, p. 555, but I have compared a recent shell from the Cataline Islands *Solariella peramabilis,* Carpenter, "Rep. Moll., West Coast of N. America," 'Brit. Assoc.,' p. 653, 1864, with the Crag species. The recent shell has a more elevated spire, and in consequence a more contracted umbilicus, while the striæ in the Crag shell are rather more distinct.

The shell from the Cataline Islands is of a rufous brown, and possibly the spots remaining upon the Crag fossil may be some of its original colour.

The little recent shell from the British seas, *Trochus pusilla,* is given by Dr. P. Carpenter as a synonym to *Margarita Vahlii*; the young state of *M. trochoidea* from the Crag could scarcely be separated from it.

MARGARITA ARGENTATA ? *Gould.* Supplement, Tab. V, fig. 12.

MARGARITA ARGENTATA, *Gould.* Invertebrata Mass., p 256, fig. 174.

Locality. Chillesford bed, Aldeby.

In a packet of shells found at Aldeby, and obligingly sent to me by Messrs. Crowfoot and Dowson, was the small and not quite perfect specimen figured as above. It is a young individual, and very distinctly striated all over, and I have (but with doubt) referred it to *Marg. argentata,* Gould. It has a small apex, differing in that respect from *M. trochoidea* of 'Crag Moll.'

Length, 0·1.

Mr. Jeffreys has, in vol. v, 'Brit. Conch.,' p. 202, given *argentata* as a synonym of *Margarita glauca,* Möller, 'Ind. Moll. Groenl.,' p. 8. The specimen now figured is more coasely striated than the representation of *Trochus glaucus* in 'Brit. Conch.,' vol. v, Pl. CI, fig. 6. Gould speaks of his shell as "composed of four convex whorls, the last of which is slightly angular." His figure does not show this angularity, but it is perceptible in the Crag shell.

ADEORBIS PULCHRALIS, *S. Wood.* Crag Moll., vol. i, p. 139, Tab. XV, fig. 4.

In the 'Quart. Journ. Geol. Soc.,' vol. xxvii, p. 495, it is said by Mr. Jeffreys, "*Adeorbis pulchralis.* Swedish expedition, 320—600 fathoms. *Margarita trochoidea,* S. Wood, is the same species." On a re-examination of my specimens I still believe they are distinct.

ADEORBIS STRIATUS, *Phil.* Crag Moll., vol. i, p. 137, Tab. XV, fig. 7 (as *Adeorbis striatus,* S. Wood.)

Locality. As in Crag Moll. only.

In 'Brit. Conch.,' vol. iii, p. 315, *Adeorbis striatus, A. supranitidus,* and *A. tricarinatus* are considered as varieties of a British shell called there *Trochus Duminyi,* Requien. A specimen from the Oligocene of Cassel sent me by Dr. von Koenen, with the name *carinatus* attached, approaches as near, or even nearer, to the three Crag species as (judging from Mr. Jeffreys' figure and description) does the recent *Duminyi.* While partaking, however, of a portion of the characters of the three Crag species, *carinatus* yet differs from all of them. *A. striatus* is finely striated, without carinæ; *A. supranitidus* is smooth, with one to three sharp carinæ, and coarsely striated within the umbilicus; and *A. tricarinatus* has three very elevated carinæ, with striations between them. These are the characteristics of the three Crag species, but *A. carinatus* from the Oligocene has three carinæ, of which two are more conspicuous than the third, and all are less elevated than in *tricarinatus,* while the recent *A. Duminyi* is described as having eight to ten sharp and narrow striæ on the upper part of the whorl, the lowest of which, being more prominent, forms one faint carina. *A. tricarinatus* is certainly nearer to the Oligocene species than to any other, but yet is, I think, distinct, the carinæ being so much more elevated. We have here five different forms, and I see no reason for not retaining my three Crag species under the names I gave them. Dr. Speyer unites Philippi's *dubius* with *carinatus.*

Solarium vagum, *S. Wood.* Supplement, Tab. VII, fig. 29, *a, b.*

Locality. Red Crag, Waldringfield.

Diameter, ½ an inch.

The figure above referred to represents another shell sent to me by Mr. Canham from the nodule workings at Waldringfield.

This I have placed in the genus *Solarium,* as it seems best entitled to that position, though somewhat of an aberrant character. I am unable to refer it specifically to anything known to me. The specimen is rubbed and worn, but it was probably, when perfect, nearly, or perhaps quite, smooth on the upper surface, with an obsolete ridge around or above the periphery; the under side has a moderate-sized umbilicus, edged with a sharp crenated, or rather nodulous, margin, like that of many species in this genus; its nearest resemblance is *Solarium simplex,* Bronn, but that species has only one ridge on the under side around the umbilicus, while upon our shell there are three or four spiral striæ. The present shell is the only representative of the genus *Solarium* that I know of from the Upper Tertiaries of England, and I suspect that it is derived from some older formation, for which reason I propose the name *vagum.* The shell spoken of as *Solarium pseudo-perspectivum,* from the mud deposit at Selsea,[1] 'Geol. Mag.,' vol. vi, p. 41, on which the name was founded, is a specimen of *Bifrontia Laudinensis,* washed into this mud bed from the Eocene formation beneath, where specimens of that species are abundant.

The genus *Phorus* is given by Philippi as fossil at Palermo, which deposit seems to belong to the Upper Tertiaries, but I have not seen this genus as fossil from beds newer than the Eocene in England. Mr. Whincopp showed me the cast of a species belonging

[1] This specimen is in the collection of Dr. Reed, of York.

to this genus which was obtained from the nodule workings in the Red Crag near Woodbridge, the matrix of which resembled that of an older Tertiary bed. It was evidently a derived specimen.

Cyclostrema lævis, *Philippi*. Supplement, Tab. V, fig. 13, *a*, *b*.

Delphinula lævis, *Phil.* En. Moll. Sic., vol. ii, p. 146, pl. xxv, fig. 2, 1844.

Diameter, one line, nearly.

Locality. Coralline Crag, Sutton.

I have two specimens which correspond so closely with the figure and description of the Mediterranean shell above referred to that I have adopted for them the name given by Philippi. I have compared my fossils with recent specimens of *serpuloides*, and I think the coarse and prominent ridges surrounding the umbilicus, of which there are no traces in *serpuloides*, is sufficient for specific distinction. The fine striations which cover the under side of *serpuloides* do not appear in my shell, but they may possibly have become obliterated.

Cyclostrema? sphæroidea, *S. Wood*. Crag Moll., vol. i, p. 122, Tab, XV, fig. 9 (as *Turbo*).

Locality. As in 'Crag Mollusca.'

This shell has, I find, beeen obtained by Mr. Jeffreys in the recent dredgings in the Bay of Tangiers, and in his 'Report,' 1870, p. 161, is referred by him to the genus *Cyclostrema* of Marryat, of which *Helix serpuloides* is supposed to be the type. I have here adopted that generic name, though not without misgivings, as the peretreme of my shell is not continuous. It does not seem far removed from *Adeorbis subcarinatus*.

Homalogrya atomus, *Phil.* Supplement, Tab. VII, fig. 28.

Skenea nitidissima, *Forb.* and *Han.* Vol. iii, p. 158, pl. lxxiii, f. 7, 8.
Homalogyra atomus, *Jeff.* Brit. Conch., vol. iv, p. 99.

Locality. Cor. Crag, Sutton.

This represents a very minute shell which I have lately found in the Cor. Crag of Sutton, and I am anxious to preserve its likeness on account of the dangers attending such a minim. It resembles the young state of *Valvata cristata*. My specimen is probably not full grown, as it has only two volutions. It is like the spiral portion of *Cæcum*, but it differs from that shell in having an upper and under side, whereas in *Cæcum* the whorls are perfectly horizontal. I have referred my present specimen to a recent shell, which Mr. Jeffreys considers as *Truncatella atomus*, 'Phil. En. Moll. Sic.,' vol. ii, p. 134, Tab. XXIV, fig. 5. There is a figure of the animal and shell by Mr. Jeffreys in the 'Ann. and Mag. Nat. Hist.,' January, 1859, p. 18, Pl. III, fig. 16, where it is described under the name of *Euomphalus nitidissimus*.

CÆCUM TRACHEA, *Mont.* Crag Moll., vol. i, p. 115, Tab. XX, fig. 5.
— MAMMILLATUM, *S. Wood.* Crag Moll., vol. i, p. 116, Tab. XX, fig. 4.
— GLABRUM, *Mont.* Crag Moll., vol. i, p. 117, Tab. XX, fig. 6.
— INCURVATUM, *Walker.* Crag Moll., vol. i, p. 117, Tab. XX, fig. 7, *a*, *b*.

The above four species were given by me in the 'Crag Mollusca,' but *incurvatum* only provisionally, as being possibly the young of one of the other species.

Dr. Philip Carpenter in his "Monograph on the *Cæcidæ*" 'Proc. Zoo. Soc.', 1858, dissents from my determination of *C. trachea*, and regards the shell figured by me under that name as a new form, to which he assigns the name of *tumidum*, rejecting the living species *trachea* from the Crag category.[1] My species *C. mammillatum* he recognises, as well as *C. glabrum*, Mont., while *C. incurvatum* he also thinks may be the young of one of the other species. He also recognises among my specimens placed in the British Museum a new form, which he names *liratum ;* and he makes new genera for the reception of all.

As Dr. Carpenter has made the family of *Cæcidæ* a special object of study, I think it desirable (though I do not fully agree with him) to give the Crag *Cæcidæ* according to his views, which are thus :

CARPENTER'S NAMES.	NAMES IN CRAG MOLLUSCA.
Elephantulum liratum	Not given.
Anellum tumidum	*Cæcum trachea,* vol. i, p. 115, Tab. XX, fig. 5.
Fartulum mammillatum	*C. mammillatum,* vol. i, p. 116, Tab. XX, fig. 4.
Brochina glabra	*C. glabrum,* vol. i, p. 117, Tab. XX, fig. 6.
Young of *mammillatum*	*C. incurvatum,* vol. i, p. 117, Tab. XX, fig. 7.

Dr. P. Carpenter does not recognise any of these forms as living, with the exception of *glabra*. Mr. Bell gives ('Ann. and Mag.,' May, 1871) *C. mammillatum* from the Red Crag of Walton Naze.

[1] In my Catalogue in 'Mag. of Nat. Hist.,' 1842, I placee a note of interrogation against *C. trachea,* and pointed out that the recent shell is regularly annulated and smooth, and that my Crag shell differed from it in having the annuli more irregular and rugose.

CAPULUS UNGARICUS, *Linn.* Crag Moll., vol. i, p. 155, Tab. XVII, figs. 2 *a—g*.

Localities. Cor. Crag, Sutton, Ramsholt, and near Orford. Red Crag, *passim.* Fluvio-marine Crag, Bramerton (Woodward). Middle Glacial, Hopton.

All the above localities for this shell are within my own knowledge except the Fluvio-marine of Bramerton, where, according to Woodward's list in White's 'Directory,' is said to occur small and rare. The specimens from the Middle Glacial are very young ones.

CAPULUS RECURVATUS, *S. Wood.* Crag Moll., vol. i, p. 156, Tab, XVII, fig. 3 *f* (as *C. militaris*, Mont.).

Localities. Cor. Crag, Sutton, and near Orford. Red Crag, Walton, Sutton, Newbourn, and Waldringfield.

The name of *militaris* given by Montagu to our species being posterior to that given by Linné to a different shell inhabiting the West Indies must be abandoned. I, therefore, fall back upon the name *recurvatus* given in my Catalogue of 1842, for the specimen shown in fig. 3 *f* of Tab. XVII, of 'Crag Moll.' Figs. 3 *b, c, d,* may be the young of *C. ungaricus.*

Mr. Bell has described in the 'Annals and Mag. Nat. Hist.' for September, 1870, a shell from the Red Crag of Waldringfield as a new species under the name of *C. incertus*, the specimen of which he kindly submitted to me. He has also ('Ann. and Mag.,' 1871) given the name *Brocchia sinuosa* to the shell shown in 'Supplement,' Tab. VII, fig. 26 *a, b,* which may be the same as *Patella sinuosa,* Brocchi. In the monograph of the 'Crag Moll.' I showed one of these sinuous forms of the *Capulidæ*, under the name var. *partim sinuosus* of *C. militaris*, regarding it as an accidental variation due possibly to the adherence of the shell to a *Pecten.* Looking at the various forms figured by Prof. Salvatore Bionde ('Estr. dagl Atti dell Acad. Gioenia de Sc. Nat.,' Vol. XIX, Sec. Series, 1864) in his monograph of the so-called Genus *Brocchia*, and at the specimen figured in 'Supplement,' Tab. VII, I must admit that the idea of an adherence to a *Pecten* will not explain these features. Bionde's figures of some twelve forms under the generic name *Brocchia* show one or more sinuosities in each, but they are not all in the same *part* of the shell nor in the same direction. Neither do they appear in the young shell, but only upon that part of the shell which must have been formed after the animal was half grown; and, however caused, suggest the idea that these peculiar features are due to some accidental circumstances besetting the growth of certain individuals of the genus *Capulus.* Under these circumstances I do not see my way to the adoption of the genus *Brocchia* until further investigations, especially on living forms if such be discovered, have demonstrated that this testaceous covering pertained to an animal generically differing from those producing the shell *Capulus*. For a similar reason I have not adopted as a separate species Mr. A. Bell's *C. incerta*, thinking that it is probably only a distortion of this nature of one or other of the species of Capulus described and figured in the 'Crag Mollusca.'

CALYPTRÆA CHINENSIS, *Linn.* Crag Moll., Vol. I, p. 159, Tab. XVIII, fig. 1.

Localities. Cor. Crag, Sutton, Ramsholt, and near Orford. Red Crag, *passim.* Fluvio-marine Crag, Bramerton. Chillesford Bed, Aldeby. Middle Glacial, Hopton.

This species has occurred within my knowledge at all the above localities. The apices of the shell are not uncommon in the Middle Glacial. The large squamose and imbricated form of this shell appears to be confined to the Coralline Crag, and to the Walton Red Crag, the specimens from all the other localities being the small living British form.

EMARGINULA FISSURA, *Linné.* Crag Moll., vol. i, p. 164, Tab. XVIII, fig. 3 *a.*

Localities. Cor. Crag, Sutton, and near Orford. Red Crag, Walton, Sutton, and Butley. Middle Glacial, Hopton?

This is one of the most abundant shells of the Coralline Crag at Sutton. Among these specimens may be seen very great variation both in the radiatory lines and the cancellation, also in the comparative height and in the position of the vertex. This point or apex is in some subcentral, in others it nearly overhangs the base of the shell; in some this vertex is much elevated, in others depressed with every intermediate gradation. A fragment of a shell of this genus, the sculpture on which seems to agree with *fissura*, has occurred in the Middle Glacial of Hopton.

EMARGINULA ROSEA (?), *Bell.*

EMARGINULA ROSEA, *Bell.* Zool. Journ., vol. i, p. 52, pl. iv, fig. 1, 1824.

Locality. Cor. Crag, Sutton.

Mr. Jeffreys gives this species as present in my collection in the British Museum ('Brit. Con.,' Vol. III, p. 261), and I have, therefore, inserted the species as a Cor. Crag shell with a note of interrogation, for I am not able myself to detect a sufficient difference among the many variable forms to justify their separation; *rosea, cancellata, elongata,* and *decussata,* may, perhaps, all be found among my specimens, but they so graduate into each other, and having all lived together, that I cannot venture on my own authority to call them specifically distinct from *E. fissura.* The most distinct form and the one which if we had the evidence of fossil specimens only for a guide I should be disposed to regard as most entitled to specific distinction, is that figured by me in Tab. XVIII, fig. 3 *b*, under the name of var. *punctura;* and to show this better I have given in Tab. VII, fig. 24 of this 'Supplement' an enlargement of the sculpture on this var. *punctura*. As to the proportional length of the fissure and shape of the shell, I find it to vary so irregularly as to be no guide for specific distinction. *E. capuliformis*, 'Phil. Mol. Sic.,' Vol. I, p. 116, Tab. VII, fig. 12, is merely a distortion of one or other of these forms, and I have the same among my specimens.

EMARGINULA CRASSA, *J. Sow.* Crag Moll., vol. i, p. 165, Tab. XVIII, fig. 2.

Localities as in 'Crag. Moll.'

The shell with this name from the Coralline Crag differs materially from that found in the Red Crag, being much smaller; it also has rounded and more prominent rays, is more conical or elevated, and has comparatively a deeper sinus at the margin, while it differs as much from the Red Crag shell of this name as any of the five forms, *rosea, fissura, cancellata, elongata,* and *decussata* do from each other, and if they are to remain specifically distinct I would call my Coralline Crag shell a separate species also under the name *E. crassalta.* Specimens of *E. crassa* from the Red Crag measure $2\frac{1}{4}$ inches in length.

FISSURELLA COSTARIA, *Basterot.* Supplement, Tab. VII, fig. 19.

TISSURELLA COSTARIA, *Bast.* Mem. Geol. Bord., p. 71, 1825.
— NEGLECTA, *Desh.* Exp. Sci. de Morie., p. 134, 1844-8.
— MEDITERRANEA, *Gray.* Apud. Sow. Conch. Ill., fig. 30.
— ITALICA, *Hörnes.* Vien. Foss. p. 641, t. 50, fig. 80.

Length, $1\frac{3}{4}$ inch, breadth $1\frac{1}{8}$ inch.

Locality. Coralline Crag, Sutton. Red Crag, Waldringfield (A. Bell).

A fine specimen has been obtained from Sutton by Mr. Bell and put into my hands for description with the name of *F. neglecta.* This name was first given by Deshayes, 'Coq. Foss. des Env. de Par.,' Tome II, p. 20, Pl. II, figs. 10—12, but rejected in his second work as not belonging to the Paris Basin, and Basterot adopted the above name.

This shell much resembles *F. græca,* and its principal difference appears to be that the decussating lines, or lines of growth, are stronger and closer in this species, and the rays or radiating ridges are more uniform, and not alternate, as in *F. græca;* but the young of *græca* is very variable in its markings, and the keyhole opening is broader in the very young shell, near the recurved vertex, than it is on the anterior side.

Tab. 483, figs. 1—3, 'Min. Conch.,' belongs, I believe, to *F. græca,* Linn., and not to the present species.

In the list of Crag shells by Mr. Alfred Bell, 'Ann. and Mag. Nat. Hist.,' Sept., 1870, as also in the list by Mr. Jeffreys, that accompanies Mr. Prestwich's Cor. Crag paper, is the name of *Puncturella* (*Cemoria*) *Noachina*, from the Cor. Crag of Sutton. On applying for a sight of his specimen Mr. Bell tells me it was a very small one, and has, unfortunately, been lost, and my application to Mr. Jeffreys for a sight of the specimen on the authority of which he has inserted this species in his list, has also been unsuccessful.

As *Cemoria Noachina* (*Patella Noachina*, Linn.) at the present day is a very northern form, I was anxious for clear evidence of its existence in the Cor. Crag. I thought possibly it might be the young state of *Fissurella græca*, which has a recurved apex, such as is represented at fig. 4 *c*, Tab. XVIII, of 'Crag Moll.,' and in this state of things I do not venture to give it as a Crag shell.

TECTURA ? PARVULA, *Woodward.* Crag Moll., vol. i, p. 162, Tab. XVIII, fig. 8.

Locality. Fluvio-marine Crag, Bramerton.

In the 'Crag Mollusca' I observed that this shell might possibly be the young state of *Patella vulgata* which occurs, though rarely, in the Fluvio-marine Crag. Mr. Reeve tells me there are only five specimens in the Norwich Museum, and these have been in my hands for examination. They are all small, and very thin, which I imagine must be from a loss of part of the shell. They are elongated in form, as if they lived upon the leaf or stem of a Fucus. The vertex is very excentric, like that of *Tectura,* but they are more distinctly rayed or costated. I confess not to be able to determine their true position. They much resemble *Lottia alveus*, Gould, 'Inv. Mass.,' p. 154, fig. 13, in form; but that shell is said to be ornamented with very fine radiating striæ, while the Crag shell has raised radiating costulæ. Altogether, *Tectura parvula* must be regarded as a very doubtful species.

TECTURA FULVA, *Müller.* Crag Moll., vol. i, p. 161, Tab. XVIII, fig. 7.

Localities. Cor. Crag, Sutton. Red Crag, Walton? Middle Glacial, Hopton.

In his 'Brit. Conch.,' vol. iii, p. 251, Mr. Jeffreys observes that my specimens from the Cor. Crag, which I described as this species, appear to belong to *Lepeta cæca ;* but as in his list accompanying Mr. Prestwich's Cor. Crag paper in 'Quart. Jour. Geol. Soc.,' vol. xxvii, p. 145, Mr. Jeffreys inserts *Tectura fulva,* and omits *Lepeta cæca,* I infer that he has abandoned that opinion. In his list accompanying the Red Crag paper, however, he inserts *Lepeta cæca* from the Red Crag of Walton as does Mr. Bell also ('Ann. and Mag.,' Sept., 1870). I have not, however, yet been able to see anything to justify the insertion of *Lepeta cæca* as a Crag shell.

Two small specimens of *T. fulva,* imperfect, but comprising the worn apex and larger part of the shell, have occurred in the Middle Glacial of Hopton. In the 'Crag Mollusca' I stated that this shell was by no means rare in the Cor. Crag, but that is incorrect; it seems rare there, at least, it has now become so.

Dentalium rectum, *Linn.* Supplement, Tab. V, fig. 19, *a, b.*

Dentalium rectum, *Gmelin* Syst. Nat. ed. 13, pp. 37, 38.
— — *Poli. Test. utriusque* Sic., vol. iii, t. lvi, fig. 28.
— elephantinum, *Desh.* Monog. du Gen. Dent., p. 27, pl. iii, fig. 7.

Locality. Red Crag, Sutton, Waldringfield (Bell).

The specimen figured was given to me by the late Mr. Acton, of Grundisburg, who said it was obtained from the Coprolite diggers at Sutton.

There are three species described by Linné so closely resembling each other that it is difficult to say what character will satisfactorily separate them, viz. *D. elephantinum, arcuatum,* and *rectum;* the straight form of the present shell is the greatest, perhaps the only distinction. In my fossil the sculpture appears to be generally about twelve large costæ, with a smaller intermediate one. Mr. Bell gives this from Waldringfield.

Dentalium costatum, vol. i, Tab. XX, fig. 1 *d,* from the Red Crag, may probably belong to this species.

Dentalium entalis, *Linn.* Supplement, Tab. VI, fig. 20.

Dentalium entalis, *Linn.* Syst. Nat., p. 1263.

Localities. Cor. Crag, Sutton, and near Orford. Post Glacial, Kelsea Hill.

The figure above referred to is the representation of two or three fragmentary specimens lately found by myself in the Coralline Crag at Orford and Sutton, and these are all that I have seen from that formation. They show a perfectly smooth and glossy surface, but the terminal portion is not perfect. Rubbed and worn specimens of a ribless *Dentalium* are occasionally found in the Red Crag, but they are not perfect enough for determination.

I have referred my shell as above, conceiving it most probably to be the same as the Mediterranean species. *D. tarentinum, D. abyssorum,* and the present species so much resemble each other that it is difficult to point out a sufficient difference for specific separation in the recent and perfect shells; while in the fossil it is even more difficult.

Dentalium entale is given as a fossil of Kelsea Hill in the list of shells by Mr. Jeffreys, in Mr. Prestwich's paper, 'Geol. Journ.,' vol. xvii, p. 449.

Dentalium abyssorum, *Sars.* Crag. Moll., vol. i, p. 189, Tab. 20, fig. 2 (as *D. entale*).

Locality. Upper Glacial, Bridlington.

The shell figured and described by me from Bridlington appears to belong to the arctic and deep water species or variety, *abyssorum.*

Dentalium dentalis, *Linn.* Crag Moll., vol. i, p. 188, Tab. XX, fig. 1 (as *D. costatum*).

Dentalium costatum, *J. Sow.* Min. Con., t. 70, fig. 8, 1814.

Localities. Cor. Crag, Sutton, and near Orford. Red Crag, Sutton. Middle Glacial, Billockby.

In the 'Crag Moll.' (vol. i, p. 189) I mentioned that I thought this Crag shell the same as the living Mediterranean shell, *D. dentalis,* Linn., and as this seems now the general opinion, I have here placed it under Linné's name. Two imperfect specimens, showing the strong costæ, but flattened by wear, have occurred in the Middle Glacial of Billockby, and I have no doubt of their belonging to this species.

Actæon noæ, *J. Sow.* Crag Moll., vol. i, p. 169, Tab. XIX, fig. 6.

Localities. Red Crag, Walton, Brightwell, Newbourn, Butley. Fluvio-marine Crag near Norwich?

This shell is given by S. Woodward, in his 'Geology of Norfolk' (1833), as occurring rarely near Norwich, but his son Dr. Woodward, in his list in 'White's Directory,' treats this as a mistake for *Actæon* (*Tornatella*) *tornatilis,* which also occurs in the Fluvio-marine Crag of Bramerton. I however find that *Actæon Noæ* was among a set of shells from Norwich submitted to me and the late G. B. Sowerby by Sir Chas. Lyell, and published at p. 328 of vol. III of the 'Mag. of Nat. Hist.,' New Series, which were by us carefully compared and considered. Therefore, although I have not since met with the shell from the Fluvio-marine Crag, I give it from that Crag with a doubt. Mr. Jeffreys has stated, 'Quart. Journ. Geol. Sci.,' vol. xxvi, p. 283, that this shell has been found fossil in Iceland by Prof. Steenstrup. Dr. O. Mörch also gives this species in his list of Crag Shells ('Geol. Mag.,' vol. viii, p. 395), from Hallbjarnastadir, in Iceland.

Actæon tornatilis, *Linn.* Crag Moll., vol. i, p. 170, Tab. XIX, fig. 5.

Localities. Cor. Crag, Sutton. Red Crag, Sutton and Butley. Fluvio-marine Crag, Bramerton. Chillesford bed, Burgh and Aldeby.

ACTÆON SUBULATUS, *S. Wood.* Supplement, Tab. V, fig. 16; Crag Moll., vol. i, p. 170 Tab. XIX, fig. 7.

Localities. Cor. Crag, near Orford. Red Crag, Sutton, and Butley.

The figure in Supplement, Tab. V, represents a specimen from the Coralline Crag at Orford. It much resembles, and is probably, the first incoming of the shell *A. subulatus,* figured in Tab. XIX of 'Crag Moll.,' from the Red Crag, although the present shell is a little more elongate than the last-mentioned figure. I have, however, recently obtained a specimen from the Red Crag of Butley, which is similar to the Cor. Crag one, but larger, being perhaps an older shell. The apex of the Cor. Crag fossil is obtuse, not an uncommon character with many of the Coralline Crag species; in other respects it much resembles *Tornatella sulcata*, Lam., but the pullus portion of that shell has a sinistral volution which I do not see in my own, and there is a difference in the size and position of the fold upon the columella. The striations on *sulcata* are also carried equally over the whole whorl, which is not the case in *subulata.* The resemblance of this shell to the Eocene *sulcata* is closer than is that of several Crag shells to those living species with which they have been considered by some as identical. I believe my shell figured in Crag Moll., Tab. XIX, fig. 7, to be specifically distinct from *tornatilis.*

ACTÆON LEVIDENSIS, *S. Wood.* Crag Moll., vol. i, p. 171, Tab. XIX, fig. 4.

This shell has become exceedingly rare to my researches, and, so far as I know at present, is restricted to the single locality of Sutton in the Cor. Crag. Whether this be the same as the Belgian fossil *T. elongata*, Nyst., I have not been able to ascertain, but judging from the figure by that author, I should scarcely think it was. It is, however, quite distinct from the Older Tertiary *elongatus* of J. Sowerby.

ACTÆON ? ETHERIDGEI, *A. Bell.* Supplement, Tab. V, fig. 17.

ACTÆON ? ETHERIDGII, *A. Bell.* (N. S.) Ann. and Mag. Nat. Hist., Sep. 1870.
— EXILIS ? *Jeffreys.* Quart. Journ. Geol. Soc., vol. xxvii, p. 486, Nov., 1871.

Locality. Red Crag, Walton Naze (*A. Bell*).

The specimen figured was found by Mr. A. Bell. It was forwarded to me with the above name in commemoration of the able palæontologist of the 'Geological Survey,' and I have great pleasure in adopting that specific name for our shell.

This is a strange form, and I know not in what genus it ought to be placed. Species in *Actæon* are all more or less covered with spiral striæ, but this shell seems to be quite smooth (which, however, may be accidental), and it has a projecting shoulder to the volution; perhaps it would be more correctly placed either in *Tornatina* or *Actæonina.*

I presume that this is the shell called *exilis* by Mr. Jeffreys in his list to Mr. Prestwich's Red Crag paper, p. 486.

CHITON DISCREPANS? *Brown.* Supplement, Tab. IV, fig. 27.

CHITON DISCREPANS, *Brown.* Conch., Gt. Brit., pl. xxxv, fig. 20, 1827.
— — *Forb.* and *Hanl.* Brit. Moll., vol. ii, p. 396, pl. 58, fig. 4.
— CRINITUS, *G. B. Sow.* Desc. Cat. Brit. *Chitones,* p. 2, fig. 88—93; Ency. Method., pl. 163, fig. 11—17.

Locality. Coralline Crag, Sutton.

The figure above referred to represents the valve of a *Chiton*, which I have lately found, and which I have assigned to the above-named British species, though with some slight hesitation; my specimen appears to be the third or fourth valve with the sustentacula quite perfect, and these have a peculiar form. The length of the valve is about equal to the breadth of one of its sides, and the ornamentation appears to correspond to that of the shell to which it is here assigned. Unfortunately, in the works upon British Conchology we have neither represented, nor described, the form or magnitude of these processes to the valves, which are, in my opinion, good auxiliary characters. This central valve now figured seems to differ from those of *fascicularis* in being more rounded at the lateral posterior termination of the valve, and the sustentacula are rather larger. We are not likely for some time to obtain a fossil with all the valves in position, so that we must do the best we can with the materials we possess, and I have given my figure as one step towards a correct determination.

CHITON RISSOI, *Payr.* Crag Moll., vol. i, p. 186, Tab. XX, fig. 11.

My Crag shell, which I referred as above, is regarded as *Ch. cinereus*, Linn., by Mr. Jeffreys ('Quart. Journ.,' vol. 27, p. 143). My Crag valves form a perfectly semicircular arch, without any angularity or pointed keystone like those of *cinereus*, and I have therefore retained my original name.

CHITON STRIGILLATUS, *S. Wood.* Crag Moll., vol. i, p. 186, Tab. XX, fig. 10.

This may probably be *Chiton Hanleyi* of the 'British Conchologists.'

In the 'Geol. of Norfolk' by S. Woodward, published in 1833, is the name of *Chiton octovalvis* (p. 44), and this name is repeated by his son Dr. S. P. Woodward, in his list of Norwich Crag shells, as from Thorpe, "a single valve," and is marked unique. This specimen cannot now be found, and as no confirmation of it appears in any of the collections known to me, it is impossible to say what species was intended.

SCAPHANDER LIBRARIUS? *Lovén.* Supplement, Tab. V, fig. 18 *a, b.*

SCAPHANDER LIBRARIUS, *Lovén.* Ind. Moll. Scandin., p. 10, 1846.
— — *Jeffreys.* Brit. Moll., vol. v, pl. 102, fig. 9, 1869.

Locality. Coralline Crag, Sutton.

My cabinet contains two or three specimens of the above genus, which appear to differ from *lignarius,* Linn., in being much less expanded at the lower part, and I have referred them, but with doubt, to the new species of Dr. Lovén. My specimens are not quite perfect.

BULLÆA VENTROSA, *S. Wood.* Crag Moll., vol. i, p. 182, Tab. XXI, fig. 11.

This is still a rare shell, and found only in the Cor. Crag of Sutton, so far as I know. In 'Brit. Conch., vol. iv, p. 425, Mr. Jeffreys has described a new species of *Bullæa,* under the name of *Urtriculus* (*Bullæa*) *ventrosus.* This does not appear to be the same as the Crag *ventrosa,* and his use of the name *ventrosus* may give rise to confusion. I propose that his shell be called *ventriculosus.*

Amphisphyra globosa, Lovén, is closely allied to *Bullæa ventrosa,* but it is described in 'Brit. Conch.' (*Urtriculus globosus,* vol. v, p. 223, Pl. CII, fig. 8) as having "slight, indistinct, and irregular spiral lines, which are only discernible with the aid of a magnifying power, and in certain lights." If this be an essential character, *globosa* must also differ from the Crag *ventrosa,* as the latter has very distinct and regular spiral striæ, otherwise I should have been disposed to regard the two species as identical.

In the address of the President of the Geological Society for 1871, at page liv, is a "List of Mollusca known hitherto as fossil only, and now discovered to be living in the depths of the Atlantic." In this list is the name of *Cylichna ovata* as a Coralline Crag fossil. I do not know this shell, nor can I ascertain to what the name refers.

RINGICULA BUCCINEA, *Broc.* Crag Moll., vol. i, p. 22, Tab. IV, fig. 2.

Localities. Cor. Crag, Sutton, and near Orford. Red Crag, Sutton.

In a paper by the Rev. O. Fisher in the twenty-second volume of the 'Quarterly Journal of the Geological Society,' p. 26, *R. buccinea* is given among a list of shells obtained by him from the Fluvio-marine deposit of Yarn Hill, near Potter's Bridge, Southwold. The specimen fortunately was preserved, and on re-examination it turns out to be one of *R. ventricosa,* so that *buccinea* is not known from any newer deposit than the Red Crag, in which, moreover, it is extremely rare, and may, even in that Crag, be only derivative from the Coralline.

Ringicula ventricosa, *J. Sow.* Crag Moll., vol. i, p. 22, Tab. IV, fig. 1.

Localities. Coralline Crag, Sutton. Red Crag, Sutton and Butley. Fluvio-marine Crag, Bramerton (Woodward), Yarn Hill (Fisher). Chillesford bed, Aldeby (Crowfoot and Dowson).

In the 'Crag Mollusca' *Ringicula* was placed in the section *Solenostomata* of Fleming (*Canalifera,* Lam.), depending upon the peculiar construction of the shell. Recent observations have removed it near to *Actæon,* in which position I have here placed it in deference to the Malacologists. It is, however, of a very aberrant character, possessing as it does a deep siphonal canal, very unlike its present associates. *R. ventricosa* still remains very rare in the Coralline Crag.

Since my communication in 1870 to the 'Ann. and Mag. of Nat. Hist.,' respecting the peculiarity of the Crag shells of this genus, I have found more than a hundred other specimens of *R. buccinea,* all in the presumed full-grown condition, that is, with a thickened outer lip. Of course this outer lip, while the animal is growing, must necessarily have a plain or simple margin, but the peculiarity is that it has so rarely[1] died in that condition I had imagined, and do so still, that these animals, as also those of *Trivia,* completed their shell in anticipation of their decease, and that many of the small specimens we find are young individuals that have thus assumed the adult form.

Rissoa abyssicola? *Forbes.* Supplement, Tab. VII, fig. 2.

Rissoa abyssicola, *Forbes.* Brit. Moll., vol. iii, p. 86, pl. lxxviii, figs. 1, 2.

Locality. Cor. Crag, Sutton. Living Britain, Scandinavia, and Mediterranean.

A single specimen which I have quite recently found in the Cor. Crag of Sutton is shown in the above figure. It may, I think, be referred to *abyssicola* of Forbes.

Cancellaria viridula, *Fab.* Crag Moll., vol. i, p. 66, Tab. VII, fig. 21, as *C. costellifer.*

Cancellaria viridula, var. Couthouyi. Supplement, Tab. VI, fig. 12.

This species is now considered to be the *Tritonium viridulum* of Fabricius' Fauna

[1] I, indeed, doubt whether a perfect specimen without the thickened lip has occurred in the Crag; the few such that I possess appear all of them to have had the thickened lip broken off.

Grœnlandica, 1780. A specimen of the more ovate variety, *Couthouyi*, has been obtained from the Red Crag of Butley by Mr. A. Bell, and is represented in the figure in Tab. VI of this 'Supplement.'

Scalaria varicosa, *Lamarck*. Crag Moll., p. 90, Tab. VIII, fig. 14.

Localities. Cor. Crag, Sutton. Red Crag, Walton, Waldringfield, and Sutton (Bell).

This shell is evidently the same as *S. interrupta*, J. Sow., 'Min. Conch.,' tab. 577, fig. 3. The specimen there figured is said to have come from the Eocene of Barton Cliff. Mr. F. E. Edwards, whose Eocene collection is unrivalled, tells me that he does not know the shell as an Eocene species, *S. interrupta* of Dixon's 'Geol. of Sussex' being obviously a different shell. It is therefore most probable that the specimen figured in 'Min. Conch.' was from the Coralline Crag, the colouring of the figure being that of the Cor. Crag specimens. I should have been disposed to refer the Crag shell to Brocchi's *pumicea*, but it does not quite agree with either his or Hörnes' figure of that species, and I have had no opportunity of comparing the shells themselves. Should it prove distinct then, inasmuch as Lamarck's *varicosa* is generally regarded as the same as *pumicea*, I would suggest for our Crag shell the name of *Scalaria funiculus.*

Mr. Bell ('Ann. and Mag.,' Sept., 1870) gives the shell from the Red Crag of Walton, Waldringfield, and Sutton.

Mr. Jeffreys, in his List to Mr. Prestwich's Coralline Crag Paper, says that *Scalaria subulata* is a variety of *S. foliacea*, and this again a variety of *frondosa*, but in the Red Crag Paper (p. 496) he corrects this and says that *subulata* is a distinct species, and that Mr. McAndrew had dredged it off Teneriffe. It would seem from this that if a distinct Crag form is found living it is a species, but if not, then it is only a variety.

Scalaria semicostata, *J. Sowerby*.

A specimen of this, since the foregoing 'Supplement' went to press, has been sent to me from the Red Crag by Mr. Charlesworth. Although in the greatest perfection, this specimen can only, I think, be a derivative from the Eocene. I shall figure it in the concluding part of the 'Supplement.'

Trophon elegans, *Charlesworth*.

Very recently the fragment of a shell from the Coralline Crag near Orford has been sent to me by Mr. Cavell, and this, I think, may be referred to *Trophon elegans* of

Charlesworth. If this be so the specimens hitherto spoken of under this name, and which were found on the beach at Felixstow were probably derived from the Cor. Crag.

I will figure this fragment (unless a better specimen in the meantime should be found) in the concluding part of this 'Supplement.'

PTEROPODA.

CLEODORA INFUNDIBULUM, *S. Wood.* Crag Moll., vol. i, p. 191, Tab. XXI, fig. 14.

I have obtained only one specimen of this little Pteropod since it was described as above, and this, like my others, is imperfect. It was from the Cor. Crag of Sutton.

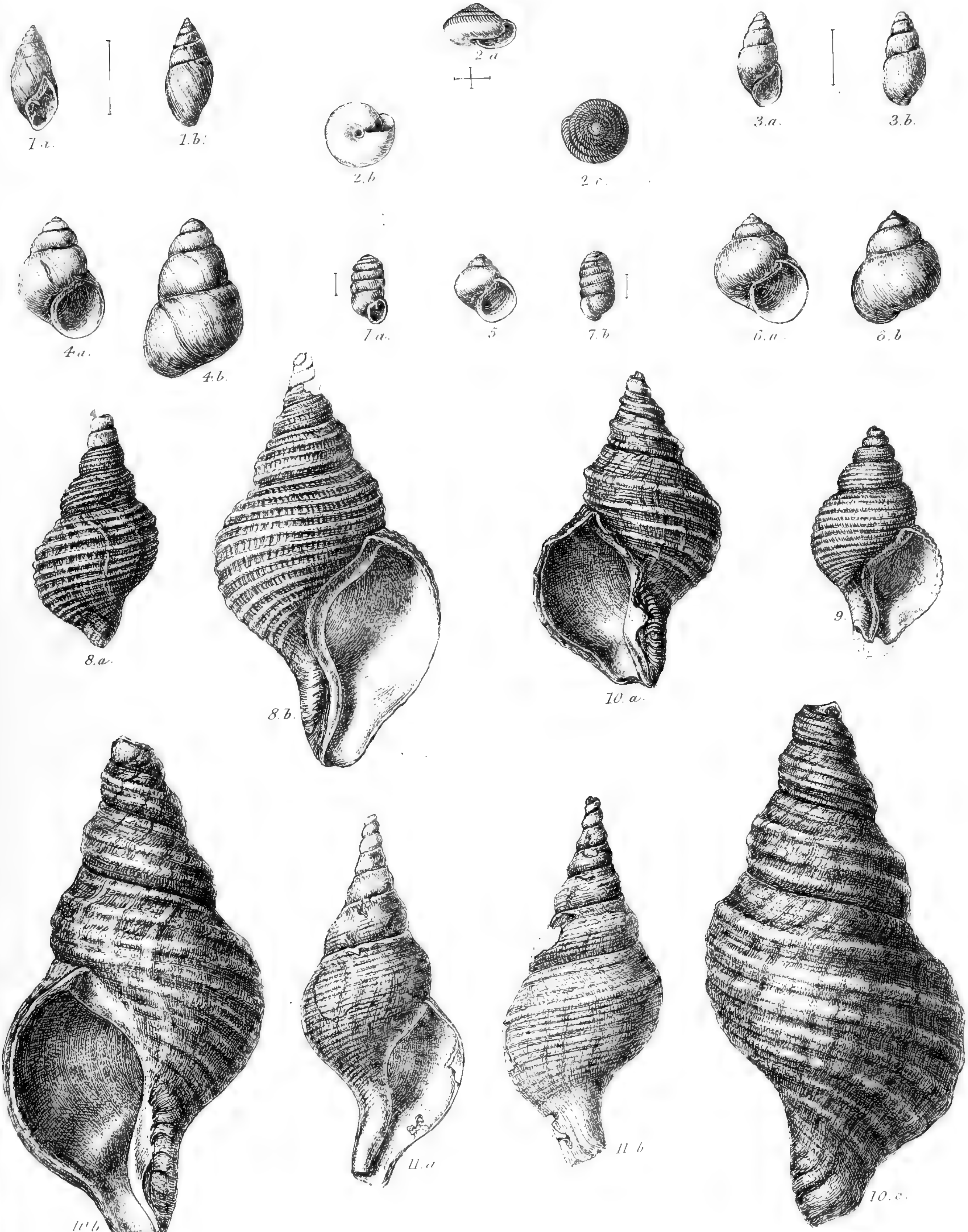
At page 120 of vol. v 'Brit. Conch.,' it is said that my Crag shell is probably *Clio caudata* of Linné, *Cleodora compressa* of Souleyet. This, however, wants confirmation. Of the recent shell it is said that "the apex is globular." I have not heard of *C. infundibulum* having been found anywhere but in the Cor. Crag of Sutton.

It may possibly be the shell so called figured in Barbut's 'Worms,' Tab. VII, fig. 7, but I have not been able to satisfy myself on the point.

PLATE I.

Fig.	Names of the shells.	Page	Localities from which the specimens figured were obtained.
1, *a*, *b*.	*Melampus fusiformis* . . .	3	Fluvio-marine Crag, Thorpe, in Suffolk.
2, *a*—*c*.	*Helix Suttonensis*	2	Cor. Crag, Sutton.
3, *a*, *b*.	*Amaura candida*	78	Red Crag, Butley.
4, *a*, *b*.	*Paludina Clactonensis* . . .	69	Post-glacial, freshwater bed, Clacton.
5.	— *vivipara*	70	Chillesford bed, Horstead.
6, *a*, *b*.	— *contecta*	69	Pre-glacial, freshwater bed, Woman Hythe, Runton.
7, *a*, *b*.	*Pupa muscorum*	3	Red Crag, Butley.
8, *a*, *b*.	*Trophon Berniciensis ?* . .	21	Fluvio-marine Crag, near Norwich.
	a. From specimen belonging to Mr. King, of Norwich.		
	b. From specimen in the British Museum.		
9.	*Trophon Sarsii*	25	Red Crag, Butley.
10, *a*—*c*.	— *antiquus*, var. *carinatus contrarius* . .	19	
	a. With prominent ridges, from the Norwich Museum. Fluvio-marine Crag ?		
	b & c. With less elevated ridges, from Red Crag, Newbourn, near Woodbridge.		
11, *a*, *b*.	*Trophon Turtoni*	22	Red Crag, Butley.

(This Plate was engraved December, 1867.)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11 b
10.c.

PLATE II.

Fig.	*Names of the shells.*	PAGE	*Localities from which the specimens figured were obtained.*
1.	*Buccinum glaciale*	17	From a recent specimen, Brit. Mus.
2.	— *undatum*, var. *Grœnlandicum* . . .	18	Red Crag, Butley.
3, *a*, *b*.	— — var. *clathratum* . . .	18	Red Crag, Butley.
4.	*Fusus imperspicuus*	29	Cor. Crag, near Orford.
5.	*Buccinum undatum ?*, var. *ovulum*	18	Red Crag, Butley.
6, *a*, *b*.	*Trophon elegans ?* (juv.) . .	22	Red Crag, Butley.
7.	*Nassa pusillina*	14	Red Crag, Butley.
8.	*Fusus abrasus*	29	Red Crag, Sutton (probably derived).
9.	*Buccinum Dalei* (sinistral) .	16	Red Crag, Walton Naze.
10.	*Fusus crispus*	29	Red Crag, Sutton (probably derived).
11.	*Murex erinaceus*	31	From a recent specimen.
12, *a*, *b*.	— *corallinus*	30	Cor. Crag, near Orford.
13.	*Trophon Actoni*	25	Red Crag, Butley.
14.	*Rostellaria lucida*	5	Red Crag, Sutton (derived ?).
15, *a*.	*Trophon propinquus* . . .	24	Red Crag, Butley (Mr. Bell's specimen).
15, *b*.	— — var. *contortus*	24	Red Crag, Sutton.
15, *c*.	— *Sabini*	23	Upper Glacial, Bridlington (Mr. Leckenby's specimen).
16.	*Columbella sulcata*	9	Red Crag, Walton Naze.
17, *a*.	*Trophon altus*, var. *costellatus*	23	Red Crag, Butley.
17, *b*.	— — var. *bucciniformis*	23	Red Crag, Butley (Mr. Bell's specimen).

(This Plate was engraved in 1869.)

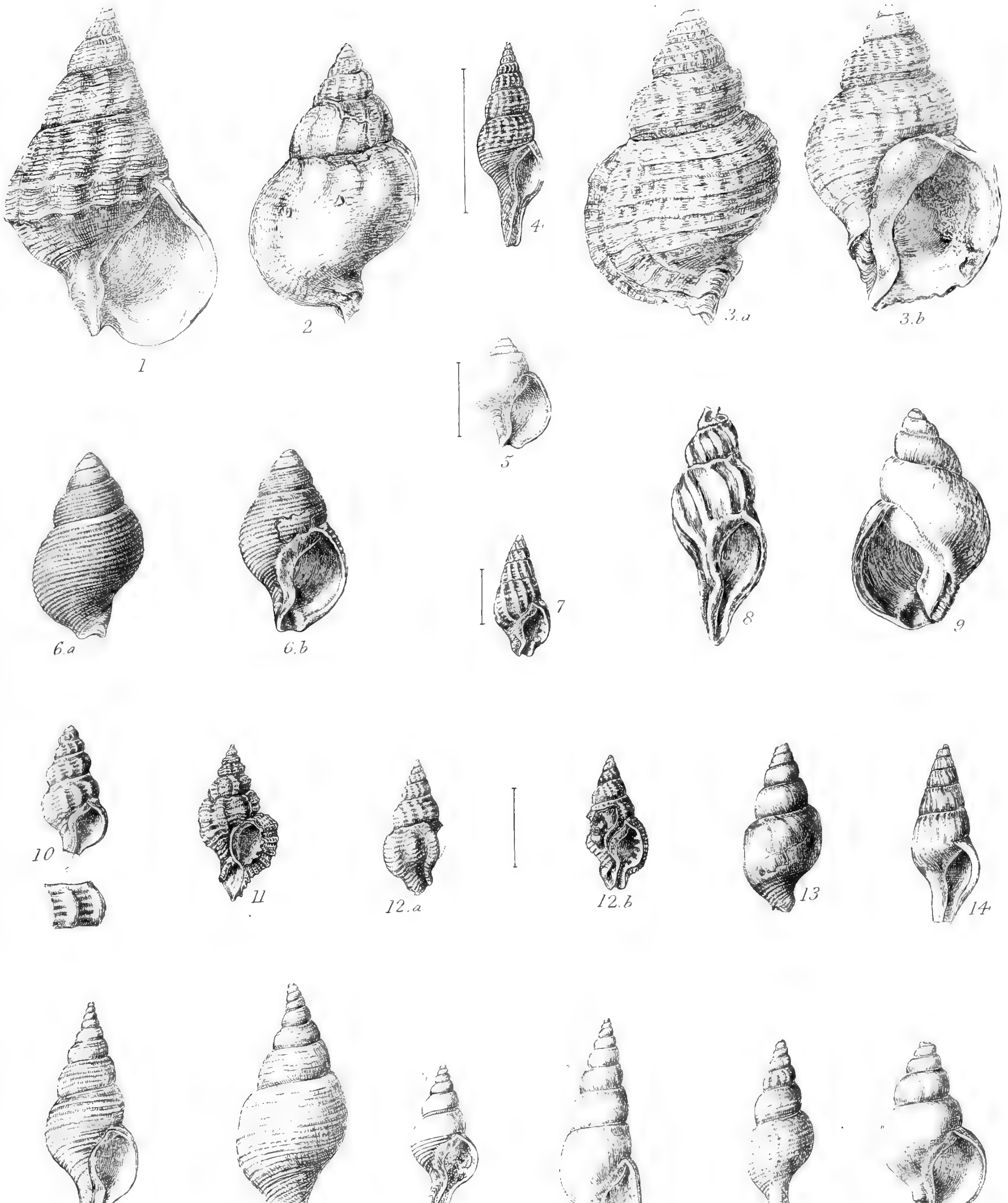
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PLATE III.

Fig.	Names of the shells.	Page	Localities from which the specimens figured were obtained.
1.	*Trophon craticulatus* . . .	25	Upper Glacial, Bridlington.
2, *a*, *b*.	*Pleurotoma inermis* . . . *a*, var. *nodulosa*; *b*. var. *nuda*	33	Cor. Crag, near Orford.
3.	*Pleurotoma hispidula* . . .	42	Cor. Crag, near Orford.
4.	*Trophon ventricosus ?* . . .	22	Upper Glacial, Bridlington.
5.	*Pleurotoma Tarentini* . . .	34	Cor. Crag, near Orford.
6.	*Mitra ebenus*, var. *uniplicata* .	7	Cor. Crag, near Orford.
7.	*Pleurotoma attenuata* . . .	38	Cor. Crag, Ramsholt.
8.	— *elegantula* . . .	36	Cor. Crag, Ramsholt.
9, *a*, *b*.	— *pyramidalis* . .	43	Fluvio-marine Crag, Thorpe, in Suffolk.
10, *a*, *b*.	*Trophon scalariformis* . . .	26	Upper Glacial, Bridlington.—N.B. Since the text was printed off, this shell has occurred in the Post-glacial gravel of March.
11.	— *Bamffius*	26	From a Clyde bed specimen.
12.	*Pleurotoma scalaris*	39	Upper Glacial, Bridlington.
13.	— *Dowsoni* . . .	39	Chillesford bed, Aldeby.
14.	— — . . .	39	Upper Glacial, Bridlington.
15.	— *elegantior* . . .	38	Upper Glacial, Bridlington.
16.	— *robusta*	40	Upper Glacial, Bridlington.
17.	— *equalis*	44	Red Crag, Butley.
18, *a*, *b*.	*Trophon Gunneri*	27	Upper Glacial, Bridlington.
19.	*Cerithium tricinctum* . . .	51	Cor. Crag, Sutton.
20.	— *? aberrans* . . .	50	Cor. Crag, near Orford.
21.	*Potamides*	51	Post-glacial, freshwater, Grays (derived ?).
22, *a*, *b*.	*Cancellaria ? Charlesworthii* .	48	Red Crag, Waldringfield (derived ?).
23.	— *gracilenta* . .	46	Cor. Crag, Sutton.
24.	— *cancellata* . .	48	Cor. Crag, Ramsholt.
25.	— *Bellardi* . .	47	Red Crag, Sutton (derived ?).
26.	— *Bonellii* . .	48	Red Crag, Sutton (derived ?).
27.	— *subangulosa* (*Admete Reedii*) .	47	Cor. Crag, near Orford.

(This Plate was engraved in the beginning of the year 1870.)

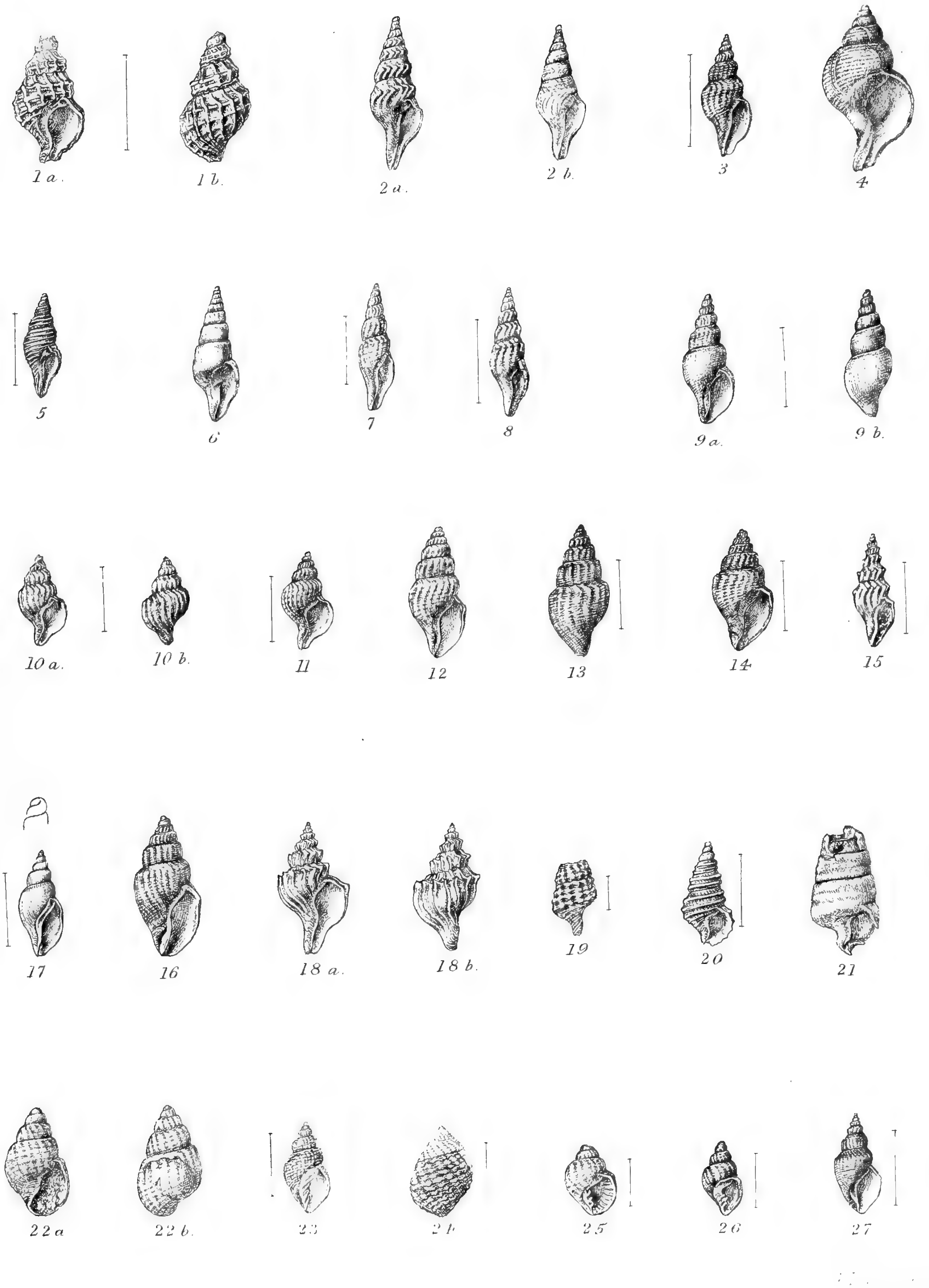
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PLATE IV.

Fig.	*Names of the shells.*	Page	*Localities from which the specimens figured were obtained.*
1.	*Terebra canalis*	8	Cor. Crag, near Orford.
2.	*Scalaria cancellata*	59	Cor. Crag, near Orford.
3.	*Nassa reticosa*, var. *simplex* .	15	Red Crag, Butley.
4.	*Limnæa Pingelii*	3	Red Crag, Butley.
5.	*Scalaria Turtoni*, var. *pseudo-Turtoni*	58	Chillesford bed, Sudbourn, Church Walks.
6.	— *Trevelyana* . . .	58	Chillesford bed, Aldeby.
7.	— *Turtoni*	58	Chillesford bed, Sudbourn, Church Walks.
8, *a*, *b*.	*Natica helicina*	74	Red Crag, Walton Naze.
9.	— *pusilla*	77	Cor. Crag, near Orford.
10.	— *Montacuti*	78	Upper Glacial, Bridlington.
11.	— *occlusa*	76	Red Crag, Butley.
12.	— *proxima*	74	Red Crag, Butley.
13, *a*, *b*.	— *catenoides*	77	Red Crag, Waldringfield.
14, *a*, *b*.	*Paludina glacialis*	68	Lower Glacial, Belaugh.
15.	*Chemnitzia rugulosa* . . .	61	Red Crag, Walton Naze.
16.	*Cerithiopsis lactea ?* . . .	52	Cor. Crag, Sutton.
17.	*Rissoa proxima*	71	Cor. Crag, Sutton.
18.	*Odostomia insculpta* . . .	62	Cor. Crag, Sutton.
19.	*Menestho lævigata*	57	Cor. Crag, Sutton.
20.	*Turritella ? penepolaris* . .	53	Cor. Crag, near Orford.
21.	*Niso ?*	65	Cor. Crag, Sutton.
22.	*Odostomia plicata*	63	Cor. Crag, Sutton.
23.	*Hydrobia ulvæ*	71	Post-glacial, freshwater bed (11 on map), Gedgrave.
24.	*Odostomia obliqua ?* . . .	64	Cor. Crag, Sutton.
25.	*Eulima stenostoma*	65	Cor. Crag, Sutton.
26.	*Odostomia ? Gulsonæ* . . .	62	Cor. Crag, Sutton.
27.	*Chiton discrepans*	95	Cor. Crag, Sutton.

(This Plate was engraved in 1870.)

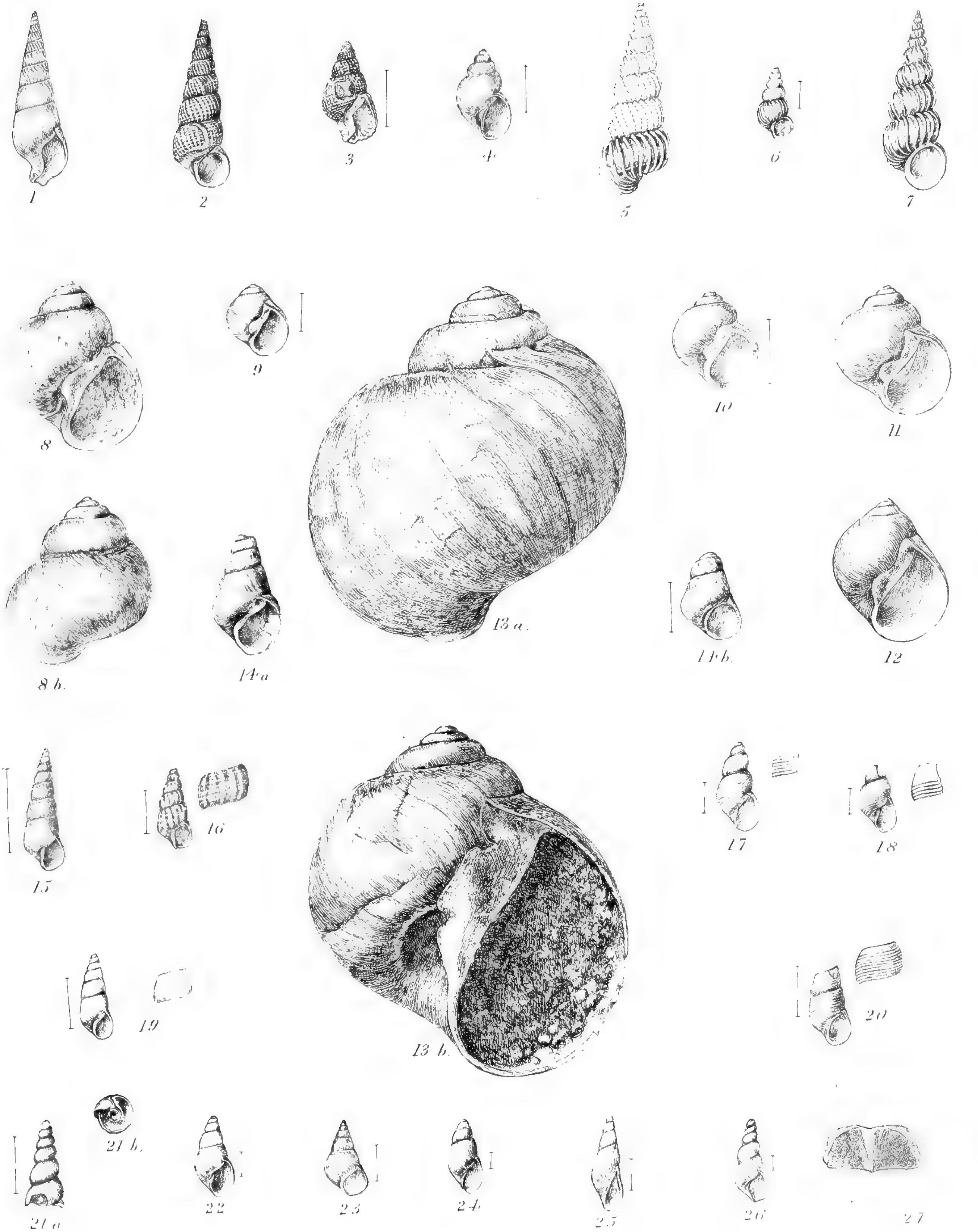
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PLATE V.

Fig.	*Names of the shells.*	PAGE	*Localities from which the specimens figured were obtained.*
1.	*Pleurotoma interrupta* . . .	32	Red Crag, Waldringfield (derived ?).
2.	— *Icenorum* . . .	35	Red Crag, Waldringfield (probably derived from Cor. Crag).
3, *a*, *b*.	*Mitra fusiformis*	8	Red Crag, Waldringfield (derived).
4.	*Buccinum pseudo-Dalei* . .	17	Cor. Crag, near Orford.
5.	*Pleurotoma senilis*	42	Red Crag, Waldringfield (derived ?).
6, *a*, *b*.	*Voluta nodosa*	6	Red Crag, Waldringfield (derived).
7.	*Ancillaria glandiformis* . .	6	Red Crag, Waldringfield (derived).
8.	*Trochus turgidulus ?*	80	Cor. Crag, Sutton.
9.	*Littorina rudis*, var. *jugosa* .	79	Fluvio-marine Crag, Bramerton.
10, *a*, *b*.	— — (distorted) .	79	Fluvio-marine Crag, Bramerton.
11, *a*, *b*.	*Margarita Grœnlandica* . .	83	Fluvio-marine Crag, near Norwich.
12, *a*, *b*.	— *argentata* . . .	84	Chillesford bed, Aldeby.
13, *a*, *b*.	*Cyclostrema lævis*	86	Cor. Crag, Sutton.
14.	*Trochus granulatus*	81	Red Crag, Walton Naze.
14†.	*Trophon Norvegicus* . . .	21	Red Crag, Waldringfield.
15.	*Rissoa senecta*	73	Cor. Crag, Sutton.
16.	*Actæon subulatus*	94	Cor. Crag, near Orford.
17.	— *? Etheridgei*	94	Red Crag, Walton Naze.
18.	*Scaphander librarius* . . .	96	Cor. Crag, Sutton.
19, *a*, *b*.	*Dentalium rectum*	92	Red Crag, Sutton (derived ?).
20.	— *entalis*	92	Cor. Crag, Sutton.
21.	*Columbella Holböllii* . . .	9	Upper Glacial, Bridlington.
22.	*Cerithium reticulatum* . . .	50	Post-glacial, Nar Valley.
23.	*Lacuna suboperta ?* (juv.) . .	80	Red Crag, Sutton.
24.	*Cypræa Europæa*, var. *globosa*	5	Red Crag, Sutton.
25, *a*, *b*.	*Turritella incrassata* (enveloped in *Cellepora edax*) . . .	55	Cor. Crag, near Orford.

(This Plate was engraved in 1870.)

Suppt Tab. V.

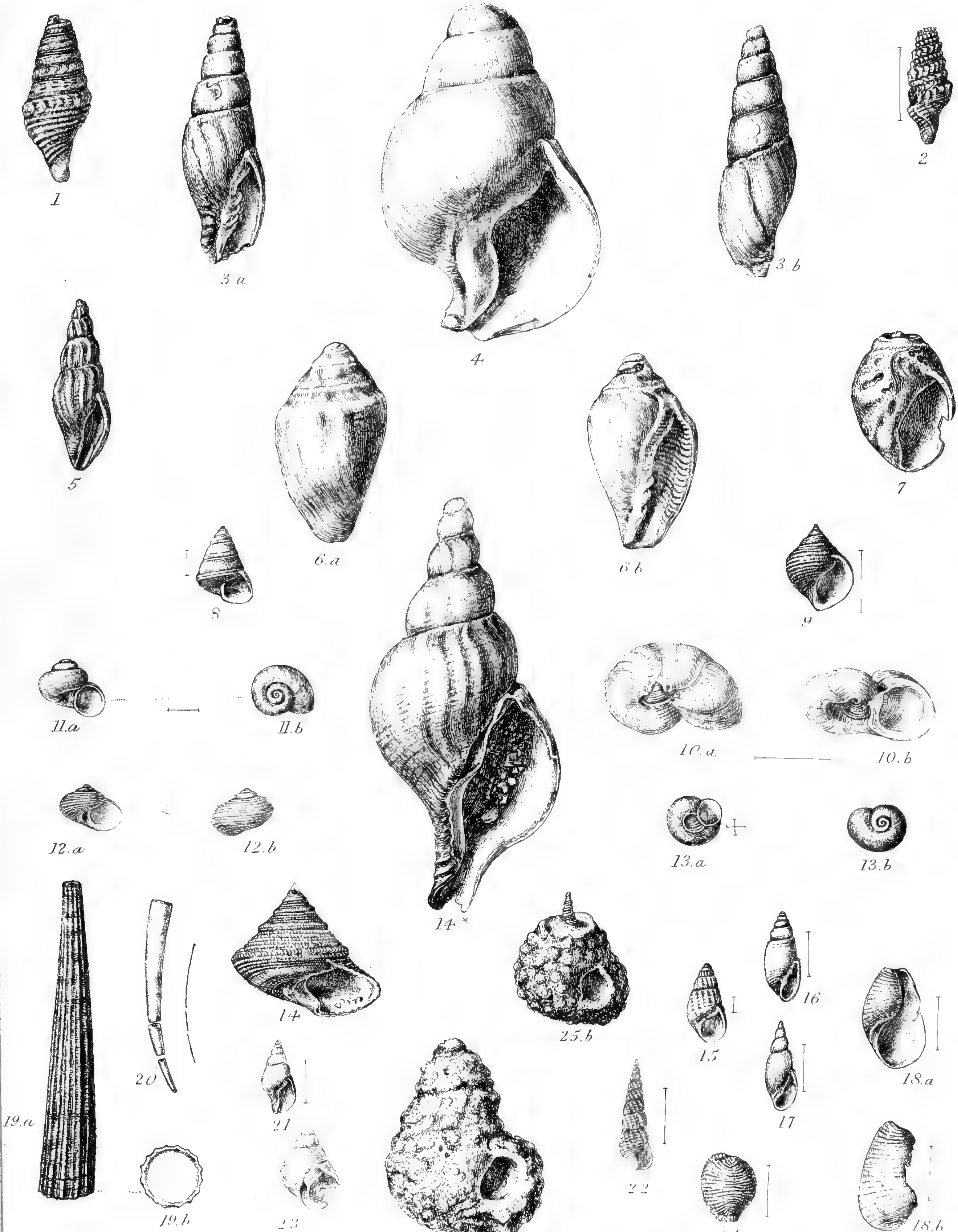
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PLATE VI.

Fig.	*Names of the shells.*	PAGE	*Localities from which the specimens figured were obtained.*
1, *a*, *b*.	*Cassis Saburon*	10	Red Crag, Waldringfield (derived?).
2, *a*.	*Cassidaria bicatenata*, var. *ecatenata*	11	Cor. Crag, near Orford.
2, *b*.	— (a young specimen)	11	Red Crag, Waldringfield.
3, *a*, *b*.	*Pleurotoma hystrix*	41	Red Crag, Walton Naze.
4.	— *coronata*	32	Red Crag, Waldringfield (derived?).
5.	*Nassa reticulata*	14	Post-glacial, Kelsey Hill.
6.	— *pygmæa*	12	Post-glacial, Nar Valley.
7.	— *pulchella*	12	Cor. Crag, near Orford.
8.	— *densecostata*	13	Cor. Crag, near Orford.
9.	*Pleurotoma Artica ?* (*P. violacea* of A. Bell)	45	Red Crag, Waldringfield.
10.	*Cancellaria spinulosa*, var. *subspinulosa*	49	Cor. Crag, Sutton.
11.	*Nassa granifera*	11	Cor. Crag, near Orford.
12.	*Cancellaria viridula*, var. *Couthouyi*	97	Red Crag, Butley.
13.	*Pleurotoma crispata*	35	Cor. Crag, Ramsholt.
14.	*Voluta luctatrix*	7	Red Crag, Waldringfield (derived?).
15.	*Pleurotoma lævigata*	42	Red Crag, Butley.
16.	— *septangularis*	38	Post-glacial, Nar Valley.
17.	— *bicarinata*	43	Red Crag, Butley.
18.	— *assimilis*	40	Middle Glacial, Billockby.
19.	*Cancellaria contorta*	46	Cor Crag, near Orford.
20.	*Trophon Barvicensis*	27	Red Crag, Waldringfield.

(This Plate was engraved in 1871.)

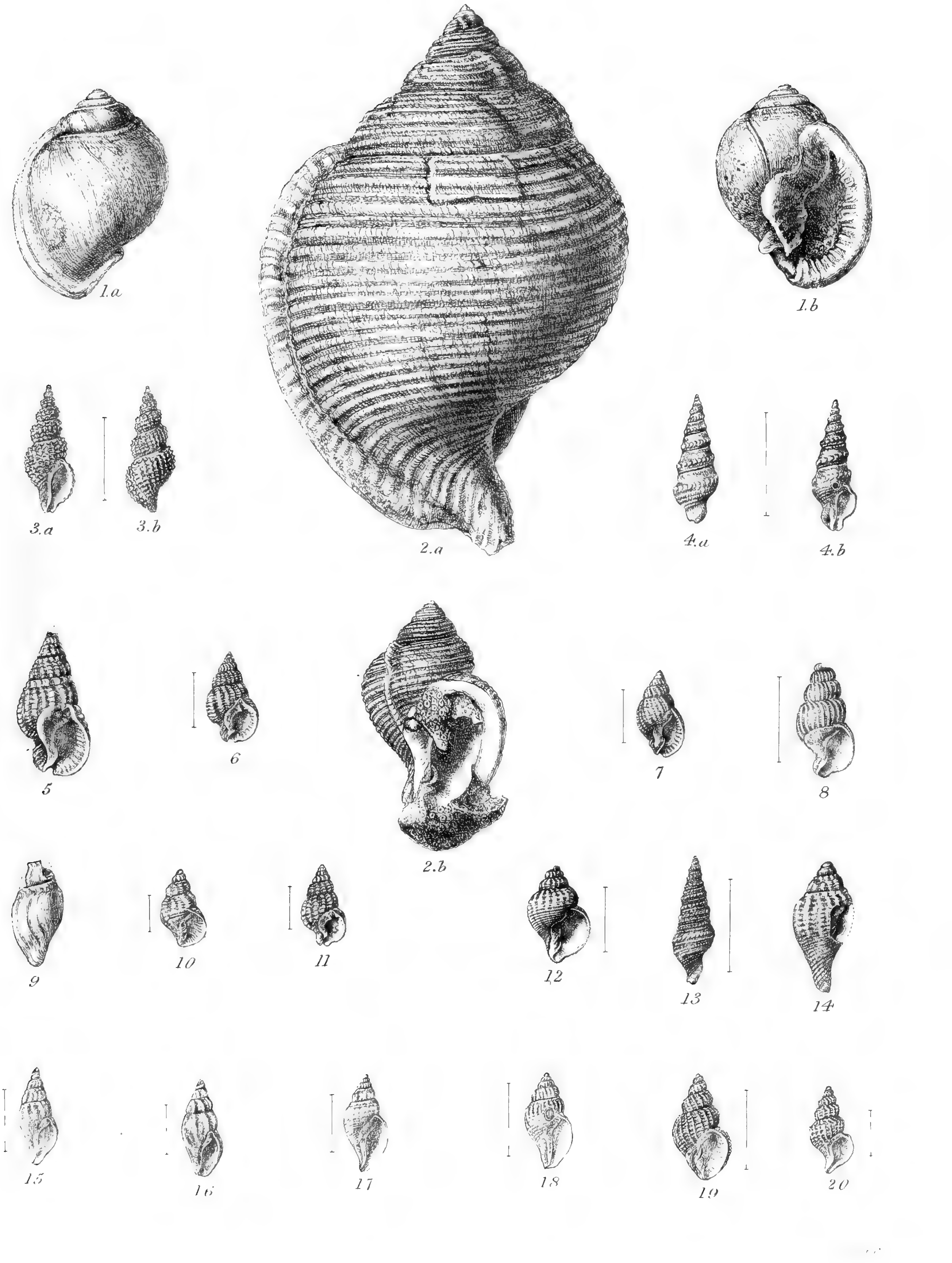
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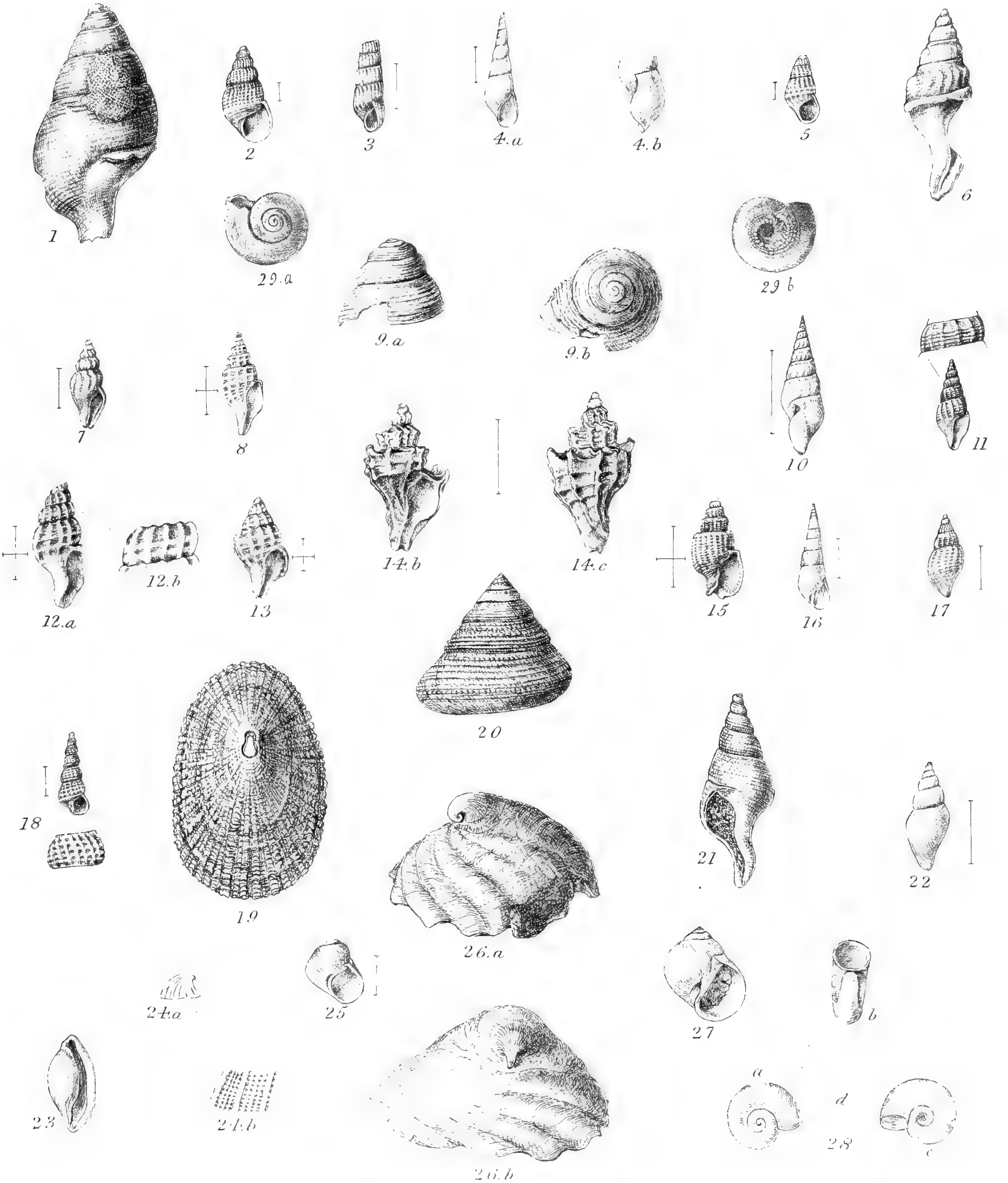
PLATE VII.

Fig.	*Names of the shells.*	Page	*Localities from which the specimens figured were obtained.*
1.	*Trophon Leckenbyi*	24	Upper Glacial, Bridlington.
2.	*Rissoa abyssicola ?*	97	Cor. Crag, Sutton.
3.	*Chemnitzia plicatula* . . .	61	Red Crag, Butley.
4, *a*, *b*.	*Eulima glabella*	67	Cor. Crag, Sutton.
5.	*Rissoa eximia ?*	72	Cor. Crag, Sutton.
6.	*Pleurotoma nodifera ?* . . .	33	Red Crag, Waldringfield (derived ?).
7.	— *nebula*	45	Cor. Crag, Sutton.
8.	— *turricula* . . .	40	Middle Glacial, Hopton.
9, *a*, *b*.	*Buccinum Dalei ?* (apex) . .	16	Cor. Crag, near Orford.
10.	*Pleurotoma crassa*	37	Cor. Crag, near Orford.
11.	— *quadricincta* . .	44	Red Crag, Butley.
12, *a*, *b*.	*Trophon mediglacialis* . . .	28	Middle Glacial, Billockby.
13.	— *Billockbiensis* . . .	28	Middle Glacial, Billockby.
14, *a*, *b*.	*Murex Canhami*	30	Red Crag, Waldringfield.
15.	*Nassa reticosa*, var. *scalarina* .	15	Red Crag, Sutton.
16.	*Eulima similis*	65	Red Crag, Walton Naze.
17.	*Pleurotoma rufa*	44	Post-glacial, March.
18.	*Chemnitzia clathrata ?* . . .	59	Cor. Crag, Sutton.
19.	*Fissurella costaria*	90	Cor. Crag, Sutton.
20.	*Trochus bullatus*	82	Red Crag, Walton Naze.
21.	*Trophon propinquus* (sinistral) .	24	Red Crag, Waldringfield.
22.	*Pleurotoma pyramidalis* . . .	43	Post-glacial, March.
23.	*Ovula spelta*, var. *brevior* . .	5	Red Crag, Walton Naze.
24.	*Emarginula fissura*, var. *punctura*	90	Cor. Crag, Sutton.
25.	*Paludina glacialis* (juv.) . .	68	Middle Glacial, Hopton.
26, *a*, *b*.	*Capulus Ungaricus*, var. *sinuosus* (*Brocchia sinuosa*) .	88	Cor. Crag, near Orford.
27.	*Natica Alderi*	74	Post-glacial, Nar Valley.
28.	*Homalogyra atomus*	86	Cor. Crag, Sutton.
29.	*Solarium vagum*	85	Red Crag, Waldringfield.

(This Plate was engraved in 1871.)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THE

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MDCCCLXXII.

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

WEALDEN FORMATION.

SUPPLEMENT No. IV.

PAGES 1—15; PLATES I—III.

DINOSAURIA (IGUANODON).

BY

PROFESSOR OWEN, F.R.S., D.C.L.,

FOREIGN ASSOCIATE OF THE INSTITUTE OF FRANCE,

ETC. ETC.

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SUPPLEMENT (No. IV)

TO THE

MONOGRAPH

ON THE

IGUANODON.

BONES OF THE FOREARM AND PAW. Plates I, II, III.

THE additional elements towards a reconstruction of the Iguanodon, which form the subject of the present supplementary monograph, have been contributed by SAMUEL HUSBANDS BECKLES, Esq., F.R.S., F.G.S., and their acquisition is due to his persevering labour, liberal indifference to expense, and intelligence directing the quest, resulting in the successful exhumation of the parts in question. They were associated with the greater part of the skeleton, of which, besides the subjects of the present Monograph, Mr. Beckles secured a dentary element of the mandible, fifty vertebræ, a sternum, scapula, and coracoid, one humerus and fragments of the other, one femur, one tibia and parts of the other, a tarsal bone, the three metatarsals, and phalanges of one hind foot, and some bones of the other hind foot.

Mr. Beckles was led to this excavation by a slight indication of bone in a Wealden clay (Hastings Series), about two miles to the west of St. Leonard's-on-Sea, Sussex. The area worked up was 200 feet square, or 10 feet by 20 feet, and 4 feet deep. The bed was below high water, and could only be wrought at during one tide in the day. Nevertheless the work of exposure was conducted with such energy that it was completed in a week. "The bones were imperfectly mineralized, and could only be secured by plaster of Paris, of which I used about thirty bags, each bag containing seven pounds. As a rule I applied the plaster with my own hands; but as the weather was severe, the wind being high and cold, with occasional sleet and snow, I was compelled to leave the manipulation of more than one bone to my navvies, and consequently one femur was destroyed, one jaw, one humerus, and one tibia, nearly destroyed. Had I not made a digging expressly for these bones, the interesting specimens you have in hand could never have been obtained."[1]

[1] Extract from a letter by Mr. Beckles to the author, of the 25th September, 1871.

The half or ramus of the lower jaw preserved is represented by the dentary element, containing many of the characteristic teeth of the great herbivorous reptile, and repeating the peculiar form of the fore part of the mandible which has been recognized in previously described and figured specimens of that bone.[1] Though dislocated, displaced, and somewhat scattered in the matrix, they impressed the discoverer with the conviction or certainty of their being parts of the skeleton of the same individual. A comparison of all the bones and fragments of bone submitted to me for determination give no indication of their having belonged to more than one animal, and all are referable to an individual of the same age and size.

The left radius and ulna are in the best state of preservation; the right radius and ulna are less entire; an os cuneiforme is recognizable in the carpal series, and there are metacarpals and a few phalanges of both right and left paws.

The radius is chiefly remarkable for its powerful spinous or spur-like appendage.

The antibrachial bones in the present collection confirm the ascription to 'radius' and 'ulna' of the two bones imbedded near the upper corner, opposite the right hand, of the great slab of the 'Maidstone Iguanodon;'[2] but Mr. Beckles' specimens having been worked out of the less intractable matrix—the Wealden clay—show the configuration and characters of the surface of the entire bone.

In the following description the surface or aspect of the bone corresponding with the olecranon and 'back' of the hand is termed 'anconal;' the opposite surface, or that answering to the 'palm' of the hand, is termed 'thenal;' the surface toward that side of the forearm where lies the radius is termed 'radial;' towards the opposite side 'ulnar.' 'Proximal' and 'distal' imply the ends of the bone respectively next to or furthest from the trunk of the animal.

Ulna. Plate I, 55.

The ulna is 1 foot $5\frac{1}{2}$ inches in length;[3] 4 inches 8 lines across the radio-humeral articulation (at *a*, *b*, fig. 1); 3 inches 8 lines across the distal end; 2 inches 10 lines being the greatest diameter of the middle of the shaft.

The olecranon (*c*, fig. 1) extends 1 inch 9 lines above the humeral articular cavity (*d*, *d'*); it is obtuse, about 2 inches thick at the base, thence gradually contracting, to be continued into the ridge (*a*, fig. 1) extending along or forming the ulnar border of the

[1] More especially in the portion of the mandible of a young Iguanodon. Palæontographical Society's 'Monograph of the Fossil Reptiles of the Wealden Formations,' 4to, 1855, p. 20, Tab. XI, *e*, *s*.

[2] Ib., Tab. XXXIV, 'Monograph on the Fossil Reptilia of the Cretaceous Formations,' 4to, 1851. "The radius and ulna lie with their proximal ends next the right hand upper corner, the latter being distinguished by its prominent olecranon, which is rounded as in the Great Monitor," p. 112.

[3] The length of the ulna in the Maidstone Iguanodon is estimated at 1 foot 6 inches. 'Monograph,' *ut supra*, p. 114.

bone, to beyond the middle of the shaft, which then becomes rounded, and finally broadens to near the distal expansion of the bone (*k*, *k'*, fig. 1).

The humeral articular surface (figs. 1 and 2, *d*, *d'*) is oblong, and extends from above obliquely downward and forward to the strong anterior ridge (*e*), which, adding to its width, is then continued down to form (at *e'*) part of the cavity for the radius. The humeral surface is concave lengthwise, and also, in less degree, transversely; but both ulnar and radial borders become convex in that direction, or are rounded off and thick. The sharpest or best defined border is that which divides the lower part of the humeral articular cavity (fig. 2, *d'*, *f*, 'greater sigmoid' of Anthropotomy) from that (*g*) presented to the radius ('lesser sigmoid cavity,' ib.).

The length of the humeral cavity is 4½ inches; the breadth across the middle 2½ inches: the surface (*d'*, *f*, *g*, fig. 2) for the head of the radius appears to be directly continued over the well-defined lower part of the border (*d*, *f*) of the preceding cavity, directly downward, or with its plane in the longitudinal axis of the bone. This 'lesser sigmoid cavity' is semi-elliptical in shape, about 2 inches 8 lines in longest diameter, 1 inch 3 lines in the opposite direction; the upper border is straight, the lower one curved. The exact extent in the direction transversely to the head of the ulna, or in the long axis of the semi-ellipse, has suffered by fracture of the antero-inferior end or angle of the combined humero-articular cavities.

About half an inch below the radial surface the ridge (*e'*, fig. 1), continued downward from the above broken angle, expands to a rough tuberosity, which was joined by syndesmosis to a similar rough tuberosity (*r*, fig. 3) at the lower part of the anterior articular ridge of the radius.

At the proximal end of the ulna a thick, rough, long tuberosity, or tuberous ridge (fig. 2, *h*, *h*), from the radial side of the humero-radial articulation, is most prominent where it bounds or defines the radial division of that joint; below which it contracts and slightly bends to its termination (*h'*). This projection augments the breadth of the back part of the ulna below the base of the olecranon. At this part the ulna is almost flat, and the surface is roughened by thick irregular ridges, which mostly affect a longitudinal direction.

The general form of the bone at its upper three fourths is three-sided. The hinder side, continued from the above flat, rough expanse, maintains its character of flatness, gradually contracting to its termination 4½ inches above the distal end, where the shaft begins to be rounded.

The ulnar surface of the olecranon is moderately convex, lengthwise and across, for 3½ inches, or to below the middle of the humeral cavity. Then the surface begins rapidly to expand, by the development of the ulnar boundary (*e*) of the articulation for the radius, gaining a breadth of 4½ inches. The ulnar surface is here (fig. 1, *i*) moderately concave, both lengthwise and across; half way down the bone the concavity is changed to a surface flattened lengthwise, and moderately convex transversely.

The third or radial side of the shaft of the ulna has been somewhat crushed in, but seems to have been rather convex transversely, and is less sharply defined than are the other two surfaces. The thick rounded border between it and the hinder surface gradually subsides at the lower fourth of the shaft, and both blend into the somewhat flattened rough surface opposite the articular one at the distal expansion of the bone.

The thick rounded border between the ulnar and radial sides of the shaft contracts about the lower fifth of the bone, inclines forward, and extends into the beginning of the rugous margin (*k*, *k'*, fig. 1), which defines, by a convex curve, the lower or distal end of the bone.

The non-articular surface of this expansion is smooth anteriorly, where the radial facet of the shaft terminates; but is roughened by oblong tuberosities posteriorly, where the hinder facet of the shaft is lost upon it.

The articular surface for the distal expansion of the radius is of a crescentic shape, with the anterior horn the longest. It is rough and irregular on the surface, indicative of the ligamentous nature of the union. The smooth ulnar surface of the shaft terminates in the hollow of the crescent. The anterior horn extends 4 inches 3 lines above the distal end of the bone; the posterior horn 2 inches 6 lines above the same end. The general breadth of the syndesmotic surface is about 2 inches, contracting at each end of the crescent.

The compact bony wall of the ulnar shaft is from 6 to 9 lines in thickness; the fine cancellous centre, of an oval form in transverse section (fig. 4), is 1 inch 3 lines by 10 lines in its diameters.

In general shape, in the better definition of the joints for the humerus and radius, and in the development of the olecranon, the ulna of the Iguanodon resembles that of the larger living *Lacertia* more than that of the *Crocodilia.* From the ulna of the Iguana and of the large Nilotic Monitor it differs in the greater relative strength and more trihedral figure, the shaft of the ulna being compressed and two-sided in the smaller recent Lizards. There is the same concavity at the proximal part of the ulnar surface of the bone; but it seems relatively deeper in the Monitor. The chief difference in the Iguanodon is the thick tuberous extension on the radial side of the radial articulation, from which is continued that border which divides and defines the posterior and radial surfaces of the shaft.

Radius. Plate I, 54.

The length of this bone is 16 inches;[1] the greatest diameter of the proximal end (fig. 3) is 4 inches; of the distal end, from the upper border of the spur-surface (fig. 1, *m*)

[1] This appears to be its length in the Maidstone Iguanodon, but one end is covered by a crushed vertebra.

to the ulnar end of the distal articulation (ib. *n*) is 7 inches, 6 lines; from the lower border of the spur-joint (*o*) to the same part (*n*) is $5\frac{1}{2}$ inches.

The proximal surface or 'head' (fig. 1, *p*), for articulation with the humerus, is semi-elliptical. The long diameter gives the breadth above quoted; the short diameter, at the middle of the ellipse, is 2 inches 4 lines; the truncate border or chord of the semi-ellipse is toward the ulna. From the posterior two thirds of this border the articular surface for the ulna (fig. 3, *q*) extends down, $1\frac{1}{4}$ inch, at right angles with the proximal surface. It is flat and rough, semi-elliptic in shape.

The proximal surface is almost flat, feebly undulate, with a linear roughness for ligamentous union with the humerus; it is continued at its fore part upon the ridge-like prominence of the bone (fig. 3, *r*, *r'*), which bends toward the ulna as it descends, terminating $2\frac{1}{4}$ inches below the humeral surface; this rough extension of the articular surface is separated from the flatter ulnar surface by a deep, smooth pit (ib. *s*), big enough to receive the end of the thumb. Beneath this articular surface the radius contracts to a breadth of 2 inches 5 lines, and a thickness of 1 inch 3 lines; and this subcompressed form, flat or subconcave toward the ulna, convex on the opposite side, but irregularly so on both sides, continues two thirds down the length of the shaft; which, then, gains in thickness and breadth, but especially and rapidly in the latter dimension by the extension of the distal end beneath that of the ulna.

The distal surface for articulation with the ulna commences about 9 inches from the proximal end of the radius in a pointed form (fig. 1, *t*), which rapidly expands to a breadth of $2\frac{1}{4}$ inches. This part of the distal ulnar surface is parallel, lengthwise, with the non-articular surface of the shaft of the radius, is almost flat or slightly convex and rough, and might be regarded as representing a partial interosseous syndesmosis; it is continued, however, at its lower broadest part into a smoother concavity upon the proximal side (ib. *u*, *v*) of the distal extension of the radius, and this concavity receives part of the distal convexity of the ulna (ib. *k*, *k'*). The distal end of the radius is excavated by two concavities for the carpal bones; that (ib. *w*) for the hemispherical part of the scaphoid is the deepest, and measures about an inch and a half in both transverse and fore and aft diameters; the shallower concavity (ib. *x*) for the convex part of the cuneiforme is continued into a slightly convex surface, extending to the apex of the distal extension ulnad (*n*) of the radius.

On the shaft of the radius may be noticed a rough, slightly prominent tuberosity (*y*), about 15 lines by 12, at the hinder or anconal margin, commencing about 4 inches from the proximal end. The shaft is not quite straight; the anconal surface below the tuberosity gains in thickness, and is slightly concave lengthwise; the thenal surface is thinner, and slightly convex lengthwise.

The exceptional feature of this radius is an oblong, irregularly flattened, rough surface, as if caused by fracture, occupying the radial aspect of the distal expansion (*m*, *o*); consequently, opposite the surface above described for articulation with the ulna. To this surface was joined, if not anchylosed, the base of a bone, corresponding with that which has been figured as the "horn" of the Iguanodon (*z*)[1]; the surface on the radius, like the co-adapted one on the base of the 'horn,' is 4 inches in long diameter, and 2 inches 4 lines in short diameter.

The unsymmetrical character of this supposed 'horn' led me to infer that it was one of a pair of bones, which I conjectured to be 'phalangeal.'[2] The rough flattened base of the original specimen, on part of which the cellular osseous texture was exposed, I believed to be due to the articular surface "having been chiselled or scraped away."[3] I now know that it was a natural surface due to separation from a close syndesmotic and partially anchylosed union with the distal end of the radius, as in the left antibrachial bones figured in Pl. I, fig. 1.

In the right radius of the Iguanodon, which has afforded the subject of the present Monograph, this horn-like appendage is anchylosed, and stands out from the radial side of the distal end like a process of the bone (Pl. II, fig. 1).

The length of the detached radial spine in the left fore-limb is 6 inches; the apex is not quite entire; the thenal surface (Pl. I, fig. 1, *z*) is less convex across and more convex lengthwise than the anconal surface (Pl. II, fig. 1, *z*). This surface is strongly convex transversely, slightly concave lengthwise, and is smooth along its distal half; it is roughened by thick and strong longitudinal ridges at its proximal third, and these are less developed at the corresponding part of the thenal surface.

The vascular channels indicate, as in a claw-phalanx, the system of supply of horny matter sheathing the bone.

The formidable spine, supported by this bony core, projected inward or from the radial side of the radius, with its distal border at right angles with the long axis of the bone, the proximal border (*z*) passing more obliquely to the apex of the spine-core.

The right ulna shows an exostosis at the back part of the shaft, near the base of the olecranon. Such instances of disease in Mesozoic reptiles are rare.

There is a slight difference in the shape of the proximal end of the right radius, which, nevertheless, belonged to the same individual Iguanodon, as the left one above described: the humeral surface, or 'head,' is 3 inches 5 lines by 2 inches 9 lines; the principal ulnar surface is 2 inches 3 lines by 1 inch 6 lines. The narrower surface for the ulna, extending upon the ridge-like process, with the digital depression dividing it from the broader ulnar surface, show the same characters, as at *r*, *s*, figure 3, Pl. I.

Fracture of the shaft of the right radius (fig. 5) shows a compact bony wall, 6 to 7 lines in thickness, surrounding a finely cancellous central tract: the shaft is sub-trihedral, approaching the cylindrical form prior to the distal expansion.

[1] Mantell, 'Illustrations of the Geology of Sussex,' 4to, 1827, p. 78, pl. xx, fig. 8.

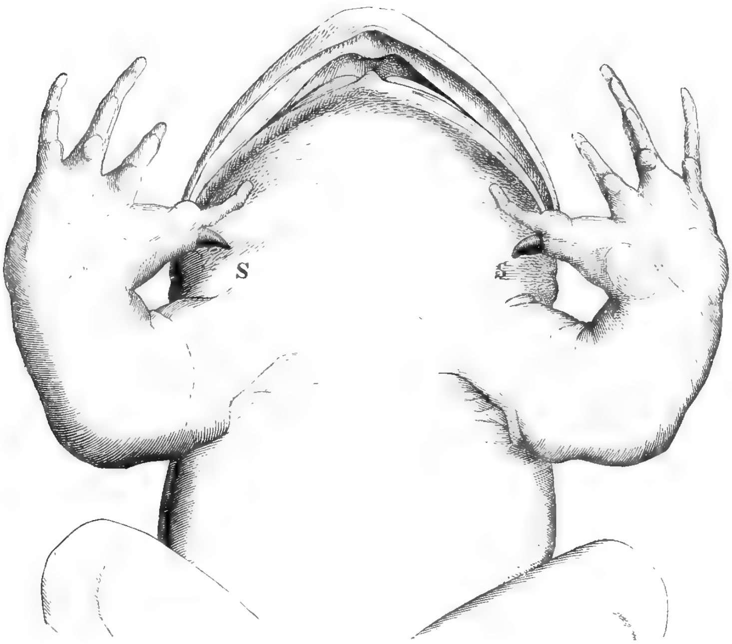
[2] 'Monograph on the Fossil Reptilia of the Wealden Formation,' 4to, 1855, p. 46.

[3] Ib., ib.

The radius of the Iguanodon resembles that of Lizards—*Iguana tuberculata, Monitor niloticus,* for example—in the larger and more definite extent of the proximal surface for the ulna, than exists in the *Crocodilia.* But no living reptile—crocodilian, chelonian, or lacertian—is armed like the extinct herbivorous Dinosaur.

Of other examples in the animal kingdom of limbs with spinous weapons, the first that suggested itself was the monotrematous reptile-like Mammals. But in both *Orni-*

Fig. 1.



Sexual spines of fore-limbs; or 'Hand-spurs,' Male of large S. Amer. Toad (*Cystignathus fuscus*).

thorhynchus and *Echidna* they are limited to the hind limbs, and are attached to the tarsus, not to the tibia.

In the class of Birds are a few 'spur-winged' species—*Anser gambensis, Parra jacana, Palamedea cornuta, Hoplopterus, e.g.*—in which the weapons are attached to the radial side of the fore-limbs; not, however, to the radius itself, but to the base of the metacarpus.

My friend and colleague, Dr. Günther, has kindly supplied me with the following example of spines or spur-like weapons in an existing cold-blooded air-breather; but it is a member of the Batrachian order. In *Cystignathus fuscus* a sharp, conical, horny spine, figure 1, *s, s,* is supported by a bony core attached to the radial side of the metacarpal of the innermost or radial digit.

Many species of Fish support and wield with effect formidable spinous weapons, forming part of the pectoral fins, the homologues of the fore-limbs in Iguanodon and other terrestrial Vertebrates.

The monotrematous and batrachian instances show the spinous limb-weapons to be related to sex, and to be present, or fully developed, only in the males.

In the class of Birds the carpal spurs are common to both sexes, but smaller in the female.[1]

The question remains—were the radial spines of Iguanodon common to both sexes, or developed only in one, most probably the male?

In the Maidstone specimen such appendage, with a concomitant considerable distal expansion of the radius, cannot be discerned. In the best preserved ends of the anti-brachial bones, those, viz., furthest from the humerus (as the separated fragments of the matrix, have been restored in the Maidstone specimen), the closest resemblance traceable to the more complete bones before me is at the proximal ends; and especially, as originally determined by me, in the ulna, or lower placed bone. In this view the distal ends, especially of the radius, are partly concealed by an overlying vertebra, yet not to the extent to obscure the beginning of the radial expansion if it had existed. The shafts of both radius and ulna seem to be more slender than in Mr. Beckles' Wealden specimen. It may be that this is of a male Iguanodon and the Maidstone specimen of a female one.

A strange instrument truly in aid of the amorous embrace; yet, as in the instance of *Cystignathus*, and perhaps also the *Ornithorhynchus* and *Echidna*, not without a parallel!

If the radial spines, on the other hand, were developed in both sexes of the Iguanodon, and wielded for purposes of defence by the otherwise weaponless herbivore, one cannot fail to discern in them a formidable means of transfixing an enemy—the carnivorous Megalosaur, *e. g.*—in a close death-struggle.

Manus. Plate III.

With the right and left anti-brachial bones and spinous appendages several bones of both the fore feet were exhumed, but not enough for a complete restoration of either foot.

They give evidence that the fore-paw was pentadactyle, and that the terminal phalanges, at least of some of the toes, were short, obtuse, rough, serving for the support of horny matter in the shape of a hoof rather than of a claw. Such evidences of the carpal bones as were collected are more or less fragmentary; and, where a satisfactory union of those belonging to one and the same bone could be made, the homology of but one bone can be safely or with probability be suggested, that, viz., which answers to the large os cuneiforme in the carpus of Lizards.

The proximal surface of this bone is divided into a convex and concave surface; the former was apparently adapted to the concavity of the ulnar extension of the distal part of

[1] The Secretary of the Zoological Society, P. L. Sclater, Esq., F.R.S., kindly informs me that this is the case in the pair (male and female) of the spur-winged geese (*Plectropterus*) now living in the Society's Gardens.

the radius; the concavity was adapted to part of the distal end of the ulna, but leaving the ulnar end of the distal convexity of that bone (Pl. I, fig. 1, *k*) for probable adaptation to an os pisiforme. The distal surface of the unciforme shows the concavity for an os magnum, and a well-defined flatter surface for a small unciforme.

The metacarpal of the pollex (Pl. III, I, *m*) is 4 inches in length; 2 inches 5 lines across the broadest part of the proximal end; 2 inches across the corresponding part of the distal articulation. Both these dimensions are in the direction of the transverse breadth of the paw, the bone being subdepressed. The proximal articulation is a shallow, circular cavity continued radially upon a rough, angular production of that end of the bone. The opposite side of the articulation is produced into a broader roughened surface for syndesmotic union with the base of the next metacarpal.

The anconal surface of the bone (shown in Pl. III), for an inch or more in advance of the distal end, is roughened by longitudinal grooves and ridges: the surface then continues smoothly to the distal convexity; but shows, on each side near that surface, evidence of the powerful lateral ligaments connecting this metacarpal with the first phalanx.

On the radial side is a rough oval pit, an inch in long diameter, with the proximal border prominent and forming an angle in the radial outline of the bone. There is a similar projection on the ulnar side, but it forms the proximal end of a triangular tuberosity.

The thenal surface of the bone is more or less rough, and is divided by a low medial prominence into two facets.

The distal articulation is of an oval shape, convex in a greater degree than the proximal articulation is concave; it is 2 inches across transversely, $1\frac{1}{2}$ inch in the opposite direction, or from the anconal to the thenal surface. The plane of both proximal and distal articular surfaces is not quite transverse to the axis of the bone, but rather oblique from the ulnar forward to the radial end. The least transverse diameter, at the middle of the shaft of this metacarpal, is 1 inch 8 lines.

The metacarpal of the pollex of both right and left fore-feet has been obtained.

The first phalanx of the pollex (ib. I, 1) is broader and more depressed, in proportion to its length than is the metacarpal which supports it. Its proximal concavity is smaller and more shallow than the convexity to which it is adapted, though this appearance may be in some degree due to the abrasion of the margins. That part which is preserved equally bespeaks the strength of the ligamentous attachment with the metacarpal; it is most produced on the radial side of the bone (*a*), as if ossification had extended there along the lateral ligament toward the metacarpal. The opposite or ulnar roughened surface is broader, more tuberous, but less produced.

The anconal surface of the bone is less regularly convex transversely than in the metacarpal; the mid part being raised so as to divide it from the surface on each side, which is flatter transversely and slightly concave lengthwise.

The smooth surface on the radial side is continued along a notch at the radial border of the phalanx, upon the palmar surface of the shaft, two thirds across. All the rest of that surface is grooved and roughened for ligamentous attachment.

The distal end of this phalanx is 2 inches in breadth; of this, a feebly convex, semi-oval articular surface occupies a transverse extent of 1 inch 5 lines; the breadth from the anconal to the thenal border of this surface gives that of the distal end of the phalanx, viz. 1 inch.

The series of bones does not include any phalanx adapted to or agreeing in size with this surface. By the analogy of *Sauria* and *Crocodilia*, I conclude the missing phalanx would be the terminal one. Of the proximal phalanx of the 'pollex,' Mr. Beckles' series includes both right and left.

The second metacarpal (Pl. III, 2, *m*), or that of the index digit, is 6 inches in length. The proximal end is subquadrate, 2 inches in breadth, deviating from flatness by a slight convexity, most marked towards the ulnar side, where it probably projected into the cleft between the trapezoides and os magnum.

There is no indication of a smooth synovial surface; the union throughout, or nearly so, seems to have been ligamentous; the longest diameter in the ancono-thenal direction is toward the ulnar side of the surface, and is 1 inch 8 lines.

Near the radial side of the base is a rough surface of limited extent, apparently for ligamentous connection with the adapted surface of the first metacarpal.

On the ulnar side of the second metacarpal a rough flattened tract projects, like an exostosis, from the whole length of that side of the bone. Its ancono-thenal breadth at the base of the metacarpal is 1 inch 6 lines; it decreases to a breadth of 6 lines where it passes into the rough surface for the lateral ligament on the ulnar side of the distal end.

The anconal surface of the shaft is smooth, becoming roughened by linear striæ as it bends upon the radial surface. The thenal surface of the shaft is ridged and grooved throughout; it is nearly flat transversely, moderately concave lengthwise. The distal articular surface is moderately convex, 1 inch 4 lines in diameter; there is a protuberance on each side of the thenal part of the distal end; the ulnar side of the bone is slightly convex; the radial one in a greater degree concave; thus, the second metacarpal is slightly bent toward the radial side of the paw.

The bone described belongs to the left foot. The proximal part of the same phalanx of the right foot is preserved.

The proximal phalanx of the second toe (ib., II, 1) is 2 inches 6 lines in length; 2 inches in breadth at the proximal end; 1 inch 9 lines at the distal end. The proximal articular surface has the smooth synovial character but slightly indicated. It is subcircular in form, about an inch in diameter, with a very feeble concavity; the rough peripheral tract on nearly the same plane, from 4 to 6 lines in breadth, indicates how large a proportion of the joint had been syndesmotic: the protuberance for the lateral ligament on the radial side projects beyond the plane of the articulation; that on the ulnar side has a more distal relation to the joint. The anconal and lateral surfaces of the shaft form a continuous convexity transversely. The thenal surface is flattened, but irregular; an oblique groove extends from the radial end of the proximal surface for about an inch onward toward the ulnar side; this groove, 4 lines in breadth, seems to be natural; the clay matrix could easily be picked out of it. Beyond the groove the short thenal surface is moderately smooth and slightly concave; a pair of hemispherical tuberosities project near the distal articulation, and are continued into the tuberosities on each side of that surface. The form of the surface is trochlear, that is, concave transversely, convex ancono-thenally; feebly defined in both directions. The breadth is 1 inch 3 lines; in the opposite diameter 10 lines. The well-defined anconal border projects a little above the level of the corresponding surface of the shaft; the breadth of the shaft at its middle is 1 inch 3 lines.

To the well-defined smooth trochlear surface of the above phalanx is adapted a surface of corresponding size, shape, and smoothness at the proximal end of a phalanx, 1 inch 3 lines in length, 1 inch $4\frac{1}{2}$ lines across that end (Pl. III, II, 2). The breadth of the distal articulation of this phalanx is 1 inch 2 lines; its ancono-thenal diameter is 6 lines, that of the proximal surface being 9 lines. Thus, the shape of this phalanx is subquadrate and subsphenoid; the apex of the wedge being cut off, so to speak, to form the distal joint. The upper surface of the short shaft is smooth, convex transversely, concave lengthwise. The under surface is flat, rough, and irregular, and is continued into rough prominences on each side of the shaft.

To the distal articular surface of the above phalanx is adapted the proximal one of the present (ib., II, 3, 3 *a*, 3 *b*), which is terminal, ending in a rough, obtuse, thickened border (3 *b*); the breadth exceeds the length in a greater degree in this than in the preceding phalanx; it equals 1 inch 3 lines, the length of the bone being 10 lines. The greatest ancono-thenal diameter of the proximal end is 9 lines, while that of the articular surface is but 6 lines; there is no trace of attachment for the claw. The non-articular surface of this obtusely wedge-shaped phalanx indicates by its roughness that it was imbedded in a callous sheath of the integument.

Thus we have evidence that the second digit of the fore-foot of the Iguanodon had three phalanges supported by a metacarpal; that it much exceeded in length the pollex or first digit, and that it was of less breadth, though with greater ancono-thenal thickness of the proximal phalanx.

The entire length of the four bones of the second digit is 10 inches 6 lines.

The metacarpal of the third or 'medius' (ib., III, *m*) digit is 6 inches 9 lines in length; the ancono-thenal exceeds the transverse diameter, except at the distal articulation, where the two are equal; the bone is most compressed laterally at the proximal end, which is strongly convex for being wedged or received into a groove-like cavity of the os magnum. The ancono-thenal diameter at this end of the bone is 2 inches; the transverse diameter at the anconal part is 1 inch 3 lines, but narrowing towards the thenal end. The radial side of the bone has a roughened tract, narrowing forward, and of the same extent as that on the contiguous surface of the second metacarpal; but it deviates from flatness at the parts, and in the degree in which that surface is convex in the attached bone. The two metacarpals were thus closely and ligamentously united, in a way and to an extent in which I have not observed the homologous bones in any recent Crocodilian or Lacertian. The anconal margin of the rough tract projects, ridge-like, along the proximal half of the bone. The anconal surface of the shaft begins, at an inch and a quarter from the proximal end, to be smooth, and is convex in both directions, but least so longitudinally. The ulnar surface of the shaft is roughened, but in a less degree than the radial one; the distal articular surface, single at its anconal half, where it is feebly concave, feebly concave transversely at its mid part, and much more convex in the opposite direction, has that curvature continued upon two lateral portions toward the thenal aspect of the bone, divided by an intervening channel.

The distal articular surface also inclines slightly to the radial side, where it projects beyond that surface of the shaft; it does not extend beyond the ulnar surface. It thus repeats the tendency to the bend radiad noticed in the second metacarpal, but here limited to the distal end.

The fourth metacarpal (Pl. III, IV, *m*) is 5 inches 6 lines in length; it is more compressed than the third, especially at the anconal part; the ulnar surface sloping anconad to meet the radial one, leaving the upper surface to be represented as a rounded border; thus, the shaft is trihedral, not quadrilateral. The proximal articular surface is 2 inches ancono-thenally by 1 inch 5 lines transversely. The chief part of the articular surface traverses that end of the bone in its long axis, with a strong convexity transversely, which passes into a flatter facet at the ulnar side; this ridge-like disposition of the chief articular prominence was probably wedged between the os magnum and unciforme. The ulnar flatter surface would articulate with the latter bone; in advance of this is a rougher tract, of small extent, for ligamentous articulation with a fifth metacarpal. The radial side of the fourth metacarpal is flattened and rough for junction ligamentously at its proximal part with the contiguous metacarpal; with an interval in the rest of the extent left by the concave curve, which this surface describes lengthwise, and which interval was probably filled up by looser ligamentous tissue.

The distal articulation, 1 inch 6 lines across, and the same in the opposite direction at the radial side, resembles in character that of the third metacarpal, but with an opposite obliquity tending to direct the toe which it supported more ulnad.

The corresponding metacarpal is preserved of the right fore-foot.

To either the third or the fourth digit belongs a proximal phalanx, 2 inches 6 lines in length, 1 inch 8 lines in transverse breadth of the proximal end, 1 inch 6 lines in the same breadth of the distal end, which supports a well-defined, smooth, shallow trochlear surface, 1 inch 1 line transversely by 10 lines ancono-thenally; it closely resembles the proximal phalanx of the second digit, but is rather narrower in proportion to its length, and shows greater disparity of size between the two distal tuberosities on the thenal surface. It may belong to the right paw.

A distal phalanx (ib., IV, 4), of the same character as that of the second toe, is longer in proportion to its breadth, and deeper ancono-thenally. The rough, obtuse termination is bounded below by a transverse groove indicative of an ungual callosity of a more definite form.

The fifth metacarpal of the right fore-foot (Pl. III, v, *m*, reversed) has been preserved. Its proximal surface is rather lozenge-shaped; the transverse diameter is 2 inches 3 lines; a circular, slightly concave, roughish articular surface is defined at the middle of the lozenge; the rougher tuberosities, extending beyond it on each side, form the truncate angles of the lozenge in that direction; a smaller extent of rough surface defines, in a feebler degree, the angles in the opposite direction. The length of this metacarpal is 1 inch 7 lines; the breadth of the distal end is 1 inch 8 lines. The upper surface is smooth, broad, and almost flat. The radial surface is continued into the thenal one, which is strongly concave lengthwise, and these combined surfaces are roughened by longitudinal ridges and grooves.

The ulnar surface slopes in that direction strongly from the upper one to meet the combined theno-radial surfaces; the distal articular surface is trapezoid in form, convex vertically, slightly concave transversely at its middle part, and continued upon a pair of tuberosities thenally; the toe which it supported would be directed obliquely to the ulnar side of the foot.

The skeleton of the fore-paw of the Iguanodon, carpus inclusive, may be set down as about 16 inches in length, and about 11 inches in extreme breadth, showing a like disproportion of size to the hind-foot which the humerus does to the femur.

In the Supplement,[1] No. 1, to the 'Monograph on the Fossil Reptilia of the Wealden and Purbeck Formations,' I remarked, in regard to its subject, "the resemblance to the hind-foot of the *Crocodilia* in the suppression of the fifth toe, and the resemblance of the third and fourth toes, in regard to their nearly equal length, to those toes in the Monitor, render it most probable that the tridactyle foot of the Iguanodon, here described, is a 'hind-foot;' but it cannot be assumed that the fore-foot may not have been similarly modified."

We have now the desired evidence, and know that the fore-foot was pentadactyle, and that its chief speciality is in the stunted character of the terminal phalanges, at least of the second and third digits. The entire length of the bony framework of the fore-foot, without the carpus, is 1 foot 1 inch; its breadth across the proximal ends of the metacarpals is 9 inches: the length of the bony framework of the hind-foot, without the tarsus, is 1 foot 8 inches; its breadth across the proximal ends of the metatarsals is 9 inches.

The fore-foot is smaller in proportion to the hind-foot in the Crocodile; it is still smaller in the Iguana.

The length of the bony framework of the hind-foot in a *Crocodilus biporcatus*, with a

[1] Vol. of the Palæontographical Society, 4to, for 1858, p. 3.

vertebral column, from the first cervical to the last sacral inclusive, of the length of 3 feet 2 inches, is 8 inches, including the tarsus; the length of the fore-foot, including the carpus, in the same skeleton, is 5 inches 4 lines.

In the skeleton of an *Iguana*, with the same part of the vertebral column 9 inches 3 lines in length, the length of the hind-foot, including the tarsus, is 4 inches 5 lines; that of the fore-foot, including the carpus, being 2 inches 3 lines.

In most recent *Reptilia* the fore limbs are shorter than the hind ones; in some of the tailless Batrachians the difference is extreme. But there is nothing in the proportions or structures, especially in the approach to the ungulate type of the unequal phalanges of the fore-foot of the Iguanodon, to justify, encourage, or even suggest that the fore limbs so terminated did not take their share, as in the Iguanas and Crocodiles, in terrestrial locomotion.

The notion of the Iguanodon being a biped, and walking like a bird, would, were it true, lend countenance to the reptilian hypothesis of the Ornithicnites.

But this notion would imply, not only ignorance of the structure of the fore limbs of the huge reptile, but also forgetfulness or disregard of the correlated conditions of avian bipedal progression on dry land.

In proportion to the bulk and weight of the bird, and to its limitation to terrestrial locomotion, is the extent of the trunk-vertebræ grasped by the splints or side bones ('ilia'), which transfer the weight of the body upon the hind limbs. Thus, the ostrich has twenty coalesced sacral vertebræ.

We have no evidence that the Iguanodon had more than four sacral vertebræ, and our knowledge of their characters is derived, as might be expected from the remains of a cold-blooded prone quadruped, from detached and unanchylosed sacral centrums.

Observation of the genesis of the bird's sacrum showed,[1] among other points, the alternating disposition of the central and neural elements; and progressive research into the osteology of the extinct *Reptilia* led to the recognition of a correspondence in this particular of the sacrum of the large Dinosaurs with that of Birds. But this afforded no ground to the Discoverer of the sacral structure for affirming or predicating a closer affinity of the Iguanodon or Megalosaur than of the Pterodactyle to the feathered class.

In the strong ligament of the head of the femur in Birds—in the depth of the socket for its reception—in the strength and close adjustment of the knee-joint, in which the fibula takes its share—in the well-turned trochlear form of the distal end of the tibia—in the rejection of any intermediate tarsus between it and the foot, and in the consolidation of the metatarsal bones for a firm and close articulation with the tibia, we may discern a perfect adaptation to the requirements of the single pair of limbs to which the functions of support, station, and progression on land, are exclusively confided.

[1] Owen, 'On the Archetype and Homologies of the Vertebrate Skeleton,' 8vo, 1848, p. 159, fig. 27; Catalogue of the Osteological Series in the Museum of the Royal College of Surgeons,' 4to, 1853, p. 266.

The reverse of all these conditions is seen in the bones of the hind limbs of the Iguanodon and other Dinosaurian reptiles.

If one takes the pleasure of speculating on the genesis of *Didus* or *Dinornis*, guiding or reining the roaming fancy by facts, the geographical limitation of such ornithicnitoid species, and their primitive association exclusively with creatures of which they could have no dread, suggest the more obvious and intelligible hypothesis of derivation from antecedent birds of flight, whose wings they still show more or less aborted, according to Buffon's principle of transmutation by degeneration,—with a progressive predominance of the legs over the wings, ultimately resulting in a maximization of the terrestrial and abortion of the aerial instruments of locomotion.

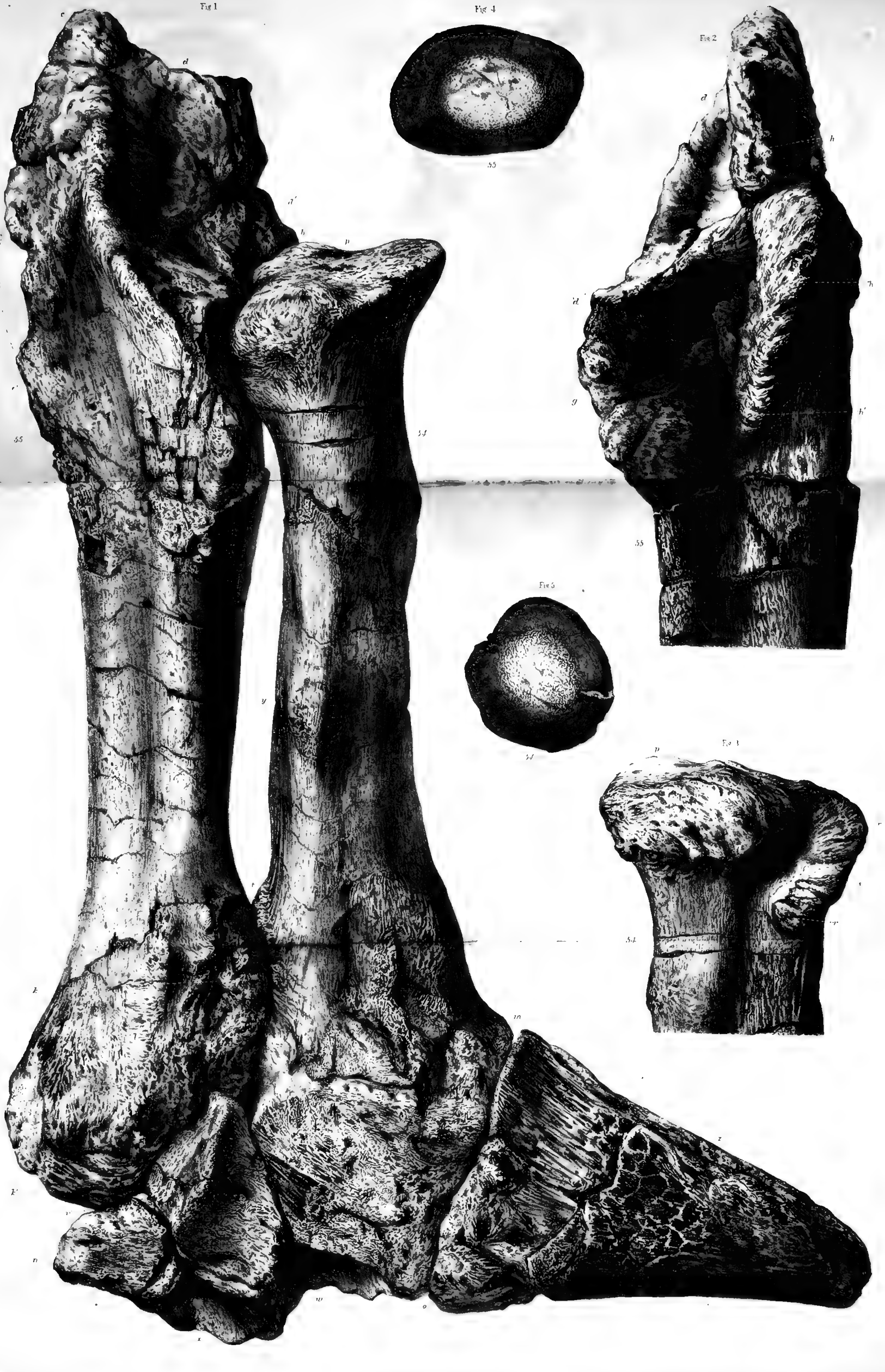
PLATE I.

Iguanodon Mantelli (nat. size).

Figs.

1. Left radius and ulna, thenal or palmar aspect.
2. Left ulna, proximal end, showing articular surface for the radius.
3. Left radius, proximal end, showing articular surface for the ulna.
4. Section of shaft of ulna.
5. Section of shaft of radius.

From the Wealden Clay, Sussex. In the Collection of S. H. Beckles, Esq., F.R.S., F.G.S., &c.



C L Griesbach del et lith.

IGUANODON MANTELLI (?)

Mintern Bros imp.

PLATE II.

Iguanodon Mantelli (nat. size).

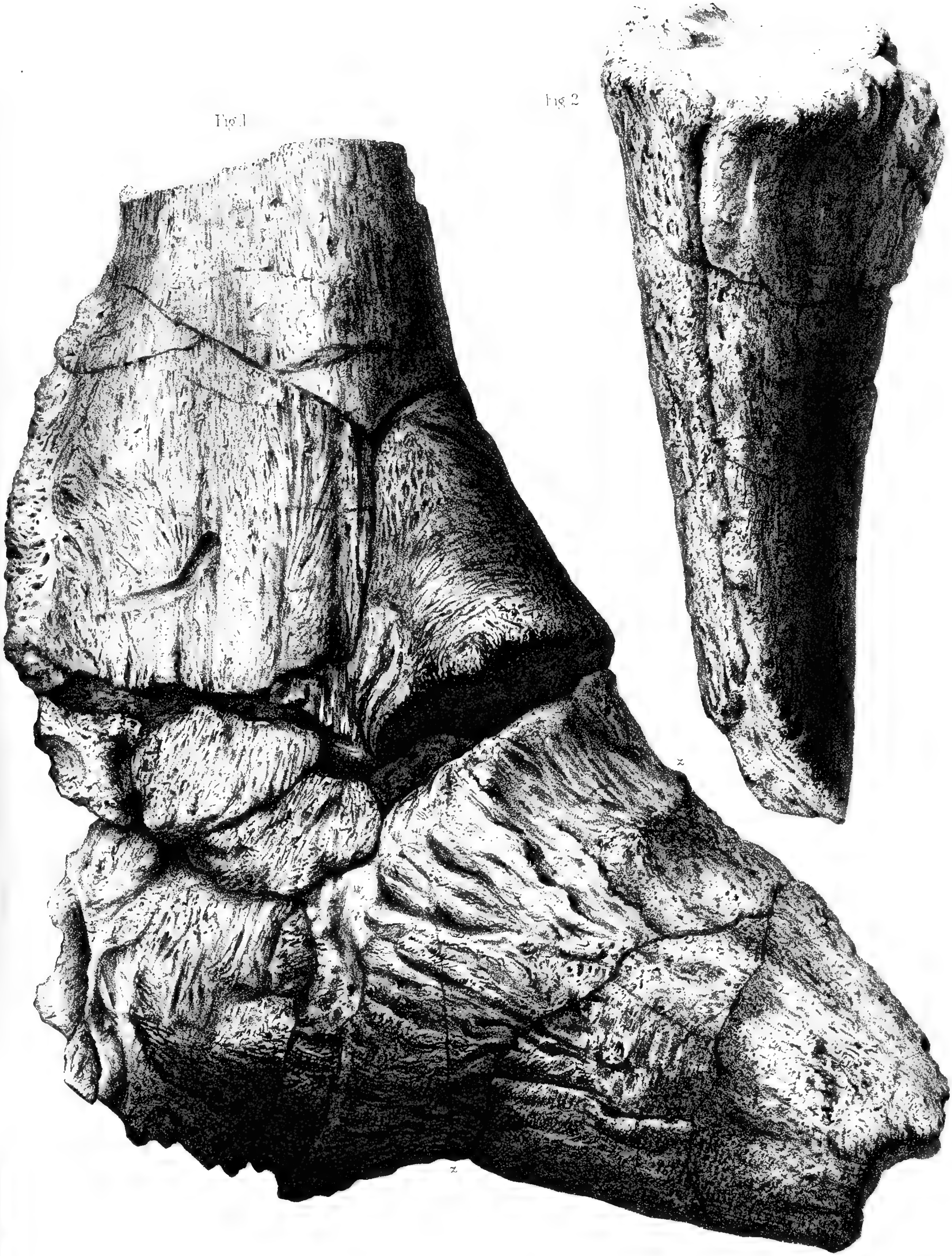
Figs.

1. Right radius, distal end, anconal or dorsal aspect.
2. Osseous core of radial spine, proximal or upper margin.

From the Wealden Clay, Sussex. In the Collection of S. H. Beckles, Esq., F.R.S., F.G.S., &c.

Pl. II.

Fig.1 Fig 2



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Mintern Bros imp

IGUANODON MANTELLI

PLATE III.

Iguanodon Mantelli (nat. size).

Fig.

1. Bones of left fore-foot.

3 *a*. Ungual phalanx of second digit, proximal or articular surface.

3 *b*. Ib., ib., distal surface.

From the Wealden Clay, Sussex. In the Collection of S. H. Beckles, Esq., F.R.S., F.G.S., &c.

C. L. Griesbach del et lith

Mintern Bros imp

IGUANODON MANTELLI.

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 IV.

BRITISH PLEISTOCENE FELIDÆ.

FELIS PARDUS, Lin.; *FELIS CAFFER*, Desm.; *FELIS CATUS*, Lin.;
MACHÆRODUS LATIDENS, Owen.

(Pages 177—194; Plates XXIV, XXV.)

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1872.

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CHAPTER XX.

Family—FELIDÆ.

Genus—Felis.

Species—Felis (leopardus) pardus, *Linnæus.*

Pl. XXIV.

§ 1. *Introduction.* The former existence of one of the larger felines closely allied to the Panther or Leopard on the mainland of Europe was first established by the discovery of remains in the Caves of Cette in the South of France, and of Gailenreuth in Bavaria, which were described by Baron Cuvier under the name of *Felis antiqua*,[1] and the specific identity of this animal with the living Panther was the opinion of our great palæontologist Dr. Falconer.[2] Subsequently the animal has been identified by M. Lartet[3] among the remains from the cavern of Mars in the Maritime Alps, and by Professor Gervais from the cave of Mialet (Gard.).[4] Since then it had a place in the Pleistocene Fauna of Europe; it was reasonable to suppose that it also inhabited Britain during the time that our island formed part of the continent, and supported the Hippopotamus, the Lion, and the Hyæna, which at the present day are to be found side by side with the Panther, south of the Sahara desert. The first evidence of the animal having lived in Britain was offered by a canine (Pl. XXIV, fig. 4) from the bone cave at Banwell, in the Collection of the Earl of Enniskillen, F.R.S.; and subsequently we were able to assign to it the following remains from the caves of the Mendip Hills: two canines (Pl. XXIV, figs. 1, 2) obtained by the Rev. J. Williams from either Bleadon or Hutton Caves; and an ulna, femur (fig. 5), two metatarsals, and an upper milk canine from Bleadon Cave in the Collection of Mr. Beard. All the remains with the ex-

[1] 'Oss. Foss.,' 1825, vol. iv, p. 193, pl, xv, fig. 7; and p. 452, pl. xxxvi, figs. 4, 5.

[2] "Dr. Falconer stated this to me in one of the many conversations on fossil bones which will ever remain in my memory."—*W. Boyd Dawkins.*

[3] 'An. des Sc. Naturelles,' 5e série, tom. viii; 'Deux Têtes de Carnassiers Fossiles.'

[4] 'Animaux Vertébrés Vivaux et Fossiles,' 4to, 1867-9, p. 68, pl. xv.

ception of the canine belonging to Lord Enniskillen are preserved in the Taunton Museum.

§ 2. *Comparison of fossil remains with most closely allied living forms.*—Under the name *Felis* (*Leopardus*) *pardus* we intend to embrace the Panther properly so called, and the Leopard, the former consisting of the larger and stouter, and the latter of the more slender and smaller individuals; since an examination of a large number of skulls, skeletons, skins, and living animals, has convinced us that the differences are only varietal, and not of specific value. At the same time there exists in Northern China, and, we have reason to believe, also in other parts of Eastern Asia, a species which is undoubtedly distinct, and which differs from the Panther, in the comparative length of the nasals and frontal processes of the maxillaries, exactly as the Tiger differs from the Lion. This species has been named by Dr. Gray ('Proc. Zool. Soc.,' 1867, p. 264) *Leopardus Chinensis;* Dr. Gray describes a third species, under the name of *Leopardus Japonensis* ('Proc. Zool. Soc.,' 1862, p. 262); and the fourth is the Jaguar of America, *Leopardus onca*, Linn. These are the only living species with which it is necessary to compare the fossils in question.[1]

On comparing the fossil teeth with those of the living Leopard and the Jaguar, we find that they agree with the former in their slender, delicate, and compressed form. In the Jaguar (*Felis onca*) the teeth are much stouter and the cusps of the molar series more obtusely conical. The canines (Pl. XXIV, figs. 1, 3, 4) present a character which at once differentiates them from those of the latter animal in the two longitudinal grooves or *sillons* which traverse the outer and the inner sides of the crown. In the Jaguar the second *sillon* on the outer side is a mere rudiment, or in some cases is altogether absent. In all these points in which the teeth correspond with those of the Leopard, *Felis pardus*, they also agree with those of the allied species *Leopardus Chinensis* of Dr. Gray. They may, however, be referred with considerable certainty to the former animal, since it has been found in several caves in France, while the latter has not been known to live out of China.

A glance at the following table will give the relative size of the fossil lower true molar as compared with that of the Leopard and Jaguar (Pl. XXIV, fig. 2).

		Leopardus. Africa. Cat. 115. Brit. Museum.	*Leopardus.* Africa. Brit. Museum.	*Felis* (*Leopardus*) *onca.* Brazils. 117 C. Brit. Museum.
Antero-posterior length	0·81	0·7	0·7	0·74
Antero-transverse diameter	0·3	0·3	0·3	0·42
Postero-transverse diameter	0·28	0·28	0·28	0·38
Height of crown	0·44	0·38	0·39	0·39

[1] A fifth species of *Leopardus*, of large size, has been recently described by M. Milne-Edwards, from Northern China. 'Ann. Sci. Nat.,' ser. 5, tom. viii, pp. 374-76.

This variation in the size of the fossil, as compared with the recent Leopard, is not greater than that presented by living individuals of the same species.

The Femur.—The left femur figured (Pl. XXIV, fig. 5) corresponds with that of a large Panther from West Africa, in the Museum of the College of Surgeons. Its proportions may be gathered from the figure, and there is no necessity for a detailed description. The rest of the bones are too fragmentary to be figured or described.

The remains from the Pleiocene beds of Mont Perrier in Auvergne ascribed by MM. Croizet and Jobert to the *Felis antiqua* are far too large[1] to have belonged to the largest Leopard. Nor can any of the other fossil felines be identified with it with any certainty. M. de Blainville,[2] however, believes that the *Felis pardinensis*, and the *F. Arvernensis* of MM. Croizet and Jobert, are identical with the Panther. The *Felis pardoides*[3] of Professor Owen, from the Red Crag, differs from the Panther in the lowness of the crown of the last true molar.

§ 3. *Associated Animals.*—The species with which the remains of the Panther have been found in Britain, France, Germany, and Gibraltar, are represented in the following table; Marcel de Serres, Dr. Falconer, Mr. Busk, and Dr. Goldfuss, being the authorities for those of Lunel-viel, Gibraltar, and Gailenreuth. The *Ursus ferox* from the last cave is based on the examination of a series of teeth obtained by Sir Philip Egerton and Lord Enniskillen.

List of Species.	Caves.					
	Banwell.	Bleadon.	Sandford Hill.	Lunel-Viel.	Gibraltar.	Gailen-reuth.
Ursus arctos, L.	...	×	×	...	...	×
U. spelæus, Gold.	×	×	×	×	...	×
U. ferox, L.	...	...	...	...	×	×
Gulo luscus, Latr.	×	×	...	...	...	×
Meles taxus, L.	...	...	...	×	...	...
Mustela putorius, L.	...	...	...	×	...	...
M. martes, L.	...	×	...	...	...	...
Lutra vulgaris, Erxl.	...	×	...	...	...	...
Canis vulpes, L.	...	×	×	×	×	×
C. lupus, L.	...	×	×	×	...	×
Hyæna (*spelæa*, Gold.) *crocuta*, Zim.	...	×	×	×	×	×
Felis catus, L.	...	×	...	×	...	×
F. (*antiqua*) *pardus*, L.	×	×	?	×	×	×
F. leo (var. *spelæa*), L.	...	×	×	×	...	×
F. pardina, L.	...	...	...	...	×	...
F. serval, Schreb.	...	...	...	...	×	...

[1] 'Oss. Foss. de Puy de Dome,' p. 214, 4to, 1828. 'Ostéographie,' article "Felis," p. 143, pl. xvi.

[2] 'Ostéographie,' article "Felis."

[3] 'Brit. Fossil Mammals,' p. 169.

List of Species.	Caves.					
	Banwell.	Bleadon.	Sandford Hill.	Lunel-Viel.	Gibraltar.	Gailen-reuth.
Cervus megaceros, Hart	...	×	...	...	...	...
C. tarandus, L.	×	×	...	...	...	×
C. capreolus, L.	...	×	...	...	...	...
C. elaphus, L.	...	×	...	×	×	×
C. *dama*, L.	...	...	...	...	×	...
Bos primigenius, Boj.	...	×	×	×	?	...
Bison priscus, Ow.	×	×	×	...	?	×
Capra ibex, L.	...	...	...	...	×	...
Hippopotamus major, Desm.	...	...	...	...	×	...
Sus scrofa, L.	...	×	...	×	×	×
Equus caballus, L.	...	×	×	×	×	×
Rhinoceros hemitœchus, Falc.	...	...	...	×	×	...
R. tichorhinus, Cuv.	...	...	×	...	...	×
Elephas antiquus, Falc.	...	×	...	...	...	...
E. primigenius, Blum.	...	×	×	...	...	×
Lemmus, sp.	...	×	...	...	...	...
Lepus cuniculus, Pall.	...	...	...	...	×	...
L. diluvianus, Serr.	...	×	...	×	...	...
Lagomys spelæus, Ow.	...	×	...	...	...	...
Spermophilus erythrogenoides, Falc.	...	?	?	...	...	...
S. —— ?	...	×	...	...	...	...
Arvicola pratensis, Bell	...	×	...	...	...	...
A. agrestis, Flem.	...	×	...	...	...	...
A. amphibius, Desm.	...	×	...	...	...	...
Castor fiber, L.	...	...	...	×	...	...
Mus musculus, L.	...	×	...	...	...	...

§ 4. *Range of F. pardus.*—The present home of the Panther or Leopard is to be found in the warm regions of Africa and Asia, and not in Europe, or the colder districts of Asia. The occurrence of the animal in the caves of Gibraltar proves that in the Pleistocene period it passed northwards into Spain, while the discovery of its remains in France indicates that it ranged over that region, and those in Gailenreuth Cave that it lived in Central Germany. The remains in the Mendip Caves show that it passed northwards over what is now the Channel, to prey upon the Reindeer, Bisons, and Horses of Somersetshire. Throughout this area it was very rare as compared with the contemporary Lions, Bears, and Hyænas.

The presence of this beautiful feline in Britain, now only living in a warm climate, may easily be explained by the hypothesis that it migrated northwards from time to time from the warmer regions around the Mediterranean; and it is very probable that the Arctic severity of the Pleistocene winter was the cause of its rarity in our latitude.

CHAPTER XXI.

The Smaller FELIDÆ.

PLATE XXIV.

§ 1. *Introduction.* | § 2. *Felis caffer.*
§ 3. *F. catus.*

§ 1. *Introduction.*—The remains of the smaller Felidæ have long been known to exist in the Pleistocene Caves and river deposits in Great Britain, France, Belgium, and Germany, and have for the most part been referred without any minute analysis of their characters to the common Wild Cat of Europe (*F. catus,* L.) M. Marcel de Serres[1] and his colleagues figure one lower jaw from the Cave of Lunel-Viel, and Dr. Schmerling[2] another from the Caves of Liége, which are larger than any well-authenticated lower jaw of Wild Cat which has passed through our hands. The former ascribe their specimen to the *Felis fera,* by which they probably mean the common Wild Cat, while the latter assigns his to the '*Felis catus magna,*' regretting at the same time his lack of recent specimens with which to compare it. The measurements of the depth of jaw given in the 'Ossemens fossiles de Lunel-Viel,' p. 120, show that the jaw figured in Pl. IX belongs to the same animal as that figured by Schmerling, while those given by the latter do not agree with his own Plate, the confusion being probably caused by the substitution of height for thickness.[3]

The smaller feline remains which we have examined from the Caves of Great Britain

[1] Marcel de Serres, 'Oss. Foss. de Lunel-Viel,' p. 120, pl. ix, figs. 12, 13, and 17.

[2] Schmerling, 'Oss. Foss. de Liége,' vol. ii, p. 88, pl. xviii, figs. 13, 14, 23, 24.

[3] In the text these measurements are—

		M.		INCH—ENG.
Hauteur de la machoire devant la première molaire .	(1)	0·007	=	0·027
la dernière . .	(2)	0·008	=	0·031
In the figures they are—	(1)	0·012	=	0· 55
	(2)	0·013	=	0· 51

The other measurements exactly agree with the figure.

seem to us to imply the existence of two species, one the *Felis caffer* of Africa, and the common Wild Cat, which is now rapidly being exterminated in our island. But on the very fragmentary evidence before us we do not attempt to define with absolute certainty the former existence of the *Felis caffer* in Britain. Nevertheless, the exact agreement in every particular of the lower jaw figured in Pl. XXIV, fig. 6, 6′, 6″, with that of the latter animal, and its disagreement in the same points with those of other animals, renders the specific identity almost certain; and with regard to the classificatory value of the points themselves in the recent lower jaws, we have found that they are present in all those of the former, and absent from all those of the latter which we have examined in the British Museum, the College of Surgeons, and elsewhere.

§ 2. *Felis caffer.*—The right lower jaw from Bleadon Cave in the Mendip Hills, figured Pl. XXIV, fig. 6, 6′, 6″, differs from the jaws of all the smaller Leopardine Cats of both the Old and New Continents, as well as from the Lynxes, by the smaller size of the molar series as compared with the depth of the jaw, while the jaws in these animals are thicker in proportion to their depth.

These smaller feline jaws being thus proved to be unlike that in question, there remain for comparison two groups of Cats, the larger, represented by the *Felis chaus* of India, which appears to have had a large share in the production of the Domestic Cat of that country; and the smaller, or that which is represented by the Wild Cat of Europe, and the *F. maniculata,* the latter probably having a share in the breed of the Domestic Cat of Europe. Intermediate between these groups are two species, the *F. caffer,* distributed at the present day throughout Africa, and the *F. torquata* of the Himalayas, which are closely related together, and are probably representative forms in their respective districts. In the series represented by *Felis chaus* the lower true molar, *m* 1 is larger in proportion to the premolars than in our fossil.

There remain, therefore, for comparison the Wild Cat of Europe, the *F. maniculata,* and the *F. caffer.* In all the well-authenticated specimens of Wild Cat which we have examined, as well as in those of the large domestic cats with brownish-grey fur, which have run wild, the posterior inner alveolar border is much thickened (Pl. XXIV, fig. 8, *c*), and rises higher than the outer border, so that the last true molar, and to a certain extent premolar 4, are thrown to the outside of the jaw. These characters are not to be found in our fossil, the molar series being set on the middle of the alveolar edge of the mandible. The ramus also in the fossil is deeper and transversely narrower than in the Wild Cat.

In the *Felis maniculata,* and the smaller specimens of Domestic Cat, the jaw is much less deep in proportion to its thickness than in the fossil. The jaw of *Felis caffer,* on the other hand, agrees with our fossil in the minutest detail, as well as with that figured by Dr. Schmerling, and measured by M. de Serres; and it is therefore impossible to resist the conclusion, that a species of Wild Cat most closely allied to the *F. caffer* lived in Britain, Belgium, and France, in the Pleistocene Period. There is indeed nothing unreasonable in the suggestion of a Cat now found only in Africa having once ranged over Europe, since the Spotted Hyæna, the Hippopotamus, and the Panther were members of our Pleistocene Fauna, as well as being now associated with *F. caffer* in Africa.

In the following table we have represented the relation of the fossil lower jaws to those of the Wild Cat and *Felis caffer*. The measurements are taken in inches:

MEASUREMENTS.	Fossil Bleadon.	Schmerling's fig.	*F. Caffer.* Coll. Surg., 4606.	*F. Caffer.* Brit. Mus., 857 A.	*F. Catus.* Scotland. Coll. Surg.,	*F. Catus.* Germany. Brit. Mus.
Length of molar series	0·91	0·92	0·91	0·92	0·82	0·74
M 1. Length	0·35	0·36	0·34	0·33	0·32	0·29
Postero-transverse diameter	0·16	...	0·16	0·14	0·13	0·11
Antero-transverse diameter	0·15	...	0·15	0·13	0·14	0·10
Height	0·11	0·13	0·11	0·10	0·09	0·08
PM 4. Length	0·34 ?	...	0·35	0·30	0·28	0·26
PM 3. Length	0·26	0·25	0·26	0·26	0·20	0·20
Transverse	0·14	...	0·15	0·13	0·10	0·10
Height	0·20	0·20	0·19	0·17	0·18	0·15
Depth of jaw at M 1	0·53	0·54	0·56	0·52	0·40	0·39
Thickness ,, ,,	0·22	...	0·23	0·21	0·25	0·22
Depth at PM 4	0·45	0·45	...	...	...	...

The fragments of ulna (fig. 8) and of femur (fig. 7) of a large Cat from Bleadon Cave may most probably be referred to the *F. caffer*, since they were obtained from the same place as the jaw which we have just described. They may, however, belong to the Wild Cat.

§ 3. *F. catus.*—The lower jaws and bones of the Wild Cat of Europe, which is now so rapidly becoming extinct in Great Britain, have been discovered in the Cave of Kirkdale by Dr. Buckland, and in that of Kent's Hole by the Rev. J. MacEnery, and differ in no respect from those of the living representative. If that figured Pl. XXIV, fig. 8, be examined, it will be seen that in its slender form it contrasts with that figured 6, 6′, 6″. The lower jaw (Pl. XXIV, 9, 9′) is from the Brickearth of Grays Thurroch, and is in the Collection of Mr. Wickham Flower: its external aspect has been figured in the 'British Fossil Mammals,' p. 172. There are no points presented by these fragments which are worthy of a detailed notice.

The remains of the Wild Cat have been obtained from several of the localities in Great Britain, and it lived in our country from the age represented by the Brickearths of the Thames Valley to the present day.

CHAPTER XXII.

FAMILY—FELIDÆ.

Genus—MACHÆRODUS, *Kaup*.

Species—MACHÆRODUS LATIDENS, *Owen*.

PLATE XXV.

§ 1. *Nomenclature.*
§ 2. *Range of Genus.*
§ 3. *History of British Remains.*
§ 4. *Relation to Machærodus cultridens.*
§ 5. *Description.*
§ 6. *Evidence that Machærodus latidens came from Kent's Hole.*
§ 7. *Continental Range of Species.*
§ 8. *Antiquity of Machærodus in Kent's Hole.*
§ 9. *Machærodus from Norfolk.*

§ 1. *Nomenclature.*—The history of the discovery of the great sabre-toothed Feline *Machærodus* shows at once the difficulty with which naturalists have to contend in assigning fragmentary remains to their rightful possessor, and of the gradual steps by which that difficulty was removed. The tooth of the animal now known as *Machærodus cultridens,* from having been associated with the remains of the Bear in the deposits of the Val d'Arno, was assigned to an abnormal species of that genus by Cuvier in 1824, or the *Ursus cultridens,*[1] and by Nesti in 1826 to the *U. drepanodon;*[2] and similar teeth found in Auvergne have been described by MM. Croizet and Jobert[3] as *U. cultridens Issidorensis.* M. Bravard,[4] however, having discovered a feline skull in the same district, which was possessed of sockets such as would fit the large compressed canines somewhat resembling those in question, and of a mandible in which there was a deep outer depression for the reception of the upper canine when the jaws were shut, inferred that the animal was a

[1] 'Oss. Foss.,' 4to, 3rd edit., 1824, vol. v, pt. ii, p. 517.
[2] 'Lettera Terza dei alcune Ossa fossili, al S. Paolo Savi,' 8vo, Pisa, 1826.
[3] 'Oss. Foss. de Puy de Dome,' p. 200.
[4] 'Monographie de deux Felis d'Auvergne,' p. 143.

Felis, and described it as *F. megantereon*. And that this conclusion of M. Bravard was true is proved, as Professor Owen remarks,[1] by the fragment of skull of an allied form in the British Museum, from the Sevalik Hills. Dr. Kaup,[2] on the other hand, who had met with the remains of the animal at Eppelsheim pointed out that the compressed and serrated canines, in which the two longitudinal grooves so characteristic of the larger Felines were absent, separated the animal to which they belonged frem the genus Felis, and he therefore proposed for them the name *Machærodus,* or the Sabre-toothed Carnivore.

On the whole, the evidence which we possess as to the affinities of the animal prove that it belongs to the great family of the Felidæ, although those points which Dr. Kaup has brought forward forbid its classification with the genus Felis, from which it differs in the enormous development of the serrated upper canines, as well as the presence of a third lobe on the sectorial edge of the upper Premolar 4. And that it is an aberrant member of the great family of Cats is the opinion of M. de Blainville, Professor Owen, and M. Albert Gaudry. Its dental formula is that of the true Felines.

§ 2. *Range of Genus.*—The genus Machærodus is of very wide range both in space and time. It has been found alike in the Meiocene deposits of India by Falconer, the plains of Marathon by Gaudry, and the river-deposit of Eppelsheim by Kaup.[3] It has been known to occur in the Pleiocene strata of the Val d'Arno since 1812, and of Auvergne since the year 1828. It has also been found in the Pleiocene Caves of Brazil by M. Lund, along with the great Sloth, the Megatherium, and the peculiar Horses at that time living in South America. The best known and most widely spread European species is that which ranged over France, Germany, Italy, and Greece, during the late Meiocene and the early Pleiocene periods, under the name of *Machærodus cultridens* of Kaup, and which has been fortunate in being described by M. Gaudry in his classical work on the 'Animaux Fossiles de l'Attique.' And the proof of the presence of a closely allied form in England we owe to the labours of the Rev. J. McEnery in Kent's Hole Cave, near Torquay.

§ 3. *History of British Remains.*—The seven teeth which afford the proof of the ancient sojourn of the Machærodus in Great Britain were discovered so long ago as 1826, and their history has been very remarkable. The Rev. J. MacEnery unfortunately did not publish the results of his explorations in Kent's Hole, which he carried on from time to time after 1825 up to his death in 1840, and the manuscripts were lost, until they fortunately fell into the hands of Mr. J. Vivian, of Torquay, who published an abstract in the year 1859. Ten years later they were published in full by Mr. Pengelly, F.R.S., and afford an authentic and circumstantial account of the discoveries, which had been lost to

[1] 'Brit. Foss. Mam.' (1846), p. 176.

[2] 'Oss. Foss. de Museum de Darmstadt,' 2nd part, 1833.

science for nearly thirty years. The lithographs also which had been originally made to illustrate a work on 'Cavern Researches,' which was never carried out, were published in part in 1859 by the permission of Mr. F. Buckland, into whose hands the stones of seventeen out of the thirty plates to which Mr. MacEnery refers in his prospectus had passed at his father's death, and now even these cannot be traced. Two more plates were fortunately added to these in the year 1869; and a third plate, which had not been known to be extant, was added subsequently, through which additional evidence as to the sojourn of the Machærodus in the Cave was obtained.

Nor were the remains of the animals which Mr. MacEnery discovered, more fortunate. At his death they were sold by auction and divided up among private collectors, and for the most part irretrievably lost. Out of the seven teeth of Machærodus we are able only to trace five. The canine in the Oxford Museum was purchased by Dr. Lovel Phillips at the sale, and given to Dr. Buckland; that in the College of Surgeons, and figured by Professor Owen, was presented by Lord Enniskillen to Professor Owen; a third, the original of pl. F′, figs. 4, 5, found its way into the Museum of the Geological Society; the fourth, figured pl. F′, figs. 1, 2, 3, is in the British Museum; and the fifth (pl. F′, fig. 7) is in the Collection of Sir Walter Trevelyan, Bart., to whom it was given shortly after its discovery by Mrs. Cazalet.[1] We are unable to trace the two incisors, one of which is figured in the fossil mammals (fig. 70).[2]

§ 4. *Relation to Machærodus cultridens.*—All the canines which had the above eventful history belong to the upper jaw, and are remarkable for their width as compared with the length of the crowns. That in the College of Surgeons, which Professor Owen takes as the type-specimen of *M. latidens* measures 6·5 inches along the outer curve, and 1·2 inches across the base of the crown, while in the Italian *Machærodus cultridens* the corresponding measurements are 8·5 inches and 1·5 inches. If the proportions of the Italian specimen be constant, it is obvious that the British specimen in question must belong to another species, since the basal measurement of the crown is so much greater. Professor Owen attaches a specific value to this greater width, while Dr. Falconer, after carefully weighing the evidence, believes that the difference has merely a varietal importance. The size of the canines is, to a certain extent, a sexual character, and therefore liable to variation in different individuals of the same species. And to what an extent this variation may take place within the limit of a species may be gathered from the comparative measurements of canines of the Cave-Lion in our Monograph on the animal. But although the character in question be not of specific value, the strongly marked serration in the incisors (woodcuts 1, 2, 3) differentiates, as M. Gervais remarks, the British from the French species of

[1] Letters to W. Boyd Dawkins, dated 11th and 26th May, 1869.

[2] Mr. Pengelly has given a full account of the teeth in question, and of their singular history, in his series of 'Essays on the Literature of Kent's Hole,' published by the Devonshire Association.

Machærodus, since it is not presented by the teeth in the cranium found in the Pleiocene strata of Auvergne by M. Bravard, and admitted by Blainville, Owen, Kaup, and Gaudry, to belong to *Machærodus cultridens*, Kaup. For this reason, therefore, we consider the British *Machærodus latidens*, Owen, to be distinct from the *M. cultridens* of the Continent. The recent discovery of a lower true molar, in the cave of Baume, in the Jura, renders it probable that all the teeth were serrated.

§ 5. *Description.*—The upper canines of Machærodus are characterised by their compression parallel to the median line, and the strongly marked serration of the ridges which traverse the teeth in front and behind, and give it a sharp cutting edge, which Professor Owen describes as uniting the power of a saw with that of a knife.[1] The regular curvature of the crown and fang causes the tooth to present an outline strongly resembling, according to Nesti, the crescent-shaped new moon when first appearing above the horizon. The crown is thicker in front than behind (Pl. XXV, figs. 3, 6), and thus possesses great strength without the penetrating power of the posterior edge being impaired. Altogether the tooth is the most perfect instrument for piercing and dividing flesh which is presented by any of the Carnivora, and doubtless belonged to an animal which lived solely on flesh.

The general shape of the upper canines from Kent's Hole may be gathered from Pl. XXV, which is a copy of the plate drawn by Mrs. Buckland, and lithographed by Mr. Scharf, for the work of the Rev. J. MacEnery, and kindly lent to us for the purpose by Mr. Pengelly, F.R.S. In figs. 1, 2, 3, the perfect crown is represented, which is now preserved in the British Museum, while figs. 4 and 5 represent the perfect fang. The lower canines are proved by the lower jaw of *Machærodus cultridens* discovered by M. Bravard, along with the perfect cranium in the Pleiocene strata of Mont Perrier in Auvergne, to be very much smaller in every dimension.[2]

The incisors of *Machærodus latidens* are now only known to have been found in Kent's Hole by three figures of the natural size in a lithograph which is deposited in the Museum of the Natural History Society of Torquay. The accompanying woodcuts have been drawn on wood from a photograph of the original, which has been placed at our disposal through the kindness of the Society, and fig. 1 representing the inner aspect of the left upper incisor, 3 is that which has been copied by Professor Owen. The anterior and posterior ridges traversing the crown *a* are serrated, as in the canines, and at the base of each there is a well-defined cusp, *b* and *c*, both of which points are unknown in the incisors of any of the living Carnivores. The incisors of the left lower mandible reproduced the peculiar characters of the corresponding upper tooth, the serration being well

[1] 'Foss. Mam.,' p. 180.

[2] M. Bravard's 'Monographie,' pl. iii. Blainville, 'Ostéographie,' Article Felis, pl. 17.

marked, and the cusps *b* and *c* clearly defined. The crown of both these teeth are considerably larger than those of any living or fossil species of the Felidæ, and are of an eminently sectorial character.[1]

Fig. 1. Fig. 2.

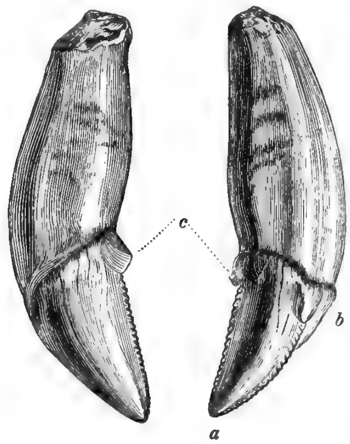
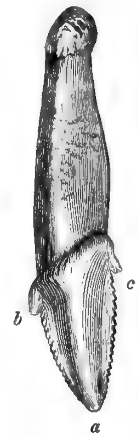


Fig. 3.



There is not the slightest evidence that the Machærodus was more closely allied to the Tiger than to any of the other larger Felines, and therefore the very tempting name of "Sabre-toothed Tiger" must be given up, as implying a relationship which does not exist.

The size of the teeth may be gathered from the following measurements in inches:

	Length of crown.	Basal width of crown.	Length of fang.
Pl. XXV, fig. 1. Brit. Mus.	2·4	1·2	...
„ „ 4. Geol. Soc.	...	1·18	3·2
„ „ 7. Sir W. Trevelyan	...	1·3	3·5
Coll. Surgeons	2·7?	1·2	3·3
Oxford Mus.	...	...	...

§ 6. *Evidence that Machærodus latidens was derived from Kent's Hole.*—There can be no reasonable doubt as to these remarkable remains having been derived from Kent's Hole, and not from the Continent, since the animal to which they belong differs specifically from the Continental Pleiocene species. The MSS. also of the Rev. J. MacEnery point out the precise circumstances under which they were found:[2]

[1] Gervais, 'Zool. et Paléont. Française,' 1859, p. 231.

[2] See Mr. Pengelly's admirable series of "Essays on the Literature of Kent's Cavern." McEnery's MSS., 'Trans. Devonshire Ass.,' 1869, pp. 55-6.

"We now returned," he writes, "to the excavation (in the 'Wolf's Passage'), which produced the Wolf's head. The stalagmite was about a foot and a half thick, and of excessive hardness, in which were imbedded rocky fragments rolled down the slope; but as we advanced inwards, the stalagmite became altogether free from foreign admixture and moulded itself upon the mass of bones. Of the quantity and condition of the remains here it is scarcely possible to give a just idea without appearing to exaggerate. They were so thickly packed together that to avoid injuring them we were obliged to lay aside the picks and to grub them out with our fingers. They had suffered considerably from pressure after having first undergone violence from the force which impelled and congregated them in this narrow neck. They were found driven into the interstices of the opposite wall, or piled in the greatest confusion against its side, with but a scanty covering of soil, and that of the finest and softest sand intermixed with greasy earth. To enumerate the amount of fossils collected from this spot would be to give the inventory of half my collection, comprising all the genera and their species including the *cultridens*, there were hoards; but I must specify the jaws and tusks of the Elephant, with the teeth in the sockets, and the bone of which was so bruised, that it fell to powder in our endeavour to extract it, a rare instance of the teeth occurring in their jaws or gums. The same may be observed of the jaws of the Rhinoceros, one portion alone of which was saved, but the teeth of both were numerous and entire. The teeth of the Elk, Horse, Hyæna, were taken out whole; the teeth of the two last were gathered in thousands, and in the midst of all were myriads of Rodentia. The earth, as may be expected, was saturated with animal matter; it was, to use the expressive words of my fellow-labourer Walsh, fat with the marrow and sinews of more wild beasts than would have peopled all the menageries in the world."

§ 7. *Continental Range of Species.*—Such as this is the evidence of the sojourn of the formidable *Machærodus latidens* in the Cave of Kent's Hole. The proof that the species lived also on the Continent of Europe is due to the discovery of an upper incisor in every respect identical with figs. 1, 2, in a deposit near Puy, in Auvergne, by M. Aymard, which is doubtfully considered "diluvium" by M. Gervais,[1] and most probably belongs to the Upper Pleiocene, or the passage beds between the Pleiocene and Pleistocene formations. M. Gervais[2] has also recently determined the existence of the same species in the Cavern of Baume, which M. Lartet considers to be of preglacial age,[4] in the Jura, associated with horse, ox, wild boar, elephant, and a non-tichorhine species of rhinoceros, the cave bear, and the cave hyæna.[3] The two teeth of Machærodus are a lower canine (? upper incisor), and a portion of the lower sectorial, both of which have serrated edges. The serration in

[1] 'Zool. et Paléont. Françaises,' 1859, p. 231.

[2] Gervais, 'Animaux vertébrés vivants et fossiles,' 4to, 1867-9, p. 78, pl. xviii, 3, *3a*, *3b*.

[3] 'Congrès Internationale d'Anthropologie et d'Archeologie Prehistoriques,' Paris volume, p. 269.

[4] M. Lartet considers the rhinoceros to be non-tichorhine.

the latter, as well as in the canine (incisor ?), renders it probable that all the teeth of this species were serrated.

§ 8. *Antiquity in Kent's Hole.*—We have now to consider the very difficult question as to the relative antiquity of the *Machærodus latidens* in Great Britain. Is it Pleiocene or is it Pleistocene? Was it a contemporary of the woolly Mammoth and Reindeer, or had it disappeared before the lowering of the temperature in the Glacial period? Unfortunately the peculiar physical conditions under which Kent's Hole has been filled with its present contents forbids an answer which is absolutely decisive. In the present cave-earth, and underneath the stalagmite which now constitutes the floor, are large masses of breccia and of stalagmite, which evidently had formed a floor that had been broken up before the introduction of the cave-earth. They are remarkable for their hard crystalline structure, and in one or two cases they have yielded fragments of very dense mineralized bones. In a portion of the cave, called the gallery, there is evidence of the undisturbed portion of the crust in a "ceiling" or uppermost floor, that extended from wall to wall, "without further support than that afforded by its own cohesion. Above it there is, in the limestone rock, a considerable alcove. This branch of the cavern, therefore, is divided into three stories or flats; that below the floor occupied with cave-earth, that between the floor and ceiling entirely unoccupied, and that above the ceiling also without a deposit of any kind." For a ceiling of this kind to have been formed it is absolutely necessary for the cave to have been filled up to its level with materials of some kind. It would, indeed, be as impossible for a solid calcareous sheet to be formed in mid-air as it would be for a sheet of ice to be formed without resting on water. From some cause or other this ancient stalagmite has been in part broken up, and the materials by which it has been supported have disappeared; and that it was deposited on cave-earth, like that now occupying the lowest story, is shown by its red colour. Prior, however, to its formation, animals dwelt in the cave, since bones are imbedded in the large fallen masses of stalagmitic breccia. Moreover, there is reason to believe that certain fragments of bone and splinters of teeth, remarkable for their mineralization, that have been found in the earth now occupying the cavern, were derived from this more ancient deposit, for they differ essentially from the remains with which they are now associated, being heavier and of a more crystalline structure. Some splinters have assumed the fracture of greensand-chert. So hard, indeed, was one of the canines of Bear that it has been splintered by the hand of man into the form of a flint-flake, and has evidently been used for a cutting purpose. Its fracture proves that it was mineralized before it was splintered; and as it was found in the present cave-earth, it must have been fashioned while the cave was being inhabited by palæolithic man, prior to the accumulation of the earth. For these reasons, the evidence in favour of these denser remains having belonged to the deposit which once supported the ancient floor seems to us incontrovertible.

To which, then, of these two periods of accumulation of cave-earth in Kent's Hole can the Machærodus be referred? Was it living at the time of the older deposit, and did it become extinct before the newer had been formed? It is impossible to give a distinct answer to these questions; but a careful examination of all the circumstances tends to the belief that the older period was that to which the Machærodus belongs. Since it is a species which differs but slightly from the *M. cultridens*, and belonging to a genus which inhabited Europe in the Meiocene and Pleiocene ages, its affinities are undoubtedly Pleiocene, and it belongs to a group of animals that inhabited Europe before the lowering of the temperature brought about the invasion of the Arctic Mammalia from the north and the east. On the other hand, in the teeth-marks on the incisors figured, as well as on the canines, we recognise the unmistakable traces that the animal to which they belonged fell a prey to the Hyena;[1] and since the Pleistocene *Hyæna crocuta* (var. *spelæa*) is abundant in the cave, to its teeth the marks in question may probably be referred. It seems, therefore, to us, to be almost certain that the animal inhabited Devonshire during an early stage of the Pleistocene, and most probably before the Arctic invaders had taken full possession of the valley of the English Channel, and of the low grounds which now lie within the hundred-fathom line along the Atlantic shore of western France. Along a great, fertile, low-lying region, which then was offered by what is now the bed of the sea, there must necessarily have been a swinging to and fro of animal life; and before the temperature of France had been sufficiently lowered to exterminate or drive out the southern forms, it is most natural to suppose that in warm seasons some of the southern Mammalia would find their way northwards, and especially a formidable Carnivore such as the Machærodus. The extreme rarity of its remains forbids the hypothesis that it was a regular inhabitant of Britain during the Pleistocene age. It seems, therefore, to us that it belongs to the earliest stage in the complicated history of the deposits in Kent's Hole, and that it probably became extinct before the great majority of Pleistocene caves in Great Britain had been filled with their present contents.

This view of the extreme antiquity of Machærodus in Kent's Hole is materially strengthened by an animal which has been determined by Professor Busk among the Mammalia from the fissures of Oreston, near Plymouth. The Rhinoceros from that cave, considered by Professor Owen to belong to the tichorhine species, so common in the Pleistocene period, turns out to belong to the megarhine, which is a well-known Pleiocene species. In that case, also, it is evident that the Southern forms of life still lingered on the British side of the valley of the English Channel, while the Pleistocene Mammalia were the normal dwellers in the British caves.

Both these animals, therefore, may be taken to indicate an early stage in the Pleisto-

[1] The Rev. J. MacEnery made the same remarks on the gnawed condition of the canines. MSS., op. cit.

cene period, and both, most probably, may be referred back to a time before the maximum point of cold was reached, in the Glacial period.

§ 9. *Machærodus from Norfolk.*—A small fragment of a right upper canine, in the collection of Mr. Jervis, probably from the Forest bed of Cromer, has been identified, by Mr. E. R. Lankester[1] with the Machærodus. It consists of a portion of the crown, with the serrated edges very well marked. It is too small a fragment to enable any conclusion to be drawn as to the species. It shows, however, that the genus was living in the Eastern Counties at a still earlier period than that indicated by the remains in Kent's Hole.

1 'Geol, Mag.,' 1869, vol. vi, p. 440.

CHAPTER XXIII.

CONCLUSION.

We have now described all the members of the family of the Felidæ which have been proved to have lived in Britain. Out of the six species we have been able to add two to the catalogue of British animals—the Panther or Leopard, and the *Felis Caffer*—and the latter of these has been hitherto unknown in Europe.

Our investigations into the osteology of the living Lion and the *Felis spelæa* have resulted in the identification of the fossil with the living animal, and the probable extension of its range into North America. We have also brought forward the very curious historical evidence as to its retreat from Europe some two hundred years before the Christian era.

The Lynx, and the Leopard or Panther, and the *Felis catus* and *Felis Caffer*, living during the Pleistocene age, have also been shown to be specifically identical with the living forms.

The *Machærodus latidens*, an aberrant member of the Felidæ, is the only Pleistocene member that has become extinct. And since it is specifically distinct from the Pleistocene and Meiocene *M. cultridens* by the serration of its incisors, it is very probably a form that characterises an early phase of the Pleistocene period, a modification of the Pleiocene type that lived on into the succeeding geological age.

In the following table we have given the range and distribution of the British Fossil Felidæ:

List of Species.	Britain.				European Continent.				North America.
	Pleiocene.	Pleistocene.	Prehistoric.	Historic.	Pleiocene.	Pleistocene.	Prehistoric.	Historic.	
Felis leo (*spelæa*), L.	...	×	...	...	...	×	×	×	×
F. lynx, L.	...	×	...	...	...	×	×	×	...
F. pardus, L.	?	×	...	...	...	×	...	...	...
F. Caffer, Desm.	...	×	...	...	×	×	...	...	...
F. catus, L.	...	×	×	×	..	×	×	×	...
Machærodus latidens, Ow.	...	×	...	...	...	×	...	...	...

The presence of the Lion in Europe in Prehistoric times is rendered necessary from the fact that it is both Pleistocene and Historic, although it has not been discovered in any Prehistoric deposit.

It may be that in the long interval which elapsed between the Pleistocene and the succeeding age, it had retreated from Northern and Central Europe, partly from the competition with man, and partly from the operation of the same obscure causes which banished the Spotted Hyæna and the Hippopotamus to Africa.

It will be seen from the above table that the Wild Cat is the only British feline which still lives, and the time is not far distant when it will become extinct in our island.

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Felis pardus, Linnæus.

(Natural size.)

Fig.

1. Internal aspect of upper canine. Bleadon Cave. Taunton Museum.
2. Lower true molar. ,, ,,
3. Internal aspect of lower canine. ,, ,,
4. External aspect of lower canine. Banwell Cave. In the Collection of the Earl of Enniskillen.
5. Posterior aspect of left femur. Taunton Museum.

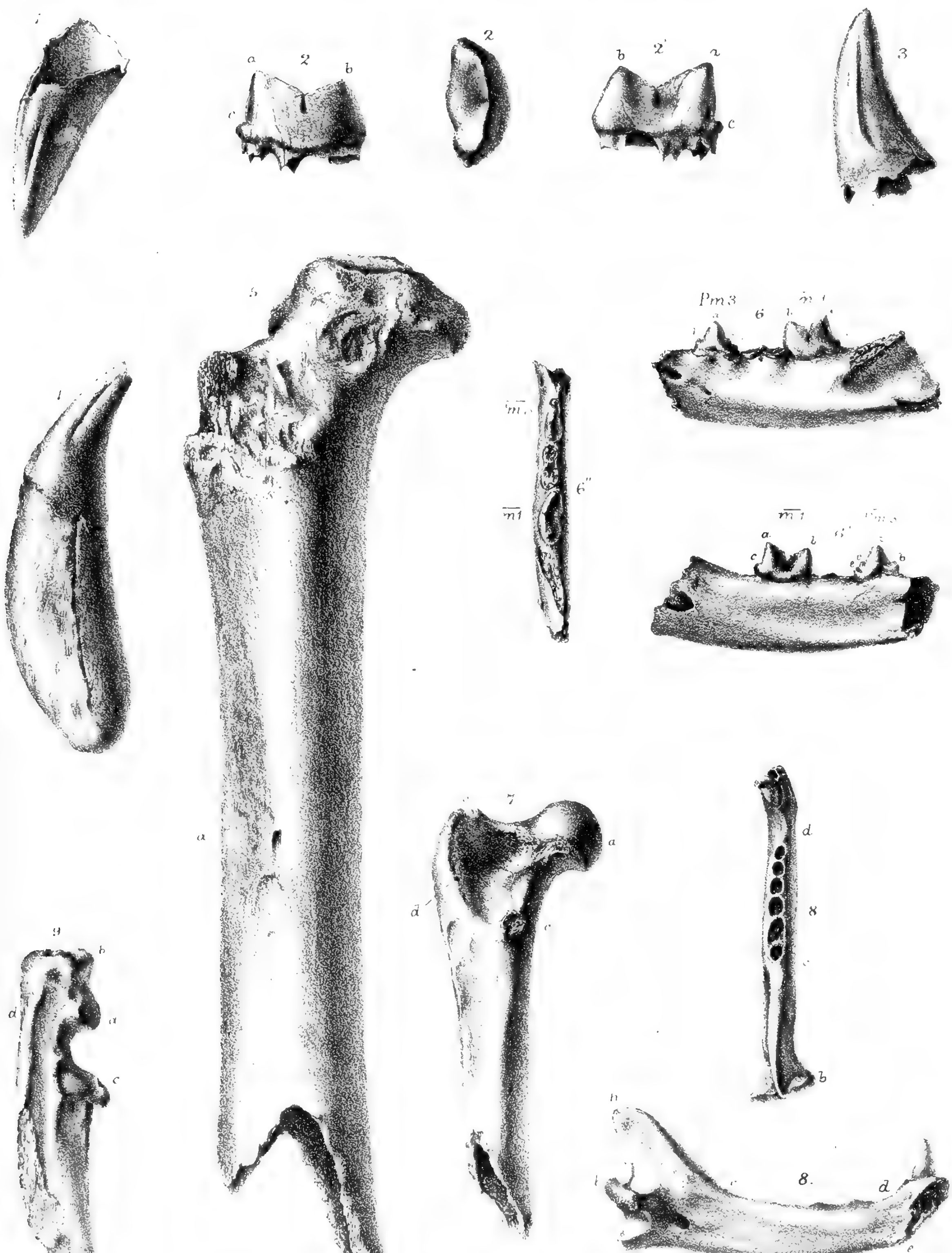
Felis Caffer, Desmarest.

6. Left mandible. Bleadon Cave. Taunton Museum.
7. Posterior aspect of upper portion of femur, which probably belongs to this species. Bleadon Cave. Taunton Musenm.
8. Radial aspect of ulna, which may belong to *Felis catus.* Bleadon Cave. Taunton Museum.

Felis catus, Linnæus.

9. Left mandible, from the Lower Brickearths of Grays Thurrock, Essex. In the possession of J. Wickham Flower, Esq., F.G.S.

The letters attached to the figures of this plate indicate the same parts as those which have been used in the plates of *Felis leo,* var. *spelæa.* In this work we propose to use one system of letters for the teeth and another for the bones of the Carnivora, since in that way the homologies can be shown with the greatest precision.



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FELIS PARDUS-ANTIQUA

CAFFER (S) 6

F. CATUS 8

PLATE XXV.

Machærodus latidens, Owen.

(Natural size.)

This plate is copied from that which was intended to have formed a portion of the 'Cavern Researches' of the Rev. J. MacEnery.

FIG.

1. Left upper canine of young adult, inner aspect. British Museum.
2. ,, ,, outer aspect.
3. ,, ,, posterior aspect.
4. Right upper canine of adult, outer aspect. Museum of the Geological Society of London.
5. ,, ,, inner aspect.
6. Right upper canine of adult, inner aspect. In possession of Sir Walter Trevellyan, Bart.
7. ,, ,, posterior aspect.

Mary Buckland del. G. Scharf lithog.

Nat. size.

Teeth of Ursus Cultridens

Found in the Cave of Kents Hole near Torquay, Devon, by Revd. Mr. McEnery Jany. 1826 in diluvial Mud mix'd with Teeth and gnaw'd Bones of Rhinoceros, Elephant, Horse, Ox, Elk & Deer, with Teeth & Bones of Hyænas, Bears, Wolves, Foxes &c.

MACHÆRODUS LATIDENS (OWEN).

THE

BRITISH

PLEISTOCENE MAMMALIA.

BY

W. BOYD DAWKINS, M.A., F.R.S., G.S.

PART V.

BRITISH PLEISTOCENE OVIDÆ.

OVIBOS MOSCHATUS, Blainville.

(Pages 1—30; Plates I—V.)

LONDON:
PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.
1872.

PRINTED BY

J. E. ADLARD, BARTHOLOMEW CLOSE.

MONOGRAPH

ON

THE BRITISH MAMMALIA

OF THE

PLEISTOCENE PERIOD.

Order—UNGULATA.

SUB-ORDER—*ARTIODACTYLA.*

FAMILY—OVIDÆ.

Genus—OVIBOS.

Species—*Ovibos moschatus*, Blainville.

CHAPTER I.

§ 1. *Introduction.* | § 2. *Zoology.*
§ 3. *Habits and present Range.*

§ 1. *Introduction.*—*Ovibos moschatus,* more commonly known as the Musk Ox of North America, has been described by naturalists under various names, as their opinions fluctuated concerning its affinities to the Oxen, Buffaloes, or Sheep. It is called the Bœuf Musqué by its original discoverer in Hudson's Bay, M. Jeremie,[1] by Drage,[2] Dobbs,[3] Ellis,[4] Hearne,[5] and all the arctic explorers of the present century. Under this name it was first systematically described by our countryman Pennant,[6] who also gives an admirable figure of the male and female, as well as by Buffon. It is described under the name of *Bos moschatus* by Gmelin,[7] Zimmermann,[8] Schreber,[9] Blumenbach,[10]

[1] 'Voyage au Nord,' t. iii, p. 314.
[2] 'Voyage,' vol. ii, p. 260.
[3] 'Hudson's Bay,' pp. 19, 25.
[4] 'Voyage,' p. 232.
[5] 'Journey A.D. 1770, 1772,' 4to, pp. 135-9.
[6] 'Arctic Quadrupeds,' vol. i, p. 8, pl. ii (A.D. 1784). See also his 'History of Quadrupeds,' published in 1781, in which he speaks of it as a Musk Buffalo, vol. i, p. 27.
[7] Lin., 'Syst. Nat.,' ed. Gmelin, i, p. 205.
[8] 'Geograph. Gesch.,' ii, p. 26.
[9] 'Saügethiere,' 302.
[10] 'Handb.,' 10, pp. 122-6.

Shaw,[1] and Cuvier,[2] by whom it was also termed "Le Buffle Musqué." M. de Blainville,[3] on the other hand, considering the animal intermediate in character between the Sheep and the Ox, proposed the name of *Ovibos moschatus,* which was adopted by Desmarest,[4] Sir John Richardson,[5] and more lately by the great French Palæontologist M. Lartet,[6] while Professor Owen[7] believes that the animal has been subgenerically separated without due grounds from the other Bubali, and especially from the Cape Buffalo (*Bubalus Caffer*), and therefore figures and describes the animal under the name of *Bubalus moschatus.* To settle this conflict of opinion as to its true place in the zoological scale is the object of the following analysis of its affinities, as well as to define the range of the animal in space and in time, and to collect together all the evidence of its sojourn in this country during the Pleistocene age. The two remarkable, allied forms discovered in the United States, and described by Professor Leidy under the name of Bootherium,[8] add considerably to the interest of an investigation into the characters of Ovibos. Before, however, we discuss any of these questions, it will be necessary to enter very briefly on the natural history of the animal.

§ 2. *Zoology.*[9]—The *Ovibos moschatus* about equals in size the small Welsh and Scotch cattle. The head is large and broad, and the nostrils are oblong, inclining towards each other from above downwards, with the inner margins covered with short bristles, and joined together at their bases by an interspace of about an inch. The rest of the end of the nose, the middle part of the upper lips, and the greater part of the lower lips and chin, are covered with close, short, yellowish-white hairs; the upper lip is furrowless, and there is no trace of a muffle. These points alone would be sufficient to separate the animal from the Bos and Bubalus, and relegate it to the ovine or caprine group of Mammals. The ears are small, as in the Yak, being three inches in length, erect and pointed, dilated in the middle. The dark umber-brown hair on the middle of the forehead is long and erect, on the cheeks smooth and pendulous, and forming with that on the throat a long beard. The horns are closely united in the old bull in the median line, and cover the brow and whole crown of the head with their bases. Each passes downwards between the eye and the ear until it reaches the plane of the mouth, when it turns upwards and forwards, and ends in the same plane as the eye. Their basal halves are of a dull white colour, oval in section and coarsely fibrous, their middle smooth and shining,

1 'General Zool.,' ii, p. 407.

2 'Oss. Foss.,' iv, p. 133, et seq.

3 'Bull. Soc. Philomat.,' 1816, pp. 76 et 81.

4 'Mammalogie.'

5 'Fauna Borealis Americana,' vol. i (1829), and 'Zool. of H.M.S. Herald' (1852).

6 'Comptes Rendus,' vol. lviii, 26.

7 'Quart. Geol. Soc. Journ.,' vol. xii, pp. 136, 137.

8 'Smithsonian Contributions to Knowledge,' vol. v, 1852.

9 The authorities which are the basis of this description are Pennant, Hearne, De Blainville, and especially Sir John Richardson, tested by an examination of the species in the British Museum. In the works of the latter the skeleton is admirably described. See 'Zoology of H.M.S. Herald.'

their tips black. The length of those belonging to the skeleton in the British Museum is twenty-seven inches, following the curvature. In the yearling male, and the female throughout life, they are small and separated by a space from each other, present a curvature outwards and downwards, and are more cylindrical than in the male in the prime of life. A similar difference in the horn development, depending upon the age and sex, is observable in the Gnu, which also closely approaches the Musk Sheep in other points of the skull. The hair on the throat and chest is long and straight, and together with that on the lower jaw hangs down like a beard or dewlap. This is shorter in the female than in the male. The neck is short and covered with long matted curly hair of a dull grizzled brown colour; it stands erect between the shoulders, and gives the appearance of a hump, as in the Yak. On the back and hips it is very long, but lies smoothly. From the shoulder, sides, and thighs, it hangs down as far as the middle of the leg. In the middle of the back it is of a lighter colour and not so long. The tail, three inches in length, is entirely concealed by the long hair of the hips. Its shortness is a character which would differentiate the animal from the Bos, Bubalus, and Bison. The body is defended from the cold by a clothing of fine brownish ash-coloured wool, which, according to Hearne, falls off in the summer. It was from this wool that M. Jeremie had gloves woven which were as soft and glossy as silk. It is not present on the legs. These latter are short and stout, terminated by unsymmetrical hoofs, the external being rounded, the internal pointed; the soft frog is partially covered with hair; the animal, as its name denotes, smells of musk. The number of its teats is two instead of four, and it has no dewlap,[1] two points in which it is separated from the Bos, Bubalus, and Bison, and closely allied to the Sheep. The dung also differs most remarkably from that of those animals, assuming the form of round pellets indistinguishable except in size from that of the Caribou[2] and the Alpine Hare.[3] The period of gestation is, however, nine months, as in the true Oxen; they take the male in August, and bring forth their young in the end of May or beginning of June.

The following measurements of animals killed by Lieut. McClintock, on Melville Island, taken from p. 87 of the 'Zoology of H.M.S. Herald,' enables us to realise the size of the animal. They are taken in inches and tenths. The weight of the males killed on that island exceeded 700 pounds, of which 400 was meat, and they stood $10\frac{1}{2}$ hands high at the withers, or 42 inches.

	Musk Bull.	Musk Cow.	Musk Cow.	Musk. Cow.
From horns to the root of tail	86·0	70·5	64·0	62·0
From the fore hoof to the top of the shoulder	57·0	55·0	—	49·5
From the hind hoof to the top of the rump	51·0	—	—	—
Length of tail	2·0	—	—	—
Length of one horn	27·0	24·0	—	19·0
From the tip of one horn to that of the other	32·0	27·3	—	27·5

[1] Sir John Richardson. [2] De Blainville. [3] Hearne.

In this brief *résumé* of the external characters of Ovibos, the truth of M. de Blainville's views as to its place in the scale between Ovis, on the one hand, and Bos on the other, is most amply proved. In addition to the absence of a muffle and of a dewlap, on which his classification is principally based, the hairiness of its nostrils, the shortness of its tail, the want of symmetry in its hoofs, differentiate it from all the Oxen, Bisons, and Buffaloes, and especially from *Bubalus Caffer*, to which it bears a mere superficial resemblance in the large size and downward direction of the horns, and the close approximation of their bases in the adult males. In these points also it has a still closer resemblance to the Gnu or Wildebest of the Cape, as well as in the long hair on its chin and neck, and the erect hair between its shoulders, while its smallness of ear, shortness of tail, and want of symmetry of hoof, are among the differences.

§ 3. *Habits and present Range.*—*The Ovibos moschatus* at the present day is confined to the North-American continent, where it ranges over the treeless barren grounds from the river Mackenzie, through 105 degrees of longitude, along with Eskimos, Reindeer, Wolvereenes, Bears, and various species of Lemming, Spermophilus, and Hare. The Mackenzie is its western limit according to Sir John Richardson; but as Capt. Beechey found that it was known to the Eskimos near Eschscholtz Bay, it probably ranges considerably further westward. Its southern limit is a line drawn along the edge of the woods " from the entrance of the Welcome into Hudson's Bay, about the 60th parallel of latitude, in a westward and northward direction, to the 66th parallel at the north-east corner of Great Bear Lake, and from thence ranging in the same direction to Cape Bathurst, in the 71st parallel." In the last century it ranged a degree further southwards, being found by Hearne, the enterprising explorer of the Copper Mine River, in 1769, a little to the north of Churchill, in lat. 59°. North of this line it is found throughout the barren grounds as far as the shores of the Arctic Sea. From the main land it comes over to the islands north and east, since Capt. Parry and Lieut. McClintock killed several of them on Melville Island, lat. 75°. It is gregarious in habit, the herds, according to Mr. Hearne, amounting sometimes to eighty or a hundred head, in which there are seldom more than two or three full-grown males. They delight in the most stony and mountainous parts, and climb rocks with great facility, being as sure-footed as the goat. They seem fondest of grass; but when they cannot get that in the winter, they feed on moss, the tops of the willows, and the tender branches of the pine trees. They are able to bear all the severity of an arctic winter, the large quantity of dung, observed by Mr. Hearne on the snow at the mouth of the Coppermine, proving that the locality had been inhabited by them during the winter of 1770-1. Generally, however, in common with the Caribou and other arctic Mammals, their migrations are regulated by the season, and they do not remain in the same place throughout the year. They are not found in Greenland or Spitzbergen.

CHAPTER II.

Osteology.

§ 1. *Skull.*	§ 3. *Place of Ovibos in classification.*
§ 2. *Limbs.*	§ 4. *Measurements.*

§ 1. *Skull.*—We have seen that *Ovibos moschatus*, in its external characters, approaches the Sheep and Goats more closely than any other Mammals; an examination of its skeleton confirms its ovine and caprine affinities, and proves how far aloof it stands from Bos, Bison, and *Bubalus Caffer*.

The basi-occipital bone in *Ovibos moschatus* (Pl. I, fig. 1) is quadrate in outline, with the sides roughly parallel, so that the area included between the anterior (*c*) and posterior (*d*) muscular impression is bounded on each side by a line roughly parallel (fig. 2) to the median line; the anterior impressions also are oval, and are not supported on a tuberosity, as in the Oxen. In the Argali, or Big-horn (fig. 4), and all the Sheep that have passed through my hands, this quadrate definition is more or less clearly marked. In *Bos taurus*, *Bison Americanus*, and *Catoblepas Gnu*, the two sides of the bone converge and give it a truncated triangular form, which reaches a maximum in *Bubalus Caffer* (fig. 3). In *Bos taurus* also the anterior muscular impressions are supported on long tuberosities. The basisphenoid is shorter, thicker, and stouter than in Bos, Bison, or Bubalus, and is untraversed by a median ridge, which is strongly marked in all these three animals.

The palatal surface of the palatines and maxillaries is more concave transversely than in the Ox, Buffalo, and Bison, and much longer in proportion to its width. The palate tapers gradually to the anterior edge of the premaxillaries, making but a slight detour round the anterior palatal foramen, instead of presenting the broad spatulate terminations seen in all these three genera. All these are decidedly ovine and caprine characteristics. In the Gnu the concavity and length of palate is united with the spatulate termination of the premaxillaries. The large space that the palatines of Ovibos take in the palate points to a bovine affinity. The paramastoid (Pl. II, *e*) process tapers gradually to its apex in Ovibos and the Sheep; in *Bubalus Caffer* the latter is enlarged.

The occiput (see Pl. II) is remarkable for its height, flatness, and the strong development of the occipital crest and nuchal spine. The supra-occipital encroaches on the coronal aspect of the skull, where it articulates with the parietals and the wormians, the occipito-parietal suture between them remaining unobliterated,[1] which two characters are never seen in the adult Bos, Bubalus, or Bison. The share which the mastoids take in the formation of the occiput is much smaller than in any of those three animals, and hence its greater height in proportion to its width. In *Bubalus Caffer* the width reaches a maximum. The occipital crest is much more strongly marked in Ovibos, Capra, and Ovis, than in any of the three animals so frequently quoted.

Coronal Surface.—We have now to discuss the most important portion of the skull, the coronal surface, which in the old male (Pl. III) is almost concealed by the large spongy bases of the horncores. In the young animal,[2] in common with all the cavicorn ruminants, the Gnu and Giraffe excepted, they are supported by the frontals, while in the old male they extend far back over the parietals, and project over the occipital surface. In the Giraffe the paired horncores are situated on the parieto-frontal suture; in the old male Gnu they extend over the suture, as in Ovibos. Each horncore in the last animal is separated from its fellow by a diastema in the median line, varying in width according to sex and age, the diastema being smallest in the old male (Pl. III), and largest in the young female (Pl. IV, fig. 1). Each (*g*) is raised above the coronal surface, in the adult (Pl. III) male at least 0·8 inch; thence it passes horizontally outwards, decreasing in size as far as a line passing in front of the orbit, where it turns suddenly downwards at a right angle, and ends in a stout obtuse point that extends further down than the tips of the paramastoid process. The fossil skull figured is an admirable example of this (Pl. III). In the female (Pl. III) the horncores are much smaller and more cylindrical than in the adult males, and they are supported by the frontal bone, as in the female Gnu.

The structure of the horncores affords a character of very great importance in the determination of the affinities of the animal. The section made of the horncore in the College of Surgeons (3817) proves that it consists of a compact spongy mass, solid for at least an eighth of its length, and with a simple vacuity merely at its base. That this character is constant is proved by the section of the fossil horncore from Crayford, as well as by the observations of M. Lartet.[3] In Bos, Bison, and Bubalus, the frontal sinuses are prolonged as far as the end of the horncores,[4] while in Ovis and Capra they are never prolonged further than the middle, and very frequently they do not enter the horncores at all, as in some of the Antelopes. In the compactness, then, of its horncores, as M. Lartet has observed, *Ovibos moschatus* is allied to Ovis, while in their position on the parietal in the old male it stands apart from all these genera. Among the points of difference between

[1] See 'Manuscript Cat. of Osteological Series in the University Museum, Oxford.' I have to thank Professor Rolleston, F.R.S., for calling my attention to this character.

[2] 'See 'Zoology of Herald,' pl. iv.

[3] Op. cit.

[4] I have, however, seen two horncores of *Bison priscus* which are solid for a distance of at least six inches from their tips. They are altogether exceptional in character, and may have been diseased.

Ovibos and *Bubalus Caffer* is the enormous development of the frontal sinuses in the latter, which causes the coronal surfaces to assume the form of a segment of a circle antero-posteriorly, while in the former the corresponding surface is but slightly curved.

The Facial Aspect.—Running transversely across the parietals at a short distance above the orbit, is a stout bony ridge (Pl. III, *i*) or step, which is peculiar to the old male Ovibos. The fronto-nasal suture extends nearly at right angles to the median line, instead of being directed obliquely forwards at a very acute angle, as in the Ovis, Capra, Bos, and especially *Bubalus Caffer.* In the European Bison it runs at a slightly greater angle than in the Bovidæ, and then suddenly ends in a right angle with the median line, while in the American it is straight throughout. The nasal bones are much wider posteriorly than anteriorly, and their anterior extremities are much narrower than in the Bovidæ, two points in which they approach Ovis and Capra. The premaxillaries are slender, and their sides converge anteriorly, as in the Goats and Sheep, while in Bubalus, Bos, and Gnu, they are nearly parallel. They do not extend, as in Bos, as far back as the nasals, a character which they share with the Bison. They end in a small rounded extremity. The facial plate of the maxillary is much more vertical in Ovibos and Ovis than in Bos, Bubalus, or Bison, and the facial ridge is represented by a stout boss above the root of the first true molar, as in *Bubalus Caffer.* The lachrymal bone also has a strong ovine character impressed upon it in the broad deep excavation in front of the orbit. In the female skull in the College of Surgeons it is very shallow, in the two skulls of old males in the same collection very broad and deep. In the majority of the Antelopes, as the Gnu, in common with the Oxen, Bison, and Buffalo, this is absent; in others, however, as the Bontebock and the Eland, it is also found.

Orbits.—The outward projection of the orbits differentiates most strongly Ovibos from the true Bovidæ, and especially from *Bubalus Caffer.* In the Bison, however, the same character is found, and is more developed in the European than in the American species. This is a decided ovine affinity. A reference to the table of measurements will give the comparative projection of the orbits in all the mammals quoted in this essay.

Summary of Head.—In fine, the whole contour of the skull of *Ovibos moschatus,* in its tapering forwards, in the prominence of its orbits, in the verticality of the facial plate of the maxillary and the lachrymal excavation, prove that the animal is more closely allied to the Sheep than to any other of the Mammalia. The analysis of the different bones of the skull proves that it is separated further from *Bubalus Caffer* than from the true Oxen or the Bisons. It approaches the Gnu nearer than any of the large cavicorn ruminants, though the following points of difference are found in the latter: the occiput is broader than high, basisphenoid keeled, premaxillary palatal surface spatulate and expanded, premaxillaries articulate with nasals; thus, although there is a superficial resemblance to Ovibos in this animal, in those points which have been enumerated in the description of the skull of the former, it is overborne by more important differences.

Teeth.—The ovine and caprine affinities visible in the skull of the Musk Sheep are visible also in the teeth; the upper true molars are differentiated from those of Bison and Buffalo by the sharpness, stoutness, and prominence of the three principal costæ on their outer surface, and the small development of the two secondary ones. The crowns also of the teeth are not so broad. On the internal aspect there is no accessory column, a point which would at once separate them from Bos, Bubalus, and Bison. There is a small accessory valley at the inner interspace between the two principal ones, which is present also in *Bos Caffer*. It is absent from many of the Oxen, and is in the Musk Sheep invariably larger and deeper than in any of the true Bovidæ. A strong process passes from the inner side of the valley in premolar, and diagonally backwards as far as its external border. The anterior edge of the first premolar (P. M. 2) is much sharper than in any of the Bovidæ, and differs in the simplicity of its crown from that of *Bubalus Caffer*. The lower jaw teeth differ from those of Oxen in the length of the anterior costa, and by its being continued past the cingulum, by the fusion of the posterior valley in molar 3 with the second, and by the narrowness of the teeth. In premolars 4 and 3, also, the posterior lobe is much more clearly defined. In other respects the lower dentition is closely allied to that of the domestic Ox. The form of the lower jaw is essentially ovine or caprine, differing from those of Ox and Bison in the proportions which are given in the measurements.

§ 2. *Vertebræ.*—The vertebræ have been described and figured so admirably by Sir John Richardson in the 'Zoology of the Herald,' pp. 72—89, that all that is necessary to be said about them here is, that their zoological evidence agrees with that of the rest of the skeleton. They consist of seven cervicals, thirteen dorsals, six lumbars, six sacrals, and six caudals.

Scapula.—The scapula, in common with that of Ovis, differs from that of Ox in the straightness of its spine, in the curvature of the dorsal edge, and the small size of the crown.

Humerus.—The humerus presents the following ovine characteristics :—The deltoid ridge is smaller and less everted, the superior tuberosity is more massive, and the ridge running from the deltoid to the outer side of the proximal articulation is less marked than in the corresponding Ox bone; the bone itself is also more slender.

Radius.—The radius presents the following differences from that of Bos :—The tuberosity on the exterior of the proximal end is further removed from the articulation, and the bone itself is smoother and rounder, the muscular impressions are not so strongly marked.

Ulna.—The superior surface of the olecranon is rounded; and is much shorter than in Bos or Bison, in which it ends in a sharp ridge; the transverse diameter of the proximal articulation is also greater; the groove at the point of anchylosis with the radius is also absent; all these are ovine and caprine characters.

Metacarpal.—The metacarpal is shorter and stouter than that of Ox, its dorsal surface bears the merest trace of an extensor groove; the synovial cavity between the articulations with the magnum and unciform is very much smaller, and the posterior edge of the proximal articulation consists of two planes meeting one another at a very obtuse angle instead of being straight. In this respect it agrees with Ovis, but it is very much shorter and stouter than the corresponding bone in that animal.

Phalange 1.—The first phalange is more slender than that of Ox. On the palmar surface the muscular ridges circumscribe a broad groove, and there is a deep excavation immediately above the distal articulation; it differs from Ovis in this latter character, and also in its greater stoutness.

Phalange 2.—The second phalange is defined from Bos and Ovis by the deep excavation in the palmar surface, which occupies the whole of the shaft; it is much stouter than in Ovis.

Phalange 3.—The hoof phalange differs from that of Ox in the articulation not extending to the superior surface of the bone; the palmar surface is more oblique than in Ox, and is not defined from the inner surface, as in that animal and the Sheep.

Pelvis.—The crest of the ilium forms an arc of a circle, while in Ox it is hollowed superiorly. The spine of the ischium is not so pronounced as in the Ox, nor is the spine on the symphysis pubis so strongly marked; the anterior edge of the pubis is straight. All these points characterise Ovis and Capra.

Femur.—The head of the femur is more clearly defined from the articular surface of the interspace between it and the great trochanter than in Bos and Bison; the latter is narrower and the cavity is deeper; the smaller trochanter is mastoidal in shape, the shaft is flatter on its dorsal surface and rounder, especially at its distal end; the inner edge of the patellar articulation is sharp instead of being rounded off, as in Ox and Bison, it is sharper even than in Ovis. All these are ovine and caprine characters.

Tibia.—The slenderness of shaft and internal malleolus, roundness of the articular surface between the inferior edges of the two femoral articulations, are ovine characters; the internal groove also on its inferior surface is slightly incurved, distally, while in Bos, Bison, and Cervus, it is straight.

Metatarsal.—The metatarsal, in its stoutness and breadth, especially of the condyles, differs from both Ovis and Bos; in the shallowness of extensor groove, and its absence from the distal third of the shaft, it resembles the former and differs from the latter animal. Its proximal facets are altogether ovine.

Hind phalange 1 differs from that of Bos by the greater flatness of its dorsal surface, by the presence of a dorsal pit above the distal articulation, and by the flat palmar area being bounded on either side by a ridge; it is stouter than that of Sheep.

Hind phalange 2.—The second phalange is shorter than in the Sheep, and more slender than in the Ox; the muscular impression on the side of the proximal articulation that faces the corresponding phalange of the foot is stouter than in Sheep or Oxen; and rises into a tuberosity which is altogether absent from the latter; the palmar surface of the shaft is excavated more deeply than in Bos or Ovis.

Phalange 3.—The articulation extends downwards nearer the palmar surface of the bone than in Ox or Sheep; in the former it is deeper than broad; the description is the same as that of the hoof phalange of the fore leg.

§ 3. *Place in Classification.*—The evidence, therefore, of its ovine affinities afforded by the external characters of the animal is proved to demonstration by its osteology. It is separated from Ovis by many characters which have been enumerated, and especially by the share which the parietals take in supporting the horns of the old male, and by the presence of a transverse ridge on the frontals in the old male, as well as by the large size of the animal and its period of gestation of nine months. In no respect has it any relation to *Bubalus Caffer*. In the zoological scale it stands, as M. de Blainville wrote in 1816,[1] between Ovis on the one hand and Bos on the other, being more closely related to the former than the latter, and being separated from the closely allied family of Capridæ, by the downward direction of the horns and their closeness to the head.

§ 4. *Measurements.*—The following tables of measurement, taken in inches and tenths, show at a glance the relation which the recent holds to the fossil Ovibos, and the enormous difference between that animal and the Buffaloes, Oxen, and Bisons. From the first table the measurements of the fossil skull, described by Pallas and Ozeretzkowsky, have been purposely excluded, because of the uncertainty as to whether they employed the French, English, or Russian inch, Cuvier taking one view and Sir John Richardson another. The terms of measurement of the pelvis and several of the other measurements are taken from the work of Sir John Richardson so often referred to.

In the table of measurements of teeth, No. 1 is the antero-posterior extent; No. 2, the antero-transverse diameter; No. 3, the postero-transverse; and all are taken at the base. In the last lower molar there is an additional transverse measurement for the additional lobe.

In the measurements of long bones the following numbers are used throughout:

1. = Maximum length.
2. = Minimum circumference.
3. = Transverse measurement of proximal articulation.
4. = Vertical ditto.
5. = Transverse measurement of distal articulation.
6. = Vertical ditto.

[1] Op. cit., Genus, xi.

Comparative Skull Measurements.	Male musk sheep, Brit. Museum.	Female musk sheep, Coll. Surg.	Male musk sheep, Sir John Richardson.	Female ditto.	Male musk sheep, 381, Coll. Surg., described by Sir J. Richardson.	Male musk sheep, Crayford (Pls. ii, iii, iv).	Male musk sheep, Maidenhead.	Male musk sheep, Freshford.	Female musk sheep, Freshford (Pl. v).	Female musk sheep, Escholtz Bay.	Bubalus Caffer, British Museum.	Bos taurus, British Museum.	Bison Europæus, Brit. Museum.	Bison Americanus, Brit. Museum.	Catoblepas gnu, Coll. Surgeons.	Caprovis argali, Brit. Museum.	Caprovis montana, Brit. Museum.	Bootherium bombifrons, Leidy.	Bootherium cavifrons.
Basal length of skull	18·0	...	...	...	19·5	...	...	...	...	...	18·2	20·8	18·3	19·0	14·2	12·9	11·3	...	...
Length of basi-occipital and basi-sphenoid	4·3	3·2	4·2	4·0	...	5·0	...	...	...	...	4·2	5·8	4·6	4·45	3·4	3·2	3·15	...	...
Breadth of posterior muscular impression on basi-occipital	2·3	2·0	2·3	2·3	...	2·8	...	...	...	...	3·6	2·5	2·5	2·72	2·06	1·9	1·65	...	...
Breadth of anterior muscular impressions	2·1	1·6	2·0	2·0	...	2·8	...	...	...	...	1·3	1·35	1·45	1·3	1·1	1·9	1·7	...	...
Breadth of basi-sphenoid close to presphenoidal articulation	0·8	0·76	0·7	0·7	...	0·8	...	...	...	...	0·75	0·7	0·85	0·95	0·4	0·5	0·45	...	...
Length of palatines...........	3·0	...	...	...	2·1	...	...	...	...	...	2·8	3·4	3·0	3·5	1·15	0·7	0·8	...	...
,, maxillaries	4·0	...	...	...	5·3	...	...	...	...	...	4·5	4·8	4·0	4·0	3·14	3·14	2·72	...	...
,, premaxillaries......	4·0	...	...	...	4·0	...	...	...	...	...	4·0	4·9	4·6	4·4	3·65	2·9	2·55	...	...
Breadth of palate behind last true molar	3·4	3·4	3·3	3·2	3·4	...	...	...	...	...	3·7	4·0	4·0	4·5	2·19	2·2	2·0	...	...
Breadth of palate in front of first premolar	2·4	...	2·3	2·2	2·3	...	...	...	...	...	3·6	3·8	2·7	3·35	1·55	1·3	1·25	...	...
Breadth of anterior edge of premaxillaries	1·2	...	...	...	1·3	...	...	...	...	...	4·5	4·2	2·7	3·6	2·9	1·0	1·45	...	...
Molar breadth (exclusive) ...	5·5	5·0	...	...	4·6	...	...	...	...	...	8·0	7·0	9·2	8·0	0·5	4·7	4·4	..	...
Glenoid breadth (inclusive)...	6·0	5·25	...	...	6·8	...	...	...	...	...	7·5	9·0	7·0	7·8	5·5	5·5	5·2	...	...
Paramastoid breadth (inclusive)........................	5·25	...	...	...	5·8	...	...	...	...	...	5·4	5·3	5·3	5·3	3·5	4·3	3·6	...	...
Height of occiput	4·5	4·0	5·0	4·5	4·9	5·8	4·5	...	...	...	4·4	7·25	5·4	5·8	3·8	2·6	2·9	...	...
Breadth of occiput	7·0	...	6·7	6·0	7·5	7·+	...	...	...	...	10·0	11·0	9·8	9·8	5·4	5·0	3·5	...	...
Breadth of foramen magnum in middle....................	1·25	...	...	...	1·5	1·5	...	...	...	...	1·8	1·8	1·3	1·1	1·05	1·2	1·3	...	...
Breadth of foramen magnum at top	1·5	...	...	...	1·8	1·3	...	...	...	..	2·5	2·25	1·5	1·5	1·25	1·3	1·13	...	...
Breadth of foramen magnum at bottom....................	0·4	...	...	...	0·5	0·4	...	...	...	...	0·67	0·45	0·5	0·4	0·4	0·56	0·2	...	...
Transverse measurement of condyle	1·5	...	...	...	2·05	1·9	1·8	...	...	...	1·9	2·0	2·3	2·5	1·5	1·0	1·0	...	...

Comparative Skull Measurements (*continued*).	Male musk sheep, Brit. Museum.	Female musk sheep, Coll. Surg.	Male musk sheep, Sir John Richardson.	Female ditto.	Male musk sheep, 381, Coll. Surg., described by Sir J. Richardson.	Male musk sheep, Crayford (Pls. ii, iii, iv).	Male musk sheep, Maidenhead.	Male musk sheep, Freshford.	Female musk sheep, Freshford (Pl. v).	Female musk sheep, Escholtz Bay.	Bubalus Caffer, British Museum.	Bos taurus, British Museum.	Bison Europæus, Brit. Museum.	Bison Americanus, Brit. Museum.	Catoblepas gnu, Coll. Surgeons.	Caprovis argali, Brit. Museum.	Caprovis montana, Brit. Museum.	Bootherium bombifrons, Leidy.	Bootherium cavifrons.
Vertical measurement of condyle	2·9	...	...	...	...	2·9	2·2	...	...	...	3·1	4·2	3·0	3·05	1·8	2·2	3·2	...	...
Occipital crest to fronto-nasal suture	11·2	7·6	...	...	13·8	...	...	...	...	...	11·8	10·5*	10·5*	10·2*	8·5*	7·5*	8·4	...	...
Fronto-nasal suture to tip of nasals	5·9	...	...	...	6·2	...	...	...	...	...	8·1	7·9	6·9	7·5	6·35	9·2	5·6	...	...
Frontal breadth between orbits	8·6	6·8	...	...	9·8	8·8	...	...	...	...	7·5	7·5	10·8	9·4	4·1	9·0	5·9	...	...
Frontal breadth at naso-frontal suture	3·4	2·5	...	...	3·4	...	...	...	...	...	4·4	6·0	6·0	6·0	2·4	4·5	2·5	...	...
Posterior breadth of nasals	3·0	...	...	...	3·3	...	...	...	...	...	2·5	2·7	3·65	4·0	0·6	3·2	2·8	...	...
Anterior breadth of nasals at maxillary, in oxen at inter-maxillary suture	2·3	...	...	...	2·5	...	...	...	...	...	2·8	2·5	3·7	2·8	0·9	2·3	1·9	...	...
Antero-posterior extent of horncore	8·8	2·3	...	...	...	9·0	6·8	6·8	...	...	7·3	2·8	2·95	3·4	8·0	...	6·0	10·0	...
Circumference of horncore	14·5	...	...	...	...	17·6	13·1	14·0	8·5	...	...	8·0	9·3	9·4	...	...	...	12·55	...
Extent of orbit beyond plane of facial process of maxillary	1·7	1·9	...	...	2·5	...	...	...	...	...	0·35	1·35	1·55	1·5	1·25	1·0	0·95	...	...
Extent of molar series	5·8	...	...	...	...	...	...	...	...	...	5·4	5·7	6·1	6·5	3·8	8·6	3·0	...	...
Length of horn	27·2	14·0	...	...	...	...	...	...	...	10·0	28·6	13·8	...	12·5+	19·5	8·7+	...	...	...
Length of horncore	...	...	...	...	2·9	14·5	11·+	...	7·2	6·5	...	9·5	10·2	8·2	...	...	...	9·0	...
Minimum distance between horncores	...	...	...	...	0·85	0·65	0·5	0·4	1·0	2·2	...	...	...	...	...	...	...	6·0	15·55

* From Inion.

Comparative Measurements of Teeth.

	Molar 3.				Molar 2.			Molar 1.			Premolar 4.			Premolar 3.			Premo. 2.		Canine.		Incisor 3.		Incisor 2.			Incisor 1.		
Upper jaws—	1.	2.	3.	4.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	1.	2.	1.	2.	1.	2.	3.	1.	2.	3.
Musk sheep, British Museum	1·2	0·6	0·49	...	1·15	0·68	0·62	0·9	0·7	0·7	0·76	0·63	...	0·7	0·65	...	0·5	...	...	...	...	...	...	...	...	...	...	...
Bubalus Caffer, ditto	1·1	1·1	1·05	...	1·09	1·08	0·9	0·99	0·95	1·05	0·63	0·9	...	0·75	0·86	...	0·66	0·73	...	...	...	...	...	...	...	...	...	...
Bos taurus, College of Surgeons	1·38	0·9	0·86	...	1·1	0·95	0·9	0·95	0·88	0·8	0·7	0·86	...	0·71	0·71	...	0·64	0·6	...	...	...	...	...	...	...	...	...	...
Bison Europæus, British Museum..	1·28	1·02	0·88	...	1·05	1·07	1·0	0·8	1·06	0·94	...	0·8	0·9	0·7	0·7	...	0·7	0·54	...	...	...	...	...	...	...	...	...	...
Lower jaws—																												
Musk sheep, British Museum	1·6	0·6	0·5	0·32	1·12	0·6	0·58	0·9	0·59	0·57	0·8	0·45	0·41	0·58	0·35	0·35	0·4	0·25	0·3	...	2·9	2·5	0·3	0·28	0·29	2·5	...	...
Bos taurus, College of Surgeons	1·76	0·7	0·68	0·35	1·16	0·72	0·72	0·95	0·6	0·66	0·9	0·5	0·59	0·76	0·41	0·55	0·48	0·35	0·41	0·32	0·35	0·36	0·36	0·4	...	0·4	0·4	...
Bison Europæus, British Museum..	1·78	0·76	0·76	0·42	1·05	0·84	0·8	0·8	0·72	0·75	0·85	0·6	0·6	0·78	0·52	0·55	0·5	0·4	...	...	...	...	...	...	...	...	...	...

Comparative Measurements of Lower Jaws.	Musk Sheep (male), Brit. Mus.	Bison Europæus, Brit. Mus.	B. taurus, Coll. Surg.
Symphysis to condyle	16·5	16·3	17·6
Circumference anterior to premolars ...	3·2	4·75	4·2
Ditto behind last true molar	6·1	6·4	8·0
Symphysis to angle	13·1	14·3	13·0
Height of coronoid process above angle	7·8	8·0	9·7
Length of exterior border of symphysis	1·8	2·6	2·85
Maximum length of condyle	1·2	...	2·25
Breadth of ditto	0·5	...	1·0
Extent of diastema	3·8	4·4	4·8
Length of molar series....................	5·6	6·0	7·5
Depth of jaw anterior to premolars ...	1·4	1·6	1·75
Ditto posterior to last true molar	2·7	2·7	3·46
Symphysis to coronoid process	15·5	16·8	16·5
Angle to condyle	5·1	5·7	7·0
Condyle to top of coronoid process ...	1·6	1·5	2·7

Comparative Measurements of Scapula.	Female Ovibos.	Common Ox.
Maximum length	13·5	17·0
Minimum circumference	5·5	7·8
Transverse measurement of articulation	1·8	2·95
Vertical ditto	2·2	3·2
Heighth of spine above neck	2·0	2·8
Length of spine	10·6	14·8
Length of dorsal edge	7·6	10·0

Comparative Measurements of Pelvis.	Male musk sheep, Sir J. Richardson.	Female musk sheep, Sir J. Richardson.	Musk sheep, Coll. Surg.	Alderney cow.
Distance of the sternal angle of the crest of one ilium to that of the other	13·0	13·5	13·0	18·3
Transverse distance from the same point to the dorsal angle of the same ilium or length of the sterno-dorsal chord of the crest....................	7·4	7·7	7·3	9·1
Sterno-dorsal diameter of the iliac shaft at its narrowest place	1·5	1·6	1·6	2·0
Sterno-dorsal diameter of the acetabulum...........	1·9	1·9	1·9	2·1
Atlanto-sacral ditto	2·0	2·0	2·0	2·0
Transverse distance from the apex of one lateral conical process near the dorsal angle of the ischium to the apex of the other (maximum) ...	8·1	7·8	8·0	11·0
Transverse distance between the dorsal or spinous angles of the ischium, being the width of the pelvis there...	4·7	5·0	4·8	8·2
Transverse diameter of the pelvis at the stem or ramus of the ilium	5·4	5·6	5·3	7·1
Length of the foramen ovale	3·6	3·3	3·0	3·6
Sterno-dorsal diameter of ditto	2·6	2·1	2·2	2·3
Length of pelvis from the most proximal angle of the crest of the ilium to the tuberosity of the ischium	18·2	17·2	13·0	19·2
Distance from the pubal brim of pelvis to tuberosity of ischium	7·7	7·0	7·2	9·0
Distance from the dorsal angle of the ischium to the sternal symphysis of that bone	4·4	5·5	6·0	6·1
Distance from the dorsal angle of the ischium to the summit of its lateral conical process	2·0	1·7	1·5	3·2
Sterno-dorsal diameter of the dorsal ramus of the ischium	1·4	1·7	4·7	2·6
Distance from the tuberosity of the ischium to the brim of the acetabulum nearest to it..............	7·4	6·8	...	8·5
Distance from the atlantal brim of the acetabulum to the sternal corner of the iliac crest	8·0	8·0	8·0	8·8
Length of the proximal ramus of the pubal from the edge of the acetabulum to the symphysis ...	2·8	3·1	...	3·5

Comparative Measurements of Long Bones.	1.	2.	3.	4.	5.	6.
Humerus—						
Musk sheep, College of Surgeons	12·6	5·2	2·8	3·5	2·8	3·3
Bos taurus, College of Surgeons	13·9	7·3	4·4	5·0	4·9	...
Radius—						
Musk sheep	11·8	4·4	2·8	0·8	...	...
Bos taurus	14·2	6·3	4·0	...	...	...
Ulna—						
Musk sheep	15·2	2·2	...	1·05	0·86	...
Bos taurus	17·3	2·9	...	...	...	...
Metacarpal—						
Musk sheep	6·5	4·8	2·1	1·0	2·6	2·25
Bootherium cavifrons, Leidy	9·65	6·25	3·35	...	3·45	...
,, bombifrons	7·0	3·95	2·35	...	2·5	...
Bos taurus	8·5	7·6	2·8	1·3	2·9	2·7
Phalange 1—						
Musk sheep	2·4	3·0	1·0	0·9	1·1	1·2
Bos taurus	2·3	3·5	1·4	0·9	0·2	0·5
Phalange 2—						
Musk sheep	1·2	3·2	1·3	1·0	1·0	1·8
Bos taurus	1·7	3·7	1·4	1·0	1·2	2·0
Phalange 3—						
Musk sheep	2·5	0·0	0·9	...	...	...
Bos taurus	3·0	1·0	1·5	...	...	...
Femur—						
Musk sheep	14·6	4·7	3·3	2·8	3·2	6·5
Bos taurus	18·8	6·7	5·1	4·8	5·25	9·8
Tibia—						
Musk sheep	12·7	3·8	3·3	2·5	2·1	0·8
Bos taurus	14·2	6·3	4·9	3·8	...	...
Metatarsal—						
Musk sheep	8·0	3·8	1·7	1·6	2·6	2·25
Bos taurus	9·5	4·5	2·2	2·3	2·9	2·6
Hind phalange 1—						
Musk sheep	2·56	2·9	1·08	1·05	1·18	1·4
Bos taurus	2·7	3·7	1·35	1·05	1·25	1·7
Hind phalange 2—						
Musk sheep	1·62	2·8	1·28	0·73	0·9	1·7
Bos taurus	1·95	3·5	1·3	0·94	1·05	2·0
Hind phalange 3—						
Musk sheep	2·15	0·8	0·85	...	...	...
Bos taurus	2·24	...	6·95	1·35	...	...

CHAPTER III.

The Fossil Ovibos.

§ 1. *Fossil Remains in Siberia.*—The fossil remains of Ovibos found in Europe, Asia, and America, are admitted to be specifically identical with the *Ovibos moschatus* by all naturalists conversant with the latter animal. The first notice of the fossil we owe to the great Russian naturalist, Dr. Pallas, who in 1772 described and figured the skulls of two old males [1] (immania cum cornibus capita). The one found on the banks of the Obi, the other from a Tundra, or treeless barren ground, near Beresov, on the same river. He leaves their specific determination open, merely remarking that they agree with *Bubalus Caffer* in the apposition of the horncores. They are, however, recognised by his contemporary in England, Pennant, in 1784,[2] as belonging to the recent Musk Sheep, and as finally affording evidence of the former range of that animal over Northern Asia. In 1809 M. le Comte Rouminatzow found a third head at the embouchement of the Yana, with its horns preserved, and perfect with the exception of its nasals and premaxillaries. M. Ozeretskowsky describes it under the name of Bison Musqué, and believes that the animal lived in Siberia, and that possibly it may have been exterminated by the same intense cold that preserved its bones.[3] His two figures prove that the skull belonged to an old male.

§ 2. *Fossil Remains in America.*—The next discovery of the animal was made by Captain Beechey, in 1826,[4] and subsequently by Captain Kellett, in 1850, in the remarkable accumulation of bones of Mammoth, Reindeer, Elk, Bison, and Horse, originally found by Dr. Eschscholtz in the bay called after his name. They consist of two fragmentary skulls, with horncores of old males, and the atlas, third dorsal, fifth lumbar, and four sacral vertebræ, an acetabulum, pieces of the humerus, and one mutilated tibia. A large cervical vertebra from the same locality is considered by Sir John Richardson to belong

[1] 'Nov. Comm. Petrop.,' xvii, 1772, p. 57.
[2] 'Arctic Quadrupeds,' vol. i.
[3] 'Mémoires de l'Acad. de Pétersb.,' iii, 215.
[4] 'Beechy's Voyage, 4to, Lond., 1831, Appendix.

to a separate species, *Ovibos maximus*, but the differences do not seem to me to be of specific value. The observations of Captain Kellett, Dr. Goodrich, and Dr. Seeman have settled the constitution of the cliffs whence these remains were derived.[1] According to the latter they present the following section:

3. Peat from two to five feet thick; destitute of fossils.
2. Clay, river gravel, loam, and sand, from two to twenty feet, containing trees and fossil bones, and exhaling an ammoniacal odour.
1. Ice from twenty to fifty feet thick.

It is a very singular circumstance that this ancient fluviatile deposit should rest on the surface of a hard crystalline mass of ice which is now gradually melting away.

§ 3. *Fossil Remains in Germany.*—In Germany the animal has been found in four localities. Dr. Baer, in his Inaugural Address in 1823 to the University of Königsberg, mentions the animal, under the name of *Bos Pallasii*, as having been obtained at Neugartenthor, in Prussia. In 1846 the discovery of a skull in the neighbourhood of Merseburg was put on record by Dr. Giebel;[2] and Sir Charles Lyell quotes, in his 'Antiquity of Man,' a skull in the Museum of Berlin correctly named by Professor Quensted[3] as far back as 1836, which had been dug up out of drift in the Kreuzberg, in the southern suburbs of that city. The associated Mammalia are the Horse, Mammoth, and Tichorhine Rhinoceros.[4] The fourth instance of its occurrence in Germany is offered by Professor Schmid of the University of Jena, who describes in the 'Neues Jahrbuch,' for 1863, a portion of a skull found in the preceding year in the ancient alluvium of the Saale.

§ 4. *Fossil Remains in France.*—A tooth found by l'Abbé Laubert in 1859[5] in the gravel of the Oise at Viry-Noureuil, near Chauny, and determined by M. Lartet, was the first indication of the existence of Ovibos in France; it was associated with remains of *Elephas antiquus*, Mammoth, Cave Hyæna, Bear, and Reindeer; flint implements were found in the same bed of gravel. A portion of the skull found in 1859[6] in a gravel pit at Précy, in the same valley, along with a mammoth tusk, and described by M. Lartet, corroborates the truth of his determination. From the same pit a flint instrument of the St. Acheul type was obtained in 1860, and presented by M. de Verneuil to the Geological Society of France. The position of the horncores on the frontals, their small size and rounded section prove that the skull belonged to a female. In the figure appended to M. Lartet's paper the position of the parieto-frontal suture on the coronal surface is very well shown. And lastly, in the year 1864, M. Lartet and Mr. Christy discovered bones

[1] 'Zool. Herald,' p. 1—8.
[2] Leonhard u. Bronn's 'Jahrbuch,' 1846, p. 460.
[3] Ibid., 1836, p. 216.
[4] Lyell, 'Antiq. Man.,' 1863, p. 156.
[5] 'Quart. Journ. Geol. Soc. Lond.,' vol. xxi, p. 475.
[6] Comptes Rendus, 1864, lviii, 26.

of the hind limb of the animal in the refuse heap left by the Reindeer folk in the cave of the Gorge d'Enfer, in Périgord, associated with worked flints, lance heads of Reindeer antlers, and bones of the Ox, Horse, and Reindeer. The long marrow-containing bones were split, for the sake of the marrow, just in the same way as those of the other animals used for food.[1] Thus, while in the other two cases cited above there seem no grounds for doubting that the animal coexisted with the Palæolithic savages in France, there can be no doubt whatever of its having been used for food by the Reindeer folk of Auvergne.

[1] 'Quart. Journ. Geol. Soc.,' vol. xxi, p. 475, *note*.

CHAPTER IV.

FOSSIL OVIBOS IN GREAT BRITAIN.

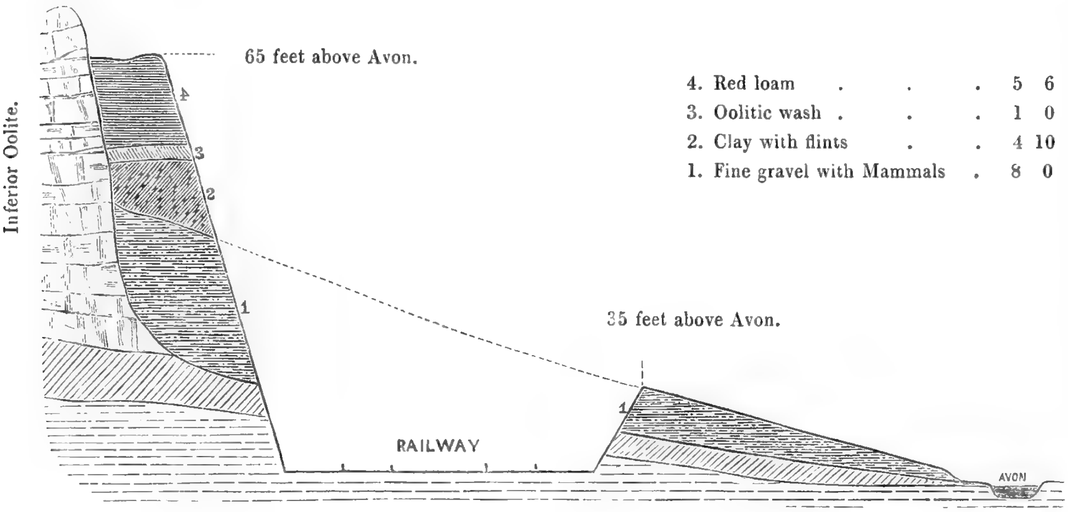
Pls. I, II, III, IV, V.

§ 1. *Remains found at Crayford and Green Street Green.*—We owe to the Rev. Charles Kingsley and to Sir John Lubbock the first proof of the animal having lived in Britain: and the skull which they discovered in the low-level Thames gravel near Maidenhead in 1855, is described under the name of *Bubalus moschatus*[1] by Professor Owen, who was probably misled by a hint of Dr. Pallas as to its affinities with the Cape Buffalo. It belonged to an adult male of rather small size; and, as it is very much broken, the position of the parieto-frontal suture, nearly in the middle of the horncores, is very well shown on the cranial surface. Sir John Lubbock has also been fortunate enough to find a fragmentary skull of a male in the gravels of Green Street Green, near Bromley in Kent, associated with the remains of Bison. Its condition proves that it has been exposed for some time to the attrition of the fluviatile sand and gravel in which it lay. These two skulls are preserved in the British Museum along with those from Eschscholtz Bay.

§ 2. *Remains found at Freshford.*—In the West of England two very well preserved fragments of the skulls of a male and female, Pl. V, fig. 1, have been found by Mr. Charles Moore in the gravels of the Avon at Freshford, near Bath. The remains of other animals which I have seen from the same place belong to the Mammoth, Bison, Horse, and Reindeer. In 1866 I examined the locality along with the Rev. H. H. Winwood, F.G.S. In the narrow valley which the river Avon has cut through the Bath and Lower Oolites, into the sands below, are patches of gravel at different heights above the present stream.

[1] 'Brit. Assoc. Rep.,' 1856, 'Trans. Sect.,' p. 72.

The section exposed near the Freshford Railway-station from which the Musk Sheep were obtained, presents a lenticular mass of gravel consisting of waterworn pebbles of Mountain-limestone, flint, chert, Oolite, hornstone, quartzite, Old Red Sandstone and fossil shells from the adjacent beds; resting on the Lower Oolite limestones at the bottom, are a



$\frac{1}{10}$th inch to 1 foot.

few big boulders, and the pebbles are larger there than in the upper or middle part. The whole bed is highly confused, and presents none of the sorting action which would be the result of pebbles transported by a river flowing under temperate conditions. It could indeed only have been deposited by an ice-burdened river, under severe climatal conditions.

The list of animals derived from it leads to the same conclusion; for two out of the five, the Reindeer and the Musk Sheep,[1] are found now only under an arctic climate, and all the species occur in the frozen cliff in Eschscholtz Bay. I have not the slightest doubt that the fluviatile ossiferous deposits in both these localities were formed under similar conditions, with this difference only, that the climatal change has only advanced so far in Kotzebue Sound as to gradually melt the ice cliffs, and thus to cause the coast-line mapped by Admiral Kotzebue to become lower, and in every respect much changed during the last eighty years, while in Somersetshire the arctic conditions have entirely passed away.

The preceding section shows the exact relation of the gravel to the beds above, which are probably rain-wash of different ages. They all abut against the oolitic limestone, which appears at the surface at a slight distance above the cutting.[2]

[1] Compare Beechey Voyage, Appendix by Dr. Buckland, with 'Zool. H. M. S. Herald,' p. 1—8.

[2] For the heights which prove that the gravel belongs to the low-level series of Mr. Prestwich, F.R.S., I am indebted to the Rev. H. H. Winwood.

The low-level gravels of Loxbrook, also near Bath, which possibly may be of the same date as those of Freshford, have afforded remains of Cave Lion, Irish Elk, Mammoth, and Tichorhine Rhinoceros.

The absence of the Musk Sheep from the bone caverns of this district, from which such vast stores of remains have been obtained, at Banwell, Bleadon, Durdham Down, Uphill, Hutton, Sandford Hill, Burrington, and especially Wookey Hole, does not prove that they have no relation to the river bed of Freshford. The Bison, Mammoth, Reindeer, or Horse, associated with the Musk Sheep, have been found in all those caverns, and therefore I think it very probable that they were open while the latter animal was ranging on the banks of the Avon, and that its rarity was the cause of its not having been yet discovered in the caves.

§ 3. *Remains found at Barnwood.*—A fourth case of the discovery of this rare animal in Britain is afforded by the basal portion of a skull obtained from the gravel of Barnwood, near Gloucester, by Mr. Lucy,[1] to whose admirable essay on the gravels of the Severn I would refer for an account of the section. The squareness of the area included between the anterior and posterior impressions for the attachment of the cervical muscles (Pl. I, fig. *c*, *d*) show at once that the animal to which it belonged was ovine or caprine, and its large size that it belonged to *Ovibos moschatus.* It measures 1·45 inches from the anterior to the posterior cervical impression, 3·2 across the posterior, and 2·45 across the anterior cervical impression. Among the other remains found in the same place I was able to identify those of the Mammoth and the Woolly Rhinoceros. Nor were these the only animals with which the Musk Sheep dwelt in the district; other gravel beds of the same geological age at Eckington, Cropthorne, Pershore, Stroud, Beckford, Fladbury, Worcester, Upton, and Tull Court, have furnished the following species:

Hippopotamus major . . .	*Cervus elaphus.*
Elephas antiquus . . .	„ *tarandus.*
Bos primigenius . . .	*Equus caballus.*
Bison priscus . . .	*Sus scrofa ferus.*

§ 4. *Remains found at Salisbury.*—The fifth discovery of the Ovibos in Great Britain, we owe to the labours of Dr. Blackmore, of Salisbury. Among the mammalian remains from the low-level gravels of Fisherton, he detected a nasal bone, a tibia, and an astragalus, which belonged to this arctic mammal.[2] They were associated with the remains of the following animals:

[1] 'The Gravels of the Severn, Avon, and Evenlode,' by W. C. Lucy, Cotteswold Club, Gloucester, April 7, 1869, p. 18.

[2] Stevens, 'Flint Chips,' 8vo, 1870, p. 16 and p. 30.

Felis spelæa.	*Elephas primigenius.*
Hyæna spelæa.	*Equus caballus.*
Canis lupus.	*Rhinoceros tichorhinus.*
Bison priscus.	*Sus crofa.*
Bos primigenius.	*Spermophilus.*
Cervus elaphus.	*Lemmus.*
,, *tarandus.*	*Lepus timidus.*

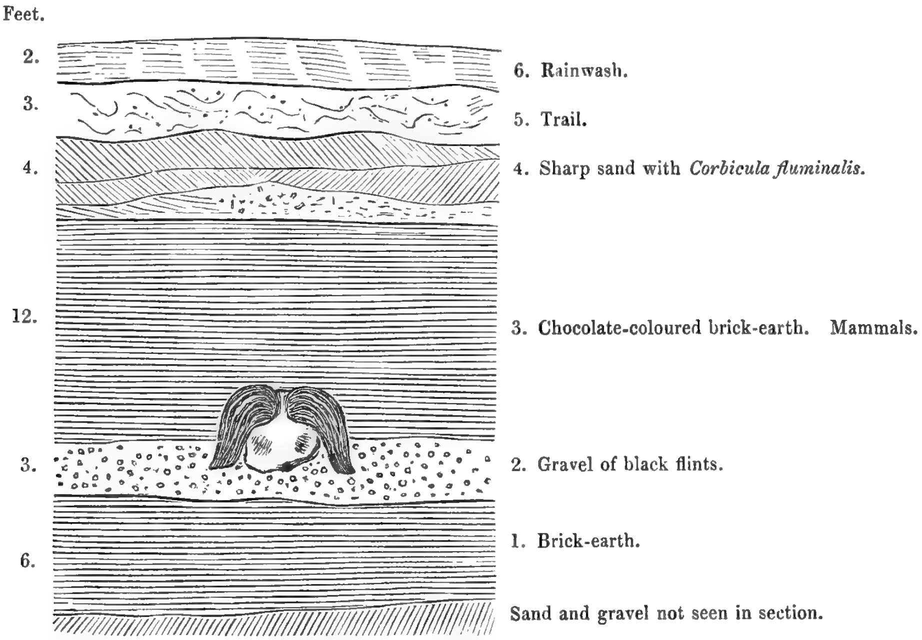
There were also in the same deposit many land and fresh-water shells, all of which still live in the neighbourhood, except *Succinea oblonga.*[1]

§ 5. *Remains found at Crayford.*—All the foregoing instances of the occurrence of Ovibos in the South of England prove that the animal lived there during a comparatively modern period, speaking in a geological sense. The beds from which they were derived are in several cases but a few feet above the level of the streams, and the associated animals are of species which are known to have existed during a late division of the Pleistocene period. That the animal dates back from a higher antiquity in Britain, at least, is proved by my discovery of a remarkably fine head in the lower brick-earths of the Thames Valley,[1] at Crayford in Kent. In November, 1866, I visited the pit in company with Mr. Flaxman Spurrell, and was fortunate enough to find, and convey safely to the Museum of the Geological Survey in London, the cranium of a fine Bull, with its two horn-cores absolutely perfect. The whole of the facial portion, including the maxillary and palatines, is wanting; the mastoids, paramastoids, and lambdoid crest, are also broken. As we dug it out of the matrix the fragmentary condition cannot be ascribed to the carelessness of the workmen. In its present state, however, it is more perfect than any other found in Britain, and enough is left to put its determination beyond all doubt. The basioccipital bone (Pl. I, fig. 1) is remarkable for the stoutness of the muscular impressions, and for the squareness of the area which they define. The anterior pair (*c*) are long and narrow, and advance obliquely forwards until a small groove in the median line prevents them from meeting. The suture between the basi- and presphenoidal suture is well marked, and the presphenoid itself is overlapped by a fragment of the former. Enough of the pterygoid remains to demonstrate its ovine affinities in the wide angle it makes with the basi- and presphenoid. The height of the foramen magnum (Pl. II *a*, 1·22), is the same as its breadth. On the occiput the nuchal space is well seen, and the two impressions for the cervical muscles are very deep. The occipital ridge above them is broken away. The occipito-parietal suture is very well shown on the coronal surface. The spongy bases of the horncores do not extend as far back as the occiput, and are separated from one another in the middle by an interspace of 0·65 inches. The horncores

[1] 'Quart. Journ.,' vol. xx, p. 192; also Stevens, 'Flint Chips,' 8vo, 1870, p. 30.

themselves agree exactly with those of the recent animal, and their description therefore would be superfluous. At a distance of 1·8 inches from the horncores a ridge runs across the frontals, from the roof of one orbit to the other, and is much more pronounced than in any of the skulls of the existing Musk Sheep. A reference to the Table of skull measure-

Section. North side of Stoneham's Pit, Crayford, with skull of Ovibos moschatus.



$\frac{1}{10}$th inch to 1 foot.

ments will show (p. 12) that this skull surpasses in size any of those which are recorded of the living or fossil animal. The exact position in which it was found is shown in the preceding section, taken on the north side of an old working, and not very far from the Manager's Office.

This section agrees essentially with that taken at some distance off, and published in my paper on the Lower Brick-earths of the Thames Valley.[1] No. 3, which furnished the head, is the principal mammaliferous bed in the pit. The lists of mammalia and shells obtained out of the same pit, and preserved in the collections of Mr. Grantham and Dr. Spurrell, are reproduced, because of their peculiar value in relation to the presence of the Musk Sheep.

[1] 'Quart. Journ. Geol. Soc.,' vol. xxiii, p. 96.

Freshwater Species.

Corbicula fluminalis.
Cyclas cornea, L.
Pisidium amnicum, Müll.
Unio litoralis, Drap.
Anodon cygneus, Mont.
Limnæa peregra, Lam.
„ *stagnalis*, L.
Planorbis carinatus, Müll.
„ *corneus*, Drap.
Paludina vivipara, Gray.
„ *tentaculata*, Lin.
Ancylus fluviatilis, Möle.
Valvata piscinalis, Müll.

Terrestrial Species.

Helix nemoralis, Müll.
„ *caperata*, Mont.
Pupa marginata, Drap.
Carychium minimum, Müll.

Fossil Mammalia.

Homo.[1]

Felis spelæa, Gold.
Hyæna spelæa „
Ursus ferox, Linn.
„ *arctos* „
Canis lupus „
Bos primigenius, Boj.
Bison priscus, Ow.
Megaceros Hibernicus, Ow.
Cervus elaphus, Linn.
Elephas antiquus, Falc.
„ *primigenius*, Blum.
Equus fossilis, Ow.
Rhinoceros tichorinus, Cuv.
„ *hemitœchus*, Falc.
„ *megarhinus*, Christ.
Arvicola amphibia, Desm.

Thus, in addition to the ordinary freshwater and land shells, and the ordinary Pleistocene Mammalia, the Musk Sheep in these beds is associated with *Rhinoceros hemitœchus*, *R. megarhinus*, and *E. antiquus*. In my essay before alluded to, I have shown that the group of deposits to which these strata belong is of an age intermediate between the preglacial forest-bed of the Norfolk shore, and the river deposits, which are later than the Boulder-clay in the centre and east of England. Basing my argument on the physical evidence, and on the presence of Pleiocene forms of life, and on the absence of the whole group of arctic mammals, and especially of the Reindeer, which is most abundant in the ordinary Pleistocene river gravels, I came to the conclusion, that the climate under which the lower Brick-earths of the Thames Valley was accumulated was temperate rather than severe. Nor is this conclusion invalidated by the subsequent discovery of the most

[1] Since this was written the Rev. O. Fisher discovered an unmistakably artificial flint flate in the undisturbed section, in the presence of the Author, April 9, 1872.

arctic of known living mammalia, the Musk Sheep, since the evidence which it offers must be weighed against that offered by the other mammalia. And among these, that of the Mammoth and Woolly Rhinoceros must be put out of court, because the first possessed a sufficiently elastic constitution to endure the severity of a Siberian climate, and to flourish alike in Italy and in the southern states; and it is very probable, from the wide range of the latter, that it had similar capacities of enduring climatal extremes. Either the Musk Sheep must have wandered into the temperate regions at the time, or the associated animals must have been fitted to endure the severity of a climate in which the Musk Sheep now lives. The former alternative seems to me to be far more likely to be true than the latter. I should be inclined to consider that the skull in question belonged to an animal that had strayed from its usual arctic haunts in the winter, southwards into the country more usually occupied by the animals with which it was found, and this view is considerably strengthened by an appeal to like cases of migration at the present day.

In North America, for example, the Bison ranged, in Hearne's time, over the open rushy plains as far to the north and east as the southern shore of Athabasca Lake in lat. 59°, while on the colder shores of Hudson's Bay, a little to the north of Fort Churchill in the same latitude, that explorer found proofs of the presence of Musk Sheep. In an unusually severe winter there would be nothing extraordinary in the latter animal occasionally straying south of Athabasca Lake, and its bones being mingled with those of the Elk, Waipiti, and Bison. I should therefore view this isolated case of the occurrence of the most arctic of all the ruminants on the banks of the Thames, during the time of the deposits of the Lower Brick-earths, as altogether exceptional, and not affecting the sum of the evidence as to climate afforded by *Rhinoceros megarhinus*, *R. hemitœchus*, *Cervus elaphus*, *C. capreolus*, *Elephas antiquus*, *Hippopotamus major*, and indeed all the other mammalia of the group found at Ilford, Gray's Thurrock, or Erith.

§ 6. *The Age of the Deposit at Crayford.*—The relation of the lower Brick-earths to the Glacial period, under which name are comprehended the complex phenomena offered by—1, the development of an ice sheet like that of Greenland; 2, the submergence of the land beneath the sea; 3, the glacier period, is one of those difficult and delicate questions which cannot be solved definitely in the present state of our knowledge. There are, however, two considerations which are of considerable value in coming to any conclusion whatever. In the first place we know, that the mammalia inhabiting the English side of the great valley of the North Sea in Pleiocene times, lived under a temperate climate; and it is only reasonable to suppose that, as the temperature became lowered in the northern regions, the northern animals would gradually pass southwards, and occupy the feeding grounds, which had been before those of the animals inhabiting the temperate zone. This must have taken place at the very beginning of the Glacial period in Great Britain, for the lowering of the temperature which dispossessed them of their ancient feeding grounds in Northern Europe and Asia, gradually passed southwards, until at last it reached its maximum, at the time when Scandinavia, Great Britain, and Ireland, lay buried under an enormous ice-sheet. The mixed character of the mammalia of the Lower Brick-earths is just what might have been expected from any such migration as this. The remains of the Pleistocene species, the Mammoth, Woolly Rhinoceros, and Cave Lion, are quite as abundant as those of the Pleiocene *R. hemitœchus*, *R. megarhinus*, and *Elephas antiquus*, and prove that the former animals were in joint occupation of the region at the time, and that the Pleiocene animals were still in competition with the new comers in the district; and that the latter should have been followed in the course of time by a stray Musk Sheep is not at all to be wondered at. On this view, the Lower Brick-earths of the Thames Valley may be ascribed, with tolerable certainty, to the age when the temperature was gradually becoming lowered, towards the beginning of the Glacial period, rather than to that during which vast herds of Reindeer lived on the site of London, and at Windsor, while the gravels were being accumulated, which are proved by the foreign pebbles, which they contain, to be posterior in date to the submergence of central and northern Britain beneath the waves of the sea. During this later period the evidence is conclusive, that the arctic division of the Pleistocene mammalia,—the Reindeer, Glutton, Musk Sheep, Marmot, and Spermophilus, had firm hold on the country, and the Reindeer ranged over the whole of Great Britain, which was free from glaciers, only comparable in number to the great migratory bands now living in northern Siberia. Had the Lower Brick-earths of the Thames Valley been deposited at this time, the Reindeer could hardly have failed to have been represented in the large collections of mammalia from Ilford, Crayford, Erith, and Grays Thurrock, since it is so abundant in the river deposits higher up the valley of the Thames. They must therefore be earlier or later in geological age; and from the facts which I have brought forward, it seems to me that they must be earlier, or before the maximum amount of cold was reached in the Glacial period in Great Britain.

This view of the high antiquity of the Lower Brick-earths in the Thames Valley, is not held by the great authority on river deposits, Mr. Prestwich,[1] who believes, because of their slight elevation above the present level of the Thames, they must belong to a late division of the Post-pleiocene, or Pleistocene age. There seem to me, however, to be insuperable objections to the view that, in every case, the level will give the relative age of the deposit. It is certain that, if all the superficial deposits in a given valley, say the valley of the Thames, had been left by the ancient representatives of the present rivers, at different levels above their present courses, those levels will give the relative antiquity of the beds of sand or gravel in question, *provided that the land has remained stationary.* The extent to which the valley is cut down will give a rough sort of idea of the lapse of past time. But if the land were elevated in one place, and depressed in another, as we are

[1] Prestwich, 'Geol. Mag.,' vol. i, p. 245.

bound to admit to be the case throughout all past time, then the evidence of relative levels is not decisive. What are now low-level deposits, may, in some cases, be of the same antiquity as those at higher levels, owing to movements in the earth's crust since they were deposited. Or again, if we suppose a valley with a river flowing through it, to be depressed beneath the surface of the sea, the higher marine may yet be younger than the lower fluviatile deposit, as in the case of the forest-bed on the Norfolk shore, on which rest marine sands and gravels, and boulder clay, which have been deposited after its submergence. Unless, therefore, in any particular case, there be no oscillations of level, and unless there can be no interference by the sea with the cutting-down action of the river, relative height is no standard of age. No proof of either of these conditions, necessary to the truth of Mr. Prestwich's view, is to be found in the lower part of the Thames Valley. On the contrary, since during the glacial epoch Scotland,[1] according to Sir Charles Lyell, was depressed to a depth of two thousand feet beneath the sea, and the hills of Wales to a still greater depth according to Professor Ramsay,[2] it seems to be incredible that the Thames Valley should not have shared, in some degree, in this depression. Whether or not the true boulder clay was ever deposited in the Thames Valley proper, is an open question; but the fact that it occupies the basin of the Roding, the affluent to the Thames, as well as those of the two rivers immediately to the north, the Blackwater and the Colne, proves that the main features of the country were sketched out before the boulder clay age, and that it also was excavated in Preglacial times. It appears therefore to me that, in this case, the evidence offered by the low-lying position of the strata is valueless as compared with that offered by the mammalia in favour of the high antiquity. Were the test of level to be applied to the forest-bed, it might be shown likewise to be of late Pleistocene age, had it not been for the accident of the boulder clay being above. And if this had been denuded away, we should merely have had the mammalia to show the true geological age of the deposit in which they were found.

§ 7. *The Range in Space and Time of Ovibos Moschatus.*—We have now quoted all the localities on record in which the remains of fossil *Ovibos* have been found. During the Pleistocene age, it ranged over northern Siberia and the plains of Germany and France, occurring very generally in the river deposits along with Reindeer, Mammoth, and Woolly Rhinoceros. In England four out of five cases of its occurrence are in ordinary Pleistocene gravels, while the fifth relegates it to a more ancient date, in which Pleiocene mammalia lived, side by side, in the valley of the Thames, with those that are characteristic of the Pleistocene period. That the animal was very rare in the Postglacial deposits in Europe is proved by its having been found in only ten places. In Siberia, although only three instances are on record of its having been found, it is probably abun-

[1] Lyell, 'Antiquity of Man.'

[2] Ramsay, 'Quart. Geol. Journ.,' 1851, p. 372.

dant in the vast unexplored stores of remains in the frozen gravel of the Tundras, and especially at Sviatoi Ness. Its rarity would imply that its head-quarters were in some district to the north and east of France and Germany in the Pleistocene period, and that it only inhabited the districts in which it is found in an unusually severe season, which would drive it from its usual haunts. We have thus traced the *Ovibos moschatus* far to the east and south of its present habitat. It coexisted with the Mammoth and the Reindeer in Eschscholtz Bay, and with that animal and the Tichorhine Rhinoceros it ranged throughout Siberia, Germany, and as far south as the valley of the Avon in Somersetshire and Périgord in France, or more than 15° south of its present southern limit in America.

CHAPTER V.

Conclusion.

§ 1. *Comparison between Ovibos and Bootherium.* | § 2. *General Conclusions.*

§ 1. *Comparison between Ovibos and Bootherium.*—The researches of Dr. Leidy[1] have proved the existence in America of a fossil animal, which he recognises as intermediate in character between *Ovis* and *Bos*, and for which, in 1852, he proposed the name of *Bootherium* (Pl. V, figs. 2, 3, 4). In his magnificent work, however, on the 'Mammalian Remains of North America,' published in 1869,[2] he admits that the fossils probably belong to the genus *Ovibos*, a conclusion which I brought before the Royal Society in 1867, and printed in abstract in the 'Proceedings' (vol. xv, p. 516). The type of his genus consists of two crania, the one from ferruginous gravel near Fort Gibson on the river Arkansas, the other from the morasses of Big Bonelick. The former of these, from the admirable figures and description, clearly possesses all the characters of male *Ovibos*, with this exception, that the bases of the horncores coalesce in the median line, and advance further forward than a line connecting the anterior edges of the orbits together, and thus almost completely covering both frontals and parietals. The horncores springing from this elongated bone, at a distance of four inches behind the anterior portion, are flattened on the top, as in male *Ovibos*, but their antero-posterior diameter is not so great, nor is the downward direction so decided. From the analogous case of the horn-development in *Ovibos*, I should infer that this cranium belonged to an old male. From the flatness and excavation of the horncores Dr. Leidy terms it *Bootherium cavifrons* (Pl. V, fig. 2). The second skull (fig. 3), which is the more perfect of the two in respect of its horncores, bears exactly the same relation to that of *B. cavifrons*, as the male to the female Musk Sheep. They are more cylindrical, smaller, and supported by the frontals. It is therefore highly probable that *B. cavifrons* and *B. bombifrons* are the male and female of the same species. As the lachrymal region is preserved in the second, there is evidence of a broad and deep lachrymal fossa in front of the orbit, which in its depth resembles that presented by

[1] Leidy, 'Smithsonian Contrib. to Knowledge,' vol. v, art. 3, "On the Extinct Species of American Ox," 1852.

[2] 'Journal of the Academy of Natural Sciences of Philadelphia,' 2nd series, vol. vii, 1869, p. 374.

Caprovis Vignei, or the *Argali* of Ladak (Coll. Surg. 3778). It is, however, also paralleled by that in a skull of an old male *Ovibos* in the College of Surgeons (3814). The direction of its horncores is downwards and forwards. In all other respects both these skulls so closely resemble *Ovibos moschatus*, that were it not for the points noted above, I should believe that they belonged to that animal. Beyond all doubt they represent a closely allied species of the same genus *Ovibos*.

§ 2. *General Conclusions.*—In this Essay I have brought forward the evidence in favour of the following conclusions: first, that *Ovibos* was rightly classified by De Blainville with the *Ovidæ*, and not with the *Bovidæ;* secondly, that it has no classificatory relationship with *Bubalus Caffer*, as Professor Owen maintains, both in his original article and in the 'Anatomy of the Vertebrates.' And lastly, that it has a greater range in time than was suspected, having been a contemporary with the Megarhine Rhinoceros during the early portion of the Pleistocene period, when the Lower Brick-earths were being deposited in the valley of the Thames.

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Ovibos moschatus, Blainville.

FIG.

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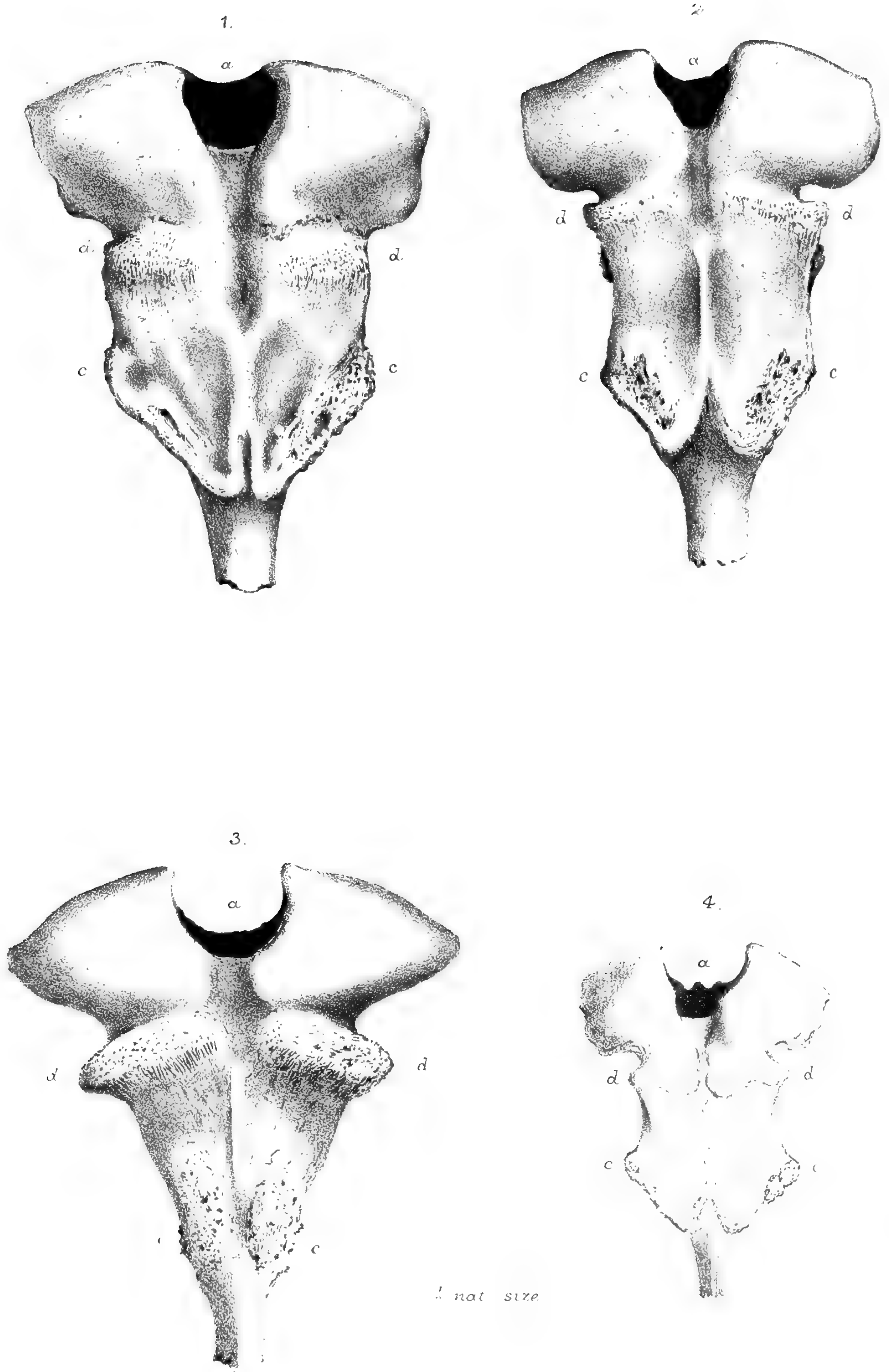
2. Basi-occipital of *Ovibos moschatus*, North America. British Museum.
3. Basi-occipital *Bubalus caffer*. British Museum.
4. Basi-occipital of *Argali*, *Caprovis Argali* of Ladak. British Museum.



G R De Wilde del

W West & Co imp

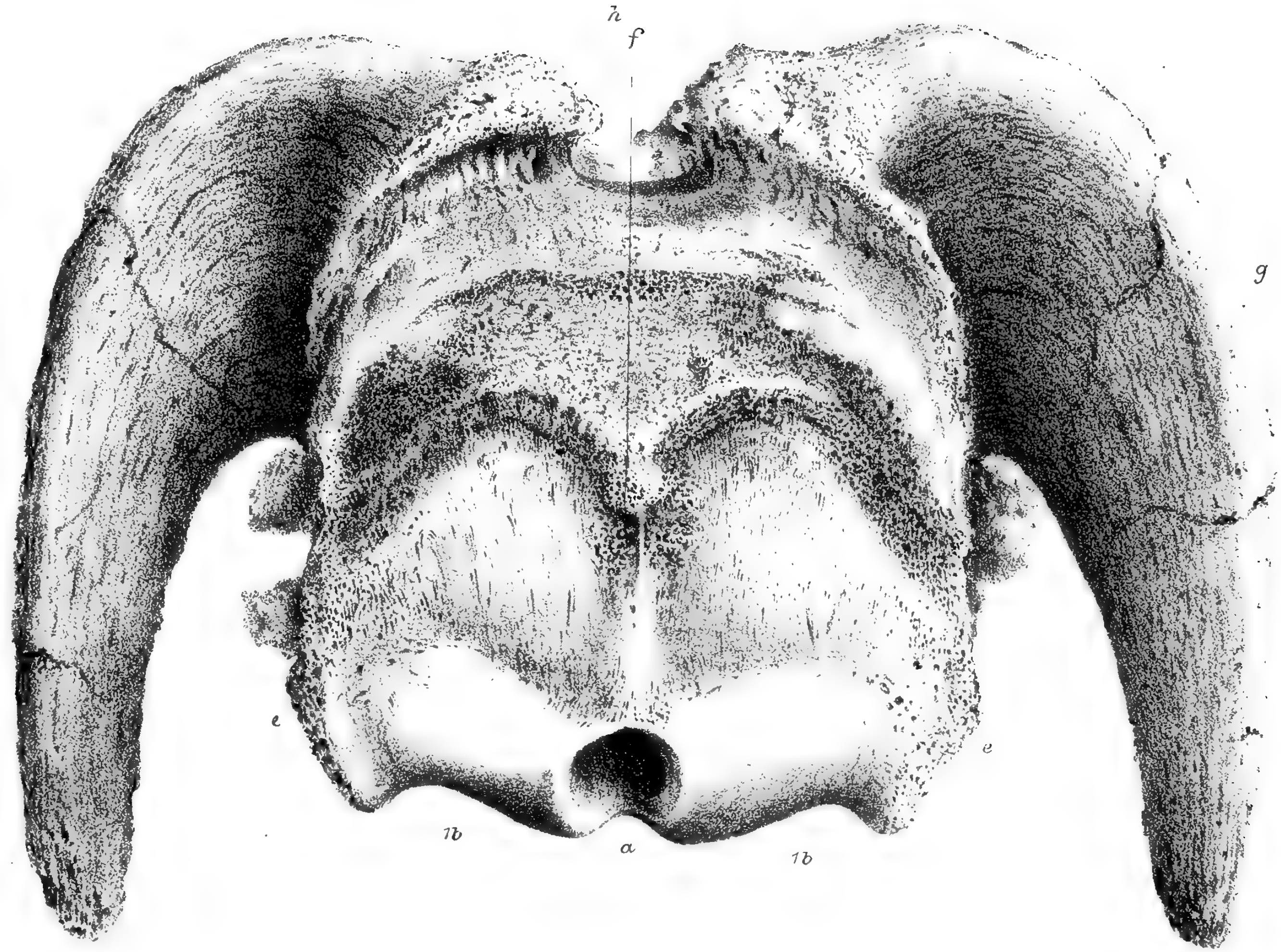
1. 2 BASIOCCIPITAL OF OVIBOS 3 BUBALUS CAFFER
4 CAPROVIS ARGALI

PLATE II.

Ovibos moschatus, Blainville.

Occipital view of skull from the Lower Brickearths, Crayford, Kent. In the Museum of the Geological Survey.

a. Foramen magnum.
b. Condyles.
e. Paramastoid process.
f. Nuchal spine.
g. Horncore.
h. Coronal interspace.



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OCCIPITAL VIEW OF SKULL OF OVIBOS MOSCHATUS.

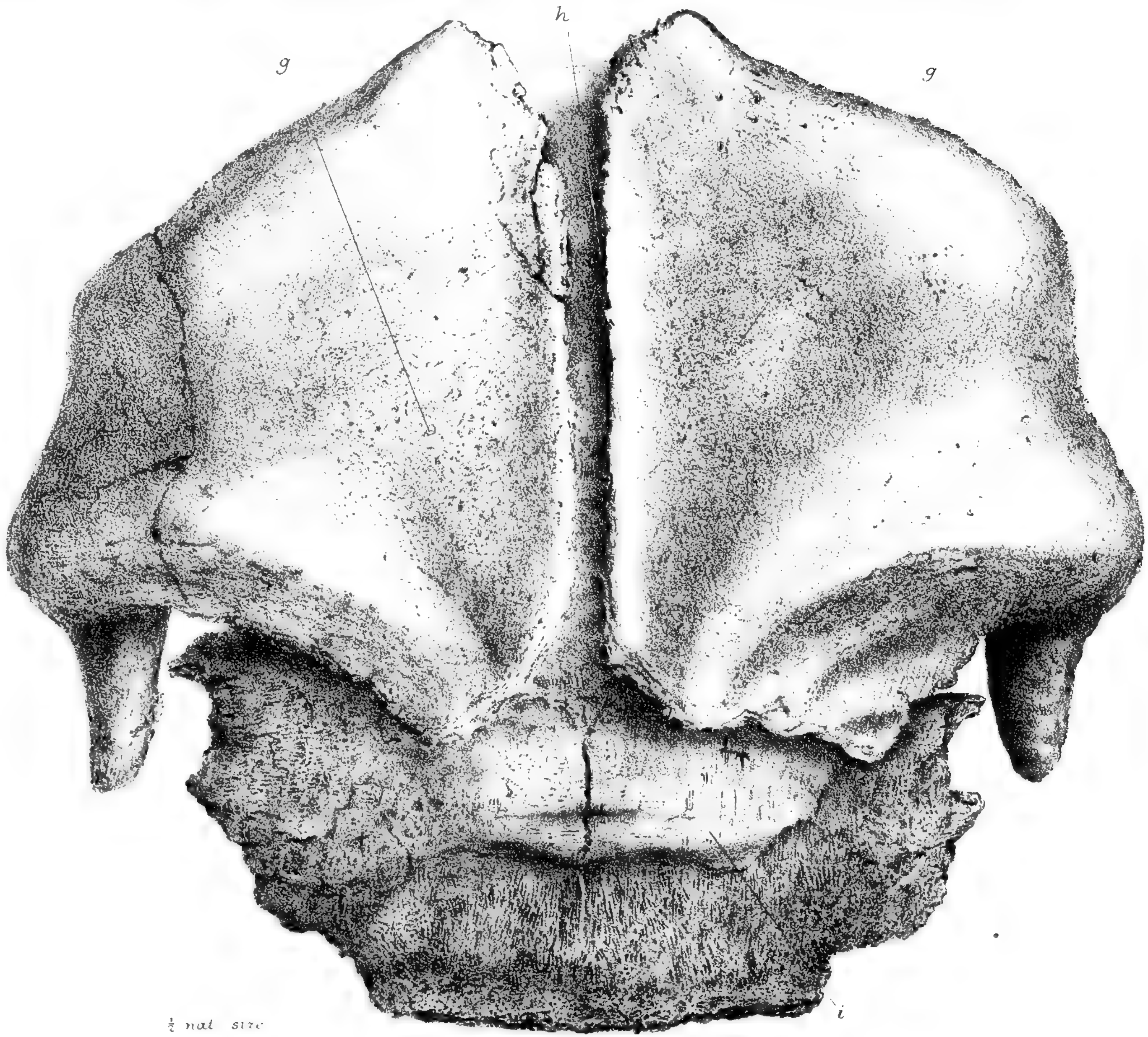
W West & Cº imp

PLATE III.

Ovibos moschatus, Blainville.

Coronal view of skull, from the Lower Brickearths, Crayford, Kent. In the Museum of the Geological Survey, figured Pl. II; and Pl. IV.

g. Horncores.
h. Coronal interspace.
i. Transverse ridge on frontals.



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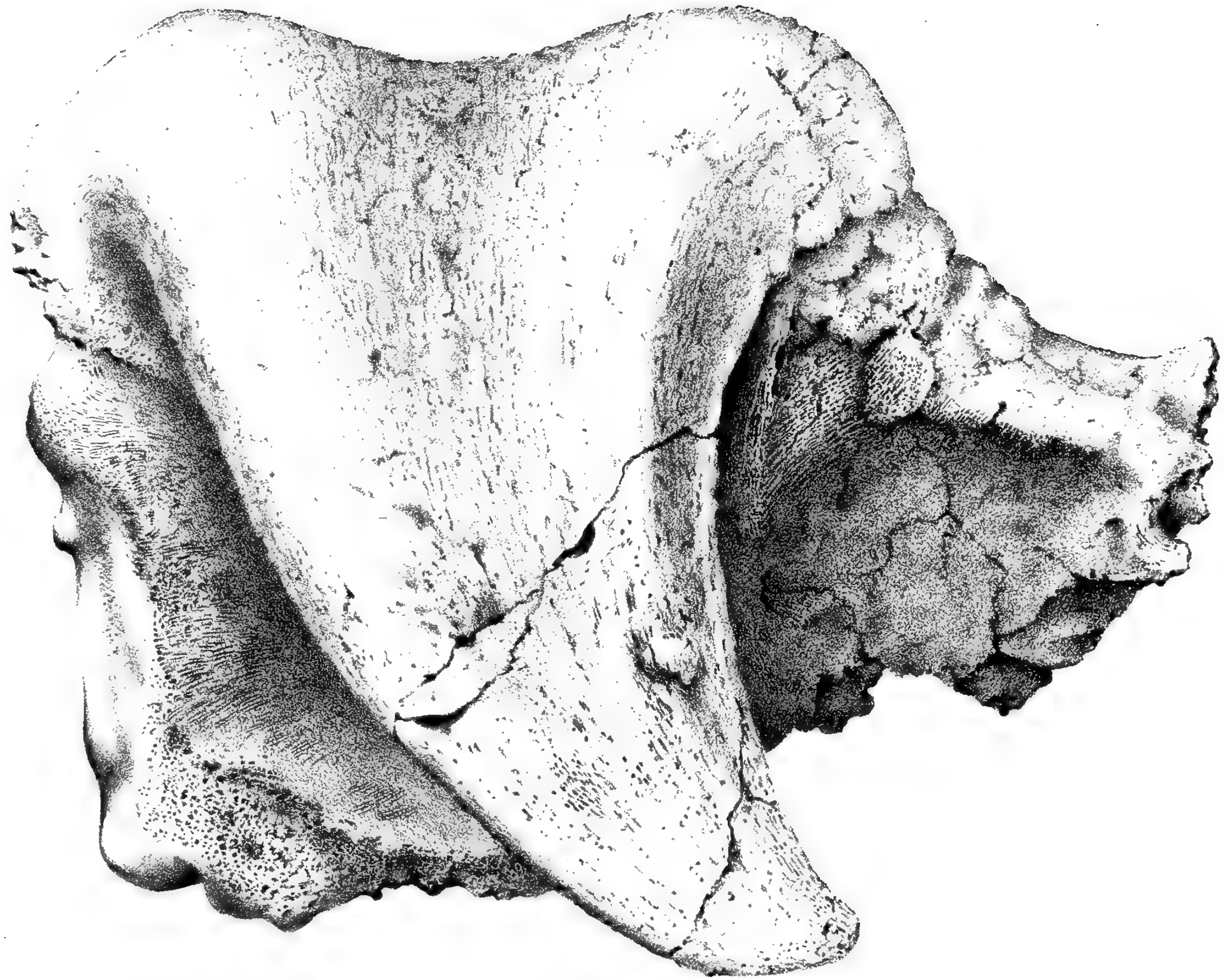
CORONAL ASPECT OF SKULL OF OVIBOS MOSCHATUS.

PLATE IV.

Ovibos moschatus, Blainville.

Lateral view of skull, from the Lower Brickearths, Crayford, Kent. In the Museum of the Geological Survey, figured Pls. II, III.



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SIDE VIEW OF OVIBOS MOSCHATUS

W West & Co imp

PLATE V.

Ovibos.

Fig.

1. Coronal view of skull of female Musk Sheep, *Ovibos moschatus*, from the Pleistocene gravel of Freshford, near Bath, Somerset. In the Collection of Charles Moore, Esq., F.G.S.

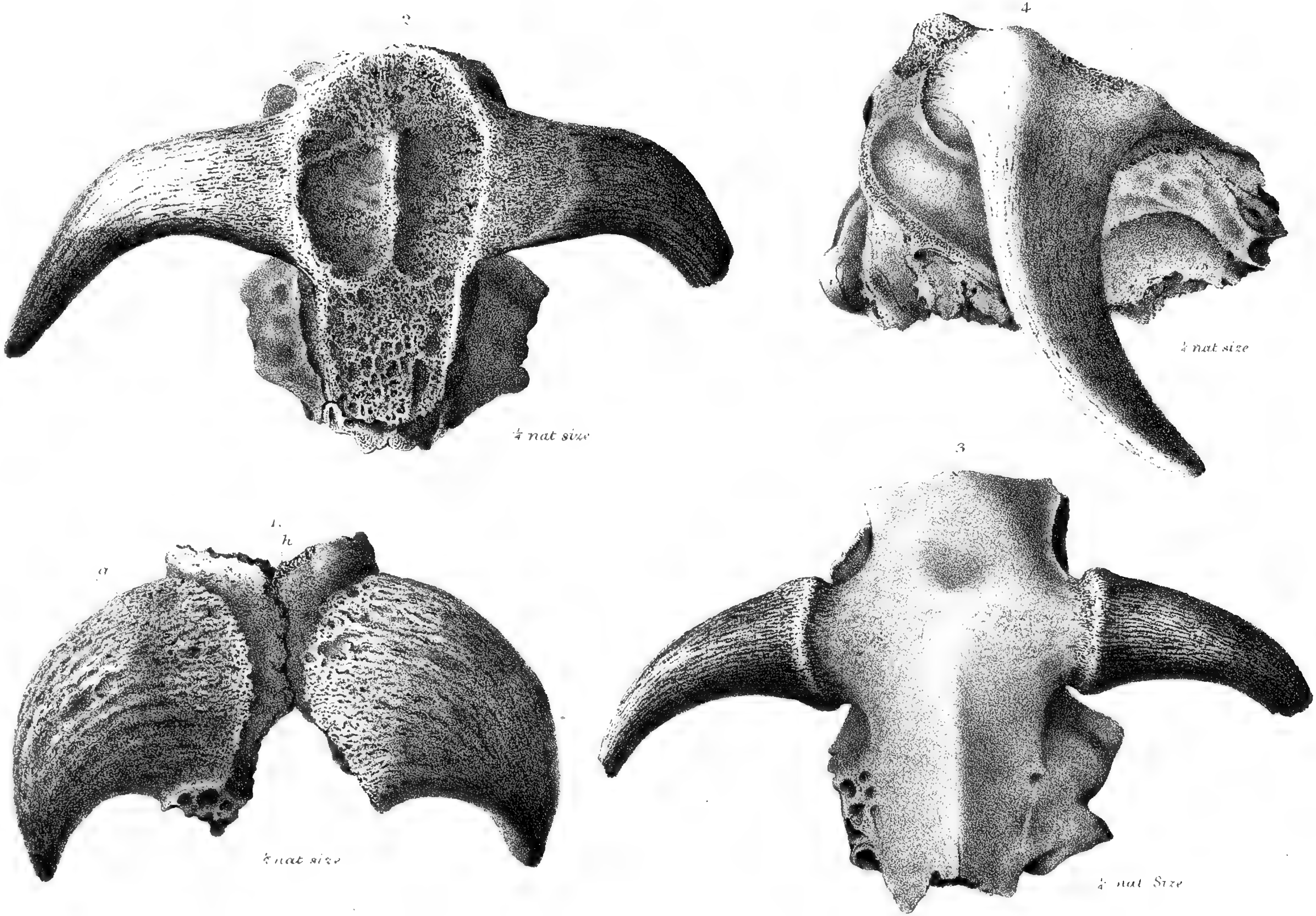
   g. Horncore.

   h. Coronal interspace.

2. Coronal view of skull of *Ovibos cavifrons*, Leidy; old male, from gravel near Fort Gibson, Arkansas. After Leidy, 'Smithsonian Contributions,' September, 1852, pl. iii, fig. 1.

3. Coronal view of skull of *Ovibos cavifrons, Bootherium bombifrons*, Leidy; adult female, from Big-bone Lick. After Leidy, op. cit., pl. iv, fig. 2.

4. Lateral view of skull of *Ovibos cavifrons;* adult female, from Big-bone Lick. After Leidy, op. cit., pl. iv, fig. 1.



J. Dinkel lith. W West & Co. imp

1. OVIBOS MOSCHATUS. 2. OVIBOS CAVIFRONS, MALE.

3 _ 4. OVIBOS CAVIFRONS, FEMALE.