PALÆONTOGRAPHICAL SOCIETY.
VOL. LXVII.

BRITISH GRAPTOLITES.

Part X.

Pages 487—526; Plates L—LII.

THE PALÆOZOIC ASTEROZOA.

Part I.

Pages 1—56; Plate I.

THE LOWER PALÆOZOIC TRILOBITES OF GIRVAN.

Supplement.

Including Title-page and Index.

Pages 1—56; Plates I—VIII.

THE PLIOCENE MOLLUSCA.

Part I.

Pages 1—200; Plates I—XXIV.

GANOID FISHES OF BRITISH CARBONIFEROUS FORMATIONS.

Part I, No. 7.

Including Title-page and Index.

Pages i—vi, 181—186.

THE FISHES OF THE OLD RED SANDSTONE.

Part II, No. 4.

Including Title-page and Index.

Pages 131—134.

Issued for 1913.

PALÆONTOGRAPHICAL SOCIETY.

VOLUME LXVII.

CONTAINING

1. BRITISH GRAPTOLITES. Part X. By Miss ELLES and Miss WOOD. Edited by Prof. LAPWORTH. Three Plates.
2. THE PALÆOZOIC ASTEROZOA. Part I. By Mr. W. K. SPENCER. One Plate.
3. THE LOWER PALÆOZOIC TRILOBITES OF GIRVAN.—SUPPLEMENT. By Dr. F. R. COWPER REED. Eight Plates.
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5. GANOID FISHES OF BRITISH CARBONIFEROUS FORMATIONS. Part I.—PALÆONISCIDÆ. No. 7. By Dr. R. H. TRAQUAIR. Title-page and Index.
6. THE FISHES OF THE OLD RED SANDSTONE. Part II, No. 4. By Dr. R. H. TRAQUAIR. Title-page and Index.

ISSUED FOR 1913.

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AGENTS FOR THE SOCIETY
DULAU AND CO., LTD., 37, SOHO SQUARE, W.

FEBRUARY, 1914.

THE PALÆONTOGRAPHICAL SOCIETY was established in the year 1847, for the purpose of figuring and describing British Fossils.

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The Annual Volumes are now issued in *two forms of Binding:* 1st, with all the Monographs stitched together and enclosed in one cover; 2nd, with each of the Monographs in a paper cover, and the whole of the separate parts enclosed in an envelope. Members wishing to obtain the Volume arranged in the LATTER FORM are requested to communicate with the Secretary.

Most of the *back volumes* are in stock. Monographs or parts of Monographs already published can be obtained, apart from the annual volumes, from Messrs. DULAU AND CO., LTD., 37, Soho Square, London, W., who will forward a complete price list on application.

Members desirous of forwarding the objects of the Society can be provided with plates and circulars for distribution on application to the Secretary, Dr. A. SMITH WOODWARD, British Museum (Nat. Hist.), South Kensington, London, S.W.

The following Monographs are in course of preparation and publication:

The Graptolites, by Prof. Lapworth, Miss Elles, and Miss Wood.

The Cambrian Trilobites, by Mr. Philip Lake.

The Palæozoic Asterozoa, by Mr. W. K. Spencer.

The Ordovician and Silurian Mollusca, by Dr. Wheelton Hind.

The Pliocene Mollusca, by Mr. F. W. Harmer.

The Pleistocene Mammalia, by Prof. S. H. Reynolds.

ANNUAL REPORT

OF THE

PALÆONTOGRAPHICAL SOCIETY, 1913,

WITH

LIST

OF

The Council, Secretaries, and Members

AND

A LIST OF THE CONTENTS OF THE VOLUMES ALREADY PUBLISHED.

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ANNUAL REPORT OF THE COUNCIL

FOR THE YEAR ENDING 31st DECEMBER, 1912.

READ AND ADOPTED AT THE

ANNUAL GENERAL MEETING,

HELD AT THE APARTMENTS OF THE GEOLOGICAL SOCIETY, BURLINGTON HOUSE, 14th MARCH, 1913.

Dr. HENRY WOODWARD, F.R.S., President,

IN THE CHAIR.

The Council, in presenting their Sixty-sixth Annual Report, have pleasure in referring to the continued activity in the study of British fossils, which still furnishes them with more than ample material for their publications. The volume for 1912 includes the final instalment of the monograph of "Cretaceous Lamellibranchia," by Mr. H. Woods, with important synoptical tables and indexes; and there are also the title-page and index for the "Fossil Malacostracous Crustacea," by the late Prof. T. Bell, which now permit the binding of that work. Instalments of the "British Graptolites," by Miss Elles and Miss Wood (Mrs. Shakespear), and the "Cambrian Trilobites," by Mr. P. Lake, form valuable continuations of these monographs. The total number of plates is again less than usual; but, as was the case last year, this deficiency is more than compensated by the very large series of text-figures of Cretaceous Lamellibranchia, which seemed to be as appropriate for the species of *Ostrea* as for those of *Inoceramus*.

Like the volume for 1911, that for 1912 was also delayed by unforeseen difficulties in the preparation of the contributions, and it was not ready for distribution until the end of February, 1913. The cost of the printing could not therefore be included in the balance-sheet for the year, and as some of the corresponding charges for the volume for 1911 were carried forward to the beginning of 1912, an analysis of the expenditure presents some difficulty. It is anticipated, however, that the total cost of the volume for 1912 will not exceed the income for the year to which it relates.

Among the members who have died during the past year, the Council desire especially to refer to the Rev. R. Ashington Bullen and Dr. R. H. Traquair. For many years Mr. Bullen was an active member of Council, and he was held in the highest esteem by his colleagues, who mourn his untimely loss. Dr. Traquair was the distinguished author of two important monographs of Devonian and Carboniferous fishes, which would have been completed in the volume for 1912 had not ill-health incapacitated him for some months before his decease.

The thanks of the Society are due to the Council of the Geological Society for permission both to store the stock of back volumes, and to hold the Council Meetings and the Annual General Meeting in their apartments.

In conclusion, it is proposed that the retiring members of Council be Mrs. Longstaff, Dr. Bather, and Mr. Upfield Green; that the new members be Dr. C. W. Andrews, Prof. E. J. Garwood, Dr. Walcot Gibson, and Prof. W. J. Sollas; that the President be Dr. Henry Woodward; the Treasurer, Dr. G. J. Hinde; and the Secretary, Dr. A. Smith Woodward.

Annexed is the Balance-sheet.

The PALÆONTOGRAPHICAL SOCIETY in account with Dr. GEORGE J. HINDE, F.R.S., Treasurer.

Cr. *From January 1st, 1912, to December 31st, 1912.* *Dr.*

		£	*s.*	*d.*	£	*s.*	*d.*
Balance from last Account					445	7	3
Members' Subscriptions—1910–1911	98	102	18	0			
,, ,, 1912	250½	263	0	6			
,, ,, 1913	8	8	8	0			
	356½				374	6	6
Carriage paid by Members					2	3	10
Sales of back stock to Members					27	12	0
Repaid Income Tax (1 year)					0	17	6
Sales by Messrs. Dulau & Co., Ltd.					72	13	3
Dividends on £500 Natal 3 per cent. Stock (less income tax)					14	2	6
Interest on Deposit					11	0	5
					£948	3	3

	£	*s.*	*d.*	£	*s.*	*d.*
Letterpress printing (Vol. LXV)	25	0	2			
Paper	5	13	1			
				30	13	3
Drawing text-figures	3	5	0			
Drawing plates	118	14	0			
Collotype printing	78	12	6			
				200	11	6
Binding (Vol. LXV)				36	16	11
Packing and distribution (Vol. LXV)				15	4	9
Secretary's honorarium				52	10	0
Postage and stationery				5	1	3
Printed Notice Cards, etc.				2	5	4
Premium Fire Insurance				0	15	0
Petty charges—Porter	0	15	0			
Bank	0	4	0			
				0	19	0
Balance at Bank—Current Account £119 6*s.* 3*d.* *minus* cheque not presented £16	103	6	3			
Balance at Bank—Deposit Account	500	0	0			
				603	6	3
				£948	3	3

We have examined the above account, compared it with the vouchers, and find it to be correct; we have also seen the receipt for £500 Natal 3 per cent. Consolidated Stock

George Barrow,
Walcot Gibson,
John Hopkinson,
Alfred W. Oke.
} Auditors.

March 7th, 1913.

LIST OF MEMBERS.*

CORRECTED TO 1st DECEMBER, 1913.

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* Members are requested to inform the Secretary of any errors or omissions in this list, and of any delay in the transmission of the Yearly Volumes.

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CATALOGUE OF THE CONTENTS OF THE ANNUAL VOLUMES

ALREADY PUBLISHED BY

THE PALÆONTOGRAPHICAL SOCIETY.

Vol. I.	Issued March, 1848, for the Year 1847	The Crag Mollusca, Part I, Univalves, by Mr. S. V. Wood (pp. i—xii, 1—208, pls. i—xxi, and title-page).
„ II.	Issued July, 1849, for the year 1848	The Reptilia of the London Clay, Vol. I, Part I, Chelonia, &c., by Profs. Owen and Bell (pp. 1—76, pls. i—xxviii, viii A, x A, xiii A, xvi A, xviii A, xix*, xix B, xix C, xix D). The Eocene Mollusca, Part I, Cephalopoda, by Mr. F. E. Edwards (pp. 1—56, pls. i—ix).
„ III.[1]	Issued Aug., 1850, for the Year 1849	The Entomostraca of the Cretaceous Formations, by Mr. T. R. Jones (pp. 1—40, pls. i—vii). The Permian Fossils, by Prof. Wm. King (pp. i—xxxviii, 1—258, pls. i—xxviii*). The Reptilia of the London Clay, Vol. I, Part II, Crocodilia and Ophidia, &c., by Prof. Owen (pp. 1—68, pls. xxix, i—xvi, ii A). The Fossil Corals, Part I, Crag, London Clay, Cretaceous, by Messrs. Milne Edwards and Jules Haime (pp. i—lxxxv, 1—72, pls. i—xi).
„ IV.	Issued June, 1851, for the Year 1850	The Crag Mollusca, Part II, No. 1, by Mr. S. V. Wood (pp. 1—150, pls. i—xii). The Mollusca of the Great Oolite, Part I, Univalves, by Messrs. Morris and Lycett (pp. i—viii, 1—130, pls. i—xv). The Fossil Brachiopoda, Vol. I, Part III, No. 1, Oolitic and Liassic, by Mr. Davidson (pp. 1—64, pls. i—xiii).
„ V.	Issued June, 1851, for the Year 1851	The Reptilia of the Cretaceous Formations, by Prof. Owen (pp. 1—118, pls. i—xxxvii, vii A, ix A). The Fossil Corals, Part II, Oolitic, by Messrs. Milne Edwards and Jules Haime (pp. 73—146, pls. xii—xxx). The Fossil Lepadidæ, by Mr. Charles Darwin (pp. i—vi, 1—88, pls. i—v).
„ VI.	Issued Aug., 1852, for the Year 1852	The Fossil Corals, Part III, Permian and Mountain-limestone, by Messrs. Milne Edwards and Jules Haime (pp. 147—210, pls. xxxi—xlvi). The Fossil Brachiopoda, Vol. I, Part I, Tertiary, by Mr. Davidson (pp. 1—23, pls. i, ii). The Fossil Brachiopoda, Vol. I, Part II, No. 1, Cretaceous, by Mr. Davidson (pp. 1—54, pls. i—v). The Fossil Brachiopoda, Vol. I, Part III, No. 2, Oolitic, by Mr. Davidson (pp. 65—100, pls. xiv—xviii). The Eocene Mollusca, Part II, Pulmonata, by Mr. F. E. Edwards (pp. 57—122, pls. x—xv). The Echinoderms of the Crag, London Clay, &c., by Prof. E. Forbes (pp. i—viii, 1—36, pls. i—iv, and title-page).
„ VII.	Issued Dec., 1853, for the Year 1853	The Fossil Corals, Part IV, Devonian, by Messrs. Milne Edwards and Jules Haime (pp. 211—244, pls. xlvii—lvi). The Fossil Brachiopoda, Introduction to Vol. I, by Mr. Davidson (pp. 1—136, pls. i—ix). The Mollusca of the Chalk, Part I, Cephalopoda, by Mr. D. Sharpe (pp. 1—26, pls. i—x). The Mollusca of the Great Oolite, Part II, Bivalves, by Messrs. Morris and Lycett (pp. 1—80, pls. i—viii). The Mollusca of the Crag, Part II, No. 2, Bivalves, by Mr. S. V. Wood (pp. 151—216, pls. xiii—xx). The Reptilia of the Wealden Formations, Part I, Chelonia, by Prof. Owen (pp. 1—12, pls. i—ix).

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

CATALOGUE OF VOLUMES—Continued.

Vol. VIII.[1] Issued May, 1855, for the Year 1854

- The Fossil Brachiopoda, Vol. I, Part II, No. 2, Cretaceous (pp. 55—117, pls. vi—xii), with Appendix and Index to Vol. I, by Mr. Davidson (pp. 1—30, pl. A).
- The Reptilia of the Wealden Formations, Part II, Dinosauria, by Prof. Owen (pp. 1—54, pls. i—xix, xvi A).
- The Mollusca of the Great Oolite, Part III, Bivalves, by Messrs. Morris and Lycett (pp. 81—147, pls. ix—xv).
- The Fossil Corals, Part V, Silurian, by Messrs. Milne Edwards and Jules Haime (pp. 245—322, pls. lvii—lxxii).
- The Fossil Balanidæ and Verrucidæ, by Mr. Charles Darwin (pp. 1—44, pls. i, ii).
- The Mollusca of the Chalk, Part II, Cephalopoda, by Mr. D. Sharpe (pp. 27—36, pls. xi—xvi).
- The Eocene Mollusca, Part III. No. 1, Prosobranchiata, by Mr. F. E. Edwards (pp. 123—180, pls. xvi—xxiii).

" IX.[2] Issued Feb., 1857, for the Year 1855

- The Mollusca of the Crag, Part II, No. 3, Bivalves, by Mr. S. V. Wood (pp. 217—342, pls. xxi—xxxi).
- The Reptilia of the Wealden Formations, Part III, by Prof. Owen (pp. 1—26, pls. i—xii).
- The Eocene Mollusca, Part III, No. 2, Prosobranchiata, continued, by Mr. F. E. Edwards (pp. 181—240, pls. xxiv—xxvii).
- The Mollusca of the Chalk, Part III, Cephalopoda, by Mr. D. Sharpe (pp. 37—68, pls. xvii—xxvii).
- The Tertiary Entomostraca, by Mr. T. R. Jones (pp. i—xii, 1—68, pls. i—vi).
- The Fossil Echinodermata, Oolitic, Vol. I, Part I, by Dr. Wright (pp. v—x, 1—154, pls. i—x).

" X. Issued April, 1858, for the Year 1856

- The Fossil Echinodermata, Oolitic, Vol. I, Part II, by Dr. Wright (pp. 155—302, pls. xi—xxii).
- The Fossil Crustacea, Part I, London Clay, by Prof. Bell (pp. i—viii, 1—44, pls. i—xi).
- The Fossil Brachiopoda, Vol. II, Part IV, Permian, by Mr. Davidson (pp. 1—51, pls. i—iv).
- The Fossil Brachiopoda, Vol. II, Part V, No. 1, Carboniferous, by Mr. Davidson (pp. 1—48, pls. i—viii).
- The Reptilia of the Wealden Formations, by Prof. Owen, Part IV (pp. 8—26, pls. iv—xi), and Supplement No. 1 (pp. 1—7, pls. i—iii).
- The Reptilia of the London Clay, Vol. I (Supplement), by Prof. Owen (pp. 77—79, pls. xxviii A, xxviii B).

" XI. Issued Nov., 1859, for the Year 1857

- The Fossil Echinodermata, Oolitic, Vol. I, Part III, by Dr. Wright (pp. 303—390, pls. xxiii—xxxvi).
- The Fossil Brachiopoda, Vol. II, Part V, No. 2, Carboniferous, by Mr. Davidson (pp. 49—80, pls. ix—xvi).
- The Reptilia of the Cretaceous Formations (Supplement No. 1), by Prof. Owen (pp. 1—19, pls. i—iv).
- The Reptilia of the Wealden Formations (Supplement No. 2), by Prof. Owen (pp. 20—44, pls. v—xii.)
- The Polyzoa of the Crag, by Prof. Busk (pp. i—xiv, 1—136, pls. i—xxii).

" XII. Issued March, 1861, for the Year 1858

- The Fossil Echinodermata, Oolitic, Vol. I, Part IV, by Dr. Wright (pp. 391—468, pls. xxxvii—xliii).
- The Eocene Mollusca, Part III, No. 3, Prosobranchiata continued, by Mr. F. E. Edwards (pp. 241—330, pls. xxviii—xxxiii).
- The Reptilia of the Cretaceous Formations (Supplements No. 2, No. 3), by Prof. Owen (pp. 27—30, pl. vii, pp. 1—25, pls. i—vi).
- The Reptilia of the Purbeck Limestones, by Prof. Owen (pp. 31—39, pl. viii).
- The Fossil Brachiopoda, Vol. II, Part V, No. 3, Carboniferous by Mr. Davidson (pp. 81—120, pls. xvii—xxvi).

" XIII. Issued Dec., 1861, for the Year 1859

- The Fossil Brachiopoda, Part V, No. 4, Carboniferous, by Mr. Davidson (pp. 121—210, pls. xxvii—xlvii).
- The Reptilia of the Oolitic Formations, No. 1, Lower Lias, by Prof. Owen (pp. 1—14, pls. i—vi).
- The Reptilia of the Kimmeridge Clay, No. 1, by Prof. Owen (pp. 15, 16, pl. vii).
- The Eocene Mollusca, Part IV, No. 1, Bivalves, by Mr. S. V. Wood (pp. 1—74, pls. i—xiii).

[1] This Volume is marked on the outside 1855.
This Volume is marked on the outside 1856.

CATALOGUE OF VOLUMES—Continued.

Vol. XIV. Issued May, 1863, for the Year 1860	The Fossil Brachiopoda, Vol. II, Part V, No. 5, Carboniferous, by Mr. Davidson (pp. 211—280, pls. xlviii—lv). The Reptilia of the Oolitic Formations, No. 2, Lower Lias, by Prof. Owen (pp. 1—26, pls. i—xi). The Reptilia of the Kimmeridge Clay, No. 2, by Prof. Owen (pp. 27, 28, pl. xii). The Fossil Estheriæ, by Prof. Rupert Jones (pp. i—x, 1—134, pls. i—v). The Fossil Crustacea, Part II, Gault and Greensand, by Prof. Bell (pp. i—vii, 1—40, pls. i—xi).
,, XV. Issued May, 1863, for the Year 1861	The Fossil Echinodermata, Oolitic, Vol. II, Part I (Asteroidea), by Dr. Wright (pp. 1—130, pls. i—x, x A, xi, xii). Supplement to the Great Oolite Mollusca, by Dr. Lycett (pp. 1—129, pls. xxxi—xlv).
,, XVI. Issued Aug., 1864, for the Year 1862	The Fossil Echinodermata, Cretaceous, Vol. I, Part I, by Dr. Wright (pp. 1—64, pls. i—iii, iii A, iv—vii, vii A, viii, xi). The Trilobites of the Silurian, Devonian, &c., Formations, Part I (Devonian and Silurian), by Mr. J. W. Salter (pp. 1—80, pls. i—vi). The Fossil Brachiopoda, Vol. III, Part VI, No. 1, Devonian, by Mr. Davidson (pp. 1—56, pls. i—ix). The Eocene Mollusca, Part IV, No. 2, Bivalves, by Mr. S. V. Wood (pp. 75—136, pls. xiv—xx). The Reptilia of the Cretaceous Formations (Supplement, No. 4), by Prof. Owen (pp. 1—18, pls. i—ix). The Reptilia of the Wealden and Purbeck Formations (Supplement, No. 3), by Prof. Owen (pp. 19—21, pl. x).
,, XVII Issued June, 1865, for the Year 1863	The Trilobites of the Silurian, Devonian, &c., Formations, Part II, by Mr. J. W. Salter (pp. 81—128, pls. vii—xiv). The Fossil Brachiopoda, Vol. III, Part VI, No. 2, Devonian, by Mr. Davidson (pp. 57—131, pls. x—xx). The Belemnitidæ, Part I, Introduction, by Prof. Phillips (pp. 1—28). The Reptilia of the Liassic Formations, Part I, by Prof. Owen (pp. 1—40, pls. i—xvi).
,, XVIII. Issued April, 1866, for the Year 1864	The Fossil Echinodermata, Oolitic, Vol. II, Part II (Liassic Ophiuroidea), by Dr. Wright (pp. 131—154, pls. xiii—xviii). The Trilobites of the Silurian, Devonian, &c., Formations, Part III, by Mr. J. W. Salter (pp. 129—176, pls. xv—xxv). The Belemnitidæ, Part II, Liassic Belemnites, by Prof. Phillips (pp. 29—52, pls. i—vii). The Pleistocene Mammalia, Part I, Introduction, Felis spelæa, by Messrs. W. Boyd Dawkins and W. A. Sanford (pp. i—1, 1—28, pls. i—v). Title-pages, &c., to the Monographs on the Reptilia of the London Clay, Cretaceous, and Wealden Formations.
,, XIX.[1] Issued Dec., 1866, for the Year 1865	The Crag Foraminifera, Part 1, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady (pp. i—vi, 1—72, pls. i—iv). Supplement to the Fossil Corals, Part I, Tertiary, by Dr. Duncan (pp. i—iii, 1—66, pls. i—x). The Fossil Merostomata, Part I, Pterygotus, by Mr. H. Woodward (pp. 1—44, pls. i—ix). The Fossil Brachiopoda, Vol. III, Part VII, No. 1, Silurian, by Mr. Davidson (pp. 1—88, pls. i—xii).
,, XX. Issued June, 1867, for the Year 1866	Supplement to the Fossil Corals, Part IV, No. 1, Liassic, by Dr. Duncan (pp. i—iii, 1—44, pls. i—xi). The Trilobites of the Silurian, Devonian, &c., Formations, Part IV (Silurian), by Mr. J. W. Salter (pp. 177—214, pls. xxv*—xxx). The Fossil Brachiopoda, Vol. III, Part VII, No. 2, Silurian, by Mr. Davidson (pp. 89—168, pls. xiii—xxii). The Belemnitidæ, Part III, Liassic Belemnites, by Prof. Phillips (pp. 53—88, pls. viii—xx).
,, XXI. Issued June, 1868, for the Year 1867	Flora of the Carboniferous Strata, Part I, by Mr. E. W. Binney (pp. 1—32, pls. i—vi). Supplement to the Fossil Corals, Part IV, No. 2, Liassic, by Dr. Duncan (pp. 45—73, pls. xii—xvii). The Fossil Echinodermata, Cretaceous, Vol. I, Part II, by Dr. Wright (pp. 65—112, pls. ix, x, xii—xxi, xxi A, xxi B). The Fishes of the Old Red Sandstone, Part I, by Messrs. J. Powrie and E. Ray Lankester (pp. 1—32, pls. i—v). The Pleistocene Mammalia, Part II, Felis spelæa, continued, by Messrs. W. Boyd Dawkins and W. A. Sanford (pp. 29—124, pls. vi—xix).

[1] From 1865 onwards the 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 VOLUMES—Continued.

Vol. XXII. Issued Feb., 1869, for the Year 1868

- Supplement to the Fossil Corals, Part II, No. 1, Cretaceous, by Dr. Duncan (pp. 1–26, pls. i—ix).
- The Fossil Merostomata, Part II, Pterygotus, by Mr. H. Woodward (pp. 45–70, pls. x—xv).
- The Fossil Brachiopoda, Vol. III, Part VII, No. 3, Silurian, by Mr. Davidson (pp. 169—248, pls. xxiii—xxxvii).
- The Belemnitidæ, Part IV, Liassic and Oolitic Belemnites, by Prof. Phillips (pp. 89–108, pls. xxi–xxvii).
- The Reptilia of the Kimmeridge Clay, No. 3, by Prof. Owen (pp. 1—12, pls. i–iv).
- The Pleistocene Mammalia, Part III, Felis spelæa, concluded, with F. lynx, by Messrs. W. Boyd Dawkins and W. A. Sanford (pp. 125–176, pls. xx—xxii, xxii A, xxii B, xxiii).

„ XXIII. Issued Jan., 1870, for the Year 1869

- Supplement to the Fossil Corals, Part II, No. 2, Cretaceous, by Dr. Duncan (pp. 27–46, pls. x—xv).
- The Fossil Echinodermata, Cretaceous, Vol. I, Part III, by Dr. Wright (pp. 113–136, pls. xxii—xxix, xxix A, xxix B).
- The Belemnitidæ, Part V, Oxford Clay, &c., Belemnites, by Prof. Phillips (pp. 109—128, pls. xxviii—xxxvi).
- The Fishes of the Old Red Sandstone, Part I (concluded), by Messrs. J. Powrie and E. Ray Lankester (pp. 33—62, pls. vi—xiv).
- The Reptilia of the Liassic Formations, Part II, by Prof. Owen (pp. 41—82, pls. xvii—xx).
- The Crag Cetacea, No. 1, by Prof. Owen (pp. 1—40, pls. i—v).

„ XXIV. Issued Jan., 1871, for the Year 1870

- The Flora of the Carboniferous Strata, Part II, by Mr. E. W. Binney (pp. 33—62, pls. vii–xii).
- The Fossil Echinodermata, Cretaceous, Vol. I, Part IV, by Dr. Wright (pp. 137–160, pls. xxx—xxxix).
- The Fossil Brachiopoda, Vol. III, Part VII, No. 4, Silurian, by Mr. Davidson (pp. 249—397, pls. xxxviii—l).
- The Eocene Mollusca, Part IV, No. 3, Bivalves, by Mr. S. V. Wood (pp. 137—182, pls. xxi—xxv).
- The Fossil Mammalia of the Mesozoic Formations, by Prof. Owen (pp. i—vi, 1—115, pls. i—iv).

„ XXV. Issued June, 1872, for the Year 1871

- The Flora of the Carboniferous Strata, Part III, by Mr. E. W. Binney (pp. 63–96, pls. xiii—xviii).
- The Fossil Merostomata, Part III, Pterygotus and Slimonia, by Mr. H. Woodward (pp. 71—120, pls. xvi—xx).
- 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 (pp. i—xxxi, 1—98, pls. i—vii, and map).
- Supplement to the Reptilia of the Wealden (Iguanodon), No. IV, by Prof. Owen (pp. 1—15, pls. i—iii).
- The Pleistocene Mammalia, Part IV, Felis pardus, &c., by Messrs. W. Boyd Dawkins and W. A. Sanford (pp. 177—194, pls. xxiv, xxv).
- The Pleistocene Mammalia, Part V, Ovibos moschatus, by Mr. W. Boyd Dawkins (pp. 1—30, pls. i–v).

„ XXVI. Issued Oct., 1872, for the Year 1872

- Supplement to the Fossil Corals, Part III (Oolitic), by Prof. Duncan (pp. 1—24, pls. i—vii), with an Index to the Tertiary and Secondary Species.
- The Fossil Echinodermata, Cretaceous, Vol. I, Part V, by Dr. Wright (pp. 161—184, pls. xl—xliv).
- The Fossil Merostomata, Part IV (Stylonurus, Eurypterus, Hemiaspis), by Mr. H. Woodward (pp. 121—180, pls. xxi–xxx).
- The Fossil Trigoniæ, No. I, by Dr. Lycett (pp. 1—52, pls. i–ix).

CATALOGUE OF VOLUMES—Continued.

Vol. XXVII. Issued Feb., 1874, for the Year 1873

The Fossil Echinodermata, Cretaceous, Vol. I, Part VI, by Dr. Wright (pp. 185—224, pls. xlv—lii).

Supplement to the Fossil Brachiopoda, Vol. IV, Part I (Tertiary and Cretaceous), by Mr. Davidson (pp. 1—72, pls. i—viii).

Supplement to the Crag Mollusca, Part II (Bivalves), by Mr. S. V. Wood (pp. 99—231, pls. viii—xi, and add. plate).

Supplement to the Reptilia of the Wealden (Iguanodon), No. V, by Prof. Owen (pp. 1—18, pls. i, ii).

Supplement to the Reptilia of the Wealden (Hylæochampsa), No. VI, by Prof. Owen (pp. 1—7).

The Fossil Reptilia of the Mesozoic Formations, Part I, by Prof. Owen (pp. 1—14, pls. i, ii).

,, XXVIII. Issued July, 1874, for the Year 1874

The Post-Tertiary Entomostraca, by Mr. G. S. Brady, Rev. H. W. Crosskey, and Mr. D. Robertson (pp. i—v, 1—232, pls. i—xvi).

The Carboniferous Entomostraca, Part I (Cypridinidæ), by Prof. T. Rupert Jones and Messrs. J. W. Kirkby and G. S. Brady (pp. 1—56, pls. i—v).

The Fossil Trigoniæ, No. II, by Dr. Lycett (pp. 53—92, pls. x—xix).

,, XXIX. Issued Dec. 1875, for the Year 1875

The Flora of the Carboniferous Strata, Part IV, by Mr. E. W. Binney (pp. 97—147, pls. xix—xxiv).

The Fossil Echinodermata, Cretaceous, Vol. I, Part VII, by Dr. Wright (pp. 225—264, pls. liii—lxii).

The Fossil Trigoniæ, No. III, by Dr. Lycett (pp. 93—148, pls. xx—xxvii).

The Fossil Reptilia of the Mesozoic Formations, Part II, by Prof. Owen (pp. 15—94, pls. iii—xxii).

,, XXX. Issued Dec., 1876, for the Year 1876

The Carboniferous and Permian Foraminifera (the genus Fusulina excepted), by Mr. H. B. Brady (pp. 1—166, pls. i—xii).

Supplement to the Fossil Brachiopoda, Vol. IV, Part II, No. I (Jurassic and Triassic), by Mr. Davidson (pp. 73—144, pls. ix—xvi).

Supplement to the Reptilia of the Wealden (Poikilopleuron and Chondrosteosaurus), No. VII, by Prof. Owen (pp. 1—7, pls. i—vi).

,, XXXI. Issued Feb., 1877, for the Year 1877

Supplement to the Eocene Mollusca (Bivalves), by Mr. S. V. Wood, 2 plates.

The Fossil Trigoniæ, No. IV, by Dr. Lycett (pp. 149—204, pls. xxviii—xl).

The Eocene Mollusca (Univalves), Part IV, by Mr. S. V. Wood (pp. 331—361, pl. xxxiv).

The Carboniferous Ganoid Fishes, Part I (Palæoniscidæ), by Dr. Traquair (pp. 1—60, pls. i—vii).

The Fossil Reptilia of the Mesozoic Formations, Part III, by Prof. Owen (pp. 95—97, pls. xxiii, xxiv).

The Fossil Elephants, Part I (E. antiquus), by Prof. Leith Adams (pp. 1—68, pls. i—v).

,, XXXII. Issued Mar., 1878, for the Year 1878

The Fossil Echinodermata, Cretaceous, Vol. I, Part VIII, by Dr. Wright (pp. 265—300, pls. lxii A, lxiii—lxix).

Index and Title Page to the Fossil Echinodermata, Oolitic, Vol. I (Echinoidea), by Dr. Wright (pp. 469—481).

The Fossil Merostomata, Part V (Neolimulus, &c.), by Dr. H. Woodward (pp. 181—263, pls. xxxi—xxxvi, and title-page).

Supplement to the Fossil Brachiopoda, Vol. IV, Part II, No. 2 (Jurassic and Triassic), by Mr. Davidson (pp. 145—242, pls. xvii—xxix).

The Lias Ammonites, Part I, by Dr. Wright (pp. 1—48, pls. i—viii).

The Sirenoid and Crossopterygian Ganoids, Part I, by Prof. Miall (pp. 1—32, pls. i, i A, ii—v).

Supplement to the Reptilia of the Wealden (Goniopholis, Petrosuchus, and Suchosaurus), No. VIII, by Prof. Owen (pp. 1—15, pls. i—vi).

The Pleistocene Mammalia, Part A (Preliminary Treatise), by Prof. Boyd Dawkins (pp. i—xxxviii).

CATALOGUE OF VOLUMES—Continued.

Vol. XXXIII. Issued May, 1879, for the Year 1879	The Eocene Flora, Vol. I, Part I, by Mr. J. S. Gardner and Baron Ettingshausen (pp. 1—38, pls. i—v). Second Supplement to the Crag Mollusca (Univalves and Bivalves), by Mr. S. V. Wood (pp. i, ii, 1—58, pls. i—vi, and title-page). The Fossil Trigoniæ, No. V, by Dr. Lycett (pp. 205—245, pl. xli, and title-page). The Lias Ammonites, Part II, by Dr. Wright (pp. 49—164, pls. ix—xviii). Supplement to the Reptilia of the Wealden (Goniopholis, Brachydectes, Nannosuchus, Theriosuchus, and Nuthetes), No. IX, by Prof. Owen (pp. 1—19, pls. i—iv). The Fossil Elephants, Part II (E. primigenius), by Prof. Leith Adams (pp. 69—146, pls. vi—xv).
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,, XXXVI. Issued June, 1882, for the Year 1882	The Eocene Flora, Vol. I, Part III, by Mr. J. S. Gardner and Baron Ettingshausen (pp. 59—86, pls. xii, xiii, and title-page). Third Supplement to the Crag Mollusca, by the late Mr. S. V. Wood (pp. 1—24, pl. i). The Fossil Echinodermata, Cret., Vol. I, Part X, by Dr. Wright (pp. 325—371, pls. lxxvi—lxxx, and title-page). Supplement to the Fossil Brachiopoda, Vol. IV, Part V, by Dr. Davidson (pp. 369—383, and title-page). Do., Vol. V, Part I (Devonian and Silurian), by Dr. Davidson (pp. 1—134, pls. i—vii). The Lias Ammonites, Part V, by Dr. Wright (pp. 329—400, pls. xlix—lii, lii A, liii—lxix).
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CATALOGUE OF VOLUMES—Continued.

Vol. XXXIX. Issued Jan., 1886, for the Year 1885	The Eocene Flora, Vol. II, Part III, by Mr. J. S. Gardner (pp. 91—159, pls. xxi—xxvii, and title-page). The Stromatoporoids, Part I, by Prof. Alleyne Nicholson (pp. i—iii, 1—130, pls. i—xi). The Fossil Brachiopoda (Bibliography), Vol. VI (pp. 1—163), by the late Dr. Davidson and Mr. W. H. Dalton. The Lias Ammonites, Part VIII, by the late Dr. Wright (pp. 481—503, pl. lxxxviii, and title-page).
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CATALOGUE OF VOLUMES—Continued.

Vol. XLVI. Issued Nov., 1892, for the Year 1892	The Stromatoporoids, Part IV (*Conclusion*), by Prof. Alleyne Nicholson (pp. 203—234, pls. xxvi—xxix, and title-page). The Palæozoic Phyllopoda, Part II, by Prof. T. R. Jones and Dr. Woodward (pp. 73—124, pls. xiii—xvii). The Jurassic Gasteropoda, Part I, No. 6, by Mr. W. H. Hudleston (pp. 273—324, pls. xxi—xxvi). The Inferior Oolite Ammonites, Part VII, by Mr. S. S. Buckman (pp. 313—344, pls. lvii—lxxvi). The Devonian Fauna of the South of England, Vol. II, Part II, by the Rev. G. F. Whidborne (pp. 57—88, pls. vi—x).
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,, LII. Issued Dec., 1898, for the Year 1898	The Palæozoic Phyllopoda, Part III, by Prof. T. R. Jones and Dr. Woodward (pp. 125—176, pls. xviii—xxv). The Carboniferous Lamellibranchiata, Part III, by Dr. W. Hind (pp. 209—276, pls. xvi—xxv). The Inferior Oolite Ammonites, Part X, by Mr. S. S. Buckman (pp. i—xxxii, Suppl. pls. i—iv). The Carboniferous Cephalopoda of Ireland, Part II, by Dr. A. H. Foord (pp. 23—48, pls. viii—xvii). The Devonian Fauna of the South of England, Vol. III, Part III, by the Rev. G. F. Whidborne (pp. 179—236, pls. xxii—xxxviii).

CATALOGUE OF VOLUMES—Continued.

Vol. LIII.	Issued Dec., 1899, for the Year 1899	The Palæozoic Phyllopoda, Part IV, by Prof. T. R. Jones and Dr. Woodward (pp. i—xv, 175, 176, 177—211, pls. xxvi—xxxi, and title-page). The Cretaceous Lamellibranchia, Part I, by Mr. H. Woods (pp. 1—72. pls. i—xiv). The Carboniferous Lamellibranchiata, Part IV, by Dr. W. Hind (pp. 277—360, pls. xxvi—xxxix). The Inferior Oolite Ammonites, Part XI, by Mr. S. S. Buckman (pp. xxxiii—lxiv, pls. v—xiv).
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CATALOGUE OF VOLUMES—Continued.

Vol. LIX. Issued Nov., 1905, for the Year 1905

- The Fossil Echinodermata, Cretaceous, Vol. II, Part III, by Mr. W. K. Spencer (pp. 67—90, pls. xvii—xxvi).
- The Cretaceous Lamellibranchia, Vol. II, Part II, by Mr. H. Woods (pp. 57—96, pls. viii—xi).
- The Carboniferous Lamellibranchiata, Vol. II, Title-pages and Index, by Dr. W. Hind.
- The Inferior Oolite Ammonites, Part XIII, by Mr. S. S. Buckman (pp. clxix—ccviii, pls. xx—xxiv).
- The Cornbrash Fauna, Part I, by the Rev. J. F. Blake (pp. 1—100, pls. i—ix).

„ LX. Issued Dec., 1906, for the Year 1906

- The Pleistocene Bears, by Prof. S. H. Reynolds (pp. 1—35, pls. i—viii).
- The Fishes of the Old Red Sandstone, Part II, No. 3, by Dr. R. H. Traquair (pp. 119—130, pls. xxvii—xxxi).
- The Cretaceous Lamellibranchia, Vol. II, Part III, by Mr. H. Woods (pp. 97—132, pls. xii—xix).
- The Lower Palæozoic Trilobites of Girvan, Part III, by Mr. F. R. Cowper Reed (pp. 97—186, Title-page and Index, pls. xiv—xx).
- The Cambrian Trilobites, Part I, by Mr. P. Lake (pp. 1—28, pls. i, ii).
- British Graptolites, Part V, by Miss Elles and Miss Wood, edited by Prof. Lapworth (pp. lxxiii—xcvi, 181—216, pls. xxvi, xxvii).

„ LXI. Issued Dec., 1907, for the Year 1907

- The Sirenoid Ganoids, Part II, by Prof. L. C. Miall (pp. 33—34, Title-page, Preface, and Postscript).
- Ganoid Fishes of British Carboniferous Formations, Part I, Palæoniscidæ, No. 3, by Dr. R. H. Traquair (pp. 87—106, pls. xix—xxiii).
- The Fishes of the English Chalk, Part III, by Dr. A. Smith Woodward (pp. 97—128, pls. xxi—xxvi).
- The Inferior Oolite Ammonites, Part XIV, by Mr. S. S. Buckman (pp. ccix—cclxii, Title-pages, Preface, and Index).
- The Cretaceous Lamellibranchia, Vol. II, Part IV, by Mr. H. Woods (pp. 133—180, pls. xx—xxvii).
- The Fossil Echinodermata, Cretaceous, Vol. II, Part IV, by Mr. W. K. Spencer (pp. 91—132, pls. xxvii—xxix).
- The British Conulariæ, by Miss Ida L. Slater (pp. 1—40, pls. i—v, Title-page and Index).
- The Cambrian Trilobites, Part II, by Mr. P. Lake (pp. 29—48, pls. iii, iv).
- British Graptolites, Part VI, by Miss Elles and Miss Wood (Mrs. Shakespear), edited by Prof. Lapworth (pp. xcvii—cxx, 217—272, pls. xxviii—xxxi).
- The Devonian Fauna of the South of England, Vol. II, Part V, and Vol. III, Part IV, by the Rev. G. F. Whidborne (Vol. II, pp. 215—222, Title-page and Index; Vol. III, pp. 237—247, Title-page and Index).
- The Cornbrash Fauna, Part II, by the Rev. J. F. Blake (pp. 101—102, Title-page and Index).

„ LXII. Issued Dec., 1908, for the Year 1908

- The Fishes of the English Chalk, Part IV, by Dr. A. Smith Woodward (pp. 129—152, pls. xxvii—xxxii).
- Illustrations of Type Specimens of Inferior Oolite Ammonites (pls. i—vii).
- The Cretaceous Lamellibranchia, Vol. II, Part V, by Mr. H. Woods (pp. 181—216, pls. xxviii—xxxiv).
- The Fossil Echinodermata, Cretaceous, Vol. II, Part V, by Mr. W. K. Spencer (pp. 133—138, Title-page and Index).
- The Cambrian Trilobites, Part III, by Mr. P. Lake (pp. 49—64, pls. v, vi.)
- British Graptolites, Part VII, by Miss Elles and Miss Wood (Mrs. Shakespear), edited by Prof. Lapworth (pp. cxxi—cxlviii, 273—358, pl. xxxii—xxxv).

„ LXIII. Issued Dec., 1909, for the Year 1909

- The Pleistocene Canidæ, by Prof. S. H. Reynolds (pp. 1—28, pls. i—vi).
- Ganoid Fishes of British Carboniferous Formations, Part I, Palæoniscidæ, No. 4, by Dr. R. H. Traquair (pp. 107—122, pls. xxiv—xxx).
- The Fishes of the English Chalk, Part V, by Dr. A. Smith Woodward (pp. 153—184, pls. xxxiii—xxxviii).
- The Cretaceous Lamellibranchia, Vol. II, Part VI, by Mr. H. Woods (pp. 217—260, pls. xxxv—xliv).
- The Mollusca of the Chalk, Part I, Cephalopoda, by Mr. D. Sharpe (Title-page and Index).
- The Belemnitidæ, by Prof. Phillips (Title-page and Index).

CATALOGUE OF VOLUMES—Continued.

Vol. LXIV.	Issued Jan., 1911, for the Year 1910	Ganoid Fishes of British Carboniferous Formations, Part I, Palæoniscidæ, No. 5, by Dr. R. H. Traquair (pp. 123—158, pls. xxxi—xxxv). The Fishes of the English Chalk, Part VI, by Dr. A. Smith Woodward (pp. 185—224, pls. xxxix—xlvi). The Cretaceous Lamellibranchia, Vol. II, Part VII, by Mr. H. Woods (pp. 261—284, pls. xlv—l). The Carboniferous Arachnida, by Mr. R. I. Pocock (pp. 1—84, pls. i—iii). British Graptolites, Part VIII, by Miss Elles and Miss Wood (Mrs. Shakespear), edited by Prof. Lapworth (pp. 359—414, pls. xxxvi—xli).
„ LXV.	Issued Feb., 1912, for the Year 1911	The Pleistocene Mustelidæ, by Prof. S. H. Reynolds (pp. 1—28, pls. i—viii). Ganoid Fishes of British Carboniferous Formations, Part I, Palæoniscidæ, No. 6, by Dr. R. H. Traquair (pp. 159—180, pls. xxxvi—xl). The Fishes of the English Chalk, Part VII, by Dr. A. Smith Woodward (pp. i—viii, 225—264, pls. xlvii—liv, including Title-page and Index). The Cretaceous Lamellibranchia, Vol. II, Part VIII, by Mr. H. Woods (pp. 285—340, pls. li—liv). The Fossil Sponges, Title-page and Index to Vol. I, by Dr. G. J. Hinde (pp. 255—264).
„ LXVI.	Issued Feb., 1913, for the Year 1912	British Graptolites, Part IX, by Miss Elles and Miss Wood (Mrs. Shakespear), edited by Prof. Lapworth (pp. 415—486, pls. xlii—xlix). The Cambrian Trilobites, Part IV, by Mr. P. Lake (pp. 65—88, pls. vii—x). The Cretaceous Lamellibranchia, Vol. II, Part IX, by Mr. H. Woods (pp. 341—473, pls. lv—lxii, including Title-page and Index). The Fossil Malacostracous Crustacea, by Prof. T. Bell (Title-page and Index).
„ LXVII.	Issued Feb., 1914, for the Year 1913	British Graptolites, Part X, by Miss Elles and Miss Wood (Mrs. Shakespear), edited by Prof. Lapworth (pp. 487—526, pls. l—lii). The Palæozoic Asterozoa, Part I, by Mr. W. K. Spencer (pp. 1—56, pl. i). The Lower Palæozoic Trilobites of Girvan.—Supplement, by Dr. F. R. Cowper Reed (pp. 1—56, pls. i—viii, including Title-page and Index). The Pliocene Mollusca, Part I, by Mr. F. W. Harmer (pp. 1—200, pls. i—xxiv). Ganoid Fishes of British Carboniferous Formations, Part I, Palæoniscidæ, No. 7, by Dr. R. H. Traquair (pp. i—vi, 181—186, including Title-page and Index). The Fishes of the Old Red Sandstone, Part II, No. 4, by Dr. R. H. Traquair (pp. 131—134, including Title-page and Index).

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A MONOGRAPH

OF

BRITISH GRAPTOLITES.

BY

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PART X.

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Affinities.—The long slender polypary of *Monog.* cf. *elongatus*, with its irregular flexure and characteristic thecæ, is distinctive. Fragments, however, somewhat resemble those of *M. intermedius* as respects the general characters of the thecæ, but the lobation of the apertural terminations is more pronounced.

Horizon and Localities.—Llandovery (zones of *M. gregarius* and *M. convolutus*).

Wales: Llanystwmdwy, near Criccieth; Rheidol Gorge, 440 yds. S.S.E. of Bryn-chwîth Farm, Pont Erwyd; 10 yds. up stream from crest of anticline, N. of Fuches-gau Farm, Pont Erwyd.

Associates, etc.—*M.* cf. *elongatus* occurs at the top of the zone of *M. gregarius* associated with *M. argutus*, *M. leptotheca* and *M. lobiferus*, and in the zone of *M. convolutus* immediately above with *M. convolutus*, *M. limatulus*, and *M. decipiens*.

Collections.—Geological Survey of England and Wales, Fearnsides.

Group VII.

Monograpti in which the mature thecæ are more or less linear and isolate, with reflexed terminations.

In the *Monograpti* included in this group the tendency to isolation reaches its maximum development. The isolate linear appearance of the thecæ foreshadowed in the proximal portion of some of the species belonging to Group VI has now become the predominating feature, and is characteristic, while the "adnate" portion of the theca hardly deserves name as such, being sometimes so insignificant that the whole "common body" of the polypary is reduced to a mere thread of extreme tenuity. For the sake of convenience, therefore, we have taken the length of the upper instead of the lower wall, as the conventional length of the theca in this group.

The form of the thecæ was distinctly tubular, but whether it was cylindrical or sub-rectangular there is not sufficient evidence to show; some examples of *Monog.* (*R.*) *Linnæi* and *M.* (*R.*) *maximus*, however, suggest the latter shape. The length of the thecæ varies considerably, as does also their remoteness or nearness. The mature thecæ may vary in length from 1·5 mm. (*M.* [*R.*] *hybridus*) to 1·8 cm. (*M.* [*R.*] *maximus*). The fraction involved in the formation of the apertural barb also varies very much—from a conspicuous fraction of about one-fifth (*M.* [*R.*] *hybridus*) to the merest tendency to reflexion—and this reflexion is often indeed concealed from the observer, appearing either as a mere rounding off of the theca at its extremity (*M.* [*R.*] *peregrinus*) or as an abrupt truncation (*M.* [*R.*] *equidistans*).

The following species are included in this group: *Monograptus* (*Rastrites*) *peregrinus*, *M.* (*R.*) *longispinus*, *M.* (*R.*) *setiger*, *M.* (*R.*) *hybridus*, *M.* (*R.*) *approximatus* var. *Geinitzi*, *M.* (*R.*) *fugax*, *M.* (*R.*) *Linnæi*, *M.* (*R.*) *maximus*, *M.* (*R.*) *equidistans*.

Monograptus (Rastrites) peregrinus (Barrande). Plate L, figs. 1 *a—e*.

1850. *Rastrites peregrinus,* Barrande, Grapt. de Bohême, p. 67, pl. iv, fig. 6.
1892. *Rastrites peregrinus,* Törnquist, Siljansområd. Grapt., ii, p. 2, pl. i, fig. 1.
1899. *Rastrites peregrinus,* Perner, Grapt. de Bohême, iii *a.*, p. 8, fig. 6; pl. xiii, figs. 33, 34.
1907. *Rastrites peregrinus,* Törnquist, Genus *Rastrites* and allied species of *Monograptus,* Lunds Univ. Årsskr., N.S., afd. 2, iii, no. 5, p. 6, pl. i, figs. 1—22.

Polypary small, arcuate, with short sharply recurved proximal portion. Thecæ eight to ten in 10 mm., from 1—2·5 mm. in length, with narrow interspaces, somewhat club-shaped, with apparently rounded extremities owing to the very slight apertural reflexion.

Description.—The polypary never seems to exceed 3 cm. in length, so that it is characteristically small, and as Törnquist has pointed out, its proximal portion is "recurved so as to present the shape of a small fish-hook"; he also lays some stress upon the direction of growth of the early thecæ, but this does not appear to us to be at all constant, varying very much with conditions of preservation, though it is true that as a whole the distal thecæ are distinctly *declined.*

Fig. 343.—*Monograptus* (*Rastrites*) *peregrinus* (Barrande).

Proximal portion, showing part of the sicula. Skelgill, Lake District; Skelgill Beds. Sedgwick Museum.

The sicula is inconspicuous.

Though the thecæ in the proximal portion do not exceed 1 mm. in length, they quickly reach their maximum length of 2·5 mm., which is maintained thereafter. The width of the interspaces between successive thecæ is generally 1 mm. in extent.

The thecæ themselves have a characteristic shape, appearing narrow at their bases, then widening and then diminishing again towards their terminations, which are generally rounded off, the result being a somewhat club-shaped appearance. There is only a slight trace of reflexion of the apertural region, which shows itself as a terminal rounding off when the reflected portion is turned away from the observer.

Affinities.—Many of the different forms included in this group (*Rastrites*) have at one time or another been referred to *Monog.* (*R.*) *peregrinus;* there can be little doubt, however, that this name should be (as recognised by Perner and Törnquist) restricted to those forms which are small and which have short club-shaped thecæ situated at fairly close intervals. *M.* (*R.*) *hybridus*, which perhaps comes nearest to *M.* (*R.*) *peregrinus* in point of size, is distinguished by the far more definitely reflexed apertural terminations.

Horizon and Localities.—Llandovery (zones of *M. gregarius* and *M. convolutus*).

S. Scotland: Dobb's Linn; Garple Linn; Belcraig Burn, etc. *Lake District:* Skelgill. *Ireland:* Coalpit Bay, Donaghadee.

Associates, etc.—*Monog.* (*R.*) *peregrinus*, as restricted above, is not as a rule very abundant in S. Scotland, though occasionally slabs covered with remains of scores of individuals have been met with. At the lower horizon it is commonly associated with *M. gregarius*, *M. triangulatus* and *Glyptog. tamariscus*, while at the higher, it is found with *M. convolutus*, *M. lobiferus*, *M. Clingani*, *M. limatulus* and other forms.

Collections.—Belfast Natural History Museum, Sedgwick Museum, Lapworth, and the Authors.

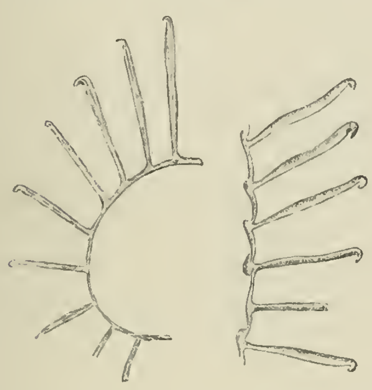
Monograptus (Rastrites) longispinus (Perner). Plate L, figs. 2 *a*—*g*.

1897. *Rastrites peregrinus* var. *longispinus*, Perner, Grapt. de Bohême, iii *a*, p. 9, fig. 7; pl. xiii, figs. 32 and 35.

1907. *Rastrites longispinus*, Törnquist, *Rastrites* and allied species of *Monograptus*, Lunds Univ. Årsskr., n.s., afd. 2, iii, no. 5, p. 10.

Polypary arcuate, with broadly recurved proximal portion approximately semicircular in form. Thecæ seven or eight in 10 mm., very long in proportion to the width of the interspaces, 3—5 mm. in length, set more or less perpendicularly, with interspaces measuring about 1 mm. in extent, and distinctly reflexed apertural terminations.

Figs. 344 *a* and *b*.—*Monograptus* (*Rastrites*) *longispinus* (Perner).



a. Proximal portion, showing sicula and thecæ. Enlargement of part of Pl. L, fig. 2 *a*.
b. Distal thecæ, partly in relief, showing reflexed apertural terminations. Enlargement of part of Pl. L, fig. 2 *g*.

Description.—The polypary is somewhat larger than that of *M.* (*R.*) *peregrinus* and the shape of the proximal end approaches that of a semicircle, being very broadly recurved.

The thecæ are conspicuously long in proportion to the width of the interspaces and frequently attain a length of nearly 5 mm. The width of the interspaces, though somewhat variable, usually averages about 1 mm. in extent.

Affinities.—*Monog.* (*R.*) *longispinus* bears a certain amount of resemblance in its distal portion to *M.* (*R.*) *setiger* but has a differently shaped proximal end. From other allied species it may be distinguished by the length of the thecæ.

Horizon and Localities.—Llandovery (zones of *M. gregarius and M. convolutus*).

S. Scotland: Dobb's Linn. *Lake District:* Skelgill. *Wales:* Rheidol Gorge, Pont Erwyd; 440 yards S.S.E. of Bryn-chwîth Farm, Pont Erwyd.

Associates, etc.—*Monog.* (*R.*) *longispinus* makes its appearance at the very base of the zone of *M. gregarius*, in the sub-zone of *M. fimbriatus* associated with *M.*

fimbriatus, M. triangulatus, Mesog. magnus, Climacog. Törnquisti and other forms. It also ranges higher, namely into the base of the succeeding zone, where it is found with *M. lobiferus, M. limatulus, Glyptog. sinuatus, Climacog. scalaris*, etc.

Collections.—Geological Survey of England and Wales, Sedgwick Museum, Lapworth, and the Authors.

Monograptus (Rastrites) setiger, sp. nov. Plate L, figs. 3 *a—d*.

Polypary with slightly arcuate proximal end, but straight or with irregularly curved distal portion. Thecæ twelve in 10 mm., very long but closely set, having in the distal portion an average length of about 5 mm. with interspaces not exceeding ·8 mm.

Fig. 345.—*Monograptus (Rastrites) setiger*, sp. nov.

Proximal portion, showing part of sicula. Enlargement of part of Pl. L, fig. 3 *a*.

Description.—There is no enrolling of the initial portion of this species; indeed, the proximal end in its general characters approaches that of *M. (R.) Linnæi*, but is stiffer.

The sicula has a length of 1 mm., and the earliest theca is short, not exceeding 1 mm. in length.

Each succeeding theca is, however, longer than the preceding one, th. 7 measuring 3·5 mm., and th. 12, 4·5 mm., so that the maximum length is rapidly attained and thereafter remains constant. The thecæ are generally disposed perpendicularly, and are of approximately uniform breadth throughout their extent, with abruptly truncated apertural terminations.

Affinities.—The characters of the thecæ, their length and proximity to each other combine to make this species easily distinguishable from all others except *M. (R.) longispinus*, and from this species the form of the proximal end serves as a ready means of separation.

Horizon and Localities.—Llandovery (zone of *M. gregarius*; sub-zone of *M. fimbriatus*).

Lake District: Skelgill. *Wales:* Pont Erwyd.

Associates, etc.—*Monog. (R.) setiger* occurs at the base of the zone of *M. gregarius* associated with *M. atavus, M. fimbriatus*, and *M. raitzhainiensis*.

Collections.—Geological Survey of England and Wales, Sedgwick Museum.

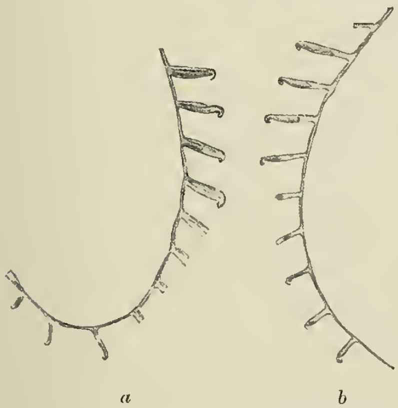
Monograptus (Rastrites) hybridus (Lapworth). Plate L, figs. 4 *a—f.*

1876. *Rastrites peregrinus*, var. *hybridus*, Lapworth, Geol. Mag. [2], vol. iii, p. 313, pl. x, fig. 5.
1892. *Rastrites hybridus*, Törnquist, Siljansområd. Grapt., ii, p. 4, pl. i, fig. 2.
1907. *Rastrites peregrinus*, var. *hybridus*, Törnquist, *Rastrites* and allied species of *Monograptus*, Lunds Univ. Årsskr., N.S., afd. 2, iii, no. 5, p. 7, pl. i, figs. 23, 24.

Polypary small, arcuate, with broadly recurved proximal end. Thecæ on the convex margin, eight to ten in 10 mm., 2 mm. only in length, with narrow interspaces, slightly declined, and with markedly reflexed apertural extremities constituting a well-defined barb.

Description.—The polypary never seems to attain any considerable size, and the thecæ are always rather short, and appear relatively closely set except in the proximal region, where they are shorter than those developed subsequently.

FIGS. 346 *a* and *b*.—*Monograptus* (*Rastrites*) *hybridus* (Lapworth).



a. Proximal portion in part relief, showing sicula. Enlargement of part of Pl. L, fig. 4 *c*.
b. Proximal and distal thecæ. Rheidol Gorge, Pont Erwyd, Cardiganshire. Geol. Survey of England and Wales.

The sicula measures barely 1 mm. in length, and there is a distance of 1·2 mm. between th. 1 and th. 2, and of 1·5 mm. between th. 2 and th. 3; thereafter the thecæ are barely 1 mm. apart, and have an average length of 2 mm.

The apertural barb is occasionally replaced by two terminal thread-like processes. Törnquist appears to consider the possession of these threads a specific character (*R. phleoides*). We are unable to satisfy ourselves that this is so, since we have discovered them in more than one species, and it seems to us possible that any *Rastrites* might show a "phleoid" development.

Affinities.—Though fragments of *Monog.* (*R.*) *hybridus* bear a considerable resemblance to those of *M.* (*R.*) *peregrinus*, the character of the proximal end and the very pronounced barb make this species distinct.

Horizon and Localities.—Llandovery (zones of *M. convolutus* and *M. Sedgwicki*). *S. Scotland:* Dobb's Linn; Belcraig Burn; Meggat Water. *Lake District:* Skelgill. *C. Wales:* 2 miles E.N.E. Pont Erwyd; E. side of Quarry N.E. of Fagwr-Fawr Farm.

Associates, etc.—*Monog.* (*R.*) *hybridus* occurs somewhat plentifully in the zone of *M. convolutus*, where it is found associated with the zone-fossil, *M. Clingani*, *M. decipiens*, *M. intermedius* var. *involutus*, *M. lobiferus* and other forms; and also in the zone of *M. Sedgwicki* with *M. Sedgwicki* and *M. jaculum*.

Collections.—Geological Survey of England and Wales, Sedgwick Museum, Lapworth, and the Authors.

Monograptus (Rastrites) approximatus, var. **Geinitzi** (Törnquist). Plate L, figs. 5 *a—d.*

1907. *Rastrites approximatus*, var. *Geinitzi*, Törnquist, *Rastrites* and some allied species of *Monograptus*, Lunds. Univ. Årsskr., N.S., afd. 2, iii, no. 5, p. 9, pl. i, figs. 32—41.

Polypary with convolute proximal extremity. Thecæ on the convex margin, twelve to ten in 10 mm., having a maximum length of 4 mm., and with interspaces averaging only 1 mm.

Description.—The shape of the polypary is characteristic, both of the typical species and its variety. They are both more markedly convolute than any other forms included in this group.

The thecæ are not very long, since none seem to exceed 4 mm.; and the interspaces separating them are small, so that the thecæ appear to be closely set. In the proximal portion the thecæ increase steadily in length from ·6 mm. in th. 1 to 2 mm. in th. 4, and thereafter the increase goes on steadily until the maximum width is reached. "Phleoid" appearances are of fairly frequent occurrence in this variety (fig. 347 *b*).

FIGS. 347 *a* and *b*.—*Monograptus* (*Rastrites*) *approximatus*, var. *Geinitzi* (Törnquist).

a *b*

a. Proximal portion, showing sicula. Enlargement of part of Pl. L, fig. 5 *b*.
b. Distal thecæ, showing "phleoid" appearance. Enlargement of part of Pl. L, fig. 5 *a*.

The sicula has a length of at least ·7 mm., and th. 1 arises near its apex.

Affinities.—The convolute proximal extremity is possessed by both the typical species and its variety; but Törnquist has rightly separated the form here described on the ground that its thecæ are about twice as long as those of the typical species.

Horizon and Localities.—Llandovery (zones of *M. gregarius* to *M. Sedgwicki*).

S. Scotland: Dobb's Linn; Belcraig Burn, etc. *Ireland:* Coalpit Bay, Donaghadee. *Wales:* Parys Mountain, Anglesea; 430 yds. S.S.E. of Bryn-chwîth Farm, Pont Erwyd.

Associates, etc.—This variety is quite common; it occurs abundantly at the lower horizon with *M. gregarius*, *M. triangulatus* and *Climacog. Törnquisti*, with *M. convolutus*, *M. lobiferus*, *M. Clingani* in the zone of *M. convolutus*, and with *M. Sedgwicki*, *M. tenuis* and *Cl. scalaris* at the top of the Llandovery.

Collections.—Geological Survey of England and Wales, Sedgwick Museum.

Monograptus (Rastrites) fugax (Barrande). Plate L, figs. 7 *a—d*.

1850. *Rastrites fugax*, Barrande, Grapt. de Bohême, p. 66, pl. iv, fig. 1.

Polypary arcuate, with thecæ on the convex margin. Thecæ six to eight in 10 mm., triangular, relatively short and broad, slightly declined, with reflexed apertural terminations; interspaces equal to about twice the length of the thecæ.

Description.—The polypary is mostly known in a fragmentary state, but even fragments are sufficiently characteristic, with their unusually short and broad thecæ. The thecæ have an average length of 1 mm., and distally the width of the interspaces is about 2 mm. The apertural terminations are not uncommonly forked instead of being reflexed, and the reflexion is often so slight as to be very inconspicuous, and in many states of preservation practically invisible.

Fig. 348.—*Monograptus* (*Rastrites*) *fugax* (Barrande).

Proximal portion, showing sicula. Enlargement of part of Pl. L, fig. 7 *b*.

The sicula has a length of ·8 mm. and is conspicuous. Th. 1 originates near its apex, so that, as usual, the sicula forms the initial extremity of the polypary.

Affinities.—Perner has considered this form as the young of *M.* (*R.*) *Linnæi* with which it is not infrequently associated, but in our opinion the thecæ are quite different and are not to be regarded as immature thecæ of *M.* (*R.*) *Linnæi.*

Horizon and Localities.—Birkhill and Gala-Tarannon (zones of *M. Sedgwicki* and *M. turriculatus*).

S. Scotland: Belcraig Burn; Duffkinnel.

Associates, etc.—*M.* (*R.*) *fugax* occurs somewhat rarely in the highest Birkhill Shales associated with *M.* (*R.*) *hybridus*, *M. Clingani* and *Glyptog. tamariscus*; and also in the basal beds of the Tarannon Shales with *M.* (*R.*) *maximus*, *M.* (*R.*) *Linnæi* and other forms.

Collections.—Geological Survey of Scotland, and Lapworth.

Monograptus (Rastrites) Linnæi (Barrande). Plate LI, figs. 1 *a—c*.

1850. *Rastrites Linnæi*, Barrande, Grapt. de Bohême, p. 65, pl. iv, figs. 2, 4.

1897. *Rastrites Linnæi*, Perner, Grapt. de Bohême, iii *a*, p. 7, figs. 4, 5; pl. xiii, figs. 27—31.

1907. *Rastrites Linnæi*, Törnquist, *Rastrites* and some allied species of *Monograptus*, Lunds Univ. Årsskr., N.S., afd. 2, iii, no. 5, p. 14, pl. ii, figs. 21—26.

Polypary arcuate proximally, with irregular curvature distally. Thecæ six to four in 10 mm., long, slightly declined, lengthening gradually from origin till the maximum length of 8 mm. is attained with interspace of about 2·5 mm. in extent; base triangular, with slightly swollen apical extremity and slightly reflexed apertural margin.

Description.—The polypary is curved somewhat irregularly, but the proximal end appears to be generally arcuate with the thecæ on the convex margin.

The thecæ in the proximal portion lengthen gradually, and the interspaces also until the maximum thecal length of 8 mm. is attained; this then remains constant, and the thecæ are separated by an interspace averaging 2·5 mm. in extent. The thecæ are, therefore, rather more than three times as long as the interspaces.

Figs. 349 *a* and *b*.—*Monograptus* (*Rastrites*) *Linnæi* (Barrande).

a *b*

a. Proximal portion, natural size, for comparison with British specimens. Zelkovitz, Bohemia. Sedgwick Museum.
b. Distal thecæ in relief, showing growth lines. Enlargement of part of Pl. LI, fig. 1*c*.

Affinities.—*Monog.* (*R.*) *Linnæi* resembles *M.* (*R.*) *maximus* in many respects; it has, however, shorter thecæ with a more uniform length, which never exceeds 7 mm., and with interspaces measuring barely 3 mm. in extent. There is, therefore, no such marked and persistent increase in the thecal length as is the case in *M.* (*R.*) *maximus*, and the increase in the proximal end is far more gradual than in the latter species.

Horizon and Localities.—Gala-Tarannon (zone of *M. turriculatus*).

S. Scotland: Belcraig Burn; Yarrow, etc. *C. Wales*: Tarannon River; Gelli-dywyll Stream, Llanbrynmair; Gelli Stream and Pont bren-dibyn, Llanbrynmair; west side of Upper Quarry, 550 yards E.S.E. of Fuches gau Farm, Pont Erwyd.

Associates, etc.—*Monog.* (*R.*) *Linnæi* is not a common fossil in S. Scotland, though it does occur at the base of the Gala beds associated with *M. turriculatus*, *M. nudus*, *M. dextrorsus* and *M. Halli.* It also occurs in Wales in much the same association.

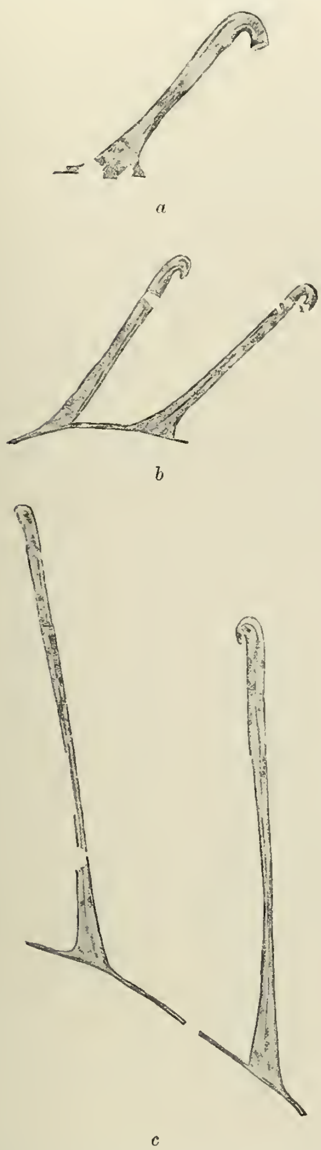
Collections.—Geological Survey of Scotland, Sedgwick Museum, and the Authors.

Monograptus (Rastrites) maximus (Carruthers). Plate L, figs. 6 *a*—*e*.

1867. *Rastrites maximus*, Carruthers, Murchison's Siluria, Fossils 90, p. 541, fig. 6.
1868. *Rastrites maximus*, Carruthers, Geol. Mag., vol. v, p. 13, pl. v, fig. 14.
1876. *Rastrites maximus*, Lapworth, Geol. Mag. [2], vol. iii, p. 313.
1876. *Rastrites maximus*, Lapworth, Cat. West. Scott. Foss., pl. i, fig. 1.
1907. *Rastrites maximus*, Törnquist, *Rastrites* and some allied species of *Monograptus*, Lunds Univ. Årssk., N. s., afd. 2, iii, no. 5, p. 15, pl. ii, figs. 27—33, pl. iii, fig. 1.

Polypary slightly arcuate, with thecæ on the convex margin; "common body" reduced to a mere thread throughout. Thecæ three to two in 10 mm., very long, commonly two to two and a half times as long as the interspace between them, steadily increasing until a length of 1·8 cm. is attained; slightly declined, with triangular base and distinctly retroflexed apertural region.

Figs. 350 *a—c.—Monograptus* (*Rastrites*) *maximus* (Carruthers).



a and *b*. Proximal thecæ (referable probably to this species), showing the marked retroflexion of the apertural region. Belcraig Burn, S. Scotland; Upper Birkhill Shales. Coll. Wood.
c. Two distal thecæ. Enlargement of part of Pl. L, fig. 6 *b*.

Description.—The polypary is only known in fragments; it must, however, be by far the largest contained within the group, the great length of the thecæ and their relative robustness as compared with the common body being unique.

The proximal end is characteristic; the sicula is small and inconspicuous; th. 1 measures only 1·5 mm., but the increase in length of each succeeding theca is most marked, th. 2 measuring 3·5 mm, th. 3, 5 mm.

While the interspaces between the first three thecæ measure 1·5 mm. and 3 mm. respectively, a later stage shows the thecæ increasing to a length of 1·3–1·4 cm. with interspaces of about 6 mm. and it would seem as if the thecæ continued to increase still further, for fragments are known in which the thecæ measure 1·8 cm. in length with interspaces of 10 mm. The aperture is situated close to the extremity of the theca, which shows distinct retroflexion (figs. 350 *a* and *b*).

Affinities.—*Monog.* (*Rastrites*) *maximus* is undoubtedly closely allied to *M.* (*R.*) *Linnæi*, and certain fragments of it would probably be hard to distinguish from fragments of that species. It is clear, however, that in *M.* (*R.*) *maximus* (unlike *M.* [*R.*] *Linnæi*) the increase in length of the thecæ is persistent, and the thecæ attain an extent never reached by those of *M.* (*R.*) *Linnæi*. The proximal end of *M.* (*R.*) *maximus* also is different, the thecæ lengthening far more rapidly than is the case with those of *M.* (*R.*) *Linnæi*.

Horizon and Localities.—Gala-Tarannon *M.* (*R.*) *maximus* band in zone of *M. turriculatus*).

S. Scotland: Berrybush Burn; Belcraig Burn; Dobb's Linn; Thirlstane

Specific Characters of Forms belong-

	GROUP I.—A. (UNIFORM).							
	M. cyphus.	*M. acinaces.*	*M. gregarius.*	*M. bohemicus.*	*M. concinnus.*	*M. Nilssoni.*	*M. leptotheca.*	*M. regularis.*
Character of polypary	Arcuate, with involute proximal portion	Straight, with arcuate proximal portion	Short, arcuate	Straight, broadly rounded proximally	Ventral curvature	Straight, with double curvature of proximal portion	Straight	Straight and rigid
Maximum width	1·5 mm.	2 mm.	·75 mm.	2 mm.	1 mm.	1 mm.	3 mm.	1·5 mm.
Length of sicula	4 mm.	5 mm.	5 mm.	1 mm.	—	1·5 mm.	—	·7 mm.
Characters of thecæ:								
1. No. in 10 mm.	10—9	6—11	10	11—9	12—10	8—9	8—10	12—8
2. Overlap	$\frac{1}{2}$—$\frac{2}{3}$	$\frac{1}{2}$—$\frac{2}{3}$	0—$\frac{1}{3}$	$\frac{1}{3}$—$\frac{1}{2}$	$\frac{1}{3}$ – $\frac{1}{2}$	$\frac{1}{3}$	$\frac{3}{4}$	Slight—$\frac{2}{3}$
3. Apertural margin	Even, normal	Even, everted	Even, normal	Wide, normal	Wide, even, everted	Even, horizontal	Even, horizontal	Wide, even, slightly everted
4. Proportion length to width (mature)	6 : 1	10 : 1	5 : 1	2—3 : 1	3 : 1	4—5 : 1	25 : 1	9 : 1

	GROUP I.—B. (BIFORM).							
	M. revolutus.			*M. difformis.*	*M. argenteus.*		*M. limatulus.*	*M. colonus.*
		var. *austerus.*	var. *præcursor.*			var. *cygneus.*		
Character of polypary	Arcuate, with broadly recurved proximal portion	Arcuate throughout	—	Arcuate, with involute proximal portion	Straight, with abrupt proximal curvature	Narrower than typical species	Arcuate or straight, with stiffly recurved proximal portion	Straight, with ventral proximal curvature
Maximum width	1 mm.	—	—	1 mm.	2·5 mm.	1·5 mm.	1 mm.	2·3 mm.
Length of sicula	—	—	—	1 mm.	1 mm.	—	With very long virgella	1·6 mm.
Characters of thecæ:								
1. No. in 10 mm.	8—10	—	—	12—10	15—11	8	12	12—10
2. Overlap (A)	Slight	—	—	Slight	Contact	—	Contact	$\frac{1}{2}$
,, (B)	$\frac{2}{3}$	—	—	$\frac{1}{2}$	$\frac{2}{3}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{2}{3}$
3. Apertural margin (A)	Retroverted	—	Tendency to isolation	Retroverted, isolated	Retroverted and isolated	—	Slightly retroverted	Ogee curvature and retroverted
,, ,, (B)	Even	—	—	Even and slightly everted	Even	—	Even, everted	Even, normal
4. Proportion length to width (mature)	7 : 1	—	—	5 : 1	7 : 1	—	4 : 1	4 : 1

A. Refers to proximal type. B. Refers to distal type.

ing to the Genus Monograptus.

GROUP I.—A. (UNIFORM).										
M. jaculum.	*M. variabilis.*	*M. nudus.*	*M. dubius.*	*M. vulgaris.*		*M. tumescens.*		*M. comis.*	*M. cf. gothlandicus.*	*M. cf. ultimus.*
					var. *curtus.*		var. *minor.*			
Straight	Straight	Straight	Straight, with proximal ventral curvature	Stiff and straight	Shorter and with slight tendency to ventral curvature	Straight, with strong ventral curvature in proximal portion	Small dwarfed form	Small with ventral curvature	Short, with slight ventral curvature	Small, slender, with slight ventral curvature
1·5 mm.	1 mm.	2 mm.	2 mm.	2·5 mm.	1·5 mm.	2 mm.	—	2 mm.	2 mm.	2 mm.
·7 mm.	1·5 mm.	1 mm.	1·7 mm.	2 mm.	—	2 mm.	—	2 mm.	2 mm.	2 mm.
14—9	12—8	9—10	11—8	12—9	—	11—9	—	11	9—8	12—11
Slight—½	Slight—⅓	½	About ½	½—⅔	—	½—⅔	—	½	⅓—½	½
Wide, even, horizontal	Even, horizontal, or slightly introverted	Even, wide	Even, flanged, normal	Even, flanged, normal	—	Even, flanged	—	Even, flanged	Even, flanged	Even
7 : 1	4 : 1	2½ : 1	2—3 : 1	4 : 1	3 : 1	4 : 1	—	3—4 : 1	4½—1	3—4 : 1

GROUP I.—B. (BIFORM).									
		M. varians.		*M. Rœmeri.*	*M. chimæra.*			*M. leintwardinensis.*	
var. *ludensis.*	var. *compactus.*		var. *pumilus.*			var. *Salweyi.*	var. *semispinosus.*		var. *incipiens.*
—	Smaller, with more curvature	Straight, slight ventral curvature	Small size and slight proximal curvature	Slight dorsal curvature distally, with slight ventral curvature proximally	Straight, with slight ventral curvature proximally	Smaller size and straighter proximal end	Broader	Short, straight, with slight proximal curvature	Broader
—	—	2 mm.	—	3 mm.	2 mm.	1·6 mm.	2·5 mm.	1·6 mm.	2·3 mm.
—	—	2 mm.	—	1·8 mm.	2 mm.	—	—	2·1 mm.	—
—	16—14	14—10	16—14	16—11	13—11	—	—	14—15	—
—	—	½	—	½	½	—	—	½	—
—	¾	½	—	⅔	½	—	—	⅔	—
One theca only retroverted	—	Like *M. colonus*	—	Like *M. colonus*	All spined, otherwise like *M. colonus*	Longer and more flexed spines	Spined	Like *M. chimæra*	Spined
—	—						Unspined		Unspined
6 : 1	—	2—3 : 1	—	5½ : 1	4 : 1	—	—	3 : 1	—

Specific Characters of Forms belonging to the Genus Monograptus.

GROUP II.

	M. atavus.	*M. Sandersoni.*	*M. incommodus.*	*M. tenuis.*	*M. argutus.*
Character of polypary .	Very long and slender with slight dorsal curvature	Very long, with ventral curvature	Irregularly curved	Slightly arcuate throughout	Arcuate distally and involute proximally.
Maximum width . .	1·2 mm.	·7 mm.	·6 mm.	1 mm.	1·5 mm.
Length of sicula . .	2 mm.	1·6 mm. ?	—	—	—
Characters of thecæ: 1. No. in 10 mm. .	9—8	8—6	8—7	7—5	8
2. Overlap . .	½ as maximum	½	⅓—½	⅓—½	½
3. Apertural margin .	Slight sigmoid curvature, with slight introversion	Introverted	Even and slightly introverted	With abrupt expansion and slight introversion	Introverted and slightly introtorted.
4. Proportion length to width	5 : 1	15 : 1	15 : 1	5 : 1	12 : 1

GROUP III.

	M. vomerinus.				*M. griestoniensis.*	*M. crenularis.*	*M. galaensis.*
		var. *basilicus.*	var. *gracilis.*	var. *crenulatus.*			
Character of polypary .	Approximately straight	Broader	Proximal portion gracefully recurved	—	Slightly flexed, very long and slender	Long, arcuate throughout	Straight or with slight curvature
Maximum width . .	2 mm.	3 mm.	1·6 mm.	—	·7 mm.	1 mm.	2 mm.
Length of sicula . .	1·5 mm.	—	1·2 mm.	1·5 mm.	·6 mm.	—	1 mm.
Characters of thecæ: 1. No. in 10 mm. .	11—10	—	13	13—10	10	12—10	10—9
2. Overlap . .	½	⅔	—	—	½	⅔	⅓—⅔
3. Apertural margin	Everted or in excavations	—	—	Apertural excavations smaller	Excavations relatively wide	Slightly everted or in excavations	Changing from slight retroversion to eversion with tag.
4. Proportion length to width . .	3 : 1	6 : 1	3 : 1	—	3 : 1	6 : 1	4 : 1

Specific Characters of Forms belonging to the Genus MONOGRAPTUS.

	GROUP IV.—A. (UNIFORM).							
	M. priodon.	*M. pandus.*	*M. Marri.*	*M. cultellus.*	*M. riccartonensis.*	*M. Flemingii.*		
							var. *primus.*	var. *compactus.*
Character of polypary	Very long, straight and rigid	Approximately straight, robust	Long and narrow, approximately straight	Very short incurved proximal extremity	Slight dorsal flexure	Straight or slightly flexed	Straighter and shorter with more rapid widening	Very small and compact
Maximum width	3 mm.	2·5 mm.	1·8 mm.	1 mm.	1·5 mm.	2·5 mm.	—	3 mm.
Length of sicula	1·5 mm.	—	1·2 mm.	1·5 mm.	1·6 mm.	1·6 mm.	—	—
Characters of thecæ: 1. No. in 10 mm.	13—8	9—10	10	20	10—8	14—9	14—8	16—18
2. Overlap	$\frac{1}{3}$—$\frac{2}{3}$	$\frac{2}{3}$	Slight	Slight	$\frac{1}{3}$—$\frac{1}{2}$	$\frac{1}{2}$	—	—
3. Apertural region, proportion to width of polypary	$\frac{1}{2}$	$\frac{1}{5}$	+ $\frac{1}{2}$	Like *M. discus*	$\frac{1}{4}$	Abruptly narrowing $\frac{1}{5}$—$\frac{1}{3}$	—	—
4. Proportion of "hook" to thecal length	$\frac{2}{3}$	$\frac{1}{3}$	+ $\frac{1}{2}$	—	$\frac{1}{2}$	$\frac{1}{2}$	—	—

	GROUP IV.—A. (UNIFORM)—*continued.*								
	M. uncinata		*M. irfonensis.*	*M. flexilis.*	*M. acus.*	*M. distans.*	*M. undulatus.*	*M. scanicus.*	*M. crinitus.*
	var. *orbatus.*	var. *micropoma.*							
Character of polypary	Short, robust and somewhat flexed	Straighter and narrower	Very slender, approximately straight	Long and flexed with reflexed proximal portion	Very long and flexed	Long and slender, irregularly but conspicuously flexed	Long, slender, flexed, with recurved proximal end	Slender, very flexed, with conspicuous proximal ventral curvature	Thread-like, irregularly flexed
Maximum width	2 mm.	1·3 mm.	1 mm.	2 mm.	2 mm.	1 mm.	1 mm.	1 mm.	·4 mm.
Length of sicula	1·6 mm.	—	1 mm.	2 mm. with long virgella	—	—	1·1 mm.	1·5 mm.	1·5 mm.
Characters of thecæ: 1. No. in 10 mm.	12—9	10—9	8—9	12—9	8	12—8	10—8	8—9	5—7
2. Overlap	$\frac{1}{2}$	—	Approximately $\frac{1}{2}$	—	Slight	Like that of proximal portion of *M. Sedgwicki*	$\frac{1}{3}$—$\frac{1}{2}$	$\frac{1}{3}$	Insignificant
3. Apertural region, proportion to width of polypary	Like *M. Flemingii.*	Beak less conspicuous	$\frac{1}{3}$	Very like *M. Flemingii,* but shorter	Very slight retroversion	—	$\frac{3}{4}$	$\frac{1}{3}$	Like *M. scanicus,* but more slender
4. Proportion of "hook" to thecal length	$-\frac{1}{2}$	—	$\frac{1}{2}$	$-\frac{1}{2}$	—	—	$\frac{1}{2}$	$\frac{1}{2}$	—

Specific Characters of Forms belonging to the Genus MONOGRAPTUS—continued.

	GROUP IV.—A. (UNIFORM)—*continued.*					GROUP IV.—B. (BIFORM).			
	M. Jækeli.	*M. gemmatus.*	*M. turriculatus.*	*M. discus.*	*M. tortilis.*	*M. Sedgwicki.*	*M. Halli.*	*M. McCoyi.*	*M. testis.* var. *inornatus.*
Character of polypary	Long, curved, robust	Very slender, arcuate, or nearly straight	Coiled in conical spiral	Very small, coiled into disc	Arcuate, in-curved, fairly robust	Straight or slightly flexed	Straighter than *M. Sedgwicki*	Very robust and rigid	Coiled into plane open spiral
Maximum width .	3 mm.	·5 mm.	1 mm.	1·5 mm.	1·5 mm.	3 mm.	3 mm.	3·5 mm.	2 mm.
Length of sicula .	—	—	1·2 mm.	1 mm.	—	1 4 mm.	—	—	—
Characters of thecæ: 1. No. in 10 mm. .	9	6–9	12	20—16	9—10	10—6	11—7	10	15
2. Overlap . .	$\frac{2}{3}$	Insignificant	$\frac{1}{2}$	—	$\frac{1}{2}$—$\frac{1}{3}$	Slight	$\frac{1}{3}$—$\frac{1}{2}$	—	—
3. Apertural region, proportion to width of polypary	$\frac{1}{5}$	$\frac{1}{2}$	$\frac{1}{2}$ spined	$\frac{1}{3}$	$\frac{2}{3}$	$\frac{1}{2}$ spined	Less retroverted and with stouter spines than *M. Sedgwicki*	Like *M. Halli*	No spines; otherwise like those of *M. Sedgwicki*
4. Proportion of "hook" to thecal length	$\frac{1}{2}$	—	—	—	$-\frac{1}{2}$	$\frac{1}{2}$	—	—	—

Score; Mount Benger Burn, etc. *Lake District:* Spengill. *Wales:* Bank of Afon Gyffin, Conway.

Associates, etc.—Monog. (*R.*) *maximus* is fairly abundant in a fragmentary condition in some localities following immediately upon the zone of *M. Sedgwicki.* It sometimes occurs in a more or less well-defined bed at the base of the zone of *M. turriculatus*, and is commonly associated with *M. Halli*, *M. turriculatus*, *M. dextrorsus*, *M. runcinatus* and *Petalog. altissimus.*

Collections.—Sedgwick Museum, Miss M. F. Macphee of Glasgow University, Lapworth, and the Authors.

Monograptus (Rastrites) equidistans[1] (Lapworth). Plate LI, figs. 2 *a*—*e*.

1876. *Rastrites distans*, Lapworth, Geol. Mag. [2], vol. iii, p. 313, pl. x, figs. 2 *a*, *b*.
1876. *Rastrites distans* var. *abbreviatus*, Lapworth, Geol. Mag. [2], vol. iii, p. 314.
1907. *Rastrites distans* var. *abbreviatus*, Törnquist, *Rastrites* and allied species of *Monograptus*, Lunds Univ. Årsskr., N.S., afd. 2, iii, no. 5, p. 12, pl. ii, figs. 11—20.

[1] Name modified to avoid confusion with Portlock's species, see *ante* p. 433.

Polypary somewhat irregularly curved, with thecæ on the convex or concave margin. Thecæ four to two in 10 mm., perpendicularly placed, of approximately uniform width, and of a maximum length of 5 mm. equal to the width of the interspace; apertural extremities very slightly reflexed.

Description.—The polypary is only known in a fragmentary condition; in what appears to be the proximal end the thecæ are usually, though not invariably, on the convex margin and measure only 2 mm. in length, the interspace being also 2 mm. in extent. Distal fragments, however, appear to be straight or to show slight concave curvature of the thecal margin.

The thecæ are very distant; after the first they appear to be of approximately the same length, and always equal to the width of the interspace; they are set perpendicularly, and show an unusual degree of uniformity in their width from base to termination, which is often somewhat truncate in appearance, owing to the very slight, but abrupt, reflexion of the apertural termination being turned away and thus concealed from the observer.

Affinities.—Fragments of *Monog.* (*R.*) *equidistans* might be confounded perhaps with *M.* (*R.*) *Linnæi*, but the shape of the thecæ is really distinct, and they are much shorter. The variety originally separated by Lapworth as *abbreviatus*, which occurs in the same beds, appears to be merely the proximal portion of the same species.

Horizon and Locality. — Gala-Tarannon (zones of *M. turriculatus* and *M. crispus*).

S. Scotland: Mount Benger; Craigmichan Scaurs; Glenkiln Burn; Meigle; Caddonhead; Elwand Water, Melrose; Waterfall at head of Dobb's Linn; Clanyard Bay, Drumore. *Lake District:* Spengill.

Associates, etc.—*Monog.* (*R.*) *equidistans* is a somewhat rare fossil in the zone of *M. turriculatus,* where it occurs associated with *M. turriculatus, M. nudus* and other species. It has also recently been found in the Tarannon Shales in a boring in Kent, where it occurs with *M. crispus, M. exiguus, M. nodifer* and *M. Marri*, an association typical of the zone of *M. crispus.*

Collections.—Geological Survey of England and Wales, Sedgwick Museum, Lapworth, and the Authors.

Specific Characters of Forms belong-

	GROUP V.						
	M. lobiferus.	*M. runcinatus.*		*M. Becki.*	*M. exiguus.*	*M. nodifer.*	*M. crispus.*
			var. *pertinax.*				
Character of polypary . . .	Slender, long, flexed or straight	Slender, somewhat flexed in proximal portion	Stiffer and straighter	Long, arcuate, or with irregular flexure in proximal portion	Short, slender, fish-hook form	Like *M. exiguus*	Like note of interrogation in form
Maximum width	2 mm.	1·5 mm.	—	1 mm.	·5 mm.	·9 mm.	–1 mm.
Length of sicula	1·2 mm.	1 mm.	—	—	·9 mm.	·9 mm.	1 mm.
Characters of thecæ: 1. No. in 10 mm.	10—7	11—8	10	10	14—12	12—10	7–9
2. Overlap	Insignificant	Insignificant	$\frac{1}{3}$	—	Insignificant	—	—
3. Proportion of apertural region to width of polypary	$\frac{3}{4}$	$\frac{1}{3}$	—	Like *M. lobiferus*	$\frac{1}{2}$	$\frac{1}{2}$ with double fold	$\frac{3}{4}$–$\frac{2}{3}$
4. Proportion of lobe to thecal length	$\frac{3}{4}$	$\frac{1}{2}$	—	—	$\frac{4}{5}$	$\frac{4}{5}$	$\frac{3}{4}$–$\frac{1}{2}$

	GROUP VI.—A (BIFORM).							
	M. convolutus.	*M. decipiens.*	*M. urceolus.*	*M. triangulatus.*		*M. raitzhainiensis.*	*M. denticulatus.*	*M. spiralis.*
					var. *major.*			
Character of polypary . .	Flat spiral	Small, irregular, plane spiral	Loose, helicoid spiral	Small, circinate, with recurved proximal portion	Curvature broader	Arcuate, with broadly circinate proximal portion	Small, arcuate, broadly recurved proximal portion	Robust, irregular spiral
Maximum width . . .	3 mm.	2 mm.	2 mm.	2 mm.	—	1·5 mm.	1·3 mm.	3 mm.
Length of sicula . . .	—	Short	—	·9 mm.	1·5 mm.	1 mm.	1 mm.	—
Characters of thecæ: 1. No. in 10 mm.	10—7	10—8	11—12	10—8	12—7	12–9	8–9	8—9
2. Proportion of "barb" to thecal length	$\frac{1}{5}$	$\frac{1}{8}$	Merest fraction	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{5}$—$\frac{1}{3}$	Proximal like *M. triangulatus*, distal like *M. communis*	$\frac{1}{2}$
3. Proportion of theca isolate (mature)	$\frac{4}{5}$	$\frac{7}{9}$	$\frac{2}{3}$	$\frac{4}{5}$	$\frac{7}{8}$	$\frac{4}{6}$	—	$\frac{1}{4}$—$\frac{1}{5}$

ing to the Genus MONOGRAPTUS.

GROUP V.								
M. flagellaris.	*M. capillaceus.*	*M. retroflexus.*	*M. dextrorsus.*	*M. remotus.*	*M. Barrandei.*	*M. knockensis.*	*M. Clingani.*	*M. millepeda.*
Small conical spiral	Flexed, incurved distally and recurved proximally	Slender, arcuate, reflexed proximal portion	Slender, arcuate or flexed	Slender, arcuate	Long, very slender, arcuate	Straight or with very slight curvature	Long, arcuate, broadly recurved proximally	Long, arcuate, abruptly involute proximal portion
1 mm.	1 mm.	·75 mm.	1 mm.	·6 mm.	·5 mm.	1·5 mm.	1·5 mm.	1·5 mm.
—	1 mm.	—	1·4 mm.	—	—	—	1·2 mm.	1 mm.
12	8—10	10	7—8	3—4	7–8	7	12—7	14—10
Slight	Insignificant	Insignificant	Slight	Increasingly remote	Insignificant	*Nil*	Slight	—
$\frac{7}{10}$	$\frac{1}{5}$	$\frac{1}{2}$—$\frac{1}{3}$	Twisted lobe	—	$\frac{3}{4}$	$\frac{2}{3}$	$\frac{1}{2}$—$\frac{2}{3}$	$\frac{5}{7}$
—	Small	Very small	—	Very small	—	$\frac{1}{2}$	$\frac{1}{2}$—$\frac{1}{3}$	$\frac{1}{2}$

GROUP VI.—B (UNIFORM).										
M. proteus.	*M. delicatulus.*	*M. involutus.*	*M. circularis.*	*M. communis.*		*M. fimbriatus.*		*M. planus.*	*M. intermedius.*	*M. cf. elongatus.*
					var. *rostratus.*		var. *similis*			
Helicoid spiral, slender proximally, but widening rapidly	Slender, irregular spiral	Irregular, involute, slender spiral	Slender, convolute, coiled into plane spiral	Arcuate or straight, with sharply recurved proximal portion	Broader	Small, broadly circinate, with circinate proximal portion	Circinate portion shorter	Small, arcuate, with recurved proximal portion	Long, arcuate, with stiffly recurved proximal portion	Long, irregularly flexed, arcuate
1·6 mm.	1 mm.	1 mm.	1 mm.	1·4 mm.	—	1·8 mm.	—	1 mm.	1 mm.	1 mm.
—	—	—	—	1·2 mm.	—	1 mm.	·7 mm.	—	—	—
7—10	10	8	8	8	Longer	12—9	18—14	14—12	8—10	8—9
$\frac{1}{3}$	Like *M. convolutus*, but smaller	Like *M. communis*	Like that of *M. communis*	$\frac{1}{3}$	—	Mere fraction	—	Considerable fraction	Insignificant	$\frac{1}{2}$
Variable	—	—	—	$\frac{7}{12}$	—	Nearly complete	—	Nearly complete	$\frac{2}{3}$	$\frac{1}{3}$

Specific Characters of Forms belonging to the Genus MONOGRAPTUS.

	GROUP VII.—(RASTRITES).								
	M. peregrinus.	*M. longispinus.*	*M. setiger.*	*M. hybridus.*	*M. approximatus,* var. *Geinitzi.*	*M. fugax.*	*M. Linnæi.*	*M. maximus.*	*M. equidistans.*
Character of polypary	Fish-hook form	Broadly arcuate	Proximally almost straight, irregular distally	Small, arcuate, broadly recurved proximal portion	Convolute proximal portion, arcuate distally	Arcuate	Arcuate, with irregular distal curvature	Slightly arcuate, thecæ on convex side	Irregularly flexed
Characters of thecæ:									
1. No. in 10 mm.	8–10	7—8	12	8—10	10—12	6—8	6—4	3—2	4–2
2. Length	2·5 mm.	5 mm.	5 mm.	2 mm.	4 mm.	1 mm.	8 mm.	1·8 cm.	5 mm.
3. Proportion of length to width of interspace (mature)	2½	5	6	2	4	½	+3	2–2½	Equal 1:1

Genus CYRTOGRAPTUS, *Carruthers.*

1867. *Cyrtograpsus,* Carruthers. Murchison's Siluria, 4th Edition. Fossils 90, fig. 1, p. 541.

Polypary unilateral, compound, with more or less spiral mode of growth.

Thecæ conical or tubular; of the type of those of *Monograptus Nilssoni* with apertural margins straight, or of the type of those of *M. spiralis* with apertural margins reflexed.

In the various forms of Monograptidæ, known collectively as *Cyrtograpti*, the mode of origin of the so-called "branches" is peculiar. As a general rule the appearance presented is that each so-called "branch" originates either directly or laterally from the apertural region, or aperture, of certain thecæ.

Each "branch" is usually initiated by a small sac-like or vesicle-like structure, through which the "branch" eventually appears to break its way (see figs. 351 *a*—*c*); and the presence of this initial "sac" gives an appearance of unusual length to the first "theca" of each "branch." This apparent mode of branching is very unlike that described by us as "dichotomous" in the cases of the families of the Dichograptidæ, Leptograptidæ, etc.

While these "branches" in *Cyrtograptus* originate in some species at fairly regular intervals along the course of the stipe, there is no constant rule, even in examples of the same species, and in some forms only a single "branch" is shown. Indeed, the appearances presented are suggestive of the view that the so-called

FIGS. 351 *a—c.—Cyrtograptus Murchisoni*, Carruthers.

a—c.—Three fragments, showing the various appearances presented by the "*saccoid*" and the first theca of the "*cladium.*" Pencerrig, Builth; Wenlock Shales (zone of *C. Murchisoni*). Coll. Elles.

"branches" are individual colonies normally destined to an independent existence, but which have remained so far permanently attached to the parent. Thus, the whole compound colony, or colony of colonies (its general form excepted), recalls in a sense the "synrhabdosome"[1] of Ruedemann, while the sac-like bodies recall the "graptogonophores"[2] of Nicholson.

In order, therefore, to avoid restricting ourselves to any particular theory, we here employ in our diagnoses of the various species in the present group the conventional term "*cladium*" for each of the so-called "branches," and the term "*saccoid*" for each of the initial sac-like expansions.

The difference in the appearance of the thecæ on the stipe and cladia is mainly an apparent one, and is due to difference in curvature. In the spiral portion of the polypary, the thecæ, being on the convex side of the curve, are stretched, whereas in the distal portion of the stipe and on the cladia the thecæ are, as a rule, on the concave side, and are therefore compressed, thus tending to show a greater degree of overlap.

In some species the spiral enrolling of the stipe is considerable (*C. Murchisoni*), while in others it is but slight (*C. Linnarssoni*).

The following species are included in this genus: *Cyrtog. Murchisoni*, *C. Lundgreni*, *C. rigidus*, *C. symmetricus*, *C. hamatus*, *C. Linnarssoni*, *C. Grayi*, *C. Carruthersi*.

Cyrtograptus Murchisoni, Carruthers. Plate LI, figs. 3 *a—c*.

1867. *Cyrtograpsus Murchisoni*, Carruthers in Murchison's Siluria, Fossils 90, fig. 1, p. 541.
1868. *Cyrtograpsus Murchisoni*, Carruthers, Geol. Mag., vol. v, p. 127, pl. v, fig. 17.
1883. *Cyrtograptus Murchisoni*, Tullberg, Skånes Grapt., ii, p. 35, pl. iv, figs. 9–11.
1900. *Cyrtograptus Murchisoni*, Elles, Quart. Journ. Geol. Soc., vol. lvi, p. 409, pl. xxiv, fig. 6.

Polypary robust, several square cm. in extent; stipe arcuate, with spirally enrolled proximal portion, which widens slightly but quickly until the

[1] Ruedemann, Grapt. New York, 1904, p. 483.

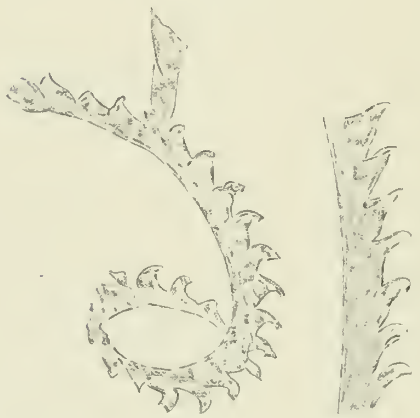
[2] Nicholson, Geol. Mag., 1866, vol. iii, p. 489.

maximum breadth of 1·8 mm. is reached; cladia numerous, of two, three or more generations. Thecæ fourteen to ten in 10 mm., of the general type of *Monog. spiralis*, those of the cladia appearing somewhat more tubular and having greater overlap than those of the greater part of the stipe.

Description.—The polypary often attains considerable size, the stipe with its cladia covering several square centimetres. The proximal end of the stipe is always spirally (usually helicoidally) enrolled, but the degree of enrolment varies with different individuals.

The place of origin of the first cladium varies considerably, and it often appears as if none of the earlier cladia remain attached. In one specimen, however, in which all appear to be present and subregularly disposed, they arise as follows: First cladium at theca 20; second cladium at theca 26; third cladium at theca 32; fourth cladium at theca 38; fifth cladium at theca 47. Thus the earlier cladia seem to come off sub-regularly every sixth theca, and the distance increases somewhat later. There does not appear to be, however, any precise regularity in this respect—a circumstance in harmony with the view already mentioned, namely, that the regularity or irregularity might possibly be determined by the number of individuals remaining attached and the number already thrown off. It would, however, seem to be clear that in this species at any rate, a considerable number of thecæ are developed on the stipe before any new individual (cladium) arises.

FIGS. 352 *a* and *b*.—*Cyrtograptus Murchisoni*, Carruthers.



a *b*

a. Portion of the stipe, showing the type of proximal thecæ. Pencerrig, Builth; Wenlock Shales. Coll. Elles.
b. Distal thecæ. Near Newtown. Wenlock Shales. Sedgwick Museum.

The cladia are commonly somewhat slender at their origin and widen fairly rapidly up to 1·8 mm. The first generation of cladia may themselves show the development of a second and even a third generation, which arise in a precisely similar fashion.

The sicula is usually small and inconspicuous.

The thecæ are slightly more closely set in the initial than in the distal portion of the stipe, but the only visible change they undergo is the tendency to appear tubular rather than sub-triangular in form, a tendency which is doubtless to be correlated with the diminution in curvature and their change in apparent position from the convex to the concave side of the curve.

Affinities.—The stipe in *Cyrtog. Murchisoni* shows decided resemblances to that of *Monog. spiralis*, but is rather more slender and less spirally enrolled, whilst the possession of cladia by the former renders its distinction easy.

Horizon and Localities.—Wenlock Shales (Denbigh Grits and Flags), (Brathay Flags), (Riccarton Beds), zone of *Cyrtog. Murchisoni*.

Welsh Border: Pencerrig, near Builth; Trecoed, near Builth; Llanelwedd Quarry, near Builth. *Lake District:* Cross Haw Beck, Sedbergh; Stockdale; Nanny Lane, Troutbeck. *S. Scotland:* Riccarton. *N. Wales:* Penarth Quarry, Carrog; Benarth Shore, Conway; Rose Mill Farm, Conway; Tarannon River.

Associates, etc.—*Cyrtog. Murchisoni* is a very abundant fossil at the base of the Wenlock Shale and its equivalents; it is commonly associated with *Monog. priodon*, *M. vomerinus*, and *Ret.* (*Gladiog.*) *Geinitzianus*.

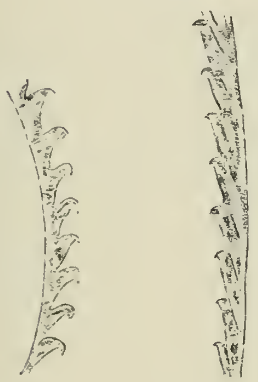
Collections.—Geological Survey of England and Wales, British Museum of Natural History, Sedgwick Museum, Lapworth, and the Authors.

Cyrtograptus Lundgreni, Tullberg. Plate LII, figs. 1 *a*—*d*.

1883. *Cyrtograptus Lundgreni*, Tullberg, Skåues Grapt., ii, p. 36, pl. iii, figs. 8—11.
1900. *Cyrtograptus Lundgreni*, Elles, Quart. Journ. Geol. Soc., vol. lvi, pl. xxiv, figs. 1 A, B, text-figs. 24 *a*, *b*.

Stipe of polypary slender and sub-circular, with several somewhat stiff cladia radiating from the convex margin. Thecæ ten in 10 mm., of the general type of *M. spiralis*, but much smaller; those of the cladia numbering eight in 10 mm., more tubular, and overlapping fully one-half their extent.

Figs. 353 *a* and *b*.—*Cyrtograptus Lundgreni*, Tullberg.



a. Thecæ of the proximal part of the stipe. Enlargement of part of Pl. LII, fig. 1 *b*.
b. Thecæ of one of the cladia. Llwynrhedith Quarry, Long Mountain; Wenlock Shales. Coll. Elles.

Description.—The stipe of the polypary is sub-circular in form and is slender, not exceeding 1 mm. in breadth, the actual proximal end being unknown; there is, however, no indication of any spiral enrolling.

The thecæ of the stipe are for the most part sub-triangular, with reflexed apertural margins, but they acquire a more tubular character with the diminishing curvature of the stipe, and the amount of overlap increases simultaneously; so that at the termination of the polypary the thecæ overlap from one-third to one-half their length and are distinctly tubular in form. All the thecæ of the cladia are of the same type as those of the termination of the stipe. It is possible that the apparent difference is somewhat exaggerated by the variation in curvature, for when the thecæ appear sub-triangular they are always on the convex side of the curve; but both at the distal termination of the main stipe and on the cladia they are on the concave side and are therefore compressed rather than stretched, so that they naturally overlap more. This circumstance is no doubt largely, though not wholly, responsible for the different appearances which they present. There are commonly eight to five thecæ in the interval separating the different cladia, but there is no absolute regularity in this respect.

Affinities.—The only other *Cyrtograptus* which approximates to a sub-circular form is *Cyrtog. Murchisoni*, and this differs from *Cyrtog. Lundgreni* in the possession of a greater number of cladia, and in the character of the thecæ.

Horizon and Localities.—Wenlock Shales (zone of *Cyrtog. Lundgreni*).

Welsh Border: Ackley Lane, near Chirbury; Llwynrhedith Quarry, Ackley Lane, near Chirbury; Sale Brook, near Middletown; Trewern Brook, near Middletown; River Irfon, Builth. *Lake District:* Cautley, near Sedbergh.

Associates, etc.—*Cyrtog. Lundgreni* is often quite abundant in the highest beds of the Wenlock Shales, where it occurs with *Monog. Flemingi*, and var. *compactus*, *M. dubius*, and *Cyrtog. Carruthersi.*

Collections.—Watney and Welch, Mr. Macgregor of Queen's College, Cambridge, and the Authors.

Cyrtograptus rigidus, Tullberg. Plate LII, figs. 2 *a*—*c*.

1883. *Cyrtograptus rigidus,* Tullberg, Skånes Graptoliter, ii, p. 38, pl. iv, figs. 12—14.
1900. *Cyrtograptus rigidus,* Elles, Quart. Journ. Geol. Soc., vol. lvi, p. 409, pl. xxiv, figs. 2, A, B, C, and text-fig. 23.

Polypary with a stipe several centimetres in length, and possessing a single cladium only; stipe, with long, slender, gracefully curved proximal portion, widening gradually and persistently from a small inconspicuous sicula till the maximum breadth of 1·5 mm. is attained. Thecæ ten to eight in 10 mm.; those of the proximal portion sub-triangular with reflexed apertural margin, in contact only, but becoming more tubular and overlapping fully one third to one half their length in the proximal portion where the number of thecæ never exceeds eight in 10 mm.; characters of the cladium in all respects like those of the distal portion of the stipe.

Description.—When well preserved the polypary often shows graceful curvature of the stipe, and the cladium is the exact counterpart of the termination of the stipe, the curvature being equal in amount, but opposite in direction. There are in all about eighteen thecæ of the proximal type, and those in the region of the inconspicuous sicula are very small, the total breadth of the stipe in this initial portion never exceeding ·5 mm.

The change in the form of the thecæ is chiefly brought about by elongation relatively to breadth and by increased amount of overlap. Of the eighteen thecæ of the proximal type thirteen are usually developed before the cladium is given off. The proximal end is straight and never enrolled, though from the frequency with which specimens are broken about midway between the sicula and the cladium, it is possible that the whole did not lie exactly in one and the same plane.

Figs. 354 *a* and *b*.—*Cyrtograptus rigidus*, Tullberg.

a. Part of stipe and cladium, showing form of proximal thecæ. Enlargement of part of Pl. LII, fig. 2 *b*.
b. Distal thecæ of the cladium. Enlargement of part of Pl. LII, fig. 2 *c*.

The sicula measures ·5 mm. in length.

Affinities.—In the possession of only one cladium, as in general characteristics, *Cyrtog. rigidus* approaches *C. symmetricus*. It is, however, a larger and more gracefully curved species; there are far more thecæ in the proximal portion before the cladium is given off, and the whole proximal end is very much more attenuated.

Horizon and Localities.—Wenlock Shales (zone of *Cyrtog. rigidus*).

Welsh Border : Dulas Brook, near Builth; River Irfon, near Builth. *Montgomeryshire :* Sale Quarry, near Middleton Station.

Associates, etc.—*Cyrtog. rigidus* occurs associated with *Monog. retroflexus*, *M. dubius* and *M. Flemingi*, var. *primus*.

Collection.—Elles.

Cyrtograptus symmetricus, Elles. Plate LI, figs. 5 *a*—*c*.

1900. *Cyrtograptus symmetricus*, Elles, Quart. Journ. Geol. Soc., vol. lvi, p. 410, pl. xxiv, figs. 4 A, 4 B.

Polypary relatively small, stipe with short stiffly recurved proximal portion, widening rapidly from the initial portion till the maximum of 1·5 mm. is attained; bearing one cladium only agreeing in all particulars with the termination of the main stipe. Thecæ twelve to nine in 10 mm. those of the proximal portion sub-triangular with reflexed apertural margins and in contact only, but becoming quickly more tubular, and overlapping fully one-third to one-half their length in the distal portion.

Fig. 355.—*Cyrtograptus symmetricus*, Elles.

Proximal portion, showing sicula, thecæ of the stipe, "saccoid," and part of cladium. Castle Crab, near Builth; Wenlock Shales. Coll. Elles.

Description.—The polypary is somewhat stiff looking, though both stipe and cladium may show slight curvature; the proximal portion is slender compared with the distal portion.

There are usually not more than eight thecæ of the proximal type, and the cladium seems to vary somewhat in its position; it usually arises from the sixth, seventh or eighth theca. In specimens from the Welsh Borderland the cladium commonly arises from the sixth theca, though it has been known also from the fifth; but in the specimens from the Lake District it usually arises from the seventh and more rarely from the eighth.

The sicula is usually conspicuous, measuring fully 1 mm. in length.

Affinities.—The only *Cyrtograptus* with which *Cyrtog. symmetricus* is likely to be confused is *C. rigidus*, and from this it differs (1) in having a much shorter and robuster proximal portion, with a more conspicuous sicula, (2) in the abrupt widening and general breadth of the adult portion as compared with the proximal portion of the polypary, and (3) in the number of thecæ in the same unit of length.

Horizon and Localities.—Wenlock Shales (zone of *Cyrtog. symmetricus*).

Welsh Border: Builth Road; Castle Crab, near Builth Road; Coed Mawr, near Builth Road. *Lake District:* Cautley.

Associates, etc.—*Cyrtog. symmetricus* is associated with *Monog. dubius* and *M. capillaceus*.

Collections.—Marr, Welch and Watney, Mr. F. A. Marr, and Elles.

Cyrtograptus hamatus (Baily). Plate LII, fig. 3.

1861. *Graptolithus hamatus*, Baily, Grapt. Co. Meath, Journ. Geol. Soc. Dublin, vol. ix, p. 305, pl. iv, figs. 6 A and B.

Fig. 356.—*Cyrtograptus hamatus* (Baily).

Proximal portion, showing sicula, thecæ of stipe, and cladium. Enlargement of part of Pl. LII, fig. 3.

Polypary small, stipe strongly recurved in the proximal portion and possessing one cladium only. Thecæ eight to six in 10 mm., subtriangular, with reflexed apertural margins in the proximal portion, but becoming more tubular distally with overlap one-third to one-half their length both on the main stipe and on the cladium.

Description.—The polypary is small, the diameter of the proximal arc not exceeding 8 mm.

The sicula is conspicuous, measuring 1·5 mm. in length, and is furnished with a short but stout virgella; th. 1 originates about half way along its length.

There are eleven thecæ of the ordinary subtriangular type and the cladium is developed at the tenth; the thecæ then become more distant and show distinct sigmoid curvature of their walls, and both on stipe and cladium they have even and horizontal apertures.

Affinities.—*Cyrtog. hamatus* recalls *C. rigidus* in general form, but is stouter in the proximal region, while the terminal thecæ of both stipe and cladium are of a different character.

Horizon and Localities.—Wenlock ?

Ireland : Townland of Garran Grena, Tipperary.

Collection.—Geological Survey of England and Wales.

Cyrtograptus Linnarssoni, Lapworth. Plate LI, fig. 4.

1880. *Cyrtograptus Linnarssoni*, Lapworth, Ann. Mag. Nat. Hist. [5], vol. v, p. 158, pl. iv, figs. 12 *a* and *b*.

1900. *Cyrtograptus Linnarssoni*, Elles, Quart. Journ. Geol. Soc., vol. lvi, pl. xxiv, fig. 3 A.

Polypary several centimetres in length; stipe slender and gracefully curved throughout, with small recurved proximal portion, widening slightly from origin until the maximum breadth of 1 mm. is attained, with two or more gracefully curved slender cladia agreeing in all details with the distal portions of the stipe. Thecæ ten to nine in 10 mm., sub-triangular in the proximal portion with reflexed apertural margins, becoming gradually more tubular with greater overlap distally.

Figs. 357 *a* and *b*.—*Cyrtograptus Linnarssoni,* Lapworth.

a. Proximal portion, showing sicula, thecæ of stipe, and cladium. Enlargement of part of Pl. LI, fig. 4.
b. Distal thecæ of the cladium. Enlargement of part of Pl. LI, fig. 4.

Description.—The polypary is characteristically slender with graceful curvature in both stipe and cladia; there is no very marked increase in width, the breadth at the origin being almost as great as that in the distal portion of the polypary. There are usually two cladia only, though there may be more, and occasionally these may show cladia of a second generation. There is a tendency to slight spiral growth in the extreme proximal portion of the stipe, so that the initial part of the polypary is rarely found on the same layer of rock as the cladia and distal portion, and this makes complete specimens difficult to obtain.

The sicula has a length of about 1 mm. and there are commonly five or six thecæ before the first cladium is given off.

The change from the sub-triangular form to the tubular form of theca takes place very gradually in passing from the proximal to the distal portion of the stipe.

Affinities.—The short slender proximal portion, the graceful curvature of the stipe and cladia, and the form of the thecæ, render this species easy of separation from all others included under this genus.

Horizon and Localities.—Wenlock Shales (zone of *Cyrtog. Linnarssoni*).

Welsh Border: Builth Road; Coed Mawr; Castle Crab, near Builth; Coppice House, near Middletown. *Dee Valley:* Moel Ferna Slate Quarries.

Associates.—*Cyrtog. Linnarssoni* is sometimes fairly common in the Middle Wenlock Shales, where it is characteristic of a definite zone; it is found with *Monog. flexilis*, *M. dubius*, and *M. Flemingii* var. *primus*.

Collections.—Sedgwick Museum, Watney and Welch, Lapworth, and the Authors.

Cyrtograptus Grayi, Lapworth. Plate LII, fig. 5.

1876. *Cyrtograptus Grayi*, Lapworth, Geol. Mag. [2], vol. iii, p. 545, pl. xx, fig. 11.

Polypary uniformly slender; stipe with graceful curvature and cladia of two generations, several centimetres in length but not exceeding ·7 mm. in width. Thecæ nine in 10 mm., of the general type of those of *M. dextrorsus*.

Description.—The graceful curvature of the stipe is most pronounced; it is, however, somewhat irregular in its nature, the thecæ being sometimes on the convex, sometimes on the concave side of the polypary. The stipe and cladia all appear to have an approximately uniform breadth of about ·6 mm.

FIG. 358.—*Cyrtograptus Grayi*, Lapworth.

Distal thecæ of part of cladium. Enlargement of part of Pl. LII, fig. 5.

The thecæ are not well preserved on the only specimen known to us belonging to this species; but so far as can be seen they appear to be of the same type throughout, and to approximate to the general type of those of *M. dextrorsus*.

Affinities.—The great flexibility of the polypary and the shape of its thecæ make *Cyrtog. Grayi* an easily recognised species. Up to the present, it is only known from one locality in S. Scotland; the examples from the Lake District which have been assigned to this species appear, upon re-examination, to be specimens of *Monog. crispus* crossing each other in intricate fashion.

Horizon and Localities.—Upper Gala (top of Penkill Beds).

S. Scotland: Penwhapple Glen.

Associates, etc.—*Monog. priodon* and *Retiolites* (*Gladiog.*) *Geinitzianus*.

Collection.—Mrs. Gray.

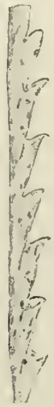
Cyrtograptus Carruthersi, Lapworth. Plate LII, figs. 4 *a*—*c*.

1876. *Cyrtograptus Carruthersi*, Lapworth, Geol. Mag. [2], vol. iii, pp. 321, 544, pl. x, figs. 6 *a*—*c*.
1900. *Cyrtograptus Carruthersi*, Elles, Quart. Journ. Geol. Soc., vol. lvi, p. 408, text-fig. 21.

Polypary slender, stipe several cm. in length, with graceful double curvature in proximal portion, but with less curvature distally. Cladia few in number, and usually approximately straight and somewhat stiff. Thecæ six to eight in 10 mm., like those of *M. Nilssoni* throughout.

Description.—The resemblance of the polypary (apart from the cladia) to that of *M. Nilssoni* is very obvious, particularly in the double curvature of the proximal portion of the stipe and the characters of the thecæ. Distally the curvature appears to be more variable, for individuals are of frequent occurrence in which the thecæ are on the convex margin instead of the concave. The cladia themselves appear very stiff and straight when compared with the flexed character of the stipe.

Fig. 359.—*Cyrtograptus Carruthersi*, Lapworth.



Distal thecæ of a cladium. Enlargement of part of Pl. LII, fig. 4 *b*.

The thecæ, both on the stipe and on the cladia, are in all respects like those of *M. Nilssoni.*

Horizon and Localities.—Wenlock Shales (Riccarton Beds), zones of *M. riccartonensis* and *Cyrtog. Lundgreni.*

S. Scotland: Shankendshiels; Elliotsfield; R. Slitrig. *Welsh Border:* Ackley Lane, S. side Long Mountain.

Associates, etc.—*Cyrtog. Carruthersi* occurs in the zone of *M. riccartonensis* associated with *M. riccartonensis*, *M. dubius*, and in the zone of *Cyrtog. Lundgreni* with *C. Lundgreni*, *M. Flemingi* var. *compactus*, and *M. dubius.*

Collections.—Lapworth, and the Authors.

Specific Characters of Forms belonging to the Genus Cyrtograptus.

	C. Murchisoni.	*C. Lundgreni.*	*C. rigidus.*	*C. symmetricus.*	*C. hamatus.*	*C. Linnarssoni.*	*C. Grayi.*	*C. Carruthersi.*
Character of polypary	Helicoid or convolute spiral Many branched	Sub-circular Many branched	Slightly flexed One branch only	Stiff, small One branch only	Small, with strong curvature in proximal portion One branch only	Slender and gracefully curved Few branches	Slender, very flexed and graceful ? Few branches	Straight, with double curvature in proximal portion Few branches
Maximum width .	1·8 mm.	1 mm.	1·5 mm.	1·5 mm.	—	1 mm.	·6 mm.	1 mm.
Character of thecæ:								
1. No. in 10 mm. .	12—10	10—8	10—8	12—9	8—6	10—9	9	7 - 8
2. Overlap . .	⅓—½	⅓—½	⅓—½	⅓—½	⅓—½	Increasing distally	—	Slight
3. No. of proximal type	Same throughout	Numerous	18	5—8	11	7	Same throughout	Same throughout

THE ZONAL RANGE OF THE BRITISH GRAPTOLOIDEA.

In the preface to this Monograph it was pointed out (Preface, p. 4) that "the primary need for a work of this kind was the natural demand of the field geologist and the palæontologist for figures and descriptions of the British species." Having now completed the figuring and description of the first and most typical section of the British Graptolites—namely, the GRAPTOLOIDEA—we shall best serve the interests of the field geologist and the palæontologist if we here summarise in tabular form the main facts bearing upon the vertical range and association in the British Isles of the various species and varieties of the Graptoloidea noticed in the preceding descriptive pages (pp. 1–513) of this Monograph, retaining throughout, for the sake of convenience of reference, the same relative palæontological order.

The first detailed arrangement of the British Graptoloidea (Rhabdophora of Allman) in successive chronological zones was made by Lapworth in his memoir "On the Geological Distribution of the Rhabdophora" ('Ann. and Mag. Nat. Hist.' [5], vols. iii, iv, v and vi, 1879–1880). For the sake of brevity, that work is here referred to as the *Memoir* and the present work as the *Monograph*.

The first of the Tables here presented—Table A, "The Zonal Distribution of the British Graptoloidea"—may be most simply regarded as the second and greatly extended edition of a combination of Table X (showing "The Vertical Range of the Genera and Species of British Rhabdophora") and Table XI (showing "The Vertical Distribution of the Tribes, Families and Genera of the Rhabdophora in the Chief Graptolite Zones of the Lower Palæozoic Rocks"), as given in the Memoir above referred to, but here carefully brought up to the present standard of knowledge and opinion.

A comparison of Table A with the tables, lists and letterpress in the Memoir affords a striking index of the advance of our knowledge of the Graptoloidea during the thirty-three years' interval which separates the Memoir and the present stage (1913) of this Monograph. In the Memoir some 20 Graptolite zones were recognised; that number has now been increased to 36. In the Memoir some 284 species and varieties of British Graptoloidea were referred to; that number has now risen to 372, in spite of the suppression of several so-called species here regarded as being founded on appearances due to conditions of preservation, etc.

In the second of the Tables here presented—Table B, "Vertical Range of the Zones of British Graptoloidea,"—the stratigraphical nomenclature employed in the Memoir is also given in brief. A comparison of this second table with the tables and details published in the Memoir of 1879–1880, shows how fully the progress of discovery has borne out the original anticipation that "future research will soon fix more definitely the composition and limit of the characteristic (Graptolite) faunas of the zones (then) already recognised, extending the range of some of the forms into neighbouring ones, and adding largely to the number of zones themselves."

It must be carefully borne in mind that a Graptolite zone is characterised by a *special association* of Graptolites, and that that form in this association which apparently combines restricted vertical range with wide horizontal distribution is most conveniently selected as the *index* of the zone.

It is not pretended that each of the Graptolite zones is of equal geological importance. Each zone, however, marks a special stage or horizon in the ascending series of the Lower Palæozoic rocks. In other words, the Graptolite zones are comparable more or less with the Ammonite zones of the Mesozoic formations. As such their importance as indices of *chronological sequence* can hardly be over-estimated; but to what extent they will prove of value as indices of *chronological duration*, only time and future geological research and discovery can be expected to show.

TABLE A.—*The Zonal Distribution of the British Graptoloidea.*

It may be noticed that in many instances the range of the species given in the table differs slightly from that given in the text; in every case the range as given in Table A is the more nearly correct one, as the table comprises the most recent knowledge to the date of its compilation.

	Zone of *Dictyonema sociale.*	Zone of *Bryograptus.*	Zone of *Dichograptus.*	Zone of *Didymog. extensus.*	Zone of *Didymog. hirundo.*	Zone of *Didymog. bifidus.*	Zone of *Didymog. Murchisoni.*	Zone of *Glyptog. teretiusculus.*	Zone of *Nemag. gracilis.*	Zone of *Climacog. peltifer* and *Mesog. multidens.*	Zone of *Climacog. Wilsoni.*	Zone of *Dicranog. Clingani.*	Zone of *Pleurog. linearis.*	Zone of *Dicellog. complanatus.*	Zone of *Dicellog. anceps.*	Zone of *Cephalog. acuminatus.*	Zone of *Orthog. vesiculosus* and *Mesog. modestus.*	Zone of *Monog. cyphus.*	Zone of *Monog. gregarius*: a. Sub-zone *M. fimbriatus.* b. " *M. triangulatus.* c. " *M. argenteus.*	Zone of *Monog. convolutus* with band of *Cephalog. cometa* at top.	Zone of *Monog. Sedgwicki.*	Zone of *Monog. turriculatus* with band of *Rast. maximus* at base.	Zone of *Monog. crispus.*	Zone of *Monog. griestoniensis.*	Zone of *Monog. crenulatus.*	Zone of *Cyrtog. Murchisoni.*	Zone of *Monog. riccartonensis.*	Zone of *Cyrtog. symmetricus.*	Zone of *Cyrtog. Linnarssoni.*	Zone of *Cyrtog. rigidus.*	Zone of *Cyrtog. Lundgreni.*	Zone of *Monog. vulgaris.*	Zone of *Monog. Nilssoni.*	Zone of *Monog. scanicus.*	Zone of *Monog. tumescens.*	Zone of *Monog. leintwardinensis.*
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
DICHOGRAPTIDÆ																																				
Didymograptus acutidens, E. & W.	..	...	...	...	...	$+^{c}$																														
— *affinis*, Nich.	..	...	...	+	+	+																														
— *amplus*, E. & W.	...	...	...	...	...	...	$+^{c}$																													
— *artus*, E. & W.	...	...	...	...	...	$+^{c}$																														
— *bifidus*, Hall	...	...	...	...	...	$+^{c}$																														
— *deflexus*, E. & W.	...	...	+ ?	+																																
— *euodus*, Lapw.	...	...	...	...	...	...	+																													
— *extensus*, Hall	...	...	...	$+^{c}$	$+^{r}$																															
— *fasciculatus*, Nich.	.	...	...	...	...	+																														
— *filiformis*, Tullb.	...	...	...	+																																
— *gibberulus*, Nich.	...	...	...	+	+																															
— *gracilis*, Tqt.	...	...	...	+	+	+																														
— *hirundo*, Salt.	...	...	...	...	$+^{c}$																															
— *indentus*, Hall	...	...	...	...	...	+	+																													
— *Murchisoni*, Beck.	...	...	...	...	...	...	$+^{c}$																													
— var. *geminus*, His.	...	...	...	...	...	...	$+^{c}$																													
— *nanus*, Lapw.	...	...	...	+ ?	+ ?	+																														
— *Nicholsoni*, Lapw.	...	...	...	+	+	$+^{c}$																														
— var. *planus*, E. & W.	...	...	...	...	+																															
— *nitidus*, Hall	...	...	...	+	+																															
— *patulus*, Hall	...	...	...	...	...	+																														
— *pennatulus*, Hall	...	...	...	...	+																															
— *serratulus*, Hall	..	...	...	...	...	...	...	...	+																											
— *simulans*, E. & W.	..	...	...	+	+																															
— *sparsus*, Hopk.	...	...	...	...	+																															
— *stabilis*, E. & W.	...	...	...	...	...	+																														
— *superstes*, Lapw.	...	...	...	...	...	...	$+^{r}$	$+^{r}$	$+^{c}$																											
— *uniformis*, E. & W.	...	...	...	+																																
— *V. fractus*, Salt.	...	...	+	+																																
— var. *volucer*, H. O. Nich.	...	...	...	+																																

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
DICHOGRAPTIDÆ																																				
Tetragraptus Amii, E. & W.	...	...	...	+																																
— *Bigsbyi*, Hall	...	...	...	+	+																															
— *crucifer*, Hall	..	...	+	+	$+^{?}$																															
— *fruticosus*, Hall	...	...	...	+																																
— *Headi*, Hall	..	...	+	+	+																															
— *pendens*, Elles	...	...	...	...	+	+																														
— *Postlethwaiti*, Elles	...	...	...	$+^{?}$																																
— *quadribrachiatus*, Hall	...	...	+	$+^{c}$	+																															
— *reclinatus*, E. & W.	...	...	...	+	+																															
— *serra*, Brong.	...	...	...	$+^{c}$	+																															
Schizograptus reticulatus, Nich.	...	...	...	$+^{?}$																																
— *tardifurcatus*, Elles	...	..	...	$+^{?}$																																
Trochograptus diffusus, Holm.	...	...	+																																	
Holograptus Deani, Lapw.	...	...	...	+																																
Dichograptus octobrachiatus, Hall.	...	...	$+^{c}$	+	$+^{r}$																															
— var. *Sedgwickii*, Salt.	..	...	+																																	
— *separatus*, Elles	...	...	$+^{?}$	$+^{?}$																																
Loganograptus Logani, Hall	...	...	$+^{c}$																																	
Clonograptus flexilis, Hall	...	...	+																																	
— *tenellus*, Linnrs.	..	+																																		
— var. *Callavei*, Lapw.	...	+																																		
Temnograptus multiplex, Nich.	...	...	+																																	
Bryograptus divergens, E. & W.	...	+																																		
— *Kjerulfi*	...	+																																		
— var. *cumbrensis*, Elles	...	+																																		
Trichograptus fragilis, Nich.	...	...	...	...	$+^{?}$	+																														
Azygograptus cœlebs, Nich.	...	...	...	...	...	+																														
— *Hicksii*, Hopk.	...	...	...	+																																
— *Lapworthi*, Nich.	...	...	+	+																																
— *suecicus*, M'Coy	...	...	...	...	+																															
Phyllograptus angustifolius, Hall	...	...	...	+	+																															
— *Anna*, Hall	..	...	...	+	+	+																														
— *ilicifolius*																																				
— var. *grandis*, E. & W.	...	...	...	+																																
— cfr. *typus*, Hall	...	...	...	...	+	+																														
LEPTOGRAPTIDÆ																																				
Leptograptus ascendens, E. & W.	...	..	...	...	...	...	...	...	+																											
— *capillaris*, Carr.	...	...	...	...	...	...	...	...	...	...	...	+	$+^{c}$																							
— *flaccidus*, Hall	...	...	...	...	...	...	...	...	...	...	...	+	$+^{c}$																							
— var. *arcuatus*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	+																							
— var. *macer*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	$+^{c}$																							
— var. *macilentus*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	$+^{c}$																							
— var. *spinifer*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	+	+																							
— *grandis*, Lapw.	...	...	...	...	...	...	...	...	$+^{r}$																											
— *latus*, E. & W.	...	...	...	...	...	...	...	...	$+^{c}$	$+^{?}$																										
— *validus*, Lapw.	...	...	...	...	...	...	...	...	$+^{c}$	+																										
— var. *incisus*	...	...	...	...	...	...	...	...	+																											
Pleurograptus linearis, Carr.	...	..	...	...	...	...	...	...	...	...	...	...	$+^{c}$																							
— var. *simplex*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	$+^{c}$																							

TABLE A.—*The Zonal Distribution of the British Graptoloidea*—(continued).

	Zone of *Dictyonema sociale.*	Zone of *Bryograptus.*	Zone of *Dichograptus.*	Zone of *Didymog. extensus.*	Zone of *Didymog. hirundo.*	Zone of *Didymog. bifidus.*	Zone of *Didymog. Murchisoni.*	Zone of *Glyptog teretiusculus.*	Zone of *Nemag. gracilis.*	Zone of *Climacog. peltifer* and *Mesog. multidens.*	Zone of *Climacog. Wilsoni.*	Zone of *Dicranog. Clingani.*	Zone of *Pleurog. linearis.*	Zone of *Dicellog. complanatus.*	Zone of *Dicellog. anceps.*	Zone of *Cephalog. acuminatus.*	Zone of *Orthog. vesiculosus* and *Mesog. modestus.*	Zone of *Monog. cyphus.*	Zone of *Monog. gregarius*: a. Sub-zone *M. fimbriatus.* b. " *M. triangulatus.* c. " *M. argenteus.*	Zone of *Monog. convolutus* with band of *Cephalog. cometa* at top.	Zone of *Monog. Sedgwicki.*	Zone of *Monog. turriculatus* with band of *Rast. maximus* at base.	Zone of *Monog. crispus.*	Zone of *Monog. griestoniensis.*	Zone of *Monog. crenulatus.*	Zone of *Cyrtog. Murchisoni.*	Zone of *Monog. riccartonensis.*	Zone of *Cyrtog. symmetricus.*	Zone of *Cyrtog. Linnarssoni.*	Zone of *Cyrtog. rigidus.*	Zone of *Cyrtog. Lundgreni.*	Zone of *Monog. vulgaris.*	Zone of *Monog. Nilssoni.*	Zone of *Monog. scanicus.*	Zone of *Monog. tumescens.*	Zone of *Monog. leintwardinensis.*
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
LEPTOGRAPTIDÆ																																				
Amphigraptus distans, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	+																							
— *divergens*, Hall	...	...	...	...	...	...	...	...	...	...	...	...	+																							
— var. *radiatus*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	+	+																							
Nemagraptus explanatus, Lapw.	...	...	...	...	...	...	...	...	+																											
— var. *pertenuis*, Lapw.	...	...	...	...	...	...	...	...	+																											
— *gracilis*, Hall	...	...	...	...	...	...	...	...	$+^{c}$																											
— var. *nitidulus*, Lapw.	...	...	...	...	...	...	...	...	+																											
— var. *remotus*, E. & W.	...	...	...	...	...	...	...	...	$+^{c}$																											
— var. *surcularis*, Hall	...	...	...	...	...	...	...	...	$+^{c}$																											
DICRANOGRAPTIDÆ																																				
Dicellograptus anceps, Nich.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	$+^{c}$																					
— *angulatus*, E. & W.	...	...	...	...	...	...	...	...	...	+	+																									
— *caduceus*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	$+^{c}$																								
— *complanatus*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	$+^{c}$	+																					
— var. *ornatus*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+																					
— *divaricatus*, Hall	...	...	...	...	...	...	+	+	+																											
— var. *rigidus*, Lapw.	...	...	...	...	...	...	...	...	+	+	+ ?																									
— var. *salopiensis* E. & W.	...	...	...	...	...	...	...	...	+	+																										
— *elegans*, Carr.	...	...	...	...	...	...	...	...	...	...	...	$+^{c}$	$+^{c}$																							
— var. *rigens*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	+	+																							
— *Forchammeri*, Gein.	...	...	...	...	...	...	...	...	$+^{r}$	$+^{r}$	+	$+^{c}$	$+^{r}$																							
— var. *flexuosus*, Lapw.	...	...	...	...	...	...	...	...	...	...	+	$+^{c}$																								
— *intortus*, Lapw.	...	...	...	...	...	...	...	+	$+^{c}$	$+^{r}$																										
— *moffatensis*, Carr.	...	...	...	...	...	+	+	+ ?	+	+	+																									
— *Morrisi*, Hopk.	...	...	...	...	...	...	...	...	...	...	...	$+^{c}$	+																							
— *patulosus*, Lapw.	...	...	...	...	...	...	...	...	...	$+^{c}$																										
— *pumilus*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	+	+																							
— *sextans*, Hall	...	...	...	...	...	...	...	...	$+^{c}$	+																										
— var. *exilis*, E. & W.	...	...	...	...	...	...	...	...	$+^{c}$	+																										

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
DICRANOGRAPTIDÆ																																				
Dicranograptus brevicaulis, E. & W.	...	...	...	...	...	...	...	...	+	+																										
— *celticus*, E. & W.	...	...	...	...	...	...	...	...	...	+																										
— *Clingani*, Carr.	...	...	...	...	...	...	...	...	...	...	...	+c																								
— *cyathiformis*, E. & W.	...	...	...	...	...	...	...	...	...	+	...	+?																								
— *furcatus*, var. *minimus*, Lapw.	...	...	...	...	...	...	...	...	...	+																										
— *Nicholsoni*, Hopk.	...	...	...	...	...	...	...	...	+c	+c	+c	+r																								
— *ramosus*, Hall	...	...	...	...	...	...	...	...	...	+r	+	+c																								
— var. *longicaulis*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	+	+																							
— var. *spinifer*, Lapw.	...	...	...	...	...	...	...	...	+c	+	+r																									
— *rectus*, Hopk.	...	...	...	...	...	...	...	+?	+r	+c	+r																									
— *tardiusculus*, Lapw.	...	...	...	...	...	...	...	...	...	+																										
— *zic zac*, Lapw.	...	...	...	...	...	...	...	...	+	+c																										
DIPLOGRAPTIDÆ																																				
Climacograptus antiquus, Hall	...	...	...	...	...	...	...	+	+c	+																										
— var. *bursifer*, E. & W.	...	...	...	...	...	...	...	...	...	+																										
— var. *lineatus*, E. & W.	...	...	...	...	...	...	...	...	...	+	+																									
— *bicornis*, Hall	...	...	...	...	...	...	...	...	+c	+	+c	+																								
— var. *peltifer*, Lapw.	...	...	...	...	...	...	...	...	...	+c																										
— var. *tridentatus*, Lapw.	...	...	...	...	...	...	...	...	...	+	+																									
— *brevis*, E. & W.	...	...	...	...	...	...	...	...	+	+																										
— *caudatus*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	+c																								
— *extremus*, H. Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+c														
— *Hughesi*, Nich.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+	+	+ + +	+ +	+															
— *innotatus*, Nich.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+	+	+ + +																	
— *latus*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+																					
— *medius*, Tqt.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+c	+	+																	
— *minimus*, Carr.	...	...	...	...	...	...	...	...	...	...	...	+	+																							
— *minutus*, Carr.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+																		
— *rectangularis*, M'Coy	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+r	+c	+c	+ + +																	
— *scalaris*, His.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...... +	+ +	+c	+														
— var. *miserabilis*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+	+	+																			
— var. *normalis*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+c	+	+	+																	
— *Scharenbergi*, Lapw.	...	...	...	...	...	+	+	+	+c	+c	+c																									
— *styloideus*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	+c																							
— *supernus*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+																					
— *Törnquisti*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+ + +	+ +																
— *tuberculatus*, Nich.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+?																				
— *tubuliferus*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	+	+																							
— *Wilsoni*, Lapw.	...	...	...	...	...	...	...	...	...	...	+c																									
— var. *tubularis*, E. & W.	...	...	...	...	...	...	...	...	...	...	+																									
Orthograptus bellulus, Tqt.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...... +	+ +c	+c															
— *calcaratus*, Lapw.	...	...	...	...	...	...	...	...	...	...	+	+c	+																							
— var. *acutus*, Lapw.	...	...	...	...	...	...	...	...	+r	+c																										
— var. *basilicus*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	+c	+																							
— var. *priscus*, E. & W.	...	...	...	...	...	...	+c	+	+r	+r																										
— var. *tenuicornis*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	+																								
— var. *vulgatus*, Lapw.	...	...	...	...	...	...	...	...	...	+r	+c	+																								
— *cyperoides*, Tqt.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+ + +	+ +																
— *insectiformis*, Nich.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+ + +	+ +																
— *mutabilis*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+	+																		

TABLE A.—*The Zonal Distribution of the British Graptoloidea*—(continued).

	Zone of *Dictyonema sociale*.	Zone of *Bryograptus*.	Zone of *Dichograptus*.	Zone of *Didymog. extensus*.	Zone of *Didymog. hirundo*.	Zone of *Didymog. bifidus*.	Zone of *Didymog. Murchisoni*.	Zone of *Glyptog. teretiusculus*.	Zone of *Nemag. gracilis*.	Zone of *Climacog. peltifer* and *Mesog. multidens*.	Zone of *Climacog. Wilsoni*.	Zone of *Dicranog. Clingani*.	Zone of *Pleurog. linearis*.	Zone of *Dicellog. complanatus*.	Zone of *Dicellog. anceps*.	Zone of *Cephalog. acuminatus*.	Zone of *Orthog. vesiculosus* and *Mesog. modestus*.	Zone of *Monog. cyphus*.	Zone of *Monog. gregarius*: a. Sub-zone *M. fimbriatus*. b. ,, *M. triangulatus*. c. ,, *M. argenteus*.	Zone of *Monog. convolutus*, with band of *Cephalog. cometa* at top.	Zone of *Monog. Sedgwicki*.	Zone of *Monog. turriculatus* with band of *Rast. maximus* at base.	Zone of *Monog. crispus*.	Zone of *Monog. griestoniensis*.	Zone of *Monog. crenulatus*.	Zone of *Cyrtog. Murchisoni*.	Zone of *Monog. riccartonensis*.	Zone of *Cyrtog. symmetricus*.	Zone of *Cyrtog. Linnarssoni*.	Zone of *Cyrtog. rigidus*.	Zone of *Cyrtog. Lundgreni*.	Zone of *Monog. vulgaris*.	Zone of *Monog. Nilssoni*.	Zone of *Monog. scanicus*.	Zone of *Monog. tumescens*.	Zone of *Monog. leintwardinensis*.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
DIPLOGRAPTIDÆ																																				
Orthograptus pageanus, Lapw.	...	...	...	...	...	...	...	...	...	...	...	+																								
— var. *micracanthus*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	+																								
— var. *abnormispinosus*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	+																								
— *quadrimucronatus*, Hall	...	...	...	...	...	...	...	...	...	...	...	...	+																							
— var. *spinigerus*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	+																							
— *rugosus*,																																				
— var. *apiculatus*, E. & W.	...	...	...	...	...	...	...	...	...	+																										
— *truncatus*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	+c	+																							
— var. *abbreviatus*, E. & W	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+c	+	+ ?																			
— var. *intermedius*, E. & W	...	...	...	...	...	...	...	...	...	...	+c	+																								
— var. *pauperatus*, E. & W.	...	...	...	...	...	...	...	...	...	...	+c	+c	+c	+	+ ?																					
— var. *socialis*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	+c																						
— *vesiculosus*, Nich.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+c	+																		
— var. *penna*, Hopk.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+r	+c																		
— *Whitfieldi*, Hall	...	...	...	...	...	...	...	...	+c	+																										
Glyptograptus dentatus, Brong.	...	...	...	+	+	+c	+																													
— var. *appendiculatus*, Tqt	...	...	...	...	...	+																														
— *persculptus*, Salt.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+	+ ?																			
— *serratus*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...... +	... +	+c															
— var. *barbatus*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+															
— *sinuatus*, Nich.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+ + +																	
— *tamariscus*, Nich.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+ + +	+ +	+															
— var. *incertus*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+ +	+															
— *teretiusculus*, His.	...	...	...	...	...	...	...	+c	+	+r	+r																									
— var. *cuglyphus*, Lapw.	...	...	...	...	...	...	...	+	+c	+c	+																									
— var. *siccatus*, E. & W.	...	...	...	...	...	...	...	...	+c	+																										

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DIPLOGRAPTIDÆ																																				
Mesograptus foliaceus, Murch.	...	...	...	...	...	...	...	+ c																												
— *magnus*, H. Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+ + c +	+																
— *modestus*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+ c	+																		
— var. *diminutus*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+	+																		
— var. *parvulus*, H. Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+																				
— *multidens*, E. & W.	...	...	...	...	...	...	...	...	...	+ c	+																									
— *compactus*, E. & W.	...	...	...	...	...	...	...	...	...	+	+ r	+ r																								
Amplexograptus arctus, E. & W.	...	...	...	...	...	...	...	+	+	+	+ r																									
— *cœlatus*, Lapw.	...	...	...	...	...	...	+	+																												
— *confertus*, Lapw.	...	...	...	...	...	+																														
— *perexcavatus*, Lapw.	...	...	...	...	...	...	...	+ c	+ c	+ c	+	+																								
Petalograptus altissimus, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+														
— *folium*, His.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...... +	+ +																
— *minor*, Elles	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+ + +	+																
— cf. *ovatus*, Barr.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+														
— *palmeus*, Barr.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	... + +	+ +	+	+														
— var. *latus*, Barr.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+ + +	+																
— var. *ovato-elongatus*, Kurck	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	... + +	+ +	+	+														
— *tenuis*, Barr.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...... +	+ +	+	+														
— (?) *phylloides*, E. & W.	...	...	...	...	...	...	...	...	+ c																											
Cephalograptus acuminatus, Nich.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+																				
— *cometa*, Gein.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	... +																
— *tubulariformis*, Nich.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+ +																
Cryptograptus antennarius, Hall	...	...	...	...	...	+																														
— *Hopkinsoni*, Nich.	...	...	...	+	..	+																														
— *tricornis*, Carr.	...	...	...	+	...	+	+	+	+ c	+ c	+ c	+																								
— var. *Schäferi*, Lapw.	...	...	...	...	...	...	+	+	+	+																										
Trigonograptus ensiformis, Hall	...	...	+	+	...	+																														
— var. *lanceolatus*, Nich.	...	...	...	..	...	+																														
GLOSSOGRAPTIDÆ																																				
Glossograptus acanthus, E. & W.	...	...	...	+	...	+																														
— *armatus*, Nich.	...	...	...	...	...	+ r	...	...	+ r																											
— cf. *ciliatus*, Emm.	...	.	...	...	...	...	...	+	...																											
— *Hincksii*, Hopk.	...	...	...	...	...	...	...	...	+	+	+ c																									
— var. *fimbriatus*, Hopk.	...	...	...	...	...	+	...	...	+	+																										
Retiograptus aculeatus, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	+																							
— *Geinitzianus*, Hall	...	...	...	...	...	...	...	...	+ r	+																										
Lasiograptus.																																				
Hallograptus mucronatus, Hall	...	...	...	...	...	...	...	...	+ c	+																										
— var. *bimucronatus*, Nich.	...	...	...	...	...	...	...	...	+ c	+ c																										
— var. *inutilis*, Hall	...	...	...	+	...	+																														
— var. *nobilis*, E. & W.	...	...	...	...	...	...	...	...	...	+																										
Thysanograptus Harknessi, Nich.	...	...	...	...	...	...	...	...	...	+	+	+																								
— var. *costatus*, Lapw.	...	...	...	...	...	...	...	...	+	+	+																									
— *retusus*, Lapw.	...	...	...	...	...	...	+	+																												
Nymphograptus velatus, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+																					
Neurograptus fibratus, Lapw.	...	...	...	...	...	...	...	...	...	...	...	+	+																							
— *margaritatus*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	+	+ ?																							

TABLE A.—*The Zonal Distribution of the British Graptoloidea*—(continued).

	Zone of *Dictyonema sociale.*	Zone of *Bryograptus.*	Zone of *Dichograptus.*	Zone of *Didymog. extensus*	Zone of *Didymog. hirundo.*	Zone of *Didymog. bifidus.*	Zone of *Didymog. Murchisoni.*	Zone of *Glyptog. teretiusculus.*	Zone of *Nemag. gracilis.*	Zone of *Climacog. peltifer* and *Mesog. multidens*	Zone of *Climacog. Wilsoni.*	Zone of *Dicranog. Clingani.*	Zone of *Pleurog. linearis.*	Zone of *Dicellog. complanatus.*	Zone of *Dicellog. anceps.*	Zone of *Cephalog. acuminatus.*	Zone of *Orthog. vesiculosus* and *Mesog. modestus.*	Zone of *Monog. cyphus.*	Zone of *Monog gregarius*: *a.* Sub-zone *M. fimbriatus.* *b.* „ *M. triangulatus.* *c.* „ *M. argenteus.*	Zone of *Monog. convolutus* with band of *Cephalog. cometa* at top.	Zone of *Monog. Sedgwicki.*	Zone of *Monog. turriculatus* with band of *Rast. maximus* at base.	Zone of *Monog. crispus.*	Zone of *Monog. griestoniensis.*	Zone of *Monog. crenulatus.*	Zone of *Cyrtog. Murchisoni.*	Zone of *Monog. riccartonensis.*	Zone of *Cyrtog. symmetricus.*	Zone of *Cyrtog. Linnarssoni.*	Zone of *Cyrtog. rigidus.*	Zone of *Cyrtog. Lundgreni.*	Zone of *Monog. vulgaris.*	Zone of *Monog. Nilssoni.*	Zone of *Monog. scanicus.*	Zone of *Monog. tumescens.*	Zone of *Monog. leintwardinensis.*
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
RETIOLITIDÆ																																				
Retiolites.																																				
Gladiograptus Geinitzianus, Barr.	...	..	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+	+	+ c										
— var. *angustidens*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	...	+											
— *perlatus*, Nich.	..	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...... +	+ +	+															
— var. *Daironi*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+														
Plegmatograptus nebula, E. & W.	...	.	...	...	...	...	...	...	...	...	...	+	+																							
— *obesus*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+														
— var. *macilentus*, Tqt.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+ ?	+ ?											
Gothograptus nassa, Holm	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+				
— *spinosus*, Wood	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	...	...	...	+			
DIMORPHOGRAPTIDÆ																																				
Dimorphograptus confertus, Nich.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+																			
— *decussatus*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+																		
— var. *partiliter*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+																			
— *elongatus*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+ r	+																			
— *erectus*, E. & W.	..	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+ r	+																			
— *extenuatus*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+																			
— *longissimus*, Kurck	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+																			
— *physophora*, Lapw.	...	...	...	..	...	...	...	...	...	...	...	...	...	...	...	...	...	+ c																		
— *Swanstoni*, Lapw.	...	...	...	...	...	...	...	.	...	...	...	...	...	...	...	+ r	+																			
MONOGRAPTIDÆ																																				
Monograptus acinaces, Tqt.	...	..	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+ ?																	
— *argenteus*, Nich.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...... +																	
— var. *cygneus*, Tqt.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...... +	+ +	+ r															
— *argutus*, Lapw.	..	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...... +	+ +																
— *atavus*, Jones	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+	+																	
— *acus*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+												

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MONOGRAPTIDÆ																																				
Monograptus Barrandei, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+													
— *Becki*, Barr.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	..	+	+r													
— *bohemicus*, Barr.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+			
— *capillaceus*, Tullb.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+c									
— *chimæra*, Barr.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+c		
— var. *Salweyi*, Hopk.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+c			
— var. *semispinosus*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+		
— *Clingani*, Carr.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+r +	+ +																
— *colonus*, Barr.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+			
— var. *compactus*, Wood	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+			
— var. *ludensis*, Murch.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+?			
— *comis*, Wood	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+			
— *communis*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+ + +	+c +																
— var. *rostratus*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+ + +	+ +																
— *concinnus*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+ + +	+ +	+															
— *convolutus*, His.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+c +c																
— *circularis*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	... +	+															
— *crenularis*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+ +																
— *crinitus*, Wood	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+			
— *crispus*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+c													
— *cyphus*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+c																		
— *cultellus*, Törnq.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+r										
— *decipiens*, Tqt.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+r	+ +	+															
— *delicatulus*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+r +r +r	+r +r																
— *denticulatus*, Tqt.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+ +c																
— *dextrorsus*, Tullb.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+	+	+?											
— *difformis*, Tqt.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+																	
— *discus*, Tqt.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+c	+	+											
— *dubius*, Suess	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+r	+	+c	+c	+c	+c	+	+c	+		
— *distans*, Portl.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	... +	+															
— *elongatus*, Tqt.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...... +?	+ +																
— *exiguus*, Nich.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+c													
— *fimbriatus*, Nich.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+c																	
— var. *similis*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+																	
— *flagellaris*, Tqt.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+?	+?													
— *Flemingi*, Salt.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+c	+r					
— var. *primus*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+	+	+					
— var. *compactus*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+					
— *flexilis*, Elles	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+							
— *galaensis*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+													
— *gemmatus*, Barr.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+ + +	+ +	+															
— *gotlandicus*, Perner	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+			
— *griestoniensis*, Nicol	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+												
— *gregarius*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+r	+ + +	+r																
— *Balli*, Barr.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+r	+c														
— *incommodus*, Tqt.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+c	+																	
— *intermedius*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...... +	+ +	+															
— *involutus*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+ +	+r															
— *irfonensis*, Elles	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+					
— *jaculum*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...... +	+ +	+															
— *Jaekeli*, Perner	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+							
— *knockensis*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+?													

TABLE A.—*The Zonal Distribution of the British Graptoloidea*—(continued).

Zones: 1. Zone of *Dictyonema sociale*. 2. Zone of *Bryograptus*. 3. Zone of *Dichograptus*. 4. Zone of *Didymog. extensus*. 5. Zone of *Didymog. hirundo*. 6. Zone of *Didymog. bifidus*. 7. Zone of *Didymog. Murchisoni*. 8. Zone of *Glyptog. teretiusculus*. 9. Zone of *Nemag. gracilis*. 10. Zone of *Climacog. peltifer* and *Mesog. multidens*. 11. Zone of *Climacog. Wilsoni*. 12. Zone of *Dicranog. Clingani*. 13. Zone of *Pleurog. linearis*. 14. Zone of *Dicellog. complanatus*. 15. Zone of *Dicellog. anceps*. 16. Zone of *Cephalog. acuminatus*. 17. Zone of *Orthog. vesiculosus* and *Mesog. modestus*. 18. Zone of *Monog. cyphus*. 19. Zone of *Monog. gregarius*: *a.* Sub-zone *M. fimbriatus*. *b.* „ *M. triangulatus*. *c* „ *M. argenteus*. 20. Zone of *Monog. convolutus* with band of *Cephalog. cometa* at top. 21. Zone of *Monog. Sedgwicki*. 22. Zone of *Monog. turriculatus* with band of *Rast. maximus* at base. 23. Zone of *Monog. crispus*. 24. Zone of *Monog. griestoniensis*. 25. Zone of *Monog. crenulatus*. 26. Zone of *Cyrtog. Murchisoni*. 27. Zone of *Monog. riccartonensis*. 28. Zone of *Cyrtog. symmetricus*. 29. Zone of *Cyrtog. Linnarssoni*. 30. Zone of *Cyrtog. rigidus*. 31. Zone of *Cyrtog. Lundgreni*. 32. Zone of *Monog. vulgaris*. 33. Zone of *Monog. Nilssoni*. 34. Zone of *Monog. scanicus*. 35. Zone of *Monog. tumescens*. 36. Zone of *Monog. leintwardinensis*.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
MONOGRAPTIDÆ																																				
Monograptus leintwardinensis, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+c
— var. *incipiens*, Wood	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+c
— *leptotheca*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	......+c	+c +	+															
— *limatulus*, Tqt.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...... +	+c +c	+c															
— *lobiferus*, McCoy	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	... + +c	+c +c	+															
— *Marri*, Perner	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+c	+c	+r											
— *McCoyi*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+														
— *millepeda*, McCoy	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	... + +																	
— *Nilssoni*, Barr.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+			
— *nodifer*, Tqt.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+													
— *nudus*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+c	+c	+												
— *pandus*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+	+												
— *planus*, Barr.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+	+	+											
— *priodon*, Bronn	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+?	+	+	+	+c	+c	+	+r							
— *proteus*, Barr.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+ +	+	+	+													
— *raitzhainiensis*, Eisel	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+ +																	
— *regularis*, Tqt.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...... +	+ +	+	+														
— *remotus*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+?														
— *retroflexus*, Tullb.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+c						
— *revolutus*, Kurck	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+																	
— var. *austerus*, Tqt.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+c	+c																	
— var. *præcursor*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+																	
— *riccartonensis*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+r	+c									
— *Rœmeri*, Barr.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+		
— *runcinatus*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+r	+c														
— var. *pertinax*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+														
— *Sandersoni*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+c	+																	
— *scanicus*, Tullb.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+c		
— *Sedgwicki*, Portl.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	... +	+c															
— *spiralis*, Gein.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+	+	+											

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
MONOGRAPTIDÆ																																				
Monograptus tenuis, Portl.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+															
— *testis*,																																				
— var. *inornatus*, Elles	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+					
— *tortilis*, Perner	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+?														
— *triangulatus*, Hark.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+ + +																	
— var. *major*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+ + +																	
— *tumescens*, Wood	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+r	+r	+c	
— var. *minor*, McCoy	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	
— *turriculatus*, Barr.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+c	+													
— *ultimus*, Perner	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+
— *uncinatus*,																																				
— var. *orbatus*, Wood	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+			
— var. *micropoma*, Jaekel	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+		
— *undulatus*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	... +	...	+?	+?													
— *urceolus*, Richter	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+ +																
— *variabilis*, Perner	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+r	+													
— *varians*, Wood	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		...	...	...	+			
— var. *pumilus*, Wood	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		...	...	...	+c	+		
— *vomerinus*, Nich.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+c	+c	+c	+c	+c	+c					
— var. *basilicus*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+	+	+	+						
— var. *crenulatus*, Törnq.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+?										
— var. *gracilis*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+										
— *vulgaris*, Wood	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+c				
— var. *curtus* E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+			
Rastrites approximatus,																																				
— var. *Geinitzi*, Tqt.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+ ... +	+ +	+															
— *equidistans*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+													
— *fugax*, Barr.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+														
— *hybridus*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+ +	+															
— *Linnæi*, Barr.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	..	...	...	+?	+														
— *longispinus*, Perner	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+ ... +	+																
— *maximus*, Carr.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+c														
— *peregrinus*, Barr.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...... +	+ +c	+?															
— *setiger*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+																	
Cyrtograptus Carruthersi, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+?	...	...	...	+					
— *Grayi*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+											
— *hamatus*, Baily	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	horizon unknown.										
— *Linnarssoni*, Lapw.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+							
— *Lundgreni*, Tullb.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+					
— *Murchisoni*, Carr.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	..	...	...	...	...	...	...	...	...	...	...	+c	+r									
— *rigidus*, Tullb.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+						
— *symmetricus*, E. & W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+	+r							

TABLE B.—*Vertical Range of the Zones of British Graptoloidea.*

Monograph, 1913.		*Memoir*, 1879–80.		
No.	*Graptolite Zones and Sub-zones.*	No.	*Graptolite Zones and Horizons.*	*Stratigraphical Nomenclature.*
36	Zone of *Monograptus leintwardinensis*			LOWER LUDLOW; MIDDLE DIVISION (SALOPIAN); SILURIAN
35	,, ,, *tumescens*			
34	,, ,, *scanicus*	20	*Monograptus Nitssoni*	
33	,, ,, *Nilssoni*			
32	,, ,, *vulgatus*	19	*Monograptus testis*	
31	,, *Cyrtograptus Lundgreni*			WENLOCK
30	,, ,, *rigidus*			
29	,, ,, *Linnarssoni*	18	*Cyrtograptus Linnarssoni*	
28	,, ,, *symmetricus*			
27	,, *Monograptus riccartonensis*			
26	,, *Cyrtograptus Murchisoni*	17	*Cyrtograptus Murchisoni*	
25	,, *Monograptus crenulatus*			Upper Gala; TARANNON; LOWER DIVISION (VALENTIAN)
24	,, ,, *griestoniensis*	16	*Cyrtograptus Grayi*	
23	,, ,, *crispus*	15	*Monograptus exiguus*	Lower Gala
22	,, ,, *turriculatus*; Band of *Monog.* (*Rast.*) *maximus*	14	*Rastrites maximus*	Upper Birkhill; LLANDOVERY
21	Zone of *M. Sedgwicki*	13	*Monograptus spinigerus* (*Sedgwicki*) (Sub-zone of *Cephalog. cometa*)	
20	Band of *Cephalograptus cometa*; Zone of *Monograptus convolutus*	12	*Monograptus gregarius*	Middle Birkhill
19	Zone of *Monograptus gregarius*; (*c*) Sub-zone of *M. argenteus*; (*b*) ,, *M. triangulatus*; (*c*) ,, *M. fimbriatus*			
18	Zone of *Monograptus cyphus*	11	*Diplograptus vesiculosus*	Lower Birkhill
17	,, *Mesograptus modestus* and *Orthog. vesiculosus*			
16	,, *Cephalograptus acuminatus*	10	*Diplograptus acuminatus*	
15	Zone of *Dicellograptus anceps*	9	*Dicellograptus anceps*	Upper Hartfell (Caradoc-Bala); CARADOC; UPPER DIVISION; ORDOVICIAN
14	,, *Dicellograptus complanatus*	8	,, *complanatus*	
13	,, *Pleurograptus linearis*	7	*Pleurograptus linearis*	Lower Hartfell
12	,, *Dicranograptus Clingani*	6	*Dicranograptus Clingani*	
11	,, *Climacograptus Wilsoni*	6-5	(zone of *C. Wilsoni*)	
10	,, *Climacograptus peltifer* and *Mesograptus multidens*	5	*Cœnograptus gracilis*	Upper Glenkiln (Llandeilo-Bala); LLANDEILO
9	,, *Nemagraptus gracilis*			
8	,, *Glyptograptus teretiusculus*			
7	,, *Didymograptus Murchisoni*	4	*Didymograptus Murchisoni*	Lower Glenkiln; LOWER DIVISION
6	,, ,, *bifidus*	3	,, *bifidus*	Upper; ARENIG
5	,, ,, *hirundo*	2	*Tetragraptus bryonoides*	Middle and Lower
4	,, ,, *extensus*			
3	,, *Dichograptus*			
2	,, *Bryograptus*	1	*Bryograptus Callavei*	TREMADOC; CAMBRIAN
1	,, *Dictyonema sociale*			

Note.—The *Llanvirn* formation of Dr. Hicks ('Popular Science Review,' N.S., vol. v, 1881, pp. 302–303) embraces Zones 6 and 7 of this Table. The *Ashgillian* of Dr. J. E. Marr ('Quart. Journ. Geol. Soc.,' 1905, vol. lvi, pp. lxxxi, etc.) includes Zones 16 ?, 15 and 14, his *Caradocian* the Zones 13, 12, and 11, his *Llandeilian* the Zones 10, 9, 8, and 7, and his *Skiddavian* the Zones 6, 5, 4, and 3.

PLATE L.

Genus **Monograptus (Rastrites).**

Figs.

1 *a—e.—Monograptus* (*Rastrites*) *peregrinus* (Barrande). (Page 488.)

1 *a*. Characteristic specimen. Dobb's Linn. Birkhill Shales (zone of *Monog. gregarius*). Elles' Collection.

1 *b*. Small fragment. Dobb's Linn. Birkhill Shales (zone of *Monog. convolutus*). Elles' Collection.

1 *c*. Fairly complete specimen. Ibid.

1 *d*. Portion of slab, showing the method of occurrence. Coalpit Bay, Donaghadee. Llandovery Beds. Belfast Natural History Museum.

1 *e*. Fragment with shorter thecæ. Craigdarkes Hill, Dunscore. Birkhill Shales. Geological Survey of Scotland.

2 *a—g.—Monograptus* (*Rastrites*) *longispinus* (Perner). (Page 489.)

2 *a*. Large and typical specimen, showing sicula. Grennan Point, Dumbreddan Bay, S. of Portpatrick. Birkhill Shales. Geological Survey of Scotland.

2 *b*. Large, but less nearly complete specimen, and with more open curvature. Coalpit Bay, Co. Down. Birkhill Shales. Belfast Natural History Museum.

2 *c*. Smaller specimen, with shorter thecæ. Dobb's Linn. Birkhill Shales. Lapworth's Collection.

2 *d*. Specimen with more open curvature at the proximal end. Garple Linn, near Moffat. Birkhill Shales. Geological Survey of Scotland.

2 *e*. Smaller specimen. Dobb's Linn. Birkhill Shales. Sedgwick Museum.

2 *f*. Long distal fragment, somewhat distorted. Mealy Gill, Coniston (zone of *Monog. fimbriatus*). Skelgill Beds. Sedgwick Museum.

2 *g*. Small specimen, preserved in relief, and showing the reflexed apertural terminations. 430 yds. S.S.E. of Bryn-chwîth Farmhouse, Pont Erwyd. Geological Survey of England and Wales, Jermyn Street.

3 *a—d.—Monograptus* (*Rastrites*) *setiger*, Elles and Wood, nov. (Page 490.)

3 *a*. Proximal fragment, showing part of sicula. 430 yds. S.S.E. of Bryn-chwîth Farmhouse, Pont Erwyd. Geological Survey of England and Wales.

3 *b*. Distal fragment. Skelgill Beck, Lake District. Skelgill Beds (zone of *Monog. fimbriatus*). Sedgwick Museum.

3 *c*. Distal fragment, showing the irregular curvature. Ibid.

3 *d*. Distal fragment. Same locality, etc., as fig. 3 *a*.

4 *a—f.—Monograptus* (*Rastrites*) *hybridus* (Lapworth). (Page 491.)

4 *a*. Typical specimen. Dobb's Linn. Birkhill Shales. Lapworth's Collection.

4 *b*. Specimen showing the typical declination of the thecæ. Skelgill Beck. Skelgill Beds. Sedgwick Museum.

4 *c*. Fragment showing proximal end. E. side of quarry, N.E. of Fagwr Fawr Farmhouse, 2 miles E.N.E. of Pont Erwyd. Geological Survey of England and Wales.

4 *d*. Two fragments in juxtaposition. Dobb's Linn. Birkhill Shales. Geological Survey of Scotland.

4 *e*. Distal fragment. Belcraig Burn. Birkhill Shales. Sedgwick Museum.

4 *f*. Distal fragment with irregular curvature. Dobb's Linn. Birkhill Shales. Sedgwick Museum.

5 *a—d.—Monograptus* (*Rastrites*) *approximatus*, var. *Geinitzi* (Törnquist). (Page 492.)

5 *a*. Fragment with proximal end enrolled; thecæ showing "phleoid" development. 10 yds. up stream from crest of anticline, 30 yds. N. of Fuches-gau Farmhouse, Pont Erwyd. Geological Survey of England and Wales.

5 *b*. Enrolled proximal fragment. S. side of old quarry, 270 yds. N.E. of Gwen Ffrwd Uchaf Farm, Pont Erwyd. Geological Survey of England and Wales.

5 *c*. Few thecæ showing "phleoid" development. Same locality, etc., as fig. 5 *a*.

5 *d*. Larger fragment. Dobb's Linn. Birkhill Shales. Sedgwick Museum.

6 *a—e.—Monograptus* (*Rastrites*) *maximus* (Carruthers). (Page 494.)

6 *a*. Typical specimens in association. Thirlstane Score, near Moffat. Upper Birkhill Shales. Lapworth's Collection.

6 *b*. Fragment near proximal end. Riskinhope Burn, S. Scotland. Upper Birkhill Shales. Lapworth's Collection.

6 *c*. Typical fragment. Same locality, etc., as fig. 6 *a*.

6 *d*. Very large specimen, with the thecæ at rather irregular intervals. Kirkhope Linn, Ettrickbridge. Geological Survey of Scotland.

6 *e*. Specimen with shorter thecæ, possibly a proximal fragment. Belcraig Burn. Upper Birkhill Shales (band of *Monog.* (*R.*) *maximus*). Miss McPhee's Collection, Glasgow University.

7 *a—d.—Monograptus* (*Rastrites*) *fugax* (Barrande). (Page 493.)

7 *a*. Typical fragment. Duffkinnel, S. Scotland. Birkhill Shales. Lapworth's Collection.

7 *b*. Proximal fragment, showing sicula. Dobb's Linn. Birkhill Shales. Lapworth's Collection.

7 *c*. Small fragment. Belcraig Burn. Birkhill Shales. Geological Survey of Scotland.

7 *d*. Specimens with irregular curvature. Duffkinnel. Birkhill Shales. Lapworth's Collection.

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MONOGRAPTUS (RASTRITES).

PLATE LI.

Genus **Monograptus** (**Rastrites**) and Genus **Cyrtograptus.**

Figs.

1 *a—c.—Monograptus* (*Rastrites*) *Linnæi*, (Barrande). (Page 493.)

1 *a*. Fragment near proximal end. Mount Benger Burn, Yarrow. Lower Gala Beds. Lapworth's Collection.

1 *b*. Several fragments in association. Belcraig Burn. Lower Gala Beds. Lapworth's Collection.

1 *c*. Specimen in relief. Pont-bren-dibyn, Llanbrynmair. Brynmair Beds (zone of *Monog. turriculatus*). Wood's Collection.

2 *a—e.—Monograptus* (*Rastrites*) *equidistans* (Lapworth). (Page 500.)

2 *a*. Type specimen. Figured Lapworth, Geol. Mag., 1876, pl. x, figs. 2 *a*, *b*. Elwand Water, Melrose. Lower Gala Beds. Lapworth's Collection.

2 *b*. Similar specimen. Ibid.

2 *c*. Proximal fragment, showing the shorter and more closely set thecæ. Clanyard Bay, Drummore, Mull of Galloway. Lower Gala Beds. Geological Survey of Scotland.

2 *d*. Similar proximal fragment. Meigle Quarry. Lower Gala Beds. Lapworth's Collection.

2 *e*. Irregular fragment with longer thecæ. Waterfall, Dobb's Linn. Lower Gala Beds. Lapworth's Collection.

3 *a—c.—Cyrtograptus Murchisoni*, Carruthers. (Page 505.)

3 *a*. Small, but well preserved specimen. Figured Elles, Quart. Journ. Geol. Soc., 1900, pl. xxiv, fig. 6. Pencerrig, near Builth. Wenlock Shales (zone of *Cyrtog. Murchisoni*). Elles' Collection.

3 *b*. Similar specimen. Ibid.

3 *c*. Large, but fragmentary specimen. Tarannon River. Nant-ysgollen Shales (zone of *Cyrtog. Murchisoni*). Wood's Collection.

4.—*Cyrtograptus Linnarssoni*, Lapworth. (Page 511.)

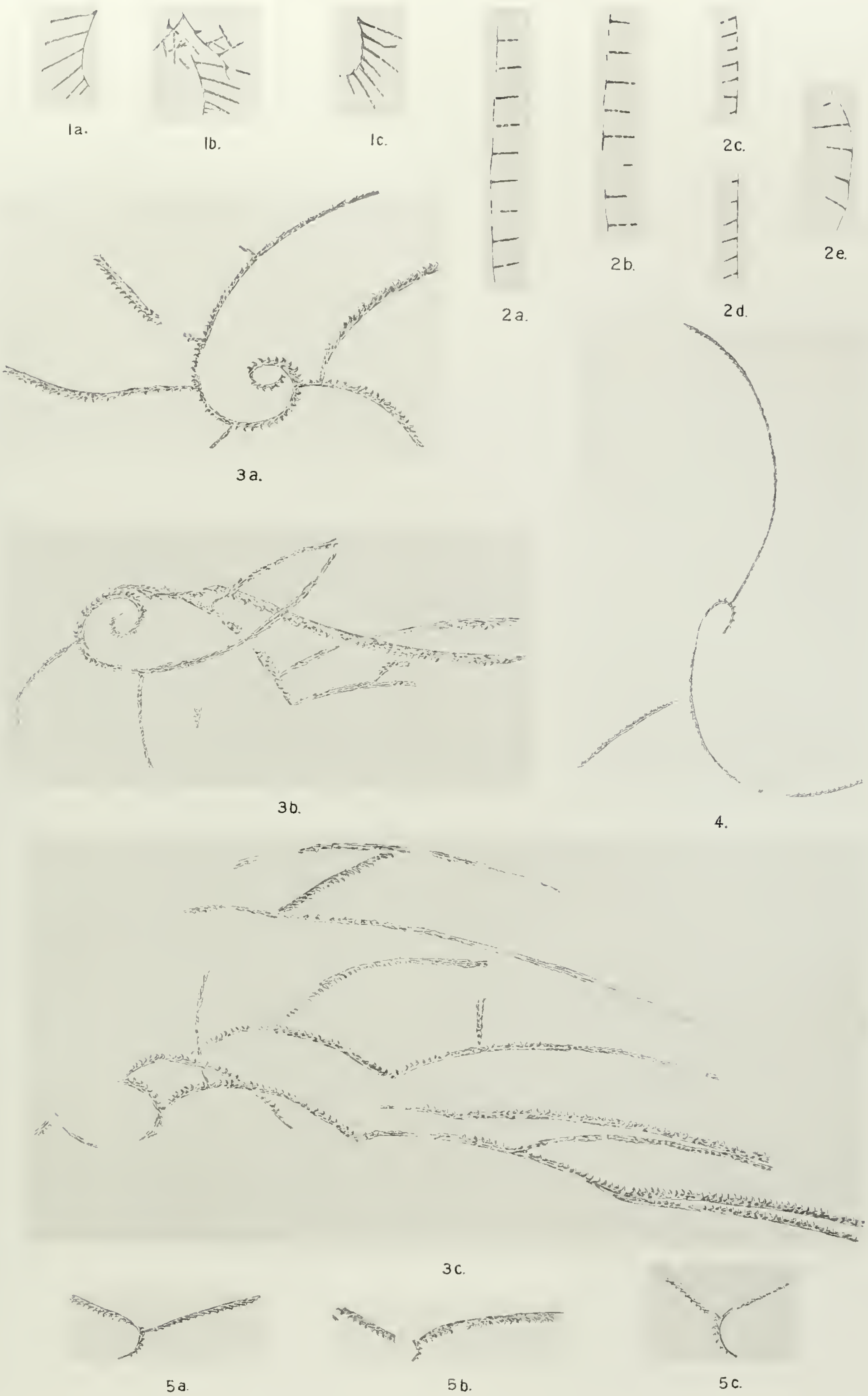
Type specimen. Figured Lapworth, Ann. Mag. Nat. Hist. [5], vol. v, pl. iv, figs. 12 *a*, *b*; and Elles, Quart. Journ. Geol. Soc., 1900, pl. xxiv, fig. 3 A. Builth Road. Wenlock Shales (zone of *Cyrtog. Linnarssoni*). Lapworth's Collection.

5 *a—c.—Cyrtograptus symmetricus*, Elles. (Page 509.)

5 *a*. Type specimen. Figured Elles, Quart. Journ. Geol. Soc., 1900, pl. xxiv, fig. 4 A. Coed Mawr, Builth. Wenlock Shales (zone of *Cyrtog. symmetricus*). Elles' Collection.

5 *b*. Co-type specimen. Ibid., fig. 4 B. Quarry, S.E. of Castle Crab, near Builth. Wenlock Shales (zone of *Cyrtog. symmetricus*). Elles' Collection.

5 *c*. Well-preserved specimen, showing sicula. Cautley, Westmoreland. Wenlock Shales. Miss Welch's Collection.



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MONOGRAPTUS (RASTRITES) AND CYRTOGRAPTUS.

PLATE LII.

Genus **Cyrtograptus.**

FIGS.

1 *a—d.*—*Cyrtograptus Lundgreni*, Tullberg. (Page 507.)

1 *a.* Incomplete, but typical specimen. Figured Elles, Quart. Journ. Geol. Soc., 1900, pl. xxiv, fig. 1 A. River Irfon, Builth. Wenlock Shales (zone of *Cyrtog. Lundgreni*). Elles' Collection.

1 *b.* Ibid., fig. 1 B. Llwynrhedith Quarry, Long Mountain. Wenlock Shales (zone of *Cyrtog. Lundgreni*). Elles' Collection.

1 *c.* Similar specimen. Same locality, etc., as fig. 1 *b.*

1 *d.* Exceptionally large and complete specimen. Bridge, River Irfon, Builth. Wenlock Shales (zone of *Cyrtog. Lundgreni*). Collected by Mr. A. M. Macgregor.

2 *a—c.*—*Cyrtograptus rigidus*, Tullberg. (Page 508.)

2 *a.* Specimen. Figured Elles, Quart. Journ. Geol. Soc., 1900, pl. xxiv, fig. 2 A. Dulas Brook, Builth. Wenlock Shales (zone of *Cyrtog. rigidus*). Elles' Collection.

2 *b.* Ibid., fig. 2 B. River Irfon, Builth. Wenlock Shales (zone of *Cyrtog. rigidus*). Elles' Collection.

2 *c.* Smaller specimen. Ibid., fig. 2 C. Same locality as fig. 2 *b.*

3.—*Cyrtograptus hamatus* (Baily). (Page 510.)

Type specimen. Figured Baily, Journ. Geol. Soc. Dublin, 1861, pl. iv, fig. 6 A. Townland of Garran Grena, Tipperary. Wenlock (?). Geological Survey of England and Wales.

4 *a—c.*—*Cyrtograptus Carruthersi*, Lapworth. (Page 512.)

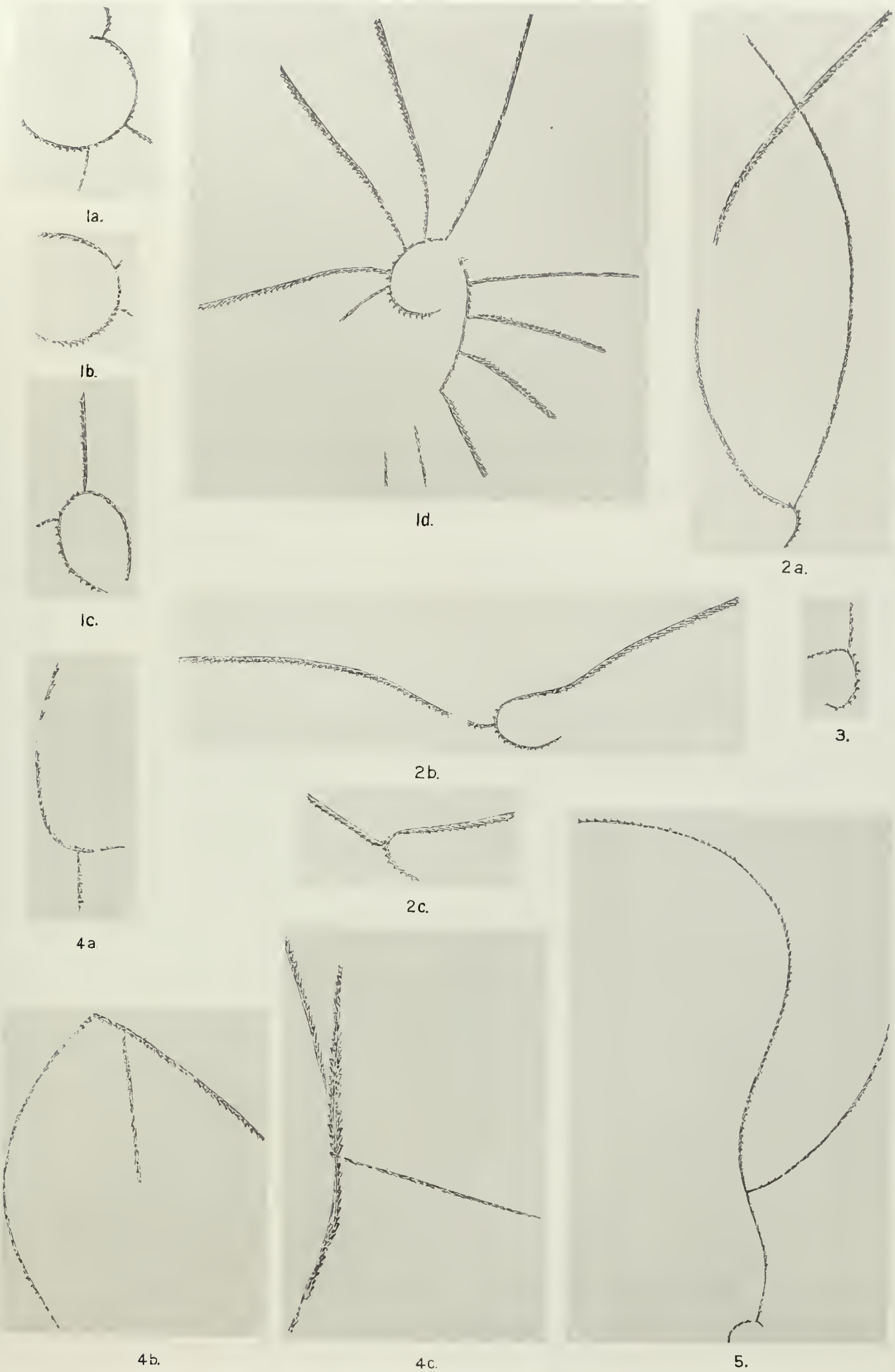
4 *a.* Type specimen, showing form of proximal end. Figured Lapworth, Geol. Mag., 1876, pl. x, fig. 6 *a*; and Elles, Quart. Journ. Geol. Soc., 1900, p. 408, text-fig. 21. Shankendshiels. Riccarton Beds. Lapworth's Collection.

4 *b.* Ibid., fig. 6 *b.*

4 *c.* Ibid., fig. 6 *c.* River Slitrig. Riccarton Beds. Lapworth's Collection.

5.—*Cyrtograptus Grayi*, Lapworth. (Page 512.)

Type specimen. Figured Lapworth, Geol. Mag., 1876, pl. xx, fig. 11. Penwhapple Glen, Girvan. Top of Penkill Beds. Mrs. Gray's Collection, Edinburgh.



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CYRTOGRAPTUS.

Palæontographical Society, 1913.

A MONOGRAPH

OF THE

BRITISH PALÆOZOIC

ASTEROZOA

BY

W. K. SPENCER, B.A., F.G.S.

PART I.

Pages 1—56; Plate I.

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BRITISH PALÆOZOIC ASTEROZOA.

INTRODUCTION.

PRELIMINARY STATEMENT.

This Monograph deals with the structure and affinities of those Palæozoic fossils which are nearly related to the Asteroidea (Starfishes) and Ophiuroidea (Sand-stars and Brittle-stars) of the present day. In order that it may be of interest alike to the specialist and to the student I am prefacing the detailed descriptions of genera and species by a somewhat long introductory section of a more general nature. I hope that this section will render the later detailed studies more intelligible, and help the reader to follow with greater interest the bearing of the work upon theories of evolution and consequent hypotheses. The endeavour made to cover the dry bones of these forms with flesh is attended with difficulties, but even if complete success is not attained, the effort may give a clearer picture of the ebb and flow of life in the dim past and provide tangible hypotheses for test by future research.

I shall endeavour to show

(1) That we can trace among the Palæozoic Asterozoa very near relations of an ancestral stock from which the two divergent branches of the true Asteroidea and Ophiuroidea arose.

(2) That from this "root-stock" branch-stocks arose. The forms belonging to these branch-stocks are neither true Asteroidea nor true Ophiuroidea, but are characterised by modifications peculiar to themselves. Certain of the branch-stocks were dominant in their day, but have since become completely extinct.

In fact, just as the most direct lineal ancestors of the flowering plants are found to have been of relatively little importance in Carboniferous times, being overshadowed by extinct tree-like Horse-tails and Club-mosses, so in the older Palæozoic rocks we obtain dominant forms of the Asterozoa which show specialisation along lines not observed in recent groups. Scott's[1] statement with

[1] D. H. Scott, 'The Evolution of Plants,' Home University Library, London, 1911.

respect to fossil plants applies with equal force to fossil Asterozoa. "What the record really shows is a succession of dominant groups, each of which reached a very high development in its time, and then, as the conditions changed, fell into the background, some new family springing up to take its place."

MATERIAL AND METHOD.

I have been very fortunate in having excellent new material placed at my disposal.

The material preserved in London Museums is scanty and often indifferently preserved, and previous observers have had to rely mainly upon these specimens for their descriptions. Mrs. Gray, of Edinburgh, has for many years made an extensive collection from the Ordovician of Girvan. There is also a large collection from the Silurian of Ayrshire in the Scottish National Museum of Edinburgh. Both these collections were kindly lent to me, and together they contain upwards of five hundred specimens—a great number considering the age of the rocks.

The collection of Mrs. Gray is especially valuable, great care having been taken to obtain both counterparts of each fossil. The specimens are preserved as moulds in a fine sandstone, and very clearly cut casts can be obtained which may show even the fine ornament of the original ossicles. The casts are usually much easier to interpret than are specimens preserved in the original calcite. They have been studied by means of a binocular stereoscopic microscope. The ossicles of the original fossil are often fused by solution and re-deposition of the calcite, and the boundary line between component plates cannot then be distinguished.

New material has also been investigated from the well-known Leintwardine (Lower Ludlow) mudstones, preserved in the Ludlow Museum, the Scottish National Museum, the collection of the Rev. W. D. La Touche, of Winstanton Rectory, and the collection of Mr. Beale, of Leintwardine. Apparently casts had not previously been made from this material, and in consequence it has been possible to identify some delicate structures which had been destroyed on the specimens preserved in the London Museums. It will be remembered that one pit at Leintwardine has yielded by far the greater number of Asterozoa which have been obtained from English Silurian rocks, and it has been of great advantage to obtain these fresh supplies.

I have also re-investigated the collections in the British Museum (Nat. Hist.), London, the Museum of Practical Geology, Jermyn Street, London, and the Sedgwick Museum, Cambridge. The British Museum (Nat. Hist.) not only contains specimens from British rocks, but also the valuable type-specimens from the Lower Devonian of Bundenbach, Germany, collected and described by Stürtz (76–80). Opportunity has been taken to compare the structure of these with that of species from British rocks.

I am greatly indebted to the officers who have kindly made it easy for me to examine the various collections thoroughly.

THE POSITION OF THE ASTEROZOA AMONG THE ECHINODERMATA.

The General Characteristics of the Echinodermata.

The consideration of the essential characters of an Echinoderm will help us to understand the position of the Asterozoa. These characters have been well portrayed both by Bather (3, 4, 9) and by MacBride (43).

(i) There appears to be no doubt that the Echinodermata are descended from bilaterally symmetrical forms which fixed themselves to the sea-floor. This fixation gradually impressed a more or less radial symmetry upon the organs.

(ii) The fixed forms were originally pear-shaped. The narrow end of the pear was a stalk, the more globular portion contained the gut and body-cavities. Food was driven to the mouth by means of currents of water created by the movement of cilia.

(iii) A division of the body-cavity (the hydrocœl) underwent a process of specialisation to produce a water-vascular system. This took the form of a ring-shaped canal which embraced the mouth and gave off radial canals (usually five in number) which ran to the periphery of the body (compare Text-fig. 1). Lateral branches came off from the radial canals and pushed out the skin so as to appear as the appendages of the body known as tube-feet or podia. The water-vascular system communicated with the exterior through a canal (the pore-canal) which opened outwards through a water-pore. The pore-canal was lined with powerful cilia and kept the water-vascular system tense with sea-water.

(iv) The tube-feet could not at first have served the purpose of locomotion. In the modern fixed forms they are covered with cilia, and these cilia help the cilia of the body in creating currents which waft the food to the mouth. We are therefore justified in surmising that the podia at first merely originated as outgrowths of the body, the purpose of which was to obtain as great a ciliated expanse as possible.

(v) The soft parts became protected by calcareous plates embedded in the flesh.

The forms of this type were the most primitive of the Pelmatozoa.

Evolution now appears to have proceeded along two divergent lines to produce the remaining Pelmatozoa and the Eleutherozoa.

A. *The remaining Pelmatozoa.*—These retained the primitive method of feeding.

The body sank in over the radial canals, and grooves were found converging on the mouth. The cilia became confined to the sunken groove (and to the podia).

Until recently the ordinary concept of a Pelmatozoon was that suggested by its name, "a form fixed by a stalk." Kirk (36) and Bather (9A) have recently shown that this is a mistake, for a large number of the forms which feed in this way lead a free or semi-free existence. Thus *Rhipidocystis*, as Bather remarks (9A, p. 503), "like little wanton boys that swim on bladders," floated in the water, supported by its swollen root-sacks; again, *Eretmocrinus* had arms shaped for paddling. (Kirk 36, p. 124). No Pelmatozoon, however, used its tube-feet for walking.

B. *The Eleutherozoa.*—This group consists of Starfishes, Brittle-stars, Sea-urchins and Sea-cucumbers, all of which use their tube-feet for progression. The geological record is neither old enough nor sufficiently complete for us to trace the beginnings of the Eleutherozoa, and in consequence only suggestions can be advanced as to the manner in which they arose from the primitive fixed form. At present two theories need consideration :

(i) The view held by Bather that the Eleutherozoa descended from the small disc-shaped sessile Edrioasteroidea. "Some of them were permanently fixed to the sea-floor, but others acquired a flexible under-surface surrounded by a rigid frame of larger plates, and they held on to the sea-floor in limpet-fashion. Some of this latter type might occasionally be washed loose by the waves, and overturned so as to bring some of their food-grooves in contact with the ground. Those which had stronger podia took advantage of these new conditions, and their podia became transformed into locomotor organs with suckers at the tips. At the same time the ciliated grooves ceased their task of sweeping food-currents to the mouth, in proportion as the animal was able to move its body and mouth from one source of food to another" (4, p. 12).

Bather further supposes that the Holothurians (Sea-cucumbers), Echinoids (Sea-urchins) and Asteroidea came off from the Edrioasteroid stock at different periods.

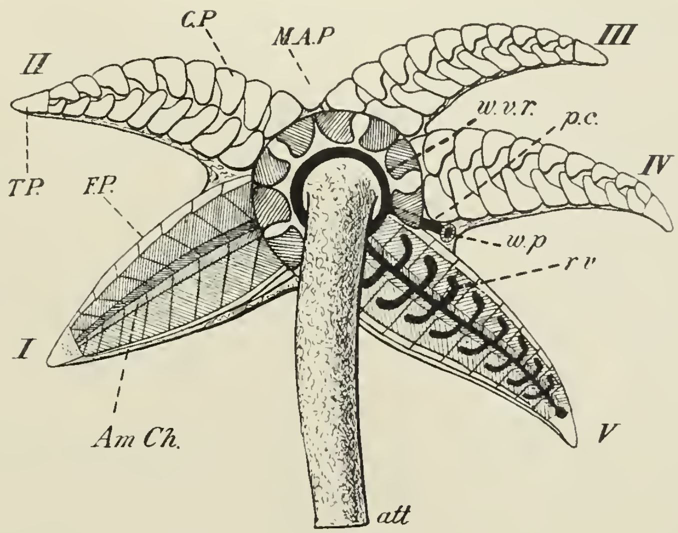
The advantage of this suggestion is that the Edrioasteroidea are known forms, to the structure of which we can refer, and that the arrangement of the ossicles bordering the groove is very similar to that found at any rate in the Asteroidea (*vide infra*).

(ii) The view of MacBride that the Eleutherozoa are descended from a fixed form which had a long flexible stalk. The upper portion of the body became flexed on the stalk, and the creature took to "grabbing" with its tube-feet at the food drifting along at the bottom of the sea. The podia obtained opportunity of use as "walking" organs, and the stalk became of less and less use as an anchor. MacBride (43) supposes that the first Eleutherozoa were asteroid-like. The remaining Eleutherozoa descended from these early "asteroid" forms.

I have attempted to reconstruct, independently, the fixed ancestor of the

Asterozoa. To do this I carefully collated and compared the observations made by embryologists with my own researches upon the new fossil material. The results suggest that the ancestor had the stalk and general form demanded by MacBride and ambulacral grooves with the fundamental characters described by Bather.

The attempt is at any rate useful, in so far as it enables the reader readily to visualise a starting-point from which he can follow later developments.



TEXT-FIG. 1.—Diagrammatic reconstruction of the Pelmatozoan ancestor of the Asterozoa. Arms I and V are drawn with the covering plates stripped away; Arm V with the mouth-angle plates also removed. *C. P.*, covering plates; *F. P.*, flooring plates; *M. A. P.*, mouth-angle plates; *T. P.*, terminal plate; *w. v. r.*, water-vascular ring; *p. c.*, pore canal; *r. v.*, radial water-vascular vessel; *w. p.*, water pore; *Am. Ch.*, ambulacral channel; *att.*, point of attachment to the sea floor.

THE "FIXED" ANCESTOR OF THE ASTEROZOA.

Text-fig. 1 is a diagram of the ancestral form, shown flexed on a stalk, issuing from the oral surface from a point inside the water-vascular ring.

(i) The stalk was well marked. MacBride has shown a stalked stage in the development of the recent starfish *Asterina* (42), and Mead (45, p. 212) has shown the same stage in the common starfish *Asterias*.

(ii) The disc is small compared with the arms (see the argument from the position of the madreporite, pp. 36, 37).

(iii) The ossicles associated with the water-vascular system are in two series: (*a*) A "flooring" series arranged to form the sides of a groove (the ambulacral groove), with the main branch-canal of the water-vascular system at the bottom of the groove and the podia retractile under cover of its walls. (*b*) A "covering" series serving as an additional means of protection to the soft structures (see p. 10).

(iv) Primitively the podia were arranged not exactly opposite to each other, but slightly alternating, and in consequence we find that both the flooring and covering plates, which are in direct association with the podia, are not exactly opposite, but arranged alternately (see p. 19).

(v) It is possible that the covering plates were finger-shaped. A comparatively slight opening of the plates of this shape would allow the podia to be easily thrust out of the groove (compare with the shape of adambulacralia in any drawing of the ambulacral groove of an Asteroid, as *e. g.* Text-fig. 4, p. 12, or Text-fig. 18, p. 20).

(vi) A terminal unpaired plate at the end of each ray supported a terminal unpaired tube-foot. Later a pigment spot developed at the extremity of the foot, which consequently became an "eye" (compare the embryological researches of Ludwig, 40).

A creature of this type which left its stalk and acquired a "freely moving" habit, would be a primitive Asterozoon.

The flooring plates then arch over the ambulacral groove, and are generally known as the ambulacral ossicles or *ambulacralia.*

The covering plates are at their base, and are known as adambulacral ossicles or *adambulacralia.*

The stalk in the adult forms appears to have been resorbed before starfishes are met with as fossils.

If this account of a primitive Asterozoon be compared with my remarks in a paper published in 1904 (73) it will be observed that my views have been considerably modified. The paper had as its primary object the furtherance of the view that the Echinoidea were derived from an Asteroid ancestor. This led me to criticise certain of Bather's views, and I stated *inter alia* (p. 44) that "it is impossible to suppose that the complicated ambulacrum and fixed skeleton of *Edrioaster* gave birth to the primitive simple ambulacrum and movable skeleton of the Asteroids." Literally, of course, this statement is correct, for the pores between the flooring plates, structures which Bather compares with the ambulacral pores of Asteroids (9), are not present in the early Asterozoa and must be secondary modifications; again, the complete roofing over of the groove by covering plates cannot be primitive.

My studies upon fossil Asterozoa, however, now compel me to recognise that in respect to the argument originally advanced I overstated my case. It is now evident that Bather was correct when he asserted that the ambulacral groove of the Asteroidea was built fundamentally upon the same plan as that of *Edrioaster.* This is seen most clearly when we compare the structures of the hypothetical ancestor with that of *Edrioaster.* It is not difficult to imagine a more primitive Edrioasteroid which would show, at any rate, near relationships with the ancestral Eleutherozoa.

TERMINOLOGY.

It is somewhat difficult to obtain suitable terms for the different aspects of the starfish body. The older observers termed the mouth side ventral as it was turned towards the earth. The upwardly directed surface was called dorsal. Unfortunately this terminology, although readily understandable, does not lend itself to the necessary morphological comparisons with the Pelmatozoa in which the mouth is directed upwards. I have in consequence adopted Bather's suggestion (compare 8, p. 60) that the mouth side should be called "oral" and the opposing side "apical." The names convey a more definite meaning to the lay reader than do the terms "actinal" and "abactinal" used customarily in this connection and are less easily confused. It is also useful to have terms which will give the orientation of the faces of individual ossicles of the ambulacral groove.

The "proximal" face is that nearest to the oro-apical pole.

The "distal" face is that farthest from the oro-apical pole.

The "inner" face is that nearest to a median line drawn the whole length of the arm.

The "outer" face is that farthest from the same line.

THE GENERAL PRINCIPLES OF CLASSIFICATION OF THE ASTEROZOA.

Because of poor material the great majority of observers have had to rely, in the main, on the general form of the fossil Asterozoa when classifying them. Only the most recent work, such as that of Jaekel, Schöndorf, Sollas and Sollas, gives details which are sufficiently full to establish true relationships. The general appearance of the fossils may be very misleading, and it is only careful investigations of the minute structure of the ossicles which are of critical value.

(A) *The Significance of the "Asteroid" Body.*—Among recent Asterozoa there are two types of body-form: the one "asteroid" (star-shaped), almost without exception characteristic of the Asteroidea, the other "disc-shaped," peculiar to the Ophiuroidea. In early Palæozoic times these characters had not the same significance. The "asteroid" type of body appears to be the primitive form common to the more lowly organised members of all the early families. The sharp separation between arm and disc arises later as a secondary modification. Embryology suggests this, for in the very young Ophiuroid (MacBride, 43, p. 478) it is found that the arms melt into a small central disc as in the starfish. Palæontology confirms the supposition. At one time all Palæozoic forms with an asteroid body were classified among the Asteroidea, and in consequence this class appeared to be well represented in Palæozoic times. Schöndorf has shown, however, that certain of these forms, as, *e.g.*, *Aspidosoma* (67) and *Sturtzaster* (68, p. 220), are widely different in structure from the true Asteroidea. In this monograph Schöndorf's argument will be further extended, and it will be shown that true Asteroidea are rare fossils in Palæozoic rocks, at any rate in Ordovician and Silurian strata.

(B) *The General Calcification of the Body.*—Observations of the general calcification of the body can also be most misleading. The methods of calcification are much more diverse than were imagined by the earlier observers, who only looked for structures found in Recent groups. In consequence, considerable revision of our fundamental conceptions has become necessary.

Apparently the first ossicles to be laid down were those associated with the water-vascular system (ossicles of the ambulacral groove and mouth-frame). The general body-skin remained uncalcified.

A leathery body-skin with few or no calcifications can be seen preserved on the pyritised specimens found by Stürtz in the Bundenbach (Lower Devonian) slates. Under less favourable conditions of preservation all traces of the skin are lost. Certain forms, *e.g. Tæniaster*, Billings, must have been in this primitive condition, for no plates except those connected with the ambulacral groove and mouth-frame have been found. The sandstone and limestone rocks in which they are found had such a coarse matrix that the leathery skin could leave no impression on its surface.

Later the leathery skin became protected by calcifications. Openings are usually left between the plates so that some portions of the skin may be left exposed to the surrounding sea-water, for the skin is the main lung of the starfish.

The manner in which calcification proceeds appears to be highly characteristic of the various branches. Thus in *the Asteroid branch* a double row of marginalia begins to become larger than the remaining plates of the disc in the Uranasteridæ (Text-fig. 20, p. 23). These marginalia increase in size, and the disc tends to become so heavily plated that the animal stands in peril of becoming choked by its too complete armour. New modifications, the Cryptozonia, arise from these Phanerozonate forms. In these later types the ossicles are cut away so that as much as possible of the skin may be exposed as a lung. Additional protection is given by modified spines, the pedicellaria, which sit upon the plates and seize any small animal which disturbs the lung outgrowths of the skin.

Branches which are now extinct had their own method of calcification. Thus the Aspidosomatidæ have been shown by Schöndorf to have had but a single row of marginalia arranged in a highly characteristic manner.

I propose, in later parts of this monograph, to follow out these divergent methods of calcification very closely. My observations (74) upon the evolution of the Cretaceous Asteroidea taught me that the only satisfactory way to separate the various lineages was to pay attention to the ornament and shape of the plates of those parts of the skeleton which were not considerably affected by the environment or mode of life. It appears to me that these principles also hold true for the older forms.

This separation into the various lineages must necessarily involve considerable descriptive detail which would be out of place here. For the moment a satisfactory provisional classification, which gives a broad view of the general lines of evolution, can be obtained from a consideration of the mode of life of the forms as judged by the structure and arrangement of the ossicles of the ambulacral groove and the mouth-frame. This classification has the further advantage that it is based upon characters which are familiar to us from a study of Recent forms.

(c) *The Structure and Arrangement of the Ossicles of the Ambulacral Groove and the Mouth-frame.*—The observations of MacBride (43) assist greatly here, and following his arguments we can divide Recent Asterozoa into two groups :

(1) *The "Graspers."*—Asteroid forms in which the tube-feet are used for walking, and for grasping and pulling open the bivalve shells of the molluscs upon which they usually feed. The ambulacralia form an arch to take the pull.

(2) *The "Wrigglers."*—Ophiuroid forms in which the tube-feet have lost locomotory powers and become much reduced. The animals progress by wriggling movements of the arm, and the ossicles of the ambulacral groove are extensively modified for this purpose. The food is pushed into the mouth by the first two pairs of tube-feet, which become considerably enlarged and are known as buccal tentacles.

If we trace the history of the forms backwards we find that the difference between them tends to disappear. Both the "graspers" and the "wrigglers" descended from a third group which I call provisionally "the primitive Asterozoa." Some of the least specialised forms of this group used their tube-feet not for grasping but for passing small particles of food to the mouth, as did their Pelmatozoan ancestor.

The Palæozoic "wrigglers" are not a homogeneous group, but contain at least two series of forms which have undergone a most remarkable analogous (homoplastic) course of development. One of these series had alternating ambulacralia (Aspidosomatidæ), the other opposite ambulacralia (Lapworthuridæ). For the present both the series are included in the Ophiuroidea.

THE GENERAL PLAN OF DESCRIPTION.

It is convenient for the purposes of description to subdivide the skeletal parts of the Asterozoa as follows :

A. The ossicles of the arm.

B. The mouth parts.

C. The accessory ossicles of the disc.

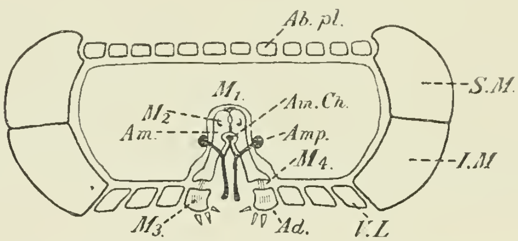
D. The madreporite.

A somewhat full account of the structure of each of these skeletal parts in Recent forms is given before certain typical fossils are dealt with. It is felt that only by such careful comparison can the true meaning of the modifications be fully understood.

A. THE OSSICLES OF THE ARM.

The Structure of the Arm in Recent Asteroidea.

(i) *The General Structure.*—The diagram given (Text-fig. 2) shows the general arrangement of the ossicles as seen in cross-section. The most important ossicles are the ambulacralia and adambulacralia, for these ossicles or their modified equivalents are found in all Asterozoa. The ambulacralia, which in the Pelmatozoan ancestor (Text-fig. 1) acted merely as flooring plates to the ambulacral groove,



Text-fig. 2.—A diagrammatic cross-section through the arm of an Asteroid. *Am.*, ambulacral; *Ad.*, adambulacral; *Am. Ch.*, ambulacral channel; *Amp.*, ampulla; *Ab. pl.*, apical plates; *S. M.*, supero-marginalia; *I. M.*, infero-marginalia; *V. L.*, ventro-lateralia; M_1, dorsal transverse muscle; M_2, dorsal longitudinal muscle; M_3, adambulacral longitudinal muscles; M_4, vertical muscle. The ventral transverse muscles are not shown. They lie just ventral to the ambulacral channel.

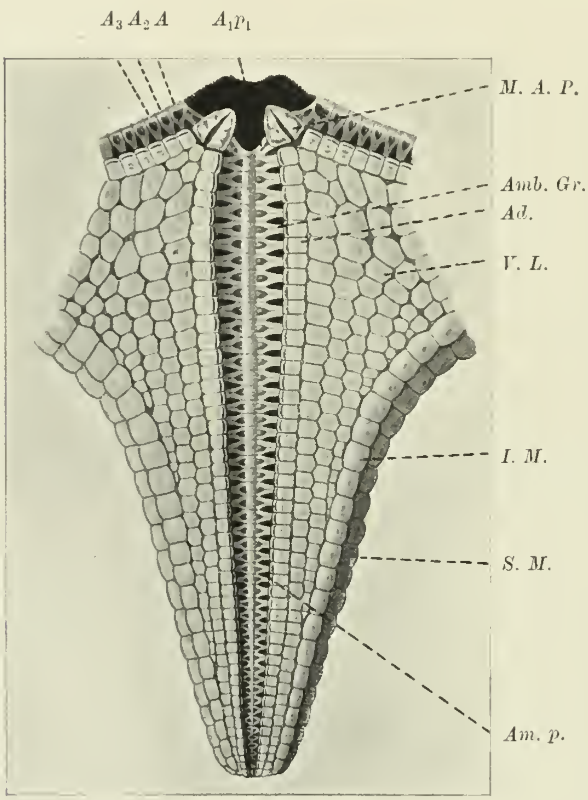
now form a high arch calculated to give firm support to the pull which is exerted through the tube-feet. The adambulacralia are no longer merely covering plates, but serve as foundations to the arch, with which they are intimately bound by means of strong vertical muscles. Spines are carried on the adambulacralia in order to protect the delicate organs in the groove. The groove can be opened for the egress of the tube-feet by means of transverse dorsal muscles, which by their contraction force the lower ends of the arch outwards. Closure can be effected by means of transverse ventral muscles. The arm can be bent by means of longitudinal muscles which stretch between the adambulacralia. The necessity for mechanical efficiency in these movements is shown by the following account of the manner in which the Asteroid eats.

MacBride (43, p. 439) states with respect to *Asterias*: "The starfish seizes its prey by the tube-feet and places it directly underneath its mouth, folding its arms down over it umbrella-fashion. The muscles which run around the arms and disc in the body-wall contract, and the pressure thus brought to bear on the incompressible fluid contained in the cœlom forces out the thin membranous peristome and partially turns the stomach inside out. The everted edge of the stomach is wrapped round the prey. Soon the bivalve is forced to relax its muscles and allow the valves to gape. The edge of the stomach is then inserted between the valves and applied directly to the soft parts of the prey, which is thus completely digested. When the starfish moves away, nothing but the cleaned shell is left behind. If the bivalve is small it may be completely taken into the stomach, and the empty shell later rejected through the mouth. It was for a long time a puzzle in what way the bivalve was forced to open. Schiemenz has, however, shown that when the starfish folds itself in umbrella-like form over the prey, it holds on to the substratum by means of the tube-feet of the distal portions of the arms, whilst, by means of the tube-feet belonging to the central portions, it drags apart the valves by main force. He has shown experimentally: (1) that whilst a bivalve may be able to resist a sudden pull of 4000 grammes, it will yield to a pull of 900 grammes long continued; (2) that a starfish can exert a pull of 1350 grammes; (3) that a starfish is unable to open a bivalve unless it is allowed to raise itself into a hump, so that the pull of the central tube-feet is at right angles to the prey. A starfish confined between two glass plates walked about all day carrying with it a bivalve which it was unable to open."

In order to aid the pull recent starfishes are provided with suckers at the extremities of the tube-feet. Each tube-foot is also provided with a reservoir, the ampulla, which assists in keeping it distended with water (Text-fig. 2).

It was formerly believed that a starfish moved by attaching its suckers to a fixed object, and then pulling upon this as a fixed point. Jennings (35, p. 98) disproved this by observing the method of progression on loose sand. He showed that the sucker merely served to prevent the foot from slipping, and the tube-feet themselves were really more or less rigid levers, which, just as the legs of the higher animals, swung the body forward. Jennings' observation helps us to understand the reason why the very primitive Asterozoa could walk. It is obvious that if they had to wait until suckers were well developed they must have been too helpless to survive.

The more detailed observations given in the succeeding paragraphs show that there is considerable complication in structure to withstand strain. The strain comes, not in walking, but in pulling open Lamellibranchiate mollusca. This method of feeding was possible only when the ambulacral arch had become sufficiently strong to withstand powerful lateral pull. It has already been suggested (p. 9) that the primitive forms probably passed small particles of food, by means of the tube-feet, to the mouth. Jennings has observed (35, p. 93) that in Recent starfishes "there are two main methods of conveying food to the mouth. Large objects are usually carried by the active bending of the ray beneath the body, till the object is applied to the mouth. . . . Small pieces of flesh are transported in a somewhat different manner. After being carried to the ventral side of the ray, near its tip, perhaps the ray bends downward and under at precisely the point where the food body touches it, so as to bring the food into contact with a point on the lower surface of the ray nearer the disc. The tube-feet of this nearer point then seize the flesh, while the more distal ones release it. Now the point at present bearing the food bends downward, applying it to a new region, whilst the point first bent straightens out. Thus the food is passed from one set of tube-feet to another, slowly along the under side of the ray, till it



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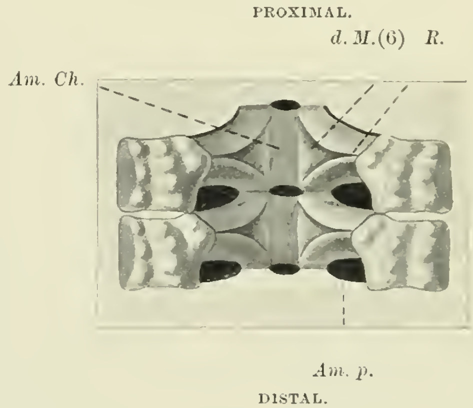

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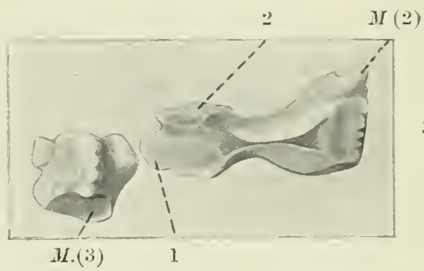

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Text-fig. 3 (on left).—A fifth part of the skeleton of *Pentaceros reticulatus*, oral view (after A. Agassiz). *M. A. P.*, mouth-angle plates; A_1, first ambulacral; A_1p_1, anterior process of first ambulacral; A_2, second ambulacral; *Ad.*, adambulacralia; *V. L.*, ventro-lateralia; *S. M.*, supero-marginalia; *I. M.*, infero-marginalia; *Amb. Gr.*, ambulacral groove; *Am. p.*, ambulacral pore.

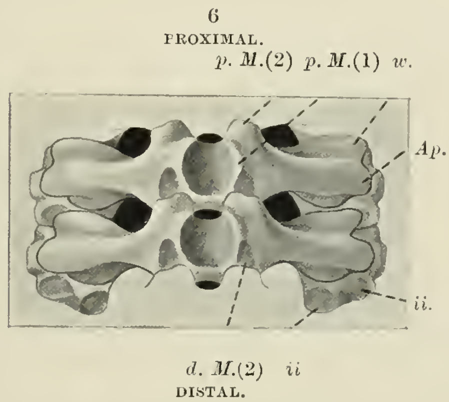
Text-fig. 4 (above).—An oral view of two pairs of ambulacralia and adambulacralia of *Archaster typicus*. *Am. Ch.*, ambulacral channel; *R.*, ambulacral ridge; *d. M.*(6), points of attachment of the ventral transverse muscles; *Am. p.*, ambulacral pore for the passage of tube leading to the ampulla.

Text-fig. 5 (below).—A disarticulated ambulacral and adambulacral of *Archaster typicus*. 1, facet on apophysis; 2, facet on wing; remaining abbreviations as in previous text-figures.

reaches the mouth." This process is probably a survival of the earliest manner of feeding.

(ii) *The Arm as seen in Oral (Ventral) View.*—Text-fig. 3 gives a good typical oral view of an Asteroid. The specimen after death dried in such a manner that the ambulacral groove has opened out, giving a clear view of the ambulacral ossicles. Much more frequently the groove closes after death, and the adambulacralia then meet across and disguise the interior structure. The fact is worthy of mention, as the closed groove causes difficulties in the investigation of many fossil forms.

As we are looking downwards the high arch formed by the ambulacralia appears as a deep groove. The bottom of the groove is excavated so as to form a channel. This channel I propose to call the "ambulacral channel." Along the ambulacral channel runs the radial branch of the water-vascular system. The ambulacralia are in opposite pairs, and follow one another in series. Regularly recurring side-branches of the radial water-vascular vessel, at the extremities of which are the tube-feet, lie between every two ambulacralia. The pores at the outer edge of the groove are for the passage of the ampullæ into the interior of the body-cavity. The groove is bordered by the adambulacral ossicles, which



Text-fig. 6 (on left).—An apical view of two pairs of ambulacralia and adambulacralia of *Archaster typicus*.
Text-fig. 7 (on right).—Apical view of two adambulacralia of *Archaster typicus* with ambulacralia removed. *p. M.*(2), process for insertion of dorsal longitudinal muscle; *d. M.*(2), depression for same muscle; *p. M.*(1), ridge for insertion of dorsal transverse muscle; *Ap.*, apophysis of ambulacral; *i*, facet on adambulacral for apophysis of ambulacral; *w.*, wing of ambulacral; *ii.*, facet on adambulacral for wing of ambulacral; *M.*(3), depression for insertion of adambulacral longitudinal muscle.

are buttressed at the sides by the ventrolateralia. The stout marginalia bind the skeleton into a firm whole. Text-fig. 4 shows an enlarged oral view of two pairs of ambulacralia and adambulacralia of *Archaster typicus* (Müller and Troschel). The adambulacralia may be seen bordering each side of the groove. They are irregularly pentagonal in shape. The outer side runs almost parallel with the length of the groove. The face nearest to the groove has two facets. The proximal facet is short and straight, the distal facet somewhat longer and slightly concave. We shall see that the appearance thus presented is characteristic of primitive Asterozoa and primitive Ophiuroidea as well as of the Asteroidea. Three rows of spines, shown in the figure by spine-pits, run along the length of the plate. In general the longitudinal arrangement of the adambulacral spines is characteristic of the Asteroidea as opposed to the side-to-side arrangement in the Ophiuroidea (*vide infra*, p. 16). Ludwig (40, p. 526) groups the whole of the adambulacral spines as the "adambulacral armature." He admits, however, that they can be subdivided into (*a*) "groove spines," that is, the row of spines which are always present as a protection to the tube-feet when these are withdrawn into the groove, and (*b*) "sub-ambulacral" spines, exterior to the groove spines. These may be absent or only represented by granules. I propose to use these terms in my later descriptions, as the subdivision appears to be of considerable importance.

If we now examine the ambulacralia, the most conspicuous features are the cross-ridges which separate the depressions for the tube-feet. Each cross-ridge is surmounted by a second ridge running parallel with the ambulacral channel and excavated on its inner face by a concave depression for the insertion of the ventral cross-muscles. The two ridges appear ⊣-shaped. This is another feature of great importance in the study of fossil forms (compare Text-fig. 18, p. 20).

8

DISTAL.

9

PROXIMAL.

Text-fig. 8 (on left).—Side view of two ambulacralia of *Stellaster childreni*. Abbreviations as in Text-fig. 6.
Text-fig. 9 (on right).—Side view of an ambulacral and adambulacral of *Archaster typicus*. Abbreviations as in Text-fig. 6.

(iii) *The Arm in Dorsal Aspect.*—The ambulacralia and adambulacralia can only be seen in apical aspect after the dorsal portion of the arm and disc has been cut away and an opening thus made into the body-cavity. The ambulacralia viewed from this aspect (Text-fig. 6) appear in full length. The point of junction of opposite components of ambulacral pairs is at the bottom of cups formed by upwardly projecting concave ridges which served as the attachment for the dorsal cross-muscles. The ambulacral pore (for the passage of the ampullæ) can be seen between the hollowed-out portions of the ambulacralia. Exterior to the pores are observable the bases of the ambulacralia, each formed from a thickened main portion, the *apophysis*, and a small forwardly directed *wing*.

(iv) *The structure of the Ambulacralia and Adambulacralia as seen after Maceration and Displacement of the Ossicles.*—Further details may be observed after maceration of the ossicles in potash. Text-fig. 5 shows an isolated ambulacral and adambulacral viewed from the oral side. The ambulacral is, however, laid almost along its extreme length instead of "on end" to form the component of an arch. The true oral face is also slightly turned to the observer so that the articulatory face for the dorsal longitudinal muscle has been rotated into view. The ambulacral canal is seen on the extreme right. This is followed by the depression for the ventral cross-muscle. On the extreme left is a depression for the main vertical muscle between the ambulacralia and adambulacralia (*vide supra*, p. 10). Proximal to this is a second smaller depression for the attachment of the ambulacral to a contiguous adambulacral.

The manner of the attachment of the ambulacralia to the adambulacralia can be better seen by reference to Text-fig. 7 which represents two succeeding adambulacralia in apical view. The base of the ambulacral fits on to two contiguous adambulacralia. Text-fig. 9 shows the same fitting in side view. The main attachment (that under the apophysis), however, is the one which connects the ambulacral to the adambulacral with which it corresponds in the series. It is necessary to emphasise this fact, as the descriptions frequently given imply that in the Recent forms the ambulacral has equal attachments to two neighbouring adambulacralia. Schöndorf has shown that in the older Palæozoic Asteroidea each ambulacral is associated only with its own adambulacral. The small extra articulation, evolved later, helps the general strengthening of the ambulacral arch by providing a firmer base of attachment.

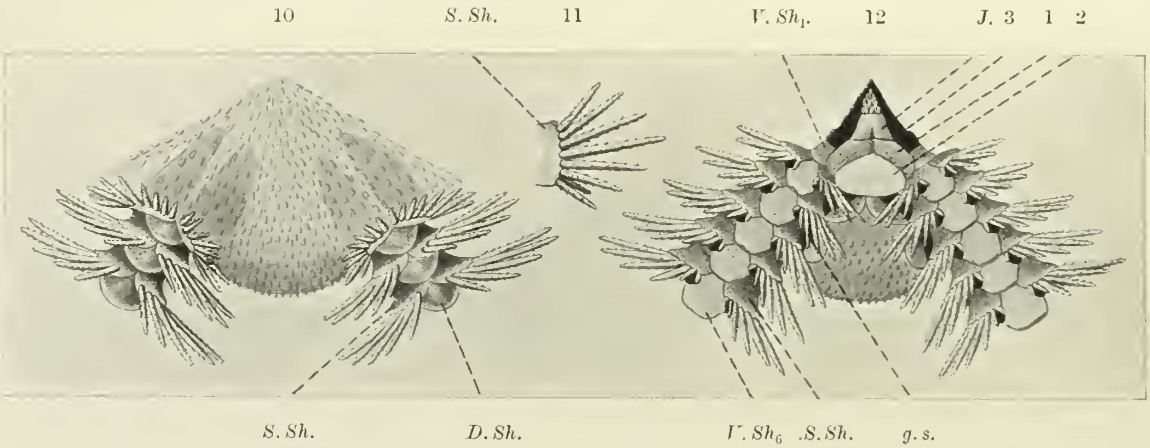
The adambulacralia after maceration readily separate. The hollow articulations (Text-fig. 7) which serve for the insertion of the longitudinal muscles, can readily be seen. Similar articulations can be observed in many fossil forms.

The Structure of the Arm in Recent Ophiuroidea.

(i) *The General Structure.*—At first sight there is little in common between the arm of an Asteroid and that of an Ophiuroid. If we examine Text-figs. 10 and 12 it is seen that the arm is sharply marked off from the disc and is covered with a complete sheathing of plates. These plates are four in number and termed the dorsal, side, and ventral shields. There is in consequence no open ambulacral groove. The tube-feet are small, and project through the above sheathing at points near the junction of the side and ventral shields.

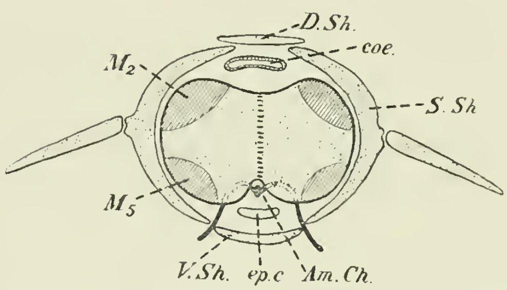
If the shields be stripped away a number of small ossicles (Text-figs. 14—17) may be seen, which on account of their shape and the character of their articulatory surfaces are known as vertebræ. The vertebræ allow that great flexibility of the arm which is characteristic of the Ophiuroid (snake-tailed) class. Their highly modified structure is specially adapted to the animal's mode of life. As MacBride has pointed out (43, p. 477), the Ophiuroids progress, not by movements of the tube-feet as do the Asteroids, but by writhing movements of their arms. The large spines attached to the side-shields (Text-fig. 11) enable them to get a grip on the surface over which they are moving. The tube-feet act mostly as respiratory or sensory organs.

The homologies of the component skeletal parts have been established by



TEXT-FIG. 10 (on left).—Apical view of portion of *Ophiothrix cæspitosa*. *D. Sh.*, dorsal shield; *S. Sh.*, side shield.
TEXT-FIG. 11 (in middle).—Side shield of same species showing spines.
TEXT-FIG. 12 (on right).—Oral view of same species. *S. Sh.*, side shield; *V. Sh$_1$.*, first ventral shield; *V. Sh$_6$.*, sixth ventral shield; *J.*, jaw; *g. s.*, genital slit: 1, lateral buccal shield; 2, buccal shield; 3, mouth slit. (All after Lyman.)

Johannes Müller, Ludwig and other workers. They can, perhaps, be most readily understood from the diagram given of a cross-section through the arm (Text-fig. 13). The ambulacral channel is seen to lie at the base of the vertebræ. There is in consequence no difficulty in recognising that the vertebræ occupy the

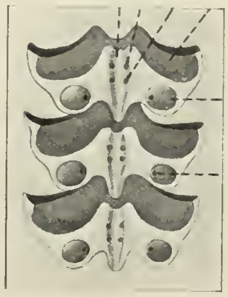


TEXT-FIG. 13.—Diagrammatic cross-section of the arm of an Ophiuroid. *D. Sh.*, dorsal shield; *S. Sh.*, side shield; *V. Sh.*, ventral shield; *M$_2$.*, dorsal longitudinal muscles; *M$_5$.*, ventral longitudinal muscles; *Am. Ch.*, ambulacral channel; *cœ.*, cœlom; *ep. c.*, epineural canal.

same position as the paired ambulacralia of the Asteroidea. Although the vertebræ of the adult are solid unpaired ossicles, in the young they arise by the fusion of paired components, and thus complete the homology established on purely anatomical grounds.

The side shields, alone of all the sheathing plates, articulate with the vertebræ (Text-fig. 15). They are really the adambulacralia. The mesenchyme from both sides has grown over and united so as to close the ambulacral groove, leaving it represented by a sinus, the epineural canal. The ventral shields are formed after closure of the groove. The dorsal shields correspond to the median ossicles on the apical surface of the arm of the Asteroids.

We may also notice at this stage the following comparisons between the musculature of the Asteroid and Ophiuroid arms.



TEXT-FIG. 14.—Oral view of vertebræ of *Ophiarachna incrassata* (after Ludwig). *Ch.*, ambulacral channel; M_5., adoral excavation for the ventral longitudinal muscle; *cup*, cup for the tube-foot; *c. t. f.*, canal from water-vascular system to tube-foot; 1, point of entry of water-vascular branch to tube-foot; 2, the same of nerve to dorsal longitudinal muscle.

A. The longitudinal (writhing) muscles are of course much more important in Ophiuroids than in the Asteroids.

(*a*) The dorsal longitudinal muscles present in both Asteroids and Ophiuroids are much larger in the latter than in the former group.

TEXT-FIG. 15.—Side view of vertebræ of *Ophiarachna incrassata* (after Ludwig). *r.*, ridge for articulation of side shields; *can.*, branch vessel to tube-foot, which here takes a convoluted course through the ossicle.

(*b*) The ventral longitudinal muscles are attached to the adambulacralia in the Asteroidea. Homologous muscles are absent in the Ophiuroidea, where they are replaced by muscles between the ambulacralia (vertebræ)—a much more advantageous position.

B. The cross-muscles between the opposite ambulacralia are only present, at any rate functionally, in the Asteroidea. They would be useless in the Ophiuroidea in consequence of the fusion of the vertebral halves.

All these changes can be followed in fossil forms.

(ii) *The Structure of the Vertebræ in Detail.*—It is best to concentrate attention upon the following points :

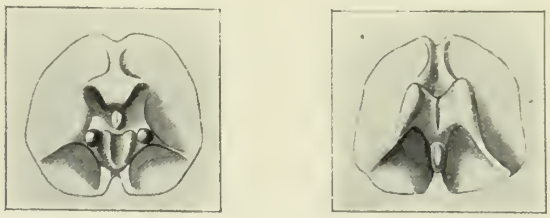
(*a*) The deep excavations for the insertion of the writhing muscles. Ventrally these excavations are more prominent proximally than distally (Text-fig. 14).

(*b*) The narrow ridge left by the deep excavations (Text-fig. 15 and Pl. I, fig. 3). The adambulacralia (side shields) articulate with this ridge. They are not bound to the ambulacralia (vertebræ) by muscles as in the Asteroidea.

(*c*) The cup for a tube-foot is not formed by two succeeding ossicles as in the Asteroidea, but is entirely situated on one vertebra.

(*d*) The manner in which the narrow branch canal from the radial water-vascular canal perforates the ossicle and runs a tortuous course (Text-fig. 15) before emerging into the cup (Text-fig. 14).

(*e*) The articulations between the vertebræ (Text-figs. 16 and 17). These are very complicated in the majority of Recent Ophiuroidea. They are described by MacBride (43, p. 481) as follows: "On the proximal surface of the central portion of the vertebra is a central knob and two ventro-lateral knobs, a median



Text-figs. 16 and 17.—Proximal and distal views of single vertebræ of *Ophiarachna incrassata* (after Ludwig).

ventral pit and two dorso-lateral pits, and on the distal surface there are pits corresponding to the knobs on the proximal side and *vice-versâ*."

We shall see that the Palæozoic Asteroidea allow us to trace the gradual evolution of these complicated structures.

The Structure of the Arm in the Palæozoic Asterozoa.

The Views of Previous Observers.

(A) *On the Form of the Primitive Ambulacralia.*—Jaekel alone (34) of previous observers has drawn attention to the correct shape of the ambulacralia in the early Palæozoic Asterozoa. His figure of *Siluraster* shows the characteristic oblong form which these plates assume. A reference to Text-fig. 18 (p. 20) of this monograph shows similar plates in a British Ordovician species, *Uranaster elizæ*, n. sp. The plates form a complete floor to the ambulacral groove. There are no pores for the passage of ampullæ. The ⊣-shaped ridges already refered to (p. 14) run across the top of each ambulacral, and divide the groove into a series of deep depressions in which were placed the tube-feet. Many investigators, owing to the poor state of preservation of their material, have described these depressions as pores for the passage of ampullæ.

This mistake caused many of the early Asterozoa to appear to be more nearly allied to the true Asteroidea than they really are.

The form of the primitive ambulacralia is important, as we can readily derive from it the more advanced ambulacralia found in the more specialised groups.

(B) *As to the Disposition of the Primitive Ambulacralia.*—We have seen that both in Recent Asteroidea and in Recent Ophiuroidea the ambulacralia are in opposite pairs. Many observers have noticed that in the older forms the ambulacralia are not exactly opposite but alternating with each other. Bronn (14), in one of the earlier classifications of the Asteroidea, used this characteristic to separate the Encrinasteriæ or Asteroidea with alternating ambulacralia from the Euasteriæ or Asteroidea with opposite ambulacra. Stürtz (76–80) made a group of the Ophio-Encrinasteriæ for Palæozoic "Ophiuroidea" which had their vertebræ in unfused alternating halves (see also p. 43).

Gregory (27) and Jaekel (34) regard this alternating condition as the primitive one.

Bather (3) also showed that *Edrioaster* had alternating flooring plates [ambulacralia], and that the Edrioasteroidea are alone among known Pelmatozoa in presenting a type of ambulacrum from which the Stellerid type could readily be derived.

The earliest strata from which Asterozoa are obtained, the Ordovician of England and America, contain forms which have their ambulacralia exactly opposite and forms with alternating ambulacralia. I intend to follow the views of Gregory, for it appears to me that the most primitive forms had ambulacralia which are irregularly alternating. From this primitive stock two sets of forms arose, namely, those with opposite ambulacralia and those with definitely alternating ambulacralia. This latter series in Ordovician times was almost entirely confined to Ophiuroid-like wriggling forms, as, *e. g.*, species of *Aspidosoma*, Goldfuss, *Protaster*, Forbes, and *Tæniaster*, Billings. Later, the conditions of existence led to the extinction of the families with alternating ambulacralia and the survival alone of families with opposite ambulacralia. This latter arrangement appears to have had the greater mechanical efficiency.

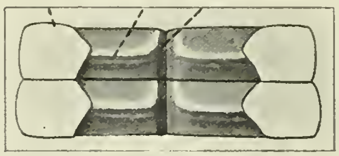
(C) *As to the Origin of the Ophiuroidea.*—Many previous observers, Stürtz (76–80), Gregory (26), Jaekel (34), and Sollas and Sollas (71), have shown that certain Palæozoic Ophiuroidea present primitive features which indicate the relationship of the class to the Asteroidea. Thus, in these early forms (1) the component halves of the vertebræ are not fused, (2) the ventral shields are not present but the ambulacral groove is directly open to the exterior. In consequence it has been customary to derive the Ophiuroidea directly from the Asteroidea.

In this monograph I have adopted the view that there is a class which is more primitive than either the Asteroidea or the Ophiuroidea, and that it was from this class that both the latter classes diverged. My ancestral class contains forms which are devoid of differentiated marginalia (see also p. 8) and possess a marginal madreporite (p. 38).

The characteristics of the families included in the Recent Asteroidea are (1) the possession of differentiated marginalia at some period of their life-history (p. 8), and (2) the apical position of the madreporite. It therefore appears desirable to limit the Palæozoic forms included in the Asteroidea to those which satisfy the above conditions. The advantages which follow from this course will become obvious when the systematic position of the various groups is considered.

The Progress to the Asteroidea.

Certain Asterozoa, *e.g.* species of *Palæasterina*, *Uranaster*, and allied genera,



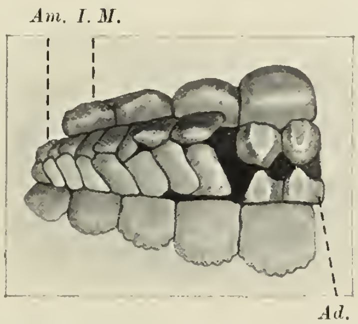
TEXT-FIG. 18.—Oral view of ambulacralia and adambulacralia of *Uranaster elizæ*. *Ch.*, ambulacral channel; *R.*, ambulacral ridge; *Ad.*, adambulacralia.

appear to be nearly related to very primitive Asteroidea. The ossicles of the arm are arranged simply, and show that adaptations to withstand strain were lacking. A cross-section of the arm of *Uranaster elizæ*, n. sp., is given (Text-fig. 20, p. 23). The ambulacralia form the usual arch, but supporting marginalia are only slightly developed.

Text-fig. 18 is based on a study of the ambulacral groove when viewed from below. The ambulacralia are seen to be rectangular in plan. Their sides closely touch one another, and there are no pores between them for the passage of ampullæ. A well-marked median transverse ridge is present. The longitudinal ridge which forms the apex of the ⊣ is but slight, and indicates the feeble development of the transverse ventral muscles. The median margins of the ambulacralia are excavated for a shallow channel, in which lies the radial water-vascular canal.

Under certain conditions of preservation it is possible to obtain an apical (dorsal) view of the ambulacralia. This view shows even more clearly the absence of ambulacral pores. Excavations for muscle-attachments are either very slight or wanting. The dorsal transverse and longitudinal muscles must have had but slight functional importance in these early forms, and the ambulacralia themselves can have been little more than mere flooring plates to the ambulacral groove. The adambulacralia have the usual typical form. It is readily seen that the depression for a tube-foot was formed by the inner margins of two consecutive adambulacralia and by succeeding cross ridges of two ambulacralia. The ornament on the adambulacralia probably consisted of sub-ambulacral granules and slight groove-spines. Each adambulacral is attached to one ambulacral. The articular faces are subtriangular in form, and are slightly excavated for the insertion of the vertical muscles (compare Text-fig. 19).

Some advance in structure upon that already described is shown by the Ordovician forms known as *Palæaster caractaci*, Gregory, and *Protopalæaster narrawayi*, Hudson. These forms, in my opinion, belong to one species, referred to here as *Protopalæaster caractaci*, of which there are several specimens in the British Museum (Nat. Hist.) and the Museum of Practical Geology. One of them possesses the ambulacralia preserved in the original calcite. From this



TEXT-FIG. 19.—Apical view of extremity of arm of *Protopalæaster* "*narrawayi*" (after Hudson). *Am*, ambulacral; *Ad.*, adambulacral; *I. M.*, infero-marginal.

specimen we learn that these plates present the same oral view as do the corresponding plates in *Uranaster*.

The excellent photographs of Hudson[1] give clear details of a specimen, which, by a fortunate accident, has lost the dorsal plates of the disc, and so exposed the ambulacral groove from above. One of these photographs is reproduced here as Text-fig. 19. It is seen that the arm differs from that of *Uranaster* in the differentiation of stout marginalia.

The figures also show that the ambulacralia are not exactly opposite to each other but are slightly alternating, that there are no ambulacral pores, and that

[1] Hudson (33), when he described this form, thought that he was looking down on the ventral (oral) surface. The ambulacral groove therefore appeared to him to be roofed over by "covering plates," and he naturally regarded these as homologous with the "covering plates" of Cystids and Crinoids (see p. 4). There can be no doubt that this interpretation is incorrect. As shown by Raymond (56), the fossil has its oral surface turned towards the rock, in which it is partially embedded. The dorsal (apical) surface is the surface exposed to the observer. The great majority of the dorsal plates of the disc are wanting, and in consequence the ambulacralia are exposed, arching over the ambulacral groove in the usual way.

neither the transverse nor the longitudinal dorsal muscles could have been well developed. All these, it will be remembered, are important primitive features.

The adambulacralia possess the usual excavations on their proximal and distal faces for the insertion of the longitudinal adambulacral muscles, as well as slight excavations on the dorsal faces for the attachment of the vertical muscles which stretch between these plates and the ambulacralia.

I hesitate, at present, to place this form among the true Asteroidea, as hitherto it has not been found possible to identify with certainty any plate which acted as a madreporite.

True Asteroidea undoubtedly occur in the Devonian (rheinischen Grauwacke) of Germany. Schöndorf has given a full account of these. His figures, *e.g.* 62, pl. xi, fig. 2, show that in these slightly older forms the ambulacralia have become exactly opposite to each other, and that small ambulacral pores have been developed. The chief advances made in Mesozoic and Tertiary times are:

(*a*) The increase in size of the ambulacral pore due to the greater functional importance of the ampullæ;

(*b*) The greater development of the transverse and longitudinal muscles between the ambulacralia which makes possible greater and more vigorous movements of the arms;

(*c*) Greater differentiation of the adambulacral armature;

(*d*) Elaboration of the attachment of the ambulacralia to the adambulacralia in order to strengthen the arch.

The Progress to the "Ophiuroidea."

It has been seen that there are relatively few modifications to be observed in the evolution of the arm of the Asteroidea. Many more changes take place in the forms now to be considered.

The Structure of the Arm of Stenaster obtusus, Forbes.

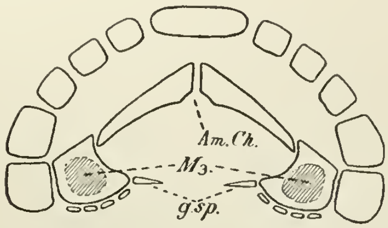
The genus *Stenaster* has hitherto been classified among the Asteroidea. The following description shows that it is really a very primitive "Ophiuroid."

(i) *Primitive Structures.*—That *Stenaster* is not far removed from the primitive Asterozoa may be judged—

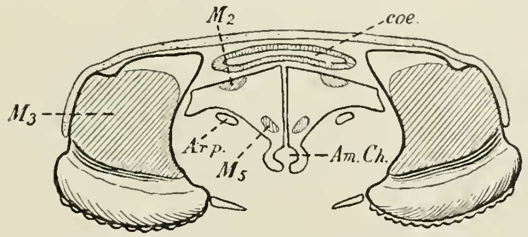
(*a*) By the structure of the ambulacral groove (Pl. I, fig. 6). The ambulacralia are oblong, closely touching, and carry the characteristic ⊣-ridge. The adambulacralia have the usual pentagonal shape and possess the same ornament, sub-ambulacral granules and groove spines, as do other primitive forms. There can be no doubt that the groove was open to the exterior.

(*b*) By the musculature. Adambulacral longitudinal muscles are well developed

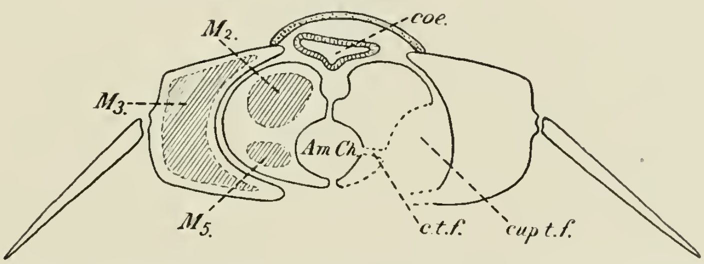
(Text-fig. 21), and the dorsal longitudinal muscles (Pl. I, fig. 7) have not yet developed beyond the stage found in recent Asteroidea.



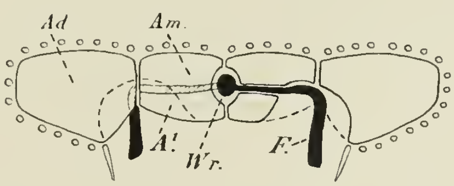
TEXT-FIG. 20.—Diagrammatic cross-section of the arm of *Uranaster elizæ*. *Am. Ch.*, ambulacral channel; *g. sp.*, groove spines; M_3, longitudinal muscles between adambulacralia.



TEXT-FIG. 21.—Diagrammatic cross-section of arm of *Stenaster obtusus*. M_2, dorsal longitudinal muscles; M_3, longitudinal muscles between adambulacralia; M_5, ventral longitudinal muscles; *Am. Ch.*, ambulacral channel; *cœ.*, cœlom; *Ar. p.*, articulating peg.



TEXT-FIG. 22.—Diagrammatic cross-section of arm of *Aspidosoma grayæ*. *c. t. f.*, branch canal to tube-foot; *cup t. f.*, cup for tube-foot; remaining lettering as in Text-fig. 21.



TEXT-FIG. 23.—Diagrammatic cross-section of the arm of an Auluroid (after Schöndorf). *Am.*, ambulacral; *Ad.*, adambulacral; *A*[1]., process of ambulacral; *Wr.*, radial branch of water-vascular system; *F.*, foot.

(ii) "*Ophiuroid*" *Structures.*—That the form has progressed somewhat towards the Ophiuroid (wriggling) mode of life is shown—

(*a*) By the large size of the adambulacralia, which occupy as much of the depth of the arm as do the side plates of Recent Ophiuroidea (Text-fig. 21).

(*b*) By the presence of articulating pegs on the ambulacralia (Pl. I, fig. 6).

(*c*) By the presence of small ventral longitudinal writhing muscles inserted between the longitudinal ridges of the ambulacralia (Text-fig. 21, M_5).

(iii) *Structures peculiar to the Palæozoic "Ophiuroidea."*—The radial water-vascular vessel does not run in an open channel as in the primitive Asterozoan or the Recent Asteroidea, but in a closed canal (Text-fig. 21) formed by overgrowths of the ridge upon which the ventral transverse muscles are usually inserted. We have here the first stages of a form of specialisation which is met with very frequently indeed among the Palæozoic "Ophiuroidea." Schöndorf (64) has laid great stress upon this character, which he regards as of fundamental importance. He has used it to aid him in establishing a new group, the "Auluroidea," which he regards as distinct from the Ophiuroidea and the Asteroidea as are the Echinoidea and the Crinoidea. I am unable to agree with this (see pp. 48—50).

The Structure of the Arm of Aspidosoma grayæ, n. sp.

The genus *Aspidosoma* was, until the recent work of Schöndorf, placed among the Asteroidea. Schöndorf made very careful and exact investigations upon the structure of the arm and the disc which led him to found the group "the Auluroidea" for this and similar forms.

Almost at once it will be noticed with respect to the form that the ambulacralia are not opposite but alternating. This character alone shows that the species is not on the direct line of descent between *Stenaster* and *Lapworthura*, the next form to be described (p. 25). Nevertheless, a description of it is inserted here as its characteristics serve to connect the two forms.

The cross-section given (Text-fig. 22) shows the essential relationships between *Aspidosoma* and *Stenaster*. In both forms the radial water-vascular vessel is enclosed in a hollow canal, the ambulacral groove is open to the exterior, and the skin on the apical surface is but weakly calcified. The canal is, however, in the species under description large and conspicuous. If the ambulacralia are preserved in their natural position (Pl. I, fig. 8) the walls of the canal may be observed in oral view as conspicuous raised hemispherical ridges divided by a median suture.

If the ambulacralia have become slightly separated, the canal can readily be seen. It is so deep that the inner halves of the ambulacralia appear to be concave throughout their entire depth.

This increase in size of the canal is not, in my opinion, due so much to a relatively greater importance of the radial water-vascular system, as to the fact that the ridge extremities act as points for the insertion of the longitudinal ventral muscles. These "wriggling" muscles have now assumed great functional importance, as may be judged by the large excavations on the proximal edges of the ossicles.

It will be noticed that the cups for the tube-feet are now much smaller, and there can be no doubt that the podia are losing (or have lost) their "walking" function and become reduced in size as in Recent Ophiuroidea. Further advances towards the Ophiuroid structure are to be seen in—

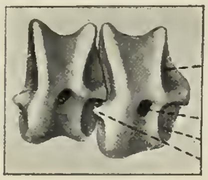
(*a*) The diminution in importance of the adambulacral longitudinal muscles as shown by the faint concavity on the faces of the adambulacra.

(*b*) The enclosure of the branch radial water-vascular canals in the substance of the ossicle.

(*c*) The presence of Ophiuroid spines on the adambulacralia (Text-fig. 22).

(*d*) The hollow ridges for the articulation of the ambulacralia with the adambulacralia.

There are forwardly projecting pegs which fit on distal processes of the preceding ambulacralia. These pegs are hidden in oral view by the large articular faces for the longitudinal muscles. They can, however, be seen in side view after removal of the adambulacralia (Text-fig. 24), or when the arm is slightly



TEXT-FIG. 24.—Side view of two isolated ambulacralia of *Aspidosoma grayæ*. *M.*(2), depression for dorsal longitudinal muscles; *M.*(5), depression for ventral longitudinal muscles; *c. t. f.*, opening of branch canal to tube-foot; *Ar. p.*, articulating peg.

bent they may be seen on the abactinal surface deep down between the ossicles. The abactinal integument contained few or no calcifications.

The Structure of the Arm of Lapworthura miltoni.

An account of the structure of the arm in *Lapworthura* has recently been given by Sollas and Sollas (71, pp. 216, 217). There is little new to add to this account. Orally (Pl. I, fig. 10), the ambulacralia are very similar to those of *Aspidosoma*, except that they are not alternate, but opposite. There is the same large proximal depression for the ventral longitudinal "wriggling" muscles, and in both forms the ossicular canal is large and the cup for the tube-feet much reduced. The branches from the radial water-vascular vessel to the tube-feet pierce through the walls of the ossicular canal. Sollas describes this branch-canal as a deep groove with thickened edges. According to my observations the branch canal may be completely enclosed in the substance of the ossicle as in *Aspidosoma*. The adambulacralia show even a further transition towards the stage met with in modern Ophiuroidea than do those of *Aspidosoma*. In *Aspidosoma* these plates are stout and closely touching, in *Lapworthura* they are thin and merely overlap at their edges. It is obvious that the adambulacral longitudinal muscles must be of small importance or perhaps absent. Further, the surfaces of contact of the ambulacralia and adambulacralia are as much reduced in *Lapworthura* as in modern Ophiuroids and the form possesses stout Ophiuroid spines.

The skin on the apical surface must have had few calcifications, for usually the ambulacralia are fully exposed in dorsal view. Observed from this aspect the ossicles, as Sollas remarks (71, p. 217), resemble "the phalanges of a Plesiosaur." Usually there is a large concavity which dips downwards between opposing ambulacral halves. Somewhat similar median excavations of the ambulacralia occur in *Onychaster*, which Miss Sollas has suggested lodged diverticula of the cœlom (72, p. 52). The point is important, as according to the interpretation of Schöndorf there is no dorsal cœlom in the Auluroidea, in which group he places *Lapworthura*. A well-marked "ophiuroid" ridge which bears spines can be seen from this view (Pl. I, fig. 9).

B. THE MOUTH PARTS.

The mouth-frames of Recent Asteroidea and Ophiuroidea are very different in outward appearance, and even now very diverse views are held as to the homologies between the various parts. It will be seen that the palæontological evidence is of great value in helping us to a definite decision on these conflicting opinions.

The Mouth-frame of Recent Asteroidea.

The mouth-frame of the Recent Asteroidea retains on the whole a primitive form, and its component ossicles are not difficult to recognise. If we examine the mouth-region in oral aspect (Text-fig. 3), five pairs of prominent projections are seen in the interradial angles bordering the mouth. These projections, when examined more closely, are observed to be composed of pairs of triangular ossicles united by muscles. They are known as "mouth-angle" plates. Radially the mouth is seen to be bounded by five pairs of ambulacralia. These first ambulacralia are larger than any other ambulacralia, and each possesses two processes instead of the one usually found. Between the first two processes rests the first tube-foot.

A better view of the mouth-parts may be obtained after removal of the apical plates of the centre of the disc and a consequent exposure of the ossicles from above (Pl. I, fig. 1). The large first ambulacralia are seen to have a pronounced downward slope towards the centre of the mouth-aperture. This slope is also found in fossil Asterozoa.

The anterior process of the first ambulacral fits on the apical surface of a mouth-angle plate. Immediately proximal to the process is a groove also found in fossil Asterozoa. Up to the present I have not been able to ascertain the function of this groove.

A strong interradial muscle ("adducteur des dents" of Viguier) stretches between strong dorsal ridges on the proximal extremities of neighbouring anterior processes. This muscle appears to have the power of rotating the mouth-angle plates upwards. The mouth-angle plates can be rotated downwards by means of a muscle (the "abducteur des dents" of Viguier), which corresponds in position to the transverse ventral muscles already mentioned.

Interradially a small unpaired plate may be seen. This is known as the odontophor. Its exact homology has offered a fruitful field for discussion.

The water-vascular ring excavates the anterior process in the species under description just behind the ridge for the interradial muscle.

The Mouth Parts of the Recent Ophiuroidea.

The mouth parts of a Recent Ophiuroid are much more complex in structure than are those of a Recent Asteroid. It will be well to give a straightforward description of the arrangement in a typical modern form before the various views as to the homologies of the mouth-ossicles in the two groups are discussed.

The essential ossicles are five pairs of so-called "jaws." These can barely be seen in oral view (Text-fig. 10), for they are almost (or entirely) covered by plates, the buccal shields and lateral buccal shields, the names of which carry their own significance. In order to see them clearly we must macerate a specimen in weak potash and remove the shields. Plate I, fig. 3, shows a portion of a specimen of *Ophiocoma erinaceus* which has been treated in this way. The jaws now appear as stout ossicles which project well into the mouth-cavity. At their apex is seen a plate, the torus, which carries stout teeth. Distally the jaws articulate with the first vertebræ.

As MacBride (43, pp. 483—484, 486) explains, the "words 'jaw' and 'tooth' are misleading." He states that there is no evidence that the jaws of a Brittle-star are ever used for crushing food. The creature "feeds on the most superficial layer of mud at the bottom of the sea. This deposit consists partly of microscopic algæ and partly of decaying organic matter, and is more easily disposed of than the living animals on which the starfish preys. The food is shovelled into the mouth by the first two or "buccal" pairs of tube-feet in each ray." [1]

The jaws merely carry the various plates, such as teeth and mouth-papillæ, which act as strainers. "By means of the muscles attaching them to the first complete vertebra in the arm they can be rotated downwards so as greatly to enlarge the mouth, and again rotated upwards and inwards, when they form an excellent

[1] Prof. MacBride informed me recently that the sand-stars may be observed to feed on worms, which they pass along to their mouth by movements of the podia.

strainer to prevent the entrance of coarse particles. To permit this extensive movement the articulatory facets on the proximal surface of the first vertebra have been much modified; the median knob and pit have disappeared, and the dorso-lateral pits are raised on to the surface of processes, so that there are in all four processes, two of which articulate with one half of a jaw. The mouth can be narrowed and the jaws forced inwards towards the centre by the simultaneous contraction of five muscles each, which unite the two halves of a jaw."

The buccal tentacles, of which mention has been made, are situated in cups on each jaw (Text-figs. 25, 27, p. 32). The first buccal tentacle points upwards and the second forwards. The position of each has, therefore, become modified from that observed in Asteroids, in which the proximal tube-feet play little part in feeding. Both buccal tentacles are supplied by a single branch, which comes directly off the water-vascular ring and bifurcates in the substance of the ossicle (Text-fig. 25). A distinct excavation for the nerve-ring is also noticeable.

The Homologies between the Mouth-parts of Recent Asteroidea and Ophiuroidea.

(1) *Those suggested by Embryology.*—The homologies until recently accepted by the majority of writers were those suggested by the classic researches of Ludwig, who arrived at his conclusions by investigations of the young stages of Recent forms. According to Ludwig the mouth-parts of both Asteroids and Ophiuroids are derived solely from modifications of the ambulacralia and adambulacralia.

It is perhaps easiest to visualise Ludwig's interpretation by reference to Text-fig. 3, p. 12. It has already been noticed that the first ambulacralia of the Asteroidea are much larger than the remaining ambulacralia, and that each of these first ambulacrals possesses two processes. If we draw a line across the base of the anterior process we may regard the first ambulacral as having two components, one of which corresponds to the mouth-angle plates and the second to the first recognisable adambulacral. The anterior process would then be a_1 and the mouth-angle plate ad_1, the posterior process would be a_2 and the first recognisable adambulacral ad_2.

Although Ludwig uses a diagram of this kind (compare 40, fig. 5, p. 530), he makes no claim that the anterior process is a true ambulacral formed by the natural growth of the embryonic ambulacral which occupies its position in the young stages. As he himself shows, the anterior process is formed secondarily by a downward growth from the body of the large ambulacral (Ludwig's a_2), which meets an upwardly projecting growth from the mouth-angle plates (Ludwig's ad_1). For all practical purposes we may therefore state that Ludwig's embryonic a_1 is not represented in the mouth-frame of the Recent Asteroidea.

Ludwig's account of the fate of the ossicles found in the earliest stages of the developing Ophiuroid is as follows:

(i) a_2 and ad_1 fuse to form the jaws.

(ii) ad_2 forms the lateral buccal shield.

(iii) a_1 migrates upwards and forms one of the plates known as the peristomial plates which fit on the upper surface of the jaws.

Practically everyone admits the conclusions (i) and (ii), but there is much controversy with respect to (iii). Dr. zur Strassen has pointed out that in very many species the number of peristomial plates is not two as required by the hypothesis of Ludwig—a fact which in itself almost disproves the theory. Generally it may be said that from our knowledge of Recent forms the plate known to Ludwig as a_1 is not definitely recognisable in the adult of either Asteroidea or Ophiuroidea.

(b) *Those suggested by Palæontology.*—Very few observers have studied the mouth-parts of fossil Asterozoa. Jaekel, Schöndorf, and Prof. and Miss Sollas have been almost alone in this branch of inquiry. Schöndorf has shown that there is no recognisable ossicle corresponding to the a_1 of Ludwig in the Devonian Asteroidea. Prof. and Miss Sollas have shown the same fact with respect to English Silurian "Ophiuroidea." These latter observers, however, accept, after a re-investigation of the embryological evidence, the views of Ludwig that there is in the early stages an a_1, but they conclude that this ossicle later fuses with a_2. My own search through a large number of forms does not reveal evidence which I can accept as conclusive of the existence of Ludwig's a_1 as a separate ossicle. In the following descriptions I have therefore followed the practice of Schöndorf and called the first recognisable ambulacral, a_1. This leaves the interradial mouth-parts without a corresponding ambulacral, and they are therefore here always called mouth-angle plates.

Perhaps later evidence will help finally to decide the matter. At any rate it is possible to confirm the evidence brought forward by Prof. and Miss Sollas that peristomial plates are wanting in Palæozoic "Ophiuroidea," and that these plates in Recent forms cannot therefore be representatives of embryonic ambulacralia.

In practically all Ordovician and Silurian "Ophiuroidea" the jaws are Asteroid, inasmuch as the mouth-angle plates have not fused with the first recognisable ambulacralia (compare Sollas and Sollas, 71, p. 226). They thus retain a condition met with only in the young of modern forms.

The following account gives some of the lines of change. Generally we may say that there are few changes to be observed in the Asteroidea, but in the Palæozoic "Ophiuroidea" there is (*a*) the same modification of the mouth-parts for feeding as in Recent forms, while (*b*) features characteristic of the period are shown inasmuch as (i) the proximal ambulacralia tend to fuse with each other, and (ii) buccal shields have not as yet developed. Various other modifications, however, took place which will be dealt with in a later volume.

The Mouth-frame in the Primitive Asterozoa.

The mouth-frame in some of the most primitive forms is almost diagrammatically simple in character. We may take as an example *Eoactis simplex*, nov. gen., nov. sp. The specimen of this form figured (Pl. I, fig. 4) has been compressed in such a manner that the ambulacral groove has been well exposed. This affords us a good opportunity to obtain a clear view of all the ossicles. It is seen that the ambulacralia and adambulacralia are almost exactly of the primitive shape noticed in *Uranaster*. There are, however, small articulating pegs which show that there is some slight advance towards the Ophiuroidea. The ossicles of the mouth-frame show scarcely any differentiation. The mouth-angle plates are not conspicuously developed. Owing to the compression of the specimen, they lie somewhat on their side, and it is easy to see that their inner faces are excavate. These excavations, together with proximal excavations of the first ambulacralia, form the cups for the first tube-feet. Probably small oral spines were present. These were, however, so slight that no trace of them is visible. The first ambulacralia are of approximately the same size as their neighbours.

The mouth-parts of forms at any rate allied to the primitive Asterozoa differed very little from those described above. Plate I, fig. 5 shows the adambulacralia and mouth-angle plates of *Protopalæaster caractaci* looked at from above. The ambulacralia have fallen away from this portion of the specimen.

Hudson's description of other portions of the specimen leaves no doubt that there was neither an ambulacral corresponding to the mouth-angle plates nor an anterior process from the first ambulacral. The position of the cup for the first tube-foot, which can readily be deduced from a comparison of the two figures, suggests that the feet themselves were directed slightly forward. They must have been able to thrust themselves freely into the mouth-cavity, and probably helped to pass small particles of food which had been seized by the podia into the stomach. If this were the case the method of feeding could not have materially differed from that of many Pelmatozoa.

The Advance towards the Asteroidea.

An advance towards the structures as seen in Recent Asteroidea is shown by the Devonian form *Xenaster margaritatus*, Simonov., *pars*, figured and described by Schöndorf (62). The first ambulacralia are considerably thicker than the remaining ambulacralia and there is a distinct anterior process.

The 'Report of the New York State Museum' for 1911, p. 44, contains an interesting account of the discovery of a Starfish bed which suggests that in Devonian times the Asteroidea had the same method of feeding as they have at the present day. The very numerous Starfishes (more than 400 in an exposure of 200 square feet) were found intimately associated with clams, *Grammysia* and *Pterinea*, in such a way as to suggest that they were feeding on the clams at the time they were buried in the strata.

The report states that "nearly every *Grammysia* or *Pterinea* found in this layer has a star in or on it, sometimes several about its edges in attitudes suggestive of attack, and it is altogether reasonable to believe that the hostility between the starfish and the bivalves had fully developed at this early day in the history of the earth."

The Transition to the Ophiuroidea.

The Mouth-Frame of Stenaster obtusus.—It has been shown that the structure of the arm of *Stenaster obtusus* shows an early stage in the advance towards the Ophiuroidea. Similarly the mouth-frame of this species helps us to understand the origin of the modifications found in recent forms of the class.

An oral view is shown in Pl. I, fig. 6. Judged from this aspect there is little advance from *Eoactis simplex*. Neither the ambulacralia nor the adambulacralia of the mouth-region are much differentiated with respect to size, and correspondingly there could have been little adaptation of the tube-feet to form the large buccal tentacles of the true Ophiuroidea.

Apically also the structure at first sight appears simple. If we examine more closely, however (Pl. I, fig. 7), we find that the first adambulacralia are reduced, and consequently not seen from the dorsal surface. Both the first and second tube-feet, as in Ophiuroids, are supplied by a single vessel which comes off from the ring canal, and pierces the first ambulacral ($c_{(2)}$ in figure). An exceedingly well-preserved specimen in my possession shows the course of this vessel (Text-fig. 28). A forwardly projecting branch runs in a groove towards the depression for the first tube-foot, and a very short downwardly projecting branch pierces the first ambulacral and supplies the second tube-foot. A comparison of this structure with that shown in Text-fig. 27 is most instructive as showing the forward shift of the second buccal tentacle in Recent Ophiuroidea and the consequent elongation of its water-vascular canal.

Besides these resemblances to the Recent Ophiuroidea, *Stenaster* shows peculiarities which are found in other Palæozoic species and serve to show their digression from the main stock. There are a comparatively large number of ambulacralia intimately connected with the mouth-frame. In Recent Ophiuroidea, it will be remembered, the "jaws" are formed from fused mouth-angle plates and a_1, while a_2 are free vertebræ. In *Stenaster* a_1 often fuses with a_2. Further, the bases of these ossicles are not approximate as in Recent Ophiuroidea, but widely separate (compare Pl. I, figs. 3, 6 and 10).

The Mouth-Frame of Lapworthura.—Sollas and Sollas have recently given a very detailed and careful account of the mouth-frame of *Lapworthura*. The following account is from my own investigations and is in one or two details slightly different from that previously published. The component ossicles are well differentiated.

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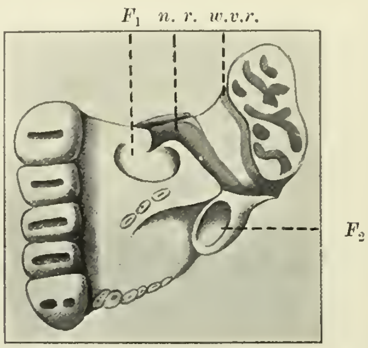

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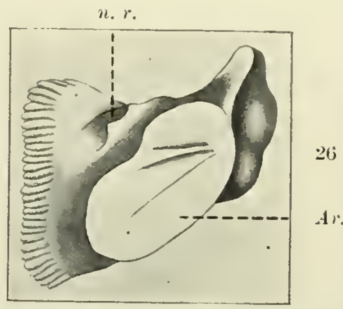
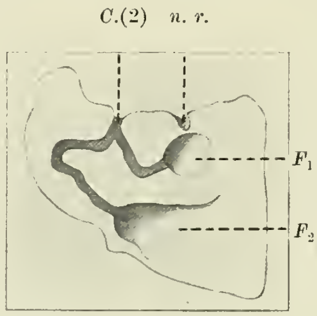
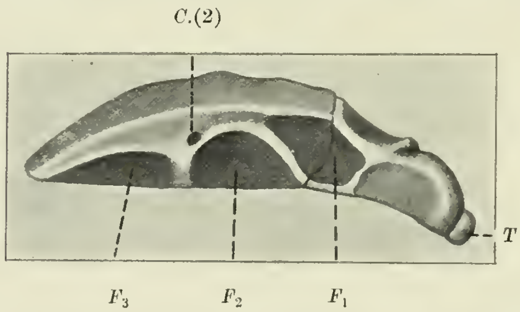


TEXT-FIG. 25 (on left).—Inner view of jaw of *Ophiarachna incrassata* (after Ludwig). Lettering as on Plate I.
TEXT-FIG. 26 (on right).—Outer view of jaw of *Ophiarachna incrassata* (after Ludwig). *Ar.*, articulating face with jaw of next radius; *n. r.*, nerve ring.



TEXT-FIG. 27.—Inner view of jaw of *Ophiarachna incrassata*, cut away to show course of canals to the first two tube-feet (after Ludwig). Lettering as on Plate I.



TEXT FIG. 28.—Inner view of mouth-parts of *Stenaster obtusus*. Lettering as on Plate I.

In fact almost the only primitive feature possessed by the mouth-frame of the form is the unfused condition of the mouth-angle plates and the first ambulacralia.

Plate I, fig. 9 shows the mouth-frame in apical view. The radial ossicles bounding the mouth are large, stout and bow-shaped. According to Prof. and Miss Sollas these ossicles consist of a_1, a_2, a_3, and an abactinal crest of a_4 and possibly a_5, these elements being fused end to end.

The a_1 of these authors is the embryonic a_1 of Ludwig, which they believe they can detect in *Lapworthura* in a constriction of the above bow-shaped ossicles.

My interpretation of the structure is as follows (Pl. I, fig. 9): All the ambulacralia slope downwards towards the mouth (*vide supra*, p. 26). The first pair of ambulacralia (a_2 of Sollas) are much larger than the immediately succeeding ambulacralia and wholly or partially hide them. The second pair of ambulacralia (a_3 of Sollas) are particularly small, and only their most dorsal tip can usually be distinguished. The third pair of ambulacralia (a_4 of Sollas) are also overlapped, but not quite so extensively as are the preceding pair.

It may be argued that a post-mortem redeposition of calcite has contributed to the apparent fusion of the apical crests of these ossicles as noticed by Sollas and Sollas. The amount of overlap appears to vary, suggesting that during life there was some play possible between the ossicles. Nevertheless, with the very clear example of *Stenaster* before us, it appears to me that the above authors are correct in their conclusion that a fusion of several pairs of ambulacralia in the mouth region may occur as a distinctive feature in many species of Palæozoic Ophiuroidea. The amount of fusion probably varies in different individuals of the same species and most commonly affects the first two pairs of ambulacralia.

Orally there is also a marked differentiation in the ambulacralia (Pl. I, fig. 10). The base of the first ambulacral is excavated into a large bowl-shaped depression, doubtless occupied by a large buccal tentacle (the second buccal tentacle). The first buccal tentacle occupies the same position as it does in *Eoactis* and *Stenaster*.

The adambulacralia are almost as much modified as in recent Ophiuroidea. The first adambulacralia (lateral buccal shields of Recent forms) are often fused with the first ambulacralia and are not to be distinguished as separate plates. The second adambulacralia are very small and appear as very thin plates in apical view. It is not until we reach the fourth or fifth ossicles of the series that the adambulacralia form a stout wall to the arm (Pl. I, fig. 9).

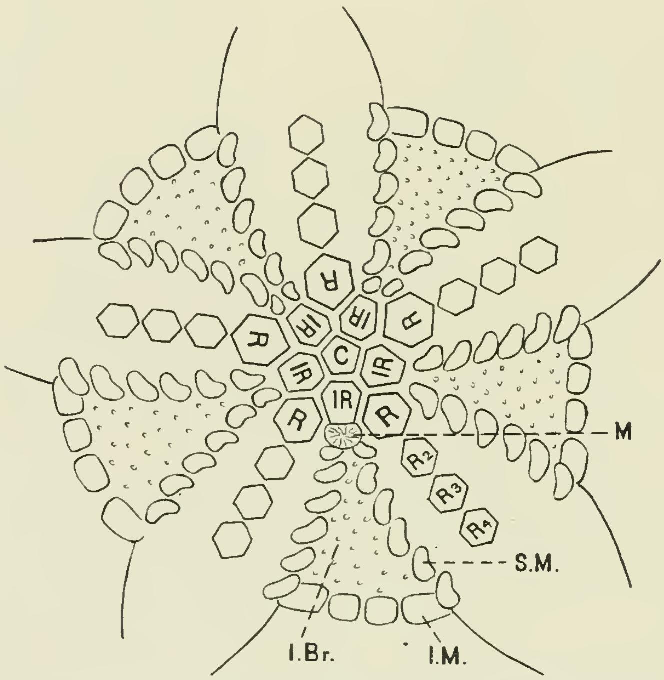
A thin plate which occupies the position of a torus is apparently present, but it is difficult to recognise it with certainty. Stout spines ("teeth") are situated at the apex of the mouth-angle plates.

As in *Stenaster*, the groove for the radial water-vascular vessel is very wide near the mouth, but quickly narrows and becomes completely closed over.

The Mouth-Frame of Aspidosoma grayæ.—The mouth-frame of *Aspidosoma* will be described in detail later. Meanwhile it is sufficient to note that its structure, just as that of the arm (p. 24), is intermediate between that of *Stenaster* and that of *Lapworthura*. Pl. I, fig. 8 shows the differentiation of the ossicles as seen in oral view.

C. THE ACCESSORY OSSICLES OF THE DISC.

The Apical System of Asteroidea and Ophiuroidea.—In certain genera of Asteroidea and of Ophiuroidea the apical surface of the disc is covered with plates which are arranged in the symmetrical manner diagrammatised Text-fig. 29. The arrangement of these plates recalls the disposition of the calyx plates in the Pelmatozoa, and various authors, *e. g.* Carpenter and Lovén, have, in consequence, attached great importance to it as suggesting the common ancestry of the Crinoidea, the Asteroidea, and the Ophiuroidea (the so-called "calycinal" theory).



TEXT-FIG. 29.—Diagrammatic representation of disc of an Asteroid to illustrate pp. 34—38. *C.*, centrale; *R.*, primary radialia; *I. R.*, primary inter-radialia; *I. Br.*, inter-brachial area; *I. M.*, infero-marginalia; *S. M.*, supero-marginalia; *M.*, madreporite.

Support seemed to be offered to this suggestion by the fact that the plates could be distinguished in young Asteroidea and Ophiuroidea even when they were not clearly apparent in the more adult forms (Ludwig, 40). Stürtz (79, p. 182) has already shown that the evidence of Palæontology is not in favour of the view that this apical system, at any rate in the Ophiuroidea, has any real significance as to ancestry. He has pointed out that no Palæozoic Ophiuroid shows an apical system, and that this appears to be a post-Palæozoic development. My own observations agree with this. They show that the most primitive Asterozoa have a leathery skin in which are embedded small irregular plates. On the other hand, many primitive Asteroidea do show this apical system. It is probable that the arrangement is not due to the retention of an ancestral feature, but is acquired secondarily and independently in many forms. The presence of the apical system is worth noting, however, because the madreporite in true Asteroidea is found very frequently at the distal end of one of the primary interradialia (Text-fig. 29).

The Interbrachial Area.—Schöndorf has shown that many Palæozoic Asteroidea have a weakly calcified area in each interradius. The area is bounded apically by the supero-marginalia, and orally by the infero-marginalia. Usually in Recent forms these two marginal series touch throughout their entire length. The interbrachial area may have been of use for respiration.

D. THE MADREPORITE.

The study of the madreporite in fossil Asterozoa is most important, as its form and position enable us to decide many questions of relationship. The madreporite is, as is well known, the perforated plate through which water is conveyed, by means of a vessel known as the "stone-canal," to the water-vascular system. The madreporite, in Recent Asteroidea, is *apical*, large, and has characteristic striations. In Recent Ophiuroidea, on the contrary, there is usually no special striated plate, but the stone-canal opens to the exterior through a small aperture in the *orally* situated buccal shields (see p. 16).

Many fossil Asterozoa do not appear to possess a madreporite, and it is probable that in those cases the water pore opened to the exterior through small openings unrecognisable in any but exceedingly well-preserved specimens. Other fossils show a madreporite that is neither oral nor apical but marginal in position.

(*a*) *The Size of the Madreporite.*—MacBride (43, p. 487) has pointed out that the size of the madreporite appears to be governed by the extent to which the tube-feet are used. In the Asteroidea the tube-feet are large and are constantly being vigorously extended. There is in consequence a loss of fluid by transudation. In the Ophiuroidea the tube-feet are merely sense-organs and the extension is no longer a vigorous act. The loss of water is much less and the madreporite is much reduced. Many Palæozoic Asterozoa do not appear to have a madreporite. I am inclined to regard this, in these old forms, as usually a primitive feature. On the other hand, a conspicuous madreporite is developed not only in the majority of the true Asteroidea, but in many Palæozoic Ophiuroid-like forms, as, *e.g.*, *Lapworthura miltoni*, Salter, and in various species of *Protaster*. This suggests that the tube-feet in these forms were more actively concerned in locomotion than in Recent Ophiuroidea, a feature also suggested by the comparatively large size of the branch canals.

At a later period the perfection of the "wriggling" movements of the arm rendered these "walking" functions of the tube-feet unnecessary, and led to a secondary reduction in the size of the opening of the stone-canal in the Ophiuroidea.

(*b*) *The Position of the Madreporite.*—Recent work has done much to clear up the various problems connected with the position of the madreporite in Palæozoic forms. Answers have to be found to the following questions:

(i) Which of the positions, oral, apical, or marginal, is the primitive one?

(ii) At what stage did the migration of the madreporite from one surface to the other occur?

Various misconceptions have arisen in the discussion of these two points. A clear account of these has recently been given by Sollas and Sollas (71), and the quotations given below are from their paper.

Stürtz at various times described a number of fossil Asterozoa regarded by him as belonging to the Asteroidea which had an actinal (ventral) madreporite. His observations led him to suggest (78, 1890) "that if the madreporite originally occurred on the same aspect of the body in both Starfishes and Brittle stars, it was actinal in both, and that it is in the Starfish and not in the Brittle star that a change has taken place." He called attention to a prediction made by Sladen in 1880, who, commenting on Agassiz's statement (1) that in very young starfish the madreporite is at first ventral (actinal) and only subsequently becomes dorsal (abactinal), suggested that ancient fossil starfish would be found in which the madreporite retained its ventral (actinal) position in the fully adult state. Stürtz added that this prophetic remark had not long to wait for justification; several fossil starfish were already known at that date in which the madreporite lies on the actinal surface of the adult.

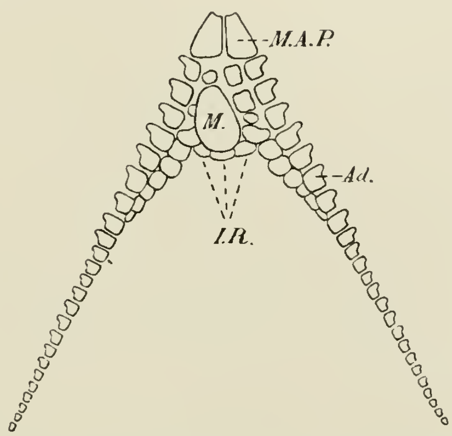
In 1896 the situation was obscured by the observations of Gregory (26), who, in his description of *Lapworthura miltoni*, followed Salter (see p. 40) in assigning the madreporite to the dorsal surface.

Salter had in consequence of this observation transferred the species to the Asteroidea. Gregory retained it in the Ophiuroidea, to which it had rightly been transferred by Stürtz, and definitely stated that the madreporite was dorsal in some Ophiuroidea.

This led Stürtz (80) to draw "attention to the difficulty which is introduced into the phylogeny of Stelleroidea by Gregory's description of *Lapworthura* and of *Eucladia*, and his statements that Bury had found a dorsal madreporite in young Ophiuroidea; for, he argued, while in Starfish we have modern forms with a dorsal (abactinal) madreporite and primitive forms with ventral (actinal) madreporite, and according to Agassiz a ventral (actinal) madreporite in young starfish, in the Ophiuroidea, on the other hand, the converse appears to be the case. Again, if in the original stock of Ophiuroidea the madreporite lay on the abactinal, and in the original stock of the Asteroidea on the actinal side, this fact would not lead to the view that the Ophiuroidea and Asteroidea were derived from the same stock."

Prof. and Miss Sollas and Schöndorf, working independently, have been able to show that Salter and Gregory were mistaken, and that the madreporite is actinal in *Lapworthura*, being in fact almost exactly in the same position as is the opening of the stone-canal in Recent Ophiuroidea (Sollas and Sollas, 71, p. 216). Further, these two authors have shown that Gregory was mistaken in his quotation of Bury, "who was speaking not of the young Ophiuroid but of the larva" (71, p. 215). The observations which caused Stürtz such misgivings may therefore be ignored.

My own observations appear to show that Stürtz was very nearly correct when he assumed that the ventral position of the madreporite was the primitive one, and that the dorsal position found in the Asteroidea has been assumed secondarily.



TEXT-FIG. 30.—View of inter-radius of *Palæasterina primæva*. *I. R.*, inter-radial plates; *M.*, madreporite; *M. A. P.*, mouth-angle plates; *Ad.*, adambulacralia.

If we consider the three groups, the primitive Asterozoa, the Ophiuroidea and the Asteroidea, we find that in the first two of these the madreporite, when known, is almost always in the same position, namely, somewhat excentric to a median line drawn through an inter-radius and adjacent to the first two or three adambulacralia (Pl. I, figs. 8 and 10). In the Ophiuroidea the madreporite (on one of the buccal shields) is on the oral surface and there is a large area of the disc external to it (Text-fig. 12). If this arrangement were the primitive one, the madreporite would have had to travel over a large surface before it reached a secondary dorsal position, and we should expect to find traces of the migration.

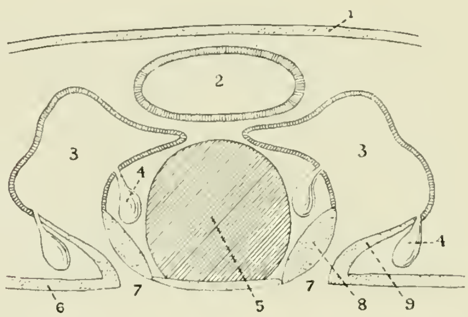
Fortunately, the observations of MacBride help us out of the difficulty. MacBride has shown (41) that the Ophiuroid disc is a secondary growth of the aboral parts of the interradii which grow round to form pouches for the reception of the stomach and for space for the genital bursæ. Primitively, the Ophiuroidea had a very small disc. Further, the overgrowth of the disc has led to the forcing of the madreporite from a marginal to an oral position.

MacBride's views are supported by investigations upon the primitive Asterozoa.

When one examines these early forms one is struck by the large number of species in which the disc is small compared with the arms. Such a form is *Palæasterina primæva* (Text-fig. 30). At the first sight the madreporite appears to be on the oral surface. If we examine the form more closely we find that the interradial area, in which is placed the madreporite, does not really belong to the oral surface, but has been squeezed by post-mortem compression into that position. The madreporite was really marginal and originally occupied a position just dorsal to the adambulacralia.

In fact, the madreporite is exactly in the position observed in Bury's figures of newly metamorphosed Asteroid larvæ (11, pl. vi, figs. 21, 22, 24).

The hypothesis advanced here also renders it comparatively easy to follow the dorsal migration of the madreporite in the Asteroidea. The primitive position of this plate must have been at about the point *I. Br.* of Text-fig. 29. The plate



Text-fig. 31.—Diagrammatic cross-section of disc of an Ophiuroid (after Lang). 1, dorsal wall of disc; 2, bulging of the digestive sac; 3, bursa; 4, gonad on the bursal wall; 5, base of the arm; 6, ventral wall of the disc; 7, genital slit; 8, genital plate; 9, bursal scale.

had only to travel a short distance through the slightly calcified interbrachial area to its final destination. It is possible that this dorsal migration was brought about when the tube-feet began to be used both for walking and for pulling. The strong cilia placed in the pores of the madreporite and in the stone-canal would tend to become clogged with mud if the current of water which they produce originated too near the sea bottom. The efficiency of the water-vascular system would thus be impaired, as the tube-feet could no longer be kept tensely filled with water.

An adapical migration of the madreporite occurred also in other branches of the primitive stock, *e g.* in *Tropidaster pectinatus*, a Liassic representative of a family the characteristics of which will be described in later portions of this monograph.

Genital Bursæ in the Aspidosomatidæ.—I found on investigating *Aspidosoma grayæ* that there was good evidence of the presence of genital bursæ in this group. The species is represented by about five or six well-preserved specimens, and the disc of each was found to be crowded with young. The only explanation which can be offered is that the form was viviparous, as are certain Recent Ophiuroids, *e. g. Amphiura squamata.* The young of the recent viviparous Ophiuroidea spend their early stages in the genital bursæ. These are five pairs of large sac-like invaginations which penetrate into the cœlom of the disc (Text-fig. 31). They communicate with the exterior by means of slit-like apertures, which lie at the base of the arms on the lower (oral) side of the disc (Text-fig. 12). The openings are strengthened on their radial side by the "genital plates" and on the inter-radial side by ossicles called the "genital scales." Gonads are attached to the walls of the bursæ. The main function of the bursæ is respiratory. They are lined with cilia, which bring about a constant inward current of fresh sea-water, the oxygen in which diffuses through the thin wall of the sac into the cœlomic fluid (MacBride, 43, p. 485). Occasionally, however (as mentioned above), they act as brood pouches.

If we accept the view that the Aspidosomatidæ possessed genital bursæ we have a ready explanation of the fact noticed by Schöndorf, that the marginalia of the Aspidosomatidæ are distinctly separate from the adambulacralia of the arm (64, p. 50). The marginalia near the arm (Pl. I, fig. 8) are arranged in a way that at once suggests that they strengthen the boundary of a slit at the edge of the disc corresponding to the genital slit in Recent Ophiuroidea. The structure, together with the presence of the young forms in the disc of *Aspidosoma grayæ*, shows the length to which the homoplastic correspondence in race development of the true Ophiuroidea and the Aspidosomatidæ has proceeded (see p. 52).

SUMMARY OF LITERATURE.

Our knowledge of the structure and relationships of Palæozoic Asterozoa may roughly be grouped round three periods:

(1) The period of the work of Forbes and Salter in England and Billings and Hall in America, 1845—1867.

(2) The period of the work of Stürtz in Germany and Gregory in England, 1885—1899.

(3) The recent researches of Schöndorf and Prof. and Miss Sollas.

The First Period.

A summary of the knowledge in 1863 from the point of view of the English palæontologist is given by Wright (81, pp. 22—37). Almost the whole of the fossil forms known at that time had come from comparatively few localities and horizons. The specimens described by Forbes were collected in the Bala (Ordovician) rocks of Wales, the Ludlow (Silurian) rocks of Westmoreland and the Wenlock Limestone (Silurian) rocks of Dudley, Staffordshire. Salter describes numerous species found only in the well-known Leintwardine (Lower Ludlow) rocks on the borders of Wales, and Hall and Billings obtained much of their material from the Trenton (Ordovician) Limestone of New York and Ottawa.

The following genera and species were known :

Palæaster, Hall.
- *Palæaster asperrimus*, Salter.
- *Palæaster obtusus*, Forbes.
- *Palæaster coronella*, Salter.
- *Palæaster ruthveni*, Forbes.
- *Palæaster hirudo*, Forbes.
- *Palæaster niagarensis*, Hall.
- *Palæaster sp.*, undescribed, from Devon.
- *Palæaster matutina*, Hall.

Palæocoma, Salter.
- *Palæocoma colvini*, Salter.
- *Palæocoma cygnipes*, Salter.
- *Palæocoma marstoni*, Salter.

Sub-genus *Bdellacoma*, Salter.
- *Bdellacoma vermiformis*, Salter.

Sub-genus *Rhopalocoma*, Salter
- *Rhopalocoma pyrotechnica*, Salter.

Palæodiscus, Salter.
- *Palæodiscus ferox*, Salter (since shown to be an Echinoid).

Palasterina, M'Coy.
- *Palasterina primæva*, Forbes.
- *Palasterina antiqua*, Hisinger.
- *Palasterina stellata*, Billings.
- *Palasterina rugosa*, Billings.

Petraster, Billings.
- *Petraster rigidus*, Billings.

Protaster, Forbes.
- *Protaster leptosoma*, Salter.
- *Protaster miltoni*, Salter.
- *Protaster salteri*, Sowerby.
- *Protaster sedgwicki*, Forbes.

Stenaster, Billings.
- *Stenaster pulchellus*, Billings.
- *Stenaster salteri*, Billings.

Tæniaster, Billings.
- *Tæniaster cylindricus*, Billings.
- *Tæniaster spinosus*, Billings.

Lepidaster, Forbes.
- *Lepidaster grayi*, Forbes.

The following forms are also mentioned :

Asterias antiqua, from the Silurian rocks in the State of Tennessee.

Asterias rhenana, Johannes Müller, from the Devonian Sandstone at Coblentz.

Asterias constellata, Thorent.

Asterias obtusus, Goldfuss, from the Muschelkalk of Würtemberg.

Wright omitted to mention *Cœlaster latiscutatus*, G. and Fr. Sandb., and *Aspidosoma arnoldi*, Goldfuss, both from the Devonian of Germany. This latter form was with great insight stated by Johannes Müller (52) to be closely related to *Protaster*, Forbes.

Wright, following the views of Salter, placed all the above genera among the Asteroidea, although he admitted that *Tæniaster* had relations with the Ophiuroidea (p. 34). Salter, in his first paper (57), had noticed the obvious resemblance of the general body-form of *Protaster miltoni* to the Ophiuroidea, and had placed it in that group. Later research (58) convinced him that the madreporite was dorsal, and he transferred the form to the Asteroidea.

This earlier work is, as may be expected, lacking in detailed observation. Workers then were not concerned with theories of evolution, and were usually satisfied with generalised descriptions, which, taken with the figured specimens, would allow identification of specimens in cabinets and museums. Few attempts were made to distinguish between the important component ossicles, *e. g.*, the adambulacralia and the marginalia; and the significance of the fact that certain forms are characterised by alternating rather than by opposite ambulacralia also appears to have escaped notice.

An advance was made by Bronn (1860, 14, pp. 217—218), who divided the extinct genera into three divisions:

(1) The **Encrinasteriæ.** Asteroids with alternating ambulacralia and a ventral madreporite.

(2) The **Euasteriæ.** Asteroids with opposite ambulacralia and a dorsal madreporite.

(3) The **Ophiurasteriæ** (the Ophiuroidea).

It is important to take notice of this classification as the terms have been much used by later systematists.

The Second Period.

The second period includes the work of Stürtz, published in 1886 (76), 1890 (78), 1893 (79), and 1899 (80), and the work of Gregory, 1896 (26), 1899 (27), and 1900 (28).

Stürtz described a number of forms from the Bundenbach (Devonian) Slates of Germany. The original calcite and frequently even the integument was, at some period, pyritised, and the forms can be developed by metallic brushes, which clear away the matrix more readily than the specimen. The great majority of the originals were afterwards purchased by the British Museum (Natural History), and were examined and compared with English specimens by Gregory.

(A) *The Classification of the Ophiuroidea.*—Stürtz regarded a number of the Palæozoic forms as true Ophiuroidea. As a basis for the classification of these Ophiuroidea the sub-division proposed by Johannes Müller was adopted.

Sub-order 1. **The Ophiuræ** (Sandstars and Brittle-stars).

Forms with undivided arms, dorsal and ventral shields and usually mouth-shields.

This sub-order contains three groups of Recent forms.

Group *Ophioglyphidæ.*

„ *Amphiuridæ.*

„ *Ophiomyxidæ* (or *Astrophyton*-like Ophiurans).

Sub-order 2. **Euryalæ** (Medusaheads, Astrophytidæ of Lyman).

Forms with dichotomously branching arms usually covered with a skin containing small calcifications. Dorsal, ventral, and mouth-shields absent.

Stürtz placed all the Palæozoic "Ophiuroidea" in one of the above sub-orders. He, however, founded two new families of the Ophiuræ.

The first of these contains forms which are Ophiuroid in appearance, but have the halves of their vertebræ alternating with each other. Adopting a nomenclature corresponding to that used by Bronn for the sub-division of the Asteroidea, Stürtz called this Family the Ophio-Encrinasteriæ.

The second Family he called the Protophiureæ. This contains the great majority of the remaining Palæozoic Ophiuroidea. The primitive character of the forms is shown by the imperfection of the union of the opposing halves of the vertebræ and by the usual absence of dorsal, ventral, and mouth shields. Stürtz regarded the Protophiureæ as related to certain recent deep-sea genera—*Ophiotholia*, *Ophiogeron*, *Ophiohelus*, and *Ophiobyrsa*—which at first sight have a similar structure of their vertebræ, and do not possess dorsal shields.

The Palæozoic Ophiuroid forms which have branched arms and a leathery skin, *e.g. Helianthaster*, were at first (79, 1893) placed among the recent Euryalæ, which possess characters similar in these respects. Later (80, 1899) Stürtz stated that he was doubtful as to the exact position of these forms, which might belong either to the Protophiureæ or to the Palæ-Euryalidæ. The observations made by Stürtz were limited by the nature of his material. The process of pyritisation frequently destroyed detail in structure. The resemblances relied upon by Stürtz to establish relationships between living and fossil forms are only superficial, and when more perfectly preserved specimens are obtained these assumed relationships can readily be disproved.

The classification of Stürtz is given in detail below, together with that of Gregory, who almost entirely adopted the views of Stürtz on the Palæozoic forms which should be placed amongst the Ophiuroidea, but took as his basis of classification that proposed by Bell (10). Bell's classification divides Recent Ophiuroidea according to the form of the articulating facets on the vertebræ.

There are three main Orders:

(1) **Streptophiuræ,** in which the faces of the vertebræ have rudimentary knobs and corresponding depressions, so that the arms can be coiled in the vertical plane. These are regarded as the most primitive of the Ophiuroidea.

The Order includes the whole of the Ophiomyxidæ and a few genera of the Amphiuridæ of Lyman.

(2) **Zygophiuræ,** in which the vertebral faces have knobs and pits which prevent their coiling in a vertical plane (Text-fig. 16, p. 18).

The Order includes the Ophioglyphidæ and the majority of the Amphiuridæ of Lyman.

(3) **Cladophiuræ,** in which the arms can be coiled as in (1), and are in most cases forked. No teeth; the arm-spines are

papillæ, the covering plates of the arm are reduced to granules.

Gregory, in order to establish a uniformity in nomenclature, founded a new Order, the **Lysophiuræ,** to contain the forms included by Stürtz in the Ophio-Encrinasteriæ. The remaining genera were placed in the Streptophiuræ, which was regarded by Bell as containing more primitive forms than those of the Zygophiuræ.

The same objections that have been urged against the views of Stürtz apply with even greater force against the classification proposed by Gregory. Investigation shows that there is a wide difference between the structure of the Palæozoic "Ophiuroidea" and that described for Recent Streptophiuræ. Indeed the recent work of Miss Sollas throws considerable doubt on the so-called "streptophiuran" structure, and it appears to me that the Streptophiuræ may be, not more primitive than the Zygophiuræ, but secondarily degenerate.

Classification of the Palæozoic Ophiuroidea, as arranged by Stürtz in 1899 *to show the correspondence of his earlier classification with that of Gregory.*

Stürtz, 1893.	Gregory, 1896.
Sub-order Ophiureæ.	OPHIUROIDEA.
1. Family Ophio-Encrinasteriæ, Stürtz, 1886, 1890, 1893.	1. Order LYSOPHIURÆ.
With five arms, disc round or pentagonal. Without dorsal, radial, ventral and mouth-shields. Two halves of the vertebræ not fused, placed alternately with each other.	Ophiuroidea in which the ambulacral ossicles are alternate and are not united into vertebral ossicles, but those of each segment are separate. There are no ventral arm-plates, and the ventral side of the arm is occupied by an ambulacral furrow.
	1. Family Protasteridæ.
	Lysophiuræ with boot-shaped ambulacral ossicles, each composed of a "body" in the median line of the arm and a lateral "wing" at right angles to it.
Protaster sedgwicki, Forbes.	*Protaster sedgwicki*, Forbes.
Protaster forbesi, Hall.	Not investigated.
Not investigated.	*Protaster biforis*, Gregory.
Bundenbachia beneckei, Stürtz.	*Bundenbachia beneckei*, Stürtz.
	2. Family Palæophiuridæ.
	Lysophiuræ in which the ambulacral ossicles consist of a bar-shaped or sub-graduate "body" without wings.
Protaster brisingoides, Gregory.	*Sturtzura brisingoides*, Gregory.
Protaster leptosoma, Salter.	*Sturtzura leptosoma*, Salter.

Stürtz, 1893.

Palæophiura simplex, Stürtz.
Tæniaster cylindricus, Billings.
Tæniaster spinosus, Billings.
Eugaster logani, Hall.
Species not recognised.
? ? *Bundenbachia grandis*, Stürtz.

2. Family Protophiuræ, 1886.

Ophiurids without mouth, dorsal and radial shields, partly with, partly without, ventral shields. Two halves of vertebræ united more or less as in Recent Ophiurids.

1. Group of the Protophiuræ, 1893.

Ophiurids without ventral shields, halves of vertebræ imperfectly united. Vertebral halves seen from the dorsal side as bar-shaped bodies.

Ophiurina lymani, Stürtz.
Not investigated.
" "

2. Group of the Protophiuræ, 1893.

Separate halves of the vertebræ united with each other. No mouth, ventral or dorsal shields.

Protaster miltoni, Salter.
Furcaster palæozoicus, Stürtz.
Ophiura zitteli, Stürtz.
Not investigated.
" "

3. Group of the Protophiuræ, 1893.

As in imperfectly developed Recent Ophiuræ, with ventral shields, but without buccal and dorsal shields. Halves of vertebræ united.

Ophiura decheni, Stürtz.
Ophiura primigenia, Stürtz.
Ophiura rhenana, Stürtz.
Not investigated.
" "

Sub-order Euryalæ.

As Recent Euryalæ, except that they are without buccal shields and have marginal arm-spines (Stürtz, 1893).

Gregory, 1896.

Palæophiura simplex, Stürtz.
Tæniura cylindricus, Billings.
Species not recognised.
Eugaster logani, Hall.
Ptilonaster princeps, Hall.
Not investigated.

2. Order STREPTOPHIURÆ.

Defined as by Bell.

1. Family Ophiuroidæ, 1896.

Streptophiuræ without ventral arm-plates and with separate ambulacral ossicles.

Ophiurina lymani, Stürtz.
Tremataster difficilis, Worthen and Mill.
? *Protaster decheni*, Dewalque.

2. Family Lapworthuridæ, 1896.

Streptophiuræ without ventral arm-plates or buccal shields. Ambulacral ossicles fused, but their articulatory surfaces plain.

Lapworthura miltoni, Salter.
Furcaster palæozoicus, Stürtz.
Palastropecten zitteli, Stürtz.
Protaster daoulasensis, Davy.
Aganaster, pars, Miller and Gurley.

3. Family Eoluidiæ, 1896.

Streptophiuræ, with ambulacral ossicles united to form vertebral ossicles. Ventral arm-plates present, but neither buccal shields nor dorsal arm-plates.

Eoluidia decheni, Stürtz.
Eospondylus primigenia, Stürtz.
Miospondylus rhenana, Stürtz.
Aganaster gregarius, Worthen and Miller.
Cholaster, Worthen and Miller.

4. Family Onychasteridæ, Bell, 1892; Gregory, 1896.

Streptophiuræ, with well-developed vertebral ossicles and very flexible unbranched arms. No external arm-plates, the integument only containing granules.

Stürtz, 1893.	Gregory, 1896.
Onychaster flexilis, Meek and Worthen.	*Onychaster flexilis*, Meek and Worthen.
	5. Family Eucladiidæ, 1896.
	Streptophiuræ, with contorted branching arms. Five pairs of large plates round the centre of the side exposed in the fossil have been regarded either as jaws or radial shields. Madreporite on the same side as the plates. Arms have no external arm-plates, but a granular integument.
Eucladia johnsoni, H. Woodward.	*Eucladia johnsoni*, H. Woodward.
Helianthaster rhenanus, Roemer emend. Stürtz.	Not investigated.

Classification of the Ophiuroidea according to Stürtz, 1899.

Sub-order Ophiureæ.

1. Family Ophio-Encrinasteriæ (characters as in 1893), including *Protaster sedgwicki*, Forbes, *P. forbesi*, Hall, *P. biforis*, Gregory, *Sturtzura brisingoides*, Gregory, *S. leptosoma*, Salter sp., *Palæophiura simplex*, Stürtz, *Tæniaster cylindricus*, Billings, *T. spinosus*, Billings, *Eugaster logani*, Hall, ? *Ptilonaster princeps*, Hall.
2. Family Protophiureæ (characters as in 1893, except that Stürtz remarks that when the opposing halves of the vertebræ are fused they are more or less of a streptophiuran type).
    1. Sub-family Ophiurinidæ, including *Ophiurina lymanni*, Stürtz.
    2. Sub-family Palæospondylidæ, including *Palæospondylus* (*Ophiura*) *zitteli*, Stürtz.
    3. Sub-family Palæophiomyxidæ, including *Palæophiomyxa* (*Bundenbachia*) *grandis*, Stürtz.
    4. Sub-family Onychasteridæ, including *Onychaster flexilis*, Meek and Worthen.
    5. Sub-family Lapworthuridæ, including *Lapworthura* (*Protaster*) *miltoni*, Salter sp.
    6. Sub-family Furcasteridæ, including *Furcaster palæozoicus*, Stürtz.
    7. Sub-family Eophiuridæ, including *Eophiurites* (*Ophiura*) *decheni*, Stürtz, *Eospondylus* (*Ophiura*) *primigenius*, Stürtz sp., *Miospondylus* (*Ophiura*) *rhenanus*, Stürtz sp.
    8. Sub-family Aganasteridæ, including *Aganaster* (*Protaster*, *Ophiopege*) *gregarius*, Worthen and Meek sp., ? *Cholaster*, Worthen and Miller.

Primitive streptospondylous forms of doubtful affinity (Protophiureæ or Palæ-Euryalidæ), including *Helianthaster rhenanus*, F. Roemer, *Eucladia johnsoni*, Woodward.

(b) *The Classification of the Asteroidea.*—Stürtz, following Bronn, divided the forms which he regarded as Asteroidea into the two sub-orders, Encrinasteriæ and Euasteroidea. These sub-orders were again subdivided into Phanerozonia and Cryptozonia. Four main groups were thus obtained:

1. Encrinasteriæ-Phanerozonia, including *Aspidosoma tischbeinianum*, Roemer em. Stürtz, *A. arnoldi*, J. Müller, *A. arnoldi*, Goldfuss, *A. petaloides*, Simonow, *A. sp.*, Stürtz, *Stenaster* (*Palæaster*) *ruthveni*, Forbes, *S. hirudo*, Forbes, *S. pulchellus*, Billings, *S. coronella*, Salter, *Urasterella* (*Stenaster*) *salteri*, Billings, *Urasterella* (*Uraster*) *obtusa*, Forbes, *Hudsonaster* (*Palasterina*) *rugosum*, Billings, *Palæaster* (many species), Hall, Billings, Salter, *Archasterias rhenana*, J. Müller, *Palæostella solida*,

Stürtz, *Palænectria devonica*, Stürtz, *Salteraster* (*Palæaster*) *asperrimus*, Salter, *Hisingeraster* (*Palasterina*) *antiqua*, *Trentonaster* (*Palasterina*) *stellata*, Billings, *Palasterina primæva*, Forbes.

2. Encrinasteriæ-Cryptozonia, including *Pseudopalasterina* (*Palasterina*) *follmanni*, Stürtz, *Palasteriscus devonicus*, Stürtz, *Palæosolaster gregoryi*, Stürtz, *Palæocoma marstoni*, Salter, *P. colvini*, Salter, *P. cygnipes*, Salter, *Bdellacoma vermiformis*, Salter, *Rhopalocoma pyrotechnica*, Salter, *Loriolaster mirabilis*, Stürtz, *Cheiropteraster giganteus*, Stürtz.

3. Eustelleridæ-Phanerozonia, including *Xenaster simplex*, Simonow., *X. margaritatus*, Simonow., *Astropecten schlüteri*, Stürtz.

4. Eustelleridæ-Cryptozonia, including *Lepidaster grayi*, Forbes, *Roemeraster asperula*, Röm.-Stürtz, *Asterias acuminatus*, Simonow., *Jaekelaster petaliformis*, Stürtz, *Echinasterella sladeni*, Stürtz, *Echinasterias spinosus*, Stürtz, *Echinodiscus multidactylus*, Stürtz, *Echinostella traquairi*, Stürtz, *Medusaster rhenanus*, Stürtz, *Protasteracanthion primus*, Stürtz.

Stürtz thought that he could establish a near relationship between these Palæozoic forms and certain Recent genera, and the table given 80, pp. 206—208, summarises his views on this point.

Gregory in 1899 (27) proposed to abandon the classification of Bronn, for, as he rightly observed, the character is difficult to use. "In some starfishes the ambulacral ossicles in one part of a ray may be alternate, while in another part they may be opposite."

Gregory preferred to rely upon Sladen's classification into Phanerozonia and Cryptozonia, and regarded the alternation of the ambulacralia as a primitive character which could be found in early members of both these groups.

Gregory's classification is as follows:

Order 1. PHANEROZONIA.

Family 1. Palæasteridæ.

Phanerozonia with the ambulacral ossicles all or mostly alternate in position. The madreporite is abactinal, and the oral armature adambulacral. The skeleton of the abactinal surface and interradial areas is tessellate. Marginal plates large.

Sub-family 1. Palæasterinæ.

Palæasteridæ with the ambulacral ossicles definitely alternate. The rays are usually long and sharply marked off from the disc, which is usually small, with interradia areas. Genera: *Palæaster*, Hall, *Argaster*, Hall, ? *Tetraster*, Etheridge, jun., and Nicholson, *Petraster*, Billings, *Monaster*, Etheridge, jun., pars.

Sub-family 2. Xenasterinæ.

Palæasteridæ with the general characters of the Palæasterinæ, but with most of the ambulacral ossicles opposite. Genus: *Xenaster*, Simonowitsch.

Sub Family 3. Lindstromasterinæ.

Palæasteridæ with alternate ambulacral ossicles, a large disc covered with tessellate plates, and large interradial areas. Genera: *Lindstromaster*, Gregory, *Uranaster*, Gregory.

Family 2. Palæasterinidae.

Phanerozonia with the ambulacral ossicles alternate, the oral armature adambulacral, and the madreporite abactinal. The disc is large and pentagonal, and the rays are short and separated by large interradial areas. The marginal plates are smaller than the adambulacral plates. Genera: *Palæasterina*, McCoy, *Schœnaster*, Meek and Worthen, *Schuchertia*, Gregory.

Family 3. Aspidosomatidæ.

Phanerozonia with alternate ambulacral ossicles, large marginal ossicles, and extensive depressed interradial areas. Rays massive, petaloid, sub-petaloid, or tapering. Genera: *Aspidosoma*, Goldfuss, *Palæostella*, Stürtz, *Trichasteropsis*, Eck.

Family 4. Tæniasteridæ.

Phanerozonia with alternate ambulacral ossicles. There is neither disc nor interbrachial area. Large marginal plates, of which the inframarginals act as the adambulacral ossicles. Rays long, petaloid or tapering gradually. Genera: *Tæniaster*, Billings, ? *Stenaster*, Billings, *Urasterella*, McCoy, *Protasteracanthion*, Stürtz, *Salteraster*, Stürtz.

Order 2. CRYPTOZONIA.

Family Lepidasteridæ.

Cryptozonia which are heavily plated, but in which there are no special marginal plates. The ambulacral ossicles are alternate (or possibly sometimes opposite). The disc is large and the rays short, thick, and blunt or clavate. There are no lateral spines. The abactinal plates are granular and closely set. Genera: *Lepidaster*, Forbes, *Etheridgaster*, Gregory.

It does not seem profitable to discuss these classifications in any detail. Many of the forms are not true Asteroidea, but merely possess a "starfish-shaped" body. The evidence afforded by a detailed study of ossicles of the ambulacral groove and mouth-frame of forms such as *Aspidosoma* and *Stenaster* shows that certain of these so-called Asteroidea are really transition-forms between the Asteroidea and the Ophiuroidea, while other genera present characteristics which enable us to place them at the base of the Astero-Ophiuroid stem. In fact, careful analysis discovers that the true Asteroidea were represented in early Palæozoic times by but few genera and species.

Mention has already been made (p. 18) of an important preliminary paper by Jaekel. A more extended study of these important forms would be of great interest.

The Third Period.

In recent years Schöndorf (60—68) and Sollas and Sollas (71, 72) have published several valuable papers on various forms of Palæozoic Asterozoa. The merit of their work lies not only in its exact observation, but also in its suggestive character. The task of all future observers in the group is much lightened by these researches.

Schöndorf has re-investigated in particular (1) the various species of *Aspidosoma*, (2) the true Asteroidea of the Greywackes (Devonian) of the Rhine. He has shown with respect to (2) that the true Asteroidea form a small compact group readily recognisable as belonging to the class, but at the same time presenting characteristics which enable them to be placed in special families distinctive of Palæozoic times.

The various species of *Aspidosoma* were shown to have a structure which differed considerably from that of an Asteroid or a Recent Ophiuroid. Indeed the research suggested to Schöndorf that the great majority of the Palæozoic forms which had previously been regarded as Ophiuroidea, and several which had been classified with the Asteroidea, really belonged to a third new class, the Auluroidea.

The characters of the Auluroidea (Text-fig. 23, p. 23) are as follows:

(1) The radial water-vascular vessel runs in a canal which is completely enclosed on all sides by ambulacralia which are approximately half-cylinders.

(2) Side branches of the vessel enter an open broad arm-groove through short canals which (*a*) sometimes penetrate the substance of the ambulacralia, (*b*) at others run between every two ambulacralia.

(3) The ambulacralia are never fused with each other; at times they are opposite, at other times they are alternating. The adambulacralia are always opposite to the ambulacralia.

(4) Both the ambulacralia and adambulacralia send out processes which meet one another. Both these series of ossicles are hollowed out on each side of the processes. (The podia were contained in the cups formed in this manner.)

(5) The ambulacralia are covered on their dorsal surface by spines and granules.

(6) The outer wall of the disc is concave (or convex ?), and may or may not have marginalia.

(7) The marginalia, if present, are confined to the disc, and are always sharply separated from the arm by the adambulacralia.

(8) The arm is bounded at the sides by the adambulacralia, and dorsally by the ambulacralia.

(9) There is a ventral arm-groove, which is broad and open. It is bounded dorsally by the ambulacralia, and at the sides by the adambulacralia.

(10) A typical madreporite lies ventrally in an interradius.

(11) The forms are confined to the older Palæozoic rocks.

The three classes are considered of equal value in classification, and to be as distinct among themselves as are the other classes of the Echinodermata (the Echinoidea, Crinoidea, etc.).

These characters can be analysed for the purposes of criticism as follows:

Primitive Characters.—(10) The ventral madreporite (see p. 37).

(9) The broad open arm (ambulacral) groove bounded by the ambulacralia and adambulacralia (see p. 23).

(3) The unfused ambulacralia (see p. 42). The position of the ambulacralia in respect to the adambulacralia (see p. 23).

(4) The way in which cups are formed for the podia (see pp. 22—25).

(2) [*b*] The passage of the side canals between every two ambulacralia (an Asteroid character, see p. 13).

Ophiuroid Characters.—(2) [*a*] The passage of the side canals through the substance of the ambulacralia (see p. 18).

(7) The sharp separation of the calcifications of the disc from the arm (see p. 15).

For other Ophiuroid characters (not described by Schöndorf) in *Lapworthura* and *Aspidosoma grayæ*, see pp. 24—26, 31—33.

Special Characters.—(1) The enclosure of the radial water-vascular system can be traced to an overgrowth of the longitudinal ridges, which, in the primitive Asteroidea, ran alongside the ambulacral channel (see pp. 21—24).

The character itself is curiously constant in Palæozoic "wrigglers," and served to protect the delicate water-vessel and its accompanying nerves and blood-canals. It must be remembered that in Recent Ophiuroidea these structures are covered over by ventral shields, and in Asteroidea they lie at the bottom of a deep groove bordered by stout spines. Nevertheless, a similar enclosure of the water-vessel may occur (possibly as a survival of an ancestral "tendency") in Recent Ophiuroidea and Asteroidea, *e.g.*, in the third vertebra of *Ophiarachna incrassata*, Müller, and in *Brisinga coronata*, Sars (Schöndorf, 67, p. 45).

The ambulacralia in many species of the Aspidosomatidæ undoubtedly have the appearance of hollow half-cylinders. This is due to the fact that the radial canal has become very large (see p. 24), and in consequence the dorsal median portions of the ambulacralia become thin and negligible. In forms such as *Lapworthura*, where the canal is relatively smaller, the ambulacralia do not take on this appearance.

(6) The peculiar marginalia of the Aspidosomatidæ; have already been referred to (p. 39).

There is a convex disc of the usual Ophiurid type in *Lapworthura;* Schöndorf is not correct (68, p. 213) in his interpretation of the disc of these forms as being slightly concave.

(5) I hesitate to accept this character. It is true that some species of the Aspidosomatidæ have sculptured ambulacralia. This sculpturing extends on the ambulacralia nearest to the mouth. I can scarcely believe that the sculpture was external ornament. The disc must have been over the ambulacralia in this region, unless we surmise either that the form was without a stomach or that the disc was reduced to inter-radial pouches.

The adambulacralia of *Stenaster obtusus* (Pl. I, fig. 7) have a similar sculpturing, and in this case there is no doubt that there was a skin with weak calcifications, external and independent of the adambulacral sculpture.

An analysis of the kind given above shows that the "Auluroidea" are really

Ophiuroid-like forms with ancestral primitive features somewhat disguised by various forms of specialisation more or less peculiar to the period in which they lived. That this is the correct interpretation can, perhaps, be seen even more clearly if we put out in full the list of Palæozoic "Ophiuroidea," "Asteroidea," and "Auluroidea" as given in Schöndorf's latest list (68, pp. 249—252).

Schöndorf's classification is as follows:

Class OPHIUROIDEA.

Onychaster flexilis, Meek and Worthen, *Eucladia johnsoni*, Woodward.

Class ASTEROIDEA.

PHANEROZONIA.

Family Palæasteridæ.

Palæaster niagarensis, Hall, ? *P. matutinus*, Hall, *P. caractaci*, Gregory, *Spaniaster latiscutatus*, Sandberger.

Family Xenasteridæ.

Xenaster, *Agalmaster*, *Rhenaster*, *Trimeraster*, *Eifelaster*, *Miomaster*.

CRYPTOZONIA.

Family Palasterinidæ.

Palasterina, *Lindstromaster*, *Schuchertia*, *Asterias acuminata*, Simonow., *Palæaster montanus*, Sturowsky.

Family Calliasteridæ.

Calliaster, Trautschold.

Class AULUROIDEA.

Ophiurasteriæ, with opposite ambulacralia.

PHANEROZONIA.

? *Ophiurina*, Stürtz.

CRYPTOZONIA.

Lapworthura, Gregory, *Sympterura*, Bather, ? *Sturtzura*, Gregory, ? *Gregoriura*, Chapman, *Sturtzaster*, Etheridge, *Furcaster*, Stürtz, *Eospondylus*, Gregory, *Eoluidia*, Stürtz, *Miospondylus*, Gregory, *Cheiropteraster*, Stürtz.

Encrinasteriæ, with alternating ambulacralia.

PHANEROZONIA.

Aspidosoma, Goldfuss.

CRYPTOZONIA.

Protaster sedgwicki, Forbes, *P. biforis*, Gregory.

It is seen that only two species are placed by Schöndorf among the Ophiuroidea, namely, *Eucladia johnsoni* and *Onychaster flexilis*.

Eucladia johnsoni, according to Sollas and Sollas (71, p. 222) should be removed from the Ophiuroidea and placed in a separate class, the Ophiocistia, possibly allied to the Ophiuroidea. My own observations suggest that *Eucladia* can have no near affinity with the Asterozoa.

Onychaster flexilis has been shown by Miss Sollas (72) to have the enclosed canal of the Auluroidea.

There remain accordingly only two classes of Palæozoic Asterozoa—the "Asteroidea" and the "Auluroidea"—if they are divided as is suggested by Schöndorf. The latter correspond to my primitive "wrigglers." The classification then approximates closely to that suggested by Professor and Miss Sollas.

These authors (71, 72) have made very exhaustive investigations of *Lapworthura miltoni* and *Onychaster flexilis*, and have drawn comparisons between the structure of these forms and that of *Eophiura*, *Palæura*, and *Bohemura* (as described by Jaekel), *Protaster sedgwicki*, *Protaster groomi*, *Rhodostoma* (*Protaster*) *leptosoma*, *Furcaster*, *Eoluidia*, *Eospondylus*, and *Miospondylus*. All these forms are regarded by the authors as being Silurian and Devonian Ophiuroidea, and are placed in a group, "the *Protophiuroidea*," of which the diagnostic characters are (1) the completeness of the ambulacral series (the first pair of ambulacral ossicles [a_1] being retained), (2) the meeting of the ambulacral series of adjacent arms on the actinal sides of the jaws, (3) the absence of upper and under arm-plates.

All the modern genera form a group, "the *Euophiuroidea*," characterised (1) by the specialised buccal armature, consisting of oral angle pieces formed by the complete fusion of a_2 and ad_1, a_1 having been lost; (2) by the presence of under arm-plates, with the single exception of *Ophioteresis*.

They state that in respect to the three characters given, "the structure of the Protophiuroidea is Asteroid in nature. The actinal position of the madreporite is also shared by some of the early Asteroidea, so that the sharp limitation of the arms from the disc is the chief distinguishing character between the early Star-fishes and Brittle-stars." They also believe that "within the Protophiuroidea a gradual evolution can be traced. In the most primitive genera the ambulacral ossicles are neither completely alternate nor completely opposite. As examples of this most primitive structure *Eophiura*, *Palæura*, and *Bohemura* may be quoted. They are further characterised by the large number of ambulacral ossicles which bound the oral angles and by the absence of fusion with one another in a longitudinal series of these ossicles. For the forms with alternating ambulacral ossicles Gregory proposed the order Lysophiuræ. We were at first inclined to retain it as a division of the Protophiuroidea, referring the remaining members of the sub-order to a division Synophiuræ characterised by opposite ambulacral ossicles. But the state of knowledge at the present time hardly permits of this. For while it is certainly clear from Jaekel's work (see, for instance, his figs. 1 and 6) that in some of the simplest genera the ambulacral ossicles were not opposite, it is also certain that free opposite ambulacral ossicles are easily displaced, either during life or after death, and it is difficult in some cases to be sure whether alternation is natural or due to displacement. We therefore think it wisest for the time merely to recognise the fact that there has been a progression within the Protophiuroidea from forms with free, partly alternating, ambulacral ossicles, on the one hand, to forms with completely alternate ambulacral ossicles, and on the other to those in which these ossicles are opposite, at first free, afterwards having slight connections, and increasing in vertical extent, and that in both groups the buccal armature has advanced in complexity" (71, p. 223).

There can be no doubt that these authors are correct in their main assumptions, namely:

(1) That the peculiarities in structure of these old forms are not of sufficient magnitude to allow us to neglect their real Ophiuroid affinities.

(2) That there has been a double line of progression within the group itself.

If, however, as is granted by Professor and Miss Sollas, there is a double line of progression, we must ask ourselves, Are we entitled to place all the forms in one group? There appears to be no doubt that the resemblances between the "Ophiuroidea," with opposite and alternating ambulacralia, are due to the fact that there has been parallel (homoplastic) evolution in the two sets of forms. The number of divergent branches of the Asterozoan stock cannot be expressed by the present dual division into Asteroidea and Ophiuroidea—a classification which, it must be remembered, is merely based on knowledge of the Recent survivors of many ages of experiment and trial.

I have only had space in this Introduction to describe a few of the medley of specialised forms found in the older Palæozoic rocks. Some of the families into which the species can be grouped are far from easy to fit in grouping which is familiar to us at present. It therefore appears desirable that a detailed description of the material at hand should be given before a further new classification is attempted.

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PLATE I.

Figures illustrative of mouth-parts of Recent and Fossil Asterozoa.

FIG.

1.—*Stellaster equestris*; apical view. × 7. (P. 26.)

2.—*Ophiarachna incrassata* (after Ludwig); apical view after removal of the peristomial plates. (P. 28.)

3.—*Ophiocoma erinaceus*; oral view after removal of the buccal, ventral and side shields. × 7. (P. 27.)

4.—*Eoactis simplex*; oral view, slightly reconstructed. × 10. (P. 30.) (Coll. Brit. Mus., E. 13154.)

5.—*Protopalæaster caractaci*; apical view (after Hudson). × 8. (P. 30.)

6.—*Stenaster obtusus*; oral view. × 9. (P. 31.) (Coll. Mrs. Gray.)

7.—*Stenaster obtusus*; apical view. × 9. (P. 31.) (Coll. Mrs. Gray.)

8.—*Aspidosoma grayæ*; oral view, slightly restored. × 10. (P. 33.) (Coll. Mrs. Gray.)

9.—*Lapworthura miltoni*; apical view. × 6. (P. 32.) (Coll. Spencer.)

10.—*Lapworthura sollasi*, n. sp.; oral view. × 6. (P. 32.) (Coll. Ludlow Mus.)

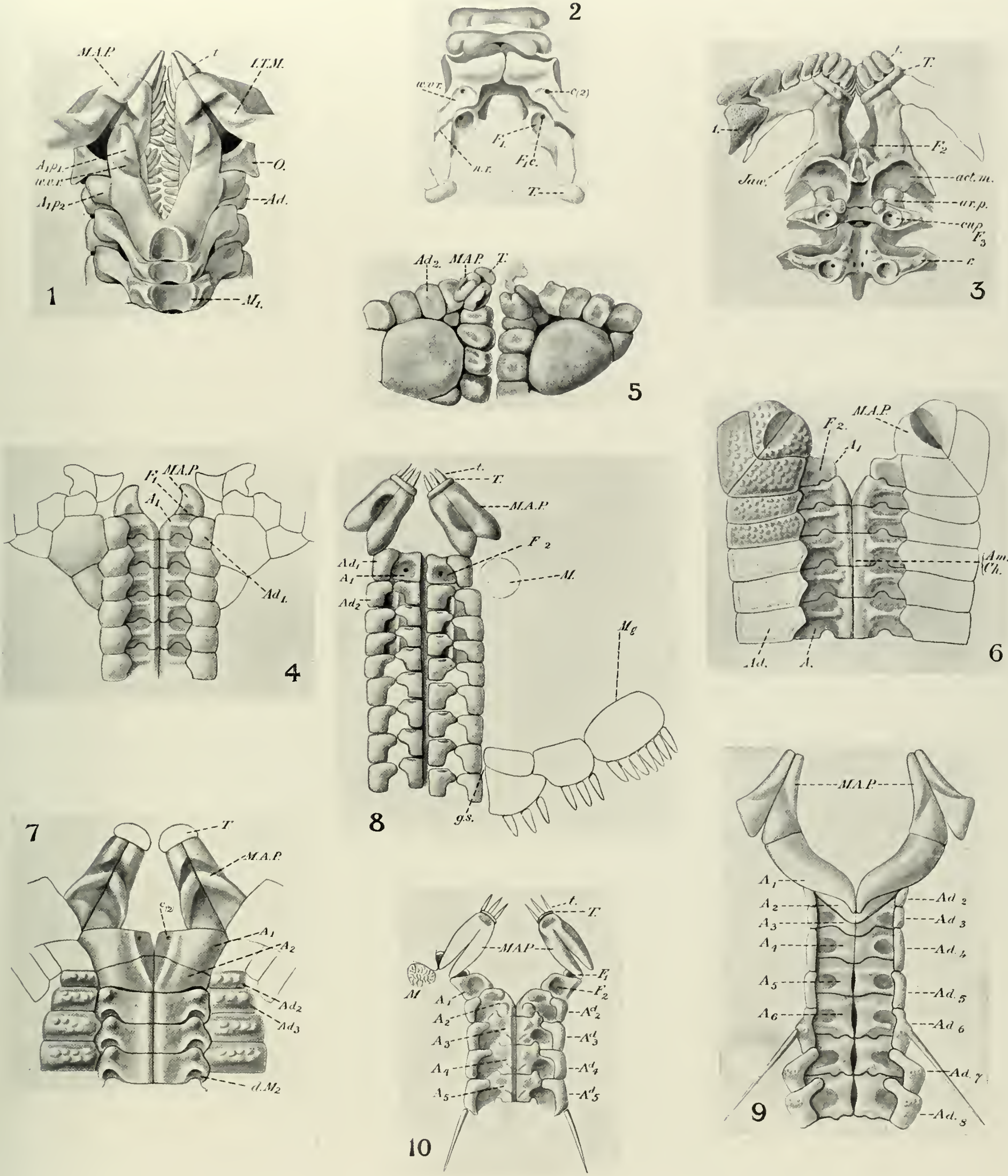
Lettering Relating to Ossicles.—1., lateral buccal shields (Ad_1); *A.*, ambulacralia; *Ad.*, adambulacralia (these are numbered so as to indicate their sequence); $A_1 p_1$, anterior process of first ambulacral; $A_1 p_2$, posterior process of first ambulacral; *ar. p.*, articulating pegs; *M.*, madreporite; *Mg.*, marginalia; *M. A. P.*, mouth-angle plates; *O.*, odontophore; *r.*, ridge for articulation of side shields with vertebræ; *T.*, torus; *t.*, teeth.

Lettering Relating to Water-vascular and Nervous Systems.—*Am. Ch.*, ambulacral channel; *c.* (2), canal to first two pairs of tube-feet; F_1, depression for first tube-foot; F_2, depression for second tube-foot; $F_1 c.$, opening of branch canal into depression for first tube-foot; *n. r.*, nerve ring; *w. r. r.*, depression for water-vascular ring.

Lettering Relating to Musculature.—*I. T. M.*, ridge for inter-radial muscle ("adducteur des dents") between jaws; M_1, ridge for articulation of dorsal transverse muscles; *act. m.*, depression for insertion of ventral longitudinal muscles.

Lettering Relating to Reproductive Organs.—*g. s.*, genital slit.

NOTE.—Exact diagnoses of the new species mentioned will be given later. The specimens figured on this plate are taken as the holotypes of the new species.


1
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t
I.T.M.
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A1p2
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M1.
2
w.v.r.
c(2)
F1.
F1c.
n.r.
T.
3
t.
T.
F2
Jaw.
act. m.
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cup
F3
c.
5
Ad2.
M.A.P.
T.
4
F1
M.A.P.
A1
Ad1.
8
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T.
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Ad4
Ad5
9
M.A.P.
A1
A2
A3
A4
A5
A6
Ad. 2
Ad. 3
Ad. 4
Ad. 5
Ad. 6
Ad. 7
Ad. 8

Palæontographical Society, 1913.

THE

LOWER PALÆOZOIC TRILOBITES OF GIRVAN.

SUPPLEMENT

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THE LOWER PALÆOZOIC TRILOBITES OF THE GIRVAN DISTRICT, AYRSHIRE.

SUPPLEMENT.

INTRODUCTORY REMARKS.

In the preparation of my Monograph of the Girvan Trilobites, of which the last part was published by the Palæontographical Society in 1906, all the material which was then available in the various collections and museums was examined and utilised. But since that date Mrs. Gray of Edinburgh has been able to collect further specimens, amongst which are several new species, so that there is now occasion for a supplement to that work. Some of the forms which were there described from imperfect material are now better known, thus necessitating a revision of the former specific determinations or diagnoses, and in other cases allowing of the establishment of distinct new species. The number of trilobites from the Girvan area is accordingly increased by the addition of twenty-three new species and of three new varieties.

The following are lists (1) of the emendations necessary in the previous Monograph, (2) of new horizons for previously described species, and (3) of the stratigraphical distribution of the new species here described.

The characters and affinities of the trilobitic fauna as a whole were sufficiently described and discussed in my previous work, and the new material and facts do not render necessary any modification of the general conclusions then reached (*op. cit.*, pt. iii, pp. 173–179). The individuality and local specific peculiarities of the Girvan assemblage in Ordovician times mark it off sharply from that of other British areas.

(1) Emendations and Corrections.

New designation or reference.	*Previous designation or reference.*
Trinucleus albidus, sp. nov.	*Trinucleus* sp. b.
Ampyx macconochiei, Eth. & Nich.	*Trinucleus? macconochiei*, Eth. & Nich.
Remopleurides nicholsoni, sp. nov.	*Remopleurides colbii*, Portl.

New designation or reference.	*Previous designation or reference.*
Asaphus (*Isotelus*) *grayæ*, sp. nov.	*Asaphus* (*Isotelus*) *gigas*, De Kay.
Cyclopyge subarmata, sp. nov.	*Cyclopyge armata* (Barr.).
Bohemilla scotica, sp. nov.	*Bohemilla* sp.
Encrinurus multisegmentatus, var. nov. *trispinosus*.	*Encrinurus multisegmentatus* (Portl.).
Cybele michelli, sp. nov.	*Cybele*, cf. *aspera* (Linnars.)
Cheirurus keisleyensis, Reed.	*Cheirurus bimucronatus* (Murch) (*pars*).
Sphærexochus mirus, var. nov. *balclatchiensis*.	*Sphærexochus mirus*, Beyr.

(2) New or Additional Horizons and Localities for previously described Species.

Dionide richardsoni, Reed, Whitehouse Group, Shalloch Mill.
Stygina latifrons (Portl.), Drummuck Group (Starfish Bed), Thraive Glen.
Illænus latus, McCoy, Balclatchie Group, Balclatchie.
Illænus portlocki, Salter, Balclatchie Group, Balclatchie; Dow Hill.
Dindymene cordai (Eth. & Nich.), Whitehouse Group, Shalloch Mill.
Staurocephalus globiceps (Portl.), Balclatchie Group, Dow Hill.

(3) Stratigraphical Distribution of New Species and Varieties.

Balclatchie Group.
Harpes (*Eoharpes*) *youngi*.
Telephus salteri.
Asaphus (*Isotelus*) *grayæ*.
Illænus peachi.
,, *richardsoni*.
Cyphaspis jamesoni.
Lichas (*Amphilichas*) *ardmillanensis*.
Encrinurus contentus.
Cybele bellatula, var. *balclatchiensis*.
,, *michelli*.
Sphærexochus mirus, var. *balclatchiensis*.
Phacops (*Pterygometopus*) *hunteri*.

Whitehouse Group.
Trinucleus albidus.
Cyclopyge bumasti.
,, *subarmata*.
Bohemilla scotica.
Acidaspis playfairi.

DRUMMUCK GROUP.	*Harpes* (*Eoharpes*) *hornei.*
	Remopleurides nicholsoni.
	Lichas (*Corydocephalus*) *maccullochi.*
	Acidaspis asteroidea.
	,, *girvanensis.*
	,, *terribilis.*
	Encrinurus multisegmentatus, var. *trispinosus.*
	Phacops (*Pterygometopus*) *retardatus.*
	,, (*Dalmanitina?*) *asteroideus.*

Family TRINUCLEIDÆ.

Genus **TRINUCLEUS**, Llwyd.

Trinucleus albidus, sp. nov. Plate I, figs. 1, 2.

1903. *Trinucleus*, sp. b., Reed, Lower Palæozoic Trilobites of Girvan (Palæont. Soc.), pt. i, p. 14, pl. ii, figs. 8, 8 *a*.
1906. *Trinucleus*, sp. b., Reed, ibid., pt. iii, p. 160.
1912. *Trinucleus*, sp. b., Reed, Geol. Mag. [5], vol. ix, p. 393.

It is now possible to define with considerable precision the unnamed species of *Trinucleus*, previously designated as "sp. b.," from the Whitehouse Group. For several more specimens, including one fine head-shield, have been collected by Mrs. Gray, and they are found to possess such definite characters as are sufficient to distinguish them from other British species. Moreover, there is no evidence that we are dealing with immature individuals, as might be suspected.

Specific Characters.—Head-shield regularly semi-circular, gently convex, not arched down strongly at sides or in front; posterior margin straight; genal angles not produced back, nearly rectangular, furnished with smooth, straight, grooved spines tapering rather rapidly and about half as long as head-shield.

Glabella composed of large swollen ovoid lobe, touching or slightly invading fringe, and of posterior unsegmented simple subcylindrical depressed neck, somewhat contracted at base and about one-fourth the total length of glabella. Small submedian tubercle present on ovoid anterior lobe of glabella, and fine reticulation over general surface of latter. Neck of glabella without notches, furrows or lobes; sides straight, parallel. Axial furrows moderately deep.

Cheeks broad, subtriangular, each forming a quadrant of a circle, gently convex, not as elevated as glabella, smooth, without median tubercle, with postero-lateral angle rounded.

Fringe narrow, nearly horizontal or slightly sloping down, not sharply marked off from cheeks, composed of two concentric rows of radially arranged large pits, disposed in rather widely separated radial pairs, which in middle anterior portion tend to be connected, so as to form short radial grooves, in which the pores lie; towards the genal angles the concentric rows become rather wider apart, and a short inner somewhat irregular row consisting of 3–4 pits is inserted at the rounded postero-lateral angles of the cheeks.

Fringe not produced genally behind posterior edge of head-shield, but ending abruptly at genal angles, which bear longitudinally-grooved straight genal spines, half the length of head-shield. Outer margin of fringe furnished with narrow thickened border, with its outer face steeply bevelled and channelled by median groove continued back along face of genal spines.

Meso-occipital ring and pleuro-occipital segment rounded, rather prominent, well marked off from glabella and cheeks by furrows.

Dimensions.—

Length of head-shield . . .	15·5 mm.
Width of ,, . . .	31·0 ,,
Length of frontal lobe of glabella . .	10·5 ,,
Width of ,, ,, . .	9·0 ,,

Remarks.—This species has been previously compared by me (*op. cit.*, p. 14) with *T. wahlenbergi*, Rouault, the glabella apparently possessing similar characters. There are not many points of resemblance to the true *T. concentricus*, Eaton, and the glabella is completely different. In *T. seticornis*, His., and *T. bucklandi*, Barr., the glabella has a lobed, not simple, neck, and the fringe is of a distinct type. In *T. hibernicus*, Reed,[1] the tendency of the radial pits to fuse into grooves is found similarly developed.

A pygidium, probably referable to this new species, which we may call *T. albidus*, has been found from the same horizon at Shalloch Mill, where head-shields possessing the specific characters occur. It has the usual subtriangular shape and obliquely bevelled striated border; the axis is conical, about one-fourth the width of the pygidium, and slightly invades the posterior border behind; it is composed of 9–10 rings, of which the first 6–7 are quite distinct, and the lateral lobes show 6–7 straight radiating simple pleuræ corresponding to them. Length, 5 mm.; width, 12 mm.

Horizon and Localities.—Whitehouse Group (M. Bala), Whitehouse Bay; Shalloch Mill.

[1] Reed, 'Geol. Mag.' [4], vol. ii (1895), p. 52, pl. iii, figs. 2—7.

Genus **AMPYX,** Dalman.

Ampyx macconochiei, Etheridge, jun., and Nicholson.

1903. *Trinucleus ? macconochiei,* Reed, Lower Palæozoic Trilobites of Girvan (Palæont. Soc.), pt. i, p. 11.

Another specimen of this imperfectly known form, with the head better preserved in some respects than in the previous examples, has been obtained at Balclatchie, and it necessitates a few corrections and additions to the earlier descriptions. The glabella is more globular than pyriform in shape, thus resembling *Ampyx globifrons,* Olin,[1] of the *Trinucleus*-Shales of Scania, and has a very narrow, depressed ring-like neck at the base, and outside the pair of pit-like depressions here situated, are seen a pair of small nodular lobes wedged in between the cheeks and the ring-like neck. These nodular lobes have not been observed in the other imperfect specimens. The cheeks are less elevated than the glabella, but arch down rather suddenly at the sides, and there are also distinctly traceable long slender genal spines curving gently backwards and reaching at least as far as the pygidium. There is certainly no trace of a fringe in this specimen, thus confirming the evidence of the others; and from the characters of the head-shield we must now move back this species into the genus *Ampyx,* in which Etheridge and Nicholson doubtfully placed it. The ornamentation of the head-shield and the characters of the thorax have been previously described. In the case of the pygidium there seem to be rather more numerous rings on the axis, for eight or nine can be counted, though only the first five or six are distinct, and the strong narrow raised radiating ribs on the flat lateral lobes correspond to the first four rings. The axis itself measures only about one-fifth the width of the pygidium, and the edge of the pygidium is slightly raised into a narrow rim. The pygidial characters suggest *Ampyx* rather than *Trinucleus,* and thus support the testimony of the head-shield.

Genus **DIONIDE,** Barrande.

Dionide richardsoni, Reed. Plate I, fig. 3.

1903. *Dionide richardsonii,* Reed, op. cit., pt. i, p. 26, pl. iv, figs. 3—8.

One good example of a complete individual has been obtained from the Whitehouse Beds of Shalloch Mill, a locality not previously known for it; and the specimen deserves mention because it beautifully shows on the cheeks fine reticu-

[1] Olin, "Chasmopskalk. o. Trinucleusskiffern i Skane," 'Medd. f. Lunds Geol. Fältklubb,' ser. B, nr. 1, 1906, p. 71, pl. iv, fig. 13.

lating nervures between the pits which form the characteristic ornamentation. These nervures, which were not clearly detected in the previously described examples from Whitehouse Bay, are specially distinct close to the glabella and posterior margin.

In a good specimen from the latter locality with the pygidium, thorax and posterior part of the head-shield well preserved, it is clearly seen that the surface-ornament of the head-shield does not consist of irregular pittings as previously described, but that the pits are arranged in somewhat broken sinuous lines running obliquely backwards towards the genal angles and lateral borders, while close to the lateral borders the interrupted raised lines between which the pits lie are much finer and more reticulated and the pits themselves smaller and more closely aggregated. The same feature is observable in the Shalloch Mill specimen.

Mr. Bernard Smith[1] has figured a portion of the head-shield of a *Dionide* from the Killey Bridge Beds, Little River, Tirnaskea, Pomeroy, which he compares with Angelin's *D. euglyptus;* it appears to belong to the same species here described as *D. richardsoni.*

Family Harpedidæ.

Genus **HARPES,** Goldfuss.

Harpes (Eoharpes) youngi, sp. nov. Plate I, figs. 4—6.

Specific Characters.—Head-shield large, subquadrate to broadly oval in shape, with posterior extremities of the limb produced backwards and curving inwards. Maximum width of head-shield at level of neck-ring.

Limb horse-shoe shaped, broad, widest at sides, nearly horizontally extended, gently convex on upper surface, concave on lower surface, slightly arched down in front and at sides; general outline sub-circular to broadly oval, with margin strongly arched outwards; posterior extremities prolonged back behind genal angles and tapering rather rapidly to end in points curving inwards and approximating; inner margin of limb strongly arched in front but less so behind genal angles. Surface of limb covered with minute closely-set punctæ arranged in a radial manner, 25—30 punctæ in a row, between delicate radiating sinuous closely-set and reticulating thread-like lines; behind the genal angles the radial arrangement seems less regular. Border of limb thickened, smooth, raised, narrow, continued round outer and inner margins of limb and in front of cheeks as narrow smooth band.

Head-shield proper embraced by limb, transverse, short, less than one-third the length of the whole horse-shoe limb, about twice as broad as long; surface

[1] Fearnsides, Elles and Smith, 'Proc. Roy. Irish Acad.,' vol. xxvi, sect. B, no. 9 (1907), p. 122, pl. viii, fig. 9.

strongly convex, rising steeply from limb in front and at sides. Glabella subconical, blunt in front, widening towards base, strongly elevated above general surface, measuring about three-fourths the length of head-shield (minus limb) and basally rather more than one-third its width; with one pair of short slightly oblique lateral furrows marking off but not separating transverse basal lobes. Axial furrows moderate, with deep sharply curved alar furrow on each side starting outwards at about half length of glabella and sweeping backwards and inwards across cheeks to enclose smooth semi-circular lateral area ("ala") cut off from rest of cheeks. Cheeks swollen, rising steeply on all sides from limb, uniting in broad pre-glabellar portion in front, and divided faintly by weakly impressed concentric "lateral line" into an upper and a lower portion, the latter (="cheek-roll") with very slight independent swelling. Eyes situated a little behind front end of glabella and distant from it less than its width, elevated on low swollen bosses and connected with side of glabella by smooth narrow horizontal ocular ridges decreasing in stoutness inwards. Meso-occipital ring rounded, with median tubercle; occipital furrow strong, prolonged on cheeks, but dying out before reaching the genal angles. Genal angles elongated backwards into broad-based, slowly tapering, steeply inclined prolongations for about half the length of horns of limb, united to it along lower edge and ornamented with punctæ, like those on limb.

Surface of cheeks behind eyes and above lateral line covered with fine sinuous more or less interrupted nervures radiating outwards and backwards from point of junction of alar furrow with side of glabella, and with small pits placed in the grooves between them. Below the lateral line the nervures are finer, more regular, more numerous and subparallel, running at right angles to the inner margin of the limb, and the pits are rather smaller; in front of the eyes and on the whole pre-glabellar portion similar radial ornamentation and pitting are present.

Thorax and pygidium unknown.

Dimensions (of largest example).—

Length of head-shield to posterior extremities of limb (estimated)	19·00 mm.
Width of head-shield including limb . .	20·00 ,,
Width of limb in front . . .	4·00 ,,
,, ,, at sides . . .	4·75 ,,
Length of head (without limb) . .	6·00 ,,
Width of ,, (,, ,,) . .	10·50 ,,

Remarks.—The material on which the above description is based consists of portions of three individuals.

The largest of them is the best preserved and shows the hollow inner surface of the head-shield with the limb attached, so that it is the interior of the shell and the under surface of the limb which are visible. The natural cast of this specimen is also perfect, and exhibits the ornamentation of the cheeks. The shell is preserved in places attached to the cast and is of a thin delicate character.

The second specimen likewise consists of the intaglio and natural cast of the head and limb, and though the shell and ornamentation are better preserved, yet the specimen has suffered somewhat from lateral compression, and is, therefore, rather crushed and distorted.

The third minute specimen, only measuring 6 mm. across, has the ornamentation in beautiful preservation.

This new species is at once distinguishable from *H. flanagani*, Portlock,[1] by its broader, more transverse form, by the curving inwards of the horns of the limb, by the radiating reticulation and much finer pitting, and by the absence of the intra-marginal row of large pits on the limb.

Its affinities appear to be specially with *H. spasski*, Eichwald,[2] which occurs in Stage C in the Baltic provinces of Russia, the characters of the limb, glabella ornamentation, etc., being closely similar. In the above description the terms suggested recently by Dr. Bather [3] for certain parts of the head-shield have been adopted, the swollen lower part of the cheeks being designated the "cheek-roll," and the smooth semi-circular areas alongside the glabella being called the "alæ." The term "lateral line" has also been used for the impressed concentric line separating off the cheek-roll from the rest of the cheeks.

The true homologies of the limb and cheek-roll of *Harpes* are still doubtful,[4] and it cannot be considered proved that the limb is represented in *Trinucleus* or *Dionide*. No clear evidence of a marginal suture round the edge of the limb nor of a bilaminar structure of the latter, as Beecher[5] stated, has been observed in these Girvan specimens.

Novak[6] put all the Ordovician species of *Harpes* into a separate genus or subgenus which he named *Harpina*, on the strength of their hypostomal characters; but in the case of this and most other British species, we are unacquainted with their hypostomes. Raymond[7] has recently shown that the name *Harpina* was preoccupied, and he has suggested the name *Eoharpes* for the group, and this has been adopted by Ruedemann[8] and others.

Horizon and Locality.—Balclatchie Group (Llandeilo); Balclatchie.

[1] Portlock, 'Geol. Rep. Londonderry,' p. 268, pl. v, figs. 5 *a*, 5 *b*, 6, 7.

[2] Schmidt, 'Rev. Ostbalt. Silur. Trilob.,' pt. iv (1894), p. 66, pl. v, figs. 3—9.

[3] Bather, "*Harpes bucco*," 'Rivista Ital. Paleont.,' vol. xv (1910), pp. 116—120.

[4] Woods, article "Trilobita" in 'Camb. Nat. Hist.,' vol. iv (1909), pp. 226, 231, 245.

[5] Beecher, 'Amer. Journ. Sci.' [4], vol. iii (1897), p. 185.

[6] Novak, "Studien Hypost. böhm. Trilob. No. 2," 'Sitzb. böhm. Gesell. Wiss.,' 1884, p. 6.

[7] Raymond, 'Amer. Journ. Sci.' [4], vol. xix (1905), p. 377.

[8] Ruedemann, 'Bull. 162, New York State Museum' (1912), p. 116.

Harpes (Eoharpes) flanagani, Portlock. Plate I, figs. 7—9.

1903. *Harpes flanagani*, Portlock, Reed, op. cit., p. 8, pl. ii, figs. 12, 12 *a*.

This species has been previously recognised and figured from the Girvan area, but several more examples have been recently obtained by Mrs. Gray, one consisting of a nearly complete head-shield with the limb attached. The whole outline of these Girvan examples is rather more oblong and less rounded than in *H. youngi*; the horns of the limb are more parallel, the width of the limb is more uniform, the pitting on it is much coarser, the pits being fewer, larger and circular, and there is the intra-marginal single row of specially large pits and a complete absence of fine reticulating radial nervures, except near the median portion of the lower surface of the limb. In addition to these features, the eyes seem to be more elevated and more centrally situated on the cheeks than in *H. youngi*. There are traces of a low pre-glabellar swelling, and an indistinct cheek-roll; the glabella appears to be keeled and more oval in shape, with longer basal lobes; the alæ are larger and divided in half by a crescentic furrow, and there is apparently an absence of strong nervures on the cheeks.

Portlock's[1] figures of *H. flanagani* were poor and unsatisfactory. The specimens (now in Jermyn Street Museum) represented by his figures 5 *a* and 6, are broader and more subquadrate than that shown by his fig. 7, which may be distinct. These two (*op. cit.*, figs. 5 *a*, 6) also show a distinct cheek-roll with radial lines of pits; the limb is narrower in the middle in front than at the sides, and has a low median swelling or fold in it as in these Girvan specimens; similarly the alæ are large, and there is a distinct oblique ocular ridge swelling out towards the eye, the latter being situated at about one-third the length of the cheek from the front; the intra-marginal row of pits on the limb is not very distinct. The shape of our Girvan specimens more resembles Portlock's fig. 7, but in other respects they agree in all important details with those represented by his figs. 5 *a* and 6.

Dimensions (of specimen from Ardmillan).—

Length of horse-shoe-shaped limb . .	22·3 mm.
Width of head-shield including limb . .	19·0 ,,
,, of limb at sides . . .	5·5 ,,

Affinities.—We may specially mention the American species *H. ottawaensis*, Billings,[2] of the Chazy Group, as showing many points of resemblance to *H. flanagani*.

Horizon and Localities.—Balclatchie Group (Llandeilo): Balclatchie; Ardmillan.

[1] Portlock, 'Geol. Rep. Londonderry,' p. 268, pl. v, figs. 5 *a*, 5 *b*, 6, 7.

[2] Raymond, 'Ann. Carnegie Museum,' vol. iii, no. 2 (1905), p. 331, pl. x, fig. 2 and Ruedemann, 'Bull. 162 New York State Mus.' (1912), p. 116, pl. ix, fig. 1.

Harpes (Eoharpes) hornei, sp. nov. Plate II, figs. 1, 2.

Specific Characters.—Shape oval; width nearly three-fourths the length. Head-shield large, sub-oval, with elongated limb; horns of limb produced back so as to embrace whole thorax and pygidium and nearly to touch each other behind it. Head-shield proper (apart from limb) semi-oval, strongly convex, rising suddenly and steeply on all sides from limb. Glabella subconical, convex, prominent, subcarinate, about one-third the width and nearly three-fourths the length of the head-shield, narrowing anteriorly; with a pair of triangular basal lobes marked off by oblique furrows arising at rather less than one-third the length of the glabella from base and meeting the occipital furrow behind at about one-third the width of the glabella on each side. Axial furrows not deeply impressed, almost obsolete in front of glabella. On each side of anterior half of glabella the cheeks rise into large low conical bosses, each of which bears two separate ocelli. Behind these bosses and adjoining glabella are flattened, smooth semicircular areas (alæ), each marked out by a strong, curved furrow arising at right angles from the axial furrows at the same level as the lateral furrows of the glabella, and sweeping round to unite with the meso-occipital furrow at the base of the glabella; each ala is longitudinally divided into two subequal, crescentic portions by a shallow gently curved groove. Meso-occipital furrow weak in middle, but strongly impressed behind basal lobes of glabella. Meso-occipital ring convex, of moderate width, simple. Pleuro-occipital segment narrow, prominent, elevated. Upper slopes of cheeks and eye-bosses covered with sparsely distributed minute pits, tending to a radial arrangement on the bosses. Lower half of cheeks (cheek-roll) and of pre-glabellar area separated from upper half by narrow continuous groove (lateral line) and in front of glabella by line of larger pits, and possessing slight independent convexity; surface of pre-glabellar area and cheek-roll coarsely pitted. At the genal angles the cheek-roll is produced posteriorly into elongated, tapering, steeply inclined prolongations reaching back as far as pygidium, closely appressed against ends of pleuræ, united along lower edge with inner margin of limb nearly at right angles and marked with line of larger pits.

Limb flat, horizontally extended, of nearly uniform width all round head-shield (*i. e.* about one-half the length of the head-shield); behind head-shield limb decreases in width very gradually and is prolonged into slowly tapering horns curving gently inwards and embracing whole thorax and pygidium, so that their pointed extremities are less than the width of the head-shield apart.

Surface of limb covered with coarse pits similar to those on cheek-roll, quite irregularly distributed, with minute punctæ between them; near the outer and inner edges of the limb the pits are somewhat larger, and a rather irregular row of still larger ones runs round the inner and outer margins. Border very narrow, sharply raised, smooth, forming a minute rim all round outer edge of limb and continued round its points to follow upper (inner) edge of the steeply inclined genal prolongations to pass finally into neck-segment.

Thorax of 23—25 segments. Axis rather less than one-third the width of thorax at anterior end, tapering gradually posteriorly, very prominent and highly convex; axial rings with distinct lateral swellings. Pleuræ straight, horizontally extended to fulcrum, which is situated at about two-thirds to three-fourths their length; extra-fulcral portion bent back and slightly downwards to taper to sub-falcate point. Surface of pleuræ marked by submedian, slightly diagonal strong furrow extending to point. Pygidium not preserved.

Dimensions.—

Length of trilobite (without pygidium) . .	32·0 mm.
Width of ,, (including limb) . . .	24·0 ,,
Length of head-shield (without limb) . .	10·0 ,,
Width of limb in front of head-shield . .	4·5 ,,
Length of glabella	7·5 ,,
Width of ditto (across basal lobes) . . .	5·5 ,,

Remarks.—The foregoing description is entirely drawn up from one remarkably fine specimen recently obtained by Mrs. Gray. With the exception of the pygidium the trilobite is complete, and as both the cast and impression are preserved the characters of the species can be given with much precision.

No example of this genus has been previously described from this horizon, and not even a fragment of any species seems to have been recorded from the Drummuck Group.

With regard to the relations of this new species, it approaches most closely to *H. wegelini*, Angelin,[1] and, in fact, appears to be almost identical with it. The *Leptæna* Limestone, in which this Swedish and Russian species occurs, is nearly homotaxial. The differences between the two species lie in the division of the alæ on each side of the glabella, in the absence of ocular ridges, the ornamentation of the upper part of the cheeks and the more gradual decrease in width of the horns of the limb posteriorly, and their greater relative length. *H. flanagani*, Portl., and *H. dorani*, Portl., are not closely allied to our species, nor is any other known British form. A doubtful example of *H. wegelini* has been recorded from the Keisley Limestone,[2] which is correlated with the *Leptæna* Limestone.

Horizon and Locality.—Starfish Bed, Drummuck Group (U. Bala): Thraive Glen.

[1] Angelin, 'Palæont. Scandin.,' p. 55, pl. xlvii, fig. 3; Schmidt, 'Rev. Ostbalt. Silur. Trilob.,' pt. iv (1894), p. 69, pl. v, figs. 10—18.

[2] Reed, 'Quart. Journ. Geol. Soc.,' vol. lii (1896), p. 436.

Family Olenidæ.

Genus **REMOPLEURIDES**, Portlock.

Remopleurides nicholsoni, sp. nov. Plate II, figs. 3—9.

1903. *Remopleurides colbii*, Reed (*non* Portlock), op. cit., pt. i, p. 36, pl. v, figs. 17 *a*, *b*.

Specific Characters.—Head-shield sub-semicircular. Glabella very slightly convex, transversely sub-elliptical, widest near base; anterior tongue strongly arched down and more than one-third the length of glabella, parallel-sided, about half as wide as glabella, with front end subtruncate and furnished with narrow band. Two pairs of lateral furrows present, fine, faintly impressed, gently arched. Fixed cheeks represented by narrow flattened band, widening a little at base of glabella (which is here constricted), marked off by strong furrow. Meso-occipital ring flattened, narrowing on each side outside base of glabella, finely serrated on posterior edge and crossed from side to side by very delicate striæ. Facial sutures bend out sharply at base, cutting posterior margin at acute angle. Free cheeks triangular, with short nearly straight posterior margin meeting lateral margin at right angles without a true genal spine. Pleuro-occipital ring broad, marked off by strong furrow, ending abruptly against lateral margin of cheek. Cheek-spine arising in front of true genal angle from side of cheek, slender, tapering, gently curved, produced back at acute angle to lateral margin behind its base so as to form a subgenal notch. Eye large, vertical, band-like, widening a little anteriorly to tongue of glabella, composed of numerous (two hundred or more) vertical rows of alternating small closely set lenses, thirty to forty lenses in a row; narrow basal rim to eye present, defined above and below by sharp groove.

Thorax composed of eleven body rings, gradually and regularly decreasing in size posteriorly. Axis conical, tapering to pygidium to less than half its anterior width, moderately convex, anteriorly about half width of thorax, with the rings ornamented by closely set slightly sinuous striæ parallel to anterior edge, and by small serrations on posterior edge. On ninth ring stout median spine (length unknown) projects upwards and backwards.

Pleuræ regularly decreasing in size posteriorly, possessing the characters of *R. colbii*, except that they are ornamented along their length by fine subparallel striæ like those on axial rings.

Pygidium oblong, with posterior edge cut into four teeth, of which the two outer ones are the shorter. Axis short, very broadly conical, well-defined, convex, about half the total length of pygidium and about two-thirds its width; composed of two segments, the first widens suddenly on each side so as to overlap the second; the second segment composed of a pair of contiguous oval swellings diverging slightly posteriorly, with a short median lanceolate pointed ridge reaching back behind them to the notch in the pygidial margin between the inner pair of teeth. Lateral lobes composed of two pairs of pleuræ produced beyond margin to form two pairs of teeth. First pleuræ directed backwards forming sides of pygidium with free points projecting beyond margin; projecting knobs on front edge to fit into sockets in last thoracic segment; surface of pleuræ marked by weak median furrow. Second pleuræ separated from first by faint inter-pleural furrow and directed backwards to end in free but somewhat stouter teeth projecting behind points of first pair and enclosing an angle of about 30°; no pleural furrow present on surface.

Surface of whole pygidium ornamented by minute tubercles and striations; on first pair of pleuræ the striæ are longitudinal, but on second pair are transverse and sinuous, with the tubercles distributed irregularly between them. Doublure of pygidium concentrically striated.

Dimensions.—

		I.	II.
	Length of glabella to base of tongue .	12·0 mm.	11·0 mm.
	,, of ,, including tongue .	17·5 ,,	16·0 ,,
	Width of ,, between eyes . .	17·0 ,,	16·0 ,,
	,, of tongue at base . .	7·5 ,,	7·0 ,,
III.	Length of free cheek . . .	13·0 ,,	
	Width of ,, near base to outer edge of spine . .	9·7 ,,	
	,, of base of cheek to subgenal notch .	6·8 ,,	
IV.	Width of thoracic axis at front end .	12·0 ,,	
	,, of ,, at posterior end .	6·0 ,,	
	Length of anterior pleuræ . .	6·0 ,,	
V.	Length of pygidium . . .	7·75 ,,	
	Width of ,, . . .	7·50 ,,	
	,, of axis at front end . .	4·20 ,,	

Remarks.—This species was previously referred by me to *R. colbii*, Portlock, as re-defined by Salter, but certain differences were at the same time pointed out, though they were not regarded as of specific value. The characters of the free-cheek and pygidium and the presence of the median spine on the ninth axial ring of the thorax were at that time unknown, but with their discovery there is sufficient reason to remove it from its previous specific association. Mrs. Gray has now obtained some nearly perfect individuals from the Starfish Bed, so that we are able to refer with certainty the detached or broken fragments hitherto only known.

The presence of the median spine on the thoracic axis and the characters of the pygidium closely recall *R. dorsospinifer*,[1] but in the latter species there is no

[1] Salter, 'Mem. Geol. Surv.,' dec. vii (1853), p. 4, pl. viii, figs. 3, 4.

median post-axial lanceolate ridge on the pygidium, and the thorax is narrower and especially the axis.

With regard to the head, the glabella of this Girvan species has a rather different shape to *R. colbii* and possesses traces of lateral furrows (though Portlock's type shows traces of them also), and the free cheek has the subgenal notch in the posterior margin, which is a character of much importance and recalls the angulation in *R.* (*Teratorhynchus*) *bicornis*, Reed.[1] A similar feature is found in the allied genus *Apatocephalus* (*e. g. A. pecten*, Wiman).[2] In some genera of the Mesonacidæ[3] it is also met with, and therefore it is to be regarded as of a primitive or reversionary nature. It appears from Walcott's researches (*op. cit.*) that the so-called "genal spine" in trilobites embraces structures belonging to at least two distinct segments of the head-shield.

With regard to foreign species we may note the resemblance of the pygidium of *R. nicholsoni* to that of *R. latus* (Olin-Wiman)[4] from the *Chasmops* Limestone of Schonen. As Wiman remarks, this pygidium may be compared with Salter's figure of *R. dorsospinifer*, which so closely resembles our Girvan form.

There is one hypostome (Pl. II, fig. 9) in Mrs. Gray's collection from the Starfish Bed which must be referred to the genus *Remopleurides*, and probably belongs to this species. Both the cast and the impression of it were found together. The description is as follows:—Shape transversely subelliptical, widest across middle, with straight anterior and posterior margins and gently rounded sides; about one and a half times as wide as long; surface flattened. Body subreniform, very slightly convex, with anterior edge bilobed and sharply notched in middle, with traces of corresponding notch in posterior edge; surface of body ornamented with very delicate close concentric lineation. Anterior border narrow, depressed, widening a little in middle at notch, and here provided with prominent triangular tubercle. Anterior wings short, stout, bent up at right-angles, situated a little behind anterior edge. Lateral borders narrow with thickened rim. Posterior border projecting slightly at sides, arched up in middle, with faint low boss in notch of body; edge thickened; marginal furrow strong, deep.

Dimensions.—Length, 5·3 mm.; maximum width, 6·8 mm.

This small hypostome bears some resemblance to the one figured by Salter[5] without a specific reference, but has more rounded sides, a more regularly elliptical body with median anterior and posterior indentations, and triangular tubercles in them.

Horizon and Locality.—Starfish Bed, Drummuck Group (U. Bala): Thraive Glen.

[1] Reed, 'Girvan Trilobites,' pt. i, p. 3, pl. v, figs. 11—13.

[2] Wiman, 'Arkiv f. Zool.,' vol. ii, no. 11 (1905), p. 6, pl. i, figs. 7—12.

[3] Walcott, "*Olenellus* and other Genera of the *Mesonacidæ*," 'Smithson. Instit. Misc. Coll.,' vol. liii, no. 6 (1910), p. 23.

[4] Wiman, 'Bull. Geol. Instit. Upsala,' vol. viii (1907), p. 134, pl. viii, fig. 26.

[5] Salter, 'Mem. Geol. Surv.,' dec. vii (1853), p. 9, pl. viii, fig. 5.

Remopleurides correctus, Reed. Plate II, fig. 10.

1903. *Remopleurides correctus*, Reed, op. cit., pt. i, p. 37, pl. vi, figs. 1—5.

A fairly well preserved thorax attached to a glabella belonging to this species extends our knowledge of this interesting member of the genus. The specimen was obtained from Balclatchie, where the typical examples of the species are found. The glabella has the rather longer tongue expanding anteriorly which the variety from Dow Hill (*op. cit.*, p. 38, pl. vi, figs. 4, 5) possesses, and near its front end the reticulate ornamentation changes into somewhat regularly and widely spaced concentric lines; in other respects the characters are typical. The thorax is elongated and narrow, and possesses in this specimen 10 or 11 segments; the axis is wider than the pleuræ, is moderately convex and tapers slowly; the axial rings are covered with small but not numerous tubercles, and on none of them is there any sign of a median spine. The pleuræ are falcate, with the fulcrum situated at about one-third of their length, and it is only marked by a slight swelling of the anterior edge and not by any definite projecting knob as in *R. colbii* and other species, and the posterior margin is not notched. A broad oblique shallow furrow traverses the surface of each pleura tapering to the tip, which is produced into a slender recurved free point; the under surface of each pleura is transversely striated. The pleuræ seem to be of uniform size, and there is no evidence that any one of them was specially enlarged or elongated. The pygidium is not preserved. The thorax measures 15 mm. in length and the axis is 5 mm. wide at its front end; the glabella attached to it measures 7·5 mm. in length.

The affinities of the thorax are with *R.* (*Teratorhynchus*) *bicornis* and also with *R. dorsospinifer*; in the simplicity of the pleuræ it agrees with the former, and in the proportions of axis and pleuræ with the latter.

In connection with this species it may be remarked that there seems to be more than a superficial resemblance between the genera *Remopleurides* and *Apatocephalus*; the presence of a pre-glabellar area on the head-shield of the latter and the absence of deflection in the tongue of its glabella seem to be the principal points of distinction. The glabella, eyes and free-cheeks of such a species as *Apato. pecten*, Wiman,[1] show many features of similarity to *R. correctus*, *R. barrandei*, *R. bicornis* and other species. There appears to be reason to believe that the pre-glabellar area has only been much reduced in *Remopleurides*. The peculiar position of the genal spine is identical in *A. pecten* and *R. bicornis*. If we compare *A. serratus* (Boeck), and *A. schlotheimi* (Billings), with the above-mentioned species of *Remopleurides*, we shall see further points of resemblance; and even when we look at the pygidium we can see how in the reduced number of axial segments in

[1] Wiman, 'Arkiv f. Zool.' (Stockholm), vol. ii, no. 11 (1905), p. 6, pl. i, figs. 7—12.

A. pecten, and in the presence of only three pairs of pleural points, a great approach is made to the condition in *R. colbii*, *R. laterispinifer* and other species.

Genus **TELEPHUS**, Barrande.

Telephus salteri, sp. nov. Plate II, fig. 11.

Specific Characters.—Head transversely elliptical. Glabella sub-cylindrical, slightly expanded at front end and projecting a little beyond cheeks, abruptly truncate, moderately convex, more than twice as long as wide at base; surface coarsely tuberculated. Axial furrows parallel for three-fourths length of glabella, diverging slightly at front end. Meso-occipital furrow distinct, marking off rounded smooth depressed meso-occipital ring, widest in middle. Cheeks rounded, nearly semi-elliptical, widest behind middle, rather wider than glabella, gently convex, with rather broad smooth flattened border extending round them and ending against glabella in front and at meso-occipital ring behind; marginal furrow strong; surface of cheeks granulated and with a few coarse tubercles on outer half.

Dimensions.—

Length of head-shield	3·6 mm.
,, of glabella	2·8 ,,
Width of head near base	5·4 ,,
,, of glabella at base	1·5 ,,
,, of cheek (maximum) . . .	2·1 ,,

Remarks.—There is only one specimen of this curious little trilobite available, but with the exception of the front end of the glabella it is well preserved. It is uncertain if a pair of anterior spines is present as in *T. bicuspis*,[1] Ang., which it much resembles, though the cheeks in ours are relatively broader and more semi-elliptical and the glabella more cylindrical, and the neck-ring smooth and projecting behind the cheeks. It is quite distinct from *T. fractus*, Barr., which the author has described from the Whitehouse Group.[2] Wiman[3] has lately recorded this genus in the Baltic region.

Horizon and Locality.—Balclatchie Group (Llandeilo) : Balclatchie.

Family ASAPHIDÆ.

Genus **ASAPHUS**, Brongniart.

Asaphus (Isotelus) grayæ, sp. nov. Plate III, figs. 1—6.

? 1904. *Asaphus* (*Isotelus*) *gigas*, De Kay, Reed, op. cit., pt. ii, p. 45, pl. vii, fig. 1.

[1] Angelin, 'Palæont. Scand.,' p. 91, pl. xli, fig. 22.

[2] Reed, op. cit., p. 44, pl. iv, fig. 11.

[3] Wiman, 'Bull. Geol. Instit. Upsala,' vol. viii (1907), p. 99.

Specific Characters.—Head-shield parabolic, slightly arched down at sides posteriorly. Glabella hour-glass shaped, wide and well defined at base, contracted between eyes, widening again in front, with sides arching out and following curve of facial sutures, passing into obtusely rounded anterior end; possessing decided independent convexity at base and to level of eyes, but anteriorly flattened with outline scarcely traceable and merging into general surface. Lateral lobes and furrows absent; but pair of small median tubercles situated on its surface just behind level of eyes. No meso-occipital ring present. Axial furrows deep near base, gradually decreasing in strength anteriorly, converging inwards to level of eyes, but bending outwards in front of them and almost obsolete round front of glabella. Fixed cheeks slightly arched down at sides, with gentle independent convexity behind eyes, but forming narrow flattened band round anterior part of glabella and scarcely separable from it.

Facial sutures meeting anteriorly in pointed ogive, thence running outwards and backwards at about 100° to less than half the distance to eyes, then curving gently inwards to eye-lobes, and behind them running obliquely back in slight convex curve to cut posterior border of head-shield at angle of about 45° and at a distance from the axial furrows equal to half basal width of glabella. Maximum distance between facial sutures in front of eyes only two-thirds that between them on posterior margin of head-shield.

Eyes small, elevated, situated behind middle of head-shield. Eye-lobes very sharply bent up and rising high above general surface at angle of 45°–60°. Free cheeks (see next page).

Thorax (only detached segments known), with axis broad, over one-third width of thorax, gently convex. Pleuræ horizontally extended to fulcrum and beyond it bent down strongly and slightly arched forwards; extremity obtusely rounded; fulcrum situated at about one-third the length. Inner portion of pleura rather convex, with strong slightly oblique furrow; outer portion chiefly composed of large triangular flattened or concave surface for articulation, bearing "Pander's organ" at about half its length and near anterior edge.

Pygidium parabolic, bluntly or acutely pointed behind, length rather greater than width; surface rather strongly convex from side to side. Axis only defined by notches on anterior margin, more than one-third the total width of pygidium apart, and with front end projecting slightly between them; no trace of axis on general surface. Axial furrows completely obsolete behind. Fulcrum situated at about one-third width of pleural lobe from side of axis, with margin here thickened and raised into sharp ridge running obliquely back to lateral margin, cutting off large triangular articulating facet at anterior lateral angles of pygidium.

Doublure very convex, about one-half width of pleural lobes, widening a little posteriorly, and marked with numerous fine parallel equidistant striæ slightly oblique to margin.

Dimensions.—

Length of middle shield to point of ogive	27·0	mm.
Width of ,, at base	26·0	,,
Width of glabella at base	16·0	,,
Width of ,, between eyes	11·0	,,
Distance of eyes from base	10·0	,,
Maximum width of middle shield between facial sutures in front of eyes	18·0	,,
Distance of tubercles on glabella from base	7·0	,,
Length of eye-lobes (about)	4·0	,,
Length of pygidium	25·5	,,
Width of ,, at front end	22·0	,,
Width of axis at front end	9·0	,,

Remarks.—No example of the head-shield with free cheeks attached or of detached free cheeks referable to this species have come under my notice from Balclatchie, but if it is correct to refer the Ardmillan specimen previously figured by me as *A. gigas* to this new species, the free cheeks may have their characters described as follows: Triangular, elongated, narrow, with genal angle produced back into short acute point. The resemblance of the head-shield of this species to the form (or forms) usually referred to *A. gigas* (De Kay) by Salter[1] and others is very close; the pair of small tubercles on the glabella is, however, a distinctive feature. The thoracic rings show no peculiar characters. But the pygidium is narrower, more elongated, and more pointed than in *A. gigas*, and the axis is obsolete on the surface. In these respects it specially resembles *A.* (*Isotelus*) *platyrhachis*, Steinh.[2]; but the sharply pointed extremity more recalls such species of *Megalaspis* as *M. acuticauda*, Ang.,[3] though there can be no doubt that our species is referable to the subgenus *Isotelus*. The classification of Asaphidæ has been recently revised by Raymond,[4] with especial reference to *Isotelus*, but only a preliminary sketch of his conclusions has at present been published.

Horizon and Locality.—Balclatchie Group (Llandeilo): Balclatchie; Ardmillan.

Genus **STYGINA**, Salter.

Stygina latifrons, Portlock. Plate III, fig. 7.

1904. *Stygina latifrons*, Portlock, Reed, op. cit., pt. ii, p. 50, pl. vii, fig. 10.

Only the pygidium of this species has previously been recognised in the Girvan

[1] Salter, 'Mon. Brit. Trilob.,' p. 161, pl. xxiv, figs. 1—5.

[2] Schmidt, 'Rev. Ostbalt. Silur. Trilob.,' pt. v, lief. ii (1901), p. 91, pl. x, figs. 13—16.

[3] Schmidt, op. cit., pt. v, lief. iv (1906), p. 42, pl. v, figs. 1—8; pl. vi, figs. 1—6.

[4] Raymond, 'Trans. Roy. Soc. Canada' [3], vol. v, sect. iv (1912), pp. 111—120.

fauna, and this occurred in the Whitehouse Beds; but a complete, partially enrolled individual in a fair state of preservation has recently been obtained by Mrs. Gray from the Starfish Bed and shows some new features, since the hypostome and epistome (= rostral shield) are in their natural position attached to the head.

The epistome is subcrescentic in shape, widest across the middle, with obliquely truncated lateral angles; the posterior edge, which is somewhat chipped, does not appear to have been arched back, for all the transverse striæ arch gently forwards concentric to the front margin; these striæ are numerous, regular, and equidistant. The doublure of the head-shield is also concentrically striated, as Salter[1] showed in his figure, but he did not believe in the existence of an epistome, and held that the facial sutures united marginally. The hypostome in our Girvan specimen is large, convex and pear-shaped, extending nearly half the length of the head-shield; its anterior end is broad and gently arched forwards while posteriorly it tapers rather rapidly to its blunt extremity, which reaches to the anterior end of the neck of the glabella. The body of the hypostome is swollen, especially anteriorly, and is transversely constricted at three-fourths of its length, where a pair of short lateral furrows mark it. Fine concentric striæ starting at right angles to the front edge, ornament it. A pair of large triangular upturned alæ not marked off by any furrow from the body but similarly ornamented, lie at the anterior lateral angles of the hypostome, and a narrow border encircles the body behind them.

Salter's figure and description of the hypostome (*op. cit.*) were not complete. The pygidium of our specimen shows a concentrically striated doublure of regular width, extending inwards to the tip of the axis, as Olin[2] figured.

Dimensions.—

Length of head-shield . . .	16·00 mm.
Width of ,, ...	23·00 ,,
Length of hypostome . . .	6·75 ,,
Width of ,, ...	6·00 ,,

Horizon and Localities.—(1) Whitehouse Group (M. Bala): Whitehouse Bay. (2) Starfish Bed, Drummuck Group: Thraive Glen.

Genus **CYCLOPYGE,** Corda.

Cyclopyge bumasti, sp. nov. Plate III, fig. 8.

Specific Characters.—Head-shield large, half the length of whole trilobite, convex from side to side. Glabella subcylindrical, elongated, half the width of head, (expanding a little in front so as to overhang eyes?), unfurrowed, ornamented by a few widely separated transverse gently arched striæ. Eyes large, oblong, about

[1] Salter, 'Mem. Geol. Surv.,' dec. xi (1864), pl. ii, fig. 4.

[2] Olin, 'Chasmopskalken o. Trinucleusskiffern,' p. 64, pl. iii, fig. 10.

four times as long as wide, extending three-fourths the length of glabella, steeply inclined on each side. No meso-occipital ring present.

Thorax of five segments; axis convex, sub-cylindrical, tapering very slightly posteriorly; rings ornamented by a few fine striæ. Pleuræ short, broad, arched down at fulcrum at about one-third their length; inner portion crossed by broad shallow pleural groove behind raised anterior margin; outer portion smooth, with triangular articulating facet; fine post-median impressed line along whole pleura parallel to posterior edge; extremities of pleuræ abruptly truncate, obtuse.

Pygidium semi-oval, nearly as long as wide, strongly and uniformly convex, smooth, sub-hemispherical, with no trace of axis except faint notches on anterior margin; slightly thickened narrow border marked off by very weak marginal furrow.

Dimensions.—

Length of trilobite	17·00 mm.
,, of head	8·50 ,,
,, of thorax	3·50 ,,
,, of pygidium	5·00 ,,
Width of head	9·00 ,,
,, of glabella at base . . .	4·25 ,,
,, of thoracic axis posteriorly . .	3·25 ,,
,, of pygidium	8·00 ,,

Remarks.—There is only one specimen of this species in Mrs. Gray's collection, and on it the above description is based. The glabella and eyes recall *C. mirabilis* (Forbes)[1] but the apparent lateral expansion of the glabella in front of the eyes is peculiar, though this part of the head is not quite satisfactorily preserved. The thorax is much like that of *C. major* (Salter)[2], but the pygidium resembles that of *C. boia* (Hicks)[3] from the Arenig beds of St. Davids; and the young individuals of *C. speciosa*, Corda, figured by Barrande,[4] have also an unfurrowed smooth pygidium.

Horizon and Locality.—Whitehouse Group (M. Bala); Shalloch Mill.

Cyclopyge subarmata, sp. nov. Plate III, figs. 9—12.

1904. *Cyclopyge armata* (Barrande) Reed, op. cit., pt. ii, p. 51, pl. vii, figs. 11—14; pl. viii, fig. 1.

Specific Characters.—Head-shield nearly as long as thorax and pygidium combined.

Glabella suboval, egg-shaped, narrowing anteriorly and produced into short, triangular, frontal spine; surface of glabella very gently convex, marked by two pairs of short transverse furrows, horizontal or slightly arched, isolated from axial

[1] Salter, 'Mem. Geol. Surv.,' dec. vii, pl. x, figs. 8, 8 *a*.

[2] Salter, ibid., pl. x, figs. 9, 9 *a*, 9 *b*.

[3] Hicks, 'Quart. Journ. Geol. Soc.,' vol. xxxi (1875), p. 185, pl. x, figs. 9, 9 *a*.

[4] Barrande, 'Syst. Silur. Bohême,' vol. i, Suppl., p. 64, pl. ii, figs. 17—18.

furrows; anterior pair situated rather behind middle of glabella; posterior pair about half way between anterior pair and base of glabella; small median tubercle situated close to base of glabella; general surface of glabella ornamented with fine undulating broken lines transverse near base but concentric to lateral margins at sides and extending on to base of frontal spine. Palpebral lobes formed by whole of narrow, flat, depressed, band-like fixed cheeks embracing sides of glabella, widening a little at base with distinct neck furrow marking off narrow pleuro-occipital ring. Eyes very large, swollen, bulging out, with convex surfaces, embracing sides of head-shield and extending forwards to tip of frontal spine, which separates them above, but confluent on lower surface and completely bounding epistome in front, narrowing posteriorly to its lateral angles; lenses alternating, arranged in regular straight rows parallel to axis of body in median part but radiating slightly at sides; 20—30 lenses in median rows on lower surface; in lateral rows lenses decrease in size to base of glabella.

Epistome (= rostral shield) triangular, subcrescentic, obtusely pointed in front, anterior edges nearly straight and meeting in middle at angle of 120° to 130°; widest across middle; narrowing to lateral angles; posterior edge concave forwards; surface flat, marked by few transverse lamellose striæ, arching simply forwards without angulation. Doublure of head-shield behind lateral extremities of epistome very narrow, somewhat bent back, with lamellose striæ from epistome continued on to it.

Thorax of six segments. Axis wide, tapering posteriorly to about two-thirds its anterior width; axial rings simple, ornamented with fine, parallel, slightly sinuous lines; first ring with small median tubercle; third ring with median pair of circular pits. Axial furrows weak. Pleuræ increasing in length to pygidium; first pleuræ very short, broad, with prominent knob on front edge fitting into notch at end of axial furrow of head-shield, and provided with long, tapering, straight spines sharply bent back and reaching to pygidium, touching or overlapping extremities of successive pleuræ, being closely pressed against sides of thorax; second and successive pleuræ with truncate ends and short recurved subfalcate points; each pleura with strong diagonal furrow on surface and a few fine lines along its length.

Pygidium semi-circular, with broad, somewhat flattened border; axis conical, short, a little more than half length of pygidium, composed of two or three rings and a triangular terminal piece; extremity pointed and connected with marginal furrow by fine groove. Lateral lobes gently convex, with one strong wide deep groove just behind and parallel to anterior margin, and two or three faint pleuræ corresponding to axial rings and indicated by fine straight radiating interpleural furrows dying out before reaching marginal furrow, each with finer line parallel to and a short distance behind the interpleural furrow. Pygidium ornamented by fine transverse sinuous lines on axis continued on to pleural lobes.

Dimensions.—

	I	II	III
Length of whole trilobite	23·0 mm.	—	—
„ of head	11·0 „	22·0 mm.	—
„ of thorax	7·5 „	—	9·0 mm.
„ of pygidium	4·5 „	—	7·5 „
Width of glabella at base	7·0 „	12·0 mm.	—
Maximum width of glabella	9·0 „	16·0 „	—
Width of thorax at front end	8·5 „	—	—
„ of pygidium	10·0 „	—	14·5 mm.
„ of axis of ditto	2·5 „	—	—

Remarks.—The shape of the glabella and the long spinose first pair of pleuræ necessitate the separation of this species from *C. armata*, Barr., to which it was previously referred. The enormous eyes recall *C. mirabilis* (Forbes),[1] but the organ of sight is not bilobed in front. The pair of pits on the third axial ring of the thorax recall *C. prisca*, Barr.,[2] and *C. binodosa*, Salter.[3] In *C. prisca*, Barr., it is the last pair of pleuræ which are produced into long spines; and the head of this species is quite distinct. The large pygidium[4] compared by me to *C. gigantea*, Barr., may probably be referred to *C. subarmata*.

Horizon and Localities.—Whitehouse Group (M. Bala): Whitehouse Bay; Shalloch Mill.

Genus **BOHEMILLA**, Barrande.

Bohemilla scotica, sp. nov. Plate IV, fig. 1.

1904. *Bohemilla* sp., Reed, op. cit., pt. ii, p. 53, pl. viii, fig. 4.

In the former specimens of *Bohemilla* from the Whitehouse Group, which were fully described by me in 1904, no traces of a border or "fixed cheek" were preserved, only the so-called glabella being known. But, in a beautiful example recently obtained by Mrs. Gray from the same locality (Whitehouse Bay) and horizon, there is seen to be present a narrow border, somewhat as represented in Barrande's figure of *B. stupenda*,[5] running round the front and sides of the first segment (the so-called frontal lobe) as a depressed band and produced in front into a small median point, while its posterior ends are slightly swollen; a narrow furrow marks off this border from the "glabella."

[1] Salter, 'Mem. Geol. Surv.,' dec. vii, p xl., figs. 1—7.

[2] Barrande, 'Syst. Silur. Bohême,' vol. i, Suppl., p. 63, pl. v, figs. 1—7; pl. vii, figs. 19, 20; pl. viii, figs. 5, 6.

[3] Salter, 'Mem. Geol. Surv.,' dec. xi, pl. iv, figs. 1—6.

[4] Reed, 'Girvan Trilob.,' p. 163, pl. xx, fig. 5.

[5] Barrande, 'Syst. Silur. Bohême,' Suppl i, Trilob. p. 137, pl. xiv, fig. 30.

With the exception of the following trifling differences, probably of no specific value, the "glabellas" of the present specimens agree completely with those previously described by me; (1) the double row of small tubercles bordering the median groove on the first segment is not so distinct, and the tubercles are more irregularly disposed, increasing progressively in size backwards to the first furrow, so that there is a cluster of three to four large tubercles on each side of the posterior end of the groove; (2) the third pair of furrows do not have such marked hooked inner ends as in most Whitehouse examples, but the parts of these furrows which are arched forwards have a short horizontal furrow behind, separating off from the segment a small transverse area on each side, just as Barrande shows in one figured specimen (*op. cit.*, fig. 30). However, these differences between our previously figured specimens and the present one are trifling and immaterial, and they must be referred to the same species.

From Barrande's *B. stupenda* our form differs in the shape of the fourth and fifth segments, in the presence of strong tubercles down the middle of the first segment, in the presence of a narrow occipital ring and in the triangular projection of the border in front. If we regard the lateral band on each side of the first segment as the anterior part of the fixed cheek or eye-lobe, then it will be defined outside by the facial sutures, and they cross the anterior border obliquely, meeting at an acute angle in the median line so as to leave a triangular piece of the border between them.

This Whitehouse form may now receive a specific name and be known henceforth as *B. scotica*.

As regards the zoological position of the curious genus *Bohemilla*, it may be suggested that it is not a trilobite at all, but is referable to some primitive section of the Arachnida.

Genus **ILLÆNUS**, Dalman.

Illænus latus, M'Coy.

1904. *Illænus latus*, M'Coy, Reed, op. cit., pt. ii, p. 63, pl. ix, figs. 6, 7.

The occurrence of this species in the Balclatchie Group is now established, some typical pygidia having been recently found by Mrs. Gray, at Balclatchie. The characters by which the pygidium is distinguishable from that of *I. portlocki* have been previously given, but it is doubtful if we can satisfactorily separate the head-shields, as they both occur in the same bed and a complete individual is unknown, isolated and non-associated head-shields and pygidia of the two species being only found. On the strength, however, of the pygidial axis in *I. latus* being narrower than that in *I. portlocki*, it is probable that the head-shields with the narrower glabella are referable to *I. latus*.

Illænus peachi, sp. nov. Plate IV, figs. 2, 3.

Specific Characters.—Cranidium subquadrate, wider than long, the length about three-fourths the width; posterior portion somewhat flattened, arched down gently at sides and more so anteriorly, anterior margin gently rounded; eye-lobes, fixed cheeks and glabella rise to same level posteriorly. Glabella about two-fifths the length of head-shield, widest at base, narrowing towards front, but suddenly expanding at front end, with decided independent convexity at base, dying out anteriorly; small, low median tubercle situated at about half its length. Axial furrows deeply sunken, strong, convergent anteriorly for greater part of length, but diverging suddenly at front end and terminating abruptly. Fixed cheeks convex, rising steeply from posterior edge of head-shield to level of glabella; eye-lobes prominent, rounded, horizontal, sub-cylindrical, semi-circular in outline, in length about one-fifth to one-sixth that of head-shield and situated less than their own length from posterior margin.

Eyes pedunculate. Facial sutures curving gently outwards from anterior margin of head-shield, then running back to eye-lobes sub-parallel, bending out sharply behind eye to cut posterior margin acutely at about 30°.

Dimensions.—

	I	II
Length of cranidium . .	26·0 mm. .	(?) 30·0 mm.
Width of ,, in front of eyes	32·0 ,, .	39·0 ,,
,, ,, across eyes .	36·0 ,, .	43·0 ,,
Length of glabella . .	11·5 ,, .	15·0 ,,
Width of ,, at base .	16·5 ,, .	20·5 ,,
,, ,, at narrowest part	12·0 ,, .	14·5 ,,

Remarks.—The shape of the glabella, the subcylindrical prominent eye-lobes, and the course of the facial sutures are characteristic features of this species; and the posterior view of the head-shield is peculiar, the eye-lobes, fixed cheeks and glabella lying at the same level owing to the steep rise of the cheeks from the depressed posterior margin, which is also bent down sharply on each side. The base of the glabella also is very convex, the axial furrows being here deeply sunken.

There are suggestions of a relationship to *I. schmidti*, Nieszk.,[1] and *I. ariensis*, Holm,[2] but the elevation of the eye-lobes recalls *I. tauricornis*, Kut.[3] We may, however, specially draw attention to its probable affinity with *I. angusticollis*, Billings,[4] and *I. conradi*, Billings, as like these species it seems to lie between the typical members of *Illænus* and the subgenus *Thaleops*.

[1] Holm, 'Rev. Ostbalt. Silur. Trilob.,' pt. iii (1886), p. 107, pl. v, figs. 1—20.

[2] Ibid., p. 80, pl. vii, figs. 1—3.

[3] Ibid., p. 74, pl. vi, figs. 1—11.

[4] Raymond, 'Ann. Carnegie Mus.,' vol. iv, nos. iii and iv (1908), p. 245, pl. lxi, figs. 1—5.

Horizon and Localities.—Balclatchie Group (Llandeilo): Balclatchie; Dow Hill.

Illænus portlocki, Salter.

1904. *Illænus portlocki*, Salter, Reed, op. cit., pt. ii, p. 67, pl. ix, figs. 14—16; pl. x, figs. 1, 1 *a*.

There are many good examples of the pygidia belonging to this species and of cranidia of the type referred to it which have been recently found by Mrs. Gray in the Balclatchie Group of Balclatchie and Dow Hill. Previously it had only been recognised in the Stinchar Limestone of Craighead.

Illænus richardsoni, sp. nov. Plate IV, figs. 4, 5.

Specific Characters.—Cranidium oblong, moderately convex from side to side, arched down steeply and suddenly in front of glabella, anteriorly truncate.

Glabella very broad, widest across middle, fully two-thirds the width of cranidium, very short, less than one-third the length of cranidium, with slight independent convexity and small median tubercle situated at half its length. Fixed cheeks narrow; eye-lobes large, semicircular, about one-fourth the width of glabella and as long as glabella, nearly touching posterior margin of head-shield behind. Axial furrows well marked, slightly sigmoidal, arching outwards in middle. Facial sutures with anterior branches subparallel, directed at right angles to anterior margin of head-shield, slightly bending inwards to eye-lobes; posterior branches very short, sharply bending out behind eyes to meet posterior margin at an acute angle.

Dimensions.—

Length of glabella	7·2 mm.
,, of preglabellar portion . . .	15·8 ,,
Width of glabella at base	14·0 ,,
,, of cranidium across eye-lobes . .	21·0 ,,
,, ,, at front end . . .	17·0 ,,

Remarks.—The characteristic features of this species are the great width and shortness of the glabella, the narrow cheeks, the large eyes set far back and the parallelism of the facial sutures in front of the eyes. Perhaps it may be allied to *I. chiron*, Holm.[1]

Horizon and Localities.—Balclatchie Group (Llandeilo): Balclatchie and Ardmillan.

[1] Holm, 'Svensk. Artern. Illæniden' (1883), p. 88, pl. iii, figs. 7—17.

Family BRONTEIDÆ.

Genus **BRONTEOPSIS,** Wyville Thomson.

Bronteopsis scotica, Salter. Plate IV, fig. 6.

1904. *Bronteopsis scotica*, Salter, Reed, op. cit., pt. ii, p. 94, pl. xiii, figs. 5—13.

In the previous description of this species the characters of the free cheeks could not be quite fully given owing to the poor material available. But we are now in a position to remedy this.

The free cheeks are found to be triangular and transversely elongated in shape, about twice as broad as long, and are produced backwards into a tapering genal angle acutely pointed at about 30°. The inner portion of the cheek is swollen, rising up steeply to the eye and forming a quarter of a circle in shape with a radius equal to about half the length of the whole free cheek. The outer marginal portion is depressed, sloping down to a rather broad slightly concave border not marked off by any distinct furrow, but only separated by a shallow depression which is most clearly developed towards the genal angle. The surface of the outer portion of the cheek is ornamented with transverse lamellose striæ, more or less curved and broken, but best developed towards the genal angle, where they run obliquely across its posterior prolongation, but bend outwards near the posterior margin. The inner portion of the cheek is ornamented by similar but shorter lamellose broken striæ, and they run in a different direction, being inclined almost at right-angles to the other set. The concentric striæ, which were stated (*op. cit.*) to ornament the border, really occur on the doublure, *i. e.* the lower surface of the head-shield.

The semicircular eyes, which are placed so far back as to touch the posterior margin, are small, being less than one-fourth the length of the cheek, and are situated on the summit of the inner convex portion at the inner posterior angle of the free cheek. The shape of the free cheek of *B. scotica* and the absence of true genal spines, the genal angle being simply produced backward, distinguishes it from *B. ardmillanensis* (*op. cit.*, pt. ii, p. 92, pl. xiii, figs. 1—4). But the above characters of the free cheeks are closely similar to those of *Bronteus lunatus*, Billings,[1] and the other features of the head-shield and thorax so closely agree that it is surprising to find the pygidia so dissimilar, particularly in the shape and segmentation of the axis.

Bronteopsis ardmillanensis, Reed. Plate IV, fig. 7.

1904. *Bronteopsis ardmillanensis*, Reed, op. cit., pt. ii, p. 92, pl. xiii, figs. 1—4.

In my previous description of this species the pygidium had not been found in

[1] Weller, 'Geol. Surv. New Jersey,' Palæont., vol. iii (1902), p. 198, pl. xv, figs. 14—16, and references.

direct connection with the head-shield, but Mrs. Gray has recently discovered a specimen with the pygidium attached, though the thorax is missing. The characters are the same as those which I described in the pygidia previously referred to it; but the new specimen shows an impression of the under surface, which is seen to possess a concentrically striated doublure of uniform width, extending inwards as far as the tip of the axis. On the upper portions of the pleural lobes within the doublure there are traces of 5—6 pleuræ, and the whole surface is finely reticulate. Behind the axis the doublure seems to have been swollen into a low boss, and the doublure itself is convex near the margin. The specimen is from the type-locality, Ardmillan. The resemblance of the pygidium of this species to that of *Stygina latifrons*, Portl., as figured by Wiman[1] is striking and suggestive; but special attention may be drawn to the many points of resemblance between *B. ardmillanensis* and the Scandinavian *Holometopus nitens*, Wiman,[2] of the older *Chasmops* Limestone.

Family PROETIDÆ.

Genus **CYPHASPIS,** Burmeister.

Cyphaspis jamesoni, sp. nov. Plate IV, fig. 8.

Specific Characters.—Head-shield parabolic, produced back at genal angles into long points reaching to sixth thoracic ring. Glabella short, subquadrate, rather more than half the length of head-shield and one-third its width, as broad as long, widening at base into sub-oval basal lobes projecting slightly at sides and extending nearly half length of glabella; basal lobes marked off by fine weak furrows. Pre-glabellar area gently convex, descending to flattened border. Eyes large, rather more than half length of glabella, closely appressed to its sides, and posteriorly nearly reaching to occipital furrow. Meso-occipital ring convex, arched gently forwards in middle and at sides, where it is subnodular. Facial sutures bend outwards in front of eyes to cut anterior margin of head-shield at about twice the width of glabella apart. Free cheeks gently convex on inner portion, with rather wide indefinite flattened border; genal angles produced back into long parallel triangular flattened points reaching to sixth thoracic ring. Pleuro-occipital segment well marked off by strong furrow continued back to tip of genal angles.

Thorax of ten segments, with broad convex tapering axis, fully one-third width of thorax; axial rings strong, rounded, with weak lateral swellings. Pleuræ strongly bent down at fulcrum, which is situated at less than half their length; surface of pleuræ with wide oblique diagonal furrow. Pygidium small, semi-circular, with convex, gently conical obtuse axis of 5—6 segments (imperfectly known).

[1] Wiman, 'Bull. Geol. Instit. Upsala,' no. 10, vol. v, pt. 2 (1900), p 171, pl. v, fig. 18 only.

[2] Wiman, ibid., vol. viii (1907), p. 112, pl. vii, figs. 19, 20.

Remarks.—This small trilobite is only represented by one specimen, measuring only about 6·5 mm. in length, which is in Mrs. Gray's collection, and it is of special interest as being the earliest example of the genus in the Girvan area. It appears to be allied to *Cyphaspis matutina*, Ruedemann,[1] of the Trenton Formation, and to *C. parvula*, Pompecki,[2] from Königsberg.

Horizon and Locality.—Balclatchie Group (Llandeilo): Balclatchie.

Family Lichadidæ.

Genus **LICHAS**, Dalman.

Lichas (Corydocephalus) maccullochi, sp. nov. Plate IV, figs. 9, 10.

Specific Characters.—Head-shield transversely semi-circular. Cranidium strongly convex, arched down anteriorly, projecting in front of free cheeks. Glabella and fixed cheeks equally swollen. Median lobe of glabella clavate, projecting in front of lateral bi-composite lobes, completely embracing their front ends with narrow recurved over-hanging lateral extensions; posterior three-fourths of median lobe parallel-sided, cylindrical, crossed at base of bi-composite lobes by transverse furrow strongly arched back, separating off posterior fifth part as post-median lobe. Bi-composite lateral lobes sub-oval, completely circumscribed, about one and a half times as long as broad, with axes parallel and with faint notch indenting inner sides behind middle. Fourth lateral lobes completely fused with fixed cheeks, forming transverse swollen cushion rising steeply from depressed neck-ring. First lateral furrows curve forwards in front of bi-composite lobes, thence run back parallel or subparallel to base of latter, where they end in deep pits connected across median lobe by transverse furrow. Post-median lobe bounded laterally by shallow parallel grooves continued back from these pits to occipital furrow. Second lateral furrows nearly at right angles to axial furrows and to first lateral furrows, defining the bi-composite lobes behind. Axial furrows only present in front of second lateral furrows, completely undeveloped behind them. Meso-occipital ring simple, rounded, broad in middle behind post-median lobe of glabella, narrowed on each side, with occipital lobes forming small subcircular swellings partly fused with posterior slopes of fourth lateral lobes. Pleuro-occipital ring narrow.

Free cheeks triangular, with genal angle produced broadly back to fourth or fifth thoracic segment, and pointed. Eyes small, prominent, situated just behind level of second lateral furrows, and distant from sides of median lobe rather more than one and a half times its width. Surface of glabella and cheeks covered with fine granulations and a few scattered tubercles.

[1] Ruedemann, 'Bull. 49 New York State Mus.,' Palæont. Papers 2 (1901), p. 62, pl. iv, figs. 5—7.

[2] Pompecki, 'Trilob. ost.-westpreuss. Diluv. Geschiebe' (1890), p. 57, pl. vi, figs. 28, 28 *a*.

Thorax of eleven segments. Axis broad, nearly as wide as pleural portions, subcylindrical, tapering very slowly behind seventh or eighth ring. Pleuræ narrow, arched back and downwards beyond weak fulcrum situated at less than half their length, divided longitudinally by weak submedian slightly diagonal furrow. Surface of thorax granulated and with a few scattered tubercles.

Pygidium transverse; axis cylindrical, three-fourths its length, showing one ring at front end and faint traces of others, with narrow pointed post-axial ridge continued to margin. Lateral lobes formed by three pairs of pleuræ ending freely on margin; first and second pairs of pleuræ lanceolate, narrow, arched back gently, each with submedian furrow and pointed extremity freely projecting; first pair with ends reaching back as far as tip of axis; second pair with ends reaching back a little behind tips of third pair; third pair large, subtriangular, broadly bifurcate, each pleura ending on margin in two blunt short points, separated by post-axial ridge, and with a small median acute re-entrant angle between their closely placed inner points. Surface of pygidium granulated and with scattered tubercles.

Dimensions.—

Length of head-shield . . .	7·5 mm.
Width of „	20·8 „
Length of thorax	9·5 „
„ of pygidium	7·3 „
Width of „	12·2 „

Remarks.—The difference between this species and *L. geikiei*, Eth. and Nich., lies in the complete fusion of the fixed cheeks with the fourth lateral lobes of the glabella of the former, in the more cylindrical median lobe of the latter, and especially in the characters of the pygidium, the axis of *L. geikiei* having more annulations and the last pair of pleuræ being not bifurcated; the ornamentation is also distinct, as one small complete individual of *L. geikiei* shows. An isolated pygidium attributed to *L. geikiei* has been previously described and figured by me,[1] but one has now been found in attachment to a perfect thorax and head-shield. The condition of the glabella in *L. maccullochi* and its fusion posteriorly with the fixed cheeks, resemble *L. haueri*, Barrande,[2] while its pygidium is much like that one compared by me to *L. wesenbergensis,* Schmidt,[3] from the Balclatchie Group.

Horizon and Locality.—Starfish Bed, Drummuck Group (U. Bala): Thraive Glen.

Lichas (Amphilichas) ardmillanensis, sp. nov. Plate V, fig. 1.

Specific Characters.—Cranidium weakly convex from side to side, not bent down in front. Glabella sub-oblong, slightly contracted behind middle, expanding

[1] Reed, op. cit., pt. iii, p. 96, pl. xiv, fig. 1.

[2] Barrande, 'Syst. Silur. Bohême,' p. 604, pl. xxviii, figs. 38—40.

[3] Reed, op. cit., pt. ii, p. 98, pl. xiv, fig. 2.

a little towards front and base, composed of a median lobe and a pair of tri-composite lateral lobes. Median lobe transversely clavate, expanded anteriorly, with prominent subconical projection in middle; lateral portions narrow and overhanging lateral lobes for nearly their full width; neck of median lobe long, narrowing posteriorly at half its length to less than a quarter the width of anterior clavate portion, then expanding again to occipital furrow to about one-third the basal width of whole glabella. Lateral lobes tri-composite, with base resting on occipital furrow, subreniform, elongated, rounded and bent down at front end, curving outwards posteriorly and obtusely pointed at outer posterior angle, widest towards front; small notch present on inner side at one-third their length from base. First lateral furrows well marked, continuous from front of lateral lobes to occipital furrow, nearly horizontal at anterior end of lateral lobes, then curving backwards with slight convergence to about half their length, then bending gently outwards to the notch on inner side of lateral lobes, then diverging outwards to meet occipital furrow at about 75°.

Axial furrows strong, continuous all round glabella, arching outwards at first from front end, then bending inwards slightly to constrict glabella behind middle, then bending outwards slightly to posterior margin. Meso-occipital furrow strong, straight and horizontal behind median lobe, sloping backwards on each side behind lateral lobes. Meso-occipital ring simple, rounded, narrowing behind lateral lobes. Occipital lobes absent. Fixed cheeks small, bent down on each side; eye-lobes semicircular, situated at level of notch on inner side of lateral lobes and close to axial furrows. Surface of cranidium tuberculated, a few larger conspicuous tubercles being irregularly distributed amongst numerous smaller ones of two or three sizes.

Dimensions.—

Length of cranidium . . .	9·7 mm.
,, of lateral lobes . . .	6·0 ,,
Maximum width of glabella across lateral lobes .	9·0 ,,
Minimum width of median lobe . .	1·8 ,,

Remarks.—The shape and anterior projection of the median lobe of the glabella recall species of *Conolichas*, but the general characters of the cranidium ally it to *L. hibernicus*, Portl., and *L. dalecarlicus*, Ang.,[1] from which, however, it is clearly distinct in the shape of the median lobe, the course of the first lateral furrows and the notched lateral lobes.

Horizon and Locality.—Balclatchie Group (Llandeilo): Ardmillan.

Lichas (Amphilichas) hibernicus, Portlock. Plate V, fig. 2.

1906. *Lichas (Amphilichas) hibernicus*, Portlock, Reed, op. cit., pt. iii, p. 106, pl. xv, figs. 1—3.

A fine pygidium (24 mm. long) of this species from Ardmillan is deserving of

[1] Schmidt, 'Rev. Ostbalt. Silur. Trilob.,' pt. ii (1885), p. 53, pl. vi, figs. 11—13.

notice because it agrees precisely with the one figured by Portlock, and possesses the same ornamentation as the head-shields from the Balclatchie Beds referred to this species. The most remarkable feature in the pygidium of *L. hibernicus* is that whereas the first two pairs of pleuræ bear furrows the third pair does not; and this character led me formerly[1] to associate it with the group *Metalichas*, typified by *L. cicatricosus* instead of with *Amphilichas*, of which *L. dalecarlicus* is the typical example. The lack or obsolescence of the third pleural furrows, however, seems to occur occasionally in *Amphilichas*, as, for instance, in *L.* (*Amphi.*) *minganensis*, Billings, as shown by Raymond.[2]

In our specimen there is only one complete ring on the axis, and this corresponds with the first pair of pleuræ. The second ring is imperfectly defined by a furrow arched backwards and incomplete at the sides, and does not correspond with the second pleuræ. The pleural furrows on the first two pleuræ are short and less than half their length. All three pairs of pleuræ have short, free points; the first two pleuræ are foliate in shape; the third pair is much broader, and their free points are closely placed in the median line with a sharply acute, narrow notch between them. The axis is not clearly marked off from the long, narrow-pointed, post-axial piece which apparently reaches the posterior notch in the margin separating the third pleuræ.

This type of pygidium is quite distinct from that attributed to *L. lævis*, Eichwald, by Schmidt[3] and regarded formerly by me[4] (on the strength of this association) as typical of *Amphilichas*. If we regard the pygidia of *L. cicatricosus* and *L. hibernicus* to be of the same structural type, it follows that a parallel development of this part has taken place in the two otherwise distinct sections of the genus, *Metalichas* and *Amphilichas*. We may also doubt now if *L. lævis* is referable to the same section as *L. dalecarlicus* and perhaps should be removed from *Amphilichas*.

Family Acidaspidæ.

Genus **ACIDASPIS,** Murchison.

Acidaspis asteroidea, sp. nov. Plate V, figs. 3—7.

Specific Characters.—Head-shield broad, transverse, crescentic. Cranidium with straight anterior margin. Free cheeks slightly arched forwards and projecting on each side. Glabella broadly semi-oval, narrowing anteriorly; width at

[1] Reed, 'Quart. Journ. Geol. Soc.,' vol. lviii (1902), p. 74, fig. 7.

[2] Raymond, '7th Ann. Rep. Vermont Geol. Surv.,' 1910, p. 232, pl. xxxvi, figs. 1—3 (*non* pl. xxxix, fig. 14).

[3] Schmidt, 'Rev. Ostbalt. Silur. Trilob.,' pt. ii (1885), pl. vi, fig. 10.

[4] Reed, op. cit., p. 80, fig. 18.

base greater than length, moderately convex; composed of median lobe and three pairs of lateral lobes. Median lobe nearly semi-cylindrical, expanding a little in front and also at base, slightly contracted between second pair of lateral lobes; anterior end obtusely rounded. Lateral lobes almost completely severed from median lobe by strong longitudinal furrows; anterior lateral lobes very minute or obsolete; second lateral lobes subcircular to subtriangular, swollen, detached, about one-fourth the length of the glabella; basal lateral lobes subcircular, swollen, much larger than second pair, extending about two-fifths the length of the glabella and with a width equal to about two-thirds that of base of median lobe, with which they are connected by narrow depressed neck. Lateral furrows deep, completely circumscribing lateral lobes, inclined to general axis at about 45°, and united internally with longitudinal furrows. Axial furrows strong, deep, converging anteriorly, arched outwards, but not in a regular continuous curve, being bent in at second lateral furrows. Meso-occipital ring broad in middle, subtriangular, being produced back into long, stout, straight, slowly tapering horizontal spine as long as or longer than glabella; small tubercle situated in middle of ring and small, subtriangular, indistinct occipital lobes behind basal lobes of glabella. Meso-occipital furrow well marked, but weaker than glabellar furrows, straight and horizontal in centre, but bent back behind basal lobes and ending in deep pit on inner sides of occipital lobes. Fixed cheeks slightly arched outwards, very narrow, but widening posteriorly to about half width of basal lobes, forming long, swollen, rounded bands descending abruptly behind to depressed neck-ring. Ocular ridges narrow, rounded, slightly arched outwards. Anterior border of cranidium narrow, straight, flattened, slightly upturned, with deep pit on each side in furrow.

Free cheeks broad, very convex, wider than long, lateral edge strongly arched outwards, with raised border armed with fringe of small spines. Genal angle produced into long stout slowly tapering spine, projecting outwards and backwards to eighth thoracic segment. Pleuro-occipital ring widening to genal angle. Eyes situated far back, close to base of glabella, very prominent, being elevated on tall vertical stalks. Facial sutures with anterior branches slightly convergent in front; posterior branches short, bending very sharply outwards behind eye to cut posterior margin at acute angle.

Surface of head-shield ornamented with tubercles of two or three sizes, irregularly distributed.

Thorax of ten segments. Axis narrow, cylindrical, convex, about one-fifth the width of thorax; rings with lateral nodules. Pleuræ horizontal, straight, produced into long free spines, increasing in length posteriorly, the last two reaching back as far as tips of pygidial spines; each pleura composed of narrow, flattened, depressed anterior and posterior band, separated by strong, elevated, rounded central ridge ornamented with a few large tubercles, and prolonged into long, stout, backwardly directed spine, with finely tuberculated surface; spines successively increase in length and become parallel to axis of body; anterior band of pleura ornamented with 6—9 small closely set tubercles.

Pygidium transverse, with rounded border, and four pairs of long marginal spines; anterior edge raised and ending laterally in short marginal pointed projections. Axis composed of two rings with a small terminal piece. Pleural lobes flattened, traversed by oblique ridge from first axial ring to base of second pair of marginal spines. Marginal spines straight, parallel, equidistant; first pair short; second pair the longest and the stoutest; third pair of same length as first; fourth pair equal in size to third pair. Surface of pygidium and spines covered with small tubercles rather closely set.

Dimensions.—

Length of glabella	4·0 mm.
Width of ,, at base . . .	6·0 ,,
Length of meso-occipital ring and spine . .	+5·0 ,,

Remarks.—One small but nearly complete individual, one cranidium with the occipital spine, a head-shield with the free cheeks and tall eye-stalks, and two pygidia constitute the material from which the above description has been drawn up.

The general characters of the head recall *A. brighti*, Murchison,[1] and *A. grayi*, Barrande[2] (non *A. grayæ*, Etheridge). The pygidium and thorax closely resemble *A. coronata*, Salter.[3]

Horizon and Locality.—Starfish Bed, Drummuck Group (U. Bala): Thraive Glen.

Acidaspis girvanensis, sp. nov. Plate V, figs. 8—10 ; Plate VI, figs. 1—3.

Specific Characters.—Head-shield transverse, broadly semi-elliptical, strongly convex from back to front and less so from side to side. Cranidium with nearly straight anterior edge projecting slightly in front of free cheeks; free cheeks large, subtriangular, arched downwards on each side, with genal angles furnished with long spines. Glabella ovate; with subcylindrical, swollen median lobe, truncate anteriorly and expanding slightly so as to overhang laterally ; three pairs of lateral lobes present, all completely circumscribed by furrows ; anterior pair of lobes very small, forming minute subcircular nodules ; middle pair subcircular or oval, slightly oblique, about a quarter the length of the glabella ; basal pair large, oval, pointed anteriorly, projecting outside base of middle pair, nearly half the length and fully a quarter the width of glabella. Axial furrows deep, gently arched outwards, forming a regular curve, converging anteriorly and ending in a deep pit in front.

[1] Lake, 'Quart. Journ. Geol. Soc.,' vol. lii (1896), p. 236, pl. vii, fig. 5.

[2] Barrande, 'Syst. Silur. Bohême,' vol. i, p. 751, pl. xxxix, figs. 20, 21.

[3] Lake, op. cit., p. 237, pl. vii, fig. 6.

Fixed cheeks with inner portion of anterior wing forming elongated rounded semicylindrical roll, increasing in width posteriorly to nearly that of basal lobes of glabella, descending steeply to occipital furrow. Ocular ridges narrow, rounded, of uniform width, curved, following edge of fixed cheeks to eyes. Posterior wing of fixed cheeks very narrow from back to front, horizontally extended laterally. Facial sutures with anterior branches gently arched out, and slightly convergent anteriorly; posterior branches bent out at eyes, nearly at right angles to anterior branches, and running obliquely back to cut posterior margin of head-shield far out at base of genal spines. Meso-occipital furrow well marked, arched gently forwards, marking off broad meso-occipital ring nearly one-third length of glabella with strong median tubercle and pair of subcircular well-defined lateral lobes. Pleuro-occipital ring of fixed cheek very narrow at axial furrows, expanding in width outwards, convex, rounded, marked off by deep furrow. Surface of cranidium ornamented with tubercles of two sizes, the larger ones fewer and irregularly distributed. Free cheeks large, subtriangular, forming quadrant of circle, convex, steeply arched down from eye; border rather broad, rounded, swollen; marginal furrow strong; margin furnished with series of 14—16 equidistant, small, slightly recurved, short stout spines increasing in size successively from facial suture to genal angle; genal angle provided with stout rounded tapering spine projecting backwards to about sixth or seventh thoracic segment. Eyes small, circular, prominent, elevated, situated far back at about one-fifth length of head-shield and behind middle of basal lobes of glabella. Surface of free cheeks and of marginal and genal spines covered with almost equidistant small tubercles of nearly uniform size.

Thorax composed of ten segments. Axis narrow, cylindrical, decreasing very slightly in width posteriorly, less than one-third total width of thorax; very convex and prominent. Axial rings with pair of distinct swollen lateral nodules and ornamented with numerous small tubercles.

Pleuræ with inner three-fourths of their length straight and horizontally extended; outer fourth bent down rather suddenly, arched gently back, with the extremity furnished with two unequal spines. Inner part of pleura divided unequally by strong straight longitudinal furrow into narrower rounded anterior band and broader more elevated posterior ridge; anterior band ornamented with single row of 6—8 equal and equidistant tubercles and produced into short free recurved spine; posterior ridge raised into prominent knob near outer extremity and beyond it produced into long stout free spine strongly bent back and down and overlapping anterior spine of next succeeding pleura; posterior ridge ornamented with marginal row of small tubercles and some scattered larger ones; general surface of both spines coarsely granulated.

Pygidium transverse, broadly semicircular, marginally spinose, more than twice as wide as long (excluding spines). Axis sub-cylindrical, narrow, less than one-third width of pygidium, convex, prominent, with obtuse end nearly reaching border behind; composed of two well-marked rings followed by pair of small tubercles behind. Lateral lobes flat, horizontally extended; each obliquely traversed by strong rounded pleural ridge running from first axial segment to margin and produced into fourth marginal spines. Border of pygidium well defined, gently raised; margin provided with six pairs of spines; posterior five pairs of spines (second to sixth inclusive) nearly straight, sub-parallel, directed backwards; first pair very small, short, slender, directed backwards; second and third pairs larger, longer, subequal in size; fourth pair the largest and longest of all, more than twice as long as pygidium; fifth and sixth pairs subequal, rather longer than pygidium itself; base of fourth pair somewhat overlaps fifth pair. Surface of pygidium and spines covered with rather sparsely distributed tubercles, of subequal size.

Dimensions.—

	I	II
Length of entire individual (without spines)	11·5 mm.	16·0 mm.
,, of head-shield . . .	3·5 ,,	5·0 ,,
Width of ,, . . .	8·0 ,,	12·0 ,,
Length of thorax . . .	6·5 ,,	9·0 ,,
,, of pygidium (without spines) .	1·5 ,,	2·0 ,,

Remarks.—The material on which the above description is based consists of the casts and impressions of several nearly perfect individuals, so that our knowledge of this species is unusually full. The affinities of this species seem to be with *A. evoluta*, Törnquist,[1] of the Leptæna Limestone, and *A. semievoluta*, Reed,[2] of the Dufton Shales. *A. hughesi*, Lake,[3] is apparently also allied. It is quite distinct from the other Girvan species from the Starfish Bed, though imperfect and poorly preserved isolated head-shields may be difficult to distinguish.

Horizon and Locality.—Starfish Bed, Drummuck Group (U. Bala): Thraive Glen.

Acidaspis playfairi, sp. nov. Plate VI, figs. 4—6.

Specific Characters.—Thorax with broad cylindrical axis, one-third the width of the thorax, and with each ring furnished with a median pair of large tubercles; pleuræ short, broad, flattened horizontally, extended, with surface bearing a faint broad submedian ridge and 2—3 large tubercles; ends of pleuræ abruptly truncated and provided with very long slender spines, the posterior segment having the spines almost parallel and projecting back behind pygidium; with traces of shorter straight horizontal denticulated spine lying at lower level.

1 Törnquist, 'Siljansom. Trilobitf.' ('Sver. Geol. Undersökn.,' Ser. C, No. 66, 1884), p. 28, pl. i, figs. 24, 25.

2 Reed, 'Geol. Mag.' [5], vol. vii (1910), p. 214, pl. xvii, figs. 1—3.

3 Lake, 'Quart. Journ. Geol. Soc.,' vol. lii (1896), p. 242, pl. viii, fig. 5.

Pygidium small, with broad blunt axis of two segments, each bearing three equidistant tubercles ; pleural lobes flat, bearing a few large tubercles ; margin provided with five pairs of delicate long radiating denticulated spines and a median one, all of the same length and equidistant. Width of thorax about 2·5 mm.

Remarks.—The above description is based on one minute incomplete specimen showing three or four thoracic segments with the pygidium attached, all more or less imperfect. But the characters are so interesting and unusual that it deserves a specific designation. Its affinities are plainly with *A. verneuili*, Barrande,[1] and *A. mira*, Barrande[2]; the double spines of the thoracic pleuræ of the former species, with the lower ones denticulated, the median pair of tubercles on the axial rings, the short broad pleuræ and the denticulated radiating spines round the margin of the pygidium are features in common. The number, however, of the pygidial spines is different, and they are longer in our form, but a more precise comparison is impossible till better material is obtained.

There is one small imperfect cranidium from Whitehouse Bay (Pl. VI, figs. 5, 6), which may probably be referred to this species, but its poor condition precludes a satisfactory or complete diagnosis. The cranidium is semi-circular; the glabella is semi-oval, with two pairs of subequal oval or subcircular lateral lobes, completely circumscribed, and a sub-cylindrical median lobe narrowing a little anteriorly to the first lateral lobes, and then suddenly expanding and slightly overhanging laterally, with a rounded, not truncate, anterior end.

The meso-occipital ring is very broad, being about one-third the length of the whole head-shield, and is furnished on its posterior margin with a pair of lateral, slightly divergent, horizontal spines, at least as long as the head-shield ; a strong horizontal furrow marks off this ring, and on the surface of the latter are six tubercles arranged in three pairs in two straight lines, the median anterior one being the largest. A few large tubercles are present also on the glabella. The eyes seem to be placed far back, and the roll-like rounded narrow fixed cheek and ocular ridge appear to be of equal size.

Horizon and Locality.—Whitehouse Group (M. Bala) : Whitehouse Bay.

Acidaspis terribilis, sp. nov. Plate VI, figs. 7—10.

Specific Characters.—Head-shield transverse, about twice as wide as long, moderately convex, arched down at sides ; anterior margin of cranidium slightly recessed owing to greater projection of free cheeks on each side. Glabella subovate, narrowing anteriorly, with strongly truncate front end and nearly straight sides. Median lobe subcylindrical, widening a little at level of second lateral furrows, and suddenly expanded in front into small lateral projections

[1] Barrande, 'Syst. Silur. Bohême,' vol. i, p. 710, pl. xxxviii, figs. 1—9.

[2] Ibid., p. 735, pl. xxxix, figs. 1—11.

overhanging lateral lobes; two pairs of lateral lobes present, both completely marked off from median lobe by continuous furrow; anterior pair rounded, subquadrate, about one-third the length of the glabella and less than one-third its width, incompletely marked off from posterior pair by short horizontal furrows, deep at inner end and starting from median longitudinal furrows, but dying out before reaching axial furrows; posterior pair of lateral lobes sub-oblong, longer than wide, nearly half the length of the glabella and nearly one-third its width. Axial furrows narrow, weak, not deeply impressed, convergent anteriorly, nearly straight for greater part of length, but arched in strongly at base.

Meso-occipital ring broad, marked off from base of median lobe by strong furrow, furnished with a median pair of stout divergent spines rising up vertically from surface.

Fixed cheeks large, convex, swollen, subtriangular, arched down, with a width at their base equal to two-thirds that of the glabella. Eyes apparently absent, or very small, situated far forward, opposite first lateral furrows of glabella. Ocular ridges very weak, short, indistinct. Pleuro-occipital segment narrow at inner angle of fixed cheeks, but widening to their rounded outer angle. Free cheeks small, narrow, crescentic, about half the width of the fixed cheeks, with outer edge strongly arched outwards and forwards; genal angles rounded, with prominent tubercle or short spine just inside margin; lateral border flattened, broad, smooth, marked off by strong marginal furrow, and armed with 14—16 (?) small marginal spines directed forwards and outwards and decreasing in length from back to front. Facial sutures obscure. Surface of head-shield ornamented with coarse tubercles of two to three sizes, irregularly scattered.

Thorax composed of nine segments. Axis strongly convex, cylindrical, about one-fourth the width of the thorax; axial rings broad, with well-marked nodular lateral swellings and with median pair of short divergent spines standing up vertically and directed obliquely outwards like those on occipital ring; general surface of rings tuberculated. Pleuræ broad, horizontally extended for inner two-thirds of length, outer third strongly bent down; furnished with narrow anterior marginal ridge produced into short, slightly recurved spine armed with minute denticles; rest of surface of inner part of pleuræ composed of a rounded, elevated, broad semi-cylindrical ridge, which at the point of bending is produced into a long free cylindrical curved spine projecting outwards and upwards in a different plane to the anterior pleural spines. General surface of pleuræ ornamented with small tubercles, especially numerous on anterior ridge. Last pair of larger pleural spines bent sharply backwards and parallel.

Pygidium transverse, about three times as wide as long, with horizontal flattened pleural lobes; anterior margin straight, with thickened rim bearing a tubercle near each end; posterior margin with indistinct border and armed with series of spines; first pair of spines small, straight, directed backwards, starting from lateral angles of pygidium; second pair large, stouter, fully twice the length of pygidium, directed backwards, slightly curved inwards; six pairs of much shorter subequal and equidistant spines behind second pair directed straight backwards from margin. (The third pair of spines is smaller than the rest, but this part of margin is somewhat indistinct.) Axis broad, short, subquadrate, convex, less than one-third width of pygidium and not touching border behind; composed of two segments with articulating ring at front end; first segment consisting of a rounded complete ring bearing a pair of stout tubercles; second segment subquadrate, separated from first by pair of deep pits in shallow furrow and bearing a pair of small tubercles. Axial furrows with pair of deep pits in them behind first segment. Lateral lobes crossed by rounded pleural ridge proceeding outwards from first axial segment parallel to anterior edge of pygidium for three-fourths its length, then curving back suddenly at a point marked by a large tubercle to pass into second marginal spine with slight basal swelling. Lateral lobes behind pleural ridge ornamented with three to four large tubercles. Whole surface of pygidium granulated.

Dimensions.—

Length of whole trilobite (without pygidial spines) .	16·5 mm.
Length of head-shield . . .	5·0 ,,
Width of ,, . . .	9·5 ,,
Length of detached pygidium (without spines) .	4·0 ,,
Width of ,, . . .	11·0 ,,
Width of axis of ,, . . .	3·0 ,,

Remarks.—One complete individual in an almost perfect condition (except the pygidium) as an internal cast with its external impression, and one detached perfect pygidium constitute the material from which the above description has been drawn up. It is very doubtful if this species possessed eyes; but if they are present they are very minute. A near ally is *A. barrandei*, Fletcher and Salter,[1] of the Wenlock Limestone; the spinose ends of the pleuræ and the spines on the axis are almost identically developed; the head-shield is very similar, but the glabella and its lateral lobes are better defined and the axial furrows more distinct. *A. verneuili*, Barrande,[2] may also be compared, and with regard to the pygidium we may specially draw attention to *A. keyserlingi*, Barrande.[3] The head-shield of *A. jamesii*[4] also possesses many features in common.

If we adopt the classification of *Acidaspis* proposed by Clarke and followed by Van Ingen,[5] we must place *A. terribilis* in the subgenus *Ceratocephala*, Warder, 1838.

Horizon and Locality.—Starfish Bed, Drummuck Group (U. Bala): Thraive Glen.

[1] Lake, 'Quart. Journ. Geol. Soc.,' vol. lii (1896), p. 241, pl. viii, figs. 1, 2, 3 (?).

[2] Barrande, 'Syst. Silur. Bohême,' vol. i, p. 710, pl. xxxviii, figs. 1—9.

[3] Barrande, ibid., p. 708, pl. xxxvi, figs. 10—22.

[4] Salter, 'Mem. Geol. Surv.,' dec. vii (1853), pl. vi, figs. 1, 1*.

[5] Van Ingen, 'School of Mines Quarterly,' vol. xxiii (1901), p. 38.

Family Encrinuridæ.

Genus **ENCRINURUS**, Emmrich.

Encrinurus contentus, sp. nov. Plate VI, figs. 11, 12.

Specific Characters.—Pygidium suboval, acutely pointed behind, strongly convex from side to side, arched down steeply behind, widest across middle.

Axis conical, elongated, slender, tapering slowly to acute tip, not reaching posterior margin, but with small narrow raised post-axial piece behind it; axis composed of 10—12 complete narrow rings, each with indistinct lateral nodules, forming half its length, followed by 12—14 incomplete rings, the median third of the axis for this posterior half being smooth; each complete ring ornamented with pair of small tubercles situated rather less than one-third the width of the axis apart.

Lateral lobes with anterior edges sloping back, arched down steeply, composed of six simple flattened pleuræ, curved back so as to lie nearly parallel to axis; first five pairs originate from anterior half of axis and end freely in short blunt points; sixth pair very short, arising at about three-fourths the length of axis, closely pressed against it and against post-axial piece, and not projecting behind. Surface of pleuræ finely and sparingly tuberculated.

Dimensions.—

Length of pygidium	8·5 mm.
Maximum width of ditto	8·6 ,,
Width of axis at front end . . .	3·0 ,,

Remarks.—This little species, of which only the pygidium is known definitely, is much like *E. sex-costatus*, Salter,[1] but differs in the longer, narrower and tuberculated axis and in the pleuræ being bent back more sharply so as to lie almost parallel to the axis.

Horizon and Locality.—Balclatchie Group (Llandeilo): Balclatchie.

Encrinurus multisegmentatus (Portlock), var. nov. **trispinosus.** Plate VII, figs. 1—3.

1906. *Encrinurus multisegmentatus* (Portlock) Reed, op. cit., pt. iii, p. 122, pl. xvi, figs. 9—11 *a*.

In the specimens referred by me to *Encrinurus multisegmentatus* (Portlock) from the Starfish Bed, there was no indication of any peculiarity in any of the thoracic segments differentiating it from this species. But in three specimens

[1] Salter, 'Mem. Geol. Surv.,' dec. vii (1853), pl. iv, figs. 1—12; Vogdes, 'Trans. San Diego Soc. Nat. Hist.,' vol. i, no. 2 (1907), p. 70, pl. ii, figs. 1—12.

from the same horizon which Mrs. Gray has recently obtained, the sixth thoracic segment is seen to possess a long, straight median spine on the axial ring projecting backwards horizontally to about the tenth or eleventh ring, and the pleuræ of the sixth segment are likewise furnished with a similar parallel spine of apparently the same length slightly curved inwards, arising at about two-thirds the length of the inner part of the pleura from the posterior ridge on its surface and directed backwards. In one of the examples showing these characters the hypostome is exposed in position and possesses the typical characters of the genus, the body being elongated and slightly pear-shaped, strongly convex and narrowing anteriorly.

In all respects, except the presence of the thoracic spines, these new specimens (which have the head-shield well preserved) agree with the form previously described. Portlock's species was based on the pygidium, and with it the pygidia of the Girvan specimens have been shown to agree very closely. The thorax was not known to Portlock, but the head-shield described by him as *Ampyx ? baccatus* (*op. cit.*, p. 262, pl. iii, fig. 11) was referred first by Salter in 1853 to the same species. There does not seem sufficient reason for separating the Girvan form specifically, but it may provisionally be regarded as a variety under the name *trispinosus.* In *E. seebachi*, Schmidt,[1] long median spines are known to exist on several successive axial rings of the thorax, and Schmidt remarks that as in some specimens there is no trace of them, they may only be a sexual distinction. But none of the pleuræ possess spines similar to those in our Girvan form.

Genus **CYBELE,** Lovén.

Cybele loveni, Linnarsson, var. **girvanensis,** Reed. Plate VII, figs. 4, 5.

1906. *Cybele loveni,* var. *girvanensis,* Reed, op. cit., pt. iii, p. 126, pl. xvii, figs. 1—4.

In the previous description of this variety there was no account given of the eye, as it was not satisfactorily known. But an unusually well-preserved head-shield from the Starfish Bed, measuring 13·5 mm. in length and 34 mm. in width, shows this organ almost uninjured, and the extraordinary height to which it rises can be measured. The eye, in fact, though not mounted on a stalk, projects as a subcylindrical rod nearly at right angles to the surface of the cheek to a height of 3·25 mm., while its diameter is about 1·75 mm.; the outer and lateral faces of the whole of this rod-like prominence are rounded and bear the lenses, while the inner side is flattened and formed by the long narrow eye-lobe.

Another specimen from the same bed deserves notice because it shows the

[1] Schmidt, 'Rev. Ostbalt. Silur. Trilob.,' pt. i, p. 229, pl. xiv, figs. 16—26; pl. xv, figs. 21—23.

posterior part of the thorax and pygidium extremely well; the spinose ends of the seventh and following pairs of pleuræ are seen to be produced back to about the same level, *i. e.* to about the end of the pygidium. The stouter and longer spinose ends of the sixth pair of pleuræ reach back to a point behind the pygidium equal to at least the length of the latter. This species, and apparently the same variety of it, has also now to be recorded from the Whitehouse Group, for Mrs. Gray has found at Whitehouse Bay a well-marked head-shield, and also a small pygidium about 7 mm. long.

Cybele bellatula, Dalman, var. nov. **balclatchiensis.** Plate VII, fig. 6.

In a fairly well-preserved thorax and pygidium of a species of *Cybele* from Balclatchie, the sixth (or seventh) thoracic segment has its pleuræ much stouter, broader and longer than the preceding ones, and they are produced back as long curved spines as far as or further than the tip of the pygidium, as in *C. loveni* var. *girvanensis*. The pleuræ of the segments behind the sixth one are likewise elongated into spines which decrease successively in length. Brögger[1] has shown this feature to exist in *C. loveni*. In the American *C. winchelli*[2] it is only the sixth pleura which is elongated and enlarged. The other thoracic pleuræ of our Balclatchie form have the characters described in the specimens which have been referred by me[3] to *C. bellatula*, Dalman, a strong rounded median ridge having a narrow depressed band on each edge. The pygidium attached to the thorax possessing these spinose posterior pleuræ is triangular in shape, and has a narrow elongated conical axis about three-fourths the length of the pygidium, with a narrow ridged and pointed conical post-axial piece extending from its tip to the margin. The axis is annulated to its blunt extremity by 17—18 narrow incomplete rings, with the median third smooth, and a pair of small tubercles is situated on each ring where it abuts against this smooth zone. The lateral lobes are composed of four pairs of pleuræ, the two posterior ones rendered indistinct by a curious subreticulate ornamentation (? pathological) of circular, elongated or irregularly fused pits covering the surface. The pleuræ are duplicate, being composed of two unequally developed ridges, the posterior one being the stronger; all end in free slightly recurved points on the margin, successively reaching further back along the sides of the pygidium. The first pair of pleuræ is the largest and most clearly divided into anterior and posterior ridges, the latter ridge being the stronger one, and embraces nearly three-fourths of the whole side of the pygidium, the free point being at about the level of the end of the axis. The third and fourth pairs of pleuræ have their ridges very slender and weak, and are difficult to distinguish

[1] Brögger, 'Die Silur. Etagen, 2 and 3,' p. 136, pl. vi, fig. 2.
[2] Clarke, 'Palæont. Minnesota,' vol. iii (1894), p. 742, text-fig. 59.
[3] Reed, 'Girvan Trilobites,' pt. iii, p. 124, pl. xvi, fig. 15.

owing to the ornamentation of the surface. The fourth pleuræ have a straight slender posterior ridge running close against the axis and continued beyond it alongside the post-axial piece to end in a small free point on the margin. A few scattered tubercles occur on the pleural ridges. The ornamentation of the lateral lobes of the pygidium sufficiently distinguishes this Girvan form from the typical *C. bellatula*.

Dimensions.—

Length of pygidium	13·3 mm.
,, of axis	9·2 ,,
Width of pygidium	13·7 ,,
,, of axis at front end . . .	4·6 ,,

Horizon and Locality.—Balclatchie Group (Llandeilo) : Balclatchie.

Cybele michelli, sp. nov. Plate VII, fig. 7.

1906. *Cybele* cf. *aspera*, Linnarsson, Reed, op. cit., pt. iii, p. 128, pl. xvi, figs. 12, 13.
? — *Cybele* sp. b. (*pars*), Reed, ibid., p. 130, pl. xvii, fig. 8 (*non* 6, 7).

Specific Characters.—Head-shield transversely semicircular, rather more than twice as broad as long, slightly arched forwards on each side and in front of glabella, convex, bent down strongly on each side and produced back to genal angles; cheeks swollen, much elevated, subconical, rising steeply from anterior margin and axial furrows; genal angles blunt; upper edge of rostral shield appearing on upper surface of head-shield and forming pre-glabellar border.

Glabella subclavate, expanding a little in front of anterior lateral furrows, convex, rounded, swollen, nearly touching anterior margin and encircled in front by rostral suture with no distinct pre-glabellar band. Three pairs of lateral furrows represented by short deep transverse pits not connected with axial furrows, set at equal distances apart and successively increasing in size posteriorly; anterior pair situated rather in front of middle of glabella.

Meso-occipital ring rounded, widest in middle, marked off from glabella by furrow strongly arched forwards in middle, with a deep pit in it on each side similar to and in a line with lateral pits on glabella.

Rostral shield with upper rounded smooth edge forming a narrow pre-glabellar marginal border, lying between the connecting sutures and in front of the rostral suture on upper surface of head-shield, about one-third the width of glabella.

Axial furrows slightly divergent anteriorly, with large round deep pit situated on each side of frontal lobe of glabella at the point where they fork, the outer stronger branch bending out and continued into marginal furrow of cheek, the inner weaker branch continued round front end of glabella, thus between them separating off subtriangular swollen anterior end of fixed cheek.

Surface of glabella coarsely but sparingly tuberculated and with a line of three equidistant specially conspicuous tubercles at front end just above marginal furrow, the middle tubercle the smallest, and with the large tubercle on the anterior end of each fixed cheek continuing the line laterally. Fixed cheeks much swollen, rising suddenly and steeply from axial furrows, bearing three large tubercles in front of eye and a large one at anterior end in angle between branches of axial furrows; posterior wing of fixed cheeks extended laterally, narrow from back to front, with smaller and fewer tubercles. Pleuro-occipital ring narrow, rounded, not tuberculate, marked off by deep furrow. Facial sutures with posterior branch nearly parallel to posterior margin of cheek, cutting outer margin a short distance in front of genal angle; anterior branches running forwards from eyes at about 120° to posterior branches and slightly converging as far as pits in axial furrows, in front of which they curve sharply inwards, bending round and uniting in front of glabella to form the rostral suture; two short connecting sutures, directed nearly at right angles to rostral suture and cutting anterior edge of head-shield at about one-third width of glabella apart, with rostral shield between them.

Free cheeks large, triangular, with inner swollen portion and steeply rising from marginal furrow, coarsely tuberculate on upper anterior portion. Eyes situated far back, opposite second lateral furrows of glabella and about one-fourth the width of cheek from side of glabella, prominent, placed a little on outer slope of subconical cheeks. Border of free cheeks broad, raised, somewhat flattened, with inner row of 7—9 large equidistant tubercles and outer less regular row of more numerous smaller ones; anterior process embracing outer third of front of glabella; marginal furrow rather weak.

Thorax composed of thirteen segments; axis convex, cylindrical, slowly tapering, with swollen lateral lobes on each ring and deep pits in axial furrows between them. Pleuræ horizontal and straight as far out as fulcrum, then bent gently downwards and backwards, composed of broad anterior depressed band somewhat flattened and widening towards pleural extremity, narrower posterior depressed band and strongly raised, rounded, slightly diagonal broad median ridge; extremities of pleuræ not preserved. Surface of thorax finely tuberculate, with 1—2 large isolated tubercles on median ridge of pleuræ.

Pygidium subquadrate, narrowing slightly posteriorly, with pleuræ of lateral lobes ending in short free points at same level along straight posterior margin. Axis about one-third the width of pygidium, broad, subcylindrical, very slightly tapering, composed of four rings at anterior end corresponding to the four pleuræ, followed by 10—12 rather narrower rings, all incomplete in middle; short pointed piece behind end of axis separating extremities of fourth pair of pleuræ. Pleuræ four in number on each side corresponding to anterior axial rings, lying in nearly same plane and successively less strongly arched outwards, the fourth pair nearly straight and lying closely pressed against sides of axis; each pleura with diagonal furrow, less than its length, cutting off anterior narrow band; extremities of pleuræ short, free, slightly bent outwards, and ending at same level posteriorly; one or two tubercles present along each pleura.

Dimensions.—

Length of head-shield . . .	9·0 mm.
Width of „ „ . . .	20·0 „
Width of glabella at base . . .	5·0 „
Length of thorax (about) . . .	17·0 „
„ of pygidium	6·0 „
Width of „	7·5 „

Remarks.—The above diagnosis is based on one complete specimen with a perfect head-shield, thorax (save for the ends of the pleuræ) and pygidium. The external impression of the same specimen is also preserved, and thus the species is capable of precise definition. It is clearly distinct from *C. aspera*, Linnarsson, with which some fragments of head-shields from Ardmillan and Dow Hill have been previously compared by the author, and it is probable that the pygidium described as *Cybele* sp. *b* is also referable to this new species.

The peculiar position of the rostral suture and shield in the species above described is met with also in *C. affinis*, Schmidt,[1] from the Baltic Ordovician, and in the other characters of the head-shield these species bear a considerable mutual resemblance. *C. wörthi*, Eichwald[2] and *C. kutorgæ*, Schmidt,[3] apart from this one feature, are allied, but our Girvan form is undoubtedly distinct from them. It is named *michelli*, after a former Woodwardian Professor.

Horizon and Localities.—Balclatchie Group: Ardmillan and Dow Hill.

Genus **DINDYMENE**, Corda.

Dindymene cordai, Etheridge, junr., and Nicholson. Plate VII, figs. 8, 9.

1906. *Dindymene cordai*, Reed, op. cit., pt. iii, p. 132, pl. xvii, figs. 9—11.

In several specimens of the head-shield of this species occurring in the Starfish Bed, there can be observed the interesting and previously undescribed feature of the presence of an apparent marginal fringe of small spines. These "spines" project forwards horizontally in the general plane of the head-shield, and are slender and curved sigmoidally outwards; all seem to be of equal or subequal size and to project a little further than the border is wide. They seem to be about 8 or 9 in

[1] Schmidt, 'Rev. Ostbalt. Silur. Trilob.,' pt. i, p. 216, pl. xiii, figs. 18, 19.
[2] Schmidt, ibid., p. 214, pl. xiii, figs. 14—17.
[3] Schmidt, ibid., p. 217, pl. xv, figs. 11—14; pl. xvi, figs. 39*a*, *b*.

number, and originate underneath the head-shield behind the hypostome, diverging radially forwards to the margin, beyond which they project, forming the fringe extending from the axial furrows back to the genal angles. Barrande[1] in his second series of figures of *Dindymene fred.-augusti*, Corda, showed a similar marginal fringe of 12—14 minute spines round the sides of the head-shield, but no mention was made of their presence in his description of this species. Lindström[2] expressed the opinion that *D. fred.-augusti* was so distinct from the type of the genus, *D. haidingeri*, that it ought to be removed into a separate new genus. If this is the case, our Girvan species would have to accompany it. The chief distinctions are the following according to Barrande[3]: (1) In *D. haidingeri* the glabella and cheeks are covered with closely set pits, while in *D. fred.-augusti* there is only a scanty granulation; (2) in *D. haidingeri* there are no tubercles on the ridge of the pleura, while they are present in the other species; (3) there is not so marked a thickening of the pleural ridge before the origin of the free spinose point in *D. haidingeri* as in the other species. These differences seem trivial and of no generic value, and both species occur on the same stratigraphical horizon in Bohemia.

Dindymene cordai has recently been discovered by Mrs. Gray in the Whitehouse Group at Shalloch Mill, which is a new locality for it.

It is clear that these so-called spines above described in the Thraive Glen specimens are not homologous with the true marginal fringing spines of *Acidaspis*, which at first sight they resemble, for they are not attached to the edge of the head-shield, but arise from near the mouth on the lower surface and run forwards in the plane of the head-shield to extend beyond the margin. This feature is only completely visible in one specimen, in which the glabella and one cheek have been broken away, but it is of great importance, and suggests that the "spines" are really of the nature of cephalic appendages, and probably should be regarded as the biramous limbs of a crowded and condensed series of circumoral paired appendages.

Family CHEIRURIDÆ.

Genus **CHEIRURUS**, Beyrich.

Cheirurus keisleyensis, Reed. Plate VIII, fig. 1.

1906. *Cheirurus bimucronatus* (*pars*), Reed, op. cit., pt. iii, p. 138.

In the light of further and better preserved specimens from the Drummuck Group it appears necessary to remove the supposed examples of *Ch. bimucronatus*

[1] Barrande, 'Syst. Silur. Bohême,' vol. i, Suppl., p. 117, pl. ii, figs. 11, 12.

[2] Lindström, "Researches on the Visual Organs of Trilobites" ('Kongl. Svensk. Vet. Akad. Handl.,' vol. xxxiv, no. 8, 1901), p. 11.

[3] Barrande, op. cit., vol. i, p. 820.

occurring in this bed to the species *Ch. keisleyensis*[1] which is found in the Upper Bala (Keisley Limestone) of Keisley. The chief difference on which the latter species was based lies in the characters of the pygidium, but there are certain other distinguishing points in the head-shield, such as the squarer shape and greater basal width of the glabella, the straighter and more horizontal course of the lateral furrows, and the more forward position of the eyes, which are situated rather in front of the second lateral furrows instead of behind them. These features are present in the specimens from the Drummuck Beds, and thus separate them from the true Silurian *Ch. bimucronatus*, Murch. One example from the Starfish Bed is of a large size, the glabella measuring rather over 50 mm. in length.

One fine hypostome from the same horizon may be attributed to the same species. The description of it is as follows: Shape oviform, narrowing posteriorly; anterior end with somewhat flattened curvature, very slightly angulated in middle; posterior end narrower, rounded. Body convex, most so at about half its length, divided by lateral furrows into anterior subrhomboidal swollen larger part and posterior less swollen crescentic smaller part. Lateral furrows situated at about two-thirds the length of body, oblique, deep at sides, uniting across middle as weak groove. Maculæ prominent, large, pointed-oval, slightly oblique. Border depressed, flattened, upturned, widening behind anterior lateral angles, of almost uniform width behind lateral furrows; marginal furrow well marked, continuous. Anterior ears not preserved. Whole surface (including border) ornamented with strong concentric equidistant regular striæ, ending abruptly against front edge of hypostome.

Dimensions.—

Length	17·0 mm.
Anterior width	13·5 ,,
Width at maculæ	12·0 ,,
Distance of maculæ from front end . .	11·5 ,,

In shape and general characters this hypostome may be compared with that of a form referred by Salter[2] to *Ch. bimucronatus* from the Chair of Kildare.

Cheirurus octolobatus, M'Coy.

1906. *Cheirurus octolobatus*, Reed, op. cit., pt. iii, p. 142.

There appears to be no reason to hesitate in separating this species from *Ch. clavifrons*, Dalman; for, apart from the general characters of the head-shield, there exist few points of similarity, and the thorax and pygidium are completely different. A complete specimen of *Ch. octolobatus* from the Starfish Bed which

[1] Reed, 'Quart. Journ. Geol. Soc.,' vol. lii (1896), p. 417, pl. xx, figs. 7—9.

[2] Salter, 'Mon. Brit. Trilob.,' pl. v, fig. 5.

has been obtained recently by Mrs. Gray, illustrates these differences well. The pleuræ are simple, rounded and cylindrical, and devoid of any furrow on their surface or transverse constriction, and they taper into free rounded slightly recurved pointed ends; in *Ch. clavifrons*[1] the inner portion is separated from the outer by a sharp constriction and bears a strong diagonal furrow upon it. In the case of the pygidium we observe that there is no enlargement of the first and second pleuræ as in *Ch. clavifrons*. Indeed the whole type of pygidium more recalls certain Bohemian species, *e. g. Ch. globosus*, Barrande,[2] and *Ch. pectinifer*, Barrande.[3]

It does not seem possible to include *Ch. octolobatus* in the sub-genus *Cyrtometopus* to which *Ch. clavifrons* belongs.

The smooth unfurrowed simple pleuræ recall those of *Sphærexochus* and some members of *Pseudosphærexochus*, and the pygidium and glabella show also features characteristic of the latter sub-genus. As mentioned by me on a previous occasion,[4] *Ch. octolobatus* possesses a combination of characters indicating wide-spread and complex affinities, and it does not seem possible to include it in any of the groups or sub-genera of *Cheirurus* which have been so far defined.

Sphærexochus mirus, Beyrich, var. nov. **balclatchiensis**. Plate VIII, fig. 2.

1906. *Sphærexochus mirus*, Reed, op. cit., pt. iii, p. 151.

Specific Characters.—Head-shield as in *Sph. mirus*. Thoracic segments with similar characters. Pygidium with conical axis ending behind in acutely pointed tip; axis composed of two complete convex rings and a third incompletely separated, followed by a pointed triangular terminal piece; lateral lobes composed of three pairs of obtuse lobate convex pleuræ with free slightly reflexed bluntly pointed ends, the third pair sub-parallel, embracing terminal piece of axis and extending behind it. Surface finely granulated.

Dimensions.—

Length of pygidium	18·0 mm.
„ of axis	15·5 „
Width of pygidium	29·0 „
„ of axis	10·5 „

Remarks.—Our previous ignorance of the pygidium prevented the separation of this Lower Ordovician form from the Wenlock species. The head-shields appear to be indistinguishable, as the author remarked in 1906. But the segmentation of the pygidial axis is different, only two rings and a terminal piece being

[1] Schmidt, 'Rev. Ostbalt. Silur. Trilob.,' pt. i, p. 153, pl. viii, figs. 4—6; pl. xvi, figs. 7—12.

[2] Barrande, 'Syst. Silur. Bohême,' vol. i, pl. xxxv, figs. 1, 2.

[3] Barrande, ibid., Suppl. p. 93, pl. iv, figs. 16—20.

[4] Reed, 'Geol. Mag.' [4], vol. iii (1896), p. 163.

present in the Silurian form; the axis is also narrower, more conical and more pointed behind, and the third pair of pleuræ are longer.

The pygidium of *Sph. angustifrons*, Ang., does not appear to have been described, unless the Keisley *Sph. latirugatus*, Reed,[1] belongs to this species, and it occurs on a higher stratigraphical horizon (Stage F) than the above described Balclatchie form. But the head-shields seem to be identical, and Billings' *Sph. parvus*[2] from the Chazy Limestone scarcely suggests specific separation.

Horizon and Locality.—Balclatchie Group (Llandeilo): Balclatchie.

Genus STAUROCEPHALUS, Barrande.

Staurocephalus globiceps (Portlock). Plate VIII, fig. 3.

1906. *Staurocephalus globiceps* (Portlock), Reed, op. cit., pt. iii, p. 152.

In my previous reference to this species doubt was expressed as to the correct identification of the specimen recorded by Nicholson and Etheridge from Ardmillan. But two nearly complete examples have now been found in the Balclatchie Beds of Dow Hill, showing all the typical characters of the head-shield, thorax and pygidium. Though the glabella is so different, the thorax and pygidium are extraordinarily like those of *Sphærocoryphe thomsoni*,[3] and indeed it is difficult to point to any constant distinctive features. Salter's[4] woodcut of a Scottish specimen gives a very fairly correct representation of the species.

Family PHACOPIDÆ.

Genus PHACOPS, Emmrich.

Phacops (Chasmops) bisseti, Reed. Plate VIII, fig. 4.

1906. *Phacops (Chasmops) bisseti*, Reed, op. cit., pt. iii, p. 157, pl. xx, figs. 1—3.

A fine specimen of a complete individual of this rare species has now been obtained by Mrs. Gray from the Starfish Bed, and it is of special interest because it has the hypostome (previously unknown) attached and in position. The full

[1] Reed, 'Quart. Journ. Geol. Soc.,' vol. lii (1896), p. 423, pl. xx, fig. 12.

[2] Raymond, 'Ann. Carnegie Museum,' vol. iii, no. 2 (1905), p. 372, pl. xiv, fig. 22; also '7th Ann. Rep. Vermont Geol. Surv.,' 1910, p. 246, pl. xxxvi, fig. 22.

[3] Reed, 'Girvan Trilob.,' p. 146, pl. xviii, fig. 17; pl. xix, figs. 1—7.

[4] Salter, 'Mon. Brit. Trilob.,' p. 86, woodcut fig. 18.

description of this species previously given by me renders superfluous any remarks on the general characters of the trilobite.

In proportion to the head-shield the great size of the hypostome is remarkable, the latter measuring 14 mm. and the former only 15·5 mm. in length. The characters of the head-shield in this specimen agree more closely with those of the smaller specimen which was figured (*op. cit.*, fig. 3) than with Mr. Bisset's type; but, as then stated, the small differences scarcely seem to indicate more than immaturity. The "second" and "third" lateral lobes between the great "cat's-ear" lobes of the glabella are particularly distinctly developed as tubercles, and there is a trace of an intermediate pair of tubercles as in the above-mentioned specimen.

The hypostome has the typical shape of the genus and is pyriform, the anterior end being wider than the posterior; the front margin is strongly arched; the anterior ears are situated at about one-third the length of the hypostome and bend up sharply at the lateral angles of the frontal lobe of the glabella; the body is gently convex with its sides straight and parallel for its anterior half, but then they sharply converge to the bluntly-pointed tip at an angle of about 45°; the lateral furrows are weak, and curve gently backwards from the angulations on the sides of the body so as to unite in a continuous curve behind separating off a feebly defined posterior band about one-sixth the total length of the body. The border of the hypostome is narrow at the sides, but widens behind at the tip to about one-fifth the whole length of the hypostome. The marginal furrow is well marked. The whole surface of the hypostome is granulated. In general characters the hypostome closely resembles that of *Ph. macroura* as figured by Salter.[1]

Dimensions.—

Length of hypostome . . .	14·00 mm.
,, of body of hypostome . . .	11·00 ,,
Width of hypostome across anterior ears .	11·75 ,,
,, ,, at level of lateral angulations	8·75 ,,
Length of head-shield . . .	15·50 ,,
,, of thorax	21·00 ,,
,, pygidium	14·00 ,,

Phacops (Pterygometopus) retardatus, sp. nov. Plate VIII, figs. 5—7.

Specific Characters.—Body elongate-oval.

Head-shield semicircular, twice as wide as long, about one-third the length of the whole trilobite; median portion somewhat flattened, cheeks steeply bent down and genal angles produced into stout spines.

Glabella very weakly convex, twice as long as wide at base, subclavate in shape, expanding anteriorly to about twice basal width; base about one-fourth width of

[1] Salter, 'Mon. Brit. Trilob.,' pl. iv, fig. 21.

head-shield; anterior end gently convex; sides concave. Frontal lobe large, transverse, subrhomboidal, slightly overhanging at sides, about half the length of the glabella. Three pairs of lateral lobes present; anterior lateral lobe triangular, not circumscribed, about one-fourth the length of glabella along axial furrow and equal in length to the two posterior lobes together; middle and basal lateral lobes oblong, transverse, of equal size, nearly parallel-sided, but basal lobes with outer portion rather swollen and subnodular.

First lateral furrows slightly sinuous, directed rather obliquely backwards and inwards, and making an angle of about 45° with axial furrows, arising at about three-fifths the length of the glabella from base and extending inwards about one-third its width, not joining second lateral furrows.

Second lateral furrows arising from axial furrows nearly at right angles about halfway between first lateral and occipital furrows, nearly straight, obliquely directed forwards and inwards, extending fully one-third across glabella.

Third lateral furrows equal in length and parallel to second pair, situated about half way between them and occipital furrow. Occipital furrow strong, continuous, arched forwards in middle. Meso-occipital ring with lateral portions narrower and swollen into small, low, rounded nodes.

Axial furrows moderately strong, curved inwards, concave outwards, strongly divergent in front of second lateral lobes. Fixed cheeks with inner portion swollen, rising higher than glabella and sloping up to eye-lobe; posterior wing very narrow behind eye, widening laterally and arched down to genal angle. Pleuro-occipital segment widening laterally, marked off by strong sigmoidal neck-furrow, bending back to genal angle outside eye. Lateral border increasing slightly in width posteriorly, with shallow marginal furrow meeting pleuro-occipital furrow at about 60°. Genal angle produced back into flattened stout spine extending to fourth or fifth thoracic segment.

Eye-lobes small, subacute, swollen, upturned, with smooth almost vertical broad outer band separated off by strong angulated furrow and closely pressed against inner surface of eye.

Facial sutures with posterior branch sigmoidally arched forwards behind eye to cut lateral margin of head-shield a little in front of base of eye.

Free cheeks small, triangular, sloping steeply upwards from margin to base of eye; border gently convex, separated off by well-marked marginal furrow.

Eyes parallel to axis, large, very high and prominent, conical, semilunar in shape, strongly curved, less than half the length of glabella, with anterior end touching axial furrow at first lateral furrow of glabella, and with posterior end opposite third lateral furrow and distant from side of glabella about one-third its basal width. Lens-bearing surface of eye very tall, almost perpendicular to general plane of head, possessing 14 or 15 lenses in middle vertical rows and about 160 lenses in all. Surface of glabella, especially frontal lobe, ornamented with sparingly distributed subequidistant tubercles of subequal size. Surface of cheeks very faintly tuberculated.

Thorax decreasing in width posteriorly, composed of eleven segments. Axis moderately convex, rather less than one-third the width of thorax at front end, subcylindrical, tapering very slowly to pygidium. Axial rings arched slightly forwards in middle and at sides, with weak lateral nodes. Pleuræ somewhat flattened, with strong diagonal furrow; fulcrum situated at less than half their length, with inner half horizontal and outer half strongly arched downwards and slightly backwards to end in short falcate point.

Pygidium parabolic to semioval, nearly or quite as long as wide, strongly arched down at sides; apex emarginate; no distinct border. Axis moderately convex, conical, about one-third the width of pygidium at front end, tapering posteriorly to bluntly pointed end, annulated with 18—20 rings, of which the first 12—14 are distinct and similar in character to those of thorax with lateral swellings, and arched forwards in middle. Pleural lobes composed of 14 well-marked flattened regular pleuræ corresponding to the distinct axial rings, decreasing successively in size posteriorly, arched gently and regularly backwards, marked by fine weak median furrow, in which lies a row of small pits, and with a faint row of small widely spaced obscure tubercles on each side of it. Front margin of pygidium furnished with flattened half pleura on each side, and articulating ring on axis. Interpleural furrows strong, regular, of uniform depth, continued nearly to margin of pygidium.

Dimensions.—

	I	II	III
Length of whole trilobite	37·00 mm.	—	—
,, of head-shield	11·75 ,,	8·00 mm.	—
Width of ,,	20·25 ,,	17·00 ,,	—
Length of glabella	*c.* 9·00 ,,	—	10·0 mm.
Width of ,, at base	*c.* 5·00 ,,	—	5·0 ,,
Height of eye from base	4·75 ,,	—	—
Length of pygidium	12·50 ,,	*c.* 6·50 ,,	—
Width of ,,	14·00 ,,	*c.* 9·50 ,,	—
,, of axis of pygidium	5·00 ,,	4·00 ,,	—
,, of axis of thorax at front end	6·00 ,,	5·50 ,,	—
Length of thorax	12·25 ,,	10·00 ,,	—

Remarks.—The above described species is based on three nearly complete individuals and one detached imperfect head-shield. In characters it is almost indistinguishable from *P. truncato-caudatus*, Portlock,[1] as defined by Salter,[2] but,

[1] Portlock, 'Geol. Rep. Londonderry,' p. 281, pl. ii, figs. 1—4.

[2] Salter, 'Mon. Brit. Trilob.,' p. 42, pl. iv, figs. 13—15.

nevertheless, there are a few points of difference which seem to warrant its specific separation. The head-shield in our Girvan form is less transversely expanded, the first lateral lobes are larger, the thoracic axis does not increase in width behind the head, the fulcrum on the pleuræ is not so far out, and there is no strong node at the base of the pleuræ; the double line of tubercles on the pleuræ of the pygidium is very much fainter.

The Russian species *Ph. kuckersianus*, Schmidt,[1] and *Ph. nieszkowskii*, Schmidt,[2] are also allied to *Ph. retardatus* in general cephalic characters.

Horizon and Locality.—Starfish Bed, Drummuck Group (U. Bala): Thraive Glen.

Phacops (Pterygometopus) hunteri, sp. nov. Plate VIII, figs. 8, 9.

Specific Characters.—Head-shield transversely semicircular, genal angles unknown. Glabella subclavate, rounded, gently convex; frontal lobe transverse, about half the length of glabella, anteriorly rounded, twice as wide as long, with lateral angles not projecting; first lateral lobes large, triangular, extending about one-third along side of glabella, and about one-third across it on each side; second lateral lobes small, oblong, not reaching axial furrows, parallel sided, not tubercular; basal lateral lobes larger than second lateral lobes, expanded at outer ends into large tubercules, extending forwards so as nearly to touch first lateral lobes on axial furrows.

First lateral furrows straight or slightly curved, obliquely directed backwards at about 45° to axial furrows; second lateral furrows shorter, straight, directed slightly forwards at about 90° to course of axial furrows; third lateral furrows short, obsolescent, not reaching axial furrow, parallel to second lateral furrows. Meso-occipital segment rounded, wider than basal lobes, marked off from glabella by strong arched furrow; with small rounded lateral nodules, projecting at sides. Surface of glabella coarsely tuberculated.

Eyes large, reaching from lateral angles of frontal lobe to neck-furrow, arched outwards, meeting pleuro-occipital segment nearly at right angles, and enclosing swollen portion of cheek fully two-thirds the basal width of glabella. Eye-lobe broad, smooth, upturned, separated from cheek and extending whole length of eye. Surface of cheek coarsely tuberculated.

Thorax with broad cylindrical axis, as wide or rather wider than pleural lobes; axial rings with well-marked lateral nodular swellings; pleuræ short, with obtuse ends, and traversed by deep diagonal pleural furrow.

Pygidium unknown.

[1] Schmidt, 'Rev. Ostbalt. Silur. Trilob.,' pt. i (1881), p. 90, pl. v, figs. 11—13.

[2] Schmidt, ibid., p. 92, pl. v, figs. 14, 15.

Dimensions.—

Length of glabella	3·8 mm.
Width of ,, across frontal lobe . .	4·2 ,,
,, ,, at base . . .	2·3 ,,
Width of middle-shield across eyes . .	7·0 ,,

Remarks.—In its general characters this small trilobite much resembles *Ph. brongniarti* (and especially Portlock's *Ph. dalmani* included therein), which occurs on the same horizon.[1] But the reduction and partial obsolescence of the second lateral lobes and the encroachment of the basal lobes of the glabella at the sides, so as almost to squeeze them out, distinguish this species and ally it to members of the subgenus *Chasmops.*

Horizon and Locality.—Balclatchie Group (Llandeilo): Balclatchie.

Phacops (Dalmanitina?) asteroideus, sp. nov. Plate VIII, figs. 10—12.

Specific Characters.—Pygidium broadly semioval, about one and half times as wide as long, produced behind into a very short rudimentary upturned mucro. Axis prominent, conical, tapering rather rapidly at about 25°—30° to obtuse apex; about three-fourths to four-fifths the length of the pygidium, and with its anterior width equal to about one-fourth or one-fifth the breadth of latter; annulated clearly for three-fourths its length with 6—8 rings, decreasing in strength posteriorly, and followed to apex by a few very faint narrow annulations; each ring bears low median tubercle. Axial furrows moderate. Lateral lobes arched gently down on each side, composed of 6—7 rather broad, flattened, slightly curved pleuræ, of which the first five are somewhat raised, and are separated by strong interpleural furrows, the posterior ones being less distinct; pleuræ faintly marked with fine median oblique furrow, especially in outer half; pleuræ and furrows die out before reaching smooth undefined border; marginal furrow absent, mucro short, acutely pointed, slightly upturned. Infra-marginal doublure convex, extending inwards to tip of axis. [? Surface of pleuræ ornamented with small crescentic flattened scales.]

Dimensions.—	I	II
Length of pygidium . .	16·0 mm. .	11·5 mm.
Width of ,, . .	26·0 ,, .	19·0 ,,
Anterior width of axis (about) .	7·0 ,, .	5·5 ,,

Remarks.—This species, of which only three pygidia have so far been found, occurs typically in the Starfish Bed, Drummuck Group. It differs from *Ph. robertsi,* Reed,[2] of the Sholeshook Limestone, by its mucronate extremity, and in the axial rings bearing tubercles, but in general characters, number of segments,

[1] Reed, 'Girvan Trilob.,' pt. iii, p. 154, pl. xix, figs. 17, 18.

[2] Reed, 'Geol. Mag.' [5], vol. i (1904), p. 106, pl. v, figs. 6, 7.

undefined border, length of axis and width of infra-marginal doublure, there is close agreement. We may also especially note its resemblance to *Ph. ecclesiasticus*, Olin,[1] of the *Chasmops* Limestone of Sweden, and to *Ph. recurvus*, Linrs.,[2] of the *Trinucleus* Shales; but unfortunately the head-shield and thorax of our Girvan form are unknown. It apparently belongs to that primitive section of the *Dalmanites* group which has been termed by the author *Dalmanitina*.[3] The incipient mucro indicates a nearer approach to the condition in the typical *Dalmanites* than is shown in *Ph. robertsi*, and thus recalls *Ph. mucronatus*, Brong.,[4] but the shape of the pleuræ and the terminal union of the pleural and interpleural furrows are distinctive features in the latter.

A specimen of a pygidium from the Whitehouse Beds of Shalloch Mill, apparently referable to *Ph. asteroideus*, is remarkable from having the shell preserved on one lateral lobe, and showing on it a peculiar ornamentation of minute crescentic scales, like an Eurypterid, with their convexity facing outwards.

Horizons and Localities.—Starfish Bed, Drummuck Group (U. Bala): Thraive Glen. Whitehouse Group (M. Bala): Shalloch Mill.

[1] Olin, "Chasmopsk. o. Trinucleusskif. Skane," Medd. Lunds Geol. Fältklubb.,' ser. B, no. 1 (1906), p. 43, pl. i, fig. 6.

[2] Olin, ibid., p. 42, pl. i, figs. 4, 5.

[3] Reed, 'Geol. Mag.' [5], vol. ii (1905), p. 224; Wedekind, 'Zeitschr. deutsch. geol. Gesell.,' vol. lxiii (1911), pp. 318—336; Raymond in Zittel-Eastman's "Palæontology" (1913), p. 726.

[4] Salter, 'Mon. Brit. Trilob.,' p. 46, pl. iv, figs. 11, 12; B. Smith, 'Proc. Roy. Irish Acad.,' vol. xxvi, sect. B, no. 9 (1907), p. 123, pl. viii, figs. 10—13.

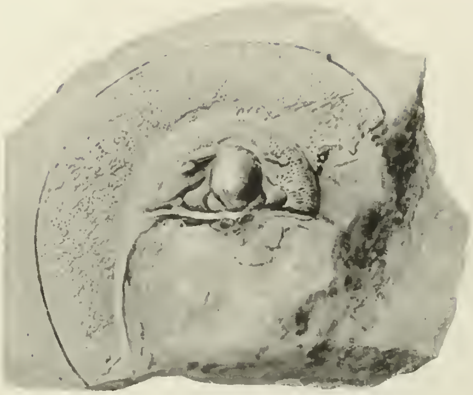
INDEX.

ADLARD AND SON, IMPR., LONDON AND DORKING.

PLATE I.

Fig.		Page.
1.	*Trinucleus albidus*, sp. nov. Head-shield. × 2. Whitehouse Group, Whitehouse Bay	3
1*a*.	Ditto. Side view of same specimen. × 2 . . .	3
2.	Ditto. Pygidium. × 4. Whitehouse Group, Shalloch Mill .	3
3.	*Dionide richardsoni*, Reed. × 6. Whitehouse Group, Shalloch Mill .	5
4.	*Harpes* (*Eoharpes*) *youngi*, sp. nov. Head-shield. × 3. Balclatchie Group, Balclatchie	6
5.	Ditto. Ditto. × 3. Same horizon and locality . . .	6
6.	Ditto. Ditto. × 6. Same horizon and locality . . .	6
6*a*.	Ditto. Ditto. × 6. Side view of same specimen . .	6
7.	*Harpes* (*Eoharpes*) *flanagani*, Portlock. Impression of head-shield. × 3. Balclatchie Group, Balclatchie	9
8.	Ditto. Internal cast of same specimen. × 3 . . .	9
9.	Ditto. Limb of smaller individual. × 3. Balclatchie Group, Ardmillan	9

1 ×2



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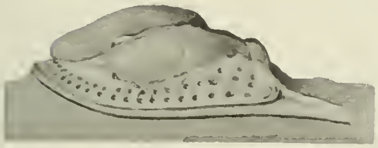
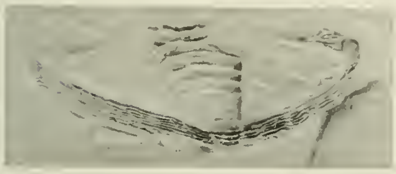


1a ×2

3 ×6

5 ×3



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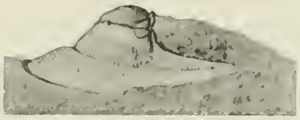
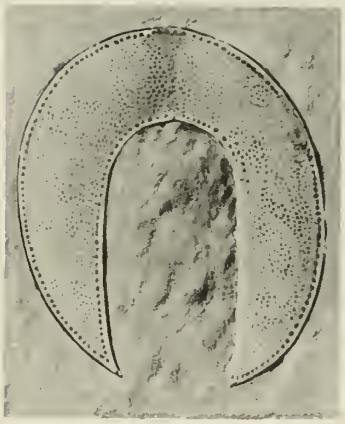


6a ×6

6 ×6

7 ×3

8 ×3



9 ×3

PLATE II.

Fig.		Page.
1.	*Harpes* (*Eoharpes*) *hornei*, sp. nov. × $2\frac{1}{2}$. Starfish Bed, Thraive Glen	10
1*a*.	Ditto. Side view of same specimen. × $2\frac{1}{2}$ . . .	10
2.	Ditto. Impression of same individual. × $2\frac{1}{2}$ . . .	10
3.	*Remopleurides nicholsoni*, sp. nov. Portion of thorax, showing base of spine on ninth ring (indicated by arrow). × 3. Starfish Bed, Thraive Glen	12
4.	Ditto. Portion of thorax, showing pleuræ with transverse striation on lower surface. × 3. Same horizon and locality . .	12
5.	Ditto. Pygidium. × 4. Same horizon and locality . .	12
6.	Ditto. Free cheek. × $2\frac{1}{2}$. Same horizon and locality . .	12
7.	Ditto. Impression of part of thorax, showing lineation on upper surface. × 3. Same horizon and locality . . .	12
8.	Ditto. Free cheek. × $2\frac{1}{2}$. Same horizon and locality . .	12
9.	Ditto.? Hypostome. × 5. Same horizon and locality . .	12
10.	*Remopleurides correctus*, Reed. Nearly complete individual (with displaced cranidium). × $2\frac{1}{2}$. Balclatchie Group, Balclatchie .	15
11.	*Telephus salteri*, sp. nov. × 5. Balclatchie Group, Balclatchie .	16

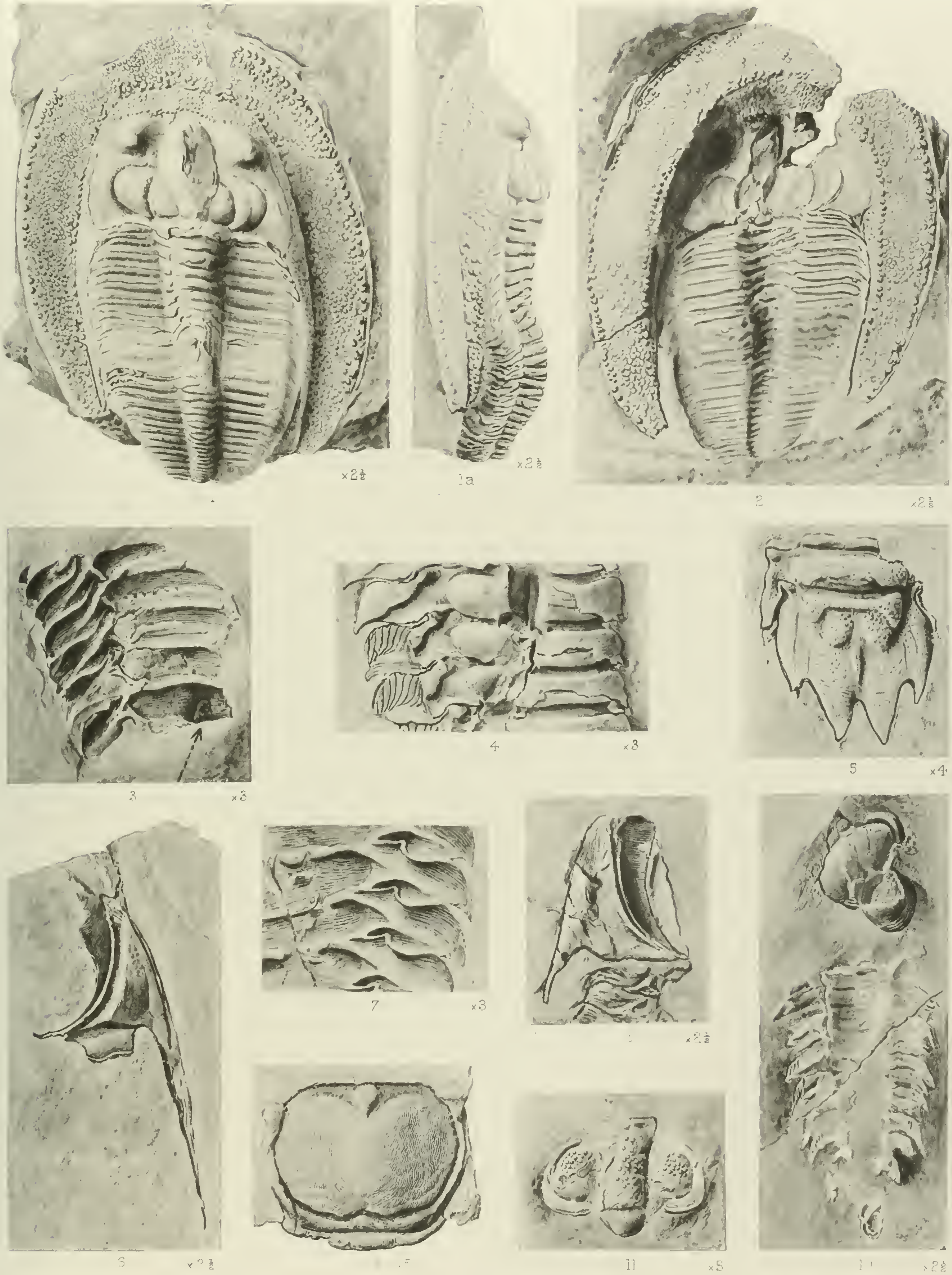

×2½
1a
×2½
2
×2½
3
×3
4
×3
5
×4
7
×3
×2½
11
×5
×2½

PLATE III.

Fig.		Page.
1.	*Asaphus grayæ*, sp. nov. Imperfect middle-shield. × $1\frac{1}{2}$. Balclatchie Group, Balclatchie	16
2.	Ditto. Middle-shield. × $1\frac{1}{2}$. Same horizon and locality . .	16
3.	Ditto. Pygidium. × $1\frac{1}{2}$. Same horizon and locality . .	16
4.	Ditto. Pygidium. × $1\frac{1}{2}$. Same horizon and locality . .	16
5.	Ditto. Thoracic segment. × $1\frac{1}{2}$. Same horizon and locality .	16
6.	Ditto. Portion of pleura showing ornamentation. × $2\frac{1}{2}$. Same horizon and locality	16
7.	*Stygina latifrons*, Portlock. Enrolled specimen, showing hypostome and epistome in position on lower side of head-shield. × $2\frac{1}{2}$. Starfish Bed, Thraive Glen	18
8.	*Cyclopyge bumasti*, sp. nov. × 3. Whitehouse Group, Shalloch Mill .	19
9.	*Cyclopyge subarmata*, sp. nov. Complete individual. × $2\frac{1}{2}$. Whitehouse Group, Whitehouse Bay	20
10.	Ditto. Pygidium. × 3. Same horizon and locality . .	20
11.	Ditto. Epistome and conjoint eyes on lower side of head-shield. × 3. Same horizon and locality	20
12.	Ditto. Head and part of thorax, showing ornamentation on shell. × 3. Same horizon and locality	20

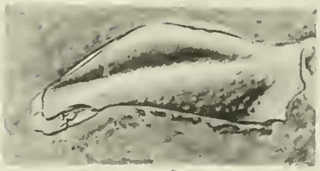
1 ×1½

2 ×1½

3 ×1½

5 ×1½

4 ×1½



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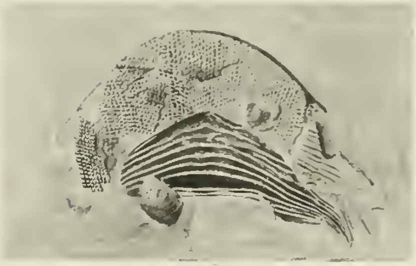

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8 ×3

12 ×2

10 ×3

9 ×2½

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PLATE IV.

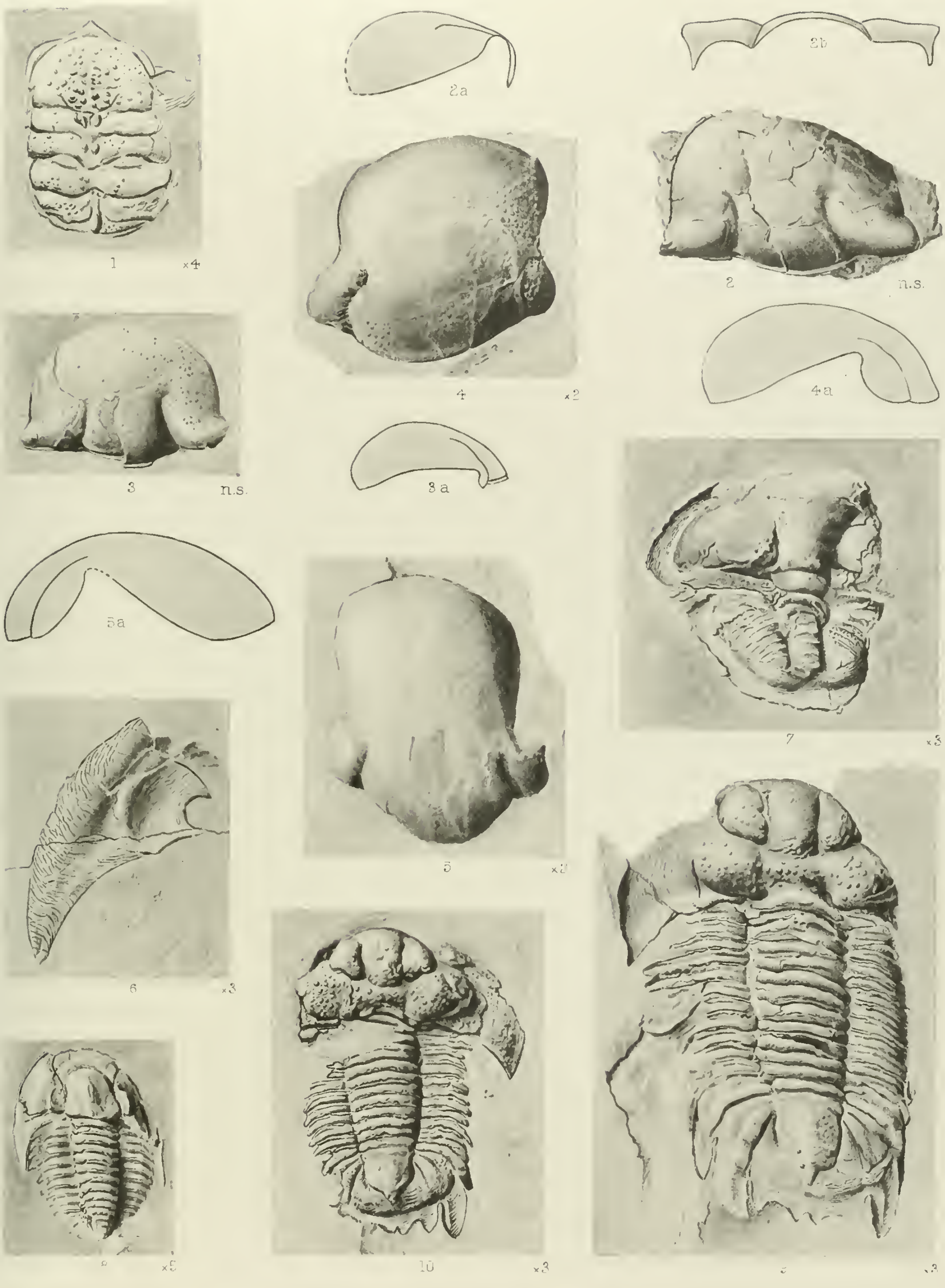

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PLATE V.

FIG. PAGE.

1. *Lichas (Amphilichas) ardmillanensis*, sp. nov. Imperfect and slightly distorted cranidium. × 3. Balclatchie Group, Ardmillan . 29

1*a*. Ditto. Outline of side view, showing projection of median lobe. × 3 29

2. *Lichas (Amphilichas) hibernicus*, Portlock. Pygidium. × $1\frac{1}{2}$. Balclatchie Group, Ardmillan 30

3. *Acidaspis asteroidea*, sp. nov. Cranidium. × 3. Starfish Bed, Thraive Glen 31

4. Ditto. Complete individual. × 4. Same horizon and locality . 31

5. Ditto. Front view of enrolled individual, showing stalked eyes. × 3. Same horizon and locality 31

6. Ditto. Impression of imperfect pygidium and two thoracic pleuræ. × 3. Same horizon and locality 31

7. Ditto. Restoration of head-shield, one thoracic segment and pygidium 31

8. *Acidaspis girvanensis*, sp. nov. Internal cast of complete individual. × 3. Starfish Bed, Thraive Glen 33

9. Ditto. Impression of same specimen. × 3 . . . 33

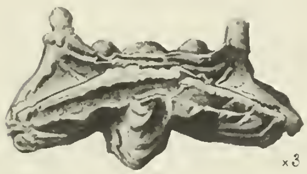
10. Ditto. Restoration of head-shield, one thoracic segment and pygidium 33

1 ×3

2 ×1½

4 ×4

1a ×3



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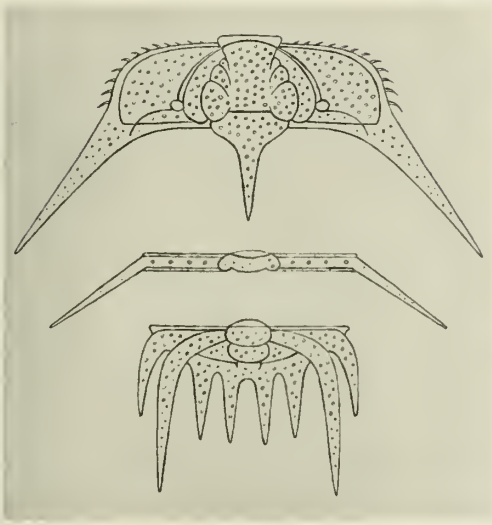

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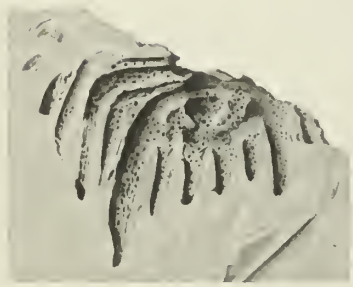

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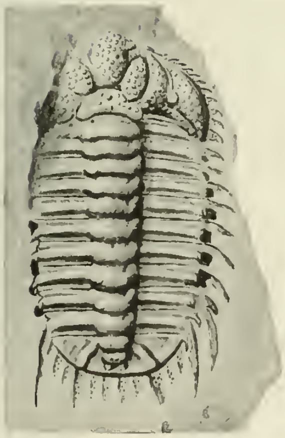

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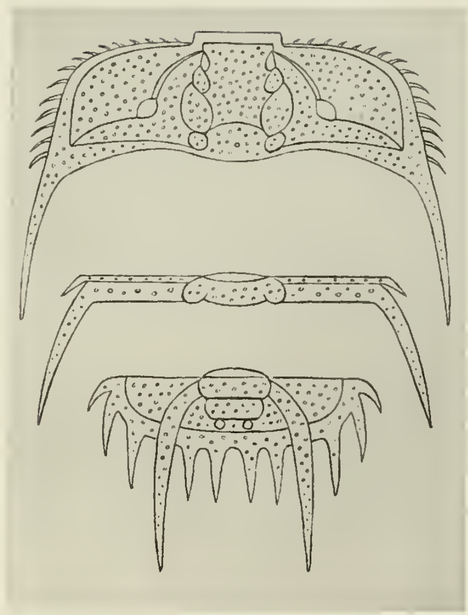

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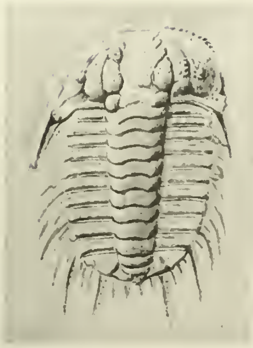
PLATE VI.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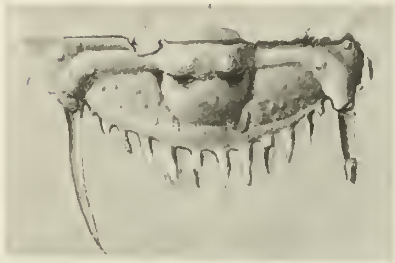
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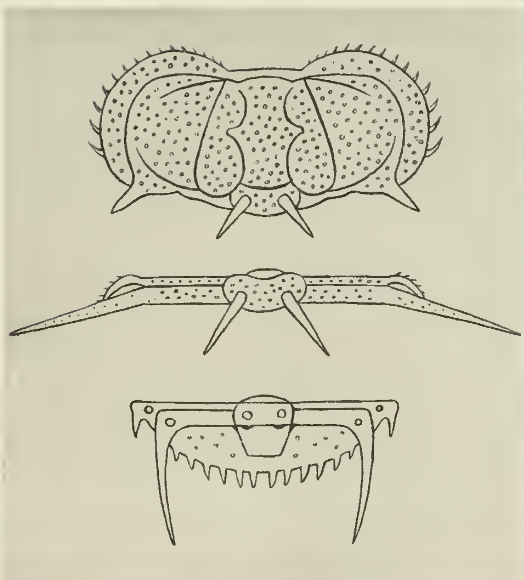
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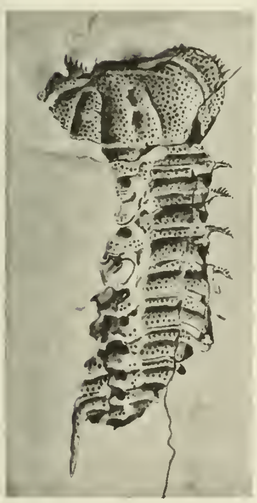
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PLATE VII.

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3 ×3

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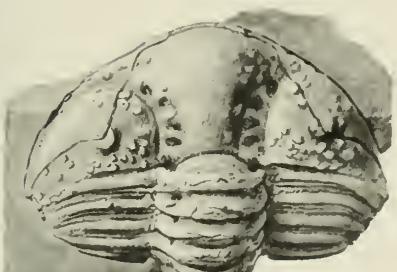
5 ×1½

6 ×2



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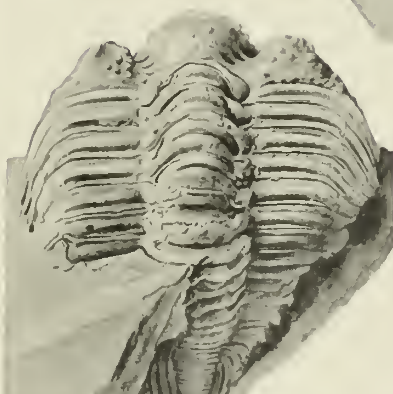
7a



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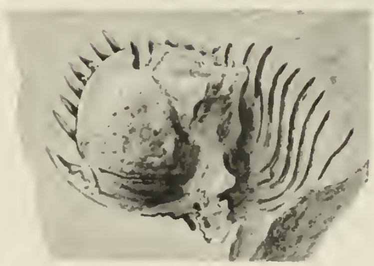
7

8 ×2½

7b ×2½

7c ×4



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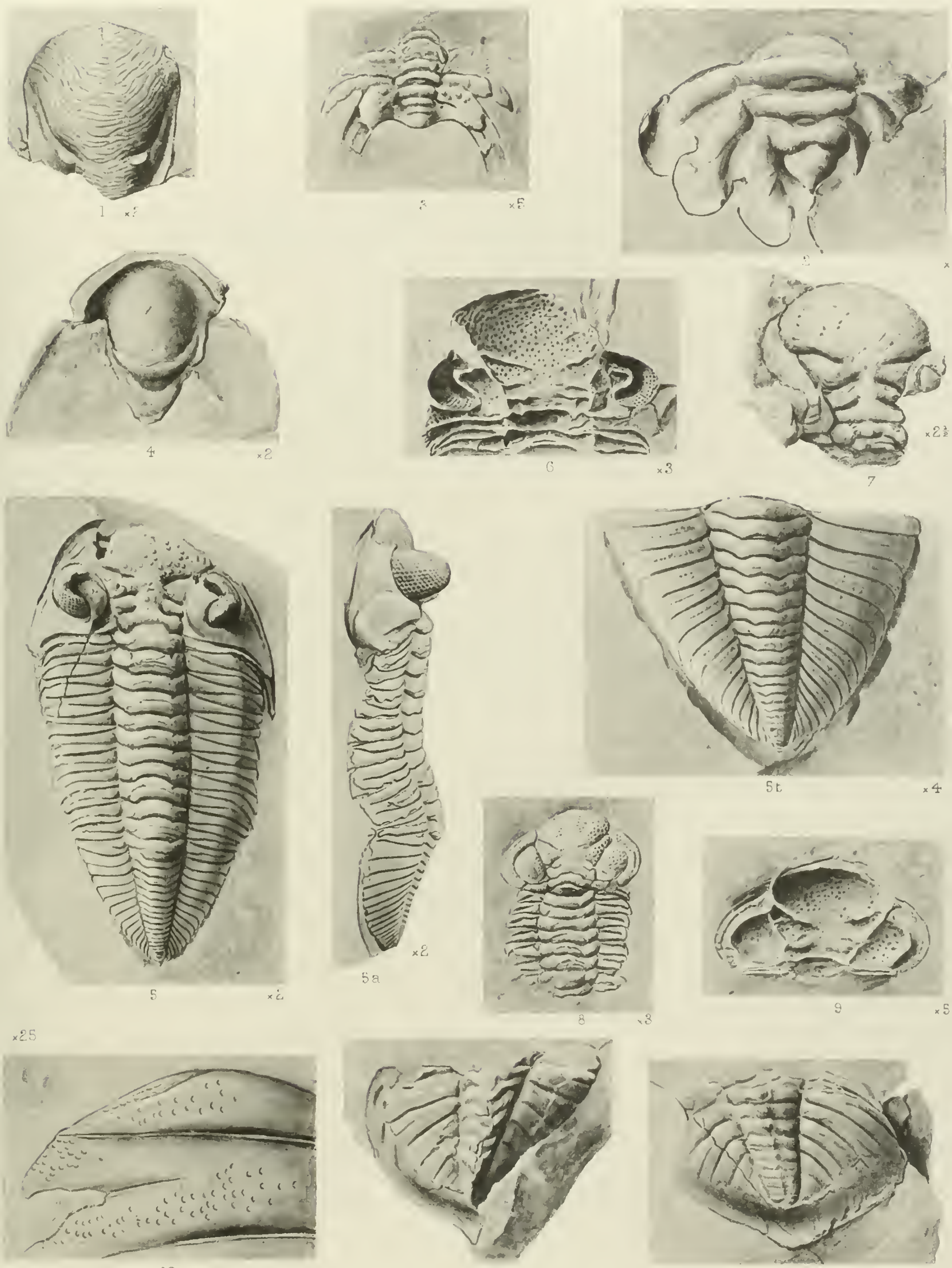

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Palæontographical Society, 1913.

THE PLIOCENE MOLLUSCA OF GREAT BRITAIN,

BEING SUPPLEMENTARY TO

S. V. WOOD'S MONOGRAPH OF THE CRAG MOLLUSCA.

BY

F. W. HARMER, F.G.S., F.R.Met.S.,

MEMBRE HONORAIRE DE LA SOCIÉTÉ BELGE DE GÉOLOGIE ET DE PALÉONTOLOGIE.

PART I.

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THE

PLIOCENE MOLLUSCA

OF

GREAT BRITAIN.

INTRODUCTION.

More than sixty years have elapsed since the publication of the classical Monograph on the Mollusca of the Crag by my old friend, Searles V. Wood, and between thirty and forty years since that of the Supplements to it. Much fresh material it seems desirable to describe has been obtained, especially from a new and interesting section at the village of Little Oakley, near Harwich, midway between Walton-on-Naze and Felixstowe.

Many important works dealing with the Pliocene and Pleistocene, as well as with the Recent Mollusca of various parts of the northern hemisphere, have appeared, moreover, during recent years. Among these may be mentioned as specially helpful to students of the Crag, Prof. G. O. Sars' 'Mollusca Regionis Arcticæ Norvegiæ' (1878), Nyst's 'Conchyliologie des Terrains Tertiaires de la Belgique' (1878–81), Bellardi's 'Molluschi dei Terreni Terziarii del Piemonte e della Liguria' (1873–88) continued by Prof. Sacco (1890–1904), Sign. Cerulli-Irelli's 'Fauna Malacologica Mariana' (1907–11), Fischer's 'Manuel de Conchyliologie' (1880–87), Seguenza's 'Studii Stratigrafici sulla formazione pliocenica dell' Italia Meridionale' (1873–7), 'Mollusques marins du Rousillon' by MM. Bucquoy, Dautzenberg, and Dollfus (1882–98), 'Mollusques provenant des campagnes de l' Hirondelle et de la Princess-Alice dans les Mers du Nord' (Monaco, 1912) by MM. Dautzenberg et H. Fischer, 'Mollusques Pliocenes de la Vallée du Rhone,' by M. Fontannes (1879–82), 'Conchyliologie du Miocene moyen du Bassin de la Loire,' by MM. Dollfus and Dautzenberg (in course of publication), 'Den Norske Nordhavs Expedition (Mollusca),' by Mr. Hermann Friele (1882–1901), 'Prodromus Faunæ Mediterraneæ,' vol. ii, by Dr. Carus (1889–93), 'Senglaciale og Postglaciale nivåforandringer i Kristianiafeltet (Molluskfaunan),' by Prof. W. C. Brøgger (1900–1), 'Catalogue of the British Species of Pisidium,' by Mr. B. B. Woodward (1913), 'Essais de Paléoconchologie comparée,' by M. Cossmann (1895–1909), 'Iconographie der schalentragenden europäischen Meeresconchylien,' by Dr. W. Kobelt (1887–1908), with a number of monographs by himself and others in the 'Syst. Conch. Cab.' of Martini and Chemnitz. These and other works which have thrown much light on Crag problems, together with many papers by various British and Continental Conchologists, will be constantly referred to in the pages of the present memoir.

I desire also to acknowledge, very cordially, my personal obligations to MM. Dollfus, Dautzenberg, and De Boury of Paris, Prof. Peyrot of Bordeaux, Prof. Welsch of Poitiers, the Marchese di Monterosato of Palermo, Prof. Sacco of Turin, Prof. Issel of Genoa, Prof. Pantinelli of Modena, Dr. Fucini of Pisa, Dr. Eisig of Naples, the late Prof. Seguenza of Messina, Dr. di Stefano of Reggio, Prof. Bucca and Dr. Scalia of Catania, Mr. Clarence Bicknell of Bordighera, Mr. Van Waterschoot van der Gracht of the Hague, Dr. Lorié of Utrecht, Dr. Tesch of Nijmegen, MM. Bernays and van de Wouver of Antwerp, MM. Van den Broeck and Rutot of Brussels, Prof. von Koenen of Göttingen, Prof. Brøgger and Dr. Øyen of Christiania, Mr. Hermann Friele of Bergen, Dr. Jensen, Dr. Ravn and Dr. Nordmann of Copenhagen, Prof. Nordgaard of Trondhjem, Dr. Sparre Schneider of Tromsö, Dr. Pjetursson of Reyjavik, Prof. Lönnberg and Dr. Odhner of Stockholm, Dr. Dall of Washington, Mr. C. W. Johnson and Prof. Shimer of Boston, U.S., Prof. H. Yabe of Sendai, Japan; and in our own country, to Dr. A. Smith Woodward, Messrs. E. A. Smith, G. C. Robson and R. B. Newton of the British Museum of Natural History, the Director of H.M. Geological Survey and Dr. Kitchin, Prof. T. McK. Hughes, Mr. F. R. Cowper Reed, Prof. P. F. Kendall, the Rev. S. N. Harrison, Canon Norman, the Rev. A. H. Cooke, Mr. J. R. le B. Tomlin, Dr. Scharff, Mr. E. R. Sykes, Mr. P. G. H. Boswell, Mr. W. M. Crowfoot, Mr. O. Grabham of the York Museum, Mr. F. Leney of the Castle Museum at Norwich, Mr. Woolnough of the Ipswich Museum, Major Moore, the Messrs. Ogden and others, who have assisted me in the most generous way, and especially in providing specimens for comparison, and permitting me to figure them where desirable.

As to the non-marine Mollusca I have gladly availed myself of the expert knowledge and the writings of Messrs. Kennard and B. B. Woodward, and of Mr. J. W. Taylor, the author of the 'Monograph of the Land and Freshwater Mollusca of the British Isles'; to them also my best thanks are due for much friendly information and assistance. For the details here given as to the distribution of such forms in the Pleistocene and Holocene deposits of Denmark and Sweden I have to thank Dr. Nordmann. I have been able, moreover, to avail myself of the long experience and accurate knowledge of Mr. Alfred Bell, who, except for Messrs. Crowfoot, Dowson, and the writer, is the only survivor of those who had the privilege of working with Searles V. Wood. To the memory of the latter and of his equally distinguished son whose friendship I enjoyed for so many years, I affectionately dedicate the following pages.

The continued study of the Crag beds is not only desirable, but likely to prove of great interest and importance.[1] Although isolated and fragmentary records of the Pliocene history occur at Lenham, St. Erth, in the Cotentin, in north-east Scotland, and probably in the Isle of Man, it is only in the Anglo-Belgian basin and the little-known Crag of Iceland that we have a more or less connected series of fossiliferous deposits from which we may ascertain the character of the molluscan fauna of the seas of north-western Europe during the period intervening between the Miocene and Pleistocene epochs. No older Pliocene strata are known in Scandinavia, any which may once have existed in that region having been destroyed by the erosion of the great ice sheets.

It does Wood's memory no discredit to admit that as to some of the Crag Mollusca his nomenclature needs revision; indeed when we remember that more than sixty years have passed since his Monograph was written, and that so much fresh light has been thrown on the subject, the wonder is that his work requires so little alteration.

As to certain shells, moreover, our best authorities are by no means unanimous, and one frequently finds in our various Museums the same form under different names. Some species were not figured or were imperfectly described, while in other cases the original figures are not sufficiently clear for correct identification. I have found it, therefore, almost impossible to arrive at satisfactory conclusions as to some of the new material which has come into my hands without obtaining verified specimens, recent or fossil, of the species to which they appeared to correspond. These specimens, with the consent of the Council of the Palæontographical Society, I propose to figure together with the Crag shells, hoping in this way to clear up some doubtful points; to have given an unsupported opinion of my own would have made in many cases "confusion worse confounded." Students will be in possession, at least, of the evidence upon which my identifications are founded, and they will have perfect specimens with which they may compare their fossils in addition to those from the Crag here figured, which are often worn or fragmentary. Where I have been in doubt, I have generally submitted my specimens to some recognised expert.

The researches upon which Wood's Monograph was principally based were, on the one hand, those carried out by himself and others in the Coralline Crag, the fossils of which are in a specially perfect state of preservation[2]; and on the other, in the Red Crag of the region lying between the rivers Orwell and Deben, of the somewhat newer deposits of the Butley district and the Icenian Crag of Norfolk and Suffolk.

The important beds of Crag at Walton-on-Naze in Essex seem to have been but imperfectly known at that time, less than 150 species from the latter place

[1] It does not seem improbable that other Crag localities might yield results similar to those obtained at Little Oakley if worked in the same manner.

[2] Most of Wood's specimens from the Coralline Crag were obtained from one pit at Sutton.

being recorded in the synoptical list of Mollusca given on pp. 203 *et seq.* of the first Supplement to his Monograph.

By the work of the brothers Bell and Prof. Kendall at Walton,[1] and especially by my own at Little Oakley, our knowledge of the Waltonian fauna has been much enlarged, between six and seven hundred species and well-marked varieties of mollusca being known now from this division of the Crag, obtained, however, during many years' labour, and by the sifting and examination of something like 200 tons of material.[2]

As a result of these investigations, it is possible to form a more correct opinion as to the true relation of the Walton bed to the rest of the Crag. Not only has the view held by Wood that it was decidedly older than any other part of the Red Crag been confirmed, but it has been shown to be much more nearly allied to the Coralline Crag than has been hitherto suspected. Indeed there is less difference between the fauna of the latter and that of the Red Crag of Walton than there is between the Walton Crag and the later deposits of Butley or Bawdsey.

With the exception of a few species, very rare in the Coralline Crag, and of some minute and fragile forms, nearly all the more characteristic Mollusca and most of the Polyzoa of the Coralline Crag have now been found in the Waltonian. A few specimens only of some of the smaller species have been met with at Walton, principally in a bed of stratified silt at the base of the section, apparently deposited under different conditions to the rest of the Red Crag; this bed has been hidden by talus for many years. Such minute forms are not everywhere present even in the Coralline Crag. In the Red Crag they are nowhere plentiful, owing to the littoral and shallow water character of that formation. Speaking generally, a large proportion of the Red Crag shells are worn and rolled, as are many of those found on our beaches at present.

In a paper recently published,[3] Mr. A. Bell has given his reasons for an opinion he has long held that a portion of the Crag of Boyton which contains, with a fauna characteristically Coralline, certain Red Crag species such as *Nassa reticosa*, almost unknown from the earlier deposit, is of Coralline age; I adopt this view, and now regard that part of the Boyton Crag as intermediate between those of Gedgrave and Walton.

It does not seem to me therefore that there is sufficient reason for such a

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[1] Prof. Kendall has very kindly placed in my hands the results of his researches for publication.

[2] To prevent disappointment to any persons who might wish to visit this prolific locality, I ought to mention that by arrangement with A. M. Garland, Esq., of Michaelston Hall, near Dovercourt, the owner of the Oakley estate, the excavations made by me from year to year were filled up and levelled down as the work proceeded. I can hardly thank Mr. Garland enough for his kindness in allowing me to carry on my investigations on such an extended scale. I propose to offer my collections from this spot to the Sedgwick Museum at Cambridge.

[3] Journ. Ipswich Field Club, vol. iii, p. 5, 1911.

separation between the Coralline and the Red Crag of Walton as that implied by regarding the one as Lower and the other as Upper Pliocene. I consider, however, that such a division does exist between the Coralline Crag and the Lenham beds, as I shall endeavour to show in an Appendix to this Memoir.

In 1899 I proposed the following classification of the Crag deposits and of their foreign equivalents; I placed all the East Anglian beds in the Upper Pliocene, leaving, as hitherto, the Lenham beds and the Boxstone fauna, together with the Diestien Sands of Belgium, and the Waenrode bed, but not the Casterlien deposits (zone à *Isocardia cor*) of Antwerp, in the lower division of that formation.

TABLE (SLIGHTLY MODIFIED) SHOWING THE CLASSIFICATION OF THE PLIOCENE STRATA PROPOSED BY ME IN 1899.[1]

		Foreign equivalents.
UPPER PLIOCENE.		
Icenian . .	Crag of Weybourne, Belaugh, etc. (zone of *Tellina balthica*)	
	Chillesford Beds (estuarine)	
	Norwich Crag (marine): Upper horizon (northern part); Lower horizon (southern part)	
Butleyan. .	Red Crag of Butley, Bawdsey, etc. (littoral and northern)	Amstelien of Holland.
Newbournian .	Red Crag of Newbourn, Waldringfield, etc. (littoral and intermediate)	Amstelien of Holland.
Waltonian . .	Red Crag of Beaumont, and Little Oakley (littoral and southern, with some northern species)	Poederlien (in part).
	Red Crag of Walton-on-Naze (littoral and southern)	Scaldisien, *zone à Chrysodomus contraria.*
Boytonian .	Coralline Crag of Boyton and Ramsholt (part)	Casterlien, *zone à Isocardia cor.*
Gedgravian .	Coralline Crag of Gedgrave and Sutton (marine, southern)	Casterlien, *zone à Isocardia cor.*
LOWER PLIOCENE.		
Lenhamian	Lenham Beds (*zone of Arca diluvii*)	Diestien, *zone à Terebratula grandis.*
	Boxstone fauna	

In the introduction to Wood's first Supplement his son and I separated from the Crag the fossiliferous deposits of Weybourne, Belaugh, and Crostwick, characterised by containing everywhere and in great abundance the shell *Tellina balthica*, a species unknown from the Norwich zone, associating them with the Pleistocene beds. For some time, however, I have grouped them as Icenian, a

[1] Rep. Brit. Assoc., Dover (1899), p. 751.

term originally suggested by the late Dr. S. P. Woodward. I shall allude to them in the following pages as the Norwich, Chillesford, and Weybourne zones of the Icenian Crag.

At the conclusion of this Memoir I propose to offer a few remarks as to the conditions under which the different Crag beds may have originated, their relation to each other and to other Pliocene deposits, and generally as to the conclusions which a prolonged investigation of the subject may have suggested.

I offer no apology for dealing at some length with the Mollusca, both recent and fossil, of other regions than our own, the study of which, indeed, has thrown much light on Crag problems.

During repeated journeys to the south of Europe I was able, not only to visit many Museums in France and Italy, but to collect largely on my own account from the fossiliferous deposits of those countries. I have been long familiar with the Belgian Crag, while as to that of Iceland I have had the privilege of examining, with Dr. Ravn, Mörch's type-specimens in the Geological Museum at Copenhagen, and of figuring those which seemed to correspond with undescribed forms from our own deposits. As to the Manx fossils, Mr. A. Bell has been kind enough to make a special visit to the Isle of Man, in order to study the collections of Mr. Kermode and the Rev. S. N. Harrison, and has selected certain examples which, with some others from Jermyn St., I am permitted to figure and describe.

The importance of the careful study of varietal forms is now universally recognised. In some Crag species so-called varieties differ more widely than shells which in other groups are considered worthy of specific rank. In certain cases, moreover, varieties have a distinct zonal value; *Purpura lapillus*, for example, is said to occur at all horizons of the Red Crag, but the prevalent varieties of this species in the earliest or Waltonian stage are different to those characteristic of the Butleyan or the Icenian. Indeed the typical *P. lapillus* of our British seas is not known from the former and occurs but sparingly at the latter. In a recent work Prof. Sollas has urged the importance of a "minute attention to details, not omitting the most insignificant"; his words are specially to be commended to students of the Crag where some interesting problems are still waiting solution.

I have not attempted to give a complete bibliography of the various species here dealt with, but have referred only to those works which I think may be the most useful.

As the present Memoir is intended to be supplementary to Wood's Monograph I have followed, more or less nearly, and for the convenience of students, the arrangement of the Marine Mollusca adopted by him, and as to the non-marine forms, that of the Conchological Society of Great Britain.

CRINGLEFORD, NEAR NORWICH; F. W. HARMER.

April, 24th, 1913.

THE NON-MARINE MOLLUSCA OF THE CRAG.

A. TERRESTRIAL.

GASTEROPODA.

But few non-marine Mollusca were known to S. V. Wood from the Crag, otherwise than from the Icenian, or as it has been generally called, the Norwich or Fluvio-marine series of these deposits. Since the publication of his Monograph, however, a number of land and freshwater shells have been found in the upper or Butleyan zone of the Red Crag by the brothers Robert and Alfred Bell, Mr. A. S Kennard, Mr. P. G. H. Boswell, and others, indicating probably the proximity of land to that part of the Crag Sea at the period in question.

As far back as 1871, indeed, Mr. Alfred Bell had announced the discovery of a seam in the Crag pit at Butley, near the Oyster Inn, where such forms were fairly common.[1] This seam, like many other sections of equal interest, is now unfortunately obscured by talus. Much information has been obtained as to other localities at which the species given by Wood have been found, and as to their distribution, both recent and fossil. The description of the non-marine Mollusca of the Crag, moreover, is scattered about in various parts of his work, while the nomenclature now current differs in many cases from that there given. For such reasons, and for the convenience of students, it seems desirable to treat the subject *de novo*, but as briefly as possible, bringing together in a systematic way all the information now available. I shall not deal with the non-marine Mollusca found only in the freshwater bed at West Runton, as I understand that Messrs. Kennard and B. B. Woodward are proposing to describe them elsewhere.

Genus **SPHYRADIUM,** Hartmann, 1841.

Sphyradium edentulum (Draparnaud).

1805. *Vertigo edentula*, Draparnaud, Moll. terr. fluv. France, p. 52, pl. iii, figs. 28, 29.
1853. *Pupa edentula*, Forbes and Hanley, Brit. Moll., vol. iv, p. 103, pl. cxxx, fig. 1.
1862. *Vertigo edentula*, Jeffreys, Brit. Conch., vol. i, p. 268, pl. xvi, fig. 6.
1879. *Pupa edentula*, S. V. Wood, Mon. Crag Moll., 2nd Suppl., p. 37, tab. iv, fig. 6.
1890. *Pupa edentula*, C. Reid, Plioc. Dep. Brit., p. 229.
1897–1901. *Sphyradium edentulum*, Kennard and B. B. Woodward, Essex Nat., vol. x (table), 1897; Proc. Malac. Soc., vol. iii, p. 190, 1899; Proc. Geol. Assoc., vol. xvii, pp. 214 *et seq.*, 1901.

[1] Geol. Mag., vol. viii (1871), p. 452.

Specific Characters.—Shell thin, oblong, nearly cylindrical, marked slightly by numerous oblique and convex lines of growth; whorls 5—6, convex, the penultimate slightly the largest; spire long, abruptly diminishing at the apex to a blunt point; suture deep; mouth circular, except where it is truncated by the last whorl; lip thin, slightly reflected; umbilicus narrow, contracted by the pillar.

Dimensions.—L. 3 mm. B. 1·5 mm.

Distribution.—*Recent:* from the Moray Firth to Guernsey, from the Amur and Lapland to Sicily; Armenia; Abyssinia (J. W. Taylor); Madeira and the Azores (Scharff); many parts of North America from Alaska to Florida.

Fossil: Icenian Crag: Bramerton (Norwich Museum). Pleistocene: Clacton, Barnwell, West Wittering, Fisherton, Copford, Ponders End, Dogholes near Carnforth, Garvel Park near Greenock. Holocene: Chignal, Crossness; Hampshire (Kennard and B. B. Woodward).

Pleistocene: Mosbach, Germany; Hungary; France. Lower and Upper Holocene of Sweden and Denmark (Nordmann). Loess of Muscatine, Iowa, U. S.

Remarks.—*S. edentulum* was found thirty years ago by Mr. Jas. Reeve at Bramerton; it has not been met with since in the Crag, either at that locality or elsewhere.

Genus **PYRAMIDULA,** Fitzinger, 1833.

Pyramidula rysa (S. V. Wood).

1848. *Helix rysa*, S. V. Wood, Mon. Crag Moll., pt. i, p. 4, tab. i, fig. 1.
1875. *Patula (Janulus) rysa*, Sandberger, Land Sussw. Conch. Vorw., p. 737.
1890. *Helix rysa*, C. Reid, Plioc. Dep. Brit., pp. 85, 229, pl. v, fig. 1.
1899. *Pyramidula rysa*, Kennard and B. B. Woodward, Proc. Malac. Soc., vol. iii, p. 190.
1909. *Pyramidula rysa*, Taylor, Land Freshw. Moll. Brit., vol. iii, p. 195, fig. 249.

Specific Characters.—See Mon. Crag Moll., pt. i, p. 4.

Dimensions.—Diam. 16 mm. H. 6 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Walton-on-Naze. Newbournian: Waldringfield.

Remarks.—In addition to the specimen from Walton in the Museum at Saffron Walden recorded by Wood, another, now at Ipswich, was subsequently obtained at Waldringfield by the Rev. H. Canham.

Jeffreys regarded this form as a variety of *P. rufescens*, but Messrs. Kennard and B. B. Woodward and Mr. J. W. Taylor follow Wood in considering it a distinct species. Mr. Taylor states its affinities are with the primitive molluscan fauna now restricted to the island of Madeira.

Pyramidula suttonensis (S. V. Wood).

1872. *Helix Suttonensis*, S. V. Wood, Mon. Crag Moll., 1st Suppl., p. 2, pl. i, fig. 2.
14 1890. *Helix suttonensis*, C. Reid, Plioc. Dep. Brit., p. 220, pl. v, fig. 2.
1899. *Pyramidula suttonensis*, Kennard and B. B. Woodward, Proc. Malac. Soc., vol. iii, p. 190.
1909. *Pyramidula suttonensis*, Taylor, Land Freshw. Moll. Brit., vol. iii, p. 195, fig. 248.

Specific Characters.—See Mon. Crag Moll., 1st Suppl., p. 2.

Dimensions.—Diam. 6 mm. H. 3·5 mm.

Distribution.—Not known living.

Fossil: Coralline Crag: Sutton.

Remarks.—This species was described by Wood from a unique specimen found in the Coralline Crag at Sutton; it still remains the only perfect example of a helicoid mollusc known from that deposit. It may possibly be a variety of the Madeiran shell *P. bifrons*, and, like the last species, related to the Recent molluscan fauna of that island.

Genus **EULOTA,** Hartmann, 1821.

Eulota fruticum (Müller). Plate I, fig 1.

1774. *Helix fruticum*, Müller, Verm. terr. fluv. Hist., pt. ii, p. 71, no. 267.
1850. *Helix fruticum*, S. V. Wood, Mon. Crag Moll., pt. ii, p. 308, tab. xxxi, fig. 19.
1875. *Helix (Eulota) fruticum*, Sandberger, Land Sussw. Conch. Vorw., p. 813, pl. xxxiv, fig. 3.
1897–1901. *Eulota fruticum*, Kennard and B. B. Woodward, Essex Nat., vol. x, pp. 106–7 *et seq.*, fig. 7, 1897; Proc. Malac. Soc., vol. iii, p. 191, 1899; Proc. Geol. Assoc., vol. xvii, p. 253, pl. xxxvii, fig. 7, 1901.
1909. *Eulota fruticum*, Taylor, Land Freshw. Moll. Brit., vol. iii, p. 205, fig. 268.

Specific Characters.—Shell rather strong, globose, varying in size; whorls 5 or 6, convex, the last much the largest; ornamented by very fine and unequal spiral striæ and by the lines of growth; suture deep; mouth oblique, lunate, rounded; lip sharp and slightly expanded; umbilicus open and deep.

Dimensions.—Diam. 18–24 mm. H. 17–20 mm.

Distribution.—*Recent:* not known in Great Britain; widely distributed over the Palæarctic region from the Pyrenees to Kamtschatka (Taylor); North Africa (Locard).

Fossil: Butleyan Crag: Hollesley.

Pleistocene: Stutton, Ilford, Grantchester, Barnwell; Germany; Austria; France; Italy. Holocene: Belgium; Germany; Denmark; Sweden.

Remarks.—This extra-British species was recorded by S. V. Wood from the Pleistocene deposit at Stutton only, but in 1885 it was discovered by the late

R. G. Bell in the Butleyan Crag of Hollesley, where Mr. Kennard also has found it. The specimen now figured is from the British Museum (Natural History); attached to it is a tablet bearing a note in Mr. Bell's writing as follows:

"This shell was taken out of a pit near the road occupied as a barn-yard, Page's farm, in company with marine shells and with *Limnæa* and *Planorbis*."

Genus **HYGROMIA,** Risso, 1826.

Hygromia hispida (Linné).

1758. *Helix hispida*, Linné, Syst. Nat., ed. x, p. 771, no. 591.
1848. *Helix hispida*, S. V. Wood, Mon. Crag Moll., pt. i, p. 2, tab. i, fig. 3.
1853. *Helix hispida*, Forbes and Hanley, Brit. Moll., vol. iv, p. 68, pl. cxviii, figs. 1—3.
1862. *Helix hispida*, Jeffreys, Brit. Conch., vol. i, p. 198, pl. xii, fig. 3.
1870. *Helix hispida*. A. Bell, Ann. Mag. Nat. Hist. [4], vol. vi, p. 213.
1890. *Helix hispida*, C. Reid, Plioc. Dep. Brit., p. 228.
1897–1901. *Hygromia hispida*, Kennard and B. B. Woodward, Essex Nat., vol. x, pp. 96 *et seq.*, 1897; Proc. Malac. Soc., vol. iii, p. 191, 1899; Proc. Geol. Assoc., vol. xvii, pp. 217 *et seq.*, 1901.

Specific Characters.—See Mon. Crag Moll., pt. i, p. 2.

Dimensions.—Diam. 8 mm. H. 5 mm.

Distribution.—*Recent:* England, Wales, Ireland; in Scotland as far as the Caledonian Canal (J. W. Taylor); abroad from Siberia and the Faroe Islands to Sicily and Northern Africa; North America (introduced); Grand Canary (Farrer).

Fossil: Butleyan Crag: Butley. Icenian—*Norwich zone:* Bramerton, Thorpe near Norwich, Horstead, Coltishall, Dunwich, Bulchamp, Yarn Hill. *Weybourne zone:* East Runton, North Walsham boring (C. Reid); Freshwater bed, West Runton. Pleistocene: Selsey (A. Bell), Woodston, near Peterborough; with many other localities in the British Isles. Holocene: Great Britain (Kennard and B. B. Woodward).

Pleistocene: France—*Limons grès à Succinées*, Normandy (Rutot), Toulouse; Austria—Nussdorf, near Vienna; Germany—loess of Lower Rhineland, Mosbach; Belgium. Holocene: Sweden and Denmark (Nordmann); France.

Remarks.—This species was known to Wood from the Icenian Crag of Bulchamp only. Mr. A. Bell, and Messrs. Kennard and B. B. Woodward have reported it, however, from Butley and from many localities in the Icenian Crag. The latter writers remark that it is the commonest helicoid species of our Pliocene and Pleistocene deposits. On the Continent it has not been observed in any earlier deposit than the Lower Pleistocene of Mosbach, where it is found not infrequently.

Hygromia incarnata (Müller). Plate I, figs. 6, 7.

1774. *Helix incarnata*, Müller, Verm. terr. fluv. Hist., pt. ii, p. 63, no. 259.
1855. *Helix incarnata*, Moquin-Tandon, Hist. Nat. Moll. terr. fluv. France, vol. ii, p. 199, pl. xvi, figs. 6, 7.
1875. *Helix* (*Monacha*) *incarnata*, Sandberger, Land Sussw. Conch. Vorw., p. 855.
1884. *Helix incarnata*, R. G. Bell, Geol. Mag. [3], vol. i, p. 264.
1890. *Helix incarnata*, C. Reid, Plioc. Dep. Brit., pp. 85, 228.
1899. *Hygromia incarnata*, Kennard and B. B. Woodward, Proc. Malac. Soc., vol. iii, p. 191.

Specific Characters.—Shell rather small, subglobose, slightly depressed, umbilicate; spire but slightly prominent; margin of lip reflexed.

Dimensions.—Diam. 10 mm. H. 7 mm.

Distribution.—*Recent:* not known in Great Britain, but occurring in Germany, Switzerland, France, Belgium, Denmark and Sweden.

Fossil: Waltonian Crag: Walton-on-Naze.

Middle Pleistocene: Cannstadt. Newer Holocene: Sweden and Denmark (Nordmann).

Remarks.—This, also an extra-British species, was recorded by Wood, though with some doubt, from a post-Pliocene deposit at Copford in Essex, but the identification is now thought to have been incorrect. An imperfect specimen now in the British Museum (Natural History) was found at Walton in 1882 by the *soi-disant* Prince of Mantua. Although not perfect Mr. R. G. Bell believed it to be identical with the continental species, an opinion which is shared by Messrs. Kennard and B. B. Woodward; I have figured with it a Recent and perfect shell.

Hygromia rubiginosa (A. Schmidt). Plate I, fig. 8.

1838. *Helix sericea*, var. *rubiginosa*, Rossmässler, Diag. Conch. terr. fluv., pt. ii, p. 3.
1853. *Helix rubiginosa* (Ziegler MS.), A. Schmidt, Zeitschr. Gesell. Nat., vol. i, p. 3.
1887. *Helix globularis*, var. *rubiginosa*, Tryon and Pilsbry, Man. Conch. (2), vol. iii, pt. i, p. 178, pl. xxxix, fig. 5.
1899. *Hygromia rubiginosa*, Kennard and B. B. Woodward, Proc. Malac. Soc., vol. iii, pt. iv, p. 191, fig. 1.

Specific Characters.—Shell rather small, horny, subglobose, umbilicate, covered with short hairs; whorls about five; mouth obliquely lunate; peristome thin, slightly patulate.

Dimensions.—Diam. 7—8 mm. H. 6—9 mm.

Distribution.—*Recent:* Scandinavia; Jutland, North Germany, Saxony, Bohemia, the Hartz, Carpathians (Kennard and B. B. Woodward).

Fossil: Icenian Crag: Southwold.

Remarks.—The shell from Southwold here figured is from the Wood Collection in the British Museum (Natural History), labelled *Helix* sp. It has been compared by Messrs. Kennard and B. B. Woodward with Recent specimens of *H. rubiginosa*, and identified by them as of that species. They state it has not been recorded hitherto from this country either as living or fossil, although it has a wide range on the Continent.

Genus **VALLONIA**, Risso, 1826.

Vallonia pulchella (Müller).

1774. *Helix pulchella*, Müller, Verm. terr. fluv. Hist., pt. ii, p. 30, no. 232.
1848. *Helix pulchella*, S. V. Wood, Mon. Crag Moll., pt. i, p. 3, tab. i, fig. 4.
1853. *Helix pulchella*, Forbes and Hanley, Brit. Moll., vol. iv, p. 78, pl. cxix, figs. 8—10.
1862. *Helix pulchella*, Jeffreys, Brit. Conch., vol. i, p. 224, pl. xiv, fig. 1.
1880. *Helix* (*Vallonia*) *tenuilimbata*, Sandberger, Kennt. Unterpleist. Sch. Eng.; Palæont., vol. xxvii, p. 102, pl. xii, fig. 13.
1889. *Helix pulchella*, Lorié, Bull. Soc. Belg. Géol., vol. iii (Mémoires), p. 435.
1890. *Helix pulchella*, C. Reid, Plioc. Dep. Brit., p. 228.
1897–1901. *Vallonia pulchella*, Kennard and B. B. Woodward, Essex Nat., vol. x, p. 108, 1897; Proc. Malac. Soc., vol. iii, p. 192, 1899; Proc. Geol. Assoc., vol. xvii, pp. 224 *et seq.*, 1901.

Specific Characters.—See Mon. Crag Moll., pt. i, p. 3.

Dimensions.—Diam. 3 mm. H. 1·5 mm.

Distribution.—*Recent:* generally distributed in Great Britain from the Orkneys to the Channel Isles; abroad from Siberia to the Atlantic Islands; in many parts of Asia, North America, Australasia; reported from the Cape Colony and Mauritius.

Fossil: Butleyan Crag: Bawdsey. Icenian: Bramerton, Beccles; Freshwater bed, West Runton. Pleistocene and Holocene of Great Britain.

Pliocene: Holland (Lorié). Lower Pleistocene: Mosbach. Valley loess of St. Gall, Switzerland; the Somme Valley, Auvergne; lacustrine marls of the Saone, Toulouse, Villefranche; loess of Tirlemont and other localities in Belgium; limestones and travertin of Algeria. In North America it has been obtained from the loess of Iowa, the old forest-bed of Indiana, and the upper Lahontan deposits of Nevada. Newer Holocene of Sweden and Denmark (Nordmann).

Remarks.—*V. pulchella* was known to Wood from the Butleyan Crag of Bawdsey only; it has since been obtained at Bramerton by Mr. Jas. Reeve, and has been reported by Dr. Lorié from a deep boring at Amsterdam in the Amstelien deposits (Pliocene), at a depth of 230 metres.

Vallonia excentrica, Sterki. Plate I, fig. 15.

1892. *Vallonia excentrica*, Sterki, in Tryon and Pilsbry, Man. Conch. (2), vol. viii, p. 249, pl. xxxii, figs. 6—9.
1911. *Vallonia excentrica*, Hughes, Proc. Geol. Assoc., vol. xxii, p. 275.

Specific Characters.—Shell minute, smooth, or very finely and regularly striate, smooth at the nucleus, slightly convex above, moderately umbilicate; umbilicus elongate, rapidly widening in the last whorl; whorls 3—3½, quickly increasing in size, the last comparatively large, rounded, expanded towards the mouth; suture moderate. Mouth somewhat oblique, inclined, forming five-sixths of a circle, subangular at the base.

Dimensions.—Diam. 2·3 mm. by 1·8 mm. H. 1 mm.

Distribution.—*Recent:* Europe and eastern North America.

Fossil: Icenian Crag: Beccles. Pleistocene: Barrington, Carnforth. Otherwise not yet worked out.

Remarks.—The specimen here figured was found by Mr. A. Bell in a collection of Norwich Crag shells which had been obtained from a well boring at Beccles by Mr. W. M. Crowfoot; it has been referred by Messrs Kennard and B. B. Woodward to the above species. Some of the localities given for *V. pulchella* may possibly belong to this shell.

Genus **HELICODONTA**, Férussac, 1820.

Helicodonta lens (Férussac). Plate I, fig. 5.

1850. *Helix lens*, Férussac, Hist. Nat. Moll. terr. fluv., vol. i, p. 110, pl. lxvi, fig. 2.
1854. *Helix lens*, Reeve, Conch. Icon., vol. vii (Helix), p. 178, pl. clxxviii, fig. 1221.
1884. *Helix lens*, R. G. Bell, Geol. Mag. [3], vol. i, p. 262.
1887. *Helix lens*, Tryon and Pilsbry, Man. Conch., vol. iii, p. 119, pl. xiv, figs. 12—14.
1890. *Helix lens*, C. Reid, Plioc. Dep. Brit., pp. 85, 228.
1899. *Helicodonta lens*, Kennard and B. B. Woodward, Proc. Malac. Soc., vol. iii, p. 193.

Specific Characters.—Shell openly and deeply umbilicate, lenticular, sharply carinated, costulato-striated by the lines of growth; whorls 7, subequal, flattened above, rounded below; margin of mouth simple, the upper part straight, the dextral and basal part reflected with a small punctiform callus at the superior insertion.

Dimensions.—Diam. 11—13 mm. H. 5—6 mm.

Distribution.—*Recent:* Morea and the Grecian Islands (Pfeiffer).

Fossil: Waltonian Crag: Walton-on-Naze.

Remarks.—R. G. Bell states that a specimen of a small and not quite adult *Helix* was found at Walton about 1881 by Mr. Larcher of King's College, London. After a careful comparison with a large series of European *Helices* in the collection of Mr. J. H. Ponsonby by himself and Dr. Gwyn Jeffreys it was identified as *H. lens.* Unfortunately, the specimen cannot now be traced. *H. lens* is a distinctly southern form. The figure here given is that of a Recent shell from Pylos in

Greece, from the late Canon Tristram's collection. Mr. A. Bell informs me that to the best of his remembrance the Crag fossil was somewhat larger.

Genus **HELICIGONA,** Risso, 1819.

Helicigona arbustorum (Linné).

1758. *Helix arbustorum*, Linné, Syst. Nat., ed. x, p. 771, no. 596.
1848. *Helix arbustorum*, S. V. Wood, Mon. Crag Moll., pt. i, p. 3, tab. i, fig. 2.
1853. *Helix arbustorum*, Forbes and Hanley, Brit. Moll., vol. iv, p. 48, pl. cxv, figs. 5, 6.
1862. *Helix arbustorum*, Jeffreys, Brit. Conch., vol. i, p. 188, pl. xi, fig. 4.
1890. *Helix arbustorum*, C. Reid, Plioc. Dep. Brit., p. 228.
1897–1901. *Helicigona arbustorum*, Kennard and B. B. Woodward, Essex Nat., vol. x, pp. 103 *et seq.*, 1897; Proc. Malac. Soc., vol. iii, p. 193, 1899; Proc. Geol. Assoc., vol. xvii, pp. 217 *et seq.* 1901.

Specific Characters.—See Mon. Crag Moll., pt. i, p. 2.

Dimensions.—Diam. 16—22 mm. H. 14—20 mm.

Distribution.—*Recent:* Great Britain, locally, in moist and shady places from Shetland to Cornwall; abroad, from Lapland and Iceland to Spain and North Italy.

Fossil: Butleyan Crag: Butley. Icenian—*Norwich zone:* Coltishall, Postwick, Easton Bavent, Southwold. *Weybourne zone:* East Runton; Freshwater bed, West Runton. Many localities in the Pleistocene and Holocene deposits of Great Britain and the Continent.

Remarks.—This species was reported by Wood from Southwold only, but specimens have been obtained since from the Red Crag of Butley and the Icenian of Coltishall (Brit. Mus.) and of Postwick (Mus. Pract. Geol.). Dr. Nordmann reports it from the Holocene of Denmark and Sweden. It occurs also in the loess of Enskirchen, Lower Pleistocene of Mosbach, in the Middle and Upper Pleistocene of Lyons, Nussdorf near Vienna, Bruchsal in Baden and elsewhere. The var. *alpestris*, Ziegler, of this species has been found in the Pleistocene gravels of Barnwell near Cambridge (A. Bell) and of Copford in Essex (Jeffreys). The latter authority states that the same form occurs living and abundantly at Hoddesdon in Hertfordshire on the marshes in the valley of the Lea.

Genus **HELIX,** Linné.

Helix lactea, Müller. Plate I, fig. 2.

1774. *Helix lactea*, Müller, Verm. terr. fluv. Hist., pt. ii, p. 19, no. 218.
1786. *Helix faux-nigra*, Chemnitz, Conch. Cab., vol. ix, p. 127, taf. 130, fig. 1161.
1853. *Helix lactea*, Reeve, Conch. Icon., vol. vii (Helix), pl. cxlvii, fig. 955.

1884. *Helix lactea*, R. G. Bell, Geol. Mag. [3], vol. i, p. 264.
1890. *Helix lactea*, C. Reid, Plioc. Dep. Brit., pp. 85, 228.
1899. *Helix lactea*, Kennard and B. B. Woodward, Proc. Malac. Soc., vol. iii, p. 193.

Specific Characters.—Shell large, imperforate, globose, depressed, transversely expanded; whorls 4—5, the uppermost flattened, the last convex, deflected in front; mouth very oblique, broadly lunar; outer lip thickened, obtuse, slightly marginate, reflected on the columella.

Dimensions.—Diam. 28—37 mm. H. 23 mm.

Distribution.—*Recent:* not known in Great Britain; occurring over the Mediterranean region in Spain, France, and North Africa; Teneriffe; Monte Video (introduced); recorded from Pondoland, South Africa (Melvill and Ponsonby).

Fossil: Waltonian Crag: Walton-on-Naze.

Remarks.—The imperfect specimen of *H. lactea*, here figured, was found at Walton in 1883 by the late R. G. Bell, and is now in the British Museum (Natural History); it is the only example of this species recorded from the Crag deposits.

Helix lactea is an extra-British species with an exclusively southern range, as to which R. G. Bell remarked that the land shells obtained from Walton agree with the marine mollusca in showing the distinction between the Red Crag of that place and the Crag of Butley, the fauna of the former being mainly southern; on the other hand both the prevalent land and marine shells of Butley are of a comparatively northern character.

He further states that the Walton fossil most nearly resembles an Algerian variety of this species.

Mr. J. W. Taylor informs me that he believes that the two specimens recorded from Yorkshire at Pateley Bridge and Scarborough were accidentally introduced.

Helix nemoralis, Linné. Plate I, fig. 3.

1758. *Helix nemoralis*, Linné, Syst. Nat., ed. x, p. 773, no. 604.
1843. *Helix Hæsendonckii*, Nyst, Coq. Foss. Terr. Tert. Belg., p. 464, pl. xxxviii, fig. 17.
1853. *Helix nemoralis*, Forbes and Hanley, Brit. Moll., vol. iv, p. 53, pl. cxv, figs. 1—4.
1862. *Helix nemoralis*, Jeffreys, Brit. Conch., vol. i, p. 185, pl. xi, fig. 3 *a*.
1875. *Helix nemoralis*, Sandberger, Land Sussw. Conch. Vorw., p. 853, taf. xxxv, fig. 3 *a*.
1890. *Helix nemoralis*, C. Reid, Plioc. Dep. Brit., p. 228.
1897–1901. *Helix nemoralis*, Kennard and B. B. Woodward, Essex Nat., vol. x, pp. 100 *et seq.*, 1897; Proc. Geol. Assoc., vol. xvii, pp. 220 *et seq.*, 1901.
1910. *Helix nemoralis*, Taylor, Mon. Land Freshw. Moll. Brit., vol. iii, p. 274, pls. xxvi, xxvii.

Specific Characters.—Shell globular, depressed below, rather solid, showing close irregular lines of growth and minute undulating spiral striæ; whorls $5\frac{1}{2}$, convex, the last three-fifths of the total length; spire short, with a blunt apex; suture slight; mouth cresent-shaped, oblique; basal lip flattened and angulated; outer lip reflected and thickened by an internal rib, much inflected above, slightly angular beneath where it makes an abrupt bend towards the columella; umbilicus closed and covered in the adult.

Dimensions.—Diam. 20—24 mm. H. 15—18 mm.

Distribution.—*Recent*: distributed over England, Wales, and Ireland, and in Scotland as far as Kincardine and the Caledonian Canal; it has only succeeded in crossing the Great Scottish Glen at one point; on the continent from Sweden and Norway to the Mediterranean (J. W. Taylor).

Fossil: Butleyan Crag: Butley. Freshwater bed, West Runton. Pleistocene: Woodston, Barnwell, Barrington, Copford, Grays, Ilford, Selsey, Torquay, Market Weighton, and elsewhere. Holocene: various parts of England and Ireland.

Miocene and Pliocene: France. Pliocene: Belgium, Holland. Pleistocene: many localities in France, Germany and Italy. Widely diffused in the Holocene deposits of Belgium, France, Sweden and Denmark.[1]

Remarks.—Mr. Kennard informs me that the only specimen of *Helix nemoralis* known to him from the Crag is one he found some years ago at Butley which was unfortunately broken. The reference of this species by the late Prof. Morris to the Coralline Crag, quoted by Mr. J. W. Taylor, was a mistake, the bed in which it occurred being one of reconstructed Crag.

Mr. C. Reid reports *H. nemoralis* from the freshwater deposits of the Cromer coast. The specimen here figured is from the Barnwell gravels.

In M. van den Broeck's opinion *H. Haesendonckii*, Nyst, from the Antwerp Crag, is identical with the present species.

Helix hortensis, Müller. Plate I, fig. 4.

1774. *Helix hortensis*, Müller, Verm. terr. fluv. Hist., pt. ii, p. 52, no. 247.
1853. *Helix nemoralis*, var. *hortensis*, Forbes and Hanley, Brit. Moll., vol. iv, p. 53.
1858. *Acavus* (*Tachea*) *hortensis*, Adams, Gen. Rec. Moll., vol. ii, p. 195.
1862. *Helix nemoralis*, var. *hortensis*, Jeffreys, Brit. Conch., vol. i, p. 186, pl. xi, fig. 3*b*.
1870. *Helix hortensis*, Gould, Rep. Inv. Mass., ed. ii, p. 429, fig. 688.
1897–1901. *Helix hortensis*, Kennard and B. B. Woodward, Essex Nat., vol. x, pp. 96 *et seq.*, 1897; Proc. Geol. Assoc., vol. xvii, pp. 224 *et seq.*, 1901.
1909. *Helix hortensis*, Scharff, Proc. Roy. Irish Acad., vol. xxviii, p. 19, fig. 4.
1911. *Helix hortensis*, J. W. Taylor, Mon. Land Freshw. Moll. Brit., vol. iii, p. 326, pl. xxix.

Specific Characters.—Shell distinguished from that of *H. nemoralis* by its smaller size and more globose form; it is thinner and more glossy than that species.

Dimensions.—Diam. 18 mm. H. 15 mm.

[1] In the work quoted above, p. 283, Mr. J. W. Taylor gives many other localities for this species.

Distribution.—Recent: generally and abundantly diffused in the British Isles; on the Continent from Scandinavia to the south of Europe; Iceland, Greenland, Labrador, Newfoundland, Maine and Massachusetts.

Fossil: Butleyan Crag: Butley. Pleistocene: Torquay, Ightham (Kent), Grays, Ilford, Copford, Clacton, Stutton, Dog Holes Cavern near Carnforth, and elsewhere.

Various Lower Pleistocene localities in Savoy, Seine et Marne, and the Alpes Maritimes. Middle Pleistocene: Saxony, Thuringia, and Silesia; St. Gall in Switzerland. Upper Pleistocene: Silesia, Bavaria (J. W. Taylor). Recorded also by Dr. Dall from the Champlain clays of Portland on the coast of Maine.

Remarks.—Helix hortensis was regarded from the time of Linné to that of Jeffreys as a variety of *H. nemoralis*, but is now considered distinct; as to this, J. W. Taylor observes: "Its specific status is firmly established by the differences in its organisation."

The specimen here figured is from the Canham collection in the Ipswich Museum, the box which contains it bearing the inscription, "*Helix hortensis*, R. G. B"(ell). The upper whorls are somewhat less convex and the suture not so clearly defined as is usually the case with that species; in some respects it resembles a small form of *H. arbustorum*, but it does not show any trace of the spiral striation characteristic of that species, and the mouth has the flattened basal lip of *H. hortensis.*

In a map accompanying the paper named above, Dr. Scharff points out that the present distribution of *H. hortensis* is practically continuous from the British Isles through the Faroes, Iceland, Greenland and Labrador, with Newfoundland and the coast of Maine, being found also in some small islands to which he thinks it could not have been introduced by man, remarking that it presents the most striking piece of evidence we possess in favour of the theory of a pre-glacial land connection between north-western Europe and north-eastern America. If R. G. Bell's reference of the Crag specimen to *H. hortensis* is correct it seems confirmatory of this view; such a connection must have been established, moreover, at a time when the polar regions were less encumbered with ice than they were during the glacial period. It has long been known that many species of marine mollusca are now common to both sides of the Atlantic. We shall find as we proceed that there is a considerable amount of correspondence between the Pliocene fauna of Iceland and that of the Crag basin, and that there are shells in the Crag which cannot be distinguished from those said to be living now only on the banks of Newfoundland, or even further west from the latter, in Behring Sea.

Gould states that he imported a hundred specimens of *H. hortensis* into North America from England in 1857, and that they increased very rapidly. He does not think, however, that this species was originally introduced from Europe.

Genus **COCHLICOPA**, Férussac, 1820.

Cochlicopa lubrica (Müller).

1774. *Helix lubrica*, Müller, Verm. terr. fluv. Hist., pt. ii, p. 104, no. 303.
1853. *Zua lubrica*, Forbes and Hanley, Brit. Moll., vol. iv, p. 125, pl. cxxv, fig. 8.
1862. *Cochlicopa lubrica*, Jeffreys, Brit. Conch., vol. i, p. 292, pl. xviii, fig. 2.
1874–9. *Bulimus lubricus*, S. V. Wood, Mon. Crag Moll., 1st Suppl., p. 1874, 187; 2nd Suppl., p. 38, tab. iv, fig. 10, 1879.
1890. *Zua subcylindrica*, C. Reid, Plioc. Dep. Brit., p. 230.
1897–1901. *Cochlicopa lubrica*, Kennard and B. B. Woodward, Essex Nat., vol. x (table), 1897; Proc. Malac. Soc., vol. iii, p. 193, 1899; Proc. Geol. Assoc., vol. xvii, pp. 215 *et seq.*, 1901.

Specific Characters.—Shell minute, smooth, elongated, oblong, the lower part subcylindrical; whorls 5 or 6, tumid, regularly tapering upwards, the last about half the total length, the upper one contracted; apex rounded; suture moderately deep, rather oblique; mouth oval, angulated above; outer lip thick, strengthened within, not expanded.

Dimensions.—L. 5 mm. B. 2 mm.

Distribution.—*Recent:* widely distributed in the Northern Hemisphere; Great Britain and Ireland; Europe; Asia; Africa; North and South America; Madeira, the Azores; New Zealand.

Fossil: Butleyan Crag: Butley (Ipswich Museum). Freshwater bed, West Runton (C. Reid). Abundant in Pleistocene and Holocene deposits of Great Britain and Ireland.

Lower Pleistocene: Mosbach. Middle Pleistocene: Cannstadt, Weimar and Mülhausen in Thuringia (Kennard and B. B. Woodward). Pleistocene loess: St. Gall, Switzerland; Lower Rhineland, Germany; Nussdorf, Austria. Pleistocene deposits: Haute Garonne, France; Muscatine, Iowa; Lawrenceburg, Indiana. Kitchen middens of Maine and Massachusetts (J. W. Taylor). Newer Holocene: Sweden and Denmark (Nordmann).

Remarks.—The only specimens of *C. lubrica* recorded from the Crag are those mentioned by Wood in 1874 which were found by the Rev. H. Canham at Butley, and are now in the Ipswich Museum. Messrs. Kennard and B. B. Woodward state, as given above, that the earliest records of this species on the Continent are from the Lower and Middle Pleistocene of southern Germany.

Genus **JAMINIA**, Leach, 1852.

Jaminia muscorum (Linné).

1758. *Turbo muscorum*, Linné, Syst. Nat., ed. x, p. 767, no. 568.
1774. *Helix muscorum*, Müller, Verm. terr. fluv. Hist., pt. ii, p. 105, no. 304.
1805. *Pupa marginata*, Draparnaud, Hist. Nat. Moll. terr. fluv. France, p. 61, pl. iii, figs. 36—38.

1826. *Jaminia muscorum*, Risso, Hist. Nat. Europ. merid., vol. iv, p. 88, no. 201.

1853. *Pupa muscorum*, Forbes and Hanley, Brit. Moll., vol. iv, p. 97, pl. cxxix, figs. 8, 9.

1862–71. *Pupa marginata*, Jeffreys, Brit. Conch., vol. i, p. 249, pl. xv, fig. 4, 1862; Quart. Journ. Geol. Soc., vol. xxvii, p. 493, 1871.

1872. *Pupa muscorum*, S. V. Wood, Mon. Crag Moll., 1st Suppl., p. 3, tab. 1, fig. 7.

1872. *Pupa muscorum*, A. and R. Bell, Proc. Geol. Assoc., vol. ii, p. 213.

1889. *Pupa muscorum*, Lorié, Bull. Soc. Belg. Géol., vol. iii (Mémoires), p. 436.

1890. *Pupa marginata*, C. Reid, Plioc. Dep. Brit., p. 229.

1897–1901. *Pupa muscorum*, Kennard and B. B. Woodward, Essex Nat., vol. x, p. 108, 1897; Proc. Malac. Soc., vol. iii, p. 194, 1899; Proc. Geol. Assoc., vol. xvii, pp. 229 *et seq.*, 1901.

Specific Characters.—Shell minute, rather solid, subcylindrical, finely striated in the lines of growth; whorls 6—7, convex, but slightly compressed, well defined, the last about one-third the total length, the first two much smaller than the rest; apex blunt and abrupt; suture distinct; mouth forming nearly two-thirds of a circle, generally with a tubercular tooth on the columella nearly in the middle; outer lip sharp, reflected, with a thick external rib a little distance from the margin; inner lip spread on the pillar; umbilicus small and shallow.

Dimensions.—L. 3·3 mm. B. 1·5 mm.

Distribution.—Recent: everywhere in Great Britain, from the Shetlands to the Channel Isles, especially near the sea coast; less plentiful in Scotland and the centre of Ireland; abroad from Iceland, Lapland, and Siberia to central Europe, Spain, Corsica, and Sicily (Jeffreys); North America (G. O. Sars); Asia and North Africa (J. W. Taylor).

Fossil: Butleyan Crag: Butley. Icenian—*Norwich zone:* Bramerton, Yarn Hill. *Weybourne zone:* North Walsham boring. Widely diffused in the Pleistocene and Holocene deposits of Great Britain.

Pleistocene of France, Holland, Belgium, Sweden and Germany; Algeria. Upper Lahontan beds of Nevada, forest bed of Lawrenceburg, Indiana, loess of Iowa. Holocene: Sweden (Nordmann).

Remarks.—The only specimens of *J. muscorum* known to S. V. Wood were one found by Mr. A. Bell in the Red Crag of Butley, and another by myself in the Icenian Crag of Bramerton. It has been obtained since from the latter horizon at Yarn Hill by Mr. R. E. Leach, and at Butley by Mr. Kennard. Dr. Lorié records it from the Amstelien deposits met with in one of the Amsterdam borings at 230 metres. Elsewhere on the continent it is unknown from any bed of earlier age than the Middle Pleistocene of Wiesbach, Cannstadt, and Wiesbaden (Kennard and B. B. Woodward).

Jeffreys, who adopted for this form Draparnaud's name of *Pupa marginata*, says that when found in marine deposits such as those of the English Crag, it indicates the former presence of littoral conditions, as it not only peculiarly affects sandy shores and maritime places, but is washed down in great numbers by estuarine rivers, and thrown up on the beach by the reflux of the tide.

Jaminia cylindracea (Da Costa). Plate I, fig. 10.

1778. *Turbo cylindraceus*, Da Costa, Brit. Conch., p. 89, pl. v, fig. 16.
1803. *Turbo muscorum*, Montagu, Test. Brit., pt. i, p. 335, pl. xxii, fig. 3.
1805. *Pupa umbilicata*, Draparnaud, Moll. terr. fluv. France, p. 58, pl. iii, figs. 39, 40.
1844. *Pupa umbilicata*, Philippi, En. Moll. Sic., vol. ii, p. 114.
1853. *Pupa umbilicata*, Forbes and Hanley, Brit. Moll., vol. iv, p. 95, pl. cxxix, fig. 7.
1862. *Pupa umbilicata*, Jeffreys, Brit. Conch., vol. i, p. 246, pl. xv, fig. 3.
1890. *Pupa umbilicata*, C. Reid, Plioc. Dep. Brit., p. 229.
1897–1901. *Pupa cylindracea*, Kennard and B. B. Woodward, Essex Nat., vol. x, pp. 103 *et seq.*, 1897; Proc. Malac. Soc., vol. iii, p. 194, 1899; Proc. Geol. Assoc., vol. xvii, p. 260, 1901.
1903. *Jaminia cylindracea*, B. B. Woodward, Journ. Conch., vol. x, p. 354.

Specific Characters.—Shell minute, rather thin, sub-cylindrical, slightly and irregularly striated in the lines of growth; whorls convex, the last about two-fifths the total length, sharply twisted upwards towards the mouth, the first two whorls much smaller in proportion to the rest; spire short, abruptly and bluntly pointed; suture rather oblique, well defined, but not deep; mouth sub-triangular, contracted or channelled below in the adult shell, with a short ridge-like tooth on the pillar near the outer lip and another on the inner lip which is spread on the pillar; umbilicus very small and oblique, contracted by a ridge at the base of the shell.

Dimensions.—L. 3 mm. B. 1·5 mm.

Distribution.—Recent: Great Britain, everywhere from Shetland to the Channel Islands; abroad, Finland to Algeria, Morocco and Tunis, as well as to the Grecian Archipelago; Azores, Madeira; Armenia, Abyssinia, Cape of Good Hope (J. W. Taylor).

Fossil: Icenian Crag: Bramerton (Norwich Museum), Yarn Hill (Leach).

Pleistocene and Holocene deposits of Great Britain (Kennard and B. B. Woodward). Holocene: shell-beds of Horn Head, Tramore, Donegal (J. W. Taylor).

Remarks.—This little shell is generally known by Draparnaud's name of *Pupa umbilicata*, a term adopted both by Forbes and Hanley and by Jeffreys. The latter admits, however, that strictly it should be called *P. cylindracea*, by which specific name it was known to Da Costa. Messrs. Kennard and B. B. Woodward have revived the latter name in their recent papers.

J. cylindracea was not known to Wood from the Crag, but has since been reported from Bramerton and Yarn Hill. Messrs. Kennard and B. B. Woodward state there is a specimen in the Castle Museum at Norwich, but it cannot now be found. The figure here given is from a Recent shell.

A single example was found by Dr. Frank Corner in the Pleistocene deposits of Ilford; it occurs abundantly at Copford, but less so elsewhere. Messrs.

Kennard and B. B. Woodward state that as a fossil this species has not been recorded from the Continent.

Genus **CLAUSILIA**, Draparnaud, 1805.

Clausilia pliocena, S. V. Wood.

1872. *Clausilia pliocena,* S. V. Wood, Mon. Crag Moll., 1st Suppl., p. 188, Add. pl., fig. 22.
1889. *Clausilia pliocena,* Lorié, Bull. Soc. Belg. Géol., vol. iii (Mémoires), pp. 435, 437.
1890. *Clausilia pliocena,* C. Reid, Plioc. Dep. Brit., p. 228.
1899. *Clausilia pliocena,* Kennard and B. B. Woodward, Proc. Malac. Soc., vol. iii, p. 194.

Specific Characters.—Shell sinistral, elongate, rather solid; whorls 9 or 10 (?), slightly convex, regularly tapering; ornamented by numerous fine, well-marked and flexuous costæ in the lines of growth; base of the last whorl angulate and contracted below; suture distinct, oblique; peristome continuous; mouth subquadrangular; outer lip slightly projecting.

Dimensions.—L. 10 mm. B. 3 mm.

Distribution.—Not known living.

Fossil: Coralline Crag: Sutton. Amstelien deposits: Amsterdam (Lorié).

Remarks.—This species is represented by a unique and incomplete example, now in the British Museum (Natural History), obtained by Wood from the Coralline Crag of Sutton. It differs from any British form. Dr. Lorié believes that he has obtained several specimens of it from a deep boring at Diermerburg, near Amsterdam, at a depth of about 230 metres in beds which I regard as Amstelien. I have not seen these fossils, but if they are correctly identified it brings down the existence of this species in the Anglo-Belgian basin to a much later date than that of the Coralline Crag.

Genus **SUCCINEA**, Draparnaud, 1801.

Succinea elegans, Risso.

1826. *Succinea elegans,* Risso, Hist. Nat. Europ. merid., vol. iv, p. 59, no. 128.
1848. *Succinea oblonga* (?), S. V. Wood, Mon. Crag Moll., pt. i, p. 6, tab. i, fig. 6.
1853. *Succinea putris,* var., Forbes and Hanley, Brit. Moll., vol. iv, p. 133, pl. cxxxi, fig. 2.
1862. *Succinea elegans,* Jeffreys, Brit. Conch., vol. i, p. 153, pl. viii, fig. 5.
1885–89. *Succinea elegans,* Lorié, Arch. Mus. Teyler [2], vol. ii, p. 210, pl. v, fig. 40, 1885; vol. iii, p. 131, 1887; Bull. Soc. Belge Géol., vol. iii (Mémoires), p. 435, 1889.
1897–1901. *Succinea elegans,* Kennard and B. B. Woodward, Essex Nat., vol. x, pp. 100 *et seq.*, 1897; Proc. Malac. Soc., vol. iii, p. 195, 1899; Proc. Geol. Assoc., vol. xvii, pp. 218 *et seq.*, 1901.

Specific Characters.—Shell oblong, thin and fragile, whorls 3—4, moderately convex, compressed above, the last much the largest, three-fourths the total length; spire short and pointed; suture moderately deep, very oblique; mouth large, oval, angulate above; outer lip slightly thickened, inflected above; pillar lip sharp.

Dimensions.—L. 16 mm. B. 7 mm.

Distribution.—*Recent:* throughout the British Isles, becoming scarce towards the north. Widely distributed in Europe from Finland to Sicily, from France to the Caucasus; reported in North Africa from Algiers to Egypt; in Asia from Palestine to Cashmere (J. W. Taylor).

Fossil: Butleyan Crag: Hollesley, Butley. Icenian: Bulchamp, Bramerton, Coltishall. Pleistocene and Holocene of England.

Holland—Pliocene: Utrecht, Amsterdam. Pleistocene: Gorkum, Purmerend. Germany—Lower Pleistocene: Mosbach. France—Upper Pleistocene: Vincennes. Upper Holocene of Denmark and Sweden (Nordmann). Holocene of the Sahara: El Goleah.

Remarks.—Messrs. Kennard and B. B. Woodward identify the specimen figured by Wood as *S. oblonga* with *S. elegans,* although it can hardly be regarded as typical of the latter. Wood's specimen, which came from Bulchamp, is in the British Museum (Natural History); the one from Coltishall mentioned by the authors named as in the Norwich Museum cannot now be found.

Dr. Lorié has reported *S. elegans* from the Pleistocene beds (Eemien) met with in some deep borings in the Vallé Gueldroise, as well as from the Pliocene deposits (Amstelien) underlying Amsterdam and Utrecht.

Succinea oblonga, Draparnaud. Plate I, fig. 13.

1805. *Succinea oblonga,* Draparnaud, Moll. terr. fluv. France, p. 59, pl. iii, figs. 24, 25.
1853. *Succinea oblonga,* Forbes and Hanley, Brit. Moll., vol. iv, p. 137, pl. cxxxi, figs. 6, 7.
1862. *Succinea oblonga,* Jeffreys, Brit. Conch., vol. i, p. 154, pl. viii, fig. 6.
1890. *Succinea oblonga,* C. Reid, Plioc. Dep. Brit., p. 229.
1897–1901. *Succinea oblonga,* Kennard and B. B. Woodward, Essex Nat., vol. x, pp. 107 *et seq.*, 1897; Proc. Malac. Soc., vol. iii, p. 195, 1899; Proc. Geol. Assoc., vol. xvii, pp. 236 *et seq.*, 1901.

Specific Characters.—Shell oblongo-oval, rather solid, striated by the lines of growth; whorls 3–4, convex, the last two-thirds the total length; spire prominent, ending in a blunt point; suture deep, oblique; mouth subovate, not oblique, nearly equalling the spire; outer lip arcuate.

Dimensions.—L. 6 mm. B. 5 mm.

Distribution.—*Recent:* Great Britain and Ireland, local, chiefly near the sea coast. Widely diffused on the Continent from Norway and Sweden to Spain and

North Italy in one direction (Jeffreys), and to Russia (including Siberia), Hungary, and Bosnia in another (J. W. Taylor).

Fossil: Icenian Crag—*Norwich zone:* Bulchamp, Southwold. *Weybourne zone:* East Runton; Freshwater beds, West Runton.

Pleistocene and Holocene deposits of Great Britain and the Continent. Loess of China: Kansu (Hilber).

Remarks.—The fossil here figured is from the Wood Collection in the British Museum (Natural History). Messrs. Kennard and B. B. Woodward, remarking that it differs somewhat from the typical form of *S. oblonga*, state that it is the only specimen known to them which can be referred to that species.

S. oblonga is rare in this country at present, but in Pleistocene times it was more common and more widely distributed, being specially abundant both here and on the Continent together with *Helix hispida* and *Pupa muscorum*, as at Swale Cliff, near Herne Bay; in the loess of Germany and the valleys of the Seine and the Somme (*limons grès à Succinées*).

M. Rutot informs me that *S. oblonga* occurs at all horizons of the Belgian Pleistocene, from the Moseen to the Hesbayen; in the latter it is accompanied by the two shells mentioned above. Lyell regards these three species as specially characteristic of the loess.[1]

It occurs, also, according to Dr. Nordmann, in the newer Holocene of Sweden and Denmark.

Mr. Taylor remarks that being a weak or recessive species, it is much scarcer in England than in the sister countries, being fairly common in Ireland, where the fauna is less dominant. He considers it is being slowly exterminated here.

Succinea putris (Linné).

1758. *Helix putris,* Linné, Syst. Nat., ed. x, p. 774, no. 614.
1848. *Succinea putris* (?), S. V. Wood, Mon. Crag Moll., pt. i, p. 5, tab. 1, fig. 5.
1853. *Succinea putris,* Forbes and Hanley, Brit. Moll., vol. iv, p. 132, pl. cxxxi, figs. 1—5.
1862. *Succinea putris,* Jeffreys, Brit. Conch., vol. i, p. 151, pl. viii, fig. 4.
1890. *Succinea putris,* C. Reid, Plioc. Dep. Brit., p. 229.
1897–1901. *Succinea putris,* Kennard and B. B. Woodward, Essex Nat., vol. x, p. 108, 1897; Proc. Malac. Soc., vol. iii, p. 195, 1899; Proc. Geol. Assoc., vol. xvii, p. 217, 1901.

Specific Characters.—Shell oval, very thin, finely striated by the lines of growth; whorls 3—4, convex, the last four-fifths of the total length; spire short, rapidly diminishing in size, ending in a blunt point; suture oblique and deep; mouth large, oval, angulate above; outer lip slightly thickened, contracted where it joins the columella; pillar-lip sharp.

Dimensions.—L. 17 mm. B. 10 mm.

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[1] Antiquity of Man, 4th ed., p. 375, 1873.

Distribution.—Recent: very widely distributed throughout the Palæarctic region; in Great Britain from Shetland to the Channel Islands; abroad in Europe, Asia; and the north of Africa.

Fossil: Butleyan Crag: Butley. Icenian: Bramerton, Yarn Hill; Freshwater bed, Mundesley. Common in English Pleistocene and Holocene deposits from Yorkshire southwards.

Italian Pliocene (de Stefani). Pleistocene: Germany—Mosbach; France—St. Acheul. Vincennes. Many other Pleistocene and Holocene localities. Newer Holocene: Sweden and Denmark (Nordmann).

Remarks.—Wood figured a shell from Bramerton as *S. putris* with a query, but it hardly represents the typical form of this species. There are two others, very small, in the Norwich Museum, and a larger one from Butley, which conform more nearly to the Recent shell; *S. putris* seems to have been variable in former times as it is at present. Specimens from the gravels of Barnwell near Cambridge, for example, differ widely both in form and size.

Genus **CARYCHIUM,** Müller, 1774.

Carychium minimum, Müller. Plate I, fig. 12.

1774. *Carychium minimum*, Müller, Verm. terr. fluv. Hist., pt. ii, p. 125, no. 321.
1853. *Carychium minimum*, Forbes and Hanley, Brit. Moll., vol. iv, p. 198, pl. cxxv, fig. 6.
1862. *Carychium minimum*, Jeffreys, Brit. Conch., vol. i, p. 300, pl. xviii, fig. 4.
1871. *Carychium minimum*, Jeffreys, in Prestwich, Quart. Journ. Geol. Soc., vol. xxvii, p. 493.
1872. *Carychium minimum*, A. and R. Bell, Proc. Geol. Assoc., vol. ii, p. 215.
1890. *Carychium minimum*, C. Reid, Plioc. Dep. Brit., p. 228.
1897–9. *Carychium minimum*, Kennard and B. B. Woodward, Essex Nat., vol. x, pp. 100 *et seq.*, 1897; Proc. Malac. Soc., vol. iii, p. 203, 1899.

Specific Characters.—Shell minute, oblong, elongate, densely and very finely striated in the line of growth; whorls $5\frac{1}{2}$, convex, tapering to a blunt point; basal contraction of shell gradual; suture deep, slightly oblique; mouth obliquely oval, with a strong spiral fold on the middle of the pillar, and another on the pillar-lip; outer lip thick and reflected, with a strong internal tooth in the middle which projects into the mouth, the upper edge of the lip being inflected; inner lip thickened, forming with the outer lip a complete peristome; umbilical slit oblique.

Dimensions.—L. 1·75 mm. B. ·85 mm.

Distribution.—Recent: generally diffused through Great Britain and Ireland; abroad from Sweden and Norway to Sicily, Algeria and Morocco; Siberia; Manchuria; Armenia (J. W. Taylor).

Fossil: Icenian Crag: Bramerton. Pleistocene and Holocene deposits of England, including Woodston, Barnwell, Grantchester, Hitchin, Kirmington, Barry Docks, Newquay. Ireland: Portrush, Newhall Caves. Loess of the Rhineland.

Remarks.—This species is given from Bramerton by Jeffreys in the list accompanying Prestwich's paper (*loc. cit.*); it has been rejected as a Crag fossil by Messrs. Kennard and B. B. Woodward on the ground that the specimen cannot now be traced, but Mr. A. Bell, who found it, informs me that he has little doubt but that it was correctly identified.

It has been suggested that the Crag shell may have been the Runton species, *C. ovatum*, described below.

Showing one of the specimens from that place to Mr. Bell, however, he said it was new to him, and to the best of his belief so unlike the one he found at Bramerton that even if his brother and he had considered it a variety of that species, they could hardly have failed to notice the difference between them.

Under the circumstances, I have figured both; possibly another specimen from the Crag may turn up hereafter. Meanwhile I include *C. minimum* in my list of Crag shells on Mr. Bell's authority.

C. minimum was regarded by Jeffreys and some other conchologists as practically identical with the American form *C. exiguum*, and as one of the circumpolar species.

Carychium ovatum, Sandberger. Plate I, fig. 11.

1880. *Carychium ovatum,* Sandberger, Palæontogr., vol. xxvii, p. 101, pl. xii, fig. 12.
1890. *Carychium minimum,* C. Reid (part), Plioc. Dep. Brit., p. 228.

Specific Characters.—Shell minute, fragile, ovate; apex obtuse, mammillate; whorls 5, moderately convex, smooth, the last more than half the total length; suture distinct; mouth ear-shaped, somewhat oblique; peristome having a wide and continuous margin, with two distinct projecting teeth on the inner side and one on the outer; umbilical chink closed.

Dimensions.—L. 1·85 mm. B. 0·85 mm.

Distribution.—Not known living.

Fossil: Freshwater bed, West Runton (not rare).

Remarks.—In 1890 Mr. C. Reid suggested that this shell is identical with *C. minimum.* Messrs. Kennard and B. B. Woodward, however, agree with Prof. Sandberger in considering it distinct. The latter states that its nearest affinities are with *C. pachychilus* from the Pliocene of Hauterive.

Genus **POMATIAS**,[1] Studer, 1789.

Pomatias Harmeri, Kennard. Plate I, fig. 9.

1909. *Pomatias Harmeri*, Kennard, Proc. Malac. Soc., vol. viii, p. 316.

Specific Characters.—Shell conical, somewhat solid, with numerous close-set spiral ridges; periphery rounded; whorls $4\frac{1}{2}$, rapidly enlarging, the last very tumid; spire produced; apex obtuse and smooth; suture very deep; mouth circular, slightly angulated above; umbilicus narrow; operculum unknown (Kennard).

Dimensions.—L. 10 mm. B. 8 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Little Oakley.

Remarks.—The shell now figured is a unique specimen from Oakley. It differs from the Recent British species *P. elegans*, and I was unable to discover anything else to which it could be referred. Submitting it to Mr. Kennard he expressed the opinion that it was new to science, and proposed to describe it under the name here adopted. I thank him for the friendly compliment.

Comparing the present specimen with *P. elegans* he says the sculpture of that species is reticulate, as in nearly all the European forms of *Pomatias*, the spiral ridges being connected by numerous longitudinal striæ. In *P. Harmeri* the ridges are coarser, and the intersecting striæ are absent; in form the shell is distinctly broader in proportion to its height.

He further remarks that he is unable to identify it with any of the eleven recent species of *Pomatias* (*Cyclostoma*) cited by Westerlund from the Palæarctic region, and that there is no extinct form known to him with which it compares. He points out, moreover, that the discovery of this shell at Oakley greatly extends the age of the genus *Pomatias* in England, as it had not previously been recorded from any deposit older than the Pleistocene. *P. elegans* occurs fossil at many localities in our Holocene and Pleistocene deposits, as for example at Barrington, Ightham and the Happaway cavern in Devonshire; it is a Recent British form, with an exclusively southern range.

[1] These shells have been known from the time of Draparnaud (1801) to the present, under the generic name of *Cyclostoma*, as for example to H. and A. Adams, Chenu and Fischer, as well as to the Conchological Society of Great Britain. Recently, however, on grounds of priority, Messrs. B. B. Woodward and Kennard have revived Studer's term *Pomatias* (1789), which had been lost sight of for more than 100 years, and had been applied by Hartmann (1821) to a different group of Mollusca. It seems an open question, however, whether under the circumstances the use of a name so long established and so widely known might not have been retained.

B. AQUATIC.

GASTEROPODA.

Genus **ACROLOXUS,** Beck, 1838.

Acroloxus lacustris (Linné). Plate I, fig. 18.

1758. *Patella lacustris,* Linné, Syst. Nat., ed. x, p. 783, no. 672.
1837. *Acroloxus lacustris,* Beck, Ind. Moll., p. 124.
1853. *Ancylus lacustris,* Forbes and Hanley, Brit. Moll., vol. iv, p. 188, pl. cxxii, fig. 5.
1862. *Ancylus lacustris,* Jeffreys, Brit. Conch., vol. i, p. 122, pl. viii, fig. 2.
1872. *Ancylus lacustris,* A. and R. Bell, Proc. Geol. Assoc., vol. ii, p. 215.
1890. *Ancylus lacustris,* C. Reid, Plioc. Dep. Brit., p. 228.
1897–1901. *Velletia lacustris,* Kennard and B. B. Woodward, Essex Nat., vol. x, pp. 93 *et seq.*, 1897; Proc. Malac. Soc., vol. iii, p. 203, 1899; Proc. Geol. Assoc., vol. xvii (tab.), 1901.
1903. *Acroloxus lacustris,* B. B. Woodward, Journ. Conch., vol. x, p. 355.

Specific Characters.—Shell minute, thin and fragile, oblong, twisted to the left, indistinctly ornamented with fine radiating striæ; beak sharp and ridge-like, placed close to the margin, turning obliquely to the left; mouth oblong; outer lip membranous, reflected.

Dimensions.—L. 6 mm. B. 2·5 mm.

Distribution.—*Recent:* widely diffused in England; less plentiful and more local in Wales, Ireland, and Scotland south of Aberdeen; abroad from Finland to Sicily (J. W. Taylor); Madeira (Bourguignat); North Africa (G. O. Sars).

Fossil: Icenian Crag: Bramerton (A. Bell); Freshwater bed, West Runton. Pleistocene of England: Barnwell, Grantchester, Hitchin, Barry Docks. English Holocene.

Pleistocene: Menchecourt, lacustrine beds near Paris; Burgtonna and Mülhausen in Thuringia. Holocene: Sweden and Denmark (Nordmann).

Remarks.—This species was reported from the Icenian Crag in 1872 by Messrs. Alfred and Robert Bell, but has been rejected by Messrs. Kennard and B. B. Woodward from their list of British non-marine Pliocene Mollusca on the ground that the specimen cannot now be traced. It seems to me improbable that a mistake could have been made by two such competent and careful observers. Mr. A. Bell, who only survives, informs me he has no doubt as to the correctness of the identification. To the best of his belief he found the specimen in question at Bramerton.

The figure now given is from a Recent shell.

Genus **LIMNÆA**, Lamarck, 1801.

Limnæa butleyensis, Kennard and B. B. Woodward.

1848. *Limnæa truncatula*, S. V. Wood, Mon. Crag Moll., pt. i, p. 8, tab. 1, fig. 8*a*.
1872. *Limnæa Holbollii*, S. V. Wood, Mon. Crag Moll., 1st Suppl., p. 3.
1899. *Limnæa truncatula* (part), Kennard and B. B. Woodward, Proc. Malac. Soc , vol. iii, p. 196.
1911. *Limnæa butleyensis*, Kennard and B. B. Woodward, Geol. Mag. [5], vol. viii, p. 402.

Specific Characters.—Shell small, ovato-conical, thin ; spire elevated, somewhat turreted; apex acute; whorls $5\frac{1}{2}$, convex; suture deep; aperture ovate, slightly contracted on the inner side; distinguished from *L. truncatula* in being larger, in having the mouth more oval, while the whorls increase more regularly (K. and B. B. W.).

Dimensions.—L. 10—12 mm. B. 5—6 mm.

Distribution.—Not known living.

Fossil : Butleyan Crag : Hollesley, Butley. Icenian : Bramerton, Thorpe (Norfolk).

Remarks.—As there seemed some doubt as to the identification of some fossils referred by Wood to the recent species *L. Pingellii* and *L. Holbollii* described by Möller, but, as far as I know, never figured, I asked Dr. Nordmann to send me some typical specimens of these two forms, which he was kind enough to do. It seemed improbable that freshwater shells unknown as fossils and at present living only in Greenland should have been denizens of the North Sea region in Pliocene times. Submitting the Recent specimens to Messrs. Kennard and B. B. Woodward, and comparing them with the Crag shells, we agreed that they were not identical. The one form has since been referred by them, as stated below, to the British species *L. palustris ;* the other they describe as new, under the present name.

Limnæa palustris (Müller).

1774. *Buccinum palustre*, Müller, Verm. terr. fluv. Hist., pt. ii, p. 131, no. 326.
1848. *Limnæa palustris* (?), S. V. Wood, Mon. Crag Moll., pt. i, p. 7, tab. 1, fig. 8.
1853. *Limnæus palustris*, Forbes and Hanley, Brit. Moll., vol. iv, p. 180, pl. cxxiv, fig. 2.
1862. *Limnæa palustris*, Jeffreys, Brit. Conch., vol. i, p. 113, pl. vii, fig. 6.
1872. *Limnæa Pingellii* (?), S. V. Wood, Mon. Crag Moll., 1st Suppl., p. 3, tab. iv, fig. 4.
1890. *Limnæa labio*, C. Reid, Plioc. Dep. Brit., p. 229.
1897–1901. *Limnæa palustris*, var., Kennard and B. B. Woodward, Essex Nat., vol. x, pp. 100 *et seq.*, 1897 ; Proc. Malac. Soc., vol. iii, p. 196, 1899 ; Proc. Geol. Assoc., vol. xvii, pp. 218 *et seq.*, 1901.

Specific Characters.—See Mon. Crag Moll., pt. i, p. 7.

Dimensions.—L. 25 mm. B. 5 mm.

Distribution.—*Recent:* throughout the British Isles to the south of the great Scottish glen; abroad from Kamschatka and Siberia to Sicily; Manchuria, Persia, Transcaucasia. North Africa: Algeria, Morocco.

Fossil: Butleyan Crag: Butley. Icenian—*Norwich zone:* Coltishall, Bramerton, Yarn Hill, Bulchamp. *Weybourne zone:* East Runton, Weybourne, North Walsham boring; Freshwater bed, West Runton. Pleistocene of England, including Woodston, the Barnwell gravels, lacustrine deposits of Holderness, Selsey, etc. English Holocene.

Pleistocene: Mosbach, Vinograd near Buczak in the Ukraine, Kilianstadten near Hanover; other localities in France, Germany, and Austria; El Goleah, Sahara. Holocene: Sweden, Denmark.

Remarks.—I give above some Crag localities for this species other than those recorded by Wood in 1848, as well as some continental localities, on the authority of Messrs. Kennard and B. B. Woodward and Mr. J. W. Taylor.

In his first Supplement, p. 3, tab. iv, fig. 4, Wood figured, as just stated, a specimen from Butley which he referred to the Greenland species *L. Pingellii*, Möller. This differs somewhat from the type form of *L. palustris* or from any Crag shells known to me, or from those figured by Jeffreys and by Forbes and Hanley under the latter name, being smaller, more tumid, and shorter in the spire. Messrs. Kennard and B. B. Woodward, however, regard it as a variety of *L. palustris*, which they state is exceedingly variable, both as Recent and from the Crag. I agree with them that it is not *L. Pingellii.*

Limnæa Harmeri, Kennard and B. B. Woodward. Plate I, fig. 14.

1911. *Limnæa Harmeri*, Kennard and B. B. Woodward, Geol. Mag. [5], vol. viii, p. 401.

Specific Characters.—Shell elongate, oblongo-conical, thin; spire elevated, slightly turreted; apex acute; whorls 6 (or 6½), convex, smooth; suture fairly deep; mouth oval, entire; inner lip reflected but apparently not spread on the columella; it does not conceal the umbilical chink (K. and B. B. W.).

Dimensions.—L. 15 mm. B. 7 mm. Mouth: L. 6 mm. B. 4 mm.

Distribution.—Not known living.

Fossil: Icenian Crag: Bramerton (unique).

Remarks.—The specimen here figured was found at Bramerton by Mr. Jas. Reeve, and is now in the Castle Museum at Norwich where it had been labelled *L. Holbollii*; it differs from anything hitherto reported from the Crag. Submitting it to Messrs. Kennard and B. B. Woodward for examination, they informed me they were unable to refer it to any species known to them, and very kindly offered to describe it under the above name. Remarking that there can be no doubt as to its specific distinctness, they state it may be distinguished from *L. tenuis*, S. Woodward (Geol. of Norfolk, tab. iii, fig. 30, 1833), *L. palustris*, S. V. Wood (Mon. Crag Moll., pt. i, tab. i, fig. 7, 1848), *L. palustris*, Kennard and B. B. Woodward (Proc. Malac. Soc., vol. iii, p. 196, 1899), and *L. Pingellii*, S. V. Wood, (Mon. Crag Moll., 1st Suppl., tab. iv, fig. 4, 1872), by its more pronounced suture, its more convex whorls and its markedly oval mouth. Though bearing a superficial resemblance to some forms of *L. palustris*, they consider that in all probability it has no affinity with that species.

Limnæa pereger (Müller).

1774. *Buccinum peregrum*, Müller, Verm. terr. fluv. Hist., pt. ii, p. 130, no. 324.
1848. *Limnæa peregra*, S. V. Wood, Mon. Crag Moll., pt. i, p. 7, pl. i, fig. 7.
1853. *Limnæus pereger*, Forbes and Hanley, Brit. Moll., vol. iv, p. 165, pl. cxxiii, figs. 3—7.
1862. *Limnæa peregra*, Jeffreys, Brit. Conch., vol. i, p. 104, pl. vii, fig. 3.
1890. *Limnæa limosa*, C. Reid, Plioc. Dep. Brit., p. 229.
1896. *Limnæa pereger*, Stefanescu, Mém. Soc. Géol. France, vol. vi, p. 105, pl. ix, fig. 36.
1897–1901. *Limnæa pereger*, Kennard and B. B. Woodward, Essex Nat., vol. x, pp. 93 *et seq.*, 1897; Proc. Malac. Soc., vol. iii, p. 195, 1899; Proc. Geol. Assoc., vol. xvii, pp. 217 *et seq.*, 1901.

Specific Characters.—See Mon. Crag Moll., pt. i, p. 7.

Dimensions.—L. 18 mm. B. 10 mm.

Distribution.—*Recent:* widely distributed in the British Isles, and abroad from Siberia and Iceland to Sicily; recorded also from various localities in Asia from Palestine to China, and in Africa from Morocco and Abyssinia (J. W. Taylor).

Fossil: Butleyan Crag: Hollesley, Butley. Icenian: Bramerton, Southwold, Bulchamp; Freshwater bed, West Runton.

Pliocene: Castell Arquato, near Piacenza. Common in the Pleistocene and Holocene deposits of Great Britain.

Pleistocene: Roumania. Pleistocene and Holocene of other parts of the Continent, including Denmark and Sweden (Nordmann).

Remarks.—This very common British species was known to Wood only from the Icenian Crag of Bramerton and Southwold. Mr. A. Bell has since found it at Butley and Hollesley, and Messrs. Kennard and B. B. Woodward have reported it from Bulchamp.

Limnæa Woodi, Kennard and B. B. Woodward.

1848. *Limnæa truncatula*, var. β, S. V. Wood, Mon. Crag Moll., pt. i, p. 8, tab. 1, fig. 8*b*.
1911. *Limnæa Woodi*, Kennard and B. B. Woodward, Geol. Mag. [5], vol. viii, p. 402.

Specific Characters.—Shell small, ovato-conical, thin; spire elevated, little more than half the total length, turreted; apex rather acute; whorls $4\frac{1}{2}$, somewhat swollen; suture deep; aperture ovate, slightly contracted on the inner side; umbilicus nearly closed; body-whorl striated parallel with the aperture. (K. and B. B. W.).

Dimensions.—L. 6 mm. B. 4 mm.

Distribution.—Not known living.

Fossil: Butleyan Crag: Butley. Icenian: Bramerton.

Remarks.—This is another of the Crag Limnæas referred by Wood to *L. truncatula* that Messrs. Kennard and B. B. Woodward consider worthy of specific rank. They distinguish it from *L. butleyensis* by its much smaller size, shorter spire, and relatively larger body-whorl. They know of only one specimen, from Butley, which they can identify with that given by Wood in 1848; they do not admit that *L. truncatula* has been reported from the Crag.

Limnæa auricularia (Linné), var. **acuta,** Jeffreys.

1758. *Helix auricularia*, Linné, Syst. Nat., ed. x, p. 774, no. 617.
1833. *Limnæus acutus*, Jeffreys, Trans. Linn. Soc., vol. xvi, p. 373.
1853. *Limnæus auricularius*, var. *acuta*, Forbes and Hanley, Brit. Moll., vol. iv, p. 171, pl. cxxiii, fig. 2.
1862. *Limnæa auricularia*, var. *acuta*, Jeffreys, Brit. Conch , vol. i, p. 109.
1879. *Limnæa auricularia*, var. *acuta*, S. V. Wood, Mon. Crag Moll., 2nd Suppl., p. 36, tab. iv, fig. *3a*.
1899. *Limnæa auricularia*, var. *acuta*, Kennard and B. B. Woodward, Proc. Malac. Soc., vol. iii, p. 195.

Varietal Characters.—Shell smaller than the typical form and more oblong, the body whorl and mouth being narrower in proportion.

Dimensions.—L. 15 mm. B. 10 mm.

Distribution.—*Recent:* widely distributed in Great Britain and Ireland; recorded also from France, Holland, and elsewhere (J. W. Taylor).

Fossil: Icenian Crag: Bramerton.

Middle Pleistocene: near Potsdam.

Remarks.—The typical form of *L. auricularia* is a widely diffused species both as a Recent shell and in our Pleistocene and Holocene deposits; it has not been reported, however, from the English Crag or the Cromer beds. The var. *acuta*, that figured by Wood, is represented in our Pliocene deposits by a single specimen from Bramerton, now in the Norwich Museum.

Genus **PLANORBIS,** Guettard, 1756.

Planorbis corneus (Linné).

1767. *Helix cornea*, Linné, Syst. Nat., ed. xii, p. 1243, no. 671.
1848. *Planorbis corneus*, S. V. Wood, Mon. Crag Moll., pt. i, p. 10, tab. 1, fig. 12.
1853. *Planorbis corneus*, Forbes and Hanley, Brit. Moll., vol. iv, p. 147, pl. cxxvi, figs. 4, 5.
1862. *Planorbis corneus*, Jeffreys, Brit. Conch., vol. i, p. 93, pl. vi, fig. 3.
1890. *Planorbis corneus*, C. Reid, Plioc. Dep. Brit., p. 229.
1897–1901. *Planorbis corneus*, Kennard and B. B. Woodward, Essex Nat., vol. x, p. 108, 1897; Proc. Malac. Soc., vol. iii, p. 196, 1899; Proc. Geol. Assoc., vol. xvii, p. 260, 1901.

Specific Characters.—See Mon. Crag Moll., pt. i, p. 10.

Dimensions.—Diam. 9 mm. H. 4·5 mm.

Distribution.—*Recent:* local in many parts of England; confined to a small area in Ireland; on the Euro-Asiatic continent from Siberia to Corsica (Jeffreys); Algeria, Morocco.

Fossil: Icenian Crag:—*Norwich zone:* Southwold, Bulchamp. *Weybourne zone:* East Runton, North Walsham boring. Pleistocene of England: Barnwell gravels, Holderness and other localities. Holocene: Great Britain.

Lower Pleistocene: Mosbach. Pleistocene: Denmark. Newer Holocene: Denmark and Sweden (Nordmann).

Remarks.—This species was known to Wood only from Bulchamp. Messrs. Kennard and B. B. Woodward report a single and immature specimen from Southwold, now in the British Museum (Natural History). They also give it from the Holocene and Pleistocene deposits of a number of localities in the south of England. The shell Mr. C. Reid reports from the Weybourne Crag and the West Runton Freshwater bed as *P. corneus* was regarded by Prof. Sandberger as a different species which he described as *P. clathratus*.

Planorbis spirorbis, Müller.

1774. *Planorbis spirorbis*, Müller, Verm. terr. fluv. Hist., pt. ii, p. 161, no. 347.
1848. *Planorbis spirorbis*, S. V. Wood, Mon. Crag Moll., pt. i, p. 9, tab. 1, fig. 11.
1853. *Planorbis spirorbis*, Forbes and Hanley, Brit. Moll., vol. iv, p. 159, pl. cxxvii, figs. 9, 10.
1862. *Planorbis spirorbis*, Jeffreys, Brit. Conch., vol. i, p. 87, pl. v, fig. 6.
1890. *Planorbis spirorbis*, C. Reid, Plioc. Dep. Brit., p. 229.
1897–1901. *Planorbis spirorbis*, Kennard and B. B. Woodward, Essex Nat., vol. x, pp. 93 *et seq.*, 1897; Proc. Malac. Soc., vol. iii, p. 197, 1899; Proc. Geol. Assoc., vol. xvii, pp. 217 *et seq.*, 1901.

Specific Characters.—See Mon. Crag Moll., pt. i, p. 9.

Dimensions.—Diam. 6 mm. H. 1 mm.

Distribution.—Recent: in all parts of Great Britain; abroad from Siberia and Iceland to Morocco, Algeria and Sicily.

Fossil: Butleyan Crag: Hollesley, Butley. Icenian—*Norwich zone:* Bramerton, Beccles, Yarn Hill, Bulchamp. *Weybourne zone:* North Walsham boring. Freshwater bed, West Runton. Pleistocene and Holocene deposits of England, including Woodston, the Barnwell gravels, lacustrine beds of Holderness, Selsey, etc.

Pleistocene: France: Menchecourt, Hers (Haute Garonne). Germany: Cannstadt, Weimar. Newer Holocene: Sweden and Denmark (Nordmann).

Remarks.—This species was known to Wood from Butley and Bulchamp. It has been found since at Hollesley and Yarn Hill, by Mr. Crowfoot at Beccles, by Mr. Jas. Reeve at Bramerton, and by Mr. C. Reid at West Runton. Messrs. Kennard and B. B. Woodward remark that it is a common Pleistocene fossil, its earliest record on the Continent being from the Middle Pleistocene of Cannstadt and Weimar.

Planorbis præcursor, Kennard and B. B. Woodward.

1848. *Planorbis complanatus*, S. V. Wood, Mon. Crag Moll., pt. i, p. 9, tab. 1, fig. 10.
1890. *Planorbis complanatus*, C. Reid, Plioc. Dep. Brit., p. 229.
1899. *Planorbis marginatus*, Kennard and B. B. Woodward, Proc. Malac. Soc., vol. iii, p. 197.
1911. *Planorbis præcursor*, Kennard and B. B. Woodward, Geol. Mag. [5], vol. viii, p. 402.

Specific Characters.—Shell sinistral, discoidal, smooth; spire depressed, nearly flat beneath; margin slightly carinated; aperture simple, lunate, sub-quadrate, oblique; outer lip thin; inner lip slightly spreading over the body whorl (K. and B. B. W.).

Dimensions.—Diam. 12 mm. H. 2 mm.

Distribution.—Not known living.

Fossil: Butleyan Crag, Hollesley, Butley. Icenian: Bramerton, Coltishall, Southwold, Bulchamp.

Remarks.—As a rule the multiplication of new species and the alteration of a well-established nomenclature are to be avoided, but it is sometimes desirable, especially in the case of shells whose disappearance may have antedated the appearance of the Recent species to which they have been affiliated.

I adopt, therefore, the view taken by Messrs. Kennard and B. B. Woodward that this and several other Crag mollusca dealt with above, though allied to the Recent forms to which they have been hitherto referred, should be separated from them.

For the Crag shell described as *P. complanatus*, Linn. (S. V. Wood), and *P. marginatus*, Drap. (K. and B. B. W.), they now propose the name *P. præcursor*, remarking that though it bears a superficial resemblance to the Recent species generally known as *P. umbilicatus*, Müll., it may be distinguished from it; it is smaller, the rate of increase in the whorls is less, the carination is not so prominent, and it is perfectly smooth, lacking the characteristic striæ of the latter species. The shell figured by Wood is not more than two-thirds the size of the one now described.

Genus **PALUDESTRINA**, D'Orbigny, 1841.

Paludestrina Reevei, Kennard and B. B. Woodward.

1879. *Hydrobia obtusa*, S. V. Wood, Mon. Crag Moll., 2nd Suppl., p. 30, pl. iv, fig. 7.
1899. *Paludestrina Reevei*, Kennard and B. B. Woodward, Proc. Malac. Soc., vol. iii, p. 198, fig. 2.

Specific Characters.—Shell minute, ovato-conical; apex obtuse; base obliquely rimate; whorls 4, smooth, rather convex, the last but slightly inflated, about two-thirds the total length; mouth oval, oblique, acutely angulate above; peristome simple, continuous; columella nearly straight, slightly reflected.

Dimensions.—L. 2 mm. B. 1 mm.

Distribution.—Not known living.

Fossil: Icenian Crag: Blake's Pit, Bramerton.

Remarks.—Of this minute shell, only known at present from one locality, there are about a dozen specimens at the British Museum (Nat. Hist.) and Norwich Museum, which were found some years ago by Mr. Jas. Reeve at Bramerton.

They were originally identified by Wood, though apparently with some doubt, with an Oligocene and Lower Miocene species, *Bithynia obtusa* of Prof. Sandberger, to which they bear a close resemblance. Messrs. Kennard and B. B. Woodward, however, comparing them with some specimens from Germany, have come to the conclusion that they are distinct. They state their reasons for this, giving enlarged representations of the foreign and British shells in the paper above-named, to which reference should be made.

Genus **LITHOGLYPHUS**, Megerle von Mühlfeldt, 1818.

Lithoglyphus fuscus (Pfeiffer). Plate I, fig. 16.

1828. *Paludina fusca* (Ziegler MS.), Pfeiffer, Naturgesch. Deutsch. Land Süssw. Moll., pt. iii, pl. viii, fig. 5.
1851. *Lithoglyphus fuscus*, S. P. Woodward, Man. Moll., p. 138, pl. ix, fig. 22.
1885. *Lithoglyphus fuscus*, Westerlund, Faun. Palæarct. Reg., pt. ii, p. 87.
1890. *Lithoglyphus fuscus*, C. Reid, Plioc. Dep. Brit., pp. 184, 186, 220, 229, pl. v, fig. 9.

Specific Characters.—Shell small, naticoid; whorls few, smooth, the last ventricose; spire exceedingly short; mouth entire, large in proportion to the size of the shell, oval, angulate above; outer lip thin; inner lip callous; umbilical slit rimate.

Dimensions.—L. 5 mm. B. 5 mm.

Distribution.—*Recent:* River Danube.

Fossil: Icenian Crag—*Weybourne zone:* East Runton, North Walsham boring.

Pleistocene deposits near Berlin.

Remarks.—For the discovery of this interesting shell in the Weybourne Crag we are indebted to Mr. C. Reid. At present it is only known in a living state from the Danube. Its occurrence in the newest zone of the English Crag, the marine fauna of which is of a boreal character, seems at first sight anomalous, but we may remember it was associated at a later period with *Corbicula fluminalis*, a species now generally characteristic of warmer climates than our own, but exceedingly abundant in England during the Pleistocene epoch. The winters in the Danubian region, however, are at present often severe; these molluscs were probably able to adapt themselves, as now, to different conditions. Their disappearance from western Europe may have been due to the competition of allied and stronger forms.

Clessin identifies *L. fuscus* with *L. naticoides*, an apparently different though allied species living in the Danube and found locally but plentifully in France (Ardennes); it is reported also from Belgium, Germany, Moravia and Galicia (J. W. Taylor).

L. fuscus appears to be fairly abundant in the Weybournian Crag at East Runton; it was met with also in the well-boring at North Walsham in deposits of similar age, together with *Tellina balthica* and other marine shells.

Genus **BITHYNIA**,[1] Gray, 1821.

Bithynia tentaculata (Linné).

1767. *Helix tentaculata*, Linné, Syst. Nat., ed. xii, p. 1249, no. 707.
1848. *Paludina tentaculata*, S. V. Wood, Mon. Crag Moll., pt. i, p. 111, tab. xii, fig. 2.
1853. *Bithinia tentaculata*, Forbes and Hanley, Brit. Moll., vol. iii, p. 14, pl. lxxi, figs. 5, 6.
1862. *Bythinia tentaculata*, Jeffreys, Brit. Conch., vol. i, p. 60, pl. iv, fig. 4.
1890. *Bythinia tentaculata*, C. Reid, Plioc. Dep. Brit., p. 228.
1897–1901. *Bythinia tentaculata*, Kennard and B. B. Woodward, Essex Nat., vol. x, pp. 93 *et seq.*, 1897; Proc. Malac. Soc., vol. iii, p. 199, 1899; Proc. Geol. Assoc., vol. xvii, pp. 217 *et seq.*, 1901.

[1] According to the Rev. G Frank Knight and Mr. B. B. Woodward, this generic name, first suggested by Leach, was derived from Bithynia in Asia Minor, and not from βυθιος, as stated by Jeffreys.

Specific Characters.—See Mon. Crag Moll., pt. i, p. 111.

Dimensions.—L. 12 mm. B. 6 mm.

Distribution.—Recent: everywhere in England and Ireland, but absent from western Wales and from Scotland north of the Firth of Forth; distributed more or less generally in Europe. Asia: Siberia, Manchuria, Asia Minor, Cashmere, Bengal, Singapore, North China. Africa: Algeria, Morocco (J. W. Taylor). Greenland (Frauenfeld).

Fossil: Icenian Crag: Bramerton, Southwold, Bulchamp; Freshwater-bed, West Runton. Pleistocene: Barnwell, Woodston, Holderness, Selsey and elsewhere. Holocene: Great Britain.

Lower Pliocene (Congeria Beds): Taman, Caucasus. Middle Pliocene: Hauterive, France (Kennard and B. B. Woodward). Pleistocene: France—Menchecourt, Joinville-le-Pont, near Paris. Germany—Potsdam (J. W. Taylor). Newer Holocene: Sweden and Denmark (Nordmann).

Remarks.—This common British species was known to Wood from Bramerton and Bulchamp. It has been since obtained in the Icenian beds at Southwold and in the freshwater deposits of West Runton. Although only found in the latest horizons of the English Crag it occurs on the Continent in beds of Lower Pliocene age. Messrs. Kennard and B. B. Woodward report it from many localities of the Holocene and Pleistocene deposits of southern England.

Mr. J. W. Taylor informs me it has been introduced into North America, and is gradually spreading.

Genus **VIVIPARA,** Lamarck, 1809.

Vivipara glacialis (S. V. Wood). Plate I, fig. 17.

1872. *Paludina glacialis*, S. V. Wood, Mon. Crag Moll., 1st Suppl., p. 68, pl. iv, fig. 14; pl. vii, fig. 25.
1880. *Paludina glacialis*, Sandberger, Palæontogr., vol. xxvii, p. 85.
1890. *Paludina glacialis*, C. Reid, Plioc. Dep. Brit., p. 229, pl. v, fig. 6.
1899. *Vivipara glacialis*, Kennard and B. B. Woodward, Proc. Malac. Soc., vol. iii, p. 199.

Specific Characters.—Shell strong, conical, elongate; whorls 5, flat, regularly tapering to a very blunt point, the last excavated below, rather more than half the total length; suture distinct, channelled; mouth oval, acute-angled above; peristome continuous; umbilicus closed.

Dimensions.—L. 20 mm. B. 10 mm.

Distribution.—Not known living.

Fossil: Icenian Crag—*Norwich zone:* Coltishall (Norton). *Weybourne zone:* East Runton, Belaugh, Rackheath; Freshwater-bed, West Runton. Middle Glacial Sands: Hopton Cliff (?).

Remarks.—The specimen here given is one of several I obtained at Belaugh from a deposit which Wood and I identified with the *Tellina balthica* Crag of Weybourne. I figure it as it has the apex perfect, a feature which is wanting in those represented in the first Supplement to the Crag Mollusca. Messrs. Kennard and B. B. Woodward, following the view we formerly held, write of the Belaugh deposit as Pleistocene. As before stated, however, I now regard it as belonging to an upper zone of the Norwich or Icenian Crag; the Weybourne Crag, morever, is clearly older than the so-called Forest-bed series, which is included by Mr. C. Reid and others with the Pliocene deposits.

I accept the late Henry Norton's statement that *V. glacialis* was found at Coltishall. He was the most scrupulously exact of observers, and anything he said may be relied on.

I agree with Messrs. Kennard and B. B. Woodward that there is some doubt as to the reference of the specimen I obtained from the Middle Glacial Sands of Hopton Cliff to this species, a view, indeed, held also by Wood.

It seems possible that the shell from the Norwich Crag figured by S. Woodward in 1833 as *Paludina obsoleta* is the same as the present species. In that case we should have to add Bramerton, Thorpe and Postwick to the localities at which the latter has been found. On the other hand, it does not appear that Mr. Reeve has ever met with it during his long researches at the first-named place.

Prof. Sandberger states that *V. glacialis* is allied to *V. pachya*, Bourguignat, from the Amur.

Vivipara media (S. Woodward).

1833. *Paludina media*, S. Woodward, Geol. Norf., p. 44, tab. iii, figs. 5, 6.
1848. *Paludina lenta*, var. β, S. V. Wood, Mon. Crag Moll., pt. i, p. 110, pl. xii, fig. 16.
1850. *Paludina parilis*, S. V. Wood, Mon. Crag Moll., pt. ii, p. 320.
1864. *Paludina media*, S. P. Woodward, in White's History of Norfolk, 3rd ed., p. 118.
1871. *Paludina lenta*, Jeffreys, Quart. Journ. Geol. Soc., vol. xxvii, p. 492.
1872. *Paludina media*, S. V. Wood, Mon. Crag Moll., 1st Suppl., p. 69.
1890. *Paludina media*, C. Reid, Plioc. Dep. Brit., p. 229.
1899. *Vivipara media*, Kennard and B B. Woodward, Proc. Malac. Soc., vol. iii, p. 200.

Specific Characters.—See Mon. Crag Moll., pt. i, p. 110.

Dimensions.—L. 20—25 mm. B. 12—19 mm.

Distribution.—Not known living.

Fossil: Newbournian Crag: Waldringfield (A. Bell). Icenian—*Norwich zone:* Bramerton, Postwick, Thorpe near Norwich, Horstead, Yarn Hill, Wangford, Dunwich, Sizewell, Easton Bavent, Southwold, Bulchamp, Thorpe near Aldeburgh. *Weybourne zone:* Rackheath; Freshwater bed, West Runton (C. Reid).

Remarks.—This form has been reported from time to time under various names. At first Wood referred it to an Eocene species, *Helix lenta*, Brander, a view adopted by Jeffreys in 1871. Dr. S. P. Woodward identified it, however, with some shells from Bramerton described by his father in 1833, adopting the name of one of them, *P. media*, and in this he has been generally followed, as by Wood in 1872, and more recently by Messrs. Kennard and B. B. Woodward.

Some of the specimens of *Vivipara* from the Crag were believed by Wood to be specifically distinct from *V. media*, for example the one figured in his first Supplement (tab. i, fig. 5) as *Paludina vivipara*. This, however, is regarded by Messrs. Kennard and B. B. Woodward as an immature example of *V. media*. The latter species is believed by Prof. Sandberger to be related to *V. laeta*, Martens, from Japan.

Wood, admitting the resemblance of some of the Crag *Paludinæ* to the Eocene *P. lenta*, suggests that they may have descended from the latter species.

Genus **VALVATA**, Müller, 1774.

Valvata cristata, Müller.

1774. *Valvata cristata*, Müller, Verm. terr. fluv. Hist., pt. ii, p. 198, no. 384.
1853. *Valvata cristata*, Forbes and Hanley, Brit. Moll., vol. iii, p. 21, pl. lxxi, figs. 11—13.
1862. *Valvata cristata*, Jeffreys, Brit. Conch., vol. i, p. 74, pl. iv, fig. 9.
1879. *Valvata cristata*, S. V. Wood, Mon. Crag Moll., 2nd Suppl., p. 36, tab. iv, fig. 8.
1890. *Valvata cristata*, C. Reid, Plioc. Dep. Brit., p. 229.
1897–1901. *Valvata cristata*, Kennard and B. B. Woodward, Essex Nat., vol. x, p. 93 *et seq.*, 1897; Proc. Malac. Soc., vol. iii, p. 201, 1899; Proc. Geol. Assoc., vol. xvii, pp. 226 *et seq.*, 1901.

Specific Characters.—Shell rather solid, forming a flat coil, concave beneath, closely and regularly striated transversely; whorls 5, the last very much the largest; spire flat or slightly concave; mouth circular; outer lip thin and somewhat reflected; inner lip separate from the columella and continuous with the outer lip; umbilicus large and open, exposing the spire.

Dimensions.—L. 6 mm. B. 3 mm.

Distribution.—*Recent:* generally throughout the British Islands, and as far south as Corsica and Sicily; doubtfully recorded from Siberia and Morocco (J. W. Taylor).

Fossil: Icenian Crag: Bramerton; Freshwater bed, West Runton. Pleistocene: Barnwell, Barrington, Grantchester, Woodston, the Fenland and elsewhere in England. Many localities in British Holocene deposits.

Pliocene: Monte Mario (Rigacci). Pleistocene: Mosbach; Denmark; Menchecourt and Joinville-le-Pont in France. Holocene: Denmark and Sweden (Nordmann).

Remarks.—This species was known to Wood from Bramerton only; no other Crag localities have been reported since the publication of his second Supplement.

Valvata piscinalis (Müller).

1774. *Nerita piscinalis*, Müller, Verm. terr. fluv. Hist., pt. ii, p. 172, no. 358.
1848. *Valvata piscinalis*, S. V. Wood, Mon. Crag Moll., pt. i, p. 112, tab. xii, fig. 3.
1853. *Valvata piscinalis*, Forbes and Hanley, Brit. Moll., vol. iii, p. 19, pl. lxxi, figs. 9, 10
1862. *Valvata piscinalis*, Jeffreys, Brit. Conch., vol. i, p. 72, pl. iv, fig. 8.
1890. *Valvata piscinalis*, C. Reid, Plioc. Dep. Brit., p. 230.
1897–1901. *Valvata piscinalis*, Kennard and B. B. Woodward, Essex Nat., vol. x, p. 108, 1897; Proc Malac. Soc., vol. iii, p. 201, 1899; Proc. Geol. Assoc., vol. xvii, pp. 217 *et seq.*, 1901.

Specific Characters.—See Mon. Crag Moll., pt. i, p. 112.

Dimensions.—L. 7 mm. B. 6. mm.

Distribution.—*Recent:* throughout the British Isles; abroad from Siberia to Naples; Transcaucasia, Turkestan, Cashmere, Thibet.

Fossil: Icenian Crag: Bramerton, Yarn Hill. Freshwater-beds: West Runton, Mundesley. Pleistocene and Holocene of Great Britain, widely distributed.

Pleistocene: Menchecourt, Joinville-le-Pont; Denmark. Holocene: Denmark and Sweden (Nordmann).

Remarks.—Bramerton was the only locality in the English Crag known to Wood at which this species had been found. Mr. A. Bell informs me he has since seen a specimen from Yarn Hill. The variety *antiqua* occurs in the Pleistocene beds at Grays (Morris), and Mr. Reid reports both the typical and depressed form from the Forest-bed series.

PELECYPODA.

Genus **CORBICULA,** Megerle von Mühlfeldt, 1811.

Corbicula fluminalis (Müller).

1774. *Tellina fluminalis*, Müller, Verm. terr. fluv. Hist., vol. ii, p. 205, no. 390.
1834. *Cyrena trigonula*, S. V. Wood, Mag. Nat. Hist., vol. vii, p. 275, fig. 45.
1836–44. *Cyrena Gemmellarii*, Philippi, En. Moll. Sic., vol. i, p. 39, pl. iv, fig. 3, 1836; vol. ii, p. 31, 1844.
1838. *Cyrena Duchastellii*, Nyst, Bull. Acad. Roy. Sci. Belg., vol. v, p. 114, pl. i, figs. 1–4.
1850. *Cyrena consobrina*, S. V. Wood, Mon. Crag Moll., pt. ii, p. 104, tab. xi, fig. 15.
1872. *Corbicula fluminalis*, S. V. Wood, Mon. Crag Moll., 1st Suppl., p. 119.

1884. *Corbicula fluminalis*, Dollfus, Mém. Soc. Malac. Belg., vol. xix, p. 48, pl. i, figs. 1–27, pl. ii, figs. 1–27.

1890. *Corbicula fluminalis*, C. Reid, Plioc. Dep. Brit., p. 230, pl. v, fig. 12.

1896. *Corbicula fluminalis*, Stefanescu, Mém. Soc. Géol. France, vol. vi, p. 79, pl. vii, figs. 35–39.

1897–1901. *Corbicula fluminalis*, Kennard and B. B. Woodward, Essex Nat., vol. x, pp. 96 *et seq.*, 1897; Proc. Malac. Soc., vol. iii, p. 201, 1899; Proc. Geol. Assoc., vol. xvii, pp. 238 *et seq.*, fig. 37 (p. 252), 1901.

1900–10. *Corbicula fluminalis*, Rutot, Bull. Soc. Belg. Géol., vol. xiv (Mémoires), p. 1, 1900; Bull. Acad. Roy. Sci. Belg., 1910, p. 164.

Specific Characters.—See Mon. Crag Moll., pt. ii, p. 104.

Dimensions.—L. 20 mm. B. 20 mm.

Distribution.—*Recent:* the Nile, Suez Canal, Algeria (Dollfus), Asia Minor, Euphrates (Niebuhr), Lebanon (Bellardi), Georgia and Persia (Eichwald), Kashmir, Turkestan; South Africa, Vaal River (A. Bell).

Fossil: Newbournian Crag: Waldringfield (A. Bell). Icenian—*Norwich zone:* Bramerton, Postwick, Aldeby, Yarn Hill, Wangford, Dunwich, Bulchamp, Thorpe near Aldeburgh. *Weybourne zone:* Belaugh, East Runton, North Walsham boring. Pleistocene: March, Chatteris (F.W.H.), Barnwell, Kelsey Hill, Croxton, Paul Cliff near Hull, Stutton, Clacton, Ilford, Grays, Crayford, Erith, Stoke Newington, Dartford (Spurrell), Swanscombe, Wear Farm, Sturry (Kent), West Wittering, Selsey, Cropthorne.

Pleistocene: France—Menchecourt near Abbeville (Somme), Cergy (Seine et Oise), Vitry-le-Francais (Marne), Bligny near Dijon, Côte d'Or. Germany—Bromberg, Teutschenthall near Halle (Saxony). Italy—Valley of the Tiber near Rome (with hippopotamus). Sicily—Cefali, near Catania. Belgium—Ostend, Blankenberghe, Hopstade near Malines. Roumania. South Russia—Omsk with *Elephas primigenius* (Dollfus). Algeria—near Oran. It has also been dredged from the North Sea, and speaking generally has a wide distribution in Pleistocene deposits, associated with *Belgrandia marginata* and remains of the hippopotamus.

Remarks.—Examples of this species, not known to be living nearer than Algeria and the Nile, have been met with in the Red Crag of Waldringfield; at the Norwich horizon of the Icenian deposits it occurs rather generally, but is always rare. Many years ago I found a specimen in the *Tellina balthica* Crag of Belaugh, near Wroxham, at a section now closed, as, alas, are all the inland exposures of that zone. It has been recorded also from the freshwater deposits of the so-called Forest-bed. In the English Pleistocene it is found in many places, and sometimes in great abundance. Prestwich states, for example, that at Kelsey Hill "it occurs literally in thousands,"[1] and Wood makes a somewhat similar remark as to Stutton and Ilford; at Barnwell, near Cambridge, it is abundant.

It occurs with *Elephas antiquus* in France and Belgium in deposits which M. Rutot and some other Belgian geologists regard as Moseen, the oldest member of

[1] Quart. Journ. Geol. Soc., vol. xvii, p. 452, 1861.

their Pleistocene series, possibly older than the great ice-sheets of the East of England.[1]

Prof. Boyd Dawkins similarly considers that the deposits of Crayford, Erith, and Grays Thurrock in the Thames valley in which this species occurs, are older than the ice-sheets, a view which M. Rutot accepts as far as Erith is concerned. Prof. Dawkins states that *E. primigenius* is more abundant at Erith and Crayford, *E. antiquus* being comparatively rare, while at Grays Thurrock *E. antiquus* is the most common.[2]

Referring to Kelsey Hill it is clear that the *Corbicula* beds of that locality represent the stage in the Pleistocene epoch in which the greater ice-sheets were disappearing; they have been shown to rest on the basement boulder-clay of Holderness, but they are overlain by a later glacial deposit, the Hessle-clay of S. V. Wood, Jun.

Corbicula fluminalis occurs in the marine gravels of Chatteris and March, to the north of Cambridge, at which places I found, many years ago, a number of specimens together with a molluscan fauna of a Recent but somewhat boreal character, containing a few northern species like *Astarte borealis*, *Tellina calcarea* and *Bela pyramidalis.* These gravels rest on the chalky boulder-clay, and are, therefore, like those of Kelsey Hill, later Pleistocene. Lyell also found *C. fluminalis* in association with marine shells (probably estuarine) at Menchecourt, near Abbeville.[3]

Such facts indicate that the mollusc in question, which had established itself in northern Europe even in Pliocene times, was able to endure the rigorous climate of the Ice Age, flourishing vigorously in Great Britain when such conditions were passing away. Its subsequent extinction over such an extended area is not easily explained, but it points, I think, to a considerable antiquity for deposits of Pleistocene age like the March gravels, lending no support to the view that in the Eastern Hemisphere at least, the period separating the Great Ice Age from our own was otherwise than prolonged.

Mr. Kennard seems inclined to consider that the English *Corbicula* differs from the typical *C. fluminalis*, but M. Dollfus, who has made a special study of the subject, says that although this species is undoubtedly variable, he cannot find any material difference between the Recent and the fossil forms; similar varieties occur in each. In the paper above referred to, the latter writer figures twenty-seven specimens from the Pleistocene beds of Belgium, France and England. Comparing

[1] M. Rutot considers that the presence of *Elephas antiquus* on the one hand, and of *E. primigenius* on the other, represent distinct stages in the Pleistocene period, the first of course being the older. This view, however, is not accepted by Prof. Boyd Dawkins. In England, at least, both forms occur together in places; they may possibly overlap in this country, one having a northern, the other a southern range.

[2] Quart. Journ. Geol. Soc., vol. xxiii, p. 102, 1867.

[3] Antiquity of Man, ed. 1, p. 124, 1863.

them with those in my own collection from Grays, and from the Fen gravels, they seem closely to correspond. The Recent shell originally figured by Chemnitz measured, however, 30 mm. in length; mine from Grays are only 20 mm., while those from March are seldom more than 15 mm.

Genus **SPHÆRIUM,** Scopoli, 1777.

Sphærium corneum (Linné).

1758. *Tellina cornea*, Linné, Syst. Nat., ed. x, p. 678, no. 57.
1850. *Cyclas cornea*, S. V. Wood, Mon. Crag Moll., pt. ii, p. 107, tab. xi, fig. 2.
1853. *Cyclas cornea*, Forbes and Hanley, Brit. Moll., vol. ii, p. 113, pl. xxxvii, figs. 3—6.
1862. *Sphærium corneum*, Jeffreys, Brit. Conch., vol. i, p. 5, pl. i, fig. 1.
1890. *Sphærium corneum*, C. Reid, Plioc. Dep. Brit., p. 230.
1897–1901. *Sphærium corneum*, Kennard and B. B. Woodward, Essex Nat., vol. x, pp. 98 *et seq.*, 1897; Proc. Malac. Soc., vol. iii, p. 202, 1899; Proc. Geol. Assoc., vol. xvii, pp. 223 *et seq.*, 1901.

Specific Characters.—See Mon. Crag Moll., pt. ii, p. 107.

Dimensions.—L. 9 mm. B. 11 mm.

Distribution.—*Recent:* widely diffused in Great Britain; abroad from Lapland and Siberia to Sicily.

Fossil: Icenian Crag: Bramerton, Thorpe (Norfolk), Bulchamp, Easton Bavent, Southwold. Freshwater beds: Mundesley, West Runton. Many localities in the Pleistocene and Holocene beds of the British Isles.

Pleistocene: Mosbach; Potsdam; Somme valley. Holocene: Sweden and Norway (Nordmann).

Remarks.—This species was known to Wood from the Icenian Crag only, being comparatively rare at that horizon. It is more or less common, however, in the Pleistocene and Holocene deposits of this country and abroad, and is said to be specially abundant in those of the Somme basin.

Genus **PISIDIUM,** Pfeiffer, 1821.

Pisidium amnicum (Müller). Plate I, fig. 21.

1774. *Tellina amnica*, Müller, Verm. terr. fluv. Hist., pt. ii, p. 205, no. 389.
1850. *Pisidium amnicum*, S. V. Wood, Mon. Crag Moll., pt. ii, p. 109, tab. xi, fig. 1.
1853. *Pisidium amnicum*, Forbes and Hanley, Brit. Moll., vol. ii, p. 133, pl. xxxvii, figs. 8, 9.
1853. *Pisidium obliquum*, Harting, Verh. Comm. Geol. Kartt. Ned., p. 117.
1862. *Pisidium amnicum*, Jeffreys, Brit. Conch., vol. i, p. 20, pl. i, fig. 5.
1885. *Pisidium amnicum*, Lorié, Arch. Mus. Teyler [2], vol. ii, p. 163.
1890. *Pisidium amnicum*, C. Reid, Plioc. Dep. Brit., p. 230.
1896. *Pisidium amnicum*, Stefanescu, Mém. Soc. Géol. France, vol. vi, p. 81, pl. vii, figs. 40—55.

1897–1901. *Pisidium amnicum*, Kennard and B. B. Woodward, Essex Nat., vol. x, pp. 95 *et seq.*, 1897; Proc. Malac. Soc., vol. iii, p. 202, 1899; Proc. Geol. Assoc., vol. xvii, pp. 217 *et seq.*, 1901.
1913. *Pisidium amnicum*, B. B. Woodward, Cat. Brit. Sp. *Pisidium*, p. 16, pl. i, fig. 1; pl. iii, fig. 1; pls. v—ix.

Specific Characters.—See Mon. Crag Moll., pt. ii, p. 109.

Dimensions.—L. 9 mm. B. 12 mm.

Distribution.—*Recent:* almost everywhere in England in slow rivers, canals and lakes; partially distributed in Wales and Ireland, scarce in Scotland, where it has not been recorded to the north of Aberdeen; abroad from Siberia to Naples and Algeria.

Fossil: Icenian Crag—*Norwich zone:* Bramerton, Thorpe near Norwich, Beccles, Southwold, Bulchamp. *Weybourne zone:* East Runton, North Walsham boring. Freshwater bed: West Runton. Pleistocene beds of England: Barnwell, Woodston, Grays, Cropthorne, Clacton, Stutton, Selsey (A. Bell), and elsewhere. Many localities in the English Holocene.[1]

Upper Pliocene: Bligny, near Dijon.

Pleistocene: Holland—Gorkum; Switzerland—Zurich; France—Menchecourt; Denmark;[2] Roumania. Holocene: Sweden and Denmark (Nordmann).

Remarks.—Southwold was the only Crag locality known to Wood for this common British species, but it has been found since at a number of places at the same horizon. It is abundant in the freshwater bed at West Runton, and occurs in many of the Holocene and Pleistocene deposits of Great Britain. The specimens figured by Wood were from Stutton and Grays; the one now given is from the Norwich Crag.

Pisidium astartoides, Sandberger. Plate I, fig. 23.

1840. *Cyclas (Pisidium) amnica*, var.?, Lyell, Phil. Mag. [3], vol. xvi, p. 364, fig. 11.
1850. *Pisidium amnicum*, var. *sulcatum*, S. V. Wood, Mon. Crag Moll., pt. ii, p. 110, tab. xi, fig. 1 b.
1864. *Pisidium amnicum*, var. *sulcata*, S. P. Woodward in White's History of Norfolk, 3rd. ed., p. 120.
1882. *Pisidium (Fluminina) astartoides*, Sandberger, Palæontogr., vol. xxvii, p. 96, pl. xii, fig. 1.
1890. *Pisidium astartoides*, C. Reid, Plioc. Dep. Brit., p. 230, pl. v, fig. 11.
1897–1901. *Pisidium astartoides*, Kennard and B. B. Woodward, Essex Nat., vol. x, pp. 103 *et seq.*, fig. 5, 1897; Proc. Geol. Assoc., vol. xvii, p. 253, fig. 37, no. 5, 1901.
1913. *Pisidium astartoides*, B. B. Woodward, Cat. Brit. Sp. *Pisidium*, p. 27, pl. i, fig. 2; pl. iii, fig. 2; pl. v, fig. 10; pls. x–xii.

Specific Characters.—Shell smaller than *P. amnicum*, inequilateral, subcordiform, ventricose, somewhat solid, ornamented by strong and rather distant concentric

[1] For complete lists of the occurrence of the different *Pisidia* here described in the Pleistocene and Holocene deposits of Great Britain and Ireland, see Mr. B. B. Woodward's recent British Museum Catalogue of the British Species of *Pisidium*.

[2] Dr. Nordmann reports the present species from the Danish Pleistocene. Medd. Dansk geol. Forening, no. 8, p. 27, figs. 2, 3, 1901.

ribs, narrower than the intervening spaces, with exceedingly fine striæ between them; umbo wide, depressed, subcentral; ligamental fossulæ short, fairly deep; teeth, both cardinal and lateral, strong and prominent, differing somewhat from those of *P. amnicum*.[1]

Dimensions.—L. 7 mm. B. 9 mm.

Distribution.—Not known living.

Fossil: Icenian Crag: Bramerton, Thorpe, Bulchamp. Fresh-water bed: Corton, Kessingland, West Runton (not rare). English Pleistocene: Erith, Clapton, Hackney, Clacton, Grays, Crayford, Ilford and Swanscombe. Pleistocene: Denmark.

Remarks.—The charming little shell here figured, from a specimen in the Reeve collection at the Norwich Castle Museum, is from the Icenian Crag of Bramerton; it seems to have been known to S. V. Wood from Grays as a short, striated variety of *P. amnicum*, and to Dr. S. P. Woodward from Thorpe and Bulchamp under Sowerby's name of *P. amnicum*, var. *sulcata;* Mr. A. Bell informs me he found a specimen of it himself at Bramerton.

It is regarded by Prof. Sandberger, Messrs. Kennard and B. B. Woodward, and by Mr. C. Reid as a species distinct from the Recent form *P. amnicum*. It is not rare at West Runton, where it is found in company with that shell and some other species of the same genus. It is smaller, however, and less inequilateral, with a rounder outline, the concentric ribs are fewer in number and more distinctly marked, especially at the umbones.

Prof. Sandberger remarks that *P. astartoides* seems to correspond both in form and sculpture with Bronn's description of *P. concentricum* from the Upper Pliocene of Italy, but that as he had no specimens of the latter he had not been able to compare the two.

Pisidium casertanum (Poli). Plate I, fig. 19.

1791. *Cardium casertanum*, Poli, Test. Utr. Sic., vol. i, p. 65, pl. xvi, fig. 1.
1868. *Pisidium casertanum*, Lallement, Ann. Soc. Mal. Belg., vol. iii (Mémoires), p. 59.
1890. *Pisidium casertanum*, C. Reid, Plioc. Dep. Brit., p. 230.
1899. *Pisidium pusillum* (Gmel.), Kennard and B. B. Woodward, Proc. Malac. Soc., vol. iii, p. 202.
1912. *Pisidium casertanum*, Kennard and B. B. Woodward, Quart. Journ. Geol. Soc., vol. lxviii, p. 234.
1913. *Pisidium casertanum*, B. B. Woodward, Cat. Brit. Sp. *Pisidium*, p. 31, pl. i, figs. 3—6; pl. iii, fig. 3; pls. xiii—xviii.

Specific Characters.—Shell minute, fragile, rounded, ovate, rather convex; ornamented by excessively fine, irregular and inconspicuous concentric striæ (B. B. W.).

[1] The difference is well shown by Mr. B. B. Woodward in an enlarged drawing of the hinge (*op. cit.*), pl. ii, fig. 2.

Dimensions.—L. 2 mm. B. 2 mm.

Distribution.—Recent: irregularly distributed over the British Isles and the Continent of Europe; Siberia; Algiers (Lallement).

Fossil: Icenian Crag: Bramerton. Freshwater bed: West Runton (C. Reid). Common in all the British Holocene and Pleistocene deposits; it occurs also in post-Tertiary beds on the Continent.

Remarks.—The shell here figured was found by Mr. Jas. Reeve some years ago in the Norwich Crag at Bramerton, from which place there are many specimens in the Norwich Castle Museum. Both this and the following have been identified by Messrs. Kennard and B. B. Woodward, who have also recently reported this species from some beds of late Pleistocene age in the Lea Valley at Ponders End, and at Edmonton near the Angel Road Station, where it was discovered by Mr. S. Hazzledine Warren together with remains of the reindeer, a species of lemming, and the northern willow, *Salix herbacea.*

Pisidium supinum, A. Schmidt. Plate I, fig. 20.

1850. *Pisidium supinum*, A. Schmidt, Zeitschr. f. Malak., vol. vii, p. 119.
1864. *Pisidium Henslowianum*, var. *supinum*, Mörch, Syn. Moll. Daniæ, p. 72.
1871–2. *Pisidium supinum*, Clessin, Mal. Blatt., vol. xviii, p. 197, 1871; vol. xix, pl. i, fig. 3, 1872.
1873. *Pisidium supinum*, Westerlund, Faun. Moll. Suec., p. 533.
1875. *Pisidium* (*Rivulina*) *supinum*, Sandberger, Land Sussw Conch. Vorw., p. 765.
1879. *Pisidium supinum*, Clessin, Martini and Chemnitz, Conch. Cab. (Cycladiæ), p. 11, pl. i, figs. 5—7.
1899. *Pisidium fontinale*, Kennard and B. B. Woodward, Proc. Malac. Soc., vol. iii, p. 202.
1912. *Pisidium supinum*, Kennard and B. B. Woodward, Quart. Journ. Geol. Soc., vol. lxviii, p. 240, pl. xvii, fig. 9.
1913. *Pisidium supinum*, B. B. Woodward, Cat. Brit. Sp. *Pisidium*, p. 100, pl. ii, fig. 5; pl. iv, fig. 7; pls. xxv, xxvi; pl. xvii, figs. 1, 2.

Specific Characters.—Shell small, comparatively thick and strong, ventricose, inequilateral, sub-trigonal; umbones rather sharp, sometimes surmounted by a projecting plate as in *P. Henslowanum*; surface of valves ornamented with fine regular concentric striæ, very strong and massive (B. B. W.)

Dimensions.—L. 3·2 mm. B. 3 mm.

Distribution.—Recent: various parts of England from Cumberland to the Thames; abroad in France and Germany.

Fossil: Icenian Crag: Bramerton, Beccles. Freshwater bed: West Runton. Pleistocene: Thames valley, Grays; Lea Valley, Ponders End (arctic bed), Walthamstow; Barnwell, Stutton and elsewhere. Holocene: home counties from Gloucestershire to the east and south-east of England.

Lower Pleistocene: Mosbach (Sandberger).

Remarks.—For the discovery of this species at Bramerton, where it seems to be abundant, we are indebted to Mr. Jas. Reeve, from whose collection in the Norwich Castle Museum the specimen here figured is taken; it has been found since by Mr. W. M. Crowfoot at Beccles. Messrs. Kennard and B. B. Woodward report it from West Runton, but state it has not been detected in any Pliocene deposit on the Continent of Europe; they consider it cannot be distinguished from *P. suilla*, Dybowski, of Lake Baikal.

In their paper on the non-marine mollusca of the alluvium of the river Lea,[1] written in 1904, they remarked that "among nine species of *Pisidium*, the most noteworthy is *P. supinum*, hitherto undetected in these islands. The specimens were large, but not so fine as those found in the Pleistocene of Grays." They are of opinion that eventually it will be found to have been widely distributed in Pleistocene and Holocene times.

Pisidium Henslowanum (Sheppard). Plate I, fig. 22.

1825. *Tellina Henslowana* (Leach, MS.), Sheppard, Trans. Linn. Soc., vol. xiv, p. 150.
1831. *Cyclas appendiculata*, Turton, Man. Land Freshw. Shells, p. 15, fig. 6.
1833. *Pisidium Henslowianum*, Jenyns, Trans. Camb. Phil. Soc., vol. iv, p. 308, pl. xxi, figs. 6—9.
1840. *Pisidium Henslowianum*, Gray, Man. Land Freshw. Shells., p. 285, pl. i, fig. 6.
1844. *Pisidium Henslowianum*, Brown, Ill. Conch. Gt. Brit., ed. 2, p. 95, pl. xxxix, fig. 25.
1852. *Pera appendiculata*, Leach, Moll. Brit. Syn., p. 292.
1853. *Pisidium Henslowianum*, Forbes and Hanley, Brit. Moll., vol. ii, p. 131, pl. xxxvii, fig. 11.
1862. *Pisidium fontinale*, var. *Henslowana*, Jeffreys, Brit. Conch., vol. i, p. 21.
1875. *Pisidium* (*Fossarina*) *Henslowanum*, Sandberger, Land Sussw. Conch. Vorw., p. 763, pl. xxxiii, fig. 3.
1913. *Pisidium Henslowanum*, B. B. Woodward, Cat. Brit. Sp. *Pisidium*, p. 93, pl. ii, fig. 4; pl. iii, fig. 9; pl. xxiii, figs. 21—31; pl. xxiv; pl. xxv, fig. 13; pl. xxvi, fig. 13.

Specific Characters.—Shell small, thin, rather tumid, oblique, sub-ovate, very inequilateral, finely but irregularly striated concentrically; ventral margin rounded, dorsal straight and sloping; posterior side blunt, rounded below, subangulate above; anterior elongate, compressed; umbones prominent, acute, furnished with a small laminar projection which in the adult occupies the summit of the shell, appearing like a ridge rising up vertically on either side of the hinge; hinge strong; anterior laterals nearly half the length of the latter.

Dimensions.—L. 5 mm. B. 4 mm.

Distribution.—*Recent:* most widely diffused in Central England; very rare and local in Wales, Ireland and Scotland; on the continent from Siberia to Sicily.

Fossil: Coralline Crag: Sutton. Freshwater bed: West Runton. Widely diffused in the English Pleistocene, as at Grays, Ilford, Lea valley, Edmonton, Stutton, Clacton, Barnwell, Woodston, Cropthorne; found also at many places in the British Holocene deposits.

Pleistocene of Europe from Sweden to the south of France (Jeffreys).

[1] Essex Nat., vol. xiii, p. 20, fig. 3, 1904.

Remarks.—Mr. B. B. Woodward informs me that Mr. Chatwin, late of the Geological Department of the British Museum (Natural History), has drawn his attention to an immature specimen in their collection which proves to be the right valve of the present species. It was obtained from the Coralline Crag of Sutton by R. G. Bell and bears a label to that effect in his writing, being the only fresh-water shell known from that horizon; it has been found, however, in the Pleistocene deposit at Edmonton by Mr. S. H. Warren.

P. Henslowanum was regarded by Jeffreys as a variety of *P. fontinale*, by other authorities it is considered distinct. It seems to be specially characterised by the lamelliform *appendicula* referred to above.

As already stated, most of the non-marine mollusca described above have been obtained from the Norwich, or, as I prefer to call it, the Icenian division of the Crag. They are more common at certain localities in the neighbourhood of Norwich than at others, as at Bramerton for example, probably representing spots near which streams discharged into the Crag sea. The wide and apparently continuous area covered by these deposits, extending in one direction from Norwich to Aldeburgh in Suffolk and in another to Yarmouth and Lowestoft, suggest the existence of a wide sandy bay, with shores gradually retreating to the north and to the east, rather than that of an estuary. Non-marine mollusca occur also in the Butleyan stage of the Red Crag at Hollesley and in one pit at Butley in the special seam before referred to, as well as in that near Butley Abbey.

The land and fresh-water fossils from the Butleyan and Icenian Crag are generally those of living British shells having a wide geographical distribution. A few have been met with, however, which Messrs. Kennard and B. B. Woodward, unable to refer to any species known to them, have described as *Limnæa butleyensis*, *L. Woodi* and *L. Harmeri*. *Corbicula fluminalis*, moreover, is found generally, though not abundantly, in the Icenian deposits, and very rarely in the later zones of the Red Crag. The latter species occurs in the Pleistocene deposits both of this country and the continent, though at present it is not known from any locality nearer than the river Nile.

The few non-marine forms which have been collected from the earlier portions of the Crag, the Gedgravian and the Waltonian, are with one exception of a different character. From the Gedgravian we have *Pyramidula suttonensis*, not known living, of a Madeiran type, with another extinct shell, *Clausilia pliocena*. From Walton-on-Naze, *Pyramidula rysa* allied to a Madeiran shell, *Hygromia incarnata* non-British, *Helicodonta lens* inhabiting Morea and the Grecian Islands, and *Helix lactea* a southern species; from Oakley, *Pomatias Harmeri* an extinct form. Such facts, as far as they go, support the view of the separation of the Waltonian fauna from that of the later horizons of the Crag.

It may be interesting to notice that none of the non-marine Crag mollusca given above have an exclusively northern range, as well as to compare them with those of a Pleistocene deposit like that described lately by the Rev. C. E. V. Kendall at Woodston, near Peterborough, from which nine species now more or less confined to the sub-Arctic region have been obtained.[1]

Distribution of the Land and Freshwater Shells of the Crag.

—		Red Crag.			Icenian.					Recent.			
	Coralline Crag.	Waltonian.	Newbournian.	Butleyan.	Norwich horizon.	Weybourne horizon.	West Runton.	Pleistocene.	Holocene.	Northern.	British.	Southern.	Not known living.
TERRESTRIAL.													
Sphyradium edentulum (Draparnaud)	...	...	...	...	×	...	...	×	×	×	×	×	
Pyramidula rysa (S. V. Wood)	...	×	×	...	...	...	...	...	...	...	...	...	×
— *suttonensis* (S. V. Wood)	×	...	...	...	...	...	...	...	...	...	...	...	×
Eulota fruticum (Müller)	...	...	...	×	...	...	...	×	...	×	...	×	
Hygromia incarnata (Müller)	...	×	...	...	...	...	...	×	...	×	...	×	
— *hispida* (Linné)	...	...	...	×	×	×	×	×	×	×	×	×	
— *rubiginosa* (A. Schmidt)	...	...	...	...	×	...	...	...	...	×	...	×	
Vallonia pulchella (Müller)	...	...	...	×	×	...	×	×	×	×	×	×	
— *excentrica*, Sterki	...	...	...	...	×	...	...	×	×	×	×	×	
Helicodonta lens (Férussac)	...	×	...	...	...	...	...	...	...	...	...	×	
Helicigona arbustorum (Linné)	...	...	...	×	×	×	×	×	×	×	×	×	
Helix lactea, Müller	...	×	...	...	...	...	...	...	...	...	...	×	
— *nemoralis*, Linné	...	...	...	×	...	...	×	×	×	×	×	×	
— *hortensis*, Müller	...	...	...	×	...	...	...	×	×	×	×	×	
Cochlicopa lubrica (Müller)	...	...	...	×	...	...	×	×	×	×	×	×	
Jaminia muscorum (Müller)	...	...	...	×	×	×	...	×	×	×	×	×	
— *cylindracea* (Da Costa)	...	...	...	...	×	...	...	×	×	×	×	×	
Clausilia pliocena, S. V. Wood	×	...	...	...	...	...	...	...	...	...	...	...	×
Succinea elegans, Risso	...	...	...	×	×	...	...	×	×	×	×	×	
— *oblonga*, Draparnaud	...	...	...	...	×	×	×	×	×	×	×	×	
— *putris* (Linné)	...	...	...	×	×	...	×	×	×	×	×	×	
Carychium ovatum, Sandberger	...	...	...	...	...	...	×	...	...	...	...	...	×
— *minimum*, Müller	...	...	...	...	×	...	...	×	×	×	×	×	
Pomatias Harmeri, Kennard	...	×	...	...	...	...	...	...	...	...	...	...	×
AQUATIC.													
Acroloxus lacustris (Linné)	...	...	...	...	×	...	×	×	×	×	×	×	
Limnæa butleyensis, Kennard and B. B. Woodward	...	...	...	×	×	...	...	...	...	...	...	...	×
— *palustris* (Müller)	...	...	...	×	×	×	×	×	×	×	×	×	
— *Harmeri*, Kennard and B. B. Woodward	...	...	...	×	...	...	...	...	...	...	...	...	×
— *pereger* (Müller)	...	...	...	×	×	...	×	×	×	×	×	×	
— *Woodi*, Kennard and B. B. Woodward	...	...	...	×	×	...	...	...	...	...	...	...	×
— *auricularia* (L.) var. *acuta*, Jeffreys	...	...	...	...	×	...	...	×	×	×	×	×	
Planorbis corneus (Linné)	...	...	...	...	×	×	×	×	×	×	×	×	
— *præcursor*, Kennard and B. B. Woodward	...	...	...	×	×	...	...	...	...	...	...	...	×
— *spirorbis*, Müller	...	...	...	×	×	...	×	×	×	×	×	×	
Paludestrina Reevei, Kennard and B. B. Woodward	...	...	...	...	×	...	...	...	...	...	...	...	×
Lithoglyphus fuscus (Pfeiffer)	...	...	...	...	...	×	...	×	...	...	...	×	
Bithynia tentaculata (Linné)	...	...	...	...	×	...	×	×	×	×	×	×	
Vivipara glacialis (S. V. Wood)	...	...	...	...	×	×	×	...	...	...	...	...	×
— *media* (S. Woodward)	...	...	×	...	×	×	×	...	...	...	...	...	×
Valvata cristata, Müller	...	...	...	...	×	...	×	×	×	×	×	×	
— *piscinalis* (Müller)	...	...	...	...	×	...	×	×	×	×	×	×	
Corbicula fluminalis (Müller)	...	...	×	...	×	×	...	×	...	...	...	×	
Sphærium corneum (Linné)	...	...	...	...	×	...	×	×	×	×	×	×	
Pisidium amnicum (Müller)	...	...	...	...	×	×	×	×	×	×	×	×	
— *astartoides*, Sandberger	...	...	...	...	×	...	×	×	...	...	...	...	×
— *casertanum* (Poli)	...	...	...	...	×	...	×	×	×	×	×	×	
— *supinum*, A. Schmidt	...	...	...	...	×	...	×	×	×	...	×	×	
— *Henslowanum* (Sheppard)	×	...	...	...	...	...	×	×	...	×	×	×	

[1] Journ. Conchol., vol. xiv, p. 85, 1913.

THE MARINE MOLLUSCA OF THE CRAG.

GASTEROPODA.

Genus **TRIVIA**, Gray, 1832.

Trivia europæa (Montagu).

1758. *Cypræa pediculus*, var. *europæa*, Linné, Syst. Nat., ed. x, p. 724, no. 522.
1808. *Cypræa europæa*, Montagu, Test. Brit., Suppl., p. 88.
1848. *Cypræa europæa*, S. V. Wood, Mon. Crag Moll., pt. i, p. 17, tab. ii, fig. 6.
1853. *Cypræa europæa*, Forbes and Hanley, Brit. Moll., vol. iii, p. 495, pl. cxiv, figs. 6–9.
1867. *Cypræa europæa*, Jeffreys, Brit. Conch., vol. iv, p. 403, pl. xcii, fig. 2.
1877. *Trivia europæa*, var. *coccinelloides*, Sacco, Moll. Terr. Terz. Piem., pt. xv, p. 46, pl. iii, fig. 27.
1883. *Cypræa* (*Trivia*) *europæa*, Bucquoy, Dautzenberg et Dollfus, Moll. mar. Rouss., vol. i, p. 127, pl. xvi, fig. 18.

Distribution.—Recent: British Seas, Scandinavia, West European, Mediterranean.

Fossil: Miocene, Pliocene, Pleistocene.

Remarks.—Specimens of this British species occur in all parts of the English Crag, being especially abundant in the Waltonian zone at Little Oakley, most of them corresponding in size with those usually found in the North Sea; they generally measure from 9 to 12 mm. in length, but smaller and larger ones are met with also at the latter place and elsewhere. S. V. Wood remarks that the Crag shells vary in size from $\frac{1}{8}$ in. to $\frac{5}{8}$ in. (3 to 16 mm.), all of them being full grown; he says he had never obtained an immature specimen.

The Marchese di Monterosato distinguishes the smallest as var. *minor*, while M. Bucquoy and his collaborateurs adopt Philippi's name of *major* for those of 14 mm.

Var. **sphæriculata**, Lamarck. Plate II, figs. 15, 16.

1810. *Cypræa sphæriculata*, Lamarck. Ann. Mus. Hist. Nat., vol. xvi, p. 107.
1873–5. *Trivia sphæriculata*, Seguenza, Boll. R. Com. Geol., vol. iv, p. 294, 1873; vol. vi, p. 153, 1875.
1886. *Trivia europæa*, var. *sphæriculata*, Dollfus et Dautzenberg, Et. prel. Coq. foss. Tour., p. 13.
1894. *Trivia sphæriculata*, Sacco, Moll. Terr. Terz. Piem., pt. xv, p. 47, pl. iii, fig. 29.

Dimensions.—L. 16—20 mm. B. 12—14 mm.
Distribution.—Not known living.

Fossil: Waltonian Crag: Walton-on-Naze, Little Oakley; probably at other horizons.

Miocene: France, Italy. Pliocene: Sicily, Italy. Pleistocene: Sicily.

Remarks.—I have a few specimens from Oakley, larger and more globose than the typical forms of *T. europæa*, which correspond with some examples of *T. sphæriculata* I obtained from the Pleistocene deposits of Sicily. Prof. Sacco remarks as to this form, tracing its descent from *T. europæa*, var. *globosa*, that though belonging clearly to the *europæa* group, with which it is generally confused, it forms a species sufficiently distinct, an opinion shared apparently by Seguenza. MM. Dollfus and Dautzenberg give it, however, from the Faluns of Touraine as *T. europæa*, var. *sphæriculata*, and I follow them as to the Crag specimens. The latter seem to form a series connecting this Miocene shell with the recent *T. europæa*, the principal difference between them being, as Wood believed, one of size.

Trivia affinis (Dujardin).

1837. *Cypræa affinis*, Dujardin, Mém. Soc. Géol. France, vol. ii, p. 304, pl. xix, fig. 12.
1848. *Cypræa affinis*, S. V. Wood, Mon. Crag Moll., pt. i, p. 16, tab. ii, fig. 9.
1856. *Cypræa affinis*, Hörnes, Foss. Moll. Tert. Wien, vol. i, p. 72, pl. viii, fig. 14.
1873–5. *Trivia affinis*, Seguenza, Boll. R. Com. Geol., vol. iv, p. 204, 1873; vol. vi, p. 153, 1875.
1886. *Trivia affinis*, Dollfus et Dautzenberg, Et. prel. Coq. foss. Tour., p. 13.
1894. *Trivia affinis*, Sacco, Moll. Terr. Terz. Piem., pt. xv, p. 50, pl. iii, fig. 37.
1898. *Cypræa (Trivia) europæa*, var. *affinis*, A. Bell, Trans. Roy. Geol. Soc. Cornwall, vol. xii, p. 136.

Specific Characters and *Dimensions.*—See Mon. Crag Moll., pt. i, p. 16.

Distribution.—Not known living.

Fossil; Coralline Crag; Red Crag—Waltonian; Newbournian. St. Erth. Miocene: Touraine, Vienna, Italy. Pliocene and Pleistocene: Sicily.

Remarks.—Of this well-known shell, characteristic of the Miocene deposits, Wood states he had obtained two specimens only from the Coralline Crag, but I have 50 or 60 from the Waltonian of Little Oakley, varying from 12 to 15 mm. in length, and from 10 to 12 mm. in breadth, which I cannot distinguish from those of the Faluns of Touraine. *T. affinis* is allied to *T. europæa* but differs from it in having a well-marked dorsal sulcus, which in the Oakley shells is even more distinct than in the one figured by Wood. It differs from *T. avellana* by its less globose form. The latter species is not very common at Oakley, but this may be accidental, as it occurs not infrequently in other Red Crag localities.

Trivia pisolina (Lamarck). Plate II, fig. 17.

1810–22. *Cypræa pisolina*, Lamarck, Ann. Mus. Hist. Nat., vol. xvi, p. 108, 1810; Hist. Nat. Anim. sans Vert., vol. vii, p. 408, no. 17, 1822.
1886. *Trivia pisolina*, Dollfus et Dautzenberg, Et. prel. Coq. foss. Fal. Tour., p. 13.

Specific Characters.—Shell smooth, oval, globular, flattened on the side next the mouth; spire depressed but not covered or hidden by the last whorl as in *T. europæa;* mouth narrow; outer lip thick and wide, nearly straight; pillar slightly curved; canal open, indistinct.

Dimensions.—L. 15 mm. B. 13 mm.

Distribution.—Not known living.

Fossil: Newbournian Crag: Waldringfield.

Upper Miocene: Sceaux, Angers.

Remarks.—The shell here figured is from Major Moore's collection. It corresponds with a specimen which M. Dollfus has kindly sent to me from the Miocene deposits of Angers. Prof. Sacco suggests that this species may possibly be related to *T. sphæriculata.* It differs from the Crag *Triviæ,* however, in its uncovered apex, a feature it shares with a different Box-stone shell. The Waldringfield fossil is probably derivative.

Genus **VOLUTA,** Linné, 1758.

Voluta suturalis, Nyst. Plate II, fig. 10.

1836. *Voluta suturalis,* Nyst, Rech. Coq. foss. Housselt, p. 38, pl. iv, fig. 100.
1843. *Voluta suturalis,* Nyst, Coq. foss. Terr. Tert. Belg., p. 592, pl. xlv, fig. 6.
1881. *Voluta suturalis,* Keeping and Tawney, Quart. Journ. Geol. Soc., vol. xxxvii, p. 111.

Specific Characters.—Shell ovate, subfusiform; spire very short, with an obtuse apex; suture inconspicuous; upper whorls nearly flat, none of them keeled, the last convex; covered externally and internally with exceedingly fine spiral ridges extending to the base of the shell, equal to the spaces between them; mouth long, ovate, nearly three-fourths the total length, ending in a short, wide, and open canal; outer lip thin, regularly arched; columella with two prominent folds.

Dimensions.—(Of crag shell) L. 18 mm. B. 10 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Little Oakley. Lower Oligocene—Brockenhurst beds: New Forest, Isle of Wight.

Lower Oligocene: Belgium.

Remarks.—I have a unique specimen from Oakley of a Volute, somewhat worn and not full grown, which closely resembles *V. suturalis,* Nyst, especially in form and the absence of any keel upon the upper part of the body whorl, although it is covered throughout by exceedingly fine spiral ridges, whereas in Nyst's figure such ornament is confined to the base of the shell. The Oakley fossil differs from that figured by Wood in his first Supplement as *V. luctatrix,* Sol. (tab. vi, fig. 14), and still more from those given under that name by F. E. Edwards in his Monograph on the Eocene Mollusca. I do not think it can be referred to that species.

V. suturalis is only known *in situ* from the Lower Oligocene. The shell here figured may be regarded, I think, as a variety of that species. It is no doubt derivative in the Crag.

It was found in 1880 by Mr. Keeping in the Oligocene beds of Hampshire and the Isle of Wight.

Genus **ANCILLA**, Lamarck, 1799.

Ancilla Nysti, sp. nov. Plate XII, figs. 32, 33.

1843. *Ancillaria obsoleta,* Nyst, Coq. foss. Terr. Tert. Belg., p. 600, pl. xlv, fig. 10.
1874. *Ancillaria obsoleta,* Van den Broeck, Ann. Soc. Malac. Belg., vol. ix, p. 135.
1912. *Ancillaria obsoleta,* Tesch, Med. v. d. Rijks. v. Delfstoffen, pt. iv, p. 86.

Dimensions.—L. 15 mm. B. 6 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Little Oakley (derivative). Miocene: Belgium; Holland. Scaldisien: Holland (derivative).

Remarks.—The little fossil here figured, obtained at Oakley, appears to correspond with that described by Nyst from the Belgian Miocene under the name of *Ancillaria obsoleta*, which M. van den Broeck says is very common in the *zone à Panopæa Menardi* of Antwerp, and has been met with in great abundance by Dr. Tesch in the Miocene deposits of the Dutch borings; the latter has also found a few similar specimens in the Scaldisien of Holland, which with the Oakley shell are no doubt derivative from some Miocene beds existing in Pliocene times in the Anglo-Belgian basin. Prof. Sacco, to whom I have submitted my fossils, thinks, however, that they cannot be correctly referred to Brocchi's species *Buccinum obsoletum*, even as a variety, nor to any other Italian form known to him, and considers I should describe them as something new, a proposal with which M. Cossmann agrees, suggesting the appropriate name of the distinguished Belgian Palæontologist who originally called attention to the subject.

Unfortunately my photograph of the Oakley fossil (Pl. XII, fig. 32) does not correctly represent the actual form of the mouth. The apparent excavation of the upper part of the columella was due to a portion of the hardened matrix adherent to it, which has since been removed.

Dr. Tesch informs me he has a thousand specimens of this form from the Miocene deposits of Belgium and Holland.

Genus **TEREBRA**, Adanson, 1757.

Terebra canalis, S. V. Wood. Plate II, fig. 1.

1848–72. *Terebra canalis*, S. V. Wood, Mon. Crag Moll., pt. i, p. 26, tab. iv, fig. 4, 1848; Mon. Crag Moll., 1st Suppl., p. 8, tab. iv, fig. 1, 1872.
1871. *Terebra canalis*, A. Bell, Ann. Mag. Nat. Hist. [4], vol. vii, p. 355.
1881. *Terebra inversa*, var. *dextra*, Nyst, Conch. Terr. Tert. Belg., p. 21, pl. ii, fig. 2 *d*.
1892. *Terebra inversa*, var. *dextrorsa*, Van den Broeck, Bull. Soc. Belge Géol., vol. vi (Mémoires), p. 131.

Specific Characters.—Shell dextral, elongate; whorls about 10, nearly flat, regularly tapering to a blunt point; ornamented by longitudinal plications, sometimes numerous and inconspicuous, at other times fewer in number and strongly marked, and by exceedingly fine spiral striæ; body-whorl abruptly excavated below; mouth ovate, angulate above; outer lip thin; canal short, turning to the left.

Dimensions.—L. 20 mm. B. 6—8 mm.

Distribution.—Not known living.

Fossil: English Crag: Gedgravian; Waltonian; Newbournian. Belgian: Poederlien.

Remarks.—This shell, peculiar to the Pliocene deposits of the Anglo-Belgian basin, has been regarded by Belgian geologists as a dextral variety of the sinistral form *T. inversa*, but Wood considered it a different species. The two seem to have been distinct in Crag times; although nearly allied, their separation must have taken place, I think, at an earlier period. The dextral shell is less common in the Crag than its sinistral congener.

Var. **costata**, nov. Plate II, fig. 2.

Dimensions.—L. 20 mm. B. 7·5 mm.

Remarks.—There are two varieties of *T. canalis* in the Anglo-Belgian deposits. The one described by Wood, a slender and rather delicate shell with numerous inconspicuous longitudinal plications, often confined to the upper whorls; the other, figured by Nyst, characteristic of the Belgian Crag, which I distinguish as var. *costata*, being ornamented by about 15 strong and prominent flexuous costæ, extending nearly to the base of the shell; this form, moreover, is more robust and less elongate. Through the kindness of M. van de Wouver of Antwerp, I am able to give a representation of the latter together with a specimen from Oakley, which, although worn, agrees with it in form and may be possibly the same; I have several more of a similar character from that place, in one of them the sinuous longitudinal costæ being clearly though faintly shown.

Terebra exilis, A. Bell. Plate II, figs. 4, 5.

1871. *Terebra exilis,* A. Bell, Ann. Mag. Nat. Hist. [4], vol. vii, p. 355.
1872. *Terebra canalis.* var. *acuminata,* S. V. Wood, Mon. Crag Moll., 1st Suppl., p. 203, tab. iv, fig. 1.

Specific Characters.—Shell dextral, slender; apex obtuse or slightly mammillated; whorls 12—14, flat or but slightly convex, regularly diminishing in size; upper whorls ornamented by fine, inconspicuous and numerous longitudinal costæ; mouth small, oval; canal short, open, turning to the left; pillar twisted.

Dimensions.—L. 15—20 mm. B. 5—8 mm.

Distribution.—Not known living.

Fossil: Coralline Crag: Gedgrave. Waltonian: Little Oakley.

Remarks.—This shell, regarded by Wood in the synoptical list of Mollusca published with his first Supplement as a variety of *Terebra canalis,* differs from the Belgian variety *costata* in sculpture, and from it and the British type in its slender and elongated spire; one or two of the Oakley specimens are more slender than the type, measuring 17 mm. in length and only 4 mm. in breath. This form was described by Mr. A. Bell as a new species under the name of *T. exilis,* and I am inclined to agree with him. None of these dextral shells are as common as the sinistral examples, either in England or Belgium. Mr. Bell's type-specimen is in the York Museum.

Terebra inversa, Nyst, var. **costata,** nov. Plate II, fig. 7.

1843. *Terebra inversa,* Nyst, Coq. foss Terr. Tert. Belg., p. 581, pl. xliv. fig. 9.
1848. *Terebra inversa,* S. V. Wood, Mon. Crag Moll., pt. i, p. 26, tab. iv, fig. 3.
1881. *Terebra inversa,* Nyst, Conch. Terr. Tert. Belg., p. 21, pl. ii, fig. 2.
1892. *Terebra inversa,* Van den Broeck, Bull. Soc. Belge Géol, vol. vi (Mémoires), p. 120.
1912. *Terebra inversa,* Tesch, Med. v. d. Rijks. v. Delfstoffen, pt. iv, p. 86.

Specific Characters.—See Mon. Crag Moll., pt. i, p. 26.

Dimensions.—L. 25—30 mm. B. 8—10 mm.

Distribution.—Not known living.

Fossil: Coralline Crag. Red Crag—Waltonian; Newbournian. Diestien, Scaldisien and Poederlien: Belgium. Scaldisien: Holland.

Remarks.—Wood seems to have found this species but rarely either in the Coralline or the Red Crag, but I have obtained 70 or 80 specimens from the Waltonian of Little Oakley. Many of them are worn or broken as Wood's were, but it does not follow that they are derivative, as they occur in fresh and perfect condition and rather abundantly at Antwerp in the Scaldisien and Poederlien deposits, where they are evidently *in situ*.

The Oakley shells are generally costated longitudinally, the costæ extending to the body-whorl as shown in Wood's figure, although they are more numerous and less prominent than in the dextral form described above. In the specimens of *T. inversa* from Antwerp given to me by M. van de Wouver, on the contrary, the costæ are inconspicuous or are confined to the upper whorls, corresponding to Nyst's figure of 1843 and to his figure 2 *b* of 1881. Similar fossils occur occasionally in the English Crag, one of them from the Coralline Crag of Boyton being here given (Pl. II, fig. 6). Dr. Tesch has found several specimens rather finely costated in one of the Dutch borings at Oss.

Genus **COLUMBELLA**, Lamarck, 1799.

Columbella scripta (Linné). Plate II, figs. 8, 9.

1758. *Murex scriptus*, Linné, Syst. Nat., ed. x, p. 755, no. 476.
1844. *Buccinum scriptum*, Philippi, En. Moll. Sic., vol. ii, p. 190.
1856. *Columbella scripta*, Hörnes, Foss. Moll. Tert. Wien, vol. i, p. 116, pl. xi, figs. 12—14.
1871. *Columbella scripta*, A. Bell, Ann. Mag. Nat. Hist. [4], vol. vii, p. 356.
1873–5. *Columbella scripta*, Seguenza, Boll. R. Com. Geol., vol. iv, p. 300, 1873; vol. vi, p. 276, 1875.
1882. *Columbella scripta*, Bucquoy, Dautzenberg, et Dollfus, Moll. mar. Rouss., vol. i, p. 73, pl. xiii, fig. 1.
1890. *Columbella scripta*, Carus, Prod. Faun. Medit., vol. ii, p. 389.
1890. *Columbella scripta*, Sacco, Moll. Terr. Terz. Piem., pt. vi, p. 39, pl. ii, fig. 38.
1901. *Mitrella scripta*, Kobelt, Icon. schalentrag. europ. Meeresconch, vol. ii, p. 36, pl. xxxix, figs. 10, 11.

Specific Characters.—Shell thick, small, turreted; spire acuminate, regularly tapering; whorls smooth, but little convex, the last rather less than half the total length; mouth oval, angulate above, with a short and open canal; outer lip denticulate within.

Dimensions.—L. 12 mm. B. 6 mm.

Distribution.—*Recent:* Mediterranean, Adriatic, Aegean; Egypt.

Fossil: Waltonian Crag: Walton-on-Naze, Little Oakley. Newbournian: Waldringfield, Sutton, Shottisham Creek (A. Bell).

Miocene and Pliocene: Italy. Miocene: North Germany, Vienna. Upper Pliocene and Pleistocene: Sicily.

Remarks.—Prof. Kendall informs me he found this species at Walton many years ago when collecting for the *soi-disant* Prince of Mantua. I have found an imperfect specimen at Oakley, and Mr. A. Bell has reported it from the Red Crag of the localities given above. The shell here figured is from Shottisham Creek, and belongs to the York Museum.

Columbella compta (Bronn).

1831. *Fusus comptus*, Bronn, Italiens tert. Geb., p. 41.
1875. *Columbella compta*, Seguenza, Boll. R. Com. Geol., vol. vi, p. 276.
1890. *Columbella (Thiarinella) compta*, Sacco, Moll. Terr. Terz. Piem., pt. vi, p. 56, pl. ii, fig. 74.

Specific Characters.—Shell subfusiform; spire acute; the upper whorls flat, the lower ones convex, the last inflated, two-fifths the total length; ornamented by longitudinal costæ, compressed, and nearly straight, which do not reach the striated base of the shell; suture subcanaliculate; mouth narrow; outer lip curved, plicate within.

Dimensions.—L. 28 mm. B. 10 mm.

Distribution.—Not known living.

Fossil; Waltonian Crag: Walton-on-Naze.

Miocene and Pliocene: Italy. Upper Pliocene: Sicily.

Remarks.—This very distinct species was reported from Walton-on-Naze by Messrs. Robert Bell and Kendall, but the specimen cannot now be traced. I have not found it either at Beaumont or Oakley. *Columbella compta* is an Italian fossil, ranging from the Middle Miocene to the Upper Pliocene. It is figured by Prof. Sacco, and there are specimens of it in the Geological Museum at Turin.

Columbella subulata (Brocchi). Plate II, figs. 11, 12.

1814. *Murex subulatus*, Brocchi, Conch. foss. subap., p. 426, pl. viii, fig. 21.
1849. *Columbella subulata*, Bellardi, Mem. Acc. Scient. Torino [2], vol. x, p. 238, pl. i, fig. 12.
1856. *Columbella subulata*, Hörnes, Fos. Moll. Tert. Wien, vol. i, p. 121, pl. ii, figs. 11—13.
1874-5. *Columbella subulata*, Seguenza, Boll. R. Com. Geol., vol. v, p. 276, 1874; vol. vi, p. 276, 1875.
1881. *Columbella subulata*, Nyst, Conch. Terr. Tert. Belg., p. 36, pl. iii, fig. 3.
1890. *Columbella (Tetrastromella) subulata*, Sacco, Moll. Terr. Terz. Piem., pt. vi, p. 44, pl. ii, fig. 49.
1912. *Columbella subulata*, Tesch, Med. v. d. Rijks. v. Delfstoffen, pt. iv, p. 78.

Specific Characters.—Shell turreted, elongate, smooth; whorls flat, the last two-fifths the total length; suture subcanaliculate; base striated; mouth quadrangular, with a well-marked canal; outer lip denticulate within.

Dimensions.—L. 12 mm. B. 4 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Little Oakley. Newbournian: Sutton.

Miocene: Vienna basin; northern Italy; south-western France. Pliocene—

Scaldisien: Belgium, Holland. Poederlien: Belgium. Pliocene of Italy: Valle Andona, Monte Mario. Upper Pliocene and Pleistocene: Sicily.

Remarks.—This species is said by Nyst to be rare in the Scaldisien deposits; M. van de Wouver has, however, obtained many specimens during the excavation of the new docks at Antwerp, and has sent me some of them for comparison with those collected at Oakley, with which they correspond.

C. subulata has not been recorded hitherto from the English Crag. Prof. Sacco reports it, "*non frequente*," from the Astian deposits of Val Andona. As it is found perfect and unworn in the Poederlien and Scaldisien of Belgium, there seems no reason to suppose that it is derivative in the English Crag. It is one of the large group of Molluscs originating in Miocene seas which were still in existence in the Anglo-Belgian basin in Waltonian times. The Crag specimen is from Mr. Ogden's collection.

Genus **ASTYRIS,** H. and A. Adams, 1853.

Astyris rosacea (Gould). Plate XIII, figs. 13, 14.

1840. *Buccinum rosaceum*, Gould, Amer. Journ. Sci., vol. xxxviii, p. 197.
1841–70. *Columbella rosacea*, Gould, Rep. Inv. Mass., ed. 1, p. 311, fig. 195, 1841; ed. 2, p. 357, fig. 627, 1870.
1842. *Mangelia Holböllii* (Beck), Möller, Ind. Moll. Groen., p. 12.
1858. *Amycla* (*Astyris*) *rosacea*, H. and A. Adams, Gen. Rec. Moll., vol. i, p. 137.
1872. *Columbella* (*Astyris*) *Holböllii*, Mon. Crag Moll., 1st Suppl. p. 9, tab. v, fig. 21.
1878. *Pyrene rosacea*, G. O. Sars, Moll. Reg. Arct. Norv., p. 251, pl. xvi, fig. 1.
1883. *Pyrene rosacea*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. ii, p. 34, pl. xxx, figs. 6—8.
1912. *Columbella* (*Astyris*) *rosacea*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 145.

Specific Characters.—Shell small, solid, ovato-conical, whorls 7, slightly convex, the last much the largest, rather more than half the total length, excavated below; ornamented near the base by spiral lines, and by fine longitudinal plications on the upper whorls; spire regularly diminishing in size, ending in an obtuse and slightly bulbous apex; suture well-marked; mouth short, ovate, angulate above; canal short, wide, turning to the left.

Dimensions.—L. 10 mm. B. 4 mm.

Distribution.—*Recent:* northern and western Norway; Spitzbergen, Greenland; New England coasts.

Fossil: Waltonian Crag: Little Oakley.

Pleistocene: England—Bridlington; Scotland—Fort William, Lochaber; Ireland—Balbriggan, Turbot bank, Antrim.

Remarks.—Wood figured a specimen of this species from Bridlington, but up to the present it has not been noticed from the Crag. I have a unique example from Oakley, and it may probably be found elsewhere if specially looked for. My Crag shell is worn and does not show either the spiral lines at the base of the shell, or the fine inconspicuous ribs on the upper whorls.[1] It corresponds sufficiently, however, with some fossils which Mr. A. Bell obtained from a Pleistocene deposit at Lochaber, N.B., to be identified with them.

This species was known to Möller, Wood and others as *C. Holböllii*, but Gould's name *rosacea* is slightly older. It is a northern form which is not known, either from the Christiania fiord or the southern coasts of Norway. Messrs Dautzenberg and Fischer state that it has been dredged in Norwegian seas, and in those of New England at depths varying from 5 to 548 metres. Although grouping it with the Columbellas they state that the conformation of the operculum is not unlike that of *Purpura*.

Genus **CASSIDARIA**, Lamarck, 1812.

Cassidaria tyrrhena (Chemnitz). Plate II, fig. 13.

1788. *Buccinum cassideum thyrhenum*, Chemnitz, Conch. Cab., vol. x, p. 192, tab. 153, figs. 1461, 1462.
1836–44. *Cassidaria tyrrhena* (part), Philippi, En. Moll. Sic., vol. i, p. 216, 1836; vol. ii, p. 186. 1844.
1859. *Cassidaria tyrrhena*, Chenu, Man. Conch., vol. i, p. 208, fig. 1136.
1873–75. *Cassidaria tyrrhena*, Seguenza, Boll. R. Com. Geol., vol. iv, p. 300, 1873; vol. v, p. 276, 1874; vol. vi, p. 278, 1875.
1881. *Cassidaria bicatenata*, var., Nyst, Conch. Terr. Tert. Belg., pl. ii, fig. 14 *b*, 14 *c*.
1882. *Cassidaria tyrrhena* (*rugosa*), Bucquoy, Dautzenberg, et Dollfus, Moll. mar. Rouss., vol. i, p. 70, pl. ix, fig. 3.
1890. *Cassidaria tyrrhena*, Carus, Prod. Faun. Med., vol. ii, p. 375.
1901. *Cassidaria tyrrhena*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. ii, p. 71, pl. xlviii, figs. 1—5.

Specific Characters.—Shell ovate, subpyriform, ventricose; whorls convex, the last much the largest; ornamented with numerous fine and regular ridges, and sometimes with a row of tubercles, not very prominent, on the upper part of the lower whorl; mouth oval, ending in a short canal which turns to the left; columella excavated; suture distinct.

Dimensions.—(Of Crag specimen) L. 45 mm. B. 30 mm.

Distribution.—*Recent:* Mediterranean; Adriatic; west European.

Fossil: Coralline Crag: Boyton. Waltonian: Little Oakley. Pliocene: Italy, North Germany, Algeria. Upper Pliocene and Pleistocene deposits: Sicily.

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[1] MM. Dautzenberg and Fischer state that such features are not always present in this species.

Remarks.—The specimen now figured is from the York Museum and was obtained at Boyton; I have several fragmentary specimens of the same species from Oakley. The Boyton shell corresponds with one I found some years ago in the Pleistocene deposits of Ficarazzi, near Palermo, and with those represented by Chenu, and in the 'Mollusques marins de Roussillon,' except that it is smaller and the sculpture is more delicate. The typical *C. bicarinata* of the Crag is larger and much stronger. One of the Scaldisien fossils figured by Nyst under the latter name (fig. 14 *b*) may be the present species.

Cassidaria bicatenata, J. Sowerby, var. **Canhami,** A. Bell. Plate II, fig. 14.

1871. *Cassidaria bicatenata*, var. *Canhami*, A. Bell, Ann. Mag. Nat. Hist. [4], vol. vii, p. 356.

Dimensions.—L. 108 mm. B. 60 mm.

Distribution.—Not known living.

Fossil: Newbournian Crag: Sutton, Waldringfield.

Remarks.—The shell here figured, which was obtained by the Rev. H. Canham from the Newbournian Crag at Waldringfield, belongs to the Ipswich Museum. It represents a variety differing from the type form of the English and Belgian Crags in the greater length of the spire and the obsolete character of the tubercles. Mr. Bell informs me there are three or four examples of the same kind at Ipswich, the one originally described by him being found at Sutton. Perfect and unworn specimens of *C. bicatenata* are not uncommon in the Scaldisien of Antwerp, the equivalent of the Waltonian horizon of the English Crag, negativing the view that they are derivative in those deposits; the Red Crag fossils are usually stronger and more solid than those found in the Coralline Crag or at Antwerp.

Genus **CASSIS,** Lamarck, 1799.

Sub-genus **SEMICASSIS,** Klein, 1753.

Cassis (Semicassis saburon) (Bruguière).

1792. *Cassidea saburon*, Bruguière, Ency. Meth., p. 420, no. iv.
1856. *Cassis saburon*, Hörnes, Foss. Moll. Tert. Wien, vol. i, p. 177, pl. xv, figs. 2—7.
1872. *Cassis saburon*, S. V. Wood, Mon. Crag Moll., 1st Suppl., p. 10, tab. vi, fig. 1.
1873–75. *Cassis (Cassidea) saburon*, Seguenza, Boll. R. Com. Geol., vol. iv, p. 300, 1873; vol. vi, p. 278, 1875.
1879–82. *Cassis saburon*, Fontannes, Moll. Plioc. Rhone, vol. i, p. 96, pl. vi, fig. 17.
1882. *Cassis saburon*, Bucquoy, Dautzenberg, et Dollfus, Moll. mar. Rouss., vol. i, p. 64, pl. vii, figs. 1, 2.
1885. *Cassis saburon*, Van den Broeck, Mel. Géol., pt. ii, p. 35.
1890. *Cassis saburon*, Carus, Prod. Faun. Medit., vol. ii, p. 374.
1892. *Cassis saburon*, Van den Broeck, Bull. Soc. Belg. Géol., vol. vi (Mémoires), p. 121.

1901. *Cassis saburon*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. ii, p. 66, pl. xlv, figs. 1—5.
1912. *Cassis saburon*, Tesch, Med. v. d. Rijks. v. Delfstoffen, pt. iv, p. 76.

Specific Characters.—Shell ovate, thick and strong; whorls 7, slightly convex, the last ventricose, much the largest, seven-eighths the total length; ornamented by regular and well-marked spiral striæ; spire very short; apex acute; mouth irregularly oval, angulated above; outer lip thick, dentated; inner lip forming a wide glaze; columella excavated, rugose, toothed towards the lower part; canal short, open, reflected.

Dimensions.—L. 40—56 mm. B. 30—40 mm.

Distribution.—*Recent:* western Europe, Mediterranean, Algeria, Morea, Smyrna, Syria.

Fossil: Newbournian Crag: Waldringfield.

Bolderien (Miocene), Diestien, and Scaldisien: Belgium. Scaldisien: Holland. Miocene: Vienna, Poland, Podolia. Miocene and Pliocene: Italy, France. Upper Pliocene and Pleistocene: Sicily.

Remarks.—This is another of the characteristic Miocene species which lingered on in the Anglo-Belgian basin until Scaldisien times. M. Van den Broeck reports it from the *Sables à Panopæa* (Miocene) of Antwerp, where it is common, from those *à Terebratula grandis* (Diestien) and *à Chrysodomus contraria* (Scaldisien). There is a specimen in the British Museum (Natural History) stated, probably in error, to have come from the Coralline Crag of Sutton,[1] and Wood recorded it from Waldringfield, at which place, however, he regarded it as derivative. It is not known from Walton, nor have I met with it either at Beaumont or Oakley. M. van den Broeck gives it from Waenrode, a deposit which I regard as Lower Pliocene.[2] It is possibly derivative in the Scaldisien of Belgium and Holland.

Seguenza gives it from the Pleistocene of Sicily, where it occurs with *Neptunea contraria*, *Modiola modiolus*, *Cyprina islandica*, and other northern species. It still lives in the Mediterranean, ranging as far west as Smyrna and the Syrian coast.

Genus **ROSTELLARIA**, Lamarck, 1799.

Sub-genus **RIMELLA**, Agassiz, 1840.

Rostellaria (Rimella) gracilenta, S. V. Wood. Plate II, fig. 3.

1882. *Rostellaria gracilenta*, S. V. Wood, Mon. Crag Moll., 3rd Suppl., p. 1, tab. i, fig. 1.

Specific Characters.—Shell strong, slender, elongate, regularly tapering to a blunt point; whorls 7 or 8, flat or nearly so; ornamented by well-marked, rounded

[1] Mr. A. Bell doubts whether this specimen is a British fossil.

[2] Quart. Journ. Geol. Soc., vol. liv, p. 319, 1898.

longitudinal costæ, rather oblique, equal to the spaces between them, 20 to 25 on the body whorl, which with the canal is somewhat less than half the total length, and by numerous thread-like spiral lines in the interspaces, closely crowded together both internally and externally; suture well-marked and channelled but not deep; mouth pyriform, acutely angulate above, ending abruptly in a straight and exceedingly narrow canal.

Dimensions.—L. 28 mm. B. 7 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Walton-on-Naze, Beaumont, Little Oakley. Newbournian: Waldringfield, Newbourn, Ramsholt, Sutton, Felixstowe.

Remarks.—This form, of which Wood had obtained a few examples only from the Newbournian Crag of Sutton and Felixstowe, was figured by him from an immature specimen. Since then many more have been found at Walton, Beaumont and Oakley; I have fifty from the last-named place, most of them worn or imperfect; some, however, are in a sufficient state of preservation to show the long, narrow canal and the delicate spiral sculpture of the shell.

R. gracilenta is not known from the Coralline, and our fossils have an appearance of being derivative in the Red Crag, as, indeed, Wood believed them to be. The difficulty in accepting this view is the comparative abundance in which they occur at Oakley. It is not easy to understand that there could have been an older fossiliferous deposit at no great distance from the Red Crag shore yielding so many specimens of this form, which did not afford also an equal or similar number of other characteristic species.

The specimen here figured, which is better preserved than that given by Wood, is from Waldringfield.

Genus **NASSA,** Lamarck, 1799.

Nassa reticosa (J. Sowerby).

1818. *Buccinum reticosum*, *Buccinum elongatum*, *Buccinum rugosum*, J. Sowerby, Min. Conch., vol. ii, pp. 15—17, tab. cx, figs. 1—3.
1848. *Nassa reticosa*, S. V. Wood, Mon. Crag Moll., pt. 1, p. 33, tab. iii, figs. 10 *a*—10 *h*.
1881. *Nassa reticosa*, Nyst, Conch. Terr. Tert. Belg., p. 12, pl. ii, fig. 4.
1885. *Nassa reticosa*, Lorié, Arch. Mus. Teyler [2], vol. ii, p. 199, pl. v, figs. 19—22.
1890. *Nassa reticosa*, A. Bell, Rep. Brit. Assoc. (Leeds), p. 410.
1892. *Nassa reticosa*, Van den Broeck, Bull. Soc. Belg. Géol., vol. vi (Mémoires), pp. 120, 131.
1894. *Nassa serrata*, Kendall, Journ. Isle of Man Nat. Hist. Soc., vol. i, p. 419, pl. i, figs. 1—3.
1912. *Nassa reticosa*, Tesch, Med. v. d. Rijks. v. Delfstoffen, pt. iv, p. 78.

Specific Characters.—See Mon. Crag Moll., pt. i, p. 33.

Dimensions.—L. 30—60 mm. B. 15—30 mm.

Distribution.—Not known living.

Fossil: Coralline Crag: Gedgrave (very rare), Boyton. Red Crag: *passim.* Icenian: Thorpe near Norwich, Postwick, Easton Bavent, Southwold. Wexford gravels; Isle of Man; Slains, Aberdeenshire.

Belgium: Diestien; Scaldisien; Poederlien. Holland: Diestien; Scaldisien; Amstelien.

Remarks.—There is no consensus of opinion among palæontologists as to the amount of departure from a given type which justifies the initiation of a new species. In the present case a number of shells, differing essentially in form and sculpture, which in a collection of some hundreds of specimens from one spot (as from Oakley) may be generally separated without difficulty, are regarded as varieties of one species. Italian geologists, on the contrary, have described many nearly allied forms of *Nassa* as separate species, as will appear in the sequel. Had Bellardi, for example, been the first to study the Crag *Nassas* he probably would have regarded some of our varieties of *N. reticosa* as specifically distinct.[1]

N. reticosa appears somewhat suddenly in the Anglo-Belgian basin, occurring in great abundance in the Red Crag, but it has now disappeared. The different varieties of this group may perhaps be regarded as incipient species, affording an illustration of the way in which species may have arisen, and explaining the fact that in many cases where specific separation has been apparently established, allied forms show so often a tendency to run into one another.

N. reticosa has been recorded very rarely from the Gedgravian or older portion of the Coralline Crag, but has been found in some abundance in the latter deposits of Boyton and Ramsholt. Specimens from those places are less worn than those of the Butleyan zone of the Red Crag, to which, for other reasons, I believe the undoubted Red Crag beds of the Boyton district should be referred.

As stated in the introduction (p. 4), Mr. Alfred Bell considers that the Coralline Crag fauna of Boyton has certain features which separate it from that of any recognised horizon of the Crag deposits. He suggests it may be intermediate between the Gedgravian and the Waltonian, probably as an upper zone of the former.[2] He finds an assemblage of shells in the upper part of the Coralline Crag at Ramsholt, similar to that of Boyton.

I have little hesitation in accepting the view that the specimens of *N. reticosa* found at those places are of Upper Coralline Crag age, and that this form should be included in the fauna of that horizon.

M. van den Broeck, moreover, reports this shell from the Diestien deposits (*zone à Terebratula grandis*) of Belgium.

The fossils figured by Prof. Kendall from the Isle of Man as *N. serrata* appear to belong to the present species; they are not the Italian *N. serrata* of Brocchi.

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[1] Some specimens of *N. aubigniensis* from the Lower Pliocene of Bosq d'Aubigny which I have received from M. Dautzenberg, approach very nearly the Crag var. *elongata*.

[2] Journ. Ipswich Field Club, vol. iii, p. 5, 1911.

Var. **pulchra**, nov. Plate III, fig. 14.

Remarks.—I have five or six imperfect and immature specimens of a *Nassa* from Oakley, which may be regarded as an undescribed variety of this polymorphous species. The sculpture is very fine and delicate, more so than in any of the varieties figured by Wood, or that I have hitherto seen. From a superficial examination they might be taken for that described by Wood as *N. reticosa*, var. *simplex* (1st Suppl., p. 15, tab. iv, fig. 3), but I do not think that is the case. There is a specimen from Walton of what I take to be the latter in the Sedgwick Museum at Cambridge which I have figured in Pl. V, fig. 7, as a variety of a new species, *N. Dautzenbergi*, to show the difference between them. The latter is a small shell, full grown, with a thickened lip, belonging to the *granulata* group, having, in my opinion, but little connection with *N. reticosa*.

Var. **lineata**, nov. Plate III, figs, 17, 18.

Remarks.—In this variety from Butley, in the Ipswich Museum, which in form resembles Wood's variety *concinna*, the longitudinal costæ are absent from the lower whorls and are hardly visible on the upper ones. I have recently found two similar specimens at Oakley, however, which show faint but numerous longitudinal costæ on the upper part of the shell. It seems to be common in the Manx beds.

Var. **cancellata**, nov. Plate III, fig. 19.

Remarks.—This also is a specimen from the Ipswich Museum, and came from Butley. It differs from any figured by Wood.

Var. **costata**, S. V. Wood. Plate III, figs. 15, 16.

1848. *Nassa reticosa*, var. *costata*, S. V. Wood, Mon. Crag Moll., pt. i, tab. iii, fig. 10 *h*.
1894. *Nassa serrata*, Kendall, Journ. Isle of Man Nat. Hist. Soc., vol. i, p. 419, pl. i, figs. 2, 3.
1903. *Nassa serrata*, Lamplugh, Mem. Geol Surv., Isle of Man, p. 475, fig. 81 (p. 336).

Dimensions.—L. 28—42 mm. B. 15—20 mm.

Distribution.—Coralline Crag—Boytonian: Boyton, Ramsholt. Red Crag: all zones. Isle of Man.

Remarks.—This form varies considerably in the length of the spire, otherwise its characteristic features are more or less constant.

The shell figured by Wood has a short spire, and does not fully represent the variety *costata* which is the most prevalent one at Boyton and Oakley. In my collection specimens from those and other localities are generally elongate.

Some of the fossils from the Isle of Man figured by Prof. Kendall and by Mr. Lamplugh as *N. serrata* seem to be the present variety. Prof. Kendall's fig. 1 corresponds with my var. *lineata* (Pl. III, fig. 18).

Var. **incisa**, nov. Plate III, fig. 4.

Dimensions.—L. 36 mm. B. 20 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Little Oakley.

Remarks.—As far as my experience goes, and with one exception, the spiral sculpture of the shells grouped by Wood as *N. reticosa* consists of raised lines or bands more or less distinct or prominent. In the variety *tiara*, however, it takes the form of rather faintly impressed or incised striæ. I have a specimen from Oakley which corresponds with the latter in this respect, but the whorls are regularly rounded and convex, and not angulated below the suture. To some extent our fossil approaches one or two varieties of the Mediterranean species *N. mutabilis* figured by Kobelt (Icon. schalentrag. europ. Meeresconch., vol. i, p. 122, pl. xxi, figs. 20, 21, 1887).

The fact that the spiral sculpture of all the specimens of *N. reticosa* known to me, except those of the present one and the variety *tiara*, consists of raised and not of grooved lines, suggests that these forms may possibly belong to a separate species.

Nassa semireticosa, Etheridge and A. Bell. Plate III, fig. 11.

1885. *Nassa serrata*, S. V. Wood, Quart. Journ. Geol. Soc., vol. xli, p. 65.
1886. *Nassa serrata*, Kendall and R. G. Bell, Quart. Journ. Geol. Soc., vol. xlii, p. 201.
1890. *Nassa serrata*, C. Reid, Plioc. Dep. Brit., p. 63.
1893. *Nassa serrata*, A. Bell, Proc. Roy. Irish Acad. [3], vol. ii, p. 626.
1898. *Nassa semireticosa*, Etheridge and A. Bell, Trans. Roy. Geol. Soc. Cornwall, vol. xii, p. 140, pl. i, fig. 7.

Specific Characters.—Shell generally thick and solid, varying greatly in size; whorls but little convex, slightly depressed below the suture; ornamented by strong longitudinal ribs, rather oblique, especially on the last whorl, crossed by spiral costæ which become tuberculate at the point of intersection; suture deep, channelled; mouth ovate, acutely angulate above; outer lip but little expanded, thickened internally and grooved in correspondence with the spiral costation; canal notched, wide and very short, opening to the left.

Dimensions.—L. 18—40 mm. B. 10—20 mm.

Distribution.—Not known living.

Fossil: Pliocene deposits: St. Erth.

Remarks.—This rather variable shell, which is exceedingly common in the Pliocene deposits of St. Erth in Cornwall, was recorded under the name of *N. serrata* by S. V. Wood, jun., in 1885, and by Prof. Kendall and Mr. R. G. Bell in 1886. It differs essentially, however, from the Italian form of that species, being larger and stronger, with much coarser sculpture, the longitudinal costæ and the spiral striations being fewer in number and distinctly tuberculate at the point of intersection.[1] Some specimens attain a length of 40 mm. or more. Messrs. Etheridge and A. Bell, considering it worthy of specific rank, have called it *N. semireticosa.* I have figured two shells from St. Erth for the purpose of comparison, the smaller of the two, var. *minor* (Pl. III, figs. 12, 13), corresponding closely with a specimen from the Coralline Crag of Boyton in the Reed collection at York. I have another from Oakley, not quite perfect, which seems the same; it differs from the other *Nassas* of that locality in the coarseness of its sculpture.

Nassa prismatica (Brocchi). Plate III, figs. 1, 2.

1814. *Buccinum prysmathicum*, Brocchi, Conch. foss. subap., p. 337, pl. v, fig. 7.
1856. *Buccinum prismaticum*, Hörnes, Foss. Moll. Tert. Wien, vol. i, p. 146, pl. xii, fig. 13.
1870. *Nassa prismatica*, A. Bell, Journ. de Conch., vol. xviii, p. 345.
1875. *Nassa prismatica*, Seguenza, Boll. R. Com. Geol., vol. vi, p. 278.
1882. *Nassa prysmathica*, Bellardi, Moll. Terr. Terz. Piem., pt. iii, p. 71, pl. v, fig. 1.
1901. *Nassa* (*Uzita*) *prismatica*, Cossmann, Ess. Paléon. comp., pt. iv, p. 206, pl. ix, figs. 4, 5.
1911. *Nassa* (*Uzita*) *limata*, Cerulli-Irelli, Faun. malac. mariana, pt. v, p. 248, pl. xl, figs. 4, 8.

Specific Characters.—Shell turreted; spire more or less elongate; apex acute; whorls convex, depressed above, the last comparatively short, rather less than half the total length; suture deep; longitudinal ribs 12—18, narrow, prominent, subacute, straight on the upper whorls, oblique or sinuous on the last, extending to the base of the shell; spiral costæ distinct, narrow, undulating, uniform, hardly equalling the spaces between them; apex acute; mouth suborbicular, angulate above, with a small notch, expanded at the base; outer lip slightly thickened outside, plicate within; inner lip covering but not wholly adherent to the columella; columella deeply excavated in the middle; canal notched, wide and open, turning sharply to the left.

Dimensions.—(Of the Crag specimen) L. 26 mm. B. 14 mm.

Distribution.—*Recent:* Adriatic.

Fossil: Coralline Crag. Waltonian: Little Oakley (possibly elsewhere in the Red Crag).

Pliocene: Italy, Sicily.

Remarks.—There seems to be considerable difference of opinion as to this species, some authorities regarding it as equivalent to the Recent Mediterranean

[1] Compare with this Pl. III, fig. 6 of the present work.

form *N. limata*. Bellardi, however, considered it to be specifically distinct, a view shared by Seguenza, whose list of fossils from the Sicilian deposits, quoted above, includes the names of both forms, as well as by MM. Dollfus and Dautzenberg, the Marchese di Monterosato and others.

Bellardi says the typical *N. prysmathica* of the Italian Pliocene is a longer shell than *N. limata*, having an acute spire and fewer longitudinal ribs, while the spiral costæ are stronger and less closely crowded together.

The shell originally figured by Brocchi has, however, a shorter spire than that of Bellardi, though otherwise it is of the same character.

Hörnes figures two shells under the name *B. prismaticum*, one of them (*op. cit.*, pl. xii, fig. 13) corresponding fairly well with the Italian form, the other (fig. 14) being smaller, with a shorter spire.

Those given by Nyst under this name in 1843, however (Coq. Foss. Terr. Tert. Belg., pl. xliii, fig. 12), and in 1881 (Conch. Terr. Tert. Belg., pl. ii, fig. 10), have little resemblance to the typical *N. prismatica;* indeed, he states as to his figure of 1881 that it appears to be intermediate between the latter species and *N. serrata*. He agrees, however, that *N. limata* is a different shell. I have not noticed the true Italian *N. prismatica* in the Belgian Crag.

Wood figured a shell in 1848 under the present name (tab. iii, fig. 6), but in his second Supplement (p. 3), finding his reference incorrect, described it as a new species, *N. microstoma*. He included *N. prismatica* in his synoptical list, however, stating that Mr. Canham had sent him a specimen from the Coralline Crag which corresponded with Brocchi's figure.

We find fossils at Oakley which may be referred, on the one hand to the Pliocene *N. prismatica*, corresponding to those from the Italian deposits, and on the other to the Recent species, *N. limata*, our Crag specimens of the latter having spiral striations as fine and delicate as in those now living in the bay of Naples.

The Crag fossil here figured as *N. prismatica* has been identified by Prof. Issel of Genoa with Brocchi's species; it agrees with specimens I have collected from several localities in Italy, one of them from Colle Valetti near Pisa being also represented to show the identity of the two; the Crag *N. limata* (Pl. IV, fig. 1) seems to me a different shell.

Nassa clathrata (Born). Plate III, fig. 3.

1780. *Buccinum clathratum*, Born, Mus. Caes. Vind. Test., p. 261, pl. ix, figs. 17, 18.
1814. *Buccinum clathratum*, Brocchi, Conch. Foss. Subap., p. 338.
1874–5. *Nassa clathrata*, Seguenza, Boll. R. Com. Geol., vol. v, p. 276, 1874; vol. vi, p. 278. 1875.
1879. *Nassa clathrata*, Fontannes, Moll. Plioc. Vall. Rhone, vol. i, p. 57, pl. v, fig. 2.
1882. *Nassa clathrata*, var. A, Bellardi, Moll. Terr. Terz. Piem., pt. iii, p. 76, pl. v, fig. 5.
1889. *Nassa clathrata*, Sacco, Cat. Pal. Bac. Terz. Piem., p. 106.
1901. *Nassa* (*Niotha*) *clathrata*, Cossmann, Ess. Paléont. comp., pt. iv, p. 203, pl. ix, fig. 3.

Specific Characters.—Shell strong, ovate, conical, whorls distinctly convex, the last ventricose, much the largest, more than half the total length, excavated below; spire comparatively short, ending in a rather blunt point; suture deep and channelled; ornamented by strong longitudinal costæ, 14 to 20 on the body-whorl, and by regular equidistant spiral ribs; mouth oval, angulate above; outer lip rounded, plicated within; columella excavated; canal wide, very short.

Dimensions.—L. 30 mm. B. 18 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Little Oakley.

Pliocene: Piedmont and Liguria. Upper Pliocene and Pleistocene: Sicily.

Remarks.—I have one or two specimens from Oakley belonging to the *N. prismatica* group, but differing distinctly from that species in their more tumid form and their coarser sculpture. Submitting them to Prof. Issel, he had no hesitation in recognising them as a variety of *N. clathrata*. They approach most nearly to var. A of Bellardi's Monograph. It is interesting to find in the Oakley Crag so many forms of *Nassa*, characteristic of the Mediterranean Pliocene, which now have wholly disappeared from more northern seas.

M. Cossmann has recently referred this species, together with *N. serrata*, *N. Cantrainii* and some others, to the sub-genus *Niotha* of H. and A. Adams.

Nassa emiliana (Mayer), var. A, Bellardi. Plate IV, figs. 5, 6.

1843. *Buccinum prismaticum*, Nyst, Coq. Foss. Terr. Tert. Belg., p. 576, pl. xliii, fig. 12.
1872. *Buccinum emilianum*, Mayer, Journ. de Conch., vol. xx, p. 236, pl. xiv, fig. 9.
1873. *Nassa Michelottiana*, Cocconi, Mem. Accad. Sci. Bologna, vol. iii, p. 485, pl. i, figs. 21, 22.
1882. *Nassa emiliana*, var. A, Bellardi, Moll. Terr. Terz. Piem., pt. iii, p. 77, pl. v, fig. 6.
1898. *Nassa emiliana*, Etheridge and A. Bell, Trans. Roy. Geol. Soc. Cornwall, vol. xii, p. 141.
1912. *Nassa emiliana*, Tesch, Med. v. d. Rijks. v. Delfstoffen, pt. iv, p. 80.

Specific Characters.—Shell smaller and less elongate than any of the group before described, ovate, turreted; spire short; whorls convex, flattened above, the last more than half the total length; ornamented by 15 or 16 longitudinal ribs, prominent and obtuse, separated by furrows, equal in width to the ribs and crossed by strong spiral costæ, about 16 on the body-whorl, which become slightly nodular at the point of intersection; apex acute; mouth oval, angulated above; outer lip grooved within, but little thickened externally; inner lip folded upon the pillar; canal wide and open, turning to the left, ending in a deep notch.

Dimensions.—L. 15 mm. B. 9 mm.

Distribution.—Not known living.

Fossil: Coralline Crag: Boyton. Waltonian: Little Oakley; probably elsewhere in the Red Crag. St. Erth. Scaldisien: Belgium. Miocene and Pliocene: Italy.

Remarks.—I have several specimens from Oakley of this Italian species which hitherto has not been recorded from the English Crag, though it was found by Mr. Alfred Bell at St. Erth. It resembles *N. serrata*, but may be distinguished from it by its more acute apex, a feature characteristic of the *prismatica* group. When examining Mr. van de Wouver's collection of Scaldisien fossils at Antwerp I noticed examples of the same shell, which I understand is not uncommon in those deposits. Nyst's figure of 1843 (pl. xliii, fig. 12), before mentioned, may be of this species. I have submitted the Oakley fossils to Prof. Issel, who has kindly confirmed my identification.

N. emiliana resembles *N. limata* in form, but the spiral sculpture of the latter is very much finer, and the outer lip is more distinctly thickened externally. Among the specimens known to me from the Crag there is no difficulty in distinguishing between the two. At Oakley, moreover, *N. limata* not infrequently assumes the features represented in Pl. IV, fig. 3, as var. *anomala*, which I have not observed in *N. emiliana* or in any other of the Crag Nassas.

The Oakley specimens correspond to Bellardi's variety A.

Nassa Cantrainii, Bellardi. Plate III, figs. 9, 10.

1882. *Nassa Cantrainii*, Bellardi, Moll. Terr. Terz. Piem., pt. iii, p. 78, pl. v, fig. 7.
1889. *Nassa Cantrainii*, Sacco, Cat. Pal. Bac. Terz. Piem., p. 106.

Specific Characters.—Shell solid, ovate; spire comparatively short; whorls convex, depressed above, forming a distinct but narrow and rounded shelf below the suture; ornamented by numerous longitudinal ribs, about 20 on the body-whorl, intersected by strong, prominent spiral costæ, less numerous and less crowded than in *N. prismatica* or *N. serrata*, and equal to the spaces between them; apex acute, as in *N. prismatica*; mouth suborbicular, angulated above, with a long fold-like tooth to the left; outer lip broadly thickened outside and grooved within; inner lip extending over the pillar and the umbilical region; columella deeply excavated; canal very short, wide, turning sharply to the left.

Dimensions.—L. 20 mm. B. 12 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Little Oakley.

Pliocene: Italy—Piacenziano; Astiano.

Remarks.—I have found one specimen only at Oakley of this form. It is not quite perfect, but appears to agree with some shells I collected from the Pliocene of Bordighera and Piacenza which have been identified as *N. Cantrainii*. I figure one from the former place to show the correspondence between the Italian and the Oakley fossils. *N. Cantrainii* has not been recorded hitherto from the Crag; it is considered by Bellardi to belong to the *prismatica* group.

Nassa microstoma, S. V. Wood. Plate IV, fig. 4.

1848. *Nassa prismatica*, S. V. Wood, Mon. Crag Moll., pt. i, p. 32, tab. iii, fig. 6
1879. *Nassa microstoma*, S. V. Wood, Mon. Crag Moll., 2nd Suppl., p. 3, tab. i, fig. 4.

Specific Characters.—Shell comparatively small, fairly solid, generally smooth and polished, ovato-conical; whorls distinctly convex, regularly tapering to a fine point, the last more than half the total length; ornamented by strong, clearly sculptured longitudinal costæ, 12 to 18 on the last whorl, with rather wide spaces between, and by strong, well-marked and somewhat distant spiral lines; apex acute; mouth small, suborbicular, angulated above; outer lip thickened outside by a wide and prominent rib, grooved within; inner lip wide, plicated, covering the pillar, with a prominent tooth near the suture; canal short, very narrow.

Dimensions.—L. 10—14 mm. B. 5—8 mm.

Distribution.—Not known living.

Fossil: Coralline Crag: Gedgrave, Sutton, Boyton. Waltonian: Walton-on-Naze, Beaumont, Little Oakley. Newbournian: Sutton, Waldringfield.

Remarks.—This form seems to be distinct from any of those previously referred to. I have found a dozen or more specimens of it at Oakley. It is much smaller than *N. prismatica*, some of my Oakley shells measuring, though adult, not more than 10 mm. in length; in sculpture, moreover, it differs from that species and from *N. limata*; the canal is narrow and does not turn so distinctly to the left. I have figured an example for comparison with the shells before described, to show the difference between them. *N. microstoma* belongs to the *prismatica* group, but out of a number of specimens it is not difficult to separate them.

In his second Supplement (p. 3) Wood suggested that this form was equivalent to *Buccinum elegans*, Dujardin, now known as *Nassa spectabilis*, Nyst; Prof. Peyrot, however, has kindly sent me a specimen from the Faluns of Touraine showing it to be different. The latter occurs also at Oakley, and is figured in Pl. V, fig. 16, of this work.

Nassa limata (Chemnitz). Plate IV, figs. 1, 2.

1786. *Buccinum limatum*, Chemnitz, Conch. Cab., vol. xi, p. 871, pl. clxxxviii, figs. 1808-9.
1873-5. *Nassa limata*, Seguenza, Boll. R. Com. Geol., vol. iv, p. 300, 1873; vol. v, p. 276, 1874; vol. vi, p. 278, 1875.
1879-82. *Nassa limata*, Fontannes, Moll. Plioc. Vall. Rhone., vol. i, p. 59, pl. v, fig. 3.
1886 *Nassa limata*, Dollfus et Dautzenberg, Et. prel. Coq. foss. Tour., p. 11.
1887. *Nassa limata*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 140, pl. xxv, figs. 10—15.
1890. *Nassa limata*, Carus, Prod. faun. Medit., vol. ii, p. 393.
1911. *Nassa (Uzita) limata*, Cerulli-Irelli, Faun. malac. mariana, pt. v. p. 248. pl. xl, fig. 11.

Specific Characters.—Shell ovato-conical, solid, much smaller and shorter in the spire than *N. prismatica*; whorls convex, the last rounded; ornamented with prominent longitudinal ribs, crossed by numerous exceedingly fine spiral striations, closely crowded together; apex acute; suture deep and undulate; mouth ovate; outer lip thickened externally by a broad labial rib, grooved within; canal very short, turning to the left.

Dimensions.—L. 15 mm. B. 10 mm. (occasionally larger).

Distribution.—*Recent:* Mediterranean, Adriatic, Ægean; coasts of western Europe; Madeira; Canaries.

Fossil: Coralline Crag; Gedgrave, Boyton. Waltonian: Walton-on-Naze, Little Oakley. Newbournian: Sutton, Newbourn (Ogden).

Pliocene: Italy; Sicily, Rhone valley. Pleistocene: Sicily.

Remarks.—The Crag *N. limata* seems to be specially characterised by its exceedingly fine and closely crowded spiral sculpture, in which respect our fossils correspond with the living shell. One of the former is here represented, together with a specimen from the Mediterranean kindly sent me by Dr. Eisig of the Stazione Zoologica at Naples; a comparison of these figures with those of *N. prismatica* will show the difference between the two.

Var. **anomala,** nov. Plate IV, fig. 3.

Dimensions.—L. 15 mm. B. 8 mm.

Distribution.—Not known living.

Fossil: Coralline Crag. Waltonian: Little Oakley. Newbournian: Newbourn.

Remarks.—In this abnormal variety of *N. limata*, of which I have obtained about a dozen specimens at Oakley, some of the delicate and inconspicuous spiral lines anastomose for a short distance, forming a series, about a third as numerous, of wide, strongly marked transverse ribs, separated by furrows of equal width which nearly obliterate the longitudinal costæ; a varix is then formed, after which the normal growth recommences, but the process is repeated just before the formation of the mature mouth; otherwise the shell agrees with the type. I have received an imperfect but recognisable specimen of this variety from the Messrs. Ogden, which they found at Newbourn.

Nassa serrata (Brocchi). Plate III, figs. 5, 6.

1814. *Buccinum serratum*, Brocchi, Conch. foss. subap., p. 338, pl. v, fig. 4.

1836–44. *Buccinum serratum*, Philippi, En. Moll. Sic., vol. i, p. 225; 1836; vol. ii, p. 191, 1844.

1848. *Nassa monensis (?)*, S. V. Wood, Mon. Crag Moll., pt. i, p. 31, tab. iii, fig. 5.

1870. *Nassa serrata*, A. Bell, Journ. de Conch., vol. xviii, p. 345.

1873–75. *Nassa serrata*, Seguenza, Boll. R. Com. Geol., vol. iv, p. 300, 1873; vol. vi, p. 278, 1875.

1882. *Nassa serrata*, Bellardi, Moll. Terr. Terz. Piem., pt. iii, p. 67, pl. iv, fig. 17.

1912. *Nassa serrata*, Tesch, Med. v. d. Rijks. v. Delfstoffen, pt. iv, p. 78.

Specific Characters.—Shell turreted; whorls convex, flattened above, with a deep suture; ornamented by longitudinal costæ, 15 or more on the body-whorl, prominent, obtuse, rather oblique, separated by furrows of equal width, intersected by narrow but strong spiral lines continuous across the longitudinal costæ, with deep and narrow sulci between them; apex somewhat obtuse; mouth suborbicular, angulated above; outer lip plicated within, corresponding with the spiral striæ outside; inner lip adherent to the pillar; canal short and wide, with a distinct notch.

Dimensions.—L. 22—32 mm. B. 14—18 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Little Oakley. Miocene and Pliocene: Holland, Italy. Scaldisien: Belgium, Holland. Upper Pliocene and Pleistocene: Sicily.

Remarks.—Of this species, characteristic of the Italian Pliocene, occurring also, but more rarely in the Miocene of that region, I have found several examples at Oakley. The true *N. serrata* has not been recorded hitherto from the East Anglian Crag or from any other British deposit; I have a few specimens from the Belgian Crag, however, which seem identical with the one here figured. My Oakley fossils correspond closely with some I collected years ago from the "argiles bleues" of the Ligurian coast, and with the figures and description of *N. serrata* given by Bellardi, except that they are somewhat shorter in the spire. Prof. Issel has kindly confirmed my reference of the Crag shells to the species named. The one given by S. V. Wood in 1848 as *N. monensis*, as to the identification of which with that species he afterwards expressed some doubt,[1] and is not the *N. monensis* of Forbes, may possibly be *N. serrata*. The apex in the present and the next species is less acute than in the *prismatica* group.

With the Oakley fossil I have figured a verified specimen from the Italian Pliocene.

Nassa ligustica, Bellardi. Plate III, figs. 7, 8.

1882. *Nassa ligustica*, Bellardi, Moll. Terr. Terz. Piem., pt. iii, p. 68, pl. iv, fig. 19.

Specific Characters.—Shell ovate, conical; whorls seven, convex, flattened above, ornamented by numerous longitudinal costæ, rather oblique and closely crowded together, and by well-marked and strong equidistant spiral ribs, giving the shell a reticulate appearance; spire gradually tapering to a somewhat abrupt point; suture deep; mouth suborbicular; outer lip broadly thickened outside, denticulate within; inner lip forming a thin but rather wide glaze upon the pillar; canal very short, turning sharply to the left.

[1] Mon. Crag Moll., 1st Suppl., p. 15, 1872.

Dimensions.—L. 25 mm. B. 14 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Little Oakley.

Lower Pliocene: Ligurian coast.

Remarks.—The unique specimen from Oakley here represented corresponds to a specimen I obtained some years ago from the "argiles bleues," I believe at Albenga, where Bellardi says this species is not uncommon.

N. ligustica belongs to the *serrata* group, but it differs from that species in form and sculpture, and is regarded by Bellardi and some other Italian palæontologists as distinct. In most of the Italian specimens of *N. ligustica* in my collection the sculpture is somewhat finer than in those now figured; Prof. Issel, however, identifies the Oakley shell as a variety of that species.

Nassa labiosa (J. Sowerby).

1825. *Buccinum labiosum*, J. Sowerby, Min. Conch., vol. v, p. 122, tab. ccccLxxvii, fig. 3.
1843. *Buccinum labiosum*, Nyst, Coq. foss. Terr. Tert. Belg., p. 577, pl. xliii, fig. 14.
1848–72. *Nassa labiosa*, S. V. Wood, Mon. Crag Moll., pt. i, p. 28, tab. iii, fig. 8; tab. vii, fig. 22, 1848; 1st Suppl., p. 15, 1872.
1871. *Nassa semistriata*, Jeffreys in Prestwich, Quart. Journ. Geol. Soc., vol. xxvii, pp. 144, 489.
1882. *Nassa labiosa*, Nyst, Conch. Terr. Tert. Belg., p. 31, pl. ii, fig. 13.
1892. *Nassa labiosa*, Van den Broeck, Bull. Soc. Belge Géol., vol. vi (Mémoires), pp. 121, 132.
1912. *Nassa labiosa*, Tesch, Med. v. d. Rijks. v. Delfstoffen, pt. iv, p. 80.

Specific Characters.—See Mon. Crag Moll., pt. i, p. 28.

Dimensions.—L. 16 mm. B. 8 mm.

Distribution.—Not known living.

Fossil: Coralline Crag: passim. Waltonian: Walton-on-Naze, Beaumont, Little Oakley (abundant); less so but generally found at all horizons of the Red Crag up to and including the Butleyan; not reported from the Icenian.

Belgium: Diestien; Scaldisien; Poederlien. Holland: Scaldisien.

Pleistocene of Sicily: Ficarazzi (F. W. H.).

Remarks.—The present species was unknown to Wood from Walton, and but rarely from the later zones of the Red Crag. He was consequently disposed to regard it as derivative in the latter from the Coralline. Recent researches, however, have shown it to be one of the characteristic fossils of the Waltonian deposits. Prof. Kendall informs me it is common at Walton, as I have found it to be at Beaumont and Oakley; I have between 300 and 400 specimens of it in my collection from the latter place. M. van den Broeck gives it also from the later zones of the Belgian Crag.

I agree with Wood that our shell, although nearly allied to it, is not identical with *Buccinum semistriatum*, Brocchi, of the Italian Pliocene, as believed by

Jeffreys, differing from it both in form and sculpture. The latter is smaller, the spire is shorter, the spiral striæ are confined to the upper whorls, which are longitudinally ribbed, and to the lower part of the last, each of the whorls having a clearly marked band at the top, immediately below the suture.

Bellardi has given about thirty closely allied species belonging to this group, but as far as I can judge from his figures, it is *N. gigantula*, Born, a species characteristic of the Upper Miocene and the Lower Pliocene, and some other similar forms that agree with our shell more nearly than does *N. semistriata*.

Some years ago, however, during a visit to Sicily, I obtained from the Pleistocene deposits of Ficarazzi near Palermo a number of specimens corresponding exactly with the Crag species in question.

N. labiosa belongs to the group of southern shells characteristic of the Mediterranean or the Italian Pliocene which occur in the earlier beds of the Crag, a gradually diminishing survival of an older Pliocene fauna of which now but little trace is left in these northern regions.

Nassa propinqua (J. Sowerby).

1825. *Buccinum propinquum*, J. Sowerby, Min. Conch., vol. v, p. 121, tab. ccccxlvii, fig. 2.
1843. *Buccinum propinquum*, Nyst, Coq. foss. Terr. Tert. Belg., p. 574, pl. xliii, fig. 10.
1843–70. *Nassa trivittata*, Gould (?), Rep. Inv. Mass., 1st ed., p. 309, fig. 211, 1843; 2nd ed., p. 364, fig. 632, 1870.
1848–72. *Nassa propinqua*, S. V. Wood, Mon. Crag Moll., pt. i, p. 30, tab. iii, fig. 2, 1848; 1st Suppl., p. 13, 1872.
1870. *Nassa propinqua*, A. Bell, Ann. Mag. Nat. Hist. [4], vol. vi, p. 215.
1871. *Nassa propinqua*, Jeffreys in Prestwich, Quart. Journ. Geol. Soc., vol. xxvii, p. 489.
1882. *Nassa propinqua*, Nyst, Conch. Terr. Tert. Belg., p. 27, pl. ii, fig. 9.
1892. *Nassa propinqua*, Van den Broeck, Bull. Soc. Belge Géol., vol. vi (Mémoires), p. 131.
1912. *Nassa propinqua*, Tesch, Med. v. d. Rijks. v. Delfstoffen, pt. iv, p. 80.

Specific Characters.—See Mon. Crag Moll., pt. i, p. 30.

Dimensions.—L. 20 mm. B. 11 mm.

Distribution.—*Recent:* north-eastern coasts of America (?).

Fossil: Red Crag: Waltonian; Newbournian; Butleyan. Icenian (rare): Bramerton, Easton Bavent. Scaldisien: Belgium; Holland.

Remarks.—Unlike many of the species already described, *N. propinqua* is of a North American rather than of a Mediterranean type. Jeffreys and A. Bell identified it with *N. trivittata*, Say, a recent species from the coast of Maine, a view which Wood seemed inclined to admit, but Nyst did not. Comparing the Crag fossil with some specimens which Mr. C. W. Johnson has kindly sent me from the Boston Museum, I am disposed to think the one may be a geographical variety of the other. The principal difference between the two is that in the American shell the upper part of the whorls and consequently of the mouth has a squared outline, and the first row of tubercles is not so distinctly separated from the others as in *N. propinqua*. Wood remarks that in the latter the outer lip is thickened and denticulated within, and that there is a small tooth on the body-whorl within the mouth. Neither of these features appears in *N. trivittata*, but in very many of my specimens of *N. propinqua* from Oakley the tooth is obsolete or nearly so, while in none of them is there any marked thickening or denticulation of the lip. If these forms are not varieties of one species they clearly belong to the same group.

Nassa monensis, Forbes. Plate IV, figs, 7, 8.

1839. *Nassa monensis,* Forbes, Mem. Wern. Soc., vol. viii, p. 95.
1846. *Nassa monensis,* Strickland, Proc. Geol. Soc., vol. iv, p. 8.
1846. *Nassa monensis,* Forbes, Mem. Geol. Surv., vol. i, p. 427.
1894. *Nassa monensis,* Kendall, Journ. Isle of Man Nat. Hist. Soc., vol. i, p. 419, pl. i, figs. 10—13.
1903. *Nassa monensis,* Lamplugh, Mem. Geol. Survey, Isle of Man, p. 475, fig. 82 (p. 336).

Specific Characters.—Shell ovate, small, solid and strong: whorls five or six, slightly concave, ornamented by a few narrow but prominent and distant ribs, varying in number, and by fine spiral thread-like lines which produce granulation where they intersect; mouth ovate, notched above; outer lip thickened outside by a strong labial rib, denticulated within; canal very short and oblique.

Dimensions.—L. 16 mm. B. 10 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Little Oakley. Newbournian: Newbourn.[1] Cranstal Point and elsewhere, Isle of Man.

Remarks.—There seems to have been an error as to the fossil figured by Wood in his Monograph (pt. i, p. 31, tab. iii, fig. 5) as *N. monensis.* He states in his first Supplement (p. 15) that being unable to trace the specimen upon which this species was originally founded, his identification must be regarded as uncertain.

In 1894, however, Prof. Kendall described some *Nassas* he had found in the Manx drift which he considered the true *N. monensis* of Forbes. As they differ widely from Wood's shell, and considerable confusion has arisen on the subject both in this country and on the continent, it seems desirable to figure a specimen which Prof. Kendall has kindly sent me, with another, not quite perfect, from Oakley, which corresponds with it. It is a special form and different from anything I know from the Crag. Mr. Lamplugh's figure does not correctly represent the present shell.

The *N. monensis* of Mörch (Geol. Mag., 1871, p. 397) is quite different; I have referred it in the sequel to *N. lamellilabra*, Nyst.

Nassa Kermodei, Kendall. Plate XIII, fig. 17.

1894. *Nassa Kermodei,* Kendall, Journ. Isle of Man Nat. Hist. Soc., vol. i, p. 419, pl. i, figs. 14—17.
1903. *Nassa Kermodei,* Lamplugh, Mem. Geol. Surv., Isle of Man, p. 475, fig. 83, p. 336.

[1] Mr. Ogden has recently sent to me a specimen of the present species from Newbourn.

Specific Characters.—Differs from *N. monensis* in its more slender form, and in the absence of spiral sculpture.

Dimensions.—L. 16 mm. B. 8 mm.

Distribution.—Not known living.

Fossil : Isle of Man.

Remarks.—This shell, which was described by Prof. Kendall as new and is regarded as distinct by Mr. Lamplugh, belongs to the *N. monensis* group. It might almost be considered a variety of that species were it not that all the specimens known to me, as well as those figured by Prof. Kendall, are without spiral sculpture. The figure in the Survey Memoir shows, it is true, fine transverse striation, but this seems to have been a mistake on the part of the artist, as the specimens in the Jermyn Street collection show no sign of it. The spire is more elongate in *N. Kermodei* than in the type form of *N. monensis.* I have a fossil from Oakley which may be the same, but it is not sufficiently good for satisfactory identification.

Nassa limatula, Dollfus and Dautzenberg. Plate IV, figs. 9, 10.

1886. *Nassa limatula,* Dollfus et Dautzenberg, Et. prel. Coq. foss. Fal. Tour., p. 11.

Specific Characters.—Shell slender, rather thin; whorls seven, very slightly convex, and flattened below the suture; spire elongate, with an obtuse apex; the first two whorls are smooth, the others ornamented with about twenty very narrow and acute longitudinal ribs, the spaces between them being wider than the ribs, together with numerous exceedingly fine thread-like spiral ridges closely crowded together, extending to the base of the shell, those just below the suture being stronger and further apart, forming a marginal band at the top of each whorl; mouth oval, acutely angulate above, with a tooth on the upper part of the inner lip; outer lip thickened outside by a strong labial rib, with a row of rounded tubercles within; canal open, very short, turning to the left.

Dimensions.—L. 10 mm. B. 5 mm.

Distribution.—Not known living.

Fossil : Waltonian Crag: Little Oakley. Miocene: Touraine.

Remarks.—I have a single specimen from Oakley of this Miocene species which MM. Dollfus and Dautzenberg are about to describe under the above name; though worn, it corresponds with one they have kindly sent me from Touraine. I have figured both to show they are identical.

Nassa consociata, S. V. Wood. Plate IV, figs. 17, 18; Plate XIII, fig. 19.

1843. *Buccinum elegans,* Nyst. Coq. foss. Terr. Tert. Belg., vol. xiii, fig. 19, p. 576, pl. xliii, fig. 13.
1848. *Nassa consociata,* S. V. Wood, Mon. Crag Moll., pt. i, p. 31, tab. iii, fig. 7.
1871. *Nassa elegans,* var., Jeffreys in Prestwich, Quart. Journ. Geol. Soc., vol. xxvii, pp. 144, 489.

1881. *Nassa elegans*, Nyst, Conch. Terr. Tert. Belg., p. 29, pl. ii, fig. 11.
1885. *Nassa elegans*, Lorié, Arch. Mus. Teyler [2], vol. ii, p. 90, pl. v, fig. 18.
1912. *Nassa consociata*, Tesch, Med. v. d. Rijks. v. Delfstoffen, pt. iv, p. 80.

Specific Characters.—See Mon. Crag Moll., pt. i, fig. 31.

Dimensions.—L. 15—20 mm. B. 8—10 mm.

Distribution.—Not known living.

Fossil: Coralline Crag: Gedgrave, Sutton, Boyton. Waltonian: Walton-on-Naze, Beaumont, Little Oakley. Newbournian: Waldringfield, Foxhall, Newbourn, Sutton, Felixstow. Butleyan: Butley. Isle of Man. Scaldisien: Belgium, Holland.

Remarks.—We have two varieties of *N. consociata* in the Crag, a short form, var. *brevis*, about 15 mm. in length, and another, with an elongate spire, which occasionally reaches 20 mm. I have found both in fair abundance at Oakley (about 50 of each).

This species made its first appearance in the Anglo-Belgian basin at the Gedgravian stage, becoming gradually less abundant in the later beds of the Red Crag, and being unknown from any deposits newer than those of Butley. It is allied to *N. elegans*, but has always been regarded as distinct, differing from the latter both in form and sculpture. *N. consociata* is a more slender shell, with an elongate and quasi-cylindrical spire; the costæ, both longitudinal and transverse, are stronger and more clearly granulate at the points of intersection. In *N. elegans* the suture is deeper and the whorls more decidedly convex, the last being wider in proportion to the length of the spire; the longitudinal ribs are almost knife-edged, instead of strong and rounded, as in *N. consociata.* It appears that Nyst reversed the names of these two species. The specimen figured by him in 1843 as *N. elegans* (*op. cit.*, pl. xliii, fig. 13), which is the more common form of the Scaldisien deposits and is still known in Belgium under that name, should be referred, I think, to Wood's species *N. consociata.* It differs slightly from the Crag shell, but is still further removed from Sowerby's *N. elegans.* I have given it in the present work (Pl. IV, fig. 18) as *N. consociata* var. *belgica.* Dr. Lorié's figure (*op. cit.*) seems to represent a short form of the same variety.

During a recent visit to the Isle of Man Mr. A. Bell discovered a specimen of the variety *brevis* near Cranstal point.

In the paper quoted above Jeffreys states, but I believe in error, that both the present species and *N. elegans* are living in the Atlantic and West European seas.[1]

Nassa elegans (Leathes, MS.) (J. Sowerby). Plate IV, figs. 19, 20.

1825. *Buccinum elegans*, J. Sowerby, Min. Conch., vol. v, p. 121, tab. cccclxxvii, fig. 1.
1848. *Nassa elegans*, S. V. Wood, Mon. Crag. Moll., pt. i, p. 30, tab. iii, fig. 1.
1881. *Nassa consociata*, Nyst, Conch. Terr. Tert. Belg., p. 24, pl. ii, fig. 5.

[1] M. Dollfus writes me that neither species is known to him living, either in the regions named or elsewhere.

Specific Characters.—See Mon. Crag Moll., pt. i, p. 30.

Dimensions.—L. 15—20 mm. B. 8—10 mm.

Distribution.—Not known living.

Fossil : Waltonian Crag (abundant) : Walton-on-Naze, Beaumont, Little Oakley. Newbournian : Bentley, Waldringfield, Newbourn, Sutton. Butleyan : Butley, Bawdsey. Isle of Man. Slains, Aberdeenshire. Scaldisien : Belgium.

Remarks.—As just stated, it seems to me that in 1843 Nyst reversed the names of this species and of the *N. consociata* of the English Crag. His specimen of 1881 (*op. cit.*, fig. 5) corresponds more nearly with Sowerby's species *N. elegans.*

The latter form has not been reported from the Coralline Crag, but is one of the most characteristic and common forms of Waltonian deposits. With the var. *intermedia* I have more than 200 specimens of it from Oakley in my collection.

Mr. A. Bell has sent me an imperfect but recognisable example from the Isle of Man which has been found recently by the Rev. S. N. Harrison.

Nassa granulata (J. Sowerby). Plate V, figs. 1—4; Plate XIII, fig. 20.

1818. *Buccinum granulatum,* J. Sowerby, Min. Conch., vol. ii, p. 18, tab. cx, fig. 4.
1843. *Buccinum granulatum (?),* Nyst, Coq. foss. Terr. Tert. Belg., p. 575, pl. xliii, fig. 11.
1848. *Nassa granulata,* S. V. Wood, Mon. Crag Moll., pt. i, p. 29, tab. iii, fig. 3.
1870. *Nassa granulata,* S. V. Wood, jun., and F. W. Harmer, Rep. Brit. Assoc. (Liverpool), Trans. Sect., p. 91.
1881. *Nassa granulata,* Nyst, Conch. Terr. Tert. Belg., p. 24, pl. ii, fig. 6.
1888. *Nassa granulata,* A. Bell, Rep. Brit. Assoc. (Bath), p. 139.
1892. *Nassa granulata,* Van den Broeck, Bull. Soc. Belg. Géol., vol. vi (Mémoires), p. 121.
1912. *Nassa granulata,* Tesch, Med. v. d. Rijks. v. Delfstoffen, pt. iv, p. 80.

Specific Characters.—See Mon. Crag Moll., pt. i, p. 29.

Dimensions.—L. 10—15 mm. B. 5—6 mm.

Distribution.—*Recent :* Japan.

Fossil : Coralline Crag. Waltonian ; Newbournian ; Butleyan ; Icenian. Isle of Man. Pleistocene : Middle Glacial sands, Billockby ; Ballybrack Bay, Killiney. Scaldisien : Belgium, Holland.

Remarks.—Of this well-known and abundant Red Crag species, specimens of which may be collected almost by the thousand in the Waltonian deposits, four well-marked varieties, here figured, occur at Little Oakley, the typical form (fig. 1) being rather the most abundant. Fig. 3, however, which I distinguish as var. *gracilis,* is exceedingly common at that place, and may be found in our public collections from other horizons in the Crag. It is a smaller and more delicate shell than the type; the sculpture is finer, both the longitudinal and transverse ridges being more numerous and less pronounced, and the intersecting points generally less nodulous, giving the shell a finely reticulate rather than a strongly granulate appearance. Mr. A. Bell has recently found a perfect specimen of this variety at Cranstal Point in the Isle of Man. Fig. 2, var. *elongata*, is somewhat similar, but the whorls are more convex, the sculpture coarser, the shell rather rugose, and the spire, as a rule, more elongated. Fig. 4, var. *fenestrata*, is a tumid form with reticulate sculpture, the transverse and longitudinal costæ being further apart than in the type, and nearly equidistant; moreover it is not so distinctly granulate.

Out of many hundred specimens in my collection from Oakley, these four varieties named may be more or less easily separated. We may regard them as incipient species, which might eventually have become distinct.

Nassa granulata is not known as a fossil from any horizon older than the English Crag, but Jeffreys gives it, probably in error, as West European.[1] Wood states, however (*fide* A. Bell), that it is living in Japanese seas.

Buccinum granulatum, Philippi, is a different species.

Nassa Dautzenbergi, sp. nov. Plate V, figs. 5, 6.

Specific Characters.—Shell short, ovato-conical, thick and strong; whorls slightly convex, regularly tapering to a blunt point, the last more than half the total length; ornamented by prominent rounded tubercles of regular form, arranged in longitudinal and transverse rows, extending nearly, but not quite to the base of the shell; in the type there are eight or nine rows of the latter on the body whorl, and four or five on the next above it; suture fairly deep; mouth short, oval, with an angulate notch at the upper end, and a tooth on the left of it; outer lip thickened outside and denticulate within; inner lip reflected on the pillar; canal very short.

Dimensions.—L. 13 mm. B. 7 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Walton-on-Naze, Little Oakley (rather rare). Newbournian: Newbourn (Ogden). Butleyan: Butley. Probably elsewhere in the Red Crag.

Remarks.—Out of the many specimens of the smaller Nassas I have examined from Oakley there are some which, separating themselves from *N. propinqua* on the one hand and *N. granulata* on the other, form a distinct group, varying somewhat *inter se* in size and sculpture, but always maintaining a special character of their own. I adopt for them the above name in honour of the distinguished conchologist whose work is so often referred to in this Monograph.

In sculpture they approach *N. propinqua* and differ from *N. granulata*: in form and size, in the mouth, and especially in the thickened outer lip, on the other hand, they come nearest to the latter. *N. granulata* is ornamented with distinctly elevated longitudinal ribs, crossed by raised and continuous spiral lines

[1] M. Dollfus informs me that neither he nor M. Dautzenberg know of any *Nassa* living in the West European region which approaches, even remotely, the present species.

which are carried over the former, and become granulate at the point of intersection. In *N. Dautzenbergi* the tubercles stand out prominently as in *N. propinqua*, the connection between them, both longitudinal and spiral, being comparatively inconspicuous. The two groups do not seem to be connected by intermediate varieties. In one of the latter, var. *crassisculpta*, the sculpture is coarser than in the type.

Probably this form has been overlooked by collectors, having been taken for a variety of *N. granulata*. One occasionally meets with specimens in collections, as at the Sedgwick Museum, Cambridge, where the difference between the two has been recognised. I noticed there an example of the species in question from Walton, which had been labelled *Nassa sp.* It is when dealing with a number of specimens, however, that its true distinction becomes apparent.

Var. **simplex**, S. V. Wood. Plate V, fig. 7.

1872. *Nassa reticosa*, var *simplex*, S. V. Wood, Mon. Crag Moll., 1st Suppl., p. 15, tab. iv, fig. 3.

Dimensions.—L. 10 mm. B. 5 mm.

Distribution.—Not known living.

Fossil: Coralline Crag: Gedgrave. Waltonian Crag: Walton-on-Naze. Butleyan: Butley.

Remarks.—The specimen here figured, which was obtained at Walton, is also from the Sedgwick Museum at Cambridge. It agrees with the type form of *N. Dautzenbergi*, except that the sculpture is more delicate. It appears to correspond with the shell figured by Wood as *N. reticosa*, var. *simplex* (*op. cit.*). Its affinities, however, are with the first named species, I think, rather than with the latter. The mouth is different from that of any of the polymorphous varieties of *N. reticosa*.

Var. **minuscula**, nov. Plate V, fig. 8.

Dimensions.—L. 6—8 mm. B. 4—6 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Walton-on-Naze, Beaumont, Little Oakley. Newbournian: Sutton, Bentley. Butleyan: Butley. Probably elsewhere in the Red Crag.

Remarks.—I have 60 or 70 specimens from Oakley of this minute shell, all about the same size, corresponding with the type form of *N. Dautzenbergi*, except that they are much smaller, and more delicately sculptured. They appear to be full grown, having the mouth perfect, and the outer lip thickened and denticulate within, as in that species. They may represent a case of adult but premature development, similar to those discussed by Prof. H. W. Shimer of Boston in his treatise on Dwarf Faunas.[1]

[1] American Naturalist, vol. xlii (1908), p. 472.

Prof. Shimer attributes the phenomenon in question to changes in the conditions under which the mollusca may have lived, as, for example, in the temperature or salinity of the water. In the present case the dwarfed and full-sized forms are found in the same deposit, although the former are the most common, possibly indicating, if the view quoted is correct, the existence of an estuarine habitat at no great distance from this part of the Red Crag sea. Dr. Øyen informs me that similar cases of dwarfed mollusca occur in Norwegian waters.

The comparative abundance of this variety at Oakley suggests that it might also be found at other horizons of the Red Crag, having been mistaken for young specimens of *N. granulata* or *N. propinqua*.

Nassa Dollfusii, sp. nov. Plate V, fig. 9.

1879. *Nassa angulata (?)*, S. V. Wood (non Brocchi), Mon. Crag Moll., 2nd Suppl., p. 4, tab. iv, fig. 14.

Specific Characters.—Shell ovate, short, small, thick and strong, with 5 whorls, more or less convex and usually with a deep suture, having 12 to 15 well-marked, elevated and slightly curved longitudinal ribs on the body-whorl, intersected by about 10 strong spiral costæ which form a slight tubercular decussation where they cross the ribs, but not of so pronounced a character as in *N. granulata* or *N. propinqua*; mouth suborbicular, notched and angular above, less than half the total length; canal distinct but narrow and very short, inclining to the left; outer lip thickened outside by a labial rib, having a row of coarse tubercles within, continuous with a series of strongly marked flutings on the inner lip, which is thick and folded back on the columella. The basal part is separated from the rest of the body-whorl by a deep groove, as in *N. incrassata*.

Dimensions.—L. 10–12 mm. B. 6—8 mm.

Distribution.—Not known living.

Fossil: Coralline Crag: Boyton. Waltonian: Little Oakley. Butleyan: Butley. Probably elsewhere in the Red Crag.

Remarks.—I have about 20 specimens of a small, strong, and coarsely sculptured *Nassa* from Oakley, which on the whole seem to correspond with the one figured by S. V. Wood as *N. angulata*, Broc. Submitting some of them to M. Dollfus he expressed a decided opinion that neither they nor that given by Wood can be referred to Brocchi's species, a view with which, from a comparison of them with some fossils from Altavilla, near Palermo, kindly sent me by the Marchese di Monterosato, I am compelled to agree.

M. Dollfus equally insists that the Oakley specimens are not a variety of *N. incrassata*, a form to which they bear some resemblance, and suggests that I should give them a fresh specific name. I venture therefore to dedicate this little shell to my old friend in acknowledgment of the assistance he has so willingly given me for many years.

N. Dollfusii seems specially distinguished by its form, the coarseness of its sculpture, both longitudinal and transverse, and by the strongly marked fluting on the inner lip.

Var. **convexa**, nov. Plate V, fig. 10.

Remarks.—This distinct form, also from Oakley, seems to belong to the present group, having the same coarse ridges on the inner lip. It differs from the type, however, in the greater convexity of its whorls, and in its longitudinal costæ, which are fewer and more prominent.

Nassa pusillina, S. V. Wood. Plate V, figs. 27, 28.

1864. *Nassa sp.*, S. P. Woodward, in White's History of Norfolk, 3rd ed., p. 117.
1870. *Nassa pusio*, S. V. Wood, jun., and F. W. Harmer, Rep. Brit. Assoc. (Liverpool), Trans. Sect., p. 90.
1870. *Nassa variabilis*, A. Bell, Ann. Mag. Nat. Hist. [4], vol. vi, p. 29.
1871. *Nassa Cuvieri*, Jeffreys, in Prestwich, Quart. Journ. Geol. Soc., vol. xxvii, p. 489.
1872–4. *Nassa pusilina*, S. V. Wood, Mon. Crag Moll., 1st Suppl., p. 14, tab. ii, fig. 7, 1872; and var. *variabilis*, p. 176, Addendum plate, fig. 24, 1874.

Specific Characters.—Shell small, slender, elongate; whorls 6, but slightly convex, regularly tapering to a fine rounded point, the two first smooth, the others ornamented with about 10 flexuous longitudinal costæ, narrower than the spaces between them, with very fine, delicately chiselled spiral striæ which cross the ribs but hardly cause tuberculation at the point of contact; last whorl not pinched up above the canal, as in *N. incrassata;* suture slight; mouth ovate, acutely angulate above, short, from one-third to one-fourth the total length of the shell; canal very short, open; inner lip reflected on the pillar.

Dimensions.—L. 8 mm. B. 3 mm.

Distribution.—Not known living.

Fossil: Newbournian Crag: Ramsholt (Ogden). Butleyan: Butley, Bawdsey. Icenian: Beccles, Bramerton (not rare). Middle Glacial Sands: Billockby.

Remarks.—There is some confusion as to the correct nomenclature of this charming little shell, which has been known to Norfolk collectors from the time of S. P. Woodward onwards. In the list of fossils from the Norwich Crag published by the latter (*op. cit.*), it is given, on the authority of the late R. Wigham, as "Nassa sp., slender, pointed, examples in all collections." It was at first called *N. pusio* by Wood the younger and myself, but as this name had been previously used for another shell, it was changed in 1872, in the 1st Supplement to the Crag Mollusca, to *N. pusillina*, being afterwards referred by Jeffreys to *N. Cuvieri;* it differs, however, from any variety of the latter species known to me, and I therefore retain the name proposed by Wood.

The specimen figured by the latter (1st Suppl., tab. ii, fig. 7) as *N. pusillina*, does not clearly represent the normal form of this species, the sculpture of which, both longitudinal and transverse, is more delicate.

In the Addendum plate of the 1st Supplement (fig. 24), however, Wood gives a shell as *N. pusillina*, var. *variabilis*, having ornamentation which approaches more nearly that of the typical *N. pusillina*, though its form is different; it is neither slender nor pointed; it may probably be a short variety. The present species, which appears to be very distinct, is more or less distinctive of the later horizons of the Crag, being rarely recorded from any earlier zone than the Butleyan. In the Norwich Crag it was formerly met with, not infrequently, at Bramerton, and Mr. W. M. Crowfoot has several specimens from the boring at Beccles. In the year 1869, S. V. Wood and I found it to be fairly common in the Middle Glacial sand at Billockby. A number of the specimens from that place are in the Norwich Castle Museum.

The Butleyan variety (Pl. V, fig. 27) is usually more elongate than that from the Norwich Crag (fig. 28).

Nassa venusta, sp. nov. Plate V, fig. 18.

Specific Characters.—Shell minute, delicate, turreted; whorls 6, slightly convex, regularly tapering; sculpture 10 or 12 longitudinal costæ, intersected by fine spiral striæ causing minute and finely chiselled nodules where they cross the costæ; suture distinct; mouth oval, with a labial notch above, and a tooth on the left side of it; outer lip ridged and denticulated within; inner lip not folded closely upon the pillar, but standing out from it, forming, except where interrupted by the canal, a flat, continuous peristome; canal short and open.

Dimensions.—L. 6 mm. B. 3 mm.

Distribution.—Not known living.

Fossil: Coralline Crag: Boyton. Waltonian: Little Oakley. Newbournian: Newbourn, Felixstow, Sutton.

Remarks.—I have found at Oakley about a dozen specimens of this little shell, most of them beautifully perfect, and Mr. W. E. Ogden has obtained another from Newbourn. They belong to the granulate group of Nassas characteristic of the Waltonian Crag, but depart sufficiently from any hitherto figured to deserve, I think, specific rank. I have shown my specimens to MM. Dollfus and Dautzenberg, and to the Marchese di Monterosato, but none of them know any Mediterranean or West European form, recent or fossil, to which they can be referred.

Var. **Woodii**, nov. Plate V, fig. 19.

Dimensions.—L. 7 mm. B. 3 mm.

Distribution.—Not known living.

Fossil : Coralline Crag : Boyton. Waltonian ; Little Oakley.

Remarks.—The shell here represented is from Oakley, and there is another from Boyton in the York Museum belonging to the same group. It appears to agree generally with *N. venusta* except that the sculpture is coarser.

Nassa Woodwardi, sp. nov. Plate V, figs. 20, 21 ; Plate XIII, fig. 18.

Specific Characters.—Shell small, strong, distinctly conical ; whorls 6, flat, rapidly and regularly diminishing in size, the last much the largest, ornamented by about 12 straight nodular ribs, continuous except as interrupted by the suture, crossed by inconspicuous spiral striæ ; suture slight ; mouth ovate, with a labial notch above, and a tooth on the left side as in the last species ; outer lip thickened outside by a labial rib, denticulated within ; canal very short, turning to the left.

Dimensions.—L. 8 mm. B. 5 mm.

Distribution.—Not known living.

Fossil : Waltonian Crag : Little Oakley. Butleyan : Butley. Probably elsewhere in the Red Crag. Wexford gravels, Rathaspic. Scaldisien : Antwerp.

Remarks.—I believe this form to be distinct, although belonging to the same smal and granulated group as the last ; it occurs not only in the English Crag but also in the Scaldisien of Belgium and in the Wexford gravels. I dedicate it to the memory of Samuel Woodward, a Norwich man, who in 1833 was publishing figures of fossils from the Crag, and of his illustrious descendants who have made for ever the Icenian patronymic Woodward a household name among geologists.

It approaches *N. recticostata*, Bellardi, which occurs at St. Erth, but is not the same.

Nassa lamellilabra, Nyst. Plate IV, figs. 11—13.

1835. *Buccinum lamellilabrum*, Nyst, Rech. Coq. foss. d'Anv., p. 33, pl. v, fig. 48.

1881. *Nassa lamellilabra*, Nyst, Conch. Terr. Tert. Belg., p. 31, pl. xxviii, fig. 10.

1887. *Nassa monensis*, var., Mörch and Poulsen, plates and MS. list in Geological Museum, Copenhagen, no. 29, tab. iv, fig. 4 (unpublished).

Specific Characters.—Shell ovato-conical, elongate, ornamented by numerous flexuous longitudinal ribs, about 20 on the body-whorl, and by faint spiral striations, subgranulose where they intersect the ribs ; whorls flattened ; mouth large, ovate, projecting beyond the canal, angulate above ; outer lip regularly curved, spreading, having a well-marked row of thread-like denticulations within, 1 mm. in length; canal open, very short.

Dimensions.—L. 16—18 mm. B. 8 mm.

Distribution.—Not known living.

Fossil: Coralline Crag: Boyton. Waltonian: Little Oakley. Scaldisien: Belgium. Pliocene of Iceland.

Remarks.—There is a perfect specimen of this very distinct form in the British Museum (Natural History) which corresponds with the shell originally figured by Nyst, and with one from Antwerp, kindly sent me by M. van de Wouver; I have, moreover, received some from Dr. Ravn of Copenhagen from the Mörch collection of Iceland Crag fossils, which are evidently the same, although referred in error to *N. monensis.* That species, however, is very different as previously shown (Pl. IV, fig. 7). *N. lamellilabra* seems allied to *N. musiva*, Brocchi, a characteristic form of the Upper Pliocene deposits of Italy.

Var. **elegantula** (S. V. Wood, MS.), nov. Plate IV, figs. 14—16.

1871. *Nassa pulchella,* A. Bell, Ann. Mag. Nat. Hist. [4], vol. vii, p. 355.
1872. *Nassa pulchella,* S. V. Wood, Mon. Crag Moll., 1st Suppl., p. 13, tab. vi, fig. 7.
1877. *Nassa monensis,* Mörch and Poulsen, plates and MS. list in Geological Museum, Copenhagen, no. 28, tab. iv, fig. 3 (unpublished).
— *Nassa elegantula,* S. V. Wood, MS., Ipswich Museum.

Dimensions.—L. 12—14 mm. B. 6—7 mm.

Distribution.—Coralline Crag: Gedgrave, Boyton. Waltonian: Little Oakley. Newbournian: Waldringfield. Scaldisien: Belgium. Iceland Crag.

Remarks.—One of the shells figured under this name is from the Ipswich Museum, and comes from the Coralline Crag. It is accompanied by a note in Wood's writing, "*Nassa elegantula.*" I have examples in my own collection of the same kind, two or three from Oakley, and another from Antwerp; it also occurs among the specimens from the Iceland Crag.

It differs from *N. lamellilabra* in size, form, and somewhat in sculpture, but may be regarded, I think, as a variety of that species. The mouth in both cases is very characteristic and differs from anything else in the Crag. One of the Oakley specimens (fig. 15), which is worn and has nearly lost the external sculpture, shows this feature distinctly. The present variety appears to correspond with the shell described by Mr. A. Bell in 1871 as *N. pulchella,* of which he remarks that it is deeply striated or grooved, as well as with that figured by Wood, by whom it was referred to a Russian fossil figured by Andrzejowski under the same name.[1] The latter, however, appears to be a different species.

Nyst, in his Monograph of 1878, makes no mention of *N. pulchella,* and as the

[1] Bull. Soc. Imp. Nat. Moscou, vol. vi, p. 438, pl. xi, fig. 2, 1833.

present form occurs in the Belgian Crag I presume he considered it distinct from the Russian shell.

Nassa spectabilis (Nyst). Plate V, figs. 16, 17.

1837. *Buccinum elegans*, Dujardin (non Sowerby), Mém. Soc. Géol. France, vol. ii, p. 298, pl. xx, figs. 3, 10.
1843. *Buccinum spectabile*, Nyst, Coq. foss. Terr. Tert. Belg., p. 577.
1886. *Nassa spectabilis*, Dollfus et Dautzenberg, Et. prel. Coq. foss. Fal. Tour., p. 11.

Specific Characters.—Shell small, rather fragile, ovato-conical; whorls convex, the last much the largest, one half the total length; spire short, with an obtuse apex; ornamented by about 16 rather blunt longitudinal ribs as wide as the spaces between them, and by very fine spiral striæ which cross the ribs but do not cause tuberculation where they intersect; suture deep; mouth ovate, acutely angulate above, with a tooth on the left, and a row of short raised ridges on the inside of the outer lip; canal short and open, turning to the left.

Dimensions.—L. 10 mm. B. 6 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Little Oakley. Miocene: Touraine.

Remarks.—The Oakley shell here figured was perfect when I found it, but was afterwards broken by accident. M. Dautzenberg, however, had previously identified it as a well-known Miocene species, *N. spectabilis*. I figure with it a perfect specimen from the Faluns of Touraine, which Prof. Peyrot was kind enough to send me.

Nassa turonica (Deshayes). Plate V, figs. 14, 15.

1837. *Buccinum graniferum*, Dujardin, Mém. Soc. Géol. France, vol. ii, pt. 2, p. 299, pl. xx, figs. 11, 12.
1844. *Buccinum turonense*, Deshayes (Lamarck), Hist. Nat. Anim. sans Vert., 2nd ed., vol. x, p. 223.
1871. *Nassa granifera*, A. Bell, Ann. Mag. Nat. Hist. [4], vol. vii, p. 355.
1872. *Nassa granifera*, S. V. Wood, Mon. Crag Moll., 1st Suppl., p. 11, tab. vi, fig. 11.
1886. *Nassa turonica*, Dollfus et Dautzenberg, Et. prel. Coq. foss. Fal. Tour., p. 11.
1897. *Nassa granifera*, A. Bell, Trans. Roy. Geol. Soc. Cornwall, vol. xii, p. 142.

Specific Characters.—Shell small, solid; whorls more or less convex, with strong longitudinal ribs, which do not reach the base of the shell; crossed by spiral striæ, giving rise to granulation at the point of intersection; mouth oval, sharply angulated above; canal notched, very short, the back of it transversely striated, separated from the body-whorl by a deep groove.

Dimensions.—L. 10 mm. B. 5 mm.

Distribution.—Not known living.

Fossil: Coralline Crag. Red Crag: Waltonian and Newbournian. St. Erth.

Miocene: Touraine.

Remarks.—S. V. Wood speaks of having obtained two examples of *N. granifera* (a shell which MM. Dollfus and Dautzenberg now identify with *Buccinum turonense*, Deshayes) from the Coralline Crag of Sutton, and another from the Red Crag of the same locality. Mr. A. Bell found it also at St. Erth.

The form is fairly common, however, at Oakley, some of the specimens being unworn.

Its occurrence at that place is interesting as its comparative abundance negatives the view that it is derivative; the frequent presence of this and other characteristic Miocene species at the Waltonian stage, tends to support the view I have taken that this, the oldest known horizon of the Red Crag, is more closely connected with the Coralline Crag which preceded it than has hitherto been supposed. My specimens correspond with Wood's figure, but they are not so tumid. In form and in other respects they agree with some I collected in Touraine, except that the Crag shells are generally more distinctly granulate; the latter may perhaps be regarded as a variety of the Miocene species. That they should differ somewhat from it need hardly surprise us when we remember that they lived in different areas and at periods widely separated.

Nassa cf. **Edwardsi,** Fischer. Plate V, figs. 22, 23.

1882. *Nassa Edwardsi*, Fischer, Journ. de Conch., vol. xxx, p. 50.
1890. *Nassa Edwardsi*, Carus, Prod. faun. Medit., vol. ii, p. 396.
1897. *Nassa Edwardsi*, Locard, Exped. Trav. Talis., vol. i, p. 267, pl. xiii, figs. 29, 30.
1898. *Nassa Edwardsi*, Bucquoy, Dautzenberg, et Dollfus, Moll. mar. Rouss., vol. ii, p. 791.

Specific Characters.—Shell small, ovato-conical; apex obtuse; whorls 6, slightly convex; suture subcanaliculate; ornamented by exceedingly fine, equidistant spiral striæ, extending to the base of the shell; mouth ovate, acutely angulate above; outer lip thickened, plicated within; inner lip forming a glaze which is spread over the pillar; canal short, open, notched.

Dimensions.—L. 10 mm. B. 6 mm.

Distribution.—*Recent:* Mediterranean.

Fossil: Waltonian Crag: Walton, Little Oakley. Newbournian: Bentley. Sicilian Pleistocene: Ficarazzi, near Palermo and elsewhere.

Remarks.—I have obtained two specimens of this shell from Oakley, one immature, the other full grown.[1] They appear to correspond with some fossil shells from Sicily received from the Marchese di Monterosato, one of which is here figured, together with another, also immature, found at Bentley by Mr. P. G. H. Boswell, F.G.S.

[1] The full-grown specimen, which showed the spiral markings distinctly, has unfortunately been lost.

Nassa Kennardi, sp. nov. Plate V, fig. 11.

Specific Characters.—Shell rather small, ovato-conical; whorls 6, slightly convex, regularly tapering, the last more than half the total length; ornamented by 8 longitudinal ribs, prominent and rounded, which are flexuous on the body-whorl and nearly reach the base of the shell; the ribs are crossed by closely set spiral ridges which do not cause tuberculation at the point of intersection; suture deep; mouth oval, angulate above; outer lip thin, curved; inner lip forming a glaze adherent to the pillar; canal open, short, notched.

Dimensions.—L. 13 mm. B. 6 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Little Oakley.

Remarks.—The interesting fossil here figured, of which I have found but one specimen during my many visits to Oakley, is strikingly different to any other of the Crag Nassas. It belongs to some group hitherto unrepresented in our East Anglian deposits.

Var. **elongata**, nov. Plate V, figs. 12, 13.

Dimensions.—L. 18 mm. B. 8 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Little Oakley. Poederlien: Antwerp.

Remarks.—Examining the collection of Mr. van de Wouver, I noticed some specimens of an undescribed species of *Nassa* which, differing in some respects from *N. Kennardi*, may probably be a variety of that species. I have several fragments of what seems the same thing from Oakley, but as they are not so nearly perfect as the Belgian fossil, I figure both. The shells in question are nearer to *N. Kennardi* than to any other species of the Crag Nassas.

Nassa pumila, sp. nov. Plate V, fig. 24.

Specific Characters.—Shell very small, strong, ovato-conical; whorls 4, somewhat convex, rapidly diminishing in size, the last tumid, two-thirds the total length; ornamented by about 15 well-marked longitudinal costæ, not so wide as the intervening spaces, and by fine spiral lines which cause partial granulation where they cross them; spire very short; suture deep; mouth ovate; outer lip thickened outside by a wide rib, grooved within; inner lip strong and strongly toothed; canal wide, very short.

Dimensions.—L. 7·5 mm. B. 5 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Little Oakley.

Remarks.—At first sight the shell here figured might be regarded as a variety of *N. incrassata*, but the fact that it was found at Oakley, where that species is unknown, is not in favour of such a view, nor does the opinion of the experts to whom it has been shown support it. As it does not appear to be specially related to any other Oakley form, except possibly as a dwarf variety of *N. Dollfusii*, I figure it provisionally under the above name.

Nassa incrassata (Ström).

1768. *Buccinum incrassatum*, Ström, Kong. Norsk. Vid. Selsk. Skr., vol. iv, p. 369, pl. xvi, fig. 25.
1848–72. *Nassa incrassata*, S. V. Wood, Mon. Crag. Moll., pt. i, p. 29, tab. iii, fig. 4, 1848; 1st Suppl., p. 12, 1872.
1853. *Nassa incrassata*, Forbes and Hanley, Brit. Moll., vol. iii, p. 391, pl. cviii, figs. 3, 4.
1867. *Nassa incrassata*, Jeffreys, Brit. Conch., vol. iv, p. 351, pl. lxxxviii, fig. 1.

Var. β. Plate V, figs. 25, 26.

1905. *Nassa incrassata*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. iii, p. 156, pl. xxvi, figs. 21—22.

Varietal Characters.—Differs from the typical British form in its smaller size, thinner texture, and more delicate sculpture; the outer lip is thickened outside, but not so strongly.

Dimensions.—L. 9 mm. B. 5 mm.

Distribution.—Recent: reported from the Scilly Isles and the Algerian coast (Tomlin); Christiania fiord.

Fossil: Coralline Crag. Newbournian: Sutton, Felixstow. Butleyan: Butley. Pleistocene: Norway.

Remarks.—In the Wood collection at the Norwich Museum there are specimens of a small and delicate variety of *N. incrassata* from the Newbournian Crag of Sutton and Felixstow, and similar fossils are not infrequently met with in the Butleyan deposits. They correspond with some shells from the Christiania fiord which I have received from Dr. Øyen. In form and texture they approach *N. pygmæa*, but are not granulate, nor do they ever show the varix so characteristic of that species.

Mr. J. R. de B. Tomlin informs me that he has this unnamed variety of *N. incrassata* in his collection from the Scilly Islands and that it has been dredged in deep water off the Algerian coast. It seems to be common in the Christiania region both as a Recent shell and in the Pleistocene beds, especially in the later horizons. *N. incrassata* was reported by Wood from the Coralline Crag, but I have not seen it at Oakley, nor have Prof. Kendall or the brothers Bell found it at Walton.

The smaller Nassas of the Waltonian Crag are predominantly granulate, *N.*

granulata and *N. propinqua* being the most abundant. In the upper zones of the Red Crag *N. incrassata*, a species but faintly granulate, becomes fairly common, the present variety being the most so. At the Icenian or Norwich horizon, *N. granulata* and *N. propinqua* are exceedingly rare, while *N. incrassata* becomes a characteristic though not a very frequent species.

The *N. incrassata* of the Italian Pliocene, figured by Bellardi (Moll. Terr. Terz. Piem., pt. iii, pl. vi, fig. 18), seems a somewhat different shell.

The present variety appears to connect itself with the type, both in this country and Scandinavia, by intermediate forms. In Crag times it appears to have been more or less distinct. Two of the Recent specimens from the Mediterranean figured by Prof. Kobelt (*op. cit.*) seem to be the same.

Genus **DESMOULEA**, Gray, 1847.

Desmoulea conglobata (Brocchi).

1814. *Buccinum conglobatum*, Brocchi, Conch. foss. subap., vol. ii, p. 334, pl. iv, fig. 15.
1848–72. *Nassa conglobata*, S. V. Wood, Mon. Crag Moll., pt. i, p. 32, tab. iii, fig. 9, 1848; 1st Suppl., p. 15, 1872.
1875. *Nassa conglobata*, Seguenza, Boll. R. Com. Geol., vol. vi, p. 276.
1882. *Nassa conglobata*, Bellardi, Moll. Terr. Terz. Piem., vol. iii, p. 83, pl. v, fig. 17.
1901. *Desmoulea conglobata*, Cossmann, Ess. Paléont. comp., vol. iv, p. 215, pl. ix, fig. 13.
1904. *Nassa (Desmoulea) conglobata*, Sacco, Moll. Terr. Terz. Piem., pt. xxx, p. 66, pl. xv, figs. 63, 64.

Specific Characters.—See Mon. Crag Moll., pt. i, p. 32.

Dimensions.—L. 35 mm. B. 26 mm.

Distribution.—*Fossil:* Waltonian Crag: Walton-on-Naze, Beaumont, Little Oakley. Newbournian: Sutton, Waldringfield.

Italian Pliocene: Piacenza (Brocchi), Asti (Sacco). Sicilian: Altavilla, Legoli (Seguenza).

Remarks.—This species, formerly grouped with the Nassas, is now referred to *Desmoulea*. It was known to Wood from Walton only, but I have found a perfect and unworn specimen at Beaumont, and another, fragmentary, at Oakley. There are two from Waldringfield in the Ipswich Museum, and one from Sutton at Cambridge.

Genus **BUCCINUM**, Linné, 1758.

Remarks.—While the general facies of the Red Crag mollusca changes gradually as we proceed from Walton to Butley, we find at Oakley, where on the whole the fauna is similar to that of Walton and prevalently southern, the abrupt appearance of boreal and even arctic species, as in the case of some of the Buccinums now to be described. This might at first sight seem antagonistic to the zonal arrangement I have adopted; the difficulty is, however, more apparent than real. Counting shells rather than species, such forms are exceedingly rare. I hope to deal with this point more fully later on. The advance of the Scandinavian ice over the bed of the North Sea would probably have driven many northern forms southwards, while their invasion of the Crag basin at the Oakley stage may have been due to a sudden breach in the land barrier which during the earlier part of the Crag history seems to have separated it from northern seas.

Buccinum undatum, Linné, 1758.

1758. *Buccinum undatum*, Linné, Syst. Nat., ed. x, p. 740, no. 410.
1848. *Buccinum undatum* (type), S. V. Wood, Mon. Crag Moll., pt. i, p. 35, tab. iii, fig. 12 *c*.
1853. *Buccinum undatum*, Forbes and Hanley, Brit. Moll., vol. iii, p. 401, pl. cix, fig. 5.
1867. *Buccinum undatum*, Jeffreys, Brit. Conch., vol. iv, p. 285, pl. lxxxii, fig. 2.

Remarks.—The typical form of this British and northern species, a strong shell with coarse sculpture and prominent ribs as shown in the works named above, is not very common in the English Crag, although some of the varieties described below are fairly so. They are not adequately represented in our public collections, as such fossils are difficult to obtain in perfect condition. Unfortunately collectors have paid but little attention to fragmentary specimens, though they are often of great interest and importance. Many such specimens have been thrown away as useless which might have been identified by careful examination.

Of the recognised forms of this shell several were described and figured by Wood, but there are others more or less abundant in our deposits which deserve notice. A number of Buccinums, moreover, generally regarded as distinct, have turned up in the Crag during recent years or have remained unnoticed in our Museums[1]; the latter are usually labelled *B. undatum*, probably under the impression that most of our Crag specimens might be considered varieties of that species.

Var. **clathrata**, S. V. Wood. Plate VI, figs. 1, 2.

1853. *Buccinum undatum*, Forbes and Hanley, Brit. Conch., vol. iii, pl. cix, fig. 3.
1872. *Buccinum undatum*, var. *clathratum*, S. V. Wood, Mon. Crag Moll., 1st Suppl., p. 18, tab. ii, fig. 3.

Remarks.—This form, agreeing generally with one of the figures given by

[1] Such forms, however, have not been wholly unnoticed. Some years ago Mr. A. Bell reported to me the discovery of the northern species, *B. groenlandicum* and *B. terræ-novæ* in the Newbournian and Butleyan Crags.

Forbes and Hanley, is not uncommon at Oakley and in the Scaldisien of Belgium. I have a somewhat similar Recent shell in my collection from Oban, on the west coast of Scotland, and Dr. Nordmann has sent me another, nearly corresponding to it, from Jutland.

The specimens here represented show more accurately the character of this variety prevalent at Oakley and elsewhere in the Red Crag and at Antwerp than does that given by Wood. Our shells are larger and longer in the spire than his figure, some of them attaining a length of 100 mm. by 55 mm. in breadth.

Nyst does not notice this form.[1] It has been found by Mr. van de Wouver rather abundantly, however, during some recent excavations at Antwerp.

Var. **striata,** Pennant. Plate VI, figs. 6, 7.

1777. *Buccinum striatum*, Pennant, Brit. Zool., vol. iv, p. 121, tab. lxxiv, fig. 91.
1848. *Buccinum undatum*, var. *striatum*, S. V. Wood, Mon. Crag Moll., pt. i, p. 36, tab. iii, fig. 12 *b*.
1867. *Buccinum undatum*, var. *striata*, Jeffreys, Brit. Conch., vol. iv, p. 286.
1912. *Buccinum undatum*, var. *striata*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 109, pl. iv, fig. 12.

Remarks.—In this distinct form the longitudinal ribs are nearly or entirely obsolete, the spiral lines being more or less regularly and clearly sculptured. It is smaller and shorter than the last, measuring from 45 to 55 mm. in length and 30 to 35 mm. in breadth. It is fairly common at Oakley, and may be regarded as one of the characteristic varieties of *B. undatum* in the Red Crag.

Jeffreys reports it living from the coralline zone on the coasts of England, Wales, and Ireland (not common), and Dr. Nordmann has sent me a somewhat similar specimen from Jutland.

Var. **cærulea,** G. O. Sars. Plate VII, figs. 3, 4.

1878. *Buccinum undatum*, var. *cærulea*, G. O. Sars, Moll. Reg. Arct. Norv., p. 255, pl. xxiv, fig. 3.
1900-1. *Buccinum undatum*, var. *cærulea*, Brφgger, Norges geol. undersφgelse, vol. xxxi, pl. xii, fig. 14.
1912. *Buccinum undatum*, var. *cærulea*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 113, pl vi, fig. 2.

Varietal Characters.—Shell ovato-conical, less solid than the type form; spire more or less elongate, regularly tapering; apex blunt; whorls 6 or 7, the last tumid, twice or three times the length of the spire; the upper whorls are generally ornamented by inconspicuous longitudinal plications, but these are often obsolete or nearly so; the spiral sculpture is at times fine and indistinct, at others more strongly marked, and there are flexuous and irregular lines of growth sometimes

[1] The shell figured by Nyst in 1881 as *B. undatum* approaches more nearly that given further on as *B. meridionale*, var. *inflata* (Pl. IX, fig. 3), than the typical form of the present species.

forming varices on the body-whorl; mouth wide, ovate, angulate above, about half the total length or rather less; outer lip thin, expanded; canal short, wide, open.

Dimensions.—L. 55 mm. B. 32 mm.

Distribution.—Recent: Finmark, Faroes.

Fossil: Waltonian Crag. Newbournian; Butleyan; Icenian.

Pleistocene: Middle Glacial sands of Billockby, Hopton; March gravels. Norway.

Remarks.—When examining the Buccinums in my collection Dr. Øyen recognised a number of them as identical with the Scandinavian variety *cærulea* of Prof. G. O. Sars, and he has since been kind enough to send me some specimens from the Pleistocene deposits of Christiania for comparison, one of which I have figured. To some extent they correspond with the variety *læviuscula* of Wood, but they are not the same and the name *cærulea* is so generally used by northern writers that it seems undesirable to alter it. Many years ago I found this form very abundantly in the March gravels, the specimens agreeing with that figured by Prof. Sars.

Were it not that I am unwilling to disturb the existing nomenclature I should be disposed to group these shells and those next to be described as specifically distinct, as originally proposed by Sowerby. They seem but distantly connected with the coarsely sculptured molluscs known to British conchologists as *B. undatum*.[1]

Var. **tenera**, J. Sowerby. Plate VI, fig. 8.

1825. *Buccinum tenerum*, J. Sowerby, Min. Conch., vol. v, p. 140, tab. cccclxxxvi, fig. 3.
1843. *Buccinum tenerum*, Nyst, Coq. foss. Terr. Tert. Belg., p. 571, pl. xliii, fig. 9.
1848–74. *Buccinum undatum*, var. *tenerum*, S. V. Wood, Mon. Crag Moll., pt. i, tab. iii, fig. 12 *d*, 1848; 1st Suppl., p. 18, 1874.
1870. *Buccinum undatum*, var. *tenerum*, S. V. Wood, jun., and F. W. Harmer, Rep. Brit. Assoc. (Liverpool), p. 90.

Dimensions.—L. 40 mm. B. 25 mm.

Remarks.—Among the Crag specimens of *Buccinum* just referred to which Dr. Øyen assigned to the variety *cærulea*, there is a form differing from the one last described in having a much shorter spire and finer transverse sculpture. This appears identical with the one described by Sowerby in 1825 as *B. tenerum*, corresponding also with that given by Wood in 1848, as will be seen by comparing his figure with the specimen from Butley here represented.

As Sowerby's name has the precedence I retain it for this shell, while the term *cærulea* of Prof. G. O. Sars may be adopted for the more elongate form.

As far as I know, neither of the varieties *tenera* or *cærulea* now live in

[1] In his 1st Supplement (p. 18) Wood expressed a similar opinion as to the variety *tenera*, which Nyst also regarded in 1843 as a distinct species.

British seas. Specimens of the former are often fragile and sometimes decorticated.

Var. **littoralis,** King. Plate VI, figs. 9, 10.

1846. *Buccinum undatum*, var. *littoralis*, King, Ann. Mag. Nat. Hist., vol. xviii, p. 250.
1877. *Buccinum undatum*, var. *littoralis*, Jeffreys, Brit. Conch., vol. iv, p. 286.
1878. *Buccinum undatum*, var. *littoralis*, G. O. Sars, Moll. Reg. Arct. Norv., p. 255, pl. xiii, fig. 12.
1912. *Buccinum undatum*, var. *littoralis*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 109, pl. v, fig. 1.

Varietal Characters.—Shell ovate, thick and solid, ventricose; spire very short; body-whorl inflated, larger in proportion than in the type form; longitudinal plications flexuous, strong; spiral costæ coarse, undulating; mouth oval; canal very short.

Dimensions.—L. 40—60 mm. B. 28—36 mm.

Distribution.—*Recent:* British seas to Denmark and the north of Norway; eastern coasts of Northern America.

Fossil: Waltonian Crag: Beaumont, Little Oakley. Newbournian: Waldringfield. Butleyan: Butley. Probably at other localities in the Red Crag.

Remarks.—I have found a number of imperfect specimens of this variety at Oakley, one of them being here figured, together with a Recent shell from Denmark kindly sent to me by Dr. Nordmann, with which my fossils correspond more or less closely.

Var. **flexuosa,** Jeffreys. Plate VI, fig. 5.

1867. *Buccinum undatum*, var. *flexuosa*, Jeffreys, Brit. Conch., vol. iv, p. 286.
1912. *Buccinum undatum*, var. *flexuosa*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 110, pl. v, fig. 6.

Dimensions.—L. 65 mm. B. 35 mm.

Distribution.—*Recent:* Hebrides, Orkneys, Shetland; Karlsö (Dautzenberg).

Fossil: Newbournian Crag: Waldringfield.

Remarks.—The fossil from the Ipswich Museum here figured differs from the prevalent varieties of the Crag Buccinums in its coarser sculpture and obliquely curved ribs, corresponding with the specimen given by MM. Dautzenberg and Fischer. Jeffreys says the variety *flexuosa* is more slender than the type, and has an elongated spire.

Var. **crassa**, King. Plate VII, figs. 1, 2.

1777. *Buccinum undatum*, Pennant, Brit. Zool., vol. iv, p. 121, tab. lxiii, fig. 90.
1847. *Buccinum undatum*, var. *crassa*, King, Ann. Mag. Nat. Hist., vol. xix, p. 337.
1853. *Buccinum undatum*, var. *crassum*, Forbes and Hanley, Brit. Moll., vol. iii, p. 404.
1900–1. *Buccinum undatum*, Brøgger, Norges geol. undersøgelse, vol. xxxi, p. 471, fig. 50.
1912. *Buccinum undatum*, var. *crassa*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 109, pl. v, fig. 2.

Dimensions.—(Of Crag Shell.) L. 65 mm. B. 40 mm.

Distribution.—*Recent:* Coasts of Northumberland, Durham and Yorkshire, from 7 to 30 fathoms. Le Croisic, France; Denmark; Reykjavik, Iceland (Dautzenberg); Maine, U.S.A.

Fossil: Newbournian Crag: Waldringfield. Butleyan: Hollesley; probably elsewhere. Pleistocene: Christiania.

Remarks.—The shell now figured which comes from Waldringfield (Canham coll., Ipswich Museum), a comparatively deep-water variety, belongs to the same group as the variety *flexuosa*, agreeing with that coarsely sculptured northern form except that it is wider in proportion, and has a shorter spire. It corresponds to some extent with a specimen in the British Museum (Norman collection) labelled var. *borealis*, and more closely with those given by MM. Dautzenberg and Fischer as var. *crassa*, and by Prof. Brøgger as *B. undatum*. Mr. de B. Tomlin has sent me, moreover, an American shell of a similar character from Casco Bay, Maine. It will be seen in the sequel that there are a number of characteristic American Buccinums in our Crag deposits, some of which occur on both sides of the Atlantic, while others are no longer found in European seas. King thought his var. *crassa* the same as that figured by Pennant as *B. undatum;* the variety *maxima* of Dautzenberg and Fischer (*op. cit.*, pl. iv, fig. 11) is a similar but larger shell.

Var. **zetlandica**, Forbes. Plate VII, fig. 5.

1835. *Buccinum undatum*, var. *zetlandicum*, Forbes, Mag. Nat. Hist., vol. viii, p. 593, fig. 62.
1844. *Buccinum anglicanum*, Brown, Ill. Conch. Great Brit., 2nd ed., p. 4, pl. iii, figs. 2, 3.
1853. *Buccinum undatum*, var., Forbes and Hanley, Brit. Moll., vol. iii, p. 405.
1869. *Buccinum undatum*, var. *zetlandica*, Jeffreys, Brit. Conch., vol. iv, p. 286; vol. v, p. 218, pl. lxxxii, fig. 5.
1912. *Buccinum undatum*, var. *zetlandica*, Dautzenberg et Fisher, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 111.

Varietal Characters.—Shell less solid and more slender and elongate than the type form; longitudinal plications when present more numerous but sometimes nearly or wholly obsolete.

Dimensions.—L. 65 mm. B. 30 mm.

Distribution.—Recent: deep water zone, west of Ireland, outer Hebrides, Orkneys and Shetland; Scandinavia (Jeffreys); Iceland (Torell).

Fossil: Butleyan Crag: Butley.

Remarks.—The Butley shell here represented, which appears to agree with that figured by Jeffreys, is from the Sedgwick Museum at Cambridge. Forbes's original specimen was brought from Zetland (Shetland), where he said it was frequently found in very deep water; Jeffreys states, on the authority of Carpenter and Thomson, that it occurs to the north of the Hebrides in 500 to 650 fathoms. It was described by Brown, though in error, under Gmelin's name of *B. anglicanum*.

Var. **acuminata**, Broderip. Plate VI, figs. 3, 4.

1830. *Buccinum acuminatum*, Broderip, Zool. Journ., vol. v, p. 44, pl. iii, figs. 1, 2.
1846. *Buccinum acuminatum*, Reeve, Conch. Icon., vol. iii (Buccinum), pl. i, fig. 4.
1853. *Buccinum undatum*, var. *acuminatum*, Forbes and Hanley, Brit. Moll., vol. iii, p. 405, pl. cx, fig. 4.
1867. *Buccinum undatum*, var. *acuminatum*, Jeffreys, Brit. Conch., vol. iv, p. 287.
1883. *Buccinum undatum*, var. *acuminata*, Kobelt, Martini und Chemnitz, Conch. Cab., ed. 2, vol. iii (Buccinum), p. 18, pl. lxxiv, fig. 5.
1887. *Buccinum undatum*, var. *acuminata*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 99, pl. xvii, fig. 6.
1912. *Buccinum undatum*, var. *acuminata*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 112, pl. v, fig. 13.

Dimensions.—L. 44 mm. B. 16 mm.

Distribution.—Recent: Great Britain and Ireland, as far north as Aberdeen, coralline zone, not common (Jeffreys); north coasts of France.

Fossil: Waltonian Crag: Little Oakley. Butleyan: Butley (A. Bell).

Remarks.—This shell is regarded as an abnormal variety of *B. undatum*. It has but little resemblance to the type form of that species, having whorls nearly flat, with indistinct or without longitudinal ribs, an acutely tapering and elongated spire, and a different mouth. The shell originally described by Broderip, now in the British Museum of Natural History, was found at Torquay: the same variety has been obtained also in the north of France; some years since I picked it up on the beach at Whitstable. I obtained a small specimen at Oakley, quite perfect, but unfortunately it has been accidentally damaged. As it is imperfect, as well as new to the Crag, I figure with it a Recent shell for the convenience of future students.

Mr. A. Bell informs me that this form may be met with occasionally in Billingsgate market.

Var. **Schneideri,** Verkrüzen. Plate VIII, figs. 1, 2.

1885. *Buccinum undatum,* var. *Schneideri,* Verkrüzen, Nachr. Deutsch. Malak. Gesellsch., vol. xvii, p. 87.

1912. *Buccinum undatum,* var. *Schneideri,* Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 111, pl. v, fig. 11.

Dimensions.—L. 55 mm. B. 32 mm.

Distribution.—Recent: Vadsö.

Fossil: Waltonian Crag: Little Oakley.

Remarks.—The Oakley shell here represented was recognised by Dr. Øyen as agreeing with Recent specimens under the above name in the Christiania Museum; there are others like it in the Norman collection at South Kensington which were dredged at Vadsö from a depth of 100 fathoms, one of them being also figured. In its spiral sculpture it approaches var. *striata,* although the ribs are not so prominent. It differs in form from the latter, being more slender and elongate, the body-whorl is not so tumid, the suture is deeper, the shell is somewhat fragile, and the upper whorls are faintly though distinctly plicated. MM. Dautzenberg and Fischer recognise it as a distinct variety. It appears to be a northern form.

Var. **pulchra,** nov. Plate X, fig. 13.

Varietal Characters.—Shell rather small, thin, ovate; whorls convex, the last tumid and often varicose, two-thirds the total length; spire short, rapidly diminishing in size; suture deep; elegantly ornamented by longitudinal plications, prominent, oblique, and sinuous, and by fine well-marked spiral lines, which on the body-whorl are bifid, with a fine line intervening; mouth ovate; outer lip very thin; canal short, notched, rather narrow.

Dimensions.—L. 40 mm. B. 25 mm.

Distribution.—Fossil: Waltonian Crag: Walton-on-Naze, Oakley; probably elsewhere in the Red Crag. Pliocene: Iceland.

Remarks.—I have several specimens of this variety from the Red Crag, some of them immature; they differ from the type in size and fragility. Dr. Øyen does not know anything like them from northern seas and suggests I should give them a distinctive name. They seem to separate themselves from other Crag varieties of *B. undatum.* There is a specimen from the Pliocene of Iceland in the Mörch collection at Copenhagen which appears to be the same as our shell; it bears the name *B. undatum,* var. *pumilio,* but as it does not correspond with the figure of that variety in the unpublished plates above referred to, I retain my own name for it.

Var. **minima**, nov. Plate VII, fig. 6.

Dimensions.—L. 25 mm. B. 15 mm.

Distribution.—*Fossil :* Waltonian Crag: Little Oakley. Pleistocene: Norway.

Remarks.—Dr. Øyen has drawn my special attention to several small specimens of Buccinum among my Oakley fossils, one of them being here figured, which he considers intermediate between *B. undatum*, var. *cærulea* and *B. grœnlandicum*. He says this variety is extensively represented in the early post-glacial sub-littoral banks and terraces of Norway. It differs from the varieties before described in size, the sculpture is much more delicate, the longitudinal plications more numerous, and the spiral striation regular and exceedingly fine.

Among the small Buccinums found at Oakley there are also a number, fragile and possibly not fully grown, varying in the convexity of their whorls and the relative proportions of length and breadth, but for the most part approaching the *cærulea* type. They are all nearly of the same size, about 20 mm. in length.

Dr. Øyen informs me that similar shells occur abundantly in the Pleistocene shell-banks of south-east Norway, at Bjørnedalen and Kolbjørnsvik, specimens of which he has been kind enough to send me. Comparing them with the Oakley fossils I find them to correspond closely both as to size and form with the different varieties of the latter.

Dr. Øyen believes that some of these are hybrid, combining the special characteristics of the three species, *B. undatum*, var. *cærulea*, *B. grœnlandicum*, and *B. finmarchianum*.

Buccinum grœnlandicum, Chemnitz. Plate VIII, figs. 4—6; Plate IX, fig. 10.

1788. *Buccinum grœnlandicum*, Chemnitz, Conch. Cab., vol. x (Buccinum), p. 182, fig. 1448.

1858. *Buccinum grœnlandicum*, Küster, Martini und Chemnitz, Conch. Cab., vol. iii (Buccinum), p. 8, pl. iii, figs. 3, 4.

1870. *Buccinum grœnlandicum*, A. Bell, Ann. Mag. Nat. Hist. [4], vol. vi, p. 215.

1878. *Buccinum grœnlandicum*, G. O. Sars, Moll. Reg. Arct. Norv., p. 259, pl. xxv, fig. 1.

1882–1901. *Buccinum grœnlandicum*, Friele, Norske Nordh. Exped. (Mollusca), vol. i, p. 29, 1882; vol. iii, p. 99, 1901.

1887. *Buccinum grœnlandicum*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 112, pl. xxi, figs. 1, 2.

1900. *Buccinum grœnlandicum*, Brøgger, Norges geol. undersøgelse, vol. xxxi, p. 654, pl. vii, fig. 1; pl. x, fig. 5; pl. xi, figs. 3, 4.

Specific Characters.—Shell smaller than the typical *B. undatum*, rather thin, ovato-conical; spire short; whorls convex, the last much the largest, two-thirds the total length; suture deep; mouth irregularly ovate, angulate above, about half the length of the shell; canal short, wide, and open; indistinct longitudinal plications on the upper part of the shell which die out on the body-whorl; surface covered with spiral lines, some rather prominent, with finer ones in the interspaces.

Dimensions.—L. 35—42 mm. B. 18—24 mm.

Distribution.—Recent: Finmark, Spitzbergen, Iceland, Greenland, Atlantic shores of Northern America, Behring Sea (G. O. Sars).

Fossil: Waltonian Crag: Little Oakley. Newbournian. Butleyan: Hollesley, Butley. Icenian. Pleistocene deposits: Bridlington, Scotland, Ireland.

Pleistocene: Norway.

Remarks.—In the first Supplement to his Monograph on the Crag Mollusca, tab. ii, fig. 2, S. V. Wood figured a shell for which he adoped the name *Buccinum undatum*, var. *grœnlandicum.* It is of the *undatum* type, and is possibly a variety of that species, but it does not agree with those figured by Prof. G. O. Sars or Brøgger as *B. grœnlandicum*, nor with Recent specimens in my collection. I have figured a unique example from Oakley, however, and another from Bramerton, which correspond with them exactly. They are smaller, less tumid, and more delicate than Wood's shell; the longitudinal plications are not so prominent, and the tranverse sculpture is different. They differ widely, moreover, from the many specimens of *B. undatum* or its recognised varieties which I have obtained from the Crag, or are to be found in our public collections, and have generally a special character by which this species may be easily distinguished.

The *Buccinum grœnlandicum* of Scandinavian conchologists is a characteristically northern form which, in Europe at least, is not now found to the south of the Arctic Circle. It was among the early arrivals of the northern shells in the Crag basin, however, and had established itself there more or less abundantly at the Butleyan stage. It is not uncommon at the latter horizon; I have found it at Butley [1] and Hollesley, while Mr. Alfred Bell reports it from the Newbournian and Icenian Crags. Our fossils approach the var. *Kobelti* of Dautzenberg.

Var. **connectens,** nov. Plate VIII, fig. 12.

Remarks.—The shell figured under this name was found at Butley; it resembles *B. grœnlandicum* in its spiral sculpture but *B. undatum* in its form and its more prominent longitudinal plications. Dr. Sparre Schneider, of Tromsö, considers it to be a hybrid between these two species. The suggestion of hybridisation as an explanation of some of these intermediate forms is an interesting one.

Var. **patula,** G. O. Sars. Plate X, fig. 9.

1878. *Buccinum grönlandicum*, var. *patula*, G. O. Sars, Moll. Reg. Arct. Norv., p. 260, pl. xxv, fig. 2.

1883. *Buccinum grœnlandicum*, var. *patula*, Kobelt, Martini und Chemnitz, Conch. Cab., ed. 2, vol. iii (Buccinum), p. 90, pl. xcii, figs. 8, 9; pl. xciii, fig. 13.

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[1] There are a fair number of typical specimens of *B. grœnlandicum* from Butley in the Wood collection at the Norwich Museum.

1887. *Buccinum grœnlandicum*, var. *patula*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 113, pl. xx, figs. 9, 10.
1899. *Buccinum grœnlandicum*, var. *patula*, Posselt, Medd. om Grönl., vol. xxiii, p. 200.
1912. *Buccinum grœnlandicum*, var. *patula*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 131, pl. viii, fig. 15.

Varietal Characters.—Shell much smaller than the type; spire short; whorls slightly convex, the last ventricose, three-fifths the total length, excavated below; ornamented by inconspicuous spiral lines, but without longitudinal plications; mouth wide, longer than the spire, angulate above; outer lip regularly curved, expanded; inner lip forming a glaze upon the columella; canal short, open, notched.

Dimensions.—L. 25 mm. B. 15 mm.

Distribution.—*Recent:* northern coasts of Norway, Greenland.
Fossil: Waltonian Crag: Little Oakley.

Remarks.—The specimen represented under the above name corresponds very closely with that originally figured by Prof. Sars, and to a somewhat less extent with one Dr. Sparre Schneider has sent me from Tromsö. I have several other small Buccinums in my collection, as, for example, that figured in Pl. IX, fig. 10, which may be unnamed varieties of *B. grœnlandicum*.

Buccinum ciliatum, Fabricius.

1780. *Buccinum ciliatum*, Fabricius, Faun. Grœnl., p. 401.
1883. *Buccinum ciliatum*, Kobelt, Martini und Chemnitz, Conch. Cab., ed. 2, vol. iii (Buccinum), p. 29, pl. lxxviii, figs. 7, 8.
1912. *Buccinum ciliatum*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 116, pl. vi, figs. 8, 9.

Var. **lævior,** Mörch. Plate X, figs. 10—12.

1857. *Buccinum ciliatum*, var. *lævior*, Mörch, Prod. Faun. Moll. Grœnl., p. 13.
1882. *Buccinum grœnlandicum*, var. *sericata* (?), Friele, Norske Nordh. Exped. (Mollusca), pt. i, p. 29, pl. iii, fig. 19.
1887. *Buccinum sericatum*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 114, pl. xxi, fig. 4.
1899. *Buccinum ciliatum*, var. *lævior*, Posselt, Medd. om Grönl., vol. xxiii, p. 211.

Varietal Characters.—Shell small, thin, ovato-conical; whorls convex, the last tumid, much the largest, five-sixths the total length; ornamented by fine spiral striations and by faint inconspicuous lines of growth; spire very short, rapidly diminishing to a small sub-papillose apex; suture deep; mouth long in proportion to the size of the shell, angulate above; outer lip regularly curved, expanded; inner lip forming a very thin glaze on the pillar; canal wide, open, very short; columella excavated, twisted below.

Dimensions.—L. 23—25 mm. B. 14—16 mm.

Distribution.—Recent: Lofoten Islands, North Cape, Greenland.

Fossil: Waltonian Crag: Little Oakley. Unknown from the Pleistocene of Norway.

Remarks.—The shell described by Mörch under this name has never been figured, and some confusion has arisen in consequence.

Posselt alludes to it (*op. cit.*) as something well known to Danish conchologists, identifying it with *B. cyaneum* (*? sericatum*), Hancock, *B. tenebrosum* var. *borealis*, Middendorff, and *B. ovum*, Turton.

Dr. Øyen has lately sent me a Recent specimen from Greenland identified as typical of Mörch's shell by Dr. A. Jensen, of the Zoological Museum at Copenhagen; this I have figured (Pl. X, fig. 11), with a fossil from Oakley (fig. 12) with which it practically agrees; the apparent difference between the two in the canal is due to the fact that in the latter the lower part of the outer lip has been broken off.

Mr. Friele has figured as *B. grœnlandicum* var. *sericata* (*op. cit.*) a specimen which closely corresponds with our Crag shell, and his figure has been reproduced by Dr. Kobelt (*op. cit.*) as *B. sericatum.* The former states, however, that it differs from the *B. sericatum* of Hancock both in form and sculpture, suggesting it may be a distinct species. MM. Dautzenberg and Fischer doubt, moreover, whether Mörch's shell is a variety of *B. ciliatum.*

Should this view be accepted hereafter I suggest it might be called *B. Frielei.* Meanwhile I adopt Mörch's name provisionally. In any case it seems probable that Dr. Øyen's specimen, that of Mr. Friele and the Crag fossils are near varieties of the same species.

Since the above was written I have received another unfigured shell from Dr. Jensen which he regards as the variety *lævior* here referred to. It differs in sculpture from Dr. Øyen's shell (fig. 11), agreeing more nearly in that respect with the Oakley specimen (fig. 10) which appears to belong to the same group; in the latter also the outer lip is imperfect.

Buccinum terræ novæ (Beck), Mörch. Plate IX, figs. 11, 12.

1869. *Tritonium Terræ Novæ* (Beck, MS.), Mörch, Ann. Soc. Malac. Belg., vol. iv (Mémoires), p. 18.

1882–01. *Buccinum Terræ Novæ,* Friele, Norske Nordh. Exped. (Mollusca), vol. i, p. 33, pl. iii, figs. 13—16, 1882; vol. iii, p. 101, 1901.

1883. *Buccinum Terræ Novæ,* Kobelt, Martini und Chemnitz, Conch. Cab., ed. 2, vol. iii (Buccinum), p. 47, pl. lxxxiii, figs. 3, 4.

1887. *Buccinum terræ novæ,* Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 108, pl. xix, figs. 2, 3.

1899. *Buccinum terræ-novæ,* Posselt, Medd. om Grönl., vol. xxiii, p. 196.

1900–1. *Buccinum terræ novæ,* Brøgger, Norges geol. undersøgelse, vol. xxxi, pp. 67, 654, pl. ii, fig. 5.

1912. *Buccinum Terræ Novæ,* Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 127, pl. viii, figs. 1—8.

Specific Characters.—Shell thin; whorls convex, angulated above, forming a sloping shelf below the suture, the last about two-thirds the total length, excavated below, covered with spiral lines, some of them more prominent than the others, the one next below the suture often forming a well-marked keel; spiral ornamentation usually clathrated by the indistinct and irregular longitudinal plications or lines of growth; mouth wide, angulated above, ending in a short open canal; outer lip thin, regularly curved; columella twisted and excavated.

Dimensions.—L. 55—85 mm. B. 35—50 mm.

Distribution.—*Recent:* Nova Zembla, Spitzbergen, Greenland; N. Asiatic Coast to Behring Sea.

Fossil: Waltonian Crag: Little Oakley. Newbournian; Butleyan (R. Bell); Icenian.

Occasionally found in the *Yoldia* clay (Norwegian Pleistocene), and in the post-glacial deposits of Norway.

Remarks.—Among the specimens of *Buccinum* in my collection from Oakley, I have one or two, imperfect or not full-grown, of this variable and arctic species. It seems specially distinguished by the angulation of the whorls by one of the spiral ribs, which forms a sloping shelf below the suture, and generally by its clathrated ornamentation.

Dr. Øyen has been kind enough to send me a specimen (imperfect) from Getinge, Halland (Norway), which I have figured together with one of my Oakley fossils. *B. terræ novæ* was dredged by the Norwegian Expedition from a depth of 60 fathoms.

Buccinum finmarchianum, Verkrüzen. Plate VIII, fig. 3.

1875. ***Buccinum finmarchianum***, Verkrüzen, Jahrb. Deutsch. Malak. Gesell., vol. ii, p. 237, pl. viii, figs. 1—3.

1878. ***Buccinum finmarchianum***, G. O. Sars, Moll. Reg. Arct. Norv., p. 262, pl. xiii, fig. 10.

1882–1901. ***Buccinum finmarchianum***, Friele, Norske Nordh. Exped. (Mollusca), vol. i, p. 30, 1882; vol. iii, p. 99, 1901.

1883. ***Buccinum Finmarkianum***, Kobelt, Martini und Chemnitz, Conch. Cab., ed. 2, vol. iii (Buccinum), p. 24, pl. lxxvii, figs. 4, 6.

1887. ***Buccinum finmarkianum***, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 103, pl. xviii, fig. 7.

1910. ***Buccinum finmarchianum***, Odhner, K. Svensk. Veten. Akad. Handl., vol. vii, p. 13.

Specific Characters.—Shell rather thin, ovato-conical; whorls more or less convex, the last much the largest, nearly twice the length of the spire; suture well-marked; mouth ovate, acutely angulate above; in the Crag specimens half the total length; outer lip regularly arched, not expanded; inner lip forming a wide glaze upon the pillar; surface of the shell covered with spiral lines, sometimes inconspicuous, without longitudinal plications; canal very short, notched.

Dimensions.—L. 55 mm. B. 27 mm.

Distribution.—*Recent:* Finmark, Lofoten Islands, Iceland, Spitzbergen.

Fossil: Waltonian Crag: Little Oakley (very rare). Pleistocene: Norway.

Remarks.—This is another of the northern species of mollusca which made their first appearance in the Crag basin at the Oakley stage, a group fairly numerous as to species, excessively rare as to specimens: I have obtained but one or two from the small pit at Oakley which has yielded me a fauna of such extraordinary variety and richness as the result of many years' work. *B. finmarchianum* was dredged by the Norwegian North Atlantic Expedition at a depth of 127 fathoms.

The imperfect shell here represented has been recognised by Dr. Øyen as *B. finmarchianum*; I give it on his authority. It corresponds more nearly with one of the specimens figured by Prof. Kobelt in 1883, *op. cit.*, pl. lxxvii, fig. 4, than with those given by Prof. G. O. Sars, being wider and shorter in the spire than the latter.

Buccinum perdix (Beck), Mörch. Plate IX, figs. 13, 14.

1868. *Tritonium grœnlandicum*, var. *perdix*, Beck, in Mörch, Faun. Moll. Isl., p. 27.
1877. *Tritonium perdix*, Beck, Mörch, in Rink, Dan. Greenl., p. 438.
1877. *Buccinum perdix*, Mörch and Poulsen, MS. list and plates in the Geological Museum, Copenhagen, no. 21, pl. iii, fig. 4 (unpublished).
1899. *Buccinum perdix*, Posselt, Medd. om Grönl., vol. xxiii, p. 203, pl. ii, figs. 9, 13.

Specific Characters.—Shell rather small, ovato-conical; whorls 6 or 7, convex, in the Crag specimens decidedly so, the last two-thirds the total length; ornamented by fine and inconspicuous spiral striæ, and usually by longitudinal plications which are not very prominent, and tend to die away towards the base of the shell, together with varix-like foldings on the body-whorl; suture deep; spire regularly diminishing in size, ending in a small and blunt point; mouth oval, shorter than the spire, rather wide; inner lip forming a thin glaze upon the pillar; pillar twisted; canal short, open.

Dimensions.—L. 30—35 mm. B. 15—20 mm.

Distribution.—*Recent:* Iceland, west coast of Greenland.

Fossil: Waltonian Crag: Little Oakley.

Remarks.—In 1899 Posselt grouped together *B. finmarchianum* and *B. Humphreysianum* under Beck's name of *B. perdix*, associating with them some shells differing materially from the forms figured as typical of the two first-named species by Profs. G. O. Sars and Kobelt, which are without longitudinal plications and have whorls but little convex. Three of those figured as *B. perdix* by Posselt, on the contrary, are strongly plicated, while in the fourth the whorls are tumid.[1] Dr. Nordmann informs me that in the museum at Copenhagen there are a series of specimens under the present name, the extreme forms of which are different, but that they are connected by intermediate varieties. He has been kind enough to send me a typical specimen of one of them which I here figure. It agrees more or less nearly with some special forms of my Oakley fossils, which appear to be different from anything else in my collection. Without expressing any definite opinion on the question of nomenclature, and as there seems some doubt with which species my Crag shells should be grouped, I figure one of them provisionally as *B. perdix.* In the convexity of its whorls it corresponds closely with one of Posselt's figures.

Buccinum hydrophanum, Hancock.

1846. *Buccinum hydrophanum,* Hancock, Ann. Mag. Nat. Hist., vol. xviii, p. 325, pl. v, fig. 7.

Var. **tumidula,** G. O. Sars. Plate IX, fig. 9.

1847. *Buccinum hydrophanum,* Reeve, Conch. Icon., vol. iii (Buccinum), pl. xiii, fig. 103.
1878. *Buccinum tumidulum,* G. O. Sars, Moll. Reg. Arct. Norv., p. 263, pl. xxv, fig. 5.
1882. *Buccinum hydrophanum,* var. *tumidula,* Friele, Norske Nordh. Exped. (Mollusca), pt. i, p. 31, pl. iii, fig. 21.
1883. *Buccinum tumidulum,* Kobelt, Martini und Chemnitz, Conch. Cab., ed. 2, vol. iii (Buccinum), p. 49, pl. lxxxiii, fig. 6.
1887. *Buccinum tumidulum,* Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 106, pl. xix, fig. 10.
1899. *Buccinum hydrophanum,* var. *tumidosa,* Posselt, Medd. om Grönl., vol. xxiii, p. 208, pl. ii, fig. 13.
1912. *Buccinum hydrophanum,* Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 135, pl. viii, fig. 18.

Varietal Characters.—Shell thin and fragile, ovato-fusiform, whorls 6 or 7, decidedly convex, the last ventricose, two-thirds the total length; suture deep, mouth nearly half the length of the shell; outer lip thin, regularly rounded; inner lip forming a wide glaze upon the pillar; surface smooth, covered with very fine, irregular and inconspicuous spiral striæ but without longitudinal plications; canal short.

Dimensions.—L. 48 mm. B. 25 mm.

Distribution.—*Recent*: Finmark, Iceland, Greenland, Davis Strait; generally throughout Arctic Seas.

Fossil: Waltonian Crag: Little Oakley, very rare.

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[1] Prof. Kobelt regards *B. perdix* as a variety of *B. grœnlandicum* (Icon. schalentrag. europ. Meeresconch., vol. i, p. 113), as did Mörch. Prof. G. O. Sars, on the other hand, considers it a synonym of *B. finmarchianum.* To some extent our shells approach one of the varieties of *B. meridionale*; the latter, however, is a Newfoundland species, while this is Scandinavian, and has a shorter mouth.

Remarks.—Mr. Friele and other recent authorities regard the *B. tumidulum* of Prof. G. O. Sars as a variety of *B. hydrophanum*, with which it agrees generally except that it has a shorter spire and more tumid whorls.

Posselt has described another and comparatively short form from Greenland which attains a maximum length of 80 mm. as var. *tumidosa*. He says it comes fairly near to *B. tumidulum*, but is much larger.

Among my many specimens of Buccinum from Oakley there is one, now figured, which nearly corresponds with some Recent shells I have received from Prof. Nordgaard as *B. hydrophanum*, although the whorls of the former are somewhat less tumid. It appears to be intermediate between the typical form of that species and *B. tumidulum;* Dr. Sparre Schneider, however, to whom I have submitted my fossil, considers it should be referred to the latter, but as a variety of *B. hydrophanum*.

Mr. Friele states that both forms occur at medium depths in all parts of the Arctic Ocean.

Buccinum tenue, Gray. Plate VIII, figs. 10, 11.

1839. *Buccinum tenue*, Gray, Zool. Beechey's Voyage, p. 128, pl. xxxvi, fig. 19.
1846. *Buccinum tenue*, Reeve, Conch. Icon., vol. iii (Buccinum), pl. iv, fig. 27.
1858. *Buccinum tenue*, Küster, Martini und Chemnitz, Conch. Cab., vol. iii (Buccinum), p. 77, pl. xiv, fig. 7.
1872. *Buccinum tenue*, J. W. Dawson, Canadian Natur. (N. S.), vol. vi, p. 397, pl. vii, fig. 5.
1883. *Buccinum tenue*, Kobelt, Martini und Chemnitz, Conch. Cab., ed. 2, pt. iii (Buccinum), p. 39, pl. lxxxi, figs. 4, 5.
1887. *Buccinum tenue*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 110, pl. xx, figs. 3, 4.
1912. *Buccinum tenue*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 137, pl. vi, figs. 10, 11.

Specific Characters.—Shell ovato-fusiform, conical, thin; whorls 7, convex, the last about five-eighths the total length; ornamented by numerous flexuous longitudinal plications, which tend to die out towards the base of the shell, and by fine inconspicuous spiral striæ; spire elongate; apex rather blunt; suture deep or well-marked; mouth oval, obtusely-angulate above; outer lip thin; pillar excavated; canal very short, open.

Dimensions.—L. 38—55 mm. B. 20—30 mm.

Distribution.—*Recent:* circumpolar: Nova Zembla, Spitzbergen, Kara Sea, Franz Joseph Land, Iceland, Arctic coasts of European and Asiatic Russia; Behring Sea, Icy Cape; Greenland, Labrador, North American coast to Halifax, (N.S.).

Fossil: Waltonian Crag: Little Oakley. Butleyan: Butley.

Pleistocene: Rivière du Loup (Canada), Greenland, Labrador, Yenisei.

Remarks.—I have one or two fragmentary specimens in my collection from Oakley, and there is another, nearly perfect, in the Sedgwick Museum at Cambridge labelled *B. undatum*, which correspond more or less nearly with the figures of this well-known and very distinct species given by the authors quoted above, and with a shell from Spitzbergen that Dr. Nordmann has kindly sent me, except that the Crag fossil is the more slender.

By some authorities *B. tenue* is identified with *B. scalariforme*, Beck. MM. Dautzenberg and Fischer, in their recent work, regard the latter as a variety of the former, the principal difference being in the length of the spire. Our Crag fossils approach their figure and those of specimens from the Rivière du Loup rather than the type form.

Buccinum angulosum, Gray.

1839. *Buccinum angulosum*, Gray, Zool. Beechey's Voyage, p. 127, pl. xxxvi, fig. 6.
1902. *Buccinum angulosum*, Dall, Proc. U.S. Nat. Mus., vol. xxiv, p. 517, pl. xxxvii, figs. 1—3.

Var. **normalis**, Dall. Plate IX, figs. 15, 16.

1883. *Buccinum angulosum*, Kobelt, Martini und Chemnitz, Conch. Cab., ed. 2, pt. iii (Buccinum), p. 66, pl. lxxvi, figs. 7, 8.
1902. *Buccinum angulosum*, var. *normale*, Dall, Proc. U.S. Nat. Museum, vol. xxiv, p. 518, pl. xxxvii, fig. 6.

Varietal Characters.—Shell ovato-conical, solid, destitute of folds except sometimes on the upper whorls or immediately below the suture, showing in places the lines of growth; whorls convex, rapidly diminishing in size, the last ventricose, excavated below, much the largest, nearly seven-eighths the total length; ornamented with very fine spiral striæ; spire very short; apex obtuse; suture well-marked; mouth large, wide, oval, projecting below the canal, angulated above; outer lip expanded, regularly curved; inner lip forming a thin glaze upon the pillar; pillar short, excavated; canal wide, open, very short.

Dimensions.—(Of Crag specimens.) L. 42 mm. B. 28 mm.

Distribution.—*Recent:* shores of the Polar Sea, near Behring Strait, Point Barrow, Cape Smythe, low water to 5 fathoms.

Fossil: Butleyan Crag: Butley, Hollesley.

Remarks.—The fossil here represented was found at Butley, and has been identified by Dr. Dall, who has kindly sent me a Recent specimen for comparison, with which it closely agrees, as it does with Prof. Kobelt's figure (*op. cit.*). In some respects it resembles *B. ventricosum*, Kiener (*op. cit.*), figured subsequently by Gould as *B. ciliatum*.[1] Dr. Dall regards it, however, as the male of the well-known but

[1] *B. ciliatum*, Fabricius, is a different and smaller species.

very differently sculptured shell originally described in the Zoology of Beechey's Voyage as *B. angulosum*, remarking that "most of these arctic Buccinums have two forms, apparently correlated with sex, the males being in several species far smaller, more slender, and less shouldered and flaring at the aperture; that the female has to carry the material for the enormous ovicapsular mass is a sufficient reason for their difference in form, and probably for the difference in size. Apart from this, many of the species have mutations of the coarser sculpture, which result in very unlike individuals."[1] In the present case the shell of the female is buttressed by strong and coarse longitudinal costæ, and the base of the body-whorl is angulate; in that of the male, according to Dr. Dall, the whorls are regularly convex and without such ornament. The first is found living on the arctic coasts of Europe and of America; the second has only been recorded from the Alaskan region. The question of sex however, introduces a new complication to the study of the fossil Buccinums.

Buccinum fragile (Verkrüzen), G. O. Sars. Plate VIII, fig. 9.

1878. *Buccinum fragile*, Verkrüzen, MS., G. O. Sars, Moll. Reg. Arct. Norv., p. 257, pl. xxiv, fig. 6.
1883. *Buccinum fragile*, Kobelt, Martini und Chemnitz, Conch. Cab., ed. 2, vol. iii (Buccinum), p. 42, pl. lxxxii, fig. 7.
1887. *Buccinum fragile*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 110, pl. xix, fig. 4.

Specific Characters.—Shell very thin and fragile; whorls decidedly convex, the last ventricose, much the largest, two-thirds the total length, the upper whorls only plicated; surface covered with distinctly marked, wavy and unequal spiral lines, not very prominent; suture deep; mouth oval, angulated above, rather less than half the length of the shell; outer lip expanded, very thin; inner lip forming a slight glaze on the pillar; canal very short and open.

Dimensions.—L. 50 mm. B. 30 mm.

Distribution.—*Recent:* Finmark, Nova Zembla, Spitzbergen, Greenland.
Fossil: Waltonian Crag: Little Oakley.

Remarks.—I have obtained one or two specimens of this northern and exceedingly fragile species at Oakley, for the identification of which I am indebted to Dr. Øyen. They correspond, moreover, in form and sculpture with a Recent shell I have received from Dr. Sparre Schneider, obtained at Vadsö at a depth of 100 fathoms.

Mr. Friele identifies *B. fragile* with *B. undulatum*, Möller. MM. Dautzenberg and Fischer consider it nearly allied to *B. Tottenii.*

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[1] See also H. and A. Adams, Gen. Rec. Moll., vol. i, p. 108, 1858; and Rev. A. H. Cooke, Cambr. Nat. Hist., vol. iii, p. 134, 1895.

Buccinum Humphreysianum, Bennett. Plate X, figs. 14, 15.

1825. *Buccinum Humphreysianum*, Bennett, Zool. Journ., vol. i, p. 398, pl. xxii, fig. 1.
1853. *Buccinum Humphreysianum*, Forbes and Hanley, Brit. Moll., vol. iii, p. 410, pl. cx, fig. 1.
1862. *Buccinum Humphreysianum*, Jeffreys, Brit. Conch., vol. iv, p. 293, pl. lxxxiii, fig. 1.
1873–75. *Buccinum Humphreysianum*, Seguenza, Boll. R. Com. Geol., vol. iv, p. 348, 1873; vol. v, p. 278, 1874; vol. vi, p. 342, 1875.
1878. *Buccinum Humphreysianum*, G. O. Sars, Moll. Reg. Arct. Norv., p. 264, pl. xxv, figs. 7, 8.
1883. *Buccinum Humphreysianum*, Kobelt, Martini und Chemnitz, Conch. Cab., ed. 2, vol. iii (Buccinum), p. 56, pl. lxxxv, figs. 2, 3.
1887. *Buccinum Humphreysianum*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 102, pl. xviii, figs. 2, 3.

Specific Characters.—Shell of medium size, thin, rather fragile, ovato-conical; whorls 6—7, slightly convex, the last nearly three-fourths the total length; ornamented by fine and inconspicuous spiral striæ; spire short, regularly tapering to a blunt point; suture distinct; mouth oval, acutely angulate above; outer lip thin, rounded; inner lip forming a very thin glaze; pillar excavated; canal open, notched.

Dimensions.—L. 36 mm. B. 18 mm.

Distribution.—*Recent:* Shetland Islands, Hebrides; Connemara (Valentia) (110 fathoms), Bantry Bay, Cork; Bay of Biscay; Mediterranean; Norwegian Coast, Finmark.

Fossil: Waltonian Crag: Little Oakley. Upper Pliocene and Pleistocene: Sicily.

Remarks.—I have had for some time several damaged shells from Oakley which I could not satisfactorily identify. Receiving on one occasion, however, some specimens of *B. Humphreysianum* from Cork, it fortunately happened that one of them, evidently corresponding to the former, was similarly imperfect. Locard reports this species from deep water off the coast of Provence, and Seguenza gives it from all stages of the Pleistocene and Upper Pliocene of Sicily.

Buccinum Donovani, Gray (non Linné). Plate VII, fig. 7.

1800. *Buccinum glaciale*, Donovan, Nat. Hist. Br. Shells, vol. v, pl. cliv.
1827. *Buccinum glaciale*, Brown, Illust. Conch. Gt. Brit., pl. xlix, figs. 12, 13.
1839. *Buccinum Donovani*, Gray, Zool. Beechey's Voyage, p. 128.
1841–70. *Buccinum Donovani*, Gould, Rep. Inv. Mass., ed. 1, p. 304, fig. 208, 1841; ed. 2, p. 369, fig. 636, 1870.
1878. *Buccinum Donovani* (?), G. O. Sars, Moll. Reg. Arct. Norv., p. 257, pl. xiii, fig. 11.
1883. *Buccinum Donovani*, Kobelt, Martini und Chemnitz, Conch. Cab., ed. 2, vol. iii (Buccinum), p. 40, pl. lxxxii, fig. 5.
1912. *Buccinum Donovani*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 124, pl. vii, fig. 11.

Specific Characters.—Shell solid, smooth and polished, ovato-conical; ornamented by numerous curved and irregular longitudinal folds, not very prominent, which do not extend to the base of the shell, together with raised spiral lines of unequal strength on the lower whorls, giving the upper ones a quasi-reticulate appearance; spire elongated; suture deep; whorls distinctly convex, the last excavated below, more than one-half, and the mouth about three-eighths of the total length; mouth short, obtusely-angulate above; outer lip rounded; inner lip forming a thin glaze upon the pillar, nearly destitute of callus; canal short, open, slightly recurved.

Dimensions.—L. 65 mm. B. 28 mm.

Distribution.—*Recent:* St. Flavie, Canada, Banks of Newfoundland, Arctic Seas.

Fossil: Waltonian Crag: Little Oakley.

Remarks.—I have a unique specimen from Oakley of a Buccinum which corresponds with Gould's figure and description of *B. Donovani* except that in the Crag fossil the longitudinal folds are more numerous. This species has not been hitherto discovered in any of the Pliocene or Pleistocene deposits of Great Britain. Prof. G. O. Sars describes a Recent shell under the same name, reporting it from Scandinavia, Greenland, and Labrador. The Oakley specimen conforms rather to the American form, however, than to Sars' figure; the latter approaches *B. undatum*, of which Dr. Øyen and Messrs. Dautzenberg and Fischer think it may be a variety.

Gould says the American shell may be distinguished from *B. undatum* by its greater polish; our Crag fossil agrees with this description. Out of some hundreds of specimens of that species known to me from the Crag, I do not remember another which approaches it in this respect. It differs from those figured by MM. Dautzenberg and Fischer in its more numerous plications, but agrees with one of them in having the short and rounded mouth which seems one of the characteristics of this species. It appears to be the same as fig. 5 of Prof. Kobelt's pl. lxxxii (*op. cit.*).

Buccinum variabile, Verkrüzen. Plate X, figs. 4, 5.

1881. *Buccinum variabile,* Verkrüzen, Jahrb. Deutsch. Malak. Gesellsch., vol. viii, p. 300.

Specific Characters.—Shell ovato-conical; whorls 6, convex, regularly tapering to a blunt point, the last three-fourths the total length; ornamented by numerous longitudinal costæ, distinct but not very prominent, which disappear on the body-whorl, and by wavy, distant and rather inconspicuous spiral lines with exceedingly fine striæ between them; suture deep; mouth oval, angulate above; outer lip regularly curved, not expanded; inner lip forming a wide glaze on the pillar; pillar twisted; canal very short.

Dimensions.—L. 48 mm. B. 25 mm.

Distribution.—*Recent:* Banks of Newfoundland.

Fossil: Waltonian Crag: Little Oakley. Newbournian: Waldringfield. Probably elsewhere in the Red Crag.

Pliocene: Iceland (?); unknown from the Pleistocene of Norway (Øyen).

Remarks.—In the Norman collection at the British Museum (Natural History) there are a number of Buccinums collected by Verkrüzen from the Banks of Newfoundland which were regarded by him as different species, and named, but neither figured nor fully described. As the specimens referred to were received by Canon Norman from Verkrüzen himself they may be taken to represent accurately the type forms. They seem a distinct and interesting group; Dr. Sparre Schneider, our best authority on the subject, informs me they are unknown in Scandinavian seas, or from any locality to the east of Newfoundland.

Comparing them with Mr. E. A. Smith at the British Museum with some Crag fossils, we agreed that there were specimens among the latter which could not be separated from Verkrüzen's types.

There appears to be some difference of opinion as to these Newfoundland species, which have been variously regarded as allied to *B. undatum*, *B. grœnlandicum*, *B. terræ-novæ*, *B. Tottenii*, or *B. Amaliæ*.

The matter, however, seems one for northern conchologists; I am content to figure such of our fossils as may appear to correspond with Verkrüzen's shells, the interesting point being that a group of mollusca said to be unknown from the coasts of Great Britain or Scandinavia had their analogues in the North Sea in Pliocene times. Dr. Sparre Schneider, having very kindly examined my specimens of this group of Buccinums, reports that taken as a whole they bear a striking resemblance to those of the Recent fauna of Newfoundland.

Speaking generally the spiral sculpture of these Newfoundland Buccinums is fine and more or less inconspicuous. It seems possible that though forming a group sufficiently distinct, some of them may be regarded as varieties of one or more central forms rather than as separate species.

The Crag specimen of *B. variabile* now figured is from Oakley; it was identified in the first case by Dr. Øyen as agreeing with one in the Museum at Christiania; the Recent shell here given is from the Norman collection.

Buccinum inexhaustum, Verkrüzen. Plate X, figs. 1—3.

1877. *Buccinum*, n. sp., Mörch and Poulsen, MS. list and plates in Geological Museum, Copenhagen, no. 16, pl. iii, fig. 1 (unpublished).

1881. *Buccinum inexhaustum*, Verkrüzen, Jahrb. Deutsch. Malak. Gesellsch., vol. viii, p. 297.

1883. *Buccinum ventricosum*, Kobelt, Martini und Chemnitz, Conch. Cab., ed. 2, vol. iii (Buccinum), p. 51, pl. lxxxiv, figs. 4, 5.

Specific Characters.—Shell solid, strong, ovate, of moderate size; whorls 6, convex, regularly diminishing, the last much the largest, three-fourths the total length; ornamented by well-marked, fine, but rough and wavy spiral ridges and by numerous lines of growth which may be seen with the aid of a lens; longitudinal plications wanting or faint and confined to the upper whorls; suture distinct; mouth oval, angulate, with a small well-marked sinus above; outer lip regularly curved; inner lip forming a glaze on the pillar; canal short, wide.

Dimensions.—L. 45—60 mm. B. 28—36 mm.

Distribution.—*Recent:* Grand Banks of Newfoundland.

Fossil: Coralline Crag: Boyton. Waltonian: Walton-on-Naze, Little Oakley. Probably elsewhere in the Red Crag.

Pliocene of Iceland.

Remarks.—The grand and very distinct shell I have given under the above name (Pl. X, fig. 1) was sent me by Dr. Sparre Schneider as a typical example of the Recent form *B. inexhaustum*, another of Verkrüzen's Newfoundland species: it agrees with those of the Norman collection in the British Museum, and apparently with some figured by Prof. Kobelt (*op. cit.*, figs. 4, 5) as *B. ventricosum.*[1]

I have found at Oakley a fair number of specimens, most of them unfortunately broken or fragmentary, which correspond more or less nearly with Dr. Sparre Schneider's, having the rough transverse sculpture characteristic of this species, the only difference being that the spiral lines are coarser than in the Newfoundland shells; this is specially so in a perfect example from Boyton in the York Museum (fig. 3).

Among the Iceland fossils in the Mörch collection at Copenhagen (*op. cit.*), there is one which may possibly be of the same species.

Although the nomenclature of Verkrüzen's Buccinums has not been generally accepted by conchologists, perhaps because they have not been adequately described or figured, the remarkable similarity that exists between them and some of our Crag fossils leads me to think they deserve recognition. I do not know any of the recognised species of this group to which the Crag forms here described can be so conveniently referred.

Buccinum elongatum, Verkrüzen. Plate VIII, figs. 7, 8.

1881. *Buccinum elongatum,* Verkrüzen, Jahrb. Deutsch. Malak. Gesellsch., vol. viii, p. 90, pl. iv, figs. 3, 4.

1883. *Buccinum elongatum,* Kobelt, Martini und Chemnitz, Conch. Cab., ed. 2, vol. iii (Buccinum), p. 68, pl. lxxxvii, fig. 1.

1899. *Buccinum Amaliæ,* var. *elongata,* Posselt, Medd. om Grönl., vol. xxiii, p. 198.

1912. *Buccinum Donovani,* var. *elongata,* Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 125, pl. vii, fig. 12.

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[1] Another of Kobelt's specimens under this name (fig. 6), which is that originally figured by Kiener (Coq. viv., Buccinum, pl. iii, fig. 7), afterwards copied by Reeve and by Tryon, seems to me a different species.

Specific Characters.—Shell turreted, elongate; whorls 7, decidedly convex; ornamented on all the upper ones but the first by fine longitudinal plications, flexuous and somewhat inconspicuous, which tend to die out on the last whorl, and by irregular wavy spiral lines of unequal size; spire longer than in the species just described; apex blunt; suture deep; mouth oval; outer lip thin; inner lip forming a thin glaze on the pillar; pillar excavated in the middle and twisted; canal open, very short.

Dimensions.—L. 45 mm. B. 25 mm.

Distribution.—*Recent:* Newfoundland; West Greenland.

Fossil: Waltonian Crag: Little Oakley. Butleyan: Hollesley.

Remarks.—*B. elongatum* is another of Verkrüzen's Newfoundland species, the description given above being based on some shells Dr. Sparre Schneider has sent me from the Tromsö Museum.

Among the Oakley fossils that he was kind enough to examine, he separated some having an elongate spire, convex whorls and a short mouth, most of them, unfortunately, young or imperfect, which he regarded as closely allied to, if not identical with, *B. elongatum.* I figure one of his Recent shells, together with a nearly perfect fossil from Hollesley which it approaches both in form and sculpture; possibly other specimens of this form may be found hereafter in the Crag.

Prof. Kobelt regards *B. elongatum* as a separate species, as does Dr. Sparre Schneider; on the contrary, MM. Dautzenberg and Fischer describe it as a variety of *B. Donovani*, and Posselt of *B. Amaliæ.* All of them consider it, however, a distinct form.

Buccinum meridionale (Verkrüzen, MS.), sp. nov. Plate IX, figs. 1, 2.

— *Buccinum meridionale*, Verkrüzen, MS.

Specific Characters.—Shell ovate, shorter than the last, rather thin; whorls convex, rapidly diminishing in size, the last tumid, nearly four-fifths the total length; ornamented with spiral striations, generally excessively fine, and in places by the faint lines of growth; longitudinal plications absent or confined to the upper whorls; spire short, ending in a blunt point; suture deep and well-marked; mouth oval, angulate above, half the length of the shell, outer lip thin, expanded, regularly curved; inner lip forming a thin glaze upon the columella; columella twisted; canal wide, open, very short.

Dimensions.—L. 35 mm. B. 22 mm.

Distribution.—*Recent:* Banks of Newfoundland, southern part; unknown further east.

Fossil: Waltonian Crag: Walton-on-Naze. Butleyan: Butley; probably elsewhere.

Remarks.—The Crag fossil from Walton here figured belongs to the Jermyn Street Museum. It corresponds closely with some Recent and undescribed Newfoundland shells I have received from the Tromsö Museum through Dr. Sparre Schneider as *B. meridionale*, which he informs me is a MS. name of Verkrüzen; they seem distinct from the last species, being especially characterised by their convex whorls, their exceedingly fine and delicate spiral sculpture, and in the type form by the absence of longitudinal plications, although the latter feature is not constant in some of its varieties.

Var. **inflata**, nov. Plate IX, figs. 3, 4.

1881. *Buccinum undatum*, Nyst, Conch. Terr. Tert. Belg., p. 19, pl. ii, fig. 3.

Dimensions.—L. 30—40 mm. B. 21—26 mm.
Distribution.—*Recent*: Newfoundland.
Fossil: Waltonian Crag: Walton-on-Naze. Butleyan: Butley. Scaldisien: Belgium.

Remarks.—The shells figured under this name, although differing somewhat from the type form of *B. meridionale*, have its exceedingly fine spiral sculpture and seem to belong to the same group; the spire is shorter in proportion to the mouth than in *B. inexhaustum*, the whorls are more tumid, and the suture deeper; the longitudinal ribs, moreover, are comparatively few and prominent, reaching the upper part only of the last whorl. There is a Recent specimen in the Norman collection at South Kensington agreeing very nearly with the Walton shell which I have also figured; Nyst's figure of *B. undatum*, from the Scaldisien of Belgium (*op. cit.*), appears to be the same.

Var. **elongato-undosa** (Sparre Schneider, MS.), nov. Plate IX, figs. 5, 6.

Dimensions.—L. 35 mm. B. 22 mm.
Distribution.—*Recent:* Newfoundland.
Fossil: Butleyan Crag: Butley.

Remarks.—In the specimen from Butley figured under Dr. Sparre Schneider's unpublished name of *elongato-undosa* the spire is longer than in that of the variety just described, and the flexuous plications on the upper whorls and on the upper part of the last are somewhat more numerous. It corresponds more or less nearly, however, with a Recent specimen he has kindly sent me, the variations of this species in Pliocene times being apparently of a similar character to those of the Recent shell.

Var. **icenica,** nov. Plate IX, figs. 7, 8.

Varietal Characters.—Differing from the type form of *B. meridionale* in its smaller size and in its stronger sculpture ; the spiral lines, which are slightly raised and clearly cut, are closely crowded together, especially on the upper and lower portions of the whorls ; the longitudinal plications are confined to the upper whorls, being small and numerous ; the whorls are decidedly convex, the last is tumid and the suture is deeper.

Dimensions.—L. 24—30 mm. B. 15—20 mm.

Distribution.—Not known living.

Fossil : Icenian Crag : Bramerton.

Remarks.—Examples of this charming and distinct little shell, which, as far as I know, has only been obtained from the Icenian Crag of Bramerton, are to be found both in the Cambridge and Norwich Museums, those figured being from the Fitch collection at the latter place. It approaches *B. ciliatum* in sculpture, but differs from it in form, and appears to associate itself more nearly with *B. meridionale*, of which species it may be regarded, I think, as a dwarf variety.[1]

Buccinum Tottenii, Stimpson. Plate X, figs. 6—8.

1865. *Buccinum Tottenii,* Stimpson, Canad. Nat. (N.S.), vol. ii, p. 385.

1872. *Buccinum Tottenii,* Dawson, Canad. Nat. (N.S.), vol. vi, p. 396.

1883. *Buccinum Tottenii,* Kobelt, Martini und Chemnitz, Conch. Cab., ed. 2, vol. iii (Buccinum), p. 34, pl. lxxx, figs. 3, 4.

1887. *Buccinum Tottenii,* Mörch and Poulsen, MS. list and plates in Geol. Mus. Copenhagen, no. 17, pl. iii, fig. 2 (unpublished).

1912. *Buccinum Tottenii,* Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii, p. 125, pl. vii, figs. 13—17.

Specific Characters.—Shell ovato-conical, whorls 6 or 7, decidedly convex, the last excavated below, two-thirds the total length ; ornamented by numerous flexuous longitudinal plications on the upper whorls and on the upper part of the last, not very prominent, which do not reach the bottom of the shell, and by well-marked, rounded spiral lines, sometimes with finer ones intervening, especially on the body-whorl ; suture deep ; mouth oval, angulate above ; canal open, very short.

Dimensions.—L. 45—60 mm. B. 28—35 mm.

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[1] Küster figured a shell in the Conch. Cab., vol. iii (1858), pl. ix, fig. 4, as *B. cyaneum,* which to some extent resembles my fig. 8. Much difference of opinion exists, however, as to the latter species. The figure originally given by Chemnitz in the Conch. Cab. (pl. clii, fig. 1448) is that of a very different shell; Reeve's figure, again (pl. ix, fig. 69), differs from both of them.

Distribution.—Recent: north-eastern coasts of North America, Newfoundland; Greenland, Spitzbergen, Franz Joseph Land.

Fossil: Waltonian Crag: Walton-on-Naze. Newbournian: Waldringfield. Butleyan: Butley.

Pliocene: Iceland. Scaldisien: Antwerp. Pleistocene of Canada: Rivière du Loup.

Remarks.—There appears to be considerable difference of opinion as to what the American *B. Tottenii* really is; it does not seem to have been figured until 1883. Mr. E. A. Smith has shown me a specimen in the British Museum, without plications, ornamented with very fine spiral lines, which Dr. Dall considered the typical form of this species; it approaches the shell I received from Dr. Sparre Schneider as *B. meridionale* (Pl. IX, fig. 2). Sir J. W. Dawson says, moreover, that *B. Tottenii* is characterised by the absence of longitudinal folds (*op. cit.*, p. 396).

On the other hand Mr. Friele identifies the latter with *B. terræ novæ*, a strongly sculptured form, while MM. Dautzenberg and Fischer, our latest authorities on the subject, have figured in their recent work as *B. Tottenii* some shells having bold and well-marked sculpture, both longitudinal and transverse. They remark that the figures given by Dr. Kobelt in the Conch. Cab. (*op. cit.*) agree perfectly with Stimpson's original description of this species.[1] There is a somewhat similar specimen from Walton in the Jermyn St. Museum, and another here figured, from Butley, in the Sedgwick Museum at Cambridge (Pl. X, fig. 6), which approach those represented by MM. Dautzenberg and Fischer, and appear to belong to the present species.

In the Mörch collection from the Iceland Crag at Copenhagen there are fossils under the present name, somewhat similar but smaller in size and with finer sculpture (fig. 7), which I propose to call var. *islandica;* one of these I have figured with another from Waldringfield (fig. 8), which seems to be the same.

There is a note in Canon Norman's writing at the British Museum expressing the opinion that most of Verkrüzen's specimens of *B. meridionale* and *B. inexhaustum* might be regarded as varieties of *B. Tottenii*, but in the Crag these forms appear to have been distinct. Following Prof. Kobelt and MM. Dautzenberg and Fischer as to *B. Tottenii*, and Dr. Sparre Schneider as to the others, I retain the latter name for the specimens now figured from Iceland, Walton, and Butley. They differ materially from Verkrüzen's type forms of *B. meridionale* and *B. inexhaustum*.

The shell I recognise as *B. Tottenii* seems to be a North American and Arctic species which ranges to Spitzbergen and Franz Joseph Land, but is unknown from Scandinavian seas.

The question of the relation of the various Crag Buccinums to each other and

[1] Students should refer to these figures, with which my Pl. X, fig. 6, very nearly agrees.

to the recognised and existing species of different regions, is an exceedingly difficult one. They run into one another in a very perplexing manner, possibly because in Pliocene times they were nearer to the ancestral forms from which they had sprung, when new variations would have a stronger tendency to revert to the old types; in discussing the Crag Neptuneas and Siphos we shall find ourselves confronted with a similar problem. Forty years ago Sir J. W. Dawson expressed the opinion that the northern Buccinums were involved in much confusion; I fear such is still the case.

The subject needs a careful and thorough revision, but it must be undertaken by a younger man than myself, who has more material, both Recent and fossil, at his disposal. The Palæontologist, moreover, who has only the shells to guide him, must always be seriously handicapped for such a task.

Adopting provisionally specific names at present current, I can only offer my small contribution from the standpoint of a student of the English Crag, showing that many Recent forms of the northern Buccinums, both European and American, were more or less nearly represented in the North Sea during the Pliocene epoch.

Genus **LIOMESUS,** Stimpson, 1865.

Liomesus canaliculatus (Dall). Plate XII, figs. 1, 2.

1872. *Trophon elegans* (?), S. V. Wood, Mon. Crag Moll., 1st Suppl., p. 22, tab. ii, fig. 6.
1874. *Buccinopsis canaliculata,* Dall, Proc. Cal. Acad. Sci., vol. v, p. 252.
1877. *Buccinopsis elegans,* Mörch and Poulsen, MS. list and plates in Geol. Museum, Copenhagen, no. 24, pl. ii, fig. 5 (unpublished).
1883. *Buccinopsis canaliculatus,* Kobelt, Martini und Chemnitz, Conch. Cab., ed. 2, vol. iii (Buccinum), p. 102, pl. lxxxviii, fig. 10.
1902. *Liomesus canaliculatus,* Dall, Proc. U.S. Nat. Mus., vol. xxiv, p. 531, pl. xxxviii, fig. 2.

Specific Characters..—Shell short, ovato-conical; whorls 5, nearly flat, diminishing regularly to a blunt and depressed apex; ornamented by strong and regular spiral ridges closely crowded together; suture well-marked; mouth ovate, angulate above; outer lip thin; canal short, wide, open, turning slightly to the left.

Dimensions.—L. 32—35 mm. B. 18—20 mm.

Distribution.—*Recent:* Behring Sea.

Fossil: Butleyan Crag: Butley. Pliocene: Iceland.

Remarks.—The shell from the Pliocene of Iceland here figured was referred by Mörch to Charlesworth's species, *Atractodon elegans*, although under the generic name of *Buccinopsis*, probably because a similar form from Butley had been described by Wood, though with some doubt (*op. cit.*), as an immature example of that species; Mr. A. Bell, however, who originally discovered the fossil in question, has always differed from this view, and from an examination of many specimens of Charlesworth's shell, both Belgian and English, I am compelled to agree with him; *Atractodon elegans* is quite a different species.

The Iceland fossil corresponds with that from Butley, except that the spiral sculpture is somewhat coarser. From photographs I have submitted to Dr. Dall, he has identified both of them with the Recent Behring Sea form, *L. canaliculatus*.

The generic name *Liomesus* has been generally adopted for the shells formerly known as *Buccinopsis*.

Genus **PURPURA**, Adanson, 1757.

Purpura tetragona (J. Sowerby). Plate XI, fig. 6; and var. **alveolata** (J. Sowerby), Plate XI, figs. 13, 18.

1825. *Buccinum tetragonum*, J. Sowerby, Min. Conch., vol. v, p. 13, tab. ccccxiv, fig. 1.
1825. *Murex alveolatus*, J. Sowerby, Min. Conch., vol. v, p. 9, tab. ccccxi, fig. 2.
1843. *Murex alveolatus*, Nyst, Coq. foss. Terr. Tert. Belg., p. 547, pl. xliii, fig. 1.
1848. *Purpura tetragona*, and varieties, S. V. Wood, Mon. Crag Moll., pt. i, p. 38, tab. iv. figs. *7a*, *7b*.
1881. *Purpura tetragona*, and varieties, Nyst, Conch. Terr. Tert. Belg., p. 39, pl. iii, fig. 5.
1885. *Purpura tetragona*, Lorié, Arch. Mus. Teyler (2), vol. ii, p. 201, pl. v, fig. 24.
1912. *Purpura tetragona*, Tesch, Med. v. d. Rijks. v. Delfstoffen, pt. iv, p. 80.

Specific Characters.—See Mon. Crag Moll., pt. i, p. 38.

Distribution.—Not known living.

Fossil: Coralline Crag—Boyton zone: Ramsholt. Red Crag—Waltonian; Newbournian; Butleyan. Scaldisien: Belgium, Holland.

Remarks.—This species has not been reported hitherto from the Coralline Crag. There is a specimen in the Ipswich Museum, from Ramsholt, however, here figured, from a bed which in Mr. A. Bell's opinion belongs to the Boyton division of that formation.

In the Waltonian Crag, whether of Walton, Beaumont, or Little Oakley, it is, together with its variety *alveolata*, among the most abundant and characteristic fossils; in the Newbournian it is not so common, and it seems to have been dying out at the Butleyan stage.

From the Norwich Crag it is unknown, if we except a doubtful specimen included in S. P. Woodward's list on the authority of the late Robert Fitch; no trace of it, however, has been met with for fifty years, as far as I know, at any locality of that horizon.

Purpura lapillus (Linné), and varieties. Plate XI, figs. 1—5, 7—12, 14—17, 19—23.

1758. *Buccinum lapillus*, Linné, Syst. Nat., ed. x, p. 739, no. 403.
1825. *Buccinum crispatum*, J. Sowerby, Min. Conch., vol. v, p. 12, tab. ccccxiii, figs. 1—3.
1825. *Buccinum incrassatum*, J. Sowerby, Min. Conch., vol. v, p. 13, tab. ccccxiv, fig. 2.
1841–70. *Purpura lapillus*, Gould, Rep. Inv. Mass., ed. 1, p. 301, 1841; ed. 2, p. 360, fig. 630, 1870.
1843. *Murex incrassatus*, Nyst, Coq. foss. Terr. Tert. Belg., p. 548, pl. xliii, fig. 2.
1848–72. *Purpura lapillus* and varieties, S. V. Wood, Mon. Crag Moll., pt. i, p. 36, tab. iv, figs. 6*a*—6*d*, 6*f*, 6*g*, 1848; 1st Suppl., p. 22, 1872.
1853. *Purpura lapillus* and vars. *incrassata* and *imbricata*, Forbes and Hanley, Brit. Moll., vol. iii, p. 380, pl. cii, figs. 1—3.
1867. *Purpura lapillus* and vars. *minor*, *major*, and *imbricata*, Jeffreys, Brit. Conch., vol. iv, p. 276, pl. lxxxii, fig. 1.
1878. *Polytropa lapillus* and var. *imbricata*, G. O. Sars, Moll. Reg. Arct. Norv., p. 250, pl. xxiii, fig. 15.
1881. *Purpura lapillus* and varieties, Nyst, Conch. Terr. Tert. Belg., p. 38, pl. iii, fig. 4.
1895. *Purpura lapillus*, Cooke, Cambr. Nat. Hist., vol. iii, p. 90, fig. 35.
1900–1. *Polytropa lapillus*, Brφgger, Norges geol. undersφgelse, vol. xxxi, pl. ix, fig. 7.

Although the name of *P. lapillus* occurs in lists of shells from all the Red Crag deposits, the most common variety of that species now living in the North Sea, that given by Jeffreys (*op. cit.*, vol. v, pl. lxxxii, fig. 1), and in Pl. XI, figs. 21—23 of this Memoir, is only known to me from the latest or Butleyan horizon, where, indeed, it is very rare, the Purpuras of the earliest zones grouping themselves with *P. incrassata*, or even with *P. tetragona*, rather than with the typical form. If *P. incrassata* were a distinct species—a view adopted by Wood in his 1st Supplement, p. 18—the specimens figured by him as varieties of *P. lapillus*, viz. *carinata*, *crispata*, *brevis*, and *imbricata*, might be regarded as varieties of the former, appearing as they did in the Anglo-Belgian basin at an earlier stage than the existing shell.

I have figured some prevalent forms of the Purpuras usually grouped with *P. lapillus* which occur in the Waltonian deposits, in order to illustrate more clearly their connection with *P. incrassata* on the one hand and *P. tetragona* on the other.

The variety *carinata* of Wood's Monograph, for example (Pl. XI, fig. 4 of the present work), is merely a dwarf form of *P. incrassata* (fig. 1); his variety *imbricata* (fig. 3) is the same shell with a flounce-like imbrication, while var. *elongata* (fig. 14) is similar, with a longer spire; Wood's var. *brevis* (fig. 5),[1] moreover, belongs to the same group.

These varieties of *P. lapillus* connect themselves in like manner with those of *P. tetragona*; the spiral sculpture of var. *elongata* (fig. 14) resembles that of the variety *alveolata* of that species (fig. 13); another, var. *angusta* (fig. 19), finds its counterpart in fig. 18, the only difference being that the varix-like ribs are present

[1] Possibly var. *minor*, Jeffreys, Brit. Conch., vol. iv, p. 277, 1867.

in the one case and absent in the other, There is a form, moreover, very common at Oakley, that I propose to call var. *oakleyensis*, which more closely connects the two groups, the specimens shown in my figs. 7, 8, 10 and 15 approaching in spiral sculpture both the Boyton shell, *P. tetragona* (fig. 6), and an Antwerp specimen of var. *imbricata* (fig. 9). A constant feature of the variety *oakleyensis* is the occurrence, especially on the body-whorl, of strong varices, as in Wood's variety *elongata*; it is never elongate, however, the body-whorl is tumid and larger than the others, the mouth is wide and the outer lip expanded; it is very common at Oakley, less so in the Newbournian and Butleyan Crag and unknown from the Icenian.

At the Newbournian stage a shell, var. *newbourniensis* (figs. 16, 17), appears in the Crag for the first time, being very characteristic of that horizon; I have dredged similar living specimens off Yarmouth. The variety *connectens* (fig. 2), however, seems intermediate between *newbourniensis* and *incrassata*.

The prevalent form at Butley, var. *butleyensis* (fig. 20), approaches a variety of the Recent shell; it is shorter in the spire, the whorls are less convex, the suture is not so deep, and the outer lip is not thickened.

The typical variety of the Recent *P. lapillus*, var. *vulgaris*, S. V. Wood (fig. 21), a strong conical shell with flattened whorls, and an outer lip thickened internally and bevelled off to a thin edge (fig. 22), is not known to me from any part of the Red Crag older than that of Butley and Bawdsey where it is by no means frequent.

This form also occurs in the Norwich Crag, although somewhat rarely, but it is common in the Pleistocene deposits, as, for example, in the March gravels (fig. 23) and the raised beach at Portland.

Specimens I have received from Bergen, Trondhjem and Denmark (fig. 12), as well as those from the Pleistocene deposits of Christiania figured by Prof. Brøgger and by Prof. G. O. Sars from the arctic shores of Norway, are more or less of this type. The latter authority states that they range in circumpolar latitudes from Scandinavia to Iceland and Greenland, occurring also in Behring Sea.

The Purpuras described by Gould from Massachusetts (fig. 11) also approach those of the later zones of the English Crag; on the contrary, all those I have seen from the Scaldisien of Belgium are of the older or Waltonian type. Nyst represents three forms only from Antwerp: *P. tetragona* and the varieties *incrassata* and *imbricata* of *P. lapillus*. Dr. Lorié figures the first-named from the Scaldisien of the Dutch borings; the Butley variety of *P. lapillus* he gives only from the later Amstelien deposits.

In vol. iii, p. 90, of the 'Cambridge Natural History,' the Rev. A. H. Cooke figures many specimens of *P. lapillus*, illustrating the fact, to which he calls attention, that this species is exceedingly variable, and he has kindly sent me for examination a number of them from different localities from his own collection. None of these, however, resemble the special type of Purpura from the Waltonian Crag, nor does he know any Recent shells identical with the latter. The fact that the group characteristic of the Waltonian deposits had well-nigh disappeared from the Crag sea before the arrival of the existing forms, suggests that the former may have been due to an earlier migration, possibly more or less contemporaneous with that which brought *Neptunea contraria* and some other Waltonian species into the Anglo-Belgian basin. The different Crag varieties are evidently closely allied, but at present we have no evidence as to the ancestral form from which they may have sprung. It seems, however, that they have a stratigraphical value, indicating the relative age of the deposits in which they occur.

Edward Forbes expressed the opinion that the British *P. lapillus* is of American origin, having been introduced to European seas during the Pleistocene epoch. That the Purpuras which now range from Scandinavia to Behring Strait had some common circumpolar origin seems probable; there is no evidence, however, to show whether they travelled to the east or the west of their original home, or in both directions at once, but as these shallow-water forms had arrived in these regions during the Crag period, their migrations must have been, I think, pre-Pleistocene, and have taken place at a time when the now submerged Greenlando-European ridge was in existence, and the northern coasts of North America were less encumbered with ice than they are at present.

Jeffreys says that *P. lapillus* is found on the coast of Brittany, in Vigo Bay, Senegal, Teneriffe, the Azores and elsewhere, but what relation these southern shells may bear to the forms now existing in the North Sea I do not know. The species in question is not reported, either Recent or fossil, from the Mediterranean; there and elsewhere it seems to be represented by an allied form, *P. hæmastoma*, which also occurs fossil in the Pleistocene of Sicily. An imbricated variety of the recent *P. lapillus* is still found in British seas. It is the habit of imbrication, however, rather than any special form which survives. The imbricated shell of Oakley belongs, as we have seen, to the older and carinated group; a Recent specimen in my collection from Copenhagen and that figured by Prof. Sars, on the contrary, are merely imbricated replicas of the existing form.

Purpura derivata, sp. nov. Plate XII, fig. 30.

1837. Cf. *Purpura exilis*, Partsch, v. Hauer, Neues Jahrb. f. Min., p. 417, no. 42.
1856. Cf. *Purpura exilis*, Hörnes, Foss. Moll. Tert. Wien, vol. i, p. 169, pl. xiii, fig. 21.

Dimensions.—L. 35 mm. B. 30 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Little Oakley (derivative).

Remarks.—The worn specimen from Oakley here represented, doubtless derivative from some older deposit, approaches that given by Hörnes as *P. exilis*, a somewhat variable Miocene species, with which it may be compared. As it is not sufficiently perfect for certain identification I have figured it provisionally under the above name. It appears to be a distinct form and different from anything hitherto recorded from the Crag; possibly a better specimen may be found hereafter.

Genus **STENOMPHALUS**, Sandberger, 1861.

Stenomphalus Wiechmanni, Von Koenen. Plate XII, fig. 31.

1872. *Stenomphalus Wiechmanni*, Von Koenen, Mioc. Nord-Deutsch. Moll. Faun., p. 47, pl. i, figs. 2, 10.

Distribution.—Not known living.

Fossil: Waltonian Crag: Little Oakley (derivative). Upper Oligocene and Miocene: North Germany.

Remarks.—The unique and immature specimen from Oakley here figured was recognised by the late Dr. Gottsche of the Hamburg Museum as of this species.[1] Although imperfect and fragmentary, it is not much worn; it appears to agree generally with Von Koenen's figure, and is no doubt derivative in the Crag. A similar and Recent shell is figured by Chenu as *Purpura* (*Trochia*) *cingulata* (Man. Conch., vol. i, p. 166, fig. 805, 1859) = *Buccinum cingulatum*, Linné. I figure the Crag fossil under the above name on Dr. Gottsche's authority.

Genus **TRITON**, Montfort, 1810.

Triton heptagonum (Brocchi). Plate XII, figs. 6, 7.

1814. *Murex heptagonus*, Brocchi, Conch. foss. subap., vol. ii, p. 404, pl. ix, fig. 2.
1872. *Triton heptagonum*, Bellardi, Moll. Terr. Terz. Piem., vol. i, p. 224.
1879. *Triton heptagonum*, var. *pyrenaica*, Fontannes, Moll. Plioc. Vall. du Rhone, vol. i, p. 33, pl. iii, fig. 9.
1890. *Triton heptagonum*, C. Reid, Plioc. Dep. Brit., p. 257.

Specific Characters.—Shell small, strong, ovate, turreted, sub-fusiform; spire short; apex depressed; whorls squarely angulate, forming a shelf below the suture, the last much the largest; suture deep; sculpture, 4—6 distant longitudinal

[1] Dr. Gottsche, who appeared at that time in perfect health, took part in our pleasant excursion to the Crag district during the Centenary meetings of the Geological Society in 1907. His premature death is much to be lamented.

costæ, with an occasional varix, the costæ being prominent on the upper whorls but less so towards the base of the shell, crossed by well-marked but irregular spiral ribs of unequal size and nodulous, especially where they intersect the varices and the longitudinal costations; mouth subquadrate, with a narrow and nearly straight canal; outer lip thickened by the labial rib, strongly denticulate within; inner lip rugose.

Dimensions.—L. 25 mm. B. 14 mm.

Distribution.—Not known living.

Fossil: Lenham Beds. Waltonian Crag: Little Oakley (probably derivative).

Northern Italy—Upper Miocene: Sta. Agata. Upper Pliocene: Asti (abundant). Pliocene: Rhone valley.

Remarks.—In his Monograph of 1848 (tab. iv, fig. 8), Wood figured a specimen from the Coralline Crag of Gedgrave under the above name, which to some extent resembles the present species in form and sculpture. Subsequently he came to the conclusion, however, that it was different (an opinion also shared by Jeffreys), and called it *T. connectens* (1st Suppl., p. 30). There is a specimen of this shell in the Ipswich Museum from the Coralline Crag of Boyton, and another from Foxhall at the same place.

Bellardi states that *T. heptagonum* is a small shell, 25 mm. only in length, specially characterised by the depth of the suture and its quadrangular mouth, and that it is very abundant at Asti. During a visit to that place some years ago I obtained several specimens of it, one of which is here figured. I have found also an imperfect and worn example at Oakley, as to the identity of which with the latter there seems little doubt. In all probability this form is derivative in the Crag of that place, possibly from some older Pliocene deposit like that of Lenham where Mr. C. Reid observed it, from which some other of the extraneous fossils of the Red Crag may have been derived.

The species in question does not appear in Seguenza's list of the Pleistocene mollusca of Sicily.

The *T. heptagonum* of Hörnes seems to differ materially from the Asti shell. The tuberculate character of the spiral costæ is well shown in the latter, as it is in Brocchi's original figures.

Triton Woodii, sp. nov.

1879 *Triton connectens* (?), S. V Wood, Mon. Crag Moll., 2nd Suppl., p. 15, tab. i, fig. 14.

Specific Characters.—Shell short, ovate, thick and strong, turreted, whorls 5, having a squarish outline above, the last much the largest, two-thirds the total length; ornamented by strong spiral ridges which thicken and become serrate on the outer lip; mouth obliquely ovate, strongly denticulate within; inner lip thickened and grooved; canal short, open; umbilicus wide and deep.

Dimensions.—L. 30 mm. B. 20 mm.

Distribution.—Not known living.

Fossil: Newbournian Crag: Waldringfield.

Remarks.—A unique specimen of this very distinct form was obtained many years ago by the late R. G. Bell from Waldringfield, and is now in the British Museum (Nat. Hist.). It was referred to *T. connectens* by Wood, though with some doubt, but it seems to me to differ from the latter sufficiently to be entitled to specific rank. I suggest it may be known appropriately as *T. Woodii.* It may be, as Wood believed, derivative in the Crag.

Genus **MUREX**, Linné, 1758.

Murex rudis, Borson. Plate XII, figs. 3—5.

1822. *Murex rudis,* Borson, Mem. Acad. Tor., vol. xxvi, p. 308, pl. i, fig. 6.
1856. *Murex rudis,* Hörnes, Foss. Moll. Wien, vol. i, p. 674, pl. li, fig. 6.
1872. *Murex rudis,* Bellardi, Moll. Terr. Terz. Piem., vol. i, p. 91, pl. vii, fig. 1.
1876. *Murex rudis,* Seguenza, Boll. R. Com. Geol., vol. vi, p. 340.
1886. *Murex (Muricanthus) rudis,* Dollfus et Dautzenberg, Et. prel. Coq. Foss. Tour., p. 12.
1894. *Fusus Forbesi,* Kendall, Journ. Isle of Man Nat. Hist. Soc., vol. i, p. 419, pl. i, fig. 5.
1898. *Murex rudis,* A. Bell, Trans. R. Geol. Soc. Cornwall, vol. xii, p. 138, pl. i, fig. 3.
1904. *Murex rudis,* Sacco, Moll. Terr. Terz. Piem., pt. xxx, p. 29.

Specific Characters.—Shell thick and solid, ovato-fusiform; spire very short with a blunt point; whorls convex, somewhat depressed below the suture, rapidly diminishing in size, the last much the largest, four-fifths the total length, excavated below; ornamented by strong, prominent and obtuse longitudinal ribs, becoming oblique in adult specimens as they approach the mouth, and by well-marked spiral costæ which extend to the base of the shell; suture distinct; mouth ovate; outer lip thickened by the labial rib, grooved within; inner lip forming a glaze upon the pillar; canal short, open, turning to the left.

Dimensions.—L. 25 mm. B. 15 mm.

Distribution.—Not known living.

Fossil: Cranstal Point, Isle of Man; St. Erth.

Pliocene: Italy, Sicily. Miocene: Touraine, Vienna, Italy.

Remarks.—The specimen figured under this name is one of the shells from the Isle of Man in the Jermyn Street collection which have been hitherto grouped under the name of *Fusus Forbesi*; probably it may be identical with fig. 5 of Prof. Kendall's plate (*op. cit.*).

It corresponds in form with a specimen of *Murex rudis*, Borson, from the Miocene of Touraine which I have received from M. Dollfus, and with that figured by Hörnes; although none of the ribs are so varicose as in the latter, it may be, I think, a water-worn variety of that species. Mr. Alfred Bell says it is the same as the St. Erth shell described by him as *Murex rudis*.

Most of the Manx fossils given in the lists published by Prof. Kendall in 1894 (*op. cit.*), and more recently by Mr. Lamplugh in his Survey Memoir, are of a comparatively recent and northern character, and are believed by those observers to owe their present position to the action of the glacial ice moving along the bottom of the Irish Sea. An examination of the collections of mollusca from the Manx Drift, however, reveals the interesting fact that they contain a group of shells of a different character, some of them beautifully perfect, which are not of Pleistocene age, having an affinity rather with Pliocene or even Miocene forms. Separating these from those of a more recent type with which they are associated, we have a fauna which does not altogether agree with that of any recognised British horizon. It contains certain species characteristic of the Crag deposits of East Anglia or of Iceland, but contains also some forms which neither I nor the specialists I have consulted have been able to identify with any hitherto described or figured.

These facts, however, are not necessarily antagonistic to the view taken by Prof. Kendall and Mr. Lamplugh of the morainic origin of the Manx beds. Fossiliferous deposits older than the Pleistocene may have existed formerly at the bottom of the Irish Sea, the Manx fauna in that case possibly containing shells derived from more than one source.[1]

Mr. Lamplugh considers that the conditions of the sea bottom surrounding the Isle of Man may date back to late Pliocene times, and that this mixed fauna and the presence of northern species imply a changing climate (*op. cit.*, p. 389).

The species which seem specially to represent a pre-Pleistocene fauna, none of them being known living, are as follows :

**Nassa consociata*, var. *brevis*.
**Nassa elegans*.
**Nassa granulata*, var. *gracilis*.
* ,, ,, var. *fenestrata*.
Nassa Kermodei.
Nassa monensis.
Nassa reticosa, var. *costata* (*N. serrata* of Prof. Kendall).
* ,, ,, var. *lineata*.
Murex rudis.
Ocinebra tortuosa, var. *minor*.
Trophon Lamplughi (*T. muricatus* of Survey Memoir).
Searlesia costifer, var. *monensis*.
Searlesia Forbesi.
Searlesia Harrisoni.
Searlesia Lundgrenii.
Searlesia Nordmanni.
Searlesia Oyeni.
**Sipho curtus*, var. *exilis*.
**Sipho menapiæ*.
**Sipho tortuosus*, var. *lirata*.
Fusus longiroster.
**Cerithium tricinctum*.

[1] Prof. Kendall has alluded to the mixed character of the Manx shells, which he says is different from the natural grouping (*op. cit.*, p. 432).

Those marked * have been recently discovered by Mr. Bell during a visit to the Isle of Man, or by the Rev. S. N. Harrison.

Genus **OCINEBRA**, Leach, 1847.

Ocinebra erinacea (Linné). Plate XII, figs. 12—14.

1758. *Buccinum erinaceus*, Linné, Syst. Nat., ed. x, p. 736, no. 390.
1853. *Murex erinaceus*, Forbes and Hanley, Brit. Moll., vol. iii, p. 370, pl. cii, fig. 4.
1867. *Murex erinaceus*, Jeffreys, Brit. Conch., vol. iv, p. 306, pl. lxxxiv, fig. 1.
1872. *Murex erinaceus*, S. V. Wood, Mon. Crag Moll., 1st Suppl., p. 31, tab. ii, fig. 11.
1873–5. *Murex erinaceus*, Seguenza, Boll. R. Com. Geol., vol. iv, p. 346, 1873; vol. vi, p. 282, 1875.
1882. *Murex* (*Ocinebra*) *erinaceus*, Bucquoy, Dautzenberg et Dollfus, Moll. Mar. Rouss., vol. i, p. 21, pl. ii, fig. 1.
1885. *Ocinebra erinaceus*, Carus, Prod. faun. Medit., vol. ii, p. 385.
1901. *Murex erinaceus*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 9, pl. ii, figs. 5—8; pl. iii, figs. 8, 9; pl. iv, figs. 2—9.
1903. *Ocinebra erinacea*, Cossmann, Ess. Pal. comp., vol. v, p. 36, pl. i, fig. 14.
1903. *Murex erinaceus*, Lamplugh, Mem. Geol. Surv., Isle of Man, p. 475.

Specific Characters.—Shell conical, thick, rugged; whorls 8—10, convex, angulated, with a flattened shelf below the suture, the last three-fourths the total length; ornamented by strong longitudinal ribs, irregularly varicose, and by spiral ridges of unequal size which cross the ribs; spire short, turreted, rapidly diminishing in size; suture wide and deep; mouth irregularly oval, inequilateral; canal open in the young state, closed and tubular in the adult; outer lip thickened outside, fluted and toothed inside; pillar nearly straight.

Dimensions.—(Of Manx specimens) L. 24 mm. B. 15 mm.

Distribution.—*Recent:* coasts of Great Britain and Ireland; Atlantic from Scandinavia to Madeira and the Azores; Mediterranean, Adriatic, Algiers, Tunis, Sicily.

Fossil: Waltonian Crag: Harwich. Butleyan: Butley. Icenian: Bramerton. Isle of Man. Kelsey Hill, Selsey, March and other British Pleistocene deposits. Upper Pliocene and Pleistocene: Sicily.

Remarks.—The generic term *Ocinebra* has been adopted (in place of *Murex*) by the Conchological Society of Great Britain for a group of shells of which *O. erinacea* is taken as the type. They are allied to *Murex* but differ from that genus in the operculum and radula, and, according to M. Cossmann, in the form of the mouth which is less symmetrically oval. Wood's figure of *O. erinacea* was taken from a Recent shell, the original Crag specimen having been lost; those here given are from the collections of the Rev. S. N. Harrison, Mr. A. Bell and the Jermyn

Street Museum. *O. erinacea* must be very rare in the Crag, as with the exception of the fragment found by Mr. A. Bell at Butley and some doubtful specimens from Harwich and Bramerton alluded to by Wood, it has not been recorded from those deposits.

Ocinebra tortuosa (J. Sowerby).

1825. *Murex tortuosus*, J. Sowerby, Min. Conch., vol. v, p. 48, tab. ccccxxxiv, fig. 2.
1848. *Murex tortuosus*, S. V. Wood, Mon. Crag Moll., pt. i, p. 40, tab. iv, fig. 9.
1881. *Murex tortuosus*, Nyst, Conch. Terr. Tert. Belg., p. 3, pl. i, fig. 1.

Var. **boytonensis**, nov. Plate XII, fig. 8.

Dimensions.—L. 36 mm. B. 18 mm.
Distribution.—Not known living.
Fossil: Coralline Crag: Boyton, Ramsholt.

Remarks.—Specimens of *O. tortuosa* from the Coralline Crag of Boyton and Ramsholt which, as before stated, is possibly an intermediate horizon between that of Gedgrave and the Red Crag of Walton, are to be found in the Museums at South Kensington, Cambridge, York, and elsewhere, and may be generally recognised by their special character and appearance; they differ from those usually found in the Red Crag in form and sculpture (*cf.* Wood's figure). The Miocene shell from the Vienna basin described by Hörnes as *M. tortuosus* seems to be a different species.[1]

Var. **minor**, nov. Plate XII, figs. 9—11.

1903. *Murex tortuosus*, Lamplugh, Mem. Geol. Surv., Isle of Man, p. 475.

Distribution.—Not known living.
Fossil: Coralline Crag: Boyton. Waltonian: Little Oakley. Probably elsewhere in the Red Crag. Isle of Man.
Dimensions.—L. 25 mm. B. 12 mm.

Remarks.—Of this shell I have about fifty specimens from Oakley which seem to be full-grown. They appear to represent a dwarf form of the typical Crag species; there are similar fossils from the Manx drift in the Jermyn Street Museum. They are thinner in texture and more delicately sculptured than the bulk of the Crag shells or than that figured by Wood.

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[1] Foss. Moll. Tert. Wien, vol. i, p. 249, pl. xxv, fig. 12, 1856.

Genus **UROSALPINX**, Simpson, 1865.

Urosalpinx cinereus (Say). Plate XII, figs. 15—17.

1821. *Fusus cinereus*, Say, Journ. Acad. Nat. Sci. Philad., vol. ii, p. 236.
1830. *Buccinum plicosum*, Menke, Syn. Meth. Moll., ed. 2, p. 59.
1841-70. *Buccinum cinereum*, Gould, Rep. Inv. Mass., ed. 1, p. 303, fig. 213, 1841; ed. 2, p. 370, fig. 637, 1870.
1881. *Fusus cinereus*, Tryon and Pilsbry, Man. Conch., vol. iii, p. 68, pl. xxxvii, fig. 139.
1887. *Urosalpinx cinereus*, Mörch and Poulsen, MS. list and plates in Geological Museum, Copenhagen, no. 5, pl. i, fig. 9 (unpublished).

Specific Characters.—Shell oblong, fusiform, solid; whorls 5 or 6, convex, compressed below the suture; ornamented by about 10 longitudinal costæ, and by fine, distinct and wavy spiral lines; mouth oval, ending in a short canal; outer lip grooved inside by the spiral lines; pillar covered by enamel which rises up by the side of a small umbilical depression.

Dimensions.—L. 20—28 mm. B. 10—15 mm.

Distribution.—*Recent:* New England coast.

Fossil: Waltonian Crag: Little Oakley.

Pliocene deposits: Iceland.

Remarks.—Among the fossils from the Crag of Iceland in the Copenhagen Museum there are some which were identified by Mörch with the New England shell *U. cinereus.* Although differing somewhat from the Recent form in size and sculpture, I do not know anything to which they can be more conveniently referred. I have two specimens from Oakley which seem to be the same, one of them being here figured, together with another from the Iceland Crag and a Recent shell from Maine that Dr. Shimer has kindly sent me from the Boston Museum. It is interesting to find our Crag shells in the Icelandic deposits. The latter seem to be the only relic of the Pliocene age in the north of Europe. At present but little is known of their fauna, but as they are said by Dr. Pjetursson to exceed five hundred feet in thickness,[1] possibly representing a lengthened and continuous period, they may one day throw much light on the history of the Tertiary epoch and on the origin of the boreal part of our Crag fauna.

Urosalpinx is grouped by Paul Fischer and others with the Muricidæ.

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[1] Pjetursson, Quart. Journ. Geol. Soc., vol. lxii, p. 713, 1906.

Genus **TROPHON,** Montfort, 1810.

Trophon clathratus (Linné). Plate XII, fig. 25.

1767. *Murex clathratus*, Linné, Syst. Nat., ed. xii, p. 1223, no. 563.
1800. *Murex Bamffius*, Donovan, Brit. Shells, vol. ii, pl. clxix, fig. 1.
1839. *Fusus lamellosus*, Gray, Zool. Beechey's Voyage, p. 118, pl. xxxvi, fig. 13.
1841–70. *Fusus scalariformis*, Gould, Rep. Inv. Mass., ed. 1, p. 288, fig. 203, 1841; ed. 2, p. 378, fig. 644, 1870.
1848–72. *Trophon scalariforme*, S. V. Wood, Mon. Crag Moll., pt. i, p. 48, tab. vi, fig. 7, 1848; 1st Suppl., p. 26, tab. iii, fig. 10, 1872.
1878. *Trophon clathratus*, G. O. Sars, Moll. Reg. Arct. Norv., p. 247, pl. xv, fig. 10.
1887. *Trophon clathratus*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 25, pl. vi, fig. 8.
1889. *Fusus scalariformis*, Lorié, Bull. Soc. Belge Géol., vol. iii, p. 434.
1894. *Fusus clathratus*, Kendall, Journ. Isle of Man Nat. Hist. Soc., vol. i, p. 419.
1903. *Trophon clathratus*, Lamplugh, Mem. Geol. Surv., Isle of Man, p. 475, fig. 86, p. 336.
1912. *Trophon (Boreotrophon) clathratus*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 147.

Specific Characters.—See Mon. Crag Moll., pt. i, p. 48.

Dimensions.—L. 30 mm. B. 13—15 mm.

Distribution.—Recent: circumpolar:—Siberia, Kara Sea, Nova Zembla, Franz Joseph Land, Russian Lapland, Spitzbergen. Norway, Denmark, Faroes, Iceland, Greenland, Labrador, New England coast. Behring Strait, northern Japan (D. and F.).

Fossil: Coralline Crag: Boyton. Waltonian: Walton-on-Naze, Beaumont, Little Oakley. Newbournian: Sutton. Butleyan: Butley, Bawdsey; Icenian—Norwich zone: Bramerton, Thorpe near Norwich, Thorpe, Suffolk. Weybournian zone: Weybourne. Isle of Man. Amstelien: Holland.

Pleistocene of Great Britain and Ireland (generally distributed), Bridlington, Middle Glacial Sands of Hopton, Billockby, Kelsey Hill, March gravels, Portland Bill. Christiania region. Uddevalla.

Remarks.—This shell was described by Wood as *Trophon scalariforme*, Gould, but is now regarded as identical with *Murex clathratus*, Linné, whose specific name is older and should be adopted for it in our list of Crag fossils.

Mr. A. Bell informs me he found it years ago in what he regards as Coralline Crag at Boyton, and I have done so more recently at Oakley where it is fairly common. It may be met with everywhere in the Red Crag, moreover, and occurs also at several places in the Icenian. It has not been recorded from the Pliocene of Belgium, but Dr. Lorié has obtained a unique specimen from the Amstelien beds in the Amsterdam boring. We have two varieties of it in the English Crag, one of which may be taken as the type, represented in Wood's figures 7 *a* and 7 *b* (*op. cit.*), having about twelve lamellate costæ on the body-whorl, the other being the variety *lamellosa* (*Fusus lamellosus*, Gray), which is more slender, the body-whorl is not so tumid, and the longitudinal ribs are more numerous (fig. 7 *c*). Some shells I found years ago in the March gravels, which occur elsewhere also in the Pleistocene deposits, as at Kelsey Hill and the Clyde beds, referred to and figured as *T. Bamffius* by Wood, in his 1st Supplement (p. 26, tab. iii, fig. 11), are much smaller and have about twenty ribs. They seem intermediate between *T. clathratus* and *T. truncatus*, but most nearly approach the latter. The type form of the Crag corresponds with specimens in my collection from Uddevalla and the Pleistocene beds of Christiania, except that the latter are larger and the ribs more numerous. Prof. Brøgger figures a specimen from the latter, 40 mm. long, as var. *major*. The American form is still larger, the example figured by Gould measuring 45 mm. by 20 mm. MM. Dautzenberg and Fischer describe the latter as *Trophon clathratus*, var. *scalariformis*. Except for its size it corresponds with the Crag shell. Prof. Kendall and Mr. Lamplugh record both the type-form of the present species (here figured, Pl. XII, fig. 25) and *T. Bamffius* from the Manx drift.

Trophon Gunneri (Lovén). Plate XII, fig. 26.

1846. *Tritonium Gunneri*, Lovén, Ind. Moll. Scand., p. 12.
1867. *Trophon truncatus*, var. *scalaris*, Jeffreys, Brit. Conch., vol. iv, p. 320.
1872. *Trophon Gunneri*, S. V. Wood, Mon. Crag Moll., 1st Suppl., p. 27, tab. iii, fig. 18.
1878. *Trophon clathratum*, var. *Gunneri*, G. O. Sars, Moll. Reg. Arct. Norv., p. 247, pl. xv, fig. 11.
1887. *Trophon clathratum*, var. *Gunneri*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 25, pl. vi, fig. 9.
1903. *Trophon clathratus*, var. *Gunneri*, Lamplugh, Mem. Geol. Surv., Isle of Man, p. 475
1912. *Trophon* (*Boreotrophon*) *Gunneri*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 151.

Specific Characters.—Differs from *T. clathratus* in that the whorls are squarish above instead of rounded, with a flat shelf below the suture; the longitudinal lamellar ribs are more prominent, with a thin knife-edge and angulate, having a spine-like point at the angle.

Dimensions.—(Of the Crag shells.) L. 20 mm. B. 10 mm.

Distribution.—*Recent:* Shetland (Jeffreys). Norwegian coast, Spitzbergen, New England (D. & F.).

Fossil: Icenian Crag: Bramerton, Thorpe, near Norwich.

Pleistocene: Scotland *passim*, Belfast, Isle of Man, Bridlington, Kelsey Hill, March gravels.

Remarks.—This form, which was originally described by Lovén as a distinct species and recognised as such by M. Sars, Mörch, Wood, and others, has been more generally regarded of late years as a variety of *T. clathratus*. MM. Dautzenberg and Fischer, however, state in their recent work, on the authority of

Troschel, that the radula is different, and have separated it from the latter species.

It was not known to Wood from the Crag, but has been found at Thorpe and Bramerton by Mr. James Reeve and myself. As far as I know, it has not been reported from any earlier horizon. In addition to the Pleistocene localities given by Wood I may add that of the March gravels, where, fifty years ago, I obtained several small specimens about 10 mm. in length. Some fossils from Christiania which I received from Dr. Øyen are much larger, measuring 30 mm. by 16 mm.

Trophon truncatus (Ström). Plate XII, figs. 23, 24.

1767. *Buccinum truncatum*, Ström, K. Norsk. Vid. Selsk. Skrift., vol. iv, p. 369, pl. xvi, fig. 26.
1841–70. *Trophon clathratus*, Gould, Inv. Mass., ed. 1, p. 289, fig. 198, 1841; ed. 2, p. 377, fig. 643, 1870.
1867. *Trophon truncatus*, Jeffreys, Brit. Conch., vol. iv, p. 319, pl. lxxxiv, fig. 6.
1877. *Trophon clathratus*, var. *truncata*, Jeffreys, Ann. Mag. Nat. Hist. [4], vol. xix, p. 325.
1878. *Trophon truncatus*, G. O. Sars, Moll. Reg. Arct. Norv., p. 246, pl. xv, fig. 9.
1887. *Trophon truncatus*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 24, pl. vi, figs. 6, 7.
1912. *Trophon* (*Boreotrophon*) *truncatus*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 152.

Specific Characters.—Shell ovato-conical; ornamented by numerous fine, laminar, longitudinal ribs, which fold over towards the mouth, extending to the suture but not to the base of the canal; surface of all the whorls but the two upper ones covered with minute, close-set and almost imperceptible spiral lines; spire rather short, ending in an abrupt and somewhat truncated point; whorls convex, the last about two-thirds the total length; suture deep; mouth oval, with a triangular outline, expanding outwards; canal short and notched, turning to the left, showing externally the lines of growth; outer lip sharp, curved, smooth inside; inner lip slight; pillar curved.

Dimensions.—L. 6—15 mm. B. 3—8 mm.

Distribution.—*Recent:* eastern and northern coasts of England; Isle of Man; Scotland; southern and eastern coasts of Ireland; Tenby.

Norway, from the Christiania fiord to Finmark; Iceland, Spitzbergen, Greenland; North America (eastern and western coasts).

Fossil: Waltonian Crag: Little Oakley. Butleyan: Butley, Bawdsey. Isle of Man.

Pleistocene deposits: Scotland, Ireland, March; Norway; Sweden—Uddevalla.

Remarks.—This species is new to our Crag lists. I have a unique specimen from Oakley, the result of many years' work there. It corresponds in size, texture and ornamentation with some Dr. Jeffreys sent me in 1870, which had been dredged from the Lynn well (the deepest part of the Wash) by Capt. Calver, of H.M.S. "Porcupine."

Although *T. truncatus* is allied to *T. clathratus*, a common fossil of the Pleistocene deposits, the equivalent, as just stated, of *T. scalariformis* of Gould and Wood, it has been generally regarded as distinct. Jeffreys believed it to be so at first, but in 1877 (*op. cit.*) adopted the view that it was a variety of *T. clathratus*.

The shell figured by Forbes and Hanley under the latter name (Brit. Moll., vol. iv, pl. cxi, fig. 1) appears to be *T. Bamffius*.

T. clathratus and *T. truncatus* are northern species; both are recorded from Norway, Iceland, Greenland, Barents Sea, and the eastern and western coasts of North America, but only the latter ranges southwards towards Great Britain.[1]

I have found *T. truncatus* in the Butleyan Crag at Bawdsey; Gwyn Jeffreys gives it from Uddevalla, and Prof. Brøgger from the *Yoldia*-clay of Christiania.

In their recent work. MM. Dautzenberg and Fischer regard *T. clathratus* and *T. truncatus* as distinct.

Trophon Fabricii (Beck), Möller.[2] Plate XII, figs. 27, 28.

1780. *Tritonium craticulatum*, Fabricius, Faun. Grœnl., p. 400.
1842. *Trophon Fabricii* (Beck), Möller, Ind. Moll. Grœnl., p. 14.
1845. *Murex borealis*, Reeve, Conch. Icon., vol. iii (Murex), pl. xxx, fig. 145.
1872. *Trophon craticulatus*, S. V. Wood, Mon. Crag Moll., 1st Suppl., p. 25, tab. iii, fig. 1.
1877. *Trophon Fabricii*, Jeffreys, Ann. Mag. Nat. Hist. [4], vol. xix, p. 325.
1878. *Trophon craticulatus*, G. O. Sars, Moll. Reg. Arct. Norv., p. 248.
1887. *Trophon craticulatus*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 27, pl. vi, figs. 11, 12.
1899. *Trophon Fabricii*, Posselt, Medd. om Grönl., vol. xxiii, p. 174.
1903. *Trophon (Fusus) Fabricii*, Lamplugh, Mem. Geol. Survey, Isle of Man, p. 475.

Specific Characters.—Shell fusiform; whorls 6, rapidly diminishing in size, the last two-thirds the total length, the upper part angulated, with a sloping shelf below the suture; ornamented by about 10 longitudinal prominent and sometimes varix-like ribs of unequal size, and by raised spiral lines, equal to the spaces between them; spire elongate, scalariform; suture deep and well-marked; mouth oval, outer lip hardly angulated by the keel, not denticulated within; canal short, open, turning slightly to the left.

Dimensions.—L. 35 mm. B. 22 mm.

Distribution.—*Recent:* Spitzbergen, Finmark, Iceland, Greenland, Labrador, Gulf of St. Lawrence, Wellington Channel, Behring Sea.

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[1] The difference between the two shells is well shown in the specimens figured by Prof. G. O. Sars (pl. xv, figs. 9, 10).

[2] The specimen figured under the above name in the Survey Memoir of the Isle of Man, p. 336, fig. 87, as from Cranstal Point, is in reality the one found by Captain James in the Wexford gravels, described below as var. *Bailyi*. That variety does not occur in the Manx beds, although a specimen of the typical form has been found there, as stated below.

Fossil: Waltonian Crag: Little Oakley. Isle of Man. Pleistocene: Worden, Bridlington. Scandinavia (Posselt).

Remarks.—This species, originally described by Fabricius as *Tritonium craticulatum*,[1] was afterwards identified by Möller and others with *Trophon Fabricii*, Beck. The only one of the earlier authorities mentioned above who has figured the living shell is Reeve, whose specimen of *Murex borealis* (*op. cit.*) accurately represents what is now recognised under the present name.[2] The Bridlington fossil given by Wood is probably intended for this form, and I have one or two immature specimens from Oakley (fig. 28) which seem to be the same.

There is a specimen of the type-form from the Isle of Man, here figured, in the Museum at Jermyn Street.

Var. **Bailyi** (A. Bell), nov. Plate XII, fig. 29.

1846. *Fusus Fabricii*, Forbes, Mem. Geol. Surv., vol. i, p. 424 (fig.).
1850. *Trophon craticulatus*, S. V. Wood, Mon. Crag Moll., pt. ii, Appendix, p. 313, tab. xxxi, fig. 4.
1903. *Trophon* (*Fusus*) *Fabricii*, Lamplugh, Mem. Geol. Survey, Isle of Man, fig. 87, p. 336.
— *Trophon Bailyi*, A. Bell, MS.

Dimensions.—L. 12·5 mm. B. 7·5 mm.

Distribution.—Not known living.

Fossil: Wexford gravels: Rathaspic.

Remarks.—This rather famous specimen, which, by the courtesy of the Director of the Geological Survey, I am permitted to figure, is the one found by Capt. James in the Wexford gravels seventy years ago and is still unique. It has been generally known as *T. Fabricii*, but differs from the typical form of that species by the distinct angulation of the whorls, which form a flat shelf below the suture; the outer lip ends upwards in a projecting spine; the general appearance of the upper part of the body-whorl is not unlike that of *T. Gunneri*. Mr. A. Bell has always considered it specifically distinct, and proposes, I believe, to describe it as such under the name of the former palæontologist of the Irish Geological Survey. It belongs, however, to the *T. Fabricii* group, and I prefer to regard it as a variety of that species.

Trophon muricatus, Montagu. Plate XII, fig. 18.

1803. *Trophon muricatus*, Montagu, Test. Brit., vol. i, p. 262, pl. ix, fig. 2.
1818. *Murex echinatus*, J. Sowerby, Min. Conch., vol. ii, p. 226, tab. cxcix, fig. 4.
1836. *Fusus echinatus*, Philippi, En. Moll. Sic., vol. i, p. 206, pl. xi, fig. 10.
1841–70. *Trophon muricatus*, Gould, Rep. Inv. Mass., ed. 1, p. 293, 1841; ed. 2, p. 379, 1870.

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[1] *Murex craticulatus*, Linné, is a different species.

[2] Jeffreys identifies *Murex borealis*, Reeve, with *Fusus Fabricii*, Beck, and with *Trophon craticulatus*, Fabricius (Brit. Conch., vol. iv, p. 322, 1867).

1848. *Trophon muricatus*, S. V. Wood, Mon. Crag Moll., pt. i, p. 50, tab. vi, fig. 5.
1853. *Trophon muricatus*, Forbes and Hanley, Brit. Moll., vol. iii, p. 439, pl. cxi, figs. 3, 4.
1867. *Trophon muricatus*, Jeffreys, Brit. Conch., vol. iv, p. 316, pl. lxxxiv, fig. 4.
1873–75. *Trophon muricatus*, Seguenza, Boll. R. Com. Geol., vol. iv, p. 348, 1873; vol. vi, p. 340, 1875.
1874. *Trophon muricatum*, Van den Broeck, Ann. Soc. Mal. Belg., vol. ix, p. 292.
1882. *Trophon muricatus*, Bucquoy, Dautzenberg et Dollfus, Moll. Mar. Rouss., vol. i, p. 39, pl. vi, fig. 7.
1887. *Trophon muricatus*, Kobelt, Icon. schalentrag. europ. Meeresconch., p. 30, pl. vi, figs. 18, 19.
1890. *Trophon muricatus*, Carus, Prodr. Faun. Medit., vol. ii, p. 384.
1912. *Trophon* (*Trophonopsis*) *muricatus*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 154.

Specific Characters.—See Mon. Crag Moll., pt. i, p. 50.

Dimensions.—L. 15 mm. B. 6 mm.

Distribution.—*Recent:* western coasts of Great Britain and Ireland; Atlantic coasts of France, Spain, and Portugal; North America (Gould).

Fossil: Coralline Crag. Waltonian: Walton-on-Naze, Beaumont, Little Oakley (very abundant). Newbournian: passim. Butleyan: Bawdsey, Butley, Hollesley, Alderton. Wexford gravels. Middle Glacial sands: Billockby. Portrush, Dublin, Isle of Arran. Scaldisien: Belgium. Upper Pliocene and Pleistocene: Sicily.

Remarks.—This well-known British and Mediterranean species occurs in the Gedgravian and Waltonian stages of the English Crag, being exceedingly common at Little Oakley, but less abundant in the Newbournian and Butleyan.

It is one of those southern shells which, common in the older beds of the Crag, gradually became rare and eventually disappeared from the Pliocene basin. It has not been recorded from the Norwich Crag or from any of the later East Anglian deposits except the Middle Glacial sands, nor is it known as living in the North Sea.

Out of several hundred specimens I have obtained at Oakley the large majority are of the type form, but I have found also at that place a number of others which present more or less distinct variation from it and deserve notice.

The Belgian fossil figured by Nyst in 1881 as *T. muricatus* (see p. 133) does not seem to be the characteristic form of the Scaldisien Crag. The specimens of this species in my own collection from Antwerp, and, as far as I could see, in that of Mr. van de Wouver, are of the usual type.

Var. **valida** (Monterosato), nov. Plate XII, fig. 21.

— *Trophon muricatus*, var. *valida*, Monterosato, MS.

Dimensions.—L. 12 mm. B. 5 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Little Oakley. Pleistocene: Sicily.

Remarks.—This variety separates itself from the type by its solid character, and its stronger and more clearly defined sculpture. Both the longitudinal and spiral costæ are fewer in number and consequently further apart, giving the shell a reticulate appearance; the whorls are indistinctly keeled, forming a sloping shelf below the suture and causing the upper part of the mouth to be somewhat more angulate than in the normal form.

On showing my specimens to the Marchese di Monterosato, he was kind enough to point out their resemblance to a fossil shell found at Oreto, near Palermo, which he calls var. *valida*. I figure one of my Oakley specimens under that name.

Var. **similis,** nov. Plate XII, fig. 20.

Dimensions.—L. 12—14 mm. B. 8 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Walton-on-Naze, Beaumont, Little Oakley.

Remarks.—I have found 50 or 60 specimens of this variety at Oakley and a few others at Walton and Beaumont. It appears to be intermediate between the typical *T. muricatus* and *T. Fabricii.*

In form and sculpture it resembles a Recent example of the latter in my collection, but it is only one third the size; it differs from that figured by Forbes from Wexford,[1] described here as *T. Fabricii*, var. *Bailyi*, and from those given by Wood as *T. Fabricii*[2] and *T. craticulatus*,[3] as well as from the Recent shell, in that the mouth has a thickened lip, denticulated within, and from Prof. Forbes' specimen in the Jermyn Street Museum, in that it is not spinous nor so strongly angulated by the keel. I do not think it is the same as the latter, and prefer to regard it as a variety of *T. muricatus.*

Var. **Nysti,** nov. Plate XII, fig. 19.

1881. *Trophon muricatus,* Nyst, Conch. Terr. Tert. Belg., p. 6, pl. i, fig. 4.

Varietal Characters.—Shell turreted, small, strong and solid; whorls convex, longitudinally and spirally costate; the spire is much shorter in proportion than in the type, and the body-whorl considerably larger than the one next above it; outer lip expanded, thickened, and strongly denticulate within; canal narrow and very short.

Dimensions.—L. 8 mm. B. 4 mm.

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[1] Mem. Geol. Surv., vol. i, p. 426, 1846.

[2] Mon. Crag Moll., pt. ii, tab. xxxi, fig. 4, 1850.

[3] Mon. Crag Moll., 1st Suppl., tab. iii, fig. 1, 1872.

Distribution.—Not known living.

Fossil : Waltonian Crag : Little Oakley. Newbournian. Butleyan. Scaldisien : Belgium.

Remarks.—In the fourth volume of the British Conchology, p. 317, Jeffreys, describing the Recent *T. muricatus*, expressed the opinion that the fossil shell known to Nyst under that name was a different species. It seems probable that he was referring to that afterwards figured by the latter author (*op. cit.*) which departs materially from it both in form and texture, being shorter and more solid.

I was at first inclined to adopt Jeffreys' view, but as the shell in question undoubtedly belongs to the *muricatus* group, which appears to have been a variable one in Crag times as it now is in the Mediterranean, I think it better to regard it as a variety of that species.

I have found a number of specimens corresponding with Nyst's figure at Oakley and in other parts of the Crag; the one now represented comes from Butley.

Trophon Lamplughi, sp. nov. Plate XII, fig. 22.

1903. *Trophon muricatus*, Lamplugh, Mem. Geol. Surv., Isle of Man, p. 475.

Specific Characters.—Shell small, turreted, solid ; whorls convex, slightly angulate above, with a sloping shelf below the suture, the last more than half the total length ; ornamented by narrow, clearly marked and prominent longitudinal costæ, 15 on the last whorl, extending to the base of the shell, continuous across the sutural shelf and occasionally varicose, as well as by spiral ridges which cross the costæ and are closely crowded together on the shelf; spire ending in a blunt point, the topmost whorls smooth ; suture deep ; mouth oval; outer lip slightly angulated by the keel, not thickened or denticulated within as in *T. muricatus* ; canal narrow, inclining slightly to the left.

Dimensions.—L. 13 mm. B. 6 mm.

Distribution.—Not known living.

Fossil : Isle of Man.

Remarks.—The Manx fossil figured under this name was found by the Rev. S. N. Harrison and is now in the Jermyn Street Museum, where it bears the name of *T. muricatus*. It seems to be full grown and, except that the apex is wanting, is perfect and unworn. In sculpture it differs so materially from any variety of that shell known to me that I am disposed to regard it as specifically distinct. Its outer lip, moreover, wants the internal denticulation characteristic of the former. As I am unable to discover anything else to which it can be satisfactorily referred, I dedicate it to my friend Mr. Lamplugh of H.M. Geological Survey, the author of the Memoir on the Isle of Man.

Genus **MEYERIA**, Dunker and Metzger, 1878.

Meyeria alba (Jeffreys). Plate XIII, figs. 15, 16.

1858. *Tritonium pusillum*, M. Sars, Forh. Norsk. Vid. Selsk., p. 71.
1873. *Latirus albus*, Jeffreys, in Wyville Thomson's Depths of the Sea, p. 464, fig. 77.
1874. *Lathyrus albellus*, Dunker und Metzger, Zool. Erg. Nordseefahrt., pp. 257, 264, pl. v, fig. 4.
1878. *Meyeria pusilla*, G. O. Sars, Moll. Reg. Arct. Norv., p. 245, pl. xiii, fig. 8.
1879. *Metzgeria alba*, Norman, Journ. of Conch., vol. ii, p. 56.
1887. *Meyeria alba*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 31, pl. vi, fig. 21.
1901. *Metzgeria alba*, Friele, Norske Nordh. Exped. (Mollusca), vol. iii, p. 95.
1911. *Meyeria albella*, Sykes, Proc. Malac. Soc., vol. ix, p. 336.

Specific Characters.—Shell rather small, solid, elongato-fusiform, turreted; whorls 7, convex, excavated below the suture, regularly diminishing in size to an acute point, the last much the largest, excavated below; ornamented by about twelve raised longitudinal costæ and by fine spiral striations; suture clearly marked, oblique; mouth pyriform, acutely angulate above, half the length of the shell; canal narrow, fairly long, inclining to the left; outer lip thin, expanded.

Dimensions.—L. 20 mm. B. 8 mm.

Distribution.—*Recent:* Finmark, Lofoten Islands.

Fossil: Waltonian Crag; Little Oakley. Pleistocene: Wexford gravels (A. Bell).

Remarks.—The immature specimen here figured was obtained at Oakley. It corresponds in form with a full-grown shell from the Lofoten Islands (fig. 15) received from Dr. Nordgaard. Mr. E. A. Smith, of the British Museum (Natural History), to whom I have shown them, considers the identification correct.

Genus **SEARLESIA**, nov.

Generic Characters.—Shell solid, fusiform; apex blunt but not bulbous; ornamented by spiral lines or ribs and by strong longitudinal costæ; canal usually short, open, straight or bending slightly to the left.

Type.—*Trophon costifer*, S. V. Wood.

Remarks.—The nomenclature of the group of shells, for which I propose the generic name of *Searlesia* in memory of my old friend and master Searles V. Wood, is one as to which much difference of opinion has existed. The fossil originally described in 1811 by Parkinson as *Murex rugosus*=*Trophon costifer*, S. V. Wood, has been referred since to *Fusus, Trophon, Chrysodomus, Buccinofusus,* *Latirus*, and *Urosalpinx*, none of which genera seem specially appropriate to it. At the British Museum (Natural History) it is called *Latirus*; at Jermyn Street and the Sedgwick Museum (Cambridge), *Trophon*; and in Mörch's collection at Copenhagen, *Urosalpinx*; while Dr. Dall has figured somewhat similar forms from Alaska as *Tritonofusus* (*Plicifusus*), though he has grouped with them some shells under the latter name, which differ materially from the Crag fossils in question.[1] *Tritonofusus*, moreover, described as without, or with feeble axial sculpture, the type taken for which is *Fusus islandicus*, has been associated by him with *Siphonorbis*, while he regards *Fusus Kröyeri* and *F. spitzbergensis* as typical of *Plicifusus*, distinguished by feebler spiral ornamentation; none of these have any obvious connection with *S. costifer*. *Latirus*, Montfort (1810), originally *Lathyrus*, a genus allied to *Fasciolaria*, having two or three oblique folds on the columella, and represented by *L. gibbulus*, Gmelin, an Australian shell, seems equally inapplicable.

M. Cossmann refers our fossil to *Chrysodomus*, and more doubtfully to *Buccinofusus*,[2] the type forms of the latter given by him being the Recent *B. berniciensis*, King, and *B. parilis*, Conrad, which is a Miocene species, but neither of these has the strong longitudinal plication of *S. costifer*. I do not think it should be referred either to *Chrysodomus*, *Fusus*, *Trophon*, or *Urosalpinx*, which latter belongs to the Muricidæ; our shell is not a *Murex*.

These fossils form a fairly distinct group, specially characteristic of the Red Crag, and common in the lower zones of it at Walton and Oakley.

It is singular, however, that none of the shells described here under the generic name of *Searlesia* are known from the Belgian Crag.

Almost unknown from European seas[3] they occur in the Pliocene of Iceland and in the Manx drift, while somewhat similar forms are living, according to Dr. Dall, in Alaska.

Under the circumstances, and to avoid further confusion, I suggest for the Crag fossils and for some others which I venture to group with them the generic name above given, in which I trust they may at last find a permanent resting-place.

Searlesia costifer (S. V. Wood). Plate XIII, fig. 1.

1811. *Murex rugosus*, Parkinson, Org. Rem., vol. iii, p. 64, tab. v, fig. 16.
1812. *Murex rugosus*, J. Sowerby, Min. Conch., vol. i, p. 75, tab. xxxiv, fig. 1.
1835. *Fusus costatus* (*rugosus*), J. Sowerby, Syst. Ind., p. 247.
1848. *Trophon costiferum*, S. V. Wood, Mon. Crag Moll., pt. i, p. 48, taf. vi, fig. 9.

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[1] Rep. U.S. Nat. Mus., vol. xxiv (1902), p. 523.

[2] Ess. Paléoconch. Comp., vol. iv (1901), pp. 35, 100.

[3] The British species *Fusus fenestratus* = *Buccinum fusiforme*, Broderip, seems a nearly allied form.

1872. *Trophon costifer*, S. V. Wood, Mon. Crag Moll., 1st Suppl., p. 204.
1911. *Trophon (?) costiferum*, Sykes, Proc. Malac. Soc., vol. ix, p. 346.

Specific Characters.—See Mon. Crag Moll., pt. i, p. 49.

Dimensions.—L. 40—45 mm. B. 20—22 mm.

Distribution.—Recent: North Atlantic, Porcupine Exped. (Sykes).

Fossil: Coralline Crag (rare): Gomer, Ramsholt, Boyton. Red Crag (*passim*)—Waltonian (abundant): Walton-on-Naze, Beamont, Little Oakley. Newbournian; Butleyan. Slains, Aberdeenshire, with other Red Crag fossils.

Remarks.—The type form (fig. 1) of this variable species, the only one figured by Wood, is a thick, strongly costated shell with a short canal. It is very common at Oakley, and is found nearly everywhere in the Red Crag, though it has not been recorded from the Icenian. The variety given by Sowerby as *M. rugosus*, var. β, equally common at the locality named, has sculpture of a more delicate character. The name of this species occurs, however, in the MS. list of fossils from the Crag of Iceland by Mörch and Poulsen in the Museum at Copenhagen already referred to, a copy of which Dr. Pjetursson was kind enough to send me, but on examination I find the specimens differ considerably from the typical Crag shell, although they seem allied to it. Jeffreys states that *S. costifer* was dredged in the Atlantic by the Swedish expedition at 110—300 fathoms.[1] Mr. A. Bell informs me, however, that he saw some of the material brought up which was much broken and in a semi-fossil condition, containing, among other things, fragments of *Terebratula grandis* and other Red Crag shells.

The shell described and figured by Posselt as *Sipho* (*Tritonofusus*) *costiferus* (Medd. om Grönl., vol. xxiii, p. 183, pl. i, fig. 6, 1899) = *Neptunea* (*Siphonorbis*) *undulata*, Friele (Norske Nordh. Exped., Mollusca, vol. i, p. 22, pl. ii, fig. 33, 1882), is a very different species.

Var. β., J. Sowerby. Plate XIII, fig. 3.

1818. *Murex rugosus*, var. *β*, J. Sowerby, Min. Conch., vol. ii, p. 225, tab. cxcix, figs. 1, 2.
1846. *Fusus incisus*, Gould (?), Otia Conch., p. 64.
1849. *Tritonium* (*Fusus*) *Sitchense (?)*, Middendorff, Mem. Acad. imp. Sci. St. Petersbourg (6), vol. viii, p. 478.

Varietal Characters.—Shell generally somewhat thinner than the type form of *S. costifer;* ornamented like the latter with irregular and wavy spiral lines closely crowded together, with finer and rather less prominent longitudinal costæ, which are confined to the upper whorls.

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[1] Quart. Journ. Geol. Soc., vol. xxvii (1871), p. 496; Mr. E. R. Sykes reports it (*op. cit.*) from the Porcupine expedition, station 13.

Dimensions.—L. 30—40 mm. B. 15—20 mm.

Distribution.—*Recent:* Puget Sound, Sitka (?).

Fossil: Waltonian Crag: not very rare at Little Oakley. Newbournian. Butleyan.

Remarks.—This form, originally described by Sowerby, may be regarded as a variety of *L. costifer.* Although differing considerably from the typical shell, I have specimens from Oakley which more or less nearly connect them.

Wood figured two varieties of *S. costifer*, one of them having finer and more numerous ribs than the other, which, however, extend in both to the body-whorl. In my Oakley specimens of the present variety, on the contrary, the longitudinal sculpture tends to die out on the penultimate whorl, and disappears on the last. It does not seem to have been known to Wood, and is but rarely represented in our public collections. Although fairly common at Oakley, I believe it is less so at other horizons of the Red Crag. It is a somewhat more delicate shell than the type, in which the sculpture is often very coarse, and it seems to pass into the variety *pulchra*, next to be described.

I have lately received from Mr. Alfred Bell some specimens procured at the sale of the Damon Collection, labelled *Fusus* (*Neptunea*) *incisus*, Gould (Puget Sound) = *Chrysodomus Sitkensis*, Middendorff, one of them being here represented (Pl. XIII, fig. 2). Although not known living nearer to us than the west coast of North America, it seems allied to the Crag shell.

Var. **pulchra,** nov. Plate XIII, fig. 12.

Dimensions.—L. 30 mm. B. 16 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Little Oakley.

Remarks.—This is a smaller and more delicate shell with finer sculpture than the one last described. I have a dozen specimens or more from Oakley.

Var. **elongata,** nov. Plate XIII, fig. 5.

Dimensions.—L. 42 mm. B. 17 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Little Oakley.

Remarks.—Specimens from Oakley having an elongate spire, like that here figured, belong as a rule to the β. variety; they are not common.

Var. **cancellata,** nov. Plate XIII, fig. 4.

Dimensions.—L. 40 mm. B. 21 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Little Oakley.

Remarks.—In this variety, of which I have obtained several specimens, the longitudinal ribs are numerous, fine, and inconspicuous, extending nearly to the base of the shell; the spiral costæ are further apart and become granulate where they cross the latter, the shell presenting a cancellate appearance.

Var. **crassa**, nov. Plate XIII, fig. 11.

Dimensions.—L. 42 mm. B. 24 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Little Oakley.

Remarks.—The shell figured under the above name, one of several I obtained at Oakley, differs from either of the more common forms of *S. costifer.* It is a coarse strong shell, the whorls being somewhat angulated above, forming a shelf below the suture; the body-whorl is proportionately larger and wider than in the type, and is excavated below; the suture is deep, and the canal very short.

Var. **islandica**, nov. Plate XIII, figs. 7—10.

1887. *Urosalpinx costifer*, var., Mörch and Poulsen, plates and MS. list in the Geological Museum, Copenhagen, no. 7, pl. i, fig. 7 (unpublished).

Varietal Characters.—Shell slender, fusiform; whorls 7, decidedly convex, the last five-eighths the total length, excavated below; ornamented by about twelve prominent longitudinal costæ, rounded and narrower than the spaces between them, and by fine spiral lines; more delicately sculptured than in the type form of *L. costifer*; spire elongate; suture deep; mouth oval, and shorter than in the latter, having a well-marked canal, which turns to the left; outer lip thin.

Dimensions.—(Of specimen from Iceland) L. 40 mm. B. 18 mm. (Of the Crag specimen) L. 30 mm. B. 14 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Walton-on-Naze, Little Oakley. Newbournian: Sutton. Pliocene: Iceland.

Remarks.—This shell, with that next to be described, seems to be separated from the typical *S. costifer* by its delicate sculpture, its more slender form, and its more distinct and somewhat longer canal. Comparing the graceful Icelandic fossil with the coarser shells of the Crag one might regard them as specifically distinct; we find specimens in our own deposits, however, which tend to connect the two. The absence of the prevalent Crag varieties of *S. costifer* from Iceland is important because it confirms the separation of *S. Björnsoni* (described below) from that species in the Icelandic deposits, and by implication in our own.

I figure a typical specimen of this form from Iceland, together with others from Oakley and Sutton, which, although not absolutely the same, come nearer to it than to the other Crag varieties of *S. costifer*; the Sutton shell (fig. 10) is from the Sedgwick Museum at Cambridge.

Var. **monensis,** nov. Plate XIII, fig. 6.

1894. *Fusus Forbesi,* Kendall, Journ. Isle of Man Nat. Hist. Soc., vol. i, p. 419, pl. i, fig. 4.

Dimensions.—L. 38 mm. B. 21 mm.

Distribution.—Not known living.

Fossil: Cranstal Point, Isle of Man.

Remarks.—The fossil figured under this name is one of those in the Jermyn Street Museum which have been grouped there as varieties of *F. Forbesi.* It appears to agree with fig. 4 in Prof. Kendall's plate.

It differs materially from Prof. Forbes' type of that species, however, corresponding more nearly with *S. costifer* of the Crag, of which I regard it as a geographical variety, though the spiral sculpture is coarser than in any specimen of the latter known to me from the East Anglian deposits. It has not the internal denticulation of the outer lip characteristic of *S. Forbesi.*

Searlesia Forbesi (Strickland). Plate XIV, figs. 1—3.

1838. *Fusus* sp., Forbes, Malac. Monen., p. 60, pl. iii, fig. 1.
1846. *Fusus Forbesi,* Strickland, Proc. Geol. Soc., vol. iv, p. 8.
1846. *Fusus Forbesi,* E. Forbes, Mem. Geol. Surv., vol. i, p. 425.
1894. *Fusus Forbesi,* Kendall, Journ. Isle of Man Nat. Hist. Soc., vol. i, p. 419, pl. i, fig. 7.
1903. *Fusus Forbesi,* Lamplugh, Mem. Geol. Surv., Isle of Man, p. 475, fig. 84 (p. 336).

Specific Characters.—Shell strong and solid, fusiform; whorls but slightly convex, regularly diminishing in size, the last two-thirds the total length; ornamented by about eleven prominent longitudinal ribs, somewhat oblique, reaching the base of the shell, and by rather coarse spiral lines; suture slight; mouth ovate, angulate above; outer lip thickened by the labial rib, which is bevelled internally and denticulated; canal short, turning slightly to the left.

Dimensions.—L. 34 mm. B. 17 mm.

Distribution.—Not known living.

Fossil: Isle of Man, Cranstal Point and elsewhere. Waltonian Crag: Little Oakley.

Remarks.—For many years the identity of the shell described and figured by the late Prof. Forbes in 1838 as *Fusus* sp., and afterwards described by Strickland as *F. Forbesi*, has remained a matter of doubt. In 1894 Prof. Kendall, studying the fossiliferous deposits of the Isle of Man, figured a number of shells differing considerably in form, size, and sculpture, grouping them under the above name as varieties of one variable species, but from this I am compelled to dissent, as will appear in the sequel.

In the fourth volume of the British Conchology, moreover, Jeffreys identified *F. Forbesi* with *Buccinum plicosum*, Menke, and with *F. cinereus*, Say, but neither can this view be accepted. Fortunately specimens have been found lately at Jermyn Street and figured in Mr. Lamplugh's Survey Memoir, which will clear up this long-standing *quæstio vexata*. They are clearly identical with the shell known to Forbes and Strickland. Prof. Kendall's fig. 7 appears to be the same.

Forbes stated that his fossil was found on the shore of the north coast of the Isle of Man, having been cast up apparently by the sea.

Although differing from *T. costifer* in the internal crenulation of its outer lip, it corresponds with it generally, and may be grouped with it, I think, as belonging to the same genus.

I have a worn specimen from Oakley (fig. 3) which seems to agree with the Manx shell.

Searlesia Björnsoni (Mörch and Poulsen, MS.), sp. nov. Plate XIV, figs. 6—8.

1887. *Urosalpinx Björnsoni*, Mörch and Poulsen, plates and MS. list in Geological Museum, Copenhagen, no. 6, pl. i, fig. 10 (unpublished).

Specific Characters.—Shell small, strong and solid; whorls 6, convex, rapidly diminishing in size, the last much the largest, two-thirds the total length; ornamented by eight very prominent longitudinal ribs, with deep, rounded sulci between them, as well as by fine but distinct and regular spiral ridges which cross the ribs but do not cause tuberculation, the ribs being less wide than the intervening spaces; suture deep; apex slightly mammiform; mouth oval; canal distinct, narrow, rather short, and nearly straight; outer lip regularly curved, slightly expanded.

Dimensions.—L. 15—25 mm. B. 8—12 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Walton-on-Naze, Little Oakley. Newbournian: Waldringfield, Newbourn. Butleyan: Butley, Oak Hill, Sutton. Pliocene: Iceland.

Remarks.—Of this delicately sculptured little shell, which is new to our Crag lists, I have obtained about a dozen specimens, apparently full-grown, from Oakley; there is one at Jermyn Street from Walton, and others at Cambridge and elsewhere.

They correspond closely with the Icelandic fossils in the Copenhagen Museum alluded to above, which were called by Mörch *Urosalpinx Björnsoni*. At first sight they might be regarded as a dwarf variety of *S. costifer*. The typical English form of that species, however, as stated above, is not known from the Iceland Crag, and the one identified with the latter by Mörch, which I have figured as var. *islandica*, is very different from it. By the kind permission of Dr. Ravn I figure an Icelandic specimen of *S. Björnsoni* from the Mörch collection at Copenhagen to show its resemblance to our Crag fossils. Most of the latter are about 15 mm. in length.

I have little doubt that *S. Björnsoni* might be found elsewhere in the Red Crag if specially looked for; indeed, it has been recently obtained by the Messrs. Ogden at Newbourn. A number of such small shells may have been overlooked, possibly under the impression that they were immature and unrecognisable specimens of some larger species.

Fig. 9 seems allied to this form; it may be a variety of it or possibly an undescribed species.

Searlesia Ravni, sp. nov. Plate XIV, figs. 15—17.

Specific Characters.—Shell strong, fusiform; whorls 6, convex; ornamented by well-marked longitudinal costæ, not so wide as the spaces between them, which disappear on the body-whorl, and by fine, wavy, close-set ridges; suture deep; mouth oval, passing into a fairly long and open canal which is nearly straight; outer lip thin, somewhat expanded; inner lip adherent to the pillar.

Dimensions.—L. 38 mm. B. 17 mm.

Distribution.—Not known living.

Fossil: Coralline Crag: Gomer pit, Gedgrave. Waltonian: Little Oakley.

Remarks.—I dedicate this shell to my friend Dr. Ravn, of the Geological Museum at Copenhagen, to whom I am so greatly indebted for allowing me to examine and figure many of Mörch's type specimens from the Crag of Iceland, the study of which has thrown much light on some Crag problems. It belongs to the *costifer* group, of which variable species I should be inclined to regard it as a variety were it not for its straight fusiform canal and general appearance. It approaches *S. Björnsoni*, moreover, on the other hand, and appears intermediate between it and the variety *islandica* of *S. costifer*; I have several specimens from Oakley, though I have not found it at any other locality. There is one, however, in the Sedgwick Museum at Cambridge from Gedgrave (fig. 16) which seems the same, and it may be found possibly elsewhere if specially looked for.

Searlesia Öyeni, sp. nov. Plate XIV, figs. 19, 20.

Specific Characters.—Shell solid, fusiform; whorls 6, convex, the last five-eighths the total length; ornamented by strong, prominent and rather distant longitudinal costæ, and by close-set spiral ridges, which become more or less obsolete below the suture; spire elongate, regularly diminishing in size, with a blunt point; suture deep; mouth oval, angulate above; outer lip regularly curved, but little expanded, thickened by the labial rib, not toothed within; canal short, narrow, turning slightly to the left.

Dimensions.—L. 17—24 mm. B. 7—10 mm.

Distribution.—Not known living.

Fossil: Isle of Man.

Remarks.—The Manx fossils from the Jermyn Street Museum here figured appear to be something new; I have been unable to find anything to which I can refer them, and they are unknown, either Recent or fossil, to the experts to whom they have been submitted. At Jermyn Street they are labelled *Fusus Forbesi*, but I doubt whether they have any connection with that species, the outer lip of which, moreover, is internally toothed. They seem allied rather to *S. Björnsoni*, but differ from the latter in form and sculpture, and in the smaller number of the longitudinal costæ. I name this shell after my friend Dr. Oyen, of Christiania, whose assistance with the Scandinavian species of mollusca I very gratefully acknowledge.

Searlesia Lundgrenii (Mörch and Poulsen, MS.), sp. nov. Plate XIV, figs. 10—14.

1887. *Urosalpinx Lundgrenii*, Mörch and Poulsen, plates and MS. list in Geological Museum, Copenhagen, no. 6, pl. i, fig. 6 (unpublished).

Specific Characters.—Shell smaller than *S. costifer*, ovate, fusiform, solid; whorls 5 or 6, convex, regularly diminishing in size, the last more than two-thirds the total length; ornamented by 10 to 12 strong longitudinal costæ, not so wide as the spaces between them, which extend nearly to the base of the shell, and by fine, regularly sculptured spiral lines which cross the longitudinal ribs, sometimes becoming tuberculate at the point of intersection; suture distinctly marked; spire short, ending in a blunt point; mouth ovate, angulate above; outer lip not thickened or denticulate within; inner lip closely adherent to the pillar; canal short, rather narrow, turning slightly to the left.

Dimensions.—L. 30 mm. B. 16 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Walton-on-Naze, Little Oakley. Newbournian: Ramsholt. Cranstal Point, Isle of Man.

Pliocene : Iceland.

Remarks.—I have a dozen specimens from Oakley of about the same size, and Mr. Ogden has found another at Ramsholt, which, although belonging to the *S. costifer* group, are smaller than the type form of that shell, and otherwise seem to deserve specific distinction.

They are specially interesting, because among some of Mörch's fossils from the Crag of Iceland which Dr. Ravn sent for my inspection, there are several under the undescribed name of *Urosalpinx Lundgrenii* which correspond with those from Oakley. I have similar shells in my collection from the fossiliferous drift of the Isle of Man which I received from Prof. Kendall some years ago, and there are others from the same locality in the Jermyn Street Museum.

They differ from *F. Forbesi* in form and sculpture and in the greater convexity of the whorls. In the latter species, as stated above, the outer lip is thickened, and is bevelled and denticulate within. In specimens of *S. Lundgrenii,* on the contrary, whether from Oakley or Iceland, it is thin and not denticulate, and the sculpture is finer. They are easily distinguished from the typical Crag forms of *L. costifer,* differing from them in size, in spiral sculpture and general appearance, and in the occasional tuberculation of the longitudinal costæ—a feature which is clearly shown in some of the Crag specimens and less so in the examples from Iceland and the Isle of Man; they are still more unlike the shell recognised by Mörch as representing *S. costifer* in the Icelandic deposits. The specimens here figured from different localities belong, I think, to the same species, and I group them, therefore, under Mörch's name of *S. Lundgrenii.*

Searlesia Harrisoni (A. Bell, MS.), sp. nov. Plate XIV, fig. 21.

1894. *Fusus Forbesi*, Kendall, Journ. Isle of Man Nat. Hist. Soc., vol. i, p. 419, pl. i, fig. 9.

Specific Characters.—Shell fusiform, conical; whorls nearly flat, regularly diminishing towards the apex; ornamented by numerous distinctly marked spiral ridges and by rather inconspicuous longitudinal costæ giving the sculpture a finely reticulate appearance; suture indistinct; mouth oval, ending in a short, open canal which turns to the left; outer lip thin, not expanded; inner lip forming a slight glaze on the pillar.

Dimensions.—L. 20 mm. B. 9 mm.

Distribution.—Not known living.

Fossil: Isle of Man.

Remarks.—But one example is known of this charming little shell which was discovered many years ago by the Rev. S. N. Harrison and is now at Jermyn Street. It was grouped in 1894 by Prof. Kendall as a variety of *S. Forbesi,* but Mr. A. Bell regards it, as I do, as worthy of specific distinction. The specimen in question has lost its apex; but Mr. Bell remembers it perfect, as indeed it was when figured in Prof. Kendall's paper, to which reference should be made.

Searlesia elegans, sp. nov. Plate XIV, fig. 18.

Specific Characters.—Shell solid, conical, fusiform, whorls but little convex; regularly diminishing towards the apex; ornamented by distinctly marked longitudinal costæ, about 10 or 12 on the last whorl, crossed by fine spiral lines; suture clearly defined; mouth oval, ending in a short, open canal.

Dimensions.—L. 20 mm. B. 10 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Little Oakley.

Remarks.—The fossil here figured was found by me at Oakley some years ago, but I have not been fortunate enough to meet with a second specimen. It has a polished exterior, and the sculpture, though somewhat worn, is clearly defined. It has hardly the appearance of a Crag shell, and may possibly belong to a group of Middle Oligocene fossils, such as those described by Dr. Ravn in 1907,[1] though with none of them does it precisely correspond. I figure it provisionally as above. The specimen is good enough to identify, though I have not been able to find the species to which it should be referred.

Mr. van der Gracht informs me that in the boulder-clay of Mecklenburg and North Germany there are erratics full of beautifully preserved fossils of Oligocene age, derived, it is believed, from some submarine deposit the exact position of which has not yet been ascertained but may be probably situated near the mouth of the Baltic. He suggests that some of the extraneous fossils of the Crag may have been derived from a more southerly and submarine extension of such beds.

Searlesia proxima, sp. nov. Plate XIV, fig. 22.

Specific Characters.—Shell fusiform, solid; whorls decidedly convex; ornamented by about twelve strong longitudinal ribs, not so wide as the interspaces separating them, and by fine closely-set spiral lines which cross the ribs; suture well marked; mouth oval, passing rather abruptly into a short, narrow and nearly straight canal; outer lip thin; inner lip forming a slight glaze upon the pillar.

Dimensions.—L. 25 mm. B. 12 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag; Little Oakley.

Remarks.—This shell, which has the polished appearance of that last described, comes also from Oakley, and may be possibly, like it, derivative in the Crag.

[1] Mém. Acad. Roy. Sci. Danemark (7), vol. iii, p. 217, 1907.

Though somewhat worn, its sculpture is sufficiently distinct for identification, and it deserves notice. It nearly approaches an Oligocene species, *Fusus Rosenbergi*, Ravn (pl. vi, fig. 7 of the work just mentioned), but I doubt whether it is the same. It seems better in such case to give a shell a distinctive name than to adopt for it an uncertain reference. I include it among the Searlesias, as it agrees generally with the species I have grouped under that name.

Searlesia Nordmanni, sp. nov. Plate XIV, figs. 4, 5.

1894. *Fusus Forbesi*, Kendall, Journ. Isle of Man Nat. Hist. Soc., vol. i, p. 419, pl. i, fig. 6 (?).

Specific Characters.—Shell strong, fusiform, turreted; whorls decidedly convex, flattened above; ornamented by about twelve longitudinal costæ, rounded, reaching the suture, equal to the spaces between them, and by strong transverse lines; suture deep and well marked; mouth oval, angulate above, ending abruptly in a short narrow canal, nearly straight or turning very slightly to the left; outer lip expanded, toothed inside as in *S. Forbesi;* inner lip closely adherent to the pillar.

Dimensions.—L. 35—40 mm. B. 15—20 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Little Oakley. Isle of Man.

Remarks.—This distinct form is allied to *S. Forbesi*, but differs from it in shape and in the decidedly convex character of its whorls. At present full-sized specimens are only known from the Isle of Man, but I have a few from Oakley, smaller and possibly immature, which appear to be the same. There is one specimen at Jermyn Street and two others in Mr. Harrison's collection from the former locality. As I cannot find any species to which they can be referred, I dedicate them to my friend Dr. Nordmann of Copenhagen. I understand he is about to undertake the serious investigation of the Iceland Crag. Perhaps he may find a specimen of this form in those interesting deposits.

Searlesia alveolata (J. Sowerby).

1829. *Fusus alveolatus*, J. Sowerby, Min. Conch., vol. vi, p. 45, tab. lxxv, fig. 1.
1844. *Fusus alveolatus*, Nyst, Coq. foss. Terr. Tert. Belg., p. 495, pl. xxxix, fig. 21.
1848. *Trophon alveolatum*, S. V. Wood, Mon. Crag Moll., pt. i, p. 49, tab. vi, fig. 8.
1885. *Fusus alveolatus*, Lorié, Arch. Mus. Teyler (2), vol. ii, p. 96, pl. v, figs. 36, 37.
1890. *Trophon alveolatus*, C. Reid, Plioc. Dep. Brit., p. 258.
1892. *Murex alveolatus*, van den Broeck, Bull. Soc. Belge Géol., vol. vi (Mémoires), pp. 120, 131.
1912. *Trophon alveolatum*, Tesch, Med. v. d. Rijks. v. Delfstoffen, pt. iv, p. 82.

Specific Characters.—See Mon. Crag Moll., pt. i, p. 49.

Dimensions.—L. 32—45 mm. B. 12—17 mm.

Distribution.—Not known living.

Fossil : Coralline Crag : Gedgrave, Ramsholt, Boyton. Waltonian: Walton-on-Naze, Beaumont, Little Oakley. Newbournian: Sutton, Brightwell, Newbourn. Butleyan : Butley.

Diestien, Scaldisien, Poederlien of Belgium ; Scaldisien, Holland.

Remarks.—This species can hardly be grouped with the Trophons ; I include it, though with some hesitation, among those described above in the genus *Searlesia*. It is not very abundant either in the Coralline or the Red Crag. Specimens from the latter are often, but not always, rolled and waterworn, and have been regarded in consequence as derivative. The fact that this shell occurs rather commonly, however, in the Scaldisien of Belgium in an unworn condition seems antagonistic to that view, indicating that it was living in the Anglo-Belgian basin as late, at least, as the Waltonian period.

Searlesia consocialis (S. V. Wood).

1848. *Trophon consocialis*, S. V. Wood, Mon. Crag Moll., pt. i, p. 49, tab. vi, fig. 11.
1881. *Murex (Trophon) alveolatus*, var. *consocialis*, Nyst, Conch. Terr. Tert. Belg., p. 4, pl. i, fig. 2.
1890. *Trophon consocialis*, C. Reid, Plioc. Dep. Brit., p. 258.
1912. *Trophon consociale*, Tesch, Med. v. d. Rijks. v. Delfstoffen, pt. iv, p. 82.

Specific Characters.—See Mon. Crag Moll., pt. i, p. 49.

Dimensions.—L. 40 mm. B. 24 mm.

Distribution.—Not known living.

Fossil : Coralline Crag: Ramsholt, Gedgrave, Boyton. Waltonian: Walton-on-Naze, Beaumont, Little Oakley. Newbournian: Newbourn, Waldringfield, Sutton. Butleyan: Butley.

Diestien: Holland. Scaldisien: Belgium.

Remarks.—This form, regarded as distinct by Wood, was described by Nyst as a variety of *S. alveolata*. It differs from the latter, however, in form and to some extent in sculpture, and I do not remember to have seen any specimens connecting the two. Although closely allied, I follow Wood in regarding them as separate species. For the reasons given above, I doubt whether they should be regarded as derivative in the Red Crag. I have found them both, not unfrequently, at Oakley.

Nyst gives this species from the Scaldisien of Belgium, and Dr. Tesch from the Diestien of Holland.

Genus **PARASIPHO,** Dautzenberg and Fischer, 1912.

Parasipho Kröyeri (Möller). Plate XV, figs. 4, 5.

1842. *Fusus Kröyeri*, Möller, Ind. Moll. Grœnl., p. 15.
1872. *Buccinofusus* (*Sipho*) *Kröyeri*, J. W. Dawson, Can. Nat. (n.s.), vol. vi, p. 398, pl. vi, fig. 10.
1879. *Trophon* (*Buccinofusus*) *Kröyeri* (?), S. V. Wood, Mon. Crag Moll., 2nd Suppl., p. 9, tab. iii, fig. 9.
1881. *Neptunea* (*Sipho*) *Kröyeri*, Kobelt, Martini und Chemnitz, Conch. Cab., vol. ii (Purpuraceæ), p. 122, pl. xli, figs. 2, 3.
1882–1901. *Neptunea* (*Sipho*) *Kröyeri*, Friele, Norske Nordh. Exped. (Mollusca), vol. i, p. 16, pl. ii, figs. 12—15, 1882; vol. iii, p. 105, 1901.
1887. *Neptunea* (*Sipho*) *Kröyeri*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 85, pl. xv, figs. 1—3.
1899. *Sipho* (*Tritonofusus*) *Kröyeri*, Posselt, Medd. om Grönl., vol. xxiii, p. 184.
1912. *Sipho* (*Parasipho*) *Kröyeri*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 100, pl. iv, figs. 6, 7.

Specific Characters.—Shell slender, fusiform, turreted; spire elongate; whorls 7 or 8, convex, regularly decreasing in size, the last much the largest, three-fifths the total length; suture deep, well defined; ornamented by inconspicuous but regular longitudinal costæ on the upper whorls, and indistinct and numerous sigmoid plications on the last; covered also by exceedingly fine spiral striæ, hardly visible on the upper whorls, but distinctly shown near the base; mouth ovate, expanded, ending in a short and well-marked canal; outer lip thin, slightly reflexed, forming an obtuse angle where it joins the body-whorl; inner lip forming a thin glaze adherent to the pillar.

Dimensions.—L. 45—70 mm. B. 22—30 mm.

Distribution.—Recent: Arctic seas: Norway, Greenland, Spitzbergen, Nova Zembla, Russian Lapland, Labrador; banks of Newfoundland, Gulf of St. Lawrence.

Fossil: Waltonian Crag: Little Oakley. Newbournian: Shottisham. Isle of Man. Pleistocene: Bridlington.

Pliocene: Iceland. Pleistocene: Rivière du Loup, Canada.

Remarks.—No general agreement has been arrived at as to the nomenclature of this very distinct species, which has received a different generic name from almost everyone who has described it, few of them, as it seems to me, being wholly satisfactory. No objection can be taken, however, to the term *Parasipho*, recently proposed as a sub-genus by Messrs. Dautzenberg and Fischer for Sipho-like shells with regular sinuous longitudinal plications and fine spiral striæ, inconspicuous, except near the base of the last whorl. Dr. Dall uses the term *Plicifusus* for this species, but he has included forms which depart widely from the present type.[1]

The broken Crag specimen which I refer to *P. Kröyeri* is from Oakley; although imperfect and worn it shows both the longitudinal and spiral sculpture Wood figures a similarly imperfect fossil from the Red Crag of Shottisham. I give a perfect shell for comparison from the Ipswich Museum, originally received from Sir J. W. Dawson as a Canadian fossil from the Pleistocene deposits of the Rivière du Loup. Mr. A. Bell has sent me another from the Isle of Man.

Mr. Friele states that *P. Kröyeri* was found in great abundance in Magdalena Bay, Spitzbergen, as many as fifty specimens being brought up in a single trawl. They all belonged to his variety *pumila* (*B*), and were from 60 to 70 mm. in length. Specimens of var. *major* (*A*) were found at the same time, one of which attained a length of 104 mm.

The specimens figured by MM. Dautzenberg and Fischer are also large, measuring 90 mm. by 40 mm.

Genus **ANOMALOSIPHO**, Dautzenberg and Fischer, 1912.

Type.—*Neptunea* (*Sipho*) *Verkrüzeni*, Kobelt.

Remarks.—The above name, appropriate, though not very euphonious, has been proposed by MM. Dautzenberg and Fischer as a sub-genus for Siphos having an elongate spire and a very short canal, of which they take *A. Verkrüzeni* as the type. I have included with it a small but similar and distinct group of Red Crag fossils represented by *Trophon altus*, S. V. Wood, together with one or two others which, although shorter, have the same general character and appearance. Such shells have been variously referred to *Trophon*, *Neptunea* and *Sipho*.

Anomalosipho Verkruzeni (Kobelt).

1876. *Neptunea* (*Sipho*) *Verkrüzeni*, Kobelt, Jahrb. Deutsch. Malak. Gesell., vol. iii, p. 70, pl. ii, fig. 1.
1887. *Neptunea Verkrüzeni*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 82, pl. xii, figs. 5, 6.
1912. *Sipho* (*Anomalosipho*) *Verkrüzeni*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 99, pl. iv, fig. 8.

Var. **plicifera**, Brøgger. Plate XV, fig. 10.

1877. *Sipho cretosus (? cretaceus)*, Mörch and Poulsen, MS. list and plates in Geological Museum, Copenhagen, no. 15, pl. iv, fig. 2, 1877 (unpublished).
1900–01. *Sipho Verkrüzeni*, var. *plicifera*, Brøgger, Norges geol. undersøgelse, vol. xxxi, pp. 50, 654, pl. i, fig. 1.

[1] Proc. U.S. Nat. Mus., vol. xxiv, pl. xxxiv, figs. 1, 2; pl. xxxvi, figs. 4, 7, 8, 10 (1902).

Varietal Characters.—Differs from the type-form in its somewhat longer mouth, its shorter spire, and in having a number of inconspicuous plications which die out towards the base of the shell.

Dimensions.—L. 45—50 mm. B. 16 mm.

Distribution.—Not known living.

Fossil : Pliocene : Iceland. Pleistocene : Yoldia-clay, Christiania region.

Remarks.—The shell here figured is from the Mörch collection of Icelandic fossils at the Copenhagen Museum. It corresponds very nearly with that figured by Prof. Brøgger (*op. cit.*) from the Yoldia-clay of Norway, as to which he says that it is allied to *S. virgatus*, Friele. It seems also to form a connecting link with *A. altus* of the English Crag, although it is more slender than the type-form of that species.

All the shells referred to this genus in the present memoir are similar in texture, differing in that respect from that of the true Siphos which are usually strong, compact and solid. *Anomalosipho* is comparatively thin and fragile, the loose texture of the shell resembling more or less nearly that of *Parasipho Kröyeri.*

Anomalosipho altus (S. V. Wood). Plate XV, fig. 6.

1848. *Trophon altus,* S. V. Wood, Mon. Crag Moll., pt. i, p. 47, tab. vi, fig. 13.

Specific Characters.—Shell not very solid, fusiform, turreted; spire elongate with an obtuse apex; whorls 7—8, convex, regularly diminishing in size, the last more than half the total length; ornamented by exceedingly fine and delicate spiral striæ, and by inconspicuous and sometimes nearly obsolete longitudinal ribs; suture distinct, oblique; mouth ovate, angulate above; outer lip thin; canal very short, turning slightly to the left.

Dimensions.—L. 40—50 mm. B. 16—22 mm.

Distribution.—Not known living.

Fossil : Butleyan Crag: Butley.

Remarks.—I include in the present species some shells that have been found living on the coast of Norway, near Bear Island and Spitzbergen, with a small group of others that are fossil in the Red Crag.

The specimen of the typical form here represented was found by Mr. Kennard at the Neutral Farm pit at Butley, from whence so many interesting fossils have been obtained. It shows the delicate spiral sculpture characteristic of this group more clearly than does the figure given by Wood.

Var. **virgata,** Friele. Plate XV, figs. 7—9.

1879. *Neptunea* (*Sipho*) *virgata,* Friele, Jahrb. Deutsch. Mal. Gesellsch., vol. vi, p. 281.
1882-1901. *Neptunea* (*Sipho*) *virgata,* Friele, Norske Nordh. Exped. (Mollusca), vol. i, p. 13, pl. i, figs. 21—25, 1882 ; vol. iii, p. 104, 1901.
1887. *Neptunea virgata,* Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 83, pl. xiv, fig. 9.

Dimensions.—L. 32—35 mm. B. 14—15 mm.

Distribution.—*Recent:* Norwegian seas to Spitzbergen, in 123—350 fathoms. *Fossil:* Waltonian Crag: Little Oakley. Newbournian: Waldringfield. Butleyan: Butley. Pleistocene: Norway (Øyen).

Remarks.—One of the fossils (fig. 8) represented under this name was found at Butley with the long-spired form which Wood figured as typical of the present species. It closely corresponds with that described as *Neptunea* (*Sipho*) *virgata* by Mr. Friele, which he originally considered (*op. cit.*) distinct from Wood's species. Having recently compared his shell with one of my Oakley specimens he has now written me that he is satisfied they are identical. I retain the term *virgata* as varietal, applicable both to the Crag and the Recent form. Wood's specific name *altus* is the older of the two.

The whorls of the Crag fossils are somewhat more convex than those of the Recent shell, but the sculpture is of the same specially fine and delicate character; the upper whorls are ornamented in both by inconspicuous longitudinal plications. The Recent specimen (fig. 7) which Mr. Friele has kindly allowed me to figure, was dredged off the Norwegian coast at a depth of 350 fathoms.

Var. **costellata,** S. V. Wood. Plate XV, fig. 11.

1872. *Trophon altus,* var. *costellatus,* S. V. Wood, Mon. Crag Moll., 1st Suppl., p. 23, tab. ii, fig. 17*a*.[1]

Distribution.—Butleyan Crag: Butley.

Remarks.—The fossil figured under this name was found by Mr. Kennard at Butley with those described above. It has their delicate sculpture, and although differing somewhat from Wood's shell is no doubt identical with it. His figure does not show the mouth and canal, which are narrower than in the type-form. Our specimen seems to be full-grown.

Anomalosipho Bellii, sp. nov. Plate XV, fig. 13.

Specific Characters.—Shell ovato-acuminate, turreted; whorls 6 or 7, convex, the last five-eighths the total length, sharply excavated below; ornamented by

[1] The artist (*op. cit.*) did not give a very accurate figure of Wood's specimen, which is in the British Museum (Nat. Hist.).

obscure longitudinal plications, by very faint spiral striæ and by the flexuous lines of growth; suture deep; mouth ovate, angulate above; outer lip regularly curved; inner lip not wholly adherent to the pillar; canal wide, open, very short, turning to the left.

Dimensions.—L. 42 mm. B. 21 mm.

Distribution.—Not known living.

Fossil: Butleyan Crag: Butley.

Remarks.—The present shell is from the Ipswich Museum. It belongs to the *A. altus* group, but differs materially from the specimens of that form figured above, and from Mr. Friele's specimens of the variety *virgata;* Mr. A. Bell, indeed, believes it to be specifically distinct. I adopt for it the above name in acknowledgment of his long, conscientious and important work in connection with the Crag deposits.

Anomalosipho Actoni (S. V. Wood). Plate XV, fig. 12.

1879. *Trophon Actoni*, S. V. Wood, Mon. Crag Moll., 2nd Suppl., p. 25, tab. ii, fig. 13.

Specific Characters.—Shell bucciniform, turreted; whorls 6 or 7, convex, obtusely angulate with a squarish shoulder above, the last much the largest; ornamented by well-marked but rather irregular spiral lines and by a few nearly obsolete longitudinal plications; suture deep and channelled; mouth ovate; outer lip expanded, regularly rounded, forming an obtuse angle with the body-whorl; inner lip a thin glaze adherent to the pillar; canal very short, wide, open.

Dimensions.—L. 32 mm. B. 16 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Little Oakley. Butleyan: Butley.

Remarks.—An imperfect specimen from Butley was figured by Wood in 1879, but not described. I have since found another at Oakley which shows the complete mouth. As this form is unknown except for these two fossils, I give it again to show the other side of the shell. It seems specially characterised by the squared outline of the whorls and the wide shelf below the suture.

Genus **VOLUTOPSIS**, Mörch, 1857.

Volutopsis Largillierti (Petit de la Saussaye). Plate XV, fig. 2.

1851. *Fusus Largillierti*, Petit de la Saussaye, Journ. de Conch., vol. ii, p. 254, pl. vii, fig. 6.
1863. *Fusus Turtoni*, Jeffreys, Trans. Brit. Assoc. (Newcastle-upon-Tyne), p. 77.
1867. *Fusus Largillierti*, Jeffreys, Brit. Conch., vol. iv, p. 331.
1870. *Fusus Largillierti*, A. Bell, Ann. Mag. Nat. Hist. [4], vol. vi, p. 214.

1872. *Fusus Largillierti*, A. and R. Bell, Proc. Geol. Assoc., vol. ii, p. 197.

1872. *Trophon Norvegicus*, S. V. Wood, Mon. Crag Moll., 1st Suppl., p. 177, tab. v, fig. 14ˣ.

1881. *Neptunea Largillierti*, Kobelt, Martini und Chemnitz, Conch. Cab., ed. 2, vol. iii (Purpuraceæ), p. 103, pl. xxxv, fig. 1.

1912. *Volutopsis norvegica*, var. *Largillierti*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 66.

Specific Characters.—Shell rather thin, elongato-oblong; spire rapidly decreasing in size, terminated by a large rounded bulb; whorls convex, sometimes with obscure longitudinal plications and faint spiral striæ, the last whorl much the largest, two-thirds the total length; suture deep; mouth oblong, angulate above; canal short; outer lip thin, expanded.

Dimensions.—L. 75—90 mm. B. 36—38 mm.

Distribution.—*Recent:* Newfoundland, Greenland, Iceland, Spitzbergen.

Fossil: Waltonian Crag: Little Oakley. Newbournian: Waldringfield. Butleyan: Shottisham Creek (A. Bell).

Pleistocene: Uddevalla.

Remarks.—The imperfect specimen from the Waltonian Crag at Little Oakley here figured corresponds with the Newfoundland shell described by Petit de la Saussaye under the name of *Fusus Largillierti*, the spire of which is longer than that of the typical *V. norvegica.*

I have some specimens in my collection of a somewhat similar form from Uddevalla which Jeffreys, in his British Association paper of 1863 (p. 77) on the Upper Tertiary fossils of that place, called *Fusus Turtoni*, but afterwards, in the British Conchology, vol. iv, p. 331, *Fusus Largillierti.*

In 1870 Mr. Alfred Bell identified a fossil he had obtained from the Red Crag at Sutton with the latter species, and another was figured by Wood in his first Supplement, tab. v, fig. 14ˣ, as *T. norvegicus.* The last seems, however, to belong to the present species, although it shows longitudinal plications which do not appear on the shell figured by Petit.[1] One of my specimens from Uddevalla, however, is indistinctly plicated in a similar manner.

The occurrence of *V. Largillierti* in the English Crag affords another instance of the connection of the Pliocene mollusca of the east of England with the Recent fauna of the western part of the North Atlantic.

MM. Dautzenberg and Fischer regard our shell as a form of *V. norvegica*, considering that they are now connected by intermediate varieties. It seems, however, that the two had acquired their distinctive characteristics at an early stage of the Crag epoch.

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[1] This fossil, now in the Ipswich Museum, is not accurately represented in Wood's figure The plications are not so prominent as there represented.

Volutopsis norvegica (Chemnitz). Plate XV, fig. 1.

1788. *Strombus Norvegicus*, Chemnitz, Conch. Cab., vol. x, p. 218, tab. clvii, figs. 1497, 1498.
1847. *Fusus Norvegicus*, Reeve, Conch. Icon., vol. iv (Fusus), pl. xii, fig. 47.
1850. *Trophon Norvegicum*, S. V. Wood, Mon. Crag Moll., pt. ii, p. 312, pl. xxxi, fig. 1.
1853. *Fusus Norvegicus*, Forbes and Hanley, Brit. Moll., vol. iii, p. 428, pl. cvii.
1867. *Fusus Norvegicus*, Jeffreys, Brit. Conch., vol. iv, p. 329, pl. lxxxv, fig. 3.
1878. *Volutopsis Norvegica*, G. O. Sars, Moll. Reg. Arct. Norv., p. 268, pl. xv, fig. 1.
1881. *Neptunea norvegica*, Kobelt, Martini und Chemnitz, Conch. Cab., ed. 2, vol. iii (Purpuraceæ), p. 59, pl. xxxiii, figs. 6, 7.
1889. *Volutopsis Norwegica*, Van den Broeck, Bull. Soc. Belge Géol., vol. vi (Mémoires), p. 121.
1900–1. *Volutopsis norvegica*, Brøgger, Norges geol. undersøgelse, vol. xxxi, pl. x, fig. 1.
1912. *Volutopsis norvegica*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 64, pl. i, fig. 5.

Specific Characters.—Shell resembling *V. Largillierti* in form, but having a much shorter spire; ornamented by fine irregular spiral striæ; apex bulbous as in the last species; mouth oval, angulate above, longer than the spire; canal wide, very short; outer lip regularly curved, expanded; inner lip consisting of a wide and thin glaze closely adherent to the pillar; pillar gently curved in the middle.

Dimensions.—L. 65—70 mm. B. 30—35 mm.

Distribution.—*Recent:* northern coasts of Great Britain; Norwegian coast, Lofoten Islands, Finmark, Russian Lapland, Iceland, Spitzbergen, Greenland, Sea of Okhotsk; Newfoundland, northern and north-eastern shores of North America (G. O. Sars).

Fossil: Waltonian Crag: Little Oakley. Newbournian: Sutton, Felixstow. Butleyan: Butley. Icenian: Thorpe near Norwich, Bramerton.

Scaldisien: Antwerp (Van den Broeck).

Pleistocene: Christiania region.

Remarks.—The perfect specimen here figured of the typical *V. norvegica* was obtained from Oakley. Wood records it, imperfect, from the Newbournian Crag of Felixstow, and from Sutton.

Genus BERINGIUS, Dall, 1879.

Beringius Turtoni (Bean). Plate XV, fig. 3.

1834. *Fusus Turtoni*, Bean, Mag. Nat. Hist., vol. vii, p. 493, fig. 61.
1847. *Fusus Turtoni*, juv., Howse, Ann. Mag. Nat. Hist. [1], vol. xix, p. 163, pl. x, fig. 8.
1850–72. *Trophon Turtoni*, S. V. Wood, Mon. Crag Moll., pt. ii (Appendix), p. 312, tab. xxxi, fig. 2, 1850; 1st Suppl., p. 22, tab. i, fig. 11, 1872.

1853. *Fusus Turtoni*, Forbes and Hanley, Brit. Moll., vol. iii, p. 431, pl. cv, fig. 4; pl. cvi, figs. 2, 3.
1867. *Fusus Turtoni*, Jeffreys, Brit. Conch., vol. iv, p. 331, pl. lxxxv, fig. 4.
1878. *Chrysodomus Turtoni*, G. O. Sars, Moll. Reg. Arct. Norv., p. 269, pl. xiv, fig. 3; pl. xxv, figs. 9, 10.
1882. *Jumala Turtoni*, Friele, Norske Nordh. Exped. (Mollusca), vol. i, p. 6, pl. iv, figs. 4—7.
1887. *Neptunea Turtoni*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 68, pl. xii, fig. 1; pl. xiii, fig. 1.
1893. *Ukko Turtoni*, Norman, Ann. Mag. Nat. Hist. [6], vol. xii, pp. 344, 352, pl. xvi, figs. 1, 2.
1901. *Ukko Turtoni*, Friele, Norske Nordh. Exped. (Mollusca), vol. iii, p. 101.
1912. *Jumala Turtoni*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 62, pl. i, fig. 4.

Distribution.—Recent: Great Britain: north east coast, Dogger bank; Norwegian coast, Finmark, Bear Island, Murman coast, Kola, Greenland, Newfoundland.

Fossil: Waltonian Crag: Little Oakley. Newbournian: Waldringfield, Ramsholt, Newbourn. Butleyan: Butley.

Remarks.—One or two full-grown examples of this species were obtained previous to 1872 by the late Robert Bell and the Rev. H. Canham from Waldringfield and Butley, but since then it has not been met with in the Crag until the recent discovery at Newbourn of a young specimen (Pl. XV, fig. 3) by Mr. Ogden. There are several others, similarly immature and corresponding with it, in the Holmes collection of British shells at the Norwich Castle Museum. The specimen figured by Howse (*op. cit.*) is of the same character.

The generic name of this shell has been often changed; I follow the Conchological Society of Great Britain in adopting for it Dr. Dall's name of *Beringius*.

Var. **minor**, nov. Plate XVIII, figs. 3, 4.

Remarks.—In his paper on the Trondhjem fiord (*op. cit.*) Canon Norman described several varieties of *B. Turtoni* differing principally in the comparative length of the spire, but all more or less of the normal size of this species. In the Holmes collection, alluded to above, there are a number of others, probably from the Dogger Bank, apparently full grown but smaller and more slender, measuring from 45 to 65 mm. in length, and I have two interesting specimens from Oakley (here figured) corresponding with them in form and sculpture, which are respectively but 26 and 37 mm. long. The upper whorls of the latter are not swollen as in the type, and the spire is not so elongate, diminishing regularly in size and ending in an abrupt and twisted apex.

They appear to represent a dwarfed variety or the arrested development discussed before (p. 79), which we meet with not infrequently in studying the Crag mollusca; I have, for example, a fair number of specimens of *N. despecta* from Oakley having 5 to 6 whorls, and but 25 to 30 mm. only in length, evidently miniature shells which could never have grown to the proportions of the typical form.

Genus **NEPTUNEA**, Bolten, 1798.

Neptunea contraria (Linné).

Var. **typica**. Plate XVI, figs. 1, 2.

1771. *Murex contrarius*, Linné, Mantissa plantarum, vol. ii, p. 551.
1812. *Murex contrarius*, J. Sowerby, Min. Conch., vol. i, p. 63, tab. xxiii.
1843. *Fusus contrarius*, Nyst, Coq. foss. Terr. Tert. Belg., p. 499, pl. xli, fig. 1.
1848. *Trophon antiquum*, var. *contrarium*, S. V. Wood, Mon. Crag Moll., pt. i, p. 44, tab. v, fig. 1.
1881. *Fusus contrarius*, Nyst, Conch. Terr. Tert. Belg., p. 14, pl. i, figs. 9 *a*, 9 *f*.
1885. *Fusus contrarius*, Lorié, Arch. Mus. Teyler [2], vol. ii, p. 203, pl. v, fig. 29.
1889. *Chrysodomus contraria*, Van den Broeck, Bull. Soc. Belge Géol., vol. vi (Mémoires), pp. 121, 131.
1898. *Fusus* (*Neptunea*) *contrarius*, F. W. Harmer, Proc. Intern. Congr. Zool. (Cambridge), p. 222, pl. iii, figs. 2, 3, 5.

Specific Characters.—See auctt.

Dimensions.—L. 75—125 mm. B. 35—75 mm.

Distribution.—*Fossil:* English Crag: Waltonian, Newbournian, Butleyan. Icenian: Norwich and Weybourne horizons.

Scaldisien, Poederlien: Belgium. Scaldisien: Holland. Isle of Man, Slains, Wexford.

Pleistocene: Middle Glacial sands of Billockby; Bridlington, Kelsey Hill, Worden, Gloppa, Cleongart (Arran), Dublin, Estuarine Clay of Belfast.

Remarks.—The question of the specific identity or otherwise of the various dextral and sinistral mollusca of which *Neptunea antiqua* has been taken as the type, is one upon which some difference of opinion has existed. The study of their distribution in space and time may possibly throw light on the subject.

In Lamarck's 'Histoire Naturelle des Animaux sans vertébres,' ed. 2, Deshayes, 1843, the names of five allied forms are given and regarded as specifically distinct. Of these, three are dextral, viz.:

Fusus antiquus, Linné.
,, *carinatus*, Pennant.
,, *despectus*, Linné.

and two sinistral, viz.:

Fusus contrarius, Linné.
,, *sinistrorsus*, Deshayes.

These two groups occupy at the present time distinct areas, which hardly overlap. Specimens of the sinistral *N. sinistrorsa* are recorded from the Mediterranean by Dr. Carus and Prof. Meli, and from Vigo Bay on the Atlantic coast of Spain, where McAndrew found them in some abundance, but they are not known now to the north of the latter locality.

The dextral *N. antiqua*, on the contrary, is characteristically boreal, ranging from British seas northwards to the Norwegian coast, and occasionally to the south of our shores, while the other dextral forms, *N. despecta* and its varieties, are even more decidedly northern, reaching from the Lofoten Islands to Vadsö, and further north in Arctic regions from the Siberian coast to Greenland. The North American shells, *Fusus tornatus* and *F. decemcostatus*, as well as the Japanese *Chrysodomus intersculptus* of G. B. Sowerby, are closely allied forms.

Referring to their former distribution, we find none but sinistral Neptuneas occurring as fossils in the south of Europe. They are found in the Pleistocene beds of Sicily, as at Ficarazzi near Palermo, and Reggio in Calabria. On the other hand, the dextral forms which occur in the later Pliocene and Pleistocene of northern Europe are unknown from any such deposits to the south of Great Britain.

Jeffreys considered the Crag *N. contraria* to be a monstrous variety of *N. antiqua*,[1] as did Forbes. It is true that reversed specimens of the latter are occasionally met with living in British seas, but they are hardly the same as the Crag fossils; except that they are left-handed, they cannot be distinguished from the right-handed shells with which they are found.

The recent *N. sinistrorsa* of Vigo Bay, on the contrary, differs materially from both *N. antiqua* and *N. despecta*, corresponding more closely with the Pliocene *N. contraria*.[2]

Deshayes regarded *N. contraria* of the English and Belgian Crag as specifically distinct from *N. sinistrorsa* of the south of Europe, whether Recent or fossil, a view subsequently taken by others. Some authorities, however, while admitting certain differences between the two, prefer to unite them. With this I agree, adopting for the southern and Recent shell the name *N. contraria*, var. *sinistrorsa*.

Belgian specimens of the Scaldisien *N. contraria* (Pl. XVI, fig. 2) occurring in deposits approximately equivalent to the Walton horizon of the English Crag, agree with the English fossils, but being less water-worn show more clearly the characteristic spiral sculpture of this species.

The arrival of this sinistral form in the Anglo-Belgian basin preceded that of the dextral Neptuneas. It appears first and in the greatest profusion at Walton-on-Naze, the earliest of the Waltonian deposits, the dextral shells establishing them-

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[1] Brit. Conch., vol. iv, p. 325, 1867.

[2] See Proc. Internat. Congress Zool. (Cambridge), p. 223, pl. iii, 1898.

selves afterwards at the Oakley horizon of the Waltonian Crag; one specimen only (now in my possession) was found in the upper part of the section at Walton-on-Naze by Prof. Kendall many years ago, and I obtained another at Beaumont, while at Oakley they are not very rare. It is the northern *N. despecta* and its varieties, however, that occur in these places and in the Red Crag generally, and not the Recent British *N. antiqua*, the typical form of which is unknown to me from either Walton or Oakley, its first appearance in the English Crag being at the Newbournian stage, where it is exceedingly rare.[1]

Taken as a whole the dextral shells are comparatively rare at Oakley and in the Newbournian Crag, while at Butley they are somewhat more numerous, *N. despecta* being everywhere the predominant form; at the Icenian stage the sinistral forms had well-nigh disappeared.

The fact that *N. contraria* appeared first in the Crag basin led Wood to the opinion, opposite to that of Jeffreys, that the progenitor of the two groups may have been left-handed. No specimen, however, is known to me from the Crag which presents the appearance of an ancestral form uniting the two. If the one had been derived from the other in Crag times we ought to find them approaching as we trace their history backwards, but this is not the case. Specimens of *N. despecta* and its varieties from Oakley differ materially from the sinistral fossils with which they are found, having a shorter spire, a less oblique suture, and different sculpture.

Several varieties of *N. contraria* are known from Oakley, but they do not approach those of the *despecta* group, and no specimen of the former has been found which could be regarded as a reversed, *i. e.* a right-handed, variety of it.

I adopt, therefore, the opinion which has been held, from the time of Linné, by foreign conchologists, almost without exception, believing that in Pliocene times these dextral and sinistral shells had become sufficiently differentiated to entitle them to specific rank. Comparing Pls. XVI and XVII, most of the specimens being from the same locality, the difference between the two is rather striking.

Originating probably in seas to the north of Great Britain, and arriving somewhat suddenly in these latitudes, when communication was first opened up between the Crag basin and the north by the tectonic subsidence referred to in one of my earlier papers,[2] it seems clear that at the time of their first recorded appearance they had become separated into distinct groups, which migrated separately, and still survive, nearly in their original form.

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[1] There is a specimen in the Jermyn Street Museum of the typical *N. antiqua* labelled Walton-on-Naze. Its colour, however, is not that of any Walton *Neptunea* known to me, and Mr. A. Bell, whose knowledge of the subject is unique, expresses a very strong opinion that it is not Waltonian, but came from some Newbournian horizon. Dr. Kitchin thinks the locality claimed for it may probably be a mistake.

[2] "Pliocene Deposits of Holland," Quart. Journ. Geol. Soc., vol. lii, p. 754, 1896.

Prof. Kendall informed me many years ago that while specimens of dextral Neptuneas in the Crag are often covered with *Balani*, he had never noticed any on the sinistral ones. I have found them occasionally on the latter, but very rarely.

Var. **sinistrorsa,** Deshayes. Plate XVI, figs. 3, 4.

1830. *Fusus sinistrorsus*, Deshayes, Encycl. Meth. Verm., vol. ii, p. 160, no. 36.
1836–44. *Fusus contrarius*, Philippi, En. Moll. Sic., vol. i, p. 205, 1836; vol. ii, p. 179, 1844.
1847. *Fusus contrarius*, Reeve, Conch. Icon., vol. iv (*Fusus*), pl. xii, fig. 46.
1873–75. *Neptunea contraria*, Seguenza, Boll. R. Com. Geol. Ital., vol. iv, p. 346, 1873; vol. v, p. 278, 1874; vol. vi, p. 282, 1875.
1887. *Neptunea contraria*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 65, pl. ii, fig. 1.
1890. *Neptunea contraria*, Carus, Prod. Faun. Medit., vol. ii, p. 400.
1895–98. *Neptunea sinistrorsa*, Meli, Boll. Soc. Geol. Ital., vol. xiii, p. 302, 1895; Boll. Soc. Malac. Ital., vol. xx, p. 115, pl. iv, figs. 1—5, 1898.
1898. *Fusus (Neptunea) contrarius*, F. W. Harmer, Proc. Intern. Congress Zool. (Cambridge), p. 222, pl. iii, fig. 1.

Distribution.—Recent: western coast of Spain—Vigo Bay; Mediterranean—Barcelona (Michaud), Algiers (Meli), Sicily (Fischer).

Fossil: Waltonian deposits: Walton-on-Naze, Little Oakley; probably elsewhere in the Red Crag. Upper Pliocene and Pleistocene: Sicily—Ficarazzi, Sciacca, Monasterace, Messina, Santa Cristina near Reggio-Calabria.

Remarks.—The specimens represented under the above name (Pl. XVI, figs. 3 and 4) from the Waltonian Crag of Oakley and the Pleistocene deposits of Ficarazzi, near Palermo, may be taken as typical of the present variety. The spiral striation is finer than in those last described, and they are generally more graceful and slender. The sculpture of some Recent specimens from Vigo Bay in the McAndrew collection at Cambridge is of an intermediate character (see my paper of 1898, *op. cit.*, fig. 4), as in those recorded by Prof. Meli from the Algerian coast (*op. cit.*).

The Recent sinistral shells figured by Reeve and by Prof. Kobelt are of the present variety, the typical *N. contraria* of the Crag being only known as fossil from the Pliocene and Pleistocene deposits of Great Britain, Belgium and Holland.

Although these left-handed shells have a southern range at present, their progenitors must have reached the Anglo-Belgian basin originally from the north.

Var. **angulata**, S. V. Wood. Plate XVI, fig. 7.

1848. *Trophon antiquum*, var. *contrarium angulatum*, S. V. Wood, Mon. Crag Moll., pt. i, tab. v, fig. 1 *h*.

Distribution.—Not known living.
Fossil: Red Crag, *passim.*

Remarks.—Wood described a rolled specimen of this variety, but his figure does not show the spiral ornamentation. I have many perfect examples equally worn in my collection from Oakley, where it is not uncommon, but there is one in the Castle Museum at Norwich (here represented) in which the original sculpture is clearly preserved. The imperfect shell from Oakley, var. *carinata* (Pl. XVI, fig. 5), figured with it, agrees with Wood's var. *sinistrorsum*; in this form the upper part of the last whorl is rounded and not shouldered.

Var. **informis,** nov. Plate XVI, fig. 6.

Distribution.—Not known living.
Fossil: Red Crag, all zones.

Remarks.—This short and abnormal variety of *N. contraria* approaches in form the Recent and arctic species, *N. deformis*, Reeve[1] (Conch. Icon., vol. iv [*Fusus*], pl. xii, fig. 45), of which specimens are to be found in the British Museum (Natural History). It is not identical with it, but possibly may be related.[2]

I have not noticed either this variety or the last in the Belgian Crag.

Neptunea despecta (Linné). Plate XVII, fig. 1.

1758. *Murex despectus*, Linné, Syst. Nat., ed. x, p. 754, no. 486.
1863. *Fusus antiquus*, var., Jeffreys, Rep. Brit. Assoc. (Newcastle-upon-Tyne), Sections, p. 77
1867. *Fusus despectus*, Jeffreys, Brit. Conch., vol. iv, p. 328.
1878. *Neptunea despecta*, G. O. Sars, Moll. Reg. Arct. Norv., p. 267, pl. xiv, fig. 4 *a*.
1881. *Neptunea despecta*, Tryon and Pilsbry, Man. Conch., vol. iii, p. 116, pl. xlvii, fig. 263.
1884. *Fusus despectus*, Jeffreys, Quart. Journ. Geol. Soc., vol. xl, p. 319.
1887. *Neptunea despecta*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 63, pl. xi, fig. 2.
1900–01. *Neptunea despecta*, Brøgger, Norges geol. undersøgelse, vol. xxxi, p. 264, fig. 28.
1912. *Neptunea antiqua*, subsp. *despecta*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 79, pl. iii, fig. 1.

Specific Characters.—Shell strong, solid, ovato-fusiform, whorls about 7, convex, but not so much so as in *N. antiqua*, the last ventricose, much the largest,

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[1] *N.* (*Pyrulofusus*) *deformis* has been found in Spitzbergen, Nova Zembla, and in the Behring Sea (Dautzenberg and Fischer).

[2] Other varieties of *N. contraria* are figured in pl. v of Wood's Monograph.

in specimens from the Crag generally three-fourths the total length; ornamented on the upper whorls by 2 or 3, and on the last by about 10 spiral ribs, closer together towards the base of the shell; in the type form they are not very prominent, having fine thread-like, wavy and irregular lines between them; suture distinct; spire comparatively short, rapidly diminishing to a blunt and sub-mammiform point; mouth large, ovate, together with the canal more than half the length of the shell, angulate above; outer lip expanded, regularly curved, not distinctly angulated by the carination of the body-whorl in the type as in some varieties; inner lip forming a glaze upon the pillar; canal short, wide, open, turning to the left, ending in a well-marked notch.

Dimensions.—(Of Crag specimens). L. 80 mm. B. 50 mm, occasionally larger.

Distribution.—*Recent:* Norwegian coast from Bergen to Finmark, Christiania fiord, Lofoten Islands, Iceland, Spitzbergen, Greenland.

Fossil: Waltonian Crag: Walton-on-Naze (unique), Little Oakley, not very common. Newbournian. Butleyan. Icenian.

Pleistocene: Kelsey Hill, Holderness, Bridlington, Slains, Dalmuir.

Denmark: *Yoldia*-clay. Southern Norway: *Tapes*-banks. Western Sweden: Uddevalla.

Remarks.—The figures of this species given by Profs. G. O. Sars and Brøgger show the spiral costation as comparatively inconspicuous, but the former remarks that in some specimens it is more prominent; possibly such specimens may represent some of the varieties described below, which differ from the type in the carination of the whorls by the uppermost rib and the consequent angulation of the outer lip. Scandinavian examples of *N. despecta* attain a larger size than do any I have noticed in the Crag, that figured by Prof. Brøgger from the Pleistocene deposits of Christiania measuring 135 mm. in length. One specimen from Hollesley in my collection, however, measures 105 mm. by 65 mm.

As before stated *N. despecta* and its varieties are the characteristic dextral Neptuneas of the various zones of the Red Crag, *N. antiqua* being comparatively rare in those deposits.

Var. **decemcostata**, Say. Plate XVII, figs. 3, 4; Plate XXV, figs. 3, 5.

1825. *Fusus 10-costatus*, Say, Journ. Acad. Nat. Sci. Philad., vol. v, p. 214.

1841–70. *Fusus decemcostatus*, Gould, Rep. Inv. Mass., ed. i, p. 287, fig. 202, 1841; ed. ii, p. 375, fig. 642, 1870.

1848. *Trophon antiquum*, var. *carinatum*, S. V. Wood, Mon. Crag Moll., pt. i, p. 44, tab. v, fig. 1 *b*.

1882. *Trophon antiquus*, var. *despectus*, S. V. Wood. Mon. Crag Moll., 3rd Suppl., p. 2, tab. i, fig. 9.

Varietal Characters.—Corresponding with the typical Crag form of *N. despecta* except that its spiral sculpture is much more prominent, consisting of strong and distinct ribs, two on the upper whorls and about ten on the last, with fine wavy and irregular lines in the interspaces; the first rib causes slight carination of the whorls, with a corresponding angulation of the outer lip; it differs from the variety *carinata* in being broader in proportion to the length; the spire is usually short and not elongate.

Dimensions.—L. 75—105 mm. B. 45—65 mm.

Distribution.—*Recent:* coasts of Massachusetts and further north.

Fossil: Red Crag: all zones.

Remarks.—This strong and coarsely ribbed shell is one of the most abundant of the dextral Neptuneas of the Red Crag. The Oakley specimen here represented agrees with Gould's figure of the American *Fusus decemcostatus* except that it is slightly narrower. I do not think the two forms can be separated, but as our shell is clearly connected with the Crag *N. despecta* it may be regarded as a variety of that species. A dwarf form of this variety with finer sculpture (Pl. XXV, fig. 3) occurs occasionally in the Icenian Crag.

Var. **carinata**, Pennant. Plate XVII, fig. 5; Plate XXV, fig. 4.

1777. *Murex carinatus*, Pennant, Brit. Zool., vol. iv, p. 107, tab. lxxvii, fig. 96.
1848. *Trophon antiquum*, var. *jugosum*, S. V. Wood, Mon. Crag Moll., pt. i, tab. v, fig. 1 *a*.
1881. *Fusus antiquus*, Nyst, Conch. Terr. Tert. Belg., p. 13, pl. i, figs. 9 *b*, 9 *d*, 9 *e*.
1885. *Fusus antiquus*, Lorié, Arch. Mus. Teyler [2], vol. ii, p. 203, pl. v, fig. 28.
1892. *Chrysodomus despecta*, var. *carinata*, Van den Broeck, Bull. Soc. Belge Géol., vol. vi (Mémoires), p. 131.
1912. *Neptunea antiqua*, subsp. *carinata*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 78, pl. ii, fig. 4.

Varietal Characters.—Differs from the typical *N. despecta* and from var. *decemcostata* in its more slender and elongate form; from the former in the somewhat greater convexity of its whorls, and its stronger spiral sculpture, and from var. *subantiquata* in having a less prominent or well-marked keel below the suture.

Dimensions.—L. 75—85 mm. B. 40—50 mm.

Distribution.—*Recent:* circumpolar Seas.

Fossil: Waltonian Crag: Beaumont (unique), Little Oakley. Newbournian: Ramsholt, Felixstow, Falkenham, Waldringfield. Butleyan: Butley, Bawdsey, Alderton. Icenian: Bramerton (rare).

Poederlien: Belgium. Amstelien: Holland.

Remarks.—The shell figured under the above name is the form of the dextral group of Neptuneas reported from the Belgian Crag by Nyst as occurring in the Poederlien of Antwerp, an upper horizon of the Scaldisien which bears a similar relation to it that the Oakley bed does to that of Walton; it was also found by

Dr. Lorié in the Amstelien of one of the Dutch borings,[1] representing in both cases the first general and apparently sudden arrival of the distinctively northern mollusca in the Anglo-Belgian basin; the Poederlien deposits of Belgium, however, may be somewhat older than those of Oakley, as such species are not so fully represented in them as they are at the latter place. The shell referred to was figured by Nyst (*op. cit.*, fig. 9 *d*) under the name of *Fusus antiquus*, but it belongs to the coarsely ribbed variety *carinata* of *N. despecta*, as subsequently recognised by Van den Broeck (*op. cit.*).[2]

Adult specimens of this variety are not very common at Oakley, but immature or dwarf shells are somewhat more so. In sculpture it approaches the Canadian species *F. decemcostatus* rather than the strongly keeled Scandinavian variety *subantiquata*, having the prominent ribs of the former; it is a more slender shell, however, and the spire is longer.

Var. **subantiquata**, Maton and Rackett. Plate XVII, figs. 6, 7; Plate XXV, fig. 2.

1807. *Murex subantiquatus*, Maton and Rackett, Trans. Linn. Soc., vol. viii, p. 147.

1819. *Murex subantiquatus*, Turton, Conch. Dict., p. 88.

1841–72. *Fusus tornatus*, Gould, Rep. Inv. Mass., ed. i, p. 286, fig. 201, 1841; ed. ii, p. 374, fig. 641, 1872.

1878. *Neptunea despecta*, var. *carinata*, G. O. Sars, Moll. Reg. Arct. Norv., p. 267, tab. xiv, fig. 4 *b*.

1900–01. *Neptunea despecta*, var. *carinata*, Brøgger, Norges geol. undersøgelse, vol. xxxi, p. 265, fig. 29.

1912. *Neptunea antiqua*, var. *subantiquata*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 78, pl. ii, fig. 3.

Varietal Characters.—Differs from the type form of *N. despecta*, and from the varieties *carinata* and *decemcostata* in its spiral sculpture, especially in the sharp and prominent keel on the last whorl, as well as in its angulated outer lip and generally in the more distinct shelf below the suture; in specimens from the Crag the spire is shorter.

Dimensions.—L. 80—100 mm. B. 45—80 mm.

Distribution.—*Recent:* widely diffused in circumpolar regions.

Fossil: Waltonian Crag: Little Oakley (very rare). Newbournian: Ramsholt. Icenian: Bramerton. Poederlien: Antwerp.

Pleistocene deposits of Christiania.

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[1] Dr. Lorié has figured an imperfect specimen of this variety (*op. cit.*) from the Amstelien of the Utrecht boring, which he has been kind enough to send me for examination; it proves to be the same as that in fig. 9 of Nyst's pl. i. The artist has mistaken the scars of some parasitic growth—which are less regular than he has shown them—for the original sculpture of the shell; the reverse side shows, however, the characteristic spiral markings of the present variety, with the form of which the fossil in question agrees.

[2] *Murex carinatus*, Turton, seems to be the variety *striata* of *N. antiqua* (Conch. Dict., p. 88, pl. xxvii, fig. 95, 1819).

Remarks.—This sharply keeled shell seems to be the prevalent form of the *despecta* group in circumpolar seas at the present day, but it is not common in the Crag. I have a full-grown specimen from the Poederlien of Antwerp, a few others, immature, from the Red Crag of Oakley and Ramsholt, and there are several in the Castle Museum at Norwich from the Icenian of Bramerton. Prof. G. O. Sars states that this strongly keeled form is more commonly found as young specimens.

It is generally known to Scandinavian conchologists under the varietal and very appropriate name of *carinata*, but Pennant's *Murex carinatus* seems to represent the variety last described. MM. Dautzenberg and Fischer have recently identified the present shell with the var. *subantiquata* of Maton and Rackett, with whose figure it agrees. Lister's figure ('Hist. Conch.,' vol. iv, pl. 1057, fig. 1, 1688) represents a typical example of this variety.

Through the kindness of Prof. Lönnberg and Dr. Odhner I am able to figure a typical Recent specimen of this variety from the Zoological Museum at Stockholm, which corresponds with our fossils from the English and Belgian Crag.

Var. **behringiana,** Middendorff. Plate XVII, fig. 8.

1849. *Tritonium (Fusus) antiquum*, var. *Behringiana*, Middendorff, Beitr. z. Mal. Ross., pt. ii, p. 131, pl. ii, figs. 3, 4.

1898. *Fusus (Neptunea) antiquus*, var. *brevispira*, F. W. Harmer, Proc. Intern. Congress Zool. (Cambridge), p. 226, pl. iii, fig. 8.

Dimensions.—L. 65 mm. B. 45 mm.

Distribution.—*Recent:* Kamtchatka, Behring Sea, Sea of Okhotsk.

Fossil: Waltonian Crag: Little Oakley.

Remarks.—The specimen here represented was described by me in 1898 as an abnormal form of *N. antiqua*. It is very distinct, closely resembling the Behring Sea shell figured by Middendorff, and may be regarded, I think, as nearly related to it. Its short spire and the banded sculpture of the Crag fossil, so far as it can be made out from its worn condition, seem rather to connect it with *N. despecta* than with *N. antiqua*; I have met with only one specimen of it.

Var. **Cobboldiæ,** nov. Plate XVIII, figs. 8, 9.

1812. *Murex striatus*, J. Sowerby, Min. Conch., vol. i, p. 61, tab. xxii.

1834. *Fusus striatus*, J. Sowerby, Syst. Ind., p. 247.

Dimensions.—L. 55—100 mm. B. 32—60 mm.

Distribution.—Newbournian Crag: Felixstow, Holywell. Butleyan: Butley, Bawdsey. Icenian: Bramerton, Dunwich.

Remarks.—The Butley fossils here represented are from my own collection, and though but half the size of that figured by Sowerby are evidently the same. They belong to the short-spired *despecta* group although they are not carinated, differing sufficiently from those before described to entitle them, in my opinion, as in Sowerby's, to be regarded as distinct. The various specimens in my collection, although from different horizons, maintain the same general character. As the name *striata* is used for another shell, I have dedicated this form to the memory of the late Mrs. Cobbold, from whom it was originally received. The section at Holywell, near Ipswich, from which the present and some other fossils figured by Sowerby came, has not been worked for many years. There are examples of this variety in the British Museum (Nat. Hist.) and in the Jermyn Street Museum.

Var. **intermedia**, nov. Plate XVII, fig. 2.

1898. *Fusus* (*Neptunea*) *antiquus*, F. W. Harmer, Proc. Intern. Congress Zool. (Cambridge), p. 222, pl. iii, fig. 7.

Dimensions.—L. 70 mm. B. 45 mm.

Distribution.—Waltonian Crag: Little Oakley; probably elsewhere in the Red Crag.

Remarks.—The shell here figured, one of the earliest forms of the dextral group to appear in the Crag basin, corresponds with the Oakley type of *N. despecta* in everything but in its spiral sculpture. Although resembling *N. antiqua* in that respect, traces of the characteristic and prominent ridges of *N. despecta* may be observed on the upper whorls; it can hardly be separated from the latter species, and must be regarded, I think, as a variety of it.

Var. **pumilio,** nov. Plate XVIII, figs. 1, 2.

1848. *Purpura lapillus*, var. *angulata,* S. V. Wood, Mon. Crag Moll., pt. i, tab. iv, fig. 6 *e*.

Varietal Characters.—Shell small, short, solid, fusiform; whorls 6, the last five-sixths the total length, excavated below; ornamented by numerous fine, wavy spiral lines, and on the upper whorls by a very prominent raised and rounded keel just above the suture; the keel is still more strongly marked on the body-whorl, the upper part of which forms a comparatively wide and sloping shelf extending to the suture, the lower part being covered with raised spiral lines of unequal size; spire very short, conical, rapidly diminishing in size, ending in a blunt point; suture slight; mouth ovate, strongly angulate above; outer lip thin, sharply angulated by the keel; inner lip forming a thin and closely adherent glaze; pillar sinuous; canal short and wide, turning to the left.

Dimensions.—L. 32 mm. B. 22 mm.

Distribution.—Fossil: Icenian Crag: Bramerton.

Remarks.—In the Fitch collection at the Norwich Museum there are several unfigured specimens from the Icenian Crag of Bramerton corresponding to some extent with a Recent shell from Behring Sea which I have received from Dr. Odhner under the name of *N. fornicata* var. *multistriata*, and somewhat less with those figured by Prof. Leche as *Fusus fornicatus*, Reeve.[1] In other respects, however, our Crag fossils differ too widely, especially in the form of the last whorl and the canal, to justify their reference to the Behring Sea shell. It seems safer, therefore, to regard them for the time as an abnormal variety of the polymorphous Crag species *N. despecta.* There are some specimens in the British Museum and in the Castle Museum at Norwich, one of them being here figured for comparison (Pl. XVIII, fig. 2). They were described by Wood (*op. cit.*) as *Purpura lapillus*, var. *angulata*, but possibly they may be a modified form of the present variety.

Var. **intersculpta** (G. B. Sowerby). Plate XVIII, fig. 5; Plate XXV, fig. 1.

1899. *Chrysodomus intersculptus*, G. B. Sowerby, Ann. Mag. Nat. Hist. [7], vol. iv, p. 371, fig. 2.

Varietal Characters.—Resembling generally the carinated varieties of *N. despecta* described above, except that the last whorl is more tumid and the sculpture different; the stronger spiral ridges are not so prominent and the intermediate ones are coarser.

Dimensions.—L. 80—130 mm. B. 48—75 mm.

Distribution.—Recent: Behring Sea; Tango, Japan.

Fossil: Butleyan Crag: Butley. Icenian: Yarn Hill; probably elsewhere in the upper horizons of the Crag.

Remarks.—The Recent shell here figured was dredged by the Vega expedition in Behring Sea (lat. 62° 39′ N., long. 177° 51′ W.), and was sent to me by Dr. Odhner under the name of *N. despecta*, var. *carinata*. *Murex carinatus*, Pennant, however, seems to have been a different form, as before explained (p. 164). These shells prove to be identical with a Japanese species recently described by Mr. G. B. Sowerby as *Chrysodomus intersculptus*, the specific name of which was suggested by the finer spiral ridges which occur between the stronger and more prominent ones.[2] If, as I suppose, this rather distinct shell is now confined to the Pacific, we are justified, I think, in retaining Mr. Sowerby's name, but as it and another similarly sculptured form, next to be described, occur in the English Crag, I am inclined with Dr. Odhner to regard the present shell as a geographical variety of *N. despecta.* I propose to figure the specimen from Yarn Hill in Pl. XXV of this Memoir.

[1] K. Svensk. Vet. Akad. Handl. Stockholm, (N. S.) vol. xvi [2], p. 66, pl. ii, fig. 27, 1878.

[2] Mr. Sowerby's figure does not accurately represent the intersculptate ridges of this shell.

Var. **curtispira**, nov. Plate XVIII, fig. 6.

Dimensions.—L. 56 mm. B. 40 mm.

Distribution.—Icenian Crag: Bramerton.

Remarks.—In this form, which I only know from the Icenian or Norwich Crag, the whorls are wound upon each other so closely that only the top of each is exposed; in consequence the spire is short and conical instead of elongate and turreted, as in the Japanese shell last considered, only one of the prominent spiral ribs being shown on each whorl just above the suture; the shell is smaller, moreover, and the canal is shorter.[1] The specimen figured is one of several in the Fitch collection in the Castle Museum at Norwich. Except in the particulars noticed above it nearly agrees with Mr. Sowerby's species, and may be regarded with it, I think, as a variety of *N. despecta.*

Var. **subspitzbergensis,** nov. Plate XIX, figs. 4—6.

1855. Cf. *Fusus spitzbergensis,* Reeve, in Belcher's Last of the Arctic Voyages, vol. ii, p. 395, pl. xxxii, fig. 6.

1910. Cf. *Neptunea despecta,* var. φyen, Kongl. Norske Videns. Selsk. Skrift., vol. ix, p. 83, pl. i, fig. 2.

Dimensions.—L. 28—42 mm. B. 14—20 mm.

Distribution.—Not recorded living.

Fossil: Waltonian Crag: Little Oakley. Butleyan: Butley. Pleistocene: Trondhjem (?).

Remarks.—I have several small Neptuneas as to the identification of which I have been long in doubt. Two of them (Pl. XIX, figs. 5, 6) are from Oakley, and are probably immature; another from Butley, belonging to the Sedgwick Museum at Cambridge (fig. 4) may be full grown. They appear to be different from anything hitherto reported from the Crag, and except for a small shell from the Pleistocene deposits of Trondhjem described by Dr. Øyen as a variety of *N. despecta,* which he thinks may be the same, are unknown to my Scandinavian friends.

The sculpture is of a special character, closely resembling that of *N. spitzbergensis.* Submitting photographs of my specimens to Dr. Dall he informs me that he can suggest nothing else to which they can be referred, remarking that out of a number of examples of that species there are usually some which vary in the direction of these Crag fossils. Comparing the latter with Reeve's type shell in the British Museum, however, I am inclined to think that although they belong to the

[1] The canal in the Crag Neptuneas is often shorter than in the Recent species to which they are referred.

spitzbergensis group, they are not sufficiently close to be referred to that species without doubt. Under the circumstances it seems better to follow Dr. Øyen in regarding them as a variety of *N. despecta*.

N. spitzbergensis is a circumpolar form, ranging from Spitzbergen to the Behring Sea.

Neptunea antiqua (Linné).

1758. *Murex antiquus*, Linné, Syst. Nat., ed. x, p. 754, no. 487.
1848. *Trophon antiquum*, S. V. Wood, Mon. Crag Moll., pt. i, p. 44.
1853. *Fusus antiquus*, Forbes and Hanley, Brit. Moll., vol. iii, p. 423, pl. civ, figs. 1, 2.
1867. *Fusus antiquus*, Jeffreys, Brit. Conch., vol. iv, p. 323, pl. lxxxv, fig. 1.
1912. *Neptunea antiqua*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 68, pl. i, fig. 8.

Specific Characters.—See auctt.

Dimensions.—L. 90—180 mm. B. 35—105 mm.

Distribution.—*Recent:* east and west coasts of Great Britain from Cornwall to Shetland (coralline and laminarian zones and deep water), rare in the English Channel. Ireland: from Bantry Bay to Dublin and the North Channel. Sweden: Bohuslan. Norway: south-west coast. France: Boulonnais; west coast to Arcachon (Lafonte).

Remarks.—This shell is generally regarded by Scandinavian conchologists as distinct from *N. despecta*, the term *antiqua* being confined to the well-known British species, which in its typical form has an elongate spire and inconspicuous spiral sculpture; the strongly carinated forms, usually shorter in the spire, wider in proportion to the length, and specially characteristic of northern seas, being grouped as varieties of *N. despecta*.

MM. Dautzenberg and Fischer have recently expressed the opinion (*op. cit.*, p. 76) that all these dextral Neptuneas, carinated or otherwise, should be regarded as varieties of *N. antiqua*; their relation to the various horizons of the Crag, both of England and Belgium, show, however, that *N. despecta* was the first to appear in the Anglo-Belgian basin, suggesting that possibly *N. antiqua* may have been an offshoot from it.

Var. **typica**. Plate XIX, fig. 1.

Dimensions.—(Of Crag specimen). L. 65 mm. B. 35 mm.

Remarks.—The fossil here figured nearly represents the typical sculpture of *N. antiqua*, corresponding with Recent specimens in my collection from the North Sea and from Bohuslan on the west coast of Sweden, except that it is smaller. It was found at Newbourn and belongs to the Sedgwick Museum at Cambridge. So far as I know, this form is very rare in the Crag, even in the later zones, the characteristic variety of those deposits being the var. *striata*, dealt with below, which, however, attains a much larger size, especially at the Icenian horizon.

Var. **striata**, S. V. Wood. Plate XIX, figs. 7—10.

1848. *Trophon antiquum*, var. *striatum*, S. V. Wood, Mon. Crag Moll., pt. i, p. 44, tab. v, fig. 1 c.
1867. *Fusus antiquus*, var. *striata*, Jeffreys, Brit. Conch., vol. iv, p. 324.
1912. *Neptunea antiqua*, subsp. *striata*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 77, pl. i, fig. 9.

Distribution.—Recent: south and south-east of Ireland, Dublin Bay, the Hebrides, Shetland (Jeffreys); Finmark.

Fossil: Newbournian Crag: Sutton. Butleyan: Hollesley, Butley. Icenian: *passim*. Pleistocene: Kelsey Hill, and elsewhere; Uddevalla (Jeffreys).

Dimensions.—L. 90 mm. B. 48 mm.

Remarks.—The term *striata* was first used in 1848 for a variety of *N. antiqua* by S. V. Wood, whose figure (*op. cit.*, pl. v, fig. 1*c*), copied probably from a worn specimen, was no doubt intended to represent the usual Icenian form of that species. Afterwards Jeffreys (*op. cit.*, p. 324) included under the same name shells having "spiral striæ stronger (than the type), two on each of the upper whorls forming prominent ridges." MM. Dautzenberg and Fischer have recently figured an example from Finmark as var. *striata* (*op. cit.*, pl. i, fig. 9), and another as var. *Browni* (pl. ii, fig. 1) both of which answer to the above description, but those from the Crag are nearer to the second than to the first. It is the variety of *N. antiqua* given on my Pl. XIX, fig. 8, and not the finely striated form of British seas or the var. *striata* of Jeffreys, which is characteristic of the English Crag.

It may be interesting to point out that the sculpture of the present variety, specially distinctive of the Icenian or latest zone of the Crag, resembles more nearly that of *N. contraria* of the Waltonian deposits, the earliest horizon of the Red Crag, than it does that of the prevalent forms of *N. despecta* which are the predominant fossils of the Newbournian or intermediate section of these deposits.

If *N. despecta* is older than *N. antiqua*, a view to which the evidence seems to point, this may represent a curious instance of reversion to an older type.

Var. **subtornata,** nov. Plate XIX, figs. 2, 3.

Varietal Characters.—Shell strong, rather small, turreted, fusiform, without any distinct keel; whorls 7, convex, regularly diminishing in size, the last three-fourths the total length; ornamented by strong, numerous, well-marked spiral costæ with finer ones in the interspaces which are inconspicuous on the upper whorls but more prominent on the last; spire rather long, ending in a blunt, submammiform apex; suture deep; mouth oval; outer lip thin, somewhat expanded; inner lip forming a thin glaze, adherent to the pillar; canal short, wide and open.

Dimensions.—(Of Crag shell.) L. 60 mm. B. 30 mm.

Distribution.—Butleyan Crag: Butley. Icenian: Thorpe near Norwich. Unknown from older horizons of the Crag.

Remarks.—The Butley fossils here figured are from the Sedgwick Museum at Cambridge, and there is a similar specimen from the Icenian Crag of Thorpe in the Fitch collection at the Norwich Museum. In form they agree with the *antiqua* group though the sculpture is different from any variety of that species known to me; they seem full-grown, belonging perhaps to some smaller shell like that figured by Prof. Leche as *N. tornata*[1] which is not unlike our own except that the spiral ribs of the latter are more numerous; they differ too widely, however, from the type of that species to be identified satisfactorily with it. I describe them therefore provisionally as a variety of *N. antiqua*; they seem to be one of the intermediate forms which connect it with *N. despecta*. None of my Scandinavian correspondents know this form from polar seas. It differs from the strongly ribbed varieties of the latter before described in the absence of a distinct keel.

Var. **icenica**, nov. Plate XIX, fig. 11.

Dimensions.—L. 55 mm. B. 27 mm.

Distribution.—*Fossil:* Icenian Crag: Dunwich, Easton Bavent.

Remarks.—This very graceful variety, which differs from the type in its slender form and narrow aperture, is unknown to me from any other than the Icenian zone. The shell here represented is from my own collection. It may possibly be related to Jeffreys' unfigured variety *gracilis* (Brit. Conch., vol. iv, p. 325), but I have not seen his specimen. Mr. Robson informs me, however, that there is nothing like it in the British Museum.

Summarising the facts given above it appears that the various forms of *Neptunea* found in the East Anglian Pliocene have a zonal value, although this has been generally overlooked. The oldest part of the Red Crag, that of Walton-on-Naze, contains practically nothing but the different varieties of the sinistral species *N. contraria*. Dextral shells, widely different from the latter, appear at Little Oakley in what I regard as an upper part of the Waltonian, but they are vastly outnumbered by the former, becoming somewhat more abundant in the later beds of the Red Crag; it is *N. despecta* and its varieties, however, that are the

[1] K. Svensk. Vet. Akad. Handl. Stockholm (n.s.), vol. xvi [2], p. 67, pl. ii, fig. 28 *a*, 28 *b*, 1878.

predominant dextral forms of the various zones of that formation, the typical *N. antiqua* being exceedingly rare. At the Icenian stage *N. contraria* had well-nigh disappeared; *N. despecta* occurs there, but not very abundantly, while *N. antiqua*, var. *striata*, becomes one of its characteristic fossils. The typical Recent and finely striated form of *N. antiqua* is a Pleistocene rather than a Pliocene shell.

The fossil evidence shows, however, that in Crag times these two dextral groups were closely allied. We find occasionally specimens as to which it is not easy to decide whether they are a *despecta*-like variety of *N. antiqua*, or an *antiqua*-like variety of *N. despecta*; the one represented in Pl. XVII, fig. 2, agrees with the latter in form, but has fine spiral sculpture; on the other hand we occasionally meet with shells having the strong ribs of *N. despecta* with a somewhat more elongate spire.

The history of these shells may illustrate the origin, distribution and local extinction of species. Such specimens as that of *N. despecta* var. *intermedia* with *despecta*-like form and *antiqua*-like sculpture, may have been gradually modified in the direction of the finely striated *N. antiqua* of British seas, while the coarsely ribbed varieties, no longer known as British shells, have survived on the coasts of Massachusetts as *N. decemcostata*, in the North Pacific as *N. intersculpta*, or in Scandinavian and circumpolar regions as different varieties of *N. despecta*.

There must have been a time in the history of mollusca which originated as varieties when, intermediate forms having disappeared, they became entitled to specific rank. Whatever may have been the case originally, however, it seems to me that these two groups are at present distinct, and that it is desirable to retain the nomenclature so long and so generally adopted, especially in view of the fact that at present the one is British and Scandinavian, the other Scandinavian and Arctic.

Neptunea ventricosa (Gray). Plate XXIII, fig. 20.

1839. *Fusus ventricosus*, Gray, Zool. Beech. Voy., p. 117.
1841–70. *Fusus ventricosus*, Gould, Rep. Inv. Mass., ed. 1, p. 285, fig. 200, 1841; ed. 2, p. 373, fig. 640, 1870.
1843. *Fusus ventricosus*, De Kay, Nat. Hist. New York, p. 144, pl. viii, fig. 183.
1872. *Trophon ventricosus*, S. V. Wood, Mon. Crag Moll., 1st Suppl., p. 22, tab. iii, fig. 4.
1880. *Fusus ventricosus*, G. B. Sowerby, Thes. Conch., vol. iv (*Fusus*), p. 93, pl. ix, fig. 98.
1881. *Neptunea* (*Sipho*) *ventricosa*, Kobelt, Martini und Chemnitz, Conch. Cab.. ed. 2, vol. iii (Purpuraceæ), p. 78, vol. xxv, fig. 6.

Specific Characters.—Shell ovate, rather thin; whorls convex, rapidly tapering, the last ventricose, much the largest, forming four-fifths of the total length; ornamented by fine, rather irregular spiral ridges, with spaces between them of equal width; spire very short; mouth ovate, angulate above, more than half the length of the shell; outer lip expanded; canal short, turning to the left.

Dimensions.—L. 50 mm. B. 28 mm.

Distribution.—*Recent:* Behring Sea, Banks of Newfoundland.

Fossil: Waltonian Crag: Little Oakley. Newbournian: Felixstow. Butleyan: Butley.

Pleistocene: Bridlington.

Remarks.—This species has not hitherto been noticed in the Crag, though Wood figured a Bridlington shell which he referred to it with some doubt. There is a specimen of what seems the same from Butley, and another from the Newbournian Crag of Felixstow in the Wood collection at the Norwich Museum. I have found a third, imperfect, at Oakley. The two last correspond with Wood's figure, and with a Recent shell in the British Museum, the Butley specimen resembling more nearly Gould's drawing of the American form except that the spire is somewhat longer and the spiral striæ more prominent. Gould reports this species from the Newfoundland fishing grounds, but I am not aware that it now lives on this side of the Atlantic. It furnishes another instance of the connection between the Crag fauna and that of the coasts of North America at the present day.

Neptunea castanea (Mörch). Plate XVIII, fig. 7.

1857. *Fusus (Volutopsius) castaneus*, Mörch, Vid. Medd. Naturh. Foren. Kjöb., p. 341.
1858. *Neptunea castanea*, Dunker, Nov. Conch., p. 7, pl. ii, figs. 1, 2 (*N. badia* in plate).
1880. *Fusus castaneus*, G. B. Sowerby, Thes. Conch., vol. iv (*Fusus*), p. 90, pl. xi, fig. 128.
1881. *Neptunea castanea*, Kobelt, Martini und Chemnitz, Conch. Cab., ed. 2, pt. iii (Purpuraceæ), p. 60, pl. ix, figs. 4, 5.

Specific Characters.—Shell ovato-fusiform, thick and strong; whorls 6, but slightly convex, regularly tapering, the last two-thirds the total length; apex obtuse; suture well-marked but not deep; ornamented by fine spiral lines, closely crowded together, and by flexuous and irregular lines of growth; mouth large, oval, angulate above, more than half the length of the shell; columella but little excavated; outer lip regularly curved, not expanded; inner lip forming a thin glaze upon the pillar; canal short, open.

Dimensions.—L. 85 mm. B. 45 mm.

Distribution.—*Recent:* west coast of North America: Sitka, Alaska, Siberia.

Fossil: Newbournian Crag: Felixstow.

Remarks.—I have one or two specimens from Felixstow, which closely correspond with the figures of *N. castanea* given by the authors quoted above, and with some Recent shells in the British Museum (Natural History). They differ from anything else known to me from the Crag deposits, and may be referred, I think, to the species named, which seems confined at present to Siberia and the Pacific coasts of North America; were it not, however, that so many of our Pliocene North Sea mollusca are closely related to those now living in the North Pacific, the present shell might have been regarded, perhaps, as an abnormal variety of *N. antiqua*.

Neptunea ignota, sp. nov. Plate XXIV, fig. 16.

Specific Characters.—Shell ovato-fusiform, coarse, thick and strong; whorls convex, the last five-sixths the total length; ornamented by rather strong spiral ribs with finer ones in the interspaces, and by numerous rough, close-set lines of growth; suture deep; mouth oval, angulate above; outer lip regularly curved, not expanded, ending in a very short, wide and open canal.

Dimensions.—L. 68 mm. B. 34 mm.

Distribution.—*Fossil:* Icenian Crag: Postwick, near Norwich.

Remarks.—The shell figured under the above provisional name is from the Castle Museum at Norwich, having been found many years ago in a section which once yielded some interesting fossils but is unfortunately no longer available.

It appears to belong to the *N. castanea* group, and in form approaches some of the mollusca from Alaska described by Dr. Dall.

I thought at first it might have been a misshapen specimen of *N. antiqua*, but it differs materially in its general character from any variety of that species I have met with, either Recent or fossil. I think it deserves notice.

Genus **FUSUS,** Klein, 1753.

Fusus longiroster (Brocchi). Plate XIV, fig. 23.

1814. *Murex longiroster*, Brocchi, Conch. foss. subap., p. 418, pl. viii, fig. 7.
1836–44. *Fusus longiroster*, Philippi, En. Moll. Sic., vol. i, p. 205, 1836; vol. ii, p. 179, 1844.
1872. *Fusus longiroster*, Bellardi, Moll. Terr. Terz. Piem., pt. i, p. 132.
1875. *Fusus longiroster*, Seguenza, Boll. R. Com. Geol. Ital., vol. vi, p. 282.
1879. *Fusus longiroster*, Fontannes, Moll. Plioc. Vall. Rhone, vol. i, p. 14, pl. ii, fig. 9.
1901. *Fusus longiroster*, Cossmann, Ess. Paléoconch. comp., vol. iv, p. 10, pl. i, fig. 7.
1903. *Fusus longiroster*, Lamplugh, Mem. Geol. Surv., Isle of Man, p. 475, fig. lxxxv, p. 336.
1904. *Fusus longiroster*, Sacco, Moll. Terr. Terz. Piem., pt. xxx, p. 24, pl. vii, figs. 5, 6.

Specific Characters.—Shell strong, fusiform, turreted; whorls convex, subangular above, with a slightly concave shelf below the suture, the last whorl excavated below; ornamented by nine to twelve strong, rounded, longitudinal ribs, which die out towards the base of the shell, and by wavy spiral ridges of unequal size, which become strongly oblique at the back of the canal; suture deep; spire elongate, regularly diminishing in size; mouth oval, contracted below; canal long, straight, subtubular.

Dimensions.—L. 70—90 mm. B. 24—27 mm.

Distribution.—Not known living.

Fossil: Cranstal Point, Isle of Man. Lower Pliocene: northern Italy; Rhone Valley. Upper Pliocene: Sicily.

Remarks.—This is one of the group of fossils found by the Rev. S. N. Harrison in the glacial drift of the Isle of Man, which point to the former existence in the basin of the Irish Sea of deposits of pre-Pleistocene age.

It was reported by Bellardi in 1872 from deposits at Albenga and elsewhere, then thought to be Upper Miocene, but now regarded by Prof. Sacco and others as Lower Pliocene (Piacentino). The Miocene shell described by Hörnes as *F. longirostris* was considered by Bellardi a different species.

The specimen here figured is from Jermyn Street. Mr. A. Bell has recently received another, imperfect, from the Rev. S. N. Harrison. Both of them were obtained at Cranstal.

Fusus lamellosus, Borson. Plate XIV, fig. 24.

1821. *Fusus lamellosus*, Borson, Mem. Accad. Tor., vol. xxvi, p. 317, pl. i, fig. 14.
1856. *Fusus lamellosus*, Hörnes, Foss. Moll. Tert. Wien, vol. i, p. 289, pl. xxxi, fig. 16.
1872. *Fusus lamellosus*, Bellardi, Moll. Terr. Terz. Piem., pt. i, p. 142, pl. ix, fig. 17.
1874–75. *Fusus lamellosus*, Seguenza, Boll. R. Com. Geol. Ital., vol. v, p. 278, 1874; vol. vi, p. 282, 1875.
1890. *Fusus lamellosus*, C. Reid, Plioc. Dep. Brit., p. 245.
1904. *Fusus lamellosus*, Sacco, Moll. Terr. Terz. Piem., pt. xxx, p. 26.

Specific Characters.—Shell turreted, elongate; apex acute; whorls short, decidedly convex, with eight or nine prominent longitudinal costæ, and numerous fine wavy spiral ridges; body-whorl excavated, less than half the total length; suture deep; mouth oval, ending in a straight, narrow and rather short canal.

Dimensions.—L. 20—30 mm. B. 10 mm.

Distribution.—Not known living.

Fossil: Pliocene: Lenham. Coralline Crag (unique). Miocene: Vienna basin, Italy. Pliocene: Albenga. Upper Pliocene and Pleistocene of Sicily: Oliveri, Altavilla, Orciano, and elsewhere.

Remarks.—This species, characteristic of the Miocene and Pliocene deposits of the Continent, which occurs also, according to Seguenza, with *Cyprina islandica* and other northern forms in beds probably equivalent to the Pleistocene or Upper

Pliocene of northern Europe, has been found by Mr. Clement Reid at Lenham; there is also a specimen from the Coralline Crag in the Jermyn Street Museum, which by the courtesy of the Director of the Geological Survey is here figured.

F. lamellosus, Philippi (En. Moll. Sic., vol. i, p. 204, pl. xi, fig. 30), is a different species. Bellardi reported this shell from the Upper Miocene of Italy, but Prof. Sacco says this was a mistake.

Genus SIPHO, Klein, 1753.

Sipho gracilis (Da Costa). Plate XX, figs. 3, 4.

1777. *Murex corneus*, Pennant, Brit. Zool., vol. iv, p. 124, pl. lxxvi, fig. 99.
1778. *Buccinum gracile*, Da Costa, Brit. Conch., p. 124, tab. vi, fig. 5.
1853. *Fusus islandicus*, Forbes and Hanley, Brit. Moll., vol. iii, p. 416, pl. ciii, fig. 1.
1867. *Fusus gracilis*, Jeffreys, Brit. Conch., vol. iv, p. 335, pl. lxxxvi, fig. 2.
1890. *Neptunea gracilis*, Carus, Prod. faun. Medit., vol. ii, p. 400.
1902. *Tritonofusus*[1] *gracilis*, Conch. Soc. Gt. Brit., List of Brit. Mar. Moll., p. 15.
1912. *Sipho gracilis*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 82, pl. iii, figs. 3—5.

Specific Characters.—Shell solid, turreted, regularly tapering; whorls but slightly convex, the last about two-thirds the total length; ornamented by spiral ridges which extend to the suture; apex twisted, irregularly mammiform but not bulbous; suture slight; mouth oblong, oval, angulate above; canal rather short, open, turning more or less to the left, with an obliquely curved notch; outer lip thin, rounded, not contracted or incurved above; inner lip forming a glaze upon the pillar; pillar curved, angulated at the commencement of the canal.

Dimensions.—L. 75 mm. B. 30 mm.

Distribution.—*Recent*: British Seas, rare on the southern coasts; Iceland, Faroe Islands (Mörch); south-western coasts of Norway (Sars); Sweden; Cattegat; north-west coasts of France. Mediterranean, Gulf of Lyons (Kobelt).

Fossil: Coralline Crag: Boyton. Waltonian: Little Oakley. Newbournian. Butleyan. Icenian. Isle of Man. Wexford Gravels. Pleistocene: Bridlington, Kelsey Hill, Moel Tryfaen. Estuary Clays: N.E. Ireland, Belfast, Howth; Dalmuir, Girvan, Lewis.

Remarks.—The classification and nomenclature of the various species of *Sipho* found in the English and Belgian Crag is a matter upon which there is much difference of opinion. Taken by themselves the study of these forms is no easy

[1] The term *Tritonofusus* is now adopted in place of *Sipho* by the Conchological Society and some other authorities.

task, nor is it lessened when we include that of those still existing in northern seas. Much information on the subject has been published during recent years, however, and specimens for comparison are more easily obtained than formerly. The large number of such fossils I have collected at Little Oakley makes the investigation of the subject not only specially interesting, but very perplexing, one difficulty being that even where these shells may be referred to existing species, they are not always identical with them. This, however, is not surprising; the Pliocene mollusca are separated from those of the present day by a period which, though geologically unimportant, is, when measured in years, of great length, and much variation may have taken place in the interval. Unfortunately, many of the Crag mollusca, where they differ from the Recent shells to which they are affiliated, have to be regarded as varieties of the latter, which is like "putting the cart before the horse." Obviously variation must have been a departure, not from the newer, but from an older type.

It seems probable that among the Pliocene Siphos of the Anglo-Belgian basin there are a number of incipient species which had not long diverged from some common ancestral type.[1] A portion of these survive unaltered in British or Scandinavian seas or in the depths of the ocean, while others have altogether disappeared.

In 1848, Wood described some fossils (Mon. Crag Moll., pt. i, p. 46, tab. vi, fig. 10) under the name of *Trophon gracile.* In the British Conchology (vol. iv, p. 336) Jeffreys expressed the opinion that none of them were identical with that species, considering they agreed rather with a North American form, which he said was smaller and more tumid, with a shorter spire, suggesting for the Crag fossils the name of *Fusus curtus.* The latter species was never described or figured, but as Jeffreys stated in his list, published in Prestwich's well-known paper of 1871, that the shells called by Wood *T. gracile* occurred in the Red Crag "*passim*," there can be little doubt it included the group so common in those deposits which I have described in the sequel under that somewhat inappropriate name.[2]

In 1879, in his 2nd Supplement (p. 7), Wood agreed that the shells figured in 1848 were not *S. gracilis*, referring two of them (figs. 10 *a* and 10 *c*) to *Fusus* (*Sipho*) *Olavii*, Mörch, and a third (10 *b*) to *S. tortuosus*, Reeve. *S. Olavii* was insufficiently described by Mörch in the Geological Magazine for 1871 (vol. viii, p. 396), but not figured. It appears, however, to be a different shell (see p. 193).

[1] Mr. Bell informs me there are boxstones (older Pliocene) in the Ipswich Museum and elsewhere containing several distinct forms of *Sipho* (see also Journ. Ipswich Field Club, vol. iii, p. 8, 1911).

[2] Verkrüzen supposes that Jeffreys' *S. curtus* was *Fusus striatus*, Reeve (Jahrb. Deutsch. Malak. Gesellsch., 1881, p. 8). The use of the word "*passim*," however, is antagonistic to that view, as I know of nothing occurring abundantly in the Crag that can be referred to the latter species. *S. striatus* is, moreover, a very different shell.

The Recent form now recognised as *S. tortuosus*, Reeve, moreover, differs materially from some of the fossils described by Wood under that name.

In 1882 Nyst still used the name *F. gracilis* for specimens similar to those described by Wood which occur in the Scaldisien deposits of Belgium (Conch. Terr. Tert. Belg., p. 15), and it is even now generally employed in this country for such shells.

Although, following Mr. Friele, I regard many of our Crag Siphos as belonging to Jeffreys' species, *S. curtus*, there are specimens in these deposits which I think, as does Mr. Friele, should be referred to *S. gracilis* and its varieties. One of these (Pl. XX, fig. 4) may be regarded as the typical Crag form of that species; it is somewhat more slender, however, than the Recent North Sea shell.[1] Prof. Kobelt figures a more elongate specimen (see below) which approaches my fig. 7.

Var. **Coulsoni**, Jordan. Plate XX, figs. 5, 6.

1890. *Sipho gracilis*, var. *Coulsoni*, Jordan, Journ. of Conch., vol. vi, p. 232.

Dimensions.—L. 50 mm. B. 20 mm.

Distribution.—*Recent:* Unst, in 60—90 fathoms.

Fossil: Waltonian Crag: Little Oakley.

Remarks.—The imperfect Crag shell represented under this name is from Oakley. It is smaller, more slender and more delicate than the type, corresponding very nearly with a Recent specimen from Mr. de B. Tomlin's collection which I have figured with it. I have noticed a similar form, Recent, in the Zoological Museum at Stockholm.

Var. **elongata**, nov. Plate XX, fig. 7.

1876. *Sipho gracilis*, Kobelt, Jahrb. Deutsch. Malak. Gesellsch., vol. iii, p. 165, pl. iv, fig. 1.
1887. *Neptunea gracilis*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 72, pl. xiii, fig. 4.

Dimensions.—L. 60 mm. B. 24 mm.

Distribution.—*Fossil*: Coralline Crag: Boyton.

Remarks.—The fossil figured under this name, which was found at Boyton, resembles Mr. Tomlin's specimen of var. *Coulsoni* in form and in its spiral sculpture, but differs from it in being larger, somewhat less slender, and in its more elongate spire. It corresponds more or less nearly with some specimens in my

[1] The wider British form of *S. gracilis* does not occur at Oakley, and is not known to me from other horizons of the Crag.

collection of the variety *convoluta* described below, but the spiral sculpture is much finer, and the whorls are less convex.

Var. **convoluta**, Jeffreys. Plate XXV, figs. 6, 7.

1867. *Fusus gracilis*, var. *convoluta*, Jeffreys, Brit. Conch., vol. iii, p. 336.
1890. *Sipho gracilis*, var. *convoluta*, Jordan, Journ. of Conch., vol. vi, p. 232.

Dimensions.—L. 75—85 mm. B. 30—32 mm.

Distribution.—*Recent :* British seas, not common.

Fossil : Newbournian Crag : Waldringfield.

Remarks.—Jeffreys states that this variety is smaller, narrower, somewhat cylindrical and more solid, with a longer spire than the type, having sharper ridges, a deeper suture and a mouth proportionately smaller. I have an imperfect shell from Waldringfield which, except as to its size, agrees with this description, as it does with a Recent example from Brora which Mr. de B. Tomlin has been kind enough to send me. They are not unlike one of the varieties of *S. curtus* described below, and may tend to connect the latter species with *S. gracilis.* I propose to figure the specimens of the present variety, both Recent and fossil, in Pl. XXV of this Memoir.

Sipho curtus (Jeffreys). Plate XXI, figs. 1—8.

1843. *Fusus corneus*, Nyst, Coq. foss. Terr. Tert. Belg., p. 500, pl. xxxix, fig. 23.
1848. *Trophon gracile*, S. V. Wood, Mon. Crag Moll., pt. i, p. 46, tab. vi, fig. 10.
1864. *Fusus gracilis*, S. P. Woodward, in White's History of Norfolk, 3rd ed., p. 117.
1867. *Fusus curtus*, Jeffreys, Brit. Conch., vol. iv, p. 336.
1871. *Fusus curtus*, Jeffreys, in Prestwich, Quart. Journ. Geol. Soc., vol. xxvii, p. 492.
1881. *Fusus gracilis*, Nyst, Conch. Terr. Tert. Belg., p. 15, pl. i, fig. 10.

Specific Characters.—Shell fusiform, solid; whorls more or less convex, varying considerably in comparative length and breadth, sometimes compressed below the suture; ornamented by rather fine and generally inconspicuous spiral striæ, crossed by the curved lines of growth which become more distinct on the body-whorl; apex neither bulbous nor planorboid; suture well-marked, channelled; mouth oblong, oval, angulate above; inner lip forming in some varieties a thin glaze upon the pillar, while in others it is thicker and less closely adherent to it: canal varying greatly in length, usually turning, often sharply, to the left, ending in an oblique notch.

Dimensions.—L. 50—70 mm. B. 20—30 mm.

Distribution.—*Fossil :* Red Crag, *passim*, not rare at Little Oakley. Scaldisien and Poederlien of Belgium.

Remarks.—It is clear that Jeffreys was familiar with the specimens figured by Wood in 1848 as *S. gracilis.*[1] At the same time he seems to have had in mind some of the smaller Crag fossils, as his remark that those he called *Fusus curtus* were smaller than *S. gracilis*, having a short spire, does not seem descriptive of all those which I consider to be varieties of the former.

Mr. Friele has identified with *S. curtus* some shells more or less nearly allied to *S. togatus* (grouping the latter and several other species under the former name) which were dredged by the Norwegian North Atlantic Expedition at a number of places off the coasts of Norway, Finland and Spitzbergen, at depths of from 60 to 658 fathoms. Of these he figures six, varying considerably *inter se*, but only within certain limits; some of them occur in the Crag, but very rarely. As a rule, the shells to which I propose to confine the term *S. curtus* are, on the contrary, common in our East Anglian deposits and differ widely from them. Of these I may mention the variety *incurvata* (Pl. XXI, fig. 6), a strong shell with a rather long canal, turning abruptly and decidedly to the left; it corresponds more or less nearly with Wood's *Trophon gracile* (tab. vi, fig. 10*a*, 1848), and is fairly common at Oakley and at other horizons of the Red Crag; this, with Pl. XXI, fig. 1 of the present memoir, which may perhaps be regarded as the type, and a third, var. *solida* (fig. 3), are thick and coarse-looking; the latter approaches some Recent specimens of *S. gracilis* var. *convoluta* in my collection, but may be referred more appropriately, I think, to the present species. A second group of a somewhat similar character, on the contrary, have a smooth and polished appearance, including var. *lata* (fig. 7), var. *brevicaudata* (fig. 4), var. *exilis* (fig. 8), and one, var. *longicaudata* (fig. 5), with a shorter spire and an exceptionally long canal which I have been tempted to regard as specifically distinct.

All these shells are more or less allied, having certain features in common; they are strong and solid, sometimes very much so, their sculpture is generally inconspicuous, the whorls are convex, and the canal turns decidedly to the left.

In the specimens figured by Mr. Friele under the present name the canal is nearly straight, the sculpture is stronger, and the texture of the shell thin and fragile. The latter feature may possibly be due to the different conditions under which they lived. It should be noted, however, that we find other species of *Sipho* at Oakley and elsewhere in the Red Crag of a thin and fragile character.

Among the species grouped by Mr. Friele as *S. curtus* he includes, as just stated, some having strong spiral sculpture, as, *e.g.*, *Fusus togatus*, Mörch, and *Buccinum Sabinii*, Gray, which have been considered by other conchologists as distinct. Such shells, however, together with *S. cordatus*, A. Bell, when occurring in the Crag, are easily separated from the various varieties of *S. curtus* just described. The latter form by themselves rather an unwieldy group; it seems to me desirable,

[1] See Brit. Conch., vol. i, Introduction, p. xc, 1862.

therefore, if only for convenience of classification, to keep the strongly sculptured shells separate.[1]

The specimen figured by Nyst in 1843 (*op. cit.*) as *Fusus corneus*, Linné, is, I consider, the Crag form here described as *S. curtus*. That given by Pennant as *Murex corneus* is *S. gracilis*. Messrs. Dautzenberg and Fischer state (*op. cit.*, p. 85) that Linné's *Murex corneus* is a different species.

Sipho togatus (Mörch). Plate XXII, figs. 1, 2.

1869. *Fusus* (*Siphonorbis*) *togatus*, Mörch, Journ. de Conch., vol. xvii, p. 398.
1879. *Trophon tortuosus*, S. V. Wood, Mon. Crag Moll., 2nd Suppl., p. 7, tab. ii, fig. 2 *a*.
1881. *Fusus togatus*, Kobelt, Martini und Chemnitz, Conch. Cab., ed. 2, pt. iii (Purpuraceæ), pl. xxxvii, fig. 7; pl. xl, figs. 4, 5.
1882–1901. *Neptunea* (*Sipho*) *curta*, var., Friele, Norske Nordh. Exped. (Mollusca), pt. i, p. 14, 1882; pt. iii, p. 104, 1901.
1899. *Sipho togatus*, Posselt, Medd. om Grönl., vol. xxiii, p. 184.
1912. *Sipho togatus*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 91, pl. iii, figs. 12, 13.

Specific Characters.—Shell fusiform, not very solid; whorls decidedly convex, the last two-thirds the total length; ornamented by strong and prominent spiral ribs, which extend to the base of the shell, equal to the spaces between them, and by exceedingly fine lines of growth; suture deep; mouth oval, angulated above, ending in a well-marked canal which turns slightly to the left; outer lip thin, regularly curved; inner lip forming a glaze on the pillar; pillar excavated above.

Dimensions.—(Of Crag specimen.) L. 50 mm. B. 23 mm.

Distribution.—*Recent;* circumpolar: Spitzbergen, Baffin's Bay, west Greenland, north-west Atlantic.

Fossil; Waltonian Crag: Walton-on-Naze. Newbournian: Waldringfield. Butleyan: Oak Hill, Sutton, Butley.

Pleistocene deposits (*Yoldia*-clay) of the Christiania region (Øyen), and of Sweden (Mörch).

Remarks.—When examining the Reed Collection in the York Museum I noticed a specimen, one of those here figured, labelled *Fusus* sp., Waldringfield, which differed materially from anything that I had before noticed from the Crag; I subsequently found another in the Jermyn Street Museum, and a third of

[1] I much regret to differ from the nomenclature adopted by Mr. Friele, from whom I have received the most generous assistance, but I cannot help doubting whether the shells figured by him truly represent the special forms for which Jeffreys proposed the term *F. curtus*. That name must have been founded on fossils everywhere and abundantly present in the Red Crag, rather than on those which are so rare that many students of these deposits are unaware of their existence.

the same kind in my own cabinet which I obtained many years ago at Butley. Comparing these with some Pleistocene specimens from Gettinge in Helland that Dr. Øyen had kindly sent me as representing the *S. togatus* of Mörch, I found them to correspond exactly, having on the other hand but little resemblance to the various varieties of the forms I recognise as *S. curtus.* The former are rather fragile, and strongly sculptured; the latter are strong and solid with sculpture relatively inconspicuous.

S. togatus is now very generally regarded by conchologists as a distinct species, and MM. Dautzenberg and Fischer[1] are retaining the name in their description of the molluscan fauna dredged by the Prince of Monaco; it seems clear that in Crag times also the shells here figured under that name differed materially from those which Jeffreys called *S. curtus.*

The *Yoldia*-clay of Gettinge from which the Scandinavian fossil here figured as *S. togatus* (Pl. XXII, fig. 2) was taken, represents in the opinion of Norwegian geologists the melting of the last great Baltic glacier of Prof. James Geikie,[2] and the Mecklenburgian horizon of Germany.

We find in the Crag, although rarely, some distinct forms which, though differing from each other in certain respects, maintain more or less nearly the same general character, especially as to their characteristic sculpture, which is that of the typical *S. togatus.* These may be conveniently grouped with it, I think, as varieties of that species.

Var. **crassa,** nov. Plate XXII, fig. 6.

1882. *Neptunea* (*Sipho*) *curta*, var., Friele, Norske Nordh. Exped. (Mollusca), pt. i, pl. ii, fig. 1.
1887. *Neptunea togata*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 80, pl. xiv, fig. 2.

Dimensions.—L. 65 mm. B. 28 mm.

Distribution.—*Recent :* Polar Seas.

Fossil : Waltonian Crag: Little Oakley.

Remarks.—The specimen figured under this name corresponds with one of Mr. Friele's varieties of *S. curtus.* It appears to belong to the strongly sculptured group of which I take the shell described above as the type.

Prof. Kobelt reproduces Mr. Friele's figure of this variety as *Neptunea togata.*

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[1] The specimens figured by MM. Dautzenberg and Fischer under the present name differ somewhat in sculpture from our Crag shells, although otherwise they agree with them.

[2] Great Ice Age, 3rd ed., p. 614, 1894.

Var. **Frielei**, nov. Plate XXII, figs. 3, 4.

1882. *Neptunea (Sipho) curta*, var., Friele, Norske Nordh. Exped. (Mollusca), pt. i, p. 15, pl. ii, fig. 4.

Dimensions.—L. 45 mm. B. 18 mm.

Distribution.—Recent : Arctic Ocean between North Cape and Bear Island (Station 323, Friele).

Fossil; Waltonian Crag: Little Oakley. Newbournian : Waldringfield.

Remarks.—In its prominent and clearly cut sculpture the Waldringfield shell here figured resembles the typical *S. togatus.* In form it approaches the variety *sinuosa* of Prof. Brøgger, but it is hardly identical with it. Prof. Brøgger's shell, moreover, is considerably larger.

Through the kindness of Mr. Friele I am able to figure a specimen dredged between the North Cape and Bear Island in 223 fathoms which seems the counterpart of our fossil. This form, however, he includes with others in his *curtus* group. It is an interesting and important fact that these different varieties of *S. togatus* were denizens of the North Sea in Pliocene times, and are still found living, apparently unchanged, in circumpolar regions at the present day.

Var. **brevispira**, Brøgger. Plate XXII, fig. 7.

1900-01. *Sipho brevispira*, Brøgger, Norges geol. undersøgelse, vol. xxxi, p. 49, pl. iii, fig. 4.
1913. *Sipho brevispira*, Nordgaard, in Bjorlykke, Norges geol. undersøgelse, vol. lxv, p. 225.

Dimensions.—L. 43 mm. B. 22 mm.

Distribution.—Not known living.

Fossil : Waltonian Crag : Little Oakley.

Pleistocene : Christiania region.

Remarks.—The fossil here given appears to correspond with Prof. Brøgger's figure of *S. brevispira* except that the canal turns slightly to the left, whereas in the latter it is nearly straight. This, however, is a feature which in our Crag shells is subject to variation. *S. brevispira* is regarded by Prof. Brøgger as specifically distinct, in which opinion he has been followed by Dr. Nordmann, but I understand some other Norwegian authorities consider it a variety of *S. togatus*, to which it seems nearly allied. It is very rare in the Crag, and apparently in the Norwegian Pleistocene. Although differing from the type I venture to regard it as a varietal form of the latter species.

Var. **minor**, nov. Plate XXII, figs. 8—10.

Dimensions.—L. 35—38 mm. B. 12—14 mm.

Distribution.—Not known living.

Fossil : Waltonian Crag : Little Oakley. Newbournian : Sutton, Waldringfield, Foxhall, Felixstow. Butleyan : Butley, Sutton.

Remarks.—This small but strong shell may be regarded, I think, as a dwarf and slender variety of *S. togatus*. In form it resembles Prof. G. O. Sars' var. *attenuata* of *S. tortuosus*, but that species has a depressed and regularly spiral apex, belonging to the *Siphonorbis* group of Mörch. In one of the specimens now figured, however (fig. 10), the apex is distinctly bulbous.

The present variety has been found at various localities in the Red Crag, though not abundantly, but I do not know it from the Icenian.

Sipho Sabinii (Gray). Plate XXIII, figs. 1—3.

1824. *Buccinum Sabinii*, Gray, Suppl. to Append. Parry's First Voyage, p. ccxl.

1846. *Fusus Sabini*, Hancock, Ann. Mag. Nat. Hist. [1], vol. xviii, p. 330, pl. v, fig. 10.

1877. *Fusus Sabini*, Jeffreys. Ann. Mag. Nat. Hist. [4], vol. xix, p. 327.

1883. *Fusus Sabini*, Jeffreys, Proc. Zool. Soc., p. 395, pl. xliv, fig. 5.

Specific Characters.—Shell fusiform, not very solid ; whorls 7, less convex than in *S. togatus*, the last about three-fifths the total length ; spire regularly tapering ; ornamented by numerous fine but well-marked spiral lines, equal to the spaces between them, and extending to the base of the shell, crossed by exceedingly fine and numerous lines of growth ; suture fairly deep ; mouth pyriform, slightly notched inside by the impression of the spiral striæ, ending in a narrow canal, nearly straight or turning but slightly to the left ; outer lip thin ; inner lip forming a narrow glaze closely adherent to the pillar, especially to the lower part of it.

Dimensions.—L. 45 mm. B. 20 mm.

Distribution.—*Recent :* North Atlantic, Davis Strait, Baffin's Bay.

Fossil : Waltonian Crag : Little Oakley. Butleyan Crag : Butley. Pleistocene : *Yoldia*-clay, Norway.

Remarks.—The specimen here figured is from the Reed Collection in the York Museum and was found at Butley ; I have obtained half a dozen, somewhat worn, from Oakley, which seem to be the same ; they correspond in form and sculpture with those obtained during 1841 in Davis Strait, figured by Hancock as *Fusus Sabini*, and during the cruise of H.M.S. "Triton" in 1882 between the Hebrides and the Faroe Islands, described by Jeffreys under the same name. Jeffreys states that many living specimens were dredged there from depths of 608 and 640 fathoms.

Wood figured a shell from Bridlington as *Trophon Sabinii*, Hancock, which however he believed to be, as I do, a different species; I give it on p. 199 as *S. exiguus*.

S. Sabinii is one of the shells Mr. Friele included in 1882 in his *curtus* group. It appears, however, that Jeffreys considered it in 1877 and again in 1883 to be distinct from the Crag fossils for which he had originally proposed the latter name.

It differs from *S. togatus* in form, in its finer sculpture, its slighter suture and the less convexity of the whorls.

Prof. Brøgger[1] and Dr. Øyen regard *S. Sabinii*, however, as a variety of *S. togatus*. The latter has kindly sent me from the *Yoldia*-clay of Gettinge a specimen under the latter name which corresponds very nearly with our Crag shells. Although allied, I am disposed to regard the two forms as different species. The specimens I have found at Oakley maintain the same general character; none of them show any sign of approaching what I regard as the typical form of *S. togatus*. In Crag times, as far as our information goes, these shells seem to have been distinct. It is an interesting fact that both should have remained so, unchanged from the Pliocene period to the present day.

Messrs. Dautzenberg and Fischer in their recent work (p. 61), often referred to in this Memoir, remark that it is almost impossible to say what the unfigured *Buccinum Sabinii* of Gray really was. It was originally stated to be ventricose. having five convex whorls, longitudinally rib-striated, finely transversely wrinkled, 18 mm. in length, and 9 mm. in diameter, a description which seems somewhat inapplicable to the present shell. They suggest, indeed, as does Kobelt, that it was *Troschelia* (*Buccinofusus*) *berniciensis*. Our Crag fossils agree at any rate with the shells afterwards and for the first time figured by Hancock and by Jeffreys, which were regarded by them as the type of *S. Sabinii*.

Sipho Herendeenii (Dall). Plate XXII, fig. 11; Plate XXV, figs. 8, 9.

1902. *Tritonofusus* (*Plicifusus*) *Herendeenii*, Dall, Proc. U.S. Nat. Mus., vol. xxiv, p. 527, pl. xxxvi, fig. 10.

Specific Characters.—Shell solid, fusiform, turreted; whorls not so convex as in the typical form of *S. togatus*; ornamented by well-marked and regular spiral ridges, closely crowded together on the upper whorls, divided by a thin medial line on the lower, with fine intermediate lines in places towards the base of the

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[1] The minute shell figured by Prof. Brøgger as *Tritonium Sabinii* (*op. cit.*, pl. xviii, fig. 2) differs from those here given under that name, and may perhaps be a dwarf form of *S. togatus*, as he suggests. Prof. Leche's *S. Sabini* (K. Svensk. Veten. Akad. Handl., vol. xvi, p. 69, pl. i, fig. 23) seems also different.

shell; spire elongate, regularly diminishing in size, ending in a twisted and slightly bulbous but not mammiform apex: suture deep; mouth oval, angulate above; outer lip contracted below; inner lip forming a thin, narrow, well-defined glaze upon the pillar; canal bending slightly to the left; pillar sinuous.

Dimensions.—(Of Crag specimens.) L. 50—55 mm. B. 21 mm.

Distribution.—*Recent:* Behring Sea and the Aleutian Islands, in 50 to 180 fathoms.

Fossil: Waltonian Crag: Little Oakley.

Remarks.—The Crag fossils figured under this name were found at Oakley in 1911. They belong to the *togatus* group, but differ from the typical form of that species in sculpture, in their less concave whorls and nearly straight canal. There is a specimen of *S. Herendeenii* in the British Museum (Pl. XXV, fig. 9), originally obtained from Dr. Dall by Messrs. Sowerby and Fulton, which agrees very nearly with one of my shells (fig. 8); the other (Pl. XXII, fig. 11) is longer in the spire.

Our fossils are rather worn, but the bifid character of some of the spiral costæ and the fine intermediate lines towards the base may be seen in places by the aid of a lens. In view of the fact that at present *S. Herendeenii* is known only from the Behring Sea, I am disposed to agree with Dr. Dall that it should be regarded as specifically distinct. If my identification of the Oakley shells with the latter is correct it affords another link connecting the Crag fauna with that of the North Pacific.

Sipho cordatus (A. Bell). Plate XXII, fig. 5.

1871. *Fusus cordatus*, A. Bell, Ann. Mag. Nat. Hist. [4], vol. vii, p. 355.

Specific Characters.—Shell thick and strong, turreted, fusiform; spire produced, regularly tapering; apex irregularly twisted, but slightly bulbous; whorls somewhat convex, covered with strong spiral costæ which extend nearly to the base of the shell; canal narrow, bending slightly to the left; mouth ovate, angulate above; inner lip forming a thin glaze adherent to the pillar.

Dimensions.—L. 45–50 mm. B. 16–20 mm.

Distribution.—Not known living.

Fossil: Red Crag: all zones, not very common.

Remarks.—Among the Oakley specimens of *Sipho* in my collection are about a score which separate themselves distinctly from the rest by their coarse spiral ornamentation and their general form and appearance. On showing these to Mr. Alfred Bell, he recognised them as an unfigured species described by him in 1871 as *Fusus cordatus*. At that time he was disposed to think Wood's 1848 figure of *Trophon gracilis*, var. β (Mon. Crag Moll., pt. i, tab. vi, fig. 10*b*), was the same, but he now thinks this was an error. The latter specimen was afterwards referred by Wood to *Trophon* (*Sipho*) *tortuosus*, Reeve; I prefer to regard it, however, as one of the varieties of *S. curtus*.

S. cordatus belongs to the *togatus* group, but can be easily distinguished from typical specimens of the latter species, either Recent or fossil. It is a thick and coarse shell with a distinguishing spiral sculpture, apparently a special Crag form confined to those deposits. Neither Mr. Friele nor Dr. Øyen know it as Scandinavian or Arctic.

The specimens now figured have been identified by Mr. Bell.

Sipho Menapiæ[1] (A. Bell). Plate XXIII, figs. 17—19.

1888. *Fusus Menapii*, A. Bell, Rep. Brit. Assoc., 1888 (Bath), p. 135.
1893. *Fusus Menapii*, A. Bell, Proc. Roy. Irish Acad. [2]. vol. iii, p. 623.
1897. Cf. *Neptunia pupoidea*, Locard, Exped. Travaill. et Talism. (Mollusques), vol. i, p. 363, pl. xvii, figs. 26—28.
1908. Cf. *Neptunea* (*Sipho*) *pupoidea*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. iv, p. 150, pl. cxxiii, figs. 4, 5.

Specific Characters.—Shell coarse, very strong and solid, fusiform; whorls 7, but slightly convex, the last three-fifths the total length, excavated below; ornamented by spiral ridges, closely crowded together on the upper whorls, more widely separated on the last, extending to the base of the shell; suture well-marked but not deep; apex blunt, not regularly spiral; mouth oval, angulate above; outer lip regularly curved, inner lip forming a thin glaze on the pillar; canal very short, turning to the left.

Dimensions.—L. 50 mm. B. 22 mm.

Distribution.—Recent: Bay of Biscay (?).

Fossil: Wexford gravels; Isle of Man.

Remarks.—This Irish fossil resembles in some respects the Crag species *S. cordatus*, but it is thicker and more clumsy; I agree with Mr. A. Bell that it should be regarded as specifically distinct from it. It appears to resemble, perhaps more nearly, a shell from the Bay of Biscay described by Locard in 1897 as *Neptunia pupoidea*. Prof. Kobelt reproduces Locard's figure in his recent work (*op. cit.*). I have not seen any specimen of it so can only call attention to the similarity between the two. In any case Mr. Bell's name has priority.

In a paper published in 1869[2] the late Prof. Harkness regarded the Wexford gravels in which it occurs as of Pleistocene age; I prefer to consider them Pliocene, as does Mr. Bell, containing as they do more or less abundantly characteristic Crag shells such as *Neptunea contraria*, *Nassa reticosa*, *Turritella incrassata*, *Melampus*

[1] From Menapia, the ancient name of Waterford.

[2] Geol. Mag., vol. vi, 1869, p. 542.

pyramidalis, and probably *Nucula Cobboldiæ*. A specimen of *S. Menapiæ* has been discovered recently in the Manx beds by the Rev. S. N. Harrison.

Sipho islandicus (Chemnitz). Plate XX, figs. 1, 2.

1780. *Fusus islandicus*, Chemnitz, Conch. Cab., vol. iv, p. 159, tab. cxli, figs. 1312–3.
1867. *Fusus islandicus*, Jeffreys, Brit. Conch., vol. iv, p. 333, pl. lxxxvi, fig. 1.
1878. *Sipho islandicus*, G. O. Sars, Moll. Reg. Arct. Norv., p. 270, pl. xv, fig. 3.
1882. *Neptunea* (*Sipho*) *islandica*, Friele, Norske Nordh. Exped. (Mollusca), pt. i, p. 10, pl. i, figs. 9—12.
1899. *Sipho islandicus*, Posselt, Medd. om Grönl., vol. xxiii, p. 189.
1900-01. *Sipho islandicus*, Brøgger, Norges geol. undersøgelse, vol. xxxi, p. 50, pl. ii, fig. 1.
1912. *Sipho islandicus*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco (Mollusques), vol. xxxvii, p. 87, pl. iii, figs. 8, 9.

Specific Characters.—Shell large, rather thin, elongated, fusiform; spire acutely tapering, ending in a bulbous and generally prominent point; whorls 8 or 9, convex, covered with flattened spiral ridges, the last whorl occupying three-fifths or more of the total length of the shell, attenuated towards the base; suture well defined; mouth oval, angulate above; canal generally long, straight, or turning to the left, semi-tubular, ending in a curved notch; outer lip thin, regularly curved, sometimes contracted above; inner lip smooth and polished, forming a glaze, which becomes thicker towards the base, lining the inner side of the canal; pillar slightly curved and bevelled inwards.

Dimensions.—L. 100—110 mm. B. 36—40 mm.

Distribution.—Recent: Shetland, Wexford coast, between Galway and the Porcupine Bank, Gulf of Gascony; Norwegian seas north of Christiansund; Finmark, Lapland, Faroe Isles, Iceland, Spitzbergen, Nova Zembla, Greenland; Newfoundland (Dautzenberg and Fischer).

Fossil: Waltonian Crag: Little Oakley (very rare); possibly elsewhere in Red Crag. Isle of Man (Kermode).

Pleistocene: Norway.

Remarks.—This form has been confounded by some conchologists with *S. gracilis*, but is now generally considered specifically distinct. I have one large fragment from Oakley, which seems to be of the true *S. islandicus*. It corresponds in sculpture, fragility, and as far as it goes in form, with some Recent specimens I have received from Prof. Nordgaard. Dr. Øyen, when examining my collection, had no hesitation in confirming my identification. With my Oakley fossil I figure a Recent example from Vardö.

Jeffreys states (*op. cit.*, p. 335) that the *Tritonium islandicum* of Lovén is *Fusus* (*Troschelia*) *berniciensis*.

Sipho glaber (Verkrüzen), Kobelt. Plate XXIV, figs. 1, 2.

1876. *Sipho glaber* (Verkrüzen, MS.), Kobelt, Jahrb. Deutsch. Malak. Gesellsch., vol. iii, p. 174, pl. iii, fig. 3.
1877. *Sipho glaber*, Mörch and Poulsen, MS. List in Geological Museum, Copenhagen, no. 14 *b*, (unpublished).
1878. *Sipho glaber*, G. O. Sars, Moll. Reg. Arct. Norv., p. 271, pl. xv, fig. 7.
1880. *Fusus glaber*, G. B. Sowerby, Thes. Conch., vol. iv (*Fusus*), p. 93, pl. xiii, fig. 148.
1887. *Neptunea* (*Sipho*) *glabra*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 73, pl. xiii, fig. 3.
1893. *Sipho gracilis*, var. *glaber*, Norman, Ann. Mag. Nat. Hist. [6], vol. xii, p. 354, pl. xvi, fig. 4.
1899. *Sipho glaber*, Posselt, Medd. om Grönl., vol. xxiii, p. 188.

Specific Characters.—Shell fairly solid, fusiform, pyramidal, regularly tapering; spire more or less elongate, with a bulbous apex; whorls 7–8, nearly flat, the last more than half the total length, abruptly contracted towards the base; suture slight, somewhat oblique; surface smooth, with exceedingly fine and inconspicuous spiral striæ, showing numerous faint and sinuous lines of growth; mouth oval, angulate above; outer lip gently curved, not expanded; inner lip forming a thin glaze closely adherent to the flexuous pillar; canal rather short, turning to the left.

Dimensions.—L. 50—65 mm. B. 25—28 mm.

Distribution.—*Recent:* Finmark, Russian Lapland, Lofoten Islands, Iceland, Greenland.

Fossil: Waltonian Crag: Little Oakley.

Pliocene deposits: Iceland (Mörch).

Remarks.—When examining my Oakley collection Dr. Øyen had no hesitation in identifying one or two specimens with *S. glaber.* Unfortunately, like the majority of our Red Crag Siphos, they have lost their apex, which in this species is bulbous, but otherwise they correspond with some Recent specimens I have received from Dr. Nordmann in form, in the smooth and polished surface of the whorls, their fine and inconspicuous spiral sculpture and their less solid texture, differing in these respects from our Crag specimens of *S. gracilis*, to which they are otherwise not dissimilar.

The late Prof. M. Sars with Mr. Friele and some other Scandinavian conchologists have regarded *S. glaber* as a variety of the latter, but this view is not generally accepted. Possibly now that attention has been called to the matter this species may be found at other horizons of the Red Crag.

S. glaber is a northern species, unknown from the southern coasts of Norway, or from the Christiania fjord. It has been dredged in Lapland and in Greenland at a depth of from 300 to 1300 metres.

Sipho latericeus (Möller). Plate XX, figs. 10—12.

1842. *Fusus latericeus*, Möller, Ind. Moll. Grœnl., p. 15.
1850. *Tritonium incarnatum*, M. Sars, Nyt Mag. Nat., p. 191.
1878. *Sipho latericeus*, G. O. Sars, Moll. Reg. Arct. Norv., p. 276, pl. xv, fig. 8.
1881. *Neptunea latericea*, Kobelt, Martini und Chemnitz, Conch. Cab., ed. 2, pt. iii (Purpuraceæ), p. 120, pl. xl, figs. 7, 8.
1882–1901. *Neptunea* (*Sipho*) *latericea*, Friele, Norske Nordh. Exped. (Mollusca), pt. i, p. 17, pl. ii, figs. 16, 17, 1882; pt. iii, p. 105, 1901.
1899. *Sipho* (*Tritonofusus*) *latericeus*, Posselt, Medd. om Grönl., vol. xxiii, p. 182.
1910. *Sipho latericeus*, Odhner, K. Svensk. Vet. Akad. Handl., vol. vii, p. 14.

Specific Characters.—Shell small, rather thin, fusiform, turreted; spire elongate, gradually tapering; apex blunt, not planorboid; whorls 6 or 7, convex, the last about half the total length; ornamented by fine well-marked spiral striations, and generally with longitudinal plications on the upper whorls, which become fainter and sometimes disappear on the lower ones; suture distinct; mouth oval, angulate above; outer lip thin; columella flexuous; canal short, turning slightly to the left.

Dimensions.—L. 15—25 mm. B. 8—10 mm.

Distribution.—Recent: Finmark, Spitzbergen, Iceland, Greenland, North America, Gulf of St. Lawrence.

Fossil: Waltonian Crag: Little Oakley (rare). Wexford. Shellag (Isle of Man). Pleistocene: Carrickfergus, Belfast; Moel Tryfan; Bridlington.

Pleistocene: Sweden—Uddevalla.

Remarks.—I have a specimen of this northern form from Oakley, quite perfect, corresponding fairly well with some fossils in my collection from Uddevalla, and somewhat less nearly with a Recent shell dredged at 100 fathoms in the Jökelfiord, north of Tromsö, which I have received from Dr. Nordgaard. The Crag fossil does not show the longitudinal plications, nor do some of those from Uddevalla, more nearly resembling the latter than the Recent form, in which the canal is somewhat longer. There is a specimen of this species from Bridlington in the York Museum and another at Jermyn Street, from the Isle of Man.

Sipho latericeus was dredged by the Norwegian Expedition off the coasts of Finmark and Spitzbergen between 20 and 649 fathoms.

Sipho minimus, sp. nov. Plate XXIII, fig. 4.

Specific Characters.—Shell minute, fragile, fusiform; spire elongate, regularly tapering, ending in a small bulbous point; whorls 7, but slightly convex, the last excavated, about two-thirds the total length; spirally striated, the sculpture being most apparent at the base of the shell; suture deep; mouth oval, angulated above; canal short, open, notched.

Dimensions.—L. 14 mm. B. 6 mm.

Distribution.—Coralline Crag: Boyton (probably elsewhere in the Crag).

Remarks.—The charming little shell here figured from the Sedgwick Museum at Cambridge was found at Boyton. It may have been taken at other Crag localities for a young specimen of some larger species. It appears a distinct form, belonging to the same group as *S. latericeus*, though possibly it may be a variety of the latter.

Sipho tortuosus (Reeve). Plate XXIII, figs. 10—13.

1855. *Fusus tortuosus*, Reeve, Belcher's Last Arct. Voy., vol. ii, p. 394, pl. xxxii, fig. 5.
1876. *Sipho tortuosus*, Kobelt, Jahrb. Deutsch. Malak. Gesellsch., vol. iii, p. 72, pl. ii, fig. 2.
1881. *Neptunea tortuosa*, Kobelt, Martini und Chemnitz, Conch. Cab., ed. 2, vol. iii (Purpuraceæ), p. 84, pl. xxvi, fig. 4.
1878. *Sipho tortuosus*, G. O. Sars, Moll. Reg. Arct. Norv., p. 272, pl. xv, fig. 4.
1882. *Neptunea* (*Siphonorbis*) *turrita*, Friele, Norske Nordh. Exped. (Mollusca), pt. i, p. 20, pl. ii, figs. 24—27.
1887. *Neptunea tortuosa*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol i, p. 76, pl. xii, figs. 7, 8.
1912. *Sipho* (*Turrisipho*) *tortuosus*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 98, pl. iv, figs. 1, 2.

Specific Characters.—Shell rather thin, slender, elongate, fusiform; whorls more or less convex, the last rather abruptly contracted towards the base; ornamented with exceedingly fine and regular thread-like spiral lines; apex obtuse, planorboid;[1] suture distinct; mouth ovate, acutely angulate above, ending abruptly in a rather long, narrow, semitubular, and irregularly tortuous or twisted canal; outer lip thin; columella flexuous.

Dimensions.—L. 45 mm. B. 15 mm.

Distribution.—*Recent:* circumpolar: Iceland, Finmark, Lofoten Islands; dredged off the Norwegian coasts from 62° lat. as far north as the Varanger fiord, and near Spitzbergen, from 127 to 649 fathoms (Friele); Russian Lapland, Siberia, Greenland, Alaska.

Fossil: Coralline Crag: Gedgrave. Waltonian: Little Oakley.

Remarks.—A certain amount of confusion exists, among Crag geologists at least, as to the identification of the Crag shells which have been referred to *S. tortuosus*. Dr. Sparre Schneider, however, has kindly sent me a Recent specimen which he considers the type-form of this species. After examining it and those in Prof.

[1] Mörch proposed the term *Siphonorbis* as a sub-genus for *Sipho*-like shells having a depressed or planorboid nucleus; as stated below some authorities doubt whether this distinction can be always relied on.

G. O. Sars' collection at the Museum of Zoology at Christiania, I am compelled to doubt whether the fossils figured by Wood under this name were correctly identified,[1] but I have some in my own collection from Oakley, most of them immature, which more nearly correspond with them.

The typical *S. tortuosus* seems especially characterised by its very fine and regularly chiselled spiral sculpture, and by its long, narrow, twisted and semi-tubular canal; the upper part of the spire, moreover, is sometimes distorted.

In the Crag form of *S. tortuosus* the body-whorl is more tumid than in Dr. Sparre Schneider's specimen, resembling more nearly that figured by Prof. Kobelt in 1887 (*op. cit.*, vol. i, pl. xii, fig. 7).

Var. **turrita**, M. Sars. Plate XXIII, figs. 15, 16.

1858. *Tritonium turritum*, M. Sars, Forh. Vidensk. Selsk. Christ., p. 39.
1881. *Neptunea (Sipho) turrita*, Kobelt, Martini und Chemnitz, Conch. Cab., ed. 2, pt. iii (Purpuraceæ), p. 111, pl. xxxviii, fig. 4.
1882. *Sipho tortuosus*, var. *turrita*, G. O. Sars, Moll. Reg. Arct. Norv., p. 272, pl. xxv, fig. 11.
1910. *Siphonorbis turritus*, Odhner, K. Svensk. Vet. Akad. Handl., vol. vii, p. 14.

Dimensions.—L. 30 mm. B. 12 mm.

Distribution.—*Recent:* Finmark, Iceland.

Fossil: Coralline Crag: Gedgrave.

Remarks.—The fossil here represented (fig. 16) is one I obtained many years ago at Gedgrave, where at that time it was occasionally met with; it may occur rarely at other horizons of the Crag, but I have no note of the fact.

Prof. G. O. Sars figures a specimen under the above name from his father's collection, which corresponds more or less closely in form with our fossil, but is larger. The canal is nearly straight and not distorted, as in the typical form of *S. tortuosus.* He says, however, that the sculpture of this variety is less distinct than in the type; in the Crag specimens, on the contrary, it is somewhat more so. The latter are considerably smaller than that figured by Prof. Sars, but larger than a specimen from the Lofoten Islands (fig. 15), which Dr. Nordgaard was kind enough to send me. The spiral sculpture of the latter is exceedingly fine and delicate, as is that of the Coralline Crag shell. By some authorities this form is regarded as specifically distinct from *S. tortuosus.*

Var. **attenuata**, G. O. Sars. Plate XXIV, figs. 5, 6.

1878. *Sipho tortuosus*, var. *attenuata*, G. O. Sars, Moll. Reg. Arct. Norv., p. 273, pl. xv, fig. 5.
1887. *Neptunea attenuata*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 78, pl. xiv, fig. 12.
1887. *Fusus tortuosus*, var. *attenuata*, Aurivillius, Vega Exped. Vet. Jakt., Stockholm, vol. iv, p. 368.

[1] See Mon. Crag Moll., 2nd Suppl., p. 7, 1879.

Varietal Characters.—The Crag specimens of this variety are stronger and more solid than the type, differing from it also in their more regular form; the canal is shorter, straighter, less semitubular, tortuous or distorted; the spiral sculpture is very fine and generally inconspicuous.

Dimensions.—L. 45 mm. B. 16 mm.

Distribution.—Fossil: Coralline Crag: Boyton. Waltonian: Little Oakley; probably elsewhere in the Red Crag.

Scaldisien: Antwerp.

Remarks.—In 1878 Prof. Sars identified a unique specimen, described the year before by Jeffreys as *Fusus attenuatus* but not figured, with his variety *attenuata* of *S. tortuosus.*[1] In 1883, however, the latter authority expressed his dissent from this,[2] a view which Mr. E. R. Sykes has since supported, having found and figured Jeffreys' original shell.[3]

The fossils here represented have been submitted to Prof. G. O. Sars and identified by him as identical with his variety *attenuata*; they differ materially from the type-form of *S. tortuosus*, and seem to me, as to Prof. Kobelt, to be almost deserving of specific distinction. I agree with Mr. Sykes, however, that our Crag shells are not the *Fusus attenuatus* of Jeffreys.

I have several specimens in my collection of the same form from the Scaldisien of Antwerp.

Var. **lirata**, nov. Pl. XXIV, figs. 11—15.

1879. *Trophon propinquus*, S. V. Wood, Mon. Crag Moll., 2nd Suppl., p. 7, tab. ii, fig. 5.
(?) 1885. *Fusus gracilis*, Lorié, Arch. Mus. Teyler [2], vol. ii, p. 93, pl. v, fig. 26.

Varietal Characters.—Differs from the type in its stronger and clearly chiselled sculpture; the canal is somewhat longer, and neither twisted nor distorted; the spiral lines resemble those of *Sipho Sabinii*, but the shell is smaller, the whorls are less convex and the apex is planorboid.

Dimensions.—L. 36 mm. B. 15 mm.

Distribution.—Fossil: Coralline Crag: Gedgrave, Boyton. Waltonian: Little Oakley. Newbournian. Butleyan. Icenian. Isle of Man.

Poederlien: Antwerp. Amstelien: Holland (?).

Remarks.—This form associates itself with Prof. G. O. Sars' variety *attenuata* rather than with the typical *S. tortuosus.* It is not by any means common in the English Crag, although it ranges from the Coralline to the Icenian horizon. I have specimens in my collection from several localities, and M. van der Wouver has

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1 Ann. Mag. Nat. Hist. [4], vol. xix (1877), p. 326.
2 Proc. Zool. Soc., 1883, p. 395.
3 Proc. Malac. Soc., vol. ix (1911), fig., p. 337.

obtained many from the Poederlien of Antwerp. It seems a distinct form which can be easily separated from others; possibly it might be desirable to group the present shell with the variety *attenuata* as a new species. The imperfect specimen figured by Dr. Lorié (*op. cit.*) may be perhaps the same.

Sipho Olavii (Beck), Mörch. Plate XXIII, figs. 5, 6.

1871. *Fusus* (*Sipho*) *Olavii* (Beck), Mörch, Geol. Mag., vol. viii, p. 396.
(?) 1872. *Trophon propinquus*, var. *contortus*, S. V. Wood, Mon. Crag Moll., 1st Suppl., p. 24, tab. ii, fig. 15 *b*.
1877. *Sipho Olavii*, Mörch and Poulsen, MS. list and plates in Geol. Mus., Copenhagen, no. 14 *a*, pl. ii, fig. 8 (unpublished).

Specific Characters.—Shell somewhat thin, rather slender; whorls 6 or 7, but slightly convex in the type, tapering to a depressed apex, the last, with the canal, about two-thirds the total length, excavated below; ornamented by numerous fine and generally inconspicuous striæ, closely crowded together on the upper whorls, somewhat further apart and less regular towards the base of the shell; suture more or less distinct; mouth ovate, angulate above; canal long, sub-cylindrical, tortuous or twisted, turning to the left; pillar flexuous.

Dimensions.—L. 36—50 mm. B. 16—20 mm.

Distribution.—Not recorded living.

Fossil: Waltonian Crag: Little Oakley; possibly elsewhere in the Red Crag.

Pliocene: Iceland.

Remarks.—As stated above this species from the Crag of Iceland was described, but insufficiently, by Mörch under a name previously given to it by Beck, but no specimen of the fossils upon which it was founded has been known hitherto in this country. A figure of it appears, however, in one of Mörch and Poulsen's unpublished plates in the library of the Geological Museum at Copenhagen. I have since been able to examine their collection, from which Dr. Ravn has been good enough to send me some specimens for comparison.

Mörch's original description in 1871 stated as to two of his varieties of *Sipho Olavii* that they were "*Trophon gracilis*, Wood (Mon. Crag Moll., tab. vi, figs. 10*a*, 10 *b*), *non absimilis*," and it was probably on the strength of this that in his second Supplement of 1879 (p. 7), the latter referred the Crag shells, here figured as *S. curtus*, to Mörch's species. Mörch, however, had further stated that *S. Olavii* was "*parva, tenuiuscula*," and that it varied in length from 16 to 35 mm., particulars which, appropriate to the Icelandic fossils, are inapplicable to those referred to from the Crag.

The specimens of *S. Olavii* which Dr. Ravn has lent me differ in form and in the convexity of the whorls, but they maintain the same general character, being especially characterised by their long, semi-tubular and sometimes twisted canal, which in the form regarded by Mörch and Poulsen as the typical variety of this species, turns to the left. I have figured one of Dr. Ravn's fossils, together with another from Oakley, with which it closely corresponds.

S. Olavii belongs to the *tortuosus* group, but differs sufficiently from that species, I think, to justify its specific separation; moreover, the latter has not been recorded hitherto from the Iceland Crag.

Var. **Mörchii**, nov. Plate XXIII, figs. 7—9.

1877. *Sipho* sp., Mörch and Poulsen, MS. list and plates in Geol. Mus., Copenhagen, no. 12, pl. iv, fig. 1 (unpublished).

Varietal Characters.—Shell thin, fusiform, whorls 6 or 7, more convex than in the type, regularly diminishing in size, the last ventricose, excavated below; ornamented by clearly marked spiral lines, usually very fine; suture well marked but not deep; apex planorboid in the Crag specimens, blunt and twisted in those from Iceland; mouth oval, angulate above; columella sloping above, nearly straight in the middle, turning to the left where it joins the canal; canal fairly long, semi-tubular, nearly straight, usually twisted; outer lip thin, regularly curved; inner lip forming a thin glaze on the pillar.

Dimensions.—L. 35 mm. B. 15 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Little Oakley. Newbournian: Newbourn. Butleyan: Butley; probably elsewhere in the Red Crag. Pliocene: Iceland.

Remarks.—When examining the collection of Icelandic fossils at Copenhagen in 1911, with Dr. Ravn, I was fortunate enough to notice some agreeing with a number of Oakley fossils which had perplexed me for a long time. Although the Copenhagen specimens were labelled *S. Olavii*, they differed widely, especially in the greater convexity of the whorls and in the canal, from the form which had been figured by Mörch and Poulsen as the type of that species (Pl. XXIII, fig. 6), agreeing rather with my fig. 8, which in the unpublished Copenhagen list (no. 12, pl. iv, fig. 1) is described as *Sipho sp.* Dealing only with the Crag shells, I should not have hesitated to regard them as specifically distinct, but Dr. Ravn informs me that in the Mörch collection there are some of an intermediate character which in his opinion and in that of Dr. Nordmann connect the two. The view that certain fossils may appear to be specifically distinct in one area while they are specifically connected in another is interesting. I accept their opinion as to the Iceland shells, but they afford another illustration of the difficulties surrounding the student of the Crag mollusca.

It should be stated that whereas the Icelandic specimens of what I have named *S. Olavii*, var. *Mörchii*, have the slightly distorted apex characteristic of the typical *Sipho*, it is regularly spiral and planorboid, as in *S. tortuosus*, in the Oakley fossils which I identify with them.[1] Discussing the matter in Paris with MM. Dollfus and Cossmann, and afterwards with M. Dautzenberg, submitting the specimens of both to them, they all expressed a very confident opinion that this presented no real difficulty, agreeing in my identification of the Oakley shells with Mörch's specimens from the Iceland Crag. Both *S. Olavii* and its var. *Mörchii* seem to belong to the *S. tortuosus* group. As to this, however, it may be remarked that neither the typical form of the latter species, as just stated, nor any of the varieties of it here described, have been recorded at present from the Pliocene of Iceland.

Var. **conulus**, nov. Plate XXIII, fig. 14.

Dimensions.—L. 24 mm. B. 11 mm.

Distribution.—Not known living.

Fossil : Newbournian Crag: Waldringfield.

Remarks.—The specimen figured under the above name is one of two now in the York Museum which were found many years ago at Waldringfield by Mr. A. Bell.

They are somewhat similar to one of the varieties of *S. Olavii* at Copenhagen, and may be regarded, I think, either as immature, or as a dwarf form of that species, resembling the typical form in its delicate spiral sculpture, its long and semitubular canal and its conical spire, but differing in size and in its relative proportions.

Sipho propinquus (Alder). Plate XX, figs. 8, 9.

1850. *Fusus propinquus*, Alder, Trans. Tynes. Nat. Field Club, vol. i, p. 157.
1853. *Fusus propinquus*, Forbes and Hanley, Brit. Moll., vol. iii, p. 419, pl. ciii, fig. 2.
1867. *Fusus propinquus*, Jeffreys, Brit. Conch., vol. iv, p. 338, pl. lxxxvi, fig. 3.
1870. *Tritonium propinquum*, S. V. Wood, jun., Quart. Journ. Geol. Soc., vol. xxvi, p. 92.
1881. *Neptunea (Sipho) propinqua*, Kobelt, Martini und Chemnitz, Conch. Cab., ed. 2, vol. iii (Purpuraceæ), p. 79, pl. xxv, fig. 8.

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[1] The matter is still further complicated, however, by the fact that in Mörch's original description in the Geol. Mag., vol. viii, p. 396, he states as to the apex of *S. Olavii* that it is "*Littorinam obtusatam non absimilis.*" The apex of *L. obtusata* is distinctly planorboid.

Specific Characters.—Shell rather thin; whorls but slightly convex, gradually tapering; apex obtuse, regularly spiral; ornamented by very fine and inconspicuous striæ extending to the base of the shell; suture narrow, channelled; mouth oblong-oval, angulate above; canal short and wide, turning to the left; outer lip rounded, but slightly projecting, edge sharp and thin; inner lip forming a thin glaze; pillar curved, angulated at the commencement of the canal.

Dimensions.—L. 35 mm. B. 15 mm.

Distribution.—*Recent:* British and Irish coasts. Cattegat, Finmark to Gulf of Gascony.

Fossil: Waltonian Crag: Walton, Little Oakley; probably elsewhere in the Red Crag. Wexford (Sir H. James). Isle of Man.

Pleistocene: Aberdeenshire, Gamrie, King Edward, Lochgilphead, Worden. Bridlington.

Remarks.—As before stated Wood figured several fossils from the Crag as *Trophon propinquus*, but they hardly correspond with the typical *S. propinquus* of British seas. Many years ago I received from the late Dr. Gwyn Jeffreys an example of this species from the Dogger Bank, which I now figure, together with a shell from Oakley with which it appears to agree.

Sipho Jeffreysianus (Fischer). Plate XXIV, figs. 3, 4.

1867. *Fusus buccinatus*, Jeffreys, Brit. Conch., vol. iv, p. 340.
1868. *Fusus Jeffreysianus*, Fischer, Journ. de Conch., vol. xvi, p. 37.
1869. *Fusus Jeffreysianus*, Jeffreys, Brit. Conch., vol. v, p. 219, pl. lxxxvi, fig. 4.
1870. *Fusus Jeffreysianus*, A. Bell, Ann. Mag. Nat. Hist. [4], vol. vi, p. 214.
1881. *Neptunea* (*Sipho*) *Jeffreysiana*, Kobelt, Martini und Chemnitz, Conch. Cab., ed. 2, vol. iii (Purpuraceæ), p. 80, pl. xxv, fig. 7.
1890. *Neptunea Jeffreysiana*, Carus, Prod. Faun. Medit., vol. ii, p. 400.

Specific Characters.—Shell differing from *S. propinquus* in being larger, more ventricose and solid, having a conical and shorter spire; whorls but slightly convex, the last nearly three-fourths the total length; ornamented by fine, rather indistinct spiral striations which are somewhat stronger on the back of the canal; apex obtuse, regularly spiral; mouth oval, angulate above; canal short, open, turning to the left.

Dimensions.—(Of the Crag specimens.) L. 50 mm. B. 25 mm.

Distribution.—*Recent:* coasts of Ireland, southern England and western France, Gulf of Lions (Jeffreys).

Fossil: Waltonian Crag: Little Oakley. Newbournian: Waldringfield, Sutton; probably elsewhere in the Red Crag.

Remarks.—*S. Jeffreysianus*, a British shell with a southern range, resembles the *S. curtus* group in form, except that the whorls are flatter and the spire is shorter, but it differs from the latter in its regularly spiral or planorboid apex. It appears to be represented in northern seas by *S. glaber*, in which, however, the apex is bulbous.

I have found a number of specimens at Oakley corresponding more or less closely with Jeffreys' description and figure of *S. Jeffreysianus*; unfortunately the apices are invariably imperfect. Wood claimed this form as a Crag species, but did not figure it; I have given a representation of one of the Oakley fossils with that of a Recent specimen from the Devonshire coast.

Sipho ebur (Mörch). Plate XXII, figs. 13, 14.

1869. *Fusus (Siphonorbis) ebur*, Mörch, Journ. de Conch., vol. xvii, p. 398.

1882–1901. *Neptunea (Siphonorbis) ebur*, Friele, Norske Nordh. Exped. (Mollusca), pt. i, p. 18, pl. ii, fig. 20, 1882; pt. iii, p. 105, 1901.

1887. *Neptunea ebur*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 78, pl. xiii, figs. 5, 6.

1899. *Sipho (Tritonofusus) ebur*, Posselt, Medd. om Grönl., vol. xxiii, fig. 182.

1912. *Sipho (Siphonorbis) ebur*, Dautzenberg et Fischer, Camp. Scient. Pr. Monaco, vol. xxxvii (Mollusques), p. 93, pl. iii, fig. 16.

Specific Characters.—Shell fusiform, thin and fragile; whorls convex; spire short, ending in a blunt and planorboid apex; suture deep; ornamented by very fine and rather inconspicuous thread-like spiral lines, crossed by numerous and excessively delicate lines of growth; body-whorl tumid, deeply excavated below; mouth oval; canal short and open; outer lip thin, regularly curved; inner lip forming an exceedingly fine glaze, adherent to the flexuous pillar.

Dimensions.—L. 50 mm. B. 25 mm.

Distribution.—*Recent:* northern Seas, from 90 to 223 fathoms (Friele).

Fossil: Waltonian Crag: Little Oakley.

Remarks.—There seems some confusion as to the shells described as *S. ebur*, *S. Sarsii* and *S. Moebii* which some authorities regard as different varieties of one species.

The first was described by Mörch in 1869, the second by Jeffreys in the same year; unfortunately neither was figured. *S. ebur* was figured by Mr. Friele in 1882. I have a Recent specimen in my collection (Pl. XXII, fig. 13) which Dr. Nordgaard kindly sent me as typical of this species, and I have a similar one, fossil and imperfect (fig. 14), from Oakley; both agree with Mr. Friele's figure; they are fragile, with fine, irregular and inconspicuous sculpture and a clearly marked canal.

On the other hand, Messrs. Dautzenberg and Fischer, and Prof. Kobelt (*op. cit.*), figure under the same name a somewhat different form, which is larger, and has a short, wide, and open canal. The former authorities state, however, that immature examples of *S. ebur* have a rudimentary canal which disappears in the adult.

The figures of *S. Sarsii* given by Prof. G. O. Sars, S. V. Wood and Prof. Kobelt are smaller, the spiral sculpture is more distinct and regular, and the canal is clearly defined. *S. Moebii*, Dunker and Metzger, which the latter authorities regard as a variety of *S. Sarsii*, is a similar form, but the spire is more elongate.

Messrs. Dautzenberg and Fischer remark that *S. ebur* and *S. Sarsii* may be the different forms of the same species, but in default of more evidence they think the question may be left in abeyance for the present.

Sipho Sarsii (Jeffreys). Plate XXII, fig. 12; Plate XXIV, fig. 9.

1869. *Fusus Sarsi*, Jeffreys, Nature, vol. i, p. 168.
1878. *Sipho Sarsii*, G. O. Sars, Moll. Reg. Arct. Norv., p. 275, pl. xv, fig. 2.
1887. *Neptunea Sarsii*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. i, p. 79, pl. xiii, fig. 8.

Specific Characters.—Shell thin, ovato-fusiform; whorls convex, the last ventricose, excavated below; ornamented by fine and more or less regular and well-marked spiral lines; spire short, apex obtuse; suture deep; mouth ovate, angulated above; canal short, turning slightly to the left, ending in an oblique notch.

Dimensions.—L. 30 mm. B. 15 mm.

Distribution.—*Recent*: Shetland Isles, Finmark, western Norway, Lofoten Islands (Sars), Russian Lapland, Greenland, New England coast.

Fossil: Waltonian Crag: Little Oakley. Newbournian: Waldringfield. Butleyan: Butley. Pleistocene: Bridlington (Jeffreys); Norway (Øyen.)

Remarks.—Jeffreys' collection of mollusca found its way to America, and with his unfigured type-specimen of *S. Sarsii* is now in the U.S. National Museum at the Smithsonian Institution. Dr. Dall has been kind enough to compare with the latter a photograph of the fossil from Butley, now figured (Pl. XXII, fig. 12), and reports it to be the same. The sculpture of this shell is more delicate and clearly defined than that of *S. ebur*; I have one or two other specimens, immature and imperfect, from Oakley, which seem to correspond with it.

In the shells figured by Wood and by Prof. G. O. Sars as *S. Sarsii*, the sculpture is of a coarser character, the spire is shorter and the whorls are ventricose. Sars says his form is "*solidula*." I have a specimen from Oakley here given as var. *crassa* (Pl. XXIV, fig. 9), identified by Canon Norman some years ago as *S. Sarsii*, which is thick and strong, and although worn, shows some slight traces of its original spiral sculpture. It belongs, I think, to the *Sarsii* group rather than to those described above as *S. ebur*. Prof. Kobelt states that while *S. ebur* belongs to the subgenus *Siphonorbis*, *S. Sarsii* is a true *Sipho*, but possibly this is a mistake. Although all my Crag fossils of *S. Sarsii* have lost the apex, there is a Recent specimen of the latter in the Norman collection in which it is shown to be distinctly planorboid.

Sipho exiguus, sp. nov. Plate XXIV, fig. 10.

1872. *Trophon Sabini*, S. V. Wood, Mon. Crag Moll., 1st Suppl., p. 23, tab. ii, fig. 15 *c*.

Specific Characters.—Shell small, turreted, fairly strong and solid; whorls 7, convex, regularly tapering; ornamented by fine, but well-marked and regular spiral lines; apex planorboid; mouth oval, angulate above, ending in a short and open canal which turns slightly to the left.

Dimensions.—L. 35 mm. B. 15 mm.

Distribution.—*Recent:* Iceland.

Fossil: Coralline Crag: Sutton. Waltonian: Little Oakley. Butleyan: Butley; probably elsewhere in the Red Crag.

Pleistocene: Bridlington; Christiania.

Remarks.—I have five or six specimens of a small, strongly sculptured *Sipho* from Oakley, differing from anything else I have found at that place, but corresponding to the one found by Mr. Leckenby at Bridlington, figured by Wood as *Trophon Sabini*, which is now in the York Museum. In Wood's figure the spiral ridges are shown only at the base of the shell, but an examination of the specimen proves this to have been due to a mistake on the part of the artist. In the shell now figured the apex is wanting, but in another very similar, in my collection, it is shown to be planorboid. As I do not know any species of the *Siphonorbis* group to which it can be referred, I have regarded it as an undescribed and distinct form. When examining with Dr. Odhner the fine collection of Recent mollusca in the Zoological Museum at Stockholm, I noticed several specimens from Iceland, apparently full-grown, which appeared to correspond with our Crag shells. Dr. Øyen, moreover, has shown me what appears to be the same form in the University Museum at Christiania which I understand came from the Pleistocene deposits of that region.

Sipho elegans, sp. nov. (ex Mörch MS.). Plate XXIV, figs. 7, 8.

1877. *Buccinopsis elegans*, var., Mörch and Poulsen, MS. list and plates in Geol. Mus. Copenhagen, no. 25, pl. ii, fig. 6 (unpublished).

Specific Characters.—Shell ovato-fusiform; whorls 5 or 6, but slightly convex, the last two-thirds the total length; ornamented by numerous and rather fine spiral ridges closely crowded together, seen (with a lens) to be divided by an inconspicuous medial line, and by faint closely-set lines of growth; spire regularly diminishing; apex obtuse; suture well defined; mouth ovate, angulate above;

outer lip thin, not expanded; inner lip forming a narrow and thin glaze upon the pillar; pillar but slightly flexuous; canal open, turning to the left.

Dimensions.—L. 36 mm. B. 18 mm.

Distribution.—Not known living.

Fossil: Butleyan Crag: Butley.

Pliocene: Iceland.

Remarks.—For some time I have had in my collection a Sipho-like shell from Butley which I was unable to refer to any species known to me, either Recent or fossil. Receiving a parcel of material, however, from the Iceland Crag from my friend Dr. Pjetursson, I was interested to find in it a specimen evidently identical with it, corresponding, moreover, with one described in the list and plates by Mörch and Poulsen as *Buccinopsis elegans*, Charlesworth, under the impression, no doubt, that Wood's figure of *Trophon* (*Atractodon*) *elegans* (Mon. Crag Moll., 1st Suppl., tab. ii, fig. 6) was the same shell. In the Copenhagen list referred to, two Iceland fossils are given as *Buccinopsis elegans*, Charlesworth, but neither of them has, I consider, any relation to his genus *Atractodon*. One of them, together with Wood's shell, has been identified by Dr. Dall as a Behring Sea species, *Liomesus canaliculatus* (see p. 115 of the present memoir). The others, those now described, should be referred, I believe, to *Sipho*, for though the canal in neither of them is perfect, it is sufficiently so to show it is not that of *Liomesus* (*Buccinopsis*). Under the circumstances I retain Mörch's specific name of *elegans* for the present specimens, again remarking that they are not *Atractodon elegans*, and changing the generic name to *Sipho*.

When the fossil and Recent forms, either of *Neptunea* or *Sipho*, are studied on a large scale they often appear to run into one another, as do the Buccinums already discussed, but probably this might be so with other groups of mollusca were it not for the poverty of our collections and the imperfection of the geological record, the difficulty of classification being in proportion to the amount of material at our disposal.

I cannot claim to have worked out, even provisionally, a very complicated problem, but have contented myself, as in a former case, with representing typical specimens of the more characteristic forms known to me from the Crag, giving them names, usually those at present to be found in the works of the various authorities I have consulted, by which they may be identified. Whether in some cases those names should be regarded as specific or varietal, and if varietal to which of the already recognised species such varieties should be referred, I leave to the judgment of my successors. I can only express the hope that the information here given may prove of some value to those who may hereafter study the subject.

PLATE I.

Fig.		Page.
1.	*Eulota fruticum* (Müller). Hollesley. (British Museum) . .	9
2.	*Helix lactea*, Müller. Walton-on-Naze. (British Museum) . .	14
3.	*Helix nemoralis*, Linné. Barnwell. (Harmer Collection) . .	15
4.	*Helix hortensis*, Müller. Butley. (Ipswich Museum) . .	16
5.	*Helicodonta lens* (Férussac). Recent, Pylos, Greece. (Tristram Coll.) .	13
6.	*Hygromia incarnata* (Müller). Recent. (British Museum) . .	11
7.	Ditto. Walton-on-Naze. (British Museum) . . .	11
8.	*Hygromia rubiginosa* (A. Schmidt). Southwold. (British Museum) .	11
9.	*Pomatias Harmeri*, Kennard. Little Oakley. (Harmer Collection) .	26
10.	*Jaminia cylindracea* (Da Costa). Recent. (Harmer Collection) .	20
11.	*Carychium ovatum*, Sandberger. West Runton. (Norwich Museum) .	25
12.	*Carychium minimum*, Müller. Recent. (Harmer Collection) .	24
13.	*Succinea oblonga*, Draparnaud. Southwold. (British Museum) .	22
14.	*Limnæa Harmeri*, Kennard and B. B. Woodward. Bramerton. (Norwich Museum)	29
15.	*Vallonia excentrica*, Sterki. Beccles. (Crowfoot Collection) .	12
16.	*Lithoglyphus fuscus* (Pfeiffer). East Runton. (Norwich Museum) .	34
17.	*Vivipara glacialis* (S. V. Wood). Belaugh. (Harmer Collection) .	36
18.	*Acroloxus lacustris* (Linné). Recent. (Harmer Collection) . .	27
19.	*Pisidium casertanum* (Poli). Bramerton. (Norwich Museum) .	44
20.	*Pisidium supinum*, A. Schmidt. Bramerton. (Norwich Museum) .	45
21.	*Pisidium amnicum* (Müller). Bramerton. (Norwich Museum) .	42
22.	*Pisidium Henslowanum*, Sheppard. Sutton. (British Museum) .	46
23.	*Pisidium astartoides*, Sandberger. Bramerton. (Norwich Museum) .	43

Harmer, Crag Mollusca.

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PLATE II.

Fig.		Page.
1.	*Terebra canalis*, S. V. Wood. Little Oakley. (Harmer Collection)	53
2.	var. *costata*, nov. Antwerp. (Van de Wouver Collection)	53
3.	*Rostellaria gracilenta*, S. V. Wood. Little Oakley. (Harmer Collection)	60
4.	*Terebra exilis*, A. Bell. Gedgrave. (York Museum)	54
5.	Ditto. Little Oakley. (Harmer Collection)	54
6.	*Terebra inversa*, Nyst. Boyton. (Jermyn St. Museum)	54
7.	var. *costata*, nov. Gedgrave. (Jermyn St. Museum)	54
8.	*Columbella scripta* (Linné). Shottisham. (York Museum)	55
9.	Ditto. Recent. (Harmer Collection)	55
10.	*Voluta suturalis*, Nyst. Little Oakley. (Harmer Collection)	51
11.	*Columbella subulata* (Brocchi). Sutton. (Ogden Collection)	56
12.	Ditto. Antwerp. (Van de Wouver Collection)	57
13.	*Cassidaria tyrrhena* (Chemnitz). Boyton. (York Museum)	58
14.	*Cassidaria bicatenata*, J. Sowerby, var. *Canhami*, A. Bell. Waldringfield. (Ipswich Museum)	59
15.	*Trivia europæa* (Montagu), var. *sphæriculata*, Lamarck. Italian Pliocene. (Harmer Collection)	49
16.	ditto. Little Oakley. (Harmer Collection)	50
17.	*Trivia pisolina* (Lamarck). Waldringfield. (Moore Collection)	50

PLATE II

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PLATE III.

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PLATE IV.

Harmer. Crag Mollusca.

PLATE IV

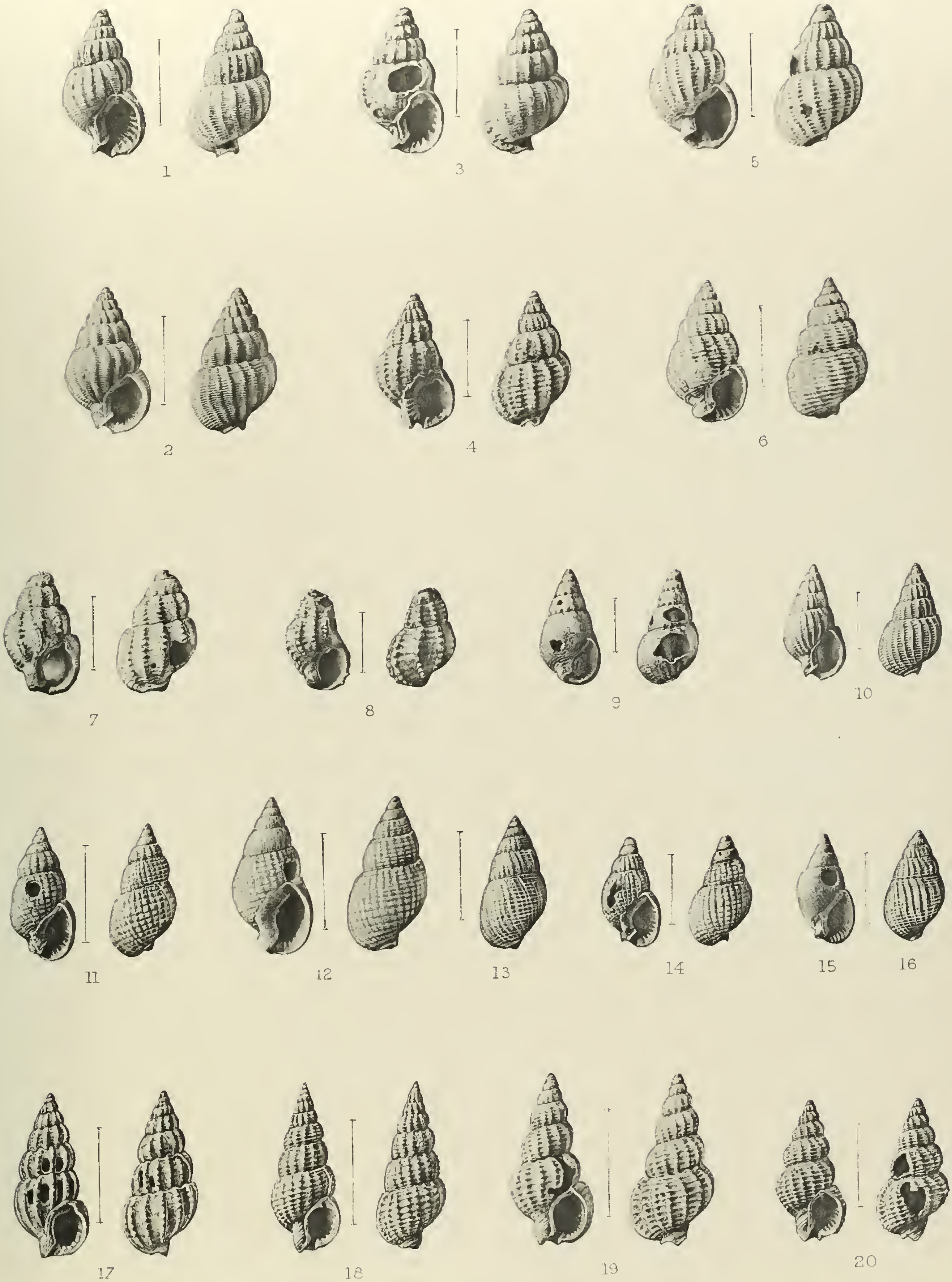

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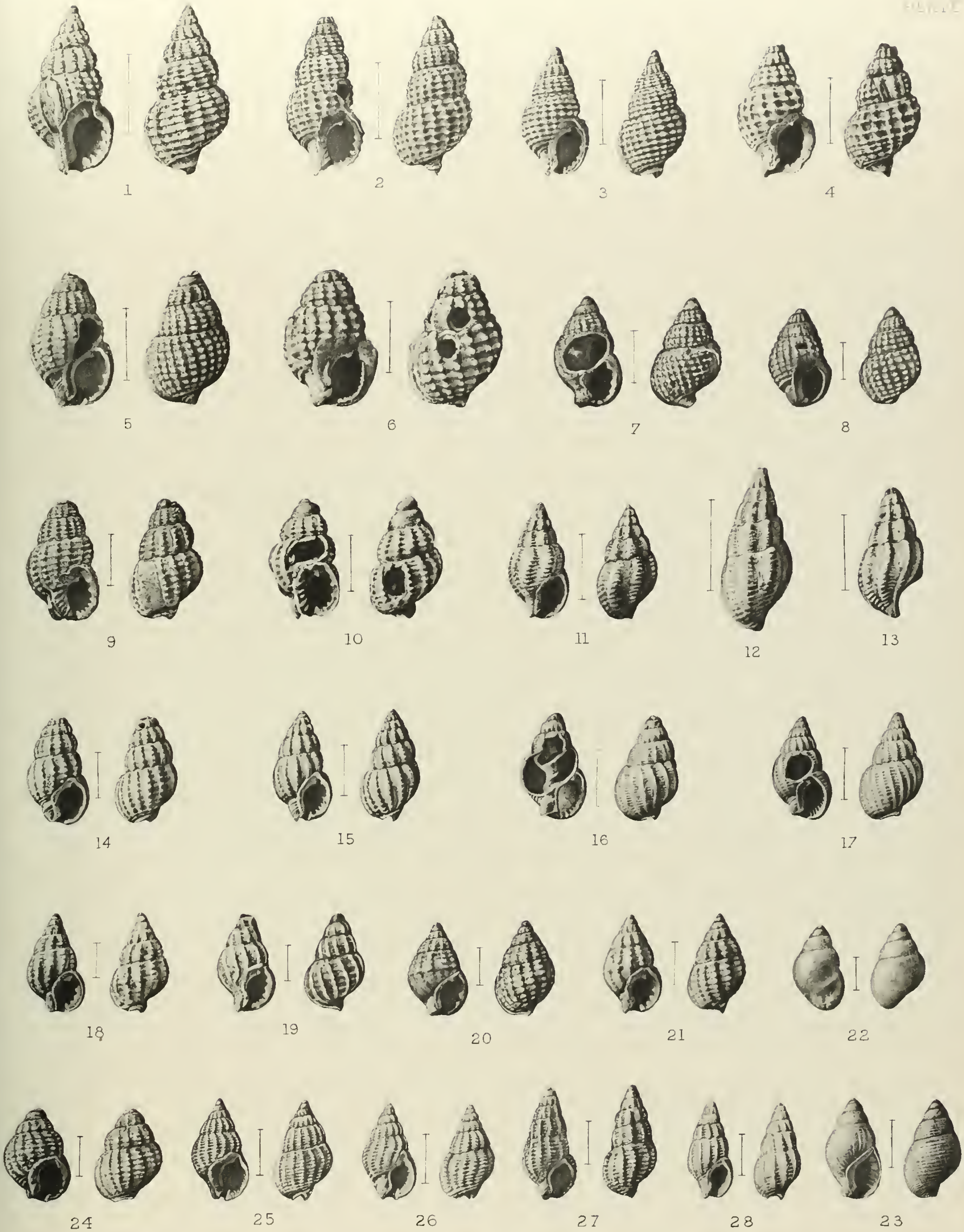
PLATE V.

Fig.		Page.
1.	*Nassa granulata* (J. Sowerby).	
	var. *typica*. Little Oakley. (Harmer Collection)	77
2.	var. *elongata*, nov. Little Oakley. (Harmer Collection)	78
3.	var. *gracilis*, nov. Little Oakley. (Harmer Collection)	77
4.	var. *fenestrata*, nov. Little Oakley. (Harmer Collection)	78
5.	*Nassa Dautzenbergi*, sp. nov. Walton-on-Naze. (Cambridge Museum)	78
6.	var. *crassisculpta*, nov. Little Oakley. (Harmer Collection)	79
7.	var. *simplex*, S. V. Wood. Gedgrave. (Cambridge Museum)	79
8.	var. *minuscula*, nov. Little Oakley. (Harmer Collection)	79
9.	*Nassa Dollfusii*, sp. nov. Little Oakley. (Harmer Collection)	80
10.	var. *convexa*, nov. Little Oakley. (Harmer Collection)	81
11.	*Nassa Kennardi*, sp. nov. Little Oakley. (Harmer Collection)	87
12.	var. *elongata*, nov. Antwerp. (Van de Wouver Collection)	87
13.	ditto. Little Oakley. (Harmer Collection)	87
14.	*Nassa turonica* (Deshayes). Little Oakley. (Harmer Collection)	85
15.	Ditto. Miocene, Touraine. (Harmer Collection)	86
16.	*Nassa spectabilis* (Nyst). Little Oakley. (Harmer Collection)	85
17.	Ditto. Miocene, Touraine. (Harmer Collection)	85
18.	*Nassa venusta*, sp. nov. Little Oakley. (Harmer Collection)	82
19.	var. *Woodii*, nov. Little Oakley. (Harmer Collection)	83
20.	*Nassa Woodwardi*, sp. nov. Little Oakley. (Harmer Collection)	83
21.	Ditto. Antwerp. (Van de Wouver Collection)	83
22.	*Nassa Edwardsi*, Fischer. Bentley. (Boswell Collection)	86
23.	Ditto. Ficarazzi. (Harmer Collection)	86
24.	*Nassa pumila*, sp. nov. Little Oakley. (Harmer Collection)	87
25.	*Nassa incrassata* (Ström), var. β. Butley. (British Museum)	88
26.	Ditto. Recent, Christiania. (Øyen Collection)	88
27.	*Nassa pusillina*, S. V. Wood. Butley. (Kennard Collection)	81
28.	Ditto. Bramerton. (Norwich Museum)	81



J. Green, del.

London Stereoscopic Co. Imp

PLATE VI.

Fig.		Page.
1.	*Buccinum undatum*, Linné.	
	var. *clathrata*, S. V. Wood. Little Oakley. (Harmer Collection)	90
2.	ditto. Antwerp. (Van de Wouver Collection) . .	91
3.	var. *acuminata*, Broderip. Recent, Whitstable. (Harmer Collection)	95
4.	ditto. Little Oakley. (Harmer Collection) . .	95
5.	var. *flexuosa*, Jeffreys. Waldringfield. (Moore Collection) .	93
6.	var. *striata*, Pennant. Little Oakley. (Harmer Collection) .	91
7.	ditto. Little Oakley. (Harmer Collection). . .	91
8.	var. *tenera*, J. Sowerby. Butley. (Norwich Museum) .	92
9.	var. *littoralis*, King. Little Oakley. (Harmer Collection) .	93
10.	ditto. Recent, Denmark. (Nordmann Collection) . .	93

J. Green. del

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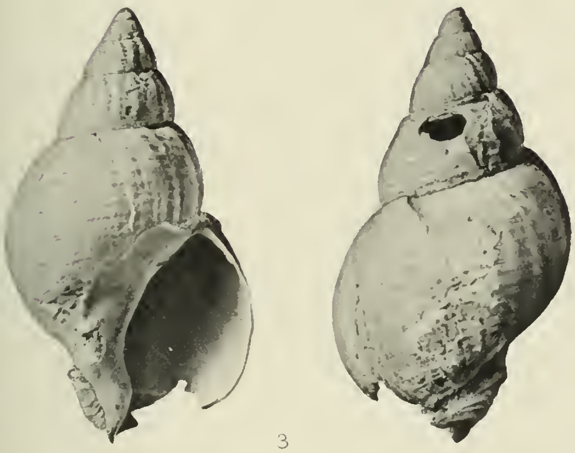
PLATE VII.

1

2



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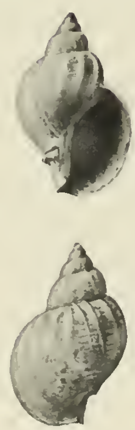

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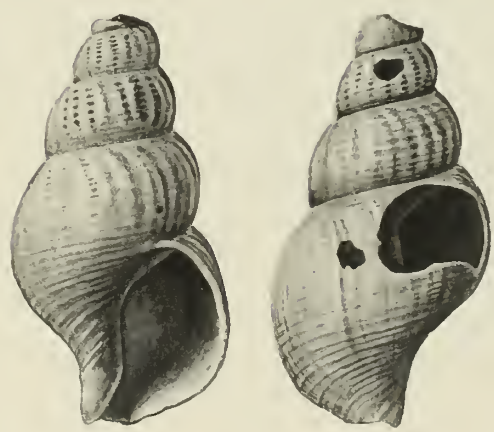

7

J. Green. del

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PLATE VIII.

FIG.		PAGE.
1.	*Buccinum undatum*, Linné, var. *Schneideri*, Verkrüzen. Recent, Vadsö. (Norman Collection)	96
2.	ditto. Little Oakley. (Harmer Collection) . .	96
3.	*Buccinum finmarchianum*, Verkrüzen. Little Oakley. (Harmer Collection)	101
4.	*Buccinum grœnlandicum*, Chemnitz. Butley. (Harmer Collection) .	97
5.	Ditto. Recent. (Harmer Collection)	98
6.	Ditto. Little Oakley. (Harmer Collection) . . .	98
7.	*Buccinum elongatum* (?), Verkrüzen. Hollesley. (Harmer Collection) .	110
8.	Ditto. Recent, Newfoundland. (Sparre Schneider Collection) .	111
9.	*Buccinum fragile* (Verkrüzen). Little Oakley. (Harmer Collection) .	106
10.	*Buccinum tenue*, Gray. Recent, Spitzbergen. (Nordmann Collection)	104
11.	Ditto. Butley. (Cambridge Museum)	104
12.	*Buccinum grœnlandicum*, Chemnitz, var. *connectens*, nov. Butley. (Norwich Museum)	98

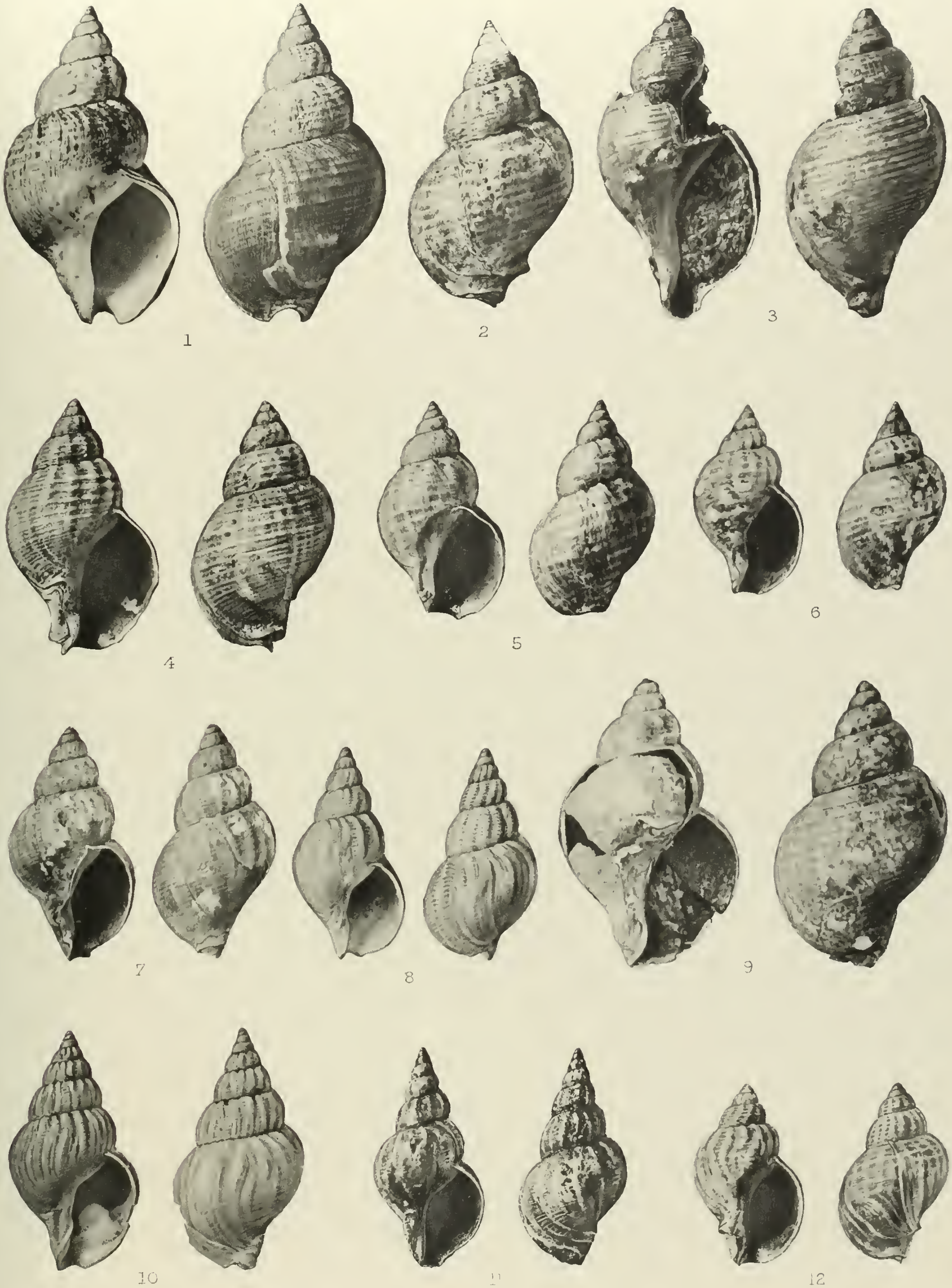

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PLATE IX.

J. Green. del

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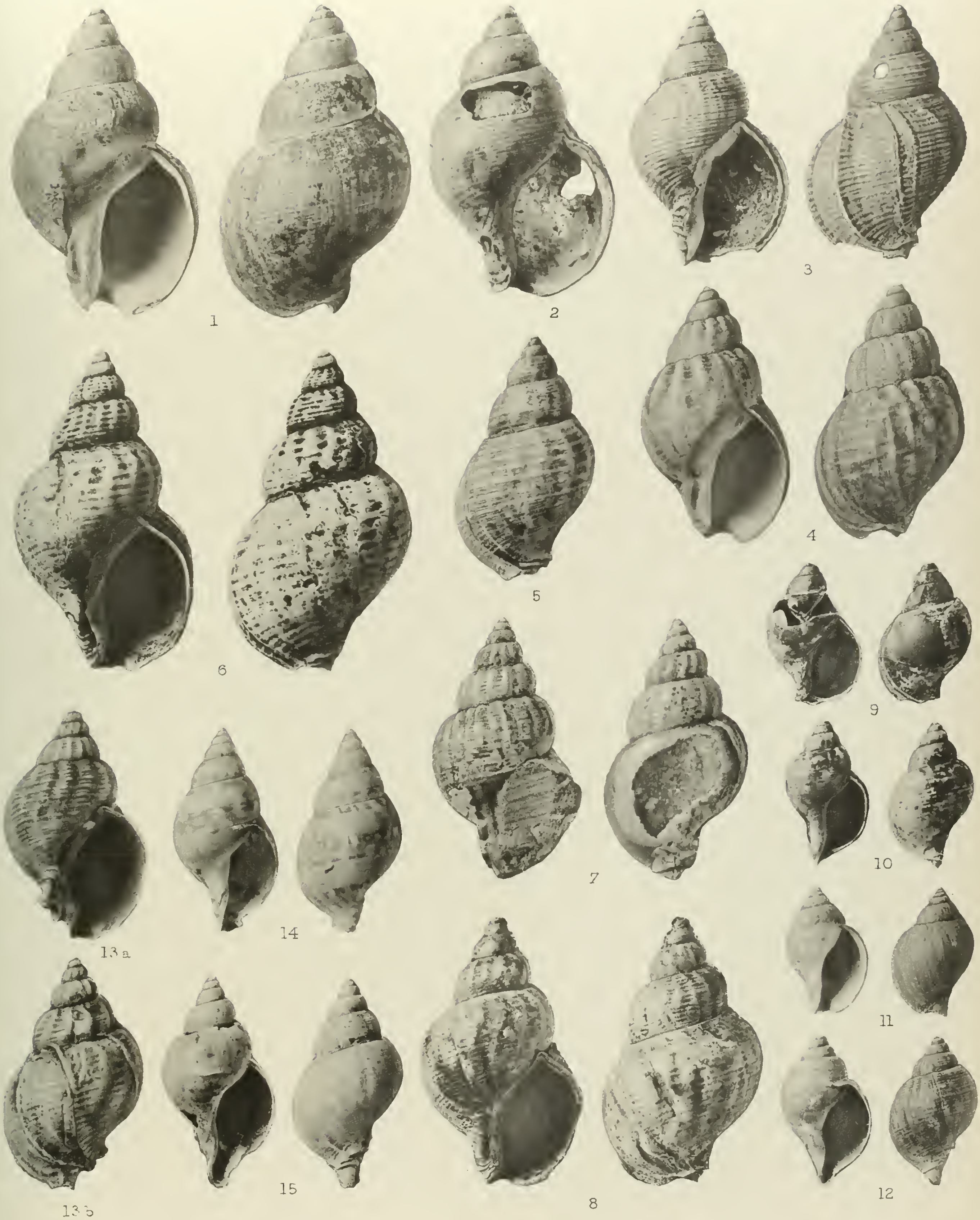
PLATE X.



J. Green. del.

London Stereoscopic Co. Im

PLATE XI.

Fig.		Page.
1.	*Purpura lapillus* (Linné).	
	var. *incrassata*, J. Sowerby. Little Oakley. (Harmer Collection)	117
2.	var. *connectens*, nov. Waldringfield. (Harmer Collection)	118
3.	var. *imbricata*, Lamarck. Little Oakley. (Harmer Collection)	117
4.	var. *carinata*, S. V. Wood. Little Oakley. (Harmer Collection)	117
5.	var. *brevis*, S. V. Wood. Little Oakley. (Harmer Collection)	117
6.	*Purpura tetragona* (J. Sowerby). Ramsholt. (Ipswich Museum)	116
7.	*Purpura lapillus* (Linné).	
	var. *oakleyensis*, nov. Little Oakley. (Harmer Collection)	118
8.	ditto. Little Oakley. (Harmer Collection)	118
9.	var. *imbricata*, Lamarck. Scaldisien, Antwerp. (Harmer Collection)	118
10.	var. *oakleyensis*, nov. Little Oakley. (Harmer Collection)	118
11.	*Purpura lapillus* (Linné). Recent, Maine. (Boston Museum, U.S.A.)	117
12.	Ditto. Recent, Norway. (Harmer Collection)	118
13.	*Purpura tetragona*, J. Sowerby, var. *alveolata*, J. Sowerby. Little Oakley. (Harmer Collection)	117
14.	*Purpura lapillus*, Linné.	
	var. *elongata*, S. V. Wood. Little Oakley. (Harmer Collection)	117
15.	var. *oakleyensis*, nov. Little Oakley. (Harmer Collection)	118
16.	var. *newbourniensis*, nov. Felixstow. (Harmer Collection)	118
17.	ditto. Bramerton. (Harmer Collection)	118
18.	*Purpura tetragona* (J. Sowerby), var. *alveolata*, J. Sowerby. Little Oakley. (Harmer Collection)	116
19.	*Purpura lapillus* (Linné).	
	var. *angusta*, nov. Little Oakley. (Harmer Collection)	117
20.	var. *butleyensis*, nov. Butley. (Harmer Collection)	118
21.	var. *vulgaris*, S. V. Wood. Recent, North Sea. (Harmer Collection)	118
22.	ditto. Bawdsey. (Harmer Collection)	118
23.	ditto. March Gravels. (Harmer Collection)	118

J. Green. del.

London Stereoscopic Co. Imp.

PLATE XII.

Fig.		Page.
1.	*Liomesus canaliculatus* (Dall). Butley. (York Museum) . .	115
2.	Ditto. Pliocene, Iceland. (Mörch Collection) . . .	115
3.	*Murex rudis*, Borson. Isle of Man. (Jermyn St. Museum) . .	122
4.	Ditto. Miocene, Touraine. (Dautzenberg Collection) . .	122
5.	Ditto. Isle of Man. (Jermyn St. Museum) . . .	122
6.	*Triton heptagonum* (Brocchi). Italian Pliocene, Asti. (Harmer Collection)	120
7.	Ditto. Little Oakley. (Harmer Collection) . . .	121
8.	*Ocinebra tortuosa* (J. Sowerby).	
	var. *boytonensis*, nov. Boyton. (Ipswich Museum) . .	125
9.	var. *minor*, nov. Isle of Man. (Jermyn St. Museum) .	125
10.	ditto. Little Oakley. (Harmer Collection) . .	125
11.	ditto. Isle of Man. (Harrison Collection) . . .	125
12.	*Ocinebra erinacea* (Linné). Isle of Man. (Harmer Collection) .	124
13.	Ditto. Isle of Man. (Jermyn St. Museum) . . .	124
14.	Ditto. Isle of Man. (Harrison Collection) . . .	124
15.	*Urosalpinx cinereus*, Say. Recent, Maine. (Boston Museum, U.S.A.) .	126
16.	Ditto. Pliocene, Iceland. (Mörch Collection) . . .	126
17.	Ditto. Little Oakley. (Harmer Collection) . . .	126
18.	*Trophon muricatus*, Montagu. Little Oakley. (Harmer Collection) .	131
19.	var. *Nysti*, nov. Little Oakley. (Harmer Collection) .	133
20.	var. *similis*, nov. Little Oakley. (Harmer Collection) .	133
21.	var. *valida*, nov. Little Oakley. (Harmer Collection) .	132
22.	*Trophon Lamplughi*, sp. nov. Isle of Man. (Jermyn St. Museum) .	134
23.	*Trophon truncatus* (Ström). March gravels. (Harmer Collection) .	129
24.	Ditto. Little Oakley. (Harmer Collection) . . .	129
25.	*Trophon clathratus* (Linné). Isle of Man. (Harrison Collection) .	127
26.	*Trophon Gunneri* (Lovén). Bramerton. (Norwich Museum) .	128
27.	*Trophon Fabricii* (Beck), Möller. Isle of Man. (Jermyn St. Museum)	130
28.	Ditto. Little Oakley. (Harmer Collection) . . .	130
29.	var. *Bailyi*, A. Bell. Wexford Gravels. (Jermyn St. Museum)	131
30.	*Purpura derivata*, sp. nov. Little Oakley. (Harmer Collection) .	119
31.	*Stenomphalus Wiechmanni*, von Koenen. Little Oakley. (Harmer Collection)	120
32.	*Ancilla Nysti*, sp. nov. Little Oakley. (Harmer Collection) .	52
33.	Ditto. Miocene, Belgium. (Harmer Collection) . .	52

J. Green. del

London Stereoscopic Co. Imp.

PLATE XIII.

Fig.		Page.
1.	*Searlesia costifer* (S. V. Wood). Little Oakley. (Harmer Collection) .	136
2.	*Searlesia incisa*, Gould. Recent, Puget Sound. (Harmer Collection) .	138
3.	*Searlesia costifer* (S. V. Wood).	
	var. β, J. Sowerby. Little Oakley. (Harmer Collection) .	137
4.	var. *cancellata*, nov. Little Oakley. (Harmer Collection) .	138
5.	var. *elongata*, nov. Little Oakley. (Harmer Collection) .	138
6.	var. *monensis*, nov. Isle of Man. (Jermyn Street Museum) .	140
7.	var. *islandica*, nov. Pliocene, Iceland. (Mörch Collection) .	139
8.	ditto. Little Oakley. (Harmer Collection) . .	139
9.	ditto. Little Oakley. (Harmer Collection) . .	139
10.	ditto. Sutton. (Cambridge Museum) . . .	139
11.	var. *crassa*, nov. Little Oakley. (Harmer Collection) .	139
12.	var. *pulchra*, nov. Little Oakley. (Harmer Collection) .	138
13.	*Astyris rosacea* (Gould). Recent, Spitzbergen. (Harmer Collection) .	57
14.	Ditto. Little Oakley. (Harmer Collection) . . .	57
15.	*Megeria alba* (Jeffreys). Recent, Lofoten Islands. (Harmer Collection)	135
16.	Ditto. Little Oakley. (Harmer Collection) . . .	135
17.	*Nassa Kermodei*, Kendall. Isle of Man. (Harmer Collection) .	74
18.	*Nassa Woodwardi*, sp. nov. Rathaspic, Ireland. (Jermyn Street Museum)	83
19.	*Nassa consociata*, S. V. Wood, var. *brevis*, nov. Isle of Man. (Harmer Collection)	76
20.	*Nassa granulata* (J. Sowerby), var. *gracilis*, nov. Isle of Man. (Harmer Collection)	77

Harmer. Crag Mollusca.

PLATE XIII

J. Green. del.

London Stereoscopic Co. I

PLATE XIV.

Fig.		Page.
1.	*Searlesia Forbesi*, Strickland. Isle of Man. (Jermyn Street Museum)	140
2.	Ditto. Isle of Man. (Jermyn Street Museum) . . .	140
3.	Ditto. Little Oakley. (Harmer Collection) . . .	140
4.	*Searlesia Nordmanni*, sp. nov. Isle of Man. (Jermyn Street Museum) .	146
5.	Ditto. Isle of Man. (Harrison Collection) . . .	146
6.	*Searlesia Björnsoni* (Mörch). Pliocene, Iceland. (Mörch Collection) .	141
7.	Ditto. Little Oakley. (Harmer Collection) . . .	141
8.	Ditto. Walton-on-Naze. (Jermyn Street Museum) . .	141
9.	Ditto, var. Little Oakley. (Harmer Collection) . . .	142
10.	*Searlesia Lundgrenii* (Mörch). Pliocene, Iceland. (Mörch Collection)	143
11.	Ditto. Little Oakley. (Harmer Collection) . . .	143
12.	Ditto. Isle of Man. (Jermyn Street Museum) . . .	143
13.	Ditto. Isle of Man. (Harmer Collection) . . .	143
14.	Ditto, var. Little Oakley. (Harmer Collection) . . .	143
15.	*Searlesia Barni*, sp. nov. Little Oakley. (Harmer Collection) .	142
16.	Ditto. Gedgrave. (Cambridge Museum) . . .	142
17.	Ditto. Little Oakley. (Harmer Collection) . . .	142
18.	*Searlesia elegans*, sp. nov. Little Oakley. (Harmer Collection) .	145
19.	*Searlesia Øyeni*, sp. nov. Isle of Man. (Jermyn Street Museum) .	143
20.	Ditto. Isle of Man. (Jermyn Street Museum) . . .	143
21.	*Searlesia Harrisoni*, sp. nov. Isle of Man. (Jermyn Street Museum) .	144
22.	*Searlesia proxima*, sp. nov. Little Oakley. (Harmer Collection) .	145
23.	*Fusus longiroster* (Brocchi). Isle of Man. (Jermyn Street Museum) .	173
24.	*Fusus lamellosus*, Borson. Boyton. (Jermyn Street Museum) . .	174

J. Green. del. London Stereoscopic Co. Im

PLATE XV.

Fig.		Page.
1.	*Volutopsis norvegica* (Chemnitz). Little Oakley. (Harmer Collection)	154
2.	*Volutopsis Largillierti* (Petit de la Saussaye). Little Oakley. (Harmer Collection)	152
3.	*Beringius Turtoni* (Bean). Newbourn. (Ogden Collection) . .	155
4.	*Parasipho Kröyeri* (Möller). Little Oakley. (Harmer Collection) .	148
5.	Ditto. Pleistocene, Canada. (Harmer Collection) . .	148
6.	*Anomalosipho altus* (S. V. Wood). Butley. (Kennard Collection) .	150
7.	var. *virgata*, Friele. Recent, Norway. (Friele Collection) .	151
8.	ditto. Butley. (Kennard Collection) . . .	151
9.	ditto. Felixstow. (Norwich Museum) . . .	151
10.	*Anomalosipho Verkrüzeni*, Kobelt, var. *plicifera*, Brøgger. Pliocene, Iceland. (Mörch Collection)	149
11.	*Anomalosipho altus*, var. *costellata*, S. V. Wood. Butley. (Kennard Collection)	151
12.	*Anomalosipho Actoni*, S. V. Wood. Little Oakley. (Harmer Collection)	152
13.	*Anomalosipho Bellii*, sp. nov. Butley. (Ipswich Museum) . .	151

J. Green. del London Stereoscopic Co. Im

PLATE XVI.

Fig.		Page.
1.	*Neptunea contraria* (Linné). Little Oakley. (Harmer Collection) .	156
2.	Ditto. Scaldisien, Antwerp. (Harmer Collection) . .	156
3.	var. *sinistrorsa*, Deshayes. Little Oakley. (Harmer Collection)	159
4.	ditto. Pleistocene, Sicily. (Harmer Collection) . .	159
5.	var. *carinata*, S. V. Wood. Little Oakley. (Harmer Collection)	160
6.	var. *informis*, nov. Little Oakley. (Harmer Collection) .	160
7.	var. *angulata*, S. V. Wood. Waldringfield. (Norwich Museum)	160

J. Green. del London Stereoscopic Co. Imp.

PLATE XVII.

J. Green. del.

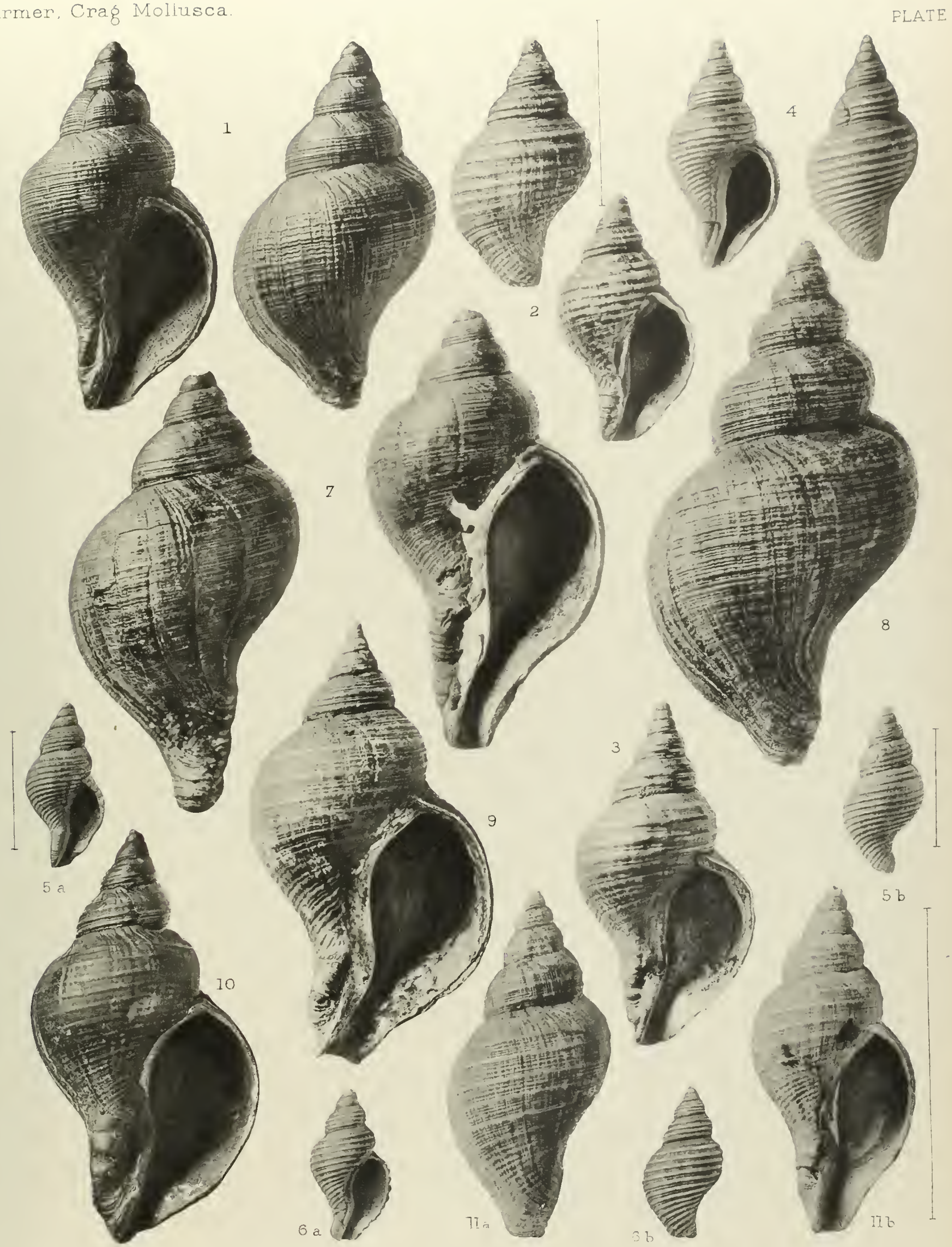
London Stereoscopic Co. Imp.

PLATE XVIII.

J. Green, del. London Stereoscopic Co. Imp.

PLATE XIX.

Fig.		Page.
1.	*Neptunea antiqua* (Linné). Newbourn. (Cambridge Museum) .	168
2.	var. *subtornata*, nov. Butley. (Cambridge Museum) . .	169
3.	ditto. Butley. (Cambridge Museum) . . .	169
4.	*Neptunea despecta* (Linné), var. *subspitzbergensis*, nov. Butley. (Cambridge Museum)	167
5.	ditto. Little Oakley. (Harmer Collection) . .	167
6.	ditto. Little Oakley. (Harmer Collection) . .	167
7.	*Neptunea antiqua* (Linné), var. *striata*, S. V. Wood. Sutton. (Harmer Collection)	169
8.	ditto. Thorpe, Norwich. (Norwich Museum) . .	169
9.	ditto. Bramerton. (Norwich Museum) . . .	169
10.	ditto. Butley. (Harmer Collection) . . .	169
11.	var. *icenica*, nov. Easton Bavent. (Harmer Collection) .	170



J. Green. del.

London Stereoscopic Co. Imp.

PLATE XX.

Fig.		Page.
1.	*Sipho islandicus* (Chemnitz). Recent, Vardö. (Harmer Collection) .	187
2.	Ditto. Little Oakley. (Harmer Collection) . . .	187
3.	*Sipho gracilis* (Da Costa). Recent, Lynn deeps. (Harmer Collection)	175
4.	Ditto. Little Oakley. (Harmer Collection) . . .	175
5.	var. *Coulsoni*, Jordan. Little Oakley. (Harmer Collection) .	177
6.	ditto. Recent. (Tomlin Collection) . . .	177
7.	var. *elongata*, nov. Boyton. (Harmer Collection) . .	177
8.	*Sipho propinquus* (Alder). Recent, Dogger Bank. (Harmer Collection)	195
9.	Ditto. Little Oakley. (Harmer Collection) . . .	195
10.	*Sipho latericeus* (Möller). Uddevalla. (Harmer Collection) . .	189
11.	Ditto. Recent. (Harmer Collection)	189
12.	Ditto. Little Oakley. (Harmer Collection) . . .	189

J. Green. del

London Stereoscopic Co. Imp

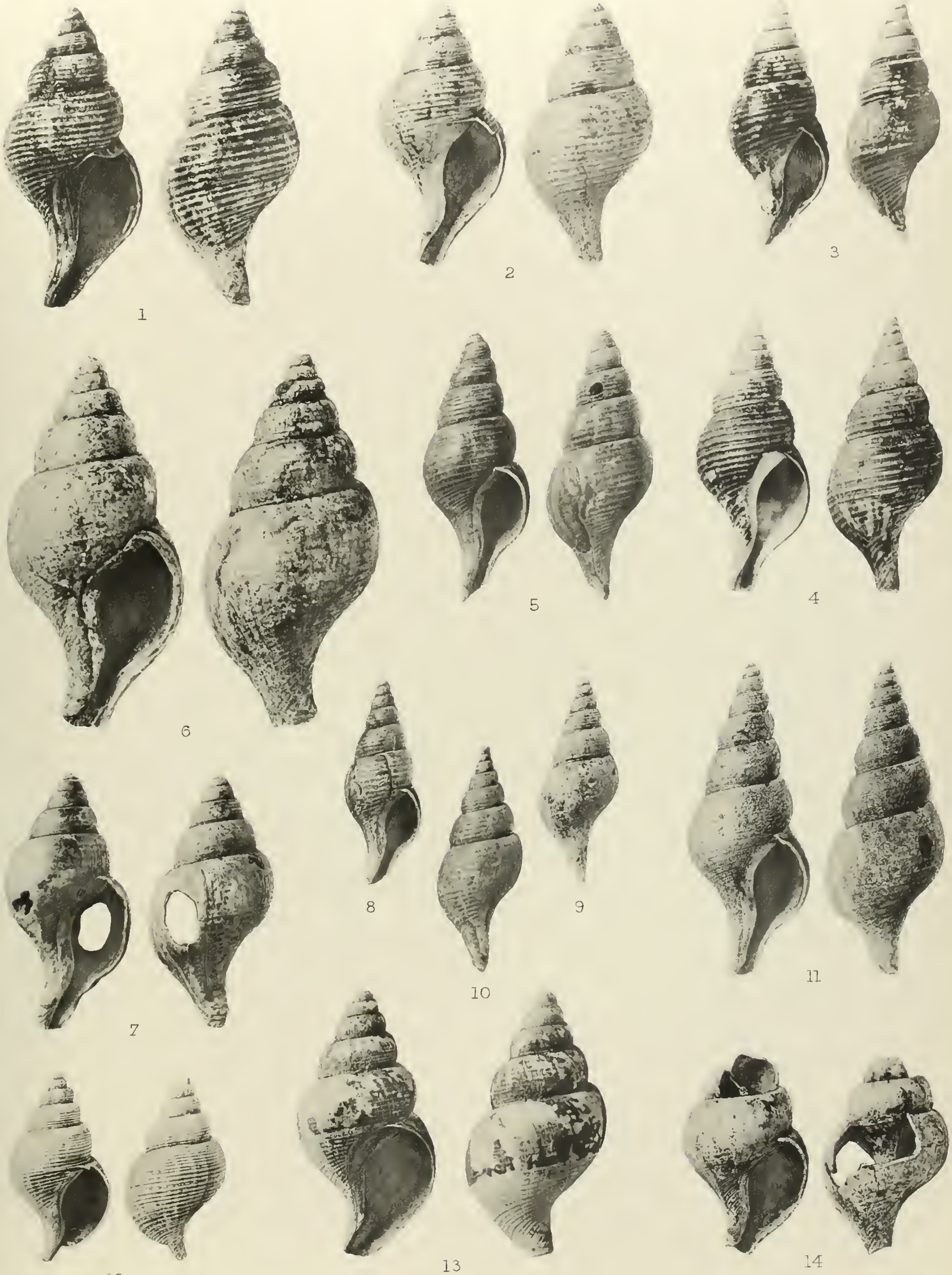
PLATE XXI.

J. Green. del

London Stereoscopic Co. Imp

PLATE XXII.

Fig.		Page.
1.	*Sipho togatus* (Mörch), var. *typica*. Waldringfield. (York Museum) .	180
2.	ditto. Pleistocene, Gettinge, Norway. (Christiania Museum) .	180
3.	var. *Frielei*, nov. Waldringfield. (Harmer Collection) .	182
4.	ditto. Recent, Polar Seas. (Friele Collection) . .	182
5.	*Sipho cordatus* (A. Bell). Little Oakley. (Harmer Collection) .	185
6.	*Sipho togatus* (Mörch), var. *crassa*, nov. Little Oakley. (Harmer Collection)	181
7.	var. *brevispira*, Brøgger Little Oakley. (Harmer Collection) .	182
8.	var. *minor*, nov. Foxhall. (Harmer Collection) . .	183
9.	ditto. Waldringfield. (Harmer Collection) . .	183
10.	ditto. Sutton. (Harmer Collection) . . .	183
11.	*Sipho Herendeenii* (Dall). Little Oakley. (Harmer Collection) .	184
12.	*Sipho Sarsii* (Jeffreys). Butley. (Jermyn Street Museum) . .	198
13.	*Sipho ebur* (Mörch). Recent, Norway. (Harmer Collection) .	197
14.	Ditto. Little Oakley. (Harmer Collection) . . .	197



J. Green. del

London Stereoscopic Co. Imp.

PLATE XXIII.

Fig.		Page.
1.	*Sipho Sabinii* (Gray). Butley. (York Museum)	183
2.	Ditto. Pleistocene, Gettinge, Norway. (Christiania Museum)	183
3.	Ditto. Little Oakley. (Harmer Collection)	183
4.	*Sipho minimus*, sp. nov. Boyton. (Cambridge Museum)	189
5.	*Sipho Olavii*, Mörch. Little Oakley. (Harmer Collection)	193
6.	Ditto. Pliocene, Iceland. (Mörch Collection)	193
7.	var. *Mörchii*, nov. Little Oakley. (Harmer Collection)	194
8.	ditto. Pliocene, Iceland. (Mörch Collection)	194
9.	ditto. Little Oakley. (Harmer Collection)	194
10.	*Sipho tortuosus* (Reeve). Recent, Northern Seas. (Friele Collection)	190
11.	Ditto. Little Oakley. (Harmer Collection)	190
12.	*Sipho tortuosus* (juv.). Recent, Northern Seas. (Friele Collection)	191
13.	Ditto. Little Oakley. (Harmer Collection)	190
14.	*Sipho Olavii*, Mörch, var. *conulus*, nov. Waldringfield. (York Museum)	195
15.	*Sipho tortuosus* (Reeve), var. *turrita*, M. Sars. Recent, Lofoten Islands. (Harmer Collection)	191
16.	ditto. Gedgrave. (Harmer Collection)	191
17.	*Sipho Menapiæ* (A. Bell). Wexford gravels. (Jermyn Street Museum)	186
18.	Ditto. Wexford gravels. (Jermyn Street Museum)	186
19.	Ditto. Isle of Man. (Harrison Collection)	186
20.	*Neptunea ventricosa* (Gray). Felixstow. (Norwich Museum)	171

J. Green del.

London Stereoscopic Co. Imp.

PLATE XXIV.

Fig.		Page.
1.	*Sipho glaber* (Verkrüzen). Recent, Vardö. (Harmer Collection)	188
2.	Ditto. Little Oakley. (Harmer Collection)	188
3.	*Sipho Jeffreysianus* (Fischer). Recent, Britain. (Tomlin Collection)	196
4.	Ditto. Little Oakley. (Harmer Collection)	196
5.	*Sipho tortuosus* (Reeve), var. *attenuata*, G. O. Sars. Boyton. (Harmer Collection)	191
6.	ditto. Scaldisien, Antwerp. (Harmer Collection)	191
7.	*Sipho elegans* (Mörch MS.), sp. nov. Pliocene, Iceland. (Harmer Collection)	199
8.	Ditto. Butley. (Harmer Collection)	199
9.	*Sipho Sarsii* (Jeffreys), var. *crassa*, nov. Little Oakley. (Harmer Collection)	198
10.	*Sipho exiguus*, sp. nov. Little Oakley. (Harmer Collection)	199
11.	*Sipho tortuosus* (Reeve), var. *lirata*, nov. Bramerton. (Harmer Collection)	192
12.	ditto. Boyton. (York Museum)	192
13.	ditto. Little Oakley. (Harmer Collection)	192
14.	ditto. Scaldisien, Antwerp. (Harmer Collection)	192
15.	ditto. Scaldisien, Antwerp. (Harmer Collection)	192
16.	*Neptunea ignota*, sp. nov. Postwick. (Norwich Museum)	173

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THE

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BY

RAMSAY H. TRAQUAIR, M.D., LL.D., F.R.S.,

LATE KEEPER OF THE NATURAL HISTORY COLLECTIONS IN THE ROYAL SCOTTISH MUSEUM, EDINBURGH.

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scales as in several other species of the genus; they are mostly smooth and flat—sometimes, however, the surface appears somewhat corrugated, but this I look on as a result of slight *post-mortem* distortion. The posterior border is sharply and minutely denticulated, the grooves between the denticles being sometimes prolonged forwards for a little distance over the surface.

Observations.—The only Carboniferous fish with which the present species could be confounded is *Rhadinichthys carinatus*, which occurs abundantly in the same shale and in the same state of preservation; but the contour of *Canobius macrocephalus* is characteristic. Its alliance with *Canobius pulchellus* and *C. politus* is in reality much more intimate.

Geological Position and Locality.—Abundant in the "Curly" Shale at Pumpherston and Roman Camp in the Broxburn district, West Lothian. Type specimen in the Collection of the Author.

5. Canobius crassus, *sp. nov.*, *Traquair.* Plate XL, fig. 5.

Description.—The length of the unique specimen represented in Pl. XL, fig. 5, is a little over $3\frac{1}{4}$ inches, but, as the head is squeezed a little backwards on the body, we may infer that its original length must have been a little more; the greatest depth of the body equals $1\frac{1}{4}$ inches. The general form is deeply fusiform, the contour of the back between the occipital region and the dorsal fin being gently rounded or arcuated.

Excepting a faint trace of the ventral between the anal and the region of the pectoral, there is nothing to be seen of the paired fins. The median fins are rather small; the dorsal and anal exhibit the usual triangular-acuminate contour; the caudal is heterocercal and deeply cleft; the rays of all the fins are delicate, distantly articulated and smooth on their surfaces.

The scales are rather small for the size of the fish; they are mostly smooth, though in some places we see the impressions of minute contorted ridges on the anterior part of the surface. There are a few large median dorsal scales just in front of the dorsal fin, but these do not form a line extending the whole distance to the occiput. The scales of the flank are prominently denticulated along their hinder margins.

Observations.—The above-described unique specimen is a sharp impression or "counterpart" representing a fish which I cannot refer to any hitherto described species, though I have no hesitation in referring it to the genus *Canobius.* Perhaps it resembles *C. politus* more than any other, but it differs conspicuously by its deep, highly arched body and small fins.

Geological Position and Locality.—From the Calciferous Sandstone Series, Glencartholm, Eskdale, in the Collection of the Author.

[Owing to the death of the Author when the Monograph had been completed thus far, the following concluding paragraphs are compiled from his published papers.]

Genus—Eurylepis, *Newberry*, 1857.

1. Eurylepis anglica, *Traquair*.

Eurylepis anglica, *Traquair*. Ann. Mag. Nat. Hist. [6], vol. xiv, 1894, p. 373, pl. ix, fig. 9.

Description.—This is the posterior part of a cranial shield, representing the fused parietals, frontals, and squamosals; it is $\frac{1}{4}$ inch in length and the same in breadth across the parietal region. It is ornamented with tolerably coarse rounded ridges, which are comparatively slightly elevated and mainly follow a direction concentric with the margins of the respective bones, except at the anterior angle of each frontal, where there is a group of ridges, which pass obliquely inwards and a little backwards, so as in the middle line to meet those of the opposite side at an obtuse angle.

Observations.—This little relic is almost identical with the similar cranial shield of *Eurylepis tuberculata*, Newberry,[1] from the Coal Measures of Linton, Ohio, but differs in the ornament being more of a ridged than tuberculated character.

Messrs. Hancock and Atthey mention, without description, the occurrence of a fish in the Northumberland coal-field which they suspected might belong to Newberry's *Eurylepis*; but there cannot be any doubt of the generic position of this, the first figured English specimen.

Geological Position and Locality.—From the Ash Coal-shale (Upper Carboniferous), Longton, Staffordshire. Collected by Mr. J. Ward, F.G.S., by whom it was lent to me for description. The specimen is now in the British Museum.

Genus—Styracopterus, *Traquair*, 1890.

A genus closely related to *Benedenichthys*, Traquair, from the Carboniferous Limestone of Belgium (*Benedenius*, Traquair, in de Koninck's 'Faune du Calcaire carbonifère de la Belgique,' pt. i, 1878, p. 15).

1. Styracopterus fulcratus, *Traquair*.

Holurus fulcratus, *Traquair*. Trans. Roy. Soc. Edinb., vol. xxx, 1881, p. 46, pl. iii, figs. 13, 14.

Styracopterus fulcratus, *Traquair*. Ann. Mag. Nat. Hist. [6], vol. vi, 1890, p. 492.

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[1] 'Geol. Survey Ohio, Palæontology,' vol. i, 1873, p. 350, pl. xxxviii, fig. 2 *c*.

Specific Characters.—Scales very similar in shape, proportions, and markings to those of *Holurus Parki*, but no denticulations visible on the posterior margins even of the most anteriorly situated flank-scales. A row of pointed imbricating azygous scales extends along the middle line of the back, from the head to the dorsal fin, and these are much stronger and with fewer and coarser ridges than in *Holurus Parki*. At the commencement of the dorsal fin, these median scales pass into a few large and prominent fulcra placed along its anterior margin; the rest of the fin is conformed as in *Holurus Parki*, extending, as in it, to the commencement of the tail pedicle, but the transverse articulations of the rays seem a little more distant. Anteriorly, the impressions of a few similar fulcra are seen adpressed to the body, as if they had belonged to the pectoral.

Observations.—The type specimen, in the collection of the Geological Survey of Scotland, shows the greater part of the body with the dorsal margin and dorsal fin, but it is deficient in the head, the ventral margin, and the other fins. Finer specimens have since been obtained by the same Survey.

Geological Position and Locality.—Lower Carboniferous (Calciferous Sandstone), Tarras Foot, Eskdale, Dumfriesshire.

INDEX.

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91—118	XIX—XXVI	1904	December, 1904
119—130	XXVII—XXXI	1906	December, 1906
131—134	—	1913	February, 1914

A MONOGRAPH

THE FISHES

OF THE

OLD RED SANDSTONE OF BRITAIN.

PART I.—THE CEPHALASPIDÆ.

BY

SIR E. RAY LANKESTER, K.C.B., F.R.S.

PART II.—THE ASTEROLEPIDÆ.

BY

RAMSAY H. TRAQUAIR, M.D., LL.D., F.R.S.

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SYSTEMATIC INDEX.

b

Fig. 3 shows the impression of the ventral surface of the carapace and of the left pectoral appendage, an internal mould of the greater part of the right one being also present. The imprints of the flat inferior portions of all four *ventro-lateral* plates are seen, also the respective positions of the *semilunar* plate (*s. l.*) and of the small lozenge-shaped *median ventral*. Owing to the oblique squeeze to which the body has been subjected, the lateral portions of the right anterior and posterior ventro-lateral plates are also seen in impression. The pectoral appendages, neither of which is complete, must have, judging from what remains of them, attained a length equal to the distance between the pectoral articulation and the posterior extremity of the ventral aspect of the carapace. I observe no evidence of denticulation on their outer margins.

Fig. 4 is one of the two specimens collected by Mr. Taylor, and shows the impression of a portion of the dorsal aspect of the carapace represented by portions of the following plates: *anterior median dorsal* (*a. m. d.*), *posterior median dorsal* (*p. m. d.*), left *anterior dorso-lateral* (*a. d. l.*), and left *posterior dorso-lateral* (*p. d. l.*). Crossing obliquely that hinder portion of the anterior median dorsal plate which is shown in this fragment, the left line of the V-shaped dorsal sensory groove is seen, but the great feature of the specimen is the impression of the median crest in the form of a deep cleft placed along the mesial line of the posterior part of the plate and the anterior part of the posterior median dorsal. The very same feature being shown quite as clearly in the second specimen, also the impression of a portion of the back, which the Edinburgh Museum owes to Mr. Taylor, and the two being compared with Dr. Gordon's original example, there can be no doubt as to the existence of the remarkable feature which led me to establish the species *cristata* on the above described material. The external sculpture of the plates in all three specimens has the same fine tuberculo-reticulate character.

Remarks.—The singular median dorsal crest distinguishes this species from all other members of the genus *Bothriolepis.*

If the nearly entire specimen represented in Figs. 1 and 2 on Pl. XXXI seems to denote an Asterolepid of a more narrow and elevated contour of body than is indicated by the fragment of the dorsal surface shown in Fig. 4, I rather think that that is due to lateral compression in the former case, and not to specific distinction.

Geological Position and Locality.—The species is known only from the Upper Old Red Sandstone of the Rosebrae Quarry, near Elgin.

INDEX.

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