PALÆONTOGRAPHICAL SOCIETY.

VOL. XXXI.

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

III. THE DATES OF ISSUE OF THE ANNUAL VOLUMES;

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

V. A STRATIGRAPHICAL LIST OF THE BRITISH FOSSILS FIGURED AND DESCRIBED IN THE YEARLY VOLUMES.

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CATALOGUE OF WORKS—Continued.

Vol. XVI.	Issued for the Year 1862	The Fossil Echinodermata, Cretaceous, Vol. I, Part I, by Dr. Wright, 11 plates. The Trilobites of the Silurian, Devonian, &c., Formations, Part I, by Mr. J. W. Salter, 6 plates. The Fossil Brachiopoda, Part VI, No. 1, Devonian, by Mr. Davidson, 9 plates. The Eocene Mollusca, Part IV, No. 2, Bivalves, by Mr. S. V. Wood, 7 plates. The Reptilia of the Cretaceous and Wealden Formations (Supplements), by Prof. Owen, 10 plates.
„ XVII.	„ 1863	The Trilobites of the Silurian, Devonian, &c., Formations, Part II, by Mr. J. W. Salter, 8 plates. The Fossil Brachiopoda, Part VI, No. 2, Devonian, by Mr. Davidson, 11 plates. The Belemnitidæ, Part I, Introduction, by Prof. Phillips. The Reptilia of the Liassic Formations, Part I, by Prof. Owen, 16 plates.
„ 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.
„ XXII.*	„ 1868	Supplement to the Fossil Corals, Part II, No. 1, Cretaceous, by Dr. Duncan, 9 plates. The Fossil Merostomata, Part II, Pterygotus, by Mr. H. Woodward, 6 plates. The Fossil Brachiopoda, Part VII, No. 3, Silurian, by Mr. Davidson, 15 plates. The Belemnitidæ, Part IV, Liassic and Oolitic Belemnites, by Prof. Phillips, 7 plates. The Reptilia of the Kimmeridge Clay, No. 3, by Prof. Owen, 4 plates. The Pleistocene Mammalia, Part III, Felis spelæa, 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.

* 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. XXIV.*	Issued for the Year 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 Prof. 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.
,, XXVI*	,, 1872	Supplement to the Fossil Corals, Part III (Oolitic), by Prof. Duncan, with an Index to the Tertiary and Secondary Species, 7 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part V, by Dr. Wright, 5 plates. The Fossil Merostomata, Part IV (Stylonurus, Eurypterus, Hemiaspis), by Mr. H. Woodward, 10 plates. The Fossil Trigoniæ, No. I, by Dr. Lycett, 9 plates.
,, XXVII*	,, 1873	The Fossil Echinodermata, Cretaceous, Vol I, Part VI, by Dr. Wright, 8 plates. Supplement to the Fossil Brachiopoda, Part I (Tertiary and Cretaceous), by Mr. Davidson, 8 plates. Supplement to the Crag Mollusca, Part II (Bivalves), by Mr. S. V. Wood, 5 plates. Supplement to the Reptilia of the Wealden (Iguanodon), No. V, by Prof. Owen, 2 plates. Supplement to the Reptilia of the Wealden (Hylæochampsa) No. VI, by Prof. Owen. The Fossil Reptilia of the Mesozoic Formations, Part I, by Prof. Owen, 2 plates.
,, XXVIII*	,, 1874	The Post-Tertiary Entomostraca, by Mr. G. S. Brady, Rev. H. W. Crosskey, and Mr. D. Robertson, 16 plates. The Carboniferous Entomostraca, Part I (Cypridinadæ), by Prof. T. Rupert Jones and Messrs. J. W. Kirkby and G. S. Brady, 5 plates. The Fossil Trigoniæ No. II, by Dr. Lycett, 10 plates.
,, XXIX*	,, 1875	The Flora of the Carboniferous Strata, Part IV, by Mr. E. W. Binney, 6 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part VII, by Dr. Wright, 10 plates. The Fossil Trigoniæ, No. III, by Dr. Lycett, 8 plates. The Fossil Reptilia of the Mesozoic Formations, Part II, by Prof. Owen, 20 plates.
,, XXX.*	,, 1876	The Carboniferous and Permian Foraminifera (the genus Fusulina excepted), by Mr. H. B. Brady, 12 plates. Supplement to the Fossil Brachiopoda, Part II, No. 1 (Jurassic and Triassic), by Mr. Davidson, 8 plates. Supplement to the Reptilia of the Wealden (Poikilopleuron and Chondrosteosaurus), No. VII, by Prof. Owen, 6 plates.
,, XXXI.*	,, 1877	Supplement to the Eocene Mollusca (Bivalves), by Mr. S. V. Wood, 2 plates. The Fossil Trigoniæ, No. IV, by Dr. Lycett, 13 plates. The Eocene Mollusca (Univalves), Part IV, by Mr. S. V. Wood, 1 plate. The Carboniferous Ganoid Fishes, Part I (Palæoniscidæ), by Dr. Traquair, 7 plates. The Fossil Reptilia of the Mesozoic Formations, Part III, by Prof. Owen, 2 plates. The Fossil Elephants (E. antiquus), Part I, by Prof. Leith Adams, 5 plates.

* These Volumes are issued in two forms of binding; first, with all the Monographs stitched together and enclosed in cover; secondly, with each of the Monographs separate, and the whole of the separate parts placed in an envelope.

§ II. LIST OF MONOGRAPHS

Completed, in course of Publication, and in Preparation.

1. MONOGRAPHS which have been COMPLETED, and which may be bound as separate Volumes:—

The Carboniferous and Permian Foraminifera (the genus Fusulina excepted), by Mr. H. B. Brady.
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 Post-Tertiary Entomostraca, by Mr. G. S. Brady, the Rev. H. W. Crosskey, and Mr. D. Robertson.
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 Eocene Bivalves, Vol. I and Supplement, by Mr. S. V. Wood.
The Eocene Cephalopoda and Univalves, Vol. I, by Mr. F. E. Edwards and Mr. S. V. Wood.
The Mollusca of the Crag, by Mr. S. V. Wood.
Supplement to the Crag Mollusca, 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.

2. 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 Carboniferous Entomostraca, by Messrs. T. Rupert Jones, J. W. Kirkby, and G. S. Brady.
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 Fossil Brachiopoda, by Mr. T. Davidson.
The Trigoniæ, by Dr. Lycett.
The Belemnites, by Professor Phillips.†
The Fishes of the Carboniferous Formation, by Prof. Traquair.
The Fishes of the Old Red Sandstone, by Messrs. J. Powrie and E. Ray Lankester, and Professor Traquair.
The Reptilia of the Wealden Formation (Supplements), by Professor Owen.
The Reptilia of the Kimmeridge Clay, by Professor Owen.
The Reptilia of the Liassic Formations, by Professor Owen.
The Reptilia of the Mesozoic Formations, by Professor Owen.
The Fossil Elephants, by Prof. Leith Adams.
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.
† Unfinished through the death of the Author, but will be continued by Mr. R. Etheridge.

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3. MONOGRAPHS which are in course of PREPARATION :‡—

The Eocene Flora, by Mr. J. S. Gardner and Baron Ettinghausen.
The Fossil Cycadeæ, by Mr. W. Carruthers.
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 Sir Wyville Thomson.
The Polyzoa of the Chalk Formation, by Mr. G. Busk.
The Palæozoic Polyzoa, by Dr. Duncan.
The Crinoidea, by Professor Sir Wyville Thomson.
Supplement to the Tertiary and Cretaceous Entomostraca, by Prof. T. Rupert Jones.
The Wealden, Purbeck, and Jurassic Entomostraca, by Messrs. T. Rupert Jones and G. S. Brady.
The Post-Tertiary Mollusca, by Dr. J. Gwyn Jeffreys.
The Cretaceous Mollusca (exclusive of the Brachiopoda), by the Rev. T. Wiltshire.
The Purbeck Mollusca, by Mr. R. Etheridge.
The Inferior Oolite Mollusca, by Mr. R. Etheridge.
The Rhætic Mollusca, by Mr. R. Etheridge.
The Liassic Gasteropoda, by Mr. Ralph Tate.
The Ammonites of the Lias, by Dr. Wright.
The Ganoid Fishes, by Mr. L. C. Miall.

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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.

§ III. 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.
,,	1872	,,	,,		,,	October, 1872.
,,	1873	,,	,,		,,	February, 1874.
,,	1874	,,	,,		,,	July, 1874.
,,	1875	,,	,,		,,	December, 1875.
,,	1876	,,	,,		,,	December, 1876.
,,	1877	,,	,,		,,	February, 1877.

§ IV. SUMMARY OF THE MONOGRAPHS ISSUED TO THE MEMBERS (*up to* FEBRUARY, 1877): *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, 1875	1868, 1871, 1872, 1875	147	24	141	16
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
The Carboniferous and Permian Foraminifera (genus Fusilina excepted), by Mr. H. B. Brady, COMPLETE	1876	1876	166	12	266	62
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 Prof. Duncan, *in course of completion*	1865, 1866, 1867, 1868, 1869, 1872	1866, 1867, 1868, 1869, 1870, 1872	232	49	797	149
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, 1858, 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, 1872, 1873, 1875	1864, 1868, 1870, 1871, 1872, 1874, 1875	264	68	892	82
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, 1872	1866, 1869, 1872, 1872	180	30	249	35
The Post-Tertiary Entomostraca, by Mr. G. S. Brady, Rev. H. W. Crosskey, and Mr. D. Robertson, COMPLETE	1874	1874	237	16	515	134
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 Carboniferous Entomostraca, by Prof. Rupert Jones and Messrs. J. W. Kirkby and G. S. Brady, *in course of completion*	1874	1874	56	5	285	50
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
		CARRIED FORWARD...	4541	617	14,218	2152

SUMMARY OF THE MONOGRAPHS ISSUED TO THE MEMBERS (*up to* FEBRUARY, 1877)—*continued.*

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.
		BROUGHT FORWARD...	4541	617	14,218	2152
Supplement to the Fossil Brachiopoda, by Mr. Davidson, *in course of completion*	1873, 1876	1874, 1876	144	16	650	107
The Trigoniæ, by Dr. Lycett, *in course of completion*	1872, 1874, 1875, 1877	1872, 1874, 1875, 1877	204	40	417	111
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, COMPLETE	1871, 1873	1872, 1874	262	12	360	172
The Eocene Mollusca, Cephalopoda and Univalves, by Mr. F. E. Edwards, continued by Mr. S. V. Wood. Vol. I, COMPLETE	1848, 1852, 1854, 1855, 1858, 1877	1849, 1852, 1855, 1857, 1861, 1877	361	34	625	275
The Eocene Mollusca, Bivalves, by Mr. S. V. Wood. Vol. I, COMPLETE	1859, 1862, 1870	1861, 1864, 1871	182	25	531	194
Supplement to the Eocene Mollusca, by Mr. S. V. Wood (Bivalves). Vol. I, COMPLETE	1877	1877	24	2	66	30
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 Carboniferous Formation, by Dr. Traquair, *in course of completion*	1877	1877	60	7	58	5
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	1853, 1855, 1857, 1858, 1859, 1861, 1864	155	62	251	17
The Reptilia of the Wealden Formations (Supplements) *in course of completion*	1871, 1873, 1876	1872, 1874, 1876	47	11	72	5
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 Reptilia of the Mesozoic Formations, by Prof. Owen, *in course of completion*	1873, 1875, 1877	1874, 1875, 1877	97	24	165	17
The Crag Cetacea, by Prof. Owen, *in course of completion*	1869	1870	40	5	43	7
The Fossil Elephants, by Prof. Leith Adams, *in course of completion*	1877	1877	68	5	18	1
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 Mammalia of the Mesozoic Formations, by Prof. Owen, COMPLETE	1870	1871	115	4	247	30
		TOTAL	8552	1259	23,096	4623

a Index. *b* Title-page to Univalves. *c* Note to Crag Mollusca. *d* Contains the Permian. *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.'

§ V. Stratigraphical Table *exhibiting the* British Fossils *already figured and described in the* Annual Volumes (1847—1877) *of the* Palæontographical Society.

	PLANTS.	PROTOZOA.		RADIATA.		ARTICULATA.					
		Sponges.	Foraminifera.	Corals.	Echinodermata.	Cirripedes.	Cypridæ, Cytherinæ, &c.	Estheriæ.	Merostomata.	Trilobites.	Malacostracous Crustacea.
Pleistocene	...	...	...	...	......	......	1874				
Crag	...	...	1865	1849	1852	1851, 1854					
Eocene	...	...	...	1849, 1865	1852	1851, 1854	1855	...	......	......	1856
Cretaceous.........	...	...	...	1849, 1868, 1869	1862, 1867, 1869, 1870, 1872, 1873, 1875	1851, 1854	1849	...	......	......	1860
Wealden	...	...	...	...	......	......	...	1860			
Oolitic	...	...	...	1851, 1872	1855, 1856, 1857, 1858, 1861	1851	...	1860			
Liassic	...	...	...	1851, 1866, 1867	1855, 1856, 1858, 1861, 1864						
Triassic	...	...	...	...	......	......	...	1860			
Permian	1849	1849	1849, 1876	1849, 1852	1849	......	1849	1860			
Carboniferous...	1867, 1870, 1871, 1875	...	1876	1852	......	......	1874	1860	1872		
Devonian	...	...	...	1853	......	......	...	1860	1865, 1868, 1872	1862	
Silurian............	...	...	...	1854	......	......	...	...	1868, 1871, 1872	1862, 1863, 1864, 1866	
Cambrian	...	...	...	...	......	......	...	...	......	1864	

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

STRATIGRAPHICAL TABLE *exhibiting the* BRITISH FOSSILS *already figured and described in the* ANNUAL VOLUMES (1847—1877) *of the* PALÆONTOGRAPHICAL SOCIETY (*continued*).

	MOLLUSCA.				VERTEBRATA.		
	Polyzoa.	Brachiopoda.	Monomyaria, Dimyaria, and Gasteropoda.	Cephalopoda.	Fishes.	Reptiles.	Mammalia.
Pleistocene	...	1873	......		...	......	1864, 1867, 1868, 1871, 1877
Crag	1857	1852, 1873	1847, 1850, 1853, 1855, 1871, 1873	...	...	......	1869
Eocene	...	1852, 1873	1852, 1854, 1855, 1858, 1859, 1862, 1870, 1877	1848	...	1848, 1849, 1856	
Cretaceous.........	...	1852, 1854, 1873	1872, 1875, 1877	1853, 1854, 1855	...	1851, 1857, 1858, 1862	
Wealden	...	... ..	......	...	...	1853, 1854, 1855, 1856, 1857, 1862, 1871, 1873, 1875, 1876	
Oolitic	...	1850, 1852, 1876	1850, 1853, 1854, 1872, 1874, 1875, 1877	1850, 1861, 1868, 1869	...	(Purbeck) 1853, 1858 (Kim. Clay), 1859, 1860, 1868, 1873, 1875, 1877 (Great Oolite) 1875	1870
Liassic	...	1850, 1852, 1876	1874, 1877	1863, 1864, 1866, 1868	...	1859, 1860, 1863, 1869, 1873	
Triassic............	...	1876	......	......	......	......	1870
Permian	1849	1849, 1856	1849	1849	1849	1849	
Carboniferous ...	...	1856, 1857, 1858, 1859, 1860	......	......	1877		
Devonian	...	1862, 1863	......	......	1867, 1869		
Silurian............	...	1865, 1866, 1868, 1870					
Cambrian							

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

THE

PALÆONTOGRAPHICAL SOCIETY.

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THE EOCENE BIVALVES.

SUPPLEMENT.

Directions to the Binder.

The Supplement may be bound to follow the sheets and plates of the "Eocene Bivalves," Volume I (pages 1—182; Plates I—XXV).

Date of Publication.

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A MONOGRAPH

OF THE

EOCENE BIVALVES

OF

ENGLAND.

BY

SEARLES V. WOOD, F.G.S.

VOLUME I.

SUPPLEMENT.

Pages 1—24; Plates A and B.

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PREFACE.

When I agreed to assist my deceased friend F. E. Edwards in the task of describing the British Eocene Mollusca by taking the Bivalve portion, it was on the understanding that the specimens in his collection (which embraced with few exceptions all the species known from this Formation) should be placed in my hands, to be retained by me so long as they might be required for examination and description, so that I might have them constantly under my own eye for study and for comparison with the figures of the French Eocene species and other published figures accessible to me. The failure of Mr. Edwards's health put an end to the further prosecution of his portion of the work, viz. the Cephalopoda and Gasteropoda, but I was enabled, by the means I have mentioned, to issue another instalment of the Bivalvia in the volume of the Palæontographical Society for 1870. Since then the collection has passed into the British Museum, and by this the desideratum which I considered indispensable for the performance of my part of the work became unattainable. I therefore gave up the idea of further prosecuting the description of the British Eocene Bivalvia; but finding that I had in my own cabinet several species of Eocene Fluviatile Shells which had not been described, and being kindly assisted by Messrs. C. J. Meyer, Caleb Evans, and the Messrs. Bott, with the loan of specimens from their cabinets, I essayed to complete so much of the work as would comprise the Fluviatile species of the Bivalvia, and with that object the accompanying two plates were engraved. Domestic trouble obliged me, however, to postpone even this part of the work, and I now find that, owing to my advanced age and to the infirmity under which I labour, I am incapable of leaving home and spending the time necessary for the thorough study of the species in the British Museum which is essential to their satisfactory description. I have therefore, with much regret, given up the idea of further describing the British Eocene Bivalve Mollusca, and leave its completion to younger and abler hands, confining myself to a description of the few species which have been thus engraved, and trusting that, under the circumstances, what I have mentioned will be received as a sufficient excuse for the incomplete state in which I am compelled to leave the subject. My thanks are due to Mr. Henry Woodward, F.R.S., of the British Museum, in whose custody Mr. Edwards' collection now is, for great facilities afforded me in the production of the present small contribution to the British Eocene Mollusca.

S. V. WOOD.

NOVEMBER, 1876.

SUPPLEMENT TO THE EOCENE BIVALVIA.

UNIO. *Phillippson*, 1788.

For generic character see 'Eocene Mollusca (Bivalvia),' Vol. I, p. 130.

Seven species of this genus were figured and described by myself in the Volume of the Palæontographical Society's Publications issued for the year 1862, and I have here introduced the figure of another form. Some of these were not in perfect condition, and will require confirmation by better specimens than any I have seen; indeed, one of these shells figured and described under the name of *Unio Edwardsii*, p. 133, T. XX, f. 16, *a b*, very doubtfully belongs to that genus, the cast only with a mutilated specimen being all that I had seen; but they were so called in Mr. Edwards's cabinet, and I did not feel justified in altering their names, as from their shape I thought they might belong to the genus *Unio*. Another specimen has been obtained from the same formation and locality by Mr. C. Meyer, but as this has only the exterior exposed, I am still doubtful as to its generic position. It was referred to *Cyrena* by Mr. Meyer, but with a doubt, and as I am inclined to think, in the absence of a view of the hinge which the nature of the matrix rendered impracticable, that Mr. Meyer's view of the genus is the more probable, I have figured it under the generic name of *Cyrena* (Tab. A, fig. 15), so that if future specimens should confirm the reference, *Unio Edwardsii* must be expunged from the list of Eocene Mollusca.

The genus *Anodonta* does not so far as I know make its appearance in the Lower Tertiaries of England, and only two species are given by M. Deshayes from the Paris Basin; these do not appear to be well established, and the exterior only has he represented (see his description, An. s. Vert. du Bas. de Par., vol. i, p. 800).

UNIO MICHAUDI? *Deshayes*. Tab. A, fig 6.

UNIO MICHAUDI, *Desh.* An. sans Vert. du Bas. de Par., p. 802, pl. lxii, figs. 1—5, 1860.
— — ? *Sandberger.* Land- und Süssw.-Conch., p. 177, pl. viii, fig. 1 (cop. Desh.), 1872.

Spec. Char. " *U. Testâ variabili, ovato-rotundatâ, plus minusve inflato-gibbosâ, valde inæquilaterali, transversim irregulariter rugosâ, inæqualiter bis terve undato-gibbosa, sæpius postice plicis tenuibus, divaricatis ornatâ; umbonibus magnis, tumidis, proeminentibus, sub-*

cordatis; lunulâ excavatâ, ovato-oblongâ; latere antico brevi, late obtuso, postico oblique truncato; cardine crasso, unidentato, altero inæqualiter bidentato; dentibus crassis triangularibus; irregulariter sulcatis; cicatriculâ musculari anticâ profundâ." (*Deshayes.*)

"*Var. β. Testâ suborbiculari, inflato-cordatâ.*

Var. γ. Testâ brevi, subquadratâ, postice transversim vel paulo obliquè truncatâ.

Var. δ. Testâ ovato-oblongâ, postice truncatâ.

Var. ε. Testâ ovatâ, paulo arcuatâ postice magis elongato-attenuatâ.

Length $2\frac{1}{2}$ inches; *height* $1\frac{1}{2}$ inches.

Localities. Britain: Dulwich. (*Meyer.*)
France: Cuis. (*Deshayes.*)

The specimen of this genus from the Lower Eocene of Dulwich, of which the figure above referred to is a representation, was obligingly sent to me for examination by Mr. C. J. Meyer, with the name of *U. Solandri*? written upon it; but I think that it can hardly be referred to that species. The specimen is a cast of the interior with a very small portion of the shell remaining, and the form is so different from that of *Solandri*, and approaches so closely to the second variety described by M. Deshayes of the very variable species *Michaudi*, that I have so referred it provisionally. The shell figured by myself under the name of *U. subparallelus* (Eocene Moll., T. XX, f. 13) appears to be proportionally so much longer that I think our present specimen must belong to a different species. The true determination of some of the recorded Lower Eocene shells of this genus will require better specimens than any I have seen, but I doubt much if any that I have seen can be correctly referred to *Unio Solandri*, although in this genus especially we are confronted with more than ordinary variation, when we consider the enormous amount of synonyms that have been given by Mr. Lee to some of the living British species (see 'Eocene Bivalves,' p. 131). Our present shell is not very far removed from the recent species *Unio complanatus*.

Dreissena serrata, Melleville ('Sables Tert. inférieurs, p. 40, pl. 1, f. 11, 12), is inserted in the List given by Mr. Whitaker in his memoir, p. 577, as from the Woolwich and Reading series, but for this no special locality is given, and I have not been able to see a specimen to justify the name. This was inserted by him, he informs me, on the authority of Mr. Prestwich's list in 'Quart. Jour. of the Geol. Soc., vol. x, p. 117, wherein Mr. Prestwich says that the specimen on which the name is inserted by him was too imperfect to admit of a positive determination.

CYRENA. *Lamarck.*

Generic Character. Shell equivalved, roundedly trigonal, ovate, or transverse, more or less inequilateral, generally thick and strong: hinge with two cardinal teeth in each valve and a large extended lateral tooth on both sides; exterior generally smooth or irregularly ridged by simple lines of growth. Connexus ligamentous; impression by the mantle with scarcely a perceptible sinus.

This genus is closely connected with *Cyclas*, but it differs in having a thick and heavy shell. Its habitation, like the latter, is for the most part in fresh water, although it is found in estuaries in association with Oysters and *Littorinæ*. In the recent state it is known only in tropical or subtropical regions, although one species, a remnant of this race, flourished in Britain during the Crag and earlier part of the Glacial, and again in the Post-glacial period, but I am not aware of any of the older Tertiary species having survived to the present day. In the Quart. Jour. Geol. Soc. for 1850, vol. vi, p. 444, *Cyrena trigonula*, Wood, the Crag and Post-glacial species just referred to (*C. fluminalis*, Müll.) is quoted by Mr. De la Condamine as having been found at Charlton in association with *C. cuneiformis*, *Melania inquinata*, &c. I have not, however, been able to see the specimen so referred by him, and think that the species referred to must have been that described (postea p. 190) as *C. trigona*, Desh. *C. Gravesii* is also given by the same author; but I have been equally unable to identify that reference by any British specimen, and Mr. Whitaker's notice of the same species in his list, page 577 of the 'Geol. Survey Memoir,' vol. iv, is, he informs me, inserted on the authority of Mr. De la Condamine's paper only.

Cyrena as proposed by Lamarck has been separated into numerous sections or subgenera, but most of these divisions appear to me to be no more than might be expected between species. Dr. Gray proposed the name of *Corbicula*, to include those species which have elongated lateral teeth, striated in a transverse direction and a somewhat imbricated exterior, taking *Tellina fluminalis*, Müller, as the type; retaining *Cyrena* for those species in which these teeth are not striated, and *Batissa*, Adams, for some intermediate forms. Several other divisions have also been made, but as I agree with M. Deshayes in thinking that all the various forms of Bivalves possessing two cardinal teeth and two more or less elongated laterals found in the Lower Tertiaries belong to one genus, *Cyrena*, I have followed his arrangement.

1. Cyrena crassa? *Deshayes*. Tab. A, fig. 10 *a*, *b*.

Cyrena crassa, *Desh.* Coq. Foss. des Env. de Par., p. 119, pl. xviii, figs. 14, 15, 1824.
— (corbicula) crassa, *Sandberger.* Land- und Süssw.-Conch., p. 252, t. xiv, figs. 4, 4 *b*, 1872.

Spec. Char. C. Testâ crassâ, cordiformi, sublævigatâ, nitiaulâ; umbones parvuli, submediani; lunulâ parvâ, paulo profundâ, obsoletè circumscriptâ; dentes cardinales bini bifidi et unicus simplex, nec non laterales inæquales, crenulis rectis plicatuli in utrâque valvâ extant. Impressione pallii breviter sinuosâ.

Length, $\frac{9}{16}$ths of an inch; *height,* $\frac{3}{8}$ths of an inch.

Localities. Britain: Peckham and Sundridge Park.

France: Damery, Auvers, &c.

A few specimens have been sent to me by Mr. C. Meyer with the name of *Cyrena intermedia,* Morris. They are much more rounded than any of that species in my possession, and appear to correspond with M. Deshayes' figures and descriptions of *crassa,* to which I have accordingly referred them with a mark of doubt. M. Deshayes gives his species as from the Upper beds.

This possibly may be the shell that has been called *Cyrena obovata?* Sowerby, in Mr. Whitaker's List ('Mem.,' p. 577) from Dulwich, of the Woolwich and Reading series. Possibly, also, the shell figured by Jas. Sowerby, 'Min. Conch.,' Tab. 162, fig. 4, as from New Cross, may be the same as the above.

2. CYRENA CORDATA, *Morris.* Tab. A, fig. 2 *a—c.*

CYRENA CORDATA, *Morris.* Geol. Journ., vol. x, p. 158, t. xi, figs. 7—9, 1854.

Spec. Char. "*C. Testâ subtrigonali, crassâ, gibbosâ, rugosâ; umbonibus prominentibus; antico rotundato, postico subrostrato, depresso, attenuato.*" (*Morris.*)

Length, $1\frac{1}{2}$ an inch; *height,* $1\frac{3}{8}$ths of an inch.

Localities. Dulwich, New Cross, Charlton. (*Meyer.*)

Numerous specimens of this species have been found, and several in a good state of preservation have been obligingly sent to me for examination by Mr. C. J. Meyer, some from Dulwich and others from Sundridge Park. In general they maintain a great uniformity of character, being tumid in the pedal region, but compressed on the other side, with a slightly angular slope on the posterior margin, and a projection at the exit of the siphons. This shell is covered generally with concentric ridges or prominent lines of growth, but I am unable to say whether these are regularly thickened striæ, or whether they are the result of irregular decortication, as some specimens are smooth or nearly so. Many of these specimens have from three or four to a dozen rays proceeding from the umbo to the ventral margin, and these rays appear to have been formed from the loss of surface. Probably they were in the living state strongly coloured like some of the *Veneridæ,* or like the freshwater shell *Galatea radiata,* and that the coloured matter caused the unequal decomposition of the surface where they existed. This is not very unlike another well-known shell in respect to these rays, viz. *Gnathodon cuneatus,* which inhabits brackish water near Mobile, in the Gulf of Mexico, where it is profusely abundant in association with *Cyrena Carolinensis.*

Our shell is usually uniform in outline, but all that I have seen have the siphonal side more or less compressed, with a prominent and slightly angular termination.

3. CYRENA CUNEIFORMIS, *J. Sowerby.* Tab. A, fig. 3 *a—c.*

CYCLAS CUNEIFORMIS, *J. Sow.* Min. Conch., t. 162, figs. 2, 3, 1817.
CYRENA — *Desh.* Coq. foss. des Env. de Par., vol. i, p. 122, pl. xix, figs. 1, 2, 20, 21, 1824.
— — *Sandb.* Land- und Süssw.-Conch., p. 181, t. viii, figs. 6 *a*, *b*, 1872.
— — *Morris.* Catal. Brit. Foss., 2nd edit., p. 199, 1854.
— — *J. Lowry.* Chart. Brit. Tert. Foss., pl. iv, 1866.
— DONACIALIS, *Desh.* Dict. Class. d'Hist. Nat., t. v, p. 290, 1824.

Spec. Char. *C. Testâ transversâ, trigonulâ, inæquilaterali, irregulariter substriatâ; anticè truncatâ, posticè angulatâ; dentibus cardinalibus tribus, dentibus lateralibus inæqualibus perpendiculariter rugosis aut striatis.*

Length, $\frac{15}{16}$ths of an inch; *height,* $\frac{5}{6}$ths of an inch.

Localities. Britain: Charlton, New Cross, Dulwich.
France: Lignites, and Sables moyens.

This is an abundant species in the Woolwich beds of this country; and it is said by M. Deshayes to be profusely spread in the Lignites and Sables moyens in France. The locality of Headen Hill is given in the 'Coq. Fos. des Env. de Par.,' Tab. 1, p. 123, but I have not been able to see a specimen of this species from the Isle of Wight, nor have I heard of its having been found there. Possibly *C. semistriata* may have been mistaken for it. The impression by the mantle exhibits a small and shallow sinus.

The variation in this species consists in an extension of the siphonal side, one variety being more inequilateral than the other. It somewhat resembles the recent species *Cyrena Floridensis.*

4. CYRENA STRIGOSA, *S. Wood.* Tab. A, fig. 4.

Spec. Char. *C. Testâ transversè trigonatâ, inæquilaterali, regulariter circinatâ vel striatâ, striis magnis acutis, anticè rotundatâ, posticè angulatâ elongatâ; dentibus cardinalibus tribus, dentibus lateralibus striatus.*

Length, $1\frac{3}{8}$ths of an inch nearly; *height,* $\frac{3}{4}$ths of an inch nearly.

Locality. Charlton. (*S. Wood.*)

This species is equally abundant with *C. cuneiformis.* It has the exterior covered with regularly concentric striæ or ridges, rounded and distinct; whereas in *cuneiformis* the lines of growth are indistinct or irregular, and sometimes scarcely perceptible; and these differences appear to me to justify a specific separation. The angular ridge over the siphonal or posterior side also is rather more distinct than in *cuneiformis*, and the anterior lateral tooth is rather narrower and more elongated; but the ornamented exterior is the principal character that seems to justify its being placed in a separate specific position.

5. CYRENA FORBESII, *Deshayes*. Tab. A, fig. 5 *a, b*.

CYRENA FORBESII, *Desh.* An. sans Vert. du Bas. de Par., t. i, p. 510, pl. xxxvii, figs. 24—27, 1860.

Spec Char. *C. Testâ ovato-trigonâ, subtransversâ, inæquilaterali, turgidulâ, posterius depressâ, obtusè angulatâ, transversim obsoletè striatâ; umbonibus prominentibus obliquis; latere antico rotundato, postico acuminato; cardine inæqualiter tridentato, dentibus divaricatis; dentibus lateralibus crassis inæqualibus.*

Length, $1\frac{1}{8}$th of an inch; *height*, 1 inch.

Localities. Britain: Charlton. (*S. Wood.*)
France: Sainceny.

This has been separated, and I think justly, by M. Deshayes from *Cyrena antiqua*, Ferussac. Speaking of *C. antiqua*, however, M. Deshayes says ('An. sans Vert. du Bas. de Par.,' tom. 1, p. 510) that "M. Hébert en a recueilli de nombreux échantillons dans les environs de Dieppe; elle est egalement en abondance dans les Lignites de Woolwich en Angleterre." This statement is, I think, an error as far as Woolwich is concerned, for I have not been able to see the true *antiqua* from our own beds.

My researches in the Woolwich beds at Charlton were confined to a large excavation that was open when I hunted it fifty years ago, and I have not since visited it. My specimens have, however, ever since been carefully kept with the localities attached, and I give them as undoubtedly genuine.

6. CYRENA DULWICHIENSIS, *Rickman*. Tab. A, fig. 14 *a—c*.

CYRENA DULWICHIENSIS, *Rickman.* Quart. Jour. Geol. Soc., vol. xvii, p. 6, 1861.
— — *Edwards.* Geologist, p. 210, pl. v, figs. 4, 5, 1860.
— — *J. Lowry.* Chart. Brit. Tert. Foss., pl. iv, 1866.

Spec. Char. *C. Testâ oblongo-transversâ, crassiusculâ, inæquilaterali, lævigatâ vel obsoletè striatâ; umbonibus minimis depressis vix obliquis; dentibus cardinalibus tribus, lateralibus inæqualibus, elongatis, angustis, tenuissime striatis.*

Length, 2 inches; *height*, $1\frac{1}{4}$ inches.

Locality. Dulwich.

Several specimens of this species have been put into my hands by Mr. Meyer and Mr. C. Evans, but they have all the valves united, or have the shell embedded in the matrix so as not to exhibit clearly the dental furniture, or impressions by the muscles. Mr. Meyer has, however, so far cleared the hinge of a left valve as to show that it has two unequally elongated, lateral teeth, with what seem to be two triangular, cardinal denticles, and a ledge for an external or ligamentous connector; so that we can confidently place it as a *Cyrena*. The large specimen which I have had figured, and which belongs to Mr. Meyer, is smooth; but there are two nearly obsolete rays. In other specimens, however, these rays are more numerous, and vary from 6 to 10.

I have given representations of some different forms. One of these has the posterior or siphonal side somewhat pointed, and another has this side broader, and the shell is nearly cylindrical, the posterior side being as broad or high as the anterior.

A full description of this species was given by Mr. Edwards, as above referred to.

7. CYRENA INTERMEDIA? *Melleville*. Tab. A, fig. 8 *a, b*.

CYRENA INTERMEDIA, *Mellev.* Sab. Tert. infér. Bas. de Par., p. 35, pl. ii, figs. 5, 6, 1843.
— — *Prestwich.* Quart. Journ. Geol. Soc., vol. x, p. 155, pl. ii, figs. 10, 11, 1854.
— — ? *Desh.* An. sans Vert. du Bas. de Par., p. 514, pl. xxxviii, figs. 19, 20, 1860.
— (LOXOPTYCHODON) INTERMEDIA, *Sandberger.* Land- und Süssw.-Conch., p. 163, t. x, fig. 3, 1872.

Spec. Char. *C. Testâ transversâ, oblongo-subtrigonâ, inæquilaterali, obsoletè transversim striatâ; umbonibus prominulis obliquis, cardine tridentato, dentibus lateralibus subæqualibus, striatis.*

Length, $\frac{3}{8}$ths of an inch.

Localities. Britain: Charlton (*S. Wood*), Sundridge (*Meyer*).
France: Lignites.

This shell corresponds with the one given by Mr. Prestwich, as above referred to; but I agree with him that its identity with the shell figured and described by Melleville is doubtful, as Melleville's figure represents a larger shell with a narrower hinge, and more rounded posterior side. I have therefore put a mark of doubt to the above name. M. Deshayes has figured and described another shell under the name of *C. Deshayesii*, Hébert, which rather more resembles our shell in having a more pointed posterior side, but the umbo is less prominent, and the shell more inequilateral as well as larger.

I have left our shell, therefore, as Mr. Prestwich originally referred it, until the French and English specimens can be closely compared. The description given by Melleville of his species agrees better with our shell than does the figure he has given. On the other hand, the figure given by Sandberger of *intermedia* more resembles the English fossil, but is larger.

8. Cyrena? pullastra, *S. Wood.* Tab. A, fig. 11.

Length, $1\frac{1}{2}$ inch; *height,* 1 inch.

Locality. Dulwich. (*Meyer.*)

The specimen figured is from the cabinet of Mr. Meyer, and it is the only one that I have seen. On the tablet Mr. Meyer had written *Cyrena* or *Unio*? The two valves are so firmly united by the matrix that I am, like Mr. Meyer, doubtful as to what genus it ought to be referred, but as it appears to be not very far removed from *Cyrena Dulwichiensis,* I have provisionally retained it under the same genus; and it may possibly even prove to be only a variety of that shell. Its shape so much resembles the genus *Tapes* or *Pullastra* that I have thought the latter a suitable specific appellation.

9. Cyrena trigona, *Deshayes.* Tab. A, fig. 9 *a—c.*

Cyrena trigona, *Desh.* Coq. Foss. des Env. de Par., t. i, p. 118, pl. xix, figs. 16, 17, 1824.

— — *Id.* An. sans Vert. du Bas. de Par., t. i, p. 513, 1860.

Spec. Char. "*C. Testâ ovato-trigonâ, minimâ, crassâ, lævigatâ, cordiformi, obliquâ; umbonibus productioribus, recurvis; dentibus cardinalibus tribus, duobus in alterâ (valvâ) lateralibus serratis.*" (*Desh.*)

Length, $\frac{3}{8}$ths of an inch.

Localities. Britain: Dulwich. (*Meyer.*)

France: Lysi, près Épernay.

A very perfect specimen (fig. 9 *c*), with the umbones in apposition, has been sent to me for examination by Mr. Meyer; and although I have only the figure of the French species for comparison, I think there is no doubt but that the British fossil is identical with it. The valves lie on the clay with only the exterior exposed. Another specimen (fig. 9 *a, b*) from Sundridge Park I have regarded as belonging to the same species, though it has a more depressed umbo, and wants the subangular ridge on the posterior side.[1] This latter specimen very closely resembles the small variety of the Crag and Post-glacial species, *C. fluminalis,* the only difference between them that I can detect being the greater length of the lateral teeth in *fluminalis,* and in the ridges or imbrications present on that species, the exterior of the Eocene shell being smooth. As, however, the ridges which are so strong on recent specimens of *fluminalis* become more or less obscure in the fossil, it is possible that the Eocene species, *trigona,* may not in life have been so destitute of imbrications as the specimens preserved fossil appear to be. *C. trigona* also closely resembles *C. pisum,* and is not far removed from *C. breviuscula,* Desh, 'An. sans Vert. du Bas. de Paris,' Pl. 36, figs. 9—11; but this latter shell is more transverse.

10. Cyrena anceps, *S. Wood.* Tab. A, fig. 12.

Length, 1 inch.
Locality. Dulwich (*Meyer*).

This represents another specimen sent to me by Mr. C. Meyer, and on the label was written, "Cyrena, a doubtful form," and said to come from the leaf clay at Dulwich. Its peculiarity seemed to me deserving of a special representation, and I have assigned it the above specific name, although it may only be a distorted specimen of *cuneiformis,* or of another of the common species from the same locality.

11. Cyrena tumida, *S. Wood.* Tab. A, fig. 7 *a, b.*

Length, 1⅜ths of an inch.
Locality. Dulwich (*C. Evans*).

This is another doubtful form. It somewhat resembles in outline *C. cuneiformis,* but I have never seen a specimen of that species inflated like the present one. The one figured is the only specimen that I have seen, and I have provisionally, therefore, assigned it as a new species under the above name. The two valves were so closely cemented together by its stony matrix that I have been unable to see the interior. It is from the cabinet of Mr. C. Evans.

[1] These two characters have not been sufficiently represented by the artist in fig. 9 *a, b.*

12. Cyrena tellinella, *Férussac.* Tab. A, fig. 13 *a—c.*

Cyrena tellinella, *Fér.* Hist. des Moll. Terrest. Fluv., tab. sans No., fig. 1, 1819.
— — *Desh.* Coq. Foss. des Env. de Par., p. 123, pl. xix, figs. 18, 19, 1824.
— — — An. s. Vert. du Bas. de Par., p. 507, pl. xxxviii, figs. 3, 4, 1860.
— — *J. Lowry.* Chart Brit. Tert. Foss., pl. iv, 1866.
— — *Sandberger.* Land- und Sussw.-Conch., p. 179, t. viii, fig. 5, 1870.

Spec. Char. *C.* "*Testâ ovato-elongatâ, transversâ, inæquilaterali, lævigatâ, depressâ; umbonibus minimis; dentibus cardinalibus minimis, duobus in utrâque valvâ, lateralibus magnis, obliquè striatis.*" (*Desh.*)

Length, 1 inch; *height,* ½ an inch.

Localities. Britain: Charlton (*S. Wood*), Woolwich, Upnor, New Cross (*Morris*).
France: Lignites, près Epernay.

This species is of a marked character, and well distinguished from all others of this genus met with in England; and its peculiarly elongated form has even been considered as a sufficient distinction to entitle it to be proposed as a new genus under the name of *Loxoptychodon,* but I think that character alone is insufficient for generic removal. The hinge is strong, with three cardinal teeth, of which the central one is bifid. There are also two lateral teeth, of which that on the posterior side is very elongated and somewhat remote, and both of them rugose or striated, the nymph or fulcrum for the external connector being sharp, long, and slightly prominent. The species was abundant at Charlton. M. Deshayes has described and figured two varieties of this species, one somewhat larger than the other, and also larger than any specimen that I have seen from our English beds.

This species is given by M. Deshayes as from the "Sables moyens" in France, as well as from the "Lignites." I have seen the British specimens only from Woolwich and Charlton.

13. Cyrena semistriata, *Deshayes.* Tab. B, fig. 1 *a, b.*

Cyrena semistriata, *Desh.* Ency. Méthod. Vers., t. xi, p. 52, No. 17, 1830.
— — *Id.* An. sans Vert. du Bas. de Par., p. 511, pl. xxxvi, figs. 21, 22, 1860.
— — *Nyst.* Coq. Foss. de Belg., p. 143, tab. vii, fig. 3, 1843.
— — *Morris.* Mem. Geol. Surv. (Isle of Wight,), p. 146, pl. ii, figs. 1, 2, 1856.
— — *Sandberger.* Land- und Sussw.-Conch., p. 309, tab. xx, fig. 2 *a, b,* 1872.

CYRENA CUNEIFORMIS, *Goldf.* Petr. Germ., t. xi, p. 224, pl. 146, fig. 2, 1838.
— TRIGONA, *Id.* Idem., figs. 3, 4.
— SUBARATA, *Bronn.* Leth. Geogn., t. xi, p. 958, pl. xxxviii, fig. 2, 1854.

Spec. Char. *C. Testâ crassâ, ovato-trigonâ vel cuneiformi, obliquè cordatâ, inæquilaterali, posticè angulatâ, anticè rotundatâ, striatâ, striis transversis imbricatis conspicuis, posticè obsoletis, cardine bidentato, dentibus lateralibus lævigatis.*

Dimensions. $1\frac{3}{8}$ths by $1\frac{1}{8}$th of an inch.

Localities. Britain: Hempstead, Bembridge (*Morris*).
France: Sables supérieurs (*Deshayes*).
Belgium: Klein Spauwen (*Nyst*).

This is said by Mr. Morris ('Mem. Geol. Survey,' 1856, p. 146) to be very abundant in Hempstead Cliff, and the specimens to be variable in form; but this variation appears to be principally in a more or less extension of the posterior side of the shell, some being more elongated than others. It resembles *C. cuneiformis* in outward form and in its variability, and is intermediate between it and what I have called *strigosa*, which is strongly and regularly ridged over all parts of the shell. The present species is not only distinguished from the two first mentioned by its exterior markings, but the hinge is narrower, with smaller denticles, the angular ridge on the posterior region is more strongly marked, and the lateral denticles are not striated. In well-preserved specimens there are, as Mr. Morris remarks, from five to seven radiating bands of colour upon the outer surface, such as may be seen on other species of this genus.

14. CYRENA BRITANNICA, *Desh.* Tab. B, fig. 2 *a*, *b*.

CYCLAS DEPERDITA, *J. Sow.* Min. Con., tab. 162, fig. 1, 1817.
CYRENA — *Morris.* Cat. Brit. Foss., 2nd edit., p. 200, 1854.
— BRITANNICA, *Desh.* An. sans Vert. du Bas. de Par., t. i, p. 501, 1860.

Locality. Charlton (*J. Sowerby*).

I have been unable to discover the specimen from which James Sowerby figured and described this species, or to learn of any other specimen having been found, and inasmuch as Mr. Sowerby speaks of it in 'Min. Con.' as a common species at Charlton, I should have supposed that he was labouring under some mistake about it, were it not that his well-known accuracy of delineation precludes the idea of his not having had before him some shell of which his figure is a fairly correct representation; and as this representation is obviously of some species of the genus *Cyrena*, and of one unlike any of the others known and described from English Eocene deposits, I have felt it necessary to have his figure copied into my plate, and to give the species among the British Eocene *Cyrenæ*.

Cyclas deperdita of Lamarck, to which J. Sowerby referred his specimen, is a different shell, and as the specific appellation of *deperdita* had been applied by Lamarck to a species of *Cyrena*, Mr. Deshayes proposed for Sowerby's shell the specific name of *Britannica*, and I have accordingly adopted his proposition.

15. Cyrena obovata, *J. Sowerby*. Tab. B, fig. 3 *a—d*.

Cyclas obovata, *J. Sow.* Min. Conch., t. 162, figs. 5, 6, 1817.
Cyrena — *Morris.* Catal. Brit. Foss., 2nd edit., p. 200, 1854.
— (corbicula) obovata, *Sandb.* Land- und Sussw.-Conch., p. 261, t. xv, figs. 2, 2 *a, b*, 1872.

Spec. Char. *C. Testâ variabili crassâ, subcordatâ, posticè angulatâ, anticè convexâ, extus lævigatâ aut irregulariter striatâ; umbonibus elevatis; dentibus lateralibus inæqualibus.*

Length, $\frac{7}{8}$ths of an inch; *height*, $\frac{3}{4}$ths of an inch, but variable.

Localities. Bembridge (*Morris*), Osborne (*Forbes*).

This is an abundant species in several parts of the Isle of Wight, and as it is variable I have had two different forms represented. Its principal distinction or, I ought to say, its claim to specific isolation, is a more prominent umbo, great tumidity, and an angularity on the posterior side. Some old specimens have a thick shell in which the impressions from the adductors are very deep. The large specimen figured by Mr. Sowerby, Tab. 162, fig. 4, and said to be from New Cross, shows a more rounded exterior than any I have from the Isle of Wight; and if it be referable to this species it must be a very aberrant form. Probably, however, it belongs to some other species as the locality, "New Cross," would imply that it came from the Woolwich Beds (Lower Eocene), whereas our Isle of Wight species belongs properly to the Upper Eocene. Mr. Whitaker in his Memoir Geol. Surv., 1872, gives at p. 577 this species as from Dulwich, with a mark of interrogation, but I have not been able to confirm it.

Mr. Morris in his Catalogue gives it from Barton, but I have not seen it from that marine locality. Mr. Sowerby has also given Barton as the locality for his figures 5, 6.

16. Cyrena obtusa, *Forbes*. Tab. B, fig. 13 *a—c*.

Cyrena obtusa, *Morris.* Catal. Brit. Foss., 2nd edit., p. 200, 1854.
— — *Forbes.* Mem. Geol. Surv., Isle of Wight, p. 149, pl. iii, fig. 4, 1856.
— — *J. Lowry.* Chart Brit. Tert. Foss., pl. ii, 1866.
— (batissa) obtusa, *Sandberger.* Land- und Sussw.-Conch., p. 311, t. xx, fig. 3 *a, b*, 1872.

Spec. Char. *C. Testâ lævi, convexâ, subtrigonâ, margine antico vix producto, margine postico angulato, subproducto, margine ventrali rotundato."* (*Morris.*)

Length, $\frac{9}{16}$ths of an inch; *height*, $\frac{1}{2}$ an inch.

Localities. Bembridge, Hempstead (*Forbes*).

There is a considerable difference in the form of this shell from *C. obovata*, on which account I have kept it specifically distinct. A large series of each, however, might possibly remove the distinction and unite this with *obovata*. My specimens show a more rounded form than *obovata*, with a much depressed umbo and an absence of the strongly angular form of the posterior side of that shell. They are also less triangular and not so inflated. The species has been kept distinct by Messrs. Forbes and Morris, and I have thought it best to follow them in so doing.

The specimens of this species have undergone considerable erosion of the umbones, so much so that a specimen which I have had represented shows the cardinal teeth standing out prominently, and these are visible even when looking at the exterior of the shell.

17. Cyrena deperdita, *Lam.* Tab. B, fig. 10 *a—d.*

Cyclas deperdita, *Lam.* Ann. du Mus., t. vii, p. 425, 1803.
Cyrena — *Desh.* Coq. Foss. des Env. de Par., p. 118, pl. xix, figs. 14, 15, 1824.
— — *S. Wood.* Lond. Geol. Journ., p. 118, 1847.
— — *Morris.* Mem. Geol. Surv. (Isle of Wight), p. 156, pl. vii, fig. 11 *a*, *b*, 1856.
— — *Lowry.* Chart Brit. Tert. Foss., pl. ii, 1866.
— — *Sandberger.* Land- und Sussw.-Conch., p. 251, t. xiv, fig. 3, 1872.

Spec. Char. *" C. Testâ ovato-ventricosâ, obliquâ, subtrigonâ, lævigatâ substriatâve; umbonibus magnis, inflatis, recurvis; dentibus cardinalibus tribus valvâ sinistrâ, duobus dextrâ; dentibus lateralibus subæqualibus, lævigatis."* (*Desh.*)

Length, $\frac{5}{8}$ths of an inch; *height*, $\frac{7}{16}$ths of an inch.

Localities. Britain: Hordle, Headon Hill (*Morris*).
France: Pontoise (*Deshayes*).

This is an abundant shell at Hordle in the purely freshwater deposit at the cliff of that locality, in association with the remains of the *Alligator*,[1] *Crocodile*, *Trionyx*, *Emys*, *Lepidosteus*, and sundry Mammalia, as mentioned by me in the 'Lond. Geol. Journ.' (1846), p. 6.

[1] All the vertebrate remains obtained by me from Hordle (which included many besides those figured in the 'London Geological Journal,' and among them the hitherto undescribed jaw of a Rodent and a bone of a Bird) were given by me to the National Collection in the British Museum in 1846.

In the Catalogue of Species from Hordle Cliff which I gave in that Journal, p. 118, I observed that this species and two others of Deshayes, *obliqua* (*obliquata*) and *cycladiformis,* were merely varieties of one species. I have, however, thought that it would be productive of less confusion, and facilitate the comparison of the French and English Eocenes, to adhere to Mr. Deshayes' specific determinations, more especially as my specimens appear to correspond with his figures and descriptions, and I have therefore done so.

Fig. 6 *a, b* represents a small and not well-determined species, of which Mr. Morris seemed doubtful when he figured it in the 'Memoirs of the Geol. Survey' by Forbes, as *Cyrena gibbosula,* Pl. vi, fig. 13. I have not seen the specimen, but have had the figure copied. It looks like a deformed specimen of *C. deperdita.*

18. Cyrena pisum, *Deshayes.* Tab. B, fig. 12 *a, b.*

Cyrena pisum, *Desh.* Desc. des Coq. Foss. des Env. de Par., p. 117, pl. xix, figs. 10—13, 1824.
— — *S. Wood.* Lond. Geol. Journ., p. 118, 1847.

Spec. Char. "*C. Testâ minimâ, subtrigonâ, globulosâ, lævigatâ; umbonibus inflatis, productioribus, obliquis; dentibus cardinalibus tribus, in alterâ binis, lateralibus subæqualibus admotis lævigatis.*" (*Desh.*)

Length, $\frac{5}{16}$ths of an inch; *height,* $\frac{1}{4}$th of an inch.

Localities. Britain: Hordle (*S. Wood*).
France: Houdan.

This shell is by no means rare in the sandy deposit at Hordle. It is difficult to separate it from *deperdita,* but that shell is more transverse, and not quite so tumid.

19. Cyrena cycladiformis, *Deshayes.* Tab. B, fig. 11 *a, b.*

Cyrena cycladiformis, *Desh.* Coq. Foss. des Env. de Par., vol. i, p. 121, t. xix, figs. 7—9, 1824.
— — *S. Wood.* Lond. Geol. Journ., p. 18, 1847.
— — *Morris.* Catal. Brit. Foss., 2nd edit., p. 200, 1854.
— — *Sandberger.* Land-Conch., p. 208, t. xi, fig. 3, 1872.

Spec. Char. "*C. Testâ ovatâ, transversâ, subæquilaterali, lævigatâ, tenui, fragili; umbonibus minimis; dentibus cardinalibus tribus valvâ dextrâ; duobus in alterâ, posticalibus bifidis; dentibus lateralibus lamellosis, minimis lævigatis.*" (*Desh.*)

Length, $\frac{5}{8}$ths of an inch; *height*, $\frac{7}{16}$ths of an inch.

Localities. Britain: Hordle (*S. Wood*).

France: Grignon, Ferme de l'Orme.

This species is not very rare in the purely freshwater deposit of Hordle. It is very transverse in form, with a narrow hinge and elongated lateral teeth, in which characters only does it appear to differ from *deperdita*. It is also slightly inequilateral and somewhat tumid, with a smooth exterior and a rather depressed umbo.

20. Cyrena obliqua? *Deshayes*. Tab. B, fig. 14.

Cyrena obliqua, *Desh.* Coq. Foss. des Env. de Par., t. i, p. 122, pl. 19, figs. 5, 6, 1824.

— obliquata, *S. Wood.* Lond. Geol. Journ., p. 118, 1847.

Spec. Char. " *C. Testâ ovato-transversâ, obliquâ, substriatâ, sub-æquilaterali; umbonibus obliquis, productiusculis, dentibus cardinalibus tribus, valvâ dextrâ, duobus, sinistrâ, lateralibus minimis; latere antico lævigato, postico tenuissimè striato.*" (*Desh.*)

Length, $\frac{9}{16}$ths of an inch; *height*, $\frac{3}{8}$ths of an inch.

Localities. Britain: Hordle (*S. Wood*).

France: Soissons (*Deshayes*).

A few specimens are in my cabinet, which appear to correspond with the French fossil which M. Deshayes originally constituted a distinct species in his first work on the fossils of the Paris Basin, and has preserved in his more copious and recent work, 'An. Foss. du Bas. de Par.,' p. 506. This is the shell spoken of by me in the 'London Geol. Journal' as *obliquata*, and there regarded by me as a variety of *deperdita* and *cycladiformis*. Probably M. Deshayes' suite of specimens of the three forms show greater differences than mine, and justify the separation.

21. Cyrena pulchra, *J. Sowerby*. Tab. B, fig. 7 *a*, *b*.

Cyclas pulcher, *J. Sow.* Min. Conch., t. 527, fig. 1, 1826.

— pulchra, *Morris.* Catal. Brit. Foss., 2nd edit., p. 200, 1854.

— — *Forbes.* Mem. Geol. Surv. (Isle of Wight), p. 148, pl. iii, fig. 1, 1856.

Cyrena — *J. Lowry.* Chart Brit. Tert. Foss., pl. ii, 1866.

— — ? *Sandberger.* Land-Conch., p. 308, t. xx, figs. 1, 1 *a*, 1872.

Spec. Char. *C. Testâ crassâ, suborbiculari, subæquilaterali, anticè paulo minore, posticè dilatatâ, obtuse angulatâ, lævigatâ vel irregulariter striatâ, umbonibus prominulis, cardine crassiusculo; dentibus inæqualibus, in valvâ sinistrâ duobus primis majoribus, in* *dextrâ posterioribus dentibus duobus bifidis, dentibus lateralibus inæqualibus, lævigatis; nymphis depressis.*

Length, $2\frac{1}{8}$th of an inch; *height*, 2 inches.

Localities. Britain: Hempstead, Bembridge (*Forbes*).
(and var. *Wrightii*) Headon beds, I. of Wight.

This is a large and handsome shell, and deserving of the name given to it by Mr. Sowerby, and I believe it is abundant at the above localities. It somewhat resembles *C. Lamberti*, Desh., p. 495, pl. xxxix, figs. 9, 10, but differs in several particulars from the figure and description of that species, which has a much longer fulcrum or support for the ligamentous connector.

The shell figured as *C. Wrightii*, Forbes, in the 'Memoirs of the Geol. Survey,' is there regarded by Mr. Morris as a variety only of *pulchra;* and following the opinion of so sound an authority, I have not given *Wrightii* here as a separate species.

22. Cyrena arenaria ?, *Forbes.* Tab. B, fig. 8 *a, b*.

Cyrena arenaria, *Morris.* Catal. Brit. Foss., 2nd edit., p. 199, 1854.
— — *Forbes.* Mem. Geol. Surv., Isle of Wight, p. 88, 1856.

Spec. Char. *C. Testâ suborbiculari, subæquilaterali, tenui, concentricè et irregulariter striatâ, umbonibus depressiusculis, areâ cardinali angustâ; dentibus lateralibus elongatis inæqualibus.*

Diameter, $1\frac{3}{8}$ths of an inch.

Locality. Headon Hill (*S. Wood*).

The present shell was found by myself at Headon Hill half a century ago, before any divisions of the Isle of Wight series had been worked out, and I am unable to say to which division of the fluvio-marine group it may belong. I have given it under the above name with doubt, in consequence of Forbes' species *arenaria* not having been figured or described. The hinge of the specimen figured is much narrower than is that of *pulchra*, and the shell itself is much thinner than in that species. Two of the cardinal teeth in each valve are bifid, but the lateral teeth are narrower and more elongated than those of *pulchra*, but none of them are quite perfect.

23. Cyrena tenera, *S. Wood.* Tab. B, fig. 9.

Spec. Char. *C. Testâ tenerâ, ovato-oblongâ, lævigatâ; valdè inæquilaterali, extremitatibus obtusis, umbonibus minimis depressis, obliquis; cardine angusto.*

Length, 1 inch; *height,* $\frac{3}{4}$ths of an inch.

Locality. Headon Hill (*S. Wood*).

Two specimens of what I have here considered a new species were found by myself at the above locality fifty years ago, and I am unable to refer them to any particular division of the beds that make up Headon Hill. Unfortunately, also, both of them have the hinge not quite perfect, but they undoubtedly belong to the present genus. The exterior and outline of my shell appear to come very near to the figure of *Cyrena angustidens,* Melleville, given by Deshayes in 'An. sans Vert. du Bas. de Par.,' t. i, pl. 37, figs. 1, 2 (p. 515). My shell, however, seems from M. Deshayes' figures to differ from *angustidens* in being thinner. It is also less elongated than the figure given of that same species by M. Melleville, who speaks of it as "épaisse, assez profonde et très oblique." So far as its imperfect state allows of an opinion, also, the hinge of the British fossil seems to be narrower. Under these circumstances, and as the French species is described as occurring only in the "Sables Tert. inférieurs," while mine comes probably from a higher horizon, I have thought it better to give my shell provisionally under a separate name, though strongly suspecting its identity with the French species above mentioned.

Cyrena transversa, Forbes, is figured in Pl. III of the 'Geological Survey Memoir on the Isle of Wight,' described at p. 149 of the same memoir in the following words:

"Testâ transversâ, depressâ, angustâ, inæquilaterali, lævi posticè productâ, truncatâ, anticè attenuatâ, rotundatâ, margine ventrali leviter arcuato."

The interior of the shell is, however, not represented, nor is the dental furniture described; and judging from the figure given, it appears to me doubtful if it belongs to the present genus.

CYCLAS, *Bruguière,* 1792.

SPHÆRIUM. *Scopoli,* 1777.

Generic Character. Shell equivalve, subequilateral, more or less ventricose, thin, and closed; smooth or slightly marked by lines of growth. Hinge with a single cardinal tooth in one and two in the other, and a distant lateral tooth in each valve. Impressions of the adductors shallow or indistinct. Palleal impression small; connexus ligamental or external.

Priority of name (as stated in 'Crag Moll.,' vol. ii, p. 106) properly belongs to *Sphærium* of Scopoli, but *Cyclas* has been so long in use and has been so generally adopted that I did not then and do not now consider it necessary to alter it; and I have therefore retained the name of *Cyclas,* following thus the example of several other modern conchologists. This has been justly separated from *Cyrena,* which is a thick and strong shell. Another division has been proposed under the name of *Pisidium* for some freshwater Bivalves very closely resembling those of *Cyclas,* being thin and semi-pellucid in the living state, like *Cyclas,* but having the shell a trifle more inequilateral, and presenting some difference in the siphon. Some of the Lower Tertiary fossils have been figured and described under each of these generic names, but those which I have seen may, I think, be referred to *Cyclas.*

1. Cyclas Bristovii? *Forbes.* Tab. B, fig. 5.

Cyclas Bristovii, *Forbes.* Mem. Geol. Surv. Isle of Wight, p. 146, pl. xi, fig. 3, 1856.
— — *Morris.* Catal. Brit. Foss., 2nd edit., p. 198, 1854.
— — *J. Lowry.* Chart. Brit. Tert. Foss., pl. ii, 1866.

"A small, somewhat quadrate and rather ventricose shell, the anterior margin rounded and the posterior truncated; the surface is concentrically marked by the fine lines of growth. This species presents considerable resemblance to a form from Headon Hill in Mr. Edwards's Cabinet."—*Morris.*

Length, $\frac{1}{8}$th of an inch; *height,* $\frac{1}{8}$th of an inch.

Locality. Hempstead (*Morris*).

A small shell apparently belonging to the genus *Cyclas* has been figured as above referred to, but it is insufficient for full description or comparison. A similar specimen is in my own cabinet, but, as it rests upon a piece of clay with its back uppermost, it cannot be satisfactory described. Mr. Morris, in the 'Geo. Survey Memoir,' has not given the characters of the hinge of the interior, so that some uncertainty attaches to his species.

M. Deshayes has figured and described three species with this generic name, and four with that of *Pisidium.* These are all said to be from Lignites or Sables inférieurs of France, but, judging from figures and descriptions, I cannot refer our shell to any one of his species.

Mr. Whitaker in his report upon the Woolwich Beds (p. 577), gives the name of "*Cyclas?* (a small Bivalve)" from Chiselhurst, but he informs me that he is unable to refer me to the specimen, and that it may be disregarded.

2. Cyclas tumidula, *S. Wood.* Tab. B, fig. 4 *a, b.*

Cyclas exigua ? *S. Wood.* Lond. Geol. Journ., p. 118, 1847.

Spec. Char. *C. Testâ minimâ, ventricosâ, tenui, ovato-transversâ, subæquilaterali, lævigatâ, glabrâ, anticè rotundatâ, obtusâ, posticè angustiore et latiore ; umbonibus minimis, vix prominentibus, parum obliquis.*

Length, $\frac{1}{4}$th of an inch; *height,* $\frac{3}{16}$ths of an inch.

Locality. Headon Hill (*S. Wood*).

The shell which I have here called *tumidula* appears to be more inflated than any other known to me. It is very smooth and glossy, with a short dorsal margin, the umbo slightly prominent, and the shell is nearly equilateral. It resembles from descriptions and figures two or three other species, viz., 1st *Cyclas Verneuilli* de Boissy, 'Mém. de la Soc. Géol. de France,' 2nd ser., t. iii, p. 270, pl. 5, fig. 5; figured also by M. Deshayes, 'An sans Vert. du Bas. de Par.,' pl. 34, figs. 40—42, but that shell does not appear so tumid as ours. 2nd. *Sphærium castrense,* Moulet, which has been figured and described by Sandberger, 'Land- und Süssw.-Conch.,' p. 221, tab. xiii, fig. 1, but this also appears less tumid and more transverse than my shell. 3rd. *Cyclas elegans,* Gould, 'Inv. Massach.,' p. 74, fig. 55, a recent species from the north-east coast of America. This latter approaches near to our Headon Hill shell, but is also less tumid. I have not been able to see the interior of my shell, but it seems to differ from *C. Bristovii* in being more tumid and equilateral.

In the year 1843 I found in the truly freshwater bed at Hordle a very small specimen of a shell belonging to this genus, to which I gave the name of *Cyclas exigua* in the 'London Geol. Jour.' Mr. Edwards not having in his cabinet a corresponding specimen, I gave him the one referred to under this name of *exigua,* but I have not been able to detect it in his collection now in the British Museum so as to determine whether it be the same as that now figured as *tumidula,* but to prevent confusion I have, under the circumstance of the shell apparently not having been preserved by Mr. Edwards, given it as the same as *tumidula.*

SCROBICULABRA. *S. Wood.*

When Mr. Morris described *S. Condamini* he was at a loss to know in what genus to place it; and not being able to see the hinge, he referred it provisionally to *Psammobia.*

M. Deshayes, in describing *Thracia Bazini*, considered it as not improbably the same shell as that described by Prof. Morris as *Psammobia Condamini*, although presenting some differences in exterior form which induced him to give it provisionally under a different specific name; and being, for a similar reason as that which influenced Mr. Morris, uncertain as to the genus he preferred rather to place it among *Thracia.*

Mr. Meyer has sent me several valves of *Condamini*, but they are all of them so fixed with the interior downwards in the indurated material as to preclude the possibility of the hinge being seen, but a single specimen of a shell so closely resembling *Condamini* in its peculiar external form as to leave little doubt of its being another species of the same genus has had the hinge worked out, so as to show pretty nearly its true characters; and I find that this does not correspond with the hinge of either of the genera to which *Condamini* has been thus referred, nor indeed does it strictly accord with any genus known to me. It will be seen from the specimen of *Dulwichiensis* figured (which is the right valve) that the hinge has a depression for the cartilage or connector sloping towards the posterior side, and there is also a very small slit at the umbo through which probably the cartilage protruded, and a similar slit may be seen in the genera *Thracia*, *Scrobicularia*, and *Abra.* Our fossil has also two large cardinal teeth diverging from the umbo at different angles; but it has no lateral teeth, and in that respect it differs from *Abra;* and although it has not quite so large or expanded a depression for the cartilage as *Scrobicularia*, yet in respect of its hinge it corresponds most nearly with that genus, appearing to be intermediate between it and *Abra*, having probably the habits of the former. I have in consequence erected the genus *Scrobiculabra* for its reception. Mr. Bott's specimen has unfortunately the interior nearly filled with indurated material, which obscures the muscle marks; and as this cannot be removed without danger to the integrity of the specimen, I am unable to give a proper diagnosis of the genus in question, and therefore prefer, beyond what is said above, not giving any rather than what might prove a partially incorrect one. The interior connector, like those of *Mactra*, *Mya*, and *Thracia*, has a slight extension outwardly, as if in those genera the compression and expansion of the cartilaginous connector were not quite sufficient for the purpose of the animal, without the assistance more or less of the external ligament to enable it to keep the margins apart.

1. Scrobiculabra Condamini, *Morris.* Tab. A, fig. 1.

Psammobia? Condamini, *Morris.* Geol. Journ., vol. x, p. 138, pl. ii, fig. 15, 1854.
— — *Watelet.* Cat. Moll. des Sables inférieurs, p. 16, 1870.
Thracia Bazini? *Desh.* An. sans Vert. du Bas. de Par., p. 267, pl. xv, fig. 3, 1860.
Psammobia Condamini, *Whitaker.* Mem. Geol. Surv., vol. iv, p. 577, 1872.

Spec. Char. "*Testâ ovato-transversâ, inæquilaterali, depressâ, subinæquivalvi, concentricè et irregulariter striatâ, margine antico rotundato, postico rostrato, attenuato, sinuato, margine postico sub-incurvato, declivi.*"—*Morris.*

Length. $1\frac{3}{8}$ths of an inch.

Localities. Counter Hill, Upnor (*De la Condamine*).
Charlton, Deptford (*A. Bott*), Dulwich (*Meyer*).

Mr. Meyer has sent me several specimens of this shell, all of which seem to correspond sufficiently with the figure given by Morris as to show that they are the same shell. The specimen figured by me is a left valve, while that figured by Mr. Morris is a right one; and, as before observed, none of Mr. Meyer's specimens allow of the interior being seen. Mr. Whitaker speaks in his memoir of a second species of *Psammobia* from the Woolwich and Reading beds of Theale, and of Castle Kiln, Reading; but as the specimens were, he informs me, only casts, it is of course impossible to specifically identify them, or to say whether they belong to the genus which I have called *Scrobiculabra.*

2. Scrobiculabra Dulwichiensis, *S. Wood.* Tab. A, fig. 16 *a*—*c*.

Spec. Char. S. Testâ tenui, elongato-ovatâ, subinæquilaterali; concentricè et obsoletè striatâ; umbonibus depressis; latere antico rotundato, latere postico obtusè angulato. Margine dorsali subangulata, margine ventrali late arcuato.

Length, 1 inch; *height,* $\frac{1}{2}$ inch.

Locality. Dulwich (*A. Bott*).

The specimen figured as above, and referred to in the remarks introducing the genus *Scrobiculabra* is unique, but the characters presented by its exterior appear to me to differ from those of *Condamini* so as to justify its specific separation, and I have accordingly assigned it the name of *Dulwichiensis* from the place of its occurrence.

SPHENIA. *Turton*, 1822.

Generic Character. "*Testá transversá, inæquivalvi, inæquilaterali, latere antico hiante. Cardo valvæ sinistræ dente elevato transversim dilatato, dextræ dente concavo cum denticulo postico; lateralibus nullis. Ligamentum internum.*"—*Turton.*

The principal difference between this and *Mya* is in the impression of the mantle, which in *Mya* has a large, broad, and deep sinus. Messrs. Forbes and Hanley have given a representation of the animal inhabitant, which shows it to be different from that of *Mya*. There is also a difference in the dental furniture of the shell, the projecting support for the connecting ligament being more extended backwardly in the left valve, while in the right one there is a distinct denticle.

1. Sphenia? angustata, *J. Sowerby*. Tab. B, fig. 15 *a, b*.

Mya? angustata, *J. Sow.* Min. Conch., t. 531, fig. 1, 1826.
— — *Morris.* Catal. Brit. Foss., 2nd edit., p. 212, 1854.
— — *J. Lowry.* Chart. Brit. Tert. Foss., pl. ii, 1866.

Spec. Char. "Valves unequal; transversely elongated, thin, antiquated, irregularly compressed; extremities obtuse, gaping; lower edge of the lesser (right) valve concave." —*J. Sowerby.*

Length, $1\frac{1}{4}$ inch; *height*, $\frac{5}{8}$ths of an inch.

Locality. Colwell Bay (*Forbes*).

This long-known shell has a projecting process like that of *Mya truncata*, on which the cartilaginous connector is placed, but not exactly of the same form; and the sinus made by the mantle is smaller, comparatively, and less deep than in *Mya*. Mr. Morris, when describing what is a closely allied species, if it be not indeed a variety of the same shell, in the Geological Survey Memoir upon the geology of the Isle of Wight, has given to it the name of *Mya* (*Panopæa*) *minor*, of which he gives two varieties. I feel at a loss what generic name to give to this shell, but it cannot be placed among the *Panopææ* because the ligament or connector is in each differently placed; *Panopæa* having a projecting ledge on the outside of the dorsal margin for the support of the connector, which acts by elongation and contraction; whereas in *Mya* and in our present shell the connector is situated within the margins, and opens the shell by expansion in opposition to the action of the adductor muscles.

2. SPHENIA? MINOR, *Forbes*. Tab. B, fig. 16 *a*, *b*.

MYA (PANOPÆA) MINOR, *Forbes*. Mem. Geol. Surv., p. 146, pl. ii, fig. 4; and p. 149, pl. iii, fig. 3, 1856.

Spec. Char. "Shell transverse, compressed, elongately-ovate, very inequilateral; the anterior side narrow, posterior side slightly dilate, the surface corrugated by lines of growth, giving it an obscurely sulcated appearance. The anterior is about one third as long as the posterior portion, and the width about half the length. The umbones are nearer the anterior margin than in *P. intermedia* (Sow.), and the surface is less corrugated than in *P. corrugata* or even *P. intermedia*."—*Morris*.

Length, $1\frac{1}{4}$ inch; *height*, $\frac{9}{16}$ths of an inch.

Localities. Bembridge and Hempstead (*Forbes*).

Mr. Morris, in describing Forbes' species in the Geological Survey Memoir on the Isle of Wight, gives two varieties of this shell.

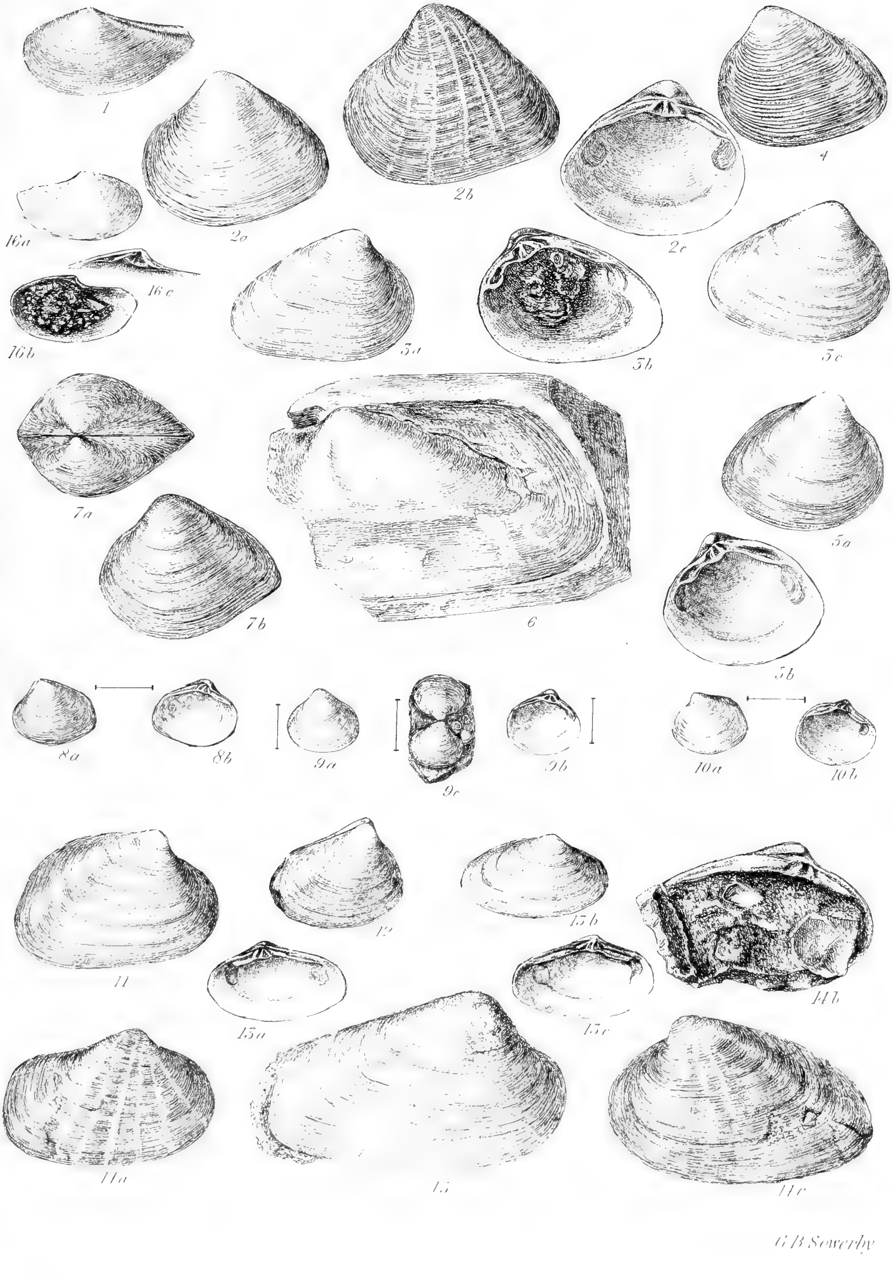
I cannot myself perceive sufficient differences in this shell to justify its separation from *angustata*, J. Sow., but as I am unwilling to disturb prior determinations under the circumstances in which I am compelled to leave the description of the British Eocene Mollusca incomplete, I have retained the species here.

INDEX TO SUPPLEMENT OF EOCENE BIVALVES.

PLATE A.

Fig.	
1.	Scrobiculabra Condamini, *p.* 21. Dulwich.
2 *a—c.*	Cyrena cordata, *p.* 4. Dulwich.
3 *a—c.*	,, cuneiformis, *p.* 5. Charlton.
4.	,, strigosa, *p.* 5. Charlton.
5 *a, b.*	,, Forbesii, *p.* 6. Charlton.
6.	Unio Michaudi, *p.* 1. Dulwich.
7 *a, b.*	Cyrena tumida, *p.* 9. Dulwich.
8 *a, b.*	,, ? intermedia, *p.* 7. Charlton.
9 *a—c.*	,, trigona, *p.* 8. Dulwich.
10 *a, b.*	,, crassa ? *p.* 3. Peckham.
11.	,, ? pullastra, *p.* 8. Dulwich.
12.	,, anceps, *p.* 9. Dulwich.
13 *a—c.*	,, tellinella, *p.* 10. Charlton.
14 *a—c.*	,, Dulwichiensis, *p.* 6. Dulwich.
15.	,, ? Edwardsii, *p.* 1. Dulwich.
16 *a—c.*	Scrobiculabra Dulwichiensis, *p.* 21. Dulwich.

Tab. A

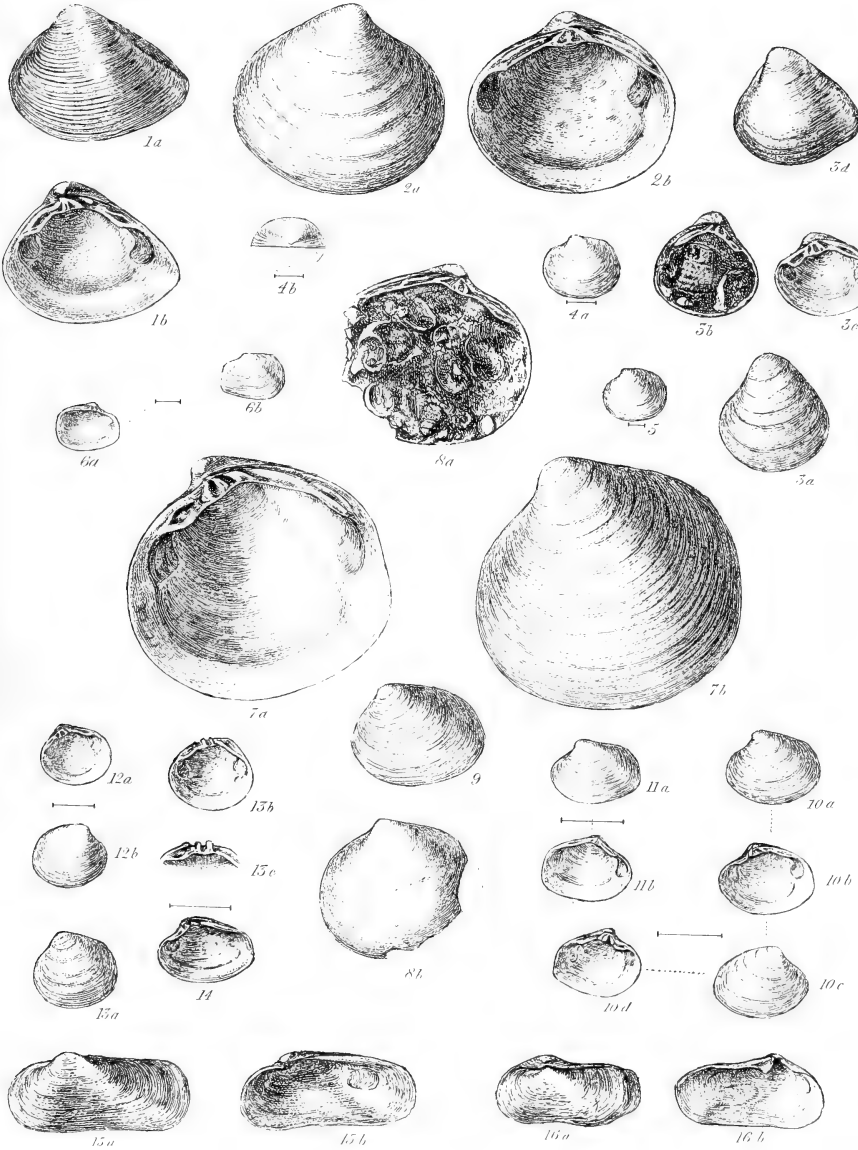


G B Sowerby

PLATE B.

Fig.		
1 *a*, *b*.	Cyrena semistriata, *p*. 10.	Hempstead.
2 *a*, *b*.	,, Britannica, *p*. 11.	Woolwich ?
3 *a*—*d*.	,, obovata, *p*. 12.	Headon Hill.
4 *a*, *b*.	Cyclas tumidula, *p*. 19.	Headon Hill.
5.	,, Bristovii, *p*. 18.	Hempstead.
6 *a*, *b*.	Cyrena gibbosula, *p*. 14.	Isle of Wight.
7 *a*, *b*.	,, pulchra, *p*. 15.	Hempstead.
8 *a*, *b*.	,, arenaria ? *p*. 16.	Headon Hill.
9.	,, tenera, *p*. 16.	Headon Hill.
10 *a*—*d*.	,, deperdita, *p*. 13.	Hordle.
11 *a*, *b*.	,, cycladiformis, *p*. 14.	Hordle.
12 *a*, *b*.	,, pisum, *p*. 14.	Hordle.
13 *a*—*c*.	,, obtusa, *p*. 12.	Headon Hill.
14.	,, obliqua, *p*. 15.	Hordle.
15 *a*, *b*.	Sphenia ? angustata, *p*. 22,	Colwell Bay.
16 *a*, *b*.	,, minor, *p*. 23.	Hempstead.

Tab. B.



G. B. Sowerby.

THE

PALÆONTOGRAPHICAL SOCIETY.

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MDCCCLXXVII.

A MONOGRAPH

OF THE

BRITISH FOSSIL TRIGONIÆ.

BY

JOHN LYCETT, L.R.C.P.E., &c.

No. IV.

Pages 149—204; Plates XXVIII—XL.

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In common with other examples of the *Costatæ* the marginal carina of the right valve is much larger than that of the other; it overwraps and partly conceals the post-carinal groove.

The other portion of the shell has about twenty-four large, plain costæ, all of which originate at the anterior border; they are small and delicate, their borders are indented or rendered nodulous by oblique, decussating lines of growth, which are conspicuous upon the anteal portion of the shell. At the curvature of the valve in passing to the side the costæ form a considerable downward curvature; they become horizontal about the middle of the valve, and form a second slight downward curvature as they approach the marginal carina, to which their extremities are united in the right valve, but the costæ of the other valve are separated from the carina, their extremities terminating abruptly at the well-defined ante-carinal groove.

Examples of the very young shell, when only four or five lines in length, have the anteal truncation less well defined; the three carinæ upon the area are prominent, acute, and without indentations; the intercarinal costellæ are scarcely formed, or there is a single small costella in each of the intercarinal spaces.

Comparative measurements of the two varieties:

The typical form	Diameter through the united valves $2\frac{7}{8}$ inches.
	Length upon the marginal carina $3\frac{6}{10}$ inches.
	Across the valve at right angles to the carina $2\frac{3}{10}$ inches.
Variety *lata*	Diameter through the united valves $1\frac{5}{10}$ inches.
	Length upon the marginal carina $2\frac{8}{10}$ inches.
	Across the valve at right angles to the carina $2\frac{3}{10}$ inches.

A good figure of the *left* valve representing the typical form is given by Agassiz ('Trigonies,' tab. iii, fig. 12), but figure 14, which is intended as a delineation of the area of the *right* valve, has apparently been drawn by the aid of a looking-glass from a specimen of the *left* valve, and is consequently altogether incorrect.

An excellent figure of the right valve is given by Quenstedt ('Der Jura,' p. 502).

Positions and Localities. Both varieties of *T. costata* occur together in beds of Inferior Oolite at various localities in the south-western counties, as at Bradford Abbas, from whence good illustrative specimens have been kindly forwarded to me by Professor Buckman; other well-known localities are Burton Bradstock, Chideock, Half-way House Quarry, Yeovil, Dundry, &c. Throughout the range of the Cotteswold Hills one or both of its varieties occur at many places, but apparently only over small areas; the external casts are sometimes clustered in great profusion in the bed called Upper Trigonia-grit, but good specimens with the tests preserved are comparatively rare.

In the extension of the same formation through Oxfordshire, Northamptonshire, Rutlandshire, and Southern Lincolnshire, the species is comparatively rare, and in Northern Lincolnshire it is absent.

In the North Riding of Yorkshire the Inferior Oolite occurs under other and peculiar conditions, and hitherto has not revealed *T. costata.* At Blue Wyke the Dogger yields numerous small valves, which have been attributed to this species, but their condition of preservation is such as to preclude any rigid scrutiny; upon the whole I am inclined to refer them to *T. denticulata,* which occurs in some abundance in a bed of limestone higher in the series upon the same coast. *T. costata* is absent in the Cornbrash of Yorkshire, in which the *Costatæ* are represented by two other large species.

A specimen of the typical form from the Cornbrash of Closworth has been kindly forwarded to me by Colonel Mansel Pleydell; it differs in no respect from Inferior Oolite examples.

The specimens quoted by Agassiz are from the Cantons of Bâle and of Soleure; the large specimens in Quenstedt's work ('Der Jura,' p. 502) is from Ehningen.

In Southern Germany the species also occurs in the highest zone of the Lower Oolites at Ehningen, associated with various Testacea well known in the Cornbrash of Britain.

The localities, both British and foreign, assigned to *T. costata* are very numerous, but as some of them do not appear to have been founded upon trustworthy specimens or upon sufficient critical knowledge of the species, but little confidence can be reposed in such determinations. The following remarks refer to specimens which have been figured:

The figures attributed to *T. costata* in the work of Knorr, Verst., Suppl., tab. 5 *c*, figs. 3, 4, are coarsely engraved, and are scarcely trustworthy illustrations of any fossil species; they are certainly distinct from *T. costata,* but appear to agree with our *T. sculpta*, to which they are referred.

To the same species should be united the *T. costata* of the 'Encyclopédie Méthodique,' Supplement, table ccxxxviii, fig. 1 *a, b.*

Also the figure of *T. costata* in the 'Lethæa Geognostica' of Bronn, table xx, fig. 4.

The *T. costata* of Zieten, 'Petref. Würtemb.,' tab. cxxxvii, fig. 3 *a, b*, appears to agree with *T. denticulata.*

The *T. costata* of Parkinson, 'Org. Rem.,' vol. 3, tab. xii, fig. 4, is altogether untrustworthy; the costated portion of the valve may represent the typical form, but the ornamentation of the area is a mere work of invention; the same remark will also apply to the surface-ornament of the escutcheon, the outline of which is also erroneous.

The *T. costata* of Smith, 'Strata Identified,' fig. 4, is a good representation of our *T. sculpta,* var. *Rolandi,* from the Cornbrash of the southern counties, and also of Lincolnshire.

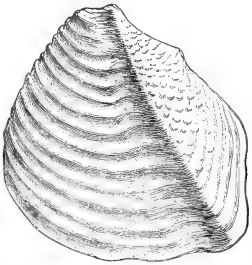
The *T. costata* of Young and Bird, 'Geol. Survey York. Coast,' tab. viii, fig. 19, is *T. Meriani,* Ag., from the Coralline Oolite of Yorkshire and of the southern counties.

The *T. costata* of Sowerby, in Grant's memoir "On the Geology of Cutch," 'Geol. Trans.,' 2 ser., vol. 5, pl. 21, fig. 17, appears to agree with our *T. elongata*, var. *lata.*

Pusch, 'Polens Paläontologie,' p. 58, tab. 7, figs. 1, 2, described and figured, as a variety of *T. costata,* a remarkable example of the section in which, as also in the *glabræ,* a diagonal space exists, anterior to the marginal carina, entirely devoid of ornamentation; this species was separated by Agassiz under the name of *T. zonata* ('Trigon.,' p. 36), and by Quenstedt as *T. interlævigata* ('Der Jura,' p. 503, tab. lxvii, fig. 8). Oppel also described it under the latter name ('Juraformation, p. 486, No. 49). Apparently it pertains to the horizon of the Cornbrash at Ehningen, Oeschingen, also near Freiburg.

A shell figured by Goldfuss under the name of *T. costata,* var. *triangularis* ('Petrefacten.,' t. cxxxvii, fig. 3 *d*), is evidently nearly allied to *T. zonata,* but is apparently distinct. The outline presents some differences in the greater height and shortness, and in the greater elevation of the escutcheon; other distinctions consist in the delicate costellæ upon the area, the small carinæ, and the more numerous and delicate costæ; it is from the Black Limestone of Lübke, the geological position of which I am unable to correlate; both of these forms are unknown in British strata.

The *T. costata* of Chapuis and Dewalque ('Foss. Ter. Second. de Luxembourg,' p. 170, pl. 25, fig. 8) represents an elegant species, which differs not only from *T. costata,* but also from every other example of the section known to me; it is remarkable for the great extent to which the anterior side is produced, so that the recurved apices of the valves are placed a little posterior to a line drawn perpendicularly through the middle of the shell; the escutcheon is remarkably large and transversely minutely costulated; the ligamental fossa is unusually lengthened; the area is very narrow, with a minutely reticulated surface, which is represented as alike upon both the valves; the bounding carinæ are small, and accord with the other delicate features of the area; the siphonal border is unusually short: altogether, the drawing differs so materially from the description given in the text as to lead to the conclusion that the latter was founded upon true examples of *T. costata,* and that by some error another costated form was substituted in the plate for the species intended to be represented.



Trigonia Moorei, Lyc. Western Australia.

Another interesting allied species, derived almost from our antipodes, is *T. Moorei,* Lyc. (Moore's memoir on "Australian Mesozoic Geology," 'Quart. Journ. Geol. Soc.,' vol. xxvi, p. 254, pl. 14, figs. 9, 10). Allied in its general aspect to *T. costata,* it differs in having the general figure more depressed; the escutcheon is unusually narrow and lengthened; the area is larger, more convex, and more expanded; it is distinctly bipartite, but has no median carina; the inner carina is slightly nodular and inconspicuous. The costæ are short and curved concentrically; anteally they approach the border almost perpendicularly; there is no distinct anteal truncation; the marginal carina of the right valve is much larger than that of the other. Numerous examples have been brought from Western Australia, but the locality and geological position have not been exactly ascertained.

TRIGONIA DENTICULATA, Ag. Plate XXIX, figs. 1, 2, 3, 4.

TRIGONIA COSTATA, *Zieten.* Petref. Würtemb., tab. cxxxvii, fig. 3 *a, b,* 1838.
— DENTICULATA, *Agassiz.* Trigonies, p. 38, tab. xi, figs. 1—3, 1840.
— SCUTICULATA, *d'Orbigny.* Prodrome de Paléont., vol. i, p. 278, No. 314, 1850.
— DENTICULATA, *Sharp.* Oolites of Northamptonshire, Quart. Journ. Geol. Soc., vol. xxvi, p. 388, 1870.
— — *Phillips.* Geology of Yorkshire, vol. i, p. 250, 3rd ed., 1875.
— — *Judd.* Mem. Geol. Surv., Rutland, &c., pp. 153, 281, 1875.

Shell smaller than *T. costata,* more ovately trigonal, and less convex; umbones prominent, pointed, much incurved and more or less recurved; anterior border produced, curved elliptically with the lower-border; hinge-border straight, sloping obliquely; its posteal extremity forms an obtuse angle with the siphonal border of the area. The area is wide and flattened, the plane of its surface forming a considerable angle with the surface of the other portion of the valve; it is bounded by two well-marked denticulated carinæ, having also in the left valve occasionally a small median carina or a costella somewhat larger than the others and separating the area into two portions, the superior one of which is depressed and concave; the intercarinal spaces have numerous small denticulated costellæ which vary much in their prominence in different specimens; in the right valve the costellæ are fewer and more irregular and unequal; there is a median groove but no distinct median carina; the marginal carina is prominent, rounded, and denticulated even to the apex; the escutcheon is lengthened, moderately wide, and slightly depressed; its superior border is somewhat elevated, its ornamentation consists of very small diverging delicately serrated plications. The other portion of the valve has the costæ differing much in numbers, narrow, usually numerous, horizontal, curved upwards to form a slight undulation anteally, so that all the costæ terminate at the anterior border. Specimens differ in the length, measured in the direction of the costæ, and also in the general convexity.

Examples from Cloughton have not uncommonly the epidermal tegument preserved over a considerable portion of the surface; the lines of granules are large and closely arranged; the matrix of soft shale appears to be the cause of this favorable condition of preservation. The lines of growth are peculiarly delicate and densely arranged.

This is an elegant and moderate-sized species of the *Costatæ;* specimens differing considerably in their general outline, and less so in the prominence of their carinæ and intercarinal costellæ; the latter are never large, usually delicate or minutely denticulated. Commonly there is no median carina excepting in the very young shell which usually has the carinæ and costellæ strongly defined; the area is also more concave.

The acquisition of numerous well-preserved valves from the grey limestone (Inferior Oolite) of Cloughton, near Scarborough, has enabled me to compare and separate from them without difficulty, a small, more narrow, costated form which occurs rather abundantly in the Great Oolite of South Lincolnshire; the valves have usually suffered compression and are rarely well preserved; a specimen in unusually good condition is figured, Pl. XXIX, fig. 4. The costæ are usually smaller and more numerous, the escutcheon more narrow, and the hinge-border shorter than in the Inferior Oolite specimens of *T. denticulata;* they are equally distinct from other recognised species: upon the whole it seems proper to arrange them as a variety of *T. denticulata.*

Affinities and Differences. Agassiz described *T. denticulata* from a single specimen, and expressed his indecision whether to regard it as a distinct species or only as a variety of *T. monilifera;* his figures of each of these species represent a single example of immature form in which the characteristic features are but slightly developed, and *T. denticulata,* although figured from a specimen in a fine condition of preservation, possesses but little of the aspect exhibited in specimens of more advanced growth, which have less general convexity, less prominence in their carinæ; and their areas are less concave.

T. monilifera, a much larger species, has its surface-ornaments altogether more prominent; its costæ are larger and more distantly arranged; the escutcheon more especially has its surface-ornaments very distinct.

T. pullus, a small species abundant in the Lower Oolites of Gloucestershire and Wiltshire, has larger costæ; the surface-ornaments of the area are coarse and conspicuous; the escutcheon is also especially distinct.

T. sculpta, including its varieties, has greater convexity, the area much more coarsely and prominently sculptured; the simple flexure upwards of their costæ, anteally, contrasts with the undulation in *T. denticulata.*

Trigonia costata differs from *T. denticulata* in the general form, which is more trigonal, truncated, and erect; in the conspicuous truncation of the anterior border; in the peculiar undulation of the costæ; in the more prominent area with its larger reticulations; it has also larger carinæ, with more conspicuous indentations.

Positions and Localities. *T. denticulata* appears to have a considerable and unusual extent of stratigraphical range, if I am correct in placing with this species costated forms nearly allied to each other, which occur in several widely separated horizons of the Lower Oolites. Possessing little prominence in their characters as species, they have nevertheless much general resemblance, and are incapable of being clearly separated; so that, as compared with other forms, they may be distinguished from them chiefly by negative characters only. The partial indecision which attaches to certain supposed examples of

T. denticulata has not resulted from any insufficient examination or lack of materials, unless indeed it may be of specimens which are required to be exceptionally well preserved to enable us to estimate fairly the amount of variability which they possess. It would have been easy to have increased the number of figures of such specimens upon our plates; the practical utility, however, of this would have been doubtful, and I content myself with offering the present explanation, together with the following brief statement of geological positions which have come under my observation.

A fine specimen was obtained by Mr. Witchell in the highest bed of Supra-liassic Sandstone, at Haresfield Hill, near Gloucester. I obtained the species in the same position, and accompanied by *T. formosa*, in the celebrated Ammonite-bed at Frocester Hill. In the Inferior Oolite of the Cotteswold Hills it is comparatively rare; the only specimens known to me were from the hard limestone of the Upper Trigonia-grit at Rodborough Hill. In the same formation through the midland and northern counties it appears to be a more common species. Upon the coast of Yorkshire at Blue Wyke the Dogger has numerous ill-preserved costated forms, and also the Millepore-bed upon the same coast, in a higher position, which should probably be referred to it, but hitherto only doubtfully. The grey limestone and shale near to Cloughton, higher in position, has produced numerous examples of different stages of growth, delicately preserved in a thinly laminated soft shaly bed. Apparently also the species may be tabulated with the Kelloway Rock, to the southward of Scarborough at Cayton Bay, but valves are rare and ill preserved; a specimen in my cabinet with the valves in position and free from compression offers no distinction when compared with Inferior Oolite specimens. The small, supposed variety from the Great Oolite of South Lincolnshire, having the general figure somewhat shorter, and the habit gregarious, has been already noticed (p. 153).

TRIGONIA ELONGATA, *Sow.* Plate XXX. The typical form, figs. 3, 3 *a*, 3 *b*, 6.
— — *ib.*, var. *angustata*, Lyc. Plate XXX, figs. 1, 1 *a*, 2.
— — *ib.*, var. *lata*, Lyc. Plate XXX, figs. 4, 5.

Trigonia elongata of various authors; for figures refer to the following works:

TRIGONIA ELONGATA, *Sowerby.* Min. Conch., tab. ccccxxxi, figs. 1, 2 (exclude fig. 3, a distinct variety from France), 1825.
— COSTATA, *var.* Sowerby in memoir by Grant on the Geology of Cutch, Trans. Geol. Soc., 2nd series, vol. v, pl. xxi, fig. 16, 1837.
— ELONGATA, *Damon.* Geo. of Weymouth, Sup., pl. ii, figs. 1, 2, 1860.
— — *Lycett.* Suppl. Monograph Great Oolite Mollusca, Pal. Soc. for 1861, p. 46, tab. xxxix, fig. 6, 1863.

The typical form ovately trigonal, short, very convex at the position of the marginal carina; umbones elevated, pointed, much arched inwards, and somewhat recurved; anterior side short, its border truncated, lengthened, depressed at the junction of the valves, its lower portion curved elliptically with the lower border, which is short and nearly straight; hinge-border very convex and short, forming a considerable angle with the siphonal border, which is equal to it in length and is excavated at its upper or anal portion. Escutcheon raised, convex, cordate; its breadth in the united valves is equal to three fourths of its length; it is well circumscribed by a prominent indented inner carina, and has a series of large, closely arranged, obliquely diverging, dentated, but depressed costellæ. Area very large; together with the escutcheon it is equal in size to the other portion of the valve, with the surface of which it forms nearly a right angle; its greatest breadth measured upon the siphonal border exceeds half the height of the entire valve; it is bounded outwardly by a large, deeply indented, marginal carina; a small but well-defined median carina divides it into two nearly equal portions; the superior portion is depressed and concave; it has a numerous series of minute, delicate, oblique, reticulated costellæ; the other or outer portion of the area has in the right valve only one or two large indented costellæ; the median carina in its lower portion usually divides into two similar costellæ; the lower portion of the other valve has four or five costellæ. The marginal carina of the left valve somewhat overwraps the ante-carinal groove; in the right valve the post-carinal groove is conspicuous, and the marginal carina is much larger than that of the other valve. The transverse striations upon the costellæ of the area are minute and delicate—a feature which affords a contrast to the more deeply sculptured indentations upon some other species of the *Costatæ*. The other portion of the surface has the costæ large, elevated, short, and only slightly oblique in their general direction; anteally they have a small, sudden undulation at the curvature of the valve, and become attenuated near the border; their number in adult forms varies from eighteen to twenty-seven. In the left valve their posteal extremities end suddenly at the border of the ante-carinal groove, where each forms a slight enlargement; in the right valve they pass onwards and are united to the marginal carina.

Dimensions of an adult specimen.—Height 30 lines; diameter of a valve at right angles to the marginal carina 21 lines; across the area of the united valves 21 lines; length of the escutcheon 15 lines; its breadth 9 lines.

There is great uniformity in the surface-ornaments in specimens of different states of development, belonging to the typical form; the area and escutcheon more especially are almost without variation, and differ only in the convexity of the escutcheon, thus rendering the hinge-border either horizontal or oblique. Specimens with the valves united often have them perfectly closed by the oblique opposition of the extremities of the marginal carina, thus indicating the exertion of muscular power when they were overwhelmed by a muddy current unfitted to be introduced into the gills by the incurrent orifice.

Altogether the characters of the *Costatæ* are more prominently developed in the typical form of *T. elongata* than in any other British example of the section; the elevated cushion-like escutcheon and the considerable concavity formed by the upper division of the area separate it both from its varieties and from other allied forms.

Position and Localities. It is not an uncommon fossil in the Oxford Clay of the southern counties of England; numerous and fine examples have long been obtained in the Backwater to the rearward of the town of Weymouth. The figures 1 and 2 of pl. ccccxxxi in Sowerby's 'Mineral Conchology' are good representations of the right and left valves from that locality; apparently figure 3, which is a French specimen, should be united to *T. cardissa*, Ag.

Variety Angustata. A very narrow form, lengthened perpendicularly, and having considerable convexity near the umbones, is depicted in Plate XXX, figs. 1, 1 *a*, 2. The costæ are numerous, more closely arranged than in the typical form, short, and nearly horizontal, excepting upon the anteal face of the valve, where they have a slight horizontal undulation. The marginal carina is comparatively inconspicuous, with small, numerous, transverse indentations. The surface of the area is similar to that of the typical form, excepting that it is not concave. The escutcheon is lengthened, sloping obliquely downwards; it has less breadth than in the typical form; its upper border is convex. Our figures represent specimens of the largest dimensions.

Position and Localities. The variety *Angustata* appears to be limited to the Cornbrash of the north of England. My few specimens are from the vicinity of Scarborough, where it has occurred only rarely; the narrow form, abrupt truncation of the lengthened anterior border, and short, horizontal costæ will usually separate it from another larger and more common variety in the same bed, or *Macrocephalus-zone* of Quenstedt and Oppel.

Variety Lata. This, the largest of the *elongata* group, is almost limited to the Cornbrash, an occasional badly preserved specimen having been obtained in the lowest bed of Kelloway Rock at the same Yorkshire locality. It is moderately abundant, occurring very rarely with the valves united; for the most part it is ill preserved, especially the surfaces of the area and escutcheon; our figures, Plate XXX, figs. 4, 5, appear to illustrate it sufficiently. The general convexity is considerable, but scarcely equals that of the typical form.

There is much variability in the proportions of the general figure; usually the area has less breadth, and is more elevated, than in the typical form; its surface forms a smaller angle with that of the other portion of the valve; its upper or inner division is more flattened, but has some depression; and the median carina is distinct. The costated portion of the valves varies in breadth and in the distinction of its anteal truncation; the costæ are large, their general direction is oblique, and they have an horizontal undulation upon the anteal surface. The marginal carina in each valve is large, but less prominent than in the typical form. The escutcheon is large and usually flattened; it slopes obliquely downwards; its length is much greater than that of the siphonal border; its surface has rugose, irregular, oblique, depressed, large-knotted costellæ; they appear to be variable in character. The interior of the valves have the dental hinge-processes unusually large and prominent.

Positions and Localities. This large variety has been obtained only in the Cornbrash of the north of England; the large valve, fig. 4, is from Southern Lincolnshire, the others are from the vicinity of Scarborough; occasionally specimens in the shortness of their costated surfaces approach to the variety *angustata,* but usually the two forms are sufficiently distinct.

The lines of growth are conspicuous upon well-preserved examples of all the varieties; when they are of fully developed growth the lines replace all the surface-ornaments.

To the Weymouth or typical form apparently should be assigned a *Trigonia,* which occurs in the Elsworth Rock of Cambridgeshire, examples of which have been forwarded to me by Mr. J. F. Walker; their condition of preservation is indifferent.

Trigonia cardissa, Agassiz, so well delineated in the work of that author ('Trigonies,' tab. xi, figs. 4—7), should be arranged as distinct from *T. elongata.* There is much general neatness in the surface-ornaments; the escutcheon is depressed; the marginal carina is comparatively small; the costæ are narrow, somewhat oblique, and curved almost perpendicularly upwards upon the anterior face of the shell, which forms a considerable excavation; this last feature in the costæ separates it decisively from the British group allied to it. Agassiz did not ascertain the stratigraphical position of *T. cardissa;* both Quenstedt and Oppel refer it to the Kelloway Rock of France and Switzerland. D'Orbigny ('Prodrome de Paléont.,' vol. i, p. 338, No. 161) makes *T. cardissa* a synonym of *T. elongata,* but excludes figures 1 and 2 of the 'Mineral Conchology,' which are Weymouth specimens, and unites them to the Neocomian *T. carinata* of Agassiz. These arrangements were made in the absence of sufficient knowledge of British species. *T. cardissa* is not known as a British species.

Trigonia sculpta, *Lyc.* Plate XXXIV, figs. 1, 2, 2 *a.*
— — *ib.,* var. *Cheltensis,* fig. 3.
— — *ib.,* var. *Rolandi,* fig. 4.

Trigonia costata, *Knorr.* Versteinerungen, Supplement, tab. v *c*, figs. 3, 4, 1772.
— — *Smith.* Strata Identified, Cornbrash, fig. 4, 1816. (Var. *Rolandi,* Cross.)
— — *Deshayes.* Encycl. Méthod., Suppl., tab. ccxxxviii, fig. 1, *a*, *b*, 1836, 1838.

LYRIODON COSTATUM, *Bronn.* Lethæa Geognostica, tab. xx, fig. 4, 1837, 1838.
TRIGONIA SCULPTA, *Lycett.* Handbook Cotteswold Hills, p. 65, 1857.
— — *Sharp.* Oolites of Northamptonshire, Quart. Journ. Geol. Soc., vol. xxix, p. 293, 1873.
— ROLANDI (*Lyc.*), *Cross.* Geol. of N. W. Lincolnshire, Quart. Journ. Geol. Soc., vol. xxxi, p. 125, 1875. (Var. of *T. sculpta*).
— SCULPTA, *Judd.* Mem. Geol. Survey, Rutland, &c., p. 281, 1875.

Shell subovate or ovately oblong, moderately convex; umbones prominent, pointed, subanterior, and slightly recurved; anterior side short, its border curved elliptically with the lower border; superior border straight, lengthened, forming an obtuse angle with the siphonal, the length of which it exceeds by one fourth. The escutcheon is lengthened, flattened, and depressed; it has some oblique irregular plications which take the direction of the lines of growth. The area has some convexity, more especially in the right valve; its greatest breadth is somewhat less than one third the breadth of the entire valve; it is rendered conspicuously bipartite by the considerable depression of the superior half; it is bounded by two deeply dentated carinæ; the intercarinal costellæ are few, large, and somewhat irregular; all are coarsely denticulated and in some specimens the first costella of the lower or outer half is slightly larger than the others, forming a median carina, a feature which is not distinct in the right valve, which has the lower half of the area more elevated and its costellæ larger. The marginal carina is large in both the valves and its denticulations are very prominent. The costæ, about twenty-seven in fully developed forms, are curved obliquely or subconcentric, are somewhat narrow and flattened, with little elevation; anteriorly their extremities are simply curved upwards; their posteal extremities approach the marginal carina nearly at right angles. In the right valve the few last-formed costæ have frequently some irregularity and less prominence, or become imperfect.

The foregoing description applies to the larger or typical form, a species as large as *T. costata*, from which it differs in some important features. The general figure is less trigonal; it has less convexity at the angle of the valve; the umbones are more pointed and terminal; the anterior border, although little produced, has nothing of the truncation of the other species; the area is somewhat less wide; its surface-ornaments, together with those of the bounding carinæ, are much larger or more coarsely sculptured; the costæ are curved obliquely, having a simple curvature upwards towards the anterior border; they are therefore destitute of the anteal undulation and slight double flexure which characterise those features of *T. costata.* The test is thick and the hinge-processes are so large that they occupy nearly one third of the interior of the shell.

Positions and Localities. *T. sculpta* has occurred rarely in the highest or Ammonite-bed of the Supra-liassic Sands at Haresfield Hill, near Gloucester; its more common position is the Gryphite-grit or Lower Trigonia-grit of the Cotteswold Hills, near Stroud and Cheltenham, where it has occurred abundantly; other localities are Dundry

Hill, and the Inferior Oolite of Oxfordshire and Northamptonshire; Mr. Sharp has also collected it in the Lincolnshire Limestone of Tinkler's Quarry near Shamford.

A distinct and smaller variety (*Cheltensis*) occurs in the Cotteswold Hills to the eastward of Cheltenham; the general outline agrees with the typical form, but the valves have somewhat less convexity and are less massive; the costæ are much smaller and more closely arranged; the area and escutheon possess all the strongly marked characters which distinguish the species. Plate XXXIV, figure 3, exemplifies this variety.

A variety designated *Rolandi* in Mr. Cross's memoir, Plate XXXIV, fig. 4, must also be arranged with *T. sculpta;* it appears to be limited stratigraphically to the upper division of the Great Oolite formation, including the Forest-marble and Cornbrash. It was figured by the venerated author of "Strata Identified," at p. 65 of that work, as a characteristic fossil of the Cornbrash. Its surface-ornaments agree closely with those of the typical form, from which it differs in the lesser breadth of the costated portion of the valve, so that the general figure is shorter, and the area, which is very wide, occupies a much larger proportion of the surface; the carinæ and intermediate costellæ, with their denticulations, possess all the prominence which characterises the two other varieties, and these features are conspicuous even in the smaller specimens. Our figure, Plate XXXIV, fig. 4, represents a specimen of medium size. This variety has occurred at several localities in Wiltshire, Oxfordshire, and Northamptonshire, and also at Appleby, North-Western Lincolnshire; it appears to be somewhat rare.

Affinities.—The Lyriodon simile of Bronn ('Lethæa,' tab. xx, fig. 3), afterwards figured by Agassiz under the name of *Trigonia similis* ('Trigon.,' tab. ii, figs. 18—21), also by Quenstedt ('Der Jura,' tab. xlv, fig. 15) under the name of *T. costata,* has affinities with *T. sculpta* in the general figure of the shell and more especially in the costæ; the coarsely sculptured area also possesses some resemblance. It differs in the general uniformity of the area, which is almost destitute of a median carina, and in the much greater angle which the surface of the area forms with the other portion of the surface, from the lesser convexity of the shell; the dental processes are also smaller and less massive, occupying a smaller portion of the interior of the shell.

The Australian *T. Moorei,* Lyc., figured with the description of *T. costata* (p. 151), resembles *T. sculpta* in the general figure and in the costæ; the surface-ornaments of the area, including the carinæ, are, however, much less prominent, the escutcheon is much narrower, imparting a greater depression to that portion of the shell.

The figures named *T. costata* in the 'Versteinerungen' of Knorr and in the 'Encyclopédie Méthodique,' appear to have been drawn from specimens of *T. sculpta;* they are very coarsely engraved, and the surface-ornaments present features apparently much exaggerated, even when compared with the deeply indented sculpture of that species.

TRIGONIA TENUICOSTA, *Lyc.* Plate XXXIII, figs. 7, 8, 9, 9 *a*.

TRIGONIA TENUICOSTA, *Lycett.* Trigonias from Inf. Ool. of the Cotteswolds, Proc. Cott. Nat. Club, vol. i, p. 252, pl. ix, fig. 4, 1853.
— — *Morris.* Catalogue, p. 229, 1854.
— — *Lycett.* Cotteswold Hills Handbook, p. 64, 1857.
— — *Judd.* Mem. Geol. Surv., Rutland, &c., pp. 153, 170, 281, 1875.

Shell ovately trigonal, very convex; umbones elevated, acute, arched inwards, and recurved; anterior side very short, its border truncated almost perpendicularly, and slightly excavated beneath the umbones; inferior border short, curved elliptically; hinge-border sloping obliquely, and forming an obtuse angle with the siphonal border, which is nearly perpendicular and equal in length to the hinge-border. Area large, concave; its surface forming nearly a right angle with the costated portion of the valve; it is rendered unequally bipartite by a minute but distinct median carina in each valve; the superior or inner portion is much depressed and concave; the entire area has numerous delicate oblique intercarinal costellæ, and is bounded by small, minutely indented, distinctly elevated carinæ. The marginal carina has its transverse plications very narrow, numerous, and nearly regular; their number is equal to thrice those of the costæ. The escutcheon is wide, heart-shaped, with the valves in contact, and slightly depressed; its superior border is convex; its surface is occupied by densely arranged oblique lines of minute granulated lineations. The other portion of the surface has the costæ, about twenty-eight in number, narrow, elevated, nearly horizontal, curving upwards anteally, and there forming a sudden undulation, their attenuated extremities meeting the anterior border horizontally. The lines of growth are minute.

The hinge-processes are large, and project considerably, in common with others of the *costatæ* which have much umbonal convexity.

Dimensions of the larger of the specimens figured.

Length measured upon the marginal carina	36 lines.
Across the valve at right angles to the carina	27 ,,
Breadth across the area	9 ,,
Across the escutcheon of a single valve	$3\frac{1}{2}$,,
Thickness through a single valve	9 ,,

The diagnostic characters may be summarised as follows:

Considerable convexity of the valves.

Narrow elevated figure, and prominent umbones.

Anteal truncation.

Wide concave area and escutcheon.
Delicately sculptured small carinæ and intercarinal costellæ.
Small horizontal costæ with their anteal undulation.

During many years only two examples of this form, from the Cotteswold Hills, have come under my notice; and, in the absence of all other information, frequent comparisons with Inferior Oolite examples of the *Costatæ* were made in the expectation that connecting forms might be found tending to unite it with them, but without result. At length five examples of *T. tenuicosta* were placed in the British Museum from the Inferior Oolite of Bradford Abbas; subsequently various specimens in differing conditions of preservation were kindly forwarded to me by Professor Buckman, from the same locality; Colonel Mansel Pleydell has also contributed a small specimen obtained by him in the Inferior Oolite at Walditch near Bridport. Comparisons of these materials have removed all doubts of their distinctness from others of the same section, and justified the separation which had been claimed by me for it in the year 1853.

Position and Localities. At Walditch, two miles from Bridport, the Inferior Oolite is seen to rest upon the Midford or Supra-liassic Sands. At Bradford Abbas, *T. tenuicosta* occurs in a single bed from three to five feet thick, termed by Professor Buckman the *Cephalopod-bed,* from the very numerous and finely preserved species of Inferior Oolite Ammonites which it has produced; it has also yielded a profusion of other Molluscan forms; the associated *Trigoniæ* consist of two varieties of *T. costata,* two varieties of *T. striata,* a variety of *T. formosa,* also *T. bella,* which is the next species described. The Cotteswold examples of *T. tenuicosta* were obtained in the Gryphite-grit of Inferior Oolite at Rodborough Hill, associated with a multitude of valves of Conchifera, including *Trigonia sculpta, T. formosa, T. Phillipsii,* and *T. hemisphærica;* the two latter species very rarely. At the same locality, by passing upwards some twenty feet, a hard shelly bed called Upper Trigonia-grit is attained, abounding in fossils which are for the most part altogether distinct from those of the lower shelly bed; the *Trigoniæ,* which are also distinct, consist of the following species: *T. costata* (two varieties), *T. signata, T. producta, T. duplicata, T. angulata, T. V-costata, T. gemmata,* and *T. denticulata.* Both beds are, as a rule, destitute of Ammonites, excepting that the upper bed has rarely been found to contain a specimen of *A. Parkinsoni.* The associations of *Trigoniæ* here enumerated apply to beds of Inferior Oolite in the Cotteswold Hills; their dissimilarity to the *Trigoniæ* of the same formation in the Somersetshire and Dorsetshire district is remarkable, more especially considering the small space by which they are separated.

A nearly allied and remarkable form of the *Costatæ* occurs in the rich fossiliferous bed of Inferior Oolite in the vicinity of Bayeaux; the general figure differs only slightly; it is apparently even shorter and more inflated; the anteal truncation is somewhat less decided. The most striking peculiarity consists in the presence of a minute row of regular beadlike papillæ upon the edges of the costæ, more especially of their posteal portions; these close-set papillæ have each also a slight depression upon its middle portion; the small transverse plications upon the marginal carina have also each a row of similar, more minute, papillary prominences. Apparently this ornamented surface is rarely preserved; my specimen has it only upon the right valve, and it is not distinguishable upon examples in the British Museum. I propose to designate this species *T. fimbriata*. *T. granigera*, Cont., from Upper Jurassic strata near Berne (Calcaire à Corbis), has fringing papillæ upon its costæ, but less regular and distinct; its costæ are smaller and more numerous; the general figure is also very different, with much less convexity.[1]

TRIGONIA BELLA, *Lyc.*, sp. nov. Plate XXXII, figs. 6, 7, 8, 8 *a*.

Founded upon fine examples of shells in different stages of growth, this species is found to possess little variability in its figure and none in the ornaments of its surface; young examples have somewhat less convexity and the figure is more lengthened, as exemplified, Plate XXXII, figs. 8, 8 *a*. Upon the whole the size is smaller than in several of the larger species of the section. Its more salient features consist in the unusually great breadth and prominence of the area, contrasted with the comparatively narrow costated portion of the shell; hence it follows that the posteal or siphonal border of the area has unusually great length, even exceeding that of the escutcheon—a feature which is not observed in any other British example of the *Costatæ*.

Diagnostic characters. Shell convex mesially, much produced and pointed at its umbonal extremity, which is only slightly, or sometimes not at all recurved. Escutcheon narrow, depressed, and excavated, so that no portion of it is seen when a valve is laid horizontally upon its borders and viewed from above; its length exceeds twice its breadth in the united valves; its borders are well circumscribed by the inner carinæ, which form an elevated ridge on each side, fringed with large obtuse nodes. The surface of the escutcheon has a numerous series of very delicate, diverging, slightly indented costellæ, which are remarkable for their distinctness and minuteness.

The area is divided into two nearly equal spaces by an unusually large, elevated, and nodose median carina; the inner or anal space has a considerable and unusual amount of concavity in both the valves; its costellæ, eight or nine in number, are very irregularly knotted or indented; the lower or outer space is more flattened, but also more elevated, having about eight intercarinal costellæ in the left valve; the right valve has only three or four larger costellæ, and its surface is more elevated. The marginal carina is

[1] For a detailed and instructive paper on the Inferior Oolite as exhibited at Bradford Abbas and the vicinity, see the 'Somersetshire Archæological and Natural History Society's Proceedings,' 1874, vol. xx, by J. Buckman, F.G.S., &c.

large, prominent, nearly straight, with deeply indented plications throughout its length. The other portion of the shell has the costæ (28 or 29) moderately elevated, narrow at their upper borders, separated by wider spaces, very oblique in their direction, and have little curvature; when the upper border of a valve is placed in a horizontal position, the costæ have their general direction nearly parallel with it, excepting near to the anterior border, where they are attenuated and curve upwards; they are therefore without the anteal undulation seen in *T. costata*, *T. tenuicosta*, and others of the same section; posteriorly they terminate abruptly at the strongly defined antecarinal groove of the left valve; they are united to the carina of the other valve. The lines of growth are conspicuous; they decussate and indent the anteal portions of the costæ.

Affinities and Differences. To separate it from *T. costata* it is only necessary to compare the general figure and proportions of the several parts of the valves above described, which will be found to be altogether dissimilar; the escutcheon, small, excavated, with very delicate costellæ, would alone be sufficient to exemplify its distinctness.

T. tenuicosta, another allied species, has the umbones much more narrow and produced; the general convexity is greater, the escutcheon is much wider, the area is more excavated, and its carinæ are small in conformity with the very delicate intercarinal costellæ. From others of the *costatæ*, the large area, the unusual prominence of the median carina, and the great length of the siphonal border afford differences sufficiently conspicuous. *T. carinata* alone has the costæ more oblique, but in other respects is only remotely allied to it.

Dimensions of two specimens in my cabinet:

	lines.	lines.
Length upon the marginal carina	42	29
Across the valves at right angles to the carina	33	22
Breadth of the area	13	11
Length of the escutcheon	17	14
Breadth of the escutcheon in the united valves	7	$6\frac{1}{2}$
Length of the siphonal border	20	17
Convexity of a single valve	10	9

Position and Locality. This well-characterised and remarkable species of the *Costatæ* has been hitherto obtained only in the ferruginous pisolite or Cephalopod-bed at Bradford Abbas. Apparently *T. bella* is somewhat rare; and, like its congeneric associate, *T. striata*, it has not been collected to the northward of the Carboniferous rocks of the Bristol coal-field. I have been favoured with specimens by Colonel Mansel Pleydell and by Professor Buckman; the examples figured are not of the largest dimensions.

TRIGONIA PULLUS, *Sow.* Plate XXXIV, figs. 7, 7 *a*, 8, 9.

TRIGONIA PULLUS, *Sow.* Min. Conch., tab. DVIII, figs. 2, 3, 1826.
— — *Agassiz.* Trigonies, p. 9, 1840.
— — *d'Orbigny.* Prodrome de Paléont., vol. i, p. 308, 1850.
— COSTATA, var. PULLUS, *Morris* and *Lycett.* Monogr. Great Oolite, Part II, p. 58, tab. 1, fig. 22 (Palæont. vol. for 1853), 1853.
— PULLUS, *Morris.* Catalogue, p. 229, 1854.
— COSTATA, *Quenstedt.* Der Jura, p. 502, tab. lxvii, fig. 13, 1858.
— — *Park.*, var. PULLUS, *Sharp.* Oolites of Northamptonshire, Quart. Journ. Geol. Soc., vol. xxvi, p. 388, 1870.
— n. sp., near to PULLUS, *J. E. Cross.* Geology of N. W. Lincolnshire, Quart. Journ. Geol. Soc., vol. xxxi, p. 125, 1875.
— COSTATA, var. PULLUS, *Judd.* Mem. Geol. Survey, Rutland, &c., pp. 151, 155, 161, 220, 281, 1875.

Shell ovately trigonal, convex; umbones prominent, acute, and recurved; anterior side moderately produced, its border curved elliptically with the lower border; hinge-border nearly straight, sloping obliquely from the posteal extremity of the escutcheon to that of the marginal carina. The escutcheon is wide and concave, delicately impressed by a twofold kind of ornamentation; its anteal portion has a series of small depressed costellæ, which pass across the surface transversely; the posteal portion has more obscure, oblique costellæ, which take the direction of the lines of growth; both series of costellæ are wrinkled. The area is wide, the plane of its surface forms a considerable angle with the costated portion of the valve; it is bounded by two well-marked carinæ, of which the inner carina is small, but distinctly dentated; the marginal carina is large; plain and smooth near the apex; its middle and posteal portions are more or less plicated. The surface of the area is somewhat concave, divided into two portions by a mesial depression; and in the young state it has also a distinct median carina, which posteally can usually only be considered as one of the costellæ which ornament the surface; posteally these costellæ become merged in the folds of growth; the right valve has the area divided into two portions, but has no distinct median carina; the costellæ are fewer and larger than in the other valve. The other portion of the valve has the costæ large, closely arranged, and rounded; their attenuated extremities are simply curved upwards to the anterior border: the largest specimens, about eighteen lines in length, have twenty costæ.

The peculiarities of the escutcheon in *T. pullus* supplies the most clear distinctive feature separating it from other small examples of the *Costatæ.*

Positions and Localities.—In the Inferior Oolite the shelly freestones of Leckhampton contain specimens of *T. pullus,* which are scarcely larger than the head of a pin. The Wiltshire Cornbrash, more especially at Hilperton, near Trowbridge, has produced a multitude of examples in a fine condition of preservation; the species is also present in the northern extension of the Great Oolite at Appleby, Lincolnshire; near to which locality it has been collected and recorded by the Rev. J. E. Cross. It is unknown in the Cornbrash of Yorkshire.

Sowerby figured a group of small costated forms from Cutch as examples of *T. pullus* ('Geol. Trans.,' 2nd series, vol. 5, plate 21, figure 7), but as the escutcheon and area are not clearly exposed the identity of the species remains doubtful.

A small area and escutcheon figured by Quenstedt ('Der Jura,' tab. 67, fig. 13), as *T. costata* from the highest member of the Great Oolite at Einingen, undoubtedly represents *T. pullus.*

TRIGONIA MONILIFERA, *Ag.* Plate XXXI, figs. 1, 1 *a*, 1 *b*, 2, 2 *a*, 10.

TRIGONIA COSTATA, *Goldfuss.* Petrefacta Germaniæ, tab. cxxxvii, fig. 3 *c*, 1836.
— MONILIFERA, *Agassiz.* Mem. sur les Trigonies, p. 40, tab. iii, figs. 4—6, 1840.
—? PARVULA, *Agassiz.* Idem, tab. xi, fig. 8, young example.
— PAPILLATA, *Agassiz.* Idem, p. 39, tab. v, figs. 10—14.
— RETICULATA, *Agassiz.* Idem, pl. xi, fig. 10.
— MONLIFERA, *d'Orbigny.* Prodrome de Paléontologie, vol. i, p. 365, No. 293, 1850.
— — *Quenstedt.* Der Jura, p. 759, 1858.
— — *Damon.* Geology of Weymouth, Suppl., pl. iv, fig. 1, 1860.
— MARGINATA. Idem, pl. vi, fig. 8 (mould of the interior).
— COSTATA, *Grewingk.* Gest. u. Geol. Livonia und Courland, Dorpat, 1864.

Shell ovately trigonal, very convex, both mesially and anteally, umbones prominent, much incurved, and more or less recurved; anterior side moderately produced, rounded, its border curved elliptically with the lower border, its superior or umbonal portion is slightly excavated; hinge-border concave, its length is one fourth greater than that of the siphonal border, with which it forms a considerable angle. The escutcheon is very wide and concave, its surface is for the most part delicately reticulated, having two series of numerous small fine ridges; the series occupying only the anteal portion of the surface passes transversely across the escutcheon, the posteal series takes the direction of the lines of growth; these are also delicate and decussate the anteal series. The area is of moderate size, distinctly bipartite, somewhat concave, and is nearly alike in both the valves; the plane of its surface forms nearly a right angle with the costated portion of the valve, it has a prominent median carina, and larger bounding carinæ; the marginal carina is prominent in both the valves, its indentations are small but are conspicuous even to the apex; that of the right valve is much larger than the other, and in specimens approaching to the adult condition its indentations over the posteal half degenerate into irregular large transverse plications which are sometimes united to the posteal extremities of the costæ; the inner carina, although small, is prominent and nodose; the intercarinal costellæ are irregular, unequal, and variable in number; usually those of the right valve are the larger, more especially adjacent to the post-carinal furrow; occasionally the median carina divides into two costellæ and then loses its prominence. The costæ (about 25 in adult forms) are large but somewhat flattened, and (excepting in the young condition) are widely separated; they have an undulation near to the anterior border, and also turn slightly downwards near to their posteal extremities, where also in adult forms the few last-formed costæ become somewhat irregular and broken. The lines of growth are prominent over the whole of the shell, and assume the form of irregular plications when specimens are of advanced growth; they also sometimes render the anteal portions of the costæ granulated.

Fully developed specimens of *T. monilifera* are probably the largest examples of the section; occasionally Dorsetshire shells have the granulated epidermal tegument preserved over the greater portion of the surface, the lines of granules are distinctly separated in the rows, and are sometimes perceptible even to the unaided vision. The convexity of the valves varies considerably in specimens of the same size from the same formation and locality even when there is no appearance of distortion or compression. The following measurements refer to two of our specimens; these are only of medium size compared with some others which have scarcely less than twice their linear dimensions; the latter, however, are usually more or less compressed, and are therefore unsuitable for comparison.

No. 1. { Length measured upon the marginal carina, $3\frac{1}{2}$ inches.
„ across the valve at right angles to the carina, 2 inches.
„ across the united valves, $1\frac{6}{10}$ inch.

No. 2. { Length upon the marginal carina, 4 inches.
„ across at right angles to the carina, $2\frac{1}{10}$ inches.
„ across the united valves to the carina, $1\frac{9}{10}$ inch.

The internal mould is smooth, but has a slight rib, indicative of the position of the marginal carina; the hinge-processes are very large, they project considerably, corresponding with the great breadth of the escutcheon, and considerable incurvation of the umbones.

The specimen figured by Agassiz ('Trigonies,' tab. 3, figs. 4—6), from the terrain á chailles or Oxford Oolite, has the general aspect of a dwarfed variety of the fine species which attains such large dimensions in the lower portion of the Kimmeridge Clay of Wiltshire and Dorsetshire.

Affinitive and Distinctive Characters.—The very considerable convexity of the valves mesially, the ornamentation of the escutcheon, the prominence and general narrow figures of the bounding carinæ, the considerable angle which the surface of the area forms with the other portion of the valve, together with the more lengthened costæ, and the absence of truncation anteally, serve in the aggregate clearly to separate it from *T. costata*, and also from others of the same section.

For comparison with *T. Meriani* the reader is referred to that species.

The *T. reticulata* of Agassiz ('Trig.,' table 2, fig. 10), which is exemplified by a single fragment, may represent a large and compressed example of *T. monilifera;* the apparent absence of a median carina in this instance is similar to a like variation in occasional Dorsetshire examples, in which the median carina divides in fully developed forms into two or three costellæ, and the carina thus disappears.

Without hesitation the *T. papillata* of the same author, 'Trig.,' tab. 5, figs. 10—14, may be referred to *T. monilifera;* here again the median carina divides into costellæ; the prominence of these and of the bounding carinæ may be taken to represent a small Dorsetshire example of our species.

I would exclude *T. monilifera*, Quenst. 'Handbuche der Petrefacten-kunde,' tab. 43, fig. 15, which represents a small Trigonia having very numerous small rows of costæ and also a species, Quenst., Jura, tab. 93, fig. 4, bearing the name *T. costata-silicea;* the latter may possibly agree with a delicately ribbed species of the Upper Oolites, *T. supra-jurentis*, Ag., Trigonies, tab. 5, figs. 1—6, page 42. The latter is unknown in the Kimmeridgian strata of Britain.

Positions and Localities. The lower beds of Kimmeridge Clay in the vicinity of Weymouth, of Wotton Basset, and of Swindon, have produced examples, some of which in their general dimensions much exceed any other species of the costatæ; these, however, are usually more or less compressed or distorted; it also occurs in the Coralline Oolite of Wilts and of Weymouth; at the latter locality specimens deprived of the test, and ill-preserved, have recently been obtained in a red pisolitic iron rock at Abbotsbury, and forwarded to me by Mr. J. T. Walker, of York.

Foreign examples recorded by Agassiz and by D'Orbigny have been obtained in the Terrain à Chailles or Lower Calcareous Grit at Argan (Haut Rhin), Birze Environs of Bale. Besançon (Doubs), Neuvizi, Trouville, Nantua, Marans. Also by Grewingk, at Poplinacny, in the Province of Kowno; Lithuania, there known as *T. costata.*

TRIGONIA MERIANI, *Ag.* Plate XXXIII, figs. 1, 2, 3.

TRIGONIA COSTATA, *Young* and *Bird.* Survey of the Yorkshire Coast, pl. viii, fig. 19, p. 225, 2nd edit., 1828.
— — *Phillips.* Geol. of Yorkshire, p. 228, 1st edit., 1829.
— MERIANI, *Agassiz.* Trigonies, p. 41, tab. xi, fig. 9, 1840.

TRIGONIA MERIANI, *d'Orbigny.* Prodrome de Paléont., vol. ii, étage 14, p. 17, No. 262.
— — *Buoignier.* Paléont. du Dep. de la Mense, p. 265, 1852.
— — *Waagen.* Der Jura in Frank. Schw. u. der Schweig., p. 218, 1864.
— CLAVELLATA (misprint?), *Phillips.* Geol. of Oxford, pl. xiii, fig. 2, 1871 (reduced figure).
— MERIANI, *Phillips.* Geology of Yorkshire, 3rd ed., 1875, vol. i, p. 250.

Shell ovately trigonal, very convex; umbones produced, pointed, arched inwards and recurved: anterior side produced, its border rounded elliptically with the lower border, which is slightly excavated posteally; escutcheon comparatively small, depressed, flattened, with its superior border somewhat raised; its surface has small, closely arranged, delicate oblique plications; it is well circumscribed by the small nodose varices of the inner carina; as the hinge-border slopes obliquely downwards and the siphonal border of the area is also oblique, their junction does not form any prominent angle, but the length of the hinge-border exceeds somewhat that of the other. The area is slightly excavated and flattened, rendered distinctly bipartite by the superior or inner half being more depressed by the other portion; it is bounded by two well-defined small carinæ; the marginal carina is elevated, peculiarly narrow in the left valve, and somewhat larger in the other valve; it has small inconspicuous plications; the inner carina forms a border fringed with closely arranged, small nodosities; there is also a small, flattened, narrow band which represents the median carina; the intercarinal costellæ are small, numerous, closely arranged and unequal; they are nearly alike in both the valves; the entire area has conspicuous, densely placed, transverse lines of growth, which strongly indent the whole of the surface. The sides of the valves have a very numerous series of costæ (forty or more in advanced growth); they are small, somewhat unequal in size, and irregular in their direction; they form a flexure near to both of their extremities; the few last formed costæ are more imperfect and irregular; their anteal portions take the direction of the lines of growth and curve upwards anteally, embracing the extremities of the costæ previously formed; in the right valve their posteal extremities pass across the marginal carina as so many plications; in the other valve they terminate at the small ante-carinal groove. The lines of growth are minute and irregularly crowded over the valves generally.

The defective, irregular figures and partial effacement of the few last-formed costæ, indicate the ultimate stage of growth in the life of the Mollusk when the mantle continues to add to the growth of the valves, but ceases to produce surface ornaments.

The hinge processes are prominent and lengthened; the posteal cardinal process of the right valve extends horizontally nearly the length of the escutcheon. The internal mould has not been ascertained.

A large example in my collection has the length of the marginal carina $4\frac{3}{4}$ inches;

at right angles to the carina across the valve $4\frac{1}{4}$ inches; convexity of a single valve $1\frac{1}{8}$th of an inch.

A smaller Trigonia occurs in the Coral Rag of Wiltshire, which appears to be a variety of *T. Meriani;* the general figure has less convexity and is somewhat more pointed at both the extremities; the other general features are alike in both the forms; our smallest figure represents this variety.

T. Meriani has scarcely hitherto been recognised as a British species; it has occurred only rarely, and in its usually defective condition has been assigned to *T. costata;* its aspect when well preserved is sufficiently remarkable both on account of its large dimensions and also for a certain elegance of figure, together with a minuteness and delicacy in the surface ornaments, which might be expected to attract attention, and offers a considerable contrast to the *T. costata* of the Inferior Oolite. Considering the large dimensions of *T. Meriani,* its more remarkable characters consist in their general diminutive size and small prominence, such as the smallness and partial irregularity of the costæ, the small and nearly plain marginal carina, the inconspicuous median and inner carina, together with the minute and almost evanescent intercarinal costellæ. The smallness and irregularity of the costæ in so large a species is a feature altogether alone in the Jurassic *costatæ,* and is suggestive of a Spanish Neocomian species, *T. peninsularis,* Coquand, 'Monogr. de l'Étage Aptien de la Espagne,' pl. xxiii, fig. 3, in which the same feature is more remarkably conspicuous.

T. monilifera, Ag., from the Coral Rag and Kimmeridge Clay of the southern counties, has in the general figure some resemblance to *T. Meriani* and sometimes occurs even of larger dimensions; it will readily be distinguished by the large, widely separated costæ, by the remarkably prominent and strongly indented carinæ, and by the great concavity both of the area and escutcheon; the costellæ of the escutcheon also offer a minute but not less distinctive feature.

Hitherto *T. Meriani* has been very insufficiently figured; the drawing intended for this shell, named *T. costata* in the work of Young and Bird above cited, is in the usual coarsely executed style of the other figures, and the surface ornaments of the area are altogether erroneous; the general contour of the valve, the characters of the costæ, and of the marginal carina are distinctive and readily recognised.

A single imperfect and insufficiently characterised specimen was figured by Agassiz; his description was founded upon better preserved examples subsequently brought to his notice.

To the present species must also be referred a reduced figure of a costated form in the work of Professor Phillips on the 'Geology of Oxford,' from the Coral Rag of Heddington (Pl. xiii, fig. 32); printed erroneously *T. clavellata.*

Position and Localities. Only a small number of specimens of this large Trigonia have come under my observation; they have all been obtained in the Coralline Oolite formation at several widely separated localities, as at Weymouth, in Wiltshire, in Oxfordshire, and in Yorkshire at Malton and Pickering; at the two latter localities it may be understood as the species intended whenever *T. costata* is mentioned in lists of their fossils. Specimens are in the Museum of the Royal School of Mines, in the Woodwardian Museum, Cambridge, in the Geological Museum of the University of Oxford, in the museum of the Philosophical Society, York, in that of the Philosophical Society, Scarborough; also in private collections.

Specimens from the Coralline Oolite of Weymouth are usually of smaller size, and are more lengthened, or measure less across the valve at right angles to the carina, than Yorkshire examples.

In Switzerland, Agassiz records its occurrence in the same geological position at Zwingen (Soleure), at which place he states that it has been obtained in considerable numbers and in a fine condition of preservation. D'Orbigny also records it in the Coral Rag of France at several localities.

TRIGONIA CASSIOPE, *D'Orb.* Plate XXXII, figs. 1, 2, 3, 4, 5.

TRIGONIA CASSIOPE, *d'Orbigny.* Prodrome de Paléont., vol. i, p. 308, 1850.
— — *Lycett.* Sup. Monog. Gr. Ool. Moll. Pal. Soc., p. 49, tab. xxxvii, fig. 10, 1863.
— — *Rigaux* and *Sauvage.* Descr. de quelques espèces nouv. de l'Étage Bathonien du Bas-Boulonnais, p. 19, 1868.
— — *Phillips.* Geology of Yorkshire, 3rd ed., vol. i, p. 250, 1875.
— — *Judd.* Mem. Geol. Survey Rutland, &c., p. 289, 1875.

Shell variable in its general figure and outline; ovately trigonal; somewhat depressed and comparatively short anteally; usually considerably lengthened and attenuated posteally; anteally and also near to the umbones the valves have much convexity, the general outline becoming subcrescentic. The umbones are small, moderately elevated, and usually much recurved; placed upon a line one third the length of the shell from the anterior border. The anterior side is rounded and inflated, its border curves elliptically with the lower border, which is lengthened and sinuated posteally; the hinge-border is lengthened and concave, forming posteally only a slight angle with the siphonal border, which is oblique and shorter than in any other British example of the section; its posteal extremity forms with the marginal carina a figure much produced and pointed. The escutchon is large, depressed, and somewhat excavated, so that when a valve is placed horizontally the escutcheon is scarcely seen when viewed from above; its surface is very delicately, obliquely plicated, and obscurely reticulated. The area is unusually narrow for so large a species, its surface forms a considerable angle with the costated portion of the shell; its surface is very delicately reticulated; it is bipartite, each portion having very small longitudinal costellæ, one of which is sometimes prominent, forming a small median carina; in other examples, and more especially in the right valve, there is no distinct median carina. The bounding carinæ are very small upon both the valves, but the marginal carina is always distinct; it is minutely, transversely plicated and the ante-carinal groove of the left valve is only slightly defined; the umbonal portion of the carina has a considerable and graceful curvature. The inner carina is commonly only indistinct; it is one of the reticulated costellæ of the area slightly separated from the more depressed surface of the escutcheon.

The other, and by much the larger portion of the shell, has the rows of costæ small and numerous; their edges are acute, little elevated, uniform in character; their number in fully developed specimens varies from 24 to upwards of 36, depending upon the more close or distant arrangement of the rows; the first formed or umbonal rows have their general direction obliquely downwards posteally; the rows subsequently formed are directed more horizontally, but curve upwards anteally, where they form a well-marked undulation; near to the lower border they take the direction of the lines of growth or conform to the figure of the border; the left valves sometimes have the posteal extremities of the costæ, each forming a short, downward prolongation; the right valve has several of the last-formed costæ passing across the marginal carina as so many plications. Well-preserved specimens have the costæ crowded with minute perpendicular lines of epidermal granules.

Young examples when less than fifteen lines in length are much depressed, the costæ have no distinct anteal undulation, and the several features which characterise the fully developed shell are scarcely perceptible.

A large, gracefully curved, and transversely lengthened form, remarkable for the large curvature of the small marginal carina, the produced and attenuated posteal extremity, the narrow, excavated, and minutely reticulated area, the considerable angle which it forms with the costal portion of the surface, the largeness of that surface and the rounded and produced anteal side; the combination of these characters will usually readily distinguish it from others of the *costatæ*.

Judging of *T. Cassiope* from our figures only, it might be imagined that the species is divisible into varieties; a more extended knowledge of this Cornbrash form will lead to the more correct inference that these figures represent nearly the extremes of variation in opposite directions; figure 1 exemplifies the more wide and depressed, and figure 2 the more narrow and inflated forms. The greater number of specimens will be found to approximate to figure 4; there is, however, so much variability both in the outline of the valves, in their convexity, and in the size and number of the costæ, that taken in combination with the frequent and, indeed, usual compression or distortion of some portion of the shell, it is scarcely possible to find any two specimens having any close agreement with each other. Occasionally a valve occurs even more inflated than the narrow specimen figure 2, so that when placed horizontally and viewed from above, no portion of the area is seen. The internal mould is not known. The hinge teeth are widely divergent, they have little prominence, and are smaller than is usual with the larger examples of the *Costatæ.*

Position and Localities. Upon the Coast of Yorkshire to the southward of Scarborough it is common in the bed of Cornbrash and also in the small exposure of the same bed to the northward of the Castle Hill, where the specimens are badly preserved or have suffered from compression—a condition which invariably occurs when the valves are in contact. The species has also been obtained rarely in the brown, sandy, lowest bed of Kelloway Rock in the same vicinity. The compression and distortion which is so common in this large Trigonia is a frequently recurring feature in the larger testacea of the Cornbrash; the other large Trigoniæ from the same bed and locality present similar defects in their state of fossilisation.

As the Trigoniæ generally are good stratigraphical guides it will appear remarkable that its representatives which characterise the Cornbrash or Forest Marble throughout the southern and midland countries of England have altogether disappeared to the northward of the Humber, where they are replaced by other species. Thus, upon the Coast of Yorkshire we look in vain for *T. pullus, T. costata, T. flecta, T. undulata,* var. *arata, T. Moretoni*, and the short variety of *T. sculpta* designated *Rolandi;* these are replaced in the northern Cornbrash by *T. Scarburgensis, T. Cassiope,* and by two varieties of *T. elongata*, all of which occur in some abundance.

The changes thus exhibited by the genus Trigonia will be found scarcely less remarkable in other associations of Molluscan forms, more especially in the numerous and varied series of *Conchifera,* some of which are identical with Kelloway Rock species and are unknown in the southern Cornbrash. These data tend to the conclusion that the Cornbrash of Yorkshire represents a deposit of marine testacea more recent than that of the southern countries or more transitional and tending to connect more nearly the mollusca of the Lower and Middle Oolites.[1]

The foreign localities assigned to *T. Cassiope* are Luc (Calvados); Vezelay (Yonne); Grange Henry rear Nantua; it also occurs rarely in the Great Oolite of the Bas-Boulonnais (Rigaux et Sauvage).

Mr. R. (now Professor) Tate, 'Quart. Jour. Geol. Soc.,' 1867, p. 171, records its occurrence in rocks (supposed to be Jurassic) in Southern Africa. The single specimen upon which this identification is founded has scarcely half the linear dimensions of Yorkshire examples; the distinctive characters are not prominent, and in the absence of more satisfactory materials for comparison, the specific identity may be regarded as doubtful.

[1] See a note by the present author on the association of generic forms of Mollusca in the Yorkshire Cornbrash compared with those of the Cornbrash of the southern counties, 'Supplementary Monograph on the Mollusca of the Stonesfield Slate, Great Oolite, Forest Marble, and Cornbrash, Palæontographical Society,' volume for the year 1861, p. 117. 1863.

Trigonia Culleni, *Lyc.*, sp. nov. Plate XXXI, figs. 9, 9 *a*.

The Marine intercalated Millepore bed, a subordinate member of the Lower Sandstones and Shales at Cloughton, a few miles to the northward of Scarborough, has associated with *Trigonia recticosta* and other testacea of the Inferior Oolite, a small costated species of Trigonia, and as the matrix is usually very hard and the tests of the Trigonia are either delicate or indifferently preserved, it rarely happens that a specimen can be separated sufficiently entire to allow of the clear development of its characteristic features; thus it happens that our sole illustrative specimen is imperfect; it appears, however, possible by its aid to describe the species and separate it from other allied forms of the *Costatæ*.

The most prominent features consist in the form unusually lengthened transversely and posteally; in the considerable recurvature of the umbones together with the produced and rounded anterior side; also in the minuteness of the lengthened horizontal rows of costæ, the specimen figured having upwards of twenty-seven; they are elevated, and so narrow as to appear almost linear, viewed from the anterior side, and with the valves united. The horizontal rows are, however, distinctly separated, and are almost without any anteal undulation.

The upper border of the shell is concave; it forms an obtuse angle with the siphonal border, which is oblique, and has considerable length; the lower border is lengthened and is only slightly curved.

The escutcheon and area are large and have no clear separation, the former is deeply excavated; the inner half of the area is also concave; the costellæ upon their surfaces are minute and very irregular. The marginal carina is small, but is distinctly transversely plicated.

The specimen figured has the length 15 lines; the height 10 lines; the diameter through the united valves 9 lines.

Named after its discoverer, Mr. Peter Cullen, a veteran and intelligent collector of fossils at Scarborough, the greater portion of whose life has been occupied in the development of the palæontological treasures of the district in which he resides.

Affinities and differences. *T. hemisphærica* with similar minute costæ has the general figure much shorter and less produced anteally, the umbones are much more nearly terminal and have little recurvature; the surface ornaments of the area and of its carinæ are much larger and more deeply sculptured. Another small gregarious example of the *Costatæ* also occurs at Cloughton; the test has usually decomposed, but the ribbing is distinct; its fewer and larger costæ separate it from the present species; it may represent the very young condition, or a variety of *T. denticulata*.

TRIGONIA HEMISPHÆRICA, *Lyc.* Plate XXXI, figs. 4, 5, 6, 7, 8. Var. *Gregaria*, Plate XXXIII, figs. 4, 5, 6.

TRIGONIA HEMISPHÆRICA, *Lycett.* Ann. and Mag. Hist., vol. xii, tab. xi, fig. 2, young specimen, 1850.
— — *Morris.* Catalogue, p. 228, 1854.
— — *Lycett.* Cotteswold Hills, Handbook, p. 137, pl. iv, fig. 4, 1857.
— — *Phillips.* Geology of Oxfordshire, p. 162, 1871.
— — *Sharp.* Oolites of Northamptonshire, Quart. Journ. Geol. Soc., pp. 267, 293, 1873.
— — *Cross.* Geology of North-west Lincolnshire, Quart. Journ. Geol. Soc., pp. 121, 124, 1875.
— — (drawf variety). Ibid., pp. 121, 125.
— — *Judd.* Mem. Geol. Sur. Rutland, &c., p. 153, 157, 281, 1875.

Shell ovately trigonal, convex, umbones prominent, pointed, slightly recurved; anterior side short, its border curved elliptically with the lower border, posterior side moderately lengthened. Escutcheon depressed, its superior border somewhat raised, moderately wide, obliquely closely plicated, its length greater than that of the siphonal border of the area with which it forms an obtuse angle. The area is of considerable breadth, or equal to one third of the entire valve, it is for the most part flattened, is depressed and slightly concave; the right valve has the lower half or that adjoining the marginal carina raised or convex. The marginal carina is large, with elevated, deeply indented irregular plications, these are in some instances scarcely more numerous than the costæ; the inner carina is also conspicuous from its prominent close set row of obtuse nodes. There is no median carina in the right valve; the left valve has occasionally some approximation to a median carina in the greater elevation of one of its costellæ. The costellæ of both valves are prominent and closely arranged with large, deeply indented reticulations; the lower half of the area has eight or nine, the upper half six or seven costellæ. In the very young state, the right valve has the costellæ of the lower half of the area fewer and larger, which is a feature not unusual with other species of the *Costatæ*.

The other portion of the surface has a very numerous regular series of narrow, elevated, closely arranged, rounded, or sometimes subacute costæ, varying from 40 to 55 or even exceeding the latter number, occasionally in specimens measuring two inches or upwards upon the marginal carina; those of the left valve are slightly enlarged at their posteal extremities and terminate abruptly at the narrow deep antecarinal groove; anteally their extremities become attenuated, and have a single curvature upwards to the border; the costæ of the right valve curve slightly downwards, where they are united posteally to the plications upon the marginal carina which is larger than that of the other valve; the last formed one or two costæ in adult specimens are more depressed or become squamous.

It is doubtful whether the internal mould has been recognised.

Dimensions of a full sized Cotteswold specimen in the Geological Museum of the University of Oxford.

Length of the marginal carina . . .	27 lines.
Across the valve at right angles to the carina . .	23 ,,
Convexity of a single valve	$9\frac{1}{2}$,,
Greatest breadth of the area	12 ,,

Dimensions of a full sized Santon specimen in my cabinet.

Length of the marginal carina . . .	25 lines.
Across the valve at right angles to the carina . .	21 ,,
Convexity of a single valve	7 ,,
Greatest breadth of the area	9 ,,

History, and local variability.—The specimen first described by me, and figured in the year 1850, was a very young Cotteswold example, and although measuring only three lines across, the valve had about twenty costæ, and was supposed to be an adult specimen; its convexity was so considerable that the figure was almost hemispherical; larger examples have much less convexity. The hinge-processes and their sulcations are large, they equal in prominence the corresponding parts of any other species of the section having equal general dimensions. The surface ornaments present no well-defined differences between the very young and advanced conditions of growth. A more than common amount of variability occurs in the size and number of the costæ, even in specimens from the same locality; one of our Santon examples, Plate XXXI, fig. 6, having the costæ more distantly arranged illustrates this feature, it does not constitute a distinct variety, as it is connected with the typical form by other examples of intermediate ribbing; neither does this variation extend to the ornaments of the area and escutcheon, which are conspicuous for their strongly defined sculpture.

The largest specimens of *T. hemisphærica* have been obtained in the Cotteswold Hills; it has occurred only in the middle portion of the range in the district to the eastward of Cheltenham extending southwards to Stroud and including Rodborough Hill; from the latter locality all the earlier known specimens were obtained; its position is the bed termed Lower Trigonia Grit, associated with the more abundant *T. sculpta* and *T. formosa*, but our species ranks as one of the most rare testacea of the district.

The museum of the Royal School of Mines has several unusually small examples obtained by the officers of the Survey in the South Lincolnshire district at Stamford, Collyweston and Wakerley, in Lincolnshire Limestone; these have the costæ unusually minute, numerous, and faintly defined; they appear to be examples of dwarfed adult forms. Other localities noted by Mr. Sharp in his memoir on the Oolites of Northamptonshire ('Quart. Jour. Geol. Soc.,' May, 1873), are Ravens Wood, Glendon, near Kettering, Ponton and Denton, near Grantham.

In North-West Lincolnshire at Santon Bridge, near to Appleby, a deep road cutting exposes a good section of the lowest beds of Inferior Oolite, reposing upon dark-coloured clays of Upper Lias; the Midford Sands are altogether absent. The lowest bed of Inferior Oolite is a dark-coloured marly rock only sparingly fossiliferous; resting upon it is a thick bedded pale brown, hard shelly limestone, containing a numerous and finely preserved series of conchifera; *Trigonia hemisphærica* is not uncommon, always as single valves which never attain the dimensions of fully developed specimens in the Cotteswold Hills; it is accompanied rarely by valves of *T. Phillipsii.*

In the same vicinity, higher in position, a small variety of our species (*gregaria*) occurs abundantly in a large quarry of Lincolnshire Limestone adjacent to the railway station at Appleby; in size the specimens agree with others from a similar position at the opposite extremity of the county near to Stamford; compared with the typical form the Lincolnshire Limestone specimens present some differences, the size measured upon the marginal carina varies from six to fourteen lines, but the greater number are from ten to twelve lines.

The costæ anteally near to the border form a slight undulation, more especially the more umbonal rows; the area in its surface and carinæ has its ornaments less conspicuously sculptured. It is difficult to separate specimens of this small variety in a condition suitable for the cabinet, the valves are often in position, but distortion is also common. The first few ill-preserved specimens are mentioned at page 11 in the introductory portion of this monograph as *T. gregaria,* a name which should be retained only as indicating the present small variety; figures of which are given upon Plate XXXIII. The matrix, a pale buff-coloured, tough limestone, is a coralline mud rock, identical in lithological characters with beds which in the Cotteswolds immediately underlie the Oolite Marl, and into which it passes insensibly; locally they abound in the Cotteswolds with clusters of *Nerinœa, Chemnitzia* and other univalves, more rarely also with Trigoniæ, of which the following seven species have been separated, *T. angulata,* Sow., *T. subglobosa,* Lyc., *T. costatula,* Lyc., *T. pullus,* Sow., *T. gemmata,* Lyc., *T. Phillipsii,* Mor. and Lyc., *T. tuberculosa,* Lyc.

At Brough, near Hull, the shelly Inferior Oolite also contains this variety, obtained by Mr. J. F. Walker, of York.

The testacea of the rock at Appleby consists chiefly of numerous genera and species of Conchifera, almost the whole of which are identical with Cotteswold forms, it is therefore the more remarkable that the Trigonæ at the northern locality are represented by a single species of the *Costatæ,* and one of the forms which in Gloucestershire occurs most rarely; the two quarries, the one Santon, the other at Appleby, together scarcely exceeding fifty feet in thickness have produced a greater number of specimens of *T. hemisphærica* than the whole of the Cotteswolds. As the geology of the vicinity of Appleby was but little known previously to the memoir by the Rev. J. E. Cross (' Quart. Jour. Geol. Soc.,' May, 1875), my thanks are especially due to that gentleman under whose guidance I visited the quarries of that vicinity in the year 1870; the specimens figured in this monograph were the gift of Mr. Cross. At Cloughton upon the coast to the northward of Scarborough, the Inferior Oolite Millepore bed contains some dwarfed examples of the variety *gregaria* associated with *T. recticosta;* owing to the hard matrix and delicate condition of the testacea; specimens are rare and usually ill-preserved, they measure from six to ten lines across the valves.

Affinities.—The distinctive features of *T. hemisphærica* are so conspicuous, that it will not readily be mistaken for any other species. The only form in the lower oolites which appears to approach to it is *T. tenuicosta;* when comparing specimens of equal dimensions it will be seen that *T. tenuicosta* has greater convexity, that it is shorter and truncated anteally; its umbones are more elevated, narrow and pointed, its area is much more excavated; its carinæ and the surface of the area generally has a much smaller and more delicate ornamentation; the costæ also have a considerable anteal undulation different from the simple anteal curvature of *T. hemisphærica.*

In the Upper Jurassic rocks of France one of the *Costatæ* resembles *T. hemisphærica* in having very numerous small costæ; *T. Etalloni*, De Lor. (' Paléont de la Haute Marne,' P. de Loriol, et E. Royer et H. Tombeck (' Mém. Soc. Lin. de Normandie,' tom. 13, Pl. XVII, figs. 13, 14, 15), has the numerous costæ curved concentrically throughout their course; the marginal carina is minute, and therefore wholly unlike the large and deeply sculptured carina of the British species.

Our species is not limited to a single stratigraphical position of the inferior oolite. It occurs in the middle portion of the range of the Cotteswold Hills, between Cheltenham and Stroud; its bed (Lower Trigonia Grit) overlies nearly two hundred feet of the Inferior Oolite. In North West Lincolnshire, at the Santon cutting, only four or five feet separate the shelly bed with *T. hemisphærica* from the dark clays of the Upper Lias; both this and the position of the Lincolnshire Limestone are widely separated from the Trigonia bearing Ragstones of the Cotteswolds; the latter occupy a much higher position, and have their ornaments more prominently sculptured than the Lincolnshire specimens, in every stage of their growth.

The steep escarpments upon the eastern side of the Naiisworth Valley, with its numerous quarries and other smaller rock exposures, has in its beds of hard white limestones and their enclosed Conchifera exact counterparts of the fauna and deposits of North Lincolnshire, reproducing upon a smaller scale the limestones which, in their more northern prolongation, acquire so much greater thickness and importance. The bed of oolite marl has disappeared in the Nailsworth valley, merged in the more indurated limestones which are altogether without *T. hemisphærica.*

The exact position of the shelly *hemisphærica* bed of the Santon section is perhaps rather doubtful, probably it should be referred to the Northampton sands, nearly at the base of the formation.

(See series of comparative vertical sections, of members of the Lower Oolites, by J. W. Judd, 'Mem. of the Geological Survey of England and Wales, Rutland, &c.,' Plate I.) A most comprehensive and instructive series of sections drawn to a scale of one inch to fifty feet.

The Museum of the Royal School of Mines has a varied series of specimens of *T. hemisphærica*, from the Cotteswolds, from the district of Rutland, from South Lincoln, and from North West Lincoln. A large Cotteswold specimen is in the geological museum of the University of Oxford. The collections of Dr. Wright, Cheltenham; Mr. Witchell, Stroud; Mr. S. Sharp, Northampton; Rev. J. E. Cross, Appleby, and my own cabinet also, fully illustrate its several aspects.

It appears to be absent in the Inferior Oolite of Northampton, Oxford, Somerset and Dorset; neither has it been recorded at any foreign locality.

[1] In the foregoing description I have expressed the conviction long since entertained by me, founded upon a comparison of fossils of Lincolnshire limestone with those of the Oolite Marl and subjacent beds in the Cotteswolds, that the fossil fauna of the two deposits are identical, and differ only in species which inhabited the variations of sea bottom, such as may be expected to occur in a deposit which extends from the estuary of the Severn to that of the Humber broken only by the upraised portions of Oxfordshire and Northamptonshire.

The general scope of this monograph will not admit of any detailed comparisons between the fauna of widely separated deposits; it may, however, be useful to indicate a few typical forms which by their considerable extension laterally connect the more distant deposits. At both localities the Ammonites are almost absent.

Amongst the Gasteropoda will be found the gigantic *Natica Leckhamptonensis*, which is rare near to Stroud and to Cheltenham, but reappears abundantly in South Lincolnshire, and is well exemplified in the Grantham Museum; it is also present in the limestone at Appleby, exemplified in the collection of the Rev. J. E. Cross.

Of the Conchifera, *Lima bellula*, Lyc., formerly obtained in the Nailsworth Valley at Culverhill in considerable numbers in a quarry long disused, is specially deserving of notice; it retains its colour partially preserved; examples are now in the Museum of the Royal School of Mines. As the rock of this quarry is extremely hard the stone is not employed commercially and the shells are rare. A small specimen of the species obtained by Professor Morris in the limestone of the Ponton cutting, South Lincolnshire, was figured in the Great Oolite monograph of this Society, vol. for 1853, pl. iii, fig. 9. More recently it has been found in South Lincolnshire, with the colours partially preserved. At the north-western extremity of the County at Appleby it is met with abundantly in a beautiful condition, in tint a dull purple with narrow concentric zones of cream colour; specimens marking all stages of growth import a peculiar aspect to the Limæ in the collection of the Rev. J. E. Cross.

Of Brachiopoda the characteristic *Terebratula fimbria* of the Cotteswolds is found to have disappeared in the limestone of Lincolnshire; it retains the accompanying *T. submaxillata*, Dav., which is also locally abundant in the Cotteswolds; at Appleby the specimens are peculiarly large, surpassing the Cotteswold forms.

In contrast to the general accordance of species of Conchifera which exists between the Lincolnshire and

§ VIII.—Byssiferæ.

Trigonia carinata, *Ag.* Plate XXXV, figs. 3, 4, 4 *a*, 5, 5*a*, 6, 6*a*.

Trigonia carinata, *Agassiz.* Trigonies, p. 45, tab. vii, fig. 7, 10, 1840.
— sulcata, *Agassiz.* Trigonies, p. 44, tab. xi, fig. 16; tab. viii, figs. 5, 11 (Moulds).
— harpa, *Deshayes.* Leymerie, Mem. de la Soc. Geol. Fran., tom. v, pl. ix, fig. 7, 1842.
— carinata, *Forbes.* Quart. Journ. Geol. Soc., tom. i, p. 244, 1845.
— — *d'Orbigny.* Pal. Fran. Terr. Cret., vol. iii, p. 132, pl. 286, 1843.
— harpa, *Matheron.* Catal. de Corps, org. foss. du Depart des bouches du Rhone, p. 166, 1842.
— carinata, *Marcou.* Rech. Geol. sur l'Jura Salin., p. 142, 1846.
— sulcata, *Marcou.* Idem.
— carinata, *Fitton.* Quart. Journ. Geol. Soc., vol. iii, p. 289, 1847.
— — *d'Orbigny.* Prodrome de Paléont., vol. ii, p. 78 (pars); exclude *T. elongata*, 17 etage, 1850.
— harpa, *Archiac.* Hist. Progr., tom. iv, p. 322, 1851.
— carinata, *Corneul.* Bull. Soc. Geol. de Fr., tom. viii, p. 435, 1851.
— — *Bavignier.* Statist. Geol. de la Meuse, p. 473, 1852.
— — *Studer.* Geol. Schweiz., tom. ii, p. 281, 1853.
— — *Morris.* Catalogue, p. 228, 1854.
— — *Cotteau.* Moll. foss. de l'Yonne, p. 76, 1854.
— — et sulcata, *Trilobet.* Bull. Soc. Natr. Neuchatel, tom. iv, p. 73, 1856.
— — *Pictet et Renevier.* Paléont Suisse, Terr. Aptien, p. 101, 1857.
— — *Archiac.* Bull. Soc. Geol. de Fr., tom. vi, p. 496, 1857.
— — *Lycett.* On a Byssiferous Fossil Trigonia, Ann. and Mag. Nat. Hist., p. 17, 1870.

Shell ovately elongated, or somewhat spindle shaped in young forms; very convex in the adult state, umbones prominent, sub-terminal, acute, much arched inwards, and slightly recurved. Anterior side very short, truncated, inflated, its border forming with the other valve a large depressed space; the posterior border is somewhat convex, curved gradually towards the lower extremity of the prominent marginal carina. Escutcheon of great breadth and length, slightly concave, its borders raised in every direction, traversed by strong diverging rugose scabrous ridges. Area very wide, conspicuously

Cotteswold districts it is remarkable that of the seven species of Trigonia obtained in the Cotteswolds above enumerated, two only, *T. pullus* and *T. Phillipsii*, occur in South Lincolnshire, and even these have disappeared in the limestone at Appleby.

bipartite, with two elevated, strongly indented, bounding carinæ; the upper half of the area or portion adjacent to the inner carina has much concavity, with six or seven small knotted costellæ which take the same direction as the carina, and disappear upon the posteal half of the area, obliterated by the large irregular plications of growth, which there cross the area and efface the surface ornaments; the other portion adjacent to the marginal carina is slightly convex, with three or four knotted costellæ which are larger than those of the upper or concave space; there is no distinct median carina, but the upper or inner costellæ acquire the semblance of a median carina from its prominent position adjacent to the more depressed concave space. The marginal carina is narrow, elevated and ridge-like upon the umbo, becoming more rounded and depressed posteally, it is crossed by large irregular sub-nodose plications, which are effaced posteally by the plications of growth; the inner carina is also prominent near to the umbo, it is occupied by a line of unequal, irregular, nodose varices formed by the lines of growth. The ante-carinal groove of the left valve is narrow, and similar in character to the post-carinal groove of the right valve. The other portion of the surface has about eighteen rows of elevated narrow plain costæ, all of which originate at the anterior border, their direction is at first horizontal upon the depressed anterior sides, but with the curvature of the valve, each bends obliquely downwards towards the marginal carina until it arrives at the groove of the left valve, when its extremity becomes suddenly attenuated and passes downwards to the extremity of the costa next in succession; in the right valve the attenuated extremities of the costæ touch the marginal carina. In fully developed shells the two or three last formed costæ have less obliquity, and follow more nearly the direction of the lower border.

The lines of growth have great prominence; they produce reticulations where they cross the costellæ of the area, and upon the sides of the valves they sometimes even break the continuity of the costæ, giving to them a wrinkled or broken aspect.

One other feature, altogether unusual in this genus, and which imparts a distinctive character to the present section, consists in the presence of a small, distinct byssal aperture, with a slightly thickened margin upon the anterior border of the valve, a feature which pertains only to examples of fully developed growth.

In fully developed specimens the length of the marginal carina is equal to twice the diameter of the united valves, and is somewhat greater than twice the diameter of a valve measured at right angles to the marginal carina.

It is distinguished from all others of the costatæ by the unusually large escutcheon, by the great prominence of the bounding carinæ to the area, by the great obliquity and straightness of the costæ; lastly, by the presence of the byssal aperture.

English Neocomian specimens, when of full size and retaining the test, are usually defective at the posteal portion of the area and escutcheon, the siphonal border and adjacent thin portions of the shell having been broken away retain the sharp fractured edges, a condition which indicates that the mollusk was destroyed suddenly, and probably perished from the attack of some predaceous species. As this does not coincide with the usual condition of fossil tests of this genus, a special cause is required to account for it. The byssal aperture indicating a fixed or sedentary condition offers an explanation; the adult mollusks fixed by their byssal appendages had not the free saltatory motions of other *Trigoniæ*, and became victims to the marine flesh-eaters which attacked the siphonal or thinner and more exposed upper portions of the valves. The appearance of the lines of growth indicate that the byssal orifice was formed at the completion of adult growth; the shell generally at that period, and more especially the area, exhibits commonly an abraded aspect similar to the appearance of adult Bysso-Arcas, and probably produced by similar conditions of existence. Usually, therefore, it is only upon immature specimens that the surface ornaments of the area have been fully preserved, and even in such instances the posteal portion had no longer distinct carinæ or costellæ, their positions are occupied by transverse rugose folds.

Some alteration in the figure of the area and escutcheon took place during the progress of growth; the young specimen, figure 4 *a*, has the escutcheon comparatively small and concave; the surface of the area equals the other portion of the valve, so that the length of the siphonal border is equal to the hinge-border; in the adult state the escutcheon extends fully three fifths of the posteal slope, and the siphonal border is comparatively short.

The figures of *T. carinata*, given in the work of Agassiz ('Trigonies,' tab. vii, figs. 7—10) represent two small specimens deprived of their tests; the surfaces of the area and escutcheon are not preserved, and the costæ are only faintly indicated. *T. sulcata* of the same work (tab. viii, figs. 5—7) represents an internal mould of *T. carinata*. Fig. 8 is a large example deprived of the test; it has traces of the oblique costæ, but has no portion of the surfaces of the area and escutcheon; figure 10 represents a very young specimen destitute of any portion of the surface; the species, therefore, is very inadequately illustrated by the figures of these two supposed species.

The figures of *T. carinata* given by d'Orbigny ('Paléont. Fran. Terr. Crét.,' plate 286), although affording beautiful examples of lithographic art, are not altogether satisfactory representations of the species. The larger of the specimens is not of adult growth, but should represent the changes which had taken place over the posteal portion of the area in the effacement of the carinæ and intercarinal costellæ by rugose irregular plications; on the contrary, the carinæ, including a delicate median carina and the intercarinal costellæ, continue prominent even to the siphonal border; there are no differences in the intercarinal spaces; the escutcheon assumes the aspect of a deep concavity, and the costæ although prominent are without the posteal terminal attenuations. These several features differ essentially from the more perfectly preserved examples of the species from Atherfield, so celebrated for the fine condition of its Neocomian Testacea. The description in the text of the same work is so concise that it does nothing to rectify the incorrect details of these figures.

Affinities and Differences. The *Lyrodon sulcatum* of Goldfuss is one of the Cretaceous *Scabræ*, and altogether a different species; it is better known as *Trigonia sulcataria*, to which the reader is referred. *T. peninsularis*, Coquand ('Monogr. de l'étage Aptien de l'Espagne,' pl. xxiii, fig. 3), is the only other costated *Trigonia* known in the Cretaceous rocks; its general aspect is that of sectional degeneracy, and has no near affinity with *T. carinata;* it is chiefly remarkable for the very irregular and unequal costæ, some of which are angulated mesially; the few last formed become irregular plications.

By a singular error, which could only have arisen from an imperfect acquaintance with British *Trigoniæ*, D'Orbigny ('Prodr. de Paléont.,' vol. i, p. 338, No. 161; also vol, ii, p. 78, No. 288) made Sowerby's figures 1, 2, of *T. elongata*, from the Oxford Clay of Weymouth, to be identical with the Neocomian *T. carinata.* Our figures of each of these species render any detailed comparison between them unnecessary.

Positions and Localities. T. carinata occurs in the Upper Neocomian formation, in the lowest or *Perna Mulleti* bed at the Atherfield section in the Isle of Wight; the test is usually only partially preserved; specimens are of every stage of growth, but it is somewhat rare, and its condition of preservation compares unfavorably with the numerous valves of Conchifera at that celebrated locality; other localities and Neocomian positions are Hythe, Lympne, and Maidstone, at which places the test is usually absent, the fossil consisting of glauconitic sandstone. It is unknown in the Middle Neocomian Stage at Speeton, Tealby, Norfolk, and Cambridgeshire.

Our figures represent Atherfield specimens excepting Plate XXXV, fig. 3, from Upper Greensand, near to Ventnor. The latter, although deprived of the test, has the surface ornaments well preserved. Apparently also the range of *T. carinata* is even more considerable than is indicated by the Isle of Wight specimens. Certain internal moulds, very imperfect and unfit to be submitted to the artist, were forwarded to me by Mr. Cunnington from the Upper Greensand of Devizes and from the Chloritic Marls of Warminster; their occurrence at the latter locality and position in the highest beds of the glauconitic series extends the range of *T. carinata,* and exceeds that of any other known example of the genus.

It is also noteworthy that, although the range both stratigraphically and geographically is so considerable, no separation into varieties occur; the more close or more distant arrangement of the costæ represent the limits of variation. It will be observed that the small specimen from Upper Greensand of Ventnor, Plate XXXV, fig. 3, offers no distinction from the specimen, fig. 4, which is of similar size, and obtained in the lowest bed of the Neocomian formation at the Atherfield section, separated from the newer position by upwards of 1000 feet of strata.

T. carinata is absent in the Gault both of Kent and of the Isle of Wight, and equally so in the Greensand of the Blackdown and Haldon regions and in the Chloritic Marls of the South Devon Coast.

Foreign localities cited are all Neocomian; these are Saint Saveur, Vaux-sur-Blaize, Brillon, Gréaux, Vorey, near Besançon. Switzerland—Hautervive, near Neuchatel.

ADDENDA.

Species and Varieties of Trigoniæ figured in this Monograph which were not received sufficiently early to allow of the descriptions being placed in their proper sectional order.

Trigonia scapha, *Ag.* Pl. XXXVIII, fig. 6 (Scaphoideæ).

Trigonia scapha, *Agassiz.* Trigonies, p. 15, pl. vii, figs. 17—20, 1840 (internal moulds).
— — *d'Orbigny.* Prodrome de Paléont., vol. ii, p. 79, No. 293, 1850.
— — *Pictet.* Paléont. Suisse, pl. cxxviii, figs. 6—8, 1866.
— Hunstantonensis, *Seeley.* On the Fossils of the Hunstanton Red Rock, Ann. and Mag. Nat. Hist., 3 series, No. 82, p. 276, October, 1864 (mould).

Shell scaphoidal, anterior side short, somewhat truncated, posterior side produced, rather depressed; umbones elevated, somewhat recurved, superior border lengthened, nearly straight, curved posteally with the siphonal border, which is of moderate length, its lower extremity curving elliptically with the lower border. The escutcheon is moderately lengthened and depressed; the area is wide and slightly convex. The only specimen at my disposal is deprived of the test; the area therefore exhibits only the muscle scar; the other portion of the shell or pallial surface retains traces of the surface ornaments; there are a few nearly perpendicular subnodose costæ which pass downwards from the angle of the valve to the middle, where they meet the extremities of another oblique anteal series of similar but smaller costæ. The dental hinge processes are large.

Dimensions of the mould above described:

Length, 26 lines; height, 14 lines; thickness, 9 lines. The convexity is less than in the mould figured by Agassiz, which is probably the effect of vertical pressure.

The only British specimen known is in the Woodwardian Museum: Cambridge, the surface ornaments are obscure. It was deposited there by Mr. H. Seeley, and catalogued by him in his list of Hunstanton fossils under the name of *Trigonia Hunstantonensis*, 'Ann. and Mag. Nat. Hist.,' October, 1864. Subsequently in a communication to the same periodical Mr. Seeley expressed his belief that the fossil was not derived from the red rock of Hunstanton, but that it came from the drift of Norfolk. The general aspect of the mould agrees with the latter conclusion.

Position and Localities. The moulds figured by Agassiz are from the Neocomian formation at Voray, near Besançon. The specimen figured by Pictet ('Paléont. Suisse,' plate 128, figures 6—8) has the test preserved; the broad area with its median groove, large transverse plications, and bounding tuberculated carinæ is conspicuous; the first-formed six rows of pallial varices are nodose and transverse; they pass across the valve without interruption, the succeeding rows are broken and angulated about the middle of the valve; all are nodose.

Within the period during which these sheets were passing through the press I have been favoured by the Rev. T. Wiltshire with moulds of two Trigoniæ from his fine collection of Hunstanton fossils obtained by him in the Red Chalk (Gault) of that locality. The moulds represent a short suborbicular form distinct from *T. scapha*, but their condition of preservation will not allow of comparison with any other recognised species.

Trigonia exaltata, *Lyc.*, sp. nov. Pl. XXXVIII, fig. 2 (Scaphoideæ).

Shell scaphoidal, somewhat depressed, truncated anteally, much produced posteally; umbones subanterior, much elevated, incurved, and recurved, anterior side very short, forming a flattened surface anteally, curved elliptically with the lower border; superior border lengthened, concave. Escutcheon lengthened, plain, concave, its upper border raised. Area narrow, flattened, traversed longitudinally by an oblique mesial furrow and crossed by very numerous, irregular, wrinkled, and rugose plications which become prominent at the position of the inner carina and at the median furrow; at the outer angle of the valve near to the apex is a distinct small and narrow carinal elevation, which with advance of growth changes to a line of small papillated oblique elevations; these become evanescent over the posteal moiety of the valve which has no carinal elevation. The other portion of the shell is characterised by a series of nearly straight, large, nodose varices, about fourteen in number; the nodes are large, and rounded near to the angle of the valve; the more posteal six rows have the nodes more cordlike or unequal and irregular near to the pallial border; the first-formed few rows of varices are oblique and near to the anteal curvature of the valve are replaced by or are united irregularly with a smaller, more numerous, shorter series of varices, the few first formed of which become attenuated and pass across the flattened anterior surface of the valve to the pedal border; the junctions of the extremities of the two series are throughout very irregular; and the last-formed three or four posteal perpendicular rows are also very irregular. The lines of growth are large and widely separated.

Dimensions of the large specimen figured upon our plate:

Length $5\frac{1}{4}$ inches; height $3\frac{1}{2}$ inches; thickness through the single valve 10 lines.

Affinities and Differences. The nearest analogue of this grand species is *T. navis*, Lam.; the latter has the general figure shorter and more convex; the anteal flattening of the valve is more pronounced; the escutcheon is wider, more excavated, and shorter; the smooth area and pallial rows of varices, attenuated upwards, are also very distinctive features.

T. scapha, Ag., a much smaller and shorter species, is characterised by the angularity formed by the two portions of the varices about the middle of the valve, by the smaller elevation of the umbo, by the absence of any distinct anteal flattening or truncation, and by the greater breadth of the valve at the siphonal border.

T. Robinaldina, D'Orb., from the Neocomian formation of Saint Sauveur (Yonne), one of the *Scaphoideæ*, has the general convexity much more considerable, so that the diameter through the united valves is equal to three fifths of the length; the area is without tubercles at the angle of the valve; it has no median furrow and has no clear separation from the pallial surface; the escutcheon is short and has great breadth.

Position and Locality. Our figure represents the largest known example of the *Scaphoideæ;* the original is a specimen in the British Museum which bears the inscription Drift of Norfolk; its history is unknown. The general aspect indicates that its original seat was the Middle Neocomian formation of West Norfolk, a locality from whence the specimens of *T. ingens* in the Lynn Museum were derived and probably also the mould of *T. scapha* in the Woodwardian Museum last described.

TRIGONIA PULCHELLA, *Ag.* Pl. XXXVIII, figs. 10, 11, 12, 12 *a* (SCAPHOIDEÆ).

TRIGONIA PULCHELLA, *Agassiz.* Trigonies, p. 14, tab. ii, figs. 1—7, 1840.
— — *Marcou.* Recherches Géologiques sur le Jura Salinois, Soc. Géol. de France, § 47, 1846.
— — *Terquem.* Paléont. du Dép. de la Moselle (Extr. de la Stat. de la Moselle), p. 23, 1855.
— — *Quenstedt.* Der Jura, p. 311, tab. xliii, fig. 1, 1857.
— — *Oppel.* Jura-Formation, Würtemb. Natur. Jahreshafte, 12—14 Jahrg., p. 406, No. 426, 1857.
— — *Quenstedt.* Handbuch der Petrefactenkunde, tab. xliii, fig. 14, 1867.
— — *Lepsius.* Beiträge zur Kentniss der Jura-Formation im Unter-elsass, p. 48, 1875.

Shell small, subquadrate, moderately convex mesially, depressed anteally and posteally; umbones small, anterior, little elevated; hinge-border lengthened, straight; anterior side perpendicular, abruptly truncated; lower border slightly curved, having near to its posteal extremity two or three short perpendicular folds corresponding with as many depressions and prominences in the interior of the shell; its extremity forms nearly a right angle with the siphonal border, the superior extremity of which forms a similar angle with the posteal extremity of the lengthened, narrow, elliptical escutcheon. The area is somewhat convex, its size is nearly equal to the other portion of the valve; it has a series of large acute transverse costellæ, which are somewhat broken at the position of the usual median furrow, which is not distinct. The marginal carina is represented by a row of regular, minute, rounded papillæ. The other or pallial portion of the valve has a small series of subnodose varices which are variable in figure; occasionally the anteal varices are curved and entire, more frequently they are broken mesially, when their anteal portions become horizontal; posteally there are two or three short perpendicular rows. The interiors of the valves have the nacreous layer of the test preserved; the hinge processes are unusually large; the borders of the valves are plain excepting the depressions and prominences near the posteal extremity of the pallial border.

The anteal truncation and the characters of the varices ally it to the *Scaphoideæ;* the internal pits near to the posteal extremity of the pallial border resemble a similar feature in the Cretaceous *Quadratæ,* from which section, however, it is separated decisively by its plain escutcheon.

The *T. pulchella* of Reuss ('Die Versteinerungen der Böhmischen Kreideformation,' tab. 41, fig. 3) is a minute form, having no affinities with the species to which Agassiz had previously given the same name; only two lines in length, it is allied to and may possibly represent the very young condition of *T. disparilis,* D'Orb. ('Pal. Fran. Terr. Crét.,' vol. 3, plate 299), which it resembles in its radiating, knotted, unequal costæ, and in the transverse costellæ which cross both the area and escutcheon; it has not occurred in Britain.

The stratigraphical range of *Trigonia pulchella,* Ag., appears not to be limited to a single geological position; it was first obtained by M. Gressly at Urweiler and at Mühlhausen (Department of the Haut-Rhin), in beds which were assigned by himself and by Agassiz to Upper Lias, but regarded by them as representing a peculiar and local development of that formation.

M. Terquem obtained this *Trigonia* in the bed of Marly Sandstone or Grés Supra-liassique of the Department of the Moselle, associated with *Trigonia navis, T. litterata,* and a series of Testacea, several of which have their equivalents in some portion of the Supra-liassic Sands of England, in the Cotteswold Hills, and in the southern counties. The more northern or Yorkshire development of these sands presents differences both lithological and palæontological.

Professor Quenstedt from an extensive knowledge of the strata of Urweiler and its numerous Testacea exemplified in plates 42, 43 of his 'Der Jura,' determined the position of *T. pulchella* to be the lowest zone of Inferior Oolite or that of *Ammonites torulosus,* associated with *Trigonia navis, Ammonites opalinus, A. Hircinus, Venulites trigonellaris, Trigonia similis,* &c., a remarkable association of Testacea which is almost wholly distinct from any British assemblage of Inferior Oolite fossils. Several of these forms have their analogues or are even identical with Cotteswold species of the Supra-liassic Sands.

Professor Oppel also ('Juraformation,' p. 406) referred *T. pulchella* to the lower portion of the Inferior Oolite, of which he regarded it as a characteristic species; he recorded its occurrence at Gundershofen (Bas Rhin), Milhau (Aveyron), and Metz (Moselle).

It is only recently that *T. pulchella* has become known as a British species; its discovery in a lower stratigraphical position has resulted from the persevering researches of Mr. Keeping, of the Woodwardian Museum, Cambridge, who obtained specimens in the Upper Lias at Bracefield brick-pits, near Lincoln, associated with *Ammonites serpentinus, A. bifrons, A. communis,* and other Ammonites special to that zone. The Lincoln specimens are smaller than those figured by Agassiz, and by Quenstedt in his 'Der Jura;' they agree better with the figure given by the latter author in his 'Handbuch der Petrefactenkunde,' tab. 43, fig. 14. It has not been obtained at any other British locality.

TRIGONIA AFFINIS, *Miller*. Pl. XXI, fig. 7, also Pl. XL, fig. 2 (GLABRÆ).

TRIGONIA AFFINIS, *Sow.* Min. Conch., tab. ccviii, fig. 3, vol. 3, 1818.

The description of this species and also of *T. excentrica* given at pages 94 and 95 require to be supplemented by the revised present description.

Shell short, convex mesially, umbones not prominent, erect, anterior side produced and rounded, hinge-border short, its outline slightly convex, curved elliptically, with the posteal extremity, which is obtusely rounded. The sides of the valves have numerous small regular subconcentric costæ which have prominence anteally even to the border; they disappear rather suddenly about the middle of the valve, and the posteal half of the shell is plain; the posteal slope is slightly flattened and is distinct only near to the apex. The lines of growth are only slightly defined; there are three arrests of growth, which are also only obscure. The hinge characters have not been exposed.

The specimen, Plate XL, fig. 2, contributed by Mr. Vicary, has the length 31 lines, the height 24 lines, the convexity of a single valve $7\frac{1}{2}$ lines.

Compared with *T. excentrica* the general figure is larger, much shorter, or more equilateral; the umbones have less prominence, the costæ are more numerous, imperfectly developed, and nearly approach the concentric figure. Specimens of advanced growth acquire much thickness and their costæ become evanescent. For the most part the specimens upon the tablets of our Greensand Collections, both public and private, are very indifferently preserved and are not separated from specimens of *T. excentrica.*

Positions and Localities. The specimen figured, Pl. XL, fig. 2, was obtained by Mr.

Vicary at Great Haldon in the pebble-bed which overlies the Blackdown and Haldon Greensand, associated with other characteristic *Trigoniæ* of the Upper Greensand. Another imperfect specimen was obtained by Mr. Meÿer in the Chloritic Marls in the vicinity of Axmouth. It appears to be rare.

TRIGONIA DUNSCOMBENSIS, *Lyc.*, sp. nov. Pl. XL, figs. 5, 6 (GLABRÆ).

Shell subovate or ovately oblong, very convex, umbones antero-mesial, prominent, not recurved; superior border slightly concave, its posterior extremity curved elliptically with the siphonal border, which is short and curved with the inferior border; the anterior border is produced and rounded. In the young condition the costæ are very closely arranged or almost linear; they pass horizontally across the valve and are slightly undulated at each of the extremities in a manner resembling *T. excentrica*, but less pronounced. With advance of growth the costæ become narrow, prominent, and much more distantly arranged, their prominence continues in well-preserved specimens even to the lower border; they disappear posteally, so that about one third of the valve is plain. The valves have no decided arrest of growth, but the lines of growth are irregular and strongly defined.

The nearest ally is *T. excentrica*, compared with which the general figure is shorter or less produced posteally; the convexity is much more considerable; the costæ are more prominent, less excentric anteally, the rows are also more widely separated, more especially upon the middle portion of the valve and near to the lower border, at which part of the valve in *T. excentrica* the costæ are usually evanescent.

Dimensions of the specimen, Pl. XL, fig. 5:

Height 21 lines; length 26 lines; diameter through the single valve 9 lines.

The test is of considerable thickness and is often found separated into two layers, of which the inner layer is of much the greater thickness; its surface consists of a series of minute, closely set perpendicular lines, often of unequal size; they are more or less impressed by distantly arranged concentric lines of growth.

Numerous specimens have been placed at my disposal by Mr. Meÿer, collected by him in the Chloritic Marls of the South Devon Coast, near Sidmouth; more especially in the cliffs at Dunscombe, Branscombe, and Beer Head. All the specimens are more or less imperfect or fragmentary and their outlines are rarely preserved entire; they afford little information concerning the hinge processes or of the interior of the shell; as, however, large portions of the surface are often very well preserved, the costæ can be compared with and separated from the *T. excentrica* of the Blackdown Greensand. The general very defective condition of the *Trigoniæ Glabræ* in the Upper Greensands will account for my having mistaken some of them for *T. excentrica* as at p. 96. I therefore take the present opportunity of stating that in no instance does it appear certain that an example of *T. excentrica* has occurred in a higher position than the Blackdown Greensand.

TRIGONIA DEBILIS, *Lyc.*, sp. nov. Pl. XL, figs. 8, 8 *a* (GLABRÆ?).

Shell small, subovate, moderately convex, umbones pointed, produced, antero-mesial; costæ upon the sides of the valves, depressed, rounded, very closely arranged, horizontal, or transverse, each having an undulation and becoming smaller posteally where their extremities are suddenly turned upwards, meeting the divisional line of the valve at a considerable angle. The small posteal slope has the costellæ crowded, transverse, and scabrous.

The single specimen figured is broken at the siphonal and lower borders; the height and length are nearly equal, or 5 lines. The costæ are thirteen in number, but apparently five others would be required to render the shell perfect to the apex.

Probably this is only the young condition of a much larger species; it has some resemblance to young shells of the *Glabræ*, but is quite distinct from either of the known Greensand species in their young states.

Collected by Mr. Meÿer in the bed No. 10 of the Chloritic Marls of Dunscombe Cliffs.

TRIGONIA CRENULIFERA, sp. nov. Pl. XL, figs. 1, 1 *a*, 1 *b*, 7, 9, 9 *a* (SCABRÆ).

Shell near to the general figure of *T. scabricola*, but shorter and wider, or more expanded posteally; the umbones are remarkable for their great elevation and their recurvature; the anterior side is very short, but is curved elliptically with the lower border; the anterior face of the shell has little convexity with considerable breadth. The hinge-border is concave and short; the escutcheon is very large and concave, its borders are raised; it is traversed transversely by a series of scabrous costellæ which are not altogether regular and have their direction somewhat oblique; they curve irregularly where they pass across to the area, which has greater breadth than in species generally of the *aliformis* group; it has much convexity, is conspicuously bipartite, its boundaries, separating it from the escutcheon and from the sides of the valves, are well defined; it has a deep mesial furrow which interrupts a series of prominent crenulated costellæ which are disposed somewhat irregularly or nearly in zigzag order; in the adult condition the posteal portion of the area widens and becomes more flattened; the costellæ are ultimately replaced by irregular transverse plications.

The sides of the valves are covered by a very numerous and closely arranged series of crenulated costæ sometimes twenty-five or more in number, small at the divisional angle of the valve; they enlarge downward, the summits of the rows are everywhere narrow, and delicately crenulated; their direction is obliquely downwards over the middle portion of the valves; the first formed or more umbonal rows are curved forwards anteally, becoming attenuated and almost horizontal upon the anteal face of the shell.

The internal mould is usually seen in the South Devon specimens; the dividing ridge of the area is strongly defined; the lower borders of the valves are slightly dentated and the impressions of the costæ are more or less visible, resulting from the considerable attenuation of the test, a feature in which it differs from allied species of the *aliformis* group.

Dimensions. Length of the largest specimen figured 32 lines. Height 30 lines; convexity of a single valve 10 lines.

Affinities. Compared with *T. crenulata* from Le Mans, our species has the costæ usually more prominent, rugose, and less numerous; the area and escutcheon are more steep, or form a more considerable angle with the other portion of the shell; the posteal slope in *T. crenulata* is therefore more expanded and more fully exposed when a valve is placed horizontally and viewed from above; the median furrow is distinct, but is without the deeply impressed groove of *T. crenulifera;* but the chief distinction consists in the prominent zigzag costellæ upon the area and escutcheon which imparts a characteristic aspect to that portion of our shell.

T. crenulata is exemplified in specimens from Le Mans in the 'Paléontologie Française' of D'Orbigny, vol. 3, pl. 295, which has the area destitute of costellæ. The splendid specimen figured by Agassiz, 'Trigonies,' pl. vi, figs. 4, 6, obtained at the same locality, is depicted with very small irregular crenulated transverse costellæ upon the umbonal or anteal portion of the area—a varietal character forming some approximation to, but distinct from, the prominent and peculiar costellæ of our species. Compared with *T. scabra*, Lam., the latter form has the costæ upon the sides of the valves much larger; they pass across the area and escutcheon continuously, much reduced in size, but are not interrupted by the elevated boundaries which mark the limits of that portion of the shell; they are therefore without the large irregular or broken costellæ of our species.

The peculiarities of the costellæ possess some resemblance to a similar feature exhibited upon the area and escutcheon in one of the *Scabræ* from Bogota, figured and described by D'Orbigny under the name of *T. subcrenulata*, 'Coquilles foss. de Colombie,' pl. iv, figs. 7, 8; the latter shell has the general figure much more inflated, with a much smaller and more concave area, which, however, is altogether without the deeply impressed median groove of *T. crenulifera*, the junction with the escutcheon is ill defined, the transverse costellæ have an undulation not broken by a median groove as in *T. crenulifera;* the crenulated costæ upon the sides of the valves are very small and widely separated.

Stratigraphical positions and Localities. Numerous specimens more or less defective in their general condition have been obtained by Mr. Meÿer, in hard rock of the Chloritic Marls in cliffs between Beer Head and Sidmouth, also from Pinhay Cliff near Lyme Regis; they present some variability in the prominence of the lines of growth, and also in the costellæ upon the area and escutcheon. Mr. Meÿer states that specimens occur of much larger dimensions in the cliffs near Dunscombe; but from the hardness of the rock he has found it impossible to get them out.

Associated with them are the following species of *Trigonia*—*T. sulcataria*, *T. pennata*, *T. Meyeri*, *T. Vicaryana*, *T. Archiaciana*, *T. scabricola;* and in the cliff a large specimen has been seen of what Mr. Meÿer believes to be *T. quadrata*, Ag., and also indications of another large species. Ample and valuable imformation upon the position of our species in connection with its localities and the associated Testacea will be found in a paper by Mr. Meÿer, 'Quart. Jour. Geol. Soc.,' August, 1874. The beds 10 to 12 of the classified section in the memoir contain one species, there assigned doubtfully to *T. crenulata*.

The specimens from Pinhay Cliff are usually more rugose, their costæ are more highly ridged, their crenulations indistinct, the costæ are of larger size and fewer in number, probably it should be regarded as a variety, but their usual condition of preservation forbids any rigid comparison.

With the numerous Cretaceous *Trigoniæ* kindly forwarded to me by Mr. Cunnington, were several examples from the Upper Greensand of Potterne, near Devizes, which although partially deprived of the test retained some portions of their surface ornaments upon the escutcheon and area, and should apparently be referred to the present species; they are now deposited in the Museum of the Royal School of Mines.

T. crenulata, Lam., has also been recorded by Professor R. Tate, in the Hibernian Greensand of the North East of Ireland, 'Jour. Geol. Soc.,' 1864, p. 30. As the position accords with that of our species, it is not improbable that both of them represent the same *Trigonia*.

TRIGONIA CYMBA, *Cont.* Pl. XXXVIII, fig. 1 (CLAVELLATÆ).

TRIGONIA CYMBA, *Contejean.* Étude de l'Etage Kimmeridien dans les env. de Montbeliard, et dans le Jura de France et Angleterre, Extr. Mém. de la Soc. d'emulation du Doubs, pl. xiv, figs. 1, 2, 1859.

One of the *Clavellatæ,* remarkable for the considerable elongation of the valves posteally, for the small curvature of the rows of costæ which are nearly horizontal, for their inconspicuous tubercles, and for the small development of the ornaments upon the valves generally.

The general figure has some resemblance to the more lengthened forms of the *Pholadomyæ ;* the umbones are large, elevated, and nearly erect, placed within the anterior third of the valves; the anteal portion of the shell has considerable convexity, the posteal and more lengthened portion is comparatively much depressed. The escutcheon is lengthened, narrow, flattened, and slightly depressed. The area is narrow, bounded upon each side by a row of minute tubercles over the anteal or umbonal half of its length ; over the same portion there is also a distinct median furrow and delicate transverse plications; these ornaments disappear about the middle of the valve; the posteal half of the area has only transverse rugæ which are not very strongly defined; it is also much depressed. The other portion of the shell has rows of clavellated costæ about fifteen or sixteen in number, small, nearly horizontal, or coinciding in their direction with the lines of growth ; anteally they do not extend to the border of the valve. The tubercles in the rows are small, nearly equal, compressed, little elevated, and near to the lower border they become small scabrous elevations.

Length of the specimen figured $4\frac{1}{4}$ inches ; height 2 inches; convexity of the single valve 7 lines.

The imperfect example herewith figured was obtained by J. C. Mansel Pleydell, Esq., in Portland Sand of the cliffs in Kimmeridge Bay, Dorsetshire. The minuteness and delicacy with which the characters of the surface have been preserved leave little cause to regret the absence of the test, but the surface ornaments have much less prominence than in the fine specimen figured by M. Contejean, from Mont. Beliard, at which locality he states that it is abundant.

The unusually lengthened and much curved figure, together with the numerous, small, nearly horizontal rows of costæ, and inconspicuous closely set tubercles, serve to separate it from other clavellated *Trigoniæ* of the Upper Oolites. The convexity anteally is considerable and contrasts with the lengthened and depressed posteal portion of the valves ; these comparisons refer more especially to *T. Pellati,* Mun., *T. Cottaldi,* Mun., *T. Alina,* Cont., and *T. muricata,* Goldf.

Trigonia Alina, *Cont.* Pl. XXXVIII, fig. 3 (Clavellatæ); also variety, Pl. IX, fig. 2 (corrected).

Trigonia Alina, *Contejean*. Étude de l'Etage Kimmeridien dans les environs de Montbeliard et dans le Jura de France et Angleterre, Extr. Mém. de la Soc. d'Emulation du Doubs., pl. xiv, figs. 3—5, 1859.

— — *P. de Loriol, E. Royer, et H. Tombeck.* Descr. Géol. et Paléont. des Étages Jurassiques supérieurs de la Haut Marne, Mém. Soc. Linn. de Normandie, tom. xiii, fig. 5, pl. xvii, 1872.

Shell ovately trigonal, convex, short anteally, lengthened posteally; umbones anteal, prominent, obtuse, much arched inwards. Hinge-border lengthened, slightly raised, its posteal extremity forming an obtuse angle with the short siphonal border; anterior and lower borders curved elliptically. Escutcheon large, lengthened, and concave, its length being equal to the height of the valve. Area narrow and flattened, its width not exceeding that of the escutcheon; it has the usual median furrow, and has transverse irregular plications which enlarge slightly at their extremities, forming small bounding elevations or carinæ.

The other portion of the shell has numerous, closely arranged rows of small nodose varices (our specimen, a small one, has seventeen rows); their general direction have but little curvature, but are not altogether regular and symmetrical in their course; their posteal extremities form right angles with the angle of the valve which they touch; the nodes in the rows are small, rounded, closely arranged, often touching each other, and vary little in size, excepting that the three or four rows last formed have the nodes larger and less closely arranged; but as our sole specimen is not of adult growth this feature has but little significance; the few first formed or umbonal rows are nearly plain or slightly knotted.

Compared with other allied examples of the *Clavellatæ*, the distinctive characters consist of the narrow and nearly smooth area, the large escutcheon, the general figure of the shell curved and lengthened posteally, the considerable number and close arrangement of the small nodose costæ, together with the small curvature which the rows make upwards near to the angle of the valve.

Upon comparing the original figure in the work of Contejean with that of de Loriol, Royer, and Tombeck, some differences exist; the latter has the rows of costæ less numerous, the tubercles are fewer or more widely separated in the rows, the diminution in the size of the few last-formed costæ is also a distinctive feature; the general figure of the shell has greater height, and is more attenuated at the posteal extremity; it would appear also that the rows of costæ have a greater curvature upwards towards the carina than obtains in the specimen figured by Contejean.

Stratigraphical position and Locality. The specimen upon which our description is founded is deposited in the Museum of the University of Oxford, and was obtained in the Portland Limestone of Shotover Hill; it is of less advanced growth than the specimen figured by Contejean, and still less so than the one figured by De Loriol; the area and its bounding carinæ are only indifferently preserved, so that their little plications are not shown.

For this addition to the *Trigoniæ* of the Portland formation I am indebted to the liberality of the late Professor Phillips, who obtained and forwarded to me well-executed plaster casts of all the *Trigoniæ* in the Geological Museum of the University of Oxford.

Increased knowledge of the *Clavellatæ* of the Kimmeridge Clay has led me to regard the specimen figured, Plate IX, fig. 2, and there given as a supposed variety of *T. incurva*, as referable rather to a variety of *T. Alina*, Cont., having fewer costæ than the shell of the Portland Oolite, but possessing no other distinctive feature.

TRIGONIA HUDLESTONI, *Lyc.*, sp. nov. Pl. XXXIV, figs. 5, 6; Pl. XXXIX, figs. 1 *a* and 2 (CLAVELLATÆ).

Shell ovately trigonal, depressed, excepting the posterior slope which is steep and convex. Umbones prominent, pointed, nearly erect; anterior side very short, its border curved elliptically with the lower border; hinge-border straight, lengthened, sloping downwards, forming less than a right angle with the anterior border. Area narrow, flattened, transversely delicately plicated; marginal carinæ small, minutely and densely tuberculated, excepting upon its lower third, where the tubercles disappear, and it becomes plicated or obscurely nodose; inner carina large, transversely prominently plicated; median carina small and distinct, represented at the upper half of the shell by a row of minute, closely placed tubercles, which become obsolete over the lower half of the area. Escutcheon depressed, somewhat excavated, flattened obliquely, irregularly plicated; its length is considerable, or exceeding half the length of the entire valve; no part of its surface is visible when a valve is placed horizontally and viewed from above.

The rows of tuberculated costæ are about eighteen in the fully developed form; they are narrow and elevated with about twelve or thirteen tubercles in each row, the rows are widely separated, have little curvature, their carinal extremities become nearly perpendicular and are much attenuated and imperfectly subnodose or cord-like.

The most prominent distinctive features in this large species consist in the short depressed, subtrigonal form, the narrow area, its steep slope; the widely separated narrow costæ attenuated at both of their extremities, together with the considerable angle which they form with the marginal carina.

The specimen figured, Pl. XXXIX, figs. 1 *a*, 2, exposes the diverging hinge processes of the right valve which are unusually lengthened, more especially the posteal one, which is upwards of eighteen lines in length, the entire border of the escutcheon having a length of thirty-two lines; the nymphal plate is also much lengthened.

For the loan of this fine *Trigonia* I am indebted to W. H. Hudleston, Esq., who states "that he obtained it in a limestone quarry at Cawklass, in the North Riding of Yorkshire, in a compact calcareous stone full of sparry shells, and having a few oolite granules. This rock belongs in all probability to the upper part of the Coralline Limestones associated with Corals, though there are no Corals in this bed."

The imperfect specimen, Pl. XXXIV, fig. 5, is from the Coral Rag of Heddington, near Oxford, and is deposited in the Oxford Museum.

The smaller specimen, Pl. XXXIV, fig. 6, has the outline nearly perfect; it is from the Elsworth Rock, Cambridgeshire, and belongs to the collection of Mr. J. F. Walker, of York.

Compared with the allied species *T. Alina,* the general figure has less convexity; the rows of costæ are smaller and less curved, or become nearly perpendicular as they approach the carina, and are much attenuated at each of their extremities; the tubercles in the rows are irregular and unequal.

TRIGONIA BRODIEI, *Lyc.* Pl. XXXV, figs. 8, 9 (CLAVELLATÆ).

TRIGONIA STRIATA, *Quenstedt.* Handbuch der Petrefactenkunde, tab. xliii, fig. 13 (not *T. striata,* Mill.), 1867.

Shell smaller than *T. striata,* more oblong, with greater convexity. Umbones large, prominent, obtuse, much recurved, placed one third the length of the shell from the anterior border, which is convex and prominently rounded; the superior or hinge-border is lengthened and concave; the area is narrow, transversely delicately striated, having a mesial furrow, and bounded by minutely tuberculated carinæ; they form together with the area a concave space at the hinge-border. The costæ, about twelve in number, are narrow and elevated; their tubercles are small, closely arranged, irregular, rounded, and attenuated anteally; the rows of costæ have considerable curvature, they are more widely separated than is usual in allied species of the same group.

As a British *Trigonia* this species appears to be rare; my knowledge of it is limited to the two specimens herewith figured; the left-hand specimen is from the collection of the Rev. P. B. Brodie, and was obtained by him in the Inferior Oolite (Northampton Sands) of Milcomb Hill, Oxon., a locality described by Mr. Beesley, in his excellent little memoir on the Geology of Banbury (Warwickshire Nat. Field Club, 1872); the numerous Inferior Oolite fossils recorded at the locality in question contain *Trigonia costata*, *T. signata*, *T. formosa*, and *T. Phillipsi*, the last named being intended for the present species; the locality, with a list of the fossils, is also mentioned by Prof. J. W. Judd, in the 'Memoirs of the Geological Survey' (Rutland, &c.), pp. 23 and 25, 1875, and in Phillips's 'Geology of Oxford,' Appendix B, p. 512. The other specimen figured agrees entirely in its aspect and matrix with the Milcomb specimen, and I have no doubt pertains to the same rock; it belongs to my collection, but unfortunately no note has been retained of the locality.

The small specimen figured by Quenstedt is slightly more lengthened, but offers no other material distinction; it possesses some differences with the *T. striata* of the same author ('Jura,' pl. xlvi, figs. 2, 3); both forms are sufficiently distinct from the specimens figured in the 'Mineral Conchology.'

TRIGONIA KEEPINGI, *Lyc.*, sp. nov. Pl. XXXV, figs. 1, 2 (CLAVELLATÆ).

Shell with the general figure much shorter and more convex than *T. ingens;* it has also much greater breadth across the pallial surface of the valve; the escutcheon is depressed, of moderate breadth, its upper border is somewhat raised. The area is comparatively narrow and slightly convex or raised; it has a well-marked median furrow; it is crossed by some irregular and unequal plications, which differ much in prominence upon the two specimens at my disposal. The marginal carina is represented by a row of large rounded, or ovate, closely arranged nodes; there is a row of minute papillary prominences at the position of the inner carina, but the area generally is irregular in its ornamentation. The other portion of the valve has the rows of costæ very numerous, regular, and closely placed; they meet the carina at a considerable angle and have only a small curvature; the nodes in the rows, sixteen or more in each, are nearly equal in size, rounded, prominent, and very closely arranged those; of the last-formed two or three rows become ovate; their longer diameters are across the rows. Upon the whole the rows diminish somewhat in size near to the marginal carina. *T. ingens*, Lyc., and *T. Keepingi*, Lyc., represent the only examples of the *Clavellatæ* known in the Cretaceous Rocks.

The name adopted for this species is that of the able Curator of the Woodwardian Museum, Cambridge, who obtained the specimens in the Middle Neocomian formation at Acre House near Tealby, and kindly brought them to my notice. For ample information respecting the geological position of the Tealby beds and their relations to Neocomian strata at other localities refer to three memoirs by Prof. J. W. Judd, 'Quart.

Jour. Geol. Soc.,' vol. xxiii, p. 227, 1867; vol. xxiv, p. 218; also vol. xxvi, p. 326, 1870.

The difficulties attendant upon the examination of Clavellated *Trigoniæ* with fragile crystalline tests preserved in a hard matrix have necessitated the use of specimens defective in their outline, but otherwise in a fine condition of preservation; they were obtained in the vicinity of Tealby, in the bed of hard limestone which has also yielded *T. Tealbyensis,* a bed distinct from the brown ferruginous pisolite of the same locality, which is the source of the specimens of *T. ingens,* Pl. XXXVI, figs. 5, 6. The originals of *T. Keepingi* are in the Woodwardian Museum, Cambridge, and had not been discovered when p. 24 was printed, where *T. ingens* is stated to be the only example of the *Clavellatæ* known in the *Cretaceous Rocks.* The general aspect of these clavellated forms is such that they would readily be mistaken for Jurassic *Trigoniæ* in the absence of all knowledge of their geological position—a fact which appears to lend some support to the views of those palæontologists who would arrange the Neocomian formation with the Upper Jurassic rather than with the Cretaceous Rocks. One distinctive feature exemplified in these delicately preserved *Trigoniæ* consists in the lines of growth having their edges minutely and densely fringed or granulated, visible only under a magnifier, and resembling a similar feature in the Cretaceous *Glabræ,* as in *T. excentrica;* a kind of surface which is absent in the Jurassic *Clavellatæ,* and is distinct from the epidermal tegument which is not preserved.

TRIGONIA WITCHELLI, *Lyc.*, sp. nov. Pl. XXXVIII, figs. 8, 9. (CLAVELLATÆ.)

For examples of this small species I am indebted to Mr. Witchell, of Stroud, who discovered them in the Fuller's Earth of that locality; their condition of preservation is only indifferent, the test is not preserved, the ornaments of the surface are in relief upon a black pigment, which renders them distinct and prominent, notwithstanding their minuteness and delicacy. They possess some general resemblance to *T. imbricata,* Pl. XXXVI, figs. 9, 10, but are sufficiently distinct. Compared with that little species, they are larger, more lengthened, and pointed posteally; the umbones are more elevated and produced; the surface ornaments are more minute.

The area is narrow, having three very small plain, linear carinæ, and is traversed transversely by a few widely separated, regular costellæ. The escutcheon is narrow, its superior border is somewhat raised. Upon the sides of the valves the rows of tuberculated costæ, about 9 or 10 in number, are concentric, much curved, equal in size, small, and minutely papillated. The larger specimen has two of the costæ with their anteal portions broken, and their papillæ scattered irregularly; their figures are slightly lengthened and pointed downwards. The very diminutive size of the costæ causes the

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rows to appear widely separated—a feature which at once serves to separate it from *T. imbricata.*

T. Witchelli has also some affinities with a little Kimmeridge Clay species kindly communicated by Wm. Topley, Esq., and known only from a partially exposed posteal portion of the valve in black shale, brought up in the Sub-Wealden exploration from a depth of 402 feet. The general figure appears to be similar, but the area has no median carina; the rows of costæ are more closely arranged, their nodes are also larger; each of them is slightly prolonged or pointed downwards; they are distinct in the rows: apparently about a third part of the valves is exposed.

Dimensions. The length of the largest specimen of *T. Witchelli* measured upon the marginal carina is 9 lines; the opposite measurement is 6 lines; apparently the species has but little convexity.

Position and Locality. The few specimens obtained are ill preserved; they are the sole representatives of the genus hitherto known in the Fuller's Earth. The matrix is a soft pale grey marly rock; in the same bed were fragments of *Ammonites Parkinsoni.* Hitherto this *Trigonia* has been obtained only at a single locality adjacent to the town of Stroud.[1]

TRIGONIA SNAINTONENSIS, *Lyc.*, sp. nov. Plate XLI, figs. 1, 2.

Shell having a resemblance in its general aspect and the surface ornaments to *T. recticosta* (p. 16, Pl. I, figs. 4—6), but having a much more considerable convexity; the area also differs materially in its more narrow figure and in the absence of a median furrow; in the latter feature it exactly resembles *T. gemmata* (p. 15, Pl. I, fig. 7), and is similarly bounded by a plain marginal carina and a minutely papillated inner carina. The first few rows of costæ are concentric and tuberculated as in *T. recticosta;* the others, whose perpendicular direction accords with those of the latter species, are larger, more ridge-like, more elevated, and are much less distinctly and less regularly tuberculated; they are also somewhat fewer in number; the whole aspect of the surface has, therefore, much less neatness and minuteness in its ornamentation.

The imperfect examples figured are almost the only specimens known; they were obtained by Mr. W. H. Hudleston, and are communicated for the present Monograph.

[1] With much regret I announce that the two specimens so carefully figured on Pl. XXXVIII were lost on their return to Stroud through miscarriage of the post. It may be hoped that the loss is not altogether irreparable, as, although the species has been obtained only at one locality, other specimens are, I believe, in the cabinet of Mr. Witchell. I am not aware that in any other instance a loss of fossils has occurred in transmission through the post.

The larger of the two specimens has the costæ somewhat more oblique, but does not appear to differ as a species from the smaller specimen. The position and locality is the Lower Calcareous Grit of Snainton, near Scarborough.

Trigonia Rupellensis, *D'Orb.* Page 28, Plate VIII, fig. 4; also Plate XXXVI, figs. 1, 2, 3, 4.

During many years the original of our figure Pl. VIII, fig. 4, was the only well-preserved British specimen known. Recently a considerable number, representing every stage of growth and varying greatly in figure and in surface ornaments, have been procured in shore beds of Kelloway Rock at Cayton Bay, near Scarborough. The rock, hard, subsiliceous, varying in colour and structure, has been found to contain over a small area a profusion of these *Trigoniæ,* with both separated and united valves; but, owing to the intractable and tough matrix, only a small minority have been obtained in a condition suitable for the cabinet. The additional figures, on Pl. XXXVI, exhibit considerable differences both in the figure of the shell and in the surface ornaments.

In some instances, as in Pl. VIII, fig. 4, the form is ovately trigonal and short posteally; the costæ are curved, and have not much general irregularity; more frequently the figure is ovately oblong, lengthened posteally; the costæ, or some of them, are broken mesially, angulated, directed anteally; or in other examples the rows of costæ descend obliquely in a confused and irregular manner to the pallial border. The surface ornaments generally have so much irregularity that scarcely any two specimens fully developed present any near approximation in their general aspect. The nodes in the rows also partake of the general variability; usually the larger nodes are those near to the marginal carina; they are rounded, obtuse, and depressed; the smaller nodes are more compressed, pointed, and elevated.

Specimens representing the earlier stages of growth have but little of the variability exhibited by more adult forms; they might readily be mistaken for young examples of other clavellated species, and have therefore not been figured upon our plates.

Numerous specimens have suffered compression, or have their tests only partially preserved; a few examples have the valves in contact, and in such the internal moulds have been more or less exposed. The cardinal processes are small, the hinge-border is concave, the posteal portion is depressed, the borders are rounded; the test is thin; the lines of growth are large, uniform, and conspicuous whenever the surface is well preserved.

Notwithstanding the considerable differences of figure and of surface ornaments, it does not seem possible to arrange them as distinct varieties; the additional figures illustrate sufficiently the several aspects of this species.

Compared with *T. Scarburgensis,* Pl. IV, figs. 1—4 (which is also a very variable species, almost limited stratigraphically to the bed of Cornbrash), the short example of *T. Rupellensis,* Pl. VIII, fig. 4, and other similar forms, show only remote alliance; neither does *T. Rupellensis* exhibit that considerable difference in the surface ornaments of opposite valves of the same shell, which so commonly occurs in the Cornbrash form. Upon the whole there is much affinity between the more lengthened forms of the two species; and, if we exclude from comparison the greater number of the left valves of *T. Scarburgensis* similar to the specimen, Pl. IV, fig. 3, it will occasionally be found difficult to give any definite distinction between the two forms. Generally it may be stated that the variability in the costæ, and also in the general figure of the valves, is much more considerable in the Kelloway Rock form, and that none of the latter have the figure so much lengthened and depressed posteally as the Cornbrash species; the latter also have the rows of costæ usually more horizontal, and they approach the carina at a lesser angle than in *T. Rupellensis.* The result of an ample comparison of specimens has been to confirm the propriety of retaining the two allied forms as separated both by palæontological and stratigraphical distinctions.

TRIGONIA UNDULATA, *From.*, var. ARATA. Page 77, Plate XVI, figs. 9—11; Plate XVII, figs. 5, 6.

The British examples figured Pl. XVI, figs. 9—11, and Pl. XVII, figs. 5, 6, described at p. 77, and alluded to p. 48 may be regarded as a variety of *T. undulata,* figured by Agassiz ('Trigonies,' tab. 10, figs. 14—16) from the Great Oolite of Piedmont. Other fine examples of the typical form have since been obtained in the mountain district of the Lebanon to the eastward of the town of Beyrout; specimens from the latter locality have been known under the name of *Trigonia Syriaca.* Compared with the British variety *arata,* it has somewhat greater convexity upon the middle and umbonal portions of the valves; the marginal carina has greater prominence and the siphonal border is more lengthened or more oblique, thus shortening the length of the hinge-border. As these differing features are very persistent, there can be no doubt of the propriety of separating the British fossils as a variety when compared with the typical form from Italy and from the Lebanon. All the latter specimens examined have the last-formed costæ scarcely developed. The subjoined engravings represent a Syrian specimen of full dimensions.

It may be a subject of doubt whether our British variety *arata* may not be fitly separated from the continental or typical form, and constitute a distinct species. Our Cornbrash and Great Oolite specimens possess much variability, and more than one of them which have come under my notice are separated but little from the typical form in the almost entire absence of tubercles upon the costæ.

The Syrian examples possess equal variability, and occasionally have the costæ not less prominently tuberculated: the typical form has the marginal carinæ always more strongly defined, and the siphonal border more lengthened, than the variety *arata.*

Trigonia undulata, From. Locality, the Lebanon east of Beyrout.

Mr. Damon, of Weymouth, who obtained the Syrian fossil, informs me that specimens are found at three localities near Abich: one in the village itself in a loose earth south of the village, 2400 feet above the sea; the best locality is two miles distant to the south-west at an elevation of 2000 feet; the third locality is directly east.

Trigonia spinosa, *Park.*, var. subovata. Page 136, Plate XXIII, fig. 10; Plate XXVIII, figs. 1, 2.

In the Upper Greensand of the Isle of Wight, *T. spinosa* occurs in the defective condition common to the Testacea of that formation; occasionally the test is partially preserved, and the costæ with their obtuse spines are more or less distinct. Usually the species is represented by a variety which also occurs not uncommonly in the Upper Greensand of Wiltshire, where it has undergone compression, and the moulds of external casts have the surface ornaments only obscurely visible. The Isle of Wight specimens sometimes have the surface better preserved, and the moulds are more free from compression. Pl. XXIII, fig. 10, represents a small specimen, the only one having the test preserved and uncompressed with which I am acquainted. Compared with the typical form (Pl. XXIV, figs. 8, 9), the convexity near the umbo is more considerable; the pallial costæ are somewhat more straight and are directed more towards the lower border; the costellæ upon the area are much decussated by the lines of growth, the costellæ also are directed more posteally or towards the siphonal border; both the costæ and costellæ are therefore less radiating, and have somewhat less curvature; the general outline of the shell is less orbicular, or is more lengthened in the direction of the divisional angle of the valve. The moulds have the costæ less conspicuous; their edges are almost smooth, having only slight indications of the obtuse spines which ornament the test. Upon the whole this variety from the Upper Greensand is readily recognised when compared with the typical form from the Blackdown Greensand; the more lengthened form appears to require a varietal designation (*subovata*), as it is readily recognised irrespective of the lesser differences alluded to.

TRIGONIA FORMOSA, *Lyc.*, var. LATA. Page 35, Pl. XXIX, figs. 11, 12; Pl. XXXV, fig. 7.

The specimens of *T. formosa* figured Pl. V, figs. 4—6, also Pl. XI, fig. 2, and an additional specimen, Pl. XXXVII, fig. 10, are characteristic forms of the species as it occurs in the Cotteswold Hills. In Somersetshire a shell occurs, recognised generally as *T. formosa,* which I regard as a variety (*lata*) of the Cotteswold form; these examples are figured, Pl. XXIX, figs. 11, 12; and Pl. XXXV, fig. 7.

Compared with the Cotteswold or typical form, the shell has somewhat less convexity, more especially upon the anal portion, which is more flattened and expanded; the area has greater breadth; the siphonal border is more lengthened and oblique, forming a smaller angle with the escutcheon, which is shorter and more horizontal; the transverse striations, which are small and regular in the Cotteswold form, become larger and fewer near to the apex in the variety; the costæ are variable in the specimens examined, but do not present any clear distinction.

At Bradford Abbas this variety is not uncommon; it occurs also at Haselbury, Somerset, accompanied by *Trigonia costata* and by the Conchifera usually met with at the former locality, but the state of preservation is much inferior. At Milcomb Hill, Oxon., it has been recorded by Mr. Beesley in the Northampton Sands.

TRIGONIA ARCHIACIANA, *D'Orb.* Page 140, Pl. XXIII, fig. 7.

In reference to this species I have been favoured with the following remarks by Mr. C. J. A. Meÿer, whose researches in connection with associated species of the Upper Greensands and Chloritic Marls of the southern counties of England entitle his opinions to the highest consideration. I fully agree with the following conclusions:

"It appears likely that two or three nearly allied species have long been included under the name of *Archiaciana* on account of the great similarity of their surface markings and the unusually indifferent condition of the specimens examined. And supposing that there are three species which have been included under the one name, the following might, I think, be a safe provisional arrangement:

"1. *T. Archiaciana*, D'Orb. Syn. *T. Archiaciana*, Pictet and Renevier.	Horizon: Aptian. *Loc.* Varennes (Meuse), Perte du Rhône.
"2. *Trigonia*, a small species which would include Pl. XXV, fig. 10. Syn. *T. spinosa*, Ag. 'Trig.,' Pl. VII, fig. 6. ? *T. pumila*, Nilsson.	Horizon: Upper Greensand, Chloritic Marl, Grèsvert. *Loc.* Dunscomb Cliffs, Isle of Wight, and Warminster.
"3. *T. Vicaryana*, Lyc. Pl. XXV, figs. 8, 9; Pl. XXIII, fig. 7; Pl. XL, figs. 3, 4; Pl. XXVIII, figs. 4, 4 *a*. Syn. *T. Archiaciana*, Pictet and Roux. — — 'Morris Catal.,' 1854. — *T. spinosa*, D'Orb.	Horizon: Upper Greensand and Chloritic Marl. *Loc.* Chardstock, Axmouth, Dunscomb Cliffs, Great Haldon.

"No. 2 seems to occur sparingly in Dunscomb Cliffs, in company with *T. Vicaryana*, from which it appears to differ in being smaller, more convex, and less elongated. It *appears* (?) also to want the closely set series of small, oblique, supplementary costellæ on the upper half of the pedal border of the shell, which are very conspicuous in well-preserved specimens of *T. Vicaryana.*

"The third species (your *T. Vicaryana*) seems to be sufficiently distinguishable from others of the *spinosa* group by its large size and (usually) more oblique outline.

"It seems probable that the *T. Archiaciana*, D'Orb., may have to be given up as a British species, in so far at least as the Dunscomb and Great Haldon examples are concerned."

Trigonia Vicaryana, *Lyc.* Page 141, Pl. XXIII, fig. 7; Pl. XXV, figs. 8, 9; Pl. XXVIII, figs. 4, 4 *a*; Pl. XL, figs. 3, 4.

Recent researches of Mr. Meÿer have shown that this species is abundant in the Chloritic Marl of Dunscombe Cliffs, more especially in the beds 10 and 12 of his classified section. See 'Quart. Journ. Geol. Soc.,' vol. xxx, p. 371.

Mr. Vicary has also obtained specimens in the pebble-bed which overlies the Greensand at Great Haldon, where the species, although more rare, has the surface ornaments preserved with great delicacy and beauty; the little perpendicular pillars forming the sides of the costæ have great uniformity and prominence, but are scarcely depicted with sufficient distinctness upon the magnified figure, Pl. XXVIII, fig. 4 *a;* their upper extremities are obtuse, forming upon each row a high narrow ridge bordering upon the channelled base of each succeeding costa, features which are altogether distinct from the plain step-like rows of costæ depicted by D'Orbigny upon the magnified surface of *T. Archiaciana.* The specimen, Pl. XXIII, fig. 7, tabulated *T. Archiaciana*, proves to belong to *T. Vicaryana.* Other small examples from the highest bed of the Haldon

Greensand possess similar features and reduce the supposed examples of *T. Archiaciana* to the little moulds exemplified, Pl. XXV, fig. 16, from the Upper Greensand of the Isle of Wight and of Warminster; these are, however, altogether ill preserved and doubtful as examples of that species. See also p. 141.

I am also inclined to regard our specimens of *T. Vicaryana* as identical with the *T. spinosa* of D'Orbigny, which that author mistook for the *T. spinosa* of Parkinson and of Sowerby; no figure has been given of *T. Pyrrha*, D'Orb., but the few words of description agree with the *T. spinosa* of British authorities.

Trigonia signata, *Ag.* Page 29, Plate II, figs. 1, 2, 3.

In the description of this species, p. 29, no allusion was made to the figure of *T. clavellata* in the work of Knorr ('Verst.,' vol. ii, pl. B, fig. 1 *a*; 1775), which was referred to by Agassiz as one of the types of his *T. signata;* this omission resulted from a lack of confidence in an engraving of one of the *Clavellatæ* in a work of such considerable antiquity.

The figures of *T. clavellata* in Zieten's 'Die Versteinerungen Würtembergs' are also quoted by Agassiz as one of his types of *T. signata;* and, as they are free from the objection above referred to, and also agree generally with British Inferior Oolite specimens within slight limits of variation, and as the number of specimens collected within the last thirty years from Yorkshire, Oxfordshire, and Gloucestershire are very considerable and all approach nearly to Zieten's type, I preferred to regard the latter as the species intended by Agassiz.

In this arrangement we should regard the figure given by Agassiz, 'Trig.' pl. ix, fig. 5, as a variety, excluding his pl. iii, fig. 8, which represents a specimen very defective in condition and doubtful as a species. The example given in 'Trigonies,' pl. ix, fig. 5, is apparently founded upon Knorr's figure, and differs as a variety from the figures by Zieten; it is remarkable for the much greater upward curvature given to the posteal portions of the costæ, which are also more attenuated; the same feature equally characterises the imperfect specimen figured by Dewalque and Chapuis, 'Pal. Luxemb.,' p. 172, pl. xxvi, fig. 1. As the two figures (Knorr's aud Agassiz') above mentioned differ from all the known British specimens, and the latter have a general unity of aspect and accordance with Zieten's figures, I have adopted the last for the type of *T. signata.*

The description at p. 29 sufficiently records the differing positions in the Inferior Oolite in which the species has occurred; it may, however, be mentioned that the Upper Trigonia-grit of the Cotteswolds has supplied the specimens having the growth most fully developed, and that in such the rows of costæ anteally sometimes become irregular and confused; in specimens from other positions in Oxfordshire and Yorkshire the rows of costæ are remarkable for their regularity and uniformity.

PLATE XXVIII.

Fig.		
1, 2.	*Trigonia spinosa* var. *subovata*, Lyc.	Chloritic Sands, Warminster. See also Pl. XXIII, fig. 10. (Page 136.) My collection.
3.	,, *sulcataria*, Lam.	Pebble bed, Haldon. See also Pl. XXVI, fig. 8. (Page 135.) Coll. W. Vicary, Esq.
4, 4 *a*.	,, *Vicaryana*, Lyc.	Portion of the surface magnified. See also Pl. XXV, figs. 8, 9. Pebble bed, Haldon. (Page 141.) Coll. W. Vicary, Esq.
5, 5 *a*.	,, *aliformis*, Park.	Also Pl. XXV, figs. 3, 3 *a*, 4, 4 *a*. Greensand, Blackdown. (Page 116.) Coll. W. Vicary, Esq.
6, 6 *a*, 9, 10.	,, *excentrica*, Park.	Specimens exhibiting the change from *T. sinuata* to *T. excentrica*. Greensand, Blackdown. (Page 94.) Coll. W. Vicary, Esq.
7.	,, *Tealbyensis*, Lyc.	Middle Neocomian Formation, Tealby. (Page 114.) Woodwardian Museum, Cambridge.
	,, *dædalæa*, Park.	Inner surface. See also Pl. XXII, figs. 7, 8, and Pl. XXIII, figs. 2, 3. (Page 100.) Greensand, Blackdown. My cabinet.

Pl. 28

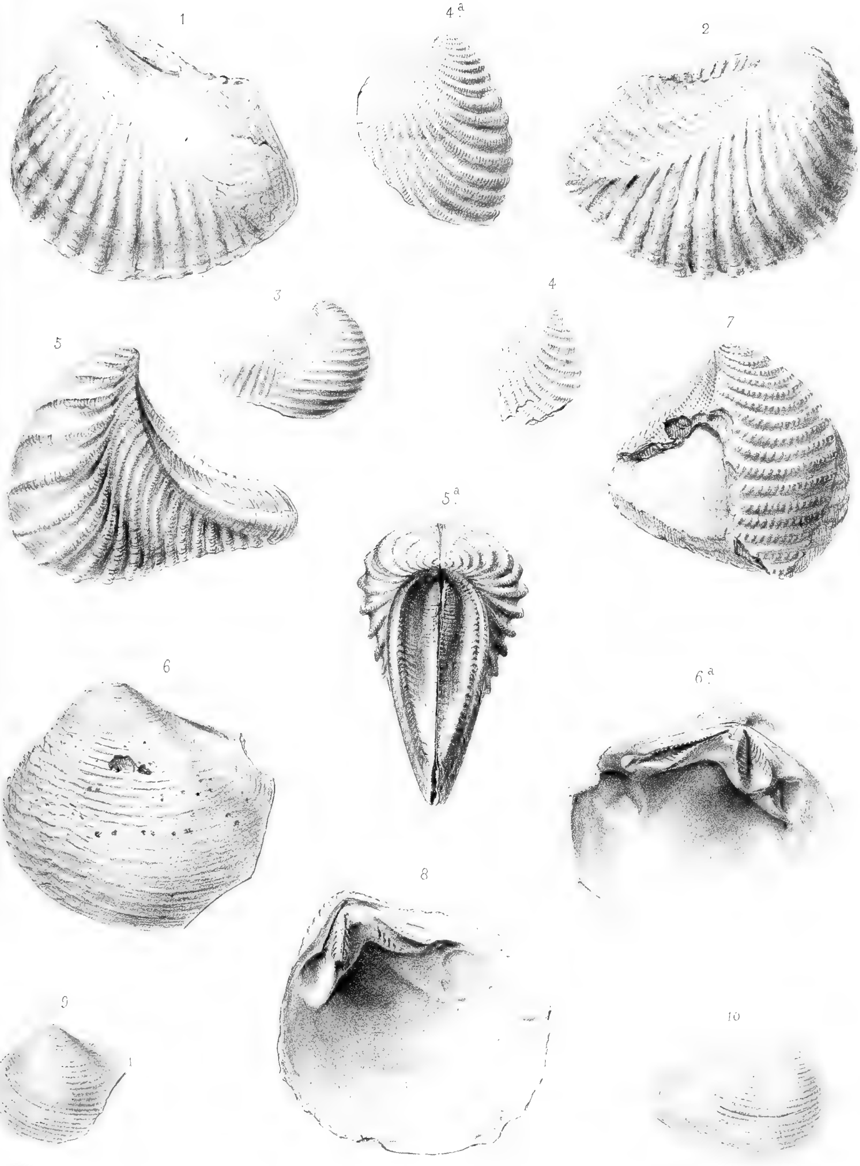

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PLATE XXIX.

FIG.

1, 2, 3. *Trigonia denticulata,* Ag. Inf. Oolite, grey limestone. Cloughton, near Scarborough. (Page 152.) My collection.

4. ,, ,, Id. Small variety. Great Oolite, South Lincolnshire. My collection.

5, 6, 7. 8. ,, *costata,* Sow. The typical form. Inf. Oolite, Bradford Abbas. (Page 147.) My collection.

9, 10. ,, ,, var. *lata,* Lyc. Inf. Oolite. (Page 149.) Cotteswold Hills. My collection.

11, 12. ,, *formosa* var. *lata,* Lyc. Inf. Oolite, Bradford Abbas. See also Pl. XXXV, fig. 7. (Pages 35, 202.) My collection.

PL. 29.

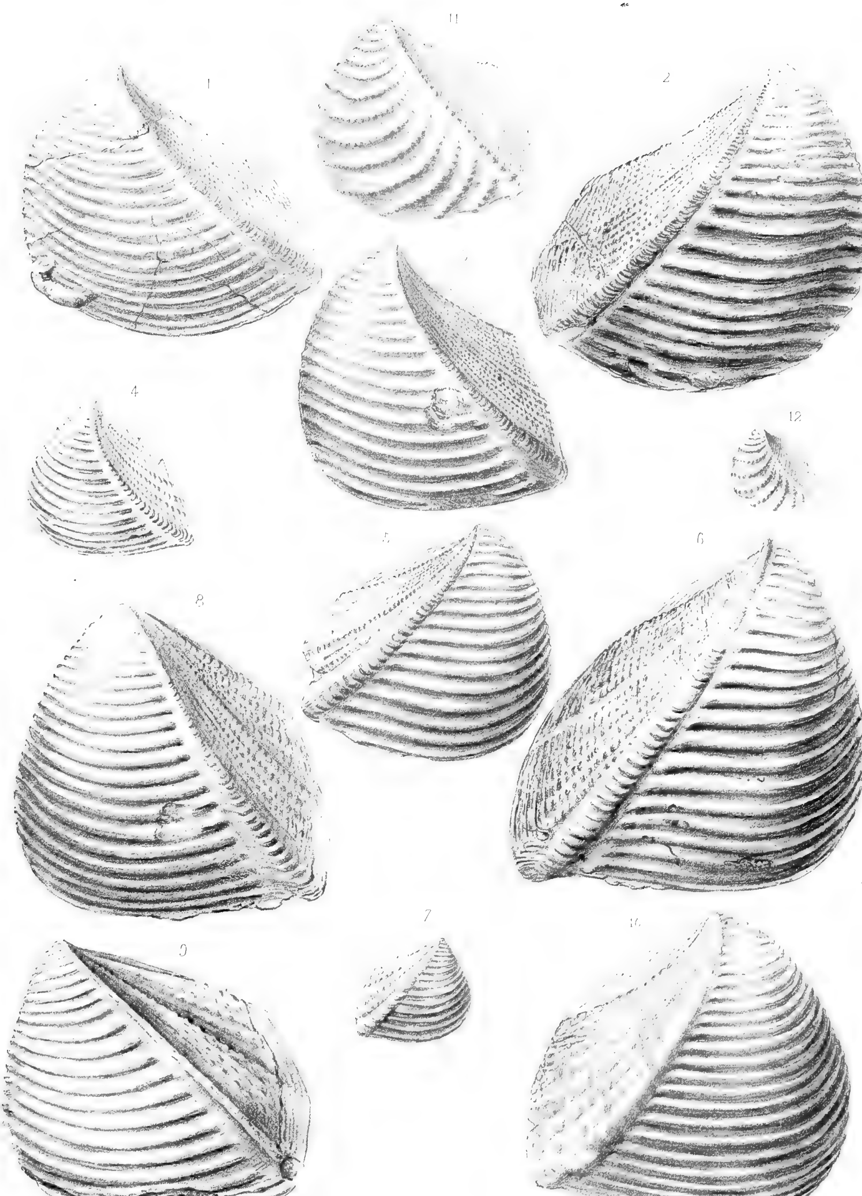

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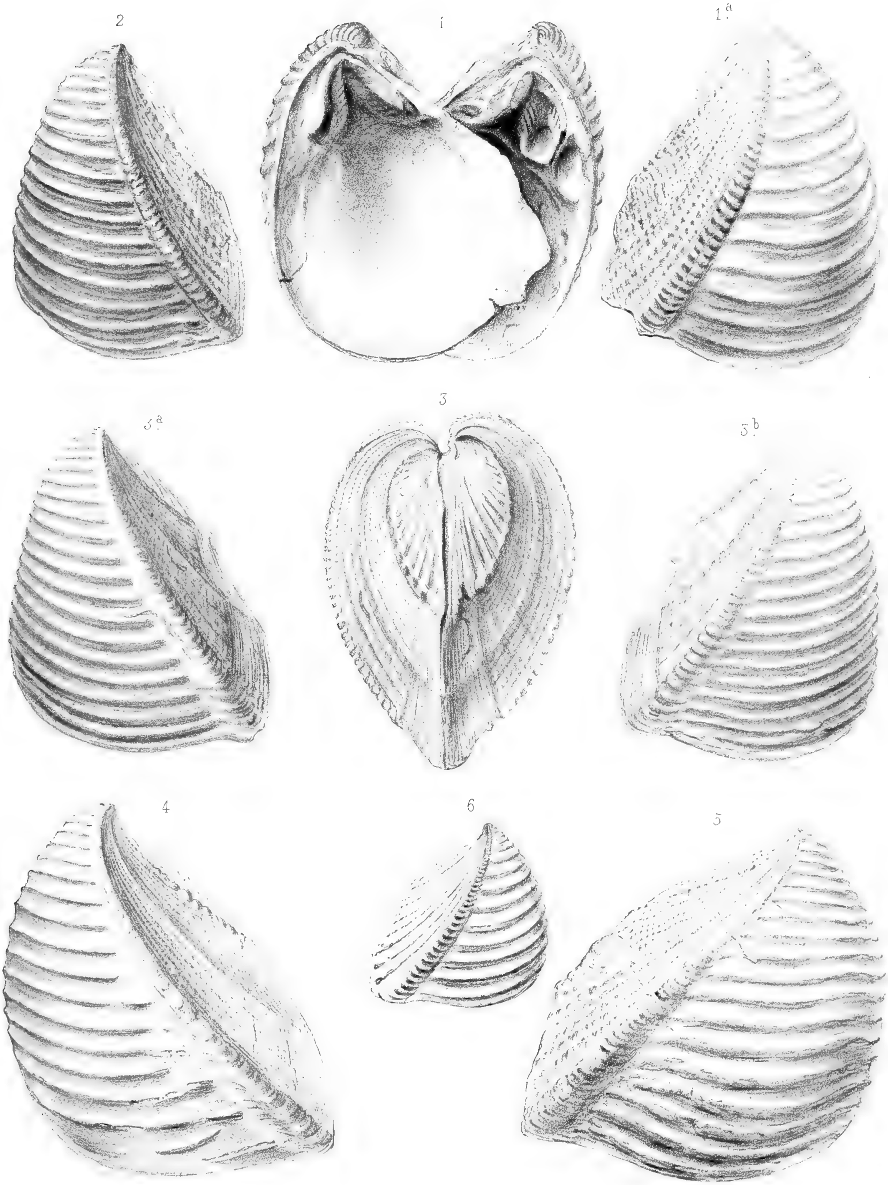
PLATE XXX.

Fig.

1, 1 *a*, 2. *Trigonia elongata* var. *angustata*, Lyc. Cornbrash, Scarborough. (Page 154.) My collection.

3, 3 *a*, 3 *b*, 6. ,, ,, The typical form. Oxford Clay, Weymouth. (Page 154.) My collection.

4, 5. ,, ,, var. *lata*, Lyc. Cornbrash, Scarborough. Also South Lincolnshire. (Page 154.) My collection.



Lackerbauer (Karmanski) ad. lap. del

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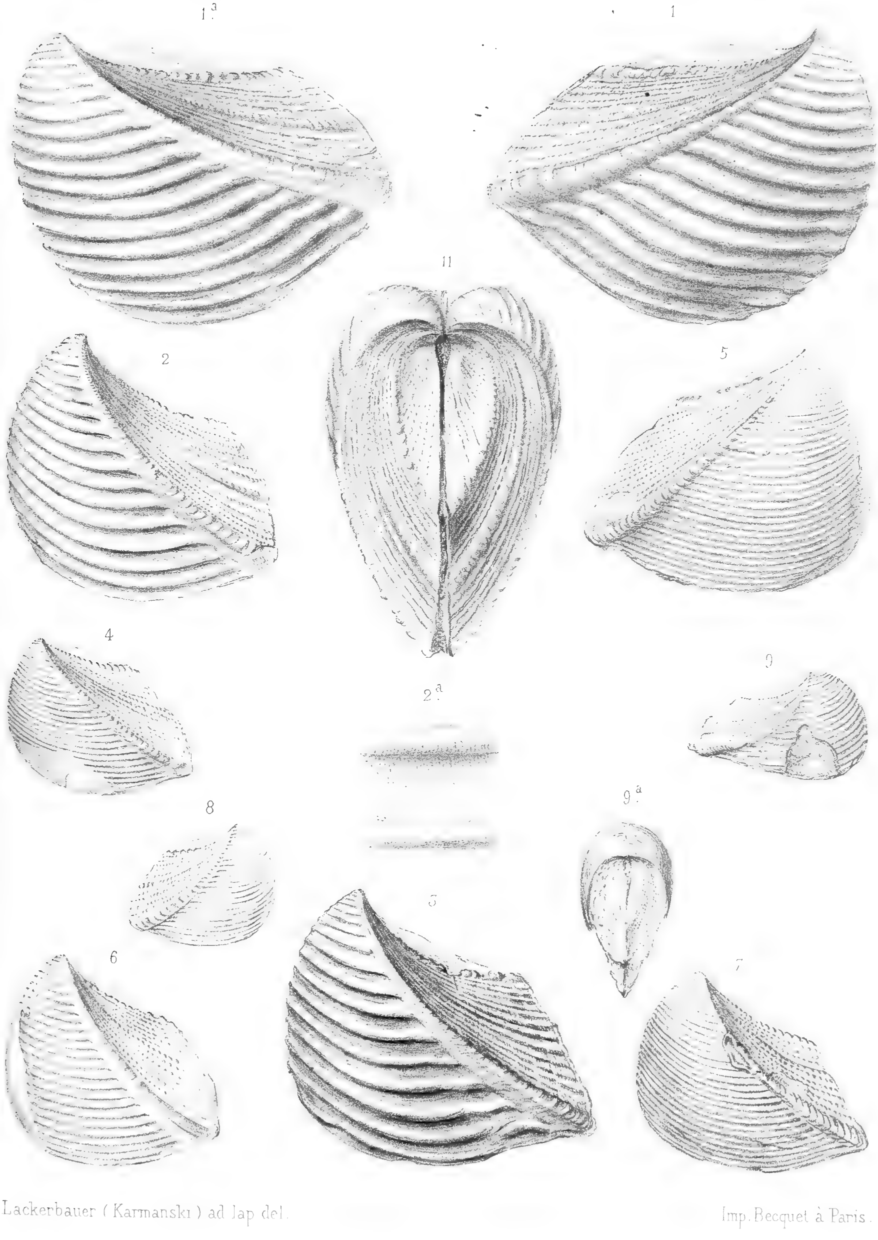
PLATE XXXI.

Fig.	
1, 1 *a*, 2, 3, 10.	*Trigonia monilifera*, Ag. Kimmeridge Clay, Weymouth. (Page 165.) My collection.
2 *a*.	,, ,, Portion of the surface magnified.
4, 5, 7, 8.	,, *hemisphærica*, Lyc. Inf. Oolite, Santon Bridge, near Appleby. (Page 174.) My collection.
6.	,, ,, Specimen with the costæ fewer and larger. Inf. Oolite, Santon Bridge. My collection.
9, 9 *a*.	,, *Culleni*, Lyc. Inf. Oolite, Millepore bed, Cloughton. (Page 173.) My collection.



Lackerbauer (Karmanski) ad Jap del.

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PLATE XXXII.

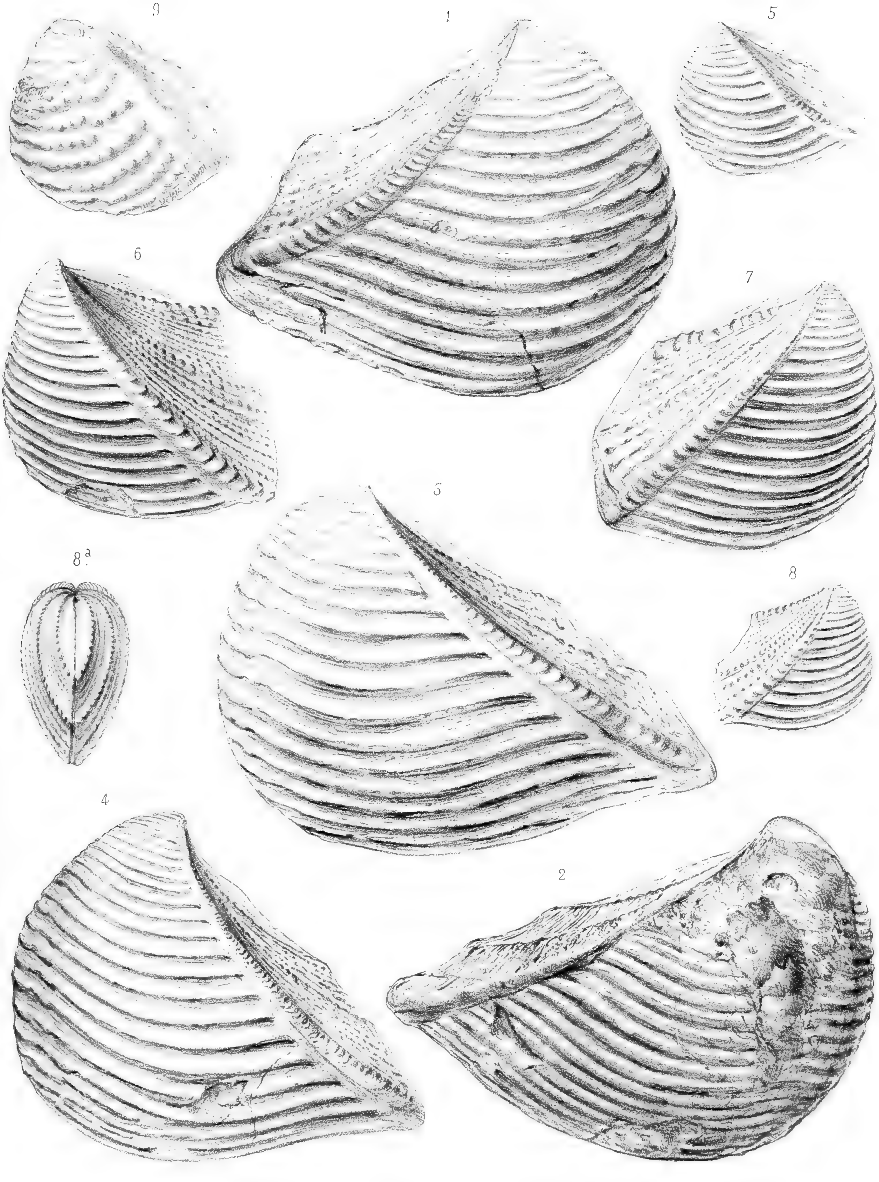
Fig.

1, 2, 3, 4, 5. *Trigonia Cassiope*, D'Orb. Cornbrash, Scarborough. (Page 170.) collection.

6, 7. ,, *bella*, Lyc. Bradford Abbas. Inf. Oolite. (Page 162.) My collection.

8, 8 *a*. ,, ,, Small specimen. The same locality. Coll. Col. Mansel-Pleydell.

9. ,, *geographica*, Ag. Also Pl. X, fig. 6. Coral Rag, Pickering. (Page 69.) My collection.



Lackerbauer (Karmanski) ad lap del.

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PLATE XXXIII.

FIG.

1, 2. *Trigonia Meriani*, Ag. Coral Rag, Pickering. (Page 167.) My collection.

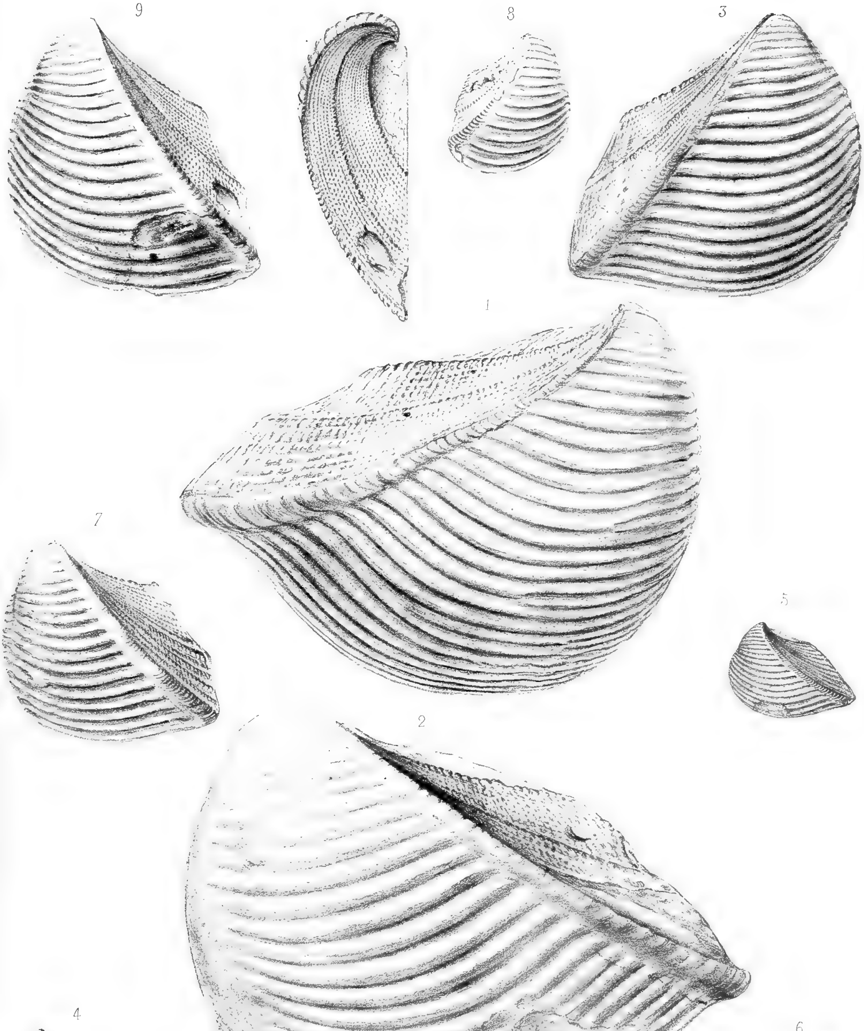
3. ,, ,, Calcareous Grit, Weymouth. My collection.

8. ,, *tenuicosta*, Lyc. Inf. Oolite, Walditch. (Page 160.) Coll. Col. Mansel-Pleydell.

7, 9, 9 *a*. ,, ,, Inf. Oolite, Bradford Abbas. My collection.

4, 5, 6. ,, *hemisphærica* var. *gregaria*, Lyc. Appleby, N. W. Lincolnshire. (Page 174.) Coll. Rev. J. E. Cross. Also my collection.

Pl. 55.



Lackerbauer (Karmanski) ad lap del

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PLATE XXXIV.

FIG.

1, 2, 2 *a*. *Trigonia sculpta*, Lyc. Inf. Ool., near Stroud. (Page 157.) My collection.

3. ,, ,, variety *Cheltensis*, Inf. Ool., Cotteswold Hills. (Page 159.) My collection.

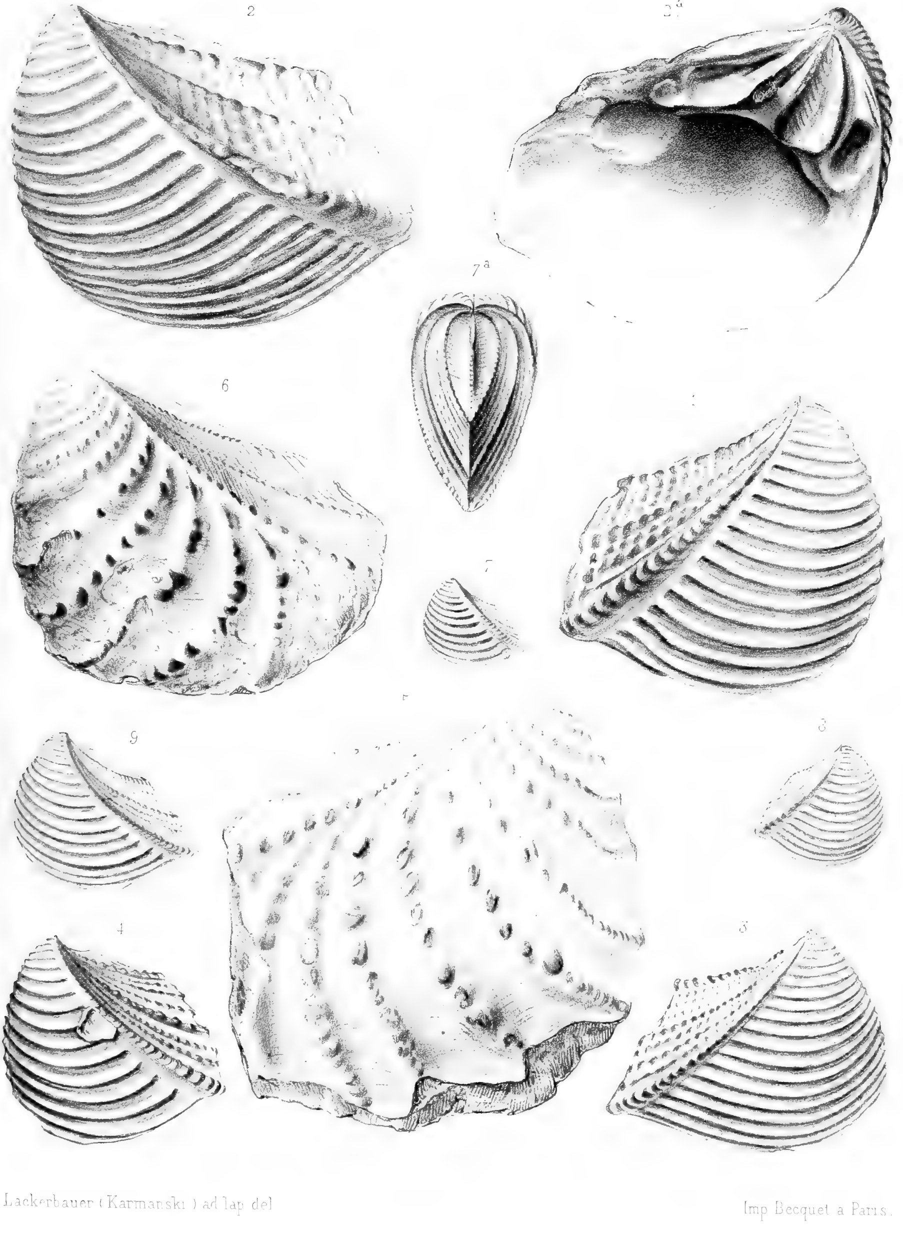
4. ,, ,, variety *Rolandi*, Cross. Cornbrash, North Lincolnshire; also Cornbrash, Hilperton, Wilts. (Page 159.) My collection.

5. ,, *Hudlestoni*, Lyc. Coral Rag, Headington, near Oxford. See also Pl. XXXIX, figs. 1 *a*, 2. (Page 194.) University Museum, Oxford.

6. ,, ,, Elsworth Rock, Cambridge. Coll. J. F. Walker, York.

7, 7 *a*. ,, *pullus*, Sow. Cornbrash, Hilperton, Wilts. (Page 164.) My collection.

8, 9. ,, ,, Great Oolite, Minchinhampton. My collection.



Lackerbauer (Karmanski) ad lap del

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PLATE XXXV.

Fig.		
1, 2.	*Trigonia Keepingi*, Lyc.	Middle Neocomian Formation, Tealby, Lincolnshire. (Page 196.) Coll. Woodwardian Museum, Cambridge.
3.	,, *carinata*, Ag.	Young specimen. Upper Greensand, Isle of Wight, Ventnor. (Page 179.) My collection.
4, 4 *a*.	,, ,,	Young specimen. Neocomian Formation, Atherfield, Isle of Wight. My collection.
5.	,, ,,	Specimen of more fully developed growth. Atherfield.
5 *a*.	,, ,,	Anterior side, exhibiting the byssal aperture. Atherfield, Isle of Wight. My collection.
6, 6 *a*.	,, ,,	Atherfield, Isle of Wight. My collection.
7.	,, *formosa* var. *lata*, Lyc.	Inf. Ool., Bradford Abbas. See also Pl. XXIX, figs. 11, 12. (Pages 35, 202). My collection.
8.	,, *Brodiei*, Lyc.	Inf. Ool., Northampton Sands, Milcombe Hill, Oxon. (Page 195.) Coll. Rev. P. B. Brodie.
9.	,, ,,	My collection.

Pl. 53

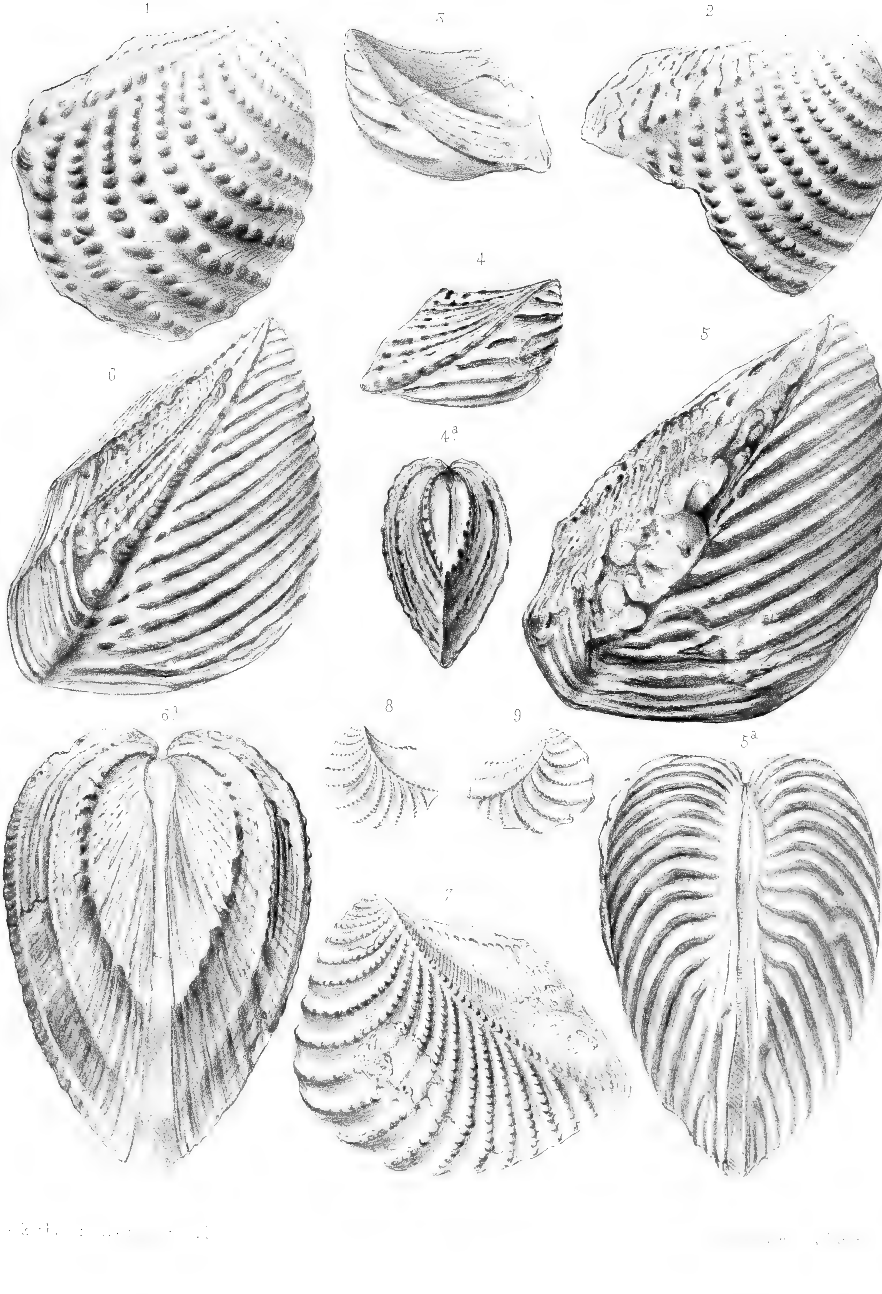

PLATE XXXVI.

FIG.

1, 2, 3, 4. *Trigonia Rupellensis,* D'Orb. Kelloway Rock. Also Pl. VIII, fig. 4. Cayton Bay, Scarborough. (Page 28.) My collection.

7. ,, *triquetra,* Seeb. Also Pl. VI, figs. 1, 1 *a,* 2. Coral Rag, Filey Point. (Page 26.) My collection.

5, 6. ,, *ingens,* Lyc. Young specimens. Also Pl. VIII, figs. 1, 3. Middle Neocomian formation, Tealby, Lincolnshire. (Page 24.) My collection.

9, 10. ,, *imbricata,* Sow. Also Pl. VI, fig. 5 *a, b.* Great Oolite. (Page 33.) British Museum.

8. ,, *parcinoda,* Lyc. Inf. Oolite. (Page 46.) British Museum.

11, 11 *a.* ,, *Griesbachi.* Also Pl. III, figs. 10 *a, b.* (Page 34.) Coll. Rev. A. W. Griesbach.

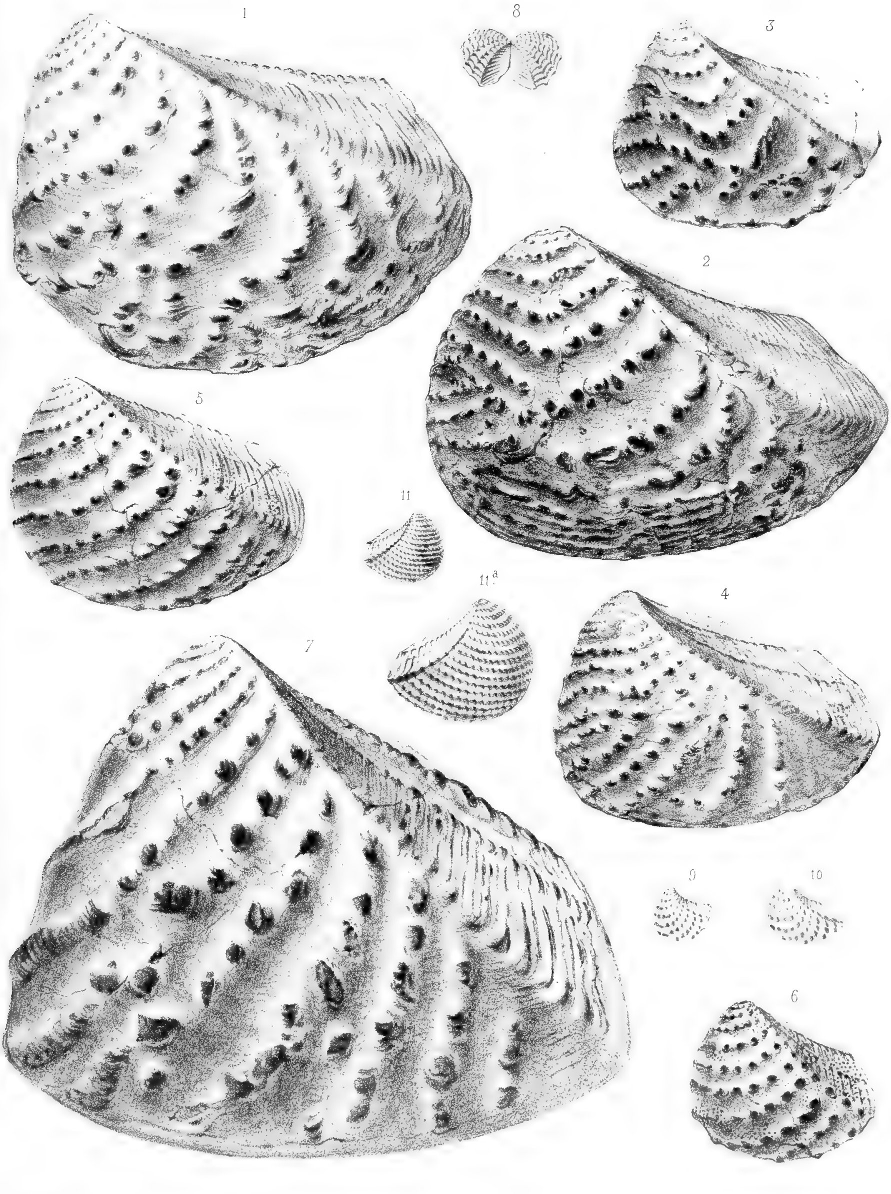

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PLATE XXXVII.

Fig.

1, 2. *Trigonia producta*, Lyc. Also Pl. XIII, figs. 1, 2, 3, 4. Inferior Oolite, Hook Norton, Oxon. (Page 60.) Coll., Royal School of Mines.

3. ,, *paucicosta*, Lyc. Kelloway Rock, Scarborough. See also Pl. XI, figs. 8, 9, and Pl. XVI, fig. 7. (Page 57.) My collection.

4, 4 *a*. ,, *pennata*, Sow. 4 *a*, magnified. Also Pl. XXIV, figs. 4, 5. Chloritic Marl, South Devon. (Page 133.) Coll. W. Vicary, Esq.

5, 5 *a*. ,, *nodosa*, Sow. Specimen less developed than the figures upon Pls. XXIV and XXV. (Page 106.) Neocomian formation, Atherfield. My collection.

6. ,, ,, Young specimen; the costæ had not acquired nodes. Neocomian formation, Atherfield. My collection.

7, 8. ,, *angulata*, Sow. Specimens of advanced stages of growth. See also Pl. XIV, figs. 5, 6. Inferior Oolite, near Stroud. (Page 54.) Coll. E. Witchell, Esq.

9. ,, ,, Young specimen having costæ without angularity. Inf. Oolite, Stroud. Coll. E. Witchell, Esq.

10. ,, *formosa*, var. Inferior Oolite, Bradford Abbas. See also Pl. V, figs. 4, 5, 6. (Page 35.) My collection.

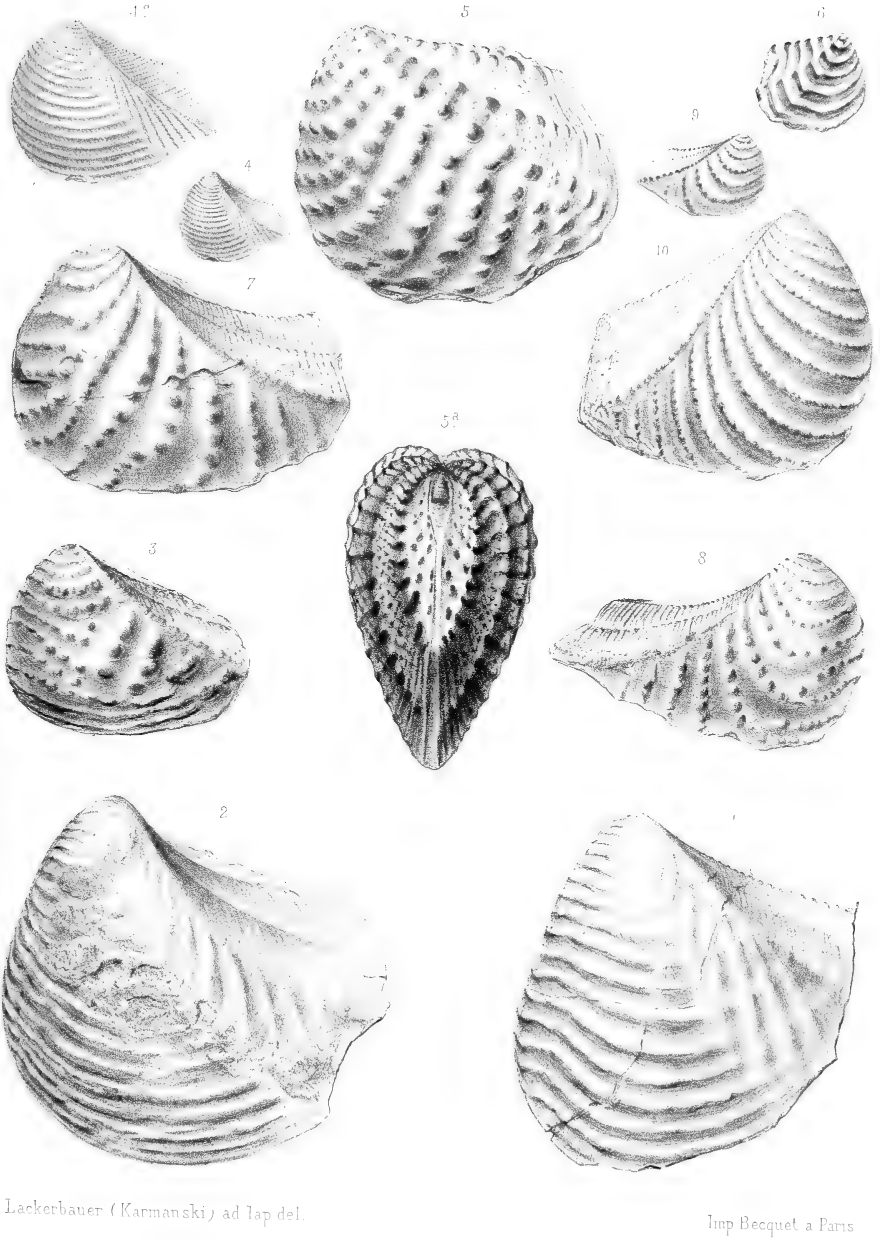

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PLATE XXXVIII.

Fig.		
1.	*Trigonia Cymba*, Cont.	(Mould). Portland Sand, Dorset. (Page 192.) Coll. Col. J. C. Mansel-Pleydell.
2.	,, *exaltata*, Lyc.	Middle Neocomian formation, Norfolk. (Page 184.) Coll. British Museum.
3.	,, *Alina*, Cont.	Portland Limestone, Shotover Hill. (Page 193.) See also Pl. IX, fig. 2; there mentioned as a variety of *T. incurva*. Coll. Museum, Oxon.
4.	,, *compta*, Lyc.	Slate of Collyweston. Specimen unusually large, having the posteal terminal tubercle of each costa much developed. See also Pl. XV, figs. 5, 6, 7. (Page 70.) Coll. S. Sharp, Esq.
6.	,, *scapha*, Ag.	Middle Neocomian formation, Norfolk. (Page 183.) Woodwardian Museum, Cambridge.
7.	,, *Williamsoni*, Lyc.	Kelloway Rock, Scarborough. See also Pl. XVI, fig. 8. (Page 53.) My collection.
8, 9.	,, *Witchelli*, Lyc.	Fullers' Earth, Stroud. (Page 197.) Coll. E. Witchell, Esq.
10, 11, 12, 12 *a*.	,, *pulchella*, Ag.	Upper Lias, Lincoln. (Page 185.) My collection.

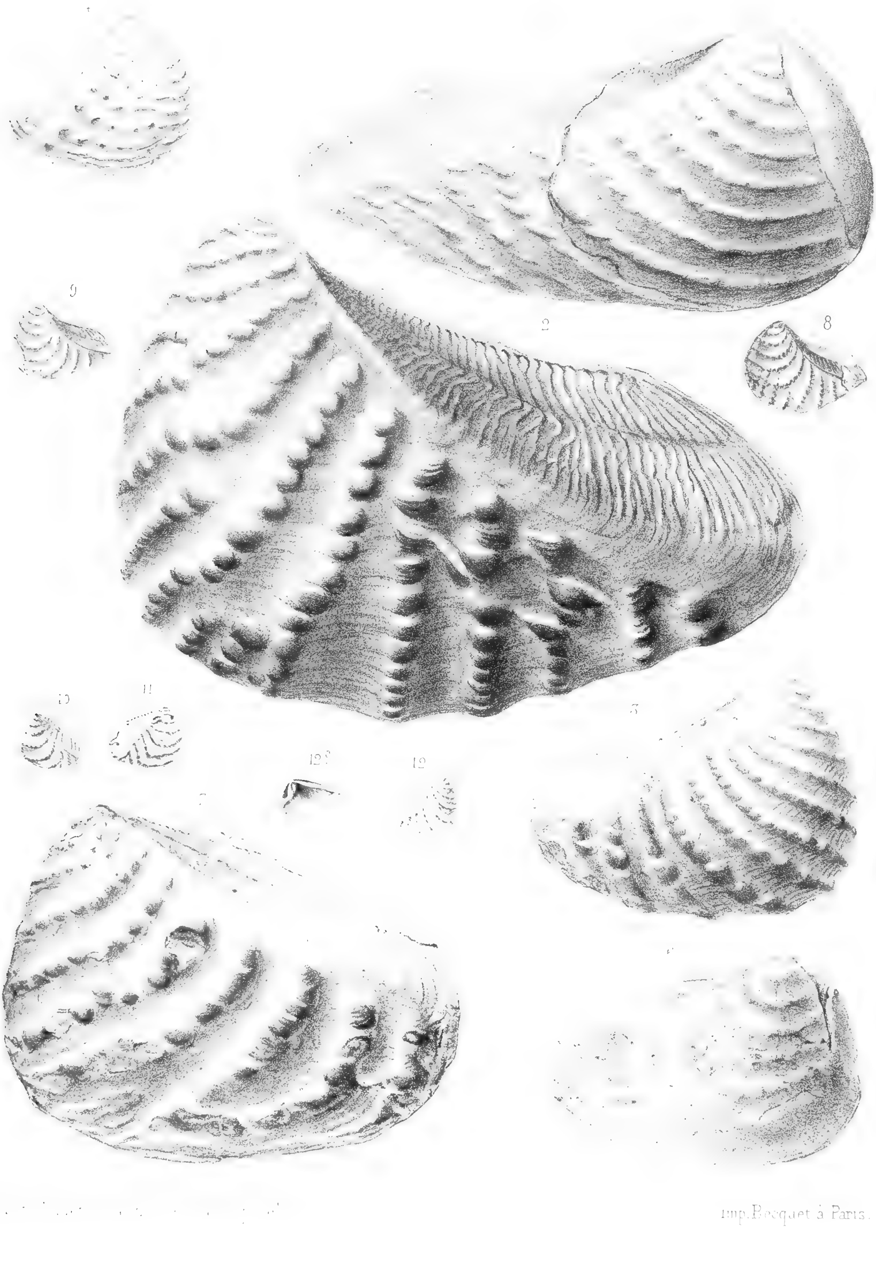

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PLATE XXXIX.

FIG.

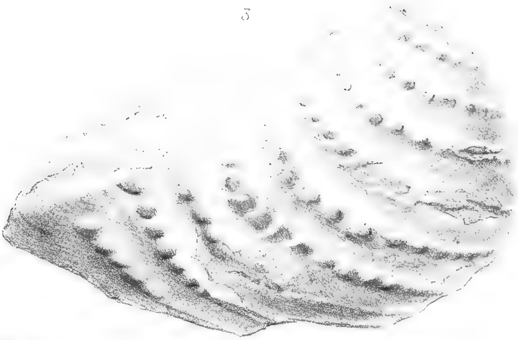
1. *Trigonia Pellati*. Mun. Chal. . Oxford Clay, St. Ives. See also Pl. VII, figs. 1, 2 *a*, *b*, and Pl. XI, fig. 1. (Page 41.) Coll. J. F. Walker, Esq.

1 *a*, 2. „ *Hudlestoni*, Lyc. Coral Rag, Cawkley. Also Pl. XXXIV, figs. 5, 6. (Page 194.) Coll. W. H. Hudleston, Esq.

3. „ *irregularis*, Seeb. Var. Kimmeridge Clay, Wotton Basset. The costæ are nearly without the irregularity of the figures upon Pl. V. (Page 39.) My collection.

4. „ *Upwarensis*, Lyc. Neocomian formation, Upware, Cambridgeshire. See also Pl. XXIII, figs. 8, 9. (Page 143.) Coll. J. F. Walker, Esq.

3



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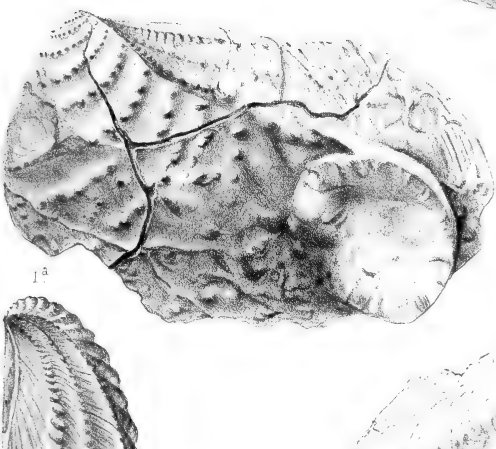

1a

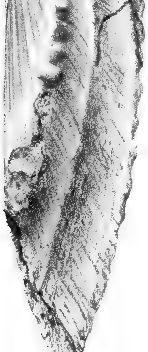

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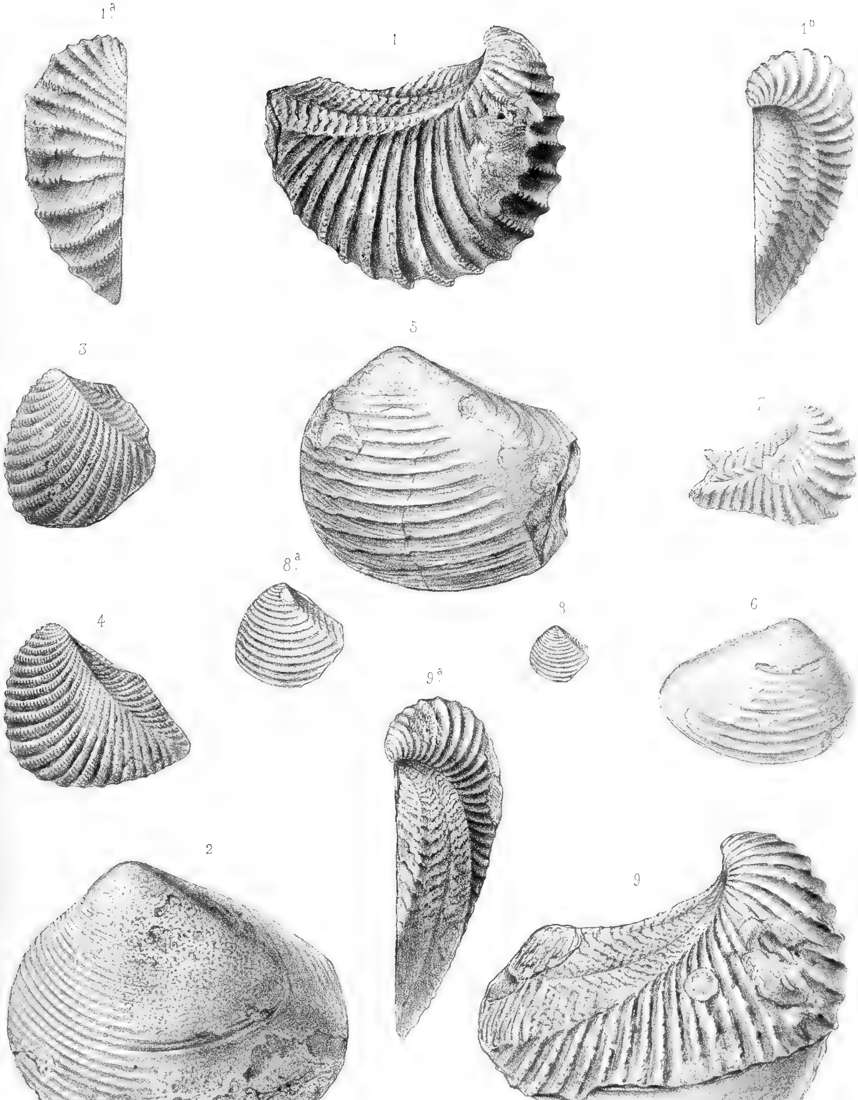
PLATE XL.

Fig.		
1, 1 *a*, 1 *b*, 7, 9, 9 *a*.	*Trigonia*	*crenulifera*, Lyc. Chloritic Marls, Dunscomb Cliffs. (Page 189.) Coll. Meÿer.
2.	,,	*affinis*, Sow. Pebble bed, Great Haldon. (Page 187.) Coll. Vicary.
3, 4.	,,	*Vicaryana*, Lyc. Chloritic Marls, Dunscomb Cliffs, near Sidmouth. (Page 203.) Coll. Meÿer.
5, 6.	,,	*Dunscombensis*, Lyc. Chloritic Marls, Sidmouth. (Page 188.) Coll. Meÿer.
8, 8 *a*.	,,	*debilis*, Lyc. Chloritic Marls, Dunscomb Cliffs. (Page 189.) Coll. Meÿer.



Lackerbauer (Karmanski) ad lap. del.

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THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

VOLUME FOR 1877.

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MDCCCLXXVII.

A MONOGRAPH

OF

THE EOCENE MOLLUSCA,

OR,

DESCRIPTIONS OF SHELLS

FROM

THE OLDER TERTIARIES OF ENGLAND.

BY THE LATE

FREDERIC E. EDWARDS, F.G.S.

CONTINUED BY

SEARLES V. WOOD, F.G.S.

PART IV.

PULMONATA AND PROSOBRANCHIATA.

(INDEX TO VOLUME I AND DIRECTIONS FOR BINDING.)

Pages 331—361; Plate XXXIV.

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1877.

PRINTED BY
J. E. ADLARD, BARTHOLOMEW CLOSE.

THE EOCENE CEPHALOPODA AND UNIVALVES.

DIRECTIONS TO THE BINDER.

The Monograph on the Eocene Mollusca (Cephalopoda and Univalvia) will be found in the publications of the Palæontographical Society issued for the years 1848, 1852, 1854, 1855, 1858, and 1877.

Cancel the title-pages affixed to the separate parts in the volumes for the years 1848, 1852, 1854, 1855, 1858, and 1877, and *substitute* that provided in the volume for 1877. *Cancel* also the corrigenda printed on slips in the volumes for the years 1852, 1854, 1855, and 1858, and *substitute* that provided in the volume for 1877. *Cancel* in addition the "List of Conidæ" (following page 330) printed in the volume for 1858; and let the order of binding be—(1) New title-page to the complete Monograph (in 1877 vol.); (2) Preface (in 1877 vol.); (3) Notice to Subscribers (sheet 7* in 1852 vol.); (4) Corrigenda (in vol. for 1877); (5) Pages 1—361; and (6) Plates I—XXXIV.

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181—240	XXIV—XXVII	1855	February, 1857
241—330	XXVIII—XXXIII	1858	March, 1861
331—361	XXXIV	1877	February, 1877

A MONOGRAPH

OF THE

EOCENE CEPHALOPODA AND UNIVALVES

OF

ENGLAND.

BY THE LATE

FREDERIC E. EDWARDS, F.G.S.

CONTINUED BY

SEARLES V. WOOD, F.G.S.

VOLUME I.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1849—1877.

PRINTED BY
J. E. ADLARD, BARTHOLOEW CLOSE.

PREFACE.

Owing to failing health Mr. F. E. Edwards was unable to continue his Monograph of the Eocene Gasteropoda after the year 1860, but with the facilities afforded by specimens from his Cabinet I was enabled to produce some instalments of the Monograph of the Bivalvia in the years 1864 and 1871. Mr. Edwards' death took place in 1875, and terminated the possibility of any further prosecution of the work by him, his Collection having gone to the British Museum some years previously. I essayed, however, to make some progress with both portions of the work, and the solitary Plate of the Gasteropoda now given was in consequence engraved. I found, however, that owing to advanced years and other circumstances I was unable to carry out my wish, and have been compelled to relinquish it with the solitary Plate referred to.

SEARLES V. WOOD.

1st November, 1876.

CORRIGENDA.

Page 65, line 24, ***substitute*** " Sconce " ***for*** " Headon Hill."
„ 70 „ 13 „ „ „ „
„ 78 „ 15 „ „ „ „

In the head-lines to sheets 17, 18, and 19 (p. 129 *et seq.*), *for* " Pulmonata " *read* " Prosobranchiata."

Page 126, line 10, *for* " Cypræa " *read* " Cypræae."
„ 133 „ 14, *for* " figs. 3 *a—d* " *read* " figs. 4 *a—c*."
„ 134 „ 27, *for* " Basingstoke " *read* " Cuffel, near Basingstoke."
„ 155 „ 28, *for* " (t. 25) " *read* " (t. 5)."
„ 155 „ 30, after the word " size " *insert* " axis 1 in. and $\frac{4}{10}$ths ; diameter $\frac{6}{10}$ths of an inch."
„ 158 „ 14, *for* " figs. 4 *a—c* " *read* " figs. 4 *a—d*."
„ 160, last line but one, after " axis " *insert* " 2 inches nearly," and after " diameter " *insert* " 1 in. and $\frac{1}{10}$th."
„ 168, line 33, *for* " figs. 2 *a—b* " *read* " figs. 3 *a—b*."
„ 212 „ 3 from bottom, *add* " Nuneham " to the list of localities.
„ 255 „ 13, *dele* " Barton."
„ 274, last line, *add* " Brook."
„ 275, first line, *for* " fig. 13 *a, b* " *read* " fig. 15 *a, b*."
„ 279, line 25, *for* " Hampstead Railway Tunnel " *substitute* " Potter's Bar."
„ 282, last line, *add* " Highgate, Potter's Bar, and Southampton."
„ 285, line 17, *add* " Hornsey."
„ 290 „ 16, *for* " fig. 8 *a—c* " *read* " fig. 6 *a—c*."
„ 295 „ 8, *add* " Highgate."
„ 300, last line, *add* " Highcliff."

Genus 6th.—Helix. *Linné,* 1758.

For generic character see *antè,* p. 60.

No. 253. Helix Morrisii, *F. E. Edwards,* MS., Tab. XXXIV, fig. 5 *a, b.*

Spec. Char. H. Testâ orbiculata, lenticulatâ, subdepressâ, obsoletè striato-plicatâ, ad peripheriam angulatâ; spirâ brevi; anfractibus quinis convexiusculis, suturâ simplici junctis, lente crescentibus; ultimo majore, subtus convexiusculo, lævigato, umbilicato; aperturâ paulo obliquâ, subquadratâ; labro acuto simplici.

Diameter, $\frac{3}{8}$ths of an inch.

Locality. Sconce (*Edwards*).

After my plate had been arranged I ascertained that several species of this genus, belonging to the Upper Eocene of the Isle of Wight, which had not been figured by Mr. Edwards, were in his cabinet, and I have been here able to introduce one of these as above referred to, and as Mr. Edwards had probably given to it a careful examination, and satisfied himself that it was a new species, I have much pleasure in adopting the name he has proposed for it.

It slightly resembles a shell from the Lower Tertiaries of France, *H. Heberti*, Deshayes ('An. sans Vert. du Bas. de Par.,' tom. ii, p. 813, pl. lii, figs. 5—7); but, judging from the figure, it appears to possess several differences. M. Deshayes also figured and described a shell (' Desc. de Coq. Foss. des Env. de Par.,' p. 55, pl. vi, fig. 3), to which he gave the name of *H. dubia,* from near Versailles, and he gave for it also the locality of the Isle of Wight; but in his second work, at p. 826, he has doubted the propriety of that statement, and thinks that his shell is an incomplete specimen of *H. Moroguesi,* but the figure of this (*dubia*) more resembles our shell than does any other. Mr. Edwards, he says, has denied the presence of *H. dubia* in our English beds, and I have not the means of making a comparison.

I fear that some of these fossil *Helices* must be carefully compared with the specimens of the foreign species before a perfect identity or non-identity can be relied on; and this I am not able to do. M. Deshayes has not given as a synonym any *Helix* from the English Tertiaries.

FAM.—CYCLOPHORIDÆ.

Genus 28*th*.—CYCLOSTOMA. *Lamarck*, 1799.

Generic character. "Shell turbinated, thin; axis perforated, aperture oval, peristome continuous, simple or expanded, epidermis thin, operculum shelly paucispiral."

A large group of land shells have been described under the above generic name, which seem to have only one character in common, viz. a circular mouth, with a thickened, expanded, or reflected peritreme, the shells themselves being some of them nearly cylindrical like *C. flanulum*, or discoidal like *C. planorbulum;* and they have in consequence been separated into numerous proposed genera, depending for those divisions principally, if not entirely, upon the differences in the angle of volution.

Two species from our Eocene deposit at Sconce have been described by Mr. Edwards under one of these divisions, called *Cyclotus*, with a depressedly conical form (see his remarks on the Genus, p. 116 of his work).

No. 254. CYCLOSTOMA ? MUMIA, *Lamarck*. Tab. XXXIV, fig. 2 *a—d*.

CYCLOSTOMA MUMIA, *Lamk*. An. du Mus., t. viii, pl. xxxvii, fig. 1 *a*, *b*, 1806.
— — *Desh.* Coq. foss. des Env. de Par., p. 76, pl. vii, figs. 1, 2, 1824.
— — *Id.* An. sans Vert. du Bas. de Par., tom. ii, p. 882, 1858.
— — *Forbes.* Mem. Geol. Surv. Isle of Wight, p. 68, 1856.
— — *Morris.* Catal. Brit. Foss., 2nd edit., p. 244, 1854.
— — *J. W. Lowry.* Chart Brit. Tert. Foss., pl. ii, 1866.
MEGALOMASTOMA MUMIA. *Sandberger.* Land- und Süssw.-Conch., p. 217, t. ii, fig. 20, and t. xv, fig. 16 *a—c*, 1872.

Spec. Char. C. "*Testâ cylindraceo-conicâ, transversim striatâ, striis longitudinalibus subtillissimis; aperturâ obliquè ovatâ; labro crasso.*"—Desh.

Length, 1 inch; *breadth*, $\frac{3}{8}$ths of an inch.

Locality. Brading Harbour, *Forbes*. Sconce, *Edwards*.
France, Grignon and numerous other Upper Eocene localities.

This fossil is said to be abundant in some of the numerous localities given for it in the Upper Eocene beds of France. It is at Grignon in association with many marine shells, and it appears to be there of larger dimensions than our own specimens. It has long been known, and its habits have been frequently a subject of discussion from its occurrence with a marine fauna. In this country specimens are not abundant, and all that I have seen are casts. M. Deshayes describes five distinct varieties:

Var. A. *Testâ majore striis transversis numerosioribus.*
,, B. *Testâ striis transversis distantioribus obsoletis; longitudinalibus subnullis.*
,, C. *Testâ lævigatâ; labro incrassato.*
,, D. *Testâ tribus lineis rufis pictâ.*
,, E. *Testâ angustiore clathratâ, striis transversis distantioribus et longitudinalibus raris; labro reflexo, rarè marginato.*

M. Deshayes has given the figure of an operculum of what he considered might belong to this species, but as it was not found in position this is uncertain. The apex of this shell is generally broken in the French specimens, but this probably is accidental; my figures 2 *b*, *d* are from a specimen in Mr. Edwards' Cabinet, which have the volutions slightly convex; figures 2 *a*, *c* are made from a fragment in my own cabinet, with more flattened volutions, and the shell of it appears to have been more cylindrical than *Cy. mumia.* This fragment has upon it a few broad spiral striæ, and I thought possibly it might be the cast of some species of *Cylindrella,* a genus not uncommon on the western side of the Atlantic, and for this reason I had it represented, but I now believe it to be only a variety of *C. mumia,* although the cast of a shell represents the volutions as more convex than would the shell itself; the matrix only filling the cavity after the absence of the animal.

Genus 29th.—Callia. *Gray,* 1840.

This genus appears to have been proposed in the year 1840 for a group of the Family Cyclophoridæ by Dr. J. E. Gray, when he gave an undescribed species as the type, and it forms another division of a large group of shells once united under the name of *Cyclostoma.* Since then Chenu (p. 490) has thus described the genus:—"*Coquille pupiforme, couverte d'un enduit lisse, brillant. Overture arrondie, un peu déviée, péristome mince opercule mince, membraneux, à tours étroits.* C. lubrica, *Sowerby,* f. 3631-2." *Callia* is closely united to *Pupina,* differing from it in not having an open canal at the base of the aperture, which characterises the former genus; and as our shell seems destitute of this canal, I have thought it best to give the only species of this group known to me from the British Eocenes under this generic name, because it has been previously adopted for it, without expressing any opinion of my own as to the propriety of the generic division of the group.

No. 255. Callia (?) lævis, *F. E. Edwards,* MS. Tab. XXXIV, fig. 3 *a—c.*

Pupina? lævis, *F. Edwards,* MS.
Callia? — *Sandb.* Land- und Süssw.-Conch., p. 298, taf. xvii, fig. 13, 1872.

Height, $\frac{5}{16}$ths of an inch.

Locality. Sconce (*Edwards*).

This shell has been figured by Sandberger, as above referred to, who says (p. 298), "*Pupina* (?) *lævis*, F. Edwards, in litt. et specim., 1861," but the specimens in Mr. Edwards' cabinet in the British Museum have the name *Cistula lævis* attached. This I mention to prevent confusion hereafter.

Genus 30*th.*—Pomatias. *Hartmann*, 1821.

This generic name does not appear to be generally adopted, and there is some little confusion respecting it from the great similarity of the two generic names, *Pomatia*, Beck, 1837, a portion of *Helix* (*H. pomatia*?), and *Pomatias*, Hartmann, 1821 (*Cyclostoma patula*). The British Eocene shell having, however, been figured by Sandberger under this generic name, I think it best to retain it so.

No. 256. Pomatias lamellosus, *F. E. Edwards*, MS. Tab. XXXIV, fig. 4 *a*, *b*.

Pomatias lamellosus, *Sandb.* Land- und Süssw.-Conch., p. 299, t. xvii, fig. 14, 1872.
Cyclostoma lamellosum, *F. E. Edwards*, MS.

Height, $\frac{3}{8}$ths of an inch.

Locality. Headon Hill (*Edwards*).

This is, I believe, very rare as a British fossil, and I know it only in Mr. Edwards' cabinet, by a specimen from which my figure is taken. That given by Sandberger was also taken from a specimen sent to him by Mr. Edwards.

Genus 7*th.*—Bulimus. *Scopoli*, 1786.

For generic character see *antè*, p. 71.

No. 257. Bulimus Rillyensis ?, *Deshayes*. Tab. XXXIV, fig. 9 *a*, *b*.

Pupa Rillyensis, *Boissy*. Mém. Soc. Géol. de Fr., 2nd ser., t. iii, p. 273, pl. v, fig. 15, 1848.
— — *Chenu*. Man. de Conch., t. i, p. 443, fig. 3259, 1859.
Bulimus — *Desh.* An. sans Vert. du Bas. de Par., t. i, p. 830, pl. lv, figs. 3, 4, 1860.
Amphidromus Rillyensis, *Sandberger*. Land- und Süssw.-Conch., p. 152, t. vii, fig. 5, 1871.

Spec. Char. "*B. Testâ sinistrorsâ, ovato-oblongâ, spirâ longiusculâ, convexâ, apice obtuso; anfractibus septenis, sensim crescentibus, vix convexiusculis, suturâ planâ, lineari junctis, longitudinaliter et obliquè densè striatis, striis æqualibus, regularibus, sublamellosis, ultimo anfractu dimidiam partem testæ æquante obliquè paulo deflexo, basi imperforato; aperturâ ovato-semilunari; labro tenui, latè expanso, reflexo.*"—*Desh.*

Height, $1\frac{1}{4}$ inch; *breadth,* $\frac{1}{2}$ inch.

Locality. Britain: Dulwich (*A. Bott*).
France: Rilly (*Deshayes*).

A specimen from which the figure above referred to has been taken is from the cabinet of Mr. Arthur Bott. It is a cast only, the shell having entirely disappeared, but seems to correspond with the French fossil, except that our specimen has the last volution somewhat smaller, and the body is apparently rather larger. Our specimen has, however, been slightly distorted and thrown out of its regular form. The figure by M. Deshayes represents the French shell as being spirally striated; but the disappearance of the exterior of our specimen renders it impossible to say what might have been the ornamentation of the English fossil. I have therefore thought it most prudent to add a note of interrogation to the specific name.

This genus when first proposed contained many hundred species with shells that varied much in outward appearance, some being terrestrial and some aquatic in their habits. It has since been separated into a large number of genera or sections, some of these depending upon differences in the animals which are not available by the palæontologist.

No. 258. Bulimus convexus, *F. E. Edwards,* MS. Tab. XXXIV, fig. 6.

Spec. Char. B. Testâ elongatâ, turritâ; anfractibus 6 *convexis, suturâ depressâ, basi convexâ, aperturâ ovatâ, labro acuto, simplici, columellâ subreflexâ, umbilico parvo.*

Height, $1\frac{1}{4}$ inch; *breadth,* $\frac{7}{8}$ths nearly.

Locality. Sconce (*Edwards*).

A fine specimen with the above name is in Mr. Edwards' collection, and I know of no species with which it can be identified or even to which it presents a close approximation. I have adopted the name given to it by Mr. Edwards.

The nearest fossil with which I can compare it is *Bulimus mirus,* Desh., but our shell differs so materially from the figure given of this species that it is scarcely necessary to mention their possible connection. The French shell, however, is the nearest ally I can find, and I mention it only for the purpose of comparison when the two shells of each species can be placed together.

No. 259. Bulimus? (Pomatias?) Vectiensis, *F. E. Edwards*. Tab. XXXIV, fig. 7 *a, b*.

Spec. Char. *B. Testâ elongato-conicâ, spirâ elevatâ, apice acuminato; anfractibus septenis subplanis, lente crescentibus, suturâ distinctâ, basi subangulatâ, aperturâ obliquâ; labro acuto simplici.*

Height, $\frac{5}{16}$ths of an inch; *breadth*, $\frac{3}{16}$ths of an inch.

Locality. Sconce (*Edwards*).

This is another fossil from that rich locality in the Isle of Wight in Mr. Edwards's Collection. I have adopted the specific name which he has given to it. As to the genus it does not from its shape strictly deserve the name of *Bulimus,* and I have therefore referred it only provisionally to that genus; indeed, so close do some of the so-called *Cyclostomæ* approach other shells called *Bulimi* that it is difficult to draw a satisfactory line between them. The nearest resemblance to this shell known to me is *Bulimus turgidulus,* Desh., 'An. sans Vert. du Bas. de Par.,' t. xi, p. 833, pl. liv, figs. 25—27; but judging from the figure and description of that species, it is, I think, quite distinct.

Genus 11*th.*—Succinea. *Draparnaud,* 1801.

For generic character see *antè*, p. 80.

No. 260. Succinea Sparnacensis? *Deshayes.* Tab. XXXIV, fig. 10*.

Succinea Sparnacensis, *Desh.* An. sans Vert. du Bas. de Par., t. ii, p. 795, pl. lii, figs. 30—32, 1858.

Spec. Char. *S. Testâ elongato-ovatâ, obliquâ, tenui, lævi; spirâ acutiusculâ; anfractibus depressis; aperturâ ovatâ, obliquâ, anticè subdilatatâ; columellâ tenui; labro acuto.*

Length, $\frac{7}{16}$ths of an inch.

Locality. Headon Hill (*Edwards*).

A very perfect specimen of a species of *Succinea* is in Mr. Edwards's Cabinet, of which the figure as above referred to is a representation. It has somewhat the appearance of a recent specimen from its perfection, but seems to want the amber-coloured tinge of the common living shell. So little difference is shown among the so-called species of this genus that it becomes a matter of extreme difficulty to distinguish them; I give it, however, as a fossil from its being in Mr. Edwards's Collection and marked from Headon Hill, but I cannot warrant its genuineness. The specific name of *gracilis* is attached to Mr. Edwards's specimen, and I would have adopted it, but this name has been used by the late Mr. Alder for a variety of *Succinea putris* (very well figured by Capt. Brown in his 'Brit. Conchology,' pl. xlii, figs. 34, 35), and I thought the double use of this name would cause confusion. Our present shell so much resembles a species figured and described by M. Deshayes that I have referred it as probably identical, though with doubt, as I am unable to compare it with a specimen of the French Eocene species and have to rely on the figure. In describing this fossil M. Deshayes observes that it is exceedingly difficult with his shell (of which I presume he must have had more than one specimen, as he speaks of it as being in his own cabinet and also that of M. Dutemple) to point out a difference. He says (p. 795), "Cette espèce a beaucoup de rapports avec le *Succinea putris*, qui habite en Europe; mais elle n'en a pas moins avec d'autres qui se plaisent dans les regions chaudes de l'Inde et de l'Amerique," and I can fully endorse this remark. In comparing the figure of our shell with specimens of the common living British species in my own cabinet (*S. putris*) there does appear to be a slight difference, the fossil having its volution a trifle less inflated or convex, or rather they seem to be more depressed. The French shell is from the "Lignites of Bernon near Epernay," a deposit which is considered to be equivalent to our Lower Eocene, whereas ours comes from the upper division of that formation. It is to be feared we attach more importance to trifling variation in our specific determination of these freshwater shells than we do to those which come from salt-water deposits.

Genus 31*st.*—Bythinia.[1] *Gray*, 1824 (Prideaux, MS.).

Generic Character. Shell conical, turbinated; volutions convex; aperture slightly angular behind; peristome simple, entire, continuous; operculum testaceous, irregularly concentric, with its nucleus nearly in the middle.

Animal oviparous, eyes sessile.

This genus has been separated from *Paludina* in consequence (as it is said) of its being oviparous, while *Paludina* is ovoviviparous; but this distinction is not well established, and if it were it would be unavailing to the palæontologist. It differs in having a calcareous operculum, while in *Paludina* this is corneous. It is also said that the eyes of *Bythinia* are somewhat differently placed.

[1] The name for this genus has been variously spelt:
Bithinia, J. E. Gray, G. P. Deshayes.
Bithynia, Watelet.
Bythinia, Jeffreys, Sandberger.

No. 261. Bythinia conica ? *Prévost.* Tab. XXXIV, fig. 8 *a*, *b*.

Paludina conica, *Prév.* Journ. de Phys., p. 11, 1821.
— — *Desh.* Coq. foss. des Env. de Par., t. xi, p. 129, pl. xvi, fig. 7, 1824.
— ? impurata, *S. Wood.* Lond. Geol. Journ., p. 118, 1846.
Bithinia conica, *Desh.* An. sans Vert. du Bas. de Par., t. ii, p. 494, 1858.
Hydrobia (Bithynia) conica, *J. Lowry.* Chart Brit. Tert. Foss. pl. ii, 1866.
Assiminea conica, *Sandb.* Land- und Süssw.-Conch., p. 212, t. xi, fig. 11, 1872.

Spec. Char. "*B. Testâ ovato-conicâ, lævigatissimâ, acuminatâ, anfractibus planulatis, suturâ superficiali separatis; aperturâ ovato-angulatâ; marginibus acutis.*"—*Desh.*

Height, $\frac{5}{16}$ths of an inch.

Locality, Britain: Hordle (*S. Wood*), Headon Hill (*Edwards*).
France: Vaugirard (*Deshayes*).

I have copied the specific diagnosis as given by Deshayes for *B. conica* which seems to correspond so precisely with that of our fossil that I think the two may fairly be referred to one and the same species. Many years ago I found a specimen of this genus at Hordle to which I gave the name of *Paludina ? impurata* from its very close resemblance to the one so common in our own freshwaters, and so very abundant in the freshwater deposits of our Upper Tertiaries, at Grays and Clacton (*Paludina impura*, Brard, *Helix tentaculata*, Linné).

The figures given in my plate are somewhat enlarged. This species may probably be variable where a large number of individuals are found like these specimens of *B. tentaculata* so numerous at Grays and Clacton, where they show a considerable variation in their proportionate dimensions, some being much more elongated than others, a variation which produces one also in the tumidity of the volutions.

Dr. Sandberger has referred this to *Assiminea*, a genus proposed by Dr. Leach for a shell found in the Woolwich marshes and sent by him to the late Dr. Fleming with the name *Assiminea Grayana* "as the type of a new freshwater genus," 'Hist. Brit. An.,' p. 275. This shell much resembles that of *Bythinia*, but it is described as having an operculum that is spiral, while that of *Bythinia* is increased by concentric layers; and although we have not the operculum of this shell to guide us, it seems so very closely to resemble our common shell *Bythinia tentaculata*, that I think it must belong to the same genus.

The operculum when it can be obtained is, I think, a good character to assist in establishing a genus, but the operculum of our species has not yet been found. In *Paludina* and *Bythinia* the operculum is increased by concentric layers, while in *Hydrobia*, *Nematura*, and *Assiminea* it is spiral. A small shell, *Nematura pupa*, Nyst, is very abundant in our Upper Eocene Beds at Headon Hill, but its operculum has not yet been found, as in all probability it was a corneous one. The late Mr. G. B. Sowerby figured and described ('Mag. of Nat. Hist.' for 1837, p. 217) a recent species, *N. Deltæ*, in which the operculum is represented *in sitú*, and this is spiral and horny. M. Bosquet has, however, figured a fossil found in the Limbourg Beds as *Nematura pupa* ('Reck. Paléont. Terr. Tert. du Limb.,' 1859, p. 7, pl. i, fig. 6), and at fig. 7 he represents what he thinks may be the operculum of this species, but which is quite different in form from the one figured as recent, being in shape like *Ancylus? latus* (F. Edwards, 'Eocene Moll.,' p. 110, pl. xiv, fig. 15), and of which the late Dr. S. P. Woodward, in his 'Manual of Mollusca,' p. 16, says, "This fossil appears to be a *Limax*."

The following Fluviatile shells from the Lower Tertiaries of England may, I think, be separated into genera or sectional divisions, as indicated by the operculum; and had I been able to continue this work, it was my intention to have done this.

1. Pitharella, *Edwards*, 1860.

"Shell subcylindrical; spire obtuse, more or less produced; aperture oval-oblong, rounded in front, narrowed behind; columella straight or very slightly twisted, arched anteriorly; outer lip simple, acute; inner lip thickened."

Operculum unknown.[1]

Type. P. Rickmani, *Edwards*.[2]

2. Paludina, *Lamarck*, 1812.

"Operculum horny, irregularly concentric, having its nucleus on the inner side."

Type. Helix vivipara, *Linné*.

3. Bythinia, *J. E. Gray*, 1821.

"Operculum testaceous and solid, irregularly concentric, having its nucleus nearly in the middle."

Type. Helix tentaculata, *Linné*.

?4. Amnicola, *Gould and Haldemann*, 1841.

"Shell ovate-conical, thin; spire acute, composed of a few rounded whorls; aperture small, oblique, and roundedly ovate; lips continuous, simple. Operculum horny, spiral, with few volutions."

Type. Amnicola Parkinsoni, *Sandberger*.

[1] In Mr. A. Bott's cabinet is a fossil which has the appearance of an operculum. This I intended to have had figured. It is of an elongately oval or lanceolate form, and apparently with concentric ridges, though these are not very distinct. I think possibly it may have belonged to the above genus.

[2] A shell resembling this generically is figured and described by Prof. Deshayes as *Ampullaria problematica* ('An. sans Vert. du. Bas. de Par.,' tom. xi, p. 521, pl. xxxvi, figs. 1, 2), and another, *possibly* the same species, is figured and described by Melleville in his 'Mém. sur les Sab. Tert. Infér.,' p. 72, pl. x, fig. 1, as *Buccinum arenarium*.

5. Assiminea, *Leach*, 1816.

"Operculum horny; paucispiral nucleus on the inner side of the mouth."

Type. Assiminea Grayana, *Leach.*

6. Hydrobia, *Hartmann*, 1821.

"Operculum horny and thin, marked with flexuous and rather strong lines of growth, and having a small lateral spire of three whorls."

Type. Turbo ulvæ, *Pennant.*

7. Nematura, *Benson*, 1836.

"Operculum spiral, horny, of few volutions, somewhat concave externally, rather larger than the aperture."

Type. Nematura Deltæ, *Benson.*

? 8. Valvata, *Müller*, 1874.

"Operculum horny, circular, slightly compressed in the middle, forming a concentric spire of from 10 to 12 whorls, the outer edges of which are thickened and raised so as to project over and partly overlap the succeeding whorl."

Type. Nerita piscinalis, *Müller.*

Genus 13*th.*—Planorbis. *Geoffroy*, 1767.

For generic character see *antè*, p. 97.

No. 262. Planorbis lævigatus? *Deshayes.* Tab. XXXIV, fig. 1 *a—b.*

Planorbis lævigatus, *Desh.* Coq. foss. des Env. de Par., t. xi, p. 85, pl. x, figs. 1, 2, 1824.
— — *Id.* An. sans Vert. du Bas de Par., tom. ii, p. 746, 1858.
— — *Prestwich.* Geol. Journ., vol. x, p. 118, 1854.
— — *Whitaker.* Geol. Surv., vol. iv, p. 576, 1872.

Spec. Char. "*Pl. Testâ discoideâ, lævigatissimâ, tenui, symmetricâ, depressâ, rotundatâ, anfractibus quaternis, valdè apparentibus; utroque latere umbilico æquali.*"—*Desh.*

Diameter, $\frac{3}{16}$ths of an inch.

Locality. Brit.: Dulwich (*Bott.*), Counter Hill (*Whitaker*), Peckham (*Meyer*).
France: Bernon, near Epernay (*Deshayes*).

Two or three specimens of this species have been found in our English beds, but all that I have seen are in the condition of casts; they, however, appear to correspond with the figure and description given by M. Deshayes. The species, as he says, much resembles the young state of *Pl. rotundatus,* but the sutures are deeper, and it approaches nearer in form to *Pl. Sparnacensis.* This latter shell is, however, spirally striated, whereas our species is said to be perfectly smooth—a feature which our specimens, being casts, of course do not show; but *Sparnacensis* appears to have a larger number of volutions in the same space, and from what can be seen of the form of the volution in our specimen it appears to have had a semilunate aperture, the volutions on the under side being rather more convex than those on the upper, which is the flatter of the two.

The figure represents a specimen from Mr. Bott's cabinet, and is the most perfect one that I have seen.

Planorbis elegans, F. Edwards, 'Eocene Moll.,' p. 107, tab. xv, fig. 12 *a—b,* so far as figures and description go, appears to correspond with *Pl. Baudoni,* Desh., 'An. sans Vert. du Bas. de Par.,' t. xi, p. 750, pl. xlvi, figs. 28—31.

Genus 12*th.*—Limnæa. *Lamarck.*

For generic description see *antè,* p. 81.

No. 263. Limnæa elongata, *Marcel de Serres.* Tab. XXXIV, fig. 10.

Limneus elongatus, *Sandb.* Land- und Süssw.-Conch., p. 287, t. xvi, fig. 6, 1872.
— — *Marcel de Serres.* Ann. Sci. Nat., p. 179, pl. xii, fig. 7, 1844.

Spec. Char. "*Testâ ovato-conicâ, turritâ, apice peracutâ, anfractus septem paulo convexi, suturis tenuibus disjuncti, transversim subtiliter striati, ultimus inflatior $\frac{2}{3}$ omnis altitudinis æquat; aperturâ ovali, basi paulo dilatatâ columellâ tenui, paulo contortâ.*"—*Sandberger.*

Height, $1\frac{1}{8}$th of an inch; *width,* $\frac{1}{2}$ an inch.

Locality. Hordle (*S. Wood*).

Three individuals of this form are in my cabinet, having been found by myself at Hordle, and I have assigned them to the above species with some doubt.

The spire of this shell is small and tapering, with about eight volutions; these are slightly convex like those of *L. longiscata,* but there is no flatness or semisulcation on the left lip or columella; on the contrary, this is sharp and prominent. It seems also to differ from *L. fusiformis,* which has more flattened volutions, and a comparatively larger aperture. I had previously considered it as an aberrant form of *L. pyramidalis* with closer volutions. Figure 11 of the same Plate represents a specimen belonging to the recent British species, *L. stagnalis,* which I have introduced in order to show the variation to which some of the species of this genus have been subject, and the consequent uncertainty which attaches to their identification.

Sandberger has figured and described a British fossil under the above name *elongatus*, which, he says, was received from Mr. Edwards, but his figure is rather less elongated than are my specimens.

I have not seen any specimen of *Limnæa* from the Lower Eocene of England, neither have I seen any fossil from either our Upper or Lower Eocene beds that can be referred to the genus *Physa*, though several species of that genus have been figured by M. Deshayes from the Paris Basin.

Fam.—NERITIDÆ.

Genus 32*nd*.—Neritina. *Lamarck*, 1809.

Generic Character. "*Testa tenuis, semiglobosa vel ovalis, subtus planulata, non umbilicata; aperturâ semi-rotundâ; labro columellari planulato; margine acutiusculo subrecto, plerumque denticulato, labro externo intus nec dentato nec crenulato; operculum testaceum semicirculare; internè appendice laterali instructum.*"

This has been separated from *Nerita*, and intended for those species which inhabit fresh water; but there is little or no difference in the form and general character of the shells of the two genera, and most of our present species inhabit waters that are neither salt or fresh, as it is to be presumed did their fossil congeners. They can only be distinguished under the above respective generic names by the palæontologist, according to the indication of habit which at their association with either known marine or estuarine species affords, although among living species there are two (*N. viridis* and *N. meleagris*) which, belonging to the section grouped as *Neritinæ*, nevertheless, are found in the sea.

This diagnosis of *Neritina*, as given by Lamarck (*tenuis*), is not restricted to the number of shells that have have been figured and described under this generic name, several of them being as thick and ponderous as many of the species called *Nerita*. Some are not externally smooth, but are ornamented with ridges and carinæ; others have denticulations more or less upon the outer and inner lips, while the opercula of *Nerita* and *Neritina* are thick and possess the same characters alike. M. Deshayes, in the second edition of Lamarck's 'Hist. Nat. An. sans Vert.,' vol. viii, p. 565, has made some very just remarks upon the similarity of these genera; and in his last work, 'Hist. des An. sans Vert. du Bas. de Par.,' he has grouped all these hitherto called *Neritinæ* as simply a section of *Nerita*. As, however, I am describing land and fluviatile shells of the older Tertiaries, I have thought it best to retain the name of *Neritina* for those species which, if not restricted to a habitat in fresh water, are met with where the water is not purely salt, and where also they are found in association with such truly freshwater genera as *Limnæa* and *Planorbis*. The most general distinction among existing species is that the *Neritinæ* are generally smooth shells and free from spiral ridges, but this rule is not without exception, as some few species possess spiral striæ or depressed ridges.

The form of the species of this genus varies, but in a slight degree, and the larger number of the fossils have the external markings well preserved; but these markings are so variable on specimens even of the same species, not unfrequently resembling the markings usual on other species, that they do not afford much assistance in their specific separation. The dark lines seem to be as well preserved on some of our fossils as are the red spots on other shells of older date; so that the preservation of colour on several of our Tertiary species is not reserved to red alone.

No. 264. Neritina globulus, *Férussac*. Tab. XXXIV, fig. 18 *a, b*.

Neritina globulus, *Férussac*. Hist. des Moll. Pl. de Neritines Foss., fig. 14, 1851.
— — *Desh.* Coq. foss. des Env. de Par., p. 151, pl. xvii, figs. 19 20, 1824.
— — *Desh.* An. sans Vert. du Bas. de Par., t. xi, p. 22, 1858.
— — *Whitaker.* Mem. Geol. Surv., vol. iv, p. 576, 1872.
— uniplicata, *J. Sow.* Min. Conch., t. ccclxxxv, figs. 9, 10, 1823.
— callifera ? *G. B. Sow.* Genera of shells; Neritina, fig. 7, 1855.

Spec. Char. *N. Testá ovato-globulosá, spirá brevissimá, planiusculá, anfractibus tribus, ultimo maximo oblongo lævigato, supra convexo, subtus concavo; aperturá magná latè semilunari; areá columellari planá, lævigatá, margine acuto, in medio paulo excavato, posterius unidentato.*

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

Localities. Brit.: Charlton (*S. Wood*), Plumstead, Peckham, New Cross (*Meyer*).
France: Epernay, Mont Bernon (*Deshayes*).

This is by no means rare, and it appears to be restricted to the Lower Eocene Formation in England, as it is also said by M. Deshayes to be in France.

The apex of this shell is very slightly elevated, and generally more or less eroded; the volutions are indicated by a narrow line of suture; the columella is broad, flat, and moderately sharp when the specimen is in good condition, and furnished with one prominent tooth at the upper part, but on the lower the denticles are obsolete or very minute, and there are no spiral striæ on the exterior. This is a plain-looking shell; and sometimes portions of the epidermis have been preserved on the specimens.

No. 265. Neritina consobrina, *Férussac*. Tab. XXXIV, fig. 13 *a, b*.

Neritina consobrina, *Férussac*. Hist. des Moll. Pl. de Neritines Foss., fig. 12, 1820.
— — *Desh.* Coq. foss. des Env. de Par., tom. ii, p. 153, tab. xix, figs. 5, 6, 1824.
— — *Id.* (2nd edit. *Lam.*). Hist. An. sans Vert., tom. viii, p. 595, 1838.
— — *Id.* An. sans Vert. du Bas. de Par., t. cxi, p. 22, 1858.
— — *Morris.* Catal. Brit. Foss., 2nd edit., p. 264, 1854.
— — *Whitaker.* Mem. Geol. Surv., vol. iv, p. 579, 1872.
— ornata ? *Melleville.* Sables. Tert. Inf., p. 50, pl. vi, figs. 9, 10, 1843.

Spec. Char. N. Testâ ovato-globosâ, spirâ brevi, obtusissimâ; anfractibus tribus, ultimo maximo convexo, lævigato, aperturâ semilunari, areâ columellari latissimâ, in medio tenui dentatâ, posterius uniplicatâ, labro dextro plano.

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

Localities. Britain: Charlton (*S. Wood*), Peckham (*Meyer*).
France: Lignites, Epernay (*Deshayes*).

Specimens of this species do not appear to be very rare from the Woolwich beds, and Mr. C. J. Meyer sent me for examination a good series of them.

So far as I am able to determine this species, its greatest difference from *globulus* consists in a more elevated spire and in a broad depression on the upper part of the volution a little below the suture. It is not so globular. The specimens from near Epernay are said to have retained much of their original colour; "sur le dernier tour on voit trois zones transverses inégales, blanchâtres sur un fond d'un brun noir quelquefois roussâtre;" *Desh.*, Lamarck, 2nd edit. The specimens which I have seen, however, are of one uniform colour.

Neritina pisiformis, Férus., is given by Mr. De la Condamine in 'Quart. Journ. Geol. Soc.,' vol. vi, p. 446, and by Mr. Prestwich, 'Quart. Journ. Geol. Soc.,' vol. x, pp. 103 and 118, as from the Lower Eocene Beds at Woolwich and Charlton, and it is on this authority inserted by Mr. Whitaker, as he informs me, in his lists in the 'Geol. Survey Memoir,' pp. 576 and 579; but I have seen nothing among the specimens of my collecting friends which could by that name be specifically distinguished from *N. globulus* or from *N. consobrina.* Probably the shell thus referred to may have been a variety of one or the other of these, unless the shell now called *N. jaspidea* should be the one intended.

No. 266. Neritina vicina ?, *Melleville*. Tab. XXXIV, fig. 15 *a, b*.

Neritina vicina, *Mellev.* Mém. Sables Tert. Inf. du Bas. de Par., p. 51, pl. vi, figs. 11, 12, 1843.
— — *Whitaker.* Mem. Geol. Surv., vol. iv, p. 579, 1872.

Spec. Char. *N. Testâ minutâ, ovato-oblongâ, transversâ; spirâ brevi depressâ; supra convexâ, subtus concavâ; anfractibus tribus, primis minimis, ultimo maximo, lævigato, nitido; aperturâ semilunari; areâ columellari latâ, planâ aut subconcavâ.*

Diameter, $\frac{1}{8}$th of an inch.

Localities. Britain: Charlton (*S. Wood*).

France: Env. de Chalons (*Deshayes*).

A small shell in my cabinet, figured as above, seems to correspond with the figure and description given by M. Melleville in some respects, but not quite so in others; and I have in consequence put a mark of doubt to the name. It differs from the small and young specimens of *globulus* (*uniplicata*, Sow.), a shell abundant in the Woolwich beds, in being more expanded or extended outwardly; and there is a difference in the left lip or columella which is thicker and not so flat, and is destitute of a tooth on the upper part. It is less elevated in the spire than *consobrina* and more expanded than *jaspidea*. Unfortunately I have only met with the one specimen of this shell, which is figured.

No. 267. NERITINA JASPIDEA ?, *Deshayes.* Tab. XXXIV, fig. 17 *a—c.*

NERITINA JASPIDEA, *Desh.* An. sans Vert. du Bas. de Par., t. iii, p. 20, pl. lxv, figs. 14—16, 1858.

Spec. Char. "*N. Testâ ovato-oblongâ, supra-convexâ, subtus concavâ; spirâ brevi, obtusissimâ, submarginatâ; anfractibus tribus, primis minimis, ultimo maximo, lævigato, nitido; lineis fuscis irregularibus, undulatis, plus minusve numerosis ornato, aliquantisper zonolis angustiusculis interruptis; aperturâ obliquâ, minimâ, semilunari; areâ columellari latâ, planâ vel concavâ, declivi; margine columellari acuto, concavo, posterius unidentato.*" —Deshayes.

Diameter, $\frac{1}{7}$th of an inch.

Localities. Britain: Dulwich (*Meyer*).

France: Brimont, Chalons-sur-Vesus, Gueux (*Deshayes*).

Some specimens beautifully marked have been obligingly sent to me for examination by Mr. C. Meyer, two of which with very varied markings I have had figured as above and referred them with doubt to *jaspidea.* Our specimens do not conform strictly to the one given and described under this name by M. Deshayes, but they differ greatly from the little shell which I have called *N. vicina*, which is much more expanded in its volutions, has a more extended aperture, and appears to be destitute of exterior ornamentation, though, as before observed, this latter is not a reliable character. The specimens figured much resemble a recent Jamaica form, *N. pupa.* The prominent tooth, shown by M. Deshayes, is indistinct in the British fossil.

No. 268. Neritina concava, *J. Sowerby*. Tab. XXXIV, fig. 14 *a—c*.

Neritina concava,	*J. Sow.*	Min. Conch., tab. ccclxxxv, figs. 1—8, 1823.
— —	*Desh.*	(2nd edit. *Lamk.*). An. s. Vert., t. viii, p. 597, 1838.
— —	*Morris.*	Catal. Brit. Foss., 2nd edit., p. 264, 1854.
— —	*J. Lowry.*	Chart Brit. Tert. Foss., pl. iii, 1866.
— —	*Lyell.*	Students' Elemts. of Geol., p. 231, 1871.
— —	*Sandberg.*	Land- und Süssw.-Conch., p. 267, tab. xv, fig. 13, 1872.
Nerita —	*Nyst.*	Coq. foss. de Belg., p. 436, pl. xxxvii, fig. 30, 1843.

Spec. Char. *N. Testâ ovato-globosâ, lævigatâ, apice obtuso; lineolis fuscis parallelis vel reticulatis tenuissimis ornatâ; anfractibus suprâ concavis; aperturâ semicirculari; columellâ arcuatâ, in medio tenuiter denticulatâ.*

Diameter, $\frac{3}{8}$ths of an inch.

Localities. Hempstead (*Morris*), Headon Hill, Muddiford (*S. Wood*).
Belgium: Kleyn-Spauwen (*Nyst*).

This species is abundant at Headon Hill, and the operculum also is sometimes found, a figure of which I have given. This operculum is flat on the exterior, and has not the curvilinear depression possessed by that of *N. Forbesii.* The projecting prominent teeth on the inside appear also to be different from that on the operculum of *Forbesii,* the two bifurcations of the denticle being unequal in size, and expanding more widely. The outer lip of our shell is plain and sharp, the inner moderately extended; and the columella is sharp-edged and slightly concave, and has upon its centre about half a dozen fine denticles. These shells are variously ornamented on the exterior, generally having fine cancellated openings, produced by lines of oblique brownish colouring matter, crossed by similar oblique lines which together form small, lozenge-shaped, white spaces, but the lines are sometimes confluent.

This species is not mentioned as a fossil of the Paris Basin, but the shell from Kleyn Spauwen, as given by M. Nyst, appears to be identical with it, and that author has given as a synonym of it *N. picta*, of Dubois, from Volhynia, though with a doubt. In the description of Dubois' species, however, the words "columella unidentata" occur, a character which our species does not possess.

Mr. Whitaker, in his 'Memoir,' at p. 579, has introduced *concava* as from the Woolwich beds at Charlton, but this I have not been able to verify, and I conclude that it was inserted on the authority of the reference by J. Sowerby in 'Min. Con.,' tab. 385, of that shell to Charlton, an erroneous reference, as pointed out by Mr. Prestwich in 'Quart. Journ. Geol. Soc.,' vol. x, p. 121. Mr. Sowerby also in the same table represents a specimen said to be from Highgate, but it does not look like our own shell, as the volutions (which in that figure are sinistral) do not exhibit that concave depression on their upper part which is peculiar to this species, and from which its name was, I presume, given. Some specimens have a white spiral band, like that upon *N. ornata.*

No. 269. Neritina tristis, *Forbes.* Tab. XXXIV, fig. 12 *a, b.*

Neritina tristis, *Forbes.* Mem. Geol. Surv. Isle of Wight, p. 46, 1856.
— — *J. W. Lowry.* Chart Brit. Foss., pl. ii, 1866.

Spec. Char. N. Testâ fuscâ, ovato-oblongâ, tenui, spirâ brevi, obtusâ, anfractibus tribus, ultimo magno, aperturâ magnâ semilunari, columellâ planâ margine simplici, labro acuto, edentulo.

Diameter, $\frac{5}{16}$ths of an inch.

Locality. Hempstead (*Forbes*).

A few specimens were many years ago given to me by the late Edward Forbes with the above specific name attached. These appear to differ from *N. concava* in having a rather less elevated spire and a slight depression round the upper part of the volution, as in *concava;* but I can discover no angularity in the volutions. It is of a uniform sombre or brownish colour, from which I presume it received its name. This has not been figured in the 'Geol. Survey Memoir,' but it is very well represented by Mr. Lowry in his 'Illustrations of British Fossils' above referred to. Forbes described it ('Memoir Geol. Survey,' p. 46) as "a small globose shell, with volutions rather angulated; aperture semilunate, inner lip obscurely denticulated, surface smooth without ornamentation."

No. 270. Neritina aperta, *J. Sowerby.* Tab. XXXIV, fig. 20 *a, b.*

Nerita aperta, *J. Sow.* Min. Conch., t. ccccxxiv, figs. 2, 3, 4, 1823.
— — *Morris.* Catal. Brit. Foss., 2nd edit., p. 264, 1854.
— — *J. Lowry.* Chart Brit. Tert. Foss., pl. iii, 1866.
Neritina (Mitrula) aperta, *Sandb.* Land- und Süssw.-Conch., p. 269, t. xv, figs. 15, 15 *a*, 1872.

Spec. Char. N. Testâ subglobosâ, apice depresso, vix conspicuo; anfractibus 2—3; lineis tenuibus ornatâ; aperturâ semilunari; margine dextro, acuto; columellâ planâ, margine acuto, in medio minutè denticulatâ, posteriore unidentatâ.

Height, $\frac{1}{4}$ of an inch; *diameter,* $\frac{5}{16}$ths of an inch.

Localities. Colwell Bay (*J. Sowerby*), Headon Hill, Milford (*S. Wood*).

The shell figured by Sowerby as above referred to is a good representation of a small specimen of this species, which is not rare in the Upper Eocene of Hampshire and the Isle of Wight. I have not, however, seen any so small as those represented in figures 3 and 4 of tab. 424 of 'Min. Conch.,' which, no doubt, were immature specimens. The ornamentation is variable, as pointed out by Mr. Sowerby, and the shells have more or less of the original colour remaining upon them; but those I have from Milford, which appear to be of the same species, though rather larger, are destitute of colour or markings of any kind. The upper part of the outer lip is generally, though not always, slightly elevated above the vertex, and somewhat thickened within, at some distance from the edge. The inner lip is thick and flattened, with a sharp edge to the columella, which has a few denticles in the centre and a distinct tooth at the upper part.

This species seems to partake of the characters by which the genus *Nerita* is distinguished as well as of those of the genus *Neritina,* in which I have placed it.

No. 271. Neritina Forbesii, *S. Wood.* Tab. XXXIV, fig. 16 *a—c.*

Spec. Char. N. Testâ ovato-oblongâ, lævigatâ, tenuissime lineolatâ vel ornatâ; spirâ depressâ; anfractibus rapidè crescentibus, aperturâ semilunari expansâ; areâ columellari latâ, planâ, in medio tenuissimè denticulatâ; labro acuto simplici.

Diameter, $\frac{3}{8}$ths of an inch.

Locality. Headon Hill (*S. Wood*).

This is equally abundant with *N. aperta,* and I have separated it in consequence of its difference in form. Our present shell is narrower; that is to say, it has a more extended outer lip, the aperture being wider or more expanded from the inner lip to the outer than in the preceding species. The apex is also much depressed, and the upper part of the shell is nearly flat, with spire indicated by a narrow depressed suture. The coloured markings are various.

I have obtained several specimens of this species with its operculum in position, and this adjunct I have had figured. The inner side of the operculum is furnished with a prominent projection at the lower part, which is bifid or forked, expanding at an angle of about 45°. The outer side of this operculum shows a curvilinear depression with a corresponding elevation on the inner surface. *N. Forbesii* much resembles *N. fluviatilis,* but that shell has a more elevated spire. It does not differ greatly from *N. transversa,* Ziegler, figured by Rossinasler, 'Icon.,' pl. vii, fig. 121, but I have not specimens of that species with which to compare it.

No. 272. Neritina zonula, *S. Wood.* Tab. XXXIV, fig. 19.

Spec. Char. N. Testâ rotundato-ovatâ, lævigatâ; vertice depresso; anfractibus convexiusculis, zonulatis aut parum angulatis, supernè concavis; lineolis fuscis parallelis *vel reticulatis tenuissimis ornatâ; aperturâ semilunari; columellâ arcuatâ, in medio denticulatâ.*

Diameter, $\frac{5}{16}$ths of an inch.

Locality. Headon Hill (*S. Wood*).

This is a fossil of which I have myself found several specimens at the above locality. It resembles *N. aperta* in outward form, its most material difference consisting in its having six or seven very distinct ridges or carinulæ not quite equidistant, and somewhat rounded, but these the artist has unfortunately not sufficiently shown in the figure. No one, however, on comparing specimens with those of *aperta*, would fail to perceive these carinulæ.

No. 273. Neritina planulata, *F. E. Edwards,* MS. Tab. XXXIV, fig. 21 *a, b.*

Neretina planulata, *J. Lowry.* Chart Brit. Tert. Foss., pl. iii, 1866.
— — *Sandberger.* Land- und Süssw.-Conch., p. 268, t. xv, fig. 14, 1872.

Spec. Char. " *Testâ globosâ, apice obtuso, paulo eroso. Anfractus tres infrâ suturas tenuissimas subimpressi, ceterum convexi, nitidi, flavidi, guttulis albis æqualiter conspersis aut seriatim depositis variegati; ultimus ceteris omnibus quadrato altior. Aperturâ paulo obliquâ semilunari, margine dextro et basali tenui, acuto, pariete et columellâ callo nitido, leviter concavo, intus mediâ parte plicâ supremâ maximâ et duodecim minoribus obtusis munito obtectis. Operculum semilunare, infernè apophysibus duabus arcuatis discrepantibus armatum.*"—Sandberger.

Height, $\frac{5}{16}$ths of an inch.

Locality. Headon Hill (*Edwards*).

A very determinable figure is given of a shell under the above name by Mr. Lowry, who tells me it is a MS. name given by Mr. Edwards. This has been figured and described also by Sandberger from a specimen sent to him by Mr. Edwards. Our shell is prettily ornamented with diagonal and dark wavy lines. I have not the species.

Genus 33rd.—Nerita. *Adanson.*

For generic characters see *antè*, p. 342.

No. 274. Nerita tricarinata, *Lamarck.* Tab. XXXIV, fig. 22 *a, b.*

Nerita tricarinata, *Lamk.* Ann. du Mus., tom. viii, pl. lxii, fig. 4 *a, b*, 1806.
— — *Desh.* Coq. foss. des Env. de Par., t. ii, p. 160, 1824.

NERITA TRICARINATA, *Morris.* Catal. Brit. Foss., 2nd edit., p. 264, 1854.
— — *J. Lowry.* Chart Brit. Tert. Foss., pl. iii, 1866.

Spec. Char. *N. Testâ ovatâ, supra convexâ, subtus convexiusculâ; anfractibus tribus, ultimo magno, spiraliter tricarinato; spirâ retusâ; aperturâ semicirculari; areâ columellari planâ, margine minutè denticulato, labro acuto.*

Diameter, $\frac{5}{16}$ths of an inch.

Localities. Bracklesham (*Edwards*).

France: Retheuil, Cuise-la-Motte, Houdan (*Deshayes*).

The figure I have given is from a specimen in Mr. Edwards' cabinet. The shell has a fine denticulation on the sharp edge of the columella, but appears to be destitute of any prominent tooth on that edge, so far as I have been able to detect, in which respect it seems to agree with Deshayes' figure. The inside of the outer lip, however, appears to be free from those denticulations which usually ornament those species which are grouped under the generic name *Nerita.* This species is especially distinguished by being ornamented with three prominent spiral ridges, between which the surface is covered with regular and somewhat fine striæ. This species is said by M. Deshayes to be common in some localities of the Paris Basin, especially in the sands of Cuisse-la-Motte. He also observes that several varieties of it occur in the Calcaire grossier. I am not aware of its having occurred in England in any other bed than the Bracklesham. M. Deshayes thus describes the operculum of this species ('An. sans Vert. du Bas. de Par.,' t. iii, p. 17):—"Il est lisse en dessus, obliquement partagé par une étroite depression, qui part du sommet. Il est fort remarkable en ce qu'il porte deux apophyses; l'une *subapiciale, bifide,* c'est celle qui existe invariablement dans toutes les espèces; l'autre *mediane* consiste en une proéminence aplatie et pointue, qui glisse en dessous du bord columellaire."

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*** *The Synonyms are printed in Italics.*

PLATE XXXIV.

NOTE.—*The lines indicate the actual dimensions of the specimens.*

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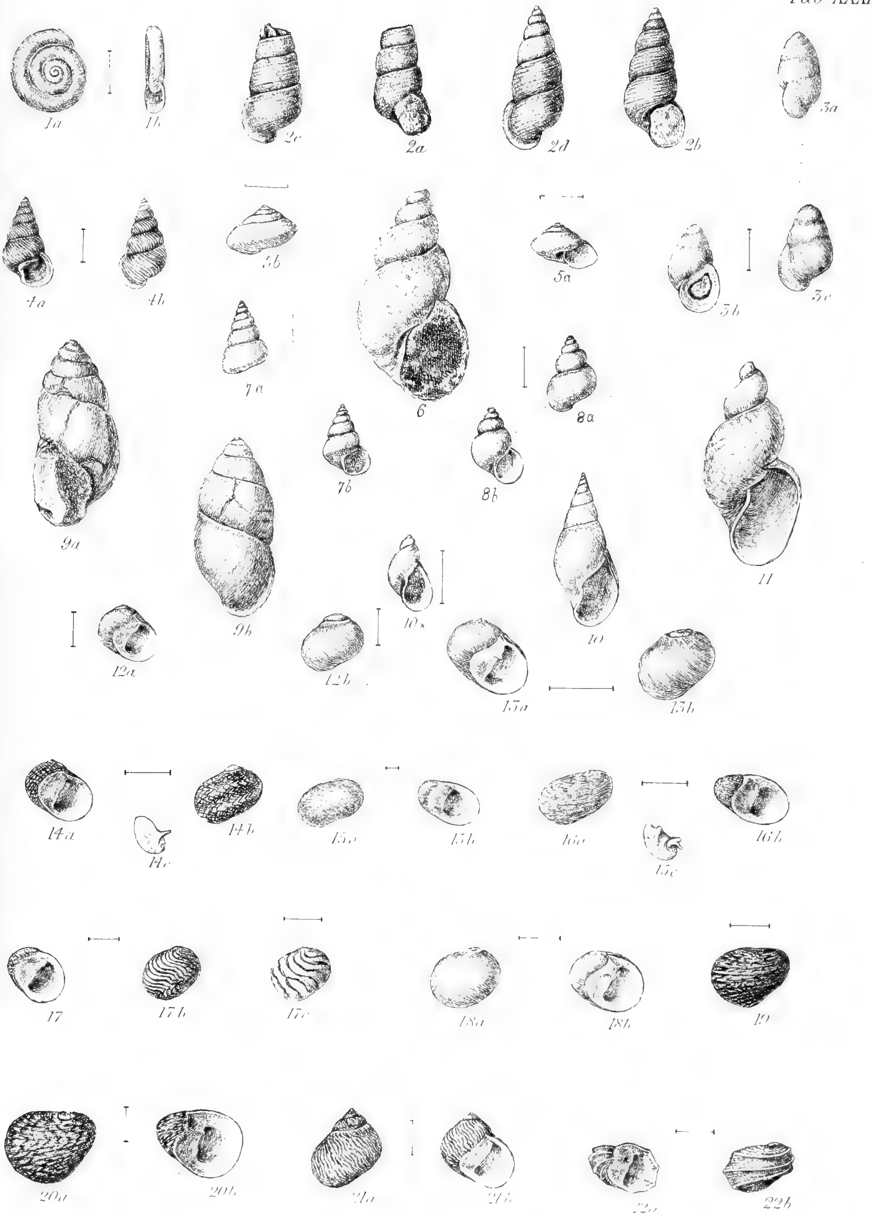
Tab XXXIV



G.B.Sowerby.

THE

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THE

GANOID FISHES

OF THE

BRITISH CARBONIFEROUS FORMATIONS.

BY

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PART I.

PALÆONISCIDÆ.

PAGES 1—60; PLATES I—VII.

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THE

GANOID FISHES

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BRITISH CARBONIFEROUS FORMATIONS.

INTRODUCTION.

The Ganoid Fishes of the British Carboniferous strata had been but little collected at the time of the publication of Agassiz's great work. In his general list of Fishes from the various formations, published in 1843, mention is made of forty species of British Carboniferous Ganoids, of which only nine were described; the rest, to which only names had been attached, being reserved for one of those supplementary monographs which were to contain descriptions and figures of those species not included in the larger work. Unfortunately, the only one of those promised additional monographs ever published was that on the Fishes of the Old Red Sandstone, so that a large number of fishes of the Carboniferous as well as of other formations remained, furnished with names it is true, but without descriptions or figures whereby they might be identified. Several of the Carboniferous forms here included have been subsequently described by other authors; to others, it is to be feared, all clue is lost.

Since Agassiz's time the writings which have appeared on British Carboniferous Ganoids have been comparatively few and scattered, although the researches of Sir Philip Grey Egerton, Professor Young, and Messrs. Hancock and Atthey, have done much to increase the catalogue of species and our knowledge of the structure of the various forms. The works of these and of other authors will be referred to in the proper places.

A very large amount of material having been accumulated since the Carboniferous Fishes had been previously systematically treated of, and many kind friends having offered me the use of their valuable collections for purposes of description, I have, with the sanction of the Council of the Palæontographical Society, undertaken to prepare a Monograph on the Ganoids of this formation. In connection with this work I must here acknowledge with warmest thanks the obligations I am under to the Earl of Enniskillen, Sir Philip Grey Egerton, Bart., Prof. Huxley, Prof. Geikie, Prof. Prestwich, Prof. Hughes, Rev. Prof. Duns, Mr. John Ward, of Longton, Dr. Hunter, of Braidwood, Mr. Grossart, of Salsburgh, Mr. Binney, of Manchester, Mr. Plant, of Salford, Mr. Aitken, of Bacup, Messrs.

James Armstrong, James Thomson, and John Young, of Glasgow, and Mr. Davies, of the British Museum, for the liberality with which they have assisted me by affording me facilities for the examination of specimens, in some cases belonging to themselves as private collectors, in others under their charge as public officials.

In indicating the stratigraphical occurrence of the various species to be described in the present Monograph I shall follow the nomenclature applied to the subdivisions of the Carboniferous strata of Great Britain used by Mr. Bristow in his 'Table of British Strata.' The entire series of Carboniferous rocks may be grouped into two great divisions, *Upper* and *Lower*. The Upper division, the great repository of coal and ironstone in England and Wales, constitutes the true "Coal Measures," and is throughout the island singularly alike in its mineralogical and palæontological characteristics. It consists of a great series of sandstones, shales, and fireclays, with workable seams of coal and clay-ironstone, in which typically marine fossils are comparatively rare, the strata having apparently owed their origin to deposition under estuarine conditions extending over a vast area, and in many cases obviously to the successive temporary submergence of extensive low-lying tracts densely clothed with subaërial vegetation. The Lower division, on the other hand, differs equally remarkably in its characters in different parts of the United Kingdom, purely marine conditions having evidently prevailed in some districts, while in others estuarine strata essentially similar to those of the Coal Measures were being deposited. Thus, in England and Ireland the Lower Carboniferous rocks are mainly represented by the well-known Carboniferous or "Mountain Limestone," rich in Brachiopoda and Corals, and in some places, as in Derbyshire, attaining an enormous thickness; while in Scotland, on the other hand, the purely marine beds are comparatively thin, and occupy an entirely subordinate position in an immense mass of strata containing land plants and seams of coal, and in general aspect closely resembling the Coal Measures above.

The subdivisions of the Carboniferous rocks of the southern parts of Great Britain are given by Mr. Bristow as below:

	South Wales, &c.	*Lancashire, Derbyshire, and South Yorkshire.*	*North Yorkshire, Northumberland, and borders of Cumberland.*
Upper Carboniferous	Upper Coal Measures.	Upper Coal Measures.	Upper Coal Measures.
	Central Coal Measures or Pennant Grits.	Middle Coal Measures.	Middle Coal Measures.
	Lower Coal Measures.	Gannister Beds or Lower Coal Measures.	
Lower Carboniferous	Millstone Grit.	Millstone Grit.	Millstone Grit.
	Upper Limestone Shale.	Limestone Shale or Yoredale Rocks.	Yoredale Rocks.
	Carboniferous Limestone.	Carboniferous Limestone; no base.	Carboniferous Limestone.
	Lower Limestone Shales.		

The change to the state of matters found in Scotland begins already to appear in the North of England, coal having been wrought in the Carboniferous Limestone series in Northumberland, not far from Berwick. As the fossil ichthyology of the Scottish strata is peculiarly interesting, a more special explanation of their arrangement and subdivisions, which have been well wrought out by Professor Geikie[1] and the officers of the Scottish Geological Survey, may be not unacceptable to southern readers.

The Coal Measures of Scotland are essentially similar to those of England, to which they are considered as being generally equivalent. Below the Coal Measures there also occurs some thickness of reddish Sandstones known as "Rosslyn Sandstones" or "Moor Rock," which, both from their stratigraphical position and lithological characters, may be considered as representing the Millstone Grit.

The Carboniferous Limestone Series consists, however, of sandstones and shales, with valuable seams of coal and ironstone, and contains, moreover, towards its upper and lower limits, a few comparatively thin beds of marine limestone. In the latter, Mollusca, Corals, and Polyzoa similar to those of the English Carboniferous Limestone occur, though the catalogue of species is smaller, and, as regards the Brachiopoda at least, many exceedingly common English and Irish species are either totally absent or very rare, while others are distinguished by their very small size.

Below the Carboniferous Limestone series, and especially developed on the eastern side of Scotland, there exists a great thickness of strata, the "Calciferous Sandstone" series of Maclaren. The upper portion of this series, known as the "Cement-stone Group," consists of white and yellowish sandstones, with bituminous shales, beds of limestone, including the well-known "Burdiehouse Limestone," cement-stones, and clay-ironstones. It contains likewise a few seams of coal, but except in one instance, the Houston coal, formerly wrought to the west of Edinburgh, these are too thin to be of the smallest economic value; the bituminous shales are, however, in many places wrought for the manufacture of paraffin oil. This group is essentially estuarine in character, although occasionally beds occur containing marine shells and Polyzoa, especially in the east of Fifeshire. The lower portion of the Calciferous sandstone series, termed the "Cornstone Group," consists of reddish sandstones and cornstones, almost entirely destitute of fossils, and rests conformably on and passes into the Upper Old Red Sandstone, to which latter formation the ichthyolite-bearing beds of Dura Den, Clashbennie, and Melrose must be referred, if the aspect of their contained fish-remains is to be taken into account.

The Carboniferous rocks of Scotland may be thus tabulated:[2]

Upper Carboniferous	Coal Measures . .	Upper Red Sandstone Series. Flat Coal Series.

[1] 'Mem. Geol. Survey of Gt. Britain, Explanation to Sheet 32 (Scotland),' 1861.

[2] Copied from Mr. Bristow's 'Table of British Strata' already quoted.

Lower Carboniferous	Millstone Grit	Rosslyn Sandstones, or Moor Rock, with their coals.
	Carboniferous Limestone Series	Upper Limestones, with their coals.
		Edge Coal Series, with Ironstones.
		Lower Limestones.
	Calciferous Sandstone Series	Cementstone Group.
		Cornstone Group.

The arrangement of the Carboniferous rocks of Ireland is on the whole similar to that in England, the marine limestones of the Carboniferous Limestone series being very largely developed and covering a great extent of country, from which the overlying Coal Measures have been mostly swept away by denudation, and now exist only as small isolated patches, whose horizon is supposed to be that of the Lower or Gannister beds of England. Mr. Hull is, however, of opinion that the coal-bearing strata of Ballycastle in the north of Ireland belong to the same geological horizon as the Edge Coal series of Scotland, namely, to that of the Carboniferous Limestone. Below the Carboniferous Limestone there is also found in the south-western parts of Ireland an extensive series of strata consisting of grits and slaty rocks, for the most part very unfossiliferous, though in some places they contain marine fossils of well-known Carboniferous types, *e.g. Spirifer cuspidatus*, *Rhynchonella pleurodon*, &c. This series, known as the "Carboniferous Slates," is probably contemporaneous with the Calciferous Sandstones of Scotland, although formed under different conditions. Like the last-named set of rocks, the Carboniferous Slates rest conformably on the Upper Old Red Sandstone, the fossiliferous beds of Kiltorcan being evidently equivalent to the *Holoptychius*-bearing beds of Dura Den and other places in Scotland already referred to.

Remains of Fishes occur throughout the Carboniferous series, frequently occurring only as detached teeth, bones, spines, and scales; frequently also, and especially in certain localities, entire specimens of the smaller forms are met with. They occur usually in the shales, ironstones, and limestones, very rarely in the sandstones, and in the case of the ironstones they frequently form the nuclei of the concretions known as "nodules" or "ironstone balls." Entire specimens are usually so much crushed and flattened, the bones of their heads so broken and squeezed together, as to render the investigation of their cranial structure a matter of extreme difficulty; indeed, in too many cases the crushed heads cleave more or less through the middle, so as to present nothing more to the eye than a confused paste-like bony mass, which is utterly unreadable. For structural investigations the heads contained in ironstone nodules are the best, as here the matrix seems to have acquired a consistency sufficiently hard and unyielding to preserve the contour of the bones in tolerable condition before the operation of those immense crushing agencies, which in other cases have left the structural features undecipherable or nearly so. The comparison of species from different localities and horizons is also much interfered with from the different conditions of preservation so often displayed by specimens imbedded in rocks of different or even only slightly different mineral character. While, for instance, the fishes in the hard clay-ironstone nodules of Wardie afford much excellent information as to their cranial osteology, the external sculpture of the scales is usually invisible, owing to the flaking off and adherence to the counterpart of the external ganoine layer; on the other hand, the specimens found in the blackband ironstone of Gilmerton or in the Limestone of Burdiehouse almost invariably have the head in a state of complete "mash," while the outer surface of the scales is well displayed. Another circumstance, which renders necessary the greatest caution, as well as the examination and comparison of a great number of specimens, in the determination of species, is constituted by the remarkable distortions and alterations of form which are so often met with, the result of changes which have occurred after the death of the fish, and before or during its entombment in the ancient mud, now hardened into the stony matrix of the fossil. As a predisposing cause of these effects the soft or notochordal nature of the vertebral axis in so many genera and species must have operated very largely. But no one can devote close attention to the study of Palæozoic Fishes without being struck by the fact that in very many cases the attempt to define species by the proportional measurements of the specimens, as they lie before us on the stone, would only result in our making nearly as many species as specimens! It is therefore in the highest degree unsafe to rely on such measurements as specific characters except in cases where the arrangement of the scales and of the bones of the head is clearly undisturbed, and where the specimens otherwise show no evidence of lengthening out or of crumpling together.

In classifying the Fishes of the Carboniferous formation, I shall follow Professor Huxley in retaining the great divisions of Fishes in general, and the conception of a Ganoid Fish in particular, laid down by Johannes Müller. The class *Pisces* will accordingly be divisible into the following seven "orders:"

1. *Pharyngobranchii—Amphioxus.*
2. *Marsipobranchii—Petromyzon, Myxine, Bdellostoma.*
3. *Selachii—Scyllium, Squatina, Raia, Cestracion,* &c.
4. *Chimæroidei—Chimæra, Callorhynchus.*
5. *Dipnoi—Ceratodus, Lepidosiren.*
6. *Ganoidei—Acipenser, Polypterus, Lepidosteus,* &c.
7. *Teleostei—Salmo, Gadus, Labrus, Perca,* &c.

The Fishes whose remains are found in Carboniferous rocks are referable to the orders *Selachii, Dipnoi,* and *Ganoidei*, the present Monograph dealing only with the last.

In the *Ganoidei* the heart is, as in the *Selachii,* provided with a peculiar "conus arteriosus," from which the branchial arterial trunk takes its origin. This conus arteriosus is not the same as the "bulbus" or dilated origin of the branchial artery of Teleostei, but is a differentiation of the anterior part of the ventricle; it is muscular, and contains internally many rows of valves. The optic nerves do not simply cross as in the

Teleostei, but again, as in the Selachii, form a "chiasma" with decussation only of a few fibres. The intestine contains a spiral valve (rudimentary in *Lepidosteus*). The branchiæ have, however, as in the Teleostei, free extremities, and are contained in a gill-cavity covered by an operculum (except in the doubtful group of *Acanthodei*). There is a swimbladder (sometimes double, as in *Polypterus*), provided with an air-duct. The internal skeleton shows a wide range of development of its hard constituents; in some the notochord is altogether persistent (*Polyodon*); in some osseous hemi-vertebræ are present (*Pycnodus*, &c.); in others ring-vertebræ (*Megalichthys*), while in others biconcave vertebræ of the usual Teleostean type are developed, and in *Lepidosteus* they actually become opisthocœlous. The termination of the vertebral column exhibits a portion of soft unsegmented notochord. The anterior margins of the fins are frequently, though not always, furnished with the peculiar little scales, or supplementary raylets, known as "fulcra." The skull is, as in Teleostei and most Selachii, hyostylic, thus differing from the autostylic skull of the Dipnoi. As in the Dipnoi and Teleostei, the cranial roof is provided with membrane bones; as in many Physostomous Teleostei, the maxilla forms part of the edge of the mouth and ordinarily bears teeth, but the vomer is duplex. The skin is covered with hard scales, plates, or scutes of various forms, save in *Polyodon* and *Chondrosteus*, where these structures are confined to the termination of the body axis in the region of the caudal fin. These scales are ordinarily of osseous substance and covered externally with a thin layer of a peculiar structureless substance known as "ganoine"—popularly as "enamel," and to which that lustrous appearance is due from which the order takes its name.

The *Ganoidei* are thus seen to occupy a peculiarly intermediate position between the *Selachii*, *Dipnoi*, and *Teleostei*, having some characters in common with each; while it is at the same time difficult to find a distinctive mark which will be exclusively diagnostic of every member of the entire series. With the *Selachii* they are connected by their heart and optic chiasma, though widely separated by their free gills, opercular apparatus, cranial bones, and swimbladder. Here, however, we are confronted by the singular extinct group of *Acanthodei*, which, with an absence of several important Ganoid characteristics, seem to approach the *Selachii* in their general aspect. Though the *Ganoidei* are separated from the *Dipnoi* by their hyostylic skull, a transition to the latter order is afforded by those Crossopterygian forms with acutely lobate pectorals (*Holoptychius*, *Glyptolepis*); while, indeed, the position in the one or in the other group of such genera as *Phaneropleuron* and *Uronemus* is not by any means definitely settled. Through the *Amiadæ* the *Ganoidei* graduate into the *Teleostei*, a transition not sufficiently recognised by Günther in his recent proposal to unite the *Selachii*, *Chimæroidei*, *Dipnoi*, and *Ganoidei* into one subclass of *Palæichthyes*, a second and distinct subclass being formed by the Teleostei.[1] For, indeed, many Mesozoic genera (*Thrissops*, *Leptolepis*, &c.)

[1] Description of *Ceratodus*, 'Phil. Trans.,' 1871.

described as Ganoids by Agassiz have been by subsequent writers confidently referred to the *Teleostei*, their true position still awaiting further investigation.

This undoubted passage towards the Teleostei seems to be the principal reason that of late years more than one author has been led to question the desirability of retaining the Ganoidei as one of the great divisions of Fishes, notwithstanding that Agassiz considered the establishment of this Order as his own greatest achievement in ichthyology. Cope, for instance, has retained as an order only the Crossopterygii; the Acipenseroid, Lepidosteoid, and Amioid forms being united with ordinary osseous fishes in his order of "Actinopteri."[1] Thiollière had previously, in classifying the fishes of the Jura, proposed to revert to the system of Cuvier, except as regards the Sturgeons, which along with the other Agassizian Ganoids he placed in the division *Malacopterygii abdominales* of the *Pisces Ossei.*[2] In like manner Lütken has proposed to include, not merely the entire series of Ganoids, but also the *Dipnoi*, in the Physostomous division of Müller's *Teleostei.*[3]

A careful perusal of Dr. Lütken's elaborate memoir has, however, failed to convince me of the advantage of his position. The recent researches of Professor Huxley into the anatomy of *Ceratodus*[4] go to show that the *Dipnoi*, notwithstanding their Ganoid affinities, are better retained as a distinct order; much less, then, can a position be claimed for them among the *Teleostei*. For the rest, it does not seem to me that the occurrence of transitional forms destroys the validity or naturalness of an "order" if its members otherwise form a well-connected series, such as the Ganoids seem to do, if we meanwhile leave out of view the problematic groups of *Acanthodei*, *Placodermi*, and *Cephalaspidæ*, which must still be considered as "*incertæ sedis.*" We cannot doubt that the strict separation of groups which, however natural they may be, must always be more or less arbitrary, and that were we really acquainted with the entire succession of organic forms such things as absolutely defined "orders," &c., would be found to have no existence in nature. And lastly, it must be borne in mind that the relative value of certain structural characters as being of "ordinal," "subordinal," or "family" importance, frequently very much depends upon the subjective idiosyncrasy of the writer.

The arrangement of the Ganoids in minor subdivisions is, in the present state of

[1] "Observations on the Systematic Relations of the Fishes" (abstract), 'Ann. and Mag. Nat. Hist.' (4), ix, 1872, pp. 155—168.

[2] "Note sur les Poissons fossiles du Bugey, et sur l'Application de la Méthode de Cuvier à leur Classement," 'Bull. Soc. Géol. de France,' 1858. (Reprinted in the second part of the "Poissons Fossiles du Bugey," Paris and Lyons, 1873, pp. 8—11).

[3] "Ueber die Begrenzung und Eintheilung der Ganoiden," von Dr. Chr. Lütken, aus dem Dänischen übersetzt von Dr. R. v. Willemoes-Suhm, 'Palæontographica,' Bd. xxii, 1ste Lieferung, 1873. The original essay is contained in the 'Videnskabelige Meddelelser fra den Naturhistoriske Forening i Kjöbenhavn," 1868.

[4] "Contributions to Morphology. Ichthyopsida—No. 1. *Ceratodus Forsteri*, with observations on the Classification of Fishes," 'Proc. Zool. Soc.,' January, 1876.

knowledge, still a matter of some difficulty, especially seeing that, in attempting to co-ordinate fossil with living forms, we are here, as in other departments of Palæontology, limited to the analogies of the hard parts of the skeleton and the inferences deducible therefrom. The few surviving recent members of the order fall readily into four distinct types—that of *Polypterus*, of *Acipenser*, of *Lepidosteus*, and of *Amia*. With each of the first three at least there may be co-ordinated an extensive series of fossil forms; there are others, however, whose systematic position, even to their being retained as Ganoids at all, is still quite uncertain.

The following arrangement here adopted is based on that of Professor Huxley, who, following up the philosophic researches of Pander, has done more than any other naturalist of recent years to enable us to obtain some insight into the classification of the Ganoids on true morphological principles.

A. *Veri.*

Suborder I. *Crossopterygii.*—Pectoral, and sometimes also the ventral, fins lobate; infraclaviculars present; rays of dorsal and anal fins frequently exceeding in number their supporting interspinous bones, præoperculum extending forward on the cheek; jugular plates in place of branchiostegal rays; vertebral column in various stages of development; tail heterocercal or diphycercal, sometimes abbreviate-diphycercal; scales cycloidal or rhomboidal. Including the families *Phaneropleuridæ* (?), *Holoptychiidæ*, *Cyclodipteridæ*, *Rhombodipteridæ*, *Cœlacanthidæ*, and *Polypteridæ*.

Suborder II. *Acipenseroidei.*—Tail completely heterocercal; notochord persistent; paired fins not lobate; infraclaviculars present; rays of dorsal and anal fins exceeding in number their supporting interspinous bones; præoperculum, when present, tending to extend forwards over the cheek; branchiostegal rays in most, but large jugulars in none. Skin in many furnished with osseous scutes or with rhomboidal scales; in some naked, save on the prolongation of the body along the upper lobe of the caudal fin. Including the families *Acipenseridæ*, *Spatularidæ*, *Chondrosteidæ*, *Palæoniscidæ*, *Platysomidæ*.

Suborder III. *Lepidosteoidei.*—Tail abbreviately heterocercal; vertebral column in various stages of development; paired fins non-lobate; no infraclaviculars; opercular bones as in Teleostei; branchiostegal rays, with frequently a so-called "median jugular" in front; rays of dorsal and anal fins corresponding in number to their supporting interspinous bones; scales rhomboidal, sometimes replaced by angular scutes. Including, besides the recent and somewhat aberrant *Lepidosteidæ*, a great series of Mesozoic semi-heterocercal forms (*Lepidotus*, *Eugnathus*, &c.) not yet satisfactorily limited, or divided into families.

Suborder IV. *Amioidei.*—Tail abbreviately heterocercal; paired fins non-lobate; no infraclaviculars; opercular bones as in Teleostei; branchiostegal rays, with median "jugular" in front; scales thin, cycloidal; aspect Teleostean-like. Includes the recent

Amiadæ. How far certain Mesozoic genera with cycloidal scales and well-developed vertebral column (*Leptolepis, Oligopleurus, Megalurus,* &c.) may be related to *Amia* remains matter for additional investigation.

B. "*Incertæ Sedis.*"

Acanthodei.—Scales minute, shagreen-like; lateral line running *between* two rows of modified scales; tail heterocercal; fins furnished in front with strong spines, those of the pectoral attached to a clavicle; the other spines passing at their bases deep into the flesh; gills apparently naked; presence of cranial roof bones doubtful. *Acanthodes, Cheiracanthus,* &c.

Placodermi.—Head and body enclosed in large osseous plates; tail scaled in some, naked in others. *Pterichthys, Coccosteus, Asterolepis.*

Cephalaspidæ.—Head covered by a continuous shield; body covered with small angular plates or scales; internal skeleton, jaws, or teeth, not discovered. *Cephalaspis, Pteraspis,* &c.

The essential difference between the system given above and those usually given in the handbooks of the present time consists in the Palæoniscoid and Platysomid forms being placed in the Acipenseroid series, and the omission of the suborder of "*Lepidopleuridæ,*" proposed in 1866 by Professor Young for the reception of the Platysomids and Pycnodonts.[1] As regards the latter, their position as true Ganoids has been doubted by Professor Huxley,[2] and their systematic place is still most uncertain; provisionally they are, perhaps, best classified with the Lepidosteoidei. One thing at least is clear, namely, that with the *Platysomidæ* they have nothing specially in common but the mode of articulation of the scales. On the other hand, the affinities of the *Platysomidæ* to the *Palæoniscidæ* are most evident, and the structural peculiarities of both, but especially of the latter family, leave no doubt as to their close relationship with *Polyodon,* with which therefore, to my mind at least, they should be included in a common series. While the *Palæoniscidæ* have been hitherto referred to the Lepidosteoid series, the *Sturiones* were considered by Lütken not to be Ganoids, but to form a distinct suborder of Physostomi, placed "between the Cartilaginous Fishes and the Ganoids, with which last they are very closely related, but with which they cannot be united."[3] It will, however, be shown in the first part of this Monograph, that the *Palæoniscidæ* form

[1] "On the Affinities of Platysomus and Allied Genera," 'Quart. Journ. Geol. Soc.,' xxii, 1866, pp. 301—317.

[2] 'Dec. Geol. Survey,' x (1861), p. 28, *footnote.*

[3] Op. cit., German edition, p. 39. Heckel had also wished to make a special "Fischtypus" out of the Müllerian *Chondrostei;* "Ueber die Ordnung der *Chondrostei,* und über *Amia, Cyclurus, Notæus,*" 'Sitzungsberichte der Wiener Akad.,' Bd. vi, 1851, p. 219.

too close a link between the other Ganoids and the living Acipenseroids to admit of the separation of the latter.

The Ganoid Fishes of the Carboniferous formation are comprised in the groups of Crossopterygii, Acipenseroidei, and Acanthodei. A few fragmentary remains have also been referred to Placodermi; but, so far as I am aware, there is no authentic record of any member of the Lepidosteoid series occurring in strata of this age, though these begin already to appear in the Permian rocks above.

Although not coming first in order of arrangement, the *Palæoniscidæ* will be first considered in this Monograph, owing to their great interest, the comparatively small modicum of attention which has hitherto been bestowed on them, and the amount of ready material at present at my disposal for their description.

Class—PISCES.

Order—GANOIDEI.

Sub-order—*ACIPENSEROIDEI* (see p. 8).

Family—PALÆONISCIDÆ.

Lepidoidei heterocerci, *Agassiz.*
Sauroidei (pars), *Agassiz.*
Acanthodei (pars), *Agassiz.*
Heterocerci monopterygii (pars), *Giebel.*
Palæoniscidæ (pars), *Vogt.*
Lepidosteides (pars), *Pictet.*
Lepidosteini heterocerci, *Lütken.*
Palæoniscidæ, *Martin.*

The body is fusiform, clothed with rhombic ganoid scales; the paired fins are non-lobate, the ventrals abdominal; there is one dorsal fin, with short base of attachment, and one anal; the caudal is completely heterocercal and deeply cleft. The external head bones are ganoid and usually sculptured; the orbit is placed far forwards; the snout forms a prominence over the front of the mouth. The suspensorium is oblique, the gape correspondingly wide, the palatal arch and the jaws elongated; the præoperculum covers a portion of the cheek above the maxilla, which is large and broad posteriorly. The branchiostegal rays form a series of narrow flat imbricating ganoid plates. The notochord is persistent; there are apparently no ribs; the vertebral arches, spinous processes, and interspinous bones are ossified; two sets of interspinous bones support at least the dorsal fin. The shoulder-girdle displays well-developed infra-clavicular plates. The rays of all the fins are numerous, closely set, and, save in the principal rays of the pectoral of some genera, closely jointed; those of the azygous fins overlap with their proximal extremities their supporting ossicles, than which they are also more numerous. The anterior margin of all the fins are in most, if not in all, cases set with fulcral scales, which probably form a double series. The teeth are conical or cylindrical, very rarely plicate at the base, with large internal pulp cavity and with a distinct enamel cap on the apex.

The following genera are included in this family, an * being prefixed to the names of those which have as yet occurred in British Carboniferous rocks.

1.	*Cheirolepis*, Agassiz . . .	Old Red Sandstone.
2.	*Rhabdolepis*, Troschel . . .	Permian.
*3.	*Cosmoptychius*, Traquair . .	Carboniferous.
4.	*Palæoniscus*, Blainville . . .	Permian.
*5.	*Elonichthys*, Giebel . . .	Carboniferous.

*6.	*Acrolepis*, Agassiz . . .	Old Red Sandstone (?), Carboniferous, Permian.
*7.	*Nematoptychius*, Traquair . .	Carboniferous.
*8.	*Cycloptychius*, Huxley . . .	Carboniferous.
9.	*Centrolepis*, Egerton . . .	Lias.
*10.	*Microconodus*, Traquair . .	Carboniferous.
*11.	*Gonatodus*, Traquair . . .	Carboniferous.
12.	*Amblypterus*, Agassiz . . .	Permian.[1]
*13.	*Rhadinichthys*, Traquair . .	Carboniferous.
14.	*Oxygnathus*, Egerton . . .	Lias.
15.	*Cosmolepis*, Egerton . . .	Lias.
16.	*Thrissonotus*, Agassiz . . .	Lias.
17.	*Pygopterus*, Agassiz . . .	Permian.
18.	*Myriolepis*, Egerton . . .	Carboniferous.
19.	*Urosthenes*, Dana	Carboniferous.
(*?)20.	*Eurylepis*, Newberry . . .	Carboniferous.
21.	(?) *Saurichthys*, Agassiz . .	Trias.
22.	(?) *Coccolepis*, Agassiz . . .	Lower Oolite.

The genus *Gyrolepis* of Agassiz must be cancelled, as from deficiency of distinct characters all definition of it is impossible. *G. Rankinei*, Ag., of the British Carboniferous rocks, is in my opinion an *Acrolepis*, and the scattered scales occurring in the Trias, referred to *Gyrolepis* by Agassiz, but which also much resemble those of *Acrolepis*, have been a subject of much dispute among palæontologists,—Giebel referring them partly to "*Amblypterus*," partly to *Colobodus*, while Dr. Martin has suggested that they probably belong to *Saurichthys*, and also that the proper place of the last-named genus is among the *Palæoniscidæ*. The fragmentary condition, however, in which the fish-remains of the Muschelkalk ordinarily occur, naturally interposes great difficulties in the way of their satisfactory description and determination.

As regards *Coccolepis*, classed as one of the "*Lepidoidei Heterocerci*" by Agassiz, its relationship to the *Palæoniscidæ* seems to be indicated both by Agassiz's figure and description.[2] The late Dr. Wagner did not, during the preparation of his work on the fishes of the Bavarian Lithographic Limestone, succeed in seeing a specimen; however, he considered it as probably related to the *Caturi*, and possibly identical with his genus *Liodesmus*.[3]

[1] I regret that I have had no opportunity of forming an opinion as to the true generic position of the Triassic forms *Amblypterus Agassizii* of Münster, and *A. ornatus* and *latimanus* of Giebel, except that, judging from the descriptions, they do not seem to belong to the genus *Amblypterus* as restricted by Troschel.

[2] 'Poissons Foss.,' vol. ii, pt. ii, p. 300; 'Atlas,' vol. ii, pt. ii, tab. xxxvi, figs. 6 and 7.

[3] 'Monographie der fossilen Fische aus den lithographischen Schiefern Bayerns,' Munich, 1863, pp. 136 and 138. Reprinted from the 'Abh. der k. bayerischen Akad.,' 2 Classe, Bd. ix.

The *Palæoniscidæ* are thus seen, as far as our present information goes, to have first appeared in the Old Red Sandstone formation, and finally to have died out in the earlier part of the great Jurassic era. Their remains are, however, most abundant in and characteristic of rocks of Carboniferous and Permian age.

STRUCTURE AND SYSTEMATIC POSITION OF THE PALÆONISCIDÆ.

Hitherto there has been very little done in the way of accurate research into the anatomical structure of the *Palæoniscidæ*, especially as regards their cranial osteology, and consequently the opinions of naturalists as to their relationships with other groups of fishes, living and extinct, have not rested on a very secure basis. This is in a great measure due to the condition in which their remains usually occur; the delicate internal skeleton of the trunk being usually more or less completely obscured by the external scaly covering, while the bones of the head are in most cases so crushed, broken, and squeezed together as to render their interpretation a very difficult matter indeed.

The information derivable on these points from the writings of Agassiz is not very extensive, or of a very definite character; in fact, the *Palæoniscidæ* as a group were not understood by the illustrious author of the 'Poissons Fossiles.' For, notwithstanding certain obvious structural correspondences between the various Palæoniscoid genera with which he was acquainted, they were classed by him in three separate families, and in each case associated with the most dissimilar neighbours. While *Palæoniscus*, *Amblypterus*, *Gyrolepis*, and *Centrolepis* were included in the family of "Lepidoïdes," *Pygopterus*, *Acrolepis*, and *Thrissonotus* found a place among the "Sauroides," and *Cheirolepis* among the "Acanthodiens"—the mere size and arrangement of the teeth being relied on as the great mark of distinction, and, in the aberrant genus *Cheirolepis*, the minuteness of the scales. And although from some of the descriptions in the text it is evident that he was acquainted with many of the bones of the head, yet his restored figures, some of which, like that of *Palæoniscus* (Atlas, vol. I, tab. A, fig 4), have been so often copied into other works, are very erroneous, and completely ignore the peculiarities of the family.

Quenstedt in his 'Handbuch der Petrefactenkunde' (Tübingen, 1852, pl. xviii, figs. 3, 4, 5, 6) gives a few figures illustrating the bones of the head of *Palæoniscus* and *Pygopterus*, which, so far as they go, are very accurate. We may note here especially his recognition of the true form of the maxilla, of the peculiar backward slope of the operculum, and the enormously wide gape characteristic of the family. The figure of *Amblypterus latus* (fig. 5) is not, however, so great a success.

In 1869 I published a description of the fish from the Wardie Shales named by

Agassiz *Pygopterus Greenockii*,[1] but for which I have since established a new genus, *Nematoptychius*.[2] In this paper the bones of the exterior of the head were described, as well as the conformation of the shoulder-girdle with its *interclavicular* plates, but I was not then acquainted with the suspensorial and palato-quadrate apparatus, and many other matters of detail which have since come to light. The structure of *Nematoptychius* was found to agree in all its leading points with that of other fishes from the Edinburgh district classed by Agassiz with *Amblypterus* and *Palæoniscus*.

As regards the curious genus *Cheirolepis*, many of its head bones were correctly described and figured by Pander in 1860,[3] and he proposed to institute for it a distinct family of "Cheirolepidini," although he was also struck by the resemblance which certain of its facial bones bore to those figured by Quenstedt in *Palæoniscus*. In this view Professor Huxley acquiesced,[4] and, in alluding to the probability of the "Cheirolepidini" being referable to the great suborder of Lepidosteidæ, he pointed to the branchiostegal rays of *Cheirolepis* discovered by Agassiz, and to the absence of jugular plates. Powrie, however, in 1867[5] published a paper describing certain plates in this genus, which he considered to be principal jugulars, and referring the "branchiostegal rays" of Agassiz to the category of lateral jugulars, as in *Holoptychius*, *Megalichthys*, &c. But in 1875[6] I pointed out that those so-called jugulars in *Cheirolepis* were, in fact, *infra-clavicular* plates, closely resembling those I had already described in *Nematoptychius*, &c., and maintaining that the correspondence in general organisation between *Cheirolepis* and *Palæoniscus* was so close that they must be included in the same family. I was not, however, then acquainted with a paper by Dr. Karl Martin which had been published two years previously,[7] and in which the same opinion as to the position of *Cheirolepis* was expressed, though with an appended query. Dr. Martin's paper deals principally with the cranial structure of *Palæoniscus* and a few other allied genera occurring commonly in the Permian strata of Germany, finishing with general views as to the "systematik" of the group, which will be noticed further on, the original impulse to his researches having been given by the erroneous restoration of *Palæoniscus* given by Lütken a few years before.[8] Unfortunately Dr. Martin's definition of the family and his account of the

[1] "Description of *Pygopterus Greenockii*, with notes on the Structural Relations of the Genera *Pygopterus*, *Amblypterus*, and *Eurynotus*," 'Trans. Royal Soc. Edinb.,' vol. xxiv, 1867, pp. 701—713, pl. xiv.

[2] 'Annals and Mag. Nat. Hist.' (4), xv, p. 258 (1875).

[3] "Ueber die Saurodipterinen, Dendrodonten, Glyptolepiden, und Cheirolepiden des devonischen Systems," St. Petersburg, 1860, pp. 69—73.

[4] 'Dec. Geol. Survey,' x (1861), pp. 38—40.

[5] 'Geol. Magazine,' iv, 1867, pp. 147—152.

[6] "On the Structure and Systematic Position of the genus *Cheirolepis*," 'Annals and Mag. Nat. Hist.' (4), xv (1875), pp. 237—249.

[7] "Ein Beitrag zur Kenntniss fossiler Euganoïden," 'Zeitschrift der deutschen geologischen Gesellschaft,' xxv (1873), p. 699, tab. xxii.

[8] Op. cit., woodcut, fig. 3.

skull of *Palæoniscus* are both very open to criticism. Through the great kindness of Professor von Seebach, of Göttingen, I have enjoyed the opportunity of examining and taking notes of the specimens referred to by Martin, and with the result of finding that the author has fallen into many very serious errors of interpretation, a few of which might indeed have been avoided had he been acquainted with my paper on *Nematoptychius*, published six years previously. Of these errors one of the most remarkable is the finding of "jugular plates," not only in *Cheirolepis*, but also in *Palæoniscus*. It must, however, be borne in mind that the subject is one of such extreme difficulty that no one can with confidence imagine himself altogether free from error, and, alas! even the best preserved specimens procurable fall very far short of affording us all the information we may be in quest of.

I.—THE ANATOMICAL STRUCTURE OF THE PALÆONISCIDÆ.

The Head.

We may be very certain that the cranium in the *Palæoniscidæ* consisted internally of an extensively cartilaginous box or case, in which some primordial ossifications were present, and of which a few indistinct traces may occasionally be detected. Externally it was covered by a buckler of osseous plates firmly united by suture, ganoid and sculptured externally, which are to be considered as essentially dermal in their nature, and to be classed with the numerous plates covering the cranial cartilage of the Sturgeons. We need, therefore, hardly look for an exact correspondence of these plates in number and arrangement with the bones forming the cranial roof in ordinary Bony Fishes, in which, through the long chain of Lepidosteid and Amioid forms, these parts have undergone much modification. Some of them, however, such as the frontals and parietals, may be considered as still having their exact homologues in the skulls of modern Teleostei.

In no member of the family have I seen the elements of the cranial buckler exhibited with greater clearness than in *Nematoptychius Greenockii*, as illustrated in Pl. I, figs. 7 and 8, taken from a beautiful specimen, singularly free from crushing, preserved in an ironstone nodule from the Lower Carboniferous shales of Wardie, near Edinburgh. The specimen is, in fact, a *cast* of the inner surface of the bones of the head, and, as it exhibits not merely the sutures between the various bones, but also the lines radiating from their centres of ossification, we are enabled to map out the constituent elements with much greater certainty than if the external sculptured surface of the bones themselves were presented to us. The two somewhat square-shaped bones (*p.*) at the posterior part of the shield, articulating with each other in the middle line, may be taken as representing the *parietals*, and on the outer side of each is a somewhat longer plate (*sq.*), equivalent to the similarly placed *squamosal* of *Lepidosteus* and *Amia*. In advance of the parietals the *frontals* (*f.*) may be recognised, covering a large part of the vault of the cranium. External to each frontal, and in advance of the squamosal, is another smaller plate (*p.f.*), which may be called *post-frontal,* though it is indeed placed rather forward, and cannot be supposed exactly to represent the bone usually called "post-frontal" in osseous fishes (*Sphenotic,* Parker), which is an ossification in the periotic cartilage. It seems, however, to be the equivalent of the small superficial plate seen external to the posterior part of the outer margin of the frontal in *Amia,* and which, in that fish, coexists with a subjacent well-developed "sphenotic;" a corresponding ossification external to the frontal may also be traced in the cranial buckler of *Acipenser.* In advance of the two frontals, and forming the prominence of the snout projecting over the mouth, is a large median *super-ethmoidal* (*e.*); its right and left lateral margins are notched anteriorly, and just above the mouth, for the nasal openings (*n.*), one on each side. This lateral margin of the super-ethmoidal articulates also on each side with another bone (*a.f.*), which forms the anterior part of the orbital margin of the cranial shield in front of the post-frontal and completes the nasal notch of the first-named bone into a round opening. This we may call *pre-frontal,* pretty sure, however, that it has nothing to do with the well-known ossification in osseous fishes usually bearing that name, and which Mr. Parker has proposed more definitely to term "ecto-ethmoidal."[1]

In all the other genera of *Palæoniscidæ,* in which the cranial roof bones are well enough preserved to admit of recognition, the same general arrangement seems to prevail as in *Nematoptychius.* In *Palæoniscus* (*e. g. P. macropomus,* Pl. I, fig. 3), the very same bones, bearing the same relations to each other, may be easily made out, with the exception of the post-frontal, whose differentiation from the frontal is somewhat indistinct in all the specimens I have seen. There, as in several other genera, the buckler is proportionally wider in the parietal, narrower in the orbital and ethmoidal regions, than in *Nematoptychius.* Only in *Nematoptychius* and *Rhadinichthys* have I distinctly seen the nasal openings.

That there were ossifications in the side walls of the primordial cartilaginous cranium of the *Palæoniscidæ* is sufficiently evident from appearances presented by a few specimens *Elonichthys, Rhadinichthys*), but in no case are those appearances of sufficient distinctness to admit of description; but in a specimen of *Gonatodus punctatus,* from Wardie, a lucky fracture has disclosed a beautifully developed *parasphenoid* (*pa. s.*) represented in Pl. II, fig. 5. This bone is rather short and broad, its centre of ossification is placed a little in front of its posterior third, and opposite this there is on each side a slight constriction. The part in front of the ossific centre is slightly excavated or furrowed longitudinally when seen from below, the shorter and broader part behind being almost entirely occupied by a gently convex triangular area with anteriorly directed apex, on each side of which is a small flattened triangular wing. The "sphenoideum" represented by Dr. Martin, in *Palæoniscus* (op. cit., pl. xxii, fig. 8), is nothing more than a portion of the palatal arch seen from above.

Dr. Martin has also, in a crushed and badly preserved head of *Palæoniscus Freiesle-*

[1] "On the Structure and Development of the Skull in the Salmon (*Salmo Salar,* L.)," 'Phil. Trans.,' 1872.

beni, from Mansfeld, made out what he considers to be the duplex vomer (op. cit., pl. xxii, fig. 11 *v*). An examination of the original specimen in the Museum at Göttingen has, however, failed to convince me of the correctness of his determination, though indeed it is extremely probable that a double vomer was present in the *Palæoniscidæ*.

The *hyomandibular* in *Palæoniscus* (Pl. I, fig. 3, *h. m.*) is an elongated rather slender bone, which descends obliquely downwards and backwards from the squamosal region of the skull to the neighbourhood of the quadrate articulation, and is slightly bent a little below the middle, the posteriorly directed angle corresponding with the junction of the operculum and interoperculum. Its form is in the main cylindrical, though it is a little expanded and laterally flattened at the angle, above which it enlarges very gradually towards the upper extremity, becoming also a little flattened antero-posteriorly. The upper or longer portion is very obliquely placed on the side of the head, so that its posterior margin, in contact with the operculum, looks more upwards than backwards, the opposite anterior margin coming, in like manner, to look so much downwards as to be nearly in contact with the upper edge of the posterior part of the palato-quadrate arch. The lower and shorter portion of the bone below the angle approximates more to the vertical, and is in relation with the interoperculum behind and to the posterior margin of the palato-quadrate arch in front. Externally the hyomandibular was covered and concealed by the præ-operculum, though, owing to displacement by crushing, a portion of it is usually seen between the last-named bone and the operculum.

This bone was evidently cartilaginous at both extremities, and, to judge from its hollowness, the cartilage must have extended from above and below a long way into its interior. I have seen no trace of a *symplectic;* this element may have been absent as in *Polypterus*, or completely unossified as in *Polyodon*. The configuration of the hyomandibular is essentially the same in every genus of *Palæoniscidæ* in which I have succeeded in obtaining a view of it, as in *Nematoptychius*, *Oxygnathus* (Pl. II, fig. 2), *Elonichthys*, *Cycloptychius*, &c. In *Amblypterus* its position is much less oblique, and the gape consequently smaller in proportion (Pl. II, fig. 1).

Extending from the articulation of the lower jaw, and the lower part of the hyomandibular, forwards to the prefrontal region, is a somewhat narrow and elongated bony lamina, representing the hard palate or *palato-quadrate* arch (Pl. I, fig. 3, *pa.*). The position of the posterior and broader part of this lamina is nearly vertical; externally it is concave or longitudinally hollowed, forming a wide shallow groove covered externally by the broad posterior part of the maxilla in which the levator muscle of the lower jaw must have passed, as in the recent *Polyodon* (Pl. VII, figs. 1 and 2), nearly horizontally backwards, turning round behind, as it also does in that recent form, at a very sharp angle to attach itself to the coronoid part of the lower jaw. Immediately behind the orbit the upper margin of the palato-quadrate lamina is prominently angulated, and here its plane becomes also a little twisted so that the narrower part passing on below the eye has its surfaces looking more upwards and downwards. The greater part of this palato-quadrate lamina seems to be composed of an elongated bony plate, evidently a membrane ossification covering the inner or oral aspect of a palatal cartilage like that of *Polyodon*, in which a very similarly shaped membrane bone also exists (Pl. VII, figs. 1 and 2, *pa.*). It is probably equivalent to the ectopterygoid of osseous fishes. Posteriorly, however, there is apparently another and much smaller bony piece (*q.*) close to the articulation of the jaw, and which we may pretty safely assume to be a true *quadrate;* above which there is, in *Nematoptychius* and *Elonichthys*, at least, distinct evidence of a third piece occupying much the same position as the metapterygoid in ordinary fishes.

Placed externally to the palato-quadrate lamina is the very peculiarly shaped *maxilla* (Pl. I, fig. 2 and 11, *mx.*). This is broad behind, where it covers a large part of the cheek, but just behind the orbit its upper margin is suddenly excavated or cut away, so that its anterior extremity becomes attenuated to a fine point as it passes on below the orbit to the premaxillary region. Behind the orbit the upper margin of the maxilla is horizontal and straight, and joins the somewhat oblique posterior one at an obtuse angle; the posterior-inferior angle, slightly rounded, overlaps the lower jaw a little at its articulation. The lower or dental margin is slightly sigmoidal in its contour, passing first forwards and a little upwards, then horizontally forwards, and finally near its anterior termination a little upwards again. Excepting posteriorly, where it overlaps the mandible, the lower margin of the maxilla is slightly reflected inwards so as to form a sort of narrow ledge, which, apparently, came in contact with the infero-external margin of the palatal lamina. There does not, however, seem to have been here any such firm articulation by suture as we find in *Polypterus.*

Owing to its small size and the manner in which the heads are crushed, it is extremely difficult to make out the *premaxilla* in *Palæoniscus* and most of the other genera. It is, however, very clearly exhibited in that specimen of *Nematoptychius* which has already served as a basis for the description of the bones of the cranial roof. It is a small bone (*p. mx.*, Pl. I, fig. 8) placed at the anterior inferior corner of the orbit, meeting with its fellow of the opposite side below the projecting super-ethmoidal, with which bone, and with the prefrontal, it is firmly and immovably articulated by suture. It bears teeth like those of the maxilla. The small piece of bone marked *p. mx.* in the figure of the head of *Palæoniscus macropomus*, Pl. I, fig. 3, is, in all probability, the premaxilla a little displaced by crushing.

The *mandible*, owing to the great backward extent of the gape, is long, and in some cases rather slender, as in *Palæoniscus* and *Amblypterus*, though in many, especially in the more predaceous forms, such as *Pygopterus, Acrolepis, Nematoptychius*, it is sufficiently stout. In all it is of a tapering form; in some (*Palæoniscus*) it is tolerably straight when seen laterally, in others (*Nematoptychius*) the side view shows a gentle curvature with upwardly directed concavity. The Meckelian cartilage was evidently largely persistent, and, at least, four osseous elements can be distinctly made out. Of these the *dentary* bone (Pl. I, fig. 2, &c., *d.*) is, of course, the most conspicuous, and extends nearly the whole length of the jaw ; it is broadest behind, tapering gradually towards the symphysis, a little behind which the centre of ossification is placed. In *Cheirolepis,* the lower margin shows in front, and below the ossific centre, a wide, shallow notch. The posterior-superior angle is produced a little backwards as a sharp, posteriorly directed process, below which the thin and short posterior margin is rounded. The inner surface is concave, conspicuously grooved in front, where the bone is thickest, for the anterior part of the Meckelian cartilage. The superior tooth-bearing margin is a little reflected inwards, as in the corresponding part of the maxilla. The dentary overlaps behind a well-marked *angular* (Pl. I, fig. 2, *ag.*), forming the very obtusely rounded posterior-inferior angle of the jaw. Internally, the Meckelian cartilage was covered by a splenial element (*sp.*), which in general form resembles that of *Polyodon,* though more largely developed; its upper margin is often seen to have teeth, as in *Palæoniscus* (Pl. I, figs. 3 and 4). In *Nematoptychius* (Pl. I, fig. 10) it is of a somewhat lanceolate shape, rounded behind, acutely tapering in front; the upper margin is tolerably straight, the lower convex. The *articular* element (*ar.*) is rarely distinctly seen ; it bears on its upper aspect a rounded excavation or notch for articulation with the quadrate, as is well exhibited in the figure of the head of *Oxygnathus* given in Pl. II, fig. 2. This articular notch has also been represented by Messsrs. Hancock and Atthey in *Elonichthys Egertoni.*[1]

The only element of the *hyoid* of which I have seen any trace is the *ceratohyal,* a tolerably slender bone, slightly expanded at the extremities, narrower in the middle. I have seen the *ceratohyal* clearly enough in more than one specimen of *Oxygnathus,* also in *Elonichthys,* and in these cases its position has been parallel to the lower jaw, within and covered by the branchiostegal plates. Possibly the ceratohyal was, as in the recent *Polyodon,* the only element of the hyoid apparatus ossified.

There are no bones more readily distinguishable in the heads of the *Palæoniscidæ* than those of the *opercular* apparatus, and yet there is room for some difference of opinion as to the names which some of the pieces should bear, if we aim at finding a complete morphological correspondence between them and the opercular elements in the Teleostei and in the more modern type of Ganoids (Lepidosteoidei and Amioidei). Regarding the *operculum* there can, however, be no dispute. This is, in *Palæoniscus* (Pl. I, fig. 2, *op.*) an oblong plate, broader below than above, and very obliquely placed on the side of the head, owing to the peculiar direction of the suspensorium. Of its angles the anterior-superior one is very acute, the posterior-inferior less so, in fact nearly a right angle ; the anterior-inferior angle is rounded, but the posterior-superior is so little marked that the superior and posterior margins curve round nearly uninterruptedly into each

[1] 'Ann. and Mag. Nat. Hist.' (4), i, pl. xv, fig. 3. The lower jaw of *Palæoniscus* is described by Martin (op. cit.) as consisting only of two parts, " articulare " and " dentale," the former being represented by him in his fig. 5 and in his restored diagram (fig. A) as enormously larger than it really is. However, an examination of the original of his fig. v, a head crushed from above, betrays the fact that he has mistaken the broad posterior portion of the maxilla for the " articulare," while his " dentale " is a part of the palatal arch.

other. The operculum preserves the same general form with slightly varying proportions in most of the other genera, such as *Elonichthys, Nematoptychius, Pygopterus, Acrolepis, Oxygnathus*, &c. In *Cosmoptychius* (Pl. II, fig. 7) and *Rhabdolepis* (Pl. II, fig. 6) it is very narrow and acutely pointed inferiorly; in the latter genus it is also rather small. I rather suspect it has a similar form in *Cheirolepis*, though in that remarkable genus I have never obtained a satisfactory demonstration of its contour. In *Amblypterus* (Pl. II, fig. I) it is rather of a more quadrate form, being less deep and less obliquely placed on the side of the head. Below the inferior margin of the operculum, and overlapped by it, we find in *Palæoniscus* another plate (*i. op.*), of a somewhat quadrate form, but broader behind than in front, the posterior margin being still a little oblique, the inferior one horizontal. A corresponding plate, always more or less square-shaped in aspect, in *Amblypterus*, however, a little higher proportionally, is found in all the genera of *Palæoniscidæ*. At first sight one is inclined to set down this plate unhesitatingly as "suboperculum," and in my own previous essays on fishes of this family I have hitherto lettered it as such, but a recent examination of specimens of the Lower Permian genus *Rhabdolepis* has induced me to take another view of its homologies. In *Rhabdolepis* (Pl. II, fig. 6) there occurs below the narrow and inferiorly acutely pointed operculum, and between it and the quadrate plate (*i. op.*) last under consideration, tending also anteriorly to pass obliquely upwards for a little distance between the operculum and præoperculum (*p. op.*), another plate (*s. op.*), of a horizontally narrower form. An attenuated representative of this additional plate is found also in the beautiful *Cosmoptychius striatus* (Pl. II, fig. 7) of the Wardie shales; here it is triangular, placed above the anterior superior angle of the quadrate plate (*i. op.*), which it thus does not entirely exclude from contact with the operculum; its upper angle is produced into a slender tapering process, which extends upwards for a little distance along the anterior margin of the operculum. Now, it is clear that this plate (*s. op.*) is a part of the opercular apparatus, and as such must either correspond to the *suboperculum* or be considered as additional and supplementary. I have preferred the former alternative, and have lettered it accordingly, though in the vast majority of *Palæoniscidæ* it seems to be either entirely absent or so small as to escape notice. Consequently the quadrate-shaped plate (*i. op.*) which, on the other hand, occurs conspicuously throughout the entire family, must be the equivalent of the *interoperculum*, and, in truth, its relation to the mandible bears out this interpretation, its anterior inferior angle coming close to the articular extremity of the lower jaw; that relation being, however, somewhat concealed externally by the posterior overlapping angle of the maxilla. Covering the hyomandibular and a portion of the cheek in front of the last-described bones is a plate of a peculiar form (*p. op.*), which may best be considered as *præoperculum*. It consists of two portions or "limbs," upper and lower, set at an obtuse angle to each other, the centre of ossification being placed at the point of divergence. The upper part is narrowly triangular; the lower margin, nearly horizontal, is in contact with the maxilla; the upper margin, sloping obliquely downwards and backwards, is in contact with the operculum, and in *Rhabdolepis* and *Cosmoptychius* also with the sub-operculum; the short anterior margin is overlapped by the external suborbitals, while the backwardly directed apex is continuous with the lower limb. The latter, very narrow, passes downwards and slightly backwards between the posterior margin of the maxilla and the interoperculum. The upper limb is especially broad and conspicuous in *Nematoptychius*, *Acrolepis*, and others; it is very narrow in *Cosmoptychius*, while in *Cheirolepis* the lower limb is rather broader than is usually the case. This bone reminds us, in many respects, much more of the large præopercular plate of *Polypterus* than of the bone as we find it in *Teleostei* and in Ganoids of more modern type.

The gill-flap is completed inferiorly and anteriorly by a series of narrow enamelled plates (*br.*), representing the *branchiostegal* rays, the first of which comes on immediately below the interoperculum, the rest succeed placed closely along the margin of the lower jaw and imbricating from behind forwards. In *Palæoniscus* the number of these plates is eight or nine, the anterior one of each lateral series being much broader than the others, and in front of these and behind the symphysis is a median lozenge-shaped plate (Pl. I, fig. 6), obviously the equivalent of the median "jugular" of *Amia* and many fossil Lepidosteoids, such as *Dapedius*, *Eugnathus*, &c. This median plate does not seem, however, to be present in all *Palæoniscidæ*, though obvious in *Palæoniscus*, *Amblypterus*, *Elonichthys*, *Rhabdolepis*, *Gonatodus*. I have seen no trace of it in well-preserved specimens of *Oxygnathus* (Pl. II, fig. 3) and *Cheirolepis*, in which the large anterior plate of each lateral series is also more triangularly oblong in shape than in the genera in which the median plate occurs.[1]

The presence of a narrow *supra-temporal* chain of ossicles behind the posterior margin of the cranial buckler is probable, though not satisfactorily exhibited in any specimen I have had the opportunity of examining. I have, however, observed, what seem to me to be decided traces of their presence in *Palæoniscus*, and in fig. 2, Pl. I, *s. t.*, I have indicated them in dotted lines. The large trigonal plate (*p. t.*) behind the skull on each side so obvious in nearly every well-preserved head, and which certainly does resemble in form and position the large supra-temporal of the recent *Amia*, or of the extinct *Lepidotus* and *Semionotus*, I must refer to the shoulder-girdle, considering it to be a *post-temporal* or "supra-scapular."

The orbit is completely surrounded by a circle of narrow curved ossicles (*s. o.*), apparently four or five in number, and resembling to some extent the circumorbital

[1] In my paper on *Cheirolepis* already quoted, I pointed out that the plates considered by Powrie to be *principal jugulars* were, in fact, the infraclavicular elements of the shoulder-girdle. But, by Dr. Martin (op. cit.) the presence of "Kehlplatten" was accepted not merely for *Cheirolepis* but for *Palæoniscus* also, in which latter genus he has actually figured them. An examination, however, of the original of his fig. 8 shows a very remarkable misinterpretation of the parts exhibited. The specimen lies on its side, not on its back as he evidently supposed, one of his "jugulars" being the broad portion of the *maxilla*, while the other is part of the *præoperculum*. What he has considered to be the right *hyoid* arch is the lower jaw, and I have already referred to the fact that in the same specimen he has mistaken a small portion of the palatal arch for the "sphenoideum."

ossicles of the *Acanthodidæ;* of these the broadest and most conspicuous is that which bounds the orbital opening below and behind, the others are extremely narrow and their number excessively difficult to ascertain. But besides these there is in all *Palæoniscidæ* an outer, or rather posterior, set of suborbitals (*s. o.*), short, irregular, angular plates, placed on the cheek in front of the præoperculum and the broad part of the maxilla. In *Palæoniscus* (Pl. I, figs. 1 and 2) no fewer than five of these may readily be seen behind the narrow circumorbital ring, and these seem to pass above that ring into a set of minute quadrate ossicles between it and the external margin of the cranial buckler in that region. So crushed, however, are all the heads of these fossils, and especially in the region of the orbit, that the investigation of these bones is surrounded with extreme difficulty.[1]

Branchial Apparatus.—Several specimens have occurred yielding evidence of very complete ossification of the branchial skeleton. The best of these is represented in Pl. II, fig. 9; it is the head of a small *Elonichthys* from the limestone of South Queensferry, crushed vertically, and seen from above. The cranium proper is gone, all but its occipital portion, and in consequence a considerable amount of the branchial skeleton is exposed, consisting of the median system of basibranchials from which no less than three of the branchial arches, in the form of slender bony rods, may be seen diverging outwards and backwards. The lines of separation between the probable constituent osseous pieces of the portion of the branchial skeleton here exposed cannot be distinctly made out.

Fig. 8, Pl. II, represents the head of a specimen of *Elonichthys Egertoni*, in which the branchial cavity is exposed in front of the shoulder-girdle, showing portions of three of the branchial arches. In another specimen I have seen evidence of a fourth.

[1] Dr. Martin's representation of the circumorbital plates in his restored figure of the head of *Palæoniscus* (op. cit., fig. A) is altogether erroneous, as is likewise the entire figure.

His supposed discovery in *Palæoniscus* of "ossa intercalaria" similar to those of *Polypterus* is due to a misinterpretation of the specimen figured by him (op. cit., fig. 1). The original of this figure is a cranial shield of *P. Freieslebeni* from Richelsdorf, in which the superethmoidal and anterior frontals are deficient; the frontals also are slightly mutilated at their anterior extremities. Sutures and divisions are here indicated where none exist. His "*occipitals*" and "*parietals*" are both parts of the frontals, the position of the real parietals, obscure enough in this specimen, being overlooked. The anterior of the two so-called "*intercalaria*" is the same portion of bone which he has elsewhere, as in figs. 2 and 3, called "nasal," and which I have designated *post-frontal* in such cases as *Nematoptychius*, &c., where its differentiation from the frontal is distinct; the posterior one is part of the squamosal, the rest of the bone being here marked "*mastoid*," while in fig. 3 the very same plate is in its entirety denominated "*temporal.*"

The Internal Skeleton of the Body.

Owing to the great strength and density of the external scaly covering of the body, it is comparatively seldom that any very good views can be had of the delicate bones of the internal skeleton, which are, in point of fact, in the majority of specimens, totally obscured and covered up. It is also possible that the extent to which the parts of the internal skeleton were ossified differed in different genera, though we may also feel pretty certain that, taking the perished *cartilaginous* portions into account, its type of structure was identical in all.

Vertebral Axis.—The persistence of the notochord in the entire length of the vertebral axis may, I think, be accepted as characteristic of the entire family. The entire absence of vertebral centra in *Palæoniscus* as well as in other extinct forms (*Caturus*, &c.), in which vertebral apophyses might nevertheless be detected, was commented on by Agassiz, who was at first inclined to imagine that the missing centra had been destroyed by some unknown physical force.[1] Only in *Pygopterus* have I seen anything resembling a vertebral *body*. In this genus, in which, partly owing to the comparative thinness and smallness of the scales, the internal skeleton is more completely seen than in any other, a series of nodular-looking ossifications may generally be observed, though much crushed and obscured, extending backwards from the head along the abdominal region of the body in the position of the vertebral axis, and which certainly do remind us of vertebral centra, as which they were considered by Agassiz. That these were completely developed osseous vertebræ like those of Teleostei and certain Ganoids is not probable from their general appearance; it is more likely that they had only attained the stage of "hemi-vertebræ" or at most of "ring-vertebræ," and that in any case the notochord passed on uninterruptedly through them. They cease to be observable in the caudal region, and in no other genus of *Palæoniscidæ* have I seen any trace of similar ossifications.

Nor have I ever seen any trace of *ribs* in any Palæoniscoid Fish; their complete absence, in *Pygopterus* at least, seems to be conclusively proved by a fine specimen from Thickley, Durham, contained in the Edinburgh Museum of Science and Art.

In that specimen of *Pygopterus* a series of neural arches is, however, very distinctly traceable from the head backwards. In the abdominal region of the body these are rather oblong in shape, slightly falcately expanded above, and inclined a little forwards as well as upwards; from each there then proceeds a slender neural spine obliquely backwards and upwards. Anteriorly the contour of these spines is slightly curved, the concavity being directed forwards. The abdominal region of the vertebral column terminates a little in front of the anal fin, and from this point backwards a series of

[1] 'Poissons Fossiles,' vol. ii, pt. 1, pp. 50, 51.

hæmal arches with spines similar to those on the neural aspect of the notochord appears, the semblance of vertebral bodies becoming now speedily lost. The arrangement of the neural and hæmal spines in the region of the caudal fin, or in the caudal body-prolongation, is well shown in a tail of *Nematoptychius Greenockii* in my own collection. Here a series of short bony pieces (neural spines) is seen immediately supporting the row of **V**-scales, the so-called "fulcra," which runs along the ridge of the tail above. On the inferior aspect of this caudal part of the body-axis, separated from the neural spines by a space indicating the position of the notochord, and supporting the rays of the caudal fin, is the series of hæmal spines. Those supporting the lower lobe are of considerable length and stoutness; they get, however, very short as we pass back into the upper lobe of the fin; they are all expanded at their extremities, narrower in the middle, the small ones of the upper lobe particularly tending to assume the hourglass form.

The dorsal and anal fins are supported by well-developed interspinous bones. Those of the *dorsal* are clearly in two series, one above the other; there being first a row of very short ossicles immediately supporting the rays, flattened and expanded at their extremities, constricted in the middle, and diminishing gradually in size from before backwards. They are often very well displayed in specimens of *Rhabdolepis,* contained in the ironstone nodules of Saarbrücken and Lebach, and were described by Agassiz in *R. macropterus.*[1] Supporting these, and intervening between them and the neural spines, is a second or deeper set, considerably longer and more slender in form; their lower extremities do not dip in between the neural spines, but seem simply to meet them. There is no trace of such interspinous bones in front of the dorsal, as is the case in so many other fishes, even in the by no means distantly related *Platysomi.* The interspinous bones of the *anal fin* in *Nematoptychius* and *Pygopterus* are in front long and stout, extending downwards and backwards from the first hæmal spines; they get rapidly shorter and smaller posteriorly, so that an increasing space comes to intervene between them and the last-named spines above, and in *Pygopterus* their direction changes as we proceed backwards, so that the hinder ones come to incline downwards and forwards at an angle to the direction of the rays. I can find no clear evidence of the presence of two sets of interspinous bones in the anal.

The Shoulder-girdle.

Placed immediately behind the cranial buckler, there is, on each side, in *Palæoniscus* (Pl. I, fig. 5) and all the genera of the family, a plate (*p. t.*) of considerable size and somewhat trigonal form, having its angles rounded and its surface gently convex externally, and articulating with the bone *s. cl.* by its horizontal inferior margin. This I am disposed to regard as the *post-temporal* (supra-scapular, Owen), and not merely as a nuchal plate,

[1] 'Poissons Fossiles,' t. ii, pt. 1, p. 35.

though in form and position it does bear some considerable resemblance to the large supra-temporal of each side in such ganoids as *Amia, Lepidotus,* and *Semionotus.* It is succeeded below by a somewhat elongated plate (*s. cl.*) descending obliquely downwards and backwards along the upper part of the posterior margin of the branchial slit, parallel to and generally partially concealed by the hinder margin of the operculum. It is considerably broader above than below; the upper margin, horizontal when the bone is *in sitû,* is oblique to the anterior and posterior margins; the lower extremity is rounded or obtusely pointed. The anterior margin is gently sigmoid, the posterior one shows a slight indentation above the middle, below which the bone becomes rather suddenly narrower, this indentation marking the place where the lateral slime-canal enters from the first scale of the lateral line to tunnel its way obliquely through the plate on its way to the cranial shield. The greater part of the outer surface is ganoid and sculptured, usually with delicate ridges and furrows. Now, this bone obviously corresponds with the plate connecting the clavicle with the posterior part of the cranial shield in *Acipenser* and *Polyodon,* lying also in precisely the same relation to the edge of the branchial slit; that plate in *Acipenser* being denominated "*post-temporal*" by Parker in his treatise on the 'Shoulder-Girdle and Sternum.' But equally obviously does it correspond to the *supra-clavicular* (*scapular,* Owen) of *Polypterus* and of Osseous Fishes. I have therefore lettered it as *supra-clavicular,* being inclined to think that Parker is mistaken in his determination of the corresponding plate in the Sturgeon as post-temporal, and deeming it more probable that the post-temporal is absent in that genus and in *Polyodon.* The supra-clavicular overlaps below the upper extremity of the *clavicle* (*cl.*), a bone about whose homologies there is no room for dispute. This is a very prominent and well-marked bone, which may be described as consisting of two parts, upper and lower. The upper part, somewhat lanceolate in shape and nearly vertical in direction, sloping only a very little downwards and forwards, is slightly folded, so that its outer surface comes to be divided by a nearly perpendicular line into two moieties, the anterior of which looks rather forwards into the branchial cavity, while the other, posterior, looks nearly straight outwards. The lower portion is short and quadrate; it is placed at a considerable angle to the upper part, being reflected inwards on the ventral aspect towards its fellow of the opposite side; between the two portions posteriorly there is a well-marked notch, from which the pectoral fin issues. Connected with the clavicle are two additional pieces. The first of them (*p. cl.*) is found just behind the upper extremity of the clavicle at its junction with the supra-clavicular; it is a small flat plate with nearly straight anterior margin, convex posteriorly, and pointed above and below. This is the equivalent of the similarly placed ossicle in *Acipenser* and *Polyodon,* which is there considered as "supra-clavicular" by Parker; the very same bone, however, as occurring in *Polypterus* and *Calamoichthys* is denominated by him *post-clavicular,* and as such I have marked it in *Palæoniscus,* in accordance with the views above expressed as to the *supra-clavicular* in the Acipenseroids. The other plate (*i. cl.*) in special connection with the clavicle is affixed to the front of its lower extremity, and passes horizontally forwards on the "isthmus." It is acutely triangular in shape, with the apex directed forwards, and is sharply folded longitudinally in a direction continuing forwards the line of flexure between the upper and lower parts of the clavicle, consequently the outer surface of this plate is divided into two portions, one of which looks upwards and a little outwards into the branchial cavity, while the other is seen on the ventral surface of the isthmus, articulating in the mesial line with its fellow of the opposite side, and ordinarily more or less overlapped and concealed by the branchiostegal rays. This is the plate which in *Cheirolepis* was mistaken by Powrie for a principal "jugular." It is, however, most clearly the equivalent of the *infra-clavicular* plate of Gegenbaur (*inter-clavicular*, Parker) occurring in the recent Acipenseroid and Polypteroid fishes in a similar position in relation to the clavicle and to the isthmus.

In all the genera of *Palæoniscidæ* the above-described bones of the shoulder-girdle agree almost perfectly in their respective forms. Owing to its small size, however, the post-clavicular is only observable in especially favorable specimens.

That no trace of scapular or coracoid elements should have become as yet discovered is hardly a matter of astonishment, But in two specimens I have noticed what seems to me to be clear evidence of ossified *radials* supporting the rays of the pectoral fin. One is the left pectoral of an example of *Nematoptychius Greenockii,* in which certain slender ossicles are seen in connection with the origin of the rays; they increase in length from the lateral towards the medial edge of the fin and seem to be rather constricted in the middle, expanded at the extremities. Unfortunately, the specimen is not in very good preservation, so that the contour of these little bones is not so definite as might be wished for. The other specimen is one of *Cosmoptychius striatus,* and in it four such ossicles may be seen; they are proportionately shorter than in the last example, especially at the lateral edge, the one second removed from which is very distinctly marked and is, in hourglass fashion, constricted in the middle.

The Dermal Fin-rays.

In the form, arrangement, and structure of their fins, the resemblance between the *Palæoniscidæ* and the recent Acipenseroids is very marked, and the deviation in these respects from the type of *Lepidosteus* equally striking.

The fins vary considerably in size in the different genera, but not much in shape, being always more or less acuminated. The *dorsal* and *anal* are usually rather triangular in shape from the great length of the anterior rays and the shortness of the posterior ones, the hinder sloping border being gently concave; in *Pygopterus* the posterior short-rayed part of the anal is produced backwards for a little distance after the manner of a fringe. The *caudal* fin is always deeply bifurcate, and more or less inequilobate, the rays, except a few very short and delicate ones at the extreme end of the upper lobe, arising entirely from the lower aspect of the scaled caudal prolongation of the body-axis, which proceeds along its upper margin. The ventrals are placed about half way between the front of the head and the commencement of the caudal; their base is in most cases short, though remarkably long in *Cheirolepis, Cosmoptychius,* and *Oxygnathus.* The *dorsal* fin never occurs in front of the ventrals, being very commonly placed more or less opposite the space between those and the anal (*Palæoniscus, Elonichthys, Rhabdolepis, Amblypterus*); in some cases its anterior rays commence only a little in front of the origin of the anal (*Pygopterus, Nematoptychius, Rhadinichthys*); in *Cycloptychius* it is placed quite opposite the anal, while in *Cheirolepis* its anterior commencement is actually behind that of the last-named fin.

The rays of all the fins are very numerous, and exceed in number the ossicles supporting them, which they also slightly overlap with their pointed proximal extremities. They dichotomise freely, the division being in most cases carried to an extreme degree of fineness. This process commences in the principal rays of each fin, usually towards their extremities; but in the more posterior and delicate rays, and in those composing the whole upper lobe of the caudal, it commences in most cases earlier.

In most of the genera the outer surface of the rays, save at their extreme terminations, is ganoid, in some cases smooth and brilliant, in others marvellously ornamented with delicate ridges and striæ, as in *Acrolepis, Elonichthys,* &c. In *Pygopterus* it seems to me, however, probable that the outer surface of the fin-rays was, as in the recent *Polyodon,* non-ganoid, and covered in the living state by a delicate soft skin.

The fin-rays are very closely set throughout, and in the anterior part of each fin the demi-rays of each side overlap or imbricate over each other from before backwards; this usually ceases to be apparent posteriorly, where the rays are smaller and more delicate, and, from their origin, set side by side. All the rays, also, except in the case of the pectoral, are as far down as their emergence from the scales of the body divided by transverse articulations, whose degree of closeness, usually pretty considerable, varies in different genera and species. As regards the pectoral, in most cases the first ray or the first two or three rays are unarticulated for some distance after their origin, the immense majority of the rays being, as in the other fins, closely articulated throughout (*Palæoniscus, Amblypterus, Nematoptychius,* &c.). But in a few forms (*Pygopterus, Oxygnathus*) the principal rays of the fin are not articulated at all till towards their terminations, when bifurcation also sets in.

The tendency of the demi-rays to imbrication, together with the closeness of the transverse articulations, has often given rise to the idea that the fins, in certain forms at least, were covered with scales. If, for the sake of example, we take such a form as *Acrolepis,* we find that each joint does, in fact, much resemble a scale. Externally it is divided by a vertical line, in front of which there is a broad surface overlapped by the joint in front, and behind this line the surface is free, ganoid, and sculptured. On the internal aspect there is a vertical keel, also resembling the keel on the inner aspect of a scale, and which, when all the joints of a demi-ray are in apposition, forms with its fellows above and below a long ridge, and the groove between two such ridges may have been mistaken by Agassiz for the impression of an internal ray when seen in the entire fin of one of the smaller species, the set of demirays next the observer having been partially removed. The resemblance between the articles of the rays, when seen from the outer surface, and the scales of the body, is sometimes extremely deceptive, especially in some forms of *Amblypterus, e.g. A. lepidurus, A.* (?) *Blainvillii*, which were referred to by Agassiz as examples of *Palæoniscus*, with scaly covering to their fins, while in *Rhabdolepis macropterus* and *Palæoniscus Freieslebeni* he did not consider such a covering to exist. Nevertheless, I see no evidence in any case, that anything is shown on the outside of the fins but the ganoid surfaces of the joints of the rays themselves, as in the fins of the recent *Lepidosteus* and *Polypterus*, in which certainly no scaly covering apart from the rays exists.

The anterior margins of all the fins are in most (if not all) of the *Palæoniscidæ* ornamented with the little pointed imbricating scales, or accessory raylets, known as "fulcra." These follow immediately on the prominent azygous scales seen in front of the fins in most genera, and may frequently be seen to be at first intercalated between the extremities of the first short rays, and, as these elongate, form a more continuous series impinging on the ray at acute angles. Whether these fulcra form a single or double series is a point very difficult to determine accurately, seeing that in almost every case the fin is seen only from the side. If we consider the **V**-shaped scales along the upper margin of the caudal body prolongation to be "fulcra" (though I prefer to class these with the body-scales), they are in this case undoubtedly single, where their form is distinctly seen, save in *Cheirolepis*, where the legs of the **V** are divided at the point of meeting. But as regards the lower lobe of the caudal, and the same would doubtless hold good as to the other fins, they were believed by Müller to be double in *Acrolepis* and *Palæoniscus*, an opinion concurred in by Martin, and which is extremely probable to be the correct one, although I have not myself seen any absolutely clear demonstration of the fact.[1] I cannot, however, see that any very great systematic importance can be attached to the monostichous or distichous arrangement of the fulcra, or, indeed, to their total absence. No fulcra have been observed in *Cosmolepis* or *Thrissonotus*, or any other fins save the caudal; but, though they have been considered to be similarly absent in *Oxygnathus*, I have detected them on both the dorsal and pectoral fins in that genus. In most *Palæoniscidæ* the fulcra are very small; sometimes, as in *Rhabdolepis*, so minute that they can only be made out by very careful examination; they are, however, prominent enough in *Acrolepis*, *Pygopterus*, and *Centrolepis*.

[1] Since the above lines have been in type I have succeeded in finding undoubted evidence of the distichous arrangement of the fulcra in the anal fin of an *Elonichthys* from the north of Ireland.

Scales of the Body.

The scales in the *Palæoniscidæ* are osseous, sometimes pretty thick; their form is rhomboidal.[1] They are arranged (Pl. I, fig. 1, Pl. II, fig. 1) in oblique or slightly sigmoid dorso-ventral rows or bands, which above and below meet their fellows of the opposite side in a **V**-like manner, the point of the **V** being directed forwards on the dorsal, backwards on the ventral median line. The scales forming these bands fall also into longitudinal or lateral series, and in these the upper margin of each scale terminates posteriorly, as seen in the exterior of the body, a little above that of the scale immediately behind. The direction of the dorso-ventral bands of scales continues with slightly increasing obliquity to nearly opposite the bifurcation of the caudal fin, where the tail-pedicle terminates below and behind in a rounded contour opposite the origin of the lower lobe, being, however, above and behind continued into that narrow prolongation of the body-axis which passes along the upper lobe of the fin. Here opposite the lower caudal lobe a sudden change in the arrangement of the scales takes place, those on the sides of the prolongation of the body-axis being now arranged in very oblique rows which proceed downwards and forwards, or upwards and backwards, terminating in the acute and imbricating **V**-shaped scales which run along the upper margin, and through whose intervention they are connected with the corresponding bands of the opposite side. It is interesting to observe that this arrangement corresponds exactly with that of the scales on the caudal prolongation of the body-axis in the living Acipenseroids, and which in *Polyodon* (Pl. VII, fig. 3) are the only scales left on the body; a remnant of the same arrangement is also seen in the semiheterocercal tail of the recent *Lepidosteus* and its Mesozoic allies. Before the change takes place, the last or the two last of the ordinary dorso-ventral bands may very commonly be seen to bifurcate about half way down towards the caudal fin.

If we now take as an example one of the flank scales in *Palæoniscus,* and in the majority of the other genera they are very similarly conformed, the shape is rhomboidal, the upper margin is slightly concave, the lower correspondingly convex; the anterior and posterior margins are straight, the posterior being finely serrated, though that is in some cases plain. The outer surface shows a narrow area along the anterior margin overlapped by the scale in front, this area being very narrow in some genera (*Elonichthys,* &c.), in others rather extensive (*Acrolepis*). The upper margin is likewise slightly bevelled off to allow of the overlapping of the scale next above. The free surface is ganoid and brilliantly polished, and may be quite smooth or, as is more commonly the case, variously

[1] Professor A. Friĉ, of Prague, has recently discovered in the uppermost Carboniferous rocks of Bohemia a new genus of fishes, "die, bei dem Gesammthabitus eines Palæoniscus, mit Cycloiden-Schuppen versehen ist" ('Sitzungsb. der k. böhm. Gesellsch. der Wissenschaften,' März, 1875). This most interesting form has not yet been named or fully described; palæontologists will, therefore, look forward with much interest to the promised publication in full of Professor Friĉ's researches into the vertebrate fauna of the coal-basin of Pilsen and Rakonitz.

ornamented with punctures, furrows, ridges, or even with raised tubercles; the patterns, often of great beauty, are, however, not in every case available for the determination of species. On the inner surface near the middle there is seen a raised keel, parallel with the anterior and posterior margins, and which ends above just in front of the base of the pointed articular spine which projects from the upper margin, and is received in a corresponding pointed depression on the inner surface of the scale above just behind the lower commencement of its own keel. The anterior superior angle of the scale is more or less produced upwards, sometimes considerably so, the produced part being also overlapped partly by the scale in front, partly by that above, so that, with the proper articular spine, there may seem to be two projections from the upper margin, as in *Acrolepis*, *Pygopterus*, &c. In *Nematoptychius* the form of the scales of the flank is very peculiar. They are much higher than broad, the overlapped area is very narrow, the exposed one is indeed rhomboidal, but the acute angles are here the posterior superior and the anterior inferior. The anterior superior angle is not produced into a point distinct from the proper articular spine, which, broad, flat, and triangular, here arises from the whole or nearly the whole of the upper margin of the scale. On the under surface of the scale the keel is obsolete, but the usual socket for the spine of the scale next below is seen at the inferior margin. Some approximation in general form is here shown to the form of scale characteristic of the *Platysomidæ*, excepting of course the want of the strong rib on the inferior surface of the anterior margin found in that family. The scales of *Centrolepis* have also a very similar form, but are not so high proportionally.

But the most aberrant condition of the squamation in the entire family is that of *Cheirolepis*, and which led to considerable error as to the systematic position of the genus, before the osteology of its head was specially studied. The scales are here extremely minute, quadrangular, thick in proportion to their small size, and the amount of overlap is so small as to be hardly perceptible, so that the squamation reminds us of the shagreen-like covering of the *Acanthodei* with which *Cheirolepis* was for a long time classed. These minute scales are, however, most markedly arranged in oblique dorso-ventral bands, which, on the caudal body-prolongation, undergo a change of direction exactly as in other *Palæoniscidæ*. The outer surface is ganoid and marked with diagonal striæ, the inner one shows a well-marked keel parallel with the anterior and posterior margins, but which is not prolonged upwards into an articular spine; this keel was, in my opinion, mistaken by Agassiz in *C. Traillii* for an ornament of the *outer* surface.

Returning now to the scales of the more typical genera of *Palæoniscidæ* (*Palæoniscus*, *Elonichthys*, &c.), we find that these vary somewhat in form on different parts of the body. On the side of the flank they are usually higher than broad, but above, below, and towards the tail they get more equilateral; on the ventral aspect, indeed, they usually become very low and narrow, the anterior superior angle becoming more prolonged and overlapped, the articular spine less marked or totally lost; the latter also disappears, though the keel endures, on the scales of the tail-pedicle. Towards the tail the scales become also more acutely rhomboidal, and on the sides of the caudal body-prolongation they are very acutely lozenge-shaped. Along the middle of the back is a row of azygous scales; these for a considerable distance behind the head are of small size, and placed one at the point of convergence of each pair of right and left dorso-ventral scale bands. In most genera, as the dorsal fin is approached, these median scales become larger and imbricate more deeply, becoming first oval, then acutely pointed posteriorly, while the last seems to rise up a little on the front of the origin of the dorsal fin. In like manner behind the dorsal fin the median scales soon become large, oval, and imbricating; and as they proceed backwards on the dorsal margin of the caudal body-prolongation, they become very acutely pointed posteriorly, and anteriorly deeply notched so as to assume the form of a **V**. These **V** scales are the so-called fulcra of the upper lobe of the tail, and are prominent throughout the entire family; in most cases they seem to be simple (monostichous), and correspond closely with the similar structures seen in *Polyodon* (Pl. VII, fig. 3) and *Acipenser*. In *Cheirolepis*, however, they seem to become double by the splitting at the apex of the two legs of the **V**. A few large pointed and imbricating median scales are also seen in front of the origin of the lower lobe of the caudal.

Between the ventral and anal fins a peculiar arrangement of scales is seen in many genera apparently in connection with the orifice of the vent. In *Elonichthys*, for instance, we find behind the ventrals a large median lozenge-shaped plate or shield, flexed upwards to either side along its median line. Behind this, and overlapping its posterior extremity, there is on each side a right and left lateral plate of an oval form, not quite so large as the median one, and between these two the anal orifice was evidently placed.

Lateral Line System.—The system of "slime-canals" was doubtless well-developed on the head, though only the right and left main branches can be distinctly traced for any distance. These are shown in *Nematoptychius* (Pl. I, fig. 7) traversing longitudinally the parietal, frontal, and anterior frontal bones, and also less distinctly in *Palæoniscus* (Pl. I, fig. 3). Posteriorly the lateral canal passes obliquely through the upper part of the supra-clavicular (Pl. I, fig. 5), then enters the series of scales of the lateral line, each of which it tunnels through, manifesting its presence externally by a slight longitudinal elevation, on which from time to time a small pore, like a little vertical slit, may be observed. The lateral line proceeds backwards to the base of the caudal fin, near its bifurcation, and does not, as has been correctly pointed out by Martin (*op. cit.*), pass along the middle of the caudal body-prolongation, as in the restored figures of Agassiz and Lütken. Whether or not it proceeds further along the lower margin of that prolongation towards the extremity of the upper caudal lobe, as it does in *Polyodon*, is not clearly shown in any specimen I have seen.

Dentition.

Teeth occur in all the genera on the dentary bone of the mandible, on the maxilla, and, in *Nematoptychius* at least, they are distinctly seen on the premaxilla, so that their occurrence on that little bone may be taken for granted also as regards other forms, though, owing to the crushed condition of the head, the premaxilla is rarely recognisable. They are frequently observable also on the splenial bone (*Palæoniscus*), and on the palate (*Amblypterus*), though here again, for obvious reasons, it is impossible in the meanwhile to obtain accurate information regarding all the members of the family.

The teeth are in almost every instance slender, conical in shape, round in transverse section, acutely pointed, more or less incurved towards the apex, and furnished with a glistening enamel cap which is frequently very distinctly marked off externally. Below the enamel cap the surface is smooth, or may be ornamented with delicate striæ, or with minute longitudinal indentations; very rarely is there any indication of plication at the base. The latter occurs, however, very distinctly in *Saurichthys,* a genus whose reception into the *Palæoniscidæ* has been suggested by Martin, the teeth showing in other respects a marked correspondence with those of *Pygopterus* and *Acrolepis.* Microscopically the teeth are distinguished by the possession of a very spacious simple pulp-cavity at the base, which cavity becomes very rapidly attenuated into a narrow tube as it passes upwards through the tooth; the dentine, displaying very numerous fine tubules radiating from the central cavity or canal to the periphery, is surmounted at the apex by a hollow-conical cap of structureless enamel. From this enamel cap there extends downwards over the whole exterior of the tooth, excepting the very base, an exceedingly thin and delicate structureless film or continuation of the same substance. Such is, at least, the microscopic structure of the teeth of *Nematoptychius Greenockii,* the only species which I have myself investigated in this manner; it is in complete accordance with the figure given by Agassiz of the structure of the teeth in *Pygopterus,*[1] and the description by Messrs. Hancock and Atthey of those in *Elonichthys Egertoni.*[2]

The form and arrangement of the teeth have given rise to a considerable amount of confusion in the classification of these fishes. By Agassiz the teeth in *Palæoniscus* and *Amblypterus* were stated to be "*en brosse,*" and this seems to have been the principal reason why he disjoined these genera as "Lepidoids" from their natural allies *Pygopterus* and *Acrolepis,* which, from their possession of conspicuous laniaries, he placed among the "Sauroids."

In *Palæoniscus* proper (*e. g., P. comptus, Freieslebeni,* &c.) the teeth are very small, being only with difficulty and in favorable specimens observable at all; they are closely set in the maxilla and dentary of the mandible, those more internally placed being larger than

1 Poissons Foss., 'Atlas,' vol. ii, tab. H, fig. 1.

2 'Ann. and Mag. Nat. Hist.' (4), i, p. 358, pl. xvi, figs. 1 and 2.

those more external; minute teeth are also seen on the edge of the splenial. Though hardly "en brosse," the appearance of the teeth (Pl. I, figs. 3, 4, and 12) sufficiently accounts for Agassiz's use of that expression in characterising the genus; unfortunately, however, he included in *Palæoniscus* several Carboniferous forms in which more pronounced laniaries are conspicuously present. In like manner the smooth-scaled species of his genus *Amblypterus* (*A. latus*, *lateralis*), to which the name has been very properly restricted by Troschel, possess very minute, slender teeth, showing no trace of interspersed laniaries, and much more than in *Palæoniscus* meriting the title of "*en brosse.*" But in *Rhabdolepis*, Troschel (*e. g.*, *R. macropterus* = *Amblypterus macropterus*, Agassiz), in *Elonichthys*, Giebel, including several species referred to *Palæoniscus* by Agassiz (*E. Egertoni*, *striolatus*, *Robisoni*), in *Acrolepis*, *Nematoptychius*, *Cycloptychius*, *Rhadinichthys*, *Oxygnathus*, *Pygopterus*, &c., there exists a set of strong and powerful conical or laniary teeth placed in a row internal to an outer series of closely and somewhat irregularly placed smaller ones, with which they appear to some extent interspersed. In *Cheirolepis* the larger teeth, proportionately not so large as in some other genera, are placed in a close and even row along the margin of the jaw, while external to them is a series of numerous and more irregularly placed teeth of very minute dimensions. In *Cosmoptychius striatus* (*Amblypterus striatus*, Agass.) the dentition resembles that of *Cheirolepis* in that the laniaries are of no great size and placed tolerably closely, but outside them we still find a distinct outer series of half the size of the others or less. In the immense majority of *Palæoniscidæ*, then, the arrangement of the teeth displays the character laid down by Agassiz as distinctive of the "Sauroïdes" and "Célacanthes." And in point of fact it is clear enough that the only difference in dentition between *Palæoniscus* and such a form as *Pygopterus* is, that in the latter certain teeth occupying a certain position in the jaw are more largely developed—a difference it may be of generic, but hardly of family, importance.

In some forms, however, the dentition is a little peculiar. In *Gonatodus punctatus* (*Amblypterus punctatus*, Agassiz) the teeth are in one row, closely set, of moderate and uniform size, and with no trace, as far as can be seen, either of larger teeth internal, or of smaller ones external to them. Each tooth is first bent outwards at an obtuse angle, the apex being then sharply curved so as to point upwards. This unusual form of tooth was first described by Mr. R. Walker in a fish from the Fifeshire Calciferous Sandstone series, to which he gave the name of *Amblypterus anconoæchmodus*.[1] In the lower jaw he described the teeth as being placed alternately, one close to the outside margin, the one next to it being "fully half its own thickness further in, and so on the whole length of the bone." And in the curious little fish from North Staffordshire for which I propose the name of *Microconodus Molyneuxi*, the teeth are also apparently in one row, of uniform size, and bluntly conical, though not showing the peculiar flexures of *Gonatodus*.

[1] "On a new species of *Amblypterus*, and other fossil Fish Remains from Pitcorthie, Fife," 'Trans. Edinb. Geol. Soc.,' vol. ii, pt. i (1872), pp. 119—124.

II.—THE SYSTEMATIC POSITION OF THE PALÆONISCIDÆ.

The order of Ganoid Fishes instituted by Agassiz included, in his system of classification, the following families :—1. *Lepidoïdes ;* 2. *Sauroïdes ;* 3. *Célacanthes ;* 4. *Pycnodontes ;* 5. *Dipteriens ;* 6. *Acanthodiens ;* 7. *Cephalaspides ;* 8. *Acipenserides ;* 9. *Sclerodermes ;* 10. *Gymnodontes ;* 11. *Lophobranches ;* 12. *Siluroïdes.* We have already seen that the genera of *Palæoniscidæ* known to him were distributed in three of these families, viz. the *Lepidoïdes, Sauroïdes,* and *Acanthodiens,* on account of characters which subsequent researches have shown to be either superficial or, in other cases, untenable.

The anatomical researches of Johannes Müller[1] into the structure of the recent Ganoids resulted in his detaching from them the Scleroderms, Gymnodonts, Lophobranchs, and Siluroids, the rest being divided into two great groups or sub-orders, as below.

I. *Holostei.*—Vertebral column osseous.
Family 1. Lepidosteini.
2. Polypterini.

II. *Chondrostei.*—Skeleton partially cartilaginous ; the vertebral column consisting of a soft *chorda* instead of vertebral bodies.
Family 3. Acipenserini.
4. Spatulariæ.

Of the fossil Ganoids Müller stated that they have in their squamation more resemblance to the living Holostei than to the Sturgeons, and that he considered the separation of the families of *Lepidoids* and *Sauroids* as artificial. He did not, however, attempt definitely to remodel the classification of the fossil Ganoids, though he stated his opinion that characters of prime importance were to be found in the condition of ossification of the vertebral column, the presence or absence of fulcra on the fin-margins, and whether these fulcra, when present, were in single or double series.

Almost immediately after, in fact during, the publication of Müller's researches, the recent *Amia* was shown by Carl Vogt also to possess anatomical characters which demanded for it a position among the Ganoids.[2] The place of the *Amiadæ* in Müller's classification would, of course, be with the Holostei.

In the classification of fossil fishes proposed by Giebel in 1848,[3] Müller's great divi-

1 'Ueber den Bau und die Grenzen der Ganoiden, und über das natürliche System der Fische,' Berlin, 1846 (read before the Berlin Academy of Sciences in December, 1844).

2 "Quelques Observations sur les caractères qui servent à la classification des Ganoïdes," 'Annales des Sciences Naturelles,' 3 sér., t. iv, 1845, pp. 53—68.

3 'Fauna der Vorwelt,' vol. i, pt. 3, Leipzig, 1848.

sions of *Holostei* and *Chondrostei* were adhered to, and *Palæoniscus*, and its allies *Amblypterus*, *Elonichthys*, *Pygopterus*, *Acrolepis*, and *Cheirolepis*, were very properly brought together in one family, that of the *Heterocerci monopterygii*, which was placed in the order *Holostei*. Unfortunately this family still contained a number of heterogeneous elements, for, in addition to such forms as *Platysomus* and *Eurynotus*, several other genera (*Eugnathus*, *Conodus*, *Megalichthys*), still further removed from the *Palæoniscidæ*, are introduced.

In 1852 Vogt published a classification of the Ganoids[1] having some points of interest.

Sub-order Loricata . .	Family Cephalaspida.	
	Acipenserida.	
	Spatularida.	
Sub-order Rhombifera .	Acanthodida.	
	Polypterida.	
	Dipterida.	
	Monosticha	Sub-family Palæoniscidæ.
		Dapedidæ.
	Disticha	
	Pycnodontida.	
Sub-order Cyclifera . .	Holoptychida.	
	Cœlacanthida.	
	Amida.	

Here the Palæoniscoid fishes are included along with the Dapedii in the family Monosticha of the sub-order Rhombifera; and in this classification we find the term *Palæoniscidæ* (Palæonisciden) used for the first time, though only to indicate a sub-family in which were also included *Platysomus* and *Eurynotus*. Unnatural as was the association of these fishes in one "family" with the *Dapedii*, we must, nevertheless, consider the institution of the term "*Palæoniscidæ*" to be a step in advance, though the *Platysomids* might also with advantage have been excluded. In Mr. Dallas's 'Handbook of the Animal Kingdom' we find the term "*Palæoniscidæ*" raised to one of family importance.

The classification employed by Pictet in the second edition of his 'Traité de Paléontologie' (Paris, 1854) is in the main very similar to that of Vogt; the *Hoplopleuridæ* being, however, added as a distinct primary division of the Ganoids. Among the *Rhombifera* the family of *Lepidosteidæ* is constituted to include both the Monisticha and Disticha of Vogt, and in the subdivision of this assemblage into "tribes" the *Palæoniscidæ* are again unmercifully broken up, as may be seen below:

2e. Famille Lepidostéïdes.

1re Tribu. Lepidostéïdes homocerques à mâchoires prolongées (*Aspidorhynchus*, *Belonostomus*, *Prionolepis*).

[1] 'Zoologische Briefe,' vol. ii, Frankfurt, 1852.

2e Tribu. Lepidostéïdes homocerques à bouche et écailles normales, à dents en brosse ou obtuses (*Lepidotus, Pholidophorus, Centrolepis,*† &c.).

3e Tribu. Lepidostéïdes à bouche et ecailles normales et à dents crochues et isolées (*Lepidosteus, Caturus, Eugnathus, Thrissonotus,*† &c.).

4e Tribu. Lepidostéïdes heterocerques à dents coniques isolées (*Saurichthys, Megalichthys, Pygopterus,*† *Acrolepis* †).

5e Tribu. Lepidostéïdes heterocerques à dents en brosse ou obtuses (*Amblypterus,*† *Eurynotus, Elonichthys,*† *Palæoniscus,*† *Urosthenes,*† *Catopterus*).[1]

Cheirolepis remains an *Acanthodian.*

The subdivisions of the order Ganoidei proposed by Professor Huxley in his celebrated 'Essay on the Systematic Arrangement of the Fishes of the Devonian Epoch,' which was issued in 1861, are as below:

I. *Amiadæ.*
II. *Lepidosteidæ.*
III. *Crossopterygidæ.*
IV. *Chondrosteidæ.*
V. *Acanthodidæ.*

As regards the second sub-order, the *Lepidosteidæ,* only the following provisional sketch of an arrangement was given:[2]

"Lepidosteidæ. Heterocercal Ganoid with rhomboidal scales, branchiostegal rays, non-lobate paired fins, a preoperculum and an interoperculum.

"Fam. 1. Lepidosteini. "Maxilla divided into many pieces, branchiostegal rays few and not enamelled.

"*Lepidosteus.*

"Fam. 2. Lepidotini. "Maxilla in one piece; branchiostegal rays many and enamelled, the anterior ones taking the form of broad plates.

"(*a*). *Æchmodus, Tetragonolepis, Dapedius, Lepidotus,* &c.

"(*b*). *Eugnathus, Pachycormus, Oxygnathus,* &c.

"(*c*). *Aspidorhynchus.*

"Perhaps the genera marked *a, b, c* should form distinct sub-families."

Palæoniscus is not here specially referred to, but in sub-family *b* of the family Lepidotini *Oxygnathus,* a prominent member of the *Palæoniscidæ,* is placed along with the rather dissimilar genera *Eugnathus* and *Pachycormus.* At the end of the essay, how-

1 Those genera in the above list, to which a † is appended, are included in the family of *Palæoniscidæ,* as described and defined in the present work.

2 'Dec. Geol. Survey,' x (1861), p. 28, *footnote.*

ever, in discussing the affinities of *Cheirolepis,* Professor Huxley alludes to its resemblance to *Palæoniscus,* which he considered as a form connecting it "with that large body of fossil fishes which have more or less direct relations with Lepidosteus." *Cheirolepis,* though still retained as the type of a special family as proposed by H. Miller and by Pander, was therefore referred by Professor Huxley, though with a little doubt, to the sub-order Lepidosteidæ.

In the paper "On the Affinities of Platysomus and Allied Genera," in which Professor Young proposed to institute a new sub-order of Ganoids, that of the "*Lepidopleuridæ,*" to include the Pycnodonts and Platysomids, reference is made to the position of *Amblypterus* as being "among the *Lepidosteidæ,* not far from *Oxygnathus,*" as shown by its cranial anatomy and dentitional characters.[1]

By Dr. Lütken the Ganoidei are classed as follows, merely as part of the Teleostei or Bony Fishes:[2]

A. Bony Fishes with free gills (*Teleostei*).

1. Without air-duct (Acanthopterygii), (*Physoclysti,* s. *Acanthopteri*).
2. With air-duct (*Physostomi,* s. *Malacopteri*).

 α. *Typici.*

 β. *Ganoidei.*

  a. Lepidosteini (or *Euganoidei*) { Heterocerci—*Palæoniscus, Cheirolepis,* &c.
Homocerci—*Lepidosteus, Lepidotus,* &c. }

  b. Pycnodontes.

  c. Crossopteri.

 γ. *Sturiones.*

Dr. Martin also places the *Palæoniscidæ* with the *Lepidosteidæ* or "Euganoidei," the latter term having been first proposed by Lütken. Of the other "Euganoidei" he considers *Pholidophorus* to bear the most resemblance to *Palæoniscus.* The genera, which he includes in the family *Palæoniscidæ,* are:—*Palæoniscus, Acrolepis, Amblypterus, Pygopterus, Saurichthys* (= ? *Gyrolepis*), ? *Cheirolepis.*

Professor J. V. Carus[3] has recently adopted the following classification of the Ganoidei into sub-orders:—1, *Teleosteoidei* (including *Amia, Leptolepis, Megalurus, Caturus*); 2, *Hoplopleuridæ;* 3, *Lepidosteidei;* 4, *Lepidopleuridæ;* 5, *Crossopterygii;* 6, *Chondrostei;* 7, *Acanthodidæ;* 8, *Phractosomata* (= *Placodermi* + *Cephalaspida*).

The *Palæoniscidæ* find their place among the Lepidosteidei in the following manner:

[1] 'Quart. Journ. Geol. Soc.,' August, 1866, p. 315.

[2] Op. cit., German edition, pp. 45 and 47.

[3] 'Handbuch der Zoologie,' von J. Victor Carus und C. E. A. Gerstaecker,' Bd. i, 2te Hälfte, Leipzig, 1875.

Sub-order—*Lepidosteidei*, Huxley.

Family I. *Lepidosteini*, Huxley (*Lepidosteus*).
II. *Lepidotini*, Huxley.

† Homocercal Forms.

Sub-family 1. *Sauroidei* (Ag.), A. Wagner (*Pholidophorus, Eugnathus*, &c.).
2. *Stylodontes*, A. Wagner (*Tetragonolepis, Dapedius*, &c.).
3. *Sphærodontes*, A. Wagner (*Lepidotus, Plesiodus*, &c.).
4. *Aspidorhynchi*, A. Wagner (*Aspidorhynchus, Belonostomus*, &c.).

† † Heterocercal Forms.

Sub-family 5. *Palæoniscini*, Vogt (*Amblypterus, Palæoniscus*, &c.).

Family III. *Cheirolepidini*, Pander (*Cheirolepis*).

It must at once strike the zoologist who is at all practically acquainted with the structure of these fossil forms, that the association of the Palæoniscoid Fishes in one "family" with such genera as *Lepidotus, Eugnathus*, and *Aspidorynchus* is rather at variance with the usually received ideas of the limits of "family" comprehensiveness in other divisions of the class Pisces, or of the animal kingdom in general. Not only so, but *Cheirolepis*, whose resemblances to other *Palæoniscidæ* are perfectly plain and obvious, remains as the type of a distinct family, equivalent to the whole assemblage of "Lepidotini," in which its natural allies are placed as a mere "sub-family." The affinities of the Liassic *Palæoniscidæ* are still unrecognised, *Oxygnathus, Cosmolepis, Thrissonotus*, and *Centrolepis* being placed in the sub-family "Sauroidei," while the imperfectly heterocercal genus *Catopterus* is associated with *Palæoniscus*.

From the preceding sketch of the history of the classification of the *Palæoniscidæ* it is pretty clear that at present the generally received opinion is that the Palæoniscoid Fishes belong to the Lepidosteoid series or sub-order. We may now inquire how far that conclusion is in accordance with the details of their structure brought out in the preceding part of this essay.

First, however, it is necessary to lay down with some degree of conciseness the leading characters, however few, of that series of fishes to which we give the name of *Lepidosteidæ*, or, as I think is preferable, *Lepidosteoidei*. Now, though *Lepidosteus* itself is rather aberrant in the form of its vertebral centre, and of its præoperculum, in the composite character of its maxilla, and in the small number of its non-enamelled branchiostegal rays, yet its relationship to a large series of fossil forms is, as regards more general characters, sufficiently evident to justify our placing them together in one category, though the complete working-out of the group is one of several tasks which fossil ichthyology has still before her. As examples of Lepidosteoids may be quoted *Ischypterus, Lepidotus, Dapedius, Semionotus, Pholidophorus, Heterolepidotus, Eugnathus, Pachycormus,* &c. All these fishes have, save in their angular enamelled scales, a most remarkably " modern " or Teleostean-like aspect. The tail is only imperfectly heterocercal (that of *Ischypterus* being the most heterocercal of the series; the rays of the dorsal and anal fins do not exceed in number the interspinous bones supporting them; there are well-developed ribs; the shoulder-girdle has no infraclaviculars in front of the lower end of the clavicle; the opercular bones are conformed as in Teleostei, the præoperculum not tending to extend forwards on the cheek and having below its lower limb an interoperculum of the usual shape.

On the other hand, in the *Palæoniscidæ,* the tail is completely heterocercal; the rays of the dorsal and anal fins greatly exceed in number the interspinous bones supporting them; there are no ribs; the shoulder-girdle has prominent infraclaviculars in front of the lower extremity of the clavicle; the præoperculum tends to extend on to the cheek, while the interoperculum, if really present, is most abnormal in form and simulates a suboperculum.

If we now compare *Palæoniscus* with the living Ganoids we shall perhaps be a little astonished to find that its affinities, as indicated by the skeleton, point most strongly not to *Lepidosteus,* to which its angular scales and fulcrated fins give it a superficial resemblance, *but to Polyodon.* In many points the resemblance is indeed so striking, that if we could only clothe the sides of our *Polyodon* with rhombic scales and cut off its long snout, it could not possibly occur to any one to class them in different groups.

Polyodon is not, however, entirely without scales; and those which it does possess, viz. the patch of acutely lozenge-shaped scales along the side of the caudal body-prolongation, with the series of **V** scales, or " fulcra " above (Pl. VII, fig. 3), are identical in form and arrangement with those occurring in the same place in *Palæoniscus.* The internal skeleton is in both constituted in a very similar type; the notochord is persistent, there are no ribs, the skeletal arrangements in the caudal region seem identical; the rays of the dorsal and anal fins are much more numerous than their supporting interspinous bones. The dorsal and anal fins of *Polyodon* have each two sets of interspinous bones to support them; this is also the case, at least, with the dorsal of *Palæoniscus.* The bones of the shoulder-girdle are conformed on the very same type in both, save that the prominent post-temporal of *Palæoniscus* seems to be wanting in *Polyodon,* whose supra-clavicular is consequently attached above to the largely developed squamosal. In neither is the operculum attached to the hyomandibular by a joint, but secured in its place only by skin and muscles. The styliform hyomandibular of *Polyodon* even excels that of *Palæoniscus* in the strange obliquity of its direction, and consequently the gape shows the same enormous width and backward extent; the eye, too, occupies the same remarkably anterior position with regard to the mouth (Pl. VII, fig. 1). The snout of *Palæoniscus* is not, indeed, developed into the enormous appendage we find in *Polyodon;* nevertheless it does form rather a prominent projection over the mouth. I have already alluded to the remarkable similarity in the form of the palato-quadrate apparatus in *Palæoniscus* and in *Polyodon,* and to the fact that the levator muscle of the lower jaw must have pursued exactly the same strange course in the former as in the latter.

The opercular and branchiostegal apparatus is indeed feebly developed in *Polyodon,* and even more so in *Acipenser,* though the latter has a cranial shield of closely fitting ganoid plates. But here a connecting link is seen in *Chondrosteus,* in which, though the squamation of the body is apparently in the same condition as in *Polyodon,* we have nevertheless a well-developed opercular apparatus and a set of branchiostegal rays in the form of strong, imbricating, osseous plates. The cranial buckler of *Chondrosteus* also consists of strong closely fitting plates, as in the sturgeon.[1]

The resemblances between *Palæoniscus* and *Acipenser* are of course much less prominent. But it seems impossible to avoid the conclusion that *Palæoniscus* must accompany *Polyodon* in whatsoever group the latter is placed, and that therefore the *Palæoniscidæ* must be accepted, not as a family of the Lepidosteid, but of the Acipenseroid series. For certainly they belong neither to the Crossopterygii nor to the Amioidei: and the reasons supposed to indicate for them a place among the Lepidosteoidei may be disposed of as follows. The *Palæoniscidæ* have rhombic scales as in the Lepidosteoids, but rhombic scales are also found in *Polyodon,* though confined to a very limited portion of the body; the form of the scales can also hardly be taken as a subordinal characteristic, seeing that in such closely allied Crossopterygians as *Megalichthys* and *Rhizodus* the scales are in the former rhomboidal, in the latter cycloidal. The fins are fulcrated, but in some *Palæoniscidæ* (*Thrissonotus, Cosmolepis*) fulcra have not been discovered on any of the fins save the caudal, and they are, though exceptional in form, undoubtedly present in some Crossopterygii (*Gyroptychius, Osteolepis*). The paired fins are non-lobate, so are they also in the Acipenseroids and in the Teleostei. But in my opinion outweighing these resemblances with the Lepidosteoids, the *Palæoniscidæ* have, in common with the Acipenseroids, the completely heterocercal tail, the excess in number of the rays of the median fins over their supporting ossicles, the well-developed infraclavicular elements in the shoulder-girdle. The opercular and branchiostegal apparatus resembles that of *Chondrosteus* as much as that of the Lepidosteoids. It is true that these characters of the tail, of the fin-rays, and of the infraclaviculars, occur also (especially the two latter) in the Crossopterygii; but from this group the *Palæoniscidæ* are widely separated by the structure of the paired fins, and the replacement of the jugular plates by imbricating branchiostegal rays.

Are the *Palæoniscidæ,* however, the only group of fossil fishes which it is advisable to transfer to the *Acipenseroidei?* There is one other curious series of extinct fishes, which have been sometimes grouped along with the *Palæoniscidæ,* at other times removed from them, the details of whose structure I hope to treat of in another part of this work,

[1] See the description of *Chondrosteus* by Sir Philip Grey Egerton, 'Phil. Trans.,' 1858.

but concerning which I may at present express my conviction that they must accompany the *Palæoniscidæ* wherever the latter are placed.

The genera *Eurynotus*, *Mesolepis*, *Eurysomus*, *Platysomus*, *Amphicentrum*, and *Wardichthys*, though differing most remarkably among themselves in the form of their dental apparatus, nevertheless, in general structural characters, form a well-marked group or "Formen-Reihe." They are closely allied to the *Palæoniscidæ* in their completely heterocercal tail; in the structure of their fins, which are fulcrated, composed of numerous closely set rays, exceeding in number their supporting ossicles, and whose lateral halves or demi-rays imbricate in the fore part of the fin; the dorsal is also supported by two sets of interspinous bones. The opercular bones and branchiostegal rays are constructed on exactly the same type as in the *Palæoniscidæ*, though the mouth is smaller, from the more vertical direction of the hyomandibular, which in *Platysomus* slopes even a little forwards. The shoulder-girdle is like that in the *Palæoniscidæ*, and possesses infraclaviculars. The bones of the cranial roof are very like those of *Palæoniscus*, at least posteriorly, those about the snout (which does not project over the mouth) seem to differ a little, though here our information is not sufficiently perfect. The scales of *Eurynotus* are similarly shaped with those of the *Palæoniscidæ*, so is its anal fin, though the dorsal has already assumed the peculiar extended contour characteristic of its more immediate allies. The peculiar shape of the scales of the other genera, which are high and narrow, and have their internal rib and articular spine of unusual strength, and coincident with the anterior margin, does not seem to me to be a character of prime importance. I cannot, therefore, agree with Professor Young in associating the Platysomid fishes in one "sub-order" with the Pycnodonts, with which they have nothing in common save the deep form of the body, the persistence of the notochord, and the mode of articulation of the scales—the latter being a character which does not hold in *Eurynotus*, and is also found in the Lepidosteid *Tetragonolepis*. I shall pursue this subject further in a future part of the present work; meanwhile, however, I feel convinced that the sub-order of "Lepidopleuridæ" must be abandoned, that the *Platysomidæ* must accompany the *Palæoniscidæ*, and that the position of the Pycnodonts, or even whether they are Ganoids at all, as doubted by Professor Huxley, has yet to be determined.

According to the views here expressed the position of the *Palæoniscidæ* would be as below:

Order Ganoidei.

Sub-order I. Dipnoi.
II. Crossopterygii.
III. Acipenseroidei (see p. 8).

Family 1. *Acipenseridæ*.
2. *Spatularidæ*.

3. *Chondrosteidæ.*
4. *Palæoniscidæ* (see p. 11).
5. *Platysomidæ.*

IV. Lepidosteoidei.
V. Amioidei.

Though the characters assigned to the *Acipenseroidei,* at p. 8 of the Introduction, may seem to be few and insufficient, it must be remembered that the more our knowledge of series of forms advances, the more difficult does it become to define great groups sharply from each other, and to find characters which shall be invariably applicable to all the members of one division, and at the same time absolutely separate them from those of another. The idea of such strictly defined groups belongs in fact to that period of zoological history when the evidences of evolution had not yet began to press themselves on the minds of investigators. It seems to me that the recent *Acipenser* and *Polyodon* are the surviving members of a series of Ganoid Fishes which in earlier days sent out the families of *Palæoniscidæ* and *Platysomidæ,* more highly developed as regards the hard parts of their skeleton, but which have long since become extinct. Whether or not the long array of Lepidosteoid forms owes its origin to this series is still matter for laborious investigation.

DESCRIPTION OF THE GENERA AND SPECIES OCCURRING IN BRITISH CARBONIFEROUS ROCKS.

Genus—Cosmoptychius, *Traquair,* 1877.

Amblypterus (pars), *Agassiz.*

The body is fusiform, rather deep; the scales are large and obliquely striated. The fins are well developed; their rays are numerous, ganoid, and finely striated, the fulcra are small. The rays of the pectoral are articulated throughout, except just at the commencement of a few of the first rays at the lateral margin of the fin. The base of the ventrals is extended, as in *Cheirolepis;* the dorsal is situated nearly opposite the interval between the ventrals and the anal; the caudal is powerful and inequilobate. The suspensorium is very oblique, and the gape is consequently of very great extent; the operculum is narrow and pointed, a small subopercular plate being interpolated between it and the anterior part of the upper margin of the interoperculum; the branchiostegal rays are numerous, and there is a median plate behind the symphysis of the jaw. The dentition of the jaws consists of a row of laniary teeth, conical, sharp, moderate in size and pretty closely set, external to which is a series of still smaller teeth.

I have instituted this genus for the beautiful fish, from the Wardie Shales, first described by Agassiz as *Amblypterus striatus*. In general aspect it approaches the next genus, *Elonichthys;* but the peculiarly extended base of the ventral fin, as well as the structure of the opercular apparatus, afford perfectly valid marks of distinction. As I am as yet with certainty acquainted only with one species, an enumeration of the generic characters more minute than that given above is not required.

Cosmoptychius striatus, *Agassiz*, sp. Pl. III, figs. 1, 2, 3, 4, 5, 6, 7, 8.

Amblypterus striatus, *Agass.* Poissons Foss., vol. 2, pt. 1, p. 111; Atlas, vol. 2, tab. iv *b*, figs. 3, 4, 5, and 6, 1835.
— — *Paterson.* Edin. New Philos. Journ., vol. xxiii, p. 153, 1837.
— — *Morris.* Catalogue of British Fossils, p. 317, 1854.

Description. The length of the head is contained five times in the total, four times up to the bifurcation of the caudal fin; the greatest depth of the body is contained three times from the last-mentioned point to the tip of the snout. The general form of the fish, though rather deep, is not inelegant, as may be seen from the specimen represented in Pl. I, fig. 1, the most perfect I have ever seen, though the scales of the tail-pedicle are broken up and have almost completely disappeared. It measures $10\frac{1}{4}$ inches in length by $2\frac{3}{4}$ in depth at the origin of the ventral fins, and most of the specimens seen in collections, usually fragments, entire specimens being very rare, indicate fishes of about that size, though remains of smaller and younger individuals are also not uncommonly met with. The bones of the cranium proper are too much crushed for description; in Pl. III, fig. 2, the snout is seen to project over the mouth in a rounded prominence, not far behind which the position of the anteriorly placed orbit is evident. Behind the orbit some of the outer set of suborbitals are visible, though somewhat crushed and broken. The hyomandibular, a portion of which is also seen in fig. 2, is very obliquely placed and is of the usual form. The operculum (*op.*, Pl. III, fig. 3) is very narrow, its inferior extremity is acuminate, being bevelled off in front to admit of the intercalation between it and the forepart of the upper margin of the interoperculum of a small triangular plate (*s. op.*), whose upper acute angle is prolonged into a small slender process passing up for some distance along the anterior margin of the operculum, evidently the homologue of the larger plate which in *Rhabdolepis* (Pl. II, fig. 6, *s. op.*) entirely separates the operculum from the interoperculum below. The interoperculum (*i. op.*) is nearly square-shaped, though as usual it is broader behind than in front. The præoperculum (*p. op.*) is unusually narrow, its upper limb is very obliquely placed on the side of the head, and is about twice the length of the lower one. The maxilla is also rather narrow, the depth of its posterior broad portion being contained about four times in the entire length of the bone. The mandible is stout and nearly straight, though slightly curved upwards at its extremity; the depth of the dentary portion (*d*) is contained about five times in the entire length of the jaw; distinct articular, angular, and splenial elements may also be made out in various specimens. The branchiostegal rays (*br.*) are at least thirteen on each side, the anterior of each lateral series being broader than the others, and having between them, in front, an azygous lozenge-shaped plate. Nothing can exceed the beauty of the sculpture of the external surfaces of these facial bones, which consists of delicate yet sharply defined, nearly parallel, and slightly wavy, branching and anastomosing ridges, whose general direction is indicated in Pl. III, fig. 3. Nowhere on the head have I seen a tubercular ornament, the surface of the cranial roof-bones being everywhere ornamented by similar delicate ridges or raised striæ, which run for the most part in an antero-posterior direction.

The teeth are difficult of detection, being almost always concealed by the hard intractable ironstone matrix, usually very pyritous, but in one instance I succeeded in showing the dentition of the lower jaw by corroding away the bony matter with nitric acid, and making a squeeze in modelling wax from the preparation thus obtained, the same as that from which the representation of the facial bones given in Plate III, fig. 3, was taken. This shows a row of sharp, incurved, conical laniary teeth (Pl. III, fig. 4), each about $\frac{1}{20}$th inch long (in a jaw of $\frac{3}{10}$ths inch in depth at its stoutest part, and more than $1\frac{1}{2}$ inch in length) and rather less than their own length apart; they are thus rather small and closely set. Outside there is a series of much smaller teeth, one half the size of the inner series and less. In the same preparation, teeth are also seen in the most posterior part of the edge of the maxilla, though those of the rest of that bone are concealed.

The post-temporal is of the usual form, the supra-clavicular is broad; both are shown, though rather crushed, in the specimens represented in Pl. III, figs. 1 and 2. In fig. 1 there is a good view of the clavicle and interclavicular seen from their inner surfaces; its last-named element is in this instance transversely fractured right through its middle. In the fish represented in fig. 2 there is distinct evidence of the radial elements supporting the rays of the pectoral fin; these have been already described at p. 24.

The fins are large, though not so "immense" as Agassiz has described them, and an examination of the original specimen shows that they are greatly exaggerated by his artist in the figure of the fish given in the 'Poissons Fossiles,' Atlas, vol. 2, tab. 4 *b*, fig. 3. The pectorals are broad and acuminate (Pl. III, fig. 2), the ventrals, like those of *Cheirolepis*, are remarkable for the length of their base of origin, this equalling $1\frac{1}{4}$ inch in the same specimen, which would, if entire, measure $10\frac{1}{2}$ inches from the tip of the snout to the extreme point of the tail, and $1\frac{1}{5}$th inch in that represented in fig. 2, whose total length is $10\frac{1}{4}$ inches. The dorsal and anal are large, triangular, high and acuminate in front, somewhat concavely cut out posteriorly; the caudal is very powerful, deeply cleft, and inequilobate. The fin-rays are slender for the size of the fish; their joints are delicately striated (Pl. III, fig. 8), and in the front part of the fins are considerably longer than broad; more posteriorly, however, they gradually become shorter so as to be at last nearly square. Some difference in this respect is exhibited by one of Agassiz's type specimens—the small one figured in the 'Poissons Fossiles,' Atlas, vol. 2, tab. 4 *b*, fig. 3, and in which the ganoid surfaces of the joints of the fin-rays are proportionally longer than in the larger specimens usually met with, including those figured in the present work. It may be a question as to whether we have here to deal with a distinct species, unless this circumstance be attributable to difference in age; meanwhile I am disposed to wait for further evidence before adding a new specific name to the list. The number of rays in the fins cannot be determined with absolute certainty; as far as I can ascertain, there are at least 42 in the dorsal and anal, and 45 in the ventral; those of the caudal are very numerous and uncountable. The principal rays of the fins begin to dichotomise towards their terminations; more posteriorly, and in the case of the caudal, all along the upper lobe, the process commences earlier, viz. about the middle of their length.

The scales of the body are remarkable for their large size on the flanks of the fish, where they are higher than broad, and in the specimen represented in Pl. III, fig, 2, measure $\frac{3}{10}$ths inch in height by $\frac{1}{6}$th in breadth; they become rapidly smaller and more equilateral towards the back, belly, and tail; on the caudal region and along the margins of the fins their diminution in size is very marked. Proceeding backwards to the caudal body-prolongation, we find, indeed, an immense contrast between the small size of the acutely lozenge-shaped scales in this region and the large dimensions of those on the flank. In one of these scales, opposite the middle of the origin of the lower lobe of the caudal fin, in a specimen of about the same dimensions as that last referred to, the long diagonal measures only $\frac{1}{10}$th, the short one $\frac{1}{12}$th inch; further on towards the tip of the upper lobe (Pl. III, fig. 1) they become very minute. The caudal body-prolongation is also remarkably stout and strong, and the small size of its scales causes it to display many rows of them. In the specimen represented in fig. 2 several specially large scales are seen in front of the origin of the dorsal fin. The upper margin of each of the flank scales (Pl. III, figs. 5, 6) is remarkably concavely cut out, the concavity of the contour assuming almost the appearance of a notch; the articular spine is moderate, the keel on the under surface obsolete in the scales of the front part of the fish, and only slightly marked in those situated more posteriorly. The overlapped marginal area is very narrow; the exposed surface is exquisitely sculptured with an arrangement of fine, sharply defined, sub-parallel ridges, which pass obliquely or diagonally downwards and backwards across the scale, sometimes anastomosing, sometimes branching or increasing by intercalation. The enlarged representation of scales given by Agassiz (Atlas 'Poiss. Foss.,' vol. 2, tab. 4 *b*, fig. 6) affords a very inadequate, and not very correct representation of their form and sculpture. This scale-sculpture persists over the entire body; in fact, from the tip of the snout to the extremity of the tail, every exposed portion of bone, scale, or fin-ray, is covered with a delicate striated ornamentation, which must have rendered the appearance of the fish, when alive, one of extreme beauty.

Observations.—The original specimens described and figured by Agassiz were collected by Lord Greenock and are in the Museum of the Royal Society of Edinburgh; others, with Agassiz's handwriting on the back, are in the Hunterian Museum of the University of Glasgow. I have already indicated a slight possibility that one of these (Agassiz, tab. cit., fig. 3) may belong to a distinct species, from the greater proportional length of the joints of its fin-rays. The other two type specimens (figs. 4 and 5 of the same plate) are undoubtedly identical with those figured and described in the present work, and which are contained in the Edinburgh Museum of Science and Art, and in the private collection of the author.

Geological Position and Locality.—*Cosmoptychius striatus* is one of the most common of the fishes which occur in the ironstone nodules of the bituminous shales of Wardie, near Newhaven, on the Frith of Forth, about two miles north from Edinburgh. Most of the specimens of it which have been found are in a very fragmentary and badly preserved condition; as Dr. Paterson says in his paper on the fossils of this locality, "it constitutes the majority of those fish found in a disjointed condition." The overwhelming majority of the nodules referred to contain large coprolites, rendering the expenditure of much time and patience necessary for the acquisition of fish-remains from this locality; nevertheless no fewer than thirteen species of Ganoids, most of which are *Palæoniscidæ*, have been here obtained, along with obscure remains of Sharks. The geological position of these "Wardie Shales" is in the Calciferous Sandstone series below the horizon of the Burdiehouse Limestone; by the Geological Survey of Scotland they are also placed below the Craigleith Sandstones. A portion of shale from a bed occurring immediately above the sandstone at Craigleith Quarry, near Edinburgh, recently presented to the Edinburgh Museum by Mr. James Gaul, displays numerous scales of the same species.

The Hugh Miller Collection in the Edinburgh Museum of Science and Art likewise contains a specimen from Burdiehouse, which I am inclined to refer to this species; it is, however, so badly preserved, and so peculiarly crushed, as to render its identification a matter of great doubt and difficulty.

As yet I have no authentic proof of its occurrence in any other localities, and the record, by Giebel,[1] of its occurrence in the Coal-measures of Wettin, in Prussia, is certainly based on an erroneous identification, as I have ascertained by an examination of the specimen so labelled in the Mineralogical Museum at Halle. *Cosmoptychius striatus* must therefore be considered as essentially a Lower Carboniferous form.

[1] 'Fauna der Vorwelt,' i, 3, p. 254.

Genus—Elonichthys, *Giebel*, 1848.

Amblypterus (pars), *Agassiz.*
— (pars), *Egerton.*
Palæoniscus (pars), *Agassiz.*
— (pars), *Egerton.*
— (pars), *Jackson.*
— (pars), *Newberry.*
Pygopterus (pars), *Agassiz.*
Elonichthys, *Newberry.*

The body is fusiform, sometimes rather deep; the tail is large; the caudal fin deeply cleft, very inequilobate, the upper lobe prolonged. The dorsal fin is situated well forward, nearly opposite the interspace between the ventrals and the anal; both dorsal and anal are large, triangular, of numerous closely set and closely jointed rays. The pectorals and ventrals are acuminate, the base of the ventrals not extended; their rays are also very closely jointed, except at the commencement of the first few rays of the pectoral. The fulcra of all the fins are closely set, but very minute, usually requiring the aid of a lens to distinguish them; the **V** scales of the upper margin of the tail are, however, well developed. The scales are of moderate size, rhomboidal; those of the flank are slightly higher than long, with concave upper and convex lower margin; they get lower and narrower towards the belly, and diminish generally in size posteriorly, getting also more equilateral towards the tail. The anterior overlapped portion of each body-scale is very narrow, a mere margin in fact; the exposed area is brilliant, and variously ornamented with striæ, or coarse punctures, or both; the posterior margin is often crenulated or serrated. In many cases the scales become smooth or nearly so on the tail. There are specially large scales in front of the origin of the dorsal fin, and in front of the anal, in the region of the vent. The suspensorium is very oblique, and the gape very wide; the operculum is well developed, oblong; the inter-operculum quadrate; but, as in *Palæoniscus*, &c., there is no suboperculum. The branchiostegal plates, or rays, are numerous, sometimes numbering as many as twenty-two (*E. semistriatus*) on each side; in some other species the number is much smaller, but I feel reluctant on that account to multiply the number of genera. There is a rhomboidal median plate behind the symphysis of the jaw; and the anterior one of each lateral series is much broader than the rest. The jaws are stout, the teeth acutely conical, sharp, enamel-tipped, of two sizes, large and small, the large ones being placed in a row internal to the more closely set outer row of small ones. The ornament of the cranial bones is usually more or less tubercular; the facial bones and those of the shoulder-girdle are striated; the jaws are, however, tuberculated just at the dental margin, the tubercles appearing sometimes to pass insensibly into the outer row of minute teeth.

The name *Elonichthys* was proposed by Giebel[1] for certain Fishes (*E. Germari, crassidens,* and *lævis*), from the Coal-measures of Wettin, near Halle, which he considered intermediate in generic characters between *Amblypterus* and *Palæoniscus* as defined by Agassiz. According to the proposer of the genus, they resembled *Palæoniscus* in their fulcrated fins, but differed from it in the absence of the scaly covering to the rays, affirmed by Agassiz to exist in some *Palæonisci;* while to certain "*Amblypteri*" they showed an affinity in the striation of their scales and to "*Amblyperus*" in general in the large size of the fins. Their special characteristics were to be found in the dentition, which consisted of an external series of minute teeth, comparable with the "Bürstenzähne" of "*Amblypterus,*" between which there were larger conical teeth, "wie ich dieselben weder bei den Palæonisken noch Amblypteren finde." Unfortunately, however, for this diagnosis, the fin-rays of *Palæoniscus* are no more covered with scales than those of any other genus belonging to this family; nor are the fins of Agassiz's "*Amblypteri*" destitute of fulcra "except on the upper lobe of the tail," as has been so repeatedly stated by compilers, who, copying this error from the "Tableau synoptique," have apparently overlooked the correction of it made by Agassiz himself a few pages further on in his general description of the genus.[2] The dentition, too, of Giebel's *Elonichthys* is essentially similar to that of Agassiz's *Amblypterus macropterus* (*Rhabdolepis,* Troschel), in which large conical teeth were shown to exist by Goldfuss in 1847,[3] and again by Troschel in 1857;[4] the latter author using this character to separate the striated-scaled "*Amblypteri*" of Saarbrücken and Lebach, under the name of *Rhabdolepis* (*R. macropterus, R. eupterygius*), from their smooth-scaled associates with minute slender teeth, for which the term *Amblypterus* was retained (*A. latus, A. lateralis*).

An examination of the type-specimens of *Elonichthys* in the Mineralogical Museum at Halle has, however, convinced me that the genus is tenable, and that to it is referable an extensive series of *Palæoniscidæ*, which will include, besides several new species, various forms referred by Agassiz and other writers to *Amblypterus*, *Palæoniscus*, and *Pygopterus*. Several species, also, whose position from want of sufficient information is somewhat doubtful, may best be placed here provisionally.

Though closely resembling *Rhabdolepis*, it differs in the absence of the subopercular plate; the operculum is also usually more largely developed; while from *Amblypterus*, as restricted by Troschel, the dentition and the greater obliquity of the suspensorium are obvious marks of distinction. From *Palæoniscus*, to which some of the species (*E. Robisoni*, *striolatus*, *Egertoni*) were referred by Agassiz, it is distinguished by the large size of the fins, and by the possession of large conical teeth in the jaws. Nearly

1 'Fauna der Vorwelt,' i, 3, p. 249.

2 'Poissons Fossiles,' ii, pt. 1, p. 29.

3 'Beiträge zur vorweltlichen Fauna des Steinkohlengebirges,' p. 20.

4 'Verh. des naturh. Ver. des preussischen Rheinlandes,' XIV, p. 12.

related to *Acrolepis,* it differs from that genus in the anterior covered area of the scales being reduced to a very narrow margin; but from *Pygopterus* it is widely separated by the structure of the pectoral fin and the form of the anal—*P. Bucklandi* of Agassiz being an *Elonichthys,* and having no special affinity to the Permian genus to which he referred it.

Palæoniscus Brownii of Jackson,[1] judging from the figure given, seems to belong to this genus, and probably also does *P. peltigerus,* of Newberry.[2] The latter was, indeed, first described by Newberry as an *Elonichthys.*[3]

As defined above, *Elonichthys* is pre-eminently a Carboniferous genus, and well represented in strata of that age in Great Britain and other countries.

1. ELONICHTHYS SEMISTRIATUS, *Traquair,* sp. nov. Pl. III, figs. 9, 10, 11, 12; Pl. IV, figs. 1, 2, 3.

To judge from its remains, unfortunately rather fragmentary, this must have been a Fish of no mean dimensions. The various fragments on which the species is founded may be enumerated as follows:

No. 1 (Pl. IV, fig. 1). The greater part of the body of a Fish, but wanting both head and tail. All the fins, however, are well shown save the caudal.

Nos. 2 and 3. Two detached fragments of the body, each showing a portion of the head and of the dorsal fin.

Nos. 4 and 5. Detached tails, No 4 (Pl. III, fig. 12) being the more perfect.

No. 6. A fragment of the body, showing the greater part of the dorsal fin.

Nos. 7 and 8. Portions of shale with dislocated masses of scales.

Nos. 9 and 10. Two detached heads, compressed vertically, and seen from below; No. 10 (Pl. III, figs. 9 and 10) affords also a side view of the posterior part of the head.

All these specimens are from the "Knowles Ironstone" of Fenton, North Staffordshire. The first nine are in the collection of Mr. John Ward, F.G.S., of Longton; while No. 10 belongs to the Museum of Practical Geology, Jermyn Street, London.

Description.—The general form of the body of the Fish and of the fins is shown in specimen No. 1 (Pl. IV, fig. 1, reduced $\frac{1}{5}$), which, had it been obtained entire, would have been a most magnificent Fish. As it is, the huge nodule containing it is broken off in front just before the origin of the pectorals; while, behind, it is truncated just behind the anal fin and across the tail-pedicle. The body, thus mutilated, measures nine inches in length and four and three quarters in depth just in front of the dorsal. The left pectoral is completely

1 'Report on the Albert Coal Mine, New Brunswick,' p. 22, pl. i, fig. 2.

2 'Geol. Survey of Ohio, Palæontology,' vol. i, p. 345, pl. xxxviii, fig. 1.

3 'Proc. Acad. Nat. Sc. Philad.,' 1856, pp. 96—100.

displayed; it is pointed in shape, but not acutely so; and its length along its anterior margin is not less than $3\frac{1}{4}$ inches. Thus it extends beyond the origin of the ventral, which arises only $2\frac{1}{2}$ inches behind the origin of the pectoral. In shape the ventral is more acuminate than the pectoral, its hinder margin being more cut out; its base of attachment is $1\frac{3}{4}$ inch broad; the length of its anterior rays nearly 3 inches; and, as the extreme point of the fin is lost, it must certainly have been a little longer. The interval between the ventral and the anal is rather greater than that between the former and the pectoral, the anal fin commencing $3\frac{1}{2}$ inches behind the front of the origin of the ventral. It extends back for $2\frac{1}{2}$ inches along the inferior margin of the fish, but is not perfect posteriorly; the front part is also truncated at the distance of one inch from its origin, so that its depth cannot be seen. Judging, however, from the stoutness of the rays of the front part, the anal fin must have corresponded pretty closely in shape and size with the dorsal. The latter is situated pretty well opposite the interval between the ventrals and anal; but, as so comparatively short an interval occurs between the ventral and the pectoral, it seems placed much further forwards than is usually the case in this family of Ganoids. This dorsal fin is large and powerful, triangular in shape, very high in front, the anterior rays rising fully 3 inches from the margin of the body, and its base extends to about the same length. Unfortunately in this specimen the posterior rays are much injured; in No. 6, however, the greater part of the fin is well displayed. As regards the caudal fin, No. 4 (Pl. III, fig. 12) shows the greater part of both lobes, and must have belonged to a fish of about the same bulk as the headless and tailless body No. 1. It is completely heterocercal, deeply cleft, and evidently considerably inequilobate; both lobes must have been very powerful, although, their ends being truncated, their actual length cannot be determined. All these fins are composed of very numerous closely set rays; the demirays in the anterior part of each fin imbricating over each other from before backwards, and exquisitely ornamented on their shining ganoid surfaces with fine longitudinal, sometimes slightly oblique ridges or striæ. Towards their extremities the rays dichotomise repeatedly, and end in exceedingly fine ramifications. They are also divided by closely placed transverse articulations; the joints being nearly square in all the fins save the caudal, where, by the closeness of the articulations, they are much broader than deep. All the fins are likewise set along their anterior edges with very fine fulcral scales, so small indeed as to require a lens to distinguish them, notwithstanding the large size of the Fish.

Some evidences of *internal skeleton* are also visible. In No. 1 a line of much mutilated spinous processes may be traced along the middle of the Fish; but there is no evidence of vertebral bodies or of ribs. Remains of strong interspinous bones may be seen supporting the anal fin, the anterior of these measuring at least $1\frac{1}{2}$ inch in length; those directly supporting the dorsal are short, but in specimen No. 2 there is also evidence of a deeper set, following on their proximal extremities, and interposed between them and the spinous processes. All these internal bones are in the fossil hollow, their slender tubular cavities having been, in the recent state, occupied by cartilage.

The *scales* seem to have been rather small for the size of the Fish, and they are best seen on some of the more fragmentary specimens. As in the other species of the genus, they are remarkable for the small amount of anterior non-ganoid-covered margin. The largest scales on the flank near the front measure rather more than $\frac{9}{16}$ inch in height by rather less in breadth, and are thus nearly equilateral; the upper edge is concave, the lower convex; and from near the middle of the upper one a moderately sized articular spine projects. The articular spine disappears in the scales of the caudal region, which are also smaller; those of the belly are much less high than on the flank, and have their covered anterior margin more developed; the anterior superior angle being also considerably produced, upwards and forwards. The ornament of the exposed surface of the scales (Pl. IV, fig. 3) is characteristic. From the anterior and also from the upper margin a number of well-marked ridges with intervening furrows proceed obliquely downwards and backwards, sometimes simple, sometimes bifurcating or joining with others, sometimes multiplied by intercalation. They do not, however, proceed to their apparent destinations on the posterior and inferior margins, but soon stop short, the rest of the area of the scale being occupied by numerous well-marked, or coarse, punctures. In the most anteriorly placed scales (Pl. IV, fig. 2) the pattern seems slightly different, the ridges being more pronounced; and posteriorly and inferiorly an appearance is caused as if they blended together to form a network, the meshes of which correspond with, and are in fact the forerunners of the punctures characteristic of the scales behind them. Specimens from which the external ganoine layer has flaked off show the corresponding ridges on the bone below, passing in a wavy oblique anastomosing course right over the whole surface.

On specimens 2 and 3 portions of the head are seen, though much crushed and obscured. However, the hinder part of the gape is clearly enough seen, both jaws being armed with powerful teeth of several sizes. The larger teeth, which are pretty close together, four of them being seen in the lower jaw of No. 2 in the space of $\frac{3}{8}$ inch, are $\frac{3}{16}$ inch long, and $\frac{1}{16}$ inch in diameter at the base, and are somewhat irregularly interspersed with smaller ones, from two thirds to one half their size, some of these being in the same row with the larger teeth, others outside them. All the teeth are slender-conical in shape, sharp, smooth, and pretty strongly curved inwards towards their apices (Pl. III, fig. 11).

Specimen No. 10 presents a view of the head both from below (Pl. III, fig. 9) and from the left side (Pl. III, fig. 10); unfortunately it is not in very good preservation. The lateral view, a little distorted by the crushing to which the specimen has been subjected, displays two of the opercular bones, a portion of the maxilla, and the hindermost of the branchiostegal rays. The operculum is an oblong plate, $1\frac{1}{2}$ inch long by $\frac{5}{8}$ inch broad, with acute antero-superior and postero-inferior angles, the other two angles being correspondingly obtuse. Below it is placed the interoperculum, quadrate in shape, but with the lower margin longest, and the postero-inferior angle rather acute; as in most *Palæoniscidæ,* I see no trace of suboperculum. Above the operculum is seen the somewhat displaced post-temporal; while below and in front is a portion of the maxilla, which bone being broken off behind, the hard palate comes partly into view between it and the opercular bones. On turning the specimen round, both rami of the lower jaw are seen, along with the rest of the branchiostegal rays. Each ramus, strong, though tapering, measures nearly three inches in length from its articular to its symphysial extremity; external to the right one is seen a portion of the margin of the right maxilla, with no less than six laniary teeth in the space of half an inch; there are also traces of some of the smaller teeth. The left series of branchiostegal rays is traceable from beneath the interoperculum, round between the rami of the mandible, where they come in contact internally with the series of the other side (Pl. III, fig. 9). The number of these plates is unusually large, there being at least twenty-two on each side; they are imbricating in arrangement and narrow in form, save the anterior of each lateral series, which is much broader than the rest; while there is also clear evidence of a median lozenge-shaped plate just behind the symphysis.

As regards the external ornament of the cranial bones, the lower jaw is sculptured externally with fine, wavy, branching and anastomosing, longitudinal ridges, passing near the dental margin into a fine tuberculation; some obscure remains of the bone of the top of the head are seen in the front of the specimen, on which the ornament is apparently tubercular. On all the other bones visible it is of a finely ridged or striated character. The scales visible behind the head in this specimen are not very well preserved, but the nature of their sculpture, where visible, proves that the head belongs to the same species as that to which the other specimens are referable. The other head (No. 9), belonging to Mr. Ward, and likewise crushed vertically, does not exhibit so many details as the one just described, with which, however, it agrees in all essential points.

Observations.—This is the largest species of *Elonichthys* known, except a somewhat doubtful form from the lower strata of the Scottish Coal-fields, known as yet only by detached scales and a portion of a jaw, and to which I shall further on give the name of *E. pectinatus.* The peculiar sculpture of the scales, its deep and massive body, and the enormous size of its fins, readily distinguish *Elonichthys semistriatus* from all the other species of the genus, though in many respects, as in the conformation of the fin-rays, the configuration and external markings of the cranial bones, and the dentition, it is also closely allied to the two species next to be described from the same horizon and locality, viz. *E. caudalis* and *E. oblongus.*

Geological Position and Locality.—The specimens above described are all from the Coal-measures, and were found in the " Knowles Ironstone " and accompanying shale of Fenton, North Staffordshire. I have also reason to believe in its occurrence in the Coal-strata of Northumberland.

2. Elonichthys caudalis, *Traquair,* sp. nov. Plate V, figs. 1—4.

Of this I have only seen one specimen, the counterpart of which, being the more perfect side of the fossil, is represented in Pl. V. It is also from the Knowles Ironstone of Fenton, North Staffordshire; and, though smaller, seems to have resembled the preceding Fish very much in shape. The sculpture of the scales, however, is rather different.

Description.—The length of the specimen from the posterior margin of the gill-cover to the bifurcation of the caudal is $5\frac{1}{4}$ inches; to opposite the apparent end of the upper lobe $6\frac{1}{4}$ inches. Its greatest breadth at the front of the dorsal fin may be given at $2\frac{1}{2}$ inches. The head is, at its junction with the body, bent over to the left side at so considerable an angle that it was impossible to represent it in the drawing of the entire Fish, and a detached figure of the impressions of its bones has therefore been given (Pl. V, fig. 2). The anterior part of the head is lost; but the external bones, posterior to the orbit, are recognisable, though only in impression of their outer surfaces; a little of the bone, however, adhering here and there to the matrix. Judging from these impressions, it is evident that the suspensorium was very oblique, the operculum (*op.*) long and narrow, the interoperculum quadrate, the maxilla (*mx.*) of the usual form, broad behind and excavated or cut out above just behind the orbit. Along the upper margin of the maxilla, and in front of the operculum, is seen the impression of the upper acutely triangular portion of the præoperculum (*p. op.*), in front of which are some obscure remains of the broad outer suborbital plates (*s. o*). The gape, of course, extended very far back: only a very narrow portion of the impression of the upper margin of the mandible is seen bounding the mouth below, with some feeble traces of sharp conical teeth; behind the angle of the mouth are also seen the remains of the first two branchiostegal rays. Above the operculum and præoperculum is the concave impression of the posterior part of the cranial shield, showing very obscurely the parietal and squamosal plates. Behind this, at the upper and back part of the head, is seen the inner surface of the post-temporal (*p. t.*), a small rounded-trigonal plate, extending from which, obliquely downwards and backwards behind the operculum, is the impression of the supra-clavicular (*s. cl.*). The ornament of the outer surface of the cranial buckler is, as far as can be made out, of a tubercular character; that of the facial bones, on the other hand, consisting of delicate branching and anastomosing wavy ridges or striæ.

The disturbed aspect of the scales immediately behind the head would lead us to believe that the anterior part of the specimen has been somewhat shortened by distortion, the head being pushed backwards on the body; and in this manner the apparently abnormally anterior position of the dorsal fin, and the seeming disproportion between the caudal and abdominal portions of the Fish, may be accounted for. On the inferior margin of the specimen, part of the left pectoral fin is seen, evidently very powerful, and composed of numerous closely jointed rays, of which the anterior one, however, shows no articulations for a considerable distance; its extremity, hidden in the stone, could not be worked out without injuring the ventral, beyond whose origin it passes. The ventral (left) is also only partly seen, its anterior margin being damaged, and its extremity covered by the matrix; its proportions must have resembled those of the ventral of the preceding species; the rays are stout, numerous, and closely articulated. The dorsal fin, the anterior margin of which is injured at its origin, is of great size; and, calculating for the lost portion in front, it must have measured at least $2\frac{1}{2}$ inches in height by $1\frac{5}{8}$ in length at the base; it is larger than the anal, which is $1\frac{5}{8}$ inch deep from origin to apex, with a base of about $1\frac{3}{8}$ inch in length.[1] Both of these fins are triangular in shape, acuminated, very high in front, their posterior margins being concavely cut out. Their rays are very numerous; though they are not capable of being accurately counted, I should be inclined to estimate their number in the dorsal at about 50, and in the anal at not less than 35—40. They are closely articulated, the joints being nearly square in the coarser rays, but getting still closer and shorter posteriorly; their external ganoid surfaces are finely striated; toward their extremities they begin to dichotomise, and they end in very fine branches. Posteriorly the anal is pretty closely followed by the caudal, powerfully developed, and evidently considerably inequilobate, though the termination of neither lobe is seen. The rays of the lower lobe of the caudal dichotomise as usual towards their extremities; as we pass to the upper lobe the division takes place sooner, and the rays get more and more delicate; the articulations of the rays at the bifurcation, and in the upper lobe, are very close and short, more so than in any of the other fins. Very minute closely set fulcra may be seen on the anterior margins of the fins, wherever these are distinctly exhibited in the specimen.

A few traces of the internal skeleton, namely, of spinous processes and interspinous bones, are found in this specimen as in the species previously described.

Thus far the description of this Fish has hardly, if at all, differed from that of the larger species, *E. semistriatus*, already described. But the external sculpture of the scales affords a ready and most obvious means of distinguishing them. The scales on the front of the flank (Pl. V, fig. 3) are $\frac{1}{8}$—$\frac{1}{10}$ inch high, by $\frac{1}{16}$ broad; they get rather smaller towards the tail and on the belly (fig. 4). Their sculpture may be best described from " squeezes " in modelling wax, made from the sharp impression of their outer surfaces remaining in the stone; the appearance of these being completely corroborated by the broken remains, in places, of the outer surfaces of the scales themselves, occurring on the opposite, and in other respects more imperfect side of the nodule. Their ornament consists entirely of fine ridges, passing across the scale, which seems as in *E. semistriatus* to have the posterior margin quite entire, not serrated as in some species of the genus. No

[1] The *apex* of the anal fin is not seen in the figure (Pl. V, fig. 1), it having been cleared from the matrix only after the execution of the Plate.

two scales are exactly similar in the pattern of these ridges; but, as a rule, if we divide the scale by a diagonal, running from the antero-superior to the postero-inferior angle, the general direction of the striæ in the upper half is obliquely downwards and backwards, more or less parallel with the diagonal; while those of the lower half are more horizontal and meet the diagonal at an angle. Just below the upper margin one or two ridges may also generally be seen, running parallel with that margin. This arrangement of the striæ has some amount of resemblance to the pattern of the scales in the well-known *Rhabdolepis macropterus* of the German Lower Permian strata, though the two Fishes cannot be confounded even generically.

Observations.—This species, unfortunately known as yet only by a single example, resembles the preceding in most particulars, save the sculpture of the scales, its smaller size, and its less depth of body. Although the great preponderance of the caudal part of the body in this specimen is, as already explained, at least very largely due to post-mortem distortion, I have considered it not unallowable to use this circumstance as a basis for the specific name I have bestowed upon the Fish.

Geological Position and Locality.—*Elonichthys caudalis* is as yet only known from the Coal-measures of North Staffordshire, where it has occurred in the Knowles Ironstone of Fenton.

3. Elonichthys oblongus, *Traquair,* sp. nov. Plate VI, figs. 1—2.

Of this I have also seen only one specimen, which is represented in Plate VI.

Description.—The specimen is tolerably entire, all the fins being shown, as well as the general form of the head, though the latter is injured on the top about the orbital region. The length from the tip of the snout to the bifurcation of the caudal is $10\frac{1}{2}$ inches; the fish must originally have been rather longer, as both lobes of the very powerful tail-fin are truncated. The length of the head, measured from its anterior extremity to opposite where the posterior margin of the gill-cover should be (as indicated by the position of the clavicle), is $2\frac{1}{4}$ inches; to opposite the commencement of the dorsal fin, 4 inches; of the ventral, $4\frac{1}{2}$ inches; of the anal, $6\frac{7}{8}$ inches; of the lower lobe of the caudal, $7\frac{1}{2}$ inches. The greatest depth of the body is at the front part of the dorsal fin, where it equals $2\frac{5}{8}$ inches; that of the tail-pedicle is $1\frac{1}{4}$ inch. The Fish is thus seen to be moderately deep, but clumsy in its proportions, from the great strength of the caudal pedicle.

Unfortunately very little can be seen of the bones of the head, owing to the tenacity with which a layer of the tough shaly matrix adheres to their surfaces, as well as owing to the great crushing which the specimen has undergone; it displays, however, the wide gape, and very oblique suspensorium, characteristic of this genus, as of most others of the family. The stout lower jaw measures $1\frac{3}{4}$ inch in length; it is injured across the middle; and indeed only the front part of it, about $\frac{7}{12}$ inch in extent, is perfect; and this displays on its margin several teeth. Four of these teeth are perfect, each measuring a little less than $\frac{1}{8}$ inch in length; they are slender-conical, rounded in transverse section, smooth externally, and sharply incurved laterally. The portion of bone on which they are placed is ornamented by fine, wavy, longitudinal ridges, passing into a delicate tuberculation at the symphysis. Nothing more can be made out regarding the cranial structure, save that a gently curved elevation, passing very obliquely downwards and backwards, probably indicates the form and position of the hyomandibular element.

The position of the clavicle is indicated by a curved elevated line, just posterior to where we should have expected to have seen the hinder margin of the interoperculum. Immediately below this a small portion of the right pectoral fin is found; and the few rays which are exposed are seen to be traversed by numerous, closely placed joints. The entire ventral fin is exhibited: its numerous rays are tolerably fine, and dichotomise towards their extremities into very delicate divisions. The dorsal fin is situated far forwards, in advance of the middle of the back; there being a rather greater space between it and the caudal behind than between its anterior commencement and the posterior part of the head in front. Its anterior margin is much injured, so that the apex is not seen, and its height not ascertainable: judging from the length of the base, namely, $2\frac{3}{8}$ inches, it must have been a fin of very powerful dimensions, and very considerably larger than the anal. The latter is completely exhibited, it is acuminate in shape, and concavely cut out behind; the base measuring $1\frac{3}{8}$ inch in length, and the depth of the fin being $1\frac{3}{4}$ inch. Both of these fins have a very similar structure, the rays being very numerous, pretty stout in front, more delicate behind, finely striated externally, and with very close transverse articulations, the joints shorter than they are broad. The rays of the caudal are, of course, very numerous; the first twelve of the lower lobe are tolerably stout, the rest finer, and in the upper lobe fringing the body prolongation they are very fine; their articulations are also very close, being mostly, as in the other fins, considerably shorter than broad; externally they present the same delicate and beautiful striation.

Supporting the rays of the dorsal fin is a series of very short interspinous bones, larger in front, smaller behind, expanded at their extremities, and narrow in the middle; below these we find clear evidence of a second set, placed between them and the neural spinous processes. About the middle of the fish a few spinous processes are seen here and there among the scales. The interspinous supports of the anal are distinctly seen, at least towards the front part of that fin; they are considerably longer and more slender in their configuration than those immediately supporting the dorsal. The scales of this species are of medium size, and unfortunately very ill displayed in the specimen, being much broken and crushed up together. What is seen of them shows that they were rather higher than broad in the fore part of the fish; diminishing gradually in size, and becoming more equilateral as we pass backwards, till on the caudal body-prolongation they are small, and, as usual, acutely lozenge-shaped. They are crossed by fine, wavy, branching, and anastomosing striæ (Pl. VI, fig. 2), which persist over the greater part of the body; on the tail-pedicle, however, we find the striæ tending to become obsolete, and to be replaced, towards the hinder margin of the scale, by small punctures. On the caudal body-prolongation the scales are nearly absolutely smooth, excepting on the large scales bordering it above, in which the striæ persist so far as the specimen extends.

Observations.—In its dentition, in the relative position and size of the fins, save the *ventral*, which seems a little smaller in proportion, and in the structure of the fin-rays, this species approaches exceedingly closely the two others already described from the same locality, namely, *Elonichthys semistriatus* and *E. caudalis.* It differs, however, from both in the more oblong form of the body and the greater relative depth of the tail-pedicle. The nature of the scale-ornament separates it very distinctly from *E. semistriatus,* though in this respect its resemblance to *E. caudalis* is greater; the striæ, however, are rather more delicate than in the latter Fish, and the pattern slightly different in general aspect.

Geological Position and Locality. The specimen of *Elonichthys oblongus* just described, and the only one which I have seen, belongs to the collection of Mr. John Ward, F.G.S., of Longton, and is from the shales accompanying the "Knowles Ironstone" of Fenton, Staffordshire. It is therefore as yet only known from the Coal-measures.

4. Elonichthys striolatus, *Agassiz,* sp. Plate VII, figs. 4—15.

Palæoniscus striolatus, *Agassiz.* Poissons Foss., t. ii, pt. 1, p. 91; Atlas, t. ii, tab. 10 *a*, figs. 3 and 4, 1835.
— — *Morris.* Catalogue of British Fossils, p. 337, 1854.

Description .The most perfect example of this species which I have seen is contained in the Hugh Miller Collection, Edinburgh Museum of Science and Art, and is represented in Pl. VII, fig. 4. It measures $5\frac{1}{2}$ inches in length by $1\frac{1}{2}$ in depth at the commencement of the dorsal fin. The length of the head is contained four times in that of the entire fish up to the bifurcation of the caudal fin, and four times and three quarters up to a point opposite the extreme termination of the upper lobe; the greatest depth of the body is contained nearly four times in the total, and is equal to two and a half times the depth of the tail-pedicle.

The original of Agassiz's figure, preserved in the Museum of the Royal Society of Edinburgh, is a fish of nearly the same size as the above, but its form is a little distorted and its scales considerably broken up. Another specimen in the Edinburgh Museum, which belonged to the late Professor Jameson, and was also referred to by Agassiz, must have attained a length of nearly eight inches had it been perfect; unfortunately, however, its head and a portion of the front of the body are deficient. The largest specimen, however, of *Elonichthys striolatus* which I have seen is one belonging to the Museum of the New College, Edinburgh; both head and tail are wanting, but judging from the depth of the body and the size of the fins, one of which, the dorsal, is represented of the natural size in Pl. VII, fig. 5, it could not have originally measured less than nine inches in length.

Very little can be made out concerning the osteology of the head, the bones of which are, as is unfortunately the case with most of the smaller fishes preserved in hard limestones or bedded ironstones of the Carboniferous Period, crushed into a nearly homogeneous mass. The gape is, however, seen to be very wide, the suspensorium very oblique, the lower jaw stout and striated with fine oblique ridges. In the specimen represented in Pl. VII, fig. 7, the lower jaw of the right side is seen from within, with obvious remains of branchiostegal rays below it; of the latter, the median lozenge-shaped plate behind the symphysis is conspicuous. Here the dentary margin may be observed to be set with numerous teeth of different sizes, the largest of which measures $\frac{1}{20}$ inch in length. All these teeth are conical, sharp, and incurved, with enamel cap; the surface is polished and smooth under an ordinary lens. They are not at all arranged "en brosse," and the larger ones are, in proportion to the size of the jaw, just as large as in such a form as *Acrolepis*. Indications of similar teeth, as well as of smaller ones outside them, are also seen in the specimen represented in Pl. VII, fig. 4.

The scales are of moderate size, being larger on the front part of the flank, where the upper margin is slightly concave, than the lower convex; they become gradually smaller and more obliquely rhomboidal towards the tail. The keel on the under surface is well marked (fig. 13), and terminates above just in front of the origin of the rather prominent articular spine of the upper margin, which with the corresponding socket above the lower margin becomes less marked, and finally disappears towards the commencement of the anal fin; the keel, however, endures as far as the scales of the tail-pedicle, and is even more prominent in the posterior part of the fish (fig. 15). The external surface of the scale has the covered portion extremely narrow, the exposed area is in the anterior part of the fish (Pl. VII, fig. 12), marked with very delicate furrows, whose direction is first obliquely downwards and backwards, then passing more or less directly across the scale, and tending posteriorly to pass into short streaks and punctures; some of the uppermost of these furrows are observed to run nearly parallel with the upper margin. In front, where these furrows are most pronounced and closer together, an appearance is produced as of delicate bifurcating ridges between them, and in some of the most anteriorly placed scales (fig. 11) these ridges extend, indeed, over nearly the entire surface. As we proceed backwards along the body the appearance of striation becomes more strictly limited to the anterior part of the scale (fig. 14), the rest of the surface being occupied only by scattered points, but it is never altogether lost even on the sides of the tail. The posterior margin of the scale is sharply and delicately serrated. Very prominent large scales are seen in front of the median fins (Pl. VII, figs. 9 and 10).

The paired fins are rather small compared with those of the species from Fenton just described, the pectorals equalling only two thirds the length of the head and the ventrals scarcely half. Both are moderate in expanse and acuminate in form; the number of the pectoral fin-rays, which are closely articulated from their origins, is about twelve; in the ventral the number is probably rather less. The median fins are, however, powerfully developed; the dorsal is placed nearly opposite the interval between the ventrals and anal, commencing a little behind the origin of the former and terminating a little behind that of the latter. Both dorsal and anal fins are very similar in shape, being acutely triangular, much elevated in front, and having the posterior margin concavely excavated; in both the length of the anterior rays exceeds that of the base of the fin; the number of rays in each may be estimated at about thirty, of which the fifth or sixth is the longest. The caudal is very largely developed, deeply cleft and inequilobate, the superior lobe passing upwards with a great sweep; the lower is acutely pointed. The rays of all the fins are remarkable for the excessive closeness of their transverse articulation, the joints being broader than long, except at the commencement of the caudal. Here the rays, forming about three fourths of the lower lobe, are for some little distance divided by more distant articulations, the joints produced by which appear twice as long as broad, their apparent length being proportionally increased by the greater amount of imbrication of the demirays in this part. Likewise in the dorsal and anal, the articulations of the commencement of the more anterior rays are not so close as over the rest of the fin, but yet much closer than in the part of the caudal just referred to. Externally the ganoid surface of the rays (Pl. VII, fig. 6) is ornamented with delicate striæ, parallel with, or slightly oblique to, the direction of their length. The longer rays of the anterior part of each fin begin to dichotomise towards their extremities; this division gradually creeps up posteriorly till, in the short rays behind, it takes place about their middle; the latter condition is, of course, observable all along the upper lobe of the caudal. The fulcra are closely set and minute, though at once obvious under an ordinary lens.

Observations.—*Elonichthys striolatus* is one of a group of species, eminently characteristic of the Lower Carboniferous rocks of Scotland, yet very well marked by their moderately sized paired fins and their serrated delicately striato-punctate scales. Some of them are rather difficult to distinguish from each other, but the present species may be readily recognised by the extreme closeness of the articulations of its fin rays and the moderate size and delicate ornamentation of its scales.

Described as a "*Palæoniscus*" by Agassiz, the resemblances which this species bears to two others referred by him to "*Amblypterus*," viz. *A. nemopterus* and *A. punctatus* (pars),[1] and also to another, which he classed under "*Pygopterus*," namely, *P. Bucklandi*, are so close that it seems unaccountable that they should have ever been placed in different genera; in fact, his having done so seems only to indicate the uncertain and arbitrary nature of the distinction which he drew between *Palæoniscus* and *Amblypterus*, as well as his not having fully realised the nature of the special characters of the true *Pygopteri*. For in analysing the general descriptions given by Agassiz, of *Palæoniscus* and *Amblypterus* respectively, we find ourselves ultimately reduced to the large size of the fins of the latter and the minuteness of their fulcra as the main grounds of distinction; nevertheless, the fins of "*Palæoniscus*" *striolatus* are proportionally just as large, and their fulcra just as minute, as in the two so-called "*Amblypteri*" referred to above. And with regard to "*Pygopterus*" *Bucklandi*, we shall find in the description of that fish that it mainly differs from the present species in its large size and in the proportions and ornamentation of its scales, and can nowise be placed in the same genus with the *Pygopteri* of the Permian strata. In fact, according to the restrictions which must now be placed upon the genera *Palæoniscus, Amblypterus*, and *Pygopterus*, we are not in possession of any positive evidence of the occurrence of any of the three in Carboniferous rocks.[2]

One point in Agassiz's description of this species requires special notice, viz. his statement that at the anterior margin of the anal fin "on voit encore quelques traces des petites écailles qui recouvrent ordinairement les nageoires." An examination of the original specimen shows that the real explanation of the appearance here referred to is, that over the greater part of the fin, as is ordinarily the case with the Burdiehouse specimens, the internal aspect of one set of demirays (in this case the left) is seen, the fin having split vertically between the two series; it so happens, however, that a remnant of the demirays of the other side, showing their external ganoid surfaces, has adhered at the particular spot in question, their short joints having been consequently mistaken for remains of a scaly covering. I have already, in the general description of the structure of this family, shown that the opinion entertained by Agassiz, that the fins of some species of "*Palæoniscus*" were covered with scales, is untenable.

Geological Position and Localities. Elonichthys striolatus is a characteristic Fish of the zone of the Burdiehouse Limestone in the Calciferous Sandstone series of the East of Scotland, a zone whose position is above the horizon of the Wardie Shales and below that of the Houston Coal. The best specimens, including the type, have been

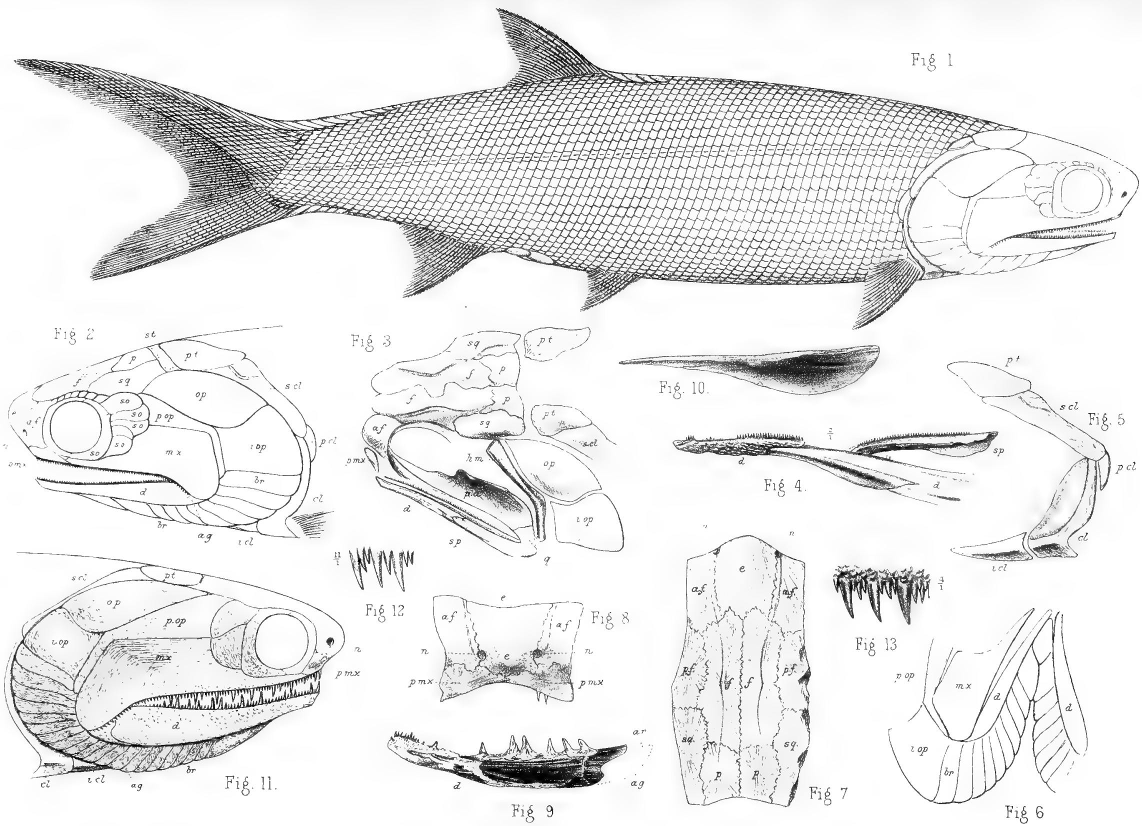
[1] An examination of the type specimens of *Amblypterus punctatus*, Agass., from Wardie, shows that it was founded on two distinct species. One of these, from the peculiarity of its dentition, must form the type of a new genus (*Gonatodus*, Traq.), retaining the specific term *punctatus;* the other is an *Elonichthys*, closely allied to *E. striolatus*, and which I propose to call *E. intermedius*.

[2] The strata at Saarbrücken, Lebach, and Berschweiler, in which the typical *Amblypteri* occur, as well as the fish-bearing beds of Münster-Appel, Kreuznach, Goldlauter, &c., in Germany, Autun in France, long believed to be of Carboniferous age, are now by continental geologists referred to the Lower Permian (unteres Rothliegendes).

PLATE I.

FIG.

1. Restored figure of *Palæoniscus macropomus,* Agassiz.
2. Diagram of the bones of the head (restored) of *Palæoniscus macropomus: p.* parietal; *f.* frontal; *sq.* squamosal; *e.* super-ethmoidal; *a.f.* anterior frontal; *p. mx.* præmaxilla; *mx.* maxillæ; *s. o.* suborbitals; *d.* dentary; *ag.* angular; *op.* operculum; *p. op.* præoperculum; *i. op.* interoperculum; *br.* branchiostegal rays; *s. t.* supratemporals (?); *p. t.* post-temporal; *cl.* clavicle; *p. cl.* post-clavicular; *i. cl.* infra-clavicular.
3. Sketch of the bones of the head of *Palæoniscus macropomus,* from the Zechstein, Ilmenau; enlarged $\frac{1}{5}$th, from a specimen in the Edinburgh Museum of Science and Art: *h. m.* hyomandibular; *pa.* palatopterygoid; *q.* quadrate; *sp* splenial. The other letters as in Fig. 2.
4. Dentary (*d.*) and splenial (*sp.*) elements of the lower jaw of *Palæoniscus comptus,* Agass., dislocated; $\frac{2}{3}$rds of the dentary being represented only by the impression of its inner surface, the bone itself with the teeth remaining at the symphysial extremity: enlarged two diameters. From a specimen from Thickley, Durham, in the Collection of the Earl of Enniskillen.
5. Bones of the shoulder-girdle of *Palæoniscus,* restored. Lettering as in Fig. 2.
6. Sketch of the arrangement of the branchiostegal rays in a specimen of *Palæoniscus comptus* in the Museum at Newcastle.
7. Sketch of the bones of the cranial shield of *Nematoptychius Greenockii,* Agass., sp.; natural size: *p. f.* posterior frontal. The other lettering as in Figs. 2 and 3. From a specimen from Wardie in the Collection of the Author.
8. Front view of the same specimen; slightly enlarged: *n.* nasal openings. Other lettering as above.
9. Dentary bone of *Nematoptychius Greenockii;* natural size. From a specimen in the Collection of Dr. Hunter, Braidwood, Lanarkshire. Most of the bone has flaked off and left behind an impression only of the inner surface; some of the laniary teeth remain on the upper margin, but are split through vertically; on the anterior extremity some of the minute external teeth are seen, the large ones being here concealed. The position which would be occupied by the angular (*ag.*) and articular (*ar.*) is indicated in dotted outline.
10. Splenial bone of *Nematoptychius Greenockii,* from the outer or aboral side; natural size. Collection of the Author.
11. Restored outline of the head of *Nematoptychius Greenockii.* Lettering as in Fig. 2.



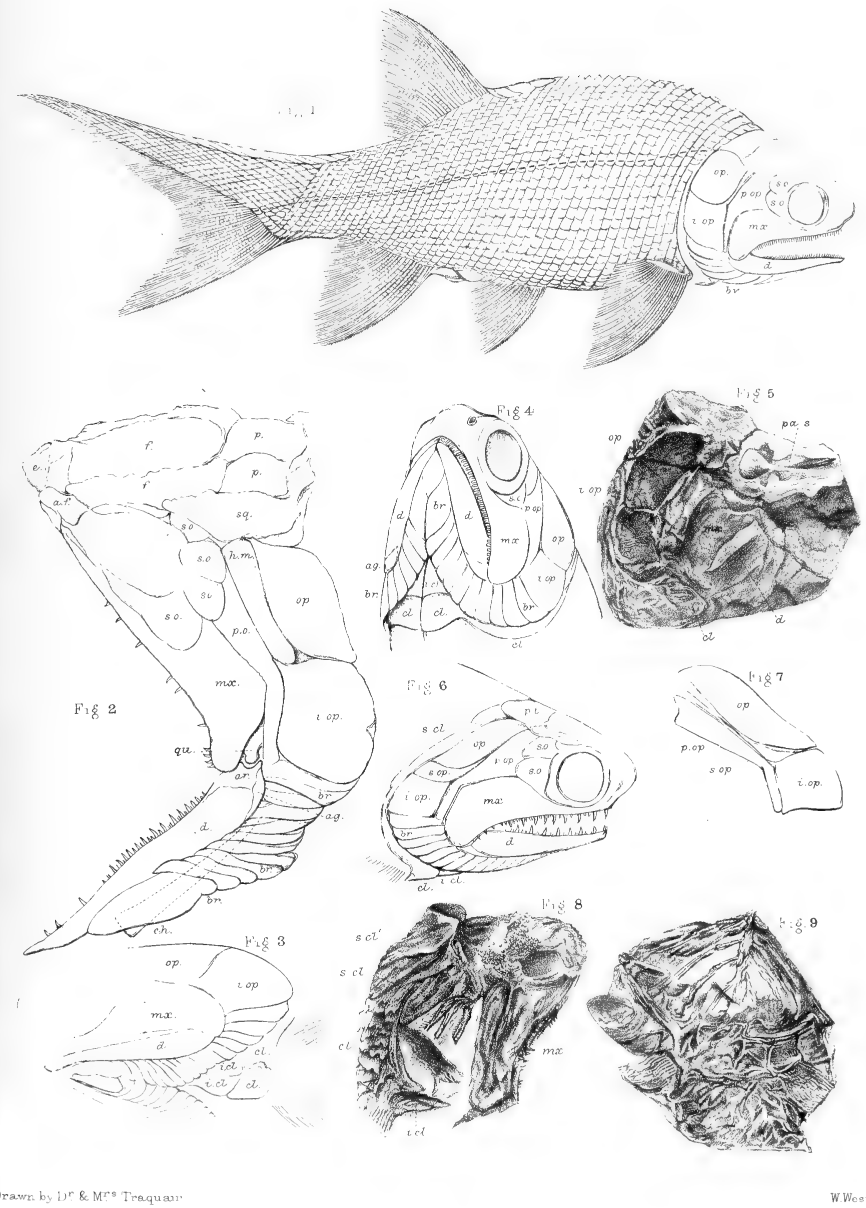
Drawn by R. H. Traquair, M. D.

F. Huth, Lithr Edinr

PLATE II.

FIG.

1. Restored figure of *Amblypterus latus,* Agass. Lower Permian of Lebach, Saarbrücken, &c.
2. Sketch of the bones of the head in *Oxygnathus ornatus,* Egerton.—Lower Lias, Lyme Regis; reduced $\frac{1}{5}$th: *c. h.* cerato-hyal, covered by the branchiostegal rays, except at its anterior extremity; the dotted lines indicate its contour as seen *through* the rays which are compressed over it; *ar.* articular; *qu.* quadrate. The other lettering as in the preceding Plate I. From a fine specimen in the Museum of Practical Geology.
3. Sketch of the bones of the lower aspect of the head and shoulder in *Oxygnathus ornatus;* reduced $\frac{1}{2}$. From one of the type specimens in the Collection of Sir Philip Grey Egerton (that whose tail is represented in pl. ix*, 'Dec. Geol. Survey,' viii, 1855).
4. Diagram to show the arrangement of the branchiostegal rays, &c., in *Gonatodus punctatus,* Agass., sp. Calciferous Sandstone Series, Wardie. Lettering as in fig. 2, &c., Plate I.
5. A fragmentary and dislocated head of *Gonatodus punctatus,* showing the parasphenoid (*pa. s.*), the operculum (*op.*), interoperculum (*i. op*), part of the clavicle (*cl.*), maxilla (*mx.*), and mandible (*d.*), as shown in impression; enlarged $\frac{1}{5}$th. Collection of the Author.
6. Diagram of the facial bones in *Rhabdolepis macropterus,* Bronn, sp. Lower Permian, Lebach, &c.: *s. o.* suboperculum. The other lettering as in the figures of Plate I.
7. Diagram of the opercular bones in *Cosmoptychius striatus,* Agass., sp. Calciferous Sandstone Series, Wardie.
8. Head of *Elonichthys Egertoni,* Agass., sp. Coal-measures, North Staffordshire; enlarged 2 diameters. The branchial cavity is exposed, and portions of three of the branchial arches seen in its upper part. In the Collection of Mr. John Ward, F.G.S., Longton.
9. Head of a species of *Elonichthys* compressed vertically, and the upper part gone so as to expose the median line of basi-branchials, and portions of three branchial arches on the left side, of two on the right. Calciferous Sandstone Series, South Queensferry, Linlithgowshire. In the Collection of the Author.

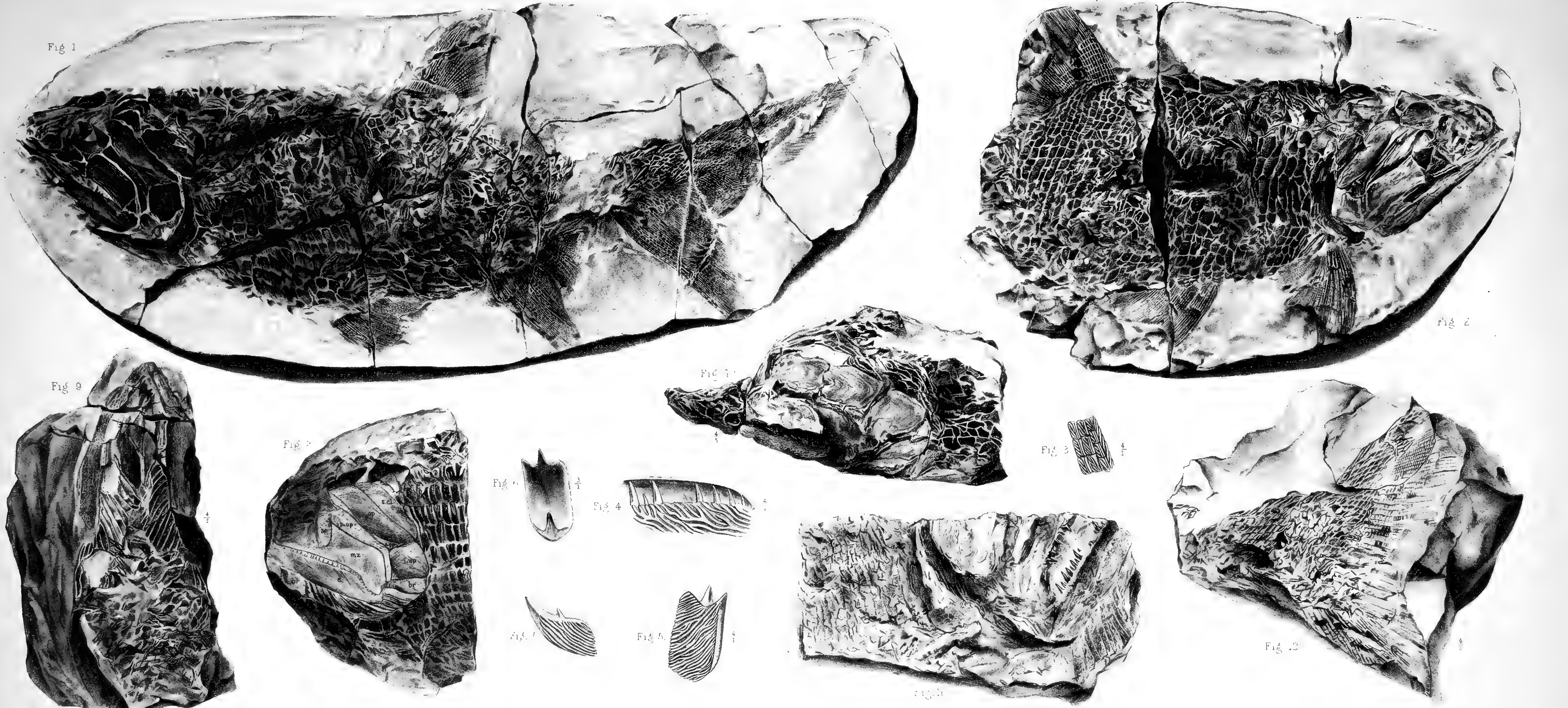


Drawn by Dr. & Mrs. Traquair W. West & Co lith.

PLATE III.

Fig.

1. *Cosmoptychius striatus,* Agass., sp.; natural size; the most perfect specimen known. From the Calciferous Sandstone Series, Wardie. The bones of the right side of the head are seen from their inner surfaces. In the Collection of the Author.
2. Another specimen of the same species from the same locality, showing the pectoral, but deficient in the anal and caudal fins. In the Hugh Miller Collection, Edinburgh Museum of Science and Art.
3. Head of the same species; natural size; to show the sculpture of the facial bones and the arrangement of the branchiostegal rays. The facial bones are drawn from a squeeze in modelling wax of the impression of their outer surfaces, occurring on the counterpart of the specimen. Specimen in the Edinburgh Museum of Science and Art. Collected at Wardie by Mr. C. W. Peach.
4. Dentition of the lower jaw of the same specimen; magnified six diameters.
5. Scale from the flank of *Cosmoptychius striatus;* magnified four diameters. From the Calciferous Sandstone Series, Craigleith, and in the Edinburgh Museum of Science and Art.
6. Inner surface of a similar scale from Wardie, magnified three diameters.
7. Scale from a position more towards the ventral aspect; magnified a little over four diameters. From Craigleith.
8. Sculpture of the joints of the dorsal fin-rays of the specimen represented in Fig. 2; magnified.
9. Head of *Elonichthys semistriatus,* Traquair. Seen from below and reduced $\frac{1}{5}$th. From the Coal-measures (Knowles Ironstone) of Fenton, Staffordshire. Museum of Practical Geology.
10. Lateral view of the same specimen; reduced $\frac{1}{5}$th.
11. Portion of the specimen of *Elonichthys semistriatus,* referred to in the text as "No. 2," to show the dentition; natural size. Coal-measures, Fenton. In the Collection of Mr. Ward.
12. Tail of the same species; reduced $\frac{1}{5}$th. In Mr. Ward's Collection, and from the same locality.



From Nature by Dr. & Mrs. Traquair
McFarlane & Erskine Lith.rs Edin.r

PLATE IV.

1. *Elonichthys semistriatus,* Traquair. The most perfect specimen known; reduced $\frac{1}{5}$. In the Collection of Mr. Ward, F.G.S.

2. Scale from the front part of the flank; magnified.

3. Scale from the side of the body rather further back; magnified.

Fig. 2

Fig. 3.

From Nature by Dr. & Mrs. Traquair.

Mc Farlane & Erskine Lithrs. Edinr.

PLATE V.

1. *Elonichthys caudalis*, Traquair. Natural size. Fenton. Collection of Mr. Ward, F.G.S.
2. Impression of the greater part of the head of the same specimen, incapable of being represented in the preceding figure, owing to its being bent over at nearly a right angle to the body at the shoulder.
3. Scale from the flank ; magnified.
4. Several scales, situated more towards the ventral aspect, and a little further back ; magnified. This and the preceding figure have been drawn from " squeezes " in modelling wax.

Fig. 1.

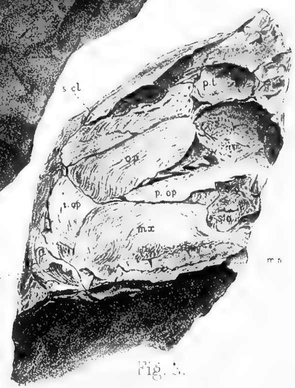


Fig. 2.

Fig. 3

Fig. 4

From Nature by Dr. & Mrs. Traquair.

Mc Farlane & Erskine Lithrs. Edin.

PLATE VI.

1. *Elonichthys oblongus,* Traquair; natural size. Fenton, Staffordshire. Collection of Mr. Ward, F.G.S.

2. Broken scales from the flank, magnified two diameters.

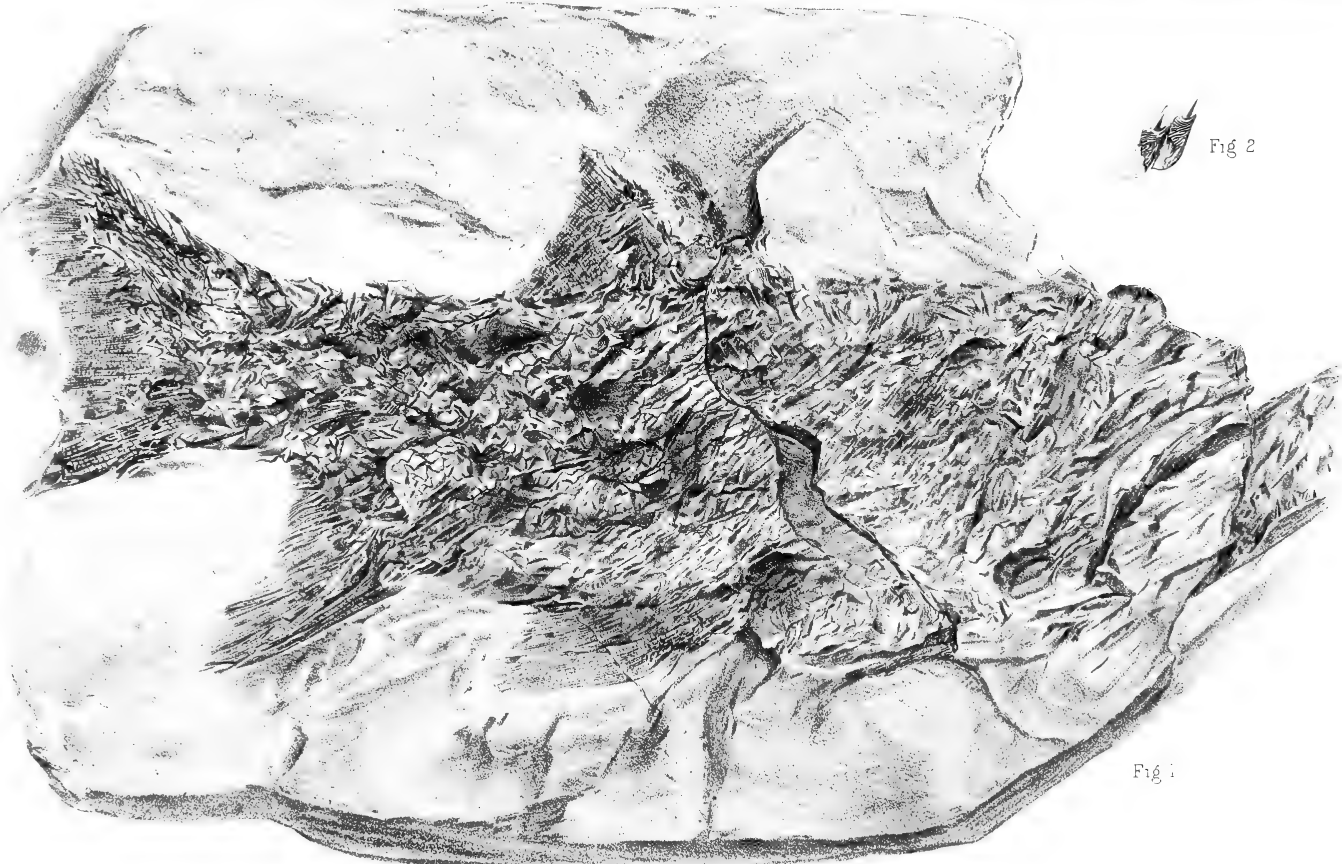


Fig 2

Fig 1

From nature by D^r & M^rs Traquair

Mc Farlane & Erskine Lith^rs Edin^r

PLATE VII.

Fig. 1. Bones of head and shoulder-girdle of the recent *Polyodon folium*, Lacép., from a moist preparation; the cartilaginous portions are dotted: *n.*, nasal chamber, behind which is the eyeball; *sq.*, squamosal; *h. m.*, hyomandibular; *sy.*, symplectic; *p. q.*, palato-quadrate cartilage; *M.*, Meckelian cartilage of lower jaw; *pa.*, palatopterygoid; *mx.*, maxilla; *d*, dentary of lower jaw; *c. h.*, ceratohyal; *op.*, operculum; *br.*, branchiostegal ray; *s. cl.*, supra-clavicular; *p. cl.*, post-clavicular; *cl.*, clavicle; *i. cl.*, infra-clavicular.

Fig. 2. Palatoquadrate arch of the same Fish with the jaws, seen from the inner aspect: *L. M.*, levator muscle of the lower jaw (removed in the preceding figure); *sp.* splenial element of lower jaw. The other lettering as in Fig. 1.

Fig. 3. Tail of *Polyodon folium*. From a dried specimen.

Fig. 4. *Elonichthys striolatus*, Agass., sp., natural size, from a specimen from Burdiehouse, in the Hugh Miller Collection, Edinburgh Museum of Science and Art.

Fig. 5. Dorsal fin, natural size, of a larger specimen from Kingscraig, Fifeshire, in the Museum of the New College, Edinburgh. The fin is so split that the internal surface of the left set of demirays is that which is exhibited.

Fig. 6. Outer sculptured surface of some of the rays of the anal fin of the same specimen, magnified 4 diameters. From a squeeze in modelling wax.

Fig. 7. Right ramus of the lower jaw, with remains of branchiostegal rays, of a specimen from Burdiehouse in the Hugh Miller Collection. Enlarged 2 diameters.

Fig. 8. Two teeth from the counterpart of the same specimen, enlarged 10 diameters.

Fig. 9. One of the large scales (enlarged 2 diameters) in front of the dorsal fin of the specimen from Kingscraig, from which Figs. 5 and 6 were taken.

Fig. 10. The large scales in front of the anal of the same specimen, also enlarged 2 diameters. The two lateral scales are displaced.

Fig. 11. One of the highly ornate scales from near the nape of the neck in a specimen from Burdiehouse, magnified 6 diameters.

Fig. 12. Scale from the flank of the large specimen from Kingscraig referred to above, magnified 4 diameters. This illustrates the prevailing type of scale-ornament in this species.

Fig. 13. Under surface of a similar scale, enlarged 4 diameters.

Fig. 14. Scale from the tail-pedicle, before the commencement of the caudal fin, of the same specimen, enlarged 4 diameters.

Fig. 15. Under surface of a similar scale, also enlarged 4 diameters.

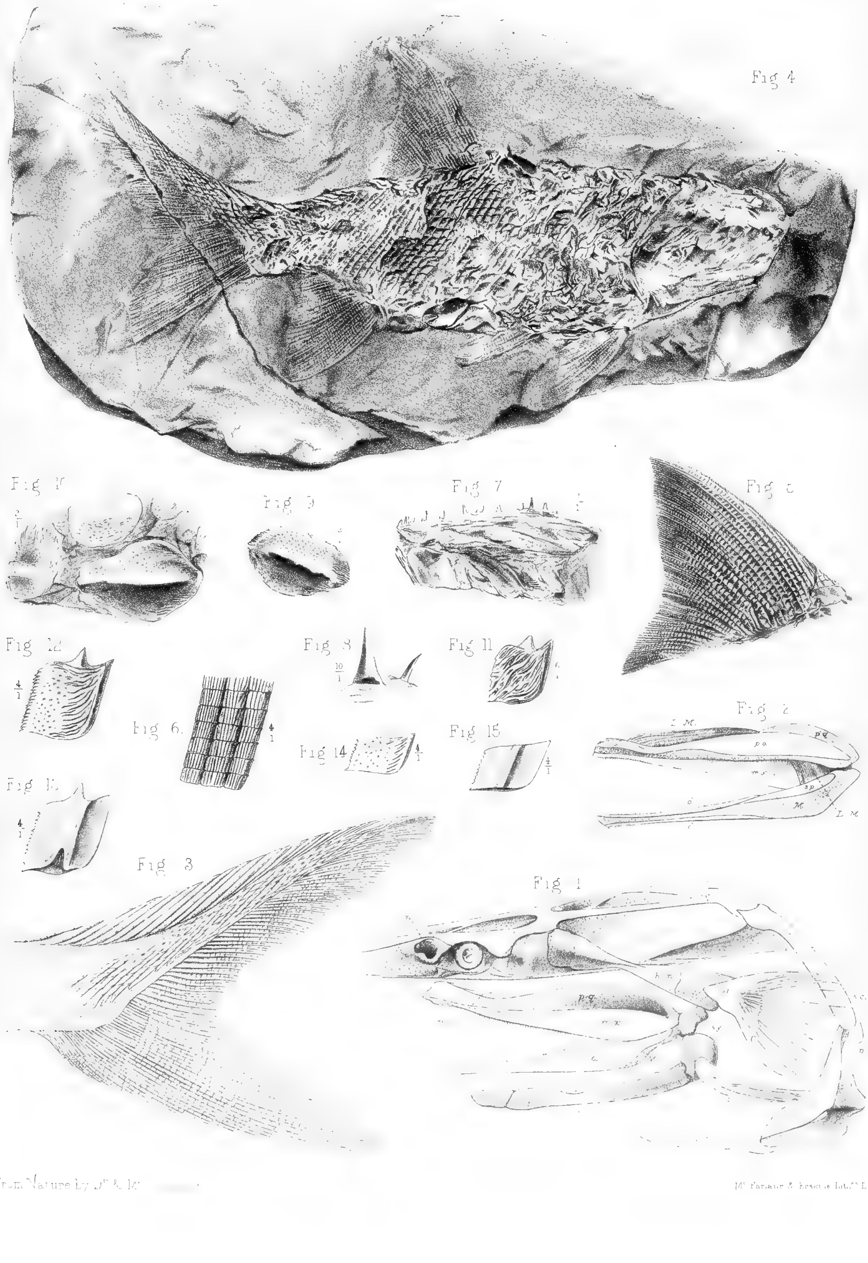


Fig 4
Fig 9
Fig 7
Fig 12
Fig 8
Fig 11
Fig 6.
Fig 14
Fig 15
Fig 2
Fig 3
Fig 1

THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

VOLUME FOR 1877.

LONDON:

MDCCCLXXVII.

MONOGRAPHS

ON THE

BRITISH FOSSIL

REPTILIA

OF THE

MESOZOIC FORMATIONS.

PART III.

PAGES 95—97; PLATES XXIII, XXIV.

(OMOSAURUS.)

BY

RICHARD OWEN, C.B., F.R.S.,

FOREIGN ASSOCIATE OF THE INSTITUTE OF FRANCE,

ETC. ETC.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1877.

PRINTED BY
J. E. ADLARD, BARTHOLOMEW CLOSE.

MONOGRAPH

ON THE

Genus *OMOSAURUS.*

(*Continued.*)

Species—*OMOSAURUS HASTIGER,* Owen. (Plates XXIII and XXIV).

If the grounds assigned in the former part of this Monograph[1] for the probable homology of the unsymmetrical spine figured in Plates XXI and XXII, which spine was found with the bones of the fore-limb of *Omosaurus armatus,* should be deemed to warrant such conclusion, a similar one may be provisionally accepted as applicable to the pair of spines of similar size and character discovered in the same division of the Kimmeridge Clay, in the Great Western Railway Cutting at Wootton Bassett, Wiltshire, briefly referred to at p. 68 of that portion of the Monograph.

Many large Saurian fossils were collected from the sections of Kimmeridge Clay at that time exposed; but none have reached me save the subjects of the present Monograph, which were there obtained by William Cunnington, Esq., F.G.S., and have passed with the rest of his collection into the possession of the British Museum. The apical portion of each spine has been broken away, but the degree of decrease from the base affords satisfactory grounds for the restoration given in Plate XXIV, the ratio of decrease being less in the present species than in the almost perfect spine of *Omosaurus armatus.*[2]

The base of the spine (ib., *b*) expands from the body, *a* (Plate XXIV), more suddenly and in a greater degree in *Omosaurus hastiger.* It is suboval in form and, as in *Omos.*

[1] Volume of the Palæontographical Society issued for the year 1875, p. 67.

[2] Ib., pl. xxi, figs. 1 and 2.

armatus, its plane is oblique to the axis of the spine. The long diameter of the base is 9 inches, the short diameter is 7 inches.

The articular surface is divided into two unequal facets by a low ridge of the base (Plate XXIII, fig. 1, *r*, *r*) parallel with the long diameter of the base; each facet is feebly convex lengthwise, less feebly concave transversely. The surface for attachment is roughened by low short ridges diverging from the long ridge, *r*, and is irregularly pierced by vascular canals; the borders are thick and irregularly notched.

The body of the spine is continued more directly from one end (Plate XXIV, figs. 1, 2, 3) of the oval base, *a*, fig. 2, sloping and expanding more gradually to the opposite end of the base, *b*, fig. 2.

The body of the spine is a full oval in transverse section (ib., fig. 4), pointed at each end, where the two opposite edges, *d*, *e*, are cut. The anterior edge (fig. 1, *d*), begins about 6 inches beyond the anterior produced part of the base; the posterior edge (fig. 3, *e*) begins about 2 inches from that end of the base. Both edges extend along the preserved portions of each spine, and were probably continued to, or near to, the pointed end. An additional advantage as a lethal or piercing weapon must have been derived from this two-edged structure.

In the right spine (fig. 1) the length preserved is 14 inches; in the left spine (fig. 3) the length preserved is 10 inches. Each spine may be estimated to have been upwards of 20 inches in length when entire.

The transverse section taken from the broken end of the left spine (fig. 4) gives 4 inches and $3\frac{1}{4}$ inches in the two diameters: the broken end of the better preserved spine gives 3 inches and $2\frac{2}{3}$ inches in the two diameters; the spine approaches to a circular section as it nears the pointed end. The texture of the outer inch is a compact bone susceptible of a high polish; it becomes finely cancellous within a few lines of the central cavity, the section of which at the part cut, viz. $8\frac{1}{2}$ inches from the base of the spine, gives 1 inch 6 lines, and 1 inch 3 lines, in the long and short diameters.

The close correspondence of the present fossil in general form, in basal modifications for attachment, and in texture, with the spine, probably left carpal, of *Omosaurus armatus*, will be obvious on comparison of Plates XXIII and XXIV with Plates XXI and XXII of the former part of this Monograph, treating of that species; and such correspondence may be deemed to support the provisional reference of the carpal (?) spines from the Kimmeridge Clay of Wootton Bassett to the same genus as that from the Kimmeridge Clay of Swindon; they manifestly indicate a distinct species on the above hypothesis of their nature.

The osseous core of the carpal spine in *Iguanodon* ('Wealden Reptilia,' Sup., No. 4, Pal. vol. for the year 1871, issued in 1872, Plate II, fig. 2) differs chiefly in its relative shortness or speedier diminution from the base to the apex.

After a comparison of these fossils with all the examples of carpal and tarsal spines in existing vertebrates, I found the nearest resemblance to the basal expansion, by which the spine of *Omosaurus* has been attached, in the tarsal spine of the Platypus (*Ornithorhynchus paradoxus*, Plate XXIII, fig. 2, twice natural size). There was the same proportion of breadth to the body of the spine; the same sudden expansion to form the base; the same medial rising in the long axis of the base, and furrows extending therefrom to the margin. But these radiating furrows are more numerous, and the spine, though it is hollow as in *Omosaurus*, has that cavity converted by terminal apertures into a canal, and this canal is traversed, as in the poison-fang of certain Ophidian Reptiles, by the duct of a gland. The affinity shown by the Monotrematous Mammals to the *Reptilia* in certain parts of the skeleton is well known, and is closer in the structure of sternum, coracoids, and clavicles, than in any Bird.

PLATE XXIII.

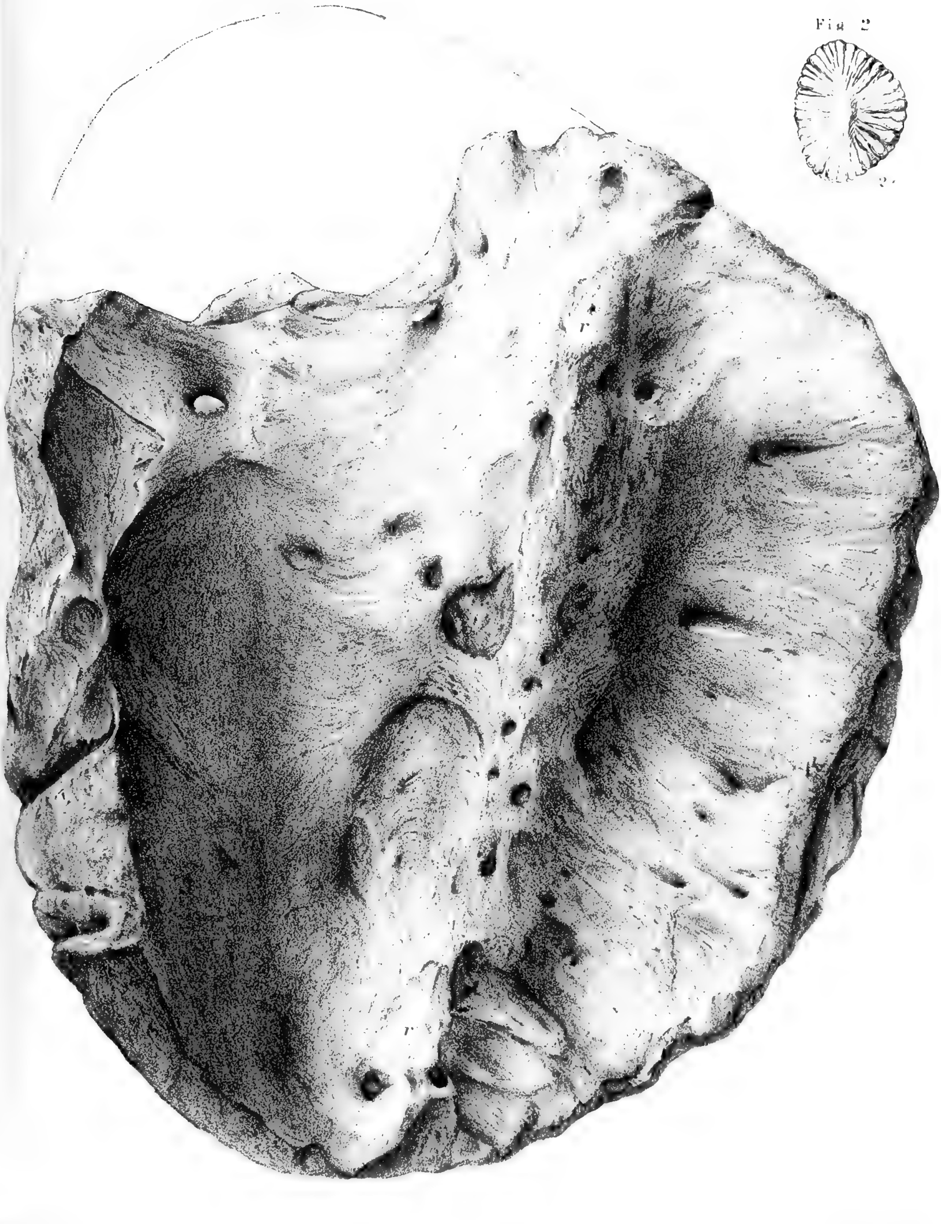
Omosaurus hastiger.

Fig. 1. Articular surface of base of carpal spine : nat. size.
Fig. 2. Articular surface of base of tarsal spine of *Ornithorhynchus paradoxus*, magn.

The fossil is from the Kimmeridge Clay of Wootton Bassett, Wiltshire. In the British Museum.

Fig 1.

Fig 2



Omosaurus hastiger

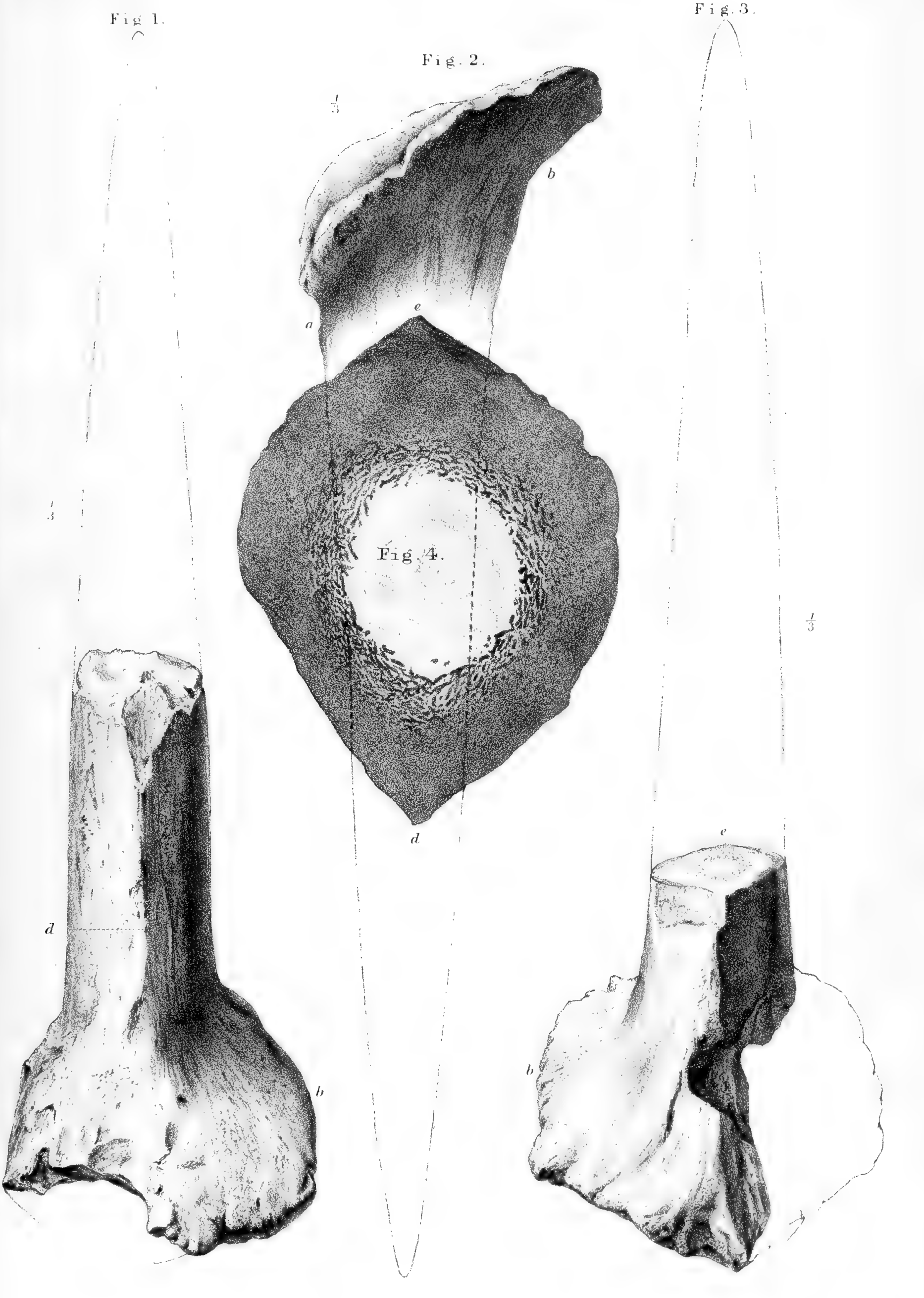
PLATE XXIV.

Omosaurus hastiger.

Fig.

1. Basal portion of right carpal spine, completed in outline: one third nat. size.
2. Side view of basal portion of right carpal spine, completed in outline: one third nat. size.
3. Basal portion of left carpal spine, completed in outline: one third nat. size.
4. Transverse section of body of left carpal spine, taken one third from the articular base: nat. size.

From the Kimmeridge Clay of Wootton Bassett, Wiltshire. In the British Museum.



L. Griesbach del. et lith. Mintern Bros. imp.

Omosaurus hastiger.

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MONOGRAPH

ON THE

BRITISH FOSSIL

ELEPHANTS.

BY

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PART I.

DENTITION AND OSTEOLOGY OF ELEPHAS ANTIQUUS (*Falconer*).

Pages 1—68; Plates I—V.

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1877.

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MONOGRAPH

ON THE

BRITISH FOSSIL ELEPHANTS.

ELEPHAS ANTIQUUS.

I.—INTRODUCTORY.

THE history of the discovery of the remains of the Elephant described in this Memoir has been narrated by Dr. Falconer in his masterly essay on 'The Species of Mastodon and Elephant occurring in the Fossil State in Great Britain.'[1] It seems important here, however, to indicate certain points in connection with the discovery. Up to the year 1844 all remains of Elephants met with in the Tertiary formations of the British Islands were considered to belong to the *Elephas primigenius*.[2] At that time Dr. Falconer was engaged in arranging and describing the rich harvest of Tertiary Vertebrata collected by himself, Sir Proby Cautley, Mr. Fraser, and others, in the Tertiary beds of the Sub-Himalaya and river deposits of Central India. During the preparation of the 'Fauna Antiqua Sivalensis,' which began to be issued during the following year, he was struck with the resemblance between molars from India and certain teeth of Elephants found in the Norwich Crag and deposits of the Thames Valley; moreover, it seemed to him that the molars from the Thames Valley agreed with similar teeth discovered by Nesti in Tuscany as far back as 1808. It is asserted, however, by Dr. Falconer that at that time he was not sufficiently conversant with the foreign specimens; inasmuch as, instead of connecting the Norwich Crag molars with those from the deposits of Tuscany, he made a mistake and correlated the molars from the Thames Valley and the latter under the name *Elephas meridionalis* of Nesti, whilst to the owner of the teeth from the older British strata he gave the name of *Elephas antiquus*. This mistake, unfortunately, was perpetuated in the representations of the two species published in the 'Fauna Antiqua

[1] 'Journal Geological Society of London,' vols. xiii, xiv, and xxi, reprinted in the 'Palæontological Memoirs of the late Dr. Falconer,' vol. ii.

[2] Owen, 'British Fossil Mammals,' p. 232.

Sivalensis;' it has, however, been fully pointed out by himself,[1] and corrected in the descriptions of the plates.[2] It may be further stated that the so-called *Elephas priscus* of Goldfuss, which Dr. Falconer considered was represented by certain molars from the Thames Valley,[3] was subsequently withdrawn by him in consequence of more extended researches establishing these teeth as being only a variety of the grinder of *Elephas antiquus*.[4]

In connection with the discovery and description of the species of Elephant under consideration, I have to observe that the first portion of Dr. Falconer's essay on the British Mastodon and Elephant referred to, was published in 1857, and the second part, after his death, in 1865.[5] The latter is so far imperfect that it does not contain the description of the entire dentition of the *Elephas primigenius*, nor any observations on the *Elephas antiquus*, which, however, in the form of note-book entries, have been published by the editor of his Memoirs.[6] These jottings of the author appear, however, to have been written prior to the latest impressions he had formed with reference to the characters of certain molars in foreign museums, which on more matured experience he conceived did not belong to *Elephas antiquus*.[7]

The flood of light thrown on the study of fossil Proboscidians by the late Dr. Falconer shines nowhere more clearly than on the molars of British fossil Elephants; inasmuch as, through the splendid discoveries made by him in the Tertiary formations of India, he received the impressions which led him to apply his inductions to European forms, and with what measure of success his masterly expositions amply show. It is to be regretted, however, that he has left no detailed account of the *Elephas antiquus* beyond "note-book entries" and a few impressions dispersed throughout his various essays. With the view, therefore, of supplying a desideratum in fossil zoology, I have attempted to bring together the results of an extensive acquaintance with such proboscidian remains as appear to me to belong to this Elephant. I have also compared them, as far as opportunities would permit, with associated and allied teeth and bones of other forms of British and foreign Elephants.[8]

It may be observed here that to attempt to draw a sharp line between molars of one

[1] 'Pal. Mem.,' vol. ii, p. 108.

[2] Idem, vol. i, p. 438, *et seq.*

[3] Idem, vol. ii, p. 94, and 'Fauna Antiqua Sivalensis,' pl. xiv, figs. 6 and 7.

[4] Idem, vol. ii, p. 251 (Note 1).

[5] 'Jour. Geol. Soc. London,' vols. xiii, xiv, and xxi.

[6] Vol. ii, p. 176.

[7] 'Pal. Mem.,' vol. ii, p. 249.

[8] The illustrations in the 'Fauna Antiqua Sivalensis' are here referred to whenever the original specimens have been examined by me. Of course, in comparing the figures with the text in that monograph the error in nomenclature pointed out above should be always borne in mind, and this will be best attained by having recourse to the description of the plates in the 'Palæontological Memoirs of the late Dr. Falconer,' compiled and edited by Dr. Murchison, F.R.S.

species of Elephant and another is impracticable in several instances; for example, although the ordinary true grinder of the Mammoth, *E. antiquus*, and *E. meridionalis*, can be easily distinguished when entire and the crown-sculpturing fully developed; still, there are varieties of crowns in these and other species barely distinguishable from one another. In making this statement I by no means desire to advance an opinion that the above-mentioned forms are mere varieties of one species of Elephant, such as is usually understood by the term species. At the same time, considering the conditions under which Pliocene and Pleistocene Elephants existed as compared with their living representatives, it seems to me that their dentitions and osteologies are likely to exhibit more extensive modifications; indeed, the variability in connection with the dental materials, here referred to *E. antiquus*, has no equal, as far as I am able to discover, in the dentition of either of the two recent Elephants.

In the 'Synoptical Table of the Species of Mastodon and Elephant' published by Dr. Falconer in 1857[1] he divides the Genus Elephas into the sub-genera Stegodon, Loxodon, and Euelephas, and characterises each sub-genus by certain dental peculiarities. The *Elephas antiquus* is included, along with *E. primigenius*, *E. Indicus*, *E. Columbi*, *E. Armeniacus*, *E. Namadicus*, and *E. Hysudricus*, in the last sub-genus, which is split up into four groups, in the second of which he places the *E. antiquus* and *E. Namadicus*.

The definition of the sub-genus Euelephas by the author is—"Dentium molarium 3 utrinque intermediorum coronis lamellosa colliculis deinceps numero auctis, anisomeris, attenuatis, compressis. Præmolares nulli."

The dental characters common to the *Elephas antiquus* and *Elephas Namadicus* are —"Colliculi approximati medio leviter dilatati, machæridibus undulatis."

With reference to these distinctions, as peculiar to the *E. antiquus* and *E. Namadicus*, although general, they cannot be accepted as invariable, as is shown by the admission subsequently, by the author, of the loxodontine type of *E. priscus* as a variety of the above, and the absence of central dilatation in the "broad-crowned" variety of the *Elephas antiquus*. Indeed, central expansion and angulation, as will be shown in the sequel, are occasionally met with in certain molars of all or nearly all the living and extinct Elephants hitherto discovered; moreover, these, as well as the other characters, are shown in all the Maltese fossil Elephants which Falconer correlated with the Loxodontes,[2] but now from data I have furnished elsewhere they come closer to the Eulephas or the anisomerous ridge formula.[3]

The close affinities between *Elephas antiquus* and the *Elephas Namadicus* seem to have been the cause of Dr. Falconer first calling in question the teeth from British strata, which had been hitherto correlated with those of the Mammoth; indeed, looking to the figures and descriptions he has left behind him, it seems to me remarkable that he

[1] 'Pal. Mem.,' vol. ii, p. 14. [2] Idem, p. 298. [3] 'Trans. Zool. Soc. Lond.,' vol. ix, p. 36.

hesitated in considering these two Elephants different in any respects, at all events, as far as their dental materials are comparable.

The general characters of the molars of *E. antiquus* are differentiated as follows:—The crown is narrow in comparison with the length and the height. This is apparent in the "broad" and "thick-plated" crowns, and is pronounced in the more common British specimens, or, in other words, what is named the "narrow crown."

There is usually in upper, and almost invariably in lower molars a slight central expansion of the disk with or without a small angular dilatation (Plate III, fig. 1). The crimping or festooning of the enamel varies. It is excessive in many members of the long narrow crown, less so in the thicker plated variety, and often faintly indicated in broad crowns where the disks are packed close together and nearly parallel, with little or no mesial expansion. This latter description of molar has been often mistaken for that of the Mammoth and also of *E. meridionalis*. It is found with the Forest-bed remains on the Norfolk coast and elsewhere; indeed, unless in entire teeth there will be a difficulty in distinguishing well-worn fragments of all these forms. The broad crown is, moreover, the characteristic type of *E. Namadicus* and of many huge molars found in the Tertiary strata of Southern Europe.

The degree of "crimping," as it has been called, of the enamel on the worn disk, whereby this vertical plaiting presents an uneven aspect, varies very much in different forms of Elephants; and it is important in estimating the amount of crimping in any one instance to bear in mind that the same tooth will show considerable discrepancies in that respect according to the circumstances whether or not its crown is just invaded and the digitations of the laminæ are not ground down, or when half-worn or when nearly worn out. This is at once evident from the examination of a single plate. Again, the central expansion and angulation of the disk will be found also to be affected in the same way, so that only by abundant materials and by fully estimating these points can a satisfactory judgment of the characters of the tooth be formed.

The crown of the molar of the Elephant, considered in the light of a masticating apparatus, has been fully discussed by Dr. Falconer in his essay on the 'American Fossil Elephant.'[1]

The degree of crimping of the enamel, the thickness, configuration, and number of the laminæ, vary immensely in the different forms of elephants. The narrow and fluted disk of the Asiatic, and the wide rhomb-shaped and more sparsely crimped disk of the molar of the African Elephant, represent extremes—modifications of which are displayed by several distinct forms, including that now under consideration.

It has been asserted by Falconer and others that the fluted crown indicates a graminivorous diet, whilst the broad uncrimped disk suggests arboreal verdure, as exemplified by the African Elephant,[2] and perhaps to some extent these views may be

[1] 'Natural History Review' for January, 1863, and 'Pal. Mem.,' vol. ii, p. 277.

[2] Baker's 'Albert Nyanza,' vol. i, p. 275.

correct. At the same time, considering the smooth, narrow, and aggregated disks of the Mammoth and the Arctic distribution of the animal, and that, in all probability, pine and other trees of woody fibre constituted the staple food of the denizens of the boreal regions, it seems that the fluted enamel would have been better adapted for the attrition of the twigs of timber trees and such like evergreen forest vegetation of high latitudes.

The evidences on which the presence in Pliocene and Pleistocene deposits, both in Great Britain and elsewhere, of the so-called *Elephas antiquus* have been hitherto confined, as far as the former is concerned, to England and Wales, whilst molars, apparently undistinguishable from remains found in British strata, have been identified by competent observers from similar formations in Belgium, Germany, Spain, France, Switzerland, Italy, and Sicily.

Reverting to the distribution of the species in the British Islands, there is no evidence, therefore, as far as is known to me, of any remains of *Elephas antiquus* having been met with in Scotland or Ireland; indeed, the cavern deposits of Kirkdale and Settle Caves of Yorkshire mark the northern limits at present. The molars on which its specific characters are chiefly established have therefore been discovered throughout England and Wales, from Yorkshire to the English Channel, and from Wales eastward to considerable depths on the sea-bottom of the German Ocean.

Stratigraphically the evidences of the existence of the species have been obtained from the pre-glacial deposits of the coast of Norfolk and Suffolk, and from more recent river and estuarine beds, and from cavern and fissure deposits. Before proceeding to an enumeration of the particular localities from whence remains have been determined, it appears necessary to observe that, although abundant traces of this form of Elephant have been met with in England, it would seem from exuviæ that the species was *par excellence* South-European; at all events, negative testimony points to the fact that, whereas its congener, the Mammoth, has left unmistakable proofs of its residence in the boreal regions of the Old and New Worlds, not a single instance of the existence of the so-called *E. antiquus* has yet been adduced from any continent or locality north of the 54th parallel of latitude in North-Western Europe; moreover, although there are cogent proofs of the Mammoth having ranged as far south as Spain and Central Italy, it would seem that the *E. antiquus* was the more common. At the same time, as in not a few instances in England, the elephantine remains of continental collections have been erroneously ascribed to the Mammoth. Indeed, little has been added since Falconer's time to our knowledge of the European distribution of the species I am now considering; inasmuch as palæontologists have been slow to admit that the evidences furnished by the teeth were sufficient to separate the aberrant from the typical molar, which, until Falconer's differentiation, had been considered to be only varieties of that of the Mammoth.

It appears from the evidences adduced in connection with the Pre-glacial deposits of the east coast of England and the river deposits of Northern Italy that the *Elephas antiquus* and *Elephas meridionalis* were contemporaneous, whilst, on the other hand, as far as yet known, there is no positive proof that the Mammoth existed in England prior to the Glacial period, but it is assumed that teeth have been found in Scotland in peat underlying the Boulder-clay.[1]

Again, there is abundant evidence to show that the *Elephas antiquus* and *E. primigenius* were contemporaneous in Europe during the Pleistocene epoch, and that, at all events, the Mammoth survived up to the human period.[2]

As regards associated animal remains the *E. antiquus* has been met with in conjunction with nearly all the Pleiocene mammals usually considered Pre-glacial,[3] and it has been also associated with all or nearly all the Pleistocene fauna of the caves and river deposits of England and Wales.[4]

Molars and bones referred to *Elephas antiquus* have been washed ashore, dredged, or removed from the so-called "elephant and forest beds"[5] at various parts along the eastern coast—to wit, Happisborough (1, 2), Cromer (1, 2), Ostend (1, 2), Easton (1, 2), Clacton (1, 2), Southwold, Mundesley (1), Harwich (1), Felixstowe, Yarmouth (1), Bacton (1, 2), &c. Abundant dental and other exuviæ of this Elephant have been met with in the gravels and brick earths of the Thames Valley at various points, in particular at Grays Thurrock (1), Erith (1), Ilford (1), Slade Green (1), London (1), Brentford (1), Abingdon, Wytham, Henley Bottom, Ballart Pit, Culham (1), Oxford (1), &c.[6]

It has been determined also from similar deposits in the valley of the Ouse (1), at Cambridge, near Huntingdon (1), at Aylesford (1), Canterbury, Bracklesham Bay (1), Copen Hall in Cheshire, Peterborough, Lawford (1), Rugby, Barrow-on-Soar, Lexden near Colchester, Stoke, Saffron Walden, Peckham in Surrey, Oundle (1) in Northamptonshire, Walton (1) in Essex.

Remains of *Elephas antiquus* have been determined from the following caverns and rock fissures of England and Wales:

In caves of Kirkdale, Victoria, Raygill, and North Cliff, in Yorkshire; Bleadon Cave (1), Mendip Hills (Falconer); Cefn, North Wales (Falconer); Bacon's Hole, Crow Hole,

[1] Bald, 'Memoirs Wernerian Society,' vol. iv, p. 64. The remains discovered at Belturbet, in Cavan, Ireland, have been inferred to have been of the same age, 'Philosophical Transactions,' vol. xxix.

[2] 'Lubbock on the Origin of Civilisation,' p. 30; Tiddeman, 'Report on Victoria Cave;' 'Reports of British Association for the Advancement of Science,' 1874 and 1875; Busk, 'Journal Anthropological Institute,' vol. iii, p. 392.

[3] 'Falconer's Palæontological Memoirs,' vol. ii, p. 471.

[4] Dawkins, 'Jour. Geol. Soc. London,' vol. xxv, p. 210.

[5] See 'Jour. Geological Society,' vol. xxvi, p. 552, and vol. xxxii, p. 123. The Rev. John Gunn, F.G.S., than whom no one is more entitled to an opinion on this point, asserts that from his large experience he is of opinion that remains of *E. meridionalis* and *E. antiquus* are met with in both of these beds, but that in the "Elephant Bed" the former prevails, whilst exuviæ of the latter elephant are more plentiful in the "Forest Bed."

[6] (1) Indicates the remains of *E. primigenius*, and (2) that remains of *E. meridionalis* have also been discovered in the same situation, although it is not established in all instances that the exuviæ were derived from the same beds.

Long Hole (1), Minchin Hole, Raven's Cliff, Spritsail Tor (1) in Glamorganshire (Falconer); Durdham Down (1) in Somersetshire (Falconer); Portland Fissure, in Dorsetshire (Busk); Castletown Bone Caves, Staffordshire (Dawkins).

II.—DENTITION.

The classification of Elephants, founded on the number of laminæ and the relative proportions and structure of the enamel, dentine, and cement, has received valuable exponents in the divisions instituted by Falconer into the sub-genera Stegodon, Loxodon, and Eulephas; moreover, believing in the persistency and uniformity of the characters of molar teeth through seemingly vast intervals of time as displayed in the Mammoth,[1] he formulated the colliculi in the successive teeth, and maintained their specific constancy within a moderate range of individual variation. He did not admit intermediate forms, and therefore viewed the dentition as broadly distinctive of species. It seems to me, after a critical examination of the dental materials of Proboscidea, that a rigorous adherence to numerical formulæ as regards the molars of Elephants in general and *Elephas antiquus* in particular as established by Dr. Falconer is incompatible with the results furnished by a close analysis of abundant specimens; indeed, as regards the very variable characters of the molars of the Elephant under consideration, it will be evident that they present very close affinities in all available characters to other teeth at present considered as belonging to distinct species, and consequently the susceptibility of mutation must be considered as an important etiological fact in the genesis of the species.

In estimating the number of ridges entering into the composition of a molar it has been the habit with several observers to eliminate the talon ridges, and only include the laminæ which arise from the common base. Now, as the proximal and distal ridges vary very much in size and configuration, it is apparent that the rejection of any single ridge however dwarfed or insignificant must greatly interfere with the accuracy of a ridge formula established from a large assortment of materials. I have, therefore, in the following included talon ridges at all worthy of the name, whether arising from the common base or from a plate.[2]

1. INCISORS.

I can find no reference anywhere to the milk incisor of *Elephas antiquus* either in museums or in published accounts. It seems to be unknown. Whether, therefore, like the

[1] Essay on the American fossil Elephant, 'Pal. Memoirs,' vol. ii, p. 252; also 'Natural History Review' for January, 1863.

[2] In giving the ridge formula I have carried out the method adopted by Dr. Falconer and others of making "x" represent the talon.

African and Maltese forms,[1] it was tipped with enamel or not remains to be shown. Indeed, the permanent tusk has yet to be identified, and this is the more remarkable considering the quantities of its grinders which are constantly discovered in British and European deposits. Professor Boyd Dawkins[2] and Mr. Davies[3] are disposed to believe that it was nearly straight; the latter describes a long tusk four feet two inches in length from ILFORD, and I have seen a similar straight or nearly straight tusk from WALTON in ESSEX, in the University Museum, Oxford; but considering how plentiful are the incisors of the Mammoth and the enormous quantities dredged up or exposed by the sea on our eastern coasts, it appears strange withal that only one description of tusk should turn up, that is, supposing the defensor of the *Elephas antiquus* differed very much in contour from that of the *E. primigenius*. The degree of curvature evidently varied in the latter, and no doubt as occasionally happens in the recent species, now and then an abnormality in the degree of curvature took place which would include probably the instances above mentioned. Moreover, the dimensions of full-grown incisors seem to vary considerably in what appear undoubted tusks of the Mammoth, and occasionally there are instances of much arcuation in defensors of the recent Elephants. There is a pair of tusks, No. 2753, in the Hunterian Museum of the Royal College of Surgeons of England of the Asiatic Elephant, fully as much curved as the usual tusk of the Mammoth, and I have seen similar examples of the African Elephant's incisor, whilst perfectly straight specimens are also not rare.

The enormous tusk from the pre-glacial deposits of the Norfolk coast in the Gunn Collection, Norwich Museum, has been considered by Falconer on account of its size and slight curvature to have belonged to *E. meridionalis,* the defensor of which, judging from the entire specimens in place in a skull at Florence, did not differ as regards contour from the generality in living elephants.

Dr. Falconer also refers to a tusk of *E. antiquus* eight feet in length from Bracklesham Bay, along with other remains of the same animal in the Chichester Museum. I find, however, that the latter specimen is broken in three places and otherwise considerably injured, so that its original contour cannot be determined with accuracy; but, judging from the fragments, I am informed by the curator Mr. Hayden that the degree of curvature does not appear to exceed that of the living species. Dr. Falconer also alludes to a tusk "seven feet long and rounded in section" in the museum at Syracuse,[4] but gives no further details with reference to its configuration.

In the Maltese fossil Elephants generally and in the largest form *Elephas Mnaidriensis,* with which and *E. antiquus* there is a very close dental and osteological assimilation, the permanent incisor partook of the configuration of the recent species.[5]

[1] Author, 'Transactions of the Zoological Society, London,' vol. ix, p. 8; and Falconer, idem, vol. vi, p. 284.

[2] Vol. xviii, Palæontographical Society, issued for the year 1864, 'Pleistocene Mammalia,' p. 35 (Introduction).

[3] 'Catalogue of the Pleistocene Vertebrata from Ilford,' p. 28.

[4] 'Pal. Mem.,' vol. ii, p. 188.

[5] 'Trans. Zool. Society of London,' vol. ix, p. 9.

2. MILK MOLARS.

Ante-penultimate Milk Molar.

The first milk molar, commonly called the ante-penultimate to distinguish it from the theoretical first, a pre-ante-penultimate milk tooth usually suppressed, is not common in collections.

There is a fragment of a left maxilla, No. 44,783, in the Palæontological Collection of the British Museum,[1] containing the ante-penultimate and penultimate milk grinders. The specimen, a late acquisition, was obtained with other elephantine remains by the late Mr. Bright from British strata, but the exact locality is unknown.

The ante-penultimate tooth is half worn; its sides are covered with a dense coat of cement, but the crown is entire and shows four ridges,[2] with the disks not sufficiently developed by wear to allow of their characters being fully ascertained. The ridges are thick, with more intervening cement than attains in the Mammoth. There are *two* fangs, a large posterior and a small anterior, which diverge at the distance of $\frac{4}{10}$ inch below the crown. The dimensions of this tooth are given in the following table, and reference will be made to the associated penultimate molar in the sequel.

Another detached unworn upper molar, No. 21,654, B. M., is represented, crown and profile, Plate I, figs. 1 and 1 *a*. It shows no trace of wear, and the fangs are not developed, consequently it must have belonged to a sucking calf or uterine individual. It is somewhat narrower than the last, and its greatest breadth is behind. The specimen is from the fluviatile deposits at Grays, Essex, so prolific in exuviæ of the Elephant in question. The thickness of the plates, the rugæ, and vertical ribbing on the enamel are diagnostic.

Two remarkably interesting and highly suggestive lower molars of this stage of the dentition were lately discovered in what are supposed to be pre-glacial deposits[3] in the Victoria Cave, Settle, Yorkshire. Both have lost the extremities of their fangs, but are otherwise perfect, and appear to have belonged to the same individual. The fang of the left tooth being the more entire, I have selected it for illustration at Plate I, figs. 2 and 2 *a*. The crowns are narrow in front and broad posteriorly; the penultimate ridge

[1] For the sake of brevity the letters B. M. after a number indicate that the specimen is in the British Museum.

[2] The term "ridges" is applied throughout to all the enamelled laminæ of a tooth, including talons. The measurements here given, unless otherwise indicated, are in English inches and tenths of an inch.

[3] 'Second Report on the Exploration of the Settle Caves;' 'Report of the British Association for the Advancement of Science' for 1874. I am indebted to Mr. Tiddeman, F.G.S., for permission to represent the above teeth; he has been also kind enough to permit me to examine the other molars of *E. antiquus* lately discovered in the Settle Caves.

has four digitations with a small flattened posterior talon, the anterior talon being single and conical. There are altogether five ridges. Here, again, the thick plates with rugæ and ribbing of the enamel are well shown; the crown displays faint traces of wear. The thickness of the ridges in all of these molars is out of proportion with that of the Mammoth, and is even thicker in comparison than in the same tooth of the Asiatic, but agrees in this respect with that of the African and Maltese fossil Elephants.[1]

It will be seen, moreover, that they are only slightly larger than the equivalent molars of the *Elephas Mnaidriensis* with which, and possibly the other forms of Maltese fossil Elephants, they agree in often possessing a compressed connate fang, at all events in lower ante-penultimate molars. Unfortunately the extremities of the fangs are wanting, but for the distance of $\frac{9}{16}$ths of an inch below the crown it is single, with a constriction down either side, forming two shallow grooves, which on a transverse section of the root divide the cavity into a large posterior and a smaller anterior hollow, equivalent to the posterior and anterior fangs in the upper molars (No. 44,783, B. M., just described). It would seem, however, that there was a bifurcation at *x*, fig. 2 *a*, inasmuch as the excentral depression is deeper at that point, and there is just an indication of a divergence on the anterior side close to the line of fracture. I think it likely, therefore, that the teeth may have been slightly furcate at the extremities of the fangs.

As compared with the lower ante-penultimate molar of the Asiatic Elephant, No. 2811 of the Osteological Collection, in the Royal College of Surgeons of England, it will be seen that the fangs diverge in the latter to form a large posterior and a smaller anterior fang. In connection with the connate condition of the fang I have been unable to ascertain if a similar condition exists in the same member of the series in the *E. meridionalis* and *E. primigenius*. Dr. Falconer makes no mention of the circumstance in describing their ante-penultimate molars;[2] judging, however, from the alveolar socket in a mandibular ramus, No. 33,403, B. M., of *Elephas primigenius*, there is evidence of two pits. I believe, therefore, whether an abnormality or natural condition, it is clear, as demonstrated by the above specimens and the Maltese molars I have described,[3] that Mr. Busk's view with reference to the connate condition in the Maltese fossil molar, referred to by Falconer, has been thoroughly substantiated,[4] and thus, as far as evidence extends, the character establishes an important relationship between the *Elephas antiquus* and the Maltese forms. It will be interesting to notice how far the data will stand the test of further comparisons.

The ante-penultimate milk molar varies in length and number of ridges in *E. antiquus*, as will be seen is the case also in the other species wherever sufficient materials have been obtained for comparison; and, as also obtains in this molar and in all members of the dental series, the maximum number of ridges is very generally found in the lower

[1] 'Trans. Zool. Soc. London,' vol. ix, p. 10, pl. i, figs. 3—6; and vol. vi, p. 286, pl. liii, fig. 2.

[2] 'Pal. Mem.,' vol. ii, pp. 114 and 161.

[3] 'Trans. Zool. Soc. London,' vol. ix, p. 10.

[4] Ibidem, vol. vi, p. 286 (footnote).

jaw. As far as data extend, the ridge formula of the first or ante-penultimate milk molar agrees pretty closely in all known fossil and recent species; the usual number in upper teeth varying from four to five ridges, and in lower from four to six. The largest known number occurs in the Asiatic and African Elephants and Mammoth. As will be seen by comparison with other species recorded in the following table, this member of the series in *E. antiquus* holds from two to three plates, exclusive of the fore and hind talon, in upper molars, and three plates and two talons in the lower jaw; but no doubt exceptions will turn up, as variability is a marked feature in the dental morphology of the species.

Table of Comparisons between the Ante-penultimate Milk Molars of Extinct and Recent Elephants.

	U. upper; L. lower.	Plates; talons *x*.	Maximum length and breadth of crown.	Remarks.
Elephas antiquus...	U	*x* 2 *x*	0·8 × 0·7	No. 44,783, B. M., p. 9.
	U	*x* 3 *x*	0·9 × 0·7	No. 21,654, B. M., pl. i, figs. 1, 1 *a*, p. 9.
	L	*x* 3 *x*	0·7 × 0·4	Right and left; Victoria Cave, Yorkshire, pl. i, fig. 2, 2 *a*, p. 9.
E. Mnaidriensis ...	U	*x* 2 *x*	0·5 × 0·4	'Trans. Zool. Soc. Lond.,' vol. ix, pl. i, fig. 3, p. 11.
	U	3 *x*	0·4 × 0·32	Ditto, vol. vi, pl.liii, fig. 2, p. 286.
	L	*x* 3 *x*	0·6 × 0·4	Ditto, vol. ix, pl. i, fig. 4, p. 12.
	L	*x* 3 *x*	0·55 × 0·3	Ditto, vol. ix, pl. i, fig. 5, p. 11.
E. Africanus[1]	U	*x* 3 *x*	0·9 × 0·6	Busk, 'Trans. Z. S. L.,' vol. vi, table, p. 307.
	U	*x* 4 *x*	0·9 × 0·68	
	L	*x* 2 *x*	0·8 × 0·6	
	L	*x* 4 *x*	1·0 × 75	
E. meridionalis ...	U	*x* 3 *x*	0·95 × 0·75	Falconer, 'Pal. Mem.,' vol. ii, p. 110.
	L	*x* 3 *x*	0·7 ×	Ditto, p. 114.
E. primigenius.........	U	4 *x*	0·8 × 0·7	Busk, 'Trans. Z. S. L.,' vol. vi, table, p. 307.

[1] The rare instance in collections of the first or pre-ante-penultimate milk molar is shown in the mandible of an African Elephant, No. 708 'Osteological Catalogue,' B. M., where a functionally developed first milk is seen on the left ramus in front of the ante-penultimate. The former is 0·6 × 0·4 inch in breadth, with a ridge formula of *x* 2 *x*, whilst the second milk holds the same number of ridges in a space of 0·85 × 0·6.

	U. upper. L. lower.	Plates; talons *x*.	Maximum length and breadth of crown.	Remarks.
E. Asiaticus[1]	U	*x* 3 *x*	0·7 × 0·5	Mus. Royal Coll. Surg. England.
	U	*x* 4 *x*	0·8 × 0·55	Busk, 'Trans. Z. S. L.,' vol. vi, table, p. 307.
	L	*x* 3 *x*	0·7 × 0·5	Mus. Royal Coll. Surg. England.
	L	*x* 4 *x*	0·75 × 0·45	Busk, 'Trans. Z. S. L.,' vol. vi, table, p. 307.

Affinities.—The first or ante-penultimate milk molar in the Mammoth is not, that I am aware of, represented in any collection, public or private, in Great Britain; and Dr. Falconer does not appear to have met with it, and surmises only as to its probable ridge formula,[2] so that his inferences are based on the strict concord which exists in the number of lamina of its successional teeth and of the Asiatic Elephant. It is of the utmost importance, however, with reference to *E. antiquus* and allied forms that comparisons should be drawn between the ante-penultimate milk molars in them and the Mammoth. It may be stated, as regards the teeth here referred to *E. antiquus,* that their discoveries in the fluviatile deposits at Grays Thurrock and in the Victoria Cave, irrespective of dental characters, are additional evidence of their connection with *E. antiquus,* seeing that the former has produced more molars of this Elephant, than perhaps any single locality in England, and the latter has furnished remains of *E. antiquus* only. Judging from what is known of the dentition of the Mammoth, it seems to me highly probable that its ante-penultimate milk molar will show a higher ridge formula and much more attenuated ridges than in *E. antiquus.*

This molar in *E. meridionalis,* according to Falconer, is "a broad oval, narrowest in front and broadest in the middle," with "very wide disks" and "thick enamel plates" in the upper jaw, whilst the lower molar is "much smaller and more compressed in front," and "cusp-shaped, like the corresponding tooth of the Sewalik" *E.* (*Loxodon*) *planifrons.*[3]

The same tooth in the Maltese fossil Elephants is quite like that of the *E. antiquus,* but is of smaller size.[4]

The ante-penultimate in the African is rather more robust ordinarily, but does not,

[1] I prefer Asiatic to Indian as a general designation for the animal of Asia, including the Hindee, Sumatran, Burmese, and Cylonese Elephants, on the score that they are only varieties of one Continental species.

[2] 'Pal. Mem.,' vol. ii, pp. 159 and 161.

[3] 'Pal. Mem.,' vol. i, p. 21 (Note), vol. ii, pp. 110 and 114, and 'Fauna Antiqua Sivalensis,' pl. xii, figs. 1, 1 *a,* 1 *b.* The close affinities between the *E. meridionalis* and *E. planifrons* on the one hand, and the *E. antiquus* and *E. Namadicus* on the other, were repeatedly pointed out by Falconer.

[4] 'Trans. Zool. Soc. Lon.,' vol. ix, p. 12, pl. i, figs. 3, 4, and 5.

as far as the few instances I have examined, differ materially from the same tooth in *E. antiquus*.

The ridges in the Asiatic Elephant are ordinarily but not always more numerous; they are, however, more attenuated than I have seen in similar teeth of *E. antiquus*.

It will be apparent from the Table that the ridge formula of x 3 x is often present in all the forms of Elephants I have referred to, and that generally the diagnoses are not likely to be so easily determined as in successional molars.

Second or Penultimate Milk Molar.

This member of the milk series varies considerably in dimensions and number of plates; besides, the crown constituents bear different ratios to one another. A thick-plated crown of unusually large dimensions is remarkably well shown in a specimen, No. 47,408, B. M., from Grays, Essex, where this *thick-plated* variety is usually met with. The tooth in question holds x 6 x in a space of 3·1 inches, and is 1·2 inch in breadth in front, 1·4 inch at the middle, and 1·6 inch behind. Only four of the anterior ridges are ground down for a short distance. This upper molar might be fairly placed with the last of the milk series but for its low ridge formula.

A good example of the tooth is seen *natural size*, Pl. I, fig. 3. It is a lower molar, and also from Grays, but the crown is narrow and holds x 6 x in a space of 2·6 inches. It is No. 18,810 of the Palæontological Collection, B. M. The central expansions, angulations (the crown is scarcely sufficiently worn to develop the latter), and excessive crimping on the one hand, the distances between the ridges, and height of crown on the other, are characteristic features of *Elephas antiquus*.

Another very good example of this tooth is seen in the fragment of the maxilla containing the penultimate milk molar referred to at p. 9. The jaw holds the two teeth, *in sitú*, and is numbered 44,783, B. M. Here there is an entire penultimate molar, showing only a ridge formula of x 5 x in 2·5 inches, with a maximum breadth of crown of 1·1 inch. Three of the anterior ridges are invaded. The specimen, as before observed, is from the Bright Collection, but its precise locality is unknown, although doubtless from British strata.

A large lower molar, No. 21,655, B. M., from Grays, Essex, holds x 7 x in 3 inches, with a maximum breadth (posteriorly) of 1·3 inches.

Besides the above there are many other excellent examples of this member of the series in the National Collection.

An upper molar from the Norwich Crag, Easton, Suffolk, holds x 6 x in 2·5×1·5 inches. The cement has been denuded in part from the plates, laying bare the *rugæ* so plentiful on the enamel of the tooth of *E. antiquus*, as compared with that of the Mammoth.

Another upper molar, No. 28,273, B. M., from Easton, likewise gives a similar number of ridges in 2·3 × 1·2 inches.

No. 27,991, B. M., from Clacton, although not entire, is a well-worn upper molar, and therefore distinctive as regards the crown pattern.

A well-worn upper molar, 40,952, B. M., from the cave of Raven's Cliff, Gower, has lost ridges by wear, leaving only six plates, which show the characteristic disk. The tooth is 2·3 × 1·4 inches.

The upper molar, 23,376, B. M., from Grays, is rather broad in front as compared with upper-jaw specimens; but perhaps in this instance the first true molar was also in wear at the same time, seeing that the latter preserves the anterior portion of the succeeding tooth from lateral detrition.

The upper tooth, 40,990, B. M., from Kent, is figured by Falconer;[1] and, although fragmentary, it is a good illustration of a molar commencing wear.

Among the recent discoveries in Victoria Cave, besides the aforementioned antepenultimate, there were two instances of the succeeding members of the milk series, both of which I have carefully examined. The penultimate is a right upper milk molar more than half worn. The cement has been denuded from the enamel, displaying the profuse elevated rugæ to an unusual degree. There is a distinct pressure mark on the posterior talon. The large posterior fang is 1·5 inch in length by 1· inch in breadth. The stumps of the two central fangs are in front of it, and the anterior ridges, ground down to the common base, are supported on a broad anterior fang 0·8 inch in breadth. All the ridges are in wear, and there is an evident loss of the anterior talon, whilst the disk of the succeeding ridge is worn out anteriorly. Altogether the ridge formula is 6 *x* in 2·1 inches, with a maximum breadth of crown of 1·2 inch. The average thickness of the plates is about 0·3 inch. The disks show the central expansion with the pronounced crimping of their machærides, and altogether the characters of *Elephas antiquus*. To me the above is a distinctive instance of the penultimate milk molars of the Elephant in question.

I am thus particular in indicating these points inasmuch as, with the foregoing and others I will refer to in the sequel, there cannot be a doubt that the remains from Victoria, Raygill, and Kirkdale Caves fix the most northern limits of the *Elephas antiquus* in the British Islands and in Europe, at all events, as far as I have been enabled to determine.

The mandibular teeth are represented by No. 47,407, B. M., from Grays. The molar is entire and of the left side, with the cement denuded, showing the ribbing very clearly. It holds *x* 6 *x* in 2·9 inches. The plates are not thick, and the crown is long and narrow.

In the British Museum there is a fragment of a left lower ramus, containing an entire penultimate milk tooth, No. 21,310, see Plate V, fig. 2. It is from the Thames Valley

[1] 'Fauna Antiqua Sivalensis,' pl. xiv A, figs. 1 and 1 *a*.

deposits at ILFORD. The crown is little worn, therefore the sculpturing is not pronounced; in consequence, Dr. Falconer could not make up his mind with reference to its specific characters.[1] The ridges, however, are thick, the crown is narrow as compared to the height, and it holds *x* 6 *x* in 2·7 inches, which are in favour of its connection with *E. antiquus.*

Two specimens in the National Collection, from BLEADON CAVE, in the Mendip Hills, each displaying a formula of *x* 7 *x* in 2·3 inches, are very characteristic of the lower penultimate milk molar of *E. antiquus.*

Mr. Fitch, F.G.S., of Norwich, has in his possession two distinctive lower molars, right and left, from the FOREST BED at Cromer. They hold *x* 6 *x* in 3 inches, and as usual are broad behind and narrow in front. The crowns are in full wear.

It is now well ascertained that all the determinable elephantine remains from KIRKDALE CAVE belong to *E. antiquus,* and not to *E. primigenius,* as was supposed prior to the differentiation of the characters of the former by Falconer. The tooth figured in the 'Reliquiæ Diluvianæ'[2] is, with others, in the Oxford Museum, and has been referred to by Falconer.[3] It shows the large ridge formula of *x* 8 *x* in a space of only 2·65 inches, but as elsewhere observed, the highest ridge formula does not necessarily carry a corresponding length of crown.

I have been unable to obtain references to specimens of the penultimate milk molar of *Elephas antiquus* in foreign collections.

Affinities.—The second milk tooth in the Mammoth ordinarily holds a ridge formula equal to the higher expression here given in connection with *E. antiquus.* The contour of the tooth also in the former partakes more of an oval than an oblong shape; consequently, the crown is relatively broader. It is the case, however, that individual instances may occur when it would be difficult to give a decided opinion. I believe, however, that in any member of the dental series a well-worn crown, perfectly entire as to ridges, will in practised hands, indicate to which of the two Elephants it belongs. The compressed laminæ with no well-defined rugæ on the enamel, and therefore an absence of crimping of the disk of wear, the breadth of the crown, as compared with the height of the ridges, and the high ridge formula will ordinarily suffice as diagnostic of this tooth, and, indeed, of all members of the series in *E. primigenius,* as compared with the Elephant in question.

This tooth in *E. meridionalis* is distinguishable generally by its comparative broader crown, more massive laminæ, with the crimping more exaggerated than in *E. antiquus,* and ridge formula of only *x* 6 *x*;[4] but it must be freely admitted that even well-worn crowns may be found presenting characters barely distinguishable from the same in the second milk molar of *E. antiquus,* especially its *thick-plated* variety.

[1] 'Pal. Mem.,' vol. ii, p. 179.

[2] Plate vii, fig. 1.

[3] 'Pal. Mem.,' vol. ii, p. 179.

[4] 'F. A. S.,' pl. xiv B, figs. 1 and 3, and 'Ossemens Fossiles,' pl. xv, fig. 4.

There is no available example of the second milk molar of *E. Namadicus* to compare with the teeth of *E. antiquus*.

In *E. Africanus* the second milk molar appears seldom to exceed a ridge formula of *x* 6 *x*, but no doubt exceptional instances do occur. The open disk and absence of pronounced crimping will ordinarily distinguish its teeth.

In *E. Asiaticus* the ridge formula is very much the same as in the Mammoth; and, excepting in the absence of the central expansion and angulation, which, however, are not always present in *E. antiquus*, there is little to distinguish individual second milk molars in the two forms. I suspect, however, that it is rare to find a tooth of this member of the series in the Asiatic Elephant with a smaller ridge formula than *x* 7 *x*.

The Maltese fossil Elephants represent in their second milk teeth all the characters of *E. antiquus* in much smaller Elephants. At the same time, as I have shown, individuals of the largest form (*E. Mnaidriensis*) possessed molars occasionally holding *x* 8 *x* in 2·4 inches.[1]

The diagnosis of the second milk molar in *E. antiquus*, although ordinarily well defined when the dental materials are well exposed, is not always easily determined. The tooth is subject to considerable variety with reference to the number of ridges; indeed, it seems futile to attempt to formulate an average. Dr. Falconer inferred that it ordinarily held five plates and two talons.[2] From the materials here furnished it would seem that *x* 6 *x* for the upper and *x* 7 *x* for the lower molar would be nearer the truth.

An analysis of the foregoing and of specimens mentioned by Falconer[3] and from other sources, I find that the ridge formulæ in upper molars vary from *x* 5 *x* to *x* 7 *x* in a space of from 1·9 inch to 3·1 inches, whilst in lower molars I find *x* 6 *x* to *x* 8 *x* in from 2·5 inches to 3 inches.

Third or Last Milk Molar.

The well-known similarity between the last milk and first true molar must always make it difficult to determine detached specimens of these teeth. In the *Elephas antiquus* and other members of the sub-genus Euelephas the true molars, in particular mandibular molars, are usually more arcuated than in milk teeth, and the crowns are broader.

The last milk molar of *Elephas antiquus* varies considerably in size and number of ridges, so that the maximum dimensions may attain to those of the succeeding tooth, and seeing that the ridge formula is about the same, there must of necessity be much uncertainty in the diagnosis.

A very characteristic example of the upper molar of this stage of growth is seen,

[1] 'Trans. Zool. Soc. London,' vol. ix, pl. i, fig. 14, and p. 16; see also figs. 7 to 16.

[2] 'Pal. Mem.,' vol. ii, p. 176.

[3] Idem., vol. ii, pp. 177 and 179.

natural size, in Plate I, fig. 4. This palate specimen, No. 21,301, B. M., is the one referred to in Dr. Falconer's notes.[1] It is from GRAYS, and holds nine plates and two talons, *i. e. x* 9 *x*, in a length of 5 inches, the maximum breadth of crown being 1·9 inch. These teeth are matched by another pair, No. 21,668, B. M., and 21,318, B. M., from the same locality. Each tooth holds *x* 9 *x* in 4·8 by 1·7 inch, with an average thickness per ridge of 0·5 inch. Another upper molar, 27,914, B. M., from CLACTON fresh-water deposits, is precisely like the foregoing in the number of ridges and length. It is scarcely necessary to dilate on the characters of these four examples. The angulation of the enamel of the disk so frequent in lower molars is not always present in the upper, but the tendency to central expansion is general, and, with crimping, narrow crown, and height of ridges, is very characteristic of the species.

The characters of the palate teeth are well seen also in the specimen in the Oxford Museum, alluded to by Dr. Falconer,[2] where *x* 10 *x* are contained in 5·3 inches. The tooth represented in the 'F. A. S.,' pl. xiv A, figs. 2 and 2 *a*, from SOUTHWOLD, holds 12—13 ridges in 5·5 inches. It is No. 8409 of the collection in the Geological Society of London. This tooth contrasts well as regards dimension with the upper-jaw specimens, figs. 3 and 3 *a* of the same plate, No. 18,789, B. M. The locality of the latter is unknown; it holds *x* 10 *x* in 6 inches. Dr. Falconer was uncertain whether to consider it as a large last milk or a small first true molar,[3] and the same doubts must be acknowledged by every experienced observer. There are imperfect upper molars, such as figs. 6 and 7 of pl. xiv A, 'F. A. S.,' the former from SUFFOLK, the latter from KENT; both are much worn and imperfect, so that they are of little use in establishing their positions in the dental series.

The mandibular teeth of this stage of growth are numerous; and wherever the jaw is preserved there is not much difficulty in assigning their proper places in the series.

In the fine collection in the British Museum there are seven excellent examples of the lower ultimate milk tooth. There is an entire lower molar in the Bright Collection, British Museum; the locality is unknown, but evidently from British strata; it holds *x* 11 *x* in a space of 5·9 inches. Like many beach specimens from the NORFOLK coast, it shows evident signs of rolling in the surf. The enamel is thin, and all the ridges excepting the last two are in wear. Similar specimens are numerous in the Layton Collection, also from the PRE-GLACIAL DEPOSITS of the EAST COAST. Thus No. 33,388, B. M., a right lower from HAPPISBOROUGH holds *x* 19 *x* in 5·6 inches. Here the ridges are broad, being each nearly 0·7 inch in thickness. No. 33,375, B. M., left lower from the same locality, like the last, shows evidence of rolling. It holds *x* 11 *x* in 5·8 inches; another tooth, 33,374, B. M., has *x* 12 *x* in 5·5 inches. These dredged specimens are further illustrated by No. 33,390, B. M., a right lower, with a formula of *x* 10 *x* in 5·9 inches, and an average thickness of each ridge of about 0·5 inch.

[1] 'Pal. Mem.,' vol. ii, p. 177. [2] Idem, vol. ii, p. 178. [3] Idem, vol. i, p. 442, and vol. ii, p. 180.

Specimens 33,387 and 33,389, B. M., are somewhat injured, but, with the above, demonstrate the typical characters of this stage of the pre-glacial specimens, which are supported by a tooth in a ramus, No. $\frac{9}{11}$ of the Jermyn Street Museum Collection; it is marked from the "FOREST BED," and holds $x\,10\,x$ in 5·5 inches.

In the Norwich Museum and in the Collection of Mrs. Fitch there are several very characteristic instances from the same formation. The lower molar, No. 304 of the Gunn Collection, from the "IRON-PAN FOREST BED," labelled by Dr. Falconer as having held $x\,10\,x$ in 4·4 inches, is a good example, although not quite entire as to length; whilst a rolled specimen containing $x\,10\,x$ in 4·5 inches, in Mrs. Fitch's cabinet, shows a seeming disposition to a crowding of the ridges and an unusual breadth of crown, such as will be shown in the sequel to characterise the *broad-crowned variety* of the ultimate true molar.

I have before me, along with the teeth already described from VICTORIA CAVE, a right upper, possibly an ultimate milk molar, from the same situation. It is fractured perpendicularly in two places, and one of the three portions does not unite, so that there is probably a loss of one or more ridges. The tooth had just been cutting the gum, and shows broad pressure marks on the cement in front and on the top of the first ridge, where it had been impinging on the tooth in front. None of the ridges are invaded. The crown is broad in front and narrow posteriorly, like lower molars. The talons are very rudimentary, the anterior being inconspicuous, whilst the posterior is reduced to a small splint attached to the last plate. The tooth presents an unusual small ridge formula of $x\,8\,x$ in 3·6 inches, but this estimate is not to be relied on for the reason just observed. Looked on, however, as a molar of *E. antiquus*, there is the thickness of the collines, which average each as much as 0·4 inch in thickness; the narrow crown, ribbing of the enamel, height of the main ridges, all favouring a belief that it belongs to this species. At all events, I have not seen a tooth of the Mammoth in any ways like it; and, considering the evidence already adduced, I think the above molar, although small, may be justly referred to the last of the milk series of *E. antiquus*.

Another very perfect and highly characteristic left lower molar from RAYGILL CAVE, in LOTHERSDALE, YORKSHIRE, has also been kindly lent to me by Mr. Tiddeman. All the ridges are in wear excepting the posterior talon. The tooth is arcuated, and holds $x\,11\,x$ in 6 inches. Accompanying the above were four posterior collines of a larger molar, either the second or else the ultimate true molar. It is also marked Raygill Cave, and its plates show all the characters of *E. antiquus*.

Foreign specimens.—The upper molar from MACCAGNONE CAVE, PALERMO, figured by Mr. Busk,[1] is doubtless the specimen No. 40,798 B. M., which was presented to the National Collection by Charles Falconer, F.G.S., after the death of his brother. The locality and position in the dental series are recorded in Dr. Falconer's handwriting on a

[1] 'Trans. Zool. Soc. London,' vol. vi, pl. liii, fig. 10, and p. 301.

label attached to the specimen. The tooth is not entire, there having been a loss of posterior ridges, leaving eight in a space of three inches. The worn crown is eminently characteristic of the species. This may be the "last upper milk molar" discovered by Falconer in the cave of Maccagnone, and which he failed to distinguish from the existing Indian Elephant[1] at the time, although it is clear from the label that he subsequently had cause to withdraw his previous decision. A third milk molar upper jaw, holding x 10 x in 0·118 m. or about 4·8 inches, is described and figured by Belgrand[2] as that of *E. primigenius.* It is from the gravel pits of Mentreuil, near Paris, where remains of *E. antiquus* have been found, including the humerus and teeth I shall refer to in the sequel. The author considers this milk tooth to belong to the Mammoth; but, as far as the figure and descriptions extend, it seems to me unquestionably that of *E. antiquus.*

A highly instructive instance of the last milk molar from the Maccagnone cave is represented by Baron Anca in the 'Bulletins of the Geological Society of France.'[3] I examined the above and other specimens in Anca's collections from the Palermo caves in 1863. Dr. Falconer, however, in his paper on the 'Natural History Review'[4] seems to have considered the tooth in question, like the above, "undistinguishable from the existing Indian Elephant;" whilst Lartet, who had also seen it in Anca's possession, was of opinion that it belonged to the last of the milk series of *E. antiquus,* and I arrived at the same opinion from an independent examination of the specimen. It is fairly represented in the plate referred to below. The crimping of the machærides in the specimen is, however, more pronounced than in the plate. The central expansion, angulations, ridge formula, and general character of the crown are undistinguishable from British specimens. It holds x 10 x in 4·8 inches.

Another specimen of apparently a well-worn last upper milk tooth, holding seven plates and a heel in 3 inches, and a third, also imperfect, were shown to me by Baron Anca. The latter specimen was nearly entire, and contained 10 x in 5 inches. Here, again, the crowns presented unmistakable characters of *E. antiquus.*

I am particular in noting these facts, more especially for the reason that teeth have been found in deposits in the basin of Palermo with such pronounced mesial expansions of their disks and other characters as to lead to the opinion that they belong to *E. Africanus;* whilst another set from the caves in the same neighbourhood display peculiarities not referable to either, and more in common with the crown of the Asiatic Elephant or its fossil ally the *E. Armeniacus.*

Affinities.—The last milk molar of *E. Namadicus* is shown in plate 12 c, figs. 2 and 3, of the 'Fauna A. Sivalensis,' and holds 11 ridges in 5·5 inches. It is impossible to distinguish the above from lower third milk molars of *E. antiquus.*

[1] 'Pal. Mem.,' vol. ii, p. 250.

[2] 'Basin de Paris, Texte,' p. 175, and pl. xvii.

[3] Second series, vol. xviii, pl. xi, fig. 8, and at p. 684.

[4] January, 1863, and 'Pal. Mem.,' vol. ii, p. 250.

The last milk molar of *E. primigenius* is ordinarily shorter in length and height, and very much broader than that of *E. antiquus*, with closely approximated and uncrimped enamel ridges, without even a tendency to central expansions and angulations of their disks, the formula usually being *x* 12 *x*.[1]

The same molar in *E. meridionalis* has a relatively broader crown than even in the Mammoth, with thick plates, generally uncrimped, and a ridge formula averaging only *x* 8 *x*.[2]

The Asiatic Elephant has the same high ridge formula as that of the Mammoth, and the crimping is excessive, whilst there is an absence of the mesial expansion and angulation so general in the disk of *E. antiquus*.

In the last milk molar of the African Elephant the low ridge formula *x* 7 *x* and the short ridges with the lozenge-shaped disks show peculiarities distinguishable from any of the foregoing.

The third milk molar in the Maltese fossil Elephants holds from 10 to 11 ridges in about three inches in the larger form *E. Mnaidriensis*, and, of course, in a much smaller space in the dwarf *E. Melitensis* and *E. Falconeri*. But, with the exception of these smaller dimensions and less pronounced crimping of the machærides, there is a very close alliance between the last milk molars I have ascribed to *E. Mnaidriensis*[3] and the same teeth in *E. antiquus*.

The closest affinities exist, therefore, between the last milk molar of *E. antiquus*, *E. Namadicus*, and *E. Mnaidriensis*. The thick-plated variety observed in the preceding member of the milk series is again repeated individually in the last of the milk series, showing the disposition to variability, which is a marked feature in the dentition of *Elephas antiquus*, and therefore noteworthy whenever noticeable.

Dr. Falconer after eliminating talons has conceded ordinarily 10 plates as the exponent of the last milk molar of *E. antiquus*.[4]

From the foregoing and other specimens it appears to me that the upper molar usually holds from 9 to 10 plates and 2 talons in a length varying from 4·5 to 5·5 inches; whilst lower teeth usually contain 9 to 11 plates, besides fore and hind talons, in a length varying from 4·5 to 5·8 in. The highest expression of 12 plates and 2 talons is doubtless rare. This tooth shows, I repeat, the tendency to variation, so generally the case with the last milk and first true molar; yet, perhaps, eleven plates and two talons would embrace by far the larger number of, at all events, British molars of *E. antiquus*.

[1] British Museum, several specimens.

[2] 'Pal. Mem.,' vol. ii, pp. 110 and 111; 'F. A. S.,' pl. xiv B, fig. 4.

[3] 'Trans. Zool. Soc. London,' vol. ix, pl. iii, figs. 4 and 5, pp. 21 and 22.

[4] 'Pal Mem.,' vol. ii, p. 176.

3. TRUE MOLARS.

First True Molar.

The first true molar in Elephants is perhaps more subject to variation than any other member of the dental series, and therefore there is a great likelihood of confounding it with the last of the milk series, seeing that their ridge formulæ are ordinarily the same.

A very distinctive instance of this tooth is shown, *natural size*, Pl. III, fig. 2. It is No. 37,241 of the National Collection, and was dredged off HAPPISBOROUGH. Here there are *x* 10 *x* in 7 inches, the average thickness per ridge being about 0·5 inch; it maintains the long laminæ with the narrow crown of *E. antiquus* as compared with that of the Mammoth.

This important distinction is always best seen in true molars. The central expansion and angulation are not always very pronounced in maxillary teeth unless the crowns are more than half detrited; whilst in mandibular specimens, from their ridges being more apart, the condition becomes developed soon after the digitations are ground down and the crown has become about one third worn. The anterior fang usually supports the first three ridges, but now and then only the anterior talon. The highest ridge in Fig. 2 is the tenth, which is six inches in height, whilst the maximum breadth of the crown is in front, where in the above it is 2·2 inches. Of course a good deal will depend on the state of attrition as to where the broadest part of the crown will be found, and this is at once obvious when the configuration of upper and lower molars of the various stages of growth are duly considered.

Another upper tooth, also from HAPPISBOROUGH, but in an imperfect state, is represented by the specimen 33,369, B. M., the crown constituents of which are precisely of the same character as in the preceding.

A mandibular example is well shown in the jaw, No. 18,789, B. M., 'F. A. S.,' pl. xiii A, figs. 5 and 5 *a*. The specimen was presented by the Earl of Aylesford (not Aylesbury, as noted by Falconer[1]). The left tooth is entire, and holds *x* 11 *x* in 6·7 inches; the crown is much arcuated, with disks well shown. Posteriorly there are clear evidences of the socket of a much larger molar, which could not have been other than a second true molar.

Either a large last milk or an unusually small first true molar is admirably shown in a mandible from the gravels of WYTHAM, in the Oxford University Museum. The rami contain two fragments of molars with the two succeeding teeth in place; the right is entire, and holds *x* 11 *x* in 6·2 inches, thus displaying small proportions for the first

[1] 'Pal. Mem.,' vol. i, p. 440, fig. 5, and vol. ii, p. 182.

true molar, which would be confirmed by the dimensions of the fragments of the third milk in front; but I am not convinced that they belong to the same jaw, which is broken at the commencement of the diastem, where the fragments of the molars have been glued to the shattered surface. The entire molar has an arcuated crown and the disks are clearly distinctive of the *E. antiquus*.

The lower jaw and molar, 18,967, B. M., is figured in the 'Fauna Antiqua Sivalensis,' Pl. xiv A, figs. 8 and 8 *a*; the latter is stated by Falconer to belong to the first true molar;[1] it is the same tooth that is shown in Lyell's 'Antiquity of Man' as a second or penultimate true molar.[2] It holds clearly *x* 11 *x* in about 8·3 inches. Here the formula is very small for a second true molar, and, on the other hand, the tooth is long for the first true molar, but, taking everything into consideration, the balance of evidence appears to lean towards Falconer's opinion.

In the Museum of the Geological Society of London there is an entire upper molar from the Norfolk coast deposits, showing an unusual broad crown and an approximation of ridges, with crimping of the machærides, and but for the latter it might have been fairly placed among the first true molars of the Mammoth. It holds *x* 12 *x* in the short space of 6·5 inches. The breadth in front is 2·6 inches, at the middle 3 inches, and behind 2·4 inches; there is barely what might be called a tendency to central expansion of the disk. This, like the last milk tooth referred to at p. 18, shows the character of the *broad-crowned variety* to be noticed in the sequel. The comparisons between the last upper milk molar, No. 21,301, B. M., Pl. I, fig. 4, and its associated specimens from Grays Thurrock, seem to me to receive additional proof of the position assigned to them by a well-worn crown of an upper first true molar in the British Museum from the same locality. The loss by wear in front is indicated, but the original formula was *x* 10 *x*, as may be seen by a careful examination of the surface, where eleven and a half ridges remain in a space of 6 inches. There is not much expansion of the disks; but, I repeat, this is not always a well-defined character in upper teeth.[3]

There are other characteristic specimens of this stage of growth in the British Museum; for example, No. 28,512 (2 specimens), from the Dixon Collection, one of which (right upper) holds *x* 11 *x* in 7·8 inches.

A right upper molar in the Norwich Museum, and lately discovered by Mr. Gunn in the Forest Bed, shows only *x* 9 *x* in 6·6 inches. The tooth is apparently too large for a last milk, only seven ridges are invaded; altogether it is very typical of *E. antiquus*.

A very characteristic example of a lower molar referable to the first true molar is represented by an entire tooth in the same collection and from the Post-glacial Bed at Mundesley. It is small for a fourth molar, but the ridges are wide apart, and the formula *x* 11 *x* is contained in 7·5 inches.

[1] 'Pal. Mem.,' vol. i, p. 443. [2] 'Antiquity of Man,' p. 133, fig. 19.

[3] There is a very striking resemblance in the above and a crown of the second true molar of *Elephas Mnaidriensis* shown in 'Trans. Zool. Soc. London,' vol. ix, pl. iii, fig. 1.

A lower molar from Oundle, Northamptonshire, with nine and a half ridges in a space of 7 inches, with thick plates on an average 0·9 inch per plate, might belong to the above, or else the second true molar. It is very characteristic of the species, but it is too much mutilated to allow its position in the series to be determined with certainty.

No. 27,906, B. M., from Clacton deposits, is an upper molar, with a highly digitated posterior, and a very fragmentary anterior talon; it holds x 11 x in 8 inches.

Other examples are numerous, such as a tooth from the Mendip caves in the Taunton Collection, referred to in Falconer's notes; it holds x 12 x in 7·2 inches. He has also figured a broken tooth, which seems to have held twelve to thirteen ridges in a space of about 7·5 inches.[1]

In the Jermyn Street Museum there is an entire upper first true molar from a cutting of the Great Northern Railway in Huntingdonshire. The crown, although just invaded and with none of the digitations worn out, is narrow, and altogether typical of the species. It furnishes a formula of x 10 x in 7·5 inches.

In the same collection there is an upper molar, with only its first three ridges invaded, from river deposits under St. James's Square, London; it holds x 12 x in 7·5 inches. The crown is also narrow.

The portion of a mandible containing a much worn molar discovered on Palling Beach, near Happisborough, and now in the Norwich Museum with the remainder of Mr. Gunn's splendid collection, is one of the two specimens on which Dr. Falconer founded the presence of *E. priscus* of Goldfuss, in British strata. The fact that Falconer mistook the characters of these teeth is sufficient to show that they differed very much from the ordinary or typical tooth of *E. antiquus*, at all events, as then known to him.

In the essay on "British and European Fossil Elephants," as also in the plates in his Memoirs,[2] Dr. Falconer goes into minute details with reference to this mandible and tooth. The specimen he considers to represent a well-worn second true molar; and, seeing that at the time he correlated it with the *Loxodontes*, the ridge formula could scarcely have admitted a larger figure than eight or nine plates besides talons. The tooth has been recently fixed in its socket so that the fangs cannot now be studied, but the representation in the plate referred to shows an anterior fang supporting two ridges, followed by two other fangs and a large curving posterior root sustaining three plates; there are clear indications of broken and worn-out ridges in front and deep pressure marks behind. Considering, therefore, that the anterior fang is now supporting two ridges, I am much inclined to consider this fragmentary tooth to be an *antepen-* instead of a *pen*-ultimate true molar, and that it may have lost four and a half of its ridges, there being seven and a half remaining in space of 6·4 inches. Whichever it may be, there can be little doubt as to its claims to a position among the teeth of *E. antiquus*. Although the plates are thicker antero-posteriorly, especially in the middle, with angular expansions and dilatations, the

[1] 'F. A. S.,' pl. xiv A, figs. 4 and 4 *a*.

[2] Vol. ii, p. 100. The tooth is shown detached from the jaw in pl. vii, figs. 3 and 4, of the same volume.

enamel is thin and well crimped; in fact, the grinder is nearly worn out, and the plane of detrition passes through the broadest part of the plates, which is ordinarily near the enamel reflections. The same will be observed in the section of the other molar from GRAYS THURROCK,[1] No. 39,370, B. M., which, with the above, were all the British specimens then known to him in connection with the variety of molar now under consideration. This interesting tooth is designated by Falconer as "a last molar, left side of the lower jaw."[2] I cannot, however, subscribe to that opinion, inasmuch as a reference to the specimen, or even a glance at the above sections in the 'Memoirs' or in the 'Fauna Antiq. Sival.,' will show a decided pressure mark posteriorly. Indeed, it may be doubtful if the tooth has claims to be considered other than a first true molar. Admitting, however, it is the second, we have a crown, nearly worn out, with eight ridges in a space of as many inches. The disk is wider than in the Norfolk tooth, and evidently the plates were relatively thicker than usually attain in lower jaw teeth; so that the condition is not altogether dependent on the state of wear, but, as will appear in the sequel, on a variety of tooth which I have named the *thick-plated molar*, a character seemingly common to other extinct species, to wit, *Elephas primigenius*, *Elephas Mnaidriensis*, and *E. Falconeri*;[3] and just lately I have been shown by Mr. John Gunn specimens of thick-plated molars of *E. meridionalis*, from the FOREST BED, so that, considered either as a sexual or race character, or even an occasional condition, the thicker plate, like the central portion of the disk of *E. antiquus*, is not confined to one species of Elephant. No doubt the imperfection of these two specimens misled Falconer a good deal at the time, and it was only after he had examined numerous collections on the Continent that he found in 1863[4] that his so-called *Elephas priscus* was a form of *Elephas antiquus*. It is also suggestive that on comparing the specimens with the teeth of *E. Africanus* the resemblance was so striking that in his essay he was inclined to consider these molars as representing the teeth of the African Elephant in a fossil state; a sufficient indication of the variability in the crown pattern of the molar of *Elephas antiquus*.

Foreign specimens.—Dr. Falconer describes a portion of a skull, including the last milk, first true molar, and the penultimate in germ behind, from MONTE VERDI at Rome. The first true molar holds $x\,10\,x$ in 5·5 inches. He also refers to a well-worn lower molar with ten plates in 5·7 inches from the same locality.[5] The former is assuredly a small first true molar, and interesting as regards the Maltese pygmies; but, as will be shown presently, such an exception is rare with *Elephas antiquus* as met with in Italian deposits, more especially in connection with the two last members of the dental series.

An injured upper molar, No. 32,539, B. M., from CHAMPAGNE holds ten and a half

[1] 'Pal. Mem.,' pl. vii, fig. 2, and 'F. A. S.,' pl. xiv, fig. 7.

[2] 'Pal. Mem.,' ii, p. 96.

[3] Dentition and Osteology of the Maltese fossil Elephants, 'Trans. Zool. Society,' vol. ix, pp. 6 and 35.

[4] 'Pal. Mem.,' vol. ii, p. 251 (footnote).

[5] Ibid., vol. ii, pp. 181 and 183.

ridges in 7·5 inches. There is a clear loss of the first two ridges, and possibly the tooth may belong to the next of the series. It presents, however, distinctive characters of the *E. antiquus.*

I examined in 1863 an entire, and what appeared to me a right lower molar in Baron Anca's collection from the PALERMO CAVES. It contained $x\,12\,x$ in 6 inches. The crown was much arcuated, and presented all the characters of the Elephant in question. It may possibly be a first true molar or else a large last milk; and, if we may judge from the huge last true molars in Italian collections, it is probably a last milk molar of a large individual.

Affinities.—The first true molar of *E. Namadicus,* 'F. A. S.,' pl. xii D, figs. 1 and 2, is in the British Museum. It is very closely allied to that of *E. antiquus,* fig. 4 of the same plate, and contains fourteen ridges or $x\,12\,x$ in 7·3 inches. The intimate resemblances between these teeth at all points are further augmented by a comparison of the mandibles to which each are adhering, as will be pointed out in the sequel. An entire lower-jaw specimen is shown in fig. 3 and 3 *a*, where $x\,12\,x$ are contained in a space of 10·5 inches.

The conditions which render it difficult to determine the last milk and first true molar in *E. antiquus* are just as conflicting in other species. In the Mammoth, from its teeth being short and very broad, together with the constant disposition of the ridges to become crowded, we find that undoubted first true molars often revert to the dimensions of the last milk molar. Ordinarily however there can never be much difficulty in discriminating between teeth of the above forms of Elephants. The intermediate molars, to wit, the last milk and first true molar in the Mammoth, as compared with the above, are much broader teeth, with aggregated plates and absence of pronounced crimping. The latter may be faintly indicated along the margins of the machærides, but never to the extent usually observed in the other. The ridge formula in the first true molar of the Mammoth varies considerably; Falconer establishes an average of twelve plates and two talons, which seems to include the majority of teeth, especially upper molars,[1] but there is much variability in this respect.

The first true molar of *E. meridionalis* is ordinarily large and massive, with a low ridge formula of about $x\ 8\ x$ in about $6\frac{1}{2}$ inches, and thick unplaited, although often faintly crimped enamel. The central dilatation and angulation are often pronounced in lower molars, but the smooth polished enamel of the worn disk with the large intervening wedges of cement and less height of the ridges, will, in a majority of instances, determine the specific relations of its molar.[2]

The first true molar of *E. Mnaidriensis*[3] has undoubted close affinities to *E. antiquus,* and holds from ten to eleven ridges in a space varying from 4·3 to 5·2 inches. The

1 'Pal. Mem.,' vol. ii, pp. 163 and 171; 'Ossem. Fossiles,' pl. xii, fig. 3.

2 'Pal. Mem.,' vol. ii, pp. 111 and 116; 'F. A. S.,' pl. xiv B, figs. 5 and 6.

3 'Trans. Zool. Soc. London,' vol. ix, pl. iii, fig. 3, pl. iv, fig. 4, and pl. viii, fig. 5.

crimping is not always so excessive as in *E. antiquus;* at the same time it would be difficult, excepting on the score of dimensions, to make out any decided distinctions.

The ridge formula in the Asiatic Elephant is the same as in the first true molar of the Mammoth, only that the crowns are not so broad and the enamel of the disk is deeply festooned.

The ridge formula in the first true molar of the African equals, according to Falconer and others, that of the last milk tooth, and stands usually at *x* 7 *x*.[1] It is quite possible in the more expanded disk of the *E. priscus* variety of *E. antiquus* to mistake its molars for those of the African; but entire specimens would doubtless clear up any ambiguity created by broken teeth, which cannot be invariably depended on in establishing the dental characters of any one form of Elephant.

In compounding the data evolved from the examination of the foregoing and other specimens of the first true molar of *E. antiquus,* referred to by Falconer in his memoirs and also in collections, it appears that the estimate of the latter authority is below the average deduced from the materials I have been enabled to study. He assigns a ridge formula of ten plates, besides talons, to the first true molar. I find that in upper teeth the ridges vary from eleven to fourteen in a space between 5·5 and 8 inches; whilst thirteen ridges is a very steady number in lower teeth, with a maximum of fourteen ridges, included between 6 and 8·3 inches.

Considering therefore that Dr. Falconer assigns twelve plates and two talons to the *penultimate* true molar of *E. antiquus*, it might be inferred that I may have included teeth in the above list which should have been placed with the second true molar. It will appear, however, that the instance in which the largest number of ridges is shown, to wit, the upper tooth from the Mendip Caves at p. 23, is given on the authority of Dr. Falconer, where *x* 12 *x* are contained in a space of 7·2 inches, and the upper tooth, p. 22, in the Geological Society's Museum, where the same number of ridges are contained in a space of only 6·5 inches, I admit, however, in this latter instance an abnormal condition of the crown, the other lower molar, p. 25, holding *x* 12 *x* in inches being the one in Baron Anca's possession, is consequently a foreign specimen. Allowing, therefore, that these excessive examples might have a doubtful relationship with the first true molar, we find that, as regards dimensions, they are short compared with instances just adduced of both upper and lower molars with thirteen ridges in a space of 8·3 inches; whilst an analysis of the entire series shows a constant variation in the number of ridges and dimensions, especially in upper molars. Perhaps about *x* 10 *x* to *x* 11 *x* for maxillary, and *x* 11 *x* for mandibular teeth, will fairly represent the ridge formula of the first true molar of *Elephas antiquus.*

[1] 'Pal. Mem.,' vol. ii, p. 89.

Second True Molar.

It will be apparent from the foregoing that long first true molars with the maximum number of ridges (14), more especially mandibular specimens, are apt to be confounded with unusually small second true molars. It is of assistance however to the observer to bear in mind that the graduating height of the ridges posteriorly as characteristic of the last of the series is also pronounced in second molars, especially in the lower jaw, and even in the first true molar; whilst the pressure scar on the heel of such worn teeth precludes the possibility of confounding the penultimate with the ultimate true molar.

The question is frequently suggested during surveys of detached molars of Elephants, When is the pressure scar developed on the disappearing tooth? It seems that certain members of the dental series are pushed forward more rapidly than others. For example, the first or antepenultimate milk tooth is soon shed, and the last milk and first true molars take on the pressure scar and impressions of the advancing septum sooner than the penultimate *milk* and penultimate *true* molars. At all events, the scar and septal pressure hollow or flattening below the posterior talon, and on the posterior fang, in both upper and lower molars become pronounced long before the crown is worn out; whereas in lower molars it is often observed that the last ridges are being ground down before the succeeding molar has made an impression on the heel of its predecessor. There are doubtless individual differences, according to the quickness or otherwise of the growth of the animal, when the teeth advance with greater or less rapidity. Perhaps the greatest strides in the growth of the Elephant take place at the age when the last milk and first true molars are being ground down, the full vigour not being attained until the second true molars come into wear, when the epiphyses of the long bones get consolidated. It may therefore be the case, that the intermediate molars advance with greater rapidity than the succeeding teeth. At the same time I have been informed by a German dealer, who has reared Elephants in the forests of Upper Burmah, that the animal's growth as regards height is pretty steady and about six inches annually.

An upper molar denuded of its external cement and unworn, No. $\frac{23{,}717,}{*}$ B. M., is from fluviatile deposits at Slade Green, Erith; a profile view of this tooth, *half natural size*, is shown in Plate II, fig. 1. It displays fifteen ridges, or x 13 x in a space of 10·5 inches. The narrowness of the crown, the height of the collines, the seventh being 6·3 inches, the ribbing and rugæ of the enamel, and thickness of plates, are characteristic of this Elephant. A beautiful plan view (*natural size*) of another second true molar is represented in Plate IV, fig. 2. The tooth is from Grays, Essex, and is one of two upper molars, right and left, No. 22,017, B. M., of probably the same individual. Like the above, it is typical as regards the long narrow crown, and is somewhat bent. It holds x 12 x in 9 inches. The crown, narrow in front, expands towards the middle, and again narrows posteriorly.

The lower molar, No. 19,844, B. M., from SLADE GREEN, referred to by Falconer,[1] is another excellent example of the usual long tapering and arcuated second true molar. It has lost, however, possibly a ridge posteriorly, leaving 13 or *x* 12 in 8·6 inches, the injury having taken place since it was examined by Dr. Falconer, as he gives twelve plates and a heel in 10 inches, or else his description refers to another tooth, as the illustrations agree with the molar as it stands at present. This tooth might be the opposing molar to the upper molar, Plate II, fig. 1, as far as state of wear, condition of ridges, general characters, and locality extend.

A fine specimen of an upper second true molar, commencing wear and showing the pronounced characters of the teeth of this Elephant, is represented by No. 22,017, B. M., from GRAYS. Here in 8·2 inches a small figmentary anterior talon and a well-marked digitated posterior talon embrace twelve plates between them.

No. 580 of the Museum, Royal College of Surgeons, is a penultimate upper molar with an injury to the anterior ridge, but the original length of the tooth is preserved. It is a good specimen of the *narrow crown* from GRAYS, and holds seventeen ridges in 9 inches.

The difficulty in determining which is a plate or a talon is well shown in another and similar upper molar, No. 22,017, B. M., from GRAYS. Here the last two ridges do not arise from the common base, just as occasionally a semilunar plate in front takes the place of an anterior talon. The tooth, moreover, shows posteriorly the narrow crown of the second as compared with the breadth of the same part in the first true molar. There are fourteen ridges altogether in 7·7 inches.

A comparison between the last and two perfect lower molars in the Jermyn Street Museum, also from GRAYS, shows no less than fifteen ridges or *x* 13 *x* in 10 inches in the latter. They are contained in a jaw with clear traces of the ultimate tooth behind, whilst another specimen of a penultimate lower tooth in the same collection from British strata contains *x* 12 *x* in 9 inches. These are again exceeded by the remarkable specimen referred to by Falconer as having been dredged up at HARWICH,[2] where a lower molar, "probably the penultimate," holds *x* 12 *x* in 10·8 inches, and an "extremely characteristic" second lower true molar holding *x* 14 *x* in 10·1 inches. It would even seem that undoubted penultimate true molars, especially in the lower jaw, have sometimes fifteen plates besides talons.

The enamel, which becomes thicker in last true molars than in any of the preceding, shows a tendency towards this condition in many specimens of the penultimate tooth. An instance in point is shown in No. 21,318, B. M., from GRAYS, ESSEX.

Another illustration is presented by specimen No. 27,916, B. M., dredged off Norwich. This *thick-plated* tooth is entire and of the lower jaw. It holds *x* 12 *x* in 8·7 inches.

[1] 'Pal. Mem.,' vol. ii, p. 184, and 'F. A. S.,' pl. xiv A, fig. 10.

[2] Ibid., vol. ii, pp. 183 and 184.

A mandible, No. 28,114, B. M., from Bracklesham Bay, has a molar *in sitû*. It contains x 13 x in 8 inches. Here we have a good illustration of the circumstance just noticed in connection with the pressure marks of advancing teeth; although all excepting the last ridge are invaded, only an insignificant portion of cement has been displaced on the heel; in fact, there is no deep pressure scar, although the ultimate molar must have been on the point of cutting the gum, as its empty socket testifies. Moreover, the crown of the molar, being protected by a fragment of the first true molar, has preserved its natural round front, which contrasts with the tapering hinder portion. The former condition is worthy of note, inasmuch as a molar unprotected by a fragment of the preceding tooth is, as elsewhere observed, liable to have its anterior portion ground down laterally as well as horizontally, and will therefore give a different aspect to the crown view.

The left tooth in the lower jaw, No. 33,366, B. M., dredged up at Happisborough, exactly proves the truth of this view as regards the two varieties of outline of the crowns of worn teeth. Here there is no trace of a preceding tooth, so that the front of the penultimate is ground down not only horizontally but laterally, and is therefore narrow in front. It holds x 12 x in 8 inches. There are other specimens illustrative of this condition in the National Collection.

A left upper molar, No. 33,330, B. M., dredged off Happisborough, is entire, with two anterior fangs and a general coalescence of the base posteriorly. The crown is just commencing wear, there being seven ridges invaded, with none of their digitations worn out. The specimen, evidently entire, holds fifteen ridges, or x 13 x in 9 inches. There is faint crimping of the enamel of the disk, but otherwise it has more the aspect of a crown surface of a last molar of *E. meridionalis.* This is one of the doubtful molars which, on account of not being sufficiently advanced in wear, presents no characteristic features whereby it can be placed with members of the penultimate true molar; indeed, the specific distinctions are by no means pronounced.

A broken left lower molar, No. 20,809, B. M., from Ilford, has its anterior ridges just invaded. It has thick plates, and is clearly a true molar of *E. antiquus.* There are ten ridges in 6 inches.

A molar of the lower jaw much arcuated with the loss of posterior ridges, and numbered 599 in the Museum of the Royal College of Surgeons, is probably of this stage of growth. It is from the "Parkinson Collection," and from the "Drift or Pleistocene Beds of Staffordshire." The crown is little more than invaded in front, and holds fourteen ridges in 8 inches.

Foreign specimens.—Distinctive mandibular specimens are cited by Dr. Falconer from the Quaternary deposits of Monte Verdi, where teeth of thirteen ridges are contained each in 9·1 inches. They are said to show very typical disks of *E. antiquus*;[1] a fragment in a ramus showing the thick plates, from Rome, will be noticed presently when this

[1] 'Pal. Mem.,' vol. ii, p. 184.

variety of last true molar comes to be considered. I recognised in 1863, in Baron Anca's collection from the Palermo caves, an undoubted second true molar of the lower jaw, containing x 12 x in 8 inches. Mr. Busk and Dr. Falconer identified an upper penultimate true molar from Europa Point, Gibraltar.[1]

Affinities.—A comparison between the first true molar of *E. antiquus* and *E. Namadicus* is illustrated by the beautiful specimen in B. M. of the second molar, shown in figs. 3 and 3 *a*, plate xii D, of the 'Fauna Sivalensis.' Here, in a left ramus, x 12 x is contained in 13·6 inches. The crown, like the other teeth, unprotected by a preceding molar, is excessively narrow, just like the equally characteristic lower first true molar of *E. antiquus*, fig. 4, of the same plate, to which reference has already been made, and also to the last upper molar, fig. 5, to which I shall allude in the sequel. All the above molars of *E. Namadicus*, as far as characters extend, are simply indistinguishable from accepted teeth of *E. antiquus*, the only exception being the unusually large size of fig. 3 as compared with a second true molar of *E. antiquus.*

The *Elephas Mnaidriensis* presents in the second as in the preceding molars all the characters of the *Elephas antiquus* in a much smaller animal, the number of ridges, twelve or x 10 x, being held in an estimated space of 6·5 inches, but, unfortunately, my determinations are computed from specimens not altogether entire;[2] however, they clearly show by comparison with ultimate molars to have been of the maximum length just stated, but with a ridge formula equal to the first true molar of *E. antiquus.*

The Asiatic Elephant, excepting in the excessive crimping and less lateral dimensions, holds relatively the same formula as the Mammoth.

In the African Elephant the low ridge formula, according to Falconer (x 8—9 x)[3] with the rhomb-shaped pattern of the disk and its short ridges will ordinarily distinguish second true molars from the vast majority of those of *E. antiquus*, excepting, perhaps, the so-called *E. priscus* variety, with which crowns of the former might be easily confounded.

The second true molar in the Mammoth is a broad-crowned tooth, with short and closely approximated ridges, in the great majority of specimens seldom averaging less than x 16 x in its ridge formula. The enamel is thin, and when at all, only faintly crimped at the outer and inner margins of the enamel.[4] Sometimes a thicker-plated example may be found, and a broad-crowned variety of the *E. antiquus* may make the diagnosis difficult, especially if the plan of the crown is not fully shown, but the exceptions will be few where the practised observer will fail to distinguish between the respective molars of the above species.

In *Elephas meridionalis* the ridges are nearly as broad as they are long, and never so numerous as in the foregoing, whilst the thick plates and grosser masses of intervening

[1] 'Jour. Geol. Soc. London,' vol. xxi, p. 366.

[2] 'Trans. Zool. Soc. London,' vol. ix, pl. iii; pl. viii, figs. 2 and 4, p. 27.

[3] 'Pal. Mem.,' vol. ii, p. 90, and 'F. A. S.,' pl. xiv, fig. 5.

[4] Ibid., vol. ii, p. 166. Numerous suggestive specimens in the British and Norwich Museums.

cement, with the usual uncrimped machærides, and ridge formula rarely above x 10 x, are good exponents of the second true molar of this form of Elephant, as usually noticed in the specimens from the Preglacial deposits of the Norfolk Coast and in Italian Collections.[1]

The ridge formula of the second true molar in *E. antiquus* may be stated to vary in upper teeth, between x 12 x and x 13 x in a space of from 8 to 10·5 inches, whilst the same number of ridges in the lower jaw are included within from 8 to 10·8 inches, with rare instances of as many as sixteen and seventeen ridges. Generally I would concede twelve to thirteen plates, besides talons, to this member of the series, the former probably being the most common number.

Third or Last True Molar.

The last of the dental series is obviously the best for the determination of specific characters. This tooth, from the absence of pressure posteriorly, preserves its integrity better, and the contour of the crown is generally characteristic.

The last molar of *Elephas antiquus* presents the same variability in the proportion of its crown constituents pointed out in the preceding molars; and representing, as it does, the aged condition of the animal, whatever tendencies in these respects are observable in the milk and other true molars, become finally confirmed in the ultimate.

From a large experience in the examination of the teeth referable to this form of Elephant, I find that although the following varieties of crown admit of being joined together by intermediate varieties, still, taking the pointed instances of each, it appears to me that they may be arranged as follows:

A.—A massive broad crown, with the ridges closely approximated.

B.—A long, narrow, and often much arcuated crown, generally typical of the British specimens.

C.—A thick-plated tooth with the dental elements in excess, and with generally a pronounced mesial expansion of the disk. This is the variety ascribed by Dr. Falconer, in the first instance, to the *Elephas priscus* of Goldfuss, and subsequently to *E. antiquus*.[2]

A well-characterised instance of any one of these types shows a crown dissimilar in many respects from the others; hence the importance of an examination of all available materials ascribed in any way to the form of elephant under consideration.

The members of *A* and *C* varieties are often colossal teeth as compared with the long, narrow crown of *B* variety. Moreover, in instances where bones have been found in conjunction with them, the same is observable, showing either that the larger molars belonged to either unusually large individual Elephants, or were peculiarities in the denti-

[1] 'Pal. Mem.,' vol. ii, p. 117, and 'F. A. S.,' pl. xiv B, fig. 7, and British Museum, also Norwich Museum.

[2] 'Jour. Geological Soc. London,' vol. xxi, p. 269, and 'Natural History Review,' 1863.

tion of the particular form, branching off towards allied forms, to wit, *E. Namadicus*, *E. meridionalis*, *E. primigenius*, *E. Africanus*, *E. Asiaticus*, *E. Mnaidriensis*, with more than one of which the *E. antiquus*, as has been shown, is very closely allied.

A. Variety.—The teeth referable to this variety of crown have the ridges packed close together. The disks have often little mesial expansion, so that they are relatively of a more uniform thickness from side to side. The angulation is often very faint or wanting.[1]

A very characteristic example is furnished by No. 16,229, B. M., from the Forest Bed, Ostend, Norfolk. A capital crown and profile view of this upper tooth is shown in the 'F. A. S.,' pl. xiv A, figs. 5 and 5 *a*. There is a loss of a few anterior ridges, leaving sixteen and a half in a space of 9 inches, with a maximum breadth of the crown of three inches. The crimping of the machærides is the only pronounced character of the disks.

Another upper tooth, No. 27,907, B. M., Plate V, fig. 1, from Clacton Freshwater Deposits, has lost about two and a half of the anterior ridges, leaving fifteen and a half in a space of 10 inches. The crown is very broad, being 3 inches in front, 3·5 inches in the middle, and 2 inches posteriorly. All the disks are developed excepting the last four, the digitations of which are not worn out. Each ridge is about 0·7 inch in thickness.

The ridges are crowded and the disks are little expanded in the middle, and, therefore, almost parallel. There are angulations however. This is a very typical instance of the broad-crowned variety.

A superb specimen of this description of molar is instanced by No. 46 of Miss Gurney's Collection in the Norwich Museum. It is a right upper molar from Cromer. Here the ridges are much aggregated with thin sheaths of enamel, which, however, are well crimped without angulations as in the last. All excepting the two last ridges are in wear. The formula is $x\,18\,x$ in 11 inches, the maximum breadth of the crown being four inches.

A left lower molar, No. 601 (Hunterian Collection), Museum Royal College of Surgeons of England, from Grays, Essex, represents a broad crown, with only fifteen and a half ridges preserved, which are contained in 10·5 inches.

A characteristic fragment of a left lower molar of this variety is shown in the 'F. A. S.,' pl. xiv A, figs. 12 and 12 *a*. Dr. Falconer states it is from Happisborough,[2] but the old British Museum Catalogue records it from Siberia. It has certainly more of the

[1] There are numerous fragments and almost worn-out crowns in the Norwich Museum so alike in many respects to plates of this variety on the one hand, and to the massive molars of *E. meridionalis* on the other, that in their broken and incomplete state it is impossible to come to a decided conclusion as to their specific identities. Thus, the enormously broad fragment from Happisborough, described in the 'Palæont. Mem.,' vol. i, p. 447, 'F. A. S.,' pl. 14 D, figs. 15 and 15 *a*, seems to me to be the shed portion of a tooth of the broad-crowned variety of *E. antiquus* rather than that of *E. meridionalis*, to which Falconer refers it. It is impossible, however, to arrive at certain conclusions with such imperfect material.

[2] 'Pal. Mem.,' vol. i, p. 443.

characters of a dredged tooth, although clearly belonging to *E. antiquus*, the probability is that, like all the early specimens of proboscidian teeth, it was supposed to have come from Siberia.

B Variety.—The long, narrow crown generally much arcuated in lower molars is the most common description met with in British strata.[1] An excellent example is furnished by No. 28,118, B. M., from GRAYS, ESSEX, and is represented in plan, *half natural size*, Plate II, fig. 2. It holds x 16 x in 11·3 inches. Each plate is about an inch in thickness, and the height of the longest colline is 6·3 inches. The disks are well developed, displaying the central expansions, angulations, and crimping of the enamel. Like ultimate molars, the crown tapers towards the heel, with the ridges not nearly so approximated, nor is the crown by any means so broad as in members of A series.

A lower-jaw specimen, No. 27,907, B. M., is shown *half natural size* in Pl. IV, figs. 1 and 1 *a*. It is from the freshwater deposits at CLACTON, and has a very hook-shaped anterior fang supporting the three first ridges, followed by six pairs of roots, and the usual coalescence posteriorly, invariably the case in teeth not far advanced in wear. There are twenty ridges, or x 18 x, in 13 inches. The first sixteen are invaded.

Here we have an excellent example of the usual description of lower molars as met with in England. The outline of the crown is spindle-shaped. It is matched by another splendid specimen, No. 3946, B. M., of a lower molar from SAFFRON WALDEN, referred to by Falconer,[2] and figured in the 'F. A. S.,' pl. xiv A, figs. 11 and 11 *a*. It holds seventeen ridges, with a loss of one or two in front, in a space of 12·3 inches. In this tooth the posterior talon rises like the other ridges from the common base. A fragment of the long, narrow crown is seen in No. 42,349, B. M., from the THAMES VALLEY deposits.

C Variety.—The thick-plated variety is typically represented by a tooth from the VALLEY OF THE THAMES, and referred to by the late Professor Phillips.[3]

It is from the low-level gravels at CULHAM, near Oxford, and is preserved in the University Museum. This superb specimen holds seventeen ridges, besides a small vermiform talon on the inside of the last plate. The ridge formula is x 16 x in 12·8 inches. The eight anterior ridges are invaded, showing large expanded disks with well-defined angulations, central expansions, and pronounced crimping of the machærides. The height of the ridges is enormous, that of the ninth being 9·5 inches, whilst the maximum breadth of the crown is 4 inches. The average of each plate is an inch. I examined, moreover, in the Oxford University Museum, two fragments of a last molar

[1] Professor Boyd Dawkins proposes ('Jour. Geol. Soc. London,' vol. xxviii, p. 413) to name *E. antiquus* the "narrow-toothed elephant," which would restrict the distinction entirely to the members of this series, to the disregarding of the broad-crowned and the thick-plated varieties.

[2] 'Pal. Mem.,' vol. i, p. 443; vol. ii, pl. ix, figs. 3 and 4, and p. 184.

[3] 'Geology of Oxford,' p. 465. I regret to have been unable to obtain a drawing of this remarkable molar, which ought to be figured.

holding two plates each. Both were also remarkable for the thickness of the enamel and dentine, so characteristic of this type of molar. The specimens were found in BALLARAT PIT, near Oxford.

There have been four late additions to the splendid collection of proboscidian remains in the British Museum, from CROMER FOREST BED and the PLEISTOCENE DEPOSITS near PETERBOROUGH. The latter represent a right and left upper molar, apparently from the same individual; neither is quite entire. The right, No. 47,121, B. M., I have selected as an excellent illustration of this variety; it is shown, *half natural size*, in the crown and plan views, Plate II, figs. 3 and 3 *a*. There is a loss of ridges posteriorly in the above, leaving fifteen ridges in 10 inches. The left tooth, No. 47,120, has fifteen ridges in 9·6 inches, the greatest breadth of crown being 3 inches respectively. The maximum height of the tenth ridge is 7·6 inches. The crowns are worn obliquely, and on that account they have the appearance of the crown of *E. Asiaticus*. The excess in the intervening cement, the thickness of the enamel, excessive crimping, with angulations and expansions here and there, are very pronounced and diagnostic of the variety of molar in question. It is clear, moreover, that if the above teeth were ground down nearly to the enamel reflections there would be a much greater expansion of the disk, approaching the rhomb-shaped dilatation of the so-called *E. priscus*. In fig. 3 *a* there is an intercalation of finger-like ridglets on the sides of the tooth, such as are often noticed in ultimate molars of other species;[1] moreover, with the exception of the central expansions and angulations, the fluted enamel gives the crown quite the aspect of that of the Asiatic Elephant.

The CROMER specimens, No. 47,119, are right and left lower; the latter is shown crown and profile, *half natural size*, in Pl. III, figs. 1 and 1 *a*. They have lost one or two of the ultimate ridges, retaining *x* 17 in 12·5 inches.

The first eleven ridges are invaded, showing large mesial expansions, crimpings, and the angulations, which, however, do not touch each other or overlap as often obtains in *E. Africanus*.

The teeth are much arcuated and narrow, with a maximum breadth of crown of 2·7 inches. The eleventh ridge, the digitations of which are just invaded, is 7·5 inches in height. The large, round, and curved anterior fang is well preserved on the left molar, fig. 1 *a*, and supports three ridges, succeeded by a coalescence of the remaining ridges. Here, again, the plates are colossal, each averaging one inch in breadth, with well-defined transverse rugæ on the enamel.

There is a fragment of the crown of what had been evidently a left upper molar in Mr. Gunn's collection, and from the NORWICH CRAG at HORSTEAD, where heretofore only remains of *E. meridionalis* and Mastodon are said to have turned up. The morsel is nearly worn down to the enamel reflections and was evidently a tooth on the point of being shed. The

[1] See 'British Fossil Mammals,' fig. 90, where an enormous lower molar of *E. Asiaticus* (not *E. primigenius*) has numerous accessory ridges on its sides and posteriorly. I found the same in ultimate teeth of *E. Mnaidriensis*. Dr. Falconer, however, supposes the condition to be a morbid state, and confined to domesticated elephants, 'Pal. Mem.,' vol. ii, p. 281.

plane of attrition passes through the broadest portion of the plate, so that the disk is relatively broader in the antero-posterior direction than would obtain at any other point in a transverse section, and looks precisely as in *E. priscus*, with marked crimping and thickness of the enamel. There are 6½ ridges in 5 inches. Considering, however, the above statement, it would be wrong to place the fragment with *E. antiquus*, seeing that crimping, mesial expansion and angulation of disks are sometimes pronounced in specimens of *E. meridionalis;* it is suggestive, however, with reference to further discoveries in the NORWICH CRAG.

I think fragmentary teeth, especially well-worn crowns of the thick-plated variety, are very liable to become confounded with molars of *E. Africanus*, but no cautious observer should come to a conclusion either way on such evidence, unless the characters are clear beyond doubt.

I can find no record or discover any ultimate molar of *E. Africanus* with a larger ridge formula than *x* 13 *x;* indeed, in far the greatest number of specimens it seldom exceeds *x* 11 *x*.

The evidence of Falconer[1] and Lartet,[2] that fossil molars discovered near Madrid, Syracuse, and Palermo, were determined by them as belonging to *Elephas Africanus*, is of such importance in connection with this *E. priscus* variety of *E. antiquus* as met with in British strata, that some account must be taken here of the instances on which their diagnoses were founded. I am unable to verify from personal examination the teeth discovered in Spain and at Syracuse,[3] but the two almost worn-out morsels[4] of teeth referred to by Falconer and represented by Baron Anca, who found them in the Cave of San Teodoro, as also a crown containing several plates, which the latter assured me was discovered in digging a sewer in one of the chief streets of Palermo, were carefully examined by me during a visit to Sicily in 1864, subsequently to that of Dr. Falconer.

With reference to these Sicilian teeth represented in figs. 5 and 6 of plate xi of the seventeenth volume of the 'Bulletin of the Geological Society of France,' and described at pp. 689 and 694, it appears to me that, as one contains only an entire disk and the other the outer, or else the inner, third of an antero-posterior section of a crown with only portions of three disks, even allowing their wide expansion and general thickness of the enamel, it would be premature, on such slender evidence, to assert their identity with teeth of *E. Africanus*, especially after the data here adduced of the thick-plated teeth of *E. antiquus*. Moreover, the planes of detrition in these two fragments pass exactly, as before stated, through the lower and thickest portion of the crown.

A more suggestive instance is represented by the other specimen, which I

1 'Pal. Mem.,' vol. ii, p. 283.

2 'Comptes Rendus,' 22 Fév., 1858, tom. xlvi.

3 The latter is described by Canon Alessi in vol. vii of the 'Atti dell' Accad. di Scienz. Nat.,' and is quoted by Falconer.

4 Plate xi, figs. 5 and 6, p. 684, vol. xvii, 'Bullet. Soc. Geol. de France' (2e série); vol. xviii, p. 90, in a letter to M. Lartet.

examined also on the occasion alluded to: and Baron Anca presented me with a lithographic plate containing a representation of the above, and also of molars of *E. antiquus* discovered by him in the caverns of Palermo. The right lower molar in question is contained in a portion of a ramus, but is much fractured both anteriorly and posteriorly. There are seven plates, the disks of five being entire, in a length of 5 inches, which allows about 0·7 inch for the thickness of each plate.

The central expansions are rhomb-shaped, but not nearly to the extent usually observed in molars of the African Elephant, with angulations which almost touch, but do not, as in the latter, *overlap* or *meet*. There is crimping of the enamel; and, altogether from these and other considerations in connection with left ramus containing the entire third milk molar (fig. 8 of the same plate) discovered also in the Cave of San Teodoro in the same deposits, and referred to by me at page 19, and from the fact that the evidence of the thick-plated molar of *E. antiquus* has been much augmented by later discoveries, I am bound to acknowledge that the opinion I entertained in common with these two distinguished anatomists, as to the proofs of the African Elephant having been found in a fossil state, has, at all events as regards the Cave of San Teodoro, been altogether shaken by more recent discoveries. It would be premature at present to speculate on the value of the other two instances; but whether or not *E. antiquus* was the ancestor from whence *E. Africanus* has been derived, there is no positive evidence furnished by the above materials from Sicilian deposits to show that they belong to the latter species.

I have digressed somewhat from the strict rule in connection with the description here of only British fossils, but it will be apparent that determinations so important with reference to the discovery of the recent species of Elephants in a fossil state have an intimate connection with extinct forms. I have therefore recorded these instances for the purpose of confirming the results obtained from studies of the thick-plated tooth of *E. antiquus* found in British strata.

The question suggested by a study of the thick-plated variety of molar is whether or not it has been discovered in connection with the other teeth of *E. antiquus,* or under conditions likely to give rise to a race or permanent variety of the species. The fact of its discovery in the fluviatile deposits throughout the VALLEY OF THE THAMES, in connection with the foregoing specimens, shows that the various forms of molars belonged in all likelihood to contemporaneous individuals, and, as before indicated in the case of the grinders of the Mammoth and Maltese Elephants, to which further reference will be made in the sequel, there were thick- and thin-plated varieties, possibly occasional or sexual conditions. Moreover, the three varieties have been met with in the PRE- and INTER-GLACIAL DEPOSITS of the NORFOLK COAST, where, however, vast epochs of time may be represented; but, indeed, there are few well-established evidences of the exact stratigraphical arrangement of the specimens from this coast either as regards the National Museum, or the valuable relics brought together by Miss Gurney, Mr. Gunn, Mr. Fitch, and others.

The intermediate varieties of molars which link together the *broad,* the *narrow,* and the *thick-plated* crowns are numerous, and establish such a gradation from the broad to the narrow tooth that a series can be arranged with these extremes at either end. This is not at present so clear in the case of the thick-plated variety, which, however, shows a disposition to pass into the characters of the narrow crown as seen in Plate III, fig. 1. It will appear, from the instances already furnished in relation to the first and second true molars, that the variability so apparent in the last of the dental series is not confined to it; even in milk teeth there are thick plates and broad and narrow crowns, which are evidently youthful conditions of similar appearances in the full-grown Elephants.

The following molars in the National Collection and elsewhere are worthy of being recorded as illustrative of the foregoing, and also of the intermediate conditions which bridge over the extremes.

Two upper teeth, Nos. 37,285 and $\frac{69}{27,907}$ B. M., show abnormalities, possibly deformed conditions of their crowns. The former from CLACTON displays a remarkable compression of the ridges on the outer and posterior part of the crown. The tooth is very small, but unquestionably a last true molar. All excepting the two last are in wear, and give a formula of 14 x in 9 inches, there being a loss of plates and the fore talon. This is an instance of a modification of A Variety. The other tooth is of the left or opposite side. It is abnormally flattened on the outside of the crown. The anterior fang supports the two anterior ridges, followed by digitations in pairs, and a contracting hollow shell posteriorly. There are no less than 20 ridges, or x 18 x, in 9·5 inches. The enamel is very thin but well crimped, and the first twelve ridges are invaded, whilst the disks which are packed close together show also central expansions with angulations. This tooth in consequence, probably, of the deformity of its sides has the aspect of a short broad crown of some varieties of the Mammoth's tooth in which there is faint crimping, but the height of the ridges seems to place it with ultimate broad-crowned molars of *E. antiquus;* it is also from CLACTON.

A dredged specimen, No. 33,327 B. M., of a lower molar from HAPPISBOROUGH, is entire excepting a portion of the posterior talon, and holds x 16 x in 11·5 inches.

Like the foregoing, its ridges are high, the longest (12th) being 7·5 inches. The ridges are aggregated, and more or less parallel without curving of the horns of the disks. The machærides are much crimped, with thicker enamel than in the last. It shows more pronounced characters of the broad crown, although not to the extent of the more typical members of A Variety.

An injured upper molar, No. 37,271, B. M., in the Brown Collection, is from the brick earths of WALTON, ESSEX. There are posterior ridges wanting, leaving 14 in a space of 8 inches. The tooth has only the first five ridges invaded. The crown is intermediate between the narrow and broad tooth.

Another broad crown is instanced by the upper molar, No. 40,385, B. M., from OUNDLE, NORTHAMPTONSHIRE. The cement has been much denuded. There is a loss of ridges in front, leaving 12 *x* in 8·5 inches. This tooth is very characteristic of the parallel aggregated disks with little central expansion or angulation; the crown is broad.

An upper molar, No. 27,515, B. M., from WALTON, in ESSEX, is more than half worn, with several of the anterior ridges worn away, leaving 14 ridges and a heel, or 13 *x*, in 8·5 inches.

The disks here are remarkably parallel and closely packed together; the enamel is thin, and the crimping is not by any means so pronounced as usual; with central angulations, altogether there is a pronounced similarity between the above and varieties of the tooth of the Mammoth. In that respect the broad-crowned variety has assuredly resemblances to the molar of the latter. The above is matched by a lower molar, No. 39,463, B. M., from SOUTHWOLD.

A fine specimen of a modification of the broad-crowned variety was discovered in fluviatile deposits in 1854, in digging the foundation of the JUNIOR UNITED SERVICE CLUB, CHARLES STREET, ST. JAMES'S, associated with remains of *Hippopotamus major*, *Bos primigenius*, and *Cervus*. This upper tooth, nearly entire, is preserved in the drawing-room of the Club. About two ridges have been broken off in front, leaving 15½ in a space of 9 inches, with a maximum breadth of crown of 3·2 inches. Each ridge is on an average 0·7 inch in thickness. The crown pattern and other characters are typical of the species of Elephant in question.

Two mutilated but very suggestive examplesof the ultimate molar, marked No. 8 and 9, are preserved in the Museum of the Geological Society, and labelled *E. primigenius*. The locality is unknown. The loss of posterior ridges in both instances prevents an exact estimate being made. It would appear that only two have disappeared; at all events, the teeth present all the characters of the broad-crowned variety of *E. antiquus*, which was formerly readily confounded with the molar of the Mammoth.

A good instance of a broad upper crown is preserved in the Oxford University Museum. It is from HURLEY BOTTOM, and is entire, with a ridge formula of *x* 16 *x* in 9·5 inches. The lower molar of the broad-crowned variety is admirably seen in the rami from BARROW-ON-SOAR, No. 33,796, B. M. I will refer again to the jaw. The molars are not quite entire, several ridges in front having been worn out by use, leaving 12 ridges and a heel in 8·3 inches. The crowns give a maximum breadth of 3·5 inches at their middle, and taper like all ultimate molars towards the posterior talon.

A mandible containing two superb molars, No. 27,908, B. M., is from ST. MARY'S STOKE, near Ipswich. The jaw is that of an aged individual, as there are several of the anterior dental ridges worn out. The teeth are suggestive instances of the broad crown.

An upper molar of the latter description marked BARROW-ON-SOAR ? is preserved in the Museum of the Royal Dublin Society. It has lost the hind talon, and the ridges in front are injured, but there is evidence of a ridge formula of *x* 17 *x* in a space of 10·5 inches. An intermediate variety of crown between the broad and narrow molars is further illustrated by a broken tooth, No. 33,337, B. M., in left ramus, dredged up off

Happisborough. All excepting the posterior talon ridge are worn, showing that it belonged to an aged individual. The number of ridges seem to have not exceeded 18, or *x* 16 *x*, in a little less than 10 inches.

The entire upper molar just commencing wear, shown in the 'F. A. S.,' pl. xiv B, fig. 16, is in the Norwich Museum. It represents the broad crown just commencing wear, there being only three ridges invaded. This molar was supposed by Falconer at first to belong to *E. meridionalis*, but the height of the ridges and their mode of arrangement are antagonistic to this belief. It holds *x* 18 *x* in 11 inches.[1]

A palate specimen in the British Museum, No. 38,491 contains portions of the last molars *in sitú*. The jaw is from Peckham in Surrey, and affords evidence of the preceding molar having been in wear at the same time. The above contains 15 ridges in 8·5 inches. The breadth across the jaws in front of the molars is 7·4 inches. The space between the molars in front is 2·2 inches, at the middle 2·8 inches, and posteriorly 3·2 inches.

In Mr. Gunn's collection at Norwich there is a highly suggestive example of the two entire upper molars *in sitú*, No. 218. They are referred to by Falconer in his notes.[2] The specimen is from the Forest bed and has pebbles still adhering to the sides of the teeth, which are intermediate between the broad and the narrow crown. Each molar holds apparently *x* 17 to *x* 18 *x* in 9·3 inches, with a maximum breadth of 2·7 inches. The pits of a fragment of the second molar are in front on the right side. The teeth are broad in front, tapering steadily towards the posterior talon. There are twelve of the anterior ridges in wear, and the front of the teeth converge, with an interspace of four inches, and at the posterior talon, five and a half inches. The ridges are, as usual, high, the fourteenth being seven and a half inches in height.

In the same museum, from Overstrand, near Cromer, No. 306 of Mr. Gunn's collection, is a left lower molar, holding 17 *x*. There is a loss of plates in front. It is very characteristic of the members of A Variety. Here there is well-marked mesial expansion, crimping, and aggregation of ridges.

The molars in the mandible presented to the Norwich Museum by Mr. Windham are referred to by Falconer.[3] The jaw was found near the jetty of Cromer. There is a loss of a ridge or two in front, but 12 *x* remain in a space of 11 inches. The breadth of the crown at the middle is 3·4 inches. The teeth in this jaw furnish good examples of the crowded ridges and broad crown of A Variety. I shall refer again to this jaw when I come to consider the Mandible.

No. 361 is in a left lower ramus, and belongs to the Gunn collection; it is from the upper portion of the Forest bed. The pits of the penultimate tooth are in front. The ultimate tooth is hidden in the jaw posteriorly, but its ridge formula can be made out to be *x* 19 or else *x* 20 *x*.

The above is a splendid example of the gigantic tooth of A Variety, and is about 11

1 'Pal. Mem.,' vol. i, p. 447; vol. ii, pp. 138 and 182. 2 Ibid., ii, p. 182. 3 Ibid., vol. ii, p. 188.

inches in length.[1] It contrasts with another in the Norwich Museum, showing the long, narrow crown of B Variety, from the "Post-Glacial Lacustrine bed at MUNDESLEY." This molar is not entire, and furnishes 16 *x*, or 17½ ridges, in 10·2 inches.

A magnificent specimen of a mandible, containing five plates of the penultimate and two entire ultimate teeth, is preserved in the Museum of the Geological Society of London. The characters of the jaw are very suggestive of the species, and will be described in the sequel. The last molars have lost the posterior talon only, but its impression is quite evident on the wall of the alveolus, so that the teeth yield *x* 19 *x* in 12·6 inches. The worn crowns are broad, and display well-marked characters of the *E. antiquus*. They give a maximum breadth of 3 inches. Unfortunately, the locality from whence the specimen was derived is unknown, but no doubt British. It is referred to and figured by Dr. Falconer.[2]

An intermediate condition of crown between the "broad" and "narrow" tooth is well seen in No. $\frac{15}{923}$, B. M., from OSTEND, NORFOLK coast. It is of the upper jaw, and remarkable for the excessive ridge formula as compared with the members of A Variety generally. The tooth is almost perfect, and although ground down to the base in front, gives satisfactory indications of having originally held 20 ridges, or *x* 18 *x*, in 12 inches. The plates are relatively thicker than in the broad-crowned type, being on an average 0·8 inches in thickness.

The crown and profile view, pl. xii D, figs. 5 and 5 *a*, 'Fauna A. Sivalensis,' shows a variety of upper molar very like the preceding. Here there are clear indications of an original ridge formula of *x* 17 *x* in a space of 11·5 inches. The specimen is in the British Museum and numbered 40,989, "from CANTERBURY Museum." A similar description of upper crown, from GRAYS, ESSEX, with thick plates, is seen in No. 602 of the Museum of the Royal College of Surgeons. These correlate A and B Varieties.

The long, narrow crown is always best observed in lower molars, of which there are abundant examples in public and private collections.

In the British Museum the following may be indicated in addition to the specimens already described.

No. 33,367, B. M., in a lower ramus, is from HAPPISBOROUGH. Here, evidently, there were 20 ridges in 13 inches. Another ramus, No. 40,840, B. M., dredged also on the EAST COAST, off NORFOLK, holds a molar of this type, and evidently *x* 17 *x* in a little over 11 inches.

[1] Since my attention was drawn to the broad-crowned variety, I am gratified to find that Mr. Gunn has been familiar for the last twenty years with specimens of this description of molar, which in his MS. Catalogue in the Norwich Museum he names the *Leptodon giganteus;* and it may have been such-like worn crowns that led Falconer to surmise what he designates "the pre-glacial variety of the *Elephas primigenius* from the Norwich coast" ('Pal. Mem.,' vol. ii, p. 170). Of the characters of this tooth he (Falconer) observes that they "diverge widely from the ordinary form of *E. primigenius* in the direction of the Indian Elephant, but still maintain all the distinctive marks of true *E. primigenius.*"

[2] 'Pal. Mem.,' vol. ii, p. 185; and 'F. A. S.,' pl. xiii A, fig. 4.

Two very characteristic instances are seen in lower molars "589" and "589 A" in the Museum of the Royal College of Surgeons of England. The localities are unknown, but their light colour is indicative of Grays Thurrock specimens. The former is entire, and holds x 15 x in 11 inches. This tooth, unquestionably the last of the series, would indicate the minimum number of ridges, as far as I have been enabled to discover. No. 589 A has lost its first ridge, but contains 18 x in 12·4 inches. In the same collection there is a crown sawn horizontally through the middle into two portions, Nos. 569 and 570. There is here a loss of ridges, leaving 16 in 10·5 inches. It is recorded from "BRENTFORD."

Another instance of the long, bent, and narrow crown, from CLACTON, is in the possession of Dr. Bree, of Colchester, who has kindly allowed me to examine his collection of dredged specimens from the Norfolk coast. Dr. Bree has been at some trouble in ascertaining the exact positions where his specimens of teeth and bones of mammals were picked up by the oyster-dredgers and other persons. The specimen referred to holds x 19 x in 13·5 inches. In this superb specimen is seen all the characters of the tooth of *E. antiquus* of the type of B Variety.

The late Mr. T. Wickham Flower showed me a suggestive example of this long, narrow, bow-shaped lower tooth from GRAYS. It held x 18 x in 13·5 inches.

The foregoing may be accepted as instances of the three varieties of molar crown, and the intermediate conditions which unite the extremes. Thus the broad, narrow, and thick-plated crowns present well-marked differences, which, in the absence of specimens lying between these extremes, might fairly be accepted as belonging to three distinct species; indeed, the differences are nearly quite as pronounced as between the two living species, so that looking to allied forms, the broad crown assimilates to that of the Mammoth, whilst the thick-plated and expanded disk is barely distinguishable from teeth of the African Elephant. Whatever may be the connection between *Elephas antiquus* and other forms accepted at present as distinct species, it can scarcely, I think, be denied that, as far as their dentitions are concerned, close alliances are traceable. Moreover, looking to the home of the present species in Asia, and the fossil exuviæ from the Mid-tertiary formations of India, it does seem that the genesis of living and extinct Elephants is to be formulated in that region, and that one form, at all events, *Elephas Namadicus*, is seemingly the representative there of the so-called *Elephas antiquus*, as will be further shown in the sequel.

Foreign specimens.—There is an interesting fragment of a large molar, figured and described by Belgrand,[1] in conjunction with a gigantic humerus, from MONTREUIL, near Paris; the latter bone will be noticed in the sequel. The crown of the tooth is clearly referable to *E. antiquus*, and from its dimensions is suggestive of the broad crown, with the closely packed ridges of the members of A Variety, but whether a penultimate or ultimate does not appear in its fragmentary state.

A detailed account of a mandible containing molars of the thick-plated variety is given

[1] 'Basin de Paris,' pl. xvi, p. 175.

by Falconer, who examined the specimen in the Museum at Rome.[1] It was found in "Volcanic Sands," in a railway-cutting between the latter city and Civita Vecchia.

An instance of the "broad crown with the aggregated ridges" of A Variety is also recorded by him. It is of the usual massive dimensions of the British specimens and *E. Namadicus,* with a length of nearly 14 and a maximum breadth of crown of 4·5 inches! It holds the exceptional ridge formula of 24 plates, with a loss of the anterior portion of the crown. The above and other fragments from the same locality, "St. Paulo," he states, "present the marked characters of the species."[2]

There is a suggestive fragment of a right lower ramus in the British Mnseum, from Rome. The same is figured and described by Falconer.[3] It holds portions of the penultimate tooth, and is confirmatory of the thick-plated variety.

Another remarkable and interesting tooth of the thick-plated variety is, according to Falconer, "a last molar of the lower jaw, left side, nearly entire, the only deficiency being in the anterior talon and part of the first ridge borne upon the large anterior fang."[4] It is preserved in the Natural History Museum of Milan, and is from near Verona. This tooth shows, apparently, evidence of x 12 x in a space of about 12 inches. Now, such a formula applied to the ultimate molar of *Elephas antiquus,* in particular a lower jaw specimen, is perfectly at variance with every other evidence, as far as I know, of the number of ridges in that tooth. It is to be understood, however, that when Falconer wrote his description of *E. priscus* he had a strong impression as to its specific characters and alliance with *E. Africanus* rather than *E. antiquus,* although at the same time impressed by the resemblances between the two latter in certain respects. It is just possible that he may have been mistaken as to the number of lost ridges, or the tooth may be a penultimate true molar; or else the thick-plated variety often furnished a minimum number of twelve plates besides talons, even in the mandible, which, if that be the case, gives a wide range to the ridge formula in the ultimate true molar of the thick-plated variety, thereby showing a pliability which must interfere materially with other deductions.

There is a tooth, No. 44,132, B. M., of precisely the same type as the broad-crowned tooth, No. 40,385, B. M., referred to at p. 37. It is from the VIA APPIA, ROME, and is unfortunately imperfect. There are several pebbles adhering to its sides. It holds four ridges in 6·2 inches, and gives evidence posteriorly of at least two more ridges, so that the tooth must have been either a penultimate or ultimate, possibly the latter.

A very characteristic specimen, No. 8, B. M., of the narrow crown of B variety, also from VIA APPIA, ROME, is shown in figs. 13 and 13 *a* of plate xiv A, 'F. A. S.' It is a

[1] 'Pal. Mem.,' vol. ii, p. 185.

[2] Dr. F. likens this tooth to the Canterbury specimen described at p. 402, and shown in the 'F. A. S.,' pl. xii D, figs. 5 and 5 *a*.

[3] Ibid., vol. i, p. 443, and vol. ii, p. 185; 'F. A. S.,' pl. xiv A, figs. 9 and 9 *a*.

[4] Ibid., vol. ii, pp. 101 and 193.

left lower molar, and has lost ridges in front and the posterior talon, leaving 14 in a space of 11 inches. The disk is large and like that of the thick-plated variety, but otherwise it is intermediate between B and C Varieties. The ridges are thick, being on an average as much as one inch. Such a tooth as the above contrasts with the long, narrow crown, and bridges over the differences between it and the typical specimens of the thick-plated molars.

Another reference is made by Falconer to an enormous tooth found near Turin, which clearly from subsequent studies he found to belong to the so-called *E. Armeniacus.*[1] Here it is that confusion creeps in to obscure the Italian history of *Elephas antiquus,* and in the absence of data I do not feel that I can at present clear up the numerous conflicting statements as to the Elephantine molars in collections at Rome, Pisa, Leghorn, &c. Whether the specimens represent the large tooth of A Variety or C Variety, or belong to a distinct species, remains to be worked out. Indeed, the *E. Armeniacus* seemed to Falconer to be very closely allied to the existing Indian species.[2] All these and many more points in relation to the southern distribution of *Elephas antiquus* are worthy of the attention of palæontologists; indeed, no one was more sensible of the want of conclusive evidence as regards the Italian specimens than Dr. Falconer.

Affinities.—It is worthy of record that a superb specimen of the palate region, holding two ultimate molars and portions of the alveoli of the incisors, is preserved in the Museum of the Royal College of Surgeons of England. Unfortunately there is no note of how the collection became possessed of this highly suggestive relic, but the associated crania render the likelihood of its Indian origin probable, whilst the matrix is seemingly of the character generally noticed on fossils from Central India,[3] therefore it may in all likelihood be a portion of the cranium of *E. Namadicus.*

The molars represent the broad-crowned variety of *E. antiquus,* modified to such an extent that they might almost represent huge grinders of the Asiatic. The anterior parts of the crowns are worn to the common base, with indications of the lost ridges, showing a formula of either $x\,16\,x$ or $x\,17\,x$ in a length of 12·5 inches. The crowns have a maximum breadth respectively of 3·5 inches, the average per ridge being about 0·6 inch. All the ridges excepting the last four are in wear. The disks are nearly parallel, with no angulations and little mesial expansion, but pronounced crimping of the machærides.

[1] 'Pal. Mem.,' vol. ii, p. 249.

[2] Idem., pp. 250 and 251, note 1.

[3] Considering the interest Dr. Falconer entertained in connection with all discoveries of Tertiary fossil remains from India, it is remarkable that he has not noted, if at all aware of the above, his impressions on this jaw, supposing the cranium in question is from the East Indies; and this is the more strange from the circumstance that he seems to have examined the other skulls, to wit, the cranium of *E. Cliftii,* in the same gallery: see 'Pal. Mem.,' vol. ii, p. 461, note 2.

There are other highly suggestive instances of the ultimate molar of *E. Namadicus* in the British Museum. For example:

The two upper last molars contained in a skull is represented in 'F. A. S.,' pl. xii B, figs. 2 and 3. Only 11 plates remain in a space of 8·1 inches. The crown shows the closely packed ridges of A Variety of *E. antiquus*.

Another huge cranium contains ultimate molars holding as many as 22 plates in a space of 13 inches.[1]

A magnificent right lower ramus, containing an entire tooth, is well shown in the 'F. A. S.,' pl. xii C, figs. 4 and 5. It is an ultimate molar, and holds *x* 19 *x* in 14·7 inches. Another mutilated mandible containing similar teeth is shown in figs. 5 and 5*a* of the same plate.

Both of these specimens are in the British Museum, as also another ultimate lower tooth, *in sitû*. Dr. Falconer refers to the "crimped characters of *Elephas antiquus*" in connection with the teeth of *E. Namadicus* in several places.[2] These molars seem to me inseparable from varieties of *E. antiquus*, in particular the long, narrow, and the broad crown with its closely packed ridges.

The last true molar of the Mammoth differs generally from that of *E. antiquus* both in contour and number of ridges. There are exceptional instances, however, in well-worn teeth of the latter, such as the specimens from Walton and Southwold described at p. 38, where a broad crown, with closely approximated ridges and faint crimping, becomes scarcely distinguishable, if at all, from an ordinary or aberrant pattern of crown of *E. primigenius*.[3] But considering the vast numbers of the molars of both species in public and private collections in Great Britain and on the Continent, and the pronounced specific dental characters of the two, it seems to me that, as far as odontography extends, nothing can be more distinct than the ordinary molars of these Elephants, and, I repeat, the only wonder is that they should have been so long confounded.

This applies with equal, if not more, force in the case of *Elephas meridionalis*, whose ultimate, like the preceding, molars are easily distinguishable from those of either of the preceding by the massiveness of the tooth, thickness of enamel and plates, with scarcely plaited machærides, the great breadth to height, and low ridge formula, which rarely, if ever, exceeds that of the second true molar of *E. antiquus*.[4]

Another doubtful example is seen in the mandible, No. 32,496, B. M., containing the last true molar in full wear on either side. Each tooth holds 19 *x*, and clearly did not exceed *x* 19—20 *x*, like the Ilford teeth of the Mammoth. It was dredged off Harwich. The ridges are closely approximated as in the members of A Variety, with the machærides

[1] 'Pal. Mem.,' vol. i, p. 435.

[2] Idem, vol. i, pp. 116, 437, note 1.

[3] 'Ossemen Fossiles,' pl. xii, fig. 5, British Museum, &c.

[4] 'Pal. Mem.,' vol. ii, pp. 112 and 116; and 'F. A. S.,' pl. xiv B, fig. 14; and British and Norwich Museums.

here and there faintly crimped, although not generally; there is also central expansion of the disk. The jaw, however, has more the characters of the Mammoth than of *E. antiquus.*

With the last true molar of either of the living species that of *E. antiquus* has ordinarily no very close alliance, further than what has been pointed out with reference to the worn disk of the thick-plated variety. The crimping of the machærides, moreover, is very often present in the latter, and generally absent in the teeth of the African Elephant, in which the angulations of the disks *meet* and often *overlap*, which has not, seemingly, been hitherto noticed in the thick-plated variety of *E. antiquus.* Again, the rhomb is more crescentic in the latter, and its anterior border is concave, and the posterior border convex, with the cornua or lateral horn of the crescent bent forwards. The crimping so pronounced in the Asiatic is especially marked in its last molars, the ridge formula of which varies from $x\,24\,x$ to $x\,27\,x$, whilst that of the African Elephant seldom exceeds 13 ridges, and never goes beyond 15 ridges.

The same variability as regards the crown constituents prevail in the Maltese Elephants as in *E. antiquus.* In their teeth there are also clear evidences of, 1st, a broad crown with packed ridges;[1] 2nd, a long, narrow crown;[2] 3rd, a thick-plated crown[3] in penultimate and ultimate milk and all the true molars.

The ultimate molar in the larger form, *E. Mnaidriensis*, usually holds $x\,12\,x$ in 7 inches, and rarely $x\,13\,x$ in 7·5 inches, scarcely equalling in these respects the dimensions of the second true molar of *E. antiquus;* whilst that of the smaller or pigmy forms is of course far more diminutive. It is suggestive, however, that the Maltese Elephants should preserve the tendency to variability in the same directions, although differing in dimensions from one another and from *Elephas antiquus.*[4]

The ultimate molar of the *Elephas meridionalis* is generally distinct from that of *Elephas antiquus.* It holds the same ridge formula as that of the Maltese Elephants,

1 'Pal. Mem.,' vol. ii, pl. xi, figs. 1 and 2; and 'Trans. Zool. Soc. London,' vol. ix, pl. ii, fig. 7.

2 Idem, pl. viii, fig. 8.

3 Idem, vol. ix, pl. iii, fig. 2; vii, fig. 1; viii, fig. 7; ix, fig. 1; and 'Pal. Mem.,' vol. ii, pl. xii, fig. 4.

4 It will appear from a comparison of the dentitions of *Elephas antiquus* and *Elephas Mnaidriensis* that, with the exception of dimensions and the ridge formula of the ultimate molars, the teeth of the two, considered as exponents of their affinities, might belong to one species. Therefore it is clear that, if the latter was a variety of the former, it differed much from the ordinary individuals of *E. antiquus* in size, and to a certain extent in the numerical estimate of its ridge formula. As regards the former a significant observation has been made by Dr. Livingstone in his 'Last Journals' at p. 29, vol. ii, where he states having seen in Central Africa a small variety of Elephant averaging 5 feet 8 inches in height with a tusk 6 feet in length. The great traveller, it is presumed, was perfectly conversant with the African Elephant and its growth, which he demonstrates by stating that this dwarf individual had a tusk of the dimensions of the adult. It remains to be ascertained whether or not the above is either an occasional small individual or else a race of the African Elephant or a distinct species. It may be observed that the stature of the *Elephas melitensis* of Falconer has been estimated by Busk at between 4 feet 2 inches and 4 feet 7 inches, whilst I found that, as compared with recent species, the *E. Mnaidriensis* may have stood from 6 to $6\frac{1}{2}$ or 7 feet at the withers (see 'Trans. Zool. Soc. London,' vol. vi, p. 307, and vol. ix, p. 116).

with occasionally an additional ridge or two. The crown is relatively much broader than in *E. antiquus*, and the massive wedges of intervening cement between the plates, with the smooth and usually uncrimped enamel, and the low height of the ridges, distinguish it generally from the same tooth in every other known species of European fossil Elephants.

It will be seen from the foregoing that the last true molar in *E. antiquus*, like its predecessors, is subject to great variations in size and number of ridges, so much so that it seems impossible to establish anything like constancy in the formula. Dr. Falconer puts the dental formula at 16 plates exclusive of talons.[1] An analysis of the British data here given shows, as regards upper molars, that in individual teeth there is a range of between 16 and 20 plates, exclusive of talons, in specimens varying between 9·5 to 12·8 inches; whilst in lower jaws as few as 15 plates and 2 talons are contained in a space of 11 inches, and ordinarily in the specimens the formula varies from the latter number of ridges to 19 (probably 20) plates, besides talons, in between 9·3 and 13 inches. It may be an approximation to the truth in estimating the ridge formula of upper teeth at 16 to 18 plates, besides talons, and of lower at 18 plates and 2 talons. No doubt larger specimens might be adduced than any entire teeth here recorded; indeed, several of the injured specimens not included in the estimate evidently attained to greater dimensions than the above; but, as far as British instances extend, I have seen no case of such a high expression of the ridge formula as is ordinarily attained in the *E. Asiaticus* and Mammoth, although it must be acknowledged that ultimate molars of the latter from Ilford show in the number of their laminæ an agreement, as will be stated presently, to the highest range in the *E. antiquus;* and, notwithstanding that the tooth of the Mammoth usually shows a considerably higher formula, it will be admitted that these instances of variation are of the utmost value in the correlation of their dentitions.

The dental formula of *Elephas antiquus* given by Falconer, exclusive of talons, is as follows:

Milk Molars.	*True Molars.*
$\frac{3 + 6 + 10}{3 + 6 + 10}$	$\frac{10 + 12 + 16.}{10 + 12 + 16.}$

The elimination of talons in computing the number of enamelled ridges of a proboscidian tooth must be often a questionable proceeding, inasmuch as it may happen that the anterior or posterior ridge is in no way distinct from the succeeding plates, whilst many instances occur of modifications of two terminal ridges, indistinguishable from the ordinary splint or rudimentary ridge, which, again, may be dwarfed to a mere appendage to the last or to the first plate. It would appear that Dr. Falconer applied a too rigorous criticism in regard to what he considered a plate, and such ridges as should be admitted only as talon appendages; and nowhere is this more evident than in his estimate of the ridge formula of *Elephas antiquus*.

[1] 'Pal. Mem.,' vol. ii, p. 176.

It can never in the future be the interest of the philosophical naturalist to create new species from a few minor characters. It seems to me, therefore, in order to realise the varying features in dental elements of Proboscidians, that strict cognizance should be taken of talons and the like in computing the ridge formula, which varies in every member of the series, not only in the recent, but in all known fossil Elephants; at all events, wherever sufficient materials have been obtained. It need scarcely be observed that the following ridge formulæ are provisional and liable to extension in accordance with future discoveries.

1. From the foregoing details it seems to me that the ridge formula of *Elephas antiquus*, as far as British specimens in particular demonstrate, is, talons included, in upper and lower jaws, as follows:

Milk Molars.			*True Molars.*		
I.	II.	III.	IV.	V.	VI.
x 2 x — x 3 x	x 5 x — x 7 x	x 9 x — x 10 x	x 9 x — x 12 x	x 12 x — x 13 x	x 15 x — x 20 x.
x 3 x — ?	x 6 x — x 8 x	x 9 x — x 11 x	x 11 x—x 12 x	x 12 x — x 13 x	x 16 x — x 19 x.

2. The ridge formulæ of the Mammoth and Asiatic Elephant according to Falconer are the same;[1] if anything, there is also a greater range in the former than in *E. antiquus*, the ultimate molar varying in number from *x* 19 *x* to *x* 27 *x*. The lowest number of ridges in the last molar of the Mammoth, according to Falconer, is stated to be *x* 24 *x*, but Mr. Davies in the describing and naming of the valuable materials collected by Sir Antonio Brady, F.G.S., in the Ilford deposits, records entire ultimate molars of the Mammoth containing *nineteen plates* and *two talons*;[2] consequently, if the extremes in the *Elephas antiquus* and *E. primigenius* meet, with the limitation in the lowest number of ridges of the last true molar as just indicated, the ridge formula of the Mammoth as given by Falconer will stand as follows:

Milk Molars.			*True Molars.*		
I.	II.	III.	IV.	V.	VI.
x 4 x — ?	x 8 x — ?	x 12 x — ?	x 12 x — x 14 x	x 16 x — x 18 x	x 19 x — x 24 x.
x 4 x — ?	x 8 x — ?	x 12 x — ?	x 12 x — x 14 x	x 16 x — x 18 x	x 19 x — x 28 x.

3. The dental formula in the African Elephant appears to vary much, but it seemingly never attains to the number of ridges in true molars that is seen in any of the three preceding species. According to Blainville, Owen, and Falconer, none of whom give exactly the same formula, supposing they have not represented more than the exact number of ridges, including talons, it stands thus:

[1] 'Pal. Mem.,' vol. ii, p. 157, and footnote, p. 236.

[2] 'Catalogue of Vertebrata for Ilford,' p. 3.

Milk Molars.			True Molars.		
I.	II.	III.[1]	IV.	V.	VI.
x 2 x — x 3 x	x 5 x — x 6 x	x 4 x — x 7 x	x 7 x — ?	x 8 x — ?	x 10 x — ?
2 x — x 3 x	x 5 x — x 6 x	x 4 x — x 7 x	x 7 x — ?	x 8 x — x 9 x	x 10 x — x 12 x.

4. The dentition in the Maltese fossil Elephants, as shown by Dr. Falconer,[2] and from materials collected by me in the Island of Malta,[3] furnishes a ridge formula in the *Elephas Mnaidriensis* as follows:

Milk Molars.			True Molars.		
I.	II.	III.	IV.	V.	VI.
x 2 x — x 3 x	x 4 x — x 6 x	x 8 x — x 9 x	x 8 x — x 9 x	x 10 x — ?	x 12 x — x 13 x —
x 2 x — x 3x	x 5 x — x 6 x	x 8 x — x 9 x	x 8 x — x 10 x	x 10 x — ?	x 12 x — x 13 x —

5. It is to be regretted that the dental series of *Elephas Namadicus* is not fully ascertained, seeing the extremely close morphological resemblances between it and the *Elephas antiquus.* As far as the few instances of lower teeth afford materials for comparison, we have:

Milk Molars.	True Molars.		
III.	IV.	V.	VI.
? — ?	? — ?	? — ?	? — 22.
x 9 x — ?	x 12 x — ?	x 12 — ?	? — x 19 x.

6. An analysis of molars of *E. meridionalis* described by Falconer[4] furnishes the following:

Milk Molars.			True Molars.		
I.	II.	III.	IV.	V.	VI.
x 3 x — ?	x 5 x — x 6 x	x 8 x — ?	x 8 x — x 9 x	x 9 x — x 10 x	x 13 x — ?
x 3 x — ?	x 6 x —?	x 8 x — ?	x 8 x — ?	x 9 x — ?	x 11 x — x 15 x.

From which he formulates the series thus:

Milk Molars.	True Molars.
3 + 6 + 8	8 + (8 — 9) + 13
3 + 6 + 8	8 + (8 — 9) × 13 — 15.

It will be observed that the highest expression of the ultimate molar of *E. Meri-*

[1] Blainville, as pointed out by Falconer, makes the second milk hold seven, and the third milk molar six ridges, which is at variance with the rules which have hitherto regulated the dental succession in the genus, 'Pal. Mem.,' vol. ii, p. 89. The dentition of *E. Africanus* is still far from being accurately determined.

[2] 'Pal. Mem.,' vol. ii, p. 298.

[3] 'Trans. Zool. Soc. London,' vol. ix, p. 36.

[4] 'Pal. Mem.,' vol. ii, p. 118.

dionalis equals the lowest expression of the last molar in *E. antiquus,* so that as far as the numbers of ridges are concerned we find *Elephas primigenius, Elephas antiquus, Elephas meridionalis,* and *Elephas Namadicus,* meeting at their extremes, and showing thereby that to sharply define their ridge formulæ, by striking an average in each case, is no exponent of the actual range of variation to which every member of the dental series is more or less subject.

The above suffices to show how much the molars of Proboscidia vary in the number of their ridges, and how arbitrary it would be to formulate an average in the case of any one species or even any one member of a dental series. The stress laid by Dr. Falconer on the dental formulæ as diagnostic of species of Mastodon and Elephant is evident when the fossil materials come to be differentiated. But it is also clear that in correlating members of the genus Elephas any formula professing to furnish an average number of plates per molar must of necessity be subject to exceptionable conditions. The data by which fossil species are determined are too few at present to admit of casting a mean, whilst the desirability of tracing evolutionary characters between them is more or less thwarted by setting up a definite formulary in each case, more especially where two or more forms of Elephants assimilate closely. The very fact that the dental elements of any one species are subject to variation as regards numbers, and that one or more particular member of the series presents exceptional conditions, is of the utmost importance in estimating the character and affinities of the species in question when taken in connection with the sculpturing of the crowns of worn disks.

I have correlated in the foregoing comparisons the dentitions, as far as I have been enabled to make out, of the seven best known species of Elephants including the recent and fossil. It is apparent, however, that there are aberrant forms, such as the *Elephas Columbi* (Falconer) and the *Elephas Armeniacus* (Falconer),[1] with which comparisons should be made; but I have not ventured on this undertaking, inasmuch as, in order to do justice to even the Elephant here described, it is necessary to compare also the entire Elephantine remains from the Sewalik Ranges of the Himalayan Mountains, the affinities of which with European or North American species are worthy of far more attention than has been bestowed on that subject.

Summary.—It will be apparent from the data furnished in the previous pages that the molars of *E. antiquus* differ considerably individually as regards dimensions and number of ridges in both the upper and lower jaws; thus in the upper jaw the differences between the extremes in the various members of the series may be instanced as follows:

The difference between the maximum and minimum length in the upper jaw of I[2] (milk molar) is 0·1, of II[3] 1·2, of III[4] 1·0, of IV[5] 2·5, of V[6] 2·5, of VI[7] 3·3 inches.

In the mandible the differences of length are: for I[8] ?, for II[9] 0·5, for III[10] 1·3, for IV[11] 2·3, for V[12] 2·8, for VI[13] 3·7.

[1] 'Pal. Mem.,' vol. ii, pp. 212 and 247. [2] See page 11, *antè*. [3] p. 16. [4] p. 20. [5] p. 26. [6] p. 31. [7] p. 46. [8] p. 11. [9] p. 16. [10] p. 20. [11] p. 26. [12] p. 31. [13] p. 46.

The maximum and minimum number of ridges (including talons) individually are as follow in upper teeth: I, 4–5; II, 7–8; III, 11–12; IV, 11–14; V, 14–15; VI, 17–22.

In the mandible: I, 5; II, 8–10; III, 11–13; IV, 13–14; V, 14–15; VI, 17–22.

The foreign data are not here included, and only such as I have been enabled to confirm by personal examination. Neither are the above advanced as the ultimate possible limits of variation, but only with the view of showing to what extent mutability extends as far as I have been able to find out. As regards the true molars, in particular the ultimate member of the series, it is highly probable that its limits with reference to dimensions and number of laminæ might be increased, especially in specimens from Southern Europe and Eastwards.

The molars of *Elephas antiquus* taken as exponents of the probable variability in the dimensions of the animal show a pliability in this respect far greater than seems to obtain in either of the living species. With reference to the latter, however, it must be borne in mind that they are restricted to smaller areas, and consequently are less exposed to influencing agencies than was the case with their extinct predecessors.

The modifications in the molars ascribed to the *Elephas antiquus* looked on either as sexual, race, or occasional conditions, are sufficiently pronounced to invite the attention of geologists as to their stratigraphical relations.

As regards the Pre-glacial Deposits of the Eastern Coast, it would seem that the large broad crown has been more commonly discovered there than in other situations, but at the same time both the typical and thick-plated molar has also been obtained to all appearances from the above-named situation.

In the lower gravels and brickearths of the Thames, all the varieties have been met with, so that, although the evidence is not altogether irrefutable, still it seems likely that the three varieties were contemporaneous. This, however, is a matter for further investigation.

Looking at the extremes of variation in the molars of *E. antiquus*, it will be observed that the *broad crown* is of the type of that of *E. Namadicus*, an Eastern form, and that this modification also approaches *E. meridionalis* on the one hand and *E. primigenius* on the other. Again, the divergence from the *narrow* or what might be named the typical crown, as far as British specimens are concerned, to the *thick-plated*, is seen to culminate in the disk allied to but distinguishable from that of the existing African Elephant, whilst certain crowns in the crimping of their machærides greatly resemble those of *E. Asiaticus* and *E. Armeniacus*. As to the relations to *Elephas antiquus* borne by the Maltese forms, the main difficulty is in relative dimensions, and if these be admitted as the result of modifying influences or belonging to a variable species restricted to narrow limits, such as we see to some extent in the continental and insular varieties of the Asiatic Elephant, then the Maltese might be accepted as offshoots or diminutive forms of *Elephas antiquus*.

III. OSTEOLOGY.

In attempting the determination of species from fossil Elephantine remains there is considerable difficulty in arriving at a certain diagnosis, partly on account of the fragmentary state and general similarities of specimens, chiefly of the long bones, whilst the minuter points at all likely to be subservient towards distinguishing the species are too often lost, or occupy a debatable position as to constancy. It is only, as elsewhere observed, when the exact distinctions between the osteologies of the living species have been ascertained from the comparison of abundant materials of *wild* individuals, that anatomists will be in a position to speak with confidence of the endoskeletons of the extinct forms. The following determinations, therefore, more especially in connection with the elements of the vertebral column and several long bones, must be considered provisional.

The circumstance of the finding of teeth and bones of the *Elephas antiquus* and *E. meridionalis* together, and of the former and *E. primigenius*, make it difficult to correlate their dental and osseous structures.

The vast number of undoubted bones of the Mammoth from Arctic and other regions seem to point to a general slender frame in this species, as compared with the colossal bones of *E. meridionalis* authenticated from Italian deposits. Again, for example, in the brickearths of the Thames Valley, and in dredging on the east coast (in the latter case, however, *E. meridionalis* is also found), humeri, femora, pelves, and vertebræ are discovered stouter in proportion, and preserving characters different from the same parts in numerous authenticated instances of the Mammoth's remains, even from the same localities. Partly on that account and partly from their larger size many of these have been considered to have belonged to *E. antiquus*, which seems to have varied much in dimensions, if we may judge by the molars alone. But specific characters established on slender and squat or large and small bones must, at the best, be considered uncertain means of diagnosis, inasmuch as these conditions are noticeable in varieties of the Asiatic[1] and likely also of the African Elephant as mentioned at p. 45. Perhaps, however, where variability at present is the exception, it was the rule before and during the later Tertiary periods.

1. CRANIUM.

I have been unable to find references to an instance of an entire skull of *E. antiquus* having been discovered in British strata. It is important, however, in comparing the dental characters of *E. Namadicus*, that the bonnet-shaped vault of the calvarium, as

[1] Falconer, 'Pal. Mem.,' vol. ii, p. 257.

shown in two skulls in the British Museum, and described and figured by Falconer,[1] if absolutely a natural character, must be considered as eminently characteristic and distinctive of, at all events, the Indian specimens; at the same time, whilst admitting the singular depression of the frontal in the situation above stated, it is probable, as in the huge cranium of *Elephas insignis*[2] also in the Sewalik Collection, British Museum, that the same agency may have distorted the calvarium in question, and thus exaggerated the frontal hollow, which, judging however from another and smaller cranium, was more pronounced than in the Asiatic species. In the absence of similar data in *E. antiquus*, I can only merely refer to the above and the palate specimen of *E. Namadicus* in the College of Surgeons, already noticed at p. 43. It may be stated, however, as regards relative dimensions, that these two crania differ in the latter being larger, whilst the British Museum specimen from the smaller tusks may, as suggested by Falconer, have probably belonged to a female.

A cranium and mandible, with other bones of *E. antiquus*, are in the Museum at Rome.[3] A few palate specimens of youthful individuals, with teeth *in sitû*, are not uncommon in British collections.

The upper jaw, containing the ultimate milk molars, described at p. 17, and shown in Plate I, fig. 4, furnishes no specific characters as regards the region represented. When compared with a palatal aspect of an Indian Elephant, No. 2666, in the Royal College of Surgeons of England, where the third milk molar is in full wear and fourteen inches of tusk protruding beyond the alveolus, the two are found to agree nearly in the distance between the molars in front, at the middle, and behind, the fossil only exceeding the recent species to a small extent, which would agree with still more advanced stage of wear of the teeth of the latter, so that individually the maxillæ of the *E. antiquus* and the Asiatic, as far as the above stage of growth extends, presented about the same dimensions. Another palate specimen of the Indian Elephant in the same collection, with the last milk molar not so far advanced, gives nearly the same admeasurements.

2. MANDIBLE.

The various stages of growth are represented in several rami. The jaw, Plate V, fig. 2, containing the penultimate or second milk molar, No. 21,310, B. M., described at p. 15, when compared with the ramus, No. 2668, of an Asiatic Elephant, in the Museum of the Royal College of Surgeons of England, presents no appreciable differences as regards dimensions, the two jaws holding teeth of the same stage of growth and about the same condition of wear. The fossil is a left ramus, with the penultimate milk molar entire, the two fang sockets of the antepenultimate in front and a fragment of the

1 'Pal. Mem.,' vol i, pp. 115 and 435 and 436; 'F. A. S.,' xii A and xii B, and pl. xxiv A, fig. 4.

2 Ibidem, 'F. A. S.,' pl. xvii, fig. 3.

3 Falconer, 'Pal. Mem.,' vol. ii, p. 187.

empty alveolus of the third milk molar behind. The diasteme is not so erect as in the adult, nor so reclinate as in a ramus of the *E. meridionalis* in the British Museum, and in the African Elephant, and is more in keeping with that of the Asiatic; whilst its mentary foramina are close to the margin. The beak is blunt, and the horizontal ramus produced; the latter resembles that of the African Elephant. These two latter characters, however, do not seem invariable in any one species, and are not to be relied on.

The mandible, No. $\frac{18,789}{*}$, B. M., described and figured by Falconer,[1] the molars of which have been already referred to at p. 21, represents the adolescent stage of growth where the first true molar is nearly in full wear. The mentary foramina are irregular in their positions—a condition more or less common to all known species of the genus, although in the African they are usually not so close to the free margin of the diasteme as in the Asiatic, Mammoth, and other species. Their numbers also vary. A large anterior dental foramen is very generally placed about two inches below the alveolus in front, with smaller openings along the side of the diasteme. The latter foramina are often irregular as regards size and numbers, even on opposite sides of the same mandible. In the above jaw the horizontal ramus is prolonged, the diasteme is erect, and the rostrum was apparently short. In all these characters it agrees with the Asiatic and the Maltese pigmy form named *E. Melitensis.*[2] A jaw of the Asiatic Elephant, with apparently the same tooth in full wear, No. 2672, of the Osteological Collection, Royal College of Surgeons of England, is not so large. This, however, may be a small individual; at all events, the discrepancies with reference to dimensions are not such as would accord a great disproportion in the sizes, at the adolescent age, of the two elephants.

The lower jaw containing the second true molar, 28,114, B. M., already noticed at p. 29, is suggestive:—1st. It shows that the beak was not so prolonged as often obtains in the African Elephant. 2nd. That the diasteme was nearly erect, as in *E. Namadicus, E. Asiaticus, E. primigenius,* and the Maltese Elephants. The other left ramus with the second molar, 33,366 B. M., described at p. 29, confirms the character of the last as regards the direction of the diasteme; the rostrum is lost. Here the two mentary foramina are placed within one and two inches of the free margin of the diasteme.

In the Jermyn Street Museum there is a lower jaw containing the second molars described at p. 28, but it is too much injured in front to admit of comparisons. Another lower jaw in the same collection has portions of the fifth and last molars *in sitú.* The gutter is entire and displays a well-developed rostrum, but not so prolonged as in the African, yet fully as large as in many of the Asiatic species. The diasteme was evidently nearly vertical. These two jaws are from Grays Thurrock, and also belonged to full-grown Elephants.

A lower jaw containing the last true molars, No. 33,796, B. M., from Barrow-on-Soar,

[1] 'Pal. Mem.,' vol. ii, p. 183; 'F. A. S.,' pl. xiii A, fig. 5.

[2] 'Trans. Zool. Soc. London,' vol. ix, p. 42, pl. vi, fig. 1 to 4.

referred to at p. 38, is extremely suggestive. It has lost all the hind portions of both rami posterior to the teeth, and the rostrum is injured and its dimensions indeterminable; but the horizontal portion of the ramus is perfect, and presents the following characters:—The diasteme is nearly vertical. The two mentary foramina are situated about midway on the side of the diasteme. The upper aperture is distant about two inches from the margin. The lower is on a line with the floor of the gutter, and about an inch from the border. From the alveolar border in front of the teeth to the middle of the gutter is 5 inches. Breadth of the latter at the middle is 3 inches. Length of gutter is 4·5 inches. Height of the ramus in front of the molar and at the middle is 7 inches.

There is a ramus of the right side containing portions of the penultimate and last true molars in the collection made by Miss Gurney and presented to the Norwich Museum. The teeth are very characteristic of the broad crown with aggregated ridges. Here the large foramen is about $2\frac{1}{2}$ inches below the alveolar margin, and the mental holes are within an inch of the free margin of the diasteme.

Another lower jaw, No. 33,337, B. M., containing the last molars, already described at p. 38, although not perfect, affords the following data:—A nearly perpendicular diasteme. A small rostrum. An unusually large upper mental foramen, just below the front of the tooth, and about 2·5 inches from the margin. A small foramen close to the free border and about the middle of the diasteme. The latter is 5 inches in length. The height of the jaw in front of the tooth is 7 inches; at its middle 7·5 inches. The length of the gutter is 5 inches.

A very perfect lower jaw, displaying all the characters just noticed and further data, is seen in the specimen, in the Museum of the Geological Society, already noticed in connection with its molars at p. 40. It contains a portion of the fifth, and almost the entire sixth or ultimate true molar. The condyle, rostrum, and a portion of the lower and inner wall of the alveoli are lost. The jaw is represented in pl. xiii A, fig. 4, of the 'Fauna Antiqua Sivalensis,' and its dimensions are given by Falconer,[1] so I shall only refer to the most characteristic features of the specimen.

The diasteme and rostrum are precisely as in the last. There are two mentary openings and one anterior dental foramen. The latter is large, but not so capacious as in several of the foregoing. It is 4·5 inches from the free margin of the diasteme, and 3 inches below the alveolus. There is a small opening about half way up the diasteme and about 1·5 inch from its border, and a third of large size near the rostrum, and about 2 inches under the symphysial canal.

The dental canal is more gaping than in either the Asiatic or the African Elephant, but the posterior border of the ascending ramus narrows towards the condyle as in the African, whereas it is usually broad and rounded in the Asiatic and Mammoth.

The bulging or greatest breadth of the ascending ramus near the base of the coronoid process is common to the Asiatic and Mammoth. The same part in *E. antiquus*,

[1] 'Pal. Mem.,' vol. i, p. 440.

E. Africanus, *E. Namadicus*, and the Maltese forms, instead of being circular in contour, is more parabolic, and widens upwards towards the neck of the condyle.

The gutter in the above specimen is not so open as in the Mammoth nor so narrow as in *E. meridionalis* and the African, and is more like the symphysial canal of the Asiatic.

In the ramus, 40,840, B. M., containing an ultimate molar, described at p. 40, the diasteme is also nearly vertical, with the mentary foramina at a distance from its free border. The large opening is as usual just under the anterior fang. The symphysial canal is 5·3 inches in length, and the jaw is 7 inches in height at the base of the coronoid process.

The mandible containing the ultimate molars, referred to at p. 39, from Cromer Jetty, shows a large foramen four inches below the crown in front. The diasteme is erect, with a small scar of the rostrum which is wanting. The mental foramina are within 1½ inches of the free margin.

Another, No. 361, of Mr. Gunn's collection shows the above-mentioned foramen in the same position. The diasteme is injured, but indications of the mentary foramina are seen within a distance of about 1½ inches of the free margin. The contour of the ascending ramus is decidedly African. These represent aged individuals.

A ramus of the lower jaw of *Elephas Namadicus* in the British Museum is figured in the 'Fauna Antiqua Sivalensis,' plate xii c, fig. 4; it contains the entire last molar already noticed at p. 44; and presents all the characters of the foregoing rami. The diasteme is also nearly vertical. Dr. Falconer states that the coronoid portion of the ramus shelves out more, and the mentary foramina are placed higher than in *E. antiquus*.[1] As regards these distinctions between the specimen, also fig. 5 of the same plate, and mandibles of *E. antiquus*, I fail to discover any marked differences whatever. The uncertainty as to numbers and exact position of the mentary foramina have been demonstrated by the preceding specimens, whilst a comparison between them and the jaws in question, together with the ramus of *E. antiquus*, plate xiii b, fig. 4, gives no appreciable differences.

As regards relative dimensions, although generally the mandible of *E. antiquus* containing the last true molar is relatively larger than the usual specimens of recent species, still there are lower jaws of the latter as large as many of the foregoing; so that the *Elephas antiquus* sometimes maintained the mandibular, and, as will also be shown presently, the general osteological proportions, met with in individuals of the living species.

With reference to the characters of the lower jaw in living and extinct species, I find in comparing the varied materials in the different museums, that as regards, 1, the contour of the chin, 2, direction of the diasteme, 3, general contour of the horizontal ramus, 4, contour of the ascending ramus posteriorly, 5, relative aspects of the symphysial canal, 6, position of the mentary foramina, there is a close relationship between the jaws of *Elephas antiquus*, *E. Namadicus*, and the Maltese fossil forms. On

[1] 'Pal. Mem.,' i, p. 437.

the other hand, whilst *E. primigenius* differs from all other species in having a very broad and rounded chin, and usually an open expansive gutter, the small rostrum and nearly vertical diasteme are in keeping with the foregoing and *E. Asiaticus.* Again, as in the latter, the contour of the border of the ascending ramus behind is circular and does not display the parabolic curve observed in the others and also in *E. Africanus* and in *E. meridionalis,* and apparently in *E. Hysudricus.* The beak is well developed in *E. Asiaticus,* and very pronounced in the *E. Africanus, E. meridionalis,* and *E. Hysudricus.*

Thus *E. antiquus* with *E. Namadicus* and to somewhat less extent the Maltese Elephants present similar characters in the lower jaws; the Mammoth and Asiatic assimilate to each other also in some important characters, whilst a clear relationship is maintained between the same parts in the *E. Africanus, E. meridionalis,* and *E. Hysudricus.* The extent of the alveolar margin from the anterior aspect of the ascending ramus to the diasteme, both relatively and absolutely, in comparison with the breadth of the ascending ramus, is apparently greater in *E. antiquus, E. meridionalis, E. Africanus,* and the Maltese forms than in *E. primigenius* and *E. Asiaticus.* The deep-rounded chin so marked in the Mammoth is less apparent in *E. antiquus;* and, whilst the small rostrum in both assimilate, we have it produced in the *E. meridionalis* and *E. Africanus,* and sometimes with a downward course. The rostrum varies in size, however, in specimens of the recent Elephants, and may therefore be omitted as characteristic of any one species; but I repeat, as regards the configuration generally of the mandible of *E. antiquus, E. Namadicus,* and the *E. Mnaidriensis,* it seems to me that there is a very close relationship between the three.

3. ATLAS.

On comparing this bone in the recent and the following extinct Elephants, there does not appear much to note of a persistent character in any one species. The contours of the neural and odontoid canals present no invariable distinctions; but the foramen for the first cervical nerve is seemingly peculiar in certain fossil atlases from Ilford and Slade Green, as compared with many specimens from the former situation, and referable to *E. primigenius.* In those exceptional atlases the foramen for the above-named nerve opens directly on the side of the arch internally, so that it is invisible on looking down upon the neural canal, and this is apparent also in an atlas of the African Elephant, and also in the one I have referred to the *Elephas Melitensis.*[1] In two typical specimens of atlases of the Mammoth in the Beechy Collection, British Museum, from the Arctic regions, as also in several from Ilford, and many in the Norwich Museum, the foramen is quite visible when the bone is placed in the above position, and the same is seemingly the case in the Asiatic Elephant.

[1] 'Trans. Zool. Soc. London,' vol. ix, pl. xiii, fig. 1 *a*.

The above character, taken in connection with a rather stouter bone than that of the typical atlas of the Mammoth, might, as Mr. Davies has supposed, place the atlas and axis referred to by him in the Brady Catalogue with the remains of *E. antiquus*.[1] It is also worthy of note that this foramen is uncovered in a huge atlas, No. 36,436, B.M., dredged up on the NORFOLK COAST, and which from its dimensions is comparable with the colossal bones ascribed to *Elephas meridionalis*, although no doubt individuals of *E. antiquus* often attained to as great dimensions.

Dr. Falconer[2] records a scapula three feet three inches in length, along with other bones, obtained from Bracklesham Bay. There are several fragments of large shoulder-blades in both the British Museum and Norwich Museum. This bone, however, does not appear to vary much, if at all, in the recent and extinct species, excepting, perhaps, in the relative length of the glenoid fossa and position of the recurved process of the acromion. The former is relatively broader in the larger of these fossil scapulæ as compared with undoubted specimens of *E. primigenius* and *E. Asiaticus*, and consequently assimilate to the African Elephant. I have not seen a specimen sufficiently entire to admit of determination of the position of the spinal process with exactness, the latter distinction being seldom preserved in the fossil state.

4. HUMERUS.

Whatever may have been the maximum height and general dimensions of *E. antiquus*—and individuals, judging from teeth alone, must have attained to enormous proportions—we find, as Falconer has pointed out, data establishing the belief that relatively this Elephant, as compared with the Mammoth, was altogether a stouter animal. This is well shown from undoubted specimens generally of the long bones of the *E. primigenius*, in particular the humerus and femur. The differences were evidently much the same as prevail between the two recent Elephants, so that the Asiatic Elephant and Mammoth would go together, whilst the *E. antiquus* and the African might be considered relatively broader and stouter animals. It would seem, however, if the bones referred to here belong to *E. antiquus*, that it was often bulkier than any of the foregoing, and approached *E. meridionalis*, which was the largest of the three British extinct forms.

Several undoubted specimens of the humerus of *E. primigenius* in the British Museum show all the characters of the Asiatic Elephant, and are generally in proportion more slender than that of the African, and than fossil humeri obtained from Grays and other deposits where teeth of *E. antiquus* are met with. They contrast, moreover, with huge specimens from the Forest Bed and other situations where teeth of *E. meridionalis* are found.

[1] See 'Catalogue of Mammalian Remains from Ilford,' p. 28, Nos. 9 and 10 D, or Nos. 45,200 and 45,201, B.M.

[2] 'Pal. Mem.,' ii, p. 188.

A humerus, No. 23,151 in the British Museum, purchased from the late Mr. Ball, is from GRAYS. The great tuberosity has been somewhat ingeniously replaced by affixing a portion of an inner condyle of another specimen; nevertheless, with the exception of loss of substance at the distal extremity its entire length is seemingly preserved, and is 41 inches. The scapular articulation is 13·5 inches in the antero-posterior diameter by 10·5 inches transversely; the girth mid-shaft is 22·5 inches.

Seeing that *E. meridionalis* has not been identified from the beds at Grays, where molars of *E. antiquus* are abundant, and in consideration of this bone being altogether more robust than that of the Mammoth, I am much inclined, with Mr. Davies, who brought the above-named specimen to my notice, to consider it to be the humerus of *Elephas antiquus*.

The three stupendous arm-bones referred by Falconer to *Elephas meridionalis*[1] deserve a few remarks; two are from the Pre-glacial Deposits of Norfolk, and the other is in the museum of Florence. I am indebted to Mr. Gunn for the following measurements of the two former, one of which belongs to his own collection, whilst the other, from Cromer, was presented to the Norwich Museum by Miss A. Gurney. Professor Owen refers to the latter,[2] and also other large humeri from the bottom of the German Ocean. The length of the larger of the two from the Mundesley Pre-glacial beds is 51 inches, whilst that from Cromer is an inch less. The middle girth, however, of the shaft in the latter exceeds that of the other by three inches, and there is a difference of as much as four and a half inches at the least circumference or termination of the deltoid ridge in favour of the Cromer humerus, which is altogether stouter in proportion and may have belonged to *Elephas antiquus*, whilst that from Mundesley may have appertained to the *Elephas meridionalis*. This, however, is mere conjecture, inasmuch as there appears to be loss of substance of the external layers of the shafts in both cases.

The entire humerus referred to *E. Namadicus* gives a length of 47 inches.[3] The proximal fragment, No. 36,700, B. M., shows an open bicipital grove which is 3 inches in breadth. The scapular head is 15 × 9 inches, and the entire girth of the proximal extremity is 45 inches.[4]

An enormous left humerus was discovered in 1866 in a gravel pit at Montreuil, near Paris.[5] The supinator ridge and portion of the proximal extremity are wanting, but the length is preserved and gives the enormous dimension of 1·35 m., or about 53 inches! A cast of this arm-bone is in the Museum of the Royal College of Surgeons of England.

I will refer to the third metacarpal found in the same situation with the above. The humerus in question exceeds any of the foregoing, and, considering that molars of *E. antiquus* were found in the same pit, the probability is that it belonged to this species.

[1] 'Pal. Mem.,' vol. ii, p. 143.

[2] 'British Fossil Mammals,' p. 251.

[3] 'Pal. Mem.,' vol. i, pp. 480 and 496.

[4] 'F. A. S.,' pl. xlviii, fig. 1.

[5] Belgrand, 'Basin de Paris,' p. 176, pl. xiv.

One of the largest humeri of recent species I have seen is represented by two specimens, right and left, No. 2744 *E*, of the Indian Elephant in the Royal College of Surgeons. Here the length is 36·5 inches; girth of the proximal extremity 33·5 inches; of the shaft (minimum) 16·5 inches; the distal extremity being 27 inches in circumference.

5. RADIUS.

There are two radii, Nos. $\frac{D}{13}$ and $\frac{C}{162}$, B. M., in the Brady Collection, from Ilford,[1] the former has been referred to *E. antiquus* by Mr. Davies; and it appears to me that this decision is well sustained by a comparison with radii of the Mammoth. Although neither of the foregoing belonged to aged individuals, and one was that of a young animal, both preserve stouter proportions than I have seen in radii of *E. primigenius*. There is a flattening of the upper and outer side of the shaft, rather more pronounced in the former than in several specimens of the Mammoth, whilst the inner side of the shaft and its border are quite flat and rounded. These bones seem to carry the radius of the African with them, whilst that of the Asiatic has the slender outline of the Mammoth. The various ridges appear to differ according to age and in individuals, as observed in numerous specimens of this bone belonging to the Mammoth and the Asiatic Elephant.

The larger of the two radii in question is 26 inches in length, and belonged to an adolescent individual, the distal epiphyses being lost. The other, that of a much younger elephant, is 19 inches in length.

I think, as far as the Maltese specimens of the equivalent bone in *E. Mnaidriensis* are concerned, that there is a close resemblance between the latter, *E. antiquus,* and *E. Africanus,* more especially in the general breadth of the shaft at the middle and lower third, whilst the afore-mentioned conditions referable to the upper third of the bone in *E. antiquus* are present in the Maltese, which I have shown elsewhere[2] have the decided aspect of the African as compared with the other living species.

6. ULNA.

Comparing the ulnæ in the Ilford collection, B. M., Nos. D 11 and 12, with similar bones from the same deposits and with Mammoth remains from the Arctic Regions, and likewise with the two recent species, I find the following distinctions:

1. The radial sulcus, round and shallow in the African, is less so in the Asiatic, and much less than either in the above.

2. The pit in front of the inner condyle seen in Asiatic and Mammoth is scarcely noticeable in the African and in the above.

[1] 'Cat.' cit., pp. 21 and 29. [2] 'Zool. Trans.,' vol. ix, p. 54.

3. The head of the olecranon arches more inwards in the African and in the bones in question than in *E. Asiaticus* and Mammoth.

The distal extremities of the specimens D 11 and 12, and also of a detached left ulna in the Museum, locality unknown, are wanting. These bones in proportion are stouter than ulnæ of the same length in the Mammoth.

There are several ulnæ in the Norwich Museum, and apparently as far as the foregoing indications are admissible it would seem that they bear out the characters assigned to the above and *E. primigenius,* by means of several examples in Mr. Gunn's and Miss Gurney's collections; it is still an open question, however, how far the larger specimens and the ulna of *E. meridionalis* differ. As regards the connection of the largest with either of the two stupendous humeri in the same Museum, and which Falconer has connected with the latter species, there can be no doubt that individually all belonged to elephants differing much in size.

Anchylosis of the forearm bones would seem to be not uncommon. I have seen the radius united at its proximal extremity in the larger Maltese form, and the specimen of, perhaps, a Mammoth's ulna and radius completely interossified throughout is preserved in the Gunn collection, showing the restricted functions of the radius in Elephants.

7. PORTION OF A FOREFOOT.

The only portion of the foot of the Mammoth referred to by Professor Owen in the 'British Fossil Mammals '[1] is a fragment[2] from GRAYS, ESSEX, of an enormous right foot comprising the cuneiform, which has lost its apex, together with the magnum, unciforme, second and third metacarpals. The combined breadth of the proximal aspects of the magnum and unciforme are 12·6 inches. The following are the dimensions of the bones:—Cuneiforme—height 4·8 inches; maximum breadth 5·8 inches:—Unciforme—height 6 inches; transverse diameter 7·9 inches; antero-posterior diameter 6·8 inches; the cuneiform surface is 5·8 inches by 4·8 inches; third metacarpal facet is 3 by 1 inch, whilst that of the fourth and fifth are 4 inches antero-posteriorly by 7 inches transversely:—Magnum—height 5·8 inches; maximum breadth 6 inches; the lunare surface is 6 inches in breadth by 5·6 inches in the antero-posterior diameter.

The second metacarpal has lost its distal epiphysis, leaving about 7 inches, with the proximal articulation intact excepting a portion of the inner facet. The magnal facet is 4 inches in antero-posterior diameter by 1·9 inch in breadth; girth, mid-shaft 10·8 inches.

These carpal and metacarpal bones when compared with authenticated remains of the Mammoth and the two recent species do not appear to differ excepting in their

[1] Page 249. [2] In the British Museum.

longer and broader measurements. A third metacarpal from Eschscholtz Bay of undoubtedly a full-grown Mammoth, when compared with the same bone in the foot here referred to, furnishes the following:—The length in the former is 8 inches, whereas in the latter it is 10 inches, whilst the maximum girth at the middle of the shaft is 10 to 10·4 inches. The marginal facet is 4·8 × 2 to 5 × 3 inches. The distal articular aspect is antero-posteriorly by tape 5·6 to 6·2 inches, and 3 to 3·4 inches in breadth.

Many fore-feet bones of different dimensions from the Norfolk Beds are to be seen in the Norwich Museum; it is at present, however, impossible to arrive at just conclusions from these remains until the characters of the skeleton of *E. primigenius* have been accurately determined.

The third metacarpal, found at Montreuil, near Paris,[1] in the same deposits with the gigantic humerus and molars already referred to at pp. 58, 41, and 19, measures 26 centimètres in length and 28 centimètres in circumference at the middle of the shaft.

A magnum of smaller proportions than the Grays specimen is also figured and described by Belgrand;[2] it is from the sand pits of Chevaleret, and has a maximum length of 0·146 m., and breadth of 0·117 m.

I mention these instances of the remains from the Paris basin, as they agree very well with the bones from the Thames Valley, both of which exuviæ evidently belonged to enormous elephants, and in all probability to large individuals of *Elephas antiquus*.

8. PELVIS.

I have seen no authenticated pelvis of the *Elephas antiquus*. There is the huge Os innominatum, described by Falconer,[3] in Mr. Gunn's Collection from the FOREST BED, and another of the right side of *E. primigenius* dredged off YARMOUTH.

The differences in these two as regards dimensions are sufficient of themselves to indicate two distinct forms of Elephants. Mr. Busk has pointed out[4] that the foramen ovale is narrowest above in the *E. Asiaticus*, and the reverse in the *E. Africanus*; and I find from data in the British Museum, and the portion of the pelvis above referred to from Yarmouth, that the Mammoth assimilates to the Asiatic species, whilst it will be seen that *E. Namadicus*[5] comes closer to the African, to which possibly the *E. antiquus* also appertains, as it does in the character of many of the bones of the extremities.

Unfortunately the foramen ovale is not entire in the large pelvis from the FOREST BED; the height of the opening, however, is no less than 10·5 inches, whereas in the smaller pelvis from YARMOUTH it is only 7 inches. Again, the breadth of the upper portion of the oval opening is 7 inches in the former and only 3 inches in the latter, whilst the breadth

1 Belgrand, 'Basin de Paris,' pl. xiii. 2 Op. cit., pl. liii. 3 'Pal. Mem.,' vol. ii, p. 142.
4 'Trans. Zool. Soc. London,' vol. vi, p. 242. 5 'F. A. S.,' pl. lvi, fig. 8.

at its lower part is 4 inches; unfortunately this measurement is not attainable in the gigantic pelvis which Dr. Falconer considered might have belonged to the colossal *E. meridionalis.* The Yarmouth specimen therefore being the more slender bone and preserving the constricted upper portion of the foramen ovale of the Mammoth and Asiatic Elephant belongs no doubt to the former.

9. FEMUR.

It is extremely probable that no long bone of *Elephas antiquus* would display more distinctive characters than its femur. Although fragments of both the shaft and extremities of thigh bones of large Elephants are contained in the Norwich Museum, it does not appear to me possible at present to differentiate their characters with certainty. A huge femur in the Gunn Collection, referred by Falconer[1] to the *Elephas meridionalis,* is from the Forest Bed. Both the extremities are wanting. The shaft does not seem to have lost much of its external layers, and gives a girth of 20 inches at the middle. The entire length of the specimen is about 47 inches. In the latter respect it far eclipses any femur of the Mammoth I have seen; at the same time, in thickness it is assuredly not in proportion to the usual robustness of the long bones inferred to belong to *Elephas antiquus.*

Two distal epiphyses of femora from Walton in Essex are preserved in the Museum of the Geological Society of London. One of them is recorded by Falconer as belonging to the *Elephas antiquus.*[2]

It seems, as far as I have been enabled to determine from materials, that the condyles do not converge closely in the African Elephant *E. Mnaidriensis,*[3] and in the femora from Walton; and it will be seen by comparing the figures or specimens of the same bone of *E. Namadicus*[4] that in all there is a pronounced resemblance, whilst in the Mammoth and *E. Asiaticus* the condyles are more apart.

With reference to the Walton epiphysis, which like its fellow is that of a young or adolescent Elephant, the internal articular surface is 17 inches in the antero-posterior by 5 inches in the transverse diameter; the external condyle being 14·7 inches by 4·6 inches. The former measurements, of course, include the patellar aspect as well as the tibial. The greatest length of the Nerbudda Valley femur of *E. Namadicus,* according to Mr. Prinsep, was no less than 5 feet 3 inches, with a girth at the head of 2 feet 3 inches, and a breadth across the lower condyles of 11 inches, the latter measurement being 1·4 inch greater than that of the Walton condyles.

1 'Pal. Mem.,' vol. ii, p. 144.

2 Ibid., vol. i, p. 490; and 'F. A. S.,' pl. liii, fig. 13.

3 'Trans. Zool. Soc. London,' vol. ix, pl. xiv, fig. 2 *a*, and p. 60.

4 'F. A. S.,' pl. lvi, figs. 1, 5, and 6; and 'Pal. Mem.,' vol. i, pp. 495, 496.

The important distinctions between the proximal extremities in the thigh-bones of the recent species naturally suggest inquiries with reference to the same characters in the extinct forms. In the shorter neck and more shallow digital pit I find an accordance in the femora of *E. Africanus*, *E. Mnaidriensis*, and *E. Namadicus*, whilst the longer neck and deep pit are observable in *E. Asiaticus* and *E. primigenius*. There are no materials, however, available by which these characters can be ascertained in the *E. antiquus* and *E. meridionalis*.

10. PATELLA.

There is a large patella from Grays, Essex, in the British Museum assigned by Falconer to the *E. antiquus*,[1] and, judging from its massive proportions, it is unlike the bone of the Mammoth; whilst the abundance of teeth of *Elephas antiquus* from that situation render it highly probable that the above belongs to this species.

11. TIBIA.

A huge left tibia, 48,134, B. M., from Camberwell, Surrey, is 26 inches in length. Compared with a left leg bone of Mammoth, 24,581, B. M., from Eschscholtz Bay, it is relatively stouter, but seemingly does not present any other distinctive character. The concavities posteriorly for the muscles of the ham are pronounced with sharp outer and inner ridges in the Mammoth, whilst in the above specimens it is shallow, and these ridges are not so angular and do not run down the bones with the distinctness seen in several tibiæ of the Mammoth, but perhaps a series would show this character to be variable. The more slender proportions of the Mammoth's tibia seem to me the only points by which the two species can at present be safely differentiated. As to other species, the tibia of *E. Mnaidriensis* is inferred to have been stout in proportion,[2] and, again, it shows an affinity with the above. These characters I found substantiated in tibiæ of Elephants from the Norfolk Forest Bed in the Norwich Museum. As to *E. meridionalis*, there are fragments of huge tibiæ in the Norwich Museum, and which might be referred to that species, and no doubt comparisons might be instituted between the recorded tibiæ[3] of *E. Namadicus* in the British Museum. The latter, however, are not at present available for study.

1 'Pal. Mem.,' vol. i, p. 494; and 'F. A. S.,' pl. lv, fig. 4.

2 'Trans. Zool. Soc. London,' vol. ix, p. 62.

3 'Pal. Mem.,' vol. i, p. 496; and 'F. A. S.,' pl. lvi, fig. 2.

12. CALCANEUM.

In pl. lv, fig. 2, 'F. A. S.,' Dr. Falconer represents what he supposed to be a left heel bone of *E. antiquus*, from Grays, Essex. It is No. 21,322, B. M., and differs from several calcanea of the Mammoth and of the Asiatic in having its sides equally compressed, with the peroneal facet *large* and *more protuberant*, in which peculiarities it agrees with the entire calcaneum of *E. Melitensis*.[1] This character is not so pronounced in the African, whereas in the Mammoth and *E. Asiaticus* the hollowing out is greater on the inside than the outside of the heel; and whilst the dorsal aspect is narrow in the Grays specimen and the Maltese heel bone, it is more rounded in the others. The interosseous pit is narrow in the Grays specimen as compared with many examples of the Mammoth, where it is usually triangular.

Two enormous calcanea, Nos. 33,420 and 33,419, B. M., from the Norfolk Coast have more the characters of the Asiatic and Mammoth as regards the projection of the peroneal facet. In the Museum at Norwich there are many heel bones in Mr. Gunn's collection; none, however, are sufficiently entire to show the hollow on either side.

IV. GENERAL SUMMARY AND CONCLUSION.

In summing up the foregoing details relating to the dental and osseous characters whereby we are enabled to differentiate three species of extinct British Elephants, it may be asked whether or not the materials admit of being accepted as the variable elements of one species subject to a range of mutability beyond any precedent in the morphologies of living or extinct members of the genus *Elephas*. When the dental materials are arranged with the view of testing their taxonomic values they will be found to admit of a classification into three very distinct series, which as far as is yet known seem to indicate both in their characters and distribution as many distinct forms of Elephants. This is apparent when their typical last true molars are placed side by side. Thus, the teeth from which the names of *Elephas primigenius*, *E. antiquus*, and *E. meridionalis* have been derived, represent such pronounced differences, that, with the knowledge of the well-known specific characters which distinguish the dental materials of the two living species, there can be no possible reason in not accepting their very divergent aspects as true morphological differences. Again, passing to a consideration of the skeletons in general, whilst we find very close affinities, still there are points

[1] 'Trans. Zool. Soc. London,' vol. ix, pl. xvi, fig. 5.

apparently distinctive of the three forms, and doubtless more extended means of comparison will afford conclusive evidences on that head.

The geological and geographical distributions of these forms as far as known are suggestive, and may admit of greater extension. At present the *Elephas meridionalis* has not been identified in British deposits more recent than the Pre-glacial beds of the Norfolk Coast, where it is associated with the *E. antiquus*, whilst the latter is also found in more recent deposits of Pleistocene age in conjunction with the remains of the *Elephas primigenius*, which has been asserted by several authorities, including the late Dr. Falconer, to be also of Pre-glacial origin.[1] This statement, however, is not clearly proven as far as England is concerned, whereas in Scotland, and probably in one instance in Cavan, Ireland, teeth of the Mammoth are said to have been found below the Boulder Clay.[2] No doubt the future will clear up a great deal of obscurity with reference to the distribution of these forms in space and in time. Suffice it for the present that, whether they merge into one another or into other forms, it is evident that individually these so-called species are subject to considerable variation in the characters of their dental elements, and in particular the form I have attempted to describe in the foregoing pages, the distinguishing features of whose dentition and osteology I shall now finally proceed to recapitulate briefly.

The general features of the incisor teeth have yet to be defined, whether they were straight as has been alleged, or much curved like the more arcuated defensors of the Mammoth, or, as in the Meridional and recent Elephants, they preserved a gentler curve; moreover, the enamel covering of the deciduous incisor of the African and Maltese Elephants has not apparently been observed on the milk-tusk of any other species.

The molars referred to *Elephas antiquus* are, as a rule, both narrower and higher than obtain in the two other British fossil species, whilst the conditions of the worn disk, to wit, the crimping of the machærides, and central expansions and angulations, maintain features broadly distinctive as compared with them. The number of ridges are also characteristic both individually as regards the successional teeth and in the aggregate of the entire laminæ of the dental series. Such are the main points of difference in the dentition, modifications of which lead towards the *Elephas meridionalis* on the one hand, and *E. primigenius* by the broad crown, which in a more pointed degree assimilates to the typical molar of *Elephas Namadicus* of India.

The ante-penultimate, or what is usually named the first, milk molar shows generally a lower ridge formula than that of the Mammoth and Asiatic Elephant, but agrees in this respect with the same tooth in the Meridional and Maltese Elephants; in its general characters we find it comes close to the Maltese forms; whilst that of *E. Namadicus* is unknown.

The second milk molar agrees in outline and characters with the Maltese, only it is

1 'Pal. Mem.,' vol. ii, pp. 240 and 586.

2 Bald, 'Mem. Wernerian Soc.,' vol. iv, pp. 64 and 58.

larger, and is usually broadly distinctive as compared with the recent species. Unfortunately I have been unable to compare it with the same tooth of *E. Namadicus*. It is sufficiently variable, and shows considerable diversity both in the ridge formula and sculpturing of the disk.

The last of the milk series being usually subject to considerable discrepancies in all known recent and extinct species of Elephants seems equally if not more various in its ridge formula and dimensions in *Elephas antiquus* than in any other form. Compared with the same tooth in the larger Maltese form and *E. Namadicus*, there is the closest affinities, and the thick-plated, narrow, and broad crowns which characterise the varieties of the molars of *E. antiquus* generally are pronounced in specimens of the ultimate milk tooth.

The first true molar is equally if not more variable than the last, and it is seemingly subject to unusual discrepancies in *Elephas antiquus* both as regards dimensions and the number of ridges. Like the ultimate milk, it has its closest ally in the same tooth of the *E. Namadicus* and *Elephas Mnaidriensis;* the latter, however, is considerably smaller.

The second true molar generally maintains a more equable ridge formula and more constant dimensions than any of the other members of the series, and this is the case to a certain extent in *Elephas antiquus.*

In all respects it is indistinguishable from the same tooth in *E. Namadicus*, and agrees in general features with the second true molar of the *E. Mnaidriensis*, which has a smaller ridge formula, as far as I have been enabled to determine, and is, of course, relatively a much smaller tooth; but the crown patterns of the two are indistinguishable, and it may be likely that second molars of *E. Mnaidriensis* will be found with a numerical expression of the colliculi equal to *E. antiquus*, although I have not met with an instance.

The last true molar, of all others, establishes the dental characteristics of the form of Elephant under consideration far better than any other member of its series. The long narrow crown tapering to a narrow heel posteriorly, with the unusual great height and the well-known worn disk, has been the general accepted molar of *E. antiquus*, and, as far as these peculiarities extend, they are very characteristic; but on viewing a vast number of teeth, and on becoming habituated to a manipulation of them, one will soon perceive the divergencies before referred to, which are traceable in every member of the dental series. Confining my observations to collections from the Norfolk Forest Bed and the fluviatile deposits of the Thames Valley between Grays Thurrock and Oxford, I find a broad crown with closely packed ridges, faintly crimped, and not displaying the central expansion and angulation to the extent observed in the long narrow crown. This type represents the usual molar of *E. Namadicus*, and is seen in the Maltese forms, which, strange to say, present the same three varieties of crown in very much smaller teeth. The broad-crowned variety can be traced gradually merging into either a thick-plated or a narrow crown, which again as gradually assumes the character of the open disk of the African Elephant. I again refer to the probability that these different varieties of crown may be sexual or individual characters, inasmuch as they have been found in the same deposits and often associated. At the same time the possibility of local varieties is quite admissible, and the divergence of the broad crown into the tooth of the *Elephas primigenius*, on the one hand, and the thick rhomb-like disk into that of the molar of *E. Africanus*, is also a possible contingency, neither of which, however, can be safely accepted as evidences of the genesis of either species, at all events, without a more extended comparison with the other extinct forms.

As to *Elephas Namadicus*, it seems to me, as far as its dentition extends, to be indistinguishable from *Elephas antiquus;* indeed, Dr. Falconer appears to have been constantly impressed with the relationship, and had he lived to carry out the brilliant researches with which his name is so intimately associated, it appears to me that, with all his bias in favour of the immutability of species, the conclusion I have come to must at length have been forced upon him.

The last true molar of the largest Maltese form is a miniature of the same tooth in the *Elephas antiquus*, with a ridge formula only equal to the second true molar of the latter; so that whilst the two go hand in hand in respect to ridge formula and crown pattern from the first milk to the first true molar, they seemingly differ in regard to the two remaining members of the series. These differences, however, may not be constant, although I found them general in a number of specimens of the ultimate molar of *Elephas Mnaidriensis*. No doubt, however, future researches in Southern Europe and eastwards will develop many seemingly discordant points in connection with *Elephas antiquus* and allied forms.

The uncertainty in regard to the bones ascribed to *Elephas antiquus* render the foregoing observations on its osteology of little value. As regards the relative dimensions of maxillæ and mandibles, it would seem that ordinarily they do not differ materially, especially in young and adolescent individuals, from those found with similar stages of growth in the Asiatic and African Elephants; and, whilst aged individuals attained to colossal proportions, the usual adult may have not averaged over 11 feet in height, or, perhaps, a little over the larger individuals of the African Elephants, which rarely exceeds 12 feet at the shoulder. The mandible, being the only available portion of the skull of *Elephas antiquus* in any way entire, presents the general characters of the African, as far as the contour of the horizontal and ascending rami are concerned, whilst the diasteme is more erect and the chin somewhat rounded, but not to the same extent observed in the Mammoth, which again bears a close resemblance in its mandible to the Asiatic Elephant, as it does generally in the other bones of the skeleton.

The general resemblances between the mandibles of *Elephas antiquus*, *E. Namadicus*, and *E. Mnaidriensis* are pronounced, whilst *E. meridionalis* has more in common with *E. Africanus*.

As regards the long bones, it would seem that as compared with the Mammoth the humerus and femur are stouter in *E. antiquus;* and this stoutness was, doubtless, the main feature in its general outline. At the same time the *E. meridionalis* was not only of colossal dimensions, but, judging from the relative thickness of its bones, presented a like proportional stoutness, so that it is impossible at present to say to which form the Elephantine bones from the Forest Bed belong, as teeth of the two species are often found together. Indeed, the relative connections between varieties of the broad crown of the molar of *E. antiquus,* and certain teeth ascribed to *E. meridionalis,* are striking and cannot be determined with certainty until the dentition and osteology of the latter have been carefully worked out.

It seems apparent from the data here advanced that the Proboscidian, to which the name *Elephas antiquus* has been given, lived in Britain before the Glacial epoch along with an allied form, *E. meridionalis,* and that both, judging from the quantities of their remains met with in Southern Europe, were southern and probably eastern forms with pedigrees extending backwards into Miocene times, as shadowed forth by their congeners from the deposits of Northern India.

It is further established that the *Elephas antiquus* survived the Ice Age, and flourished subsequently along with the Mammoth on British soil. Unlike the latter, it has not hitherto been traced to the Arctic regions nor to North America; perhaps it was not suited for boreal regions, and may have only so journeyed in England after the cold period had passed away. That it was a distinct species or form from the Mammoth cannot, I think, be doubted; at all events, the dental and apparently the osteological characters are as broadly distinctive as those which obtain between the two species now living in Asia and Africa.

PLATE I.

Figs. 1 and 1 *a*. Crown and profile of No. 21,654, British Museum, a right upper ante-penultimate milk molar, from Grays Thurrock, Essex. (Natural size.)

Figs. 2 and 2 *a*. Crown and profile of a left lower ante-penultimate milk molar, from Victoria Cave, Settle, Yorkshire. (Natural size.)

Fig. 3. Crown of a right lower penultimate milk molar, No. 18,810, British Museum, from Grays Thurrock, Essex. (Natural size.)

Fig. 4. Palate, with crown views of third milk molar, No. 21,301, British Museum, from Grays Thurrock, Essex. (Natural size).

Fig. 1

Fig. 3

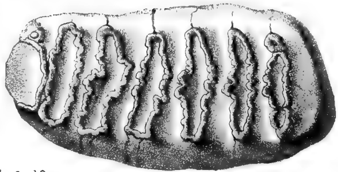
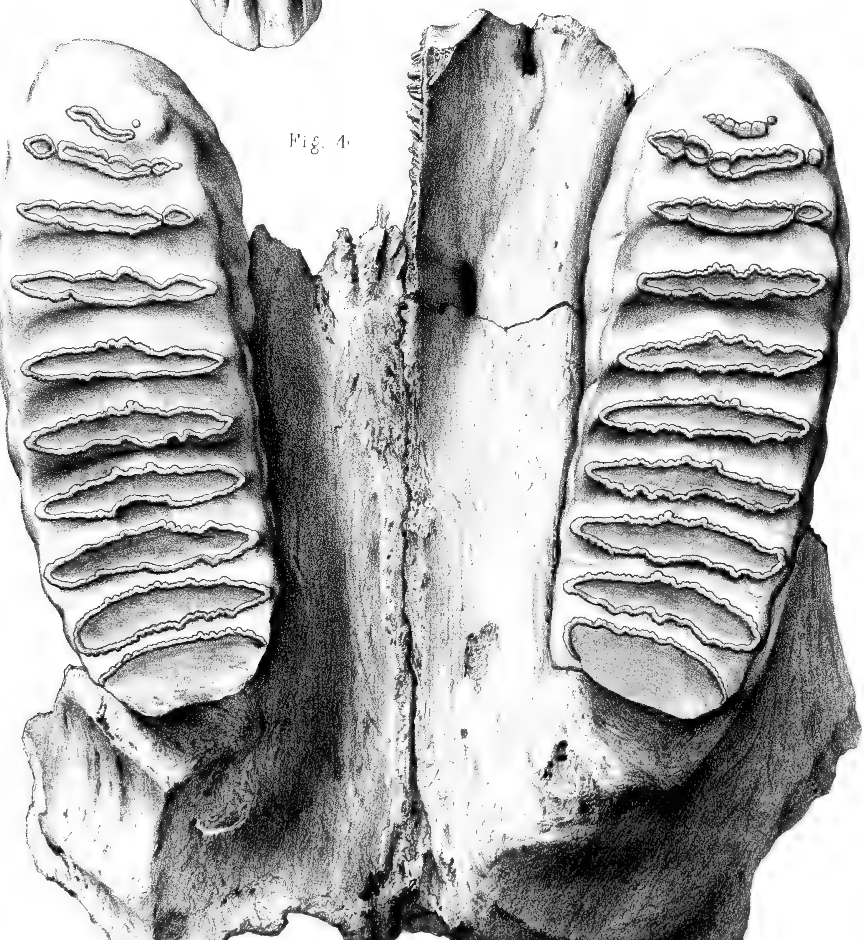


Fig. 2

Fig. 2a.

Fig. 1a.

Fig. 4.



C. L. Griesbach del. et lith.

Nat. size

W. West & Co. imp.

PLATE II.

Fig. 1. Profile of a right upper second true molar, No. $\frac{23,717}{*}$, British Museum, from Slade Green, Erith, Essex. (Half natural size.)

Fig. 2. Crown view of a left upper last true molar, No. 28,118, British Museum, from Grays Thurrock, Essex. (Half natural size.)

Figs. 3 and 3 *a*. Crown and profile views of No. 47,121, British Museum, a right upper last true molar, from Peterborough. (Half natural size.)

I have just been shown (January, 1877), but too late for description in the text, a very characteristic left upper molar, almost entire, by Professor Ramsay, F.R.S., Director-General of the Geological Survey, who lately discovered it in a marine deposit near the sea-gate of Tangier. It is of the narrow-crowned variety, like the tooth from Gibraltar, which was also found in a marine deposit.

Pl. II

Fig. 1

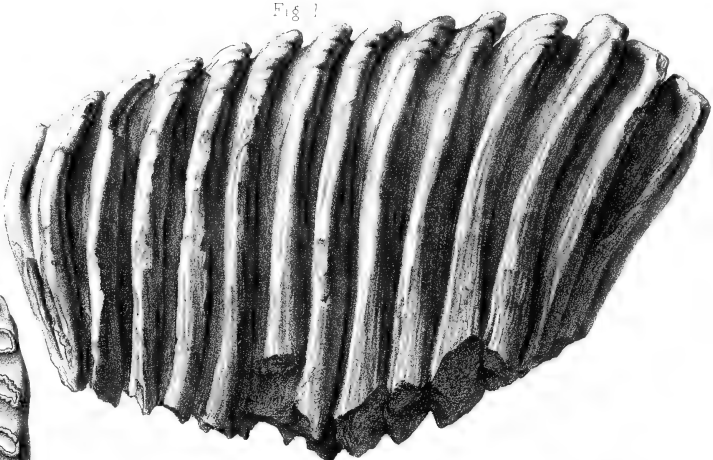


Fig. 2

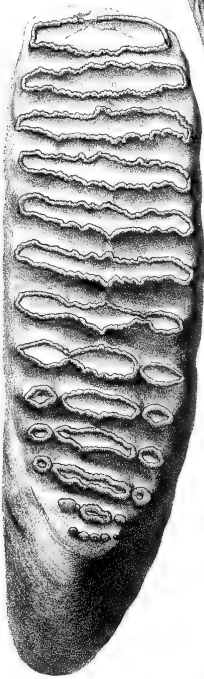


Fig. 3a

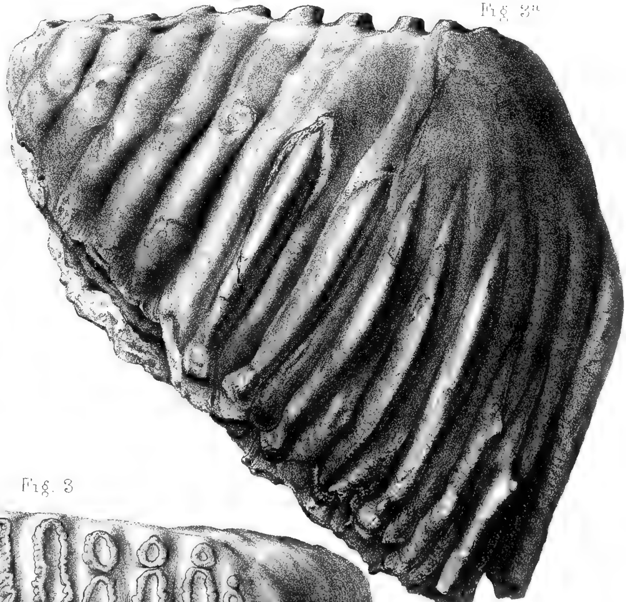
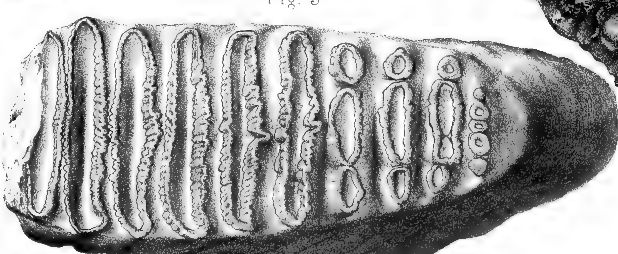


Fig. 3



L. Griesbach del et lith

W.W.

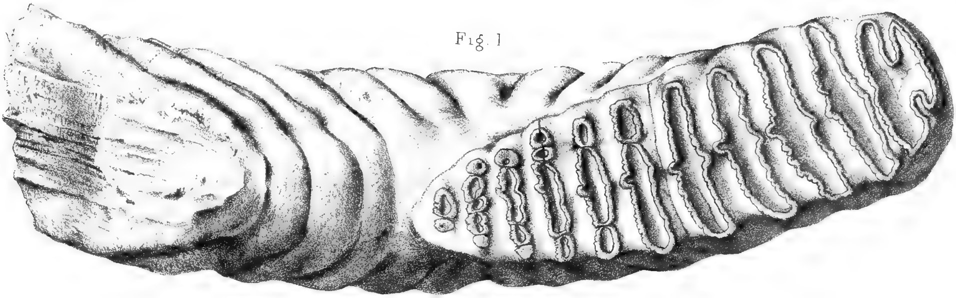
Hanhart imp.

PLATE III.

Figs. 1 and 1 *a*. Crown and profile of No. 47,119, British Museum, a left lower last true molar, from Cromer, Norfolk. (Half natural size.)

Fig. 2. Crown of No. 37,241, British Museum, a right upper first true molar, dredged from the bed of the German Ocean, Happisborough, Norfolk. (Natural size.)

Fig. 1



½ nat size

Fig. 1ª.

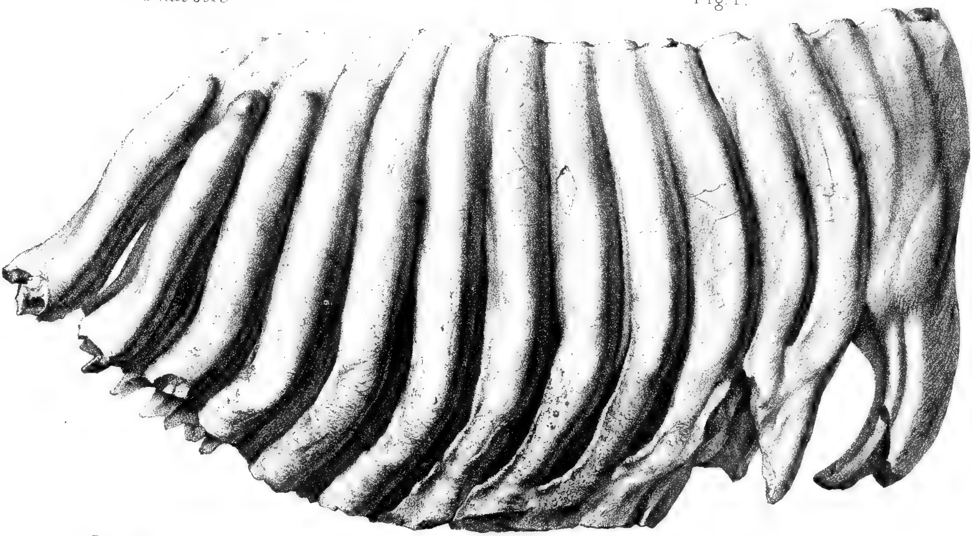
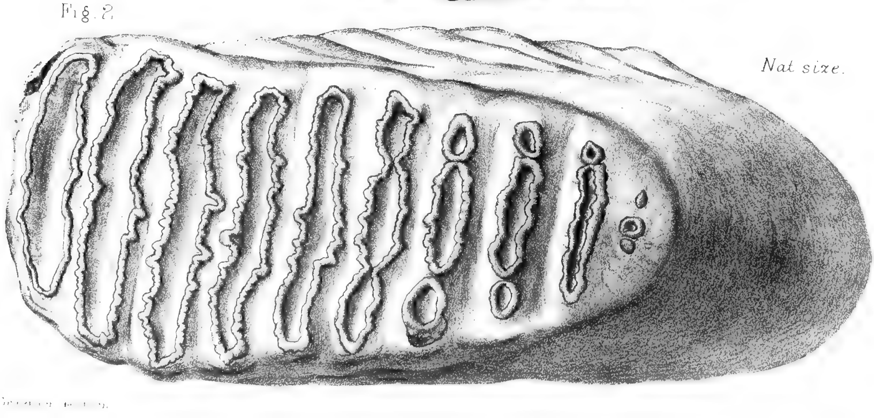


Fig. 2.



Nat size.

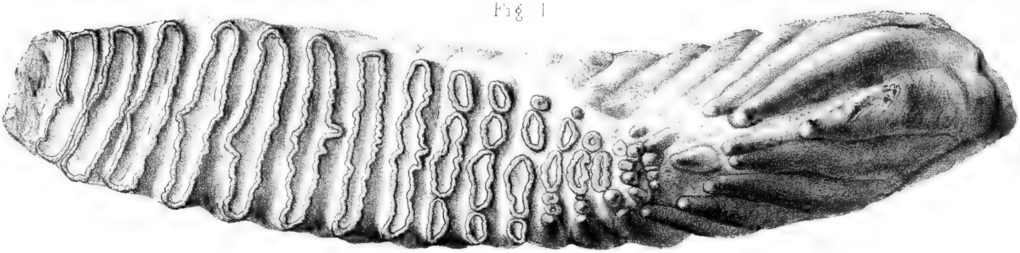
W West & Co.

PLATE IV.

Figs. 1 and 1 *a*. Crown and profile of No. 27,907, British Museum, a right lower last true molar, from the freshwater deposits at Clacton, Essex. (Half natural size.)

Fig. 2. Crown of 22,017, British Museum, a right upper second true molar, from Grays Thurrock, Essex. (Natural size.)

Fig. 1



½ nat. size

Fig. 1a

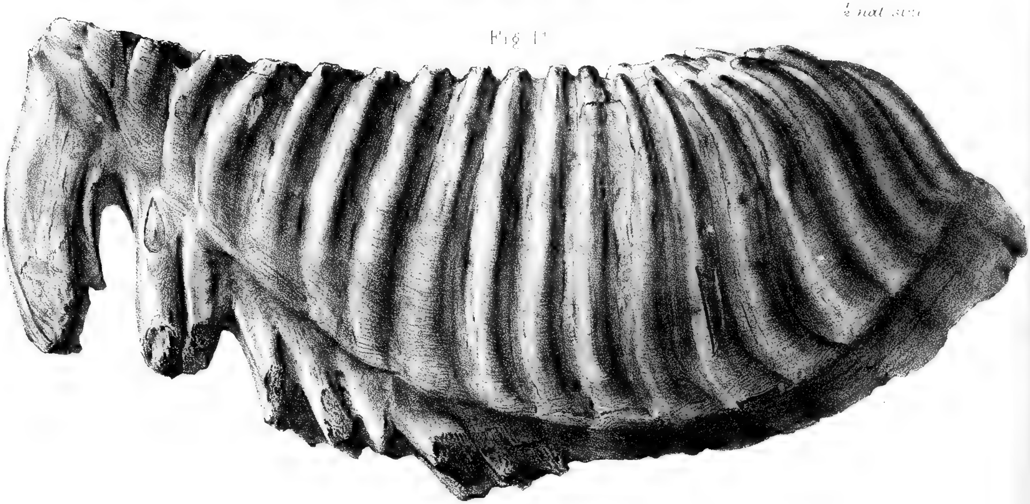
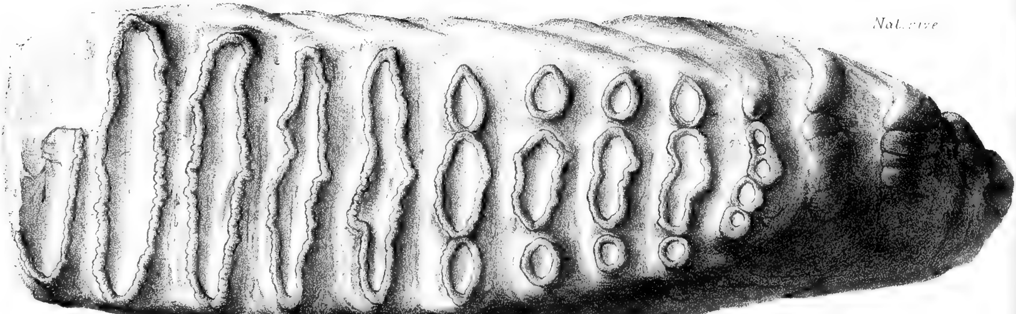


Fig. 2

Nat. size



C. L. Griesbach del et lith

PLATE V.

Fig. 1. Crown view of No. 27,907, British Museum, a right upper last true molar, from the freshwater deposits, Clacton, Essex. (Natural size.)

Fig. 2. Portion of the left ramus of a lower jaw, No. 21,310, British Museum, from Ilford, Essex, containing a penultimate milk molar. (Natural size.)

Fig 1

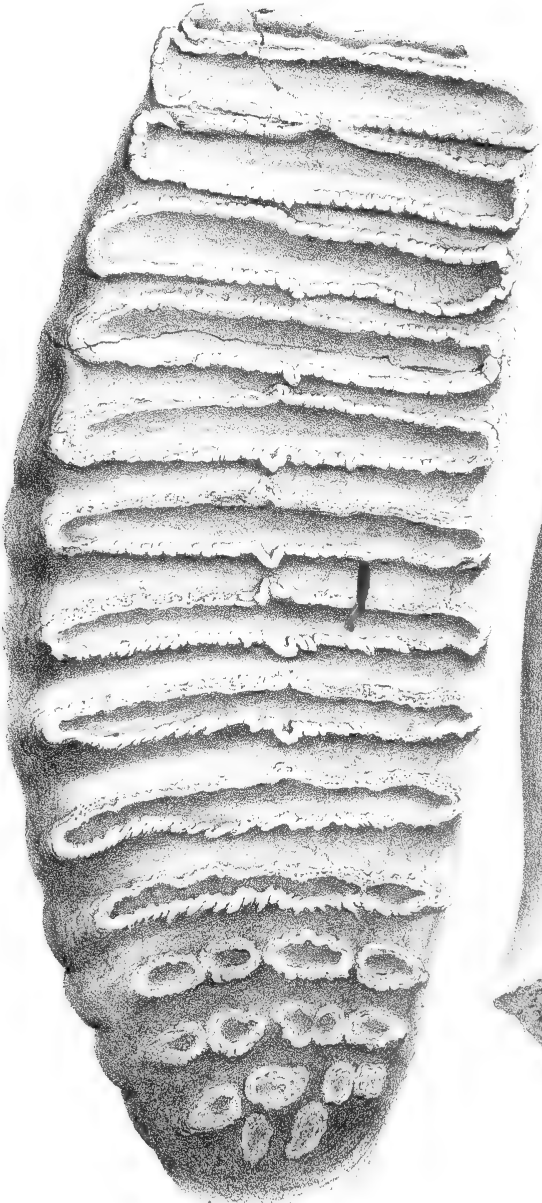
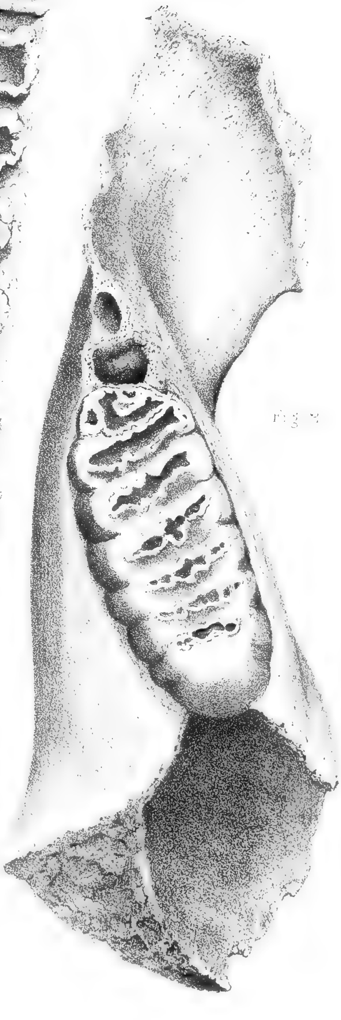


Fig 2



Nat. size.

C. R. DeWilde, del et lith.