

PALÆONTOGRAPHICAL SOCIETY.

VOL. LXI.

THE SIRENOID GANOIDS.

PART II.

TITLE-PAGE, PREFACE, AND POSTSCRIPT.

THE CARBONIFEROUS GANOID FISHES.

PART I. No. 3.

PAGES 87—106; PLATES XIX—XXIII.

FOSSIL FISHES OF THE ENGLISH CHALK.

PART III.

PAGES 97—128; PLATES XXI—XXVI.

THE INFERIOR OOLITE AMMONITES.

VOL. I.

TITLE-PAGES TO ATLAS AND TEXT VOLS., PREFACE, AND INDEX.

THE CRETACEOUS LAMELLIBRANCHIA.

VOL. II, PART IV.

PAGES 133—180; PLATES XX—XXVII.

THE BRITISH FOSSIL ECHINODERMATA.

VOL. II, PART IV.

PAGES 91—132; PLATES XXVII—XXIX.

THE BRITISH CONULARIÆ.

PAGES 1—41; PLATES I—V.

THE BRITISH CAMBRIAN TRILOBITES.

PART II.

PAGES 29—48; PLATES III, IV.

BRITISH GRAPTOLITES.

PART VI.

PAGES xcvi—cxx, 217—272; PLATES XXVIII—XXXI.

THE DEVONIAN FAUNA OF THE  
SOUTH OF ENGLAND.

VOLS. II AND III.

TITLE-PAGES AND INDEXES.

THE FAUNA OF THE CORNBURASH.

PART II.


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# PALÆONTOGRAPHICAL SOCIETY.

## VOLUME LXI.

### CONTAINING

1. THE SIRENOID GANOIDS. By Prof. I. C. MIALL. Part II, Title-page, Preface, and Postscript.
2. THE CARBONIFEROUS GANOID FISHES. Part I, No. 3. By Dr. R. H. TRAQUAIR. Five Plates.
3. THE FISHES OF THE ENGLISH CHALK. Part III. By Dr. A. S. WOODWARD. Six Plates.
4. THE INFERIOR OOLITE AMMONITES. Part XIV, Title-pages, Preface, and Index. By Mr. S. S. BUCKMAN.
5. THE CRETACEOUS LAMELLIBRANCHIA. Vol. II, Part IV. By Mr. H. WOODS. Eight Plates.
6. THE FOSSIL ECHINODERMATA, CRETACEOUS. Vol. II, Part IV. By Mr. W. K. SPENCER. Three Plates.
7. THE BRITISH CONULARIÆ. By Miss I. L. SLATER. Five Plates.
8. THE CAMBRIAN TRILOBITES. Part II. By Mr. P. LAKE. Two Plates.
9. BRITISH GRAPTOLITES. Part VI. By Miss ELLES and Miss WOOD. Edited by Prof. LAPWORTH. Four Plates.
10. THE DEVONIAN FAUNA OF THE SOUTH OF ENGLAND. Title-pages and Indexes to Vols. II, III. By Rev. G. F. WHIDBORNE.
11. THE FAUNA OF THE CORNBRAsh. Part II, Title-page and Index. By Rev. J. F. BLAKE.

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ISSUED FOR 1907.

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LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

AGENTS FOR THE SOCIETY:

DULAU AND CO., 37, SOHO SQUARE, W.

DECEMBER, 1907.

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

The Cambrian Trilobites, by Mr. Philip Lake.

The Cretaceous Lamellibranchia, by Mr. H. Woods.

The Palæoniscid Fishes of the Carboniferous Formation, and the Fishes of the Old Red Sandstone, by Dr. R. H. Traquair.

The Fishes of the English Chalk, by Dr. A. Smith Woodward.

Geology  
QE 701  
.P29

ANNUAL REPORT

OF THE

PALÆONTOGRAPHICAL SOCIETY, 1907,

WITH

L I S T

OF

The Council, Secretaries, and Members

AND

A LIST OF THE CONTENTS OF THE VOLUMES ALREADY  
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# ANNUAL REPORT OF THE COUNCIL

FOR THE YEAR ENDING 31<sup>ST</sup> DECEMBER, 1906.

READ AND ADOPTED AT THE

ANNUAL GENERAL MEETING,

HELD AT THE APARTMENTS OF THE GEOLOGICAL SOCIETY, BURLINGTON HOUSE,  
15<sup>TH</sup> MARCH, 1907.

DR. HENRY WOODWARD, F.R.S., PRESIDENT,

IN THE CHAIR.

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THE Council, in presenting their Sixtieth Annual Report, have pleasure in congratulating the Society on its continued prosperity. There is no decline in the number or value of the monographs offered for publication, and the contributions included in the volume for 1906 are no less varied than usual. This volume, which was distributed in December, contains a Monograph of the "Pleistocene Bears," by Prof. S. H. Reynolds; instalments of the Monographs of "Old Red Sandstone Fishes," by Dr. Traquair; of "Cretaceous Lamellibranchia," by Mr. H. Woods; and of "British Graptolites," by the Misses Elles and Wood; the concluding part of the "Lower Palæozoic Trilobites of Girvan," by Mr. F. R. Cowper Reed; and the first part of a new Monograph of "Cambrian Trilobites," by Mr. Philip Lake. The volume is illustrated by 32 plates.

The bank balance at the beginning of the year was only £26 11s. 3*d.*, and had risen by December 31<sup>st</sup> to £145 5s. 0*d.*; but this increase was due to exceptional circumstances. Owing to the crowding of the Society's stock-room by too large a number of copies of certain volumes, the Council decided to offer the surplus to members at one third the published price. The result was a sale of back stock on

these reduced terms to the value of £76 1s. 1*d.*—a sum which formed a welcome addition to the Society's funds. The Society is also indebted to the generosity of the Carnegie Trust for the Universities of Scotland, which presented the five plates to illustrate Dr. Traquair's Monograph of "Old Red Sandstone Fishes." Other donations were received from Prof. Charles Lapworth, Mr. F. R. Cowper Reed, and Mr. Henry Woods. Without these additional sources of income, the expenditure on the volume for 1906 would have about equalled the total receipts from normal sources of the year.

The thanks of the Society are due, not only to the several donors mentioned, but also 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.

Each year the Society sustains serious losses by death, and during 1906 the Council had to lament the death of two of its members—the Rev. J. F. Blake and Mr. Thomas Leighton. Mr. Blake was an accomplished geologist and palæontologist, and had contributed to the Society's publications the first part of a monograph of the Cornbrash fauna, which, unfortunately, remains unfinished. Mr. Leighton added to his scientific attainments wide experience in business, which he was always ready to place at the Council's disposal. Among other active supporters, Miss Caroline Birley and Mr. W. Dickinson have also died since the last Annual Meeting.

In conclusion, it is proposed that the retiring members of Council be Messrs. Bather, Harmer, and Reed; that the new members be Mr. J. Hopkinson, Mr. W. D. Lang, Mr. H. Woods, and Mr. G. W. Young; 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.



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CORRECTED TO 1ST AUGUST, 1907.

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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.<sup>1</sup> 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 Lepididæ, 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).

<sup>1</sup> 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.<sup>1</sup> 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 Balanidae and Verrucidae, 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.<sup>2</sup> 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—xxxix).
  - 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—xlvi).
  - 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).

<sup>1</sup> This Volume is marked on the outside 1855.<sup>2</sup> 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 and Wealden Formations (Supplement, No. 4), by Prof. Owen (pp. 1—18, pls. i—ix).
- „ 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 (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.<sup>1</sup> 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).

<sup>1</sup> 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).
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for the Year 1869
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- „ XXIV. Issued Jan., 1871,  
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- The Flora of the Carboniferous Strata, Part II, by Mr. E. W. Binney (33—62, pls. vii—xii).
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  - 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).
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- „ XXVI. Issued Oct., 1872,  
for the Year 1872
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  - The Fossil Merostomata, Part IV (*Stylonurus*, *Eurypterus*, *Hemiaspis*), by Mr. H. Woodward (pp. 121—180, pls. xxi—xxx).
  - The Fossil Trigonidæ, 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).
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  - 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 (Hylæochampsä), 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).
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  - The Fossil Trigonidæ, 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).
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- „ XXX. Issued Dec., 1876,  
for the Year 1876
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- „ XXXI. Issued Feb., 1877.  
for the Year 1877
- Supplement to the Eocene Mollusca (Bivalves), by Mr. S. V. Wood, 2 plates.
  - The Fossil Trigonidæ, 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).
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  - The Fossil Elephants (*E. antiquus*), Part I, by Prof. Leith Adams (pp. 1—68, pls. i—v).
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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).
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  - 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 Trigonïæ, 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, Brachydictes, Nannosuchus, Theriosuchus, and Nuthetes), No. IX, by Prof. Owen (pp. 1—19, pls. i—iv).
  - The Fossil Elephants (*E. primigenius*), Part II, by Prof. Leith Adams (pp. 69—146, pls. vi—xv).
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for the year 1880
- The Eocene Flora, Vol. I, Part II, by Mr. J. S. Gardner and Baron Ettingshausen (pp. 39—58, pls. vi—xi).
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- „ XXXV. Issued May, 1881,  
for the Year 1881
- The Fossil Echinodermata, Cretaceous, Vol. I, Part IX, by Dr. Wright (pp. 301—324, pls. lxx—lxxv).
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  - The Fossil Trigonïæ (Supplement No. 1), by Dr. Lycett (pp. 1—4).
  - The Lias Ammonites, Part IV, by Dr. Wright (pp. 265—328, pls. xxii A, xxii B, xli—xlviii).
  - The Reptilia of the Liassic Formations, Part III, by Prof. Owen (pp. 83—134, pls. xxi—xxxiii, and title-page).
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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).
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  - Do., Vol. V, Part I (Devonian and Silurian), by Dr. Davidson (pp. 1—134, pls. i—vii).
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- „ XXXVII. Issued Oct., 1883,  
for the Year 1883
- The Eocene Flora, Vol. II, Part I, by Mr. J. S. Gardner (pp. 1—60, pls. i—ix).
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  - The Fossil Trigonïæ (Supplement No. 2), by the late Dr. Lycett (pp. 5—19, pls. i—iv and title-page).
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- „ XXXVIII. Issued Dec., 1884,  
for the Year 1884
- The Eocene Flora, Vol. II, Part II, by Mr. J. S. Gardner (pp. 61—90, pls. x—xx).
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  - Supplement to the Fossil Brachiopoda, Vol. V, Part III, by Dr. Davidson (pp. 243—476, pls. xviii—xxi, and title-page).
  - The Lias Ammonites, Part VII, by Dr. Wright (pp. 441—480, pls. lxxviii—lxxxvii).

## 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).
- „ XL. Issued Mar., 1887,  
for the Year 1886
- The Morphology and Histology of *Stigmaria Fieoides*, by Prof. W. C. Williamson (pp. i—iv, 1—62, pls. i—xv).
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  - The Jurassic Gasteropoda, Part I, No. 1, by Mr. W. H. Hudleston (pp. 1—56).
  - The Inferior Oolite Ammonites, Part I, by Mr. S. S. Buckman (pp. 1—24, pls. i—vi).
  - The Pleistocene Mammalia, Part VI, by Prof. Boyd Dawkins (pp. 1—29, pls. i—vii).
- „ XLI. Issued Jan., 1888,  
for the Year 1887
- The Fossil Sponges, Part II, by Dr. G. J. Hinde (pp. 93—188, pl. ix).
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  - The Jurassic Gasteropoda, Part I, No. 2, by Mr. W. H. Hudleston (pp. 57—136, pls. i—vi).
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- „ XLII. Issued Mar., 1889,  
for the Year 1888
- The Stromatoporoids, Part II, by Prof. Alleyne Nicholson (pp. 131—158, pls. xii—xix).
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for the Year 1889
- The Cretaceous Entomostraca (Supplement), by Prof. T. Rupert Jones and Dr. G. J. Hinde (pp. i—viii, 1—70, pls. i—iv).
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  - The Inferior Oolite Ammonites, Part IV, by Mr. S. S. Buckman (pp. 145—224, pls. xxiv—xxxvi).
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- „ XLIV. Issued Apr., 1891,  
for the Year 1890
- The Stromatoporoids, Part III, by Prof. Alleyne Nicholson (pp. 159—202, pls. xx—xxv).
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  - The Inferior Oolite Ammonites, Part V, by Mr. S. S. Buckman (pp. 225—256, pls. xxxvii—xliv).
  - The Devonian Fauna of the South of England, Part III, by the Rev. G. F. Whidborne (pp. 155—250, pls. xvi—xxiv).
  - Title-pages to the Supplement to the Fossil Corals, by Prof. Duncan.
- „ XLV. Issued Feb., 1892,  
for the Year 1891
- The Jurassic Gasteropoda, Part I, No. 5, by Mr. W. H. Hudleston (pp. 225—272, pls. xvii—xx).
  - The Inferior Oolite Ammonites, Part VI, by Mr. S. S. Buckman (pp. 257—312, pls. xlv—lvi).
  - The Devonian Fauna of the South of England, Part IV (*Conclusion of Vol. I*) (pp. 251—344, pls. xxv—xxxi, and title-page).
  - „ „ Vol. II, Part I, by the Rev. G. F. Whidborne (pp. 1—56, pls. i—v).

## 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 Phyllopora, 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).
- „ XLVII. Issued Dec., 1893,  
for the Year 1893
- The Fossil Sponges, Part III, by Dr. G. J. Hinde (pp. 189—254, pls. x—xix).
  - The Fossil Echinodermata, Cretaceous, Vol. II, Part II (Asteroidea), by Mr. W. Percy Sladen (pp. 29—66, pls. ix—xvi).
  - The Inferior Oolite Ammonites, Part VIII, by Mr. S. S. Buckman (pp. 345—376, pls. lxxvii—xcii).
  - The Devonian Fauna of the South of England, Vol. II, Part III, by the Rev. G. F. Whidborne (pp. 89—160, pls. xi—xvii).
- „ XLVIII. Issued Nov., 1894,  
for the Year 1894
- The Jurassic Gasteropoda, Part I, No. 7, by Mr. W. H. Hudleston (pp. 325—390, pls. xxvii—xxxii).
  - Carbonicola, Anthracomya, and Naiadites, Part I, by Dr. W. Hind (pp. 1—80, pls. i—xi).
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- „ XLIX. Issued Oct., 1895,  
for the Year 1895
- The Crag Foraminifera, Part II, by Prof. T. R. Jones (pp. 73—210, pls. v—vii).
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  - The Devonian Fauna of the South of England, Vol. II, Part IV, by the Rev. G. F. Whidborne (pp. 161—212, pls. xviii—xxiv).
- „ L. Issued Oct., 1896,  
for the Year 1896
- The Crag Foraminifera, Part III, by Prof. T. R. Jones (pp. 211—314).
  - The Jurassic Gasteropoda, Part I, No. 9, by Mr. W. H. Hudleston (pp. 445—514, pls. xli—xliv, and title-page).
  - Carbonicola, Anthracomya, and Naiadites, Part III, by Dr. W. Hind (pp. 171—182, pl. xxi, and title-page).
  - The Carboniferous Lamellibranchiata, Part I, by Dr. W. Hind (pp. 1—80, pls. i, ii).
  - The Devonian Fauna of the South of England, Vol. III, Part I, by the Rev. G. F. Whidborne (pp. 1—112, pls. i—xvi).
- „ LI. Issued Dec., 1897,  
for the Year 1897
- The Crag Foraminifera, Part IV, by Prof. T. R. Jones (pp. vii—xv, 315—402, and title-page).
  - The Carboniferous Lamellibranchiata, Part II, by Dr. W. Hind (pp. 81—208, pls. iii—xv).
  - The Carboniferous Cephalopoda of Ireland, Part I, by Dr. A. H. Foord (pp. 1—22, pls. i—vii).
  - The Devonian Fauna of the South of England, Vol. III, Part II, by the Rev. G. F. Whidborne (pp. 113—178, pls. xvii—xxi).
- „ LII. Issued Dec., 1898,  
for the Year 1898
- The Palæozoic Phyllopora, 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—xxxii, 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).
- „ LIV. Issued Dec., 1900,  
for the Year 1900
- The Cretaceous Lamellibranchia, Part II, by Mr. H. Woods (pp. 73—112, pls. xv—xix).
  - The Carboniferous Lamellibranchiata, Part V, by Dr. W. Hind (pp. 361—476, pls. xl—liv).
  - The Carboniferous Cephalopoda of Ireland, Part III, by Dr. A. H. Foord (pp. 49—126, pls. xviii—xxxii).
  - The British Pleistocene Mammalia, Title-page for Vol. I, by Messrs. Dawkins and Sanford.
  - The Structure of Carboniferous Plants, Title-page, by Mr. E. W. Binney.
- „ LV. Issued Dec., 1901,  
for the Year 1901
- The Cretaceous Lamellibranchia, Part III, by Mr. H. Woods (pp. 113—144, pls. xx—xxvi).
  - The Carboniferous Lamellibranchiata, Vol. II, Part I, by Dr. W. Hind (pp. 1—34, pls. i—vi), Title-page and Index for Vol. I.
  - The Carboniferous Cephalopoda of Ireland, Part IV, by Dr. A. H. Foord (pp. 127—146, pls. xxxiii—xxxix).
  - British Graptolites, Part I, by Miss Elles and Miss Wood, edited by Prof. Lapworth (pp. 1—54, pls. i—iv).
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  - The Carboniferous Lamellibranchiata, Vol. II, Part II, by Dr. W. Hind (pp. 35—124, pls. vii—xxi).
  - The Carboniferous Cephalopoda of Ireland, Part V, by Dr. A. H. Foord (pp. 147—234, pls. xl—xlix), Title-page and Index.
  - The Lower Palæozoic Trilobites of Girvan, Part I, by Mr. F. R. Cowper Reed (pp. 1—48, pls. i—vi).
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for the Year 1904
- The Fishes of the Old Red Sandstone, Part II, No. 2, by Dr. R. H. Traquair (pp. 91—118, pls. xix—xxvi).
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  - The Carboniferous Lamellibranchiata, Vol. II, Part III, by Dr. W. Hind (pp. 125—216, pls. xxii—xxv).
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  - The Lower Palæozoic Trilobites of Girvan, Part II, by Mr. F. R. Cowper Reed (pp. 49—96, pls. vii—xiii).
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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).
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  - The Inferior Oolite Ammonites, Part XIII, by Mr. S. S. Buckman (pp. clxix—ccviii, pls. xx—xxiv).
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for the Year 1906
- The Pleistocene Bears, by Prof. S. H. Reynolds (pp. 1—35, pls. i—viii).
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  - 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).
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- „ 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).
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  - The Cretaceous Lamellibranchia, Vol. II, Part IV, by Mr. H. Woods (pp. 133—180, pls. xx—xxvii).
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  - The Cornbrash Fauna, Part II, by the Rev. J. F. Blake (pp. 101—102, Title-page and Index).



THE  
PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

LONDON :

MDCCCLXXVIII—MDCCCXVII.

## THE SIRENOID GANOIDS.

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### ORDER OF BINDING AND DATES OF PUBLICATION.

PAGES.	PLATES.	ISSUED IN VOL. FOR YEAR.	PUBLISHED.
1—32	I—V	1878	March, 1878
3, 34, Title-page and Preface	—	1907	December, 1907

THE  
SIRENOID GANOIDS,

WITH A DESCRIPTION OF THE

BRITISH FOSSIL TEETH OF CERATODUS.

BY

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LONDON :

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1878—1907.



## POSTSCRIPT.

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THE variable teeth grouped under the specific name of *Ceratodus polymorphus* on p. 28 had already been similarly arranged in 1850 by E. Beyrich,<sup>1</sup> who proposed that the species should be known as *C. anglicus*. It is now customary, however, to quote this type species of *Ceratodus* as *C. latissimus*, thus employing the first of the seven names given by Agassiz to the teeth in question. Numerous specimens have been discovered since the preceding pages were written, and they are now known from the Rhætic of ten localities in Gloucestershire, Somersetshire, Glamorganshire, Leicestershire, and Nottinghamshire.<sup>2</sup>

The type specimen of *Ceratodus Phillipsii*, from the Stonesfield Slate, is now known to be preserved in the Museum of Natural History at Neuchâtel. Another characteristic tooth of the same species, in the Northampton Museum, was discovered by Mr. Thomas Jesson in the Great Oolite near Northampton.<sup>3</sup>

A second example of *Ceratodus lævissimus* was found by the Rev. P. B. Brodie in the Lower Keuper of Coton End, Warwick, and is now in the British Museum.<sup>4</sup> This tooth is closely similar to that of *C. Kaupi* from the Lettenkohl of Würtemberg, but its denticles are more acute and the ridges more compressed than in the latter form.

Beyond teeth and unimportant pieces of bone, no fossil remains of *Ceratodus* have hitherto been found in Britain, and only two discoveries of characteristic portions of the skeleton have been made elsewhere. A tail closely resembling that of the existing *Ceratodus* is known from the Lettenkohl of Bavaria, and is now in the University Museum at Würzburg.<sup>5</sup> A well-preserved skull and mandible from the Upper Keuper of Polzberg, near Lunz, Austria, is also very similar to the corresponding part of the existing species, but differs in its greater degree of ossification.<sup>6</sup>

<sup>1</sup> 'Zeitschr. deutsch. geol. Gesell.,' vol. ii (1850), p. 159.

<sup>2</sup> L. Richardson, 'Proc. Cotteswold Nat. Field Club,' vol. xv (1906), pp. 267—271.

<sup>3</sup> A. S. Woodward, 'Proc. Geol. Assoc.,' vol. xi (1890), p. 292, pl. iii, fig. 5.

<sup>4</sup> A. S. Woodward, 'Ann. and Mag. Nat. Hist' [6], vol. xii (1893), p. 282, pl. x, fig. 1.

<sup>5</sup> *Calacanthus giganteus*, T. C. Winkler, 'Archiv Mus. Teyler,' vol. v (1880), p. 141, pl. ix. Identified with *Ceratodus* by K. A. von Zittel, 'Sitzungsb. k. bay. Akad., math.-phys. Cl.,' 1886 p. 259.

<sup>6</sup> *Ceratodus Sturi*, F. Teller, 'Abhandl. k. k. geol. Reichsanst.,' vol. xv, pt. 3 (1891).

Discoveries of fossil teeth during the last three decades, however, have much extended our knowledge of the geographical range of *Ceratodus* during successive geological periods. Triassic and Rhætic species are now known, not only from Europe and India, but also from South Africa.<sup>1</sup> During the Jurassic period the genus was represented in Europe (see p. 32), North America,<sup>2</sup> and Australia.<sup>3</sup> Teeth of Cretaceous age have been found in Central Africa<sup>4</sup> and Patagonia;<sup>5</sup> and evidence of a supposed extinct species occurs in the comparatively modern river-deposits of Queensland.<sup>6</sup> It is therefore probable that *Ceratodus* was nearly cosmopolitan during the greater part of the Secondary Epoch, and became restricted to the Australian region only during Tertiary times.

<sup>1</sup> *Ceratodus capensis*, A. S. Woodward, 'Ann. and Mag. Nat. Hist.' [6], vol. iv (1889), p. 243, pl. xiv, fig. 4; Stormberg Beds, Smithfield, Orange Colony.—*Ceratodus Kannemeyeri*, H. G. Seeley, 'Geol. Mag.' [4], vol. iv (1897), p. 543, with fig.; Stormberg Beds, Kraai Fontein, Cape Colony.

<sup>2</sup> *Ceratodus Guentheri*, O. C. Marsh, 'Amer. Journ. Sci.' [3], vol. xv (1878), p. 76, with fig.; Upper Jurassic, Colorado.

<sup>3</sup> *Ceratodus avus*, A. S. Woodward, 'Ann. and Mag. Nat. Hist.' [7], vol. xviii (1906), p. 2, pl. i, fig. 1: Lower Jurassic, Cape Patterson, Victoria, Australia.

<sup>4</sup> *Ceratodus africanus*, E. Haug, 'Comptes Rendus,' vol. cxxxviii (1904), p. 1529, and in Foureau, 'Docum. Sci. Miss. Saharienne,' vol. ii (1905), p. 819, pl. xvii, figs. 1—5; Djoua, Timassânine, Sahara. Also *C. minutus*, Haug, *tom. cit.*, 1905, p. 821, pl. xvii, fig. 6.

<sup>5</sup> *Ceratodus Iheringi*, F. Ameghino, 'Public. Univ. La Plata,' no. 2 (1904), p. 10, fig. 1.

<sup>6</sup> *Ceratodus Palmeri*, G. Krefft, 'Nature,' vol. ix (1874), p. 293. See also W. B. Clarke, 'Mines and Min. Statistics N. S. Wales' (1875), p. 205, and C. W. De Vis, 'Proc. Roy. Soc. Queensland,' vol. i (1884), p. 40.

Palæontographical Society, 1907.

THE  
GANOID FISHES

OF THE  
BRITISH CARBONIFEROUS FORMATIONS.

BY  
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PART I.  
PALÆONISCIDÆ.

No. 3.

PAGES 87—106; PLATES XIX—XXIII.

LONDON:  
PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.  
1907.

14. ELONICHTHYS DENTICULATUS, *Traquair*. Plate XX, figs. 1—2.

ELONICHTHYS DENTICULATUS, *Traquair*. Geol. Mag. [5], vol. iii, 1906, pp. 556, 557.

*Description*.—The remains of a Palæoniscid fish from the Lower Carboniferous rocks of Flintshire, submitted to me by Mr. J. T. Stobbs, F.G.S., are unfortunately not sufficiently perfect to afford material for a complete diagnosis. The specimen shows the impressions of the outer surface of both mandibular rami and of the left maxilla, and beyond this we have only a mass of dislocated scales—the general form of the fins, and the condition of the fin-rays being entirely lost.

The mandible is three quarters of an inch in length, slender and tapering, the external sculpture, according to the impression left, consisting of fine close ridges, which, in feather fashion, diverge upwards and forwards and downwards and forwards from a line running longitudinally along the middle of the surface, thus forming a series of backwardly directed acute angles. The maxilla is of the usual Palæoniscid form, the suborbital process being long and slender, and the expanded post-orbital portion ornamented, as shown by the impression, with fine ridges, which mostly run parallel with the posterior and superior borders.

Among the scales may be distinguished some which are nearly equilateral and only slightly oblique—these belonged to the flank; others, longer than high, were ventral in position; while others again, smaller in size and more oblique in contour, appertained to the tail. The flank scales (Pl. XX, fig. 1) are about one tenth of an inch in height and have nearly the same breadth; the overlapped area is scarcely perceptible; the free surface is marked with fine striæ, which run mostly parallel with the upper and lower margins, a very few of the lowest ones turning up in front so as to run parallel with the anterior margin; while again a number of deeper indentations divide the posterior margin into six to eight strong and sharp denticulations. The ventral scales (fig. 2), being lower in contour, have fewer denticulations on the hinder border, these numbering from three to five. As to the caudal scales, though it is evident that they remained highly ornate up to the extremity, it is not clear how far posteriorly the denticulated character persisted.

*Remarks*.—The configuration of the mandible and maxilla clearly proves that the position of the present fish is in the family Palæoniscidæ, but owing to the complete absence of fins or fin-rays the evidence as to the genus is not conclusive. According to the form and sculpture of the scales the fish might appertain either to *Rhadinichthys* or to *Elonichthys*. Perhaps the scales have the greatest resemblance in sculpture to those of *Elonichthys Egertoni* (Egerton), but the denticulations of the posterior margin are proportionally coarser. Anyway, the association on these scales of fine striæ with comparatively coarse denticulations of the hinder margin is a feature which leads me to

believe that the species is new to science, and I have consequently named it *Elonichthys denticulatus*.

*Geological Position and Locality.*—From the base of the Pendleside Series (Lower Carboniferous), near Holywell, Flintshire.

15. ELONICHTHYS STRIATULUS, *Traquair*. Plate XX, figs. 3—5.

1904. ELONICHTHYS STRIATULUS, *Traquair*. Summ. Progr. Geol. Survey for 1903, p. 121.

1907. — — — *Traquair*. Trans. Roy. Soc. Edinb., vol. xlvi, pt. i (no. 4), pp. 107, 108, pl. i, figs. 2—5.

*Specific Characters.*—Attaining a length of about three inches; length of head contained about four times in the total; scales of the flank marked with fine parallel transverse ridges, which often appear double, the two divisions uniting close to the posterior margin of the scales; paired fins badly preserved; rays of median fins slender and distantly articulated; fulcra few, elongated and very oblique.

*Description.*—The specimen represented in Pl. XX, fig. 3, is from Glencartholm, Eskdale, and measures nearly three inches in length, being tolerably perfect in contour, save that the dorsal fin is deficient. The length of the head is contained about four times in the total; its superficial bones are sculptured with comparatively coarse and distant ridges; the maxilla is striated in its post-orbital expanded portion, tubercled along its dentary margin; the opercular bones are not distinguishable. The flank scales (fig. 4) have each five or six fine but prominent transverse ridges which end in points at the posterior margin, but frequently some of the upper ridges are double, the two divisions uniting behind so as to form the point in question. I am unable to decide whether those ridge-points project beyond the margin so as to form actual denticulations. In the region of the tail (fig. 5) those ridges become more oblique in their direction across the scale; and the scales of the caudal body prolongation, both median and lateral, are highly ornate up to the very extremity. Only feeble indications of the paired fins are visible, but they seem to have been large and with very slender rays. The dorsal is not preserved, but the anal is in its place and shows the normal triangular acuminate contour; its rays are very slender, smooth and distantly articulated, and its fulcra are peculiar in being comparatively few in number; much elongated, slender, and very oblique. A similar condition characterises the rays and fulcra of the lower lobe of the caudal fin.

Another specimen, from Gullane, in East Lothian, is slightly smaller, but shows the same essential features as the above-described example from Eskdale. It is interesting as showing the greater part of the dorsal fin, and in this way it helps to complete our general idea of the external contour of the fish. The apex of the dorsal fin is cut off by

the edge of the stone, but its rays, so far as they are seen, have the same character as those of the anal in the Eskdale specimen, and it so happens that in *this* specimen it is the anal which is deficient. The paired fins are not seen at all. The ridges of the cranial roof plates pass into tubercles just at the posterior margin of the parietals. The sculpture of the scales is identical in the two specimens,<sup>1</sup> but in this one from Gullane at least five specially large azygous scales are seen in the middle line of the back just in front of the dorsal fin.

*Remarks.*—Of these two specimens the first is from Glencartholm near Laughton, in Eskdale, and belongs to the Royal Scottish Museum; the second is from the neighbourhood of Gullane, in East Lothian, and is in the collection of the Geological Survey of Scotland. This latter specimen is perhaps entitled to rank as the type as my original brief diagnosis of *E. striatulus* was entirely founded upon it, while the Eskdale example was only alluded to as referable to the same species. But as the two are undoubtedly specifically identical, and as both contribute to our knowledge of this rare form, it is best to consider them as “co-types.”

I have placed the little fish in the genus *Elonichthys* on account of its general aspect, and the form and position of the unpaired fins, though the condition of the fin-fulera deviates considerably from that which is usual in the genus. In all its details it is strikingly different from every other known species.

Finally, *Elonichthys striatulus* is one of the very few species common to the peculiar Lower Carboniferous fish-fauna of Glencartholm, in Eskdale, and that of Central Scotland on the north side of the Southern Uplands. Consideration of the question of the distribution of the genera and species of British Carboniferous Palæoniscidæ will, however, be deferred to the conclusion of this Monograph.

*Geological Position and Localities.*—The only two specimens known have occurred in Lower Carboniferous Shales, in two widely separated localities, namely Glencartholm, in Eskdale, Dumfriesshire, and the neighbourhood of Gullane, in East Lothian. In the last-named locality *E. striatulus* is associated with an assembly of other Palæoniscidæ, which seems to indicate that the horizon is probably that of the Wardie Shales in the Edinburgh District.<sup>2</sup>

#### APPENDIX TO *ELONICHTHYS*.

The following have been described without figures as new species of *Elonichthys* by Mr. E. D. Wellburn, of Sowerby Bridge. I have not seen the specimens on which they

<sup>1</sup> It is from this Gullane specimen that the magnified representations of scales (figs. 4 and 5) were taken.

<sup>2</sup> See the author's paper, “Report on Fossil Fishes collected by the Geological Survey of Scotland from Shales exposed on the Shore near Gullane, East Lothian,” ‘Trans. Roy. Soc. Edinb.’ vol. xlvi, pt. i, no. 4 (1907).

are founded, and must consequently content myself with quoting the words of their describer.

ELONICHTHYS OBLIQUUS, *Wellburn.*

ELONICHTHYS OBLIQUUS, *Wellburn.* Proc. Yorks. Geol. and Polytechnic Soc., vol. xv, pt. i, 1903, p. 73.

“*Description.*—Length about 15 cm. The head bones are ornamented with well-marked, slightly undulating ridges, which frequently branch; on the opercular bones they run more or less obliquely across the bones; in the maxilla the sculpture is very characteristic, viz., the ridges run for some distance parallel with the upper margin of the bone, they then turn downwards and run with frequent branching towards the dentary margin, where they become very numerous, and some being divided transversely there is here an appearance of tuberculation; on the mandible the ridges run obliquely upwards and forwards to cut the dentary margin at an acute angle. On the bones of the shoulder-girdle the ridges run in a direction more or less parallel to the long axes of the bones. The scales are of moderate size; those of the flank are higher than broad; posteriorly they become more oblique and equilateral, whilst towards the dorsal and ventral surfaces they are low and broad. Their ornamentation consists of well-marked ridges which run transversely across the scale from the anterior border, but below a point about the centre of this border they become more and more oblique, the lowermost ones running downwards for some little distance more or less parallel to the anterior border, then turning above the anterior inferior angle they run obliquely across the scale to the posterior border, whilst the lowermost ridges run parallel to the inferior border. The ridges frequently branch, and their number is often increased, in the posterior half of the scale, by intercalations. On some of the flank scales the sculpture is rendered more ornate by finer ridges, which run across the scale parallel to and between the coarser ridges. Further back on the body the sculpture assumes a more oblique direction, the ridges running more or less parallel to a line drawn from the anterior superior angle to the posterior inferior angle. On the lower ventral scales the sculpture is more regular in pattern, the ridges mostly running parallel to the superior and inferior borders; there is also frequent intercalation of shorter ridges on the posterior half of the scale. The posterior margins of the principal flank scales are denticulated. The fins are only represented by scattered rays, which are somewhat distantly articulated, and have a well-marked longitudinal furrow.”

Mr. Wellburn considers that this fish has a great resemblance to *E. Aitkeni*, Traquair, but differs from that species in the “more oblique and elaborate nature of its scale sculpture,” and also in the circumstance that the ridges on the mandible, instead of running tolerably parallel with the upper and lower margins, run “upwards and forwards, cutting the dentary margin at an acute angle.” Mr. Wellburn states that the type and many fragmentary specimens are in his collection. They are all from the “D Shales” of the Millstone Grit at Wadsworth Moor, Marsden, Ivy Clough, near Halifax, in Yorkshire, and at Summit and Autley Gate in Lancashire.

ELONICHTHYS ORNATUS, *Wellburn.*

ELONICHTHYS ORNATUS, *E. D. Wellburn.* Proc. Yorks. Geol. and Polytechnic Soc., vol. xv, pt. i, 1903, p. 75.

“*Description.*—The head bones are ornamented with fine, well-spaced, slightly vermiculating

ridges; on the mandible the lowermost ridges run forward parallel to the lower border of the bone, whilst the uppermost ones run forwards—the most anterior ones branching—and upwards to cut the dentary margin of the bones at a very acute angle.

“The scales of the fish are sculptured in a very striking and beautiful manner, which varies somewhat on the various parts of the body, viz., on the principal flank scales the ornamentation is of a duplex pattern, viz., below a line drawn from the anterior superior angle to the posterior inferior angle are *well-marked* ridges which run from the anterior border downwards and backwards, converging towards the posterior inferior angle, above the diagonal line *fine* ridges, which run in a more or less irregular manner towards the posterior border, while several very fine ridges run close to and parallel the superior border. Further back on the flank there are often several fine ridges running parallel to the inferior as well as the superior margin, whilst between these the coarser ridges run in a more or less irregular manner towards the posterior border, which appears to be somewhat serrated. On the lower ventral scales there are firstly several well-marked ridges running obliquely downwards and backwards from the anterior to the inferior border, whilst behind these are—on the greater part of the scale—ridges which run posteriorly more or less parallel to the superior and inferior margins. The general character of the scale sculpture is continued far back towards the caudal region. The median dorsal scales are ornamented by ridges which run in a regular manner backwards and inwards—on each lateral half of the scale—to meet along the median line.

“No fins—with the exception of some rays of the caudal—are seen. The rays of the caudal fin appear to have been somewhat distantly articulated.”

The type specimen and other fragmentary remains from the “D Shales,” Millstone Grit, Summit, Lancashire, are in the collection of Mr. Wellburn, who considers that, though the first is distinct as a species, some of its scales somewhat resemble those of *Elonichthys Robisoni* (Hibbert), as figured by me on Pl. XIV, figs. 5 and 6, of this Monograph.

*Genus*—GONATODUS, *Traquair*, 1877.

AMBLYPTERUS (*pars*), *Agassiz*.

The body is fusiform, sometimes rather deep; the scales rhomboidal, their overlapped surface narrow, the exposed surface ornamented with striæ and punctures, but sometimes nearly perfectly smooth. Rays of pectoral fin articulated; base of ventral short; dorsal and anal large, triangular-acuminate; dorsal situated behind the middle of the back, so that the middle of its base is opposite the commencement of the anal; caudal following closely on the anal, powerful, deeply-cleft, and inequilateral; rays in all the fins numerous, closely jointed, the joints scale-like. Suspensorium not quite so oblique as in *Palæoniscus*, *Elonichthys*, and most other genera of the family, but more so than in *Amblypterus*; operculum large, oblong; suboperculum quadrate; branchiostegal rays or plates numerous, with a median lozenge-shaped plate behind the symphysis of the mandible, and the anterior one of each series broader than the rest. The jaws are stout; the teeth closely set, cylindro-conical, first inclined slightly inwards, then bent

outwards at an obtuse angle, the apex coming then by another curvature to point upwards (or downwards in the case of the upper jaw).

The principal feature of this genus is the dentition, which I have only proved so far as the maxilla and the dentary of the mandible are concerned: no trace of the powerful splenial teeth of the allied genus *Drydenius* is observable in any specimen of any of the three species which I refer to *Gonatodus*. The general external appearance of these fishes resembles that of *Elonichthys*, though the dorsal fin is placed a little further back, the joints of the fin-rays are rather more scale-like, and the suspensorium is not so oblique.

*History*.—As I have already noted at p. 60 (footnote), I found in 1877 that Agassiz's "*Amblypterus punctatus*" from Wardie Beach was founded on two distinct species, each of which belonged also to a distinct genus.<sup>1</sup> One of these, for which I retained the specific name "*punctatus*," formed the type of the present genus *Gonatodus*, the other, an *Elonichthys*, was named by me *E. intermedius*, though I have more recently (p. 67 of the present work) seen reason to include it among the many varieties of *E. Robisoni* (Hibbert).

The peculiar dentition of *Gonatodus* was, however, first described in 1872 by the late Mr. R. Walker, of St. Andrews, in a fish from the Lower Carboniferous oil shales of Pitcorthie, near Anstruther, in Fifeshire, to which he gave the name of *Amblypterus anconoachmodus*. That this Fifeshire fish was referable to the same genus at least as Agassiz's "*punctatus*" from Wardie, was evident from Walker's figures and description, but it was only after his death and the acquisition of his Collection by the Edinburgh Museum, in 1881, that I was able definitely to ascertain that the species was also the same.

*Species*.—Excluding "*Molyneuxi*," which I now refer to *Drydenius*, there are three British species of *Gonatodus*, all of which are from the Lower Carboniferous rocks of the Midland Valley of Scotland. As regards foreign species, we may note that two Carboniferous fishes, one American, the other Belgian, have been referred to this genus.

*Gonatodus Brainerdi* was the name given, somewhat doubtfully, by the late Prof. Newberry to a fish from the Berea Grits (L. Carboniferous) of Chagrin Falls, Ohio, which was originally named *Palæoniscum Brainerdi* by Mr. Witt B. Thomas. The dentition does not seem to have been observed, and I can only say that the figure of the entire fish given by Newberry does not in any way suggest the genus *Gonatodus*.

More like a species of this genus in general appearance is the fish from the Lower Carboniferous of Viesville in Belgium, named by the late Prof. de Koninck *Gonatodus? Toilliezi*—indeed, it was I myself who suggested to that author that it might possibly belong here. But the absence of the head, dentition, and dorsal fin in the specimen

<sup>1</sup> See also the present writer in 'Quart. Journ. Geol. Soc.,' vol. xxxiii, 1877, p. 555, and 'Proc. Roy. Soc. Edinb.,' vol. ix, 1877, p. 268 *et seq.*

concerned renders it impossible to designate with certainty the genus to which it belongs. In fact, the last time I examined it the large size of the fulera on the fins which are present, impressed on my mind the possibility of its belonging to *Eurynotus*.

1. GONATODUS PUNCTATUS, *Agassiz*, sp. Plate II, figs. 4, 5; Plate XIX; Text-figures 2, 3a.

AMBLYPTERUS PUNCTATUS, *Agassiz*. Poiss. Foss., vol. ii, pt. i, p. 109, pl. iv c, fig. 4 (non figs. 3, 5—8), 1835.

— ANCONOÆCHIMODUS, *R. Walker*. Trans. Edinb. Geol. Soc., vol. ii, pt. i, p. 119, with plate.

GONATODUS PUNCTATUS, *Traquair*. Quart. Journ. Geol. Soc., vol. xxxiii, 1877, p. 555; and Proc. Roy. Soc. Edinb., vol. ix, 1877, p. 265; and Ganoid Fishes Brit. Carb. Form. (Pal. Soc.), 1877, pl. ii, figs. 4, 5; and Trans. Roy. Soc. Edinb., vol. xl, pt. 3, no. 28, 1903, p. 690.

— — *A. S. Woodward*. Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 434.

*Specific Characters*.—Dentary margin of maxilla gently, not suddenly, curved downwards behind the region of the orbit; anterior part of orbital margin passing likewise

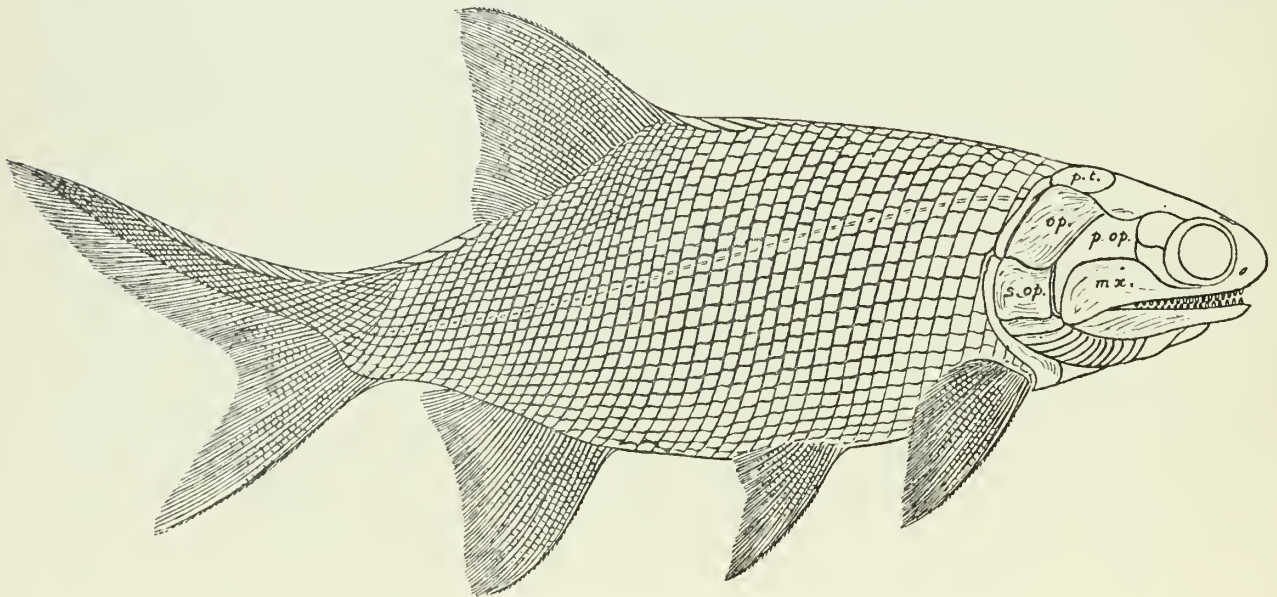


FIG. 2.—Restored figure of *Gonatodus punctatus* (*Agassiz*).

gently downwards and forwards into the upper margin of the sub-orbital process, posterior margin obtusely angulated below the middle; teeth of medium size; scales of anterior part of flank usually striated as well as punctated.

*Description*.—The length of entire specimens varies from  $5\frac{1}{2}$  to  $7\frac{1}{4}$  inches, but in

none is the extreme point of the upper lobe of the tail preserved. The length of the head is contained about four times, the greatest depth of the body about three times in the total length up to the bifurcation of the caudal fin. The head is short, with bluntly rounded snout; the external ornament of the bones of the cranium proper is rugose in character. The operculum is oblong, broader above than below, and ornamented with delicate ridges which radiate from the anterior superior angle downwards and backwards over its surface; the suboperculum is nearly square, and marked with ridges, which for the most part pass horizontally over its surface from before backwards; the preoperculum is well developed.

Of the other bones of the head, those of the jaws demand special attention. The maxilla (Pl. XIX, fig. 2) resembles in form that of the species of *Elonichthys*, the inferior or dentary margin being gently curved downwards behind the region of the orbit, the anterior part of the superior margin falling away gradually downwards and forwards into the upper border of the sub-orbital process, while the posterior margin is obtusely angulated below the middle; the broad or post-orbital part of the bone is ornamented with delicate branching and anastomosing ridges, which for the most part tend to run parallel with its posterior and superior borders. In fig. 3 we have the inner surface of the dentary element of the mandible; the outer surface of this element is covered with a close striation, the ridges running longitudinally, but the dentary margin is finely tuberculated.

The teeth with which the jaws are armed are about  $\frac{1}{4}$ th to  $\frac{1}{10}$ th of an inch in length, slender-cylindrical in shape, but near the extremity suddenly narrowed to a sharply conical apex. Each tooth (fig. 4) is first inclined a little inwards, then bent outwards at an obtuse angle, and again bent so that the apex comes to point upwards (or downwards in the case of the maxillary teeth). They are nearly uniform and arranged in a closely set row, nor have I seen evidence of smaller ones outside. But in the lower jaw, as pointed out by the late R. Walker, the teeth are very often placed alternately, one close to the outer margin, and the next to it a little further in, and so on the whole length of the range.

The branchiostegal rays or plates are thirteen on each side (Pl. II, fig. 4, *br.*), the anterior of each series being broader than those behind, and besides these there is a median lozenge-shaped plate in front. The parasphenoid bone has likewise been already figured and described in a previous part of this Monograph (p. 16, Pl. II, fig. 5). The bones of the shoulder-girdle are well shown in most of the specimens, and like those of the face are ornamented externally with flexuous branching and anastomosing ridges.

The scales of the flank (Pl. XIX, figs. 5—7) are slightly higher than broad, with gently concave upper and convex lower margin; the articular spine is well marked. On the under surface (fig. 6) the socket for the spine of the scale below is distinct, but the keel is nearly obsolete; the latter appears as we proceed backwards towards the tail,

while the spine and its socket diminish and ultimately disappear. The posterior margin of the scale is finely and obliquely serrated. On the outer surface the margin overlapped by the scale next in front is very narrow; the exposed area is, in the most anteriorly situated scales, ornamented with delicate and rather feebly marked striæ, best marked along the anterior and inferior margins, with which they run parallel, and usually becoming speedily obsolete over the rest of the scale, so as to leave a considerable space above and behind, marked only with tolerably coarse punctures (fig. 7), though in many cases (fig. 5) shallow grooves also extend for some distance forwards from the notches between the denticulations of the posterior border. These striæ are much more pronounced in some specimens than in others, except on the small scales at the base of the dorsal fin, where they are pretty well marked; they cease to be observable before the origin of the ventrals, whence backwards the only scale ornament consists of scattered punctures passing into short oblique furrows, especially near the inner margin, these punctures and furrows being persistent even on the small lozenge-shaped scales clothing the sides of the caudal body prolongation. The scales also vary considerably in size on different parts of the body, becoming rapidly smaller posteriorly, and those immediately below and adjoining the base of the dorsal fin are of particularly small size. The rest of the squamation presents nothing specially worthy of note.

The pectoral fins are acutely pointed and of considerable expanse; the length of each is equal to about three quarters that of the head. The ventrals are smaller, short-based, and have their posterior margins rather concavely cut out. The dorsal is placed behind the middle of the back, so that the centre of its base is nearly opposite the commencement of the anal; both these fins are large and triangular-acuminate; the caudal is powerful and deeply cleft. The rays of all the fins are very numerous and delicate; their number in the pectoral cannot be less than thirty; in the ventral twenty-three; in the dorsal and anal forty-five each; those of the caudal cannot be counted. The articulations of the fin-rays are also tolerably close, especially in the finer rays of the posterior part of each fin, where the joints appear nearly square, being in the other rays rather longer than broad; the articulations are more than usually distant towards the proximal extremities of the principal rays of the pectoral, and also, though to a less extent, in the lower lobe of the caudal. The joints are *scale-like* in general aspect; the distal margin of each is notched or concave, the proximal correspondingly convex; and the outer surface is in most cases marked with at least one delicate furrow parallel with the anterior and posterior borders; near the bases of the dorsal and anal fins the joints present, indeed, an appearance of fine striation. The fulcræ of the anterior margins are closely set and very minute.

*Observations.*—The salient characters which distinguish this, the type species of the genus, from the two following, are the shape of the maxilla and the moderate size of the teeth. The scales are also comparatively moderate in size, and tend to display, at least

in the front of the body, a greater amount of external ornament, though cases do occur in which they are all nearly devoid of striation.

*Geological Position and Localities.*—Scottish Lower Carboniferous, and apparently confined to the “Calciferous Sandstone” Series. *Gonatodus punctatus* is one of the commonest of the fishes which occur in the ironstone nodules of Wardie Beach near Edinburgh, and in East Lothian it has recently been collected at Gullane by the Geological Survey of Scotland. In Fifeshire, at Pitcorthy near Anstruther.

Agassiz’s type from Wardie is preserved in the Royal Scottish Museum, as are also the specimens from Pitcorthy figured by Walker.

2. GONATODUS MACROLEPIS, *Traquair*. Plate XX, figs. 9—14; Text-figure 3 *b*.

GONATODUS MACROLEPIS, *Traquair*. Quart. Journ. Geol. Soc., vol. xxxiii, 1877, p. 556; Proc. Roy. Soc. Edinb., vol. ix, 1877, p. 271, and vol. xvii, 1890, p. 391; Trans. Roy. Soc. Edinb., vol. xl, pt. iii, no. 28, pp. 692 and 694.

— — *A. S. Woodward*. Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 435, pl. xvi, fig. 8.

*Specific Characters.*—Inferior, or dentary, margin of the maxilla bent suddenly downwards shortly behind the junction of the sub-orbital process with the post-orbital plate, so that the latter appears proportionally high and broad; teeth large; scales large, mostly quite smooth with scattered punctures, and only seldom showing traces of striation along the anterior and inferior borders.

*Description.*—The usual length of examples of this species is from four to six or seven inches, but although a considerable number of specimens more or less “perfect” have been found, in no two do the proportional measurements agree owing to the greater or less amount of alteration of form which they have undergone, apparently both soon after death, and during the consolidation of the matrix. Seldom do the scales, save on the caudal body-prolongation, remain in their original relations to each other on any considerable part of the body, but are always more or less jumbled up, even though the contour of the fish may remain tolerably regular, and the shape and structure of the fins be quite intact. This condition affects nearly the whole of the smaller fishes found in the Gilmerton Ironstone, from which bed all the entire specimens of *G. macrolepis* have been derived.

The specimen represented in Plate XX, fig. 9, is on the whole the most perfect which I have seen, and measures as it lies  $6\frac{1}{2}$  inches in length, but, were the snout perfect, 7 inches would be the correct number. Allowing for the missing snout the length of the head would be contained about five times in the total, and the general shape is, like that

of the previous species, somewhat deeply fusiform, with the dorsal fin placed rather far back—so far back, indeed, as to appear almost opposite the anal, but that is no doubt the posterior position slightly exaggerated by distortion.

The external cranial bones display a rugose sculpture, but in no specimen are they well shown, being always more or less crushed and broken. So are likewise the facial bones, with the exception of the maxilla and mandible, which can often be recognised both *in situ* and in an isolated condition. A typical isolated maxilla is shown in Pl. XX, fig. 11, and is seen to be markedly different in its contour from that of *G. punctatus* (Pl. XIX, fig. 2), inasmuch as the dentary margin is pretty sharply bent downwards just behind the origin of the sub-orbital process from the post-orbital plate, which latter part appears proportionally high from above downwards, short from before backwards. Its external surface is marked with closely set ridges which run mainly parallel with the anterior, posterior, and inferior margins of the bone. The dentary element of the mandible seen from the outer surface is represented in fig. 12, and is seen to be somewhat stouter than the corresponding bone in *G. punctatus*; its ornament consists of ridges, which in the middle run straight backwards and forwards, forming a longitudinal band, above which they run obliquely upwards and forwards, and below which and along the inferior margin they are slightly contorted. The configuration of the teeth is essentially the same as in the previous species, though they are larger in size, a little more clumsy in shape (figs. 13 and 14), and not quite so regular in arrangement. The scales are proportionally considerably larger than in *G. punctatus*, except on the caudal body-prolongation, where they are equally small. Their outer and brilliantly polished free surfaces (fig. 10) display a number of delicate punctures, and occasionally, though indeed seldom, a few traces of striation along the anterior and inferior borders; the posterior margins of the flank scales are finely denticulated. The form and position of the fins are as in the Wardie species, though their rays are slightly coarser and fewer in number, though it is difficult to ascertain with accuracy their numbers in the various fins. The articulations of the rays are also a little closer, but the configuration of the joints is the same, these being scale-like, emarginate distally, convex proximally, and with a little furrow parallel with their anterior and posterior margins.

*Geological Position and Localities.*—From the Lower Carboniferous Rocks of the central valley of Scotland, but occurring at a higher horizon than is the case with *G. punctatus*. The Royal Scottish Museum contains a couple of imperfect specimens from the Dunnet Shale at Straiton, Midlothian (Calcareous Sandstone Series); all the other known specimens are from the Gilmerton Ironstone, a member of the Lower Limestone Series formerly worked at Venturefair Pit, Gilmerton. The types are in the Royal Scottish Museum and in the Collection of the Author.

3. GONATODUS PARVIDENS, *Traquair*. Plate XXI; Text-figure 3c.

GONATODUS sp., *Traquair*, Geol. Mag. [2], vol. viii, 1881, p. 34.

— PARVIDENS, *Traquair*, *Ibid.*, vol. ix, 1882, p. 546; Proc. Roy. Soc. Edinb., vol. xvii, 1890, p. 392; Trans. Roy. Soc. Edinb., vol. xl, pt. iii, no. 28, pp. 695 and 696.

— — *A. S. Woodward*, Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 435.

*Specific Characters.*—Maxillary bone having its inferior or dentary border nearly straight or only slightly deflected posteriorly, its hinder border nearly vertical, and its superior border passing gently downwards and forwards into the forwardly directed suborbital process; teeth very small; scales large, the exposed area punctate, and in the flank scales showing along the anterior margin a slight furrowed striation; posterior border of scales minutely serrated.

*Description.*—This species, which sometimes attained a length of over eight inches, resembles the two previous in general form and structure, though it differs in some prominent details. The cranial roof-bones are ornamented with rather fine contorted raised striæ, passing often into elongated or even rounded tubercles. The maxilla (Pl. XXI, fig. 4; text-figure 3c) differs in form from that bone both in *punctatus* and in *macrolepis*. Its dentary margin is only very slightly deflected posteriorly, so that this appears nearly straight; the posterior margin of the post-orbital plate is nearly vertical—in the specimen figured in Pl. XXI, fig. 4 it is even inclined downwards and forwards—the superior-anterior margin passes gently downwards and forwards into the suborbital process. The teeth, both in the maxilla and in the dentary part of the mandible (fig. 5) are very small, though they retain the shape and arrangement characteristic of the genus. The scales are proportionally large, as in *G. macrolepis*. One from the flank is represented in fig. 3; its exposed surface is smooth and punctated all over, while in addition there are close to and parallel with the anterior margin a few delicate furrows; the hinder border is minutely serrated. The fins do not seem to be specially large, and the aspect of their rays is as in the other two species of the genus. Usually the joints are rather short, but they appear somewhat elongated in the portions of fin represented in figs. 6 and 7. In fig. 6 the commencement of the fulcrum along the anterior margin of the dorsal fin is exceedingly well shown.

*Observations.*—*Gonatodus parvidens* was first determined by me in 1882 from detached maxillary bones from the Borough Lee Ironstone in my own collection, and these accordingly constitute the types of the species. The occurrence of jaws and teeth of the same form in more or less entire fishes from the same Ironstone confirmed the reference of the species to the genus *Gonatodus*, and presently I referred to the same

form, also fishes from a similar horizon at Wallyford, near Musselburgh, at Lochgelly in Fifeshire, and at Possil in Lanarkshire. Unfortunately, the jaws and dentition have only been verified in the specimens from the Borough Lee Ironstone. And here it may be as well to place together the forms in outline of the maxillary bone in the three known species of *Gonatodus*, to show how characteristic for each is the contour of that element.

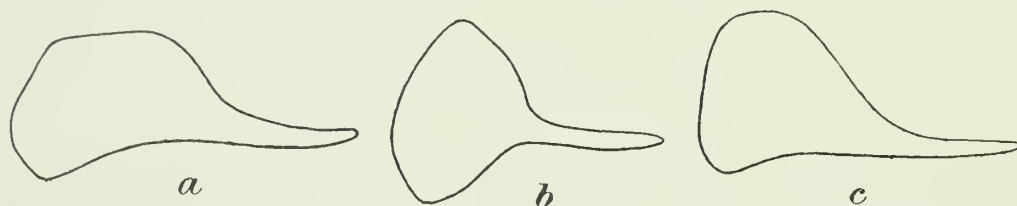


FIG. 3.—Contour of the maxillary bone in the three species of *Gonatodus*: a. *G. punctatus*, b. *G. macrolepis*, c. *G. parvidens*.

In the maxilla figured on Pl. XXI, the posterior margin of the bone is inclined somewhat downwards and forwards, but this is rather exceptional, the margin in question being, as in the above text-figure, normally nearly vertical.

*Geological Position and Localities.*—A fish of the upper part of the Lower Carboniferous series in Central Scotland.

Edge Coal Series: Borough Lee Ironstone at Borough Lee and Loanhead, near Edinburgh. Ironstone near Great Seam (?), Wallyford, near Musselburgh. Lower Possil Ironstone, Possil, Lanarkshire. Ironstone in Edge Coal Series, Lochgelly, Fifeshire.

Lower Limestone Series: In the roof shale of the "South Parrot" coal seam, Niddrie, near Edinburgh.

*Genus*—DRYDENIUS, *Traquair*, 1890.

GONATODUS (pars), *Traquair*.

*Generic Characters.*—Form of body fusiform; pectoral fins not known, dorsal fin nearly opposite the space between the ventrals and the anal; dorsal and anal triangular-acuminate, many rayed; caudal heterocercal and inequilateral; all the fins fulcrated; scales rhombic, ganoid; maxilla and dentary of mandible, each with one row of small, closely-set cylindro-conical teeth; splenial with a similar row along its upper margin, and also with a similar group of large curved teeth springing from its inner surface below the upper margin.

The salient generic character of *Drydenius* is the peculiar dental armature of the splenial bone, otherwise the resemblance to *Gonatodus* is very close.

I. DRYDENIUS INSIGNIS, *Traquair*. Plate XXII, figs. 5—9.

DRYDENIUS INSIGNIS, *Traquair*. Proc. Roy. Soc. Edinb., vol. xvii, 1890, p. 399;  
Trans. Roy. Soc. Edinb., vol. xl, pt. iii, no. 28,  
p. 695.

— — *A. S. Woodward*. Cat. Foss. Fishes Brit. Mus., pt. ii, 1891,  
p. 437.

*Specific Characters*.—Attaining a length of four inches or more. Body-scales denticulated posteriorly, anterior covered surface narrow, free surface ganoid, scattered conspicuously with vascular pores.

*Description*.—The specimen represented in Pl. XXII, fig. 5, can originally have been hardly less than  $4\frac{3}{4}$  inches in length. Its shape is seen to be fusiform, with the dorsal fin placed over the interval between the ventrals and the anal. As it happens, *both* ventrals are exhibited in this specimen.

The cranial roof-bones are covered externally with a proportionally coarse, tortuous striation, and the ornament of the facial bones is similar in character. The hinder or post-orbital part of the maxilla (fig. 6) forms a short expanded plate, from the middle of the anterior aspect of which (much as in *Gonatodus macrolepis*) the narrow sub-orbital process extends, so that the tooth-bearing margin is posteriorly bent suddenly downwards at a very considerable angle. This margin is set, as in *Gonatodus*, with a single row of proportionally stout cylindro-conical teeth, which do not seem, however, to have the peculiar double flexure characteristic of that genus. The dentary element of the mandible is rather stout and shows on its upper margin a row of similar teeth. The splenial element (figs. 7 and 8) presents a dental armature which I have not seen in any other Palæoniscid. The bone is narrow, rounded posteriorly, and tapering to a point in front, its upper straight margin (fig. 7) being set with a single row of short, conical, pointed teeth. But the inner or oral aspect (fig. 8) shows an area about the middle, and occupying more than one-third of its length, from which a row of six powerful cylindro-conical teeth arises, behind which are three or four small ones. The large teeth seem disproportionally large for the small size of the fish, and are conspicuous even in the most crushed heads. They are strongly curved, with the convexity on the oral aspect. I rather suspect that the palate is also armed with similar teeth, but I have not been able to see an isolated palate-bone.

The scales appear rather large for the size of the fish, but show the usual variation of size and form on different parts of the body. Those of the flank (fig. 9) have the posterior border sharply denticulated, and the nearly smooth exposed area is punctated with small vascular openings. Passing backwards the denticulation becomes less marked, then disappears in the scales of the caudal body-prolongation, the punctures likewise tending to become fewer in number.

The pectoral fin is not seen in any specimen, but the ventrals occupy the normal position as shown in fig. 5. The dorsal and anal fins, somewhat large, are of the usual triangular acuminate contour, the joints of the rays being very slightly longer than broad, and mostly smooth. The caudal is strongly heterocercal, deeply cleft, and inequilobate, and very distinct fulera are observable on the anterior margins of all the fins.

*Observations.*—When my attention was first drawn to the vertebrate fossils of the Borough Lee and Loanhead Blackband Ironstone, I attributed certain small jaw fragments showing peculiar bent cylindro-conical and conspicuous teeth to *Gonatodus macrolepis*, Traq.; but after collecting a considerable number of these little dentigerous bones, it began to be clear to me that I had, on the other hand, to deal with a new fish, of which more or less entire specimens with the teeth *in situ* began also to turn up. These fishes bore, in their scales and fin-rays, a considerable resemblance to *Gonatodus*, but as I had never seen any trace of such splenial teeth, for such they proved to be, in species of that genus such as *G. punctatus*, I proposed, in 1890, for this new form the generic term *Drydenius*, taken from the Vale of Dryden, which lies in close proximity to the ironstone mines of Borough Lee and Loanhead. The salient character of this genus is the peculiar dental armature of the splenial element of the mandible to which the first found “jaw fragments” are clearly referable.

*Geological Position and Locality.*—In the Borough Lee Ironstone, a member of the Edge Coal or Middle Carboniferous Limestone Series of the Lothians, worked at Borough Lee and Loanhead, near Edinburgh.

## 2. DRYDENIUS MOLYNEUXI, *Traquair*. Plate XX, figs. 6—8.

MICROCONODUS MOLYNEUXI, *Traquair*. Ganoid Fishes Brit. Carb. Form. (Pal. Soc., 1877), p. 33 (name only).

GONATODUS MOLYNEUXI, *Traquair*. Geol. Mag. [3], vol. v, 1888, p. 252.

— — *J. Ward*. Trans. N. Staffs. Inst. Mining Engin., vol. x, 1890, p. 178, pl. vi, fig. 11.

— — *A. S. Woodward*. Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 436.

*Specific Characters.*—Attaining a length of little over three inches; scales of flank with very numerous fine denticulations on the posterior border; vascular openings on free surface of scales few or absent; articulations of fin-rays distant.

*Description.*—The largest specimen of this little fish which I have seen is scarcely more than three inches in length; the shape is fusiform, rather “stumpy”; the length of the head is contained about four and a half times in the total. The cranial roof-

bones are ornamented with closely-placed, contorted, thread-like ridges; the jaws are armed with apparently one row of comparatively stout stylo-conical, bluntly-pointed teeth, which are slightly incurved towards the apex. In Pl. XX, fig. 8, a magnified view is given of the impression of a portion of the mandible, from a specimen in the Royal Scottish Museum, showing the imprints of these teeth, while another specimen in the same museum gives evidence of the presence likewise of large teeth of the same character as those forming the splenial armature of the last described species. The scales are proportionally large, with narrow overlapped surface; the exposed surface in the flank scales (fig. 7) is marked in front with a few exceedingly delicate vertical grooves or striæ turning round below, parallel with the lower margin, the rest of the surface being marked posteriorly with nearly equally minute transverse striæ ending on very delicate denticulations of the hinder margin—a nearly smooth space being left between this set of transverse striæ and the vertical one along the front. The scales become smaller and more oblique posteriorly, the striation also fading away, though the marginal denticulation remains as far back as the caudal fin. Vascular pores are rarely visible on the ganoid exposed surfaces of the scales. The fins are not well preserved in any of the specimens which I have seen. The pectorals are not visible; the dorsal (see Pl. XX, fig. 6) is nearly opposite the interval between the ventrals and the anal; the caudal is, of course, heterocercal. All seem to be rather few-rayed; the rays are comparatively coarse, with distant articulations, the joints being smooth, or ornamented with one or two delicate sulci.

*Observations.*—This well-marked species was discovered and recognised as undescribed by the late Mr. John Ward, F.G.S., of Longton, who confided the specimens to me for description with the request that I would name it *Molyneuxi*, after his deceased friend Mr. Molyneux, well known as a collector of North Staffordshire Carboniferous Fossils. It is the same fish to which I alluded, without description, as *Microconodus Molyneuxi* in my essay on the structure of the Palæoniscidæ ('Pal. Soc.,' 1877), but in 1888 I referred it somewhat doubtfully to *Gonatodus*, stating that although it had certain obvious resemblances to that genus, the teeth did not seem to exhibit the characteristic second flexure at the apex. However, the discovery in a specimen, referable to this species, of large teeth, apparently identical with the remarkable splenial teeth of *Drydenius insignis*, sheds a new light on the matter and induces me to class "*Molyneuxi*" also as a member of the same genus.

*Geological Position and Locality.*—Only known from the North Staffordshire Coal Measures, having been collected from the Deep Mine Ironstone at Longton by the late Mr. Ward. The type specimens are in the British Museum; others are in the Royal Scottish Museum, Edinburgh.

*Genus*—CRYPHIOLEPIS, *Traquair*, 1881.

*Generic Characters*.—Fusiform; strongly heterocercal; suspensorium oblique; gape wide; external bones of head closely striated; teeth conical, sharp, of different sizes, larger and smaller; fins large, all with fulera; dorsal situated about the middle of the back; principal rays of the pectoral unarticulated up to one third of their length from their origins. Scales of the body thin, rounded, but seldom symmetrically so, deeply imbricating articular peg and socket obsolete, exposed surface covered with closely-set rounded ridges which seem to be hollow internally; scales of the caudal body-prolongation acutely rhombic on the sides, and forming a median row of imbricating V-scales along the dorsal margin.

CRYPHIOLEPIS STRIATUS, *Traquair*. Plate XXII, figs. 1—4.

CÆLACANTHUS STRIATUS, *Traquair*. Geol. Mag. [2], vol. viii, 1881, p. 37.

CRYPHIOLEPIS — *Traquair*. Ibid., p. 491; Proc. Roy. Soc. Edinb., vol. xviii, p. 392; Trans. Roy. Soc. Edinb., vol. xl, pt. iii, 1903, no. 28, p. 695.

— — *A. S. Woodward*. Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 523.

*Description*.—Owing to the crushed and distorted condition in which the few specimens occur, which can in any sense be called “entire,” it is difficult to lay down accurate proportional measurements. The most complete example which has yet been found is represented in Pl. XXII, fig. 1, and measures  $5\frac{3}{4}$  inches in length as it stands; but as the front part of the head and the tip of the upper lobe of the caudal fin are wanting, the original length may be estimated at one inch more at the very least, and I should guess that the length of the head would be about equal to the greatest depth of the body and contained between four and five times in the total length of the fish. These proportions, with other details, I have endeavoured to express in the accompanying restored figure.

In no entire head are the bones in a very good state of preservation, yet they show quite enough to prove in an unmistakable way their typically Palæoniscid arrangement. The hyomandibular suspensorium is very oblique, the gape proportionally wide. Detached maxillæ and mandibular dentary bones clearly identifiable with those of the present species occur in my collection. One of the former (a sharp impression) is represented in Pl. XXII, fig. 2, and is in shape and markings very like the maxilla of *Elonichthys* (*Cosmoptychius*) *striatus* (Pl. III, fig. 3), and like it has its broad or post-orbital portion marked with fine, closely set ridges, mostly parallel with its upper and posterior margins. Of the detached dentary bones a very good example is seen in fig. 3; it is stout and tapering anteriorly, the outer surface being ornamented with ridges

similar in character to those of the maxilla, but running obliquely upwards and forwards so as to cut the upper margin of the bone at acute angles. Both the maxillary and the dentary bones have their oral margins set at short intervals with stout, conical, pointed and incurved teeth, between which may be observed others of smaller size and more externally placed. The opercular bones are ill-preserved, though evidently arranged in Palæoniscid fashion; and the external head-bones in general are marked with closely-set ridges resembling those ornamenting the outer surface of the jaws.

The clavicle is of the form characteristic of this family, and is externally ornamented with ridges which are coarser than those of the facial bones. The pectoral fin is partly seen in Pl. XXII, fig. 1, but its contour is better displayed in a specimen not figured; it is acuminate in form, and its principal rays are unarticulated up to about a third of their length. The ventral fin is long-based, and in front acuminate; both it and the anal seem large for the size of the fish, while the dorsal, placed about the middle of the

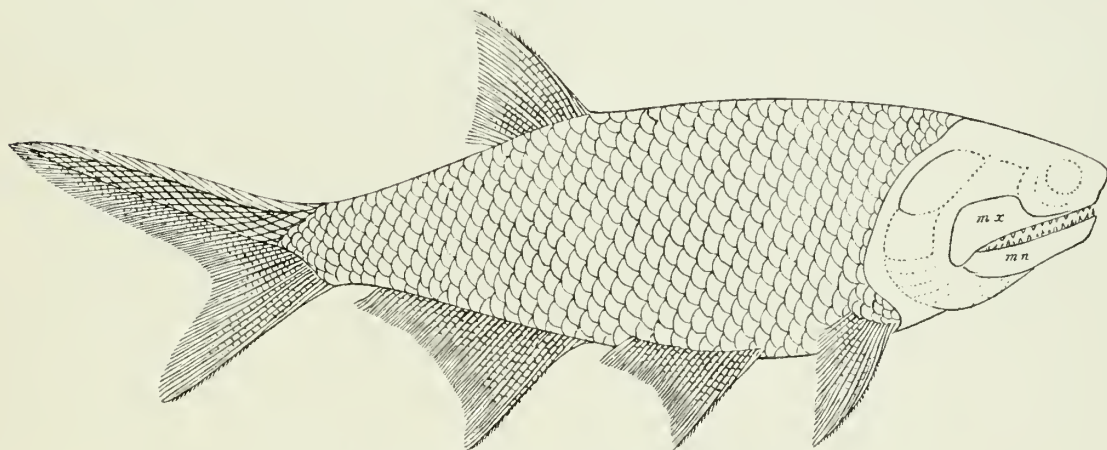


FIG. 4.—Restored figure of *Cryphiolepis striatus*, Traq.

back and arising over the interval between the ventral and the anal, is apparently proportionally smaller; the caudal is completely heterocercal, deeply cleft and inequilobate. The rays of all the fins are numerous, closely set, and divided by transverse articulations which leave the joints rather larger than broad; their outer surfaces are brilliantly ganoid, and ornamented by a few longitudinal grooves, which in the rays of the upper lobe of the caudal are sufficiently numerous and close to form a regular striation.

The caudal body-prolongation is bordered above by a row of acutely-pointed, strongly striated V-scales; those clothing its sides also conform to the ordinary Palæoniscid type, being minute, acutely lozenge-shaped, and externally nearly smooth, their ornament consisting only of one or two longitudinal grooves.

On the tail-pedicle, and over all the rest of the body, the scales (fig. 4) are thin and of a rounded shape, though it must also be observed that in few cases are they quite symmetrically rounded, there being usually more or less of a peculiar obliquity of form, which reminds us to some extent of the rhombic contour of the ordinary

Palæoniscid scale. On their attached surfaces these scales are smooth, and perfectly destitute of the vertical keel, articular spine and socket found in normal Palæoniscidæ and in most other rhombic scaled "Ganoids." The outer surface shows, posteriorly, a free ganoid and sculptured area, occupying about one third of the entire space, the remaining covered portion being dull, and, when examined by a strong lens, showing very delicate concentric lines of growth. The exposed area is covered with fine, rounded, brilliantly ganoid ridges, raised above the general surface, closely set, subparallel, and proceeding across the surface to the posterior margin without convergence; they are frequently intercalated, but more rarely appear to bifurcate. When examined by a lens, these ridges, where the surface is abraded, appear to be hollow internally, with only a very thin external covering, their tubular interiors being filled with white carbonate of lime.

*Observations.*—The first traces of this most interesting fish which came under my notice, consisted of certain isolated scales from the Borough Lee Ironstone, which, on account of their rounded contour, extensive overlapped area, and closely striated free surface, I considered to belong to a new species of *Cælacanthus*, which I accordingly, in the beginning of the year 1881, named *C. striatus*. Towards the end of the same year, however, I was startled to find that these scales belonged, not to a *Cælacanthus* at all, nor even to a Crossopterygian, but to a fish, which in other respects was of typically Palæoniscid structure. The error was no doubt a serious one, but also one which I think any person who looks at the detached scales—thin, rounded, deeply imbricating and delicately striated on their free surfaces, as they are—will readily be disposed to excuse. And, as it turned out, the fish was of much greater interest than merely a new species of *Cælacanthus*. For our knowledge of the British Palæozoic fauna was enriched by the addition of a remarkably aberrant form of Palæoniscidæ, and one which shows not only how dangerous it may be to found conclusions on fragmentary remains, but how small may be the systematic value of the mere external shape of the scales of "Ganoid" fishes. For this aberrant form I accordingly, in November, 1881, founded the new Palæoniscid genus *Cryphiolepis*.

But the occurrence of a Palæoniscid with rounded scales is not an isolated phenomenon. Already, in 1875,<sup>1</sup> Prof. A. Fritsch, of Prague, had discovered in the Lower Permian Gas Coal of Kounova, in Bohemia, a small fish, which he briefly noticed as follows:

"(Nov. gen.) Kounovensis: Ist eine neue Gattung von Fischen, die bei dem Gesamthabitus eines Palæoniscus mit Cycloidenschuppen versehen ist. Die Schwanzflosse ist heterocere, die Kiefern mit grossen spitzen Zähnen versehen."

For this new and interesting form Prof. Fritsch proposed, in 1877,<sup>2</sup> the name *Sphærolepis*, which he afterwards, in the "Heft" of his great work on the Permian

<sup>1</sup> 'Sitzungsberichte der k. böhm. Gesellsch. der Wissenschaften,' März 19, 1875.

<sup>2</sup> *Ibid.*, January, 1877, also March, 1879.



PLATE XIX.

(The cost of this plate has been defrayed by the Carnegie Trust for the Universities of Scotland.)

FIG.

1. *Gonatodus punctatus* (Agassiz); natural size. From the Calciferous Sandstone Series, Wardie. In the Collection of the Author.
2. Maxillary bone of the same species; magnified two diameters. This is one of the types of Walker's *Amblypterus anconoæchmodus*. From Pitcorthie, near Anstruther. In the Royal Scottish Museum, Edinburgh.
3. Dentary bone, magnified two diameters. This is also one of the types of Walker's *Amblypterus anconoæchmodus*. From Pitcorthie, near Anstruther. In the Royal Scottish Museum.
4. A single mandibular tooth seen antero-posteriorly and magnified eight diameters.
5. Flank scale of an ornate character from a Pitcorthie specimen; magnified four diameters. Royal Scottish Museum.
6. Under surface of a similar scale; magnified four diameters.
7. Flank scale of a less ornate character; magnified five diameters.



Fig. 2.



Fig. 3.

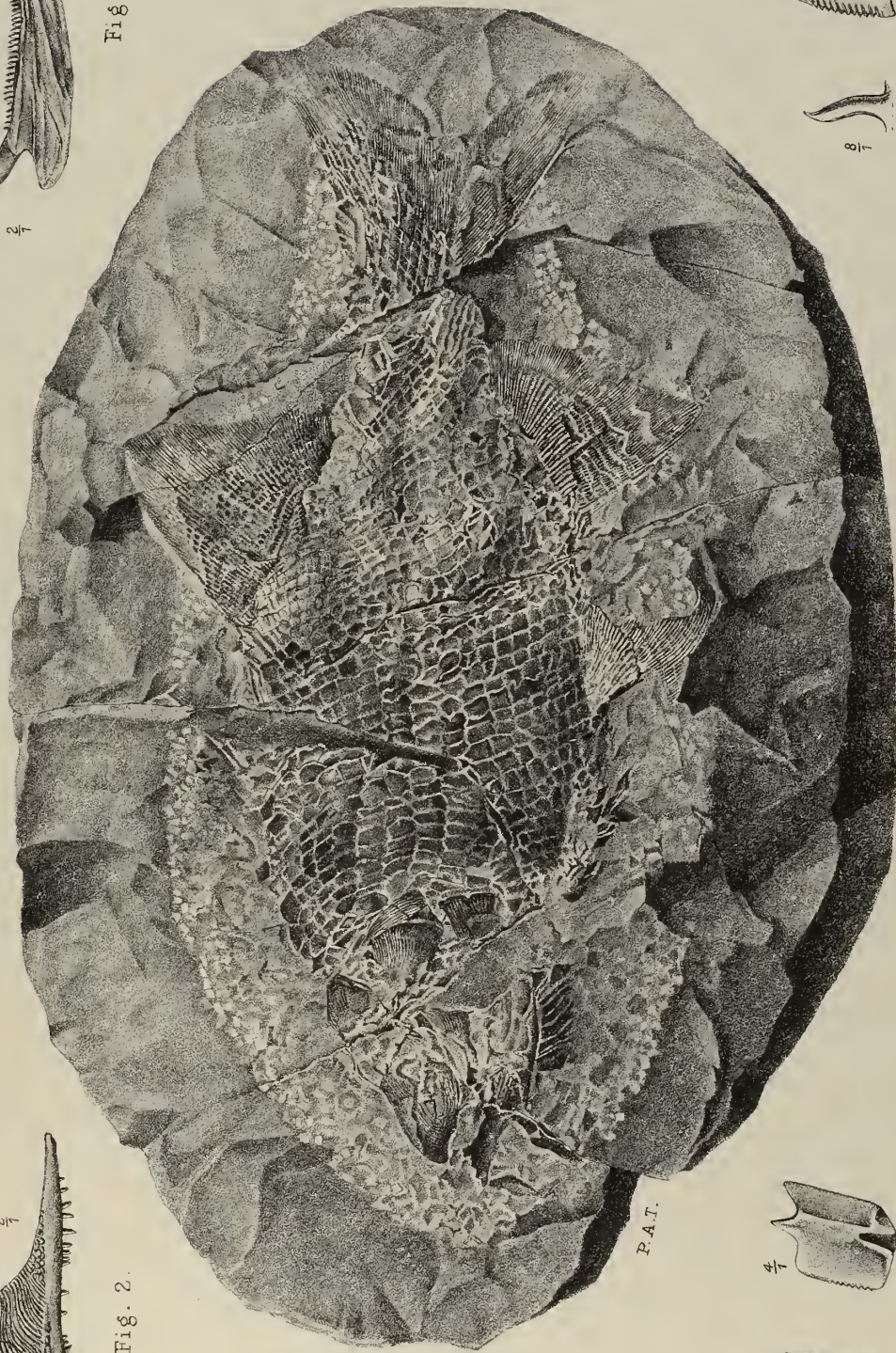


Fig. 1.



Fig. 5.

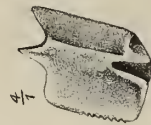


Fig. 6.



Fig. 4.



Fig. 7.



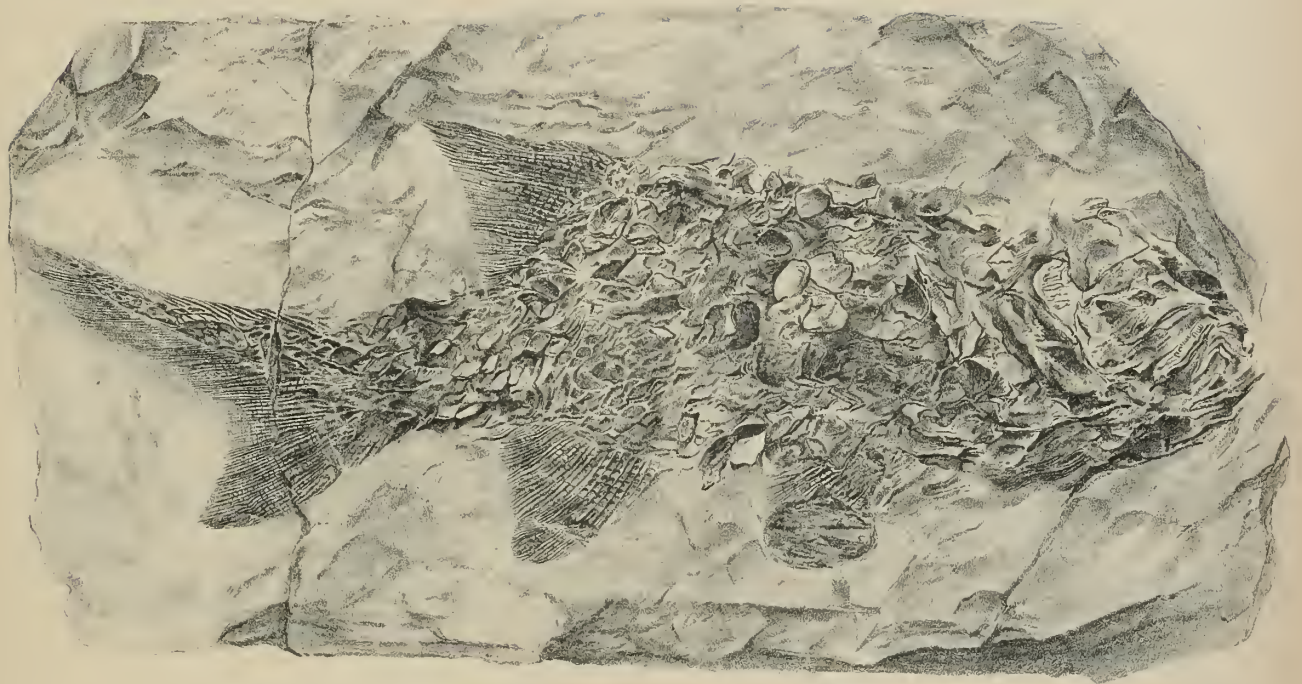


PLATE XX.

(The cost of this plate has been defrayed by the Carnegie Trust for the Universities of Scotland.)

FIG.

1. *Elonichthys denticulatus*, Traquair; flank scale, magnified ten diameters. From the Pendleside Series, near Holywell, Flintshire. Collection of J. T. Stobbs, Esq.
2. Ventral scale from the same specimen; same degree of enlargement.
3. *Elonichthys striatulus*, Traquair; from the Calciferous Sandstone Series, Glencartholm, Eskdale; natural size. In the Royal Scottish Museum. One of the type specimens.
4. Flank scale of the same species, magnified twelve diameters. From Gullane, East Lothian, in the Collection of the Geological Survey of Scotland.
5. Scale nearer the tail; same degree of enlargement.
6. *Drydenius Molyneuxi*, Traquair; from the Deep Mine Ironstone, Longton, Staffordshire; natural size. In the British Museum. Type specimen.
7. Flank scale, magnified.
8. Impression of a portion of the mandible in an example of *Drydenius Molyneuxi* from the same horizon and locality; magnified four diameters. In the Royal Scottish Museum, Edinburgh.
9. *Gonatodus macrolepis*, Traquair; type specimen from the Gilmerton Ironstone, Venturefair Pit, Gilmerton, near Edinburgh. Collection of the Author.
10. Flank scale enlarged four diameters. Same horizon and locality.
11. Maxilla with teeth, enlarged two diameters, the post-orbital plate seen in impression. In the Royal Scottish Museum, from the same horizon and locality.
12. Dentary bone of mandible with teeth, enlarged twice. In the Collection of the Author, from the same horizon and locality.
13. Two mandibular teeth, magnified eight diameters. Gilmerton Ironstone.
14. Tip of a maxillary tooth with a singularly mucronate point.



P. A. T.

Fig 9.



J. G.

Fig. 3.



P. A. T.

Fig 6.



Fig 12.



Fig. 13.



Fig 10.



Fig 14.

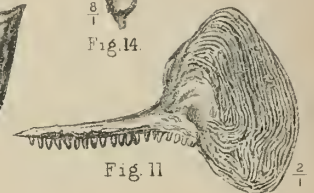


Fig 11



Fig. 1.



Fig 2.



Fig. 7.



Fig 4



Fig. 5.



Fig. 8.





PLATE XXI.

(The cost of this plate has been defrayed by the Carnegie Trust for the Universities of Scotland.)

FIG.

1. *Gonatodus parvidens*, Traquair; from a specimen from Wallyford, Midlothian. In the British Museum. Natural size.
2. Another specimen, wanting the head and shoulder, probably referable to the same species. From the Lower Possil Ironstone, Possil, Lanarkshire; natural size. James Thomson Collection in the Kilmarnock Museum.
3. Flank scale from a specimen from the Borough Lee Ironstone, Loanhead; magnified three diameters. Collection of the Author.
4. Maxillary bone with teeth seen from the inner aspect; magnified two diameters. From the Borough Lee Ironstone. In the Collection of the Author.
5. Dentary bone of mandible with teeth, seen from the inside, and magnified two and a half times. From the Borough Lee Ironstone. In the Collection of the Author.
6. Wax impression of the commencement of the dorsal fin in the specimen represented in fig. 1; magnified.
7. Wax impression of the anterior margin of the ventral fin in the same specimen; magnified.



Fig. 1.

P. A. T.

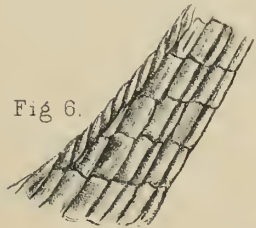


Fig. 6.



Fig. 7.



Fig. 5.



Fig. 4.



Fig. 3.

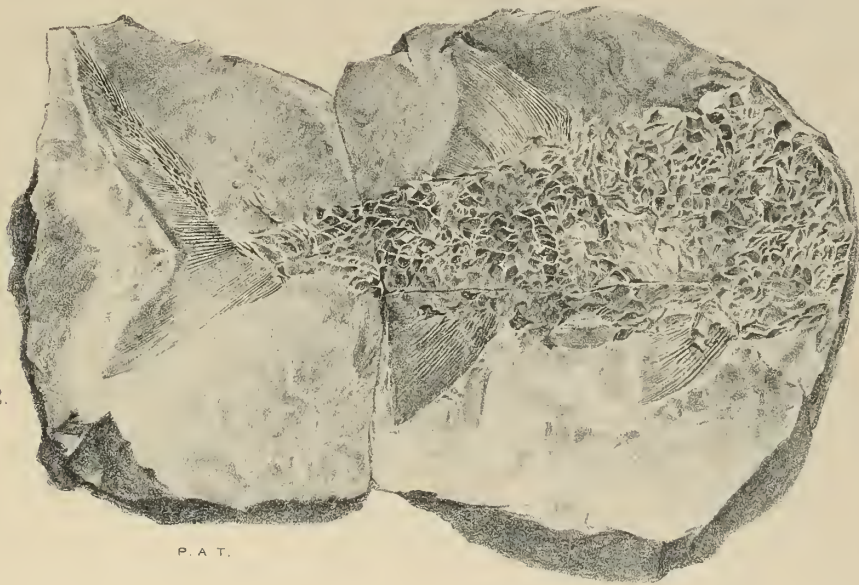


Fig. 2.

P. A. T.





PLATE XXII.

(The cost of this plate has been defrayed by the Carnegie Trust for the Universities of Scotland.)

All the specimens figured on this plate are from the Borough Lee Ironstone, Loanhead, near Edinburgh.

FIG.

1. *Cryphiolepis striatus*, Traquair; natural size. Hunter Collection in the Public Museum, Kilmarnock.
2. Impression of the outer surface of the maxilla of the same species; magnified by one half. Collection of the Author.
3. Impression of the outer surface of the dentary element of the mandible; magnified by one half. Collection of the Author.
4. External surface of a typical scale from the flank; magnified two diameters.
5. Specimen of *Drydenius insignis*, Traquair; natural size. Royal Scottish Museum.
6. Maxilla of the same species, with teeth, seen from the inner surface; magnified three diameters. Collection of the Author.
7. Splenial element of mandible, seen from the external or aboral surface; magnified four diameters. Collection of the Author.
8. Splenial element, seen from the internal or oral aspect; magnified three diameters. Collection of the Author.
9. Flank scale from the specimen represented in fig. 5; magnified six diameters.

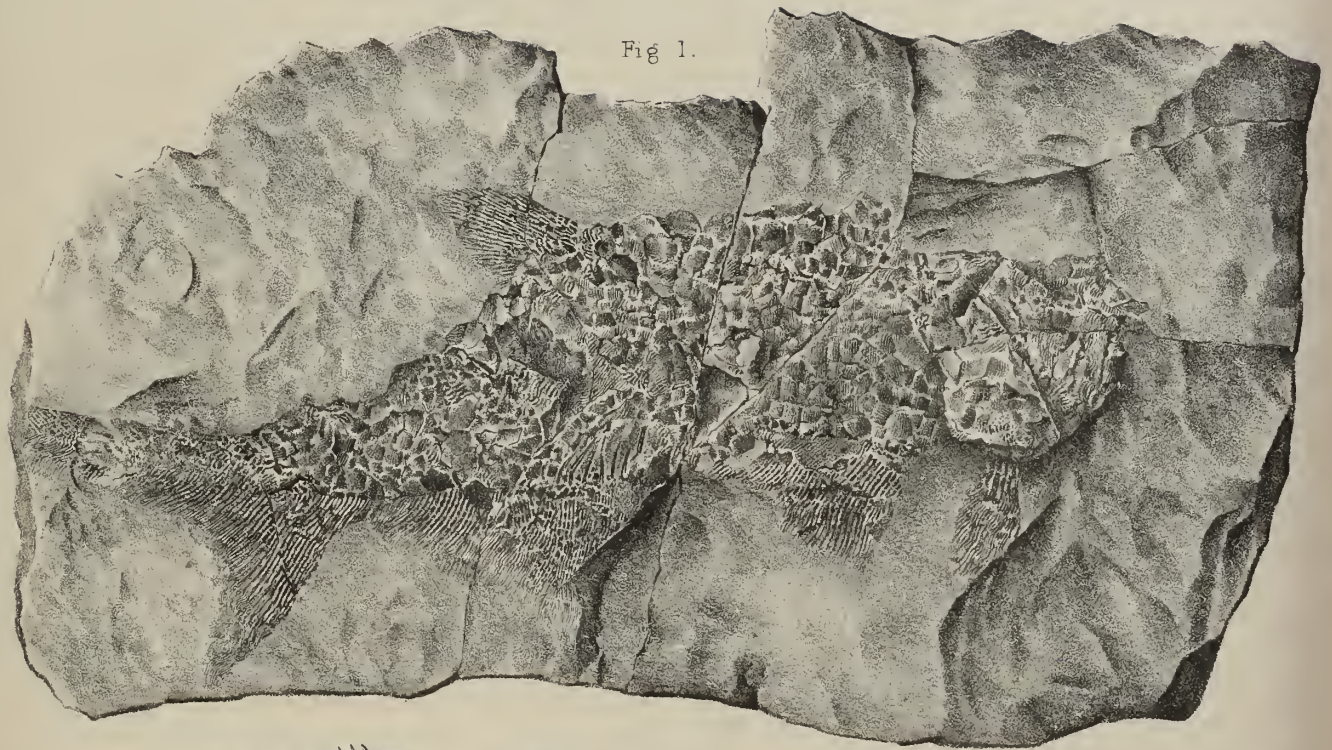
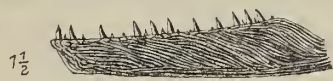


Fig 1.



$1\frac{1}{2}$

Fig. 3.



Fig. 4.

$\frac{2}{7}$



Fig. 9.

$\frac{6}{7}$



Fig. 7.

$\frac{4}{7}$

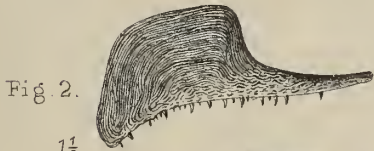


Fig. 2.

$1\frac{1}{2}$



Fig. 6.

$\frac{3}{7}$



Fig. 8.

$\frac{3}{7}$

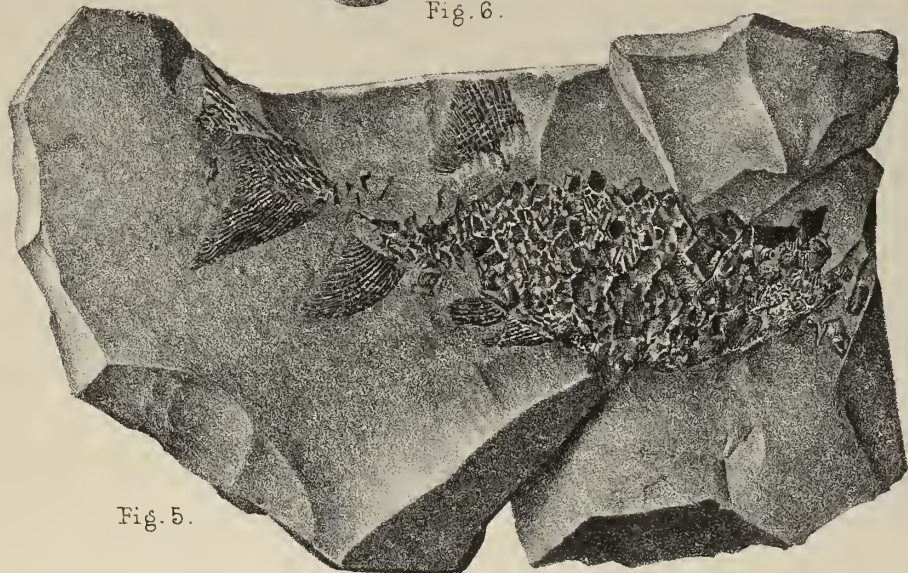


Fig. 5.



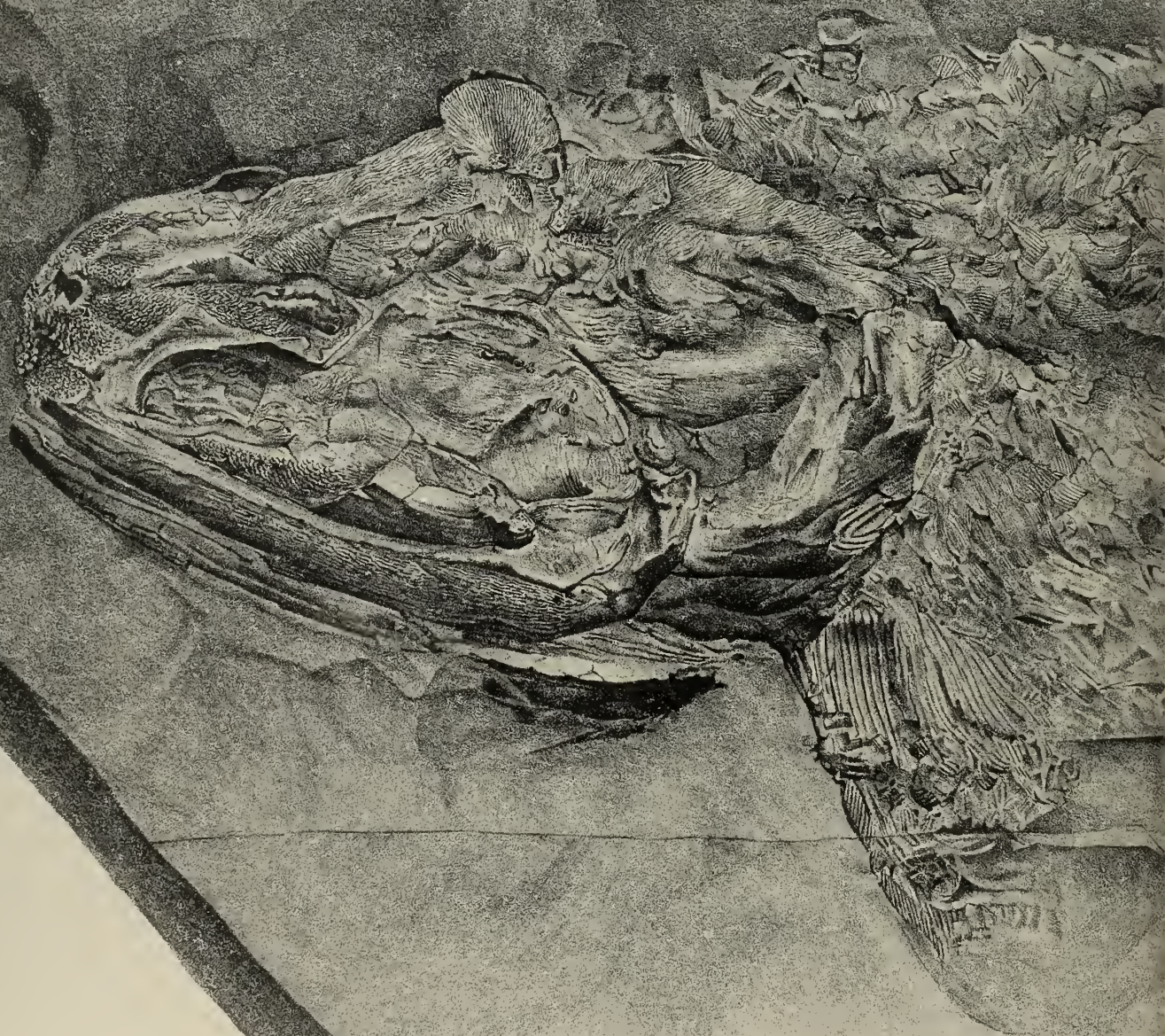


PLATE XXIII.

(The cost of this plate has been defrayed by the Carnegie Trust for the Universities of Scotland.)

*Acrolepis Hopkinsi* (McCoy). From the Roof Shale of the Low Main Coal Seam at Newsham, near Newcastle-upon-Tyne. In the Atthey Collection, Natural History Museum, Newcastle.









Palæontographical Society, 1907.

THE  
FOSSIL FISHES

OF THE

ENGLISH CHALK.

BY

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PALÆONTOGRAPHICAL SOCIETY.

PART III.

PAGES 97—128; PLATES XXI—XXVI.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1907.

PRINTED BY ADLARD AND SON, LONDON AND DORKING.

the accompanying outline-restoration (Text-fig. 23). The upper jaw is not identifiable with certainty, but the premaxilla shown of the natural size in Pl. XIX, fig. 6, probably belongs to *I. minor*. This bone is less than twice as deep as broad, and bears a slight ridge down the middle of its outer face. Its oral margin is gently convex and has five teeth, which are nearly equal in size. The three middle teeth are well preserved and closely resemble the mandibular teeth of *I. minor* in shape. The dental crown at each end of the series is broken away. On the inner abraded face of the bone one successional tooth is seen adjoining the base of its functional predecessor, not directly beneath it.

*Horizons and Localities.*—Turonian zones : Sussex and Kent. Zone of *Holaster subglobosus* : Dorking, Surrey ; probably also neighbourhood of Burham, Kent.

2. *Ichthyodectes elegans*, Newton. Text-figure 24.

1877. *Ichthyodectes elegans*, E. T. Newton, Quart. Journ. Geol. Soc., vol. xxxiii, p. 521, pl. xxii, fig. 15.

1901. *Ichthyodectes elegans*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 103, pl. ix, figs. 4, 5.

*Type.*—Imperfect dentary from zone of *Holaster subglobosus* ; British Museum.

*Specific Characters.*—Slightly smaller than *I. minor*. Oral border of dentary bone somewhat concave, curved upwards to the beak-like symphysis ; its outer

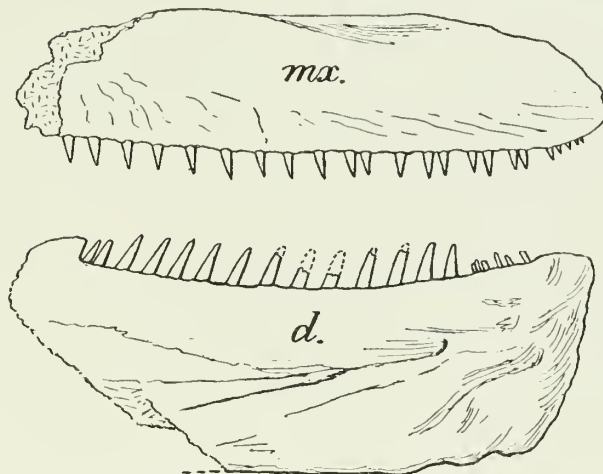


FIG. 24. *Ichthyodectes elegans*, Newton ; outlines of left maxilla, outer aspect (*mx.*) and dentary, inner aspect (*d.*), nat. size.—Zone of *Holaster subglobosus* ; Upper Halling, Kent. Harford Collection (B. M. nos. P. 5644—45).

face gently sinuous, not sharply bent or ridged ; its teeth very small at the symphysis, but of moderate size and in regular series beyond, the crowns slender, all inclined a little forwards, with the apex slightly curved inwards ; total number of tooth-sockets in dentary about 40. Maxilla scarcely deepened in front, and its

oral border straight; teeth somewhat smaller, stouter, and less inclined than those of the dentary, minute at the hinder end of the bone.

*Description of Specimens.*—The type specimen is very fragmentary, and this species is best known by the associated dentary and maxillary bones, which are figured in the British Museum Catalogue (1901, *loc. cit.*). The outlines of these two elements are reproduced in the accompanying Text-fig. 24.

*Horizon and Localities.*—Zone of *Holaster subglobosus*; Upper Halling and Dover, Kent; Dorking, Surrey.

### 3. *Ichthyodectes tenuidens*, A. S. Woodward. Plate XXI, fig. 7.

1901. *Ichthyodectes tenuidens*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 104, pl. ix, fig. 6.

*Type.*—Imperfect skull from zone of *Holaster subglobosus*; British Museum.

*Specific Characters.*—Jaws closely resembling those of *I. elegans*, but the teeth, especially those of the maxilla, more slender.

*Description of Specimens.*—The type specimen of this species is the only nearly complete head of *Ichthyodectes* hitherto obtained from the English Chalk. It is exposed in right side-view (Pl. XXI, fig. 7) and from above, but the fossil is transversely fractured and slightly distorted at the front border of the orbit. The cranial roof is narrow, exhibiting posteriorly the usual median crest, which is continued forwards along the middle line of the frontal region as far as the comparatively small ethmoid bone. None of the bones are externally ornamented. The very large size of the eye is indicated by fragments of the ossified sclerotic (*sc.*); immediately behind this are the remains of thin cheek-plates (*co.*), with traces of the slime-canal, which seems to have had radiating branches; while in front may be observed the robust prefrontal (*pf.*), with its flattened inferior facette for the palatine, which is displaced (*pl.*). The maxilla (*mx.*) is long and slender, but much fractured, so that its anterior end is displaced, and only three of the slender teeth remain; a facette postero-superiorly shows the extent of overlap of a supramaxillary bone. The outer surface of the dentary (*d.*) is smooth and only gently undulating, without any sharp longitudinal ridge. The preoperculum (*pop.*) is shown to be much expanded, with thickened anterior margin, and the usual radiating branches of the slime-canal.

Fragments of jaws of larger size, which may belong to this species, are remarkable for the delicate flaky texture of the bone.

*Horizon and Localities.*—Zone of *Holaster subglobosus*: Burham and Halling, Kent.

Genus **PORTHEUS**, Cope.

*Megalodon*, L. Agassiz (*non* Sowerby, 1829), Poiss. Foss., Feuille., 1835, p. 55 (in part).

*Hypsodon*, L. Agassiz, *loc. cit.*, 1837, p. 104 (in part).

*Xiphactinus*, J. Leidy, Proc. Acad. Nat. Sci. Philad., 1870, p. 12.

*Portheus*, E. D. Cope, Proc. Amer. Phil. Soc., vol. xii, 1872, p. 331.

*Generic Characters*.—As *Ichthyodectes*, but teeth irregular in size.

*Type Species*.—*Portheus molossus* (Cope, Proc. Amer. Phil. Soc., vol. xii, 1872, pp. 175, 333, and Vert. Cret. Form. West, 1875, pp. 184, 194, fig. 8, pls. xxxix—xli), from the Upper Cretaceous (Niobrara Group) of Kansas, U.S.A.

*Remarks*.—The remains of this genus were first discovered in the English Chalk, and were originally named *Megalodon* and *Hypsodon* by Agassiz without description or definition. The jaws were subsequently figured by the same author under the indefinite name *Hypsodon lewesiensis*, which now proves to have been given to remains of two distinct genera (see also *Pachyrhizodus*, p. 124). Similar, but more satisfactorily preserved, fossils were afterwards found in the Chalk of Kansas, and the genus to which they belong was first defined by Cope in 1872 under the name of *Portheus*. A fin-ray, doubtless of the same fish but insufficient for generic definition, was also described from the Chalk of Kansas by Leidy, who named it *Xiphactinus andax*. Later discoveries in the Chalk of Kansas<sup>1</sup> have made

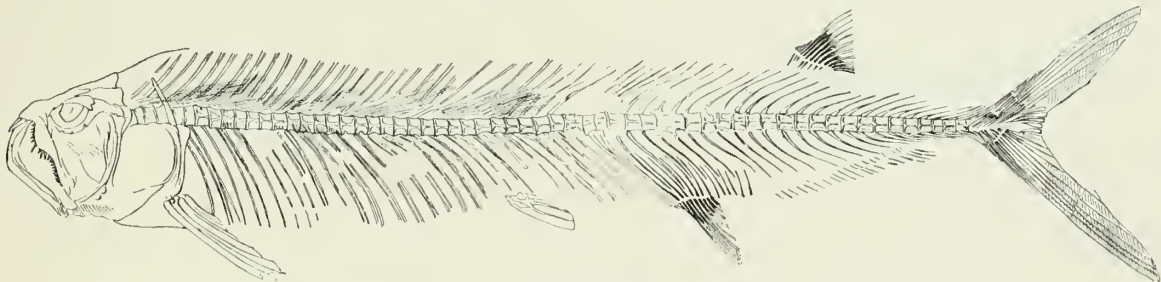


FIG. 25. *Chirocentrites coroninii*, Heckel; fish, nearly one quarter nat. size.—Neocomian; Istria.  
After J. J. Heckel.

known the whole skeleton except the dorsal and anal fins, of which it can only be stated that they were remote and opposite. The discovery of these fins is an important desideratum, because in all other features *Portheus* agrees very closely with *Chirocentrites* (Text-fig. 25), of which nearly complete skeletons were

<sup>1</sup> See especially A. R. Crook, "Ueber einige fossile Knochenfische aus der mittleren Kreide von Kansas," Palæontogr., vol. xxxix, 1892, pp. 114—122, pl. xviii; O. P. Hay, "Observations on the Genus of Fossil Fishes called by Professor Cope *Portheus*, by Dr. Leidy *Xiphactinus*," Zool. Bull., vol. ii, 1898, pp. 25—54, figs. 1—16; A. Stewart, "Teleosts of the Upper Cretaceous," Univ. Geol. Surv. Kansas, vol. vi, Paleont., pt. ii, 1900, pp. 265—295, pls. xxxiii—xlvi; H. F. Osborn, "The Great Cretaceous Fish *Portheus molossus*, Cope," Bull. Amer. Mus. Nat. Hist., vol. xx, 1904, pp. 377—381, pl. x.

described from the Cretaceous of Istria in 1850.<sup>1</sup> *Portheus* may, in fact, be merely a synonym of *Chirocentrites*.

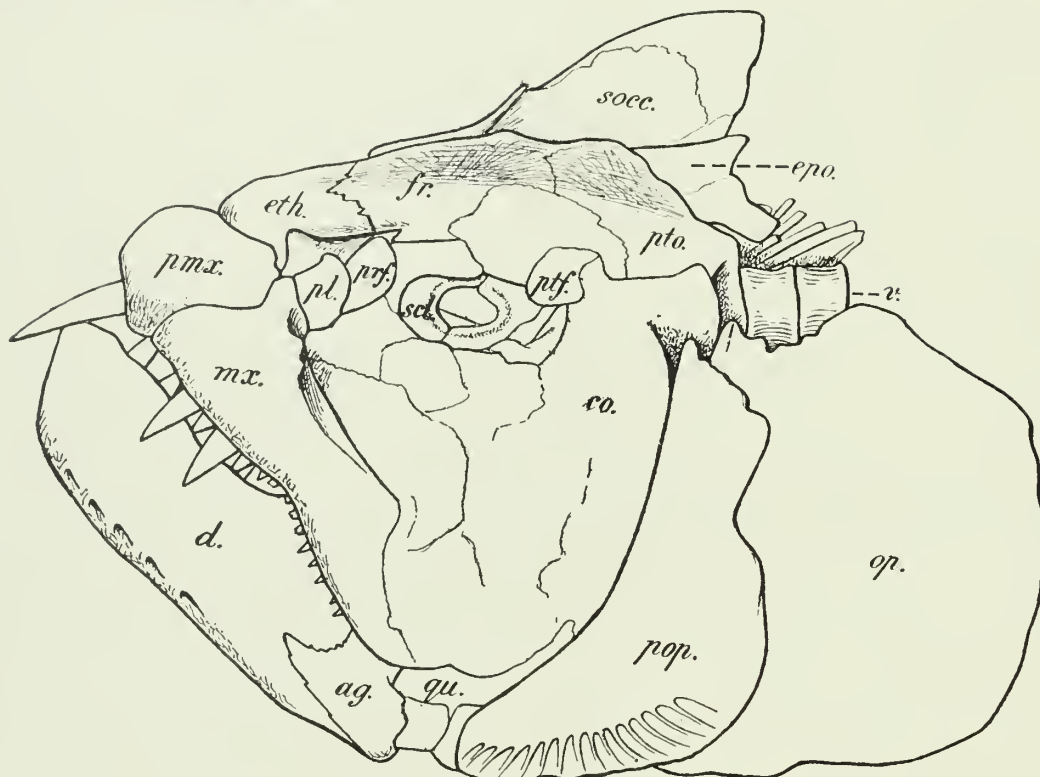


FIG. 26. *Portheus molossus*, Cope; head with opercular apparatus, about one quarter nat. size.—Upper Cretaceous (Niobrara Group); Kansas, U.S.A. *ag.*, articulo-angular; *co.*, circumorbital cheek-plates; *d.*, dentary; *epo.*, epiotic; *eth.*, mesethmoid; *fr.*, frontal; *mx.*, maxilla; *op.*, operculum; *pl.*, palatine; *pmx.*, premaxilla; *pop.*, preoperculum; *ptf.*, prefrontal; *ptf.*, postfrontal; *pta.*, pterotic (including squamosal); *qu.*, quadrate; *scl.*, ossified sclerotic; *socc.*, supraoccipital; *v.*, anterior vertebræ. After Alban Stewart.

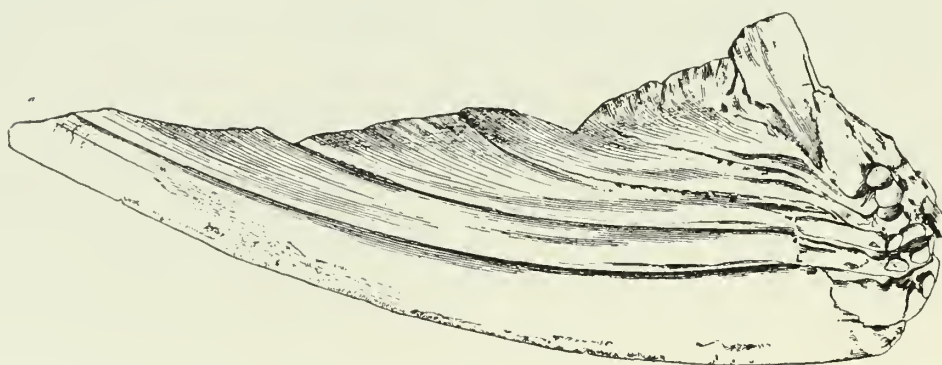


FIG. 27. *Portheus molossus*, Cope; right pectoral fin, about one fifth nat. size.—Upper Cretaceous (Niobrara Group); Kansas, U.S.A. After H. F. Osborn.

The general characters of the head and paired fins of *Portheus* are shown in the accompanying Text-figs. 26—28, which represent parts of the type species from

<sup>1</sup> J. J. Heckel, "Beiträge zur Kenntniss der Fossilen Fische Oesterreichs," Denkschr. k. Akad. Wiss., math.-naturw. Cl., vol. i, 1850, p. 203, pls. xiii—xv.

Kansas. The teeth bear much superficial resemblance to those of *Protosphyræna*

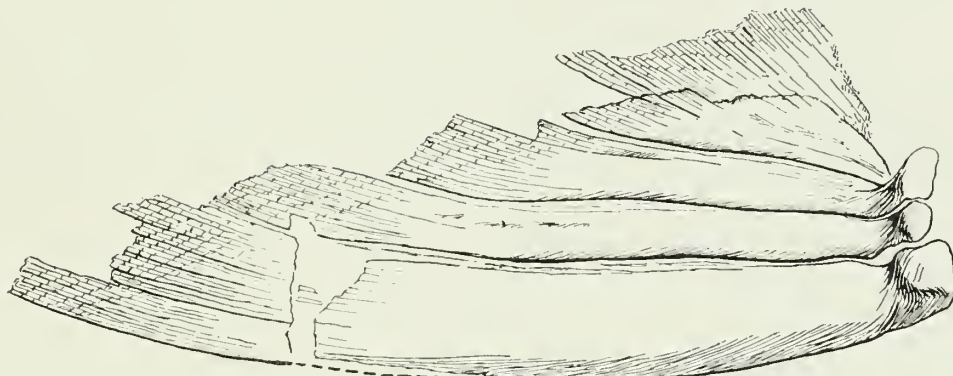


FIG. 28. *Portheus molossus*, Cope; pelvic fin, about one fifth nat. size.—Upper Cretaceous (Niobrara Group); Kansas, U.S.A. B. M. no. P. 6326.

and of Pterodaactyles, but they are distinguished by their large pulp-cavity and splintery fracture.

1. ***Portheus mantelli***, Newton. Plate XXI, figs. 8, 9; Text-figure 29.

1822. "Unknown fish," G. A. Mantell, Foss. South Downs, p. 241, pl. xlii, figs. 1, 3, 4.

1835. *Megalodon sauroides*, L. Agassiz, Poiss. Foss., Feuille., p. 55 (name only).

1836. *Megalodon ? lewesiensis*, G. A. Mantell, Descript. Catal. Geol., etc., Mus. Sussex Sci. Lit. Inst., ed. 5, p. 30.

1837-44. *Hypsodon lewesiensis*, L. Agassiz, Poiss. Foss., vol. v, pt. i, p. 100 (in part), pl. xxv a, fig. 3; pl. xxv b, figs. 1-3.

1877. *Portheus mantelli*, E. T. Newton, Quart. Journ. Geol. Soc., vol. xxxiii, p. 510.

1901. *Portheus mantelli*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 95.

*Type*.—Imperfect left maxilla and premaxilla from one of the Turonian zones; British Museum.

*Specific Characters*.—Premaxilla with five teeth of unequal size. Maxilla about four times as long as the premaxilla, and its oral border in the form of a slightly concave arch. Teeth smooth, not faceted.

*Description of Specimens*.—The type specimen in the Mantell Collection (nos. 4066-67) is an upper jaw measuring only 18 cm. in length (Pl. XXI, fig. 8); but another maxilla, sufficiently similar to have belonged to the same species, is larger, and other fragmentary remains suggest that *Portheus mantelli* attained as large a size as the typical *P. molossus*, of which the skull sometimes measures 45 cm. in length, while the whole fish cannot have been less than 4-5 metres in length. Unfortunately, only isolated bones have hitherto been found in the English Chalk.

The premaxilla (Pl. XXI, fig. 8, *pmx.*; fig. 8 a) is deeper than wide, and its

three middle teeth are much larger than the first and fifth teeth. The maxilla in the type specimen (Pl. XXI, fig. 8, *ma.*) is incomplete in front, while it is broken across and slightly displaced at its thin hinder end; but the greater part of its border is preserved. Its outer face is flattened, and only marked with a feeble tuberculation at its hinder end. The largest teeth, as usual, are fixed in the convexity of the oral border in its anterior third, but the hinder teeth are also of considerable size.

The fragment of mandible figured by Agassiz (*tom. cit.*, pl. xxv b, fig. 3) belongs to a larger fish than the type specimen, but is probably referable to the same species. A still larger left mandibular ramus, reduced in outline in Text-fig. 29, is less imperfect, and exhibits the contour of the dentary bone. The oral

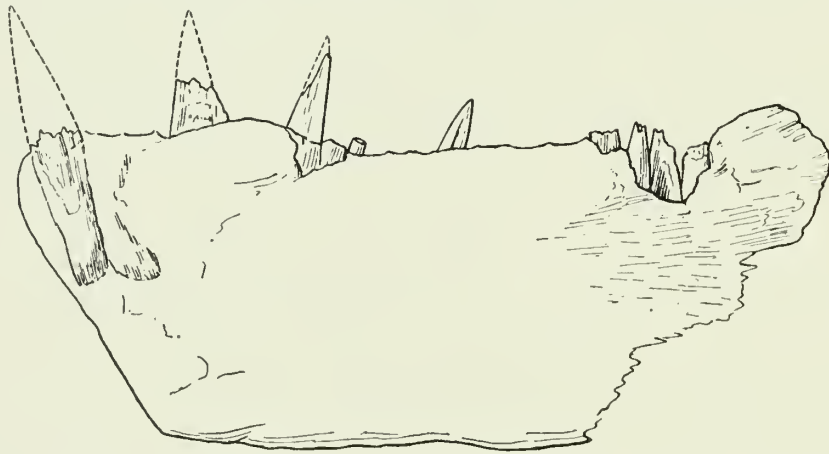


FIG. 29. *Portheus mantelli*, Newton; outline of left dentary, three eighths nat. size.—Lower Chalk; Burham, Kent. Dibley Collection (B. M. no. P. 8252).

border of this specimen is only slightly wavy, and its anterior convexity bears the usual relatively large teeth.

Many vertebræ and portions of fin-rays large enough to have belonged to the same fish as the largest jaws, have also been found in the English Chalk. A well-preserved vertebral centrum, with the two characteristic lateral pits, is shown in Pl. XXI, fig. 9.

*Horizons and Localities.*—Turonian zone: Lewes. Larger specimens from zones of *Holaster subglobosus* to *Rhynchonella curieri*: Burham, Kent. Also from undetermined zones: Warminster, Wiltshire; Guildford, Surrey.

## 2. *Portheus daviesi*, Newton. Text-figure 30.

1877. *Portheus daviesii*, E. T. Newton, Quart. Journ. Geol. Soc., vol. xxxiii, p. 511, pl. xxii, fig. 13.

*Type.*—Imperfect right maxilla, probably from zone of *Holaster subglobosus*; British Museum.

*Specific Characters.*—Maxilla remarkable for the unusually great depth and relatively long extent of the anterior portion, which has a gently convex oral border, with small teeth in front and the largest teeth on the convexity not much larger than those immediately behind. Teeth smooth, not faceted.

*Description of Specimen.*—The type specimen in the Mantell Collection (no. 28388) remains unique, and is shown in outline in Text-fig. 30. The anterior

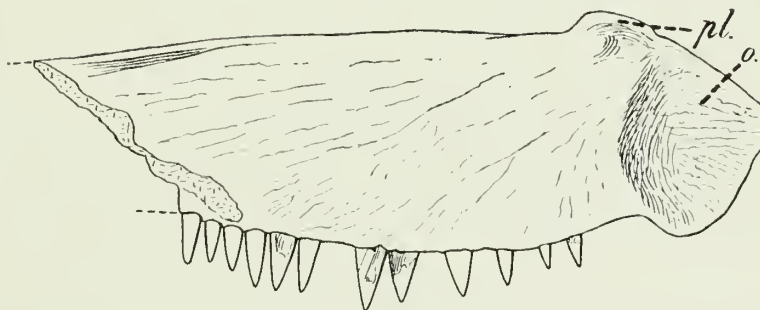


FIG. 30. *Portheus daviesi*, Newton; outline of right maxilla, the type specimen, three quarters nat. size.—Chalk; Maidstone. Mantell Collection (B. M. no. 28388). *o.*, facette overlapped by premaxilla; *pl.*, articulation for palatine.

extension of the maxilla (*o.*), which would originally be overlapped by the premaxilla, is relatively large; and the small palatine articulation (*pl.*) is only slightly raised above the upper border of the bone. So far as preserved, the outer face of the bone is not ornamented.

*Horizon and Locality.*—Probably zone of *Holaster subglobosus*: near Maidstone, Kent.

Among specifically indeterminable remains of *Portheus* may be mentioned a fragmentary mandible from the zone of *Holaster subglobosus*, Halling, Kent, which has been provisionally referred to *Portheus gaultinus*, E. T. Newton, Quart. Journ. Geol. Soc., vol. xxxiii, 1877, p. 520. The type specimen of the latter species was obtained from the Gault of Folkestone.

### Genus **SAURODON**, Hays.

*Saurodon*, I. Hays, Trans. Amer. Phil. Soc., n. s., vol. iii, 1830, p. 475.

*Daptinus*, E. D. Cope, Proc. Acad. Nat. Sci. Philad., 1873, p. 339.

*Generic Characters.*—Teeth hollow, in deep sockets, compressed to a sharp edge in front and behind; those of the maxilla, as also those of the dentary, almost uniform, only slightly increasing in size backwards, and those of the premaxilla not much enlarged; the inner margin of each dental alveolus deeply notched. A

small toothless presymphysial bone in the mandible. Vertebrae as in *Ichthyodectes* and *Portheus*.

*Type Species*.—*Saurodon leanus* (Hays, Trans. Amer. Phil. Soc., n. s., vol. iii, 1830, p. 476, pl. xvi), from the Upper Cretaceous of New Jersey, U.S.A.

*Remarks*.—This genus is best known by nearly complete skulls and other

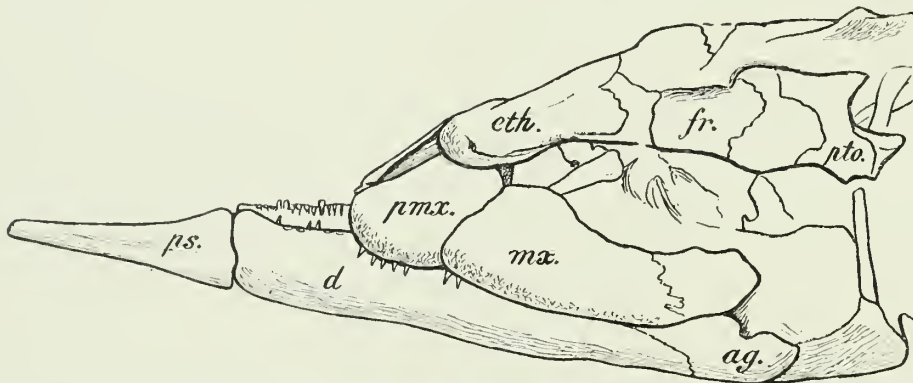


FIG. 31. *Saurodon xiphrostris*, Stewart; left side-view of crushed head, with mandible displaced forwards, about one half nat. size.—Upper Cretaceous (Niobrara Group); Kansas, U.S.A. *ag.*, articulo-angular; *d.*, dentary; *eth.*, mesethmoid; *fr.*, frontal; *mx.*, maxilla; *pmx.*, premaxilla; *ps.*, presymphysial bone; *pto.*, pterotic (including squamosal). After Alban Stewart.

remains from the Upper Cretaceous (Niobrara Group) of Kansas, U.S.A. The remarkable presymphysial bone has been found in several specimens, forming a triangular, toothless, and pointed projection in front of the mandible (Text-fig. 31, *ps.*).

### 1. *Saurodon intermedius* (Newton). Text-figure 32.

1878. *Daptinus intermedius*, E. T. Newton, Quart. Journ. Geol. Soc., vol. xxxiv, p. 440, pl. xix.

1890. *Saurocephalus intermedius*, Woodward and Sherborn, Catal. Brit. Foss. Vertebrata, p. 181.

1901. *Saurodon intermedius*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 112.

*Type*.—Head, etc., probably from zone of *Schloenbachia varians*; British Museum.

*Specific Characters*.—Teeth much longer and less compressed than in the type species; only five dental alveoli in the premaxilla and about thirty-two in the maxilla. Maximum depth of maxilla contained about two and a half times in its length; maximum depth of mandible slightly less than one quarter of its length. Bones without external ornamentation.

*Description of Specimen*.—In the type specimen (Text-fig. 32), which still remains unique, the upper jaw measures about 10 cm. in length. So far as it can be compared, the head agrees very closely with that of the species of *Saurodon*

from the Kansas Chalk; but the presymphysial bone is lacking in front of the truncated dentary. Most of the characteristic teeth are preserved, including those in the hinder part of the dentary on the right side of the fossil. The forward

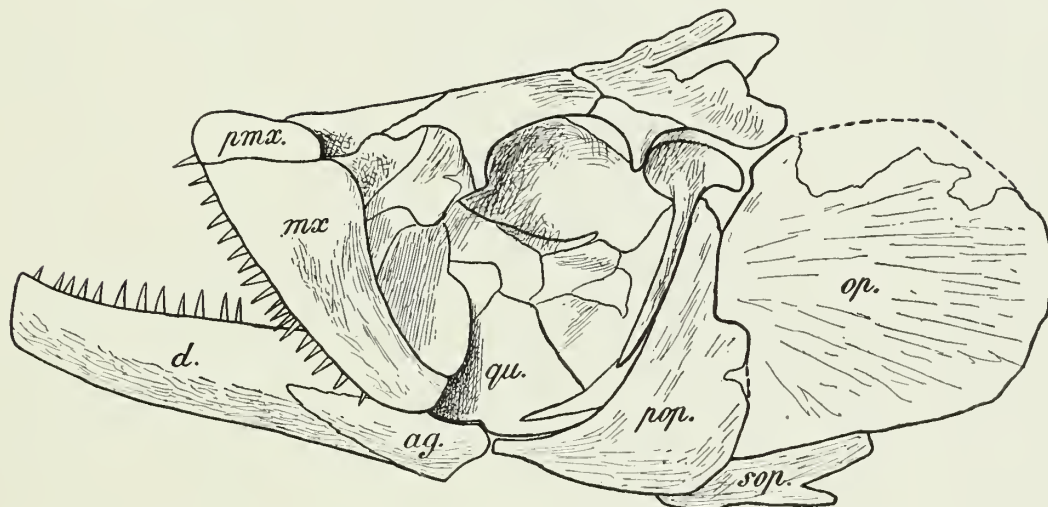


FIG. 32. *Saurodon intermedius* (Newton); outline of head with opercular apparatus, the type specimen, two thirds nat. size.—Probably from zone of *Schloenbachia varians*; Dover. Gardner Collection (B. M. no. 47250). *ag.*, articulo-angular; *d.*, dentary; *mx.*, maxilla; *op.*, operculum; *pmx.*, premaxilla; *pop.*, preoperculum; *qu.*, quadrate; *sop.*, part of suboperculum.

inclination and prominence of the mandible are well shown. The outlines of the much-expanded preoperculum (*pop.*) and the nearly square operculum (*op.*) are also distinct. The anterior abdominal vertebral centra, with slight lateral pits, are somewhat longer than deep.

A maxilla very similar to that of *Saurodon intermedius*, but ornamented with fine granulations and pittings, has been found in the same formation and locality as the preceding specimen.

*Horizon and Locality.*—Probably zone of *Schloenbachia varians*: Dover.

#### Family PLETHODONTIDÆ.

Cretaceous fishes more or less closely related to the surviving Osteoglossidæ and Albulidæ, but not yet sufficiently well known for exact classification. In the skull the parietal bones meet in the middle line, and there is a roofed posterior temporal fossa on each side. A large median dental plate is fixed to the parasphenoid and opposed to a similar dental plate, which is probably supported by the basihyal bone.

The only genus known by large portions of the skeleton is *Anognius*, from the

Family PLETHODONTIDÆ.—Genus **ANOGLMIUS**, Cope.

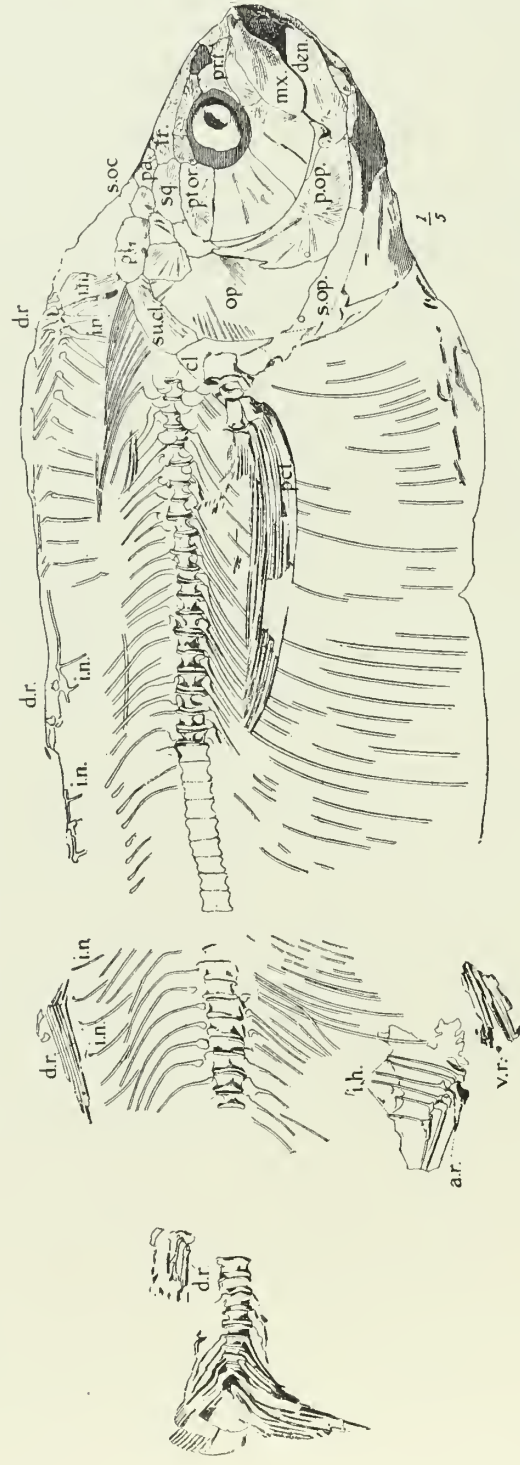


FIG. 33. *Anogmius aratus*, Cope; sketch of right side-view of imperfect skeleton, one fifth nat. size.—Upper Cretaceous (Niobrara Group); Kansas, U.S.A. *a.r.*, anal fin; *cl.*, clavicle; *d.r.*, dorsal fin; *den.*, dentary; *f.r.*, frontal; *i.h.*, interhemals; *i.n.*, interneurals; *mx.*, maxilla; *op.*, operculum; *pa.*, parietal; *pct.*, pectoral fin; *p.op.*, preoperculum; *pr.f.*, prefrontal; *pt.*, post-temporal; *pt.or.*, postorbital; *s.oc.*, supraoccipital; *s.op.*, supraoperculum; *sq.*, squamosal; *su.cl.*, supraclavicle; *v.r.*, part of pelvic fin. After O.P. Hay.

Chalk of Kansas.<sup>1</sup> In this fish (Text-fig. 33) the trunk is elongated and laterally compressed, with an extended dorsal fin occupying the greater part of the back, a small remote anal fin, and a forked caudal fin. The vertebræ resemble those of *Pachyrhizodus* (p. 124). The paired fins are small, the pectorals inserted high on the flank, and the pelvic pair far back. The scales are large, elliptical, and smooth.

Genus **PLETHODUS**, Dixon.

*Plethodus*, F. Dixon, Geol. Sussex, 1850, p. 366.

*Generic Characters*.—Skull deep and laterally compressed. Gape of mouth small; premaxilla apparently fused with the short rostrum, this, the maxilla, and dentary bearing minute teeth; ectopterygoid very slender, also with minute teeth; upper and lower dental plates consisting of clustered minute vertical tubules.

*Type Species*.—*Plethodus expansus* from the English Chalk.

*Remarks*.—This genus is known chiefly by the detached dental plates; but imperfect skulls of the smallest species have also been discovered. The dental plates, which were originally referred by Dixon to a Cestraciont shark, usually exhibit their tubular structure and a bony base of open texture; but the tubular tissue is sometimes changed to a dark translucent substance which shows only small cavities like those of the underlying bone.

1. **Plethodus expansus**, Dixon. Plate XXII, figs. 1—5.

1850. *Plethodus expansus*, F. Dixon, Geol. Sussex, p. 366, pl. xxxiii, fig. 2.

1888. *Plethodus expansus*, A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 331.

1899. *Plethodus expansus*, A. S. Woodward, Ann. Mag. Nat. Hist. [7], vol. iii, p. 354, pl. xiii, figs. 1—4.

1900. *Thryptodus* sp., F. B. Loomis, Palæontogr., vol. xlvi, p. 235.

1901. *Plethodus expansus*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 81.

*Type*.—Imperfect lower dental plate from a Turonian zone; Brighton Museum.

*Specific Characters*.—The type species, known only by lower and upper dental plates, which sometimes measure 10 cm. in length. Lower dental plate leaf-shaped, one end being comparatively broad and gently rounded, the other end nearly pointed; its grinding surface slightly convex except near the pointed end,

<sup>1</sup> See especially O. P. Hay, "On certain Genera and Species of North American Cretaceous Actinopterosus Fishes," Bull. Amer. Mus. Nat. Hist., vol. xix, 1903, pp. 26—47, with figs. Also see descriptions and figures of skulls under the names of *Thryptodus*, *Pseudothryptodus*, and *Syntegmodus*, by F. B. Loomis, Palæontogr., vol. xlvi, 1900, pp. 229—236, with figs.

where it becomes concave; its truncated border more or less tuberculated. Upper dental plate nearly as broad as long and regularly concave.

*Remarks.*—It is curious that of so large a species no bones have hitherto been identified. The skull will probably prove to be very similar to that of *Anognmius aratus* and *A. zitteli*; and it seems likely that the tip of its snout has already been wrongly described as belonging to an *Acipenseroid* fish.<sup>1</sup>

*Description of Specimens.*—The type specimen in the Willett Collection, Brighton Museum, is part of the side of a large lower dental plate, which when complete probably resembled the original of Pl. XXII, fig. 1, in size and shape. Its slightly sinuous but generally convex grinding-surface does not exhibit any punctations, and consists of a thin, yellowish, opaque layer covering the thick agglomeration of parallel vertical tubules, which form the main mass of the plate. There is a base, presumably of bone, beneath this mass, but it seems to be comparatively thin. The lateral border of the plate is somewhat truncated, and it may have borne a few blunt tubercles, but this is not quite certain.

Fragments of many similar plates are known, but no complete examples have hitherto been discovered in the Chalk. With them occur somewhat concave plates of the same structure, which evidently represent the opposing dentition of the upper jaw. One such specimen, which is remarkably concave and must have been originally about as broad as long, is shown in Pl. XXII, fig. 2. Its oral face, being unabraded, is not punctate, but the marginal area is covered irregularly with numerous shallow pits. The truncated border (fig. 2 *b*) is tuberculated, as in the leaf-shaped plates, and a median bony bar ( $\mu$ ) is especially well preserved at one end (presumably the posterior). The form and direction of this bar are shown in figs. 2, 2 *b*, while adjoining it on each side in a nearly parallel plane there are remains of a comparatively thin lamina of bone ( $\alpha$ ) of uncertain form. The attached face of the dental plate, so far as exposed, has the curious aspect shown in fig. 2 *a*. Like the attached face of the lower dental plates, it is marked by very fine reticular lines; but here the lines are most prominent in a transverse direction and pass into a remarkable cluster of vermiculating fibres on the median longitudinal ridge. This ridge does not extend to the ends of the plate; and at the end which we regard as anterior it terminates at the apex of a bilaterally-symmetrical triangular area, on which the reticular markings exhibit chiefly a divergent fan-shaped arrangement. Similar markings are seen in another specimen (fig. 3).

There is much variation in the contour of the plates of both kinds commonly referred to *Plethodus expansus*, but it seems best at present not to separate them under distinctive names. They all have the minute structure represented in Pl. XXII, figs. 4, 5. The grinding surface, when unworn in the fossils, is covered

<sup>1</sup> A. S. Woodward, "On the Palæontology of Sturgeons," Proc. Geol. Assoc., vol. xi (1889), p. 31, pl. i, fig. 6.

with a thin, dense layer, which is almost opaque in microscope-sections, showing only a granular structure, no organic tissue. Below this the main mass of the plate consists of a dense cluster of vertical tubules, which are conspicuous in sections even to the naked eye (fig. 4). Examined in transverse section under the microscope (fig. 5), each tubule is seen to consist of several concentric layers, which are variously and unequally stained in the fossils; and these layers are crossed by very minute, more or less wavy tubuli, which radiate from the central canal. The base of the plate is formed of cancellous true bone, which often penetrates the lower part of the overlying layer in slender processes between the tubuli.

*Horizons and Localities.*—Turonian zones: neighbourhood of Lewes. Zone of *Holaster subglobosus*: Halling and Burham, Kent; Glynde, Clayton, and Newtimber, Sussex. Zone of *Terebratulina gracilis*: Cuxton, Kent. Undetermined zone: South Wiltshire. Also ranging downwards to Upper Greensand and Gault.

## 2. *Plethodus pentagon*, A. S. Woodward. Plate XXII, figs. 6—8.

1899. *Plethodus pentagon*, A. S. Woodward, Ann. Mag. Nat. Hist. [7], vol. iii, p. 356, pl. xiii, figs. 5—7.

1900. *Thryptodus* sp., F. B. Loomis, Paleontogr., vol. xlvi, p. 235.

1901. *Plethodus pentagon*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 83.

*Type.*—Lower dental plate from zone of *Holaster subglobosus*; British Museum.

*Specific Characters.*—A smaller species than the type, the lower dental plate attaining a length of about 6 cm., with a maximum breadth of 4 cm. Lower dental plate elongated, pentagonal in shape, widest near the pointed end, and the border of the truncated end slightly excavated; grinding surface slightly convex. Supposed upper dental plate quadrangular.

*Description of Specimens.*—The type specimen (Pl. XXII, fig. 6) is only imperfect at one angle, where the section displays the dentinal structure characteristic of the genus (fig. 6*a*). Its oral face is abraded, and thus exhibits punctate markings due to the exposure of the ends of the constituent tubules (fig. 6*b*): it is very gently convex, and slightly curved upwards at the two sharp angles which bound the truncated end. Three pits or depressions occur on the oral face near this end. The steep lateral border is not tuberculated. Part of the pointed end of a similar plate (fig. 7) bears numerous pits or depressions on the attenuated point.

A concave dental plate which probably represents the upper or opposing dentition of *P. pentagon*, is shown in Pl. XXII, fig. 8. It is oblong and quadrangular in shape, strongly arched transversely, and less so longitudinally. Its

oral face is smooth, not abraded, but it is deeply pitted at the lateral borders, which curve downwards to the coarsely tuberculated margin (fig. 8 *a*).

*Horizon and Localities.*—Zone of *Holaster subglobosus*: Burham and Dover, Kent; Lewes, Sussex; Dorking, Surrey.

### 3. *Plethodus oblongus*, Dixon. Plate XXII, figs. 9, 10.

1850. *Plethodus oblongus*, F. Dixon, Geol. Sussex, p. 366, pl. xxxii\*, fig. 4.

1899. *Plethodus oblongus*, A. S. Woodward, Ann. Mag. Nat. Hist. [7], vol. iii, p. 357, pl. xiv.

1901. *Plethodus oblongus*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 83.

*Type.*—Lower dental plate probably from zone of *Holaster subglobosus*; Brighton Museum.

*Specific Characters.*—A very small species, the lower dental plate about 2 cm. in length, elongated and irregularly ovoid in shape, the broader end gently rounded, the narrower end truncated; grinding surface of this plate slightly convex.

*Description of Specimens.*—A small skull in the Brighton Museum (Pl. XXII, figs. 9, 9 *a*), from the same locality as the type specimen, exhibits the rounded end of a similar dental plate (fig. 9 *a*, *l.*), while a more satisfactorily preserved skull in the British Museum (Pl. XXII, fig. 10) evidently belongs to the same species. Part of the cranial osteology of *P. oblongus* can therefore be determined.

The cranium is much laterally compressed and about as deep as long, with a very steep frontal profile. The roof-bones have a peculiar fibrous and punctate structure, and some of the sutures between them are distinguishable. Two small plates posteriorly seem to be part of a supratemporal series (fig. 10, *s.t.*). There is a doubtful indication of a small supraoccipital crest (fig. 9, *x.*), in front of which the transversely-elongated parietals (*pa.*) taper a little to their meeting in the middle line. External to the parietals and supraoccipital there is a nearly square squamosal (fig. 9, *sq.*), above the articulation for the hyomandibular (*hm.*) The relatively large frontal bones (*fr.*) appear to be fused together, and are not clearly distinct from the mesethmoid. Postero-laterally, where in contact with the hinder elements, the external surface of the frontal region exhibits radiating fibres, but further forwards it becomes finely punctate and rugose. The upper part of the frontal profile is compressed to a sharp edge, but further down it displays a slight flattened concavity (fig. 10 *a*). A small depression on each side just in front of the parietal border seems to represent a mucus-pit (*m.*). The outer border of each frontal is overlapped by two plates (fig. 10, *co.*), which may be referred to the circumorbital ring. The snout terminates in a thickened and obtusely pointed mesethmoid (*eth.*), which is ornamented with close reticulating ridges and lines of

tubercles (fig. 10 *a*). The basicranial axis, so far as preserved (to the border of the hyomandibular), is straight and parallel with the ridge of the cranial roof behind the frontal angle. Its constitution is uncertain, but the greater part is likely to be a parasphenoid (*pas.*), for from it there rises a low ridge of bone uniting with an extensive laminar interorbital septum, which is probably an orbito-sphenoid (*os.*). The supposed parasphenoid expands below the position of the eye into a Plethodont plate (*u.*), which is distinctly concave on its oral face. In the mandibular suspensorium, the very deep and narrow hyomandibular (*hm.*) is conspicuous, with a prominence on its thickened hinder border for the suspension of the operculum. The metapterygoid, quadrate, and long slender ectopterygoid with its minute teeth (*ecpt.*), are also seen in a plane external to the parasphenoid dental plate in fig. 10. The articulation for the mandible seems to have been beneath the middle of the orbit. The maxilla (fig. 10, *mx.*) is a deep laminar bone, finely tuberculated at its oral margin, which forms the greater part of the upper border of the mouth. If it bore teeth, they must have been restricted to a tubercular cluster on its inner face. The premaxillæ are unknown, but may be fused with the short ornamented rostrum, which curves inwards to the mouth below, and seems to bear minute teeth. The mandible is short and very deep, the dentary (*d.*) forming by far the greater part of the ramus. Its teeth are minute, obtuse, and styliform, in more than one series, apparently forming a cluster. In one specimen (fig. 10), displaced below the mandible, is a relatively large urohyal (*uh.*).

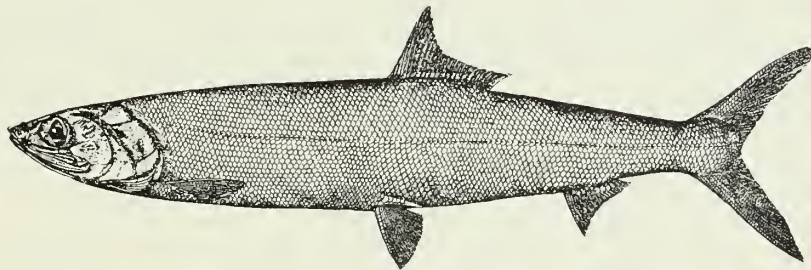


FIG. 34.—*Elops saurus*, Linn.; about one ninth nat. size.—Existing in tropical seas.  
After Jordan & Evermann.

The operculum (*op.*) displays only radiating structural lines, but is evidently incomplete in the fossils. The preoperculum (*pop.*) has a relatively large and widely expanded lower limb (well seen in fig. 9 *a*).

*Horizon and Localities.*—Zone of *Holaster subglobosus*: Clayton, Sussex; Dorking, Surrey; Burham, Kent.

## Family ELOPIDÆ.

This primitive family of bony fishes is represented in existing seas only by two genera, *Elops* (Text-figs. 34—37) and *Megalops*; but, as might be expected, it forms a much more important feature in the fish fauna of the Cretaceous period. Of the six genera from the English Chalk which appear to belong to it, only *Osmeroides* is known by nearly complete specimens. The characteristic gular plate has not yet been clearly observed in *Pachyrrhizodus*, *Elopopsis*, *Thrissopater*, or *Protelops*.

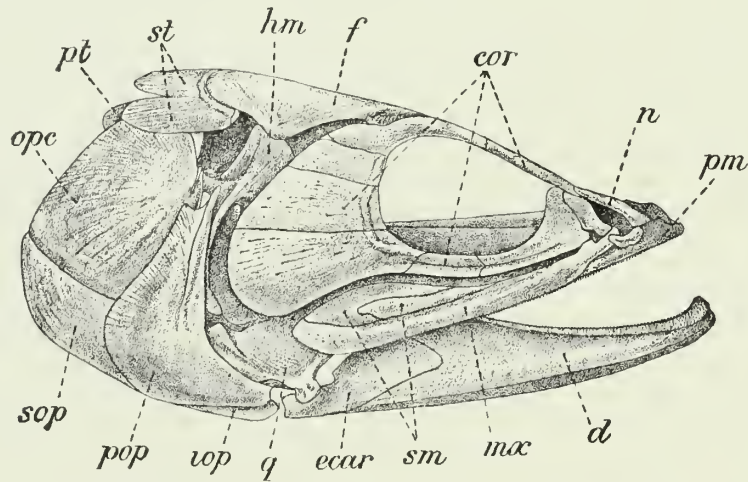


FIG. 35. *Elops saurus*, Linn.; head with opercular apparatus, right lateral aspect. *cor.*, circumorbital cheek-plates; *d.*, dentary; *ecar.*, articulo-angular; *f.*, frontal; *hm.*, hyomandibular; *iop.*, interoperculum; *mx.*, maxilla; *n.*, nasal; *opc.*, operculum; *pm.*, premaxilla; *pop.*, preoperculum; *pt.*, post-temporal; *q.*, quadrate; *sm.*, supra-maxilla; *sop.*, suboperculum; *st.*, supratemporals. After W. G. Ridewood.

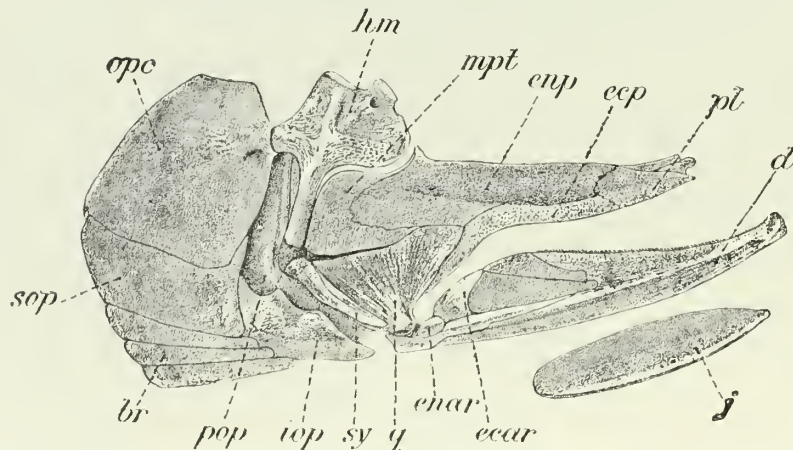


FIG. 36. *Elops saurus*, Linn.; left pterygo-palatine arcade, mandible, suspensorium, and opercular apparatus, inner aspect. *br.*, branchiostegal rays; *d.*, dentary; *ecar.*, *cnaar.*, articulo-angular; *ecp.*, ectopterygoid; *enp.*, entopterygoid; *hm.*, hyomandibular; *iop.*, interoperculum; *j.*, gular plate; *mpt.*, metapterygoid; *opc.*, operculum; *pl.*, palatine; *pop.*, preoperculum; *q.*, quadrate; *sop.*, suboperculum; *sy.*, symplectic. After W. G. Ridewood.

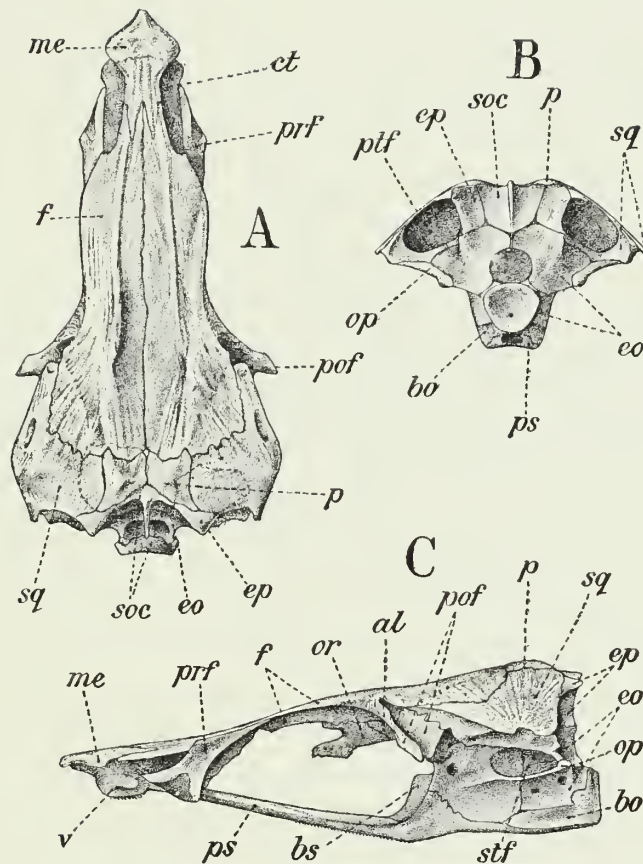


FIG. 37. *Elops saurus*, Linn.; cranium, from upper (A), hinder (B), and left lateral (C) aspects. *al.*, alisphenoid; *bo.*, basioccipital; *bs.*, basisphenoid; *ct.*, cartilage; *eo.*, exoccipital; *ep.*, epiotic; *f.*, frontal; *me.*, mesethmoid; *op.*, opisthotic; *or.*, orbitosphenoid; *p.*, parietal; *pof.*, postfrontal; *prf.*, prefrontal; *ps.*, parasphenoid; *ptf.*, posterior temporal fossa; *soc.*, supraoccipital; *sq.*, squamosal; *stf.*, subtemporal fossa, in side of otic region; *v.*, vomer. After W. G. Ridewood.

Genus **OSMEROIDES**, Agassiz.

*Osmeroides*, L. Agassiz, Poiss. Foss., vol. v, pt. ii, 1844, p. 103.

*Rhabdolepis*, W. von der Marek (non Troschel, 1857), Palæontogr., vol. xi, 1863, p. 26.

*Holcolepis*, W. von der Marek, *loc. cit.*, vol. xv, 1868, p. 278.

*Generic Characters*.—Head and trunk not much laterally compressed, and abdomen flattened. Parietal bones in contact in the median line; middle portion of cranial roof more or less flattened. Mandible a little prominent, and gape not extending behind the eye; maxilla arched, with two supramaxillary bones; margin of the jaws and some inner bones with clustered, minute, bluntly-pointed teeth, sometimes perhaps tritoral. Branchiostegal rays about 20 in number, about 5 of the uppermost and broadest supported by the epihyal. Vertebrae between 50 and 70 in number, about 20 being caudal; the centra not longer than deep, all slightly constricted and marked with small irregular longitudinal ridges. No

enlarged scale at the base of the paired fins; dorsal fin never much longer than deep, opposite or nearly opposite the pelvic pair; anal smaller than the dorsal fin; caudal fin forked; no fin-rays excessively elongated. Scales often ornamented in their exposed portion with delicate radiating lines of minute tubercles; very finely granulated in their covered portion and marked with a few radiating grooves which terminate in notches at the anterior truncated margin; hinder margin not serrated. Course of lateral line indicated by a feeble ridge and a notch in the hinder border of most of the scales.

*Type Species.*—The generic name *Osmeroides* (first published without definition in Neues Jahrb., 1834, p. 305) was originally given by Agassiz to some Scopeloid fishes from the Cretaceous of Westphalia, which are now generally known as *Sardinioides*. When it was afterwards applied to fossils discovered by Mantell in the English Chalk, Agassiz expressly stated that the determination of generic identity was uncertain and provisional. In course of time, however, the name has become universally recognised as belonging to the English specimens, and *Osmeroides lewesiensis* must be regarded as the type species.

1. ***Osmeroides lewesiensis*** (Mantell). Plate XXIII, figs. 1—8; Text-figure 38.

1822. *Salmo lewesiensis*, G. A. Mantell, Foss. South Downs, p. 235, pl. xxxiii, fig. 12; pl. xxxiv, fig. 3; pl. xl, fig. 1.  
 1837-44. *Osmeroides lewesiensis*, L. Agassiz, Poiss. Foss., vol. v, pt. i, p. 14; pt. ii, p. 105, pl. lx b, figs. 1, 2, 5-7 (*non* figs. 3, 4); pl. lx c.  
 1838. *Osmeroides mantellii*, G. A. Mantell, Wonders Geol., vol. i, p. 307, fig. 1.  
 1888. *Osmeroides lewesiensis*, A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 322.  
 1895. *Osmeroides lewesiensis*, A. S. Woodward, Proc. Zool. Soc., 1894, p. 656, pl. xlii.  
 1901. *Osmeroides lewesiensis*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 12.

*Type.*—Imperfect fish, probably from a Turonian zone; British Museum.

*Specific Characters.*—The type species, attaining a length of about 45 em. Head with opercular apparatus occupying about one quarter of the length to the base of the caudal fin. Length of cranium somewhat exceeding twice its maximum width at the occiput; each parietal bone longer than broad; bones of the hinder half of the cranial roof, cheek-plates, opercular bones, and upper branchiostegal rays ornamented with coarse radiating rugæ. Pelvic fins, each with at least eleven rays, opposed to the hinder half of the dorsal; the small anal fin nearer to the caudal than to the pelvic pair. Exposed area of scales narrow and deep, usually smooth, sometimes ornamented with very fine closely-arranged radiating lines of tubercles.

*Description of Specimens.*—The type specimen in the Mantell Collection (no. 4294) lacks the greater part of the caudal region, but otherwise displays satisfac-

torily the principal characters of the species. It is supplemented by a fine series of specimens in the British Museum, but the species is not yet well represented in other collections.

Apart from its roof, the cranium is imperfectly known. The supraoccipital,

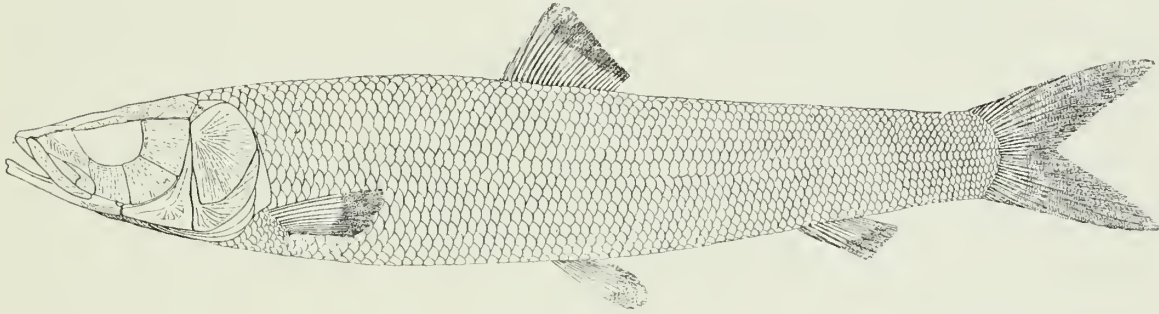


FIG. 38. *Osmeroïdes lewesiensis* (Mantell); restoration, about one third nat. size.—English Chalk.

which bears a prominent median keel on its hinder face, extends as far forwards as the frontal bones (B. M. no. P. 5680), but is completely covered by the parietals. The well-ossified epiotics, which form a slight backward prominence on each side, are also completely covered by the roofing bones. The side of the cranium beneath the articulation for the hyomandibular is impressed by a deep and extensive subtemporal fossa, as in *Elops* (well seen in B. M. no. 39433). There is a roofed posterior temporal fossa, as usual in the Elopidae. The flattened roof of the cranium, with its characteristic ornamentation, is shown in Pl. XXIII, figs. 2 a, 3. The parietal bones (*pa.*) are relatively small, longer than broad, and meet in a wavy suture in the middle line throughout their length. The squamosals (*sq.*) flank the parietals and are produced a little in front of them along the outer margin of the frontals. A small radiately rugose supratemporal plate (*st.*) overlaps the posterior border of each squamosal. The frontals (*fr.*) are very large, broad, and radiately rugose behind, tapering and nearly smooth forwards. In their hinder half the median suture between them is wavy, while in the smooth portion it is straight. The anterior extremity of each frontal, where it overlaps the mesethmoid, exhibits a  $\Lambda$ -shaped excavation. The smooth mesethmoid (*eth.*) ends in front in a rhomboidal expansion, which is about two thirds as long as broad. On either side of the frontal region, above and partly in advance of the orbit, an indent is occupied by an elongated, ovoid membrane-bone, which is radiately rugose and must probably be interpreted as a supraorbital (*spo.*). The cheek is completely covered with bony plates, which are thinner than all the other external bones except the gular plate, and have often lost their ornament by flaking in the fossils. Three large trapezoidal plates (fig. 2, *po.*) bound the orbit posteriorly and postero-inferiorly. They are traversed near their orbital border by a large slime-canal, from which branches appear to radiate among the coarse,

radiating ridge-ornament. Below and in front of the eye the exact shape of the plates is uncertain, but the antorbital (*ao.*) is longer than deep, tapers in front, and is traversed by a large longitudinal slime-canal, from which branches and ornamental rugæ are directed downwards. The sclerotic does not seem to have been ossified.

The mandibular suspensorium (Pl. XXIII, fig. 2) is inclined so far forwards that the articulation of the mandible is beneath the hinder part of the orbit. The upper end of the hyomandibular is straight, apparently with a single long articular facette; its lower end meets the metapterygoid (fig. 4, *mpt.*) and is produced posteriorly into a slender connection with the symplectic (*sym.*). The quadrate (figs. 2, 4, *qu.*) is triangular, with a robust articular head, and with an upwardly directed process arising from the lower end of its hinder border to clasp the thick, styliiform symplectic. The whole of its upper margin is apposed to the thin triangular metapterygoid (*mpt.*), and its anterior edge is in contact with the downwardly curved hinder end of the ectopterygoid (fig. 4, *ectpt.*). The entopterygoid seems to be thin, relatively large and antero-posteriorly elongated, and in the specimen figured there is evidence of clustered, minute, pointed teeth either on this bone or on a palatine. The premaxilla is imperfectly known, but it is rather small, underlaps the front end of the maxilla, and is provided with clustered minute teeth. The maxilla (fig. 5, *ma.*) is robust and arched, with a large upwardly directed process at its anterior end and a convex oral margin, which bears clustered minute teeth like those of the premaxilla. Its exposed outer face is ornamented with a coarse rugosity, in which the principal ridges are longitudinal. Its upper portion is overlapped by two large supramaxillaries (*smx.* 1, 2), of which the hinder is the deeper and sends a narrow process forwards above the upper margin of the anterior plate. These bones are also rugose. The dentary portion of the mandible (fig. 6, *d.*), which is nearly smooth, is very robust at the symphysis, and bears a cluster of several series of minute teeth, of which the points of attachment are shown in fig. 5 *a.* The dentary rises in the coronoid region, and its hinder margin is excavated for the reception of the large articulo-angular (fig. 6, *ag.*). The lower border of the mandible is slightly bent inwards; and just below the angle there extends the sensory canal, opening on the dentary by a series of pores (seen in B. M. nos. 4294 and P. 6456). The main upright portion of the angular bone is smooth, but its lower face is finely ornamented with rugæ.

The bones of the opercular apparatus are stout, but their outer ornamented face is often more or less flaked away in the fossils. The operculum (Pl. XXIII, figs. 1, 2, *op.*) is trapezoidal in shape, about two thirds as broad as deep, and marked with coarse, branched rugæ, which radiate from the point of suspension. The suboperculum (*sop.*), as coarsely ornamented, is almost sickle-shaped and deeply overlapped by the operculum, and bears a large ascending process at its

antero-superior angle. The interoperculum is small, smooth, and almost or completely covered by the lower limb of the preoperculum. The latter element (fig. 2, *pop.*) is sharply angulated, moderately expanded, deeply channelled by the slime-canal, and marked with a few radiating rugæ. The branchiostegal rays (*br.*) are not less than eighteen in number, the uppermost being large, broad, and rugose; five are borne by the epihyal. The gular plate (fig. 1, *gu.*) is remarkably thin and elongated, always smooth.

In the axial skeleton of the trunk, the vertebral centra are strengthened by secondary calcifications in the form of small irregular longitudinal ridges (Pl. XXIII, fig. 7). Those of the anterior abdominal and hinder caudal regions are deeper than long, while the remainder are about as long as deep. The arches are imperfectly known, but, as shown by Agassiz, *op. cit.*, pl. lx c, figs. 5, 6, those of the centra towards the base of the tail are especially stout. Some styliform bones in the abdominal region of B. M. no. 49892 appear to be intermuscular elements.

In the pectoral arch, a long and narrow post-temporal bone impinges on the epiotic angle of the skull. It is only marked by a few coarse horizontal rugæ at its postero-inferior angle (B. M. no. 4296). The supraclavicle and clavicle are quite smooth; and no postclavicle has been seen. The pectoral fin-rays (Pl. XXIII, fig. 1, *pct.*), which are at least fourteen in number, are unjointed for a considerable distance proximally, and the foremost ray (shown in B. M. no. 41894) exhibits an oblong expansion at its base of attachment. The rays of the pelvic fins (*plv.*), not less than eleven in number, are similarly only divided quite at the distal end, while the foremost is especially stout. The dorsal fin, placed in the middle of the back, opposite to the pelvic pair and arising somewhat in advance of the latter, is incompletely known, but consists of robust rays which are unjointed for a long distance proximally though very closely divided at the distal end. The supports of the dorsal fin-rays (shown in B. M. no. 49892) are large and dagger-shaped, having wide "wings." The anal fin (fig. 1, *a.*) is small and remote. The caudal fin appears to have been forked, and its rays are very closely articulated.

The scales (Pl. XXIII, figs. 1, 8) are in regular, uniform series, and very deeply overlapping. Their posterior border is gently rounded, while their anterior border is truncated. As a rule, they are more or less flaked or abraded in the fossils, and their exposed portion is nearly smooth or shows only the concentric lines of growth, while their covered portion is marked by a few radiating grooves, which terminate in notches at the anterior truncated border. When exceptionally well preserved (fig. 8) their exposed portion is ornamented with radiating lines of fine tubercles, while the grooves on their covered portion are obscured by a still more minute granulation. The scales of the lateral line are not enlarged or thickened; but most of them are marked by a feeble smooth ridge, which ends at a notch in the hinder border.

*Horizons and Localities.*—Turonian zones: neighbourhood of Lewes. Zone of *Holaster planus*: Cuxton, Kent.

2. **Osmeroides levis**, A. S. Woodward. Plate XXIII, figs. 9—11.

1895. *Aulolepis typus*, A. S. Woodward, Proc. Zool. Soc., 1894, p. 660 (in part), pl. xliii, figs. 2, 3, 5 (*errore*).

1901. *Osmeroides levis*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 15.

*Type.*—Imperfect fish, probably from the zone of *Holaster subglobosus*; British Museum.

*Specific Characters.*—A small species, attaining a length of about 20 cm. Head with opercular apparatus occupying nearly one third of the length to the base of the caudal fin. Length of cranium not exceeding twice its maximum width at the occiput; each parietal bone not longer than broad; all external bones remarkably smooth, the rugose markings being very coarse and feeble. Position of dorsal fin as in the type species.

*Description of Specimens.*—The type specimen (Pl. XXIII, fig. 9) exhibits nearly the whole length of the fish, though lacking the rostral part of the skull and all the fins. Only two other specimens, also in the British Museum, are known.

The cranium is slightly shorter in proportion to its width than that of the type species, and remarkable for the smooth and shining appearance of its external bones, which are only feebly rugose or wrinkled. The supraoccipital (Pl. XXIII, fig. 10, *socc.*) does not appear to extend beneath the parietals so far forwards as the frontal bones. The parietals (fig. 9, *pa.*) meet in a wavy suture and exhibit a very sinuous margin; they are not longer than broad. The squamosals (*sq.*), which are crumpled so as to be marked with slight radiating ridges, extend further forwards and flank the hinder part of the frontals. The frontals (figs. 9, 10, *fr.*) are also radiately wrinkled behind, and bear traces of a finer rugosity on the margin overhanging the orbit. They are smooth in their flattened middle portion, and their median suture is strongly wavy behind while straight in the tapering front half of the bones. The longitudinal slime-canal is marked by a series of pits just within the faintly rugose outer portion of each frontal. The mesethmoid is relatively small, and seems to resemble that of the type species. On either side of the anterior half of the frontal region, there is a relatively large supra-orbital bone (fig. 10, *spo.*), which is smooth, but traversed by a large slime-canal. The smooth postorbital cheek-plates (fig. 11, *po.*) are also relatively large, and marked only by a few faint ridges which radiate backwards from the slime-canal traversing their orbital border.

The mandibular suspensorium is inclined as much forwards as in the type

species. The premaxilla considerably underlaps the tapering front end of the maxilla (fig. 11, *mx.*), which is much arched, and bears only one longitudinal ridge close to its oral margin. The supramaxillæ are of the characteristic shape, relatively large, and marked only by a few short longitudinal ridges. Both the premaxilla and maxilla are seen to bear minute clustered teeth. The mandible (fig. 11) tapers gradually forwards from the rounded coronoid elevation to the blunt symphysis, and its post-coronoid region is very short. Its outer face is smooth, except near the lower border, where there are two longitudinal ridges, the lowermost pierced by a series of openings of the slime-canal. The dentary bone (*d.*) bears a cluster of minute teeth, which widens and spreads outwards at the symphysis; the articulo-angular (*ag.*) contracts to a very narrow bar below its articular facette.

The bones of the opercular apparatus (Pl. XXIII, fig. 11) exhibit only feeble traces of the ornament which is characteristic of the type species. The operculum (*op.*) is trapezoidal in shape, about three quarters as broad as deep. The suboperculum (*sop.*) exhibits a very large ascending process at its antero-superior angle. The interoperculum (*iop.*) is almost covered by the expanded lower end of the preoperculum (*pop.*). The upper branchiostegal rays (*br.*) are broad and nearly smooth. The gular plate (*gu.*) is very large and also smooth.

The vertebræ have been only imperfectly observed, but appear to resemble those of the type species. The hæmal arches are stout and expanded at the base of the caudal fin.

In the pectoral arch, the smooth, long post-temporal bones (Pl. XXIII, fig. 10, *ptt.*) curve slightly to their pointed anterior end, which impinges on the occipital border. The supraclavicle is rather long, and exhibits only the feeblest wrinkling on its outer surface. Of the fins, only parts of the undivided bases of the pectorals and dorsal are known. The distance between the origin of the dorsal fin (fig. 9, *do.*) and the occiput considerably exceeds the length of the head with opercular apparatus.

The scales closely resemble those of the type species, but the concentric ridges on their exposed portion appear to be generally more conspicuous, while there is no trace of fine radiating ornament. When the minute granulation is removed from the covered portion of the scales, the few radiating grooves here are conspicuous. The lateral line produces the usual smooth ridge.

*Horizon and Localities.*—Zone of *Holaster subglobosus*; Burham, Kent; Lewes, Sussex.

### 3. *Osmeroides latifrons*, sp. nov. Plate XXIV, figs. 1—3.

*Type.*—Skull, etc., from zone of *Holaster subglobosus*; British Museum.

*Specific Characters.*—An imperfectly known species, about as large as the

type species. Length of cranium equalling twice its width at the occiput; each parietal bone broader than long; rostral region very narrow and tapering; frontals without rugose ornament on the lateral expansions, only marked by structural lines. Exposed area of scales ornamented with tubercles and reticulating rugæ, scarcely radiating.

*Description of Specimens.*—The type specimen (Pl. XXIV, fig. 1) displays the characteristic skull from above and behind, with parts of the opercula, other scattered bones, and a few anterior vertebræ. The other known specimens exhibit only the head and the anterior part of the abdominal region.

The shape and contour of the cranial roof are well shown in the type specimen (fig. 1). The supraoccipital (*socc.*) and epiotics (*epo.*) form a very narrow rim at the occipital border, and the latter bones project as a pair of bluntly-pointed, backward prominences. The parietal bones (*pa.*) are much broader than long, and form a very unsymmetrical pair, with an irregular median suture. They are marked by a few coarse rugæ, which tend towards a radiating arrangement. The squamosals (*sq.*), which roof the usual posterior temporal fossa, extend slightly further forwards than the parietals. The great smooth frontals (*fr.*), which meet in a gently sinuous median suture in their hinder half, are remarkably expanded in the interorbital region and suddenly taper in front to a very slender rostrum, which terminates in a comparatively small mesethmoid (*eth.*). The only traces of rugosity on these bones are on the longitudinal elevation bounding the middle depression of the roof. There is a conspicuous, though small, smooth postfrontal or sphenotic bone (fig. 2, *ptf.*) The parasphenoid bone (as seen in a skull from Folkestone, in the Sedgwick Museum, Cambridge) is toothless, and expanded into a thin flat lamina, which is widest just in front of a sudden constriction where it passes into the floor of the suborbital canal. The three postorbital cheek-plates (fig. 2, *po.*) are thin and nearly smooth, but bear a few traces of shallow grooves radiating from the large slime-canal which traverses their orbital border. The sclerotic is ossified.

The mandibular suspensorium is inclined so far forwards that the gape must have been relatively small, as shown by the position of the quadrate (*qu.*) in fig. 2. The hyomandibular curves forwards and is very slender at its lower end, which articulates with the rod-shaped symplectic. The latter element, of which the lower end is seen in fig. 2, *sym.*, penetrates a postero-superior cleft of the quadrate. The jaws are unknown. The ceratohyal (fig. 2 *a*) is short and deep.

The operculum and suboperculum (fig. 3) are nearly similar to those of the type species, but somewhat more feebly ornamented. The preoperculum (fig. 2, *pop.*) is narrow, curves sharply forwards, and is marked on its smooth outer face with the deep groove for the slime-canal. Five branchiostegal rays appear to have been borne by the epihyal. The three upper branchiostegal rays borne by the ceratohyal are not much inferior to these in size.

The foremost vertebral centra (fig. 1, *v*) are remarkably short and deep, and exhibit round pits for the insertion both of the neural arch and of the ribs. In the middle of the abdominal region the vertebral centra are longer (B. M. no. P. 10466).

The scales (Pl. XXIV, fig. 3*a*) bear the usual minute granulation on their covered portion; but the coarser tubercles on their exposed portion tend rather towards fusion into reticulating rugæ than towards arrangement in radiating lines. Only the anterior scales are known, and the few radiating grooves on their covered portion have not yet been observed.

The finely rugose base of a very stout pectoral fin-ray is seen in B. M. no. P. 10466; and a fragment of the dorsal fin in the same fossil shows that this fin occupies its usual position.

*Horizon and Localities.*—Zone of *Schloenbachia varians*: Folkestone, Kent. Zone of *Holaster subglobosus*: Wouldham and Burham, Kent.

*Genus* **DINELOPS**, novum.

*Generic Characters.*—As *Osmeroides*, but gape of mouth much wider and maxilla long and straight, perhaps with only one supramaxilla; a single series of slender conical teeth on the margin of each jaw, partly flanked by an outer series of comparatively small teeth; and scales not marked in their covered portion with radiating grooves.

*Type Species.*—*Dinelops ornatus*, from the English Chalk.

*Remarks.*—This genus is in many respects similar to *Notelops*,<sup>1</sup> from the Upper Cretaceous of Brazil, but differs in lacking a separate bony plate above the operculum. It also closely resembles *Protelops*,<sup>2</sup> from the Turonian of Bohemia, but differs in the arrangement of the marginal teeth and in the relatively larger size of its scales.

1. **Dinelops ornatus**, sp. nov. Plate XXIV, figs. 4—6.

*Type.*—Imperfect fish, lacking caudal region; British Museum.

*Specific Characters.*—The type species, attaining a length of not less than 80 cm. Length of head with opercular apparatus much exceeding maximum depth of trunk. Lateral portions of cranial roof and operculum ornamented with coarse,

<sup>1</sup> A. S. Woodward, 'Catal. Foss. Fishes B. M.,' pt. iv (1901), p. 27.

<sup>2</sup> G. C. Laube, "Ein Beitrag zur Kenntniss der Fische des böhmischen Turons," Denkschr. k. Akad. Wiss., math.-naturw. Cl., vol. 1 (1885), p. 286, pl. i.

radiating, and partly reticulating rugæ; maxilla and dentary also rugose, but cheek-plates smooth.

*Description of Specimens.*—The type specimen (Pl. XXIV, fig. 4) is supplemented only by an imperfect skull (fig. 5), and perhaps by part of a dentary bone with teeth (fig. 6). This species is therefore very imperfectly known.

So far as preserved the skull closely resembles that of *Osmeroides*, but there is a deeper median longitudinal depression in the frontal region. Remains of the squamosal (fig. 5 *a*, *sq.*) and postfrontal (*ptf.*) bones exhibit a coarse rugose ornament, which is better shown in regularly radiating lines on the raised outer portion of the frontal (*fr.*). The median frontal depression is comparatively smooth, though there is some rugosity along the wavy line of the interfrontal suture. A long and narrow supraorbital bone (*spo.*) occurs as in *Osmeroides*, but it is sharply bent along its long axis, and only its upper lamina is marked by the coarsely rugose ornament. The orbit is rather large, but the cheek-plates are also extensive. There are three postorbitals (figs. 4, 5, *po.*), of which the lower is largest and trapezoidal in shape, while the middle plate is comparatively small, long and narrow. They are smooth, marked only by the ridge of the slime-canal along the orbital margin, and with slight radiating wrinkles. The antorbital cheek-plate (*ao.*) is elongate-triangular in shape, comparatively thick, and quite smooth on the outer face.

The mandibular suspensorium is nearly vertical, the articulation of the mandible being directly beneath the occiput. The long maxilla (Pl. XXIV, fig. 4, *mx.*, and fig. 4 *a*) is truncated in front, has a straight oral border, and only deepens backwards to form a facette which is overlapped by the supramaxilla (*sma.*). Its flattened outer face is ornamented with coarse, reticulating rugæ. The type specimen shows in the anterior half of the bone the bases of attachment of a single close series of rather large teeth on an inner ledge. The articulo-angular bone (*ag.*) is apparently smooth in its upper portion, but is traversed by a longitudinal groove below the articular facette, and here becomes coarsely rugose. The dentary (*d.*) is also traversed by a deep longitudinal groove, which separates a comparatively smooth upper portion from a coarsely rugose lower portion. In the type specimen the oral border of this bone exhibits the bases of attachment of a single close series of large teeth on an inner ledge, and of a close series of small teeth on the extreme outer edge. In part of a left dentary (fig. 6), probably of *Dincolops*, found isolated in the Lower Chalk of Kent, some of the teeth are actually preserved. They are slender and styliform, quite smooth, with a very small central cavity. One of the large inner teeth has a bluntly pointed apex, while the small marginal teeth are capped by a sharp point of transparent enamel (fig. 6 *a*).

The width of the opercular apparatus is shown by the type specimen to be about equal to that of the postorbital cheek-plates. The operculum (Pl. XXIV,

fig. 5*b*) is ornamented with coarse, rugose markings, among which ridges radiating from the point of suspension are conspicuous. The preoperculum (fig. 4, *pop.*) must have had a triangular expansion at its lower end. So far as preserved in the type specimen, the branchiostegal rays (*br.*) are nearly smooth, but part of the large gular plate (*gu.*) exhibits a slight rugosity.

The vertebral column is only partially exposed in the type specimen, but the centra throughout the abdominal region are not longer than deep, and they are clearly strengthened by numerous thin longitudinal ridges.

The clavicle (fig. 4, *cl.*) and the very large supraclavicle (*scl.*) are nearly smooth, and there seems to be a small smooth postclavicular plate (*pcl.*), which is overlapped and deeper than wide. The pectoral fin (*pct.*) comprises at least fourteen rays, of which the articulated distal ends are destroyed in the fossil. The long non-articulated bases of some pelvic fin-rays (*plv.*) are seen below the dorsal fin, which is represented only by some fragments of extremely stout rays (*do.*).

The scales are large, thin, and deeply overlapping. Most of them are smooth and exhibit only concentric lines of growth, but there are occasional traces of an outer layer of very fine granulations. The course of the lateral line is marked by a smooth flattened ridge.

*Horizon and Localities.*—Zone of *Holaster subglobosus*: Kent; Dorking, Surrey.

#### Genus **PACHYRHIZODUS**, Dixon.

*Megalodon*, L. Agassiz (*non* Sowerby, 1829), Poiss. Foss., Feuille, 1835, p. 55 (in part).

*Hypsodon*, L. Agassiz, *loc. cit.*, 1837, p. 104 (in part).

*Raphiosaurus*, R. Owen, Trans. Geol. Soc. [2] vol. vi, 1842, p. 413.

*Pachyrhizodus*, F. Dixon (*ex* Agassiz MS.), Geol. Sussex, 1850, p. 374.

*Acrodontosaurus*, J. W. Mason, Quart. Journ. Geol. Soc., vol. xxv, 1869, p. 444.

*Generic Characters.*—Parietal bones small and separated by the supraoccipital; frontal region indented with a deep and wide median depression, which is crossed by a slight transverse ridge between the orbits and becomes deepest in front of this ridge. External bones smooth or exhibiting only fibrous texture. Teeth robust and conical, with a small pulp-cavity, fused at their expanded non-enamelled base with the supporting bone; mandible with a single close series nearly regular in size; premaxilla horizontally extended, with a single close series of small teeth round the antero-lateral border and two larger teeth (or one tooth and its successor) within; maxilla robust, with a single series of teeth smaller than those of the mandible. Minute conical teeth clustered on some bones of the roof of the mouth. Vertebral centra deeper than long, slightly constricted, smooth or impressed with

numerous small, elongated, shallow pits at the sides. An enlarged postclavicular scale above the pectoral fin. Scales large and thin, deeply overlapping; their covered portion not marked by radiating grooves, their exposed sector smooth or ornamented with a minute rugosity and fine radiating ridges and furrows.

*Type Species.*—*Pachyrhizodus basalis*, from the English Chalk.

*Remarks.*—The remains of this genus were first discovered in the English Chalk, and the jaws and cranium were originally described and figured by Agassiz under the indefinite name *Hypsodon lewesiensis* (see p. 99). The description, however, was both inaccurate and inadequate, and part of a similar jaw was afterwards referred by Agassiz himself to another genus to which he gave the MS. name *Pachyrhizodus*. The description and figures of *Pachyrhizodus basalis* published by Dixon in 1850, though also unsatisfactory, sufficed for recognition; and the genus *Pachyrhizodus* was eventually defined by Cope, who described remains of five species from the Chalk of Kansas.

The cranium of *Pachyrhizodus* (Text-fig. 39, p. 130) resembles that of the existing *Chanos*, lacking the subtemporal fossa in the side of the otic region, and showing even the same deep keel on the basioccipital. The teeth have a large expanded base, which is not enamelled, and they are firmly fused with the supporting bone. They are fixed in a single spaced series on a nearly flat ledge which equals their basal width, and they are flanked externally by a thin low wall of bone, which is often more or less destroyed in the fossils, thus giving them a longer or shorter appearance when viewed from their outer side. They must have been replaced alternately, each space between two teeth showing a very shallow socket (sometimes two shallow sockets) for a developing germ, which is rarely seen in the fossils, but must have been removed with the enveloping soft tissues.

The total number of vertebræ in a skeleton of *Pachyrhizodus caninus* from the Chalk of Kansas, in the U. S. National Museum, is between fifty and sixty. All the vertebral centra are shorter than deep, and most of them have smooth sides; but some centra in the anterior abdominal region are impressed with small and shallow elongated pits. There are no transverse processes, the ribs being directly received in small pits on the centra.

The small caudal region from the Chalk of Cuxton represented of one half nat. size in Pl. XXVI, fig. 6, may be referred to *Pachyrhizodus*. The vertebral centra, though partly decayed, show the smoothness of their sides, and bear comparatively slender neural and hæmal arches. A few hæmals are expanded at the base of the tail, but their outlines are indistinct in the fossil. The remains of the front part of the anal fin (*a.*) indicate that it was small and remote, with the stout rays very closely articulated and divided distally. Part of the forked caudal fin (*c.*) displays the very stout rays, which are articulated distally with close wavy sutures and eventually become finely divided. The scales are large and thin, deeply overlapping, only marked in their exposed portion with feeble radiating furrows.

1. *Pachyrhizodus basalis*, Dixon. Plate XXV, figs. 1, 2.

1850. *Pachyrhizodus basalis*, F. Dixon, Geol. Sussex, p. 374, pl. xxxiv, figs. 9, 10.

1901. *Pachyrhizodus basalis*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 37.

*Type*.—Right premaxilla; British Museum.

*Specific Characters*.—The type species, known only by fragments of the upper jaw. Premaxilla somewhat more than twice as long as broad, its small marginal teeth about nine in number and inclined outwards, its large inner teeth with a long and remarkably straight crown, which is not hooked or inclined inwards.

*Description of Specimens*.—Of the two fragments figured by Dixon the premaxilla alone is characteristic and must be regarded as the type specimen. The so-called "lower jaw" from Steyning is part of a right maxilla, and may belong either to this or to the next species. The right premaxilla (Pl. XXV, figs. 1, 1 *a*.) is slightly imperfect both in front and behind, but displays all the essential characters noted in the diagnosis. The outwardly inclined bases of four marginal teeth (*m*.) are shown, there are three empty sockets, and a fragment of another tooth appears at each end of the series. The anterior inner tooth (*i*.) is complete, and its expanded base does not quite reach the inner edge of the supporting bone. The posterior inner tooth is represented merely by its shallow socket. Part of another premaxilla in the British Museum (Pl. XXV, fig. 2) exhibits the two inner teeth complete and of equal size, with a small additional or replacing tooth behind.

There is some reason to infer that the shape of the mandible of *P. basalis* resembles that of *P. gardneri*, but bears relatively more slender and less incurved teeth. No associated sets of jaws or other remains, however, have hitherto been discovered.

*Horizon and Localities*.—Probably zone of *Holaster subglobosus*; Burham, Kent.

2. *Pachyrhizodus gardneri* (Mason). Plate XXV, figs. 3—8; Plate XXVI, fig. 5.

1837–44. *Hypsodon lewesiensis*, L. Agassiz, Poiss. Foss., Feuille., p. 104, vol. v, pt. i, p. 99 (in part), pl. xxv *a*, figs. 1, 2, 4; pl. xxv *b*, figs. 4–7.

1846. "Reptile or Fish," T. Smith, Lond. Geol. Journ., p. 21, with woodcut.

1869. *Acrodontosaurus gardneri*, J. W. Mason, Quart. Journ. Geol. Soc., vol. xxv, p. 444, pl. xix.

1877. *Hypsodon lewesiensis*, E. T. Newton, Quart. Journ. Geol. Soc., vol. xxxiii, p. 508.

1888. *Pachyrhizodus gardneri*, A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 314.

1901. *Pachyrhizodus gardneri*, A. S. Woodward, Catal. Foss. Fishes B.M., pt. iv, p. 40.

*Type*.—Anterior end of dentary probably from zone of *Holaster subglobosus*; British Museum.

*Specific Characters*.—A large species, the mandible attaining a length of at

least 30 cm. Crown of all teeth with slender apex, which is more or less curved. Premaxilla scarcely more than twice as long as broad, its small marginal teeth not inclined outwards, its inner teeth with the base much expanded and the crown very stout and curved inwards. Dentary bone deep, but rapidly contracting in front into a narrow thickened symphysis, and sharply bent inwards in the lower two thirds throughout its length; its outer face without any deep longitudinal depressions, but with a slight groove which extends backwards and upwards from the middle of the symphysial border until lost at the oral border; its total number of tooth-sockets between 25 and 30.

*Description of Specimens.*—The type specimen is the anterior end of a right dentary, originally described by Mason as the premaxillary region of a reptile. Part of a similar dentary is shown in association with the maxilla and premaxilla in Mantell's specimen, which was referred to *Hyposodon levesiensis* by Agassiz, *op. cit.*, pl. xxv a, fig. 2. The same jaws occur with a group of scattered head-bones on the slab of chalk described by Toulmin Smith, *loc. cit.*, 1846; and they are associated with part of the cranium itself in another specimen in the British Museum from Ditchling, Sussex. Although the remains are fragmentary, it is therefore possible to identify many bones of this species.

The cranium associated with jaws from Ditchling (B. M. no. 49905) is so much fractured that it does not exhibit the outer face of the bones; but in size, shape, and general contour it agrees so closely with the hinder half of a cranium figured by Agassiz, *op. cit.*, pl. xxv a, fig. 1, that there need be no hesitation in referring the latter to the same species. It is thus clear that in *Pachyrhizodus gardneri* the frontal bones extend backwards as far as the supraoccipital and widely separate the small parietals, while a true squamosal covers the pterotic on each side. The shape of the hinder part of the cranial roof resembles that of *P. subulidens* described below (p. 129), the posterior half of the median frontal depression being especially well displayed. The basioccipital bears on its lower face a deep longitudinal keel, which is seen again in a fragmentary smaller specimen, probably of this species, in the Toulmin Smith Collection (B. M. no. 41671). Part of an ossified sclerotic is also shown in the Ditchling specimen.

The hyomandibular is a thin lamina of bone, much expanded in its upper half, with a single long articular facette at its upper end. It resembles the corresponding element of *Megalops* and *Chanos* in the shortness of the process for the support of the operculum, and in the relative narrowness of the lower part of the bone. The triangular quadrate, with very stout articular end, is well shown by Agassiz, *op. cit.*, pl. xxv b, figs. 4, 5; but the symplectic has not yet been identified. The ectopterygoid is evidently the long thin lamina of bone which occurs in several specimens covered on its inner face with a dense cluster of minute, bluntly-conical teeth. A bone, which may perhaps be palatine, is partly covered with a similar cluster of teeth.

The premaxilla in the group of jaw-bones referred to *Hypsodon lewesiensis* by Agassiz (*op. cit.*, pl. xxv *a*, fig. 2) is much fractured, but is better preserved in the originals of Pl. XXV, figs. 3, 3 *a*, 3 *b*, 4, 4 *a*. As shown in upper and lower view (figs. 3, 4), its shape nearly resembles that of the premaxilla of *P. basalis*; but, as seen in front view (fig. 3 *a*), the tumid base of the large inner tooth (*i.*) extends to the inner edge of the bone, while its crown curves inwards, and the small lateral marginal teeth (*m.*) are nearly upright in implantation. The total number of marginal tooth-sockets is probably about nine. An empty tooth-socket is shown at *s.* in fig. 4, while the partially absorbed bases of shed teeth are seen at *b.*, *b.* in the same specimen. The maxilla is not completely known, but its total length must have been from three to four times as great as that of the premaxilla. As already described by Agassiz, the anterior half of the bone is very thick, but it becomes a comparatively thin, laterally-compressed lamina behind, where it curves slightly downwards. When seen in direct outer view (fig. 5) the bone appears to taper in front, but here there is a great thickening, which is produced forwards and inwards as a stout process, well displayed from below in Pl. XXVI, fig. 5. The teeth, which are badly drawn in the figure by Agassiz quoted above, are much smaller than the marginal premaxillary teeth (*cf.* Pl. XXV, figs. 4 and 5). The dental crowns are smooth and curve inwards. No supramaxilla has been observed.

The type specimen of *P. gardneri* is merely the symphyseal end of the dentary bone, crushed and broken in such a manner as to mislead its original describer to suppose that the bone is crossed by a fused suture. The nearly complete right dentary is shown from below and from the side in Pl. XXV, figs. 8, 8 *a*. Its oral border (fig. 8 *a*) is upright, but the greater part of the lamina of the bone (fig. 8), is in a nearly horizontal plane. It is almost smooth externally, only marked by a feeble groove which trends gradually upwards and backwards from the middle of the symphysis towards the oral border. The shape of its hinder end is best seen in the original of Pl. XXV, fig. 7, in which the comparatively short articulo-angular bone (*art.*) also occurs, though slightly displaced and a little imperfect behind. The teeth of the dentary are fixed on a stout ledge or shelf of bone, which is always conspicuous when viewed from within (Pl. XXV, fig. 6). Their stout bony bases are flanked outside by a thin wall of bone, which is more or less broken in the fossils; and they are so much crowded that their externo-internal diameter is often greater than their antero-posterior diameter. The dental crown is invariably smooth and conical, with the sharp apex curved backwards and inwards. The teeth are in a single series, nearly uniform in size, only diminishing at each end. On the thickened symphysis there is an additional tooth within the outer row of small teeth (fig. 8 *a*, *i.*). The total number of tooth-sockets in the dentary cannot be more than thirty.

*Horizons and Localities.*—Zone of *Schloenbachia varians*: Glynde, Sussex.

Zone of *Holaster subglobosus* : Ditchling, Sussex ; Burham, Halling, Cuxton, and Folkestone, Kent. Turonian zones : neighbourhood of Lewes. Zone of *Micraster coranquinum* : South Croydon, Surrey.

3. ***Pachyrhizodus dibleyi***, A. S. Woodward. Plate XXVI, figs. 1—4.

1901. *Pachyrhizodus dibleyi*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 38, text-fig. 3.

*Type*.—Premaxilla and portions of maxillæ from zone of *Holaster subglobosus* ; British Museum.

*Specific Characters*.—A robust species, attaining a larger size than *P. gardneri*. All teeth with a remarkably stout and much-expanded base, and a comparatively short stout crown, which is scarcely, if at all, incurved at the apex. Premaxilla about twice as long as broad. Maxillary teeth in very irregular series, the bases of those in the hinder portion excessively compressed antero-posteriorly.

*Description of Specimens*.—The type specimen is an associated set of remains of the upper jaw, exhibiting the characteristic teeth, though very much broken. The premaxilla (Pl. XXVI, figs. 1, 1 *a*) must evidently have been comparatively long and narrow. One of its posterior marginal teeth (*m.*) is about as large as an anterior maxillary tooth ; while the posterior inner tooth (*i.*) well displays the relatively wide base and the blunt stumpy crown, which is a little worn at the apex. The anterior inner tooth is represented only by its socket. The maxilla (figs. 2, 3) is very stout and of coarsely fibrous texture, with a large antero-internal process (*p.*) for union with the premaxilla. The right and left maxillæ are similar in shape and size, so far as they can be compared, but the teeth of the two sides are very different and quite irregular in disposition. All the teeth preserved are worn and blunt at the apex ; and the antero-posterior compression of their base is especially well seen in the displaced tooth shown in fig. 2 *a*. A laminar bone of the pterygoid arcade is covered with a dense cluster of minute conical teeth.

The tooth-bearing ledge of a dentary bone discovered separately by Mr. Dibley (Pl. XXVI, fig. 4), evidently belongs to this species, exhibiting teeth of the characteristic shape, which are very slightly curved at the apex. The articular end of the same mandible has a coarsely fibrous structure.

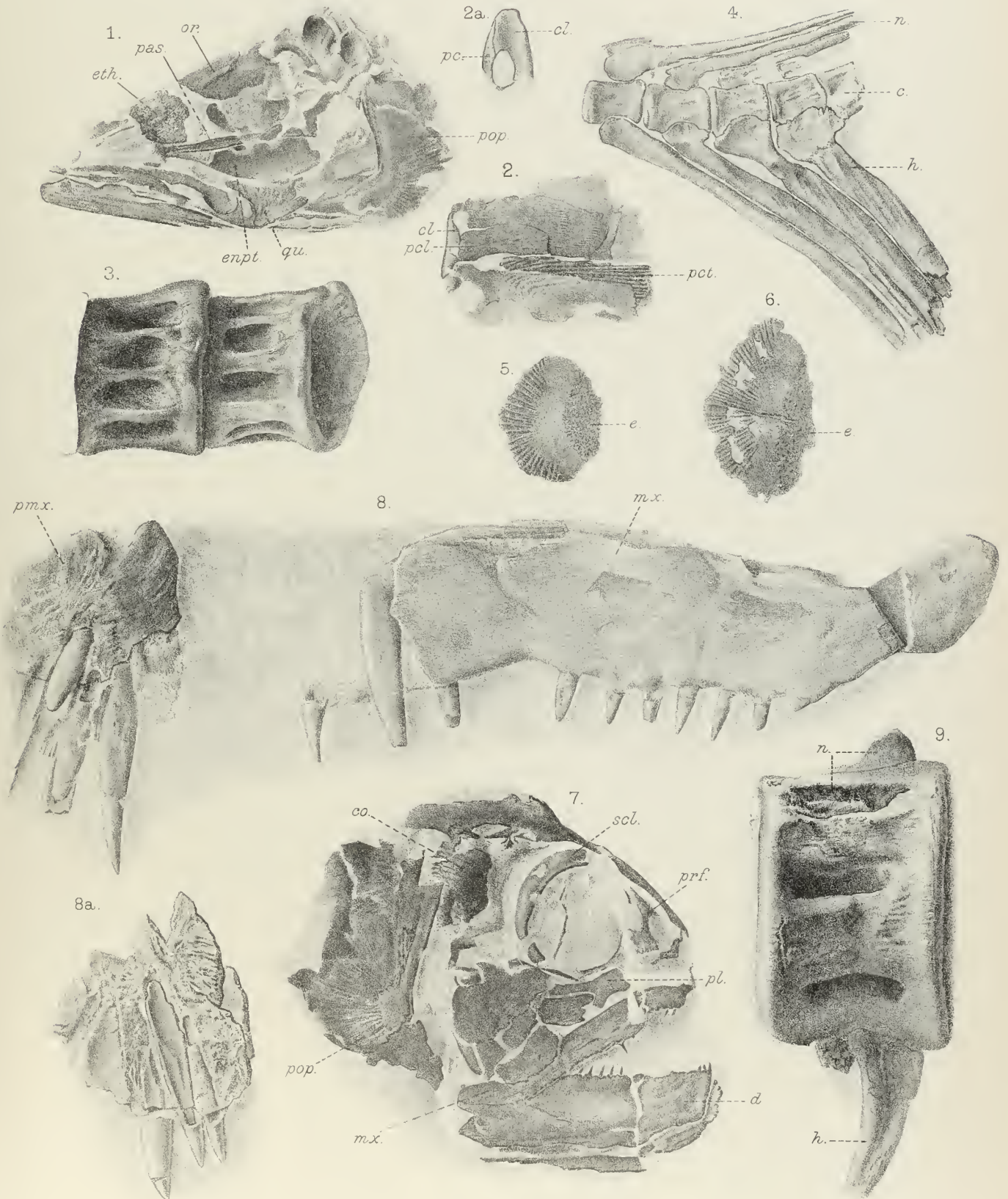
*Horizon and Localities*.—Zone of *Holaster subglobosus* : Burham, Kent ; Merstham, Surrey.



PLATE XXI.

FIG.	PAGE.
1. <i>Syllæmus anglicus</i> (Dixon); head, left lateral aspect.—Chalk; Guildford. Enniskillen Collection (B. M. no. P. 4246). <i>enpt.</i> , entopterygoid; <i>eth.</i> , mesethmoid; <i>or.</i> , orbitosphenoid; <i>pas.</i> , parasphenoid; <i>pop.</i> , preoperculum; <i>qu.</i> , quadrate.	90.
2. Ditto; region of left pectoral fin, with front view of part of left clavicle (2 <i>a</i> ).—Zone of <i>Holaster subglobosus</i> ; Blue Bell Hill, Burham, Kent. S. J. Hawkins Collection (B. M. no. P. 6532). <i>cl.</i> , clavicle; <i>pc.</i> , pre-coracoid arch; <i>pcl.</i> , postclavicular scale; <i>pct.</i> , base of pectoral fin.	91.
3. <i>Ichthyodectes</i> sp.; two vertebral centra, showing lateral pits, side view.—Chalk; Burham. Harford Collection (B. M. no. P. 5718).	95.
4. <i>Ichthyodectes</i> sp.; five terminal caudal vertebræ, left side view.—Chalk; Burham. Toulmin Smith Collection (B. M. no. 41691). <i>c.</i> , centra; <i>h.</i> , hæmal arches; <i>n.</i> , neural arches.	95.
5. <i>Ichthyodectes</i> sp. ( <i>Cladoeclus lewesiensis</i> , Agassiz); scale.—Chalk; Sussex. Dixon Collection (B. M. no. 25861). <i>e.</i> , exposed sector.	96.
6. Ditto; scale.—Zone of <i>Holaster subglobosus</i> ; Burham. Toulmin Smith Collection (B. M. no. 41712). <i>e.</i> , exposed sector.	96.
7. <i>Ichthyodectes tenuidens</i> , A. S. Woodward; head, right side view.—Probably from zone of <i>Holaster subglobosus</i> ; Burham. Mrs. Smith's Collection (B. M. no. 49054). <i>co.</i> , circumorbital cheek-plate; <i>d.</i> , right dentary (the left crushed below); <i>mx.</i> , maxilla; <i>pl.</i> , palatine; <i>pop.</i> , preoperculum; <i>prf.</i> , prefrontal; <i>scl.</i> , ossified sclerotic.	98.
8. <i>Portheus mantelli</i> , Newton; the type specimen, showing the imperfect left premaxilla ( <i>pmx.</i> ) and maxilla ( <i>mx.</i> ), outer aspect, with the counterpart half of the same premaxilla (8 <i>a</i> ).—Probably from a Turonian zone; Lewes. Mantell Collection (B. M. nos. 4066-67).	101.
9. <i>Portheus mantelli</i> , Newton (?); centrum of caudal vertebra, side view showing lateral pits.—Chalk; "Gravesend." Bowerbank Collection (B. M. no. 39065). <i>h.</i> , base of hæmal arch; <i>n.</i> , base of neural arch.	102.

All the figures of the natural size.



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1, 2. *Syllæmus*. 3, 4, 7. *Ichthyodectes*.  
5, 6. *Cladocycclus*. 8, 9. *Portheus*.

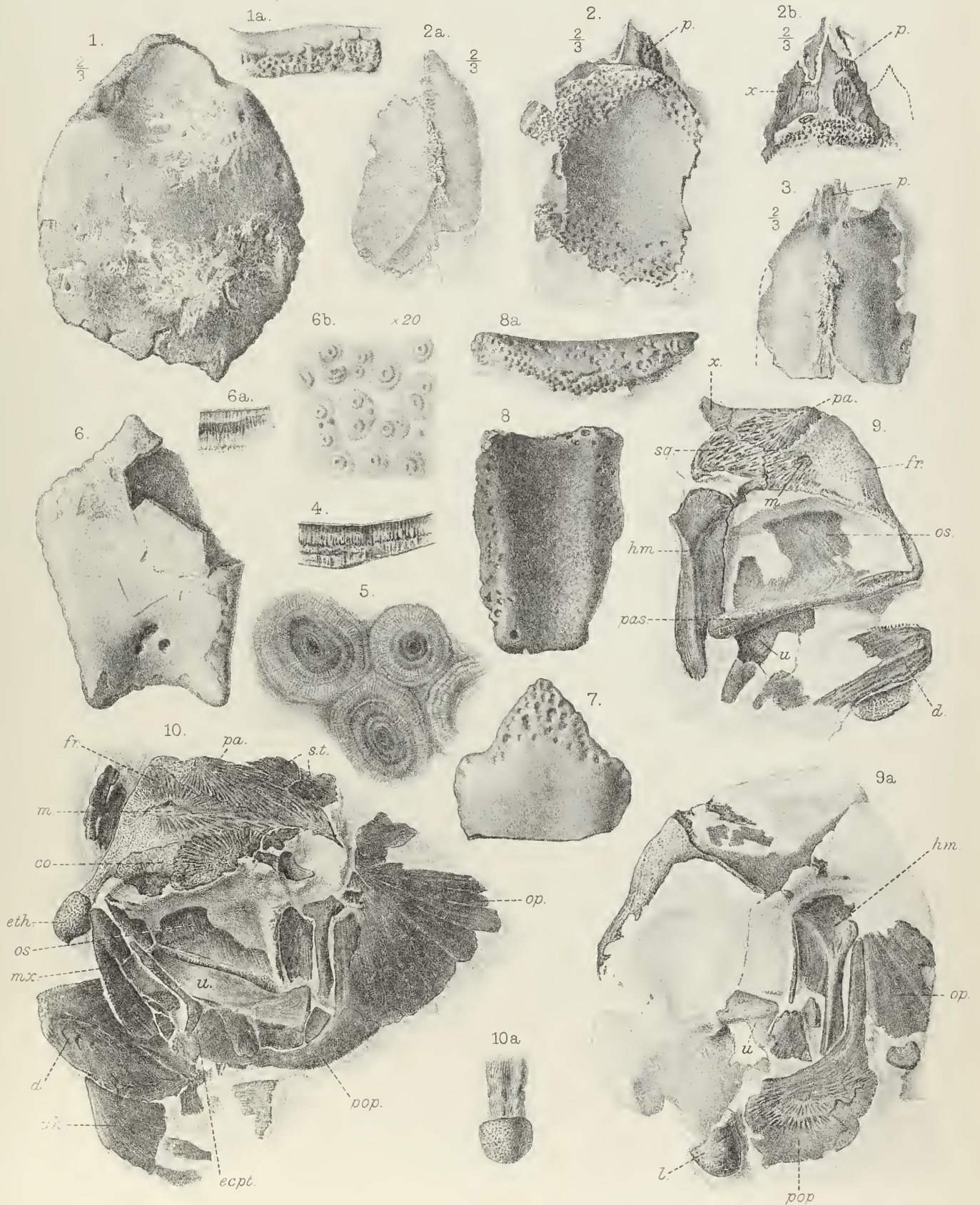




PLATE XXII.

FIG.		PAGE.
1.	<i>Plethodus expansus</i> , Dixon; lower dental plate, oral face, two thirds nat. size, and view of tuberculated rim (1 <i>a</i> ), nat. size.—Cambridge Greensand. B. M. no. 35369.	108.
2.	Ditto; upper dental plate, oral face, aboral face (2 <i>a</i> ), and posterior end view (2 <i>b</i> ), two thirds nat. size.—Chalk; Kent. B. M. no. 38585. <i>p.</i> , ascending median bony process; <i>x.</i> , lateral bony plate.	108.
3.	Ditto; upper dental plate, aboral face, two thirds nat. size.—Probably zone of <i>Holaster subglobosus</i> ; near Maidstone. Bowerbank Collection (B. M. no. 39091). <i>p.</i> , ascending median bony process.	108.
4.	Ditto; portion of vertical section of upper dental plate, showing tubules and surface-layer.—Zone of <i>Holaster subglobosus</i> ; Halling, Kent. B. M. no. 43079.	108.
5.	Ditto; transverse section of three dentinal tubules, highly magnified.—Chalk; South Wiltshire. Cunnington Collection (B. M. no. 46392).	108.
6.	<i>Plethodus pentagon</i> , A. S. Woodward; lower dental plate, oral face, with portion of vertical section, nat. size (6 <i>a</i> ), and with portion of abraded oral face showing tubules, magnified twenty times (6 <i>b</i> ). Type specimen.—Zone of <i>Holaster subglobosus</i> ; Burham, Kent. Toulmin Smith Collection (B. M. no. 41716 <i>a</i> ).	109.
7.	Ditto; pointed end of lower dental plate, oral face, showing pittings.—Ibid. B. M. no. 47947.	109.
8.	Ditto; upper dental plate, oral face, with view of pitted and tuberculated lateral face (8 <i>a</i> ).—Chalk; Kent. Harford Collection (B. M. no. P. 5626).	109.
9.	<i>Plethodus oblongus</i> , Dixon; imperfect head, right and left (9 <i>a</i> ) lateral aspects.—Zone of <i>Holaster subglobosus</i> ; Clayton, Sussex. Willett Collection no. 154, Brighton Museum. <i>d.</i> , dentary; <i>fr.</i> , frontal; <i>hm.</i> , hyomandibular; <i>l.</i> , portion of lower dental plate; <i>m.</i> , mucus-pit; <i>op.</i> , operculum; <i>os.</i> , orbitosphenoid; <i>pa.</i> , parietal; <i>pas.</i> , parasphenoid; <i>pop.</i> , preoperculum; <i>sq.</i> , squamosal; <i>u.</i> , upper dental plate; <i>x.</i> , supra-occipital (?).	110.
10.	Ditto; imperfect head, left lateral aspect, with end of rostrum in front view (10 <i>a</i> ).—Zone of <i>Holaster subglobosus</i> ; Dorking, Surrey. Capron Collection (B. M. no. 49895). <i>co.</i> , two upper plates of circumorbital ring; <i>cept.</i> , ectopterygoid; <i>eth.</i> , mesethmoid; <i>mx.</i> , maxilla; <i>s.t.</i> , supratemporals; <i>uh.</i> , urohyal; other letters as in fig. 9.	110.

Unless otherwise stated, the figures are of the natural size.



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West Newman imp

Plethodus.





PLATE XXIII.

FIG.	PAGE.
1. <i>Osmeroïdes lewesiensis</i> (Mantell); imperfect fish, ventral aspect, four fifths nat. size.—Turonian zone; Southover, Lewes, Sussex. B. M. no. P. 7188. <i>a.</i> , base of anal fin; <i>d.</i> , dentary; <i>gu.</i> , gular plate; <i>ma.</i> , maxilla; <i>op.</i> , operculum; <i>pect.</i> , pectoral fins; <i>plr.</i> , pelvic fins; <i>sma.</i> 2, posterior supramaxilla; <i>sop.</i> , suboperculum.	114.
2. Ditto; head, left lateral aspect, with upper view of rostral region.—Turonian zone; Lewes. Mantell Collection (B. M. no. 4296). <i>ao.</i> , antorbital; <i>br.</i> , branchiostegal rays; <i>eth.</i> , mesethmoid; <i>fr.</i> , frontal; <i>po.</i> , postorbital cheek-plate; <i>pop.</i> , preoperculum; <i>qu.</i> , quadrate; other letters as in fig. 1.	115.
3. Ditto; cranial roof, lacking ethmoid region, upper aspect.—Ibid. Mantell Collection (B. M. no. 4295). <i>fr.</i> , frontal; <i>pa.</i> , parietal; <i>st.</i> , supratemporal; <i>spo.</i> , supraorbital; <i>sq.</i> , squamosal.	115.
4. Ditto; right quadrate ( <i>qu.</i> ), metapterygoid ( <i>mpt.</i> ), ectopterygoid ( <i>cept.</i> ), and symplectic ( <i>sym.</i> ), outer aspect.—Chalk; Kent. Harford Collection (B. M. no. P. 5680).	116.
5. Ditto; left maxilla ( <i>ma.</i> ), with supramaxillæ ( <i>sma.</i> 1, 2), outer aspect, and (5 a) anterior end of dentaries, oral aspect.—Turonian zone; Lewes. Capron Collection (B. M. no. 49891).	116.
6. Ditto; right mandibular ramus, outer aspect.—Ibid. Mantell Collection (B. M. no. 4296). <i>ag.</i> , articulo-angular; <i>d.</i> , dentary.	116.
7. Ditto; two caudal vertebral centra, lateral aspect, three halves nat. size.—Ibid. Capron Collection (B. M. no. 49892).	117.
8. Ditto; scale, three times nat. size.—Zone of <i>Holaster subglobosus</i> ; Dorking, Surrey. Capron Collection (B. M. no. 49894).	117.
9. <i>Osmeroïdes lewis</i> , A. S. Woodward; imperfect fish, dorsal aspect. Type specimen.—Zone of <i>Holaster subglobosus</i> ; Burham, Kent. Harford Collection (B. M. no. P. 5681). <i>do.</i> , dorsal fin; <i>fr.</i> , frontal; <i>pa.</i> , parietal; <i>sq.</i> , squamosal.	118.
10. Ditto; head, upper aspect.—Ibid. Egerton Collection (B. M. no. P. 1854). <i>op.</i> , operculum; <i>ptt.</i> , post-temporal; <i>socc.</i> , supraoccipital; <i>spo.</i> , supraorbital.	118.
11. Ditto; head with opercular apparatus, left lateral aspect.—Zone of <i>Holaster subglobosus</i> ; Lewes. Capron Collection (B. M. no. 49903). <i>ag.</i> , articulo-angular; <i>br.</i> , branchiostegal rays; <i>d.</i> , dentary; <i>gu.</i> , gular plate; <i>iop.</i> , interoperculum; <i>ma.</i> , maxilla; <i>op.</i> , operculum; <i>po.</i> , postorbital; <i>pop.</i> , preoperculum; <i>sop.</i> , suboperculum.	118.

Unless otherwise stated, the figures are of the natural size.



Osmeroides.





PLATE XXIV.

FIG.		PAGE.
1.	<i>Osmeroides latifrons</i> , sp. nov.; skull and anterior vertebræ, upper aspect, two thirds nat. size. Type specimen.—Zone of <i>Holaster subglobosus</i> ; Wouldham, Kent. Dibley Collection (B. M. no. P. 10465). <i>epo.</i> , epiotic; <i>eth.</i> , mesethmoid; <i>fr.</i> , frontal; <i>pa.</i> , parietal; <i>socc.</i> , supraoccipital; <i>sq.</i> , squamosal; <i>v.</i> , vertebral centra.	120.
2.	Ditto; head, left lateral aspect, with a view of right ceratohyal ( <i>ch.</i> ) and branchiostegal rays ( <i>br.</i> ) (2 <i>a</i> ), two thirds nat. size.—Ibid. Dibley Collection (B. M. no. P. 9699). <i>op.</i> , operculum; <i>po.</i> , post-orbital; <i>pop.</i> , preoperculum; <i>ptf.</i> , postfrontal; <i>qu.</i> , quadrate; <i>sym.</i> , symplectic; other letters as in fig. 1.	120.
3.	Ditto; right operculum ( <i>op.</i> ) and suboperculum ( <i>sop.</i> ), two thirds nat. size, with scales enlarged three times (3 <i>a</i> ).—Ibid. Dibley Collection (B. M. no. P. 10466). <i>l.</i> , tube of lateral line.	120.
4.	<i>Dincolps ornatus</i> , gen. et sp. nov.; anterior half of fish, right lateral aspect, one half nat. size, with parts of maxilla, nat. size (4 <i>a</i> ). Type specimen.—Probably zone of <i>Holaster subglobosus</i> ; Kent. Bowerbank Collection (B. M. no. 39432). <i>ag.</i> , articulo-angular; <i>ao.</i> , antorbital; <i>br.</i> , branchiostegal rays; <i>cl.</i> , clavicle; <i>d.</i> , dentary; <i>do.</i> , remains of dorsal fin; <i>gu.</i> , gular plate; <i>mx.</i> , maxilla; <i>pcl.</i> , post-clavicle; <i>pet.</i> , pectoral fin; <i>plv.</i> , pelvic fin; <i>scl.</i> , supraclavicle; <i>sma.</i> , facette for supramaxilla; other letters as in fig. 2.	122.
5.	Ditto; imperfect head, right lateral and (5 <i>a</i> ) upper aspects, with remains of left operculum (5 <i>b</i> ), two thirds nat. size.—Zone of <i>Holaster subglobosus</i> ; Dorking, Surrey. Egerton Collection (B. M. no. P. 1812). <i>spo.</i> , supraorbital; other letters as in figs. 2, 4.	122.
6.	Ditto (?); portion of left dentary, outer aspect, nat. size, with four teeth enlarged six times (6 <i>a</i> ).—Chalk; Kent. Mrs. Smith's Collection (B. M. no. 49091).	122.



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1-3. Osmeroides. 4-6. Dinelops.



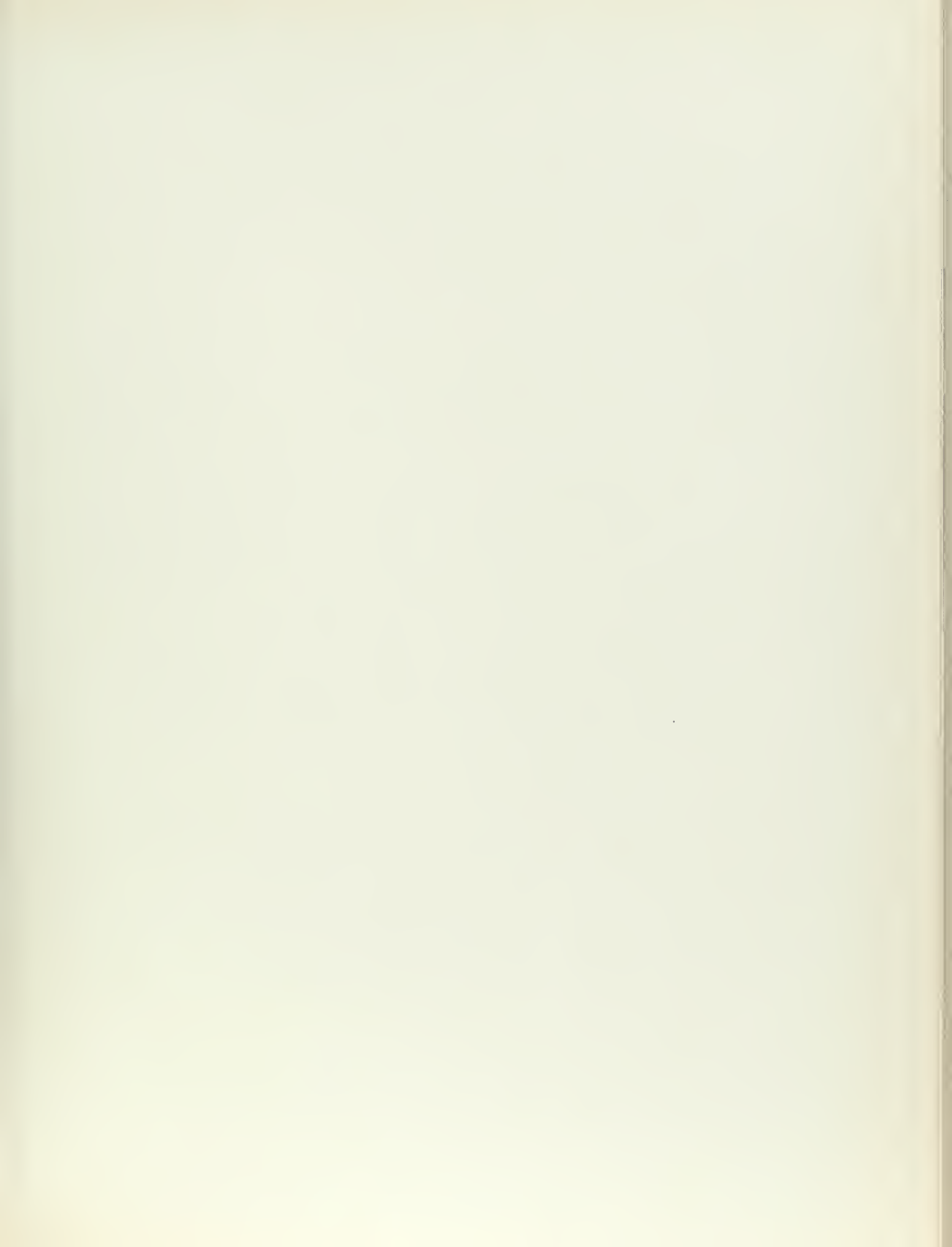


PLATE XXV.

FIG.	PAGE.
1. <i>Pachyrhizodus basalis</i> , Dixon; right premaxilla, upper and (1 <i>a</i> ) anterior aspects, nat. size. Type specimen.—Chalk; Kent. Mrs. Smith's Collection (B. M. no. 49014). <i>i.</i> , inner tooth; <i>m.</i> , bases of marginal teeth.	125.
2. Ditto; portion of right premaxilla, inner aspect, showing two large inner teeth.—Chalk; Kent. Harford Collection (B. M. no. P. 5655).	125.
3. <i>Pachyrhizodus gardneri</i> (Mason); incomplete right premaxilla, upper, anterior (3 <i>a</i> ), and outer (3 <i>b</i> ) aspects, two thirds nat. size.—Zone of <i>Holaster subglobosus</i> ; Burham, Kent. Taylor Collection (B. M. no. 33257). <i>i.</i> , inner tooth; <i>m.</i> , marginal teeth.	127.
4. Ditto; incomplete left premaxilla, oral aspect, with (4 <i>a</i> ) outer view of a marginal tooth, two thirds nat. size.—Ibid. Toulmin Smith Collection (B. M. no. 41674). <i>b.</i> , partially absorbed base of marginal tooth; <i>i.</i> , inner tooth; <i>m.</i> , marginal tooth; <i>s.</i> , vacant tooth-socket.	127.
5. Ditto; greater part of left maxilla of same specimen, outer aspect, two thirds nat. size.	127.
6. Ditto; portion of right dentary of same specimen, inner aspect, showing teeth on a ledge and inside a thin wall, two thirds nat. size.	127.
7. Ditto; greater part of left mandibular ramus, outer aspect, showing partly displaced articulo-angular ( <i>art.</i> ), two thirds nat. size.—Zone of <i>Schloenbachia varians</i> ; Glynde, Sussex. B. M. no. P. 9016.	127.
8. Ditto; right dentary, lower and (8 <i>a</i> ) outer aspects, two thirds nat. size.—Zone of <i>Holaster subglobosus</i> ; Burham, Kent. Harford Collection (B. M. no. P. 5656). <i>i.</i> , small inner symphysial tooth.	127.

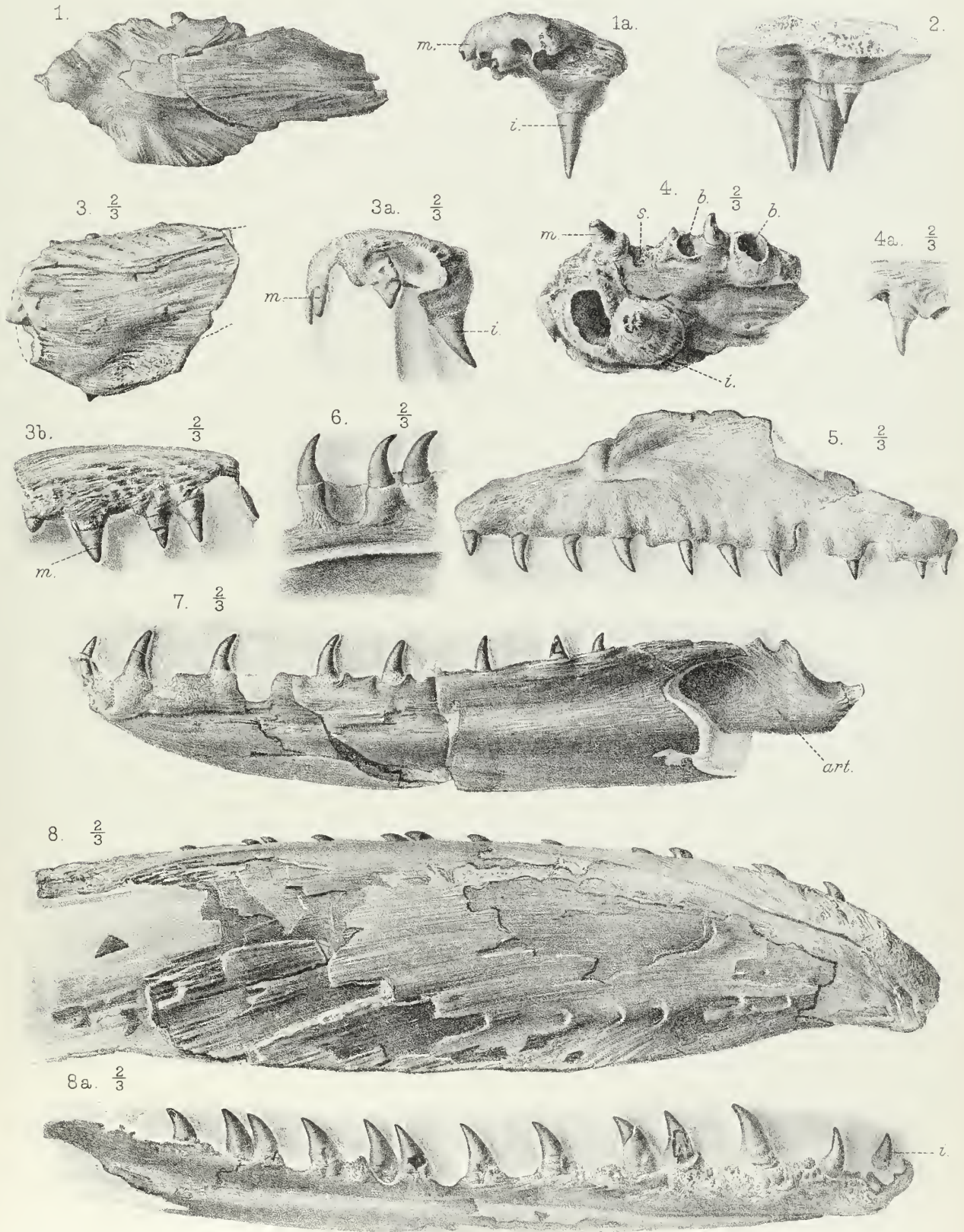
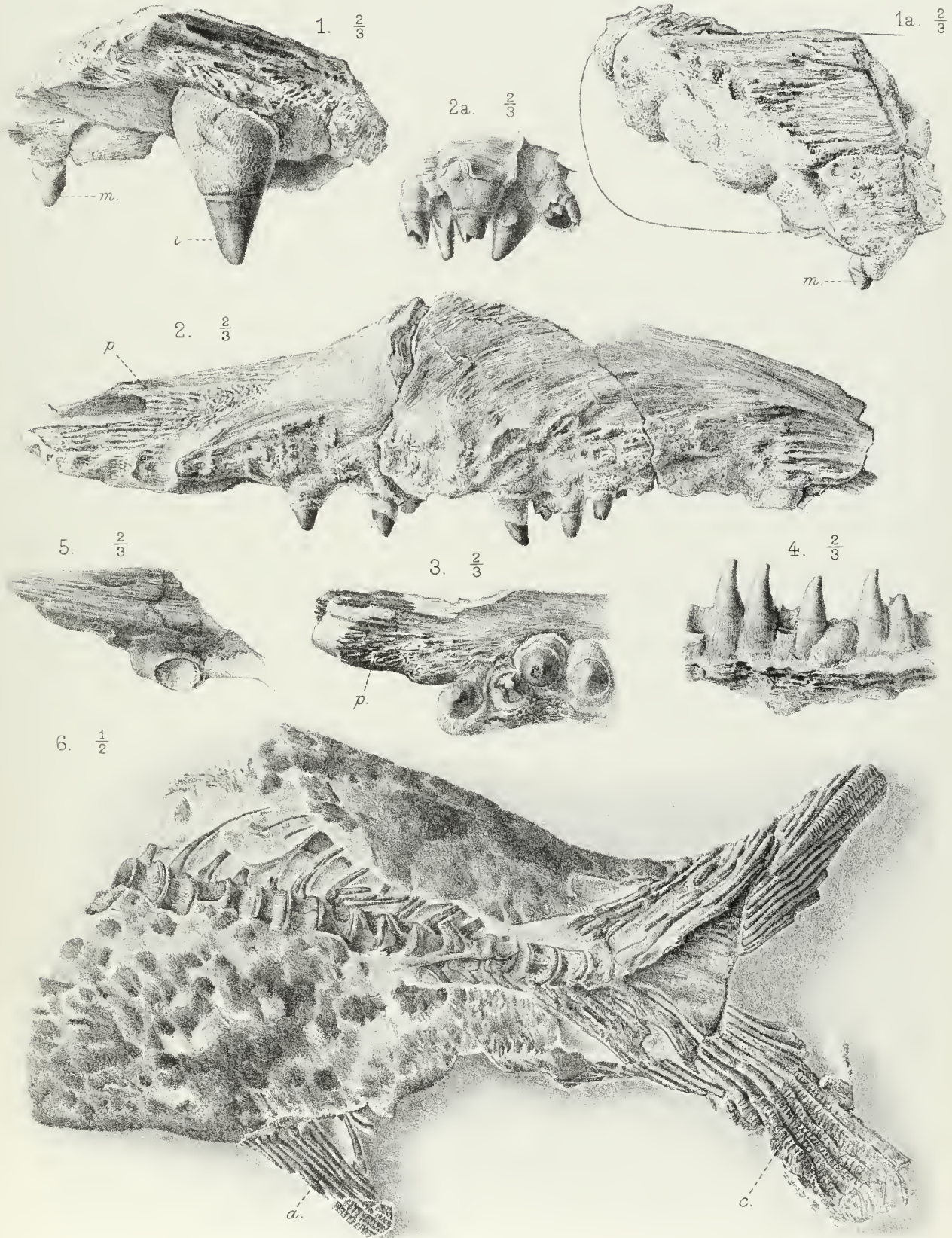






PLATE XXVI.

FIG.		PAGE.
1.	<i>Pachyrhizodus dibbleyi</i> , A. S. Woodward; left premaxilla, inner and (1 <i>a</i> ) upper aspects, two thirds nat. size. Type specimen.—Zone of <i>Holaster subglobosus</i> ; Burham, Kent. Dibley Collection (B. M. no. P. 9115). <i>i.</i> , inner tooth; <i>m.</i> , marginal tooth.	128.
2.	Ditto; left maxilla of same specimen, outer aspect, and (2 <i>a</i> ) inner view of some displaced teeth, two thirds nat. size. <i>p.</i> , antero-internal process for overlap of premaxilla.	128.
3.	Ditto; lower aspect of anterior end of right maxilla of same specimen, showing irregular teeth and antero-internal process ( <i>p.</i> ), two thirds nat. size.	128.
4.	Ditto; inner view of teeth of right dentary, two thirds nat. size.—Zone of <i>Holaster subglobosus</i> ; Merstham, Surrey. Dibley Collection (B. M. no. P. 10042).	128.
5.	<i>Pachyrhizodus gardneri</i> (Mason); lower aspect of anterior end of right maxilla, showing a tooth-socket and the antero-internal process, two thirds nat. size.—Zone of <i>Holaster subglobosus</i> ; Ditchling, Sussex. Capron Collection (B. M. no. 49905).	127.
6.	<i>Pachyrhizodus</i> sp.; tail, left lateral aspect, showing remains of anal ( <i>a.</i> ) and caudal ( <i>c.</i> ) fins, one half nat. size.—Chalk; Cuxton, Kent. Harford Collection (B. M. no. P. 5659).	124.





THE  
PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

LONDON :

MDCCCLXXXVII—MDCCCXVII.

## AMMONITES OF THE "INFERIOR OOLITE SERIES."

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### ORDER OF BINDING AND DATES OF PUBLICATION.

PAGES.	PLATES.	ISSUED IN VOL. FOR YEAR.	PUBLISHED.
Title-pages and Preface	Corrections in Names	1907	December, 1907
1— 24	I—VI	1886	March, 1887
25— 56	VII—XIV	1887	January, 1888
57—144	XV—XXIII and A	1888	March, 1889
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245—256	XXXVII—XLIV	1890	April, 1891
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313—344	LVII—LXXVI	1892	November, 1892
345—376	LXXVII—XCII	1893	December, 1893
377—456	XCIII—CIII	1894	November, 1894
Suppl. i—xxxii	Suppl. I—IV	1898	December, 1898
„ xxxiii—lxiv	„ V—XIV	1899	December, 1899
„ lxv—clxviii	„ XV—XIX	1904	December, 1904
„ clxix—ccviii	„ XX—XXIV	1905	November, 1905
„ ccix—ccx	—	1907	December, 1907
Index, cexi—cclxii }			

A MONOGRAPH  
OF THE  
**AMMONITES**

OF THE  
“INFERIOR OOLITE SERIES”

(STAGES—TOARCIAN, PARS; AALENIAN; BAJOCIAN;  
BATHONIAN, PARS)

BY

S. S. BUCKMAN, F.G.S.,

HON. MEMBER OF THE YORKSHIRE PHILOSOPHICAL SOCIETY, OF THE CHELTENHAM NATURAL SCIENCE SOCIETY, ETC.

VOL. I. ATLAS.

PLATES I—CIII, AND A; SUPPLEMENT, PLATES I—XXIV.

HILDOCERATIDÆ, PLATES I—XXXVII, AND A; SUPPL., PLATES I—XXIII.  
POLYMORPHIDÆ, PLATES XXX, XXXVII, XXXIX—XLVIII; SUPPL., PLATES XXIII, XXIV.  
ARIETIDÆ, PLATE XXXVIII.  
AMALTHEIDÆ (SONNININÆ), PLATES XXII, XXIII, XLVIII—CIII.  
OPPELIDÆ, PLATES XX, XXI.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1887—1907.

PRINTED BY ADLARD AND SON, LONDON AND DORKING.

## CORRECTIONS OF NAMES IN EXPLANATIONS OF PLATES.

The corrections are marked by broad-faced type = **Welschia**.

The references to pages where the correction is made follow the name. The Arabic numerals refer to the main work; the small Roman to the Supplement.

Where no author's name is appended, the writer of this Monograph is the giver of the trivial appellation.

### PLATE I.

Murchisonæ hemera.

**Welschia obtusiformis**, p. li.

### PLATE II.

[Murchisonæ hemera.]

Figs.

3, 4. **Strophogyria pinax**, p. lxiii.

[Concavi hemera.]

6, 7. **Ludwigella concava** (J. Sowerby), p. lxxxvi.

About drawing of Fig. 7 see p. 62.

### PLATE III.

[Murchisonæ hemera.]

3. **Ludwigina patula**, p. lxi.

4, 5. **Ludwigia tuberculata**, p. lxix.

[Bradfordensis hemera.]

6, 7. **Brasilina Baylii**, p. lxxxiii.

### PLATE IV.

Concavi hemera.

1, 2. **Ludwigella arcitenens**, p. lxxxv.

3, 4. **Ludwigella cornu**, p. lxxxv.

Bradfordensis hemera.

5, 6. **Brasilia bradfordensis**, p. lxxx.

7. **Hyattina** ? sp., p. cxxx.

8. **Apedogyria platychora**, p. lx.

### PLATE V.

Bradfordensis hemera.

**Apedogyria platychora**, p. lx.

### PLATE VI.

Concavi hemera.

**Lucya magna**, p. lxxvi.

### PLATE VII.

Bradfordensis hemera.

Figs

1, 2. **Ludwigia ambigua**, p. lxxii.

3, 4. **Brasilia effricata**, p. lxxxii.

[Discitæ hemera.]

5, 6. **Braunsella lenis**, p. cii.

Bradfordensis hemera.

7. **Ancolioceras costatum**, p. xlvi.

### PLATE VIII.

[Concavi hemera.]

1, 2. **Ludwigella concava** (J. Sowerby), p. lxxxvi.

Discitæ hemera.

3, 4. **Graphoceras decorum**, p. xlviii.

5, 6. **Brasilia sublineata**, p. lxxx.

7, 8. **Graphoceras flaccidum**, p. xlviii.

### PLATE IX.

1—4. **Lucya cavata**, p. lxxvi.

5, 6. **Graphoceras stigmatum**, p. xlvii.

7. **Graphoceras limitatum**, p. xlvii.

8—10. **Graphoceras stigmatum** (abnormal), p. xlvii.

### PLATE X.

1, 2. **Depaoceras formosum**, p. lxxix.

3, 4. **Brasilia pulchra**, p. lxxx.

5, 6. **Graphoceras v-scriptum**, p. xlvii.

7, 8. **Graphoceras limitatum**, p. xlvii.

9. **Graphoceras undulatum**, p. xlvii.

10, 11. **Platygraphoceras apertum**, p. xlvii.



## CORRECTIONS OF NAMES

### PLATE XI.

Bradfordensis hemera.

FIGS.

1. *Wiltshireia gigantea*, p. lxxviii.

Discitæ hemera.

- 2, 3. *Reynesia intermedia*, p. ciii.  
 4, 5. *Reynesia lepida*, p. civ.  
 6, 7. *Reynesia laxa*, p. ciii.

### PLATE XII.

- 1—3. *Brasilia pinguis*, p. lxxxii.  
 4. *Wiltshireia gigantea*, p. lxxviii.  
 5—7. *Welschia pagana*, p. lii.  
 8, 9. *Brasilia decipiens*, p. lxxxii.  
 10, 11. *Darellia semicostata*, p. cxiii.

### PLATE XIII.

- 1—3. *Cypholloceras opaliniforme*, p. xlv.  
 4, 5. *Canavarina* sp., p. cxliii.  
 6. *Lioceras striatum*, p. xlii.  
 7—10. *Walkeria subglabra*, p. cxli.  
 11. *Lioceras partitum*, p. xxxix.  
 12. *Lioceras striatum*, p. xlii.

### PLATE XIV.

- 1, 2. *Lioceras* sp., p. xlii.  
 3, 4. *Lioceras partitum*, p. xxxix.  
 5, 6. *Cypholloceras plicatum*?, p. cxxx.  
 7—9. *Cypholloceras renovatum*, p. xlvi.  
 10, 11. *Depaoceras fallax*, p. lxxviii.

### PLATE XV.

- 1, 2. *Brasilia similis*, p. lxxxii.  
 3, 4. *Platygraphoceras compactum*, p. xcv.  
 5, 6. *Pseudographoceras*? *compressum*, p. xciii.  
 7, 8. *Braunsina*? *futilis*, p. ci.  
 9, 10. *Platygraphoceras* sp. A., p. xciv.  
 11—13. *Ludwigella rudis*, p. lxxxv.  
 14, 15. *Ludwigella subrudis*, p. lxxxvii.  
 16, 17. *Braunsina*? *angulifera*, p. ci.

### PLATE XVI.

- 1, 2. *Toxolloceras Walkeri*, p. cxxvi.  
 3, 6. *Darellia*? *polita*, p. cxiv.  
 7, 9. *Reynesella piodes*, p. cix.  
 10, 11. *Reynesia coela*, p. civ.  
 12, 13. *Hyperlioceras discitiforme*, p. cxxiv.

### PLATE XVII.

FIGS.

- 1, 2. *Hyperlioceras liodiscites*, p. cxxv.  
 3, 4. *Hyperlioceras rudidiscites*, p. cxxiv.  
 5. *Hyperlioceras subleve*, p. cxxiii.

### PLATE XVIII.

- 1, 2. *Hyperlioceras rudidiscites*, p. cxxiv.  
 3. *Hyperlioceras subleve*, p. cxxiii.  
 4, 5. *Darellia lævis*, p. cxiii.

### PLATE XIX.

- 1, 2. *Hyperlioceras deflexum*, p. cxxii.  
 3, 4. *Deltotoceras subsectum*, p. cxxi.  
 5, 6. *Deltoidoceras subdiscoideum*, p. cxviii.

### PLATE XX.

- 1, 2. *Deltoidoceras subdiscoideum*, p. cxviii.  
 3, 4. *Pseudolioceras gradatum*, p. clviii.  
 5, 6. *Pseudolioceras pumilum*, p. clix.  
 9, 10. *Pseudolioceras replicatum*, p. clx.  
 11, 12. *Lioceras subcostosum*, p. xxxvii.  
 13, 14. *Æcotraustes nodifer*, p. cxev.  
 15—17. *Æcotraustes costiger*, p. cxciv.

### PLATE XXI.

- 3, 4. *Hyperlioceras Lucyi*, p. cxxiii.  
 5, 6. *Dissoroceras tabulatum*, p. cxv.  
 7—9. *Depaoceras fallax*, p. lxxviii.  
 10, 11. *Lucya caduceifera*, p. lxxv.

### PLATE XXII.

- 30, 31. *Hildoceras semipolitum*, p. clvi.  
 32, 33. *Sonninia sulcata*, p. exciii.  
 34. *Sonninia* aff. *Buckmani* (Haug.), p. exciii.  
 35, 36. *Brodiceras curvum*, pp. xxxii, xxxiii.

### PLATE XXIII.

Sauzei hemera.

1. *Sonninia sulcata*, p. exciii.  
 [Witchelliae hemera.]

- 2, 3. *Witchellia* sp., p. exciii.

Sauzei hemera.

- 5, 6. *Sonninia dundriensis*, p. exciii.  
 7, 8. *Sonninia* aff. *Buckmani* (Haug.), p. exciii.

Variabilis hemera.

- 9, 10. *Brodiceras*? *Witchelli*, p. xxxiii.  
 11—13. *Haugia jugosa*, p. xxv.  
 14, 15. *Haugia grandis*, p. xxvi.  
 16, 17. *Phymatoceras Dumortieri*, p. xxx.



## CORRECTIONS OF NAMES

### PLATE A.

Figs.

2. *Ludwigia tuberculata*, p. lxix.
5. *Lucya caduceifera*, p. lxxv.
7. *Ludwigella rudis*, p. lxxxv.
9. *Ecotraustes costiger*, p. xciv.
11. *Ancolioceras costatum*, p. xlvi.
12. *Wiltshireia gigantea*, p. lxviii.
13. *Brasilia similis*, p. lxxxii.
16. *Graphoceras v-scriptum*, p. xevi.
17. *Platygraphoceras compactum*, p. xev.
19. *Graphoceras undulatum*, p. xevii.
21. *Graphoceras v-scriptum*, p. xevi.
24. *Toxolloceras Walkeri*, p. cxxvi.
25. *Hyperlioceras deflexum*, p. cxxii.
28. *Hildoceras semipolitum*, p. clvi.
36. *Phymatoceras Dumortieri*, p. xxx.

### PLATE XXIV.

*Haugia grandis*, p. xxvi.

### PLATE XXV.

1. *Haugia grandis*, p. xxvi.
2. *Haugia aff. variabilis*, p. xxiii.
- 5, 6. *Haugia ? inæqua*, p. xxix.
7. *Haugia ? fascigera*, p. xxix.

### PLATE XXVI.

- 1, 2. *Haugia sculpta*, p. xxix.
- 3—5. *Haugia aff. illustris*, p. xxvii.

### PLATE XXVII.

- 3—6. *Phlyseogrammoceras Orbigny*, p. clv.

### PLATE XXVIII.

- 4—6. *Grammoceras audax*, p. cxxxii.
- 14, 15. *Pseudogrammoceras explicatum*, p. cxlvi.
- 16, 17. *Grammoceras penestriatulum*, p. cxxxiii.
- 20, 21. *Canavarella ? arenacea*, p. cxxix.

### PLATE XXIX.

- 1—5. *Pseudogrammoceras ? doerntense*  
(Denckm.), p. cliii.
- 6, 7. *Pseudogrammoceras ? sp.*, p. cliv.
- 8—10. *Pseudogrammoceras ? placidum*, p. cliii.

### PLATE XXX.

Figs.

- 1, 2. *Canavarina folleata*, p. cxli.
- 3, 4. *Pleydellia ? mactra ?* (Dunn.), p. cxxxix.
- 5—7. *Cotteswoldia limatula*, p. cxxxiv.
- 8, 9. *Walkeria ? lotharingica ?* (Branco), p. cxl.
10. *Walkeria ? sp.*, p. cxl.
- 11, 12. *Pleydellia sp., A.*, p. cxxxviii.
- 13, 14. *Pleydellia ? subcompta ?* (Branco), p. cxxxviii.
- 15—17. *Dumortieria linearis*, p. clxxxiii.
18. *Dumortieria subfasciata*, p. clxxxi.
19. *Dumortieria subexcentrica*, p. clxxxii.

### PLATE XXXI.

- 1, 2. *Pleydellia fluens*, p. cxxxvii.
- 3, 4. *Cotteswoldia crinita*, p. cxxxvii.
- 5, 6. *Canavarina venustula*, p. cxliii.
- 7—9. *Pleydellia ? sp. B.*, p. cxxxix.
- 10—12. *Canavarina venustula*, p. cxliii.
- 13, 14. *Cotteswoldia sp.*, p. cxxxv.
- 15, 16. *Cotteswoldia misera*, p. cxxxv.

### PLATE XXXII.

- 1, 2. *Cotteswoldia superba*, p. cxxxiv.
- 3—6. *Pleydellia aalensis* (Ziet.), p. cxxxvii.
- 7, 8. *Cotteswoldia subcandida*, p. cxxxv.
- 9, 10. *Walkeria burtonensis*, p. cxxxix.
- 11, 12. *Walkeria arcuata*, p. cxxxix.

### PLATE XXXIII.

- 1, 2. *Cotteswoldia distans*, p. cxxxvi.
- 3, 4. *Cotteswoldia costulata* (Ziet.), p. cxxxiii.
- 5—10. *Pleydellia leura*, p. cxxxviii.
- 11, 12. *Pseudogrammoceras ? placidum*, p. cliii.
- 13—16. *Asthenoceras nannodes*, p. xlix.
- 17, 18. *Pseudogrammoceras subfallaciosum*, p. cxlvii.

### PLATE XXXIV.

- 1, 2. *Pseudogrammoceras pachu*, p. eli.
- 3—5. *Pseudogrammoceras Bingmanni*  
(Denckm.), p. cxlv.
- 6, 7. *Pseudogrammoceras aff. quadratum*  
(Haug), p. cxliv.
- 8, 9. *Pseudogrammoceras Muellerei* (Denckm.),  
p. eli.
- 10, 11. *Pseudogrammoceras expeditum*, p. cxlviii.
12. *Grammoceras sp. A.*, p. cxxxi.



## CORRECTIONS OF NAMES

### PLATE XXXV.

Figs.

- 1—3. *Pseudogrammoceras* *Muelleri* (Denckm.),  
p. cli.  
4—7. *Pseudogrammoceras* *Cotteswoldiæ*, p.  
cxlix.

### PLATE XXXVI.

- 1, 2. *Phlyseogrammoceras* *metallarium*  
(Dum.), p. clv.  
3—5. *Pseudogrammoceras* *subquadratum*, p.  
cxlv.  
6—8. *Pseudogrammoceras* *thrasu*, p. cxlv.

### PLATE XXXVII.

- 6—8. *Dumortieria* *sub-solaris*, p. clxxiv.  
14, 15. *Dumortieria* *Munieri* (Haug.), p. clxxv.  
16, 17. *Dumortieria* *yeovilensis*, p. clxxviii.  
18, 19. *Dumortieria* *costula* (Rein.), p. clxxv.

### PLATE XXXIX.

- 1, 2. *Catullocceras* *subaratum*, Brasil, p. clxxii.  
3—5. *Catullocceras* *aratum*, p. 280.

### PLATE XL.

- 1, 2. *Dumortieria* *externicostata* (Branco), p.  
clxxvii.  
3—9. *Dumortieria* *mutans*, p. clxxvii.  
10—12. *Dumortieria* *declinans*, p. clxxvii.

### PLATE XLI.

- 4—6. *Dumortieria* *regularis*, p. clxxviii.  
7, 8. *Catullocceras* *psamminum*, p. clxxi.

### PLATE XLII.

- 1, 2. *Dumortieria* *sp.*, p. clxxx.  
3—5. *Dumortieria* *penexigua*, p. clxxxi.  
6, 7. *Dumortieria* *signata*, p. clxxix.  
11, 12. *Dumortieria* *metita*, p. clxxviii.  
13—15. *Dumortieria* *diphyes*, p. clxxx.

### PLATE XLIII.

- 1—4. *Dumortieria* *sp.*, p. clxxxiv.  
5—7. *Dumortieria* *diphyes*, p. clxxx.  
8—10. *Dumortieria* *latescens*, p. clxxxv.  
11, 12. *Dumortieria* *exigua*, p. clxxxiv.

### PLATE XLIV.

Figs.

- 1—3. *Dumortieria* *lata*, p. clxxxiii.  
4—6. *Dumortieria* *sp.*, p. clxxxiii.  
7, 8. *Dumortieria* *subexcentrica*, p. clxxxii.  
10—12. *Dumortieria* *munda*, p. clxxxvi.

### PLATE XLV.

- 4, 5. *Dumortieria* *rustica*, p. clxxxvi.  
6, 7. *Dumortieria* *exacta*, p. clxxxvii.  
8, 9. *Dumortieria* *Brancoi*, p. clxxxvi.  
10—12. *Dumortieria* *rustica*, p. clxxxvi.  
13, 14. *Dumortieria* *inclusa*, p. clxxx.  
15, 16. *Dumortieria* *sp.*, p. clxxvi.

### PLATE XLVI.

*Discitæ* *hemera*.

- 1—3. *Fontannesia* *grammoceroïdes*, p. clxxxviii.  
4, 5. *Fontannesia* *luculenta*, p. clxxxix.  
6, 7. *Fontannesia* *explanata*, p. clxxxviii.

### PLATE XLVII.

*Discitæ* *hemera*.

- 1—5. *Fontannesia* *curvata*, p. clxxxix.  
6, 7. *Fontannesia* *despecta*, p. cxcii.  
8, 9. *Fontannesia* *tortiva*, p. cxcii.  
10—12. *Fontannesia* *luculenta*, p. clxxxix.  
13, 14. *Fontannesia* *carinata*, p. clxxxix.  
15—17. *Fontannesia* *grammoceroïdes* (Haug.), p.  
clxxxviii.

### PLATE XLVIII.

- 1, 2. *Tmetoceras* *circularæ*, p. clxx.  
8—10. *Tmetoceras* *Regleyi* (Dum.), p. clxxi.  
16, 17. *Sonninia* *reclinans*, p. 421.

### PLATE I.

- 16—22. *Sonninia* *locuples*, p. 431.

### PLATE LII.

- 1—3. *Dorsetensia* *Lenneri*, Brasil, p. cxcii.  
For *Lycettia* at bottom of page, read *Dorsetensia*. *Lycettia* was said to have been used, the information arriving as the part was in the press.

### PLATE LXIV.

- Sonninia* *regularis*?, p. 395.



CORRECTIONS OF NAMES

PLATE LXV.

Figs.

- 3, 4. *Sonninia reclinans*, p. 421.  
6, 7. *Fontannesia curvata*, p. clxxxix.

PLATE LXVII.

- 1, 2. *Sonninia aff. dominans*, p. 438.  
3, 5. *Sonninia sp.*, p. 438.

PLATE LXIX.

*Sonninia dominica*, p. 410.

PLATE LXXIV.

- 4—6. *Sonninia spinifera*, p. 418.

PLATE LXXVII.

- 6—9. *Sonninia subirregularis*, p. 426.

PLATE LXXXV.

Figs.

- 7, 8. *Sonninia obtusifomis*?, p. 430.

PLATE LXXXVIII.

4. *Sonninia subirregularis*, p. 426.

PLATE CIII.

Fig. 2 at bottom of plate should be Fig. 24.

SUPPLEMENT, PLATE II.

In the footnote, for "spines" read "species."

SUPPLEMENT, PLATE IV.

- 7—9. *Brodiceras junctum*.

SUPPLEMENT, PLATE X.

- 35—37. *Brasilina Tutcheri*?, p. cxxx.



THE  
PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

LONDON :

MDCCCLXXXVII—MDCCCVII.

## AMMONITES OF THE "INFERIOR OOLITE SERIES."

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### ORDER OF BINDING AND DATES OF PUBLICATION.

PAGES.	PLATES.	ISSUED IN VOL. FOR YEAR.	PUBLISHED.
Title-pages and Preface	Corrections in Names	1907	December, 1907
1— 24	I—VI	1886	March, 1887
25— 56	VII—XIV	1887	January, 1888
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345—376	LXXVII—XCII	1893	December, 1893
377—456	XCI—CIII	1894	November, 1894
Suppl. i—xxxii	Suppl. I—IV	1898	December, 1898
„ xxxiii—lxiv	„ V—XIV	1899	December, 1899
„ lxv—clxviii	„ XV—XIX	1904	December, 1904
„ clxix—ccviii	„ XX—XXIV	1905	November, 1905
„ ccix—ccx	„	1907	December, 1907
Index, cexi—cclxii			

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VOL. I. TEXT.

PAGES 1—456; SUPPLEMENT, PAGES i—ccx; INDEX.

HILDOCERATIDÆ, PAGES 16—114, 142—224; SUPPL., PAGES i—clxviii.

POLYMORPHIDÆ, PAGES 231—286; SUPPL., PAGES clxix—cxc.

ARIETIDÆ, PAGES 225—231.

AMALTHEIDÆ (SONNININÆ), PAGES 115—121, 286—456; SUPPL., PAGES cxcii—cxciv.

OPPELIDÆ, SUPPL., PAGES cxciv—cxcvi.

GEOLOGY, PAGES 2—10, 41—53; SUPPL., PAGES cciv—ccix

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1887—1907.



## P R E F A C E.

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A PERIOD of twenty-one years has been taken up in the issue of the parts of this work illustrating British Inferior Oolite Ammonites. Yet the subject is very far from completion; for many families of these Ammonites have not been touched at all. The richness of the Inferior Oolite Ammonite fauna is almost incredible; and, though a mass of material has been accumulated, yet it would be vain to suppose that anything like a complete toll of species has been obtained. The few feet in extent of the various quarries can give an imperfect sample of the contents of the miles of fossiliferous rocks by which they are surrounded; especially when those rocks are so varied, and have suffered so much from pene-contemporaneous denudation.

How varied are the rocks, may be seen in the fact that twenty-three distinct fossiliferous horizons are embraced in the scope of this Monograph; while pene-contemporaneous denudation has removed some of these horizons from such large areas that there is hardly a quarry in which they can be explored. Yet so capricious is the erosion that these missing horizons might be found within a few yards of some existing exposures.

However, if the Inferior Oolite is likely to yield much new material for a long time, it may yet be seen that much has now been recorded.

How much progress has been made can be ascertained from the following comparison:—In the early part of the nineteenth century the Sowerbys, in their ‘Mineral Conchology,’ described eighteen Inferior Oolite (and Lias) Ammonites, which would be within the scope of the present work; but only three of their species, *A. concavus*, *A. striatulus*, and *A. jugosus* belong to the series which have fallen within the purview of the present volume. In 1854 Morris, in his ‘Catalogue,’ enumerated thirty-three Inferior Oolite species: of those thirteen are within this volume. In 1881 the author, dealing with Dorset-Somerset (excluding Dundry), described forty-one species, of which eleven come within the purview of this portion of the work. In 1883 he added four more species, two of which, coming under this portion, make the number the same as Morris, thirteen. But in 1907 the portion of the fauna of Inferior Oolite Ammonites,

which these thirteen represented, is found to have been described in this Monograph in about 450 species, distributed among some 75 genera.

These comparisons may give some idea of what has to be done to complete the work. If the three of the Sowerbys have become 450, then their fifteen, which belong to series untouched by the present portion of the work, might be expected to produce five times as many. However, this proportion is too high. The proportion in Morris is thirteen to twenty; and that seems to agree with what is known of the undescribed portion of the fauna. Therefore, there are rather more than as many species again to be described before the British Inferior Oolite Ammonites are anything like completely known.

The many years over which the appearance of the parts of the work has been spread, ought to be taken in account in any judgment on the work as a whole. The work should be regarded as an example of the evolution of ideas concerning the fauna and the strata whence the fauna has come. During all these years the author has been the learner carrying on researches; and, as those researches became more and more complete, they showed the necessity for greater discrimination with regard to the names of strata and of species. This has involved many alterations in names, which are to be found in the Supplement. Therefore, the reader will do well to study the Supplement first, and to interpret the early parts of the work by means of the Supplement. This Supplement may be said to represent the author's mature conclusions as to the classification and nomenclature of the species and the strata in which they occur—conclusions arrived at through researches carried on while the Monograph was in progress.

Perhaps the volume would have been more consistent had the publication of the earlier parts been delayed until these researches were more complete; but, on the other hand, it is certain that these researches were carried out just because of the incentive which the publication of the Monograph gave: lacking that, they might not yet have been undertaken by the author, faced by a constant struggle with ill-health and anxiety.

To many fellow-workers the author desires to express his very great indebtedness. To the late Prof. Alpheus Hyatt and to Prof. Emile Haug he is very particularly indebted—the views of the former upon tachygenesis, and those of the latter upon convergence have had very much influence upon the system of classification now adopted. To these authors he also desires to express his best thanks for the kind presentation of their works; while for similar welcome and important additions to his library he owes hearty thanks to Prof. Guido Bonarelli; Dr. L. Brasil; Profs. W. Branco, E. W. Benecke, M. Canavari; Dr. Paul Choffat, Dr. A. Denckmann; Prof. G. Gemmellaro; Dr. G. Geyer; Profs. W. Kilian, G. Meneghini, E. Mojsisovics, C. F. Parona, A. Pavlow, J. F. Pompeckj; Dr. J. Siemiradzki, Dr. J. P. Smith, Dr. M. Vacek; Prof. F. Wähler; and to so many

others that it would be impossible to enumerate all here by name. The author much regrets that he has not been able to repay fully all the courtesy thus extended to him; but he hopes that any omissions in this respect will be excused: he has done what he could with the copies of works at his command.

To those friends in Dorset who, in the early days of his Ammonite studies, subscribed and presented to him some important works, the author desires to express again his hearty thanks. And he cannot refrain from mentioning that, in connection with these and other studies, he has so often experienced the great kindness of friends in their giving and lending of valuable works.

For the use of specimens, whether by presentation, loan, or otherwise, the author desires to express his great obligation to many of those who have been mentioned above, and to Mr. E. T. Newton, F.R.S., for the kind loan of specimens from the Jermyn Street Museum; to Mr. W. H. Hudleston, F.R.S.; the late Mr. J. F. Walker, F.G.S.; Rev. H. H. Winwood, F.G.S.; the late Mr. E. Wilson, F.G.S., Curator of the Bristol Museum; the late Mr. T. C. Maggs, F.G.S.; Messrs. J. W. Tutchter, J. W. D. Marshall, Charles Upton; the late Rev. F. Smithe, F.G.S.; Mr. B. Thompson, F.G.S., and many others. To several of these geologists is he further indebted for presentations of works and papers.

To Mr. C. Davies Sherborn, F.Z.S., the writer gives very many thanks for much kind assistance in matters of bibliography, and also for the pains which he has taken to check generic names as regards the matter of pre-occupation. The same thanks are due to Mr. G. C. Crick, F.G.S., who has also taken much trouble to reply to the author's inquiries, and who has always most willingly placed his great knowledge of fossil Cephalopoda at the writer's service.

As an official of the British Museum (Nat. Hist.) Mr. Crick's services have often deserved the writer's grateful thanks; and for similar kind assistance he is greatly indebted to Dr. H. Woodward, F.R.S.; Prof. Bigot; Dr. F. A. Bather, F.G.S., and the officials of various museums, some of whom have been already mentioned. Unfortunately the author has not had the time or the opportunity to make visits to many museums to search for specimens. For many years all efforts were directed towards collecting specimens in the field for the elucidation of the stratigraphical problem, to freeing them from matrix, and to their scientific study afterwards. It may be understood that on this account, coupled with the regulations forbidding specimens to leave certain institutions, the collections of museums have not been drawn upon so much as they deserve in connection with this Monograph.

To the Government Grant Committee of the Royal Society for assigning him a grant to assist him in the labour of finishing this work; to the Council of the Palæontographical Society for their liberality in the matter of plates; to Prof. Rupert Jones, F.R.S., for care given to the reading of proof sheets; to the Editors,

Artists, and all who have assisted in the production of this volume, and to all who have in so many ways kindly rendered services, scientific or technical, in connection with this work and its associated studies, the writer cordially expresses his most grateful thanks.

With this work the author desires to associate three names—that of the late Dr. Thomas Davidson, F.R.S., one of his earliest geological friends, from whom he experienced much kindness and encouragement; that of Mr. R. D. S. Darell, F.L.S., F.G.S., formerly Mr. Darell Stephens, one of his earliest companions in the field, from whom he received many practical lessons in the zonal distribution of Ammonites (what the immense collection formed by Mr. Darell's enthusiastic labours has added to our knowledge of Ammonites is partly shown in these pages and plates); and that of his late father, Prof. James Buckman, from whom the author received so many scientific lessons, and to whom he owes his taste for scientific work. It was the father's great desire that his son should undertake the describing of the Inferior Oolite Ammonites—a task which he himself had formerly hoped to achieve.

Finally, the author desires to dedicate this work to his wife, his companion in many geological excursions, to whose skill he owes a number of good specimens. These words are written in the month which sees the completion of twenty-five years of married life, and the receipt of the many kind congratulations incidental to a silver wedding.

TOWERSEY, BUCKINGHAMSHIRE

(UNDER THAME);

*June 17th, 1907.*

	SOMERSET: Bath . . . . .	The bed below the Midford Sands.
	Ilminster district . . . . .	Clay and clay stones of upper part of Upper Lias.
	Dundry . . . . .	Blue ironshot bed.
	DORSET: Down Cliffs . . . . .	Upper layer of Junction bed, often missing.
	YORKSHIRE: Blea Wyke . . . . .	<i>Striatulus</i> shales.
<i>Variabilis</i> . . . . .	GLOUCESTERSHIRE: Coaley Wood, Frocester, Nibley, etc. Chalford . . . . .	The upper part of the Cotteswold Sands. "Upper Lias," blue sandy clay of the Waterworks.
	SOMERSET: Ilminster district . . . . .	Clay and clay stones of "Upper Lias."
	YORKSHIRE . . . . .	? Nodular shale above Alum shales.
<i>Lilli</i> . . . . .	GLOUCESTERSHIRE: Coaley Wood, Frocester, etc. Nailsworth . . . . .	The lower part of the Cotteswold Sands. A hard yellow, often blue sandstone.
	SOMERSET: Ilminster district . . . . .	Clay and clay stones, not far below Yeovil Sands.
	NORTHAMPTONSHIRE: Moulton . . . . .	Upper <i>Leda ovum</i> beds.

The following general terms, which are also in use, and have sometimes been quoted in this work, may deserve explanation.

UPPER RAGSTONES . . . . .	GLOUCESTERSHIRE: Cotteswolds ;	<i>Clypeus</i> and Upper <i>Trigonia</i> -grits.
MIDDLE RAGSTONES . . . . .	" "	<i>Phillipsiana</i> to <i>Wilchellia</i> beds.
LOWER RAGSTONES . . . . .	" "	Gryphite to Lower <i>Trigonia</i> -grits.
UPPER BEDS . . . . .	DORSET-SOMERSET	Strata of hemeræ <i>Garantianæ</i> to <i>fuscæ</i> , in which <i>Parkinsonia</i> is dominant.
PARKINSONI-BEDS . . . . .		
LOWER BEDS . . . . .	" "	Generally strata of hemeræ <i>Murchisonæ</i> and <i>Bradfordensis</i> .

Such terms as Cephalopod Bed, Fossil Bed, Freestone, Building Stone, Road stone, Sands, denote very different horizons at different localities. They must be interpreted accordingly, and the foregoing table will be a guide in this respect.

## ERRATA.

- Page 10, line 4, after *concerned* put ,
- Page 14, line 24, delete from *I have given* to end.
- Page 16, lines 1-4, delete, and read *Family, Hildoceratidæ, Hyatt.*
- Page 21, line 1, for *Hildoceratinæ* read *Hildoceratidæ.*
- Page 34, line 23, for *specimens which*, etc., read *specimens which lack the body chamber, or specimens which possess a similar amount of it.*
- Page 35, line 1, after *specimen*, put *which is from Bradford Abbas.*
- Page 38, line 23, for *this species* read *that species (Am. elegans).*
- Page 44, line 8, erase *Striatulum-subzone, C<sup>1</sup>*
- Page 44, line 13, for *Gramm. striatum* read *Dumortieria sp.*
- Page 45, line 13, remove *Striatulum-subzone* to opposite Bed 7, and insert C' before the 7.
- Page 54, line 29, for *could find no strong reason*, read *could then find no stronger reason.*
- Page 135, line i of note, for *each character* read *each new character.*
- Page 157, line 2 from bottom, for *fig. 2* read *fig. 1.*
- Page 159, line 8, for *doenteuse* read *doertense.*
- Page 159, line 12, for *meeting* read *joining.*
- Page 162, line 6, for *striatum* read *toarcense.*
- Page 162, line 5 sub *Dumortieria*, delete, after lobe.
- Page 162, line 6 sub *Dumortieria*, for *practically no* read *small.*
- Page 168, line 2 from bottom, for *Quatrième* read *Quatrième.*
- Page 172, line 11, for *Gramm.* read *Harpoceras.*
- Page 174, line 11, for *viii* read *vii.*
- Page 174, line 18, for *spathulate* read *spatulate.*
- Page 175, line 8, for *sands<sup>1</sup>* read *sands<sup>3</sup>.*
- Page 189, line 4 from bottom, delete *my.*
- Page 208, line 4, for *this species* read *Oppel's.*
- Page 217, line 25, for *tuft to* read *tuft in.*
- Page 274, line 8 from bottom, for *Catulloceras* read *Tmetoceras.*
- Page 293, opposite 5th line of note, read *Witchellia zone.*
- Page 294, line 17, delete *new.*
- Page 298, line 7 from bottom, delete . after *Cap.*
- Page 298, line 6 from bottom, delete ( ).
- Page 303, line 12 from bottom, for *has* read *have.*
- Page 306, line 7 from bottom, for *Branns* read *Brauns.*
- Page 383, line 3 from top, for  $\frac{y}{4}$  read  $\frac{y}{6}$ .
- Page 383, line 17 from top, for  $\frac{x}{2} + \frac{x}{2}$  read  $\frac{x}{2} + \frac{y}{2}$ .
- Page 452, line 17 from top, for *westerly* read *easterly.*
- Page 452, line 23 from top, for *eastwards* read *westwards.*
- Page xxxiii, line 8 from bottom, for *as the type of* read *in.*
- Page xlv, line 12 from top, for 7, 9 read 7-9.
- Page exci, line 11 from bottom, for *D.* read *F.*
- Page ccv, line 2 from bottom, for *falciferu* read *falciferum.*

## INDEX

**Heavy type** marks accepted species, their figures and technical descriptions. *Italic type* shows names, etc., revised. Roman type denotes casual mention of species, etc., and all general matter. A \* marks a species foreign to the scope of the monograph, geographically, geologically, or technically. Species are indexed under trivial names, but listed under generic. Species casually mentioned in articles which describe others of the same genus have seldom been indexed.

- aalense*, *Grammoceras*, Pl. 31, figs. 15, 16, see *misera*, *Cotteswoldia*; Pl. 32, figs. 1, 2, *superba*, C.; Pl. 32, figs. 3-6, *aalense*, *Pleydellia*; Pl. 32, figs. 7, 8, *subcandida*, *Cotteswoldia*; Pl. 32, figs. 9, 10, *burtonensis*, *Walkeria*; p. 192, see spp. var. above
- aalense*, *Grammoceras*, 44, 54, 222, 227, 244, cxxxiv, cxxxv, cxxxvii, cxxxix
- aalense*, *Harpoceras*, 37, 176, 192, 197, 253, 255, clxxxii; analysis of species so named, 193
- aalense* type, species of the, xxxv
- aalensis*, *Ammonites*, 12, 28, 37, 54, 62, 127, 178, 182, 184, 192, 194, 197, 198, 248, cxli
- cf. *aalensis*, *Ammonites*, 259
- Aalensis* *hemera*, vi, xxxv; strata of, xxxv, ccviii
- aalensis*, *Ludwigia*, 190, 192
- aalensis*, *Pleydellia*, Pl. 32, figs. 3-6; p. 192 (*Grammoceras aalense*); **Suppl., Figs. 112, 113, p. clxv; p. cxxxvii**
- aalensis*, *Pleydellia*, *hemera*, ccv
- aalensis* *costula*, *Ammonites*, 237, 238
- Aalenian* stage, ccv
- Abnormal form, 75; specimen, xcvi; variation, 289
- Abnormalities of septa, 381
- Abnormality, hypostrophlic, xcvi
- abnormis*, *Sonninia*, Pl. 85, figs. 4-6; pp. 377, 387, 404
- Absorption of living chamber, 312
- acanthodes*, *Sonninia*, Pls. 58, 59, 60, 63, fig. 1; Pl. 100, fig. 8; pp. 319, 390, 419; 301, 317, 318
- Acanthodes*-stock, differential characters of, 331
- Acanthopleuroceras*, clxix
- Acme*, 357; and *Inferior Oolite*, excix: of genetic series, cc; genetic, cc; morphogenetic, ccii
- actæon*, *Ammonites*, 14; *Harpoceras*, 13
- acutum*, *Arieticeras* (*hemera*), ccv; *Grammoceras*, 163
- acutus*, *Ammonites*, 24
- Additional species, clxi
- adicrum*, *Harpoceras*, 346, 347; *Hannatoceras*, 13
- Adult characters of *S. zigzag*, 272
- Ægoceras*, 14, 129; *belcheri*, *intermedium*, *liassicum*
- Ægoceratidæ*, 14, 16, 127, 287
- Ægoceratinae*, 14
- affine, *Pelecoceras*, 175
- affinis*, *Ammonites*, 228, 229
- affinis*, *Hudlestonia*, Pl. 38, figs. 1-8; p. 228
- Affinity, criteria of, i
- Agassiceras*; *striaries*, *miserabile*
- Age of specimen, causing difference in description, xciv
- Ages, ccv
- agria*, *Strophogyria*, **Suppl., Fig. 19 in text, p. lxii**
- Alderley*, xxviii
- algovianus*, *Ammonites*, 127, 132
- alsaticum*, *Harpoceras*, 304
- alternata*, *Sonninia*, Pl. 76, figs. 7-9; Pl. 77, figs. 3-5; Pl. 103, fig. 7; pp. 346, 390, 424
- Alticarina*, iv
- Alticarinate*, cvi; (series), cxix
- Alum-shale*, 168, 175, 203
- Alum Shales*, above, and *variabilis*, ccix
- Amaltheas*, 287

Amaltheidæ, 286, 293, ccxii, xiv; relationship of (Table VI), p. 291; classification, excviii  
 Amaltheinæ, 287  
 amaltheiforme, Hammatoceras, 157  
 Amaltheoidæ, 15, 286  
 Amaltheus, 14, 110, 286, 287, 315, lxxii, cci; coronatus, engelhardti, \*margaritatus, \*nudus, \*præstabilis, subserrodens, subspinatus, turgidus; allied to Somminia, 110, 130; from Hudlestonia, 225; from Sommininæ, 314; and Pleuroceras, separation of; characters of, 288  
 Amberleya, 46  
 Aumers Hill, lxxvii, lxxxiii  
 ambigua, Ludwigia, Pl. 7, figs. 1, 2; p. 26 (Lioceras ambiguum); Suppl., Pl. 17, fig. 31 a, b; p. lxxii  
 ambigua, Ludwigia, cci  
 ambiguum, Lioceras, Pl. 7, figs. 1, 2, see ambigua, Ludwigia; Pl. 7, figs. 3, 4, effricata, Brasilia; Pl. 7, figs. 5, 6, lenis, Braunsella; p. 26, see spp. var. above  
 ambiguum, Lioceras, 43, xlvi, lxxxii, cii  
 ambiguum, var. costatum, Lioceras, Pl. 7, fig. 7, p. 29, costatum, Ancolioceras  
 Ammatoceras, 13  
 Ammonitacea, excviii  
 Ammonite, 273; bed, 2; branches, dying out of specialised forms; branches, repetition of eyes of evolution in, 270; classification, 10-14, 126; development, excviii; fauna, independent of lithic conditions, xvi; groups, 127; horizons, cciv; ontogeny, remarks on, 288; radicals, 270; stocks, do not complete cycle, ccii  
 Ammonites, 14, 45, 46, 47, 50, 53, 446, 454, cci; aalensis, a. costula, actæou, acutus, affinis, algovianus, antiquus, arbustigerus, arenatus, armatus, bayani, beyrichi, bifer, bifrons, bingmanni, birchi, blagdeni, bosensis, boweri, braikenridgii, bronni, cadomensis, canaliculatus, candidus, capellinus jurensis, carnensis, collenottii, comensis, compactilis, complanatus, comptus, concavus, confusus, conjungens, conybeari, costula, costulatus, curioni, cycloides, deltafalcatus, depressus, desori, discites, discoides, \*discoideus, discus, dispansus, dumortieri, edouardianus, elegans, erbaensis, escheri, eseri, exaratus, falcifer, falcodiscus, falcofila, f. macer, f. sparsicosta,

fallaciosus, fallax, fluitans, frantzi, fredericii, fridericii, globosus, grunowi, guibali, lawskerensis, hecticus, herveyi, humphriesianus, illustris, impendens, insignis, insignisimilis, iserensis, jamesoni, jugifer, jugosus, jurensis, kurrianus, læviusculus, levesquei, levisoni, liassicus, lilli, lineatus, lympharum, lythensis, macrocephalus, mactra, mæandrus, malagma, masseanus, mercati, metallarius, miserabilis, moorei, murchisonæ, m. acutus, m. falcatus, m. intralævis, m. obtusus, m. planatus, navis, niortensis, normannianus, obtusus, occidentalis, ogerieni, opalinoides, opalinus, o. costosus, oxynotus, pettos-blagdeni, planicosta, propinquans, pustulifer, quadratus, radians, r. amalthei, r. compressus, r. costula, r. depressus, r. gigas, r. numismalis, r. quadratus, radiosus, regleyi, rheumatisans, robustus, romani, sæmanni, sauzei, seissus, serpentinus, serrodens, simpsoni, solaris, sowerbyi, s. insignoides, s. ovalis, stellaris, striatulo-costatus, striatulus, struckmanni, subcarinatus, subradiatus, sutneri, taylori, tessonianus, thouarsensis, tirolensis, toarcensis, toltarius, torulosus, trimarginatus, truelli, undulatus, valdani, variabilis, v. var. dispansus, werthi, wurttenbergeri, ziphus; (Hammatoceras) illustris; (Harpoceras) bingmanni, dispansus, doeritensis, muelleri, striatulus, struckmanni; (Hildoceras) quadratus

Ammonites, sub-family, 14; suggested classification, 14, 15—afterwards erased, 126; divisions on occurrence of, 164; abnormalities of, 381; faunæ, 447; fossilisation of, 454; delicate mouth borders of, their preservation an argument against dispersal, 455; where found most abundantly, 456; unable to accommodate themselves to changes in deposit (Thompson), xv—criticisms on, xv; same species living in areas of different deposit, xv; changes of species independent of lithic conditions, xvi; opalinoid; remarks on, xxiii; striate, xli

Ammonitidæ, 14

Ammonitiferous beds, thin deposits contemporaneous with thick deposits, 447; not coastal deposits; conditions under which they were formed, 455

- Amontiferous, deposits, 456; horizon, cviii  
 Ammonitinae, 289  
 Ammonoidea, 126; restricted range of certain sub-orders of, 456  
**amœna, Reynesia, Suppl., Pl. 20, figs. 40–42; p. ciii**  
 Anagenesis, 289, ceii, ceiii, excix  
 Anagenetic, characters, cc; costate stage, clxix  
 Anaplasia, 357  
 Anbury Quarry, 5, 96  
 Ancestor, Arietan, 159; binodate, cxxx  
**Ancolioceras, p. xlvii; cariniferum, costatum, substriatum**  
 Ancolioceras, from Manselia, lviii; classification, excviii  
 Ancyloceras, 14, ceii  
 Andium, Hammatoceras (Sonninia), 453; Harpoceras, 157, vi  
 Andoversford, 91, lxvi, clxx  
 anglica, Zeillera, xxxvii, lviii, lxix  
**angulata, Paquieria, Suppl., fig. 24, p. lxvii**  
 angulata, Schlottheimia, 234  
 Anglo-Parisian Basin, 452  
**angulifera, Braunsina, Pl. 15, figs. 16, 17, p. 103; (Ludwigia rudis); Suppl., fig. 63, in text, p. ci**  
 Anguliradiatae, xc  
 Anguliradiate, iii  
 Anguliradiate (series), lxiv  
 Anguliradius, iii; position of, in evolution, lxxiv  
 Angustilobate (series), lxiv  
 Angustisellati, 126  
 Angustumbilicate, v, excvii  
 Angustumbilicate (series), ciii, cvii  
 Angustumbilicate terminals, xcix  
 Angustumbilication, ceii  
 Annular radii, 267  
 annulatum, Dactyloceras, 272  
 antiquum, Grammoceras, 133, 140, 161–163  
 antiquus, Ammonites, 132  
**Apedogyria, p. lix, patellaria, platychora, subcornuta**  
 Apedogyria, from Ludwigia, lxi; classification, excviii  
*apertum, Lioceras, Pl. 10, figs. 10, 11, see apertum, Platygraphoceras; Pl. 15, figs. 3, 4, see compactum, Platygraphoceras; Pl. 15, figs. 7, 8, futilis, Braunsina; Pl. 15, figs. 9, 10, sp., Platygraphoceras; p. 76, see spp. var. above.*  
*apertum, Lioceras, xcv, ci.*  
**apertum, Platygraphoceras, Pl. 10, figs. 10, 11; p. 76 (Lioceras apertum); Suppl., Pl. 15, fig. 23; Fig. 55 in text, p. xciv**  
 Appendages of mouth, 454  
 Apennines, Central, 220, xviii  
 Aptychus, not known in South of England, 11; of Dumortieria subundulata, 262  
*arata, Dumortieria, Pl. 39, figs. 1, 2, see subaratum, Catullocceras; Pl. 39, figs. 3–5, aratum, Catullocceras*  
*arata, Dumortieria, clxxii*  
**aratum, Catullocceras, Pl. 39, figs. 3–5 (Dumortieria arata), p. 280**  
*aratum, Catullocceras, p. 280 (pars), see subaratum, C.*  
*aratum, Catullocceras, clxxii*  
 arbustigerus, Ammonites, 272  
 Arcestidae, 14  
 Archetype lobe, 381  
**arctenens, Ludwigella, Pl. 4, fig. 1, 2, p. 20 (Ludwigia cornu); Suppl., Fig. 46 in text, p. lxxxv**  
**arcuata, Ludwigella, Suppl., Pl. 20, figs. 28–30, p. lxxxix**  
**arcuata, Walkeria, Pl. xxxii, figs. 11, 12, p. 199 (Grammoceras sp.); Suppl. fig. 121, p. clxvii; p. cxxxix**  
 Arcuate ribs, 142  
**arcuatum, Lopadoceras, Suppl., Pl. 21, figs. 19–21, p. cxii**  
**arenacea, Canavarella?, Pl. 28, figs. 20, 21, p. 173 (Grammoceras striatulum); Suppl., fig. 101, p. clxv; p. cxxxix**  
**arenaria, Dumortieria, Suppl., Pl. 22, figs. 34–36, p. clxxxv**  
 arenata, Sonninia, 315  
 arenatus, Ammonites, 315  
 Argentine Republic, 148, 157  
 Arietan, ancestor, 159; stage, 159, 223  
 Arieticeras; acutum  
**Arietidae, 225**  
 Arietidae, 15, 128, 280, 284, 294, 299, cci, excviii; evolved from Caloceras, 223; genera, excix  
 arietiforme, Harpoceras, 13  
 Arietites, 14, 109, 110, 128  
 Arietitidae, 128  
 armatum, Cerithium, 5

- armatus, Ammonites, iii; group, 314  
 armipotens, Kiliaia, Suppl., Fig. 23, p. lxv  
 Arnioceras, 170, 226, 280  
 Arrested development, specimen showing, li, lxxiv  
 Ascending series, 200, 207  
 aspera, Braunsina, Suppl., Pl. 17, figs. 13-15, p. xcix  
 aspera, Denckmannia, Suppl., p. xxi  
 Association of characters, ceiv  
 Astarte, 45, 46  
 Asterocheras, 280; obtusum  
 Asthenoceras, p. xlix; nannodes  
 Asthenoceras, classification, cxviii  
 astrictum, Deltoidoceras, Suppl., Fig. 79, p. clxv, Fig. 81, p. cxviii  
 Asymmetry of lobes, considered, 382  
 Atavie senility, 357  
 Atavism, 265, 280, 301  
 attenuata, Ludwigella, Suppl., Pl. 19, figs. 10-12; p. xxxvii  
 attenuatum, Pelecoceras, 225  
 attracta, Ludwigella, Suppl., Pl. 19, figs. 31-33; p. lxxxvii  
 attrita, Cotteswoldia, Suppl., Pl. 23, figs. 12-14; p. cxxxiv  
 attrita, Sonninia, Pl. 90, figs. 4-6; pp. 371, 387, 408  
 audax, Grammoceras, Pl. 28, figs. 4-6, p. 169 (Grammoceras toarcense); Fig. 104, p. clxv; p. cxxxii  
 Auricles, spatulate, 455; lateral, Fontannesia, clxxxix  
 aurita, Fontannesia, Suppl., Pl. 24, fig. 7; p. cxc  
 Auxology, terms of, 357  
 Aveyron, 208, 215, 220, cxlviii, cxlix  
 Axial terminal lobule, 364  
 Axis of bulla, iii
- Babylon Hill, section at, 5; Vacek's remarks on, notice of, 96; fossils from, labelled as Yeovil, 97  
 Baculites, 14, ceii  
 Bajocian, of Normandy, 63; of Toulon, 294; stage, cev  
 bajociana, Ceromya, 48  
 Bajocien, 173  
 Band, partition, 81, xvi  
 Barnes Batch, strata of, cevi  
 Barrington, near Ilminster, Somerset, xxii, xxxii  
 Basin, Dorset-Somerset, 249; Paris, 249; Anglo-Parisian, 452; Rhone, xiii  
 Batcombe, cxlvi  
 Bath, 173, 175, clxix, clxxxv; strata of, ceviii  
 Bather, Dr. F. A., on terms of Auxology, 357  
 Bathonian stage, cev  
 Bayani, Ammonites, 109, vi, xii, xxxii  
 Bayani group, xxxi  
 Bayani, Lillia, 109  
 Bayle, E., 13, 17, 18, 35, 108, 146, 148, 155, 156, 158, 170, 176, 190, 192, 204, 206, 207, 227, 238, 287, 313, 450, vii, xiii, xxii, xxiii, lix, lxxi, cxxxii, cxlvii, elii, eliii, clxxxii; on Ludwigia, 16; and Am. Murchisonæ, lxix  
 Bayle & Coquand, 255, 258, 453, clxxxiii  
 Baylii, Brasilina, Pl. 3, figs. 6, 7, p. 18 (Ludwigia Murchisonæ var. Baylii); Suppl., Pl. 11, fig. 34; p. lxxxiii.  
 Baylii, Ludwigia, 18  
 Beaminster, 19, 23, 25, 26, 376, xlvi, li, lix, lx, lxiii, lxiv, lxix, lxxxii, xevi, ei  
 Bed (beds), ammonite, ammonitiferous, blue iron-shot, bottom, brachiopod, cadomensis, cephalopod, concavum, conglomerate, coral, coralline, dew, dispansum, Dumortieria, ferruginous, fossil, ironshot, Leda-ovum, limestone, lower, marl, Moorei, navis (Trigonia), nodular, opalinum, opalinus, ornatus, parkinsoni, paving, phillipsiana, pisolite, plant, red, ringens, sand, sandy ferruginous, striatulum, subdecorata, upper, variabilis, wild, Witchellia, zigzag  
 Bed, see Beds, Bett, Zone  
 Beds, note on term, 166; ironshot, date of, ceviii  
 Beecher, C. E., Brachiopoda, cxcix  
 Belcheri, Ægoceras, 232  
 Belemnites, 45-47  
 belophora, Canavarella, Suppl., Pl. 22, figs. 22-24; Fig. 100, p. clxv; p. cxxxix  
 Benecke, Prof. E. W., 273, clv  
 benigna, Reynesia, Suppl., Pl. 22, figs. 10-12; p. cv  
 Berlin Museum, cxvii  
 Berne, 62  
 Besançon, cxlix  
 Bett, jurensis, torulosus, 2  
 Beyrichi, Ammonites, 87

- Beyrichi, Harpoceras, 87  
**beyrichi**, *Pseudolioceras*, Pl. 20, figs. 7, 8, p. 87; Pl. A, fig. 22; Suppl., Fig. 160, p. clxvii; p. clx  
*Beyrichi*, *Pseudolioceras*, Pl. 20, figs. 9, 10, p. 87 (pars), see **replicatum**, P.  
 Biarciradiate (series), lxxix, cxii  
 Biarciradiatæ, lxxxix  
 Biarciradius, position of, in evolution, lxxiv  
 Biarcuate (series), cvii, cxxvi  
**bifax**, *Cotteswoldia*, Suppl., Fig. 110 A, p. cxxxvi  
 bifer, Ammonites, 289  
**bifidatum**, *Lioceras*, Suppl. Pl. 7, figs. 1-6, p. xxxviii  
 bifrons, Ammonites, 48, 50, 112; zone, 169  
 bifrons, Harpoceras, 114; zone, 114  
 \***bifrons**, *Hildoceras*, Pl. A, figs. 29, 30, p. 125  
*bifrons*, var., *Hildoceras*, Pl. 22, figs. 30, 31, p. 112, see **semipolitum**, *Hildoceras*  
 bifrons, *Hildoceras*, 44, 45, 47, 50, 111, 127, 165, xii, clvi; (hemera), cvv; its position in Cotteswold sands [*H. semipolitum*], 50  
 bifrons-zone, 291  
 bifrontis hemera, xii, cliv  
 Bingmanni, Ammonites, 206; (? Harpoceras), 205  
**bingmanni**, *Pseudogrammoceras*, Pl. 34, figs 3-5, p. 204 (*Grammoceras fallaciosum*, var. *Bingmanni*); Suppl., Fig. 137, p. clxvii; p. clxv  
**binodata**, *Chartronia*, Suppl., Pl. 1, figs. 11-15; p. xvi  
 binodata, *Chartronia*, ix  
 Binodate ancestor, cxxx  
 Binomial nomenclature, remarks on, 315  
 Bioplastology, phenomena of, cxci  
**biplicata**, *Sonninia*, Pl. 78, figs. 1-5; Pl. 103, fig. 6; Figs. in text, 20, p. 389; 46, p. 417; 72, p. 443; pp. 345, 417  
 biplicata stock, 344  
 Birchi, Ammonites, 289  
 Birdlip, 30, lv, lxx  
 Bispinous stage, examples of, 289; decline of, cxcii  
 Bitubulate, iv  
 Bituberculation, ce  
 Blagdeni, Ammonites, basin-shaped umbilicus of, v  
 Blagdeni, *Cœloceras*, ce; hemera, cvv  
 Blagdeni hemera, vi; strata of, cvv  
 Blagdeni, *Stephanoceras*, 271  
 Blake, Prof. J. F., 83, 84, 86, 174, clviii; and Harpoceras, 13; on Harpoceras concavum, 61; on Ammonites compactilis, 86; use of palmate by, 374  
**blanda**, *Ludwigella*, Suppl., Pl. 19, figs. 22-24; p. lxxxvii  
 Blea Wyke, strata of, cviii, cxix  
 Bloomfield, localities in Yeovil sands, clxix  
 Blue ironshot bed, date of, cxix  
 Blue Wyke, 228, 229, 329  
 Body chamber, contraction of, 140; inflation of, cviii  
 Body chamber thickens (series of), cvii  
 Bœvingen, 258  
 Bonarelli, G., xvii, xviii; on Hectici, cxvii  
 boreale, *Hildoceras*, 112, 172  
 bosensis, Ammonites, 132, 136, 138, 306  
 Botanical series, development, cxci  
 Bottom bed, date of, cvii  
 Bourton-on-the-Water, 91, 96  
 Bow, Greek, radial line like, lxxix  
 Bower, Rev., and A. Boweri, cx  
 Boweri, Ammonites, cx  
**boweri**, *Fontannesia*, Suppl., Pl. 24, figs 1-4; p. cxc  
 Boweri, Harpoceras, cx; and *Fontannesia*, clxxxviii  
*Boweri*, *Sonninia*, p. 119 = Boweri, *Fontannesia* and *Zurcheri*, *Sonninia*  
 Boweri, *Sonninia*, and *Fontannesia*, cx  
 Bowcott Wood, cxxxiii, clxxv, clxxxi, clxxxvi  
 Boxtone Hill, cli  
 Brachiopod-beds, date of, cvii  
 Brachiopoda, 62, 455  
 Brachysceles, 381  
 Bradford Abbas, Dorset, 5, 19-34, 62-106, 179, 251, 258, 266, 278, 296-301, 317-440, lvii-cxxviii, clvii, clxx, clxxii, clxxxiii, clxxxv, clxxxviii, clxxxix, cxc, cxci, cxcv; sands of, compared to strata in Gloucestershire, J. Buckman, 3; zones at, 6; section at, considered, 7; opalinum-zone absent, 7, 52; fauna distinct from Osborne, 9; Vacek's remarks on, notice of, 96; strata of, cvv  
*bradfordense*, *Lioceras*, Pl. 4, figs. 5, 6, see **bradfordensis**, *Brasilia*; Pl. 4, fig. 7, see sp., *Hyattina*; Pl. 4, fig. 8, Pl. 5, see **platychora**, *Apedogyria*; p. 22, see spp. above

- bradfordense, *Lioceras*, lxxviii, lxxx, cxxx  
*bradfordense*, var. *giganteum*, *Lioceras*, Pl. 11, fig. 1, Pl. 12, fig. 4, see *gigantea*, *Wiltshireia*; Pl. 12, figs. 5-7, *pagana*, *Welschia*; p. 25, see spp. above
- bradfordensis**, *Brasilia*, Pl. 4, figs. 5, 6, p. 22 (*Lioceras bradfordense*); **Suppl. Pl. 17, fig. 28; Fig 39 in text, p. lxxx**
- bradfordensis*, *Brasilia*, *hemera*, ccv  
*Bradfordensis hemera*, vi; strata of, cevii
- Braikenridgii*, *Ammonites*, 455; *Stephanoceras*, 120
- Branco, Dr. E. W., 169, 170, 176, 179, 182, 189, 190, 196, 197, 198, 227, 230, 238, 243, 246, 248, 250, 254, 255, 258, 259, 262, 279, cxxxviii, clxxvii, clxxxi, clxxxvi; on *Dogger*, 4; on *A. subserrodens*, 180; on *Harpoceras lotharingicum*, 199; and *H. subundulatum*, 244, 260; and *Am. Moorei*, 256; and *Amaltheus subserrodens*, clxiii
- brancoi**, *Dumortieria*, Pl. 45, figs. 8, 9, p. 259 (*D. subundulata*); p. clxxxvi
- Brasil, Dr. L., xlili, l, lv, lvii, lix, lxxviii, lxx, lxxi, lxxii, lxxiv, cxliv, cxlviii, cxlix, clxxi, clxxii, clxxiii, clxxiv, cxvii
- brasili**, *Hyattina*, **Suppl.**, Pl. 13, figs. 7, 8; **Fig. 14 in text, p. lvii**
- Brasilia**, **Suppl.**, p. lxxx; *bradfordensis*, *effricata*, *decipiens*, *pinguis*, *pulchra*, *similis*, *sublineata*
- Brasilia*, classification, cxeviii; from *Brasilina*, lxxxiii
- Brasilina**, **Suppl.**, p. lxxxiii; *baylii*, *crinalis*, **tutcheri**
- Brasilina*, from *Ludwigella*, lxxxiv; classification, cxeviii
- Brauner *Jura*, 3
- Brauns, 228, 229, 278, 306
- Braunsella**, **Suppl.**, p. cii; *lenis*, *rotabilis*, *semi-lenis*
- Braunsella* from *Reynesia*, ciii; classification, cxeviii
- Braunsia*, cii; see *Braunsella*; *lenis*
- Braunsina**, **Suppl.**, p. xcix; *angulifera*, *aspera*, *contorta*, *cornigera*, *elegantula*, *fastigata*, *futilis*, *projecta*, *subquadrata*
- Braunsina*, classification, cxeviii
- Breakheart Hill, 279, xxix
- bredonensis**, *Denckmannia*, **Suppl.**, p. clxi
- Brephic, 357
- brevispinata**, *Sonninia*, Pl. 75, figs. 6-8; pp. 343, 388, 414
- Bridport, 61, 251, xxiii, xxiv, lviii; strata of, cevi, ceviii
- Bridport Sands, clxxvii; and *Dumortieria*; and opalinoid ammonites, clxxxiii; strata of, ceviii
- Bristol, 103, clxix
- Bristol Museum, 61, 63, lvi
- British Association Committee and Hybrid names, 276; and generic names, 284
- British Museum, 60, 62, 146, 174, 175, 212, 256
- Broad Windsor, 26, 51, 61, 275, 399, 401, lxiv, lxxviii, lxxiv, lxxxiii, cx, clxxi; limestone beds at top of so-called *Inferior Oolite*, v; strata of, cevi, cevii
- Brockhampton Quarry, lxvi
- Brodia*, a genus of fossil insects, xxxiii
- Brodie, Rev. P. B., and *Brodieia*, xxxi
- Brodiceras**, **Suppl.**, pp. xii, xxxi (*Brodieia*), xxxiii; **curvum**, **junctum**, **witchelli**
- Brodiceras*, classification, cxeviii
- Brodiei*, *Stephanoceras*, 272
- Brodieia*, **Suppl.**, pp. xii, xxxi, see **Brodiceras**; *curva*, *juneta*, *witchelli*
- Brodieia*, replaced by **Brodiceras**, xxxiii
- Brongniarti, *Sphaeroceras*, 120
- Bronn, H. G., 188
- Bronni, *Ammonites*, 268, 283
- Bronni, *Polymorphites*, 234
- Bronni, *Posidonomya*, zone of, 50, 51
- Brunswick, 88
- Buch, L. von, vii
- Buekholt Wood, 173, 179, 183, 188, 194, 197, 208, 210, 213, 240, 242, 245, 251, 252, 258, cxxix, cxxx, cxxxiii, cxxxiv, cxxxvi, cxlix, clxi, clxix, clxxv, clxxviii, clxxxi, clxxxvi, clxxxvii; section, 164
- Bucklandi, *Ammonites*, xvii
- Buckman, James, 20, 68, 113, 246, 304, 306, 335, cxc; *Lias and Oolite division*, 3
- [Buckman, J.] papers by, referred to, 65, 71, 91, 113, 305, c
- Buckman, S. S., 17, 20, 22, 25, 37, 38, 56, 117, 192, 225, 255, 262, 273, 275, 300, 304, 313, 317, 319, 341, 395; on terms of *Auxology*, 357; and *Wilson*, E., vi

- [Buckman, S.] papers by, referred to, 8, 25, 26, 38, 50, 91, 120, 164, 167, 173, 213, 223, 250, 274, 288, 299, 314, 347, 359, 378, 447, 451, 456, v, lviii, cliv
- Buckmani-grit, date of, cvii
- aff. **buckmani**, *Sonninia*, Pl. 23, figs. 7, 8, Pl. 22, fig. 34, p. 107 (*Sonninia*, sp.); p. cxci
- Buckman's (Prof.) quarry, 335
- Bugstone, date of, cvii
- Building Freestone, 7; date of, cvii
- Building stone, meaning of, ccix; date of, cvii, cviii
- Bulla, 353, 405; axis of, iii
- Bullicostæ, 350, 353
- Bullicostate, 405
- bullatum, *Stephanoceras*, 312
- bullifera**, *Hyattia*, Suppl., Pl. 14, figs. 1, 2; p. lv
- Bulk, acme of, individual, cc
- Bulk-decline, cciii
- Bulk-development, acme of, cc
- Burton Bradstock, 19, 40, 41, 52, 55, 56, 194, 274, xxxvi, xliii, lxxii-lxxxiv, xc, cxiv, cxvi, cxix, cxxxviii, cxl, cxli, clxx, cxv; section at, 47; correlation, 166; sands at, 51; strata of, cvii; cliff, 102
- burtonensis**, *Walkeria*, Pl. 32, figs. 9, 10, p. 192 (*Grammoceras aalense*); Suppl., p. cxxxix
- cadomensis, *Ammonites*, 117, 120
- Cadomensis-beds, 119
- caduceifera**, *Lucya*, Pl. 21, figs. 10, 11; Pl. A, fig. 5; p. 104 (*Ludwigia Lucyi*); Suppl., Fig. 30 in text, p. lxxv
- Caduceiform radial line, p. lxxiv
- caducifera, *Lucya*, p. lxxv
- callosa**, *Ludwigella*, Suppl., Pl. 19, figs. 16-18, p. lxxxviii
- Caloceras*, 232, 233, 236, 267, 289, 290; and *Arietida*, 233; liassicum
- Calvados, lvii, lix, lxxiii, lxxii, lxxiv
- Cam Down, 41, 158, 204, 208, 231, 239, 251, 253, xxviii, cli, clxxiv, clxxv, clxxviii, clxxix, clxxx, clxxxvi, clxxxvii
- camura**, *Sonninia*, Pl. 99, figs. 4-6; pp. 386, 403
- Canaliculati, 132
- canaliculatum, *Harpoceras*, 13
- canaliculatus, *Ammonites*, 127, 129
- Canaries, 454
- Canavarella**, p. cxxviii; *arenacea*, *belophora*, *sceleta*, *toma*
- Canavarella, classification, cxxviii
- Canavari, Prof. Mario, and specimens of *Lillia*, 109; and **Canavarina**, cxli
- Canavaria, cxli, see *Canavarina*; *folleata*, *venustula*
- Canavarina**, p. cxli; *digna*, *folleata*, sp., **steinmanni**, *venustula*
- Canavarina*, classification, cxxviii
- candidus*, *Ammonites*, 28, 192, cxxxvii
- Cap San Vigilio, 54, 295, 298; absence of *Sonninia* from, 316
- capellinus jurensis*, *Ammonites*, 215
- capillatum*, *Grammoceras*, 163
- capricornum*, *Liparoceras*, 289
- carbatinum**, *Platygraphoceras*, Suppl., Pl. 20, figs. 16-18; p. xciv
- Carina*, iv; solid, 81, iv; Oppel's mistake concerning, 156; false, 205; appearance of, in development, 290; crenulate, 295; false, example of, 296; development, 299; lettering referring to, explanation of, 308; hollow character lost with age, 325; disappearance of, in age, 352; decline of, hypostrophic, lxxii; relative size of, as a distinction, cv; terms of, cvi; old age affecting, cvi; degenerate form of hollow, clv; when developed, in *Hildoceratida*, in *Polymorphida*, clxix; want of, clxxi
- Carina* (hollow), 81, iv, clv; in classification, 82; works dealing with, 83; cause of mistakes, 156; infilling of, restored, 205; degenerate form of, clv
- Carina*, see also *alticarina*, *non-septicarina*, *parvicarina*, *septicarina*
- Carina* variable (series), cxii
- carinata**, *Fontannesia*, Pl. 47, figs. 13, 14, p. 262 (*Dumortieria grammoceroïdes*); p. clxxxix
- earinata**, *Ludwigella*, Suppl., Pl. 19, figs. 40-42, p. xc
- carinata*, *Waldheimia*, 5
- Carinate, see *alticarinata*, *distincticarinata*, *parvicarinata*, *parvicarinata*, *subalticarinata*
- Carinate series (*Fontannesia*), clxxxix
- Carinate-bisulcate, iv
- Carinati- and *levigati-tabulate*, cv

- Carinati-convex; -sulcate, iv  
 Carinati-tabulate, iv; (series), cv; periphery, cv  
 cariniferum, *Ancolioceras*, *Suppl.*, **Pl. 11**, **figs. 7-9**; p. **xlvii**  
 cariniferum, *Pseudographoceras?*, *Suppl.*, **Pl. 20**, **figs. 13-15**, p. **xciii**  
 carusensis, *Ammonites*, 232  
 casta, *Ludwigella*, *Suppl.*, **Pl. 20**, **figs. 31-33**; p. **lxxxix**  
 Catabatic, 357  
 Catagenesis, 289, excix, cc, ccii, cciii  
 Catagenesis, gerontic, effect on suture line, cxxvi  
 Catagenetic, characters, cc; species, latumbilicate, cliv; stage, clxix  
 Cataplasis, 357  
 Catullia, 276  
 Catullo and *Catulloceras*, 276  
*Catulloceras*, p. clxxi; *aratum*, *dumortieri*, *insignisimile*, *leesbergi*, *\*macrum*, *meneghinii*, *perroudi*, *psamminum*, *subaratum*, *scissum*, *vernosæ*  
*Catulloceras*, clxix; geological position of, 235; literature on, 236; from allies, 267; classification, excviii  
*caumonti*, *Parkinsonia*, ontogeny of, 271  
*cavata*, *Lucya*, **Pl. 9**, **figs. 1-4**, p. **68** (*Lioceras concavum* var. *v-scriptum*); *Suppl.*, **Pl. 15**, **fig. 20**, p. **lxxvi**  
 Cells, interlobular, 373  
 Central Apennines, 220, xviii  
 Cephalopod bed, xii, xvi, xxxv; meaning of term, ccix; date of, ccviii: (*Cotteswold*) five *Ammonite* faunas in; not a case of rapid entombment; contemporaneous with several hundred feet of deposit elsewhere, 447  
 Cephalopod shells, remarks concerning distribution, etc., of, 456  
 Cephalopoda bed, 7, 42; sections, 43-46; Ramsay's statement about thickness of, 49; greatest development of, 49; of Gloucestershire and Dorset district, 97; Upper Lias, 175  
 Chalford, xxvi, xxvii; strata of, ccix  
 Chamber, living, absorption of, 312  
 Chambers, painted, 380  
 Chapuis & Dewalque, 60, 146, 170, 184, 189, 241, vii, xxiii  
 Characters, association of, cciv; and morphogeny, cc; of *Ammonites*, excix; of *S. zigzag*, 272  
 Chartron, C., cxxxiv, clxxviii, clxxx; and *Chartronia*, xvi  
*Chartronia*, *Suppl.*, p. xvi; *binodata*, *costigera*  
*Chartronia*, ix, clxix; distinction from *Gammiradiata* species, cxxx; classification, excviii  
 Cheltenham, 7, lv, cxxi, cxci; pisolite beds compared to sands at Frocester, J. Buckman, 3; district and Fontannesia, cxci  
 Chemnitzia, 45  
 Chideock, 324, xxxv, lii, liii, liv, lv, lvi, lix, lx, lxiii, lxv, lxvi, lxxiv, xci, cxxxix, clxx, clxxxiii, clxxxvii; strata of, ccvi, ccvii, ccviii  
 Chili, 258, 453, clxxxiii  
 chronology, v; to indicate sequence of species, v; of *Pseudogrammoceras*, cliv  
*Cidaris*, 43  
*circulare*, *Tmetoceras*, **Pl. 48**, **figs. 1-3** (*T. scissum*); *Suppl.*, p. clxx  
*cirrata*, *Cosmogoria*, *Suppl.*, **Pl. 10**, **figs. 32-34**; p. liv  
*cirrata*, *Cosmogoria*, note on, lxxxii  
 Clark, J. E., and *Catulloceras Dumortieri*, 278  
 Classification, 14, 125-141; by Zittel, 126; by Haug, 127; by descent, 129; object of generic, 446; ornament no value for, 447; value of features for, i; outward form subordinate in value in, i; criteria of affinity in, i; modern, difficulties in, owing to large volumes; the necessity for mounting figures on separate slips, viii; of *Lillia-Haugia* series, ix; hemeral, ccv; generic, excvii  
 Clatcombe, 108  
*clausus*, *Nautilus*, cci  
 Clay beds, upper, date of, ccviii  
 Cleeve Hill, 6, 19; strata of, ccvi, ccvii  
*elimacomphalum*, *Hammatoceras*, 157  
 Closeworth, exc  
 Clypeus grit, 7, ccix; date of, ccvi; limestones above, date of, ccvi  
 Coaley, 166  
 Coaley Peak, 179, 196, 198, 255; geology of, 44  
 Coaley Wood, 40, 41, 86, 88, 114, 148, 151, 152, 153, 158, 173, 181, 183, 184, 202, 204, 208, 220, xxii, xxv, xxvi, xxvii, xxxi, cxxx, cxxxii, cxxxiii, cxxxv, cxxxvii, cxliii, cxlv, cxlvi, cxlvii, cxlviii, cxlix, clviii, clx; section of, 45; strata of, ccix  
*coarctata*, *Dictyothyris*, *hemera*, ccv

- Coastal deposits, 455
- cœla**, **Reynesia**, **Pl. 16**, **figs. 10, 11**, **p. 92** (**Hyperlioceras Walkeri**); **Suppl.**, **Pl. 18**, **fig. 26**; **p. civ**
- Cœloceras**; **blagdeni**
- cognatum**, **Cardium**, 48
- Coiling**, **excentric**, **exliv**, **cliv**
- Coiling in**, **stages of**, **cei**
- Coiling out**, **stages of**, **cei**
- Cold Comfort**, **rubbly oolite compared**, 3; **strata of**, **cevii**
- Cole**, **strata of**, **ceviii**
- Collenotii**, **Ammonites**, 226
- Collyweston Slate**, 48
- comata**, **Pleydellia**, **Suppl.**, **Pl. 10**, **figs. 11-13**; **p. cxxxviii**
- Combinations**, **innumerable number of**, **ceix**
- comensis**, **Lillia**, 109; **Ammonites**, 109, 170, vii, x, xi, xii
- Commune-zone**, 131, 163, 165, 223, 282; **reason for term**, 114
- compactile**, **Harpoceras**, 45, 46, 47, 85
- compactile**, **Pseudolioceras**, **p. clix**
- compactile Pseudolioceras**, **Pl. 20**, **figs. 3, 4**, **see gradatum, P.**; **Pl. 20**, **figs. 5, 6**, **pumilum, P.**; **p. 85**, **see spp. above**
- compactile**, **Pseudolioceras**, 81, **clviii**, **clix**
- compactilis**, **Ammonites**, 85
- compactum**, **Platygraphoceras**, **Pl. 15**, **figs. 3, 4**, **Pl. A**, **fig. 17**, **p. 76** (**Lioceras apertum**); **Suppl.**, **Fig. 57 in text**, **p. xciv**
- Comparative development** (**Dumortieria**), **clxxxiv**
- Comparative table**, 144
- complanata**, **Dorsetensia**, **Pl. 53**, **figs. 1-10**; **p. 306**
- complanatus**, **Ammonites**, 127, 217
- Compressa**, **cxxiii**
- compressa**, **Haugia**, **Suppl.**, **Pl. 2**, **figs. 8-10**; **p. xxvii**
- compressa**, **Haugia**, xi
- Compression**, **progressive**, **lxxxix**
- compressum**, **Pseudographoceras**, **Pl. 15**, **figs. 5, 6**; **p. 72** (**Lioceras concavum**); **Suppl.**, **Pl. 15**, **fig. 21**; **p. xciii**
- Compton**, 19, 266
- comptum**, **Harpoceras**, 53
- comptum**, **Lioceras**, **Suppl.**, **Pl. 7**, **figs. 7-12**; **p. xliii**
- comptum**, **Lioceras**, 43, 52
- comptus**, **Ammonites**, 54, 184, 248; **Nautilus**, 53, xxxvi, xliii
- concava**, **Ludwigella**, **Pl. 2**, **figs. 5, 6**; **Pl. 8**, **figs. 1, 2**; **p. 56** (**Lioceras concavum**); **Suppl.**, **Fig. 51 in text**, **p. lxxxvi**
- concava**, **Ludwigella**, **hemera**, **cev**
- concave**, **iv**
- concavi-fastigate**, **iv**
- Concavi hemera**, **vi**; **strata of**, **cevii**
- Concavum bed**, **developments of**, 61, 62
- Concavum beds**, **remarks on**, 63; **correlation with Cotteswold strata**, 65
- concavum**, **Harpoceras**, 56
- concavum**, **Lioceras**, **Pl. 2**, **figs. 6, 7**, **see concava**, **Ludwigella**; **Pl. 6**, **see magna**, **Lucya**; **Pl. 8**, **figs. 1, 2**, **see concava**, **Ludwigella**; **Pl. 8**, **figs. 3, 4**, **decorum**, **Graphoceras**; **Pl. 8**, **figs. 5, 6**, **sublineata**, **Brasilia**; **Pl. 8**, **fig. 7**, **flaccidum**, **Graphoceras**; **Pl. 9**, **figs. 8-10**, **stigmatum**, **Graphoceras**; **Pl. 10**, **figs. 3, 4**, **see pulchra**, **Brasilia**; **Pl. 10**, **fig. 9**, **undulatum**, **Graphoceras**; **Pl. 15**, **figs. 5, 6**, **see compressum**, **Pseudographoceras**; **p. 56**, **see spp. above**
- concavum**, **Lioceras**, 9, 12, 301, 374, 447, lxxvi, lxxix, lxxx, lxxxi, lxxxvi, xciii, xevi, xvii, xviii
- concavum var. formosum**, **Lioceras**, **Pl. 10**, **figs. 1, 2**, **p. 65**, **see formosum**, **Depaoceras**
- concavum**, **var. pingue**, **Lioceras**, **Pl. 12**, **figs. 1-3**, **p. 66**, **see pinguis**, **Brasilia**
- concavum**, **var. v-scriptum**, **Lioceras**, **Pl. 9**, **figs. 1-4**, **see cavata**, **Lucya**; **Pl. 9**, **figs. 5, 6**, **stigmatum**, **Graphoceras**; **Pl. 9**, **fig. 7**, **limitatum**, **Graphoceras**; **Pl. 10**, **figs. 5, 6**, **v-scriptum**, **Graphoceras**; **Pl. 10**, **figs. 7, 8**, **limitatum**, **Graphoceras**; **p. 68**, **see spp. above**
- concavum**, **Lioceras**, **table of varieties of**, 74
- Concavum-zone**, 223, 282, 291, 292, 317, 320, 321; **regarded as Sowerbyi-zone**, 342; **absent or destroyed from large part of Continent**, 452; **divisible into two or three parts**, 447; **note on**, **see Explanation of Pl. 46**
- Concavumbilicate**, **iv**; **species**, **relation to gradumbilicate**, **xviii**; **species**, **note concerning homœomorphy of**, **xviii**
- concavus**, **Ammonites**, 35, 56, 68, lxxxvi; **bowl-shaped umbilicus of**, **iv**
- Concentric umbilicus**, 323

- concentrica*, Fontannesia, Suppl., Pl. 24, figs. 5, 6; p. cxci  
 Concentrilatumbilicate, v  
 Concentrumbilicate, v  
 Conch, i  
*concinna*, Darellia, Suppl., Pl. 18, figs. 16-18; p. cxiv  
 Cone, coiling of, cci  
*confusum*, Lytoceras, cc  
*confusus*, Ammonites, 268  
*confusus*, Polymorphites, 234  
 Conglomerate-bed, date of, cevi  
*conjungens*, Ammonites, cxcv  
*conjungens*, *Æcotraustes*, Pl. 20, figs. 13, 14, see *nodifer*, **Æ.**; Pl. 20, figs. 15-17, *costiger*, **Æ.**  
*conjungens*, *Æcotraustes*, cxiv, cxv  
*connectens*, Hildoceras, xxxvi  
*contorta*, Braunsina, Suppl., Pl. 17, figs. 16-18; Fig. 62 in text, p. xcix  
*contusa*, Sonninia, Pl. 88, figs. 5-7; pp. 387, 409  
 Convergence, 77, 177, 195, 234; manner of, 137; and law of development, 178; of Dumortieria and Grammoceras, 234; of Dumortieria and Sonninia, 340; complicated cases of, 257, 340; degeneration producing; senescent and senile period producing, 284  
 Convex, iv  
 Convexi-fastigate, iv  
 Convexi-fastigate (series), lxxx, ciii  
 Conybeari, Ammonites, xvii  
 Conybearii, Vermiceras, cc  
 Cooke, M. C., on name Dumortieria, 286  
 Coquand, see Bayle & Coquand  
 Coral bed, upper, 7  
 Coralline beds, date of, cevi  
 Cordilleras, 148, 157  
 Cornubash, 230  
*cornigera*, Braunsina, Suppl., Pl. 20, figs. 4-6; p. c  
 cornu, Harpoceras, 20; Hildoceras, lxxxv; Hildoceras (Ludwigia), 20  
*cornu*, Ludwigia, Pl. 4, figs. 1, 2, see *arcitenens*, Ludwigella; Pl. 4, figs. 3, 4, see *cornu*, Ludwigella; p. 20, see spp. above  
 cornu, Ludwigia, 223, 301, lxxxv; typical form of, 65  
 cornu, Ludwigella, Pl. 4, figs. 3, 4; Pl. A, fig. 6; p. 20 (Ludwigia cornu); Suppl., Figs. 48-50 in text, p. lxxxv  
 Coronate, radical, 272; Ammonites, 454  
 Coronaten-schichten, 293  
*coronatus*, Amaltheus, 287, 291  
 Coronicerias, 289, 290, cc, cci  
 Correlation, Bradford Abbas and Stroud, 7; of Osborne and Wyke, 9; Dundry and Dorset, 63; Yorkshire, Northampton, Cotteswolds, Dorset-Somerset, 168; of deposits, cevi  
*corrugata*, Ludwigia, 375  
*corrugatum*, Harpoceras, 302  
 Corton, strata of, cevii  
 Corton Downs, 19, 61, 62, 275; strata at, like Oolite Marl, Notgrove; fossils of, not those of Oolite Marl, 9  
 cortonensis, Terebratula, 63  
*cosmia*, Strophogyria, Suppl., Fig. 20 in text, p. lxiii; p. lxii  
 Cosmoceras, 14, 270; *garantianum*, *hollandæ*, *nortensis*, *parkinsoni*, *regleyi*, *subfureatum*  
 Cosmogyria, p. lii; *cirrata*, *maggsi*, *obtusa*, *sp. subtabulata*  
 Cosmogyria, from Ludwigia, lxix; classification, cxviii  
 Costa, iii; see also *costistria*, *crassicostate*, *densicostate*, *parvicostate*, *paucicostate*, *radius*, *striicosta*  
 Costæ connate (series), cxxxiv; simple (series), cxxxiii  
*costata*, Sonninia, Pl. 74, fig. 1; Pl. 75, figs. 1, 2; Figs. in text, 6, p. 384; 32, p. 394; 58, p. 443; pp. 338, 385, 395  
 Costata stock, 336  
 Costate and striate stages, xxxviii  
 Costate, Sonninia, 448; species, xxxvi  
 Costate stage, species, xxxvi; examples of, 289; (*Æcotraustes*), cxv  
 Costate (series of Dumortieria), clxxvi  
 Costate to Spissicostate (series of Dumortieria), clxxix  
 Costate to Striate (series of Dumortieria), clxxx  
 Costation, cc; progressive decline of, lxxxix  
 Costi-stria, iii  
*costatum*, Ancolloceras, Pl. 7, fig. 7; Pl. A, fig. 11; p. 29 (*Lioceras ambiguum* var. *costatum*); Suppl., Pl. 17, fig. 30; p. xlvi

- costatum, *Lioceras*, 20
- costiger**, *Æcotraustes*, Pl. 20, figs. 15–17; Pl. A, fig. 9 (*E. conjungens*); Suppl., Fig. 190, p. cxevi; p. cxcv
- costigera**, *Chartronia*, Suppl., p. clxi
- costigera**, *Sonninia*, Pl. 102, figs. 1–3; Figs. in text, 26, p. 391; 52, p. 428; 78, p. 443; p. 428
- costosa**, *Ludwigia*, Pl. 20, figs. 11, 12, p. 102, see subcostosum, *Lioceras*
- costosum**, *Lioceras*, Suppl., Pl. 6, figs. 1–4, p. xxxvii
- costula**, *Ammonites*, 12, 127, 197, 227, 238, 259, xxxvi, cxxxiii, cxxxiv; list of species so identified, 238
- costula**, *Dumortieria*, Pl. 37, figs. 12, 13, p. 237; Pl. 37, figs. 18, 19, p. 245 (*Dumortieria* sp.); Suppl., Fig. 166, p. cxcvii; p. clxxv
- costula**, *Dumortieria*, Pl. 37, figs. 14, 15, p. 237 (pars), see *munieri*, D.
- costula**, *Harpoceras*, 197, 238; *Harpoceras* (*Dumortieria*), 239; *Ludwigia*, 238; *Nautilus*, 237, clxxv
- costulata**, *Cotteswoldia*, Pl. 33, figs. 3, 4, p. 197 (*Grammoceras costulatum*); Suppl., Pl. 23, figs. 4, 4 a; p. cxxxiii
- costulatus**, *Ammonites*, 197
- costulatum**, *Grammoceras*, Pl. 33, figs. 3, 4, p. 197, see **costulata**, *Cotteswoldia*
- costulatum**, *Grammoceras*, p. cxxxiii
- Cotteswold district, 37
- Cotteswold Hills, 158
- Cotteswold Sands, 7, 43, 168, xii; Opperl, opinion on, 50; position of, 113; sections, 44, 45, 46, 47, 164; (Frocester Hill), base of so-called Inferior Oolite, v; argillaceous, clvi; date of, ceix
- Cotteswold Sections, analysis of, 49
- Cotteswold strata, xxxv
- Cotteswoldia**, Suppl., p. cxxxiii; *attrita*, *bifax*, *costulata*, *crinita*, *distans*, *egena*, *limatula*, *misera*, *particostata*, *paucicostata*, sp., *subcandida*, *superba*
- Cotteswoldia*, from *Pleydellia*, cxxxvii; classification, cxviii
- cotteswoldiæ*, *Grammoceras*, 200, 222, 223, 224
- cotteswoldiæ**, *Pseudogrammoceras*, Pl. 35, figs. 4–6; p. 204 (*Grammoceras fallaciosum* var. *Cotteswoldiæ*); Suppl., fig. 144, p. clxvii; p. cxlix
- Cotteswolds, 50, 61, 91, 96, 145, 167, 213, 244, 249, 258, 274, clxx; geological phenomena xii; stratal succession in, xxxv; strata of, cevi, cevii, ccix
- Crammore, 208; presence of *Grammoceras* at, 168; strata of, ceviii
- crassa**, *Sonninia*, Pl. 82, figs. 1, 2; Pl. 100, fig. 10; Figs. in text, 8, p. 385; 34, p. 397; 60, p. 443; pp. 350, 398,
- Crassa*-stock, 347; separation of species in, 348
- crassibullata**, *Sonninia*, Pl. 80, figs. 1–3; Pl. 103, fig. 17; Figs. in text, 10, p. 386; 36, p. 400; 62, p. 443; pp. 353, 400
- Crassicarinate* (series), cxix
- crassicostata**, *Sonninia*, Pl. 80, figs. 4–6; Pl. 103, fig. 18; pp. 354, 385, 398
- Crassicostate*, iii
- crassiformis**, *Sonninia*, Pl. 79, figs. 1–6; Figs. in text, 11, p. 386; 37, p. 401; 63, p. 443; pp. 348, 401
- crassiformis*, *Sonninia*, to preserve spines of, 413
- crassinuda**, *Sonninia*, Pl. 81, figs. 1–4; pp. 351, 399
- crassispinata**, *Sonninia*, Pl. 57, figs. 1, 2; Pl. 65, fig. 5; Pl. 93, fig. 7; pp. 317, 390, 425
- crassispinata**, *Sonninia*, Pl. 48, figs. 16, 17, see *reclinans*, S.; Pl. 50, figs. 16–22, *locuples*, S.; Pl. 65, figs. 3, 4, see *reclinans*, *Sonninia*; p. 317 (pars), see spp. above
- crassispinata**, *Sonninia*, 421, 425, 431, 432
- Crassornate*, iv, viii, ix
- crassum**, *Dactylioeceras*, 272
- Craterumbilicate*, v
- Crenulate carina*, late appearance, 295
- Creaceous species*, multispinous stage, 289
- Crewkerne*, species akin to *Ancolioeceras* at, xlviii
- Crewkerne Station*, 10, 194; strata of, cevi
- Crick, G. C., on *Harp. variabile*, 146; drawings of *A. striatulus*, 176; and *A. Moorei*, 256; and *Am. jugosus*, xxv; on *Brodia*, xxxiii; and *Crickia*, lxxiii; and *A. concavus*, lxxxvi; on *Harp. radians*, cxlv, cxlix
- Crick, W. D., and *Lioceras comptum*, 55
- Crickia**, Suppl., p. lxxiii; *reflua*
- Crickia*, classification, cxviii
- crinalis**, *Brasilina*, Suppl., Pl. 10, figs. 29–31; p. lxxxiv

- crinita, *Cotteswoldia*, Pl. 31, figs. 3, 4; p. 177  
 (Grammoceras maetra); **Suppl.**, **Fig. 111**, p.  
 clxv; p. cxxxvii  
 Criteria of affinity, i  
 Cruciform, arrangement of, lobes considered, 382  
 Crussol, lxxiii  
 Cucullæa, 48  
 Cumings, E. R., and Brachiopoda, excix  
 cuneatum, *Deltotoceras*, **Suppl.**, **Pl. 16**, figs. 7-9;  
 p. cxix  
 Curioni, Ammonites, 84, 132, 138, 139  
*curva*, *Brodieia*, **Suppl.**, p. xxxii, see *curvum*,  
*Brodiceras*  
*curva*, *Hugia*, **Suppl.**, **Pl. 18**, figs. 19-21 a; **Pl.**  
**21**, figs. 25-27; p. cxi  
*curvata*, *Fontannesia*, **Pl. 47**, figs. 1-5; **Pl. 65**,  
 figs. 6, 7; p. 262 (*Dumortieria grammoc-*  
*eroides*); p. clxxxix  
*curvicostatum*, *Hyperlioceras*, **Suppl.**, **Pl. 16**, figs.  
 4-6; p. cxxiv  
*curvifrons*, *Terebratula*, different, in South of  
 England and *Cotteswolds*, 9  
*curvum*, *Brodiceras*, **Pl. 22**, figs. 35, 36; **Suppl.**, p.  
 xxxii (*Brodieia curva*)  
 Cycle of Development, ceii  
*Cycloceras*, 14, 127, clxix  
*Cycloceratidæ*, 13  
*cycloides*, Ammonites, 115, 117; *Harpoceras*, 117;  
*Hildoceras*, 117  
*cycloides*, *Pœcilomorphus*, **Pl. 22**, figs. 1-22; **Pl.**  
**A**, figs. 31, 32; p. 117  
*cycloides*, *Pœcilomorphus*, table of dimensions,  
 118; *Phylloceras*, 115, 116, 119  
*Cylicoceras*, **Suppl.**, p. xlix; *undatum*  
*Cylicoceras*, from *Geyeria*, 1; from *Welschia*, li;  
 classification, excviii  
*cymatera*, *Sonninia*, **Pl. 73**, figs. 2, 3; **Pl. 100**,  
 figs. 5-7; pp. 332, 390, 420  
*Cymbites*, ceii; *globosus*  
*cymbium*, *Ostrea*, 258  
*cynocephala*, *Rhynchonella*, 8, 44, 46, 48, 52,  
 164  
*Cypholioceras*, **Suppl.**, p. xliii; *opaliniforme*,  
*pigrum*, *plicatum*, *renovatum*, *vitiosum*  
*Cypholioceras*, xxxv; history of, xxxiii, xliv;  
 geological position of, xliv; from *Lioceras*,  
 xxxiv; from *Geyeria*, 1; classification, excviii  
*Cypricardia*, 45  
*Dactylioceras*, 272; *annulatum*, *crassum*, *holandrei*  
*Damon*, cxviii; and Maggs' Collection, 247  
*Darell*, *Darell Stephens*, change of surname, cxii;  
 and see *Stephens, Darell*  
*Darelleinae*, classification, excviii  
*Darellella*, **Suppl.**, p. cvii; *recticostata*  
*Darellella*, from *Reynesella*, cix; classification,  
 excviii  
*Darellia*, **Suppl.**, p. cxii; *concinna*, *lævis*, *polita*,  
*semicostata*, *toxeres*  
*Darellia*, from *Toxolioceras*, cxxvi; from *Stokeia*,  
 cxxviii; classification, excviii  
*Darellina*, **Suppl.**, p. cvi; *docilis*, *dorsetensis*,  
*planaris*  
*Darellina*, from *Darellella*, cvii; classification,  
 excviii  
*Davidson*, Dr. T., 1; on *Tereb. simplex*, 8  
*Davidsoni*, *Perisphinctes*, 10; descent of, 272  
*debile*, *Graphoceras.*, **Suppl.**, **Pl. 20**, figs. 22-24;  
 p. xcvi  
*decepiens*, *Brasilia*, **Pl. 12**, figs. 8, 9, p. 30 (*Lioc-*  
*eras decepiens*); **Suppl.**, **Pl. 11**, **fig. 35**;  
**Fig. 43** in text, p. lxxxii  
*decepiens*, *Lioceras*, **Pl. 12**, figs. 8, 9, p. 30, see  
*decepiens, Brasilia*  
*decepiens*, *Lioceras*, lxxxii, ciii, civ, cxiii  
*decepiens* var. *intermedium*, *Lioceras*, **Pl. 12**, figs.  
 2, 3, see *intermedia, Reynesia*; **Pl. 12**, figs.  
 4, 5, *lepida*, R.; **Pl. 12**, figs. 6, 7, *laxa*, R.; **Pl.**  
**12**, figs. 10, 11, *semicostata*, *Darellia*; p. 33,  
 see spp. above  
*decepiens* var. *simile*, *Lioceras*, **Pl. 15**, figs. 1, 2, p.  
 31, see *similis, Brasilia*  
*declinans*, *Dumortieria*, **Pl. 40**, figs. 10-12, p. 243  
 (*D. striatuloecostata*); **Suppl.**, **Fig. 171**, p.  
 cxevi; p. clxxvii  
 Decline (effects of), cxxx; progressive, lxxxix  
*decora*, *Sonninia*, **Pl. 84**, figs. 12-14, pp. 361, 387,  
 412  
*decorata*, *Sonninia*, **Pl. 84**, figs. 7, 8, pp. 360, 387,  
 412  
*decorum*, *Graphoceras?*, **Pl. 8**, figs. 3, 4, p. 56  
 (*Lioceras concavum*); **Suppl.**, **Pl. 15**, **fig. 19**;  
 p. xcvi  
 Definition, note concerning, xciv  
 Definitions, generic, interpretation of, ceiii  
*deflexum*, *Hyperlioceras*, **Pl. 19**, figs. 1, 2, p. 98  
 (*Hyperlioceras discoideum*); p. cxxii

- Degeneration, lxiv; of spinicostæ into nodicostæ, 357; features of, cxxxi; and septicarina, cliii, clvii; of carina, see carina
- deletum, *Pseudographoceras*, Suppl., Pl. 11, figs. 22-24, p. xci
- delicata, *Edania*, Suppl., Pl. 21, figs. 10-12, p. cviii
- delicata, *Walkeria*, Suppl., Fig. 122, p. cxl
- deltafalcatus, *Ammonites*, 82
- Deltiradiate (series), cxvii
- Deltoceras, cxix, see *Deltotoceras*; subsectum
- Deltoid, cxvii
- Deltoidoceras**, Suppl., p. cxvii; *astriatum*, *idoneum*, *subdiscoideum*
- Deltoidoceras, from *Deltotoceras*, cxix; classification, cxviii
- Deltotoceras**, Suppl., p. cxix; *cuneatum*, *discoideum*, *subsectum*, *triangulare*
- Deltotoceras, classification, cxviii
- Denckmann, Dr. A., 83, 85, 87, 146, 153, 169, 174, 182, 200, 202, 203, 205, 207, 209, 211, vii, viii, ix, x, xi, xvii, xxvi, xxvii, xlv, xlviii; on *Ann. Sæmanni*, etc., 206; and *Denckmannia*, xvii
- Denckmannia**, Suppl., pp. ix, xvii; *aspera*, *bredonensis*, *iserensis*, *malagma*, *obtecta*, *torquata*, *tumefacta*
- Denckmannia*, clxix; from *Haugia*, xxii; classification, cxviii
- densicostata**, *Sonninia*, Pl. 88, figs. 8, 9 a, p. 375
- Densicostate, iii
- Densisept, 111, cc
- Densiseptate, v
- Depaceras**, Suppl., p. lxxvii; *fallax*, *formosum*, *hamatum*
- Depaceras, from *Lueya*, *Paineia*, lxxiv; suggested relationship to *carinatitabulate* forms, cxiv; from *Deltoidoceras*, cxvii; classification, cxviii
- Deposit, no influence on *Ammonites*, xv
- Deposits, coastal, 455; fossiliferous, 455; *Ammonitiferous*, 456; correlation of, ccvi
- depressus, *Ammonites*, 216
- Deroceras, 129, 295; character of spines, 314; character of tubercles of, iii
- Descendants of *S. zigzag*, 272
- Description, note concerning, xciv
- Descriptions, specific, interpretation of, cciii
- Desori, *Ammonites*, 97, 98; *Harpoceras*, 97
- desori, **Hyperlioceras**, Pl. 17, figs. 6, 7, p. 97; Suppl., Fig. 89; Fig. 90, p. clxv; p. cxxii
- despecta, *Fontannesia*, Pl. 47, figs. 6, 7, p. 262 (*Dumortieria grammocerooides*); p. cxci
- Deux-Sèvres, 172
- Development, laws of, 134; omission of intermediate stages in, 159; of ventral area, changes in, 159; reversion, 159; omission of dissimilar stage, 224; introduction of modifications, 224; more rapid earlier inheritance of latest stages, 224; elimination of useless stages, 224; persistence of embryonic characters, 224; stages of, 289; renewed progressive, 290; renewed progressive, example of, 334; formulæ of, 382, 383; temporary or arrested, li; arrested, specimen showing, lxxiv; comparative (*Dumortieria*) clxxxiv; relative, cxix; phenomena of, cxix; normal, stages of, cci; cycle of, ccii; see *Hildoceratidæ*
- Developmental variation, 289
- Dew bed, suggested equivalence to Gloucestershire Cephalopod bed, 7; date of, ccviii
- Dewalque, see *Chapuis & Dewalque*
- difalensis, *Parkinsonia*, 272
- Differentiation, formulæ of, 382, 383
- digna, *Canavarina*, Suppl., fig. 127, p. clxvii; fig. 129, p. cxli
- Digne, *Ammonites* from, 301
- Dimensions, terms for, cxvii
- dimorphum, *Morphoceras*, ccii
- diphyes, *Dumortieria*, Pl. 42, figs. 13-15; Pl. 43, figs. 5-7, p. 253 (*D. radiosa*); p. clxxx
- Direct ribs, 231
- Discitæ hemera, vi
- Discitæ, hemera, strata of, ccvii
- discites, *Ammonites*, 94, cxvii
- \*discites, **Hyperlioceras** [Foreign], Fig. 87, p. clxv; Fig. 88, p. cxxii
- discites*, *Hyperlioceras*, Pl. 16, figs. 12, 13, see *discitiforme*, **Hyperlioceras**; Pl. 17, figs. 1, 2, *liodiscites*, H.; Pl. 17, figs. 3, 4, *rudidiscites*, H.; Pl. 17, fig. 5, *subleve*, H.; Pl. 18, figs. 1, 2, *rudidiscites*, H.; Pl. 18, fig. 3, *subleve*, H.; Pl. 18, figs. 4, 5, *lævis*, *Darellia*; p. 94, see spp. above

- discites, *Hyperlioceras*, 88, 434, cxiii, cxvi, cxxiii, cxxiv, cxxv
- discites, *Hyperlioceras*, hemera, cev
- discitiforme, *Hyperlioceras*, Pl. 16, figs. 12, 13, p. 94 (H. discites); Suppl., Pl. 18, figs. 7-9, 23; p. cxxiv
- Discoceratidæ, 13
- discoides, *Ammonites*, 12, 40, 45, 165, 175, 215; sutures of, mistakes in by d'Orbigny, 219; *Harpoceras*, 215; *Leioceras*, 215; *Oxynticeras*, 45
- discoides, *Polyplectus*, Pl. 37, figs. 1-5, p. 215; Suppl., Fig. 157, p. clxvii; p. clvii
- discoides, *Polyplectus*, 223, xxxiii
- aff. discoideum, *Deltotoceras*, Suppl., p. cxx
- discoideum, *Hyperlioceras*, Pl. 19, fig. 1, 2, see deflexum, H., Pl. 19, figs. 3, 4, subsectum, *Deltotoceras*; p. 98, see spp. above
- discoideum, *Hyperlioceras*, cxx, cxxi, cxxii
- \*discoideus, *Ammonites*, Quenstedt [Foreign], Fig. 85, p. cxx
- discoideus, *Ammonites*, 98, cxxiv
- discus, *Ammonites*, 230; *Oppelia*, hemera, cev
- Dispansi hemera, vi, cliv; strata of, ceviii
- Dispansum beds, 164, 165, 166, 167, cliv
- dispansum, *Grammoceras*, Pl. A, figs. 41, 42, p. 211, see dispansum, *Phlyseogrammoceras*
- dispansum, *Grammoceras*, 164, 165, clv; *Harpoceras*, 192, 211; and *Haugia variabilis*, comparison of, 212
- dispansum, *Phlyseogrammoceras*, Pl. A, figs. 41, 42, p. 211 (*Grammoceras* dispansum); Suppl., p. clv
- dispansum, *Phlyseogrammoceras* (hemera), cev
- dispansus, *Ammonites*, 211; Lycett's remarks on, 185; (*Harpoceras*), 211
- Dissoroceras, Suppl., p. cxv; excavatum, subornatum, tabulatum
- Dissoroceras, classification, cxxviii
- distans, *Cotteswoldia*, Pl. 33, figs. 1, 2, p. 196 (*Grammoceras* distans); Suppl., Pl. 23, fig. 8, p. cxxxvi
- distans, *Grammoceras*, Pl. 33, figs. 1, 2, p. 196, see distans, *Cotteswoldia*
- distans, *Grammoceras*, cxxxvi
- Distincticarinata, cvi
- Distincticarinata (series), cvii, cxii
- Distinction, specific, cxcix
- Distinctive fossils, ce
- diversa, *Sonninia*, Pl. 81, figs. 5, 6; Pl. 83, figs. 1, 2; Pl. 103, fig. 8; Figs. in text, 9, p. 385; 35, p. 398; 61, p. 443; pp. 355, 399
- docilis, *Darellina*?, Suppl., Pl. 22, figs. 4-6, p. cvii
- dœrntense, *Grammoceras*, Pl. 29, figs. 1-5, see dœrntense, *Pseudogrammoceras*; Pl. 29, figs. 6, 7, sp., P.; Pl. 29, figs. 8-10, Pl. 33, figs. 11, 12, placidum, P., p. 182, see spp. above
- dœrntense, *Grammoceras*, 164, 244, cliii
- dœrntense, *Pseudogrammoceras*?, Pl. 29, figs. 1-5, p. 182 (*Grammoceras* dœrntense); Suppl., Fig. 151, p. clxvii; p. cliii
- dœrntensis, *Ammonites* (*Harpoceras*), 182
- Dogger, 167, 229, ceviii
- Dohnsen, 96
- dominans, *Sonninia*, Pl. 66, figs. 1, 2; Pl. 94, figs. 1, 2; Pl. 95, fig. 1; Pl. 97, fig. 4; Figs. in text, 29, p. 391; 55, p. 435; 81, p. 443; pp. 322, 435
- dominans, *Sonninia*, Pl. 67, figs. 1, 2, see sp. *Sonninia*; Pl. 69, see dominica, *Sonninia*; p. 323, see spp. above
- dominans  $\beta$ , *Sonninia*, p. 323, see dominata, *Sonninia*
- dominans  $\delta$ , *Sonninia*, p. 323, see dominatrix, *Sonninia*
- dominans, *Sonninia*, 392, 408, 438, ce
- dominata, *Sonninia*, Pl. 97, figs. 1-3; Figs. in text, 13, p. 387; 39, p. 408; 65, p. 443; p. 408
- dominata, *Sonninia*, 436
- dominatrix, *Sonninia*, Pl. 94, figs. 3, 4; Pl. 95, fig. 2; Figs. in text, 4, p. 384; 30, p. 392; 56, p. 443; p. 392
- dominatrix, *Sonninia*, 436
- dominica, *Sonninia*, Pl. 69, figs. 1-3 (S. dominans); Pl. 103, fig. 14; Figs. in text, 14, p. 387; 40, p. 410; 66, p. 443; pp. 388, 410
- dominica, *Sonninia*, 436
- Dornseatas, 359
- Dorset, 3, 5-10, 19, 22, 23, 26, 28, 31, 40, 41, 47, 50-53, 61-65, 96-100, 106, 108, 115, 117, 247, 251, 258, 265, 266, 274-276, 278, 292, 296, 297, 304, 305, 310, 312, 320, 321, 324, 360, 361, 363, 376, 397, 399, 401, 455, xv, xxiii, xxxiv-xliv, xlvi, li-lxvi, lxxiii-lxxii, lxxiv-cxxi, cxxiv-cxxix, cxxxviii, cxi, cxlii,

- clvii, clxxi, clxxii, clxxxv, clxxxviii-exciii, cxcv ;  
Cephalopod bed compared, 3; not to add shire,  
359; stratal succession in, xxxv; strata of,  
cevi-ceix; see North Dorset, South Dorset
- Dorset Coast, Dumortieria strata on, clxxxiii
- Dorset-Somerset, 163, 164, clxxviii; district, 168
- Dorsetensia**, p. 302; Suppl., p. excii; *complanata*,  
*edouardiana*, *lennieri*, *liostraca*, *pulchra*,  
*romani*, *sp.*, *subtecta*, *tecta*
- Dorsetensia, genealogy of (Table VII), 312; from  
Somminia, 314; classification, cxviii
- dorsetensis**, **Darellina**, Suppl., Fig. 67, p. cvi
- dorsetensis*, Parkinsonia, cc
- Douvillei, Hildoceras, 112, 116, 136
- Douvillé, 14, 17, 287; 293, 294, 295, 298, lxx; on  
*Ludwigia Haugi*, 16
- Down Cliff, Upper Lias clay of, belongs to Dumor-  
tieria beds, 251; strata of, ceix
- Dumbleton, Middle Lias, species by mistake  
from, c
- Dumortier, E., 35, 61, 85, 107, 143, 146, 147, 149,  
150, 155, 156, 168, 170, 174, 176, 189, 190,  
192, 200, 202, 203, 204, 206, 207, 210, 215,  
227, 230, 238, 241, 246, 248, 250, 256, 268,  
269, 272, 273, 277, 278, 283, vi, vii, viii, xiv,  
x, xi, xvii, xviii, xx, xxi, xxii, xxiv, xxv, xxx,  
xxxii, xxxvi, cxliv, cxlvii, cxlviii, clxxxviii, clxxxix,  
clxxxvii; on *A. concavus*, 39; on *A. Ogerieni*,  
149; remarks on *Ammonites tolutarius*, lxxiii;  
& Fontannes, 277
- Dumortieri, Ammonites, 277
- dumortieri** **Catullocheras**, Pl. 39, figs. 6-9, p.  
277
- Dumortieri, Dumortieria (*Catullocheras*), 276, 277;  
*Harpoceras*, 277
- dumortieri*, *Haugia*, p. 152, see **dumortieri**, **Phyma-**  
**toceras**
- dumortieri*, *Haugia*, xi, xxx
- dumortieri**, **Phymatoceras**, Pl. 23, figs. 16, 17;  
Pl. A, fig. 36 (*Haugia Ogerieni*); p. 152  
(*Haugia Dumortieri*); Suppl., p. xxx
- dumortieri**, **Pseudolioceras**, Suppl., p. clviii
- dumortieri*, *Simoceras*, 277
- Dumortieria**, p. 231; Suppl., p. clxxii; *arata*,  
*arenaria*, *brancoi*, *costula*, *declinans*, *diphyes*,  
*exacta*, *exigua*, *explanata*, *externicompta*,  
*externicostata*, *falcofila*, *grammoceroïdes*, *in-*  
*clusa*, *jamesoni*, *lata*, *lutescens*, *lessbergi*,  
*levesquei*, *linearis*, *metita*, *moorei*, *multicos-*  
*tata*, *munda*, *munieri*, *mutans*, *novata*, *pauci-*  
*septata*, *penexigua*, *prisca*, *pseudoradiosa*,  
*radians*, *r. var. exigua*, *radiosa*, *r. var. gunders-*  
*hofensis*, *regularis*, *rhodanica*, *rustica*, *sig-*  
*nata*, *solaris*, *sp.*, *sparsicosta*, *striatulocostata*,  
*subexcentrica*, *subfasciata*, *subsolaris*, *sub-*  
*undulata*, s. var. *externicompta*, s. var. *exter-*  
*nicostata*, s. var. *striatulocostata*, *suevica*,  
*tabulata*, *vernosæ*, **yeovilensis**; (*Catullocheras*)  
*dumortieri*
- Dumortieria, 127, 163, 186, 290, 305, 339, 379,  
clxix; from *Grammoceras*, 162; geological  
position, 235; literature on, 236; note on prior  
use of name, 286; genus of *Hepaticæ*, 286;  
*sp.* for *Grammoceras striatum*, xliv; *syn.*  
of *Grammoceras*, cxxxi; localities for, clxix;  
strata, on Dorset coast, clxxxiii; comparative  
development in, clxxxiv; *syn.* of *Fontannesia*,  
clxxxvii; from *Fontannesia*, clxxxvii
- Dumortieria beds, 164, 165, 166, 167; importance  
of, 166; as Upper Lias Clay at Down Cliff,  
251
- Dumortieria, thickness of strata yielding, clxxxiii;  
*sp. hemera*, vi, cev; *hemera*, strata of, cxviii
- dundriensis**, **Sonninia**, Pl. 23, figs. 5, 6 (*Son-*  
*ninia?* *sp.*); Suppl., p. exciii
- Dundry, 1, 61, 63, 73, 90, 103, 117, 168, 173, 278,  
292, 434, xxix, liii, lvi, xevi, xevii, cii, ciii,  
cix, cxiii, cxiv, cxxv, cxxviii, cxlvi, cxlviii,  
clxxxviii, cxci, exciii; ironshot, compared to  
sands at Frocester, J. Buckman, 3; strata at,  
63, 90; presence of *Grammoceras* at, 168;  
section of, 292-293; *Sonninia* at, 316; emen-  
dation of section of, 316; specimens from,  
how marked, cix; and *Fontannesia*, clxxxviii;  
strata of, cevi, cevii, cxviii, ceix; see *Maes*  
*Knoll*; (*Castle Farm*), lxvi; *Hill*, see *Dundry*;  
*Hill*, *West End*, c
- duplicata**, **Sonninia**, Pl. 99, figs. 1-3, pp. 386,  
402
- Dursley, 231, 251, 253, 279, cxxx, cxxxiii, cxliii,  
cli, clxix, clxxv, clxxix, clxxx; strata of, cxviii;  
see *Bowcott Wood*, *Breakheart Hill*, *Cam*  
*Down*, *Coaley Wood*, *Stinchcombe Hill*
- Duston, Northampton, Northamptonshire, xl;  
strata of, cevii; see also *New Duston* and  
*Old Duston*

- Dwarf, *Ludwigia*, 130; race, 261; form, xevi; forms, clxxxiv; series, clxxxv; series (Fontannesia), clxxxix; *Sonninia*, exciii
- $\eta$  = hemera, clxx, exci
- Earlier inheritance, see inheritance
- East Coker, 23, 61, 71, exciv; sinistral gastropods at; *Parkinsoni* zone on *Murchisonæ* zone at, 7
- East Hill Quarry, 5, 96, 335
- Echoceras*, cei
- Economy in ornament, ce; in growth, ce
- Ectobrachysceles*, 381
- Edouardi*, *Harpoceras*, 304
- edouardiana*, *Dorsetensia*, Pl. 49, fig. 4; Pl. 52, figs. 8-24; p. 304
- Edouardianum*, *Harpoceras*, 13, 304
- Edouardianus*, *Ammonites*, 304
- effricata*, *Brasilica*, Pl. 7, figs. 3, 4, p. 26 (*Ludwigia ambigua*); *Suppl.*, p. lxxxii
- egena*, *Cotteswoldia*, *Suppl.*, Pl. 23, figs. 9-11, p. cxxxiv
- Elaboration, stages of, excix
- elegans*, *Ammonites*, 38, xxxvi; *Astarte*, 48; *Harpoceras*, 35, 38, 60; *Lioceras*, 12, 39, 80
- elegantula*, *Braunsina*, *Suppl.*, Pl. 19, figs. 1-3; p. c.
- elmagum*, *Harpoceras*, 277
- elongata*, *Pleurotomaria*, 293
- Elsass-Lothringen*, *Grammoceras* in, 169
- Embryonic, 357
- Endobrachysceles*, 381
- Engelhardti*, *Amaltheus*, 291
- English Channel, 456
- Epacme*, 357
- Ephebie*, 357
- Equicellate terminal lobule, 364
- Equiposed lateral lobules, 364
- erbaensis*, *Ammonites*, 109, vii, ix, xvii
- Erosion, contemporaneous, 452
- Erycites*; *fallax*
- Eseri*, *Ammonites*, 107, 109, vii, xi
- Eseri*, *Ammonites*, 143, 155, 204, vii, xxix, cxlvii; *Grammoceras*, 155; *Harpoceras*, 155; group, xxviii
- eseri*, *Haugia* (*Oppel*), Pl. 25, figs. 3-7; Pl. 26, figs. 1, 2; Pl. A, fig. 37, p. 155; *Suppl.*, p. xxviii
- Eseri*, *Haugia*, Pl. 25, figs. 5, 6, see *inæqua*, H. Pl. 25, fig. 7, *fascigera*, H.; Pl. 26, figs. 1, 2, *sculpta*, H.; p. 155, see spp. above
- Eseri*, *Haugia*, 164, 223, xxix
- Eterville*, lix
- Etheridgii*, *Terebratula*, 8
- Eudes Deslongschamps*, E., 172; on *Infra-Oolitic Marls*, 4
- Eudesi*, *Terebratula*, 9, 63
- euides*, *Lopadoceras*, *Suppl.*, Pl. 21, figs. 22-24, p. cxii
- euromphalica*, *Sonninia*, Pl. 85, fig. 1-3, pp. 362, 387, 405
- Europe, correspondence of faunal sequence in South America and, 454; Southern, 456
- evertens*, *Geyeria*?, *Suppl.*, Pl. 11, figs. 10-12, p. 1
- Evolute stage, smooth, 289
- exacta*, *Dumortieria*, Pl. 45, figs. 6, 7, p. 259 (*Dum. subundulata*); p. clxxxvii
- exaratus*, *Ammonites*, 155
- excavatum*, *Dissoroceras*, *Suppl.*, Fig. 78, p. cxvi
- Excentric coiling, cxliv, eliv
- Excentrilatumbilicate*, v
- Excentrumbilicate*, v
- Excentrumbilication*, cei, ceii
- exigua*, *Dumortieria*, Pl. 43, figs. 11, 12, p. 252 (*Dum. radians* var. *exigua*); *Suppl.*, Fig. 184, p. cxevi; p. clxxxiv
- expeditum*, *Pseudogrammoceras*, Pl. 34, figs. 10, 11; Pl. 35, fig. 7, p. 204 (*Grammoceras fallaciosum* var. *Cotteswoldiæ*); *Suppl.*, Fig. 142, p. cxlviii
- explanata*, *Dumortieria*, *Suppl.*, Pl. 22, figs. 28-30, p. clxxxv
- explanata*, *Fontannesia*, Pl. 46, figs. 6, 7, p. 262 (*Dumortieria grammoceroïdes*); *Suppl.*, Fig. 187, p. cxevi; p. clxxxviii
- explicatum*, *Pseudogrammoceras*, Pl. 28, figs. 14, 15, p. 171 (*Grammoceras* "toarcense-striatulum"); *Suppl.*, fig. 139, p. clxvii; p. cxlvi
- externicompta*, *Dumortieria*, *Suppl.*, p. clxxxix
- externicostata*, *Dumortieria*, Pl. 40, figs. 1, 2, p. 243 (*Dum. striatulo-costata*); *Suppl.*, Fig. 169, p. cxevi; p. clxxxvii
- Extreme-, when used, cxevii
- Extremilatumbilicate*, cxevii
- Extremipaehygyral*, cxevii

- Faculiformes [ribs], 294  
 Falcate (series), cxi, cxxvii  
 Falcate to biarcuate (series), cvii  
**falcidiscus, Pseudolioceras, Suppl., p. clx**  
 falcifer, Ammonites, 12, 138, 158; type of Harpoceras, xxxiii  
 Falciferen, 127  
 Falciferi, 12, 13, 38  
 falciferum, Harpoceras, 38, 84, 127, 165, 217, 223, 294; Harpoceras, hemera, cev; zone, 131, 165, 223, 282, 291  
 Falciform, sculpture, 14; ribs, 73, 294  
 Falciformes [ribs], 294  
**falcigera, Œdania, Suppl., Pl. 21, figs. 1-3 a, p. cviii; Fig. 69, p. clxv**  
 Falciradiate (series), clvi  
 falcodiscus, Ammonites, 85, clx  
 falcofila, Ammonites, 241, clxxiv  
**falcofila, Dumortieria, Suppl., Fig. 164, p. clxxiv**  
 falcofila macer, Ammonites, clxxiv  
 falcofila-sparcicosta, Ammonites, 237, 239, clxxiii-iv  
*fallaciosum, Grammoceras, Pl. 33, figs. 17, 18, p. 204, see subfallaciosum, Pseudogrammoceras*  
 fallaciosum, Grammoceras, 45, 156, 165, 204, clxv, clxvii, clxviii, clxix  
 Fallaciosum-group, 163, 200; how to obtain good examples of; peculiarities of ornament in, 201  
 fallaciosum, Harpoceras, clxvii, clxviii, clxix  
**fallaciosum, Pseudogrammoceras, Suppl., Fig. 150, p. clii**  
*fallaciosum* var. *Bingmanni*, Grammoceras, Pl. 34, figs. 3-5, p. 206, see *bingmanni*, Pseudogrammoceras  
*fallaciosum* var. *Cotteswoldiæ*, Grammoceras, Pl. 34, figs. 10, 11; Pl. 35, fig. 7, see *expeditum*, Pseudogrammoceras; Pl. 35, figs. 4-6, *cotteswoldiæ*, P.; p. 206, see spp. above  
 fallaciosum var. *Muelleri*, Harpoceras, clxix  
*fallaciosum* var. *Struckmanni*, Grammoceras, p. 206, see *struckmanni*, Pseudogrammoceras  
 fallaciosus, Ammonites, 144  
 fallax, Ammonites, descent of, 129  
**fallax, Depaoceras, Pl. 14, figs. 10, 11, p. 79** (Lioceras fallax); **Pl. 21, figs. 7-9, p. 104** (Ludwigia Lucyi); **Suppl., Pl. 16, figs. 1-3; Figs. 34-36 in text, p. lxxviii**  
 fallax, Erycites, 301; Hammatoceras, 140  
*fallax, Lioceras, Pl. 14, figs. 10, 11, p. 79, see fallax, Depaoceras*  
 fallax, Lioceras, p. lxxviii  
 Family, 14, cxxviii  
**fasciata, Geyeria, Suppl., Pl. 6, figs. 7-10, p. 1**  
**fascigera, Haugia, Pl. 25, fig. 7, p. 156** (Haugia Eseri); **Suppl., p. xxix**  
**fastigata, Braunsina, Suppl., Pl. 20, figs. 1-3, p. c**  
 Fastigate, 411, iv; see also concavifastigate, convexifastigate, planifastigate  
 Fastigation of periphery, in relation to development, lxxvii  
 Fauna, Ammonite, independent of lithic conditions, xvi; of hemera, extension of, xvi; richness of, cxcix  
 Favre, on classification of Ammonites, 11  
 Ferruginous beds, 7, 43  
 Feuguerolles, lv, lvii, lix, lxxii, clxxi  
 fidicula, Pholadomya, 46, 48  
 fimbriatum, Lytoceras, cc  
 fissilobata, Sonninia, 328  
 fissilobata-ovalis horizon, date of, cvii  
 Fissilobati, 287  
**flaccidum, Graphoceras, Pl. 8, figs. 7, 8, p. 56** (Lioceras concavum); **Suppl., Fig. 60 in text, p. xcvi**  
 Flexicostate (series), Fontannesia, clxxxix  
**flexilis, Ludwigella, Suppl., Pl. 19, figs. 28-30, p. lxxxviii**  
 Flexiradiate (Pseudogrammoceras series), clxiv  
 Flexiradius, iii  
**floccosa, Paquieria, Suppl., Pl. 10, figs. 20-24, p. lxxvii**  
**fluens, Pleydellia, Pl. 31, figs. 1, 2, p. 176** (Grammoceras mactra); **Suppl., Fig. 114, p. clxv; p. cxxxvii**  
 fluitans, Ammonites, 190  
*fluitans, Grammoceras, Pl. 30, figs. 1, 2, p. 190, see folleata, Canavarina*  
 fluitans, Grammoceras, 222, cxli; Harpoceras, 190, 191  
**folleata, Canavarina, Pl. 30, figs. 1, 2, p. 190** (Grammoceras fluitans); **Suppl., Fig. 128, p. clxvii; p. cxli**  
 Fontannes, F., and Fontannesia, clxxxvii; see also Dumortier & Fontannes

- Fontannesia**, p. clxxxvii; *aurita*, *boweri*, *carinata*, *concentrica*, *curvata*, *despecta*, *explanata*, *luculenta*, *grammoceroïdes*, *obruta*, *tortiva*
- Fontannesia**, classification, cxcviii
- Fontenay-le-Pesnel**, clxxiv
- Forbesi**, *Rhynchonella*, 9, 63
- Form**, similarity of, hiding septal differences, 379
- Formenreihen**, 127
- formosum**, **Depaoceras**, Pl. 10, figs. 1, 2, p. 65 (*Lioceras concavum* var. *formosum*); **Suppl.**, Fig. 38 in text, p. lxxix
- Formula** for species, 382
- Fossil bed**, meaning of term, ccix
- Fossil beds**, dates of, ccvi, ccvii
- Fossiliferous**, deposit, 455; horizon in sands, clxxxiii
- Fossilisation**, conditions of, 455
- Fossils**, distinctive, ccv
- France**, 208, 215, 220, clxxviii, clxxx, exciii
- Frantzi**, *Ammonites*, 112
- Fredericii**, *Ammonites*, 227, 230
- Freestone**, Building, 7; date of, ccvi; Upper, 7; Lower, date of, ccvii; meaning of term, ccix; Upper, date of, ccvii; see Building, Lower, Notgrove, Upper Freestone
- Fridericii**, *Ammonites*, 180; *Pelecoceras*, 180
- Frith Quarry**, 90, 94, 96, 100, civ
- Frocester**, 19, 40, 41, 49, 50, 113, 114, 179, 185, 188, 191, 194, 196, 197, 212, 213, xvi, xlii, exxix, exlix, eliii, clxix, clxxxi, cxxxiii, cxxxiv, cxxxv, cxxxvi, cxxxvii; strata of, ccix
- Frocester Hill**, Oppel's division of strata at, 2; sands of, and Pea grit, J. Buckman, 3; geology of, 44; Cotteswold Sands at base of so-called Inferior Oolite, v; Bugstone at, ccvii
- Frocester district**, strata of, ccviii
- Frodgen Quarry**, 292, 306, xcvi
- furcatum**, **Lopadoceras**, **Suppl.**, Pl. 21, figs. 16-18; p. cxii
- furcillata**, **Reynesia**, **Suppl.**, Pl. 22, figs. 1-3; p. civ
- Fullers' Earth Clay**, 6
- Furrows**, 134
- Furzey Knaps**, Yeovil, Somerset, clxxii, clxxiv
- fusca**, *Oppelia*, *hemera*, ccv
- Fusca hemera**, vi; strata of, ccvi
- futilis**, **Braunsina**, Pl. 15, figs. 7, 8; p. 76 (*Lioceras apertum*); **Suppl.**, Fig. 64 in text, p. ci
- G 4, ccv
- G 5, ccv
- \*gallica**, **Kiliania**?, **Suppl.**, p. lxxviii (Foreign)
- Gammiradiata**, cxxx
- Garantiana**, *Parkinsonia*, 272; ontogeny of, 271
- Garantianæ hemera**, vi, strata of, ccvi
- Garantianum**, *Cosmoceras*, 10; *Strenoceras*, *hemera*, ccv
- Garda See**, 452
- Gasteropoda**, 47; *Pleuroceras* used for, 258
- Gasteropods**, sinistral, at East Coker, 7
- Gawan**, A., 31, 151
- Gemmellaro**, Prof. G. G., 272, 276
- Genealogy** (Table II), 131; (Table III), *Hildoceratidæ*, 132; of *Polymorphidæ*, Haug's views thereon criticised, 234; remarks on *Ammonite*, 444; methods of, 444; (Table IX), *Sonniniæ*, 445; is an attempt to interpret characters, 446; homœomorphous species, 446
- Genera**, separation of *Sonniniæ* into, 450
- Generic**, classification, cxvii; definitions, interpretation of, cciii; distinction, excix; group, 15; subgroups, 15
- Genetic acme**, cc
- Genotype**, cciii
- Genus**, view concerning, cciv
- Geological**, characters, 2-10; range of *Grammoceras*, 162; position, *Sonniniæ*, 292; position, *Lillia-Haugia*, xii; phenomena, xii; details, cciv
- Geological Survey**, ccv; Museum of, 178
- Geology**, sections, 164; see **Geological**
- Germani**, *Lytoceras*, 165
- Gerontic**, 357; form, clix
- Gervillei**, *Sphæroceras*, 120
- Geyer**, Dr. G., and *Geyeria*, 1
- Geyeria**, **Suppl.**, p. 1; *evertens*, *fasciata*
- Geyeria**, classification, cxviii
- Giant of Inferior Oolite**, cc
- gibbera**, *Sonninia*, Pl. 87, figs. 4, 5; Pl. 88, figs. 1-3; **Figs. in text**, 22, p. 390; 48, p. 420; 74, p. 443; p. 421
- Giebel**, 216

- gigantea*, Wiltshireia, Pl. 11, fig. 1; Pl. 12, fig. 4; Pl. A, fig. 12, p. 25 (*Lioceras bradfordense* var. *giganteum*); Suppl., Pl. 11, fig. 31; Pl. 15, figs. 7, 8; p. lxxviii
- giganteum*, *Lioceras*, 26
- glevensis*, *Ludwigella*, Suppl., Pl. 20, figs. 25–27, p. lxxxix
- globata*, *Terebratula*, 7, 45, 165
- Globose stage, examples of, 289
- globosus*, *Ammonites*, 289; *Cymbites*, 268, 283
- Gloucestershire, 2, 3, 6–9, 19, 22, 30, 37, 42, 50, 53, 94, 96, 97, 107, 113, 147, 158, 173, 179, 208, 220, 229, 247, 275, 279, 281, xv, xvi, xxi, xxii, xxiv–xxix, xxxi–xxxiii, xliv, xlv, l, lviii, lxxv, lxxvi, lxxix, c, civ, ex, exxi, cxxix, cxxx, cxxxii–cxxxvii, cxxxix, cxliii, cxlv–cliii, clviii–clxi, clxx–clxxiii, clxxv, clxxvii–clxxxi, clxxx–clxxxvii; sections, 41; strata of, ccvi–ccix
- Goniatite stage, 159, 170, 173
- Gottsche, 148, 273, 453, vi, viii, clxx; on *Harpoceras Andium*, 157
- gracile*, *Lioceras*, Suppl., Pl. 6, figs. 11–13, p. xxxviii
- gradata*, *Ludwigia*, Suppl., Fig. 27, p. lxxi
- gradatum*, *Pseudolioceras*, Pl. 20, figs. 3, 4, p. 85 (*P. compactile*); Suppl., Fig. 159, p. clxvii; p. clviii
- gradumbilicate*, iv, v; species, relation to *concaumbilicate*, cxviii
- Grammoceras**, p. 158; Suppl., p. cxxxi; *aalense*, *acutum*, *antiquum*, *audax*, *bingmanni*, *capillatum*, *costulatum*, *cotteswoldiae*, *dispausum*, *distans*, *doerntense*, *eseri*, *fallaciosum*, *f. var. bingmanni*, *f. var. cotteswoldiae*, *f. var. struckmanni*, *fluitans*, *kurrianum*, *leurum*, *lotharingicum*, *maetra*, *metallarium*, *moorei*, *muelleri*, *nannodes*, *nitescens*, *normannianum*, *orbignyi*, *ovatum*, **penestriatulum**, *radians*, *quadratum*, *scemanni*, *serpentinum*, **sp. striatulum**, *struckmanni*, *subcomptum*, *subquadratum*, *subserrodens*, *thouarsense*, *toarcense*, *toarcense-striatulum*, **toarciense**
- Grammoceras*, 12, 13, 127, 129, 221, 222, 223, 284, 379, cxxix; from *Haugia*, 144; geological range of, 162; works specially dealing with, 169; horizon of, wanting between Stroud and Yorkshire, 175; and *Haugia*, remarks on, 221; from *Dumortieria*, 232; and *Arietan* stage, 233; and *Dorsetensia*, 305; from *Cotteswoldia*, cxxxiii; from *Canavarina*, cxli; classification, cxviii
- Grammocerata*, 52, 222; hollow carinate, 200; genealogy and horizons of (Table IV), 221
- Grammoceratan* stage, 159
- Grammoceratinae*, classification, cxviii
- Grammoceratoid*, cxxix
- grammoceroides*, *Dumortieria*, Pl. 46, figs. 1–3, see **grammoceroides**, *Fontannesia*; Pl. 46, figs. 4, 5, 8, *luculenta*, F.; Pl. 46, figs. 6, 7, *explanata*, F.; Pl. 47, figs. 1–5, *curvata*, F.; Pl. 47, figs. 6, 7, *despecta*, F.; Pl. 47, figs. 8, 9, *tortiva*, F.; Pl. 47, figs. 10–12, *luculenta*, F.; Pl. 47, figs. 13, 14, *carinata*, F.; Pl. 47, figs. 15–17, **grammoceroides**, F.; Pl. 65, figs. 6, 7, *curvata*, F.; p. 262, see spp. above
- grammoceroides*, *Dumortieria*, 339, 340, clxxxviii, clxxxix, cxei; morphological equivalent to, 334; resemblance to *Sonninia*, 235, 340; involute senescent development of, notes on, 340
- grammoceroides*, *Fontannesia*, Pl. 46, figs. 1–3; Pl. 47, figs. 15–17, p. 262 (*Dumortieria grammoceroides*); Suppl., Fig. 186, p. cxevi; p. clxxxviii
- grandis*, *Haugia*, Pl. 23, figs. 14, 15 (*Haugia variabilis*); Pl. 24; Pl. 25, fig. 1; Pl. 28, figs. 1–3, p. 149 (*Haugia jugosa*); Suppl., Pl. 2, fig. 11; p. xxvi
- Graphoceras*, Suppl., p. xcvi; *decorum*, *debile*, *flaccidum*, *limitatum*, *inclusum*, *mirabile*, *robustum*, *stigmatum*, *undulatum*, *v-scriptum*
- Graphoceras*, cci; from *Braunsina*, xcix; classification, cxviii
- Graphoceratinae*, classification, cxviii
- grave**, *Lioceras*, Suppl., Pl. 8, figs. 4–6, p. xli
- Great Oolite, 47
- Gregorio, de, 277, 278
- Group, *fallaciosum*, 163; *striatulum*, 163
- Groups (*Ammonite*), 127; (*Lioceras*), xxxvi
- Growth, acme, cc; individual, cc
- Growth-lines, ii
- Grunowi, *Ammonites*, 201, cxliv
- Gruppe, see Groups
- Gryphite grit, 7, ccix; and *Dorset Cephalopod* bed, 3; *Ammonites* of, at Stroud, 90; age of, 91; date of, cevi

- Greek bow, radial line like, lxxix  
 Guibali, Ammonites, 226  
 Gundershofen, 187, 258  
 Gyroceras, cci  
 Gyroceratan, ccii
- Halfway House, 8, 19, 34, 61, 62, 67, 71, 73, 75, 99, 103, 106, 266, 322, 324, 343, liv, lviii, lxxv, lxxix, lxxxi, lxxxiv, lxxxv, lxxxvii, ci, exxviii, clxxxviii, clxxxix, exc, exci; Parkinsoni zone fossiliferous at, 10; strata of, ccvi, ccvii
- Ham Hill, 251; position of Freestone beds at, 52; strata of, ccviii
- hamatum, Depaoceras, Suppl., Fig. 37 in text, p. lxxix**
- Hamites, 14
- Hammatoceras, 13, 14, 53, 129, 157, 226, 287, 294, 313, 314, 316, 378, 379, 452; adierum, amaltheiforme, climacomphalum, insigne, occidentale, ogerieni, patella, pertinax, pugnax, sowerbyi, variabile; (Sonninia) andium, ogerieni, polyacanthum; species of, Opalinum zone of Northampton and Dorset, 53; from Haugia, 144; loss of marginal knobs, 157; from Sonninia, 314; spinose species of Sonninia confounded with, 342; from Fontanesia, clxxxviii
- Hammatocerata, migration of, 452; great abundance near Mediterranean, 452; sandstone yielding, ccviii
- Hammatoceratidæ, 15, 16
- Hammatoceratinae, 15
- Hanbury quarry, 96
- Hanover, 88
- Haploceras, 14
- Haplopleuroceras, p. 299; mundum, subspatum**
- Haplopleuroceras, 290, 314, ccxii; from Dorsetensia, 303; and Zuercheria, ccxii; classification, ccxviii
- Haresfield, compared with Burton Bradstock, 51
- Haresfield Beacon, 182
- Haresfield Hill, 36, 40, 41, 42, 49, 51, 55, 56, 88, 163, 179, 181, 191, 194, 196, 197, 198, xlv, xlvi, l, cxxxiii, cxxxv, cxxxvi, cxxxix; Opalinum zone at, Wright's remarks on, 4; section of, 43; correlation, correction, 166; Granmoceras striatulum at, correction of, 175; strata of, ccviii
- Haresfield-Wotton district, 166
- haresfieldensis, Terebratula, 44, 164, 269
- Harford Sands, date of, ccvii
- Harpoceras, 5, 13, 14, 38, 82, 84, 127, 129, 130, 158, 217, 223, 287, 302, 313, cci; aalense, actaeon, adierum, alsaticum, andium, arietiforme, beyrichi, boweri, canaliculatum, compactile, comptum, concavum, cornu, corrugatum, costula, cycloides, desori, discoides, dispansum, dumortieri, edouardi, edouardianum, elegans, elmagum, eseri, falciferum, fallaciosum, fluitans, hecticum, henrici, kurrianum, lessbergi, levesquei, lotharingicum, mactra, lythense, masseanum, moorei, munieri, murchisonæ, m. var. bradfordiense, nitescens, occidentale, ogerieni, opalinum, pseudoradiosum, radians, radiosum, simon, sowerbyi, sp., steinmanni, strangwaysi, striatulum, s. var. comptum, subcomptum, subplanatum, subundulatum, s. var. externe-comptum, s. var. externe-costatum, s. var. externe-punctum, trimarginatum, variabile, zio, zitteli; (Dumortieria) costula; (Pseudolioceras) compactile; zone, 4; for true Falciferi, 38; restriction of generic term, 39; from Pseudolioceras, 83; characters of, 138; from Haugia, 144; from Polyplectus, 214; type species of, xxxiii; from Pseudogrammoceras, cxliv; from Vacekia, clvi; from Polyplectus; clvii; from Pseudolioceras, clviii
- Harpoceratan Age, ccv
- Harpoceratidæ, 126, 127, 287
- Harpoceratinae, 14, 15, 16, 287
- Harpoceratites, 287
- Haselbury, 19, 29, 30, 40, 55, xlvi, lvii, lxxvii, lxxix, lxxxi; sands at, 51; strata of, ccvii
- Hauer, F. R. von, 115, vii, viii, xii, xiii, xiv, xviii
- Haug, Dr. Emile, 12, 14, 17, 20, 35, 53, 56, 77, 83, 85, 86, 87, 97, 98, 108, 112, 114, 117, 118, 119, 120, 127, 128, 130, 138, 139, 143, 144, 146, 149, 154, 155, 157, 160, 161, 170, 177, 186, 187, 190, 192, 193, 198, 199, 201, 203, 205, 211, 215, 220, 227, 231, 232, 234, 236, 237, 238, 239, 240, 241, 242, 243, 244, 246, 248, 250, 252, 253, 254, 256, 257, 258, 259, 260, 261, 262, 267, 268, 269, 270, 272,

- 274, 276, 277, 279, 283, 285, 286, 287, 288, 295, 297, 302, 304, 313, 357, 375, 376, 452, viii, xiii, xiv, xviii, xxviii, xxxvi, lxx, cxliv, clxxv, clxxix, exciii; on Harpoceratidæ, 12; on *Am. serpentinus*, 13; on Harpoceras, 16; on *Lioc. opalinum*, 53; on *Harp. opalinum*, 54; and *A. compactilis*, 86; remarks on jurense-zone, 114; on *Harpoceras falciferum*, 128; on *Dumortieria Jamesoni*, 130; on *Ludwigia*, 138; on *Pseudolioc. compactile*, 139; and *Am. Eseri*, 143; and *Am. occidentalis*, 144; on *Haugia Eseri*, and *occidentalis*, 154; and Ammonite convergence, 177; and *Grammoceras radians*, 186; on *Am. aalensis*, 194; on *Dumortieria Mumeri*, 238; on *Dumortieria*, 239; and Gundershofen, 258; and *Harp. subcomptum*, 261; on *Polymorphidæ*, 265; and *Polymorphites*, 268; on *Leesbergi*, 279; and *Ludwigia Haugi*, lxx; and *Gram. fluitans*, cxli; and *Dumortieria grammoceroides*, clxxxviii; correction by, exciii
- Haugi*, *Hildoceras*, 17
- haugi*, *Ludwigia*, *Suppl.*, Pl. 14, figs. 8-10, p. lxx
- Haugi*, *Ludwigia*, 17
- Haugia**, pp. 45, 142; *Suppl.*, p. x, xxii; *compressa*, *dumortieri*, *eseri*, *eseri*, *fascigera*, *grandis*, *illustris*, aff. *illustris*, *illustris*, *inæqua*, *jugosa*, *navis*, *occidentalis*, *ogerieni*, *patelliformis*, *sculpta*, sp., *variabilis*, aff. *variabilis*
- Haugia*, 82, 207, 226, clxix; and *Grammoceras*, remarks on, 221; from *Dorsetensia*, 309; characters, vi; from *Chartronia*, xvi; from *Phymatoceras*, xxx; from *Pseudogrammoceras*, cxliii; classification, cxviii
- Haugia*, *Lillia*-, series, vi; species of, vi, viii; works on, vii; characters, viii; classification, ix; geological position, xii; *hemera* of, xii
- Haugina*-, classification, cxviii
- hawskerensis*, *Ammonites*, 289; *Pleuroceras*, 291, 295, 299, 301
- hectica*, *Ludwigia*, 128
- Hectici*, 132, exciv
- hecticus*, *Ammonites*, 127
- hecticum*, *Harpoceras*, 13
- Hemera*, a period of time, 447; importance of the hemeral system, 452; a chronological unit, v
- Hemera*-, list of, vi; strata of certain, xxxv; of *Pseudogrammocerata*, cliv; *aalensis*, *acuti*, *bifrontis*, *blagdeni*, *bradfordensis*, *coarctata*, *concavi*, *disci*, *discitæ*, *dispausi*, *Dumortieria* sp., *falciferi*, *fuscæ*, *garantiani*, *lilli*, *maxillatæ*, *moorei*, *murchisonæ*, *niortensis*, *opalini-formis*, *sauzei*, *scissi*, *Sommia* sp., *striatuli*, *struckmanni*, *subcontracti*, *truellii*, *variabilis*, *Witchellia* sp., *zigzag*
- Hemeral* system, 452; classification, ccv; terms, ccv
- Henbury* quarry, 96
- Hendford* Hill, 237, clxxii
- Henleyi*-zone, 132, 283
- Henrici*, *Harpoceras*, 13
- Hereditary* force, 280
- Herveyi*, *Ammonites*, 272
- heterogenum*, *Liparoceras*, 289
- Heteromorphous* species, cciv
- heterophyllum*, *Phylloceras*, 119
- Hiatus* between Upper Freestone and Gryphite grit, 64; between *Murchisonæ* and *Sowerbyi* zones, 64
- Hildoceras**, p. 111; *Suppl.*, p. clvi; \**bifrons*, *bifrons* var., *boreale*, *cornu*, *cycloides*, *douvillei*, *kiliani*, *haugi*, *murchisonæ*, *quadratum*, *sæmanni*, *semipolatum*
- Hildoceras* (*Ludwigia*) *cornu*, 13, 14, 128, 129; from *Pœcilomorphus*, 115; furrows of, 135; from *Grammoceras* 160; classification, cxviii
- Hildoceratidæ*, 21, 81, 88, 101, 111, 115, 142, 158, i
- Hildoceratidæ*, 13, 129, 284, 314, cci; where to be used, correction, 101; remarks on family, 222; the compressed involute shape a necessity, 223; advantage of involute over evolute in the struggle for existence, 223; their tendency towards the compressed involute shape, 223; the early forms near the Mediterranean, 223; less modified successors ousting more changed predecessors, 223; constant immigration of waves of less modified species, 223; omission of stages, 224; new immigrants become like the older, 224; the less modified forms perpetuate the race, 224; revision of, additions to, i; supplementary description of species of, xiii; from *Polymorphidæ*, clxix; complication in, excix; classification, cxviii

- Hildoceratinae, 15, 16, 21; read Hildoceratidæ for, 81; classification, excviii
- Hinton, 175
- Hollandrei, *Daetyloceras*, 165
- Holm, lxx
- Hollandæ, *Cosmoceras*, 273, 275
- hollandæ, *Tmetoceras*, Pl. 48, figs. 11, 12; p. 275
- Hollow carina, 81, iv; and see carina
- Hollow carinate *Grammocerata*, 200
- Homœomorph, xlvi
- Homœomorphous, 368; fossils, examples of, 381; species, cciv
- Homœomorphs, examples, lxxviii
- Homœomorphy, deceptions of, ii; case of deception of, clxxxii; of concavumbilicate species, xcviii
- Homogenous, 280
- Homoplastic, 280; developments, 272
- Hook Norton, 40, 52, 53
- Horethorne Down, 275; strata of, ccvii
- Horn Park, lix, lx
- Horizon, fossiliferous in Sands, clxxxiii; of *Tmetoceras*, clxx
- Hudleston, W. H., 47, 61, 63, 64, 119, 167, 168, 175, 188, 194, 225, 228, 229, 274, 374, xlvi
- on Inferior Oolite, 4; on Burton Bradstock, 47; on Midford Sands, 51; and Concavum beds, 63; on Gasteropoda, 64; Concavum beds, 65; sent specimens, 228; and Sherborne excavations, 374
- Hudlestonia**, p. 225; *affinis*, *serrodens*, *sinon*
- Hudlestonia*, from Dorsetensia, 309; classification, excviii
- Hugia**, Suppl., p. cxi; *curva*, *micca*
- Hugia* from Lopadoceras, cxii; classification, excviii
- Humphriesianum, *Stephanoceras*, 5, 9, 63, 120, 272
- Humphriesianum-zone, 4, 6, 8, 9, 63, 64, 119, 291-293; thickness of, fossils of, 10
- Humphriesianum-Sauzei-zone, 316
- Humphriesianus, *Ammonites*, 63
- Humphriesianus-zone, absence of, in Cotteswolds, 91
- Hyatt, *Alpheus*, 12, 13, 35, 111, 143, 146, 158, 159, 173, 192, 215, 225, 226, 232, 233, 234, 270, 280, 286, 289, 290, 312, 315, 357, xxx, xxxv, lv, cxxxi; on classification of Ammonites, 11; on genera of Ammonites, 12; on *Ammonites*, 13; and *Tropidoceras*, 14; lists of papers by, 160; on *Pelecoceras*, 225; and *Ophioceras*, 232; on *pilæ*, 233; and *Amaltheidæ*, 290; on absorption of living chamber, 312; on *Phymatoceras robustum*, xxx; and *Hyattia*, lv; and *Arietidæ*, excix
- Hyatteinæ*, classification, excviii
- Hyattia**, Suppl., p. lv; *bullifera*, *pustulifera*, *subcava*, *wilsoni*
- Hyattia*, from Manselia, lviii; classification, excviii
- Hyattina**, Suppl., p. lvii; *brasili*, sp.
- Hyattina*, from Manselia, lviii; from *Apedogyria*, lix; classification, excviii
- Hyperioceras**, p. 88; Suppl., p. cxxi; *curvicoatum*, *deflexum*, *desori*, \**discites*, *discites*, *discoideum*, *discitifforme*, *iodiscites*, *lucyi*, *occlusum*, *rudidiscites*, *subdiscoideum*, *subleve*, *walkeri*
- Hyperioceras*, 223, 447, iv; from Dorsetensia, 309; from *Toxiloceras*, cxxvi; ancestor not *Pseudoloceras*, clviii; classification, excviii
- Hypostrophic, 357; characters, association of, lxxii; abnormality, xcvii
- Hypostrophy, signs of, clix
- Ibex zone, 132, 283
- Identification, necessity of noting small differences in young specimens, 426; necessity of correctly measuring umbilicus in young specimens, 440; obscure characters must be attended to, 451
- idoneum**, *Deltoidoceras*, Suppl., Fig. 80 in text, p. cxvii
- ignobilis*, *Ludwigia*, 128
- illustris*, *Ammonites*, 153, vii, xi; (*Hammatoceras*), 153, xxvi, xxvii
- illustris*, *Haugia*, Pl. 26, figs. 3-5, p. 153, see aff. *illustris*, H.
- illustris*, *Haugia*, Suppl., pp. xxvi, xxvii
- aff. *illustris*, *Haugia*, Pl. 26, figs. 3-5, p. 153 (*Haugia illustris*); Suppl., p. xxvii
- illustris*, *Haugia*, xxvii
- Ilminster, 175, 213, 231, xxii, xxv, xxvi, lxxxvi, cxliv; Opper's statement about Ammonites in Sands at, 50; and Yeovil, lxxxvi; concavum strata distant from, lxxxvi; strata of, ccviii, ccix

- impendens, Ammonites, 226
- impolita**, *Ludwigella*, Suppl., Pl. 19, figs. 25-27, p. lxxxv
- inæqua**, *Haugia*, Pl. 25, figs. 5, 6, Pl. A, fig. 37, p. 156 (*Haugia eseri*); Suppl., p. xxix
- inæqua**, *Sonninia*, Pl. 101, figs. 4-6, pp. 386, 400
- Inæquiorate, iv, x
- Incoiling, clv
- incisum**, *Toxiloceras*, Suppl., Pl. 21, figs. 31-33, p. cxxvi
- inclusa**, *Dumortieria*, Pl. 45, figs. 13, 14, p. 254 (*Dum. radiosa* var. *gundershofensis*); p. clxxx
- inclusum**, *Graphoceras*, Suppl., Pl. 15, figs. 15-17, p. xcvi
- inconstans**, *Zurcheria*, Pl. 50, figs. 4-10, p. 297
- Indo-Pacific province, 454
- Inferior Oolite, its limits, 2; division, Deslongs-champ's views on, 4; to begin with *Sauzei* zone, 4; Hudleston's suggestion as to its division, 4; strata in Dorset differ in short distances, 8; thickness of, in South of England, 9; diminution westwards in Dorset-Somerset, 10; greatest thickness for South England expected near Sherborne, 10; maximum developments of, 10; and *Opalimum-zone*, 42; Limestone, 168; and *Toarcien*, 173; time of, divided into twenty-three hemeræ, v; deposits of, limits of, v; and acme, excix; giant of, cc; extent of; and upper Lias, cciv; (*G5*), ccv; Limestones, ccv; sands, 113, ccv
- Inferior Oolite Series, 113, 175, ccv
- inflata**, *Ædania*, Suppl., Pl. 21, figs. 13-15, p. cviii
- infra-oolithica*, *Terebratula*, 52, xxxvii
- Infra-Oolitic Marls, 4
- Inheritance, Earlier, ccii; law of, 134, 224; theory of diminishing rate of progress, 224; modifying action, 288; partial or modifying action of, 290; unequal action of, 290; modified action, examples of, 295, 296, 297, 313; see development, tachygenesis
- Inner margin, recession of, 36
- inops**, *Reynesella*, Suppl., Pl. 21, figs. 37-39, p. cx
- Inornatilobate, v
- Insigne group, 143
- insigne, *Hammatoceras*, 13, 45, 46, 128, 143, 164, 165, 220
- Insignes, 13
- insignis, Ammonites, 13, 129, 279
- insigni-simile**, *Catullocceras*, Pl. 39, figs. 12-14, p. 278
- insigni-similis, Ammonites, 278
- insignoides, *Sonninia*, 315
- Interlobular cells, 373
- intermedia**, *Reynesia*, Pl. 11, figs. 2, 3, p. 23 (*Lioceras decipiens* var. *intermedium*); Suppl., Pl. 18, fig. 27, p. ciii
- intermedium, *Ægoceras*, 232
- Intersection of ornament, cc
- Intra-axial, 369
- Inverted triangle, 360
- Involution, how attained, 134
- Ironshot, Bed, 293; beds, date of, cviii; limestone, xxxv; limestone, date of, cvii; marly stone, xxxv; Oolite, 63; Oolite, date of, cvi; see White ironshot
- Irregulari-ornate, iv, viii
- irregularis**, *Sonninia*, Pl. 61; Pl. 98, fig. 6; pp. 320, 389, 417
- iserensis, Ammonites, xvii
- iserensis**, *Denckmannia*, Suppl., Pl. 2, figs. 1, 2, p. xvii
- iserensis, *Lillia*, xvii
- Isosceloid terminal lobe, 364
- Italy, 220, clxx
- Jackson, Dr. R. T., excix
- Jamesoni**, Ammonites, 234, 268, 283; and *Poly-morphites*, Haug's opinion on, 268; *Dumortieria*, as ancestor of *Levesquei*, reasons against, 161
- Jamesoni-zone**, 132, 162, 221, 283
- Java, 454
- Jermyn Street Museum, 258, clxxxii
- Jones, Prof. T. Rupert, and change of names, 286
- Jorquera, Chili, 258
- Judd, Prof. J. W., on Gryphite grit, 91; on locality of *A. Murchisonæ*, lxx
- jugifer, Ammonites, 82
- jugosa**, *Haugia*, Pl. 23, figs. 11-13, p. 149; Suppl., p. xxv
- jugosa*, *Haugia*, Pl. 21, 25, fig. 1 (Pl. 28, figs. 1-3?) p. 149, see **grandis**, *Haugia*
- jugosa*, *Haugia*, x, xi, xii, xxvi; and *H. variabilis*, comparative dimensions, 150

- jugosus*, Ammonites, 149, vii, xi, xxv  
*juncta*, Brodieia, Suppl., Pl. 4, figs. 7-9, p. xxvii;  
 see *junctum*, Brodiceras  
*juncta*, Brodieia, xii  
*juncta*, Reynesella, Suppl., Pl. 17, figs. 4-6, p. cix;  
 Fig. 70, p. clxv  
 Junction Bed, ccix  
*junctum*, Brodiceras, Suppl., Pl. 4, figs. 7-9, p.  
 xxxii (Brodieia *juncta*)  
 Jura, Brauner, 3; Schwarzer, 3; of Berne, 62  
*jurensis*, Lytoceras, 6, 44, 46, 50  
*jurensis*-zone, 6, 50, 51, 114, 163, 221, 222, 223,  
 282, 291, xv  
*jurensis*, Ammonites, 44, 49, 50, 51, 52; as British  
 species doubtful, 50; zone of, 49  
*Jurensis*, Bed, 2; Bett, 2
- Kilian, Prof. W., and Kiliania, lxiv  
 Kiliani, Hiloceras, 112, 116  
*Kiliania*, Suppl., p. lxiv; *armipotens*, \**gallica*,  
*laciniosa*, *tuberala*  
*Kiliania*, clxix; from Paquieria, lxvii; from Wilt-  
 shireia, lxviii; from Ludwigia, lxix; from  
 Lucia, lxxiv; classification, cxviii  
 Knorr, 273  
 Krause, Dr. P. G., Photographs supplied by,  
 cxvii  
*Kurrianum*, Grammoceras, and *fallaciosum*, Gram.,  
 relationship doubtful, 163; descent of latter  
 from former, doubtful, 208  
*Kurrianum*, Harpoceras, 127  
*Kurrianus*, Ammonites, 132, 144, 216; and Poly-  
 plectus *discoides*, suggestion about, 216
- L, 382, xix  
 l, 382  
*La Porcarella*, 220  
*La Verpillière*, xvii, lxxiii, cxli  
*laciniosa*, Kiliania, Suppl., Pl. 15, figs. 4-6; Fig.  
 22a in text, p. lxv  
*laciniosa*, Kiliania, Fig. 22, p. lxiv; see *murchisonæ*,  
*Ludwigia*  
*lævigata*, Ludwigia, Suppl., Pl. 11, figs. 13-15, p.  
 lxxi  
*lævigata*, Sonninia, Pl. 82, figs. 5, 6; Pl. 101, figs.  
 7-9; Pl. 103, fig. 9; pp. 356, 399  
*Lævigata*, iv  
*Lævigatitabulate*, cv
- lævis*, Darellia, Pl. 18, fig. 4, 5, p. 94 (Hyper-  
 lioceras *discites*); Suppl., Fig. 74, p. clxv;  
 Fig. 75, p. cxiii  
 \**læviuscula*, Witchellia, Pl. A, fig. 47  
*læviuscula*, Witchellia, 82  
*læviusculus*, Ammonites, doubtful identification,  
 53; confounded with *Hyperlioceras*, etc., 91  
*Lamellibranchiata*, 45  
 Langheim, ornatus beds of, as locality for Am.  
*mæandrus*, xl  
*lata*, Dumortieria, Pl. 44, figs. 1-3, p. 252 (Dum.  
*radians* var. *exigua*); Suppl., Fig. 183, p.  
 cxvii; p. clxxxiii  
*Latangulate* radial line, cvii  
*Lateral auricles*, Fontannesia, clxxxix  
*Lateral lobules*, 364  
*lataescens*, Dumortieria, Pl. 43, figs. 8-10, p. 259  
 (Dum. *subundulata*, var.); Suppl., Fig. 185,  
 p. cxvii; p. clxxxv  
*Lataescens* series (Dumortieria), clxxxiv, clxxxv  
*Latilobate* (series), lxiv, lxvi  
*Latisellati*, 126  
*Latissept*, 111, cc  
*latum*, *Platygraphoceras*, Suppl., Pl. 20, figs. 19-  
 21; p. xciv  
*Latumbilicate*, v, cxvii  
*Latumbilicate* and catagenetic species, cliv  
 Law of earlier inheritance, see *Inheritance*, earlier,  
 law of  
*laxa*, Reynesia, Pl. 11, figs. 6, 7, p. 23 (*Lioceras*  
*decipiens* var. *intermedium*); Suppl., Pl. 18,  
 fig. 28, p. cxiii  
 Le Bernard, cxxxiv, clxxviii, clxxx  
 Le Moulin Drapeau, cxxxiv  
 Leachii, Cirrus, 7  
 Leckhampton, strata of, cxi  
 Leckhampton Hill, 7, 19, xxxix, lviii, lxvi; rubbly  
 oolite compared, 3; opalinum zone absent  
 (Wright), 7  
*Leda-ovum* beds, Upper, Mr. Thompson's remarks  
 on; date of, xv; date of, ccix  
 Leesberg and Leesbergi, 279  
*leesbergi*, *Catulloceras*, Pl. 39, figs. 10, 11, p.  
 279; p. clxxi  
*Leioceras*, 13, 127; *discoides*, opalinum  
*lenis*, Braunsella, Pl. 7, figs. 5, 6, p. 26 (*Lioceras*  
*ambiguum*); Suppl., Pl. 17, fig. 32, p. cxii  
*lenis*, Braunsia, cii

- Lennieri**, *Dorsetensia*, Pl. 52, figs. 1-3, p. 304 (*Dorsetensia* sp. A) ; p. cxcii
- lepida**, *Reynesia*, Pl. 11, figs. 4, 5, p. 23 (*Lioceras* *decipens* var. *intermedium*) ; Suppl., Pl. 18, fig. 29, p. civ
- Lepsius, 35, 253
- lepta**, *Ædania*, Suppl., Pl. 21, figs. 4-6, p. cviii
- Leptogyral, iii, cxcvii
- Lessbergi, *Dumortieria*, 279 ; *Harpoceras*, 279
- leura**, *Pleydellia*, Pl. 33, figs. 5-10, p. 195 (*Grammoceras* *leurum*) ; Suppl., Figs. 115, 116, pp. clxv, clxvii ; p. cxxxviii
- leurum*, *Grammoceras*, Pl. 33, figs. 5-10, p. 195 ; see **leura**, *Pleydellia*
- leurum*, *Grammoceras*, 222, 223, cxxxviii
- Levesquei, *Ammonites*, 232, 241, 281 ; and *Fontannesia*, clxxxviii
- Levesquei*, *Dumortieria*, Pl. 37, figs. 6-8 ; see **sub-solaris**, D.
- Levesquei*, *Dumortieria*, Pl. 45, figs. 15, 16, sp. **Dumortieria** ; p. 241, see spp. above
- Levesquei, *Dumortieria*, 161, 162, 172, clxxiv, clxxvi ; Haug's descent of, noticed, 161
- Levesquei, *Harpoceras*, 241, 262
- Levigation pronounced (series), ci
- Levisoni, *Ammonites*, 203 ; *Hildoceras*, 112
- Lias, to end with Jurensis zone, Deslongschamps, 4
- Lias, Lower, 230
- Lias and Inferior Oolite, same species of *Ammonites* in, how error caused, 175
- Lias and Oolite, opinions on, 2
- Lias and Oolite division, Wright, 44
- Lias and Oolite, division between, 42
- Lias, Middle, xv, c
- Lias-Oolite division, question of, 2
- Lias-Oolite, xv
- Lias Sands, 3
- Lias, Upper, 4, 7, 44, 46, 47, 48, 133, 168, 173, 175, xii
- Lias, Upper, Clay, Sands, and Cephalopod-beds, same species in, how error arose, 175
- Lias, Upper, Clay of Down Cliffs, note on, 251
- Lias, Upper, Clay and Cotteswold Sands, clvi
- Lias, Upper, Clay and *Dumortieria*, clxxxiii
- Lias, Upper, and Inferior Oolite, cvv
- Lias, Upper, date of, cviii, ceix
- Lias, Upper, Clay, date of, cviii
- Liassic rocks, xl
- liassicum, *Ægoceras*, 232 ; *Caloceras*, 236
- liassicus, *Ammonites*, 201
- Liassien, 173
- lilli, *Ammonites*, 109, vii, ix, xiv
- Lilli hemera, vi, xii, xv, cliv ; strata of, ceix
- lilli**, *Lillia*, Suppl., Pl. 1, figs. 1-6, p. xiv
- Lilli, *Lillia*, 109, vii, ix ; (hemera), ccv
- Lillia**, p. 108 ; Suppl., pp. ix, xiii ; bayani, comensis, iserensis, lilli, *narbonensis*, *sulcata*
- Lillia, 108, 127, 128, 129, 221, clxix ; from *Hildoceras*, 112 ; from *Pœcilomorphus*, 115 ; from *Haugia*, 144 ; characters, vi ; from *Chartronia*, xvi ; from *Denckmannia*, xvii ; from *Haugia*, xxii ; from *Phymatoceras*, xxx ; distinction from *Gammiradiata* species, cxxx ; from *Grammoceras*, cxxxi ; from *Pseudogrammoceras*, cxliii ; classification, cxviii
- Lillia-Haugia series, vi ; species of, vi, vii ; works on, vii ; characters, viii ; classification, ix ; geological position, xi ; Hemerae of, xii ; the non-tuberculate or Eseri group, xxviii
- Lima toarcensis, 45, 46
- limatula**, *Cotteswoldia*, Pl. 30, figs. 5-7, p. 176 (*Grammoceras* *mactra*) ; Suppl., Fig. 106, p. clxv ; p. cxxxiv
- limitatum**, *Pseudographoceras*, Suppl., Fig. 54, p. xcii
- Limestone, Lower, Beds, 7, 43, v
- Limestone, ironshot, xii ; date of, xxxv
- Limestone and Marl beds, date of, ccvii
- Limestone, sandy ferruginous, xxxv ; and see sandy ferruginous beds
- Limestones, upper, date of, ccvi ; above the Clypeus Grit, date of, ccvi
- limitatum**, *Graphoceras*, Pl. 9, fig. 7 ; Pl. 10, fig. 7, p. 68 (*Lioceras* *concauum* var. *v-scriptum*) ; Suppl., Pl. 15, fig. 22, p. xcvi
- linearis**, *Dumortieria*, Pl. 30, figs. 15-16, p. 255 (*Dum. Moorei*) ; Suppl., Fig. 181, p. cxevi ; p. clxxxiii
- lineata**, *Reynesella* ?, Suppl., Pl. 17, figs. 25-27, p. cx
- lineatum**, *Lioceras*, Suppl., Pl. 8, figs. 1-3, p. xl
- lineatus*, *Ammonites*, 253
- Linguiform figures on periphery, cxii
- Lioceras**, p. 21 ; Suppl., p. xxxv ; *ambiguum*, a. var. *costatum*, *apertum*, *bradfordense*, b. var. *giganteum*, *bifidatum*, *concauum*, c. var. *formosum*, c. var. *pingue*, c. var. *v-scriptum*,

- costatum*, *costosum*, *decipiens*, *d. var. intermedium*, *d. var. simile*, *elegans*, *fallax*, *giganteum*, *gracile*, *grave*, *intermedium*, *lineatum*, *opalinum*, *opalinum*, *o. var. comptum*, *partitum*, *pingue*, *plectile*, *plicatellum*, *simile*, *sp.*, *striatum*, *subcostosum*, *thompsoni*, *uncinatum*, *uncum*, *undulatum*, *v-scriptum*
- Lioceras, 12, 14, 127, 129, 223, xlii, xliii, lxxviii, lxxx, xcv; opalinum selected as type of genus, 12; from Ludwigia, 16; from Pseudolioceras, 83; from Hyperlioceras, 89; and Opalinoid Ammonites, xxxiii; history of, xxxiii; the genus, and Opalinoid Ammonites, remarks on, xxxiii; the type of, xxxiv; contrasted with Cypholioceras, xxxiv; definition of (amended), xxxv; literature of; correction of; costate spp. of, xxxvi; costate-striate species of, xxxviii; striate spp. of, xl; renovate spp. of, xlii; foreign spp. of, xliii; from Cypholioceras, xliii; from Ancolioceras, xlvi; from Geyeria, 1; from Depaoceras, lxxvii; from Canavarella, cxxviii; classification, cxviii
- Lioceratan stage, 159
- Lioceratoid genera, from Pseudolioceras, clviii
- Lioceratoid genus, cxxviii
- liodiscites, *Hyperlioceras*, Pl. 17, figs. 1, 2, p. 94 (*H. discites*); *Suppl.*, Fig. 95; Fig. 96, p. clxv; p. cxxv
- liostraca, *Dorsetensia*, Pl. 53, figs. 11-16; Pl. 54, figs. 1, 2; Pl. 55, figs. 3-5; Pl. 56, fig. 1; p. 310
- liostraca group, 308
- liostraca, *Rhynchonella*, 63
- Liparoceras, ontogeny of, 289; capricornum, heterogenum, striatum
- Lissoceras, 14, 295
- Lissoceratidæ, 15
- Lissoceratinæ, 14, 287, 294
- litteratum, *Pseudographoceras*, *Suppl.*, Pl. 11, figs. 19-21, p. xci
- Lithic characters, xvi
- Little Sodbury, 40, 49, 175, xxviii, xxix, lxi, cxlvi, cliii; section, 164; strata at, 166; see Sodbury
- Littoral forms, 454
- Living chamber, absorption of, 312
- Lobe, accessory, 217, 219; archetype, 381; papilioniform, 368; siphonal, in *Amaltheus margaritatus*, 217
- Lobes, development of, 134; siphonal, 217; and saddles, 219; auxiliary, 219; changes in, 381; asymmetry of, etc., 382; skeleton, 443
- Lobules, 364
- Localities, for Polymorphidæ, clxix; foreign, for *Tmetoceras*, clxx
- loculosa, *Sonninia*, Pl. 92, figs. 5-7, pp. 391, 437
- locuples, *Sonninia*, Pl. 50, figs. 16-18 (19-22?) (*S. crassispinata*); Pl. 92, figs. 1-4, pp. 391, 431
- Longitudinal ornament, cc
- Lopadoceras, *Suppl.*, p. xci; *arcuatum*, *euides*, *furcatum*
- Lopadoceras, from *Darellia*, cxiii; classification, cxviii
- lotharingica, *Walkeria*?, Pl. 30, figs. 8, 9, p. 199 (*Grammoceras lotharingicum*); *Suppl.*, Fig. 123, p. clxvii; p. cxl
- lotharingicum*, *Grammoceras*, Pl. 30, figs. 8-10, p. 190, see *lotharingica*, *Walkeria*
- lotharingicum, *Grammoceras*, cxl; *Harpoceras*, 199
- Louse Hill, 34, 62, 67, 73, 103, 104, 120, 121, 266, lii, liv, lxi, lxxxv-lxxxvii, cxxix, clxxxviii, cxi; strata of, cxvii
- Lombardy, 220
- Long Wood, 242, 245, 279
- Lower beds, ccix; date of, cxvii
- Lower Inferior Oolite, ccv
- luculenta, *Fontannesia*, Pl. 46, figs. 4, 5, 8, p. 262 (*Dumortieria grammoceroides*); Pl. 47, figs. 10-12; p. clxxxix
- Lucy, W. C., and Lycett's MS., 37; and *lucyi*, 106; and *Lucya*, lxxiv; collection, lxxv
- Lucya*, *Suppl.*, p. lxxiv; *caduceifera*, *caducifera*, *cavata*, *magna*, *marginata*
- Lucya*, from *Depaoceras*, *Paineia*, lxxiv; from *Paineia*, lxxvi; from *Depaoceras*, lxxvii; akin to *Brasilia*, lxxxii; suggested relationship to carinatitabulate forms, cxiv; classification, cxviii
- lucyi*, *Hyperlioceras*, Pl. 21, figs. 3, 4, p. 104 (*Ludwigia Lucyi*); *Suppl.*, Fig. 91; Fig. 92, p. clxv; p. cxxiii
- Lucyi*, *Ludwigia*, Pl. 21, figs. 3, 4, see *lucyi*, *Hyperlioceras*; Pl. 21, figs. 5, 6, *tabulatum*, *Dissoroceras*; Pl. 21, figs. 7-9, *fallax*, *Depaoceras*; Pl. 21, figs. 10, 11, *caduceifera*, *Lucya*; p. 104, see spp. above

- Lueyi, *Ludwigia*, lxxv, lxxviii, cxv, cxliii  
 Lueyinae, classification, cxviii
- Ludwigella**, p. lxxxiv; *arcitenens*, *arcuata*, *attenuata*, *attracta*, *blanda*, *callosa*, *carinata*, *casta*, *concava*, *cornu*, *flexilis*, *glevensis*, *micra*, *impolita*, *modica*, *nodata*, *opaca*, *rudis*, *rugosa*, *subobsoleta*, *subrudis*, *tenuis*, *vibrata*; classification, cxviii
- Ludwigellæ carinatae*, xc; *compressæ*, lxxxvii; *curvæ*, lxxxviii; *paucicostatae*, lxxxvii; *pingues*, lxxxix; *subrectæ*, xc; *veræ* (series), lxxxv
- Ludwigia**, p. 16; **Suppl.**, p. lxxix; *aalensis*, *ambigua*, *baylii*, *cornu*, *corrugata*, *costosa*, *costula*, *gradata*, *haugi*, *hectica*, *ignobilis*, *lævigata*, *lueyi*, *mactra*, *murchisonæ*, *m. var. baylii*, *m. var. obtusa*, *obtusa*, *opalina*, *rudis*, *sinon*, *sp.*, *tuberculata*
- Ludwigia*, 127, 128, 129, 221, 223, 378, lxxix, lxxiv, lxxxiv; from *Lillia*, 108; from *Hildoceras*, 112; from *Pœcilomorphus*, 115; from *Grammoceras*, 160; from *Rhæboceras*, lxxii; from *Crickia*, lxxviii; and *Hectici*, cxv; classification, cxviii
- Ludwigian Age, ccv
- Ludwigina**, **Suppl.**, p. lxxi; *patula*, *umbilicata*
- Ludwigina*, from *Strophogyria*, lxxii; classification, cxviii
- Lycett, Dr. J., 178, 185, 188, 189, 255, 256; MS. notes by, 37; on thickness of Cephalopoda bed, 42; and *Ammonites opalinus*, 54; on *Am. dispansus*, 211; remarks on *A. Moorei*, clxxxii, clxxxiii; see *Morris & Lycett*
- Lycetti, *Waldheimia*, 165
- Lycettia*, *Explan.* Pl. 52, misprint for *Dorsetensia lympharum*, *Ammonites*, cxix
- Lyncombe, 173, 175; Cutting, section, 165
- lythense*, *Harpoceras*, 127
- lythensis*, for *compactilis*, xxxiii
- lythensis*, *Ammonites*, 12, 85, 87, 155, 195, vii, clviii
- \**lythense*, *Pseudolioceras*, **Suppl.**, fig. 158, p. clxxvii
- lythense*, *Pseudolioceras*, 83
- Lytoceras*, 46; *confusum*, *fimbriatum*, *germaini*, *jurense*, *pygmæum*, *rubescens*, *sigalœn*, *sublineatum*, *torulosum*, *wrighti*
- Lytocerata*, 374, cc
- Lytoceratidæ*, 14
- Lytoceratinae*, 289
- macer*, *Pœcilomorphus*, Pl. 22, figs. 23-29; Pl. A, fig. 33, p. 116
- macrocephalus*, *Ammonites*, 272
- \**macrum*, *Catulloceras*, **Suppl.**, p. clxxiv
- mactra*, *Ammonites*, 176
- mactra*, *Grammoceras*, Pl. 30, figs. 3, 4, see *mactra*, *Pleydellia*; Pl. 30, figs. 5-7, *limatula*, *Cotteswoldia*; Pl. 31, figs. 1, 2, *fluens*, *Pleydellia*; Pl. 31, figs. 3, 4, *crinita*, *Cotteswoldia*: p. 176 see spp. above
- mactra*, *Grammoceras*, 164, 222, 284, cxxxiv, cxxxvii, cxxxix; a polygenetic series, 257; *Harpoceras*, 176, 255; *Ludwigia*, 176
- mactra Pleydellia*?, Pl. 30, figs. 3, 4, p. 176 (*Grammoceras mactra*); **Suppl.**, Fig. 119, p. clxxvii; p. cxxxix
- mactra-subserrodens*, *Grammoceras*, 222
- mæandrus*, *Ammonites*, xl; *Nautilus*, xxxvi, xl; N., discussion of, xl
- Maes Knoll*, *Dundry*, cxlvi, cxlviii, clxxix; strata of, ccvi
- Maggs*, T. C., collection, 108, 247; and *Cosmogyrria Maggsi*, liv
- Maggsi**, *Cosmogyrria*?, **Suppl.**, Pl. 10, figs. 23-28, p. liv
- magna*, *Lucya*, Pl. 6 (*Lioceras concavum*, var. A.); p. 68 (*L. concavum* var. v-scriptum); **Suppl.**, Fig. 32 in text; p. lxxxvii
- Magnilobate* (series), lxiv
- magnispinata*, *Sonninia*, Pl. 76, figs. 1-6; Pl. 98, figs. 1-3; Figs. in text, 17, p. 388; 43, p. 412; 69, p. 443; pp. 341, 413
- Magnispinata stock*, 341
- malagma*, *Ammonites*, 225, vii, x, xxi
- malagma*, *Denckmannia*, **Suppl.**, Pl. 4, figs. 1-3 p. xx
- Malformation*, 75
- Mansel-Pleydell*, J. C., and *Manselia*, lviii; and *Pleydellia*, cxxxvii
- Manselia**, **Suppl.**, p. lviii; *subacuta*, *subfalcata*, *trichina*
- Manselia*, classification, cxviii
- Mapperton*, xlvi, li, lxiii, lxiv
- \**margaritatus*, *Amaltheus*, Pl. 49, figs. 1, 2; p. 288
- margaritatus*, *Amaltheus*, 287, 291; suture line of, 217; zone, 133, 163, 283, 291
- marginata*, *Lucya*, Fig. 31 in text, p. lxxxv

- marginata*, *Sonninia*, Pl. 62; Pl. 63, fig. 2; Pl. 65, figs. 1, 2; Pl. 96, fig. 6; pp. 321, 387, 407  
*marginata*, *Sonninia*, Pl. 61, p. 321, see *regularis*, *Sonninia*
- marginata*, *Sonninia*, 395
- Marl, argillaceous, 167
- Marl Bed, 5; date of, *cevi*; with green grains, 292
- Marl Beds, limestone and, date of, *cevii*
- Malière, 64
- marmorea*, *Stokeia*, Suppl., Pl. 22, figs. 13-15; Fig. 99, p. clxv; p. cxxviii
- Marston Road, 275, lix, lxi; strata of, *cevii*
- Martinsii*, *Perisphinctes*, 10, 272
- Mascke, E., remarks on *Dumortieria radiosa*, clxxx
- Masseanum, *Harpoceras*, 13
- Masseanus, *Ammonites*, 14
- Matrix, variation of, advantage in noting it, 106; value of, greater than labels, 106; method of removal of, 413
- maxillata*, *Terebratula*, *hemera*, *cevi*
- May-sur-Orne, lxxviii, lxx, lxxi, lxxiv
- Mayer, C., 80, 228, lv, cxv
- Measurements, how taken, cxvii
- Mediterranean, 220; abundance of *Hammatoceras* near, 452; borders, xiii
- Mendip axis, and Dorset-Somerset basin, 249; and separation, clxxxviii
- Mendips, 167
- Meneghini, Prof. G., 112, 138, 170, 182, 189, 203, 204, 215, 216, 281, vii, viii, x, xi, xii, xviii
- Meneghini, *Catullocceras*, 281
- Mercati, *Ammonites*, 115, 136; *Pœcilomorphus*, 116
- Mercati-group, xiii
- metallarium*, *Grammoceras*, Pl. 36, figs. 1, 2, p. 210, see *metallarium*, *Phlyseogrammoceras*
- metallarium*, *Phlyseogrammoceras*, Pl. 36, figs. 1, 2, p. 210 (*Grammoceras metallarium*); Suppl., p. clv
- metallarius*, *Ammonites*, 210
- Metamorphosis, 235
- Metaplasia, 357
- metita*, *Dumortieria*, Pl. 42, figs. 11, 12, p. 248 (*Dum. radians*); Suppl., Fig. 173, p. cxvii; p. clxxxviii
- Micaceous Sands, 166, 167
- micca*, *Hugia*, Suppl., Pl. 21, figs. 28-30, p. cxi
- micra*, *Ludwigella*, Suppl., Pl. 19, figs. 7-9, p. lxxxix
- Microderoceras*, 129
- Middle Inferior Oolite, *cevi*
- Middle Lias, xv; species by mistake from, c
- Middle Ragstones, *ceix*
- Midford, *Parkinsoni* zone at, 51; sands at, 113; strata of, *cevi*
- Midford Sands, 3, 50, 51, 113, 167, 173, 175, 213; to include Yeovil and Cotteswold Sands, Woodward, 50; difficulty in correlation, 50; position of, 113; section, 165; contents, etc., of, 166; (G 4), *cevi*; date of, *ceviii*, *ceix*
- Milborne Wick, 120, 305
- Milhan, 208, 215, 216, 218, 219, 220, xvii, clxviii, clxix
- Miller, 341
- mirabile*, *Graphoceras*, Suppl., Pl. 15, figs. 12-14, p. cxvii
- misera*, *Cotteswoldia*, Pl. 31, figs. 15, 16, p. 192 (*Grammoceras aalense*); Suppl., Fig. 108, p. clxv; p. cxxxxv
- miserabile*, *Agassiceras*, 232, 268
- miserabilis*, *Ammonites*, 289
- Missing link, 64
- Misterton, 19, 40; strata of, *cevii*
- modesta*, *Sonninia*, Pl. 68; Pl. 95, figs. 3-5; Pl. 96, figs. 1, 2; Pl. 103, fig. 5; Figs. in text, 23, p. 390; 49, p. 420; 75, p. 443; pp. 325, 422
- modica*, *Ludwigella*, Suppl., Pl. 19, figs. 37-39, p. xci
- Modifications, 289
- Moericke, W., remarks on a paper by, 452
- Moesch, 89, 97
- Monk, xc, cxvi
- Moore, Charles, and Am. Moorei, 256
- Moorei, *Ammonites*, 38, 246, 253, 255; Lycett on, 37, clxxxii; confusion about, 178; remarks concerning original specimen of, 256
- Moorei beds, 164, 166, 167
- Moorei and Opalinum beds, *Ammonites* of, probably absent from Yorkshire, 167
- moorei*, *Dumortieria*, Pl. 44, fig. 9, p. 255; Fig. 179, p. clxxxii
- Moorei*, *Dumortieria*, Pl. 30, figs. 15-17, see *sublinearis*, D.; Pl. 30, fig. 19, *subexcentrica*, D.; Pl. 41, figs. 4-6, see *sp.*, D.; Pl. 44, figs. 7, 8, *subexcentrica*, D.; p. 255, see spp. above

- Moorei, *Dumortieria*, 164, 176, 177, 178, clxxxii, clxxxiii
- Moorei, *Dumortieria*, *hemera*, cv
- Moorei, *Grammoceras*, 44, 52, 54; *Harpoceras*, 5, 6, 7, 37, 255
- Moorei *hemera*, vi; strata of, cviii
- Morieri, *Terebratula*, 5
- Morphogenesis, *cei*; septal, *ceii*
- Morphic equivalent, *cii*
- Morphic equivalents, 444; necessity of comparing, 382; table of (Table 10), 449
- Morphic prefiguration, *ceiii*
- Morphic representation, *ce*, *ceiii*
- Morpho-, as prefix, 357
- Morphoceras, mode of growth compared, 263; expansion of umbilicus, *ceii*; dimorphism
- Morphogenesis, 357
- Morphogenetic acme, *ceii*
- Morphogeny, *ce*
- Morphological equivalence, ease of, 295
- Morphological equivalents, 334, 339
- Morphological prefiguration, 315
- Morphological representation, 315
- Morris & Lycett, entombment of *Ammonites*, 446, 454
- Moulton, xv, xviii; strata of, *ceix*
- Mouth-border, 264, 454
- Mouth-borders figured, xxxiv
- Mouth-processes, 455
- Muelleri, *Ammonites* (*Harpoceras*), 209
- Muelleri*, *Grammoceras*, *Pl. 34*, *figs. 8, 9*; *Pl. 35*, *figs. 1-3*, p. 209, see *muelleri*, *Pseudogrammoceras*
- Muelleri, *Grammoceras*, 222, *eli*
- muelleri*, *Pseudogrammoceras*, *Pl. 34*, *figs. 8, 9*; *Pl. 35*, *figs. 1-3*, p. 209 (*Grammoceras* *Muelleri*); *Suppl.*, *Figs. 148*; 149, p. clxvii; p. *eli*
- multicostata*, *Dumortieria*, *Suppl.*, *fig. 168*, p. clxxvi
- multicostata*, *Sonninia*, *Pl. 86*, *figs. 1-3*; pp. 388, 410
- multispinata*, *Sonninia*, *Pl. 50*, *figs. 11-13*; *Pl. 103*, *fig. 3*; pp. 317, 390, 425
- multispinata*, *Sonninia*, 314, 315
- Multispinous stage, 288; examples of, 289
- Multituberculation, *ce*
- munda*, *Dumortieria*, *Pl. 44*, *figs. 10-12*, p. 259 (*Dum. subundulata* var.); p. clxxxvi
- mundum*, *Haplopleuroceras*, *Pl. 51*, *figs. 11, 12*, p. 302
- mundum*, *Toxolioceras*, *Suppl.*, *Pl. 18*, *figs. 4-6*, p. cxxvi
- Munier-Chalmas, 447, 452
- munieri*, *Dumortieria*, *Pl. 37*, *figs. 14, 15*, p. 237 (*Dum. costula*); *Suppl.*, *Fig. 167*, p. cxevi; p. clxxv
- Munieri*, *Dumortieria*, 188, 237; *Harpoceras*, 237, clxxv
- Murchisonæ*, *Ammonites*, 17, 47, 48, 53, 127, 227, xxxv, lxx, lxxii, lxxiii
- Murchisonæ* bed, 2
- Murchisonæ*, *Harpoceras*, 8, 17, 53
- Murchisonæ hemera*, vi, xxxv; strata of, xxxv, *cevii*
- Murchisonæ*, *Hildoceras*, 17, xxxvi
- Murchisonæ*, *Ludwigia*, *Pl. 2*, *figs. 1, 2, 5*; *Pl. 3*, *figs. 1, 2*; *Pl. A*, *fig. 8*, pp. 17, 124; *Suppl.*, *fig. 22*, p. lxiv (*Kiliania laciniosa*); *fig. 26*, p. lxix; p. lxx
- Murchisonæ*, *Ludwigia*, *Pl. 1*, see *obtusiformis*, *Welschia*; *Pl. 2*, *figs. 3, 4*, see *pinax*, *Strophogyria*; *Pl. 3*, *fig. 3*, see *patula*, *Ludwigina*; p. 17, see spp. above
- Murchisonæ*, *Ludwigia*, 16, 18, 65, 108, 128, 227, li, lxxi, lxxxiii
- Murchisonæ*, *Ludwigia*, in *Opalinum* zone, 102 = *undatum*, *Cylicoceras*
- Murchisonæ*, *Ludwigia*, *hemera*, *cev*
- Murchisonæ acutus*, *Ammonites*, 22, lix
- Murchisonæ falcatus*, *Ammonites*, lxxxiii
- Murchisonæ intra-lævis*, *Ammonites*, lxi
- Murchisonæ obtusus*, *Ammonites*, 17, liii, lxvi
- Murchisonæ planatus*, *Ammonites*, 31
- Murchisonæ* var. *Baylii*, *Ludwigia*, *Pl. 3*, *figs. 6, 7*, p. 18, see *Baylii*, *Brasilina*
- Murchisonæ*, var. *bradfordiense*, *Harpoceras*, 22
- Murchisonæ* var. *obtusata*, *Ludwigia*, *Pl. 3*, *figs. 4, 5*, p. 17, see *tuberculata*, *Ludwigia*
- Murchisonæ* zone, 3, 4, 6, 7, 63, 221, 223, 282, 291, 292; found in Dorset, 8; spp., showing its presence in Dorset, list, 8; thickest at Corton Downs, 10; and *Opalinum*, intimate connection at Symonsbury Hill, 274
- Museum, of Geological Survey, 178; of Practical Geology, 255, 256, 376; see Bristol, British, Jernyn Street, etc.

- mutans, *Dumortieria*, Pl. 40, figs. 3-8, p. 243  
(*Dum. striatulo-costata*, var.); **Suppl.**, Fig. 170, p. cxcvi; p. clxxvii
- mutans, *Sonninia*, Pl. 91, figs. 4-6, pp. 387, 414
- Mutation, 100, 289
- Nailsworth, 107, xxi, xxxiii; strata of, ccix
- nannodes, *Asthenoceras*, Pl. 33, figs. 13-16, p. 213  
(*Grammoceras nannodes*); **Suppl.**, Pl. 11, fig. 28, p. xlix
- nannodes, *Grammoceras*, Pl. 33, figs. 13-16, p. 213;  
see nannodes, *Asthenoceras*
- nannodes, *Grammoceras*, xlix
- narbonensis, *Lillia*, **Suppl.**, Pl. 2, figs. 3, 4, p. xiv
- narbonensis, *Lillia*, ix
- Nautilus, 48, cci; dead shells of, dispersal of, 454, 455; clausus, comptus, costula, mæandrus, opalinus, radians
- navis, *Ammonites*, vii, ix, x, xxii
- Navis group, xxii
- navis, *Haugia*, **Suppl.**, Pl. 2, figs. 5-7, p. xxii
- navis, *Trigonia*, bed, 2; zone of, 49; beds, 258
- Neanic, 357
- Neumayr, 13, 14, 225, 269, 287; on Classification of *Ammonites*, 11
- Neumayria, 14
- New Duston, 40, 55; reason for name, 52; see Duston, Old Duston
- Newton, E. T., 178, 376, clxi; suture line of *Am. Moorei*, 178; on *A. Moorei*, 255, 256, 258
- Newton, Surgeon-Major Isaac, clxi
- Nibley, strata of, ccix; see North Nibley
- Nibley Knoll, 86; section of, 46; correlation, 166
- Nicklès, Prof. R., and tracing septa, 380
- Nilssoni, *Phylloceras*, 301
- niortense, *Strenoceras*, hemera, ccv
- niortensis, *Ammonites*, 10, 270, 272, clxx; *Parkinsonia*, characters of, as compared to *Tmetoceras*, 270; *P.*, specialised development of *Park. garantiana*, 271; hemera, vi
- nitens, *Paineia*, **Suppl.**, Fig. 33, p. lxxvii
- nitescens, *Grammoceras*, cxxxi; *Harpoceras*, cxxxi
- nodata, *Ludwigella*, **Suppl.**, Pl. 19, figs. 34-36, p. xc
- nodata, *Sonninia*, Pl. 89, figs. 1-5; pp. 369, 387, 407
- Nodate stage (*Æcotraustes*), cxcv
- Nodi, 357
- Nodicostæ, 357
- Nodicostate, 357, 405
- nodifer, *Æcotraustes*, Pl. 20, figs. 13, 14 (*Æ. conjungens*); **Suppl.**, Fig. 191, p. cxcvi; p. cxcv
- nodosus, *Cirrus*, 7
- Nodules, 44, 45, 47
- Nodular Bed, 293
- Nodular shale, date of, ccix
- Nodus, 405, iii
- Nomenclature, 315; rules of, 15; British Association Committee on hybrid names, 276; on generic names, 284
- Non-septicarina, iv
- Non-septicarinata (*gammiradiata*), cxxxi; (series), cxx, clvi, clvii
- Non-septituberculate, iv
- Non-tuberculate group, xxviii; (series), cxliii
- norma, *Polymorphites*, 267, 268, 269, 284
- Normal variation, 289
- Normandy, 8, 9, 62, 120, clxx, clxxi, clxxii, clxxiv, cxcii; strata, 64; and *Sonniniæ*, 452; species of *Lioceras*, xliii; strata of, ccvi
- normannianum, *Grammoceras*, 163, 189
- normannianus, *Ammonites*, 132
- North Coker, lxxxv
- North Cotteswolds, 64
- North Dorset, 61, 324
- North Nibley, 40, 55, 87, 88, 151, 153, 158, 173, 181, 196, 199, 209, 213, 220, 231, xxiii, xxiv, xxvi, xxvii, xxviii, xxix, xxxi, xxxii, clviii, clix, clx; a species from, described, clxi
- North Germany, 96
- North Oxfordshire, 40
- North Sea, 456
- North Stoke, xxvi, clxxxv; strata of, ccvi, ccviii
- Northampton, xl; district, section, 47
- Northampton Sand, 48, 52
- Northampton Sands, 168; section, 48; represent *Opalinum* zone, 168; for *Tmetoceras*, clxx; date of, ccvii
- Northamptonshire, 40, 53, 55, xv, xviii, xl, clxx; remarks on strata of, xv; Liassic rocks, xl; strata of, ccvii, ccix
- Notgrove Freestone, date of, ccvii
- Notgrove Station, 9
- novata, *Dumortieria*, **Suppl.**, Fig. 163, p. clxxiii

- nuda, *Sonninia*, Pl. 82, figs. 3, 4; Pl. 103, fig. 10; pp. 352, 386, 402
- \*nudus, *Amaltheus*, Pl. 49, fig. 3. p. 288
- nudus, *Amaltheus*, 287
- Numerical acme, excix
- obesum, *Pseudogrammoceras*, Suppl., Fig. 146, p. cl
- Oborne, 117, 120, 292, 304, 305, 306, 309, 310, 312; section at, 8; strata of, 10, ccvi; see Frogden Quarry
- obruta, *Fontannesia*, Suppl., Pl. 24, figs. 8-11, p. clxxxix
- Obsoleticarinata, note on, xciv
- obtecta, *Denckmannia*, Suppl., Pl. 4, figs. 4-6, p. xxi
- obtecta, *Denckmannia*, x
- obtusa, *Cosmogyrria*, Suppl., Pl. 4, figs. 10-12 d, p. liii
- obtusiformis, *Sonninia*, Pl. 72, figs. 3-5; Pl. 90, fig. 10 (Pl. 85, figs. 7, 8<sup>?</sup>); Figs. in text, 27, p. 391; 53, p. 428; 79, p. 443; pp. 333, 430
- obtusiformis, *Welschia*, Pl. 1, p. 17 (*Ludwigia Murchisonæ*); Suppl., Pl. 4, fig. 19; Pl. 12, figs. 1-3 a; p. li
- obtusum, *Asteroceras*, morphological equivalent, 334
- obtusus, *Ammonites*, 226
- occidentale, *Hammatoceras*, 154; *Harpoceras*, 154
- occidentalis, *Ammonites*, 144
- occidentalis, *Haugia*, Pl. 27, figs. 1, 2, p. 154; Suppl., p. xxviii
- occidentalis, *Haugia*, 165
- occlusum, *Hyperlioceras*?, Suppl., Pl. 21, figs. 34-36
- Œcotraustes*, p. exciv; *conjungens*, *costiger*, *nodifer*, *rugosus*
- Œcotraustes*, 140
- Œdania*, Suppl., p. cvii; *delicata*, *falcigera*, *inflata*, *lepta*, *parvicostata*
- Œdania*, classification, excviii
- Œkotraustes*, exciv
- Ogerieni, *Ammonites*, 149, 152, vii, x, xi, xxiv, xxv; *Hammatoceras*, 148, 287, 313, x, xxiii; *Hammatoceras* (*Sonninia*), 149
- ogierieni, *Haugia*, Suppl., p. xxiv
- Ogerieni*, *Haugia*, Pl. 23, figs. 16, 17, see *Dumortieri*, *Phymatoceras*
- Ogerieni, *Haugia*, 46, 152, xxx
- Old age affecting carina, cvi
- Old Duston, 52; stonepit, section at, 48; Northampton Sand, 52; see Duston
- Oligogyral, ii
- omphalica, *Sonninia*, Pl. 83, figs. 5-9; pp. 363, 387, 405
- Omphalica stock, separation of species in, 362
- Ontogeny, Hyatt's scheme of stages, 357; terms of, 357; six stages of, 357; not repeating phylogeny, causes of, 290; and phylogeny, excix; events in, ccii
- Oolite, Great, 47
- Oolite, ironshot, date of, ccvi
- Oolite, from Lias, 5; see Inferior Oolite, Lias-Oolite division
- Oolite Marl, 7, 65; date of, ccvii
- Oolite Sands, 3
- oolitica, *Rhynchonella*, 43
- opaca, *Ludwigella*, Suppl., Pl. 19, figs. 19-21, p. xc
- opalina, *Ludwigia*, 35
- Opalini hemera, change of name, xlv
- opaliniforme, *Cypholioceras*, Pl. 13, figs. 1-3; Pl. A, fig. 10, p. 35 (*Lioceras opalinum*); Suppl., Pl. 10, figs. 1-4, p. xlv; figs. 1, 3, p. xxxiv
- aff. opaliniforme, *Cypholioceras*, Suppl., p. xlvi
- opaliniforme, *Cypholioceras*, hemera, ccv
- Opaliniformis hemera, vi, xlvi; strata of, xxxv, ccviii
- Opalinoid *Ammonites*, position of, clxxxiii; species, xxxv
- opalinoïdes, *Ammonites*, 228, xxxiii; type chosen, 80, 228
- Opalinum beds, 164, 166-168
- opalinum, *Harpoceras*, 4, 13, 35, 53, 127, xxxvi, xlii, xlvi; *Lioceras*, 35
- opalinum, *Lioceras*, Suppl., Pl. 10, figs. 6-8; fig. 2, p. xxxiv; p. xli
- opalinum*, *Lioceras*, Pl. 13, figs. 1-3, see opaliniforme, *Cypholioceras*; Pl. 13, figs. 4, 5, sp., *Canavarina*; Pl. 13, fig. 6, *striatum*, *Lioceras*; Pl. 13, figs. 7-10, *subglabra*, *Walkeria*; Pl. 13, fig. 12, *striatum*, *Lioceras*; p. 35, see spp. above

- opalinum, *Lioceras*, 12, 13, 21, 43-52, xxxv, xxxix, xli, xlii, xlv, cxxx, cxli, cxliii; selected as type of genus, 12; correction, xli; confounded with *Cypolioceras opaliniforme*, xlv
- Opalinum zone, 2, 4-7, 43, 45, 46, 51, 52, 53, 163, 166, 222, 223, 282, 291; localities where found, fossils of, 10; geology of, 41; occurrence in several countries, 53
- opalinum*, var. *comptum*, *Lioceras*, *Pl. 13, fig. 11*, see *partitum*, *Lioceras*; *Pl. 11, figs. 1, 2, sp., Lioceras*; *Pl. 11, figs. 3, 4, partitum, L.*; *Pl. 11, figs. 5, 6, plicatum, Cypolioceras*; *p. 53*, see spp. above
- Opalinum, var. *comptum*, *Harpoceras*, 54
- Opalinus, remarks concerning mistaken identification of, xli; *Ammonites*, 14, 35, 47-53, 127, 255, xxxvi, xli, clxxxii; *Am.*, *Quenstedt's* confusion about, xxxv
- opalinus, zone of, 49, 51
- Opalinus beds, necessity for correction concerning, xxxv; term rejected, xxxv
- opalinus, *Nautilus*, 35, xxxvi, xli
- opalinus costosus, *Ammonites*, 102, xxxvi, xxxviii
- Ophioceras, 13, 201, 232, 233
- Opis, 45
- Oppel, Dr. A., 2, 17, 49, 87, 117, 146, 155, 156, 170, 173, 189, 192, 205, 304, 306, vii, viii, xvii, xviii, xxix; on *Jurassic* Rocks, 2; his zones, 49; *Am. jurensis*, 51; mistake about carina, 156
- Oppelia, 14, 40, 140, 217, 295; not derived from *Arietites*, 130; discus
- Oppelidae, exciv; radial lines, excvi
- Opposite lateral lobules, 364
- Orbigny, A. d', 9, 17, 55, 60, 86, 117, 121, 124, 146, 148, 153, 169, 170, 184, 188, 192, 215, 217, 219, 241, 304, 305, 309, vii, viii, x, xxiii, xxvii, cxxxii, cxxxvii; on subdivision of *Ammonites*, 10; on *Am. primordialis*, 55; on *Am. concavus*, 60, 86; on *Am. eadomensis*, 120; on *Am. cycloides*, 124; and *Am. radians*, 187; and *A. discoides*, 217
- Orbignyi*, *Grammoceras*, *Pl. 27, figs. 3-6, p. 184*, see *orbignyi*, *Phlyseogrammoceras*
- Orbignyi, *Grammoceras*, 183, clv
- orbignyi, *Phlyseogrammoceras*, *Pl. 27, figs. 3-6, p. 184* (*Grammoceras Orbignyi*); *Suppl.*, *Fig. 135, p. clxvii*; *p. clv*
- Ornament, importance of character of, i; manner of, not the kind important, ii; (test), excix; acme, cc; intersection of, cc; longitudinal, cc; transverse, cc; elaboration, acme of, cc; longitudinal examples of, cci; on periphery, cci
- Ornaments, 270
- Ornamentation, iv; as criterion of affinity, ii
- Ornate, iv, viii; see also *crassornate*, *inaequiornate*, *irregulari-ornate*, *levigate*, *parviornate*, *regulari-ornate*
- Ornatilobate, v
- Ornatus beds, xl
- Orthoceras, cci, ccii
- Ostreae, 455
- Otley Hill, 40, 52; strata of, ccvii
- Outcoiling, clv
- ovalis, *Sonninia*, 315
- ovatum, *Grammoceras*, 163
- Overbury, clvi, clxi
- ovum, *Leda*, upper beds of, date of, xv
- Oxford, 53
- Oxford Clay, 131, 133, xl
- Oxfordshire, 52, ccvii
- Oxynoticeras, 45, 225, 226; *discoides*, *oxynotum*; from *Hudlestonia*, 225
- Oxynotoceras; *oxynotus*
- oxynotum*, *Oxynoticeras*, 227, 230
- oxynotus*, *Ammonites*, 226; *Oxynotoceras*, xl
- Oysters, 43
- pachu, *Pseudogrammoceras*, *Pl. 34, figs. 1, 2, p. 203* (*Grammoceras Samanni*); *Fig. 147, p. clxvii, p. cli*
- Pachygyral, iii, excvii
- pagana, *Welschia*, *Pl. 12, figs. 5-7, p. 25* (*Lioceras bradfordense* var. *giganteum*); *Suppl. Pl. 11, fig. 32, p. lii*
- Paine, Dr. T., and *Paineia*, lxxvi
- Paineia*, *Suppl.*, *p. lxxvi*; *nitens*
- Paineia*, from *Lueya*, *Depaoceras*, lxxiv; classification, excviii
- Painswick, 94, 96, 100
- Paleontological horizons, confusion, xv; phenomena, xii
- Paleontology, 10; geological importance of correctness in, 342; confusion and difficulty caused by incorrect, 342; geology marred by "sufficiently near" identification, 342

- palmata*, *Sonninia*, Pl. 90, figs. 7-9; Figs. in text, 15, p. 388; 41, p. 411; 67, p. 443; pp. 372, 412
- Palmate, 374; Professor Blake's use of, 374
- Paltoleuroceras, *eci*; *spinatum*
- papilionacea*, *Sonninia*, Pl. 90, figs. 1-3; Figs. in text, 5, p. 384; 31, p. 394; 57, p. 443; p. 367
- Papilioniform superior lateral lobe, 368
- Papilla, iii
- Paquier, V., and Paquieria, lxvi
- Paquieria*, Suppl., p. lxvi; *angulata*, *floccosa*
- Paquieria, classification, cxviii
- Paracme, 357
- Parallela, cxviii
- Parvicarinate, xev; (series), xev
- Paris Basin, 249
- Parkinsoni beds, cxix
- Parkinsoni, *Cosmoceras*, 10
- Parkinsoni zone, 4, 6-8, 46, 51, 165; places where found, thickness of, 10; at Halfway House, fossiliferous, 10
- Parkinsonia, 269, 272; *Caumonti*, *difalensis*, *dorsetensis*, *garantiana*, *niortensis*, *sutneri*, *veneris*
- Parkinsonia, specialised development of *Stephanoceras*, 271; ontogeny of, 271; derived from a pettos-Blagdeni radical, 271; periodic constrictions of, 272
- Parkinsonian Age, ccv
- particostata*, *Cotteswoldia*, Suppl., Pl. 23, figs. 5-7; p. cxxxiii
- Partition band, 81, xvi
- partitum*, *Lioceras*, Pl. 13, fig. 11; Pl. 14, figs. 3, 4, p. 55 (*L. opalinum* var. *comptum*); Suppl., Pl. 9, figs. 4-6; p. xxxix
- Parvicarina, iv
- Parvicarinate, cvi; (series), cvi
- parvicostata*, *Ædania*, Suppl., Pl. 21, figs. 7-9 a; p. cviii
- parvicostata*, *Sonninia*, Pl. 74, figs. 2, 3; Pl. 75, figs. 3-5; Figs. in text., 7, p. 385; 33, p. 395; 59, p. 443; pp. 339, 396
- Parvicostate, iii
- Parvilobate (series), lxiv
- Parviornate, viii
- parvispinata*, *Zurcheria*, Pl. 49, figs. 18-20; Pl. 50, figs. 1-3; p. 296
- parvispinata*, *Zurcheria*, 381
- Parvituberculate stage, clxix
- parvula*, *Rhynchonella*, 5
- patella, *Hammatoceras*, 13
- patellaria*, *Apedogyria*, Suppl., Pl. 14, figs. 3-5; fig. 16, p. lix
- patelliformis*, *Haugia*, Suppl., Pl. 3, figs. 1-3, p. xxv
- patelliformis*, *Haugia*, x
- Pathological cases, 289
- patula*, *Ludwigina*, Pl. 3, fig. 3, p. 17 (*Ludwigia Murchisonæ*); Suppl., Pl. 14, figs. 7, 8; Fig. 17 in text; p. lxi
- paucicostata*, *Cotteswoldia*, Suppl., Pl. 23, figs. 1-3; p. cxxxiii
- Paucicostate, iii; (series of *Dumortieria*), clxxii; stage, absence of, clxxii; to costate (series of *Dumortieria*), clxxvi
- Paucicostata*, xev
- paucinodata*, *Sonninia*, Pl. 91, figs. 7-9; pp. 370, 387, 408
- paucinodata* stock, 368
- pauciseptata*, *Dumortieria*, Suppl., Fig. 165, p. clxxv
- Pauciseptate, v
- pauper*, *Phymatoceras*, Suppl., Pl. 3, figs. 7-9; p. xxxi
- pauper*, *Phymatoceras*, xi
- Paucituberculate, ix
- Paving Bed, 19, 62, 214; date of, ccvii; of Bradford Abbas, for *Tmetoceras*, clxx
- Pea grit, 3, 7; date of, ccvii; of Brockhampton, lxvi; series, 43, 65, xxxv
- Peak, 173, 188
- pedicum*, *Pseudogrammoceras*, Suppl., Fig. 140, p. cxlvii
- Pedigerous, 405
- Pelagic forms, 454
- Pelecoceras*, 13, 119, 180, 225; *attenuatum*, *affine*, *Fridericii*, *serrodens*, *sinon*; from *Hudlestonia*, 225; Hyatt's remarks on, 225, 226
- penestriatulum*, *Grammoceras* Pl. 28, figs. 16, 17, p. 173 (*Grammoceras striatulum*); Suppl., p. cxxxii
- Penetabulate, cvi
- penexigua*, *Dumortieria*, Pl. 42, figs. 3-5; p. clxxxii

- Penn Wood, 153, 229, 231, 239, 251, 252, 253, 275, 281, xlii, clxix, clxxi, clxxii, clxxiii, clxxvii, clxxviii, clxxix, clxxv, clxxxvi, clxxxvii
- Penn Wood, strata of, cviii
- Pentacrinites, 43
- Per-, use of, cxvii
- Perangustumbilicate, cxvii
- peregrinus, Polymorphites, 234
- Periodic constrictions, 263
- Peripleral projection, loss of, lxxii
- Periphery, nomenclature for, iv; fastigation of, in relation to development, lxxvii; carinatitabulate, cv; degrees of tabulation of, cvi; carinatitabulate, polyphyletic, cxv; ornament on, cc; subtabulate (division), lxxvi; tabulate (division), lxxv; angulate, cci; carinate, cci; carinatisulcate, cci; tuberculate, how produced, cci
- Perisphinctes, 14, 256, 272; Davidsoni, Martinsii, procerus; and Parkinsonia, 272; polygenetic origin of, 272; descended from coronate radical, 272; as senile development of Stephanoceras, 272
- Perlatumbilicate, cxvii
- Perleptogyral, cxvii
- perovalis, Terebratula, 8
- Perpachygyral, cxvii
- Perplatygyral, cxvii
- Perroudi, Ammonites, clxxii; Catulloceras, 277, 281, 282, 285
- Perstenogyral, cxvii
- pertinax, Hammatoceras, 294, 297
- pertinax, Zurcheria, Pl. 49, figs. 21, 22; p. 297
- pettos-Blagdeni, Ammonites, 271, 272
- Phenomena of development, cxix
- Phillips, Professor J., 241, clxxiv
- Phillipsiana beds, ccix; date of, cevi
- Physeogrammoceras, p. cliv; dispansum, metalarium, orbigny
- Physeogrammoceras, classification, cxviii
- Photography, example of incorrectness of, 320; applied to suture lines, 380; errors of, 380
- Phylembryonic, 357
- Phylephebic, 357
- Phylhypostrophic, 357
- Phylloceras, 119; cycloides, heterophyllum, milsoni, subcarinatum, trifoliatum, ultramontanum
- Phylo-, as prefix, 357
- Phylobreptic, 357
- Phylocatabatic, 357
- Phylocatagenesis, cci, ccii
- Phylogenetic series, 295
- Phylogeny, ccii; not repeated in ontogeny, causes of, 289; terms of, 357; stages of, how distinguished by terms, 357; and ontogeny, cxix
- Phylogerontic, 357; stage, lxiv
- Phyloneanic, 357
- Phylseogrammoceras, cliv (misprint), see Phylseogrammoceras
- Phymatoceras**, p. 108; **Suppl.**, pp. xi, xxx; **dumortieri**, **pauper**, **robustum**, **tirolyense**
- Phymatoceras, 13; from Brodieia, xxxi; from Phylseogrammoceras, clv; classification, cxviii
- Phymatoidæ, 13, 15
- pingrum**, **Cypholloceras**, **Suppl.**, **Pl. 5**, figs. 3, 4; p. xlv
- Pilæ, Hyatt on, 233
- pinax**, **Strophogyria**, **Pl. 2**, figs. 3, 4 (*Ludwigia Murchisonæ*); **Suppl.**, **Fig. 21**, p. lxiii
- Pingua, cxviii, cxlix
- pinguis**, **Brasilia**, **Pl. 12**, figs. 1-3, p. 66 (*Lioceras concavum* var. *pingue*); **Suppl.**, **Fig. 42** in text, p. lxxxii
- piodes**, **Reynesella**, **Pl. 16**, figs. 7-9, p. 92 (*Hyperlioceras Walkeri*); **Suppl.**, **Pl. 18**, figs. 24, 25; p. cix
- Pipley Bottom, xxvi
- Pisolite beds, 3
- Pisolite character absent, lxvi
- Pisolitic beds, conditions, 3
- pisolithica, Terebratula, 43
- placidum**, **Pseudogrammoceras**?, **Pl. 29**, figs. 8-10; **Pl. 33**, figs. 11, 12; p. 182 (*Grammoceras dœrntense*); **Suppl.**, **Fig. 152**, p. clxvii; p. cliii
- planaris**, **Darellina**, **Suppl.**, **Pl. 17**, figs. 22-24; **Pl. 22**, figs. 7-9; p. cvi
- Planate, iv
- planicosta, Ammonites, 232, 289
- Planicostan abdomen, 233, 264
- plani-fastigate, iv; (series), lxxxii
- Plant bed, 47
- Planulati, Lias, not ancestors of Perisphinctes, 272

- platychora, *Apedogyria*, Pl. 5; Pl. 4, fig. 8, p. 22 (*Lioceras bradfordense*); *Suppl.*, Pl. 11, fig. 33; p. lx
- Platygraphoceras*, *Suppl.*, p. xciii; *apertum*, *carbatinum*, *compactum*, *latum*, sp.
- Platygraphoceras*, from *Graphoceras*, xev; classification, cxeviii
- Platygyral*, iii, cxevii
- platystonum*, *Stephanoceras*, 312
- plectile*, *Lioceras*, *Suppl.*, Pl. 9, figs. 10-12, p. xxxix
- Pleuroceras*, 286, 287, 288, 295, 300, 301, 314; *hawskerense*, *pseudocostatum*, \**spinatum*, *subspinatum*, *vittatum*; allied to *Sonninia*, 110; prior use of name for a genus of *Gastropoda*, Haug's note, 288; and *Amaltheus*, separation of characters of, 288; spp. of, compared to *Zurcheria*, 295; from *Sonninia*, 314
- Pleydellia*, *Suppl.*, p. cxxxvii; *aalensis*, *fluens*, *comata*, *leura*, *mactra*, sp., *subcompta*
- Pleydellia*, from *Walkeria*, cxxxix; classification, cxeviii
- plicata*, *Sonninia*, Pl. 97, figs. 6-8; *Figs. in text*, 18, p. 388; 44, p. 415; 70, p. 443; p. 415
- plicata*, *Terebratula*, 7, 43
- plicatellum*, *Lioceras*, *Suppl.*, Pl. 8, figs. 10-12; Pl. 9, figs. 7-9; p. xxxviii
- plicatum*, *Cypholioceras*, *Suppl.*, Pl. 8, figs. 7-9, p. xlv; and ? Pl. 14, figs. 5, 6, p. 54 (*Lioceras opalinum* var. *comptum*); p. cxxx
- Plottii*, *Clypeus*, 7
- Podagrosi*, 109, x
- Pœcilomorphus*, p. 115; *Suppl.*, p. cxcciii; *cycoloides*, *macer*, *mercati*
- Pœcilomorphus*, classification, cxeviii
- Pœcilomorphy*, acme of, cxcix
- polita*, *Darellia* ?, Pl. 16, figs. 3-6, p. 92 (*Hyperlioceras Walkeri*); *Suppl.*, Pl. 18, fig. 31; p. cxiv
- polyacanthum*, *Hammatoceras* (*Sonninia*), 453
- polyacanthus*, *Ammonites*, remarks upon, proportions of, 376; *Sonninia*, 375, 376
- Polygenetic*, specimens, 257; forms, how distinguished, cxviii
- Polygyral*, ii
- Polymorphidæ*, 231, 266, 267, 269; revision, clxix; résumé of, 281; genealogy of (Table V), 282, 293; radial lines, cxevi; classification, cxeviii
- Polymorphism*, 243
- Polymorphites*, p. 267; *Bronni*, *confusus*, *norma*, *peregrinus*, *polymorphus*, p. *costatus*, p. *lineatus*, *senescens*, *vernosa*, *zitteli*
- Polymorphites*, from allies, 267; classification, cxeviii
- polymorphus*, *Polymorphites*, 161, 232, 234, 266, 267, 283, 284, 289
- polymorphus costatus*, *Polymorphites*, 267, 283
- polymorphus lineatus*, *Ammonites*, 289; *Polymorphites*, 232, 267, 283
- Polyphyletic* origin of similar peripheries, cxv
- Polyplectus*, p. 214; *Suppl.*, p. clvii; *discoides*
- Polyplectus*, classification, cxeviii
- Polyzoa*, 43
- Port-en-Bessin*, strata of, cxvi
- Portree*, lxx
- Posidonomya Bronni*, zone of, 50
- Post-nodate* stage (*Ecotraustes*), cxcv
- \**præstabilis*, *Amaltheus*, Pl. 49, fig. 3; *nudus*, *Amaltheus*
- præstabilis*, *Amaltheus*, 287
- Prefiguration*, morphological, 315; *morphie*, cciii
- Primary* ribs, 16
- primordialis*, *Ammonites*, 35, 55
- prisca*, *Dumortieria*, Pl. 37, figs. 9-11, p. 236; p. clxxii
- prisca*, *Dumortieria*, clxxiii
- Prisca* style of ribbing, clxxxv
- procera*, *Chemnitzia*, 164
- procerus*, *Perisphinctes*, 272
- Progression*, in development, 289; of ventral area, 299
- Progressive* decline, of rostration, lxxx; of costation, *umbilicus*, compression, lxxxix
- projecta*, *Braunsina*, *Suppl.*, Pl. 20, figs. 7-9; p. c
- propinquans*, *Ammonites*, 143; *Sonninia*, 450
- Proportional* triangles, cxevii
- Prorsicostate* (series, *Fontannesia*), cxci
- Prorsiradiata*, iii
- Prorsiradius*, iii
- Prorsum*, iii
- Prosiphonata*, 126
- proximum*, *Harpoceras*, 158
- Prussia*, *Grammoceras* in, 169
- psamminum*, *Catulloceras*, Pl. xli, figs. 7, 8, p. 248 (*Dumortieria radians*); *Suppl.*, p. clxxi
- pseudocostatum*, *Pleuroceras*, 287, 291, 295

- Pseudogrammoceras**, p. cxliii; **Bingmanni**, *cotteswoldiæ*, *dœrntense*, *expeditum*, *explicatum*, *fallaciosum*, *muelleri*, *obesum*, *pachu*, *pedicum*, *placidum*, *quadratum*, *aff. quadratum*, *regale*, *sæmanni*, *sp.*, *struckmanni*, *subfallaciosum*, *subquadratum*, *thrasu*
- Pseudogrammoceras**, dates of existence of species of, cliv; from *Phlyseogrammoceras*, clv; classification, cxviii
- Pseudographoceras**, *Suppl.*, p. xci; *cariniferum*, *compressum*, *deletum*, *limatum*, *litteratum*, \**sp.*
- Pseudographoceras**, from *Platygraphoceras*, xciii; from *Graphoceras*, xcv; from *Braunsina*, xcix; from *Braunsella*, cii; from *Reynesia*, ciii; from *Graphoceras*, xcv; classification, cxviii
- Pseudolioceras**, p. 81; *Suppl.*, p. clviii; *beyrichi*, *compactile*, *dumortieri*, *falcidiscus*, *gradatum*, \**lythense*, *pumilum*, *replicatum*
- Pseudolioceras**, 60, 129, 223; from *Haugia*, 143, 144; from *Pseudogrammoceras*, cxliv; classification, cxviii
- pseudoradiosa**, *Dumortieria*, *Pl.* 41, *figs.* 1-3, 9, 10, p. 246
- pseudoradiosum**, *Harpoceras*, 246, 253, 259
- Psiloceras**, 170, clxxxvi
- ptyeta**, *Sonninia*, *Pl.* 73, *fig.* 1; *Pl.* 96, *fig.* 7; *Figs. in text*, 21, p. 389; 47, p. 418; 73, p. 443; pp. 332, 390, 420
- Pueckham Farm**, lxvi
- pugnax**, *Hammatoceras*, 294, 298
- pugnax**, *Zurcheria*, p. 298; *Suppl.*, *Fig.* 188, p. cxcii
- pugnax**, *Zurcheria*, 291, 295, 296, 299, 300
- pulchra**, *Brasilia*?, *Pl.* 10, *figs.* 3, 4, p. 72 (*Lioceras concavum* var.); *Suppl.*, *Fig.* 41 in text, p. lxxxii
- pulchra**, *Dorsetensia*, *Pl.* 52, *figs.* 25-27, p. 306
- pumilum**, *Pseudolioceras*, *Pl.* 20, *figs.* 5, 6, p. 85 (*P. compactile*); *Suppl.*, p. clix
- punctum**, *Stephanoceras*, 301
- pustulifer**, *Ammonites*, 258, 453
- pustulifera**, *Hyattia*, *Suppl.*, *Pl.* 13, *figs.* 1-3, p. lv
- pustulifera**, *Sonninia*, 258
- pygmæum**, *Lytoceras*, 301
- quadratum*, *Grammoceras*, *Pl.* 34, *figs.* 6, 7, p. 201; see *aff. quadratum*, *Pseudogrammoceras*
- quadratum*, *Grammoceras*, 221, 222, cxliv
- quadratum*, *Hildoceras*, 201, cxliv
- quadratum*, *Pseudogrammoceras*, cxliv
- aff. quadratum**, *Pseudogrammoceras*, *Pl.* 34, *figs.* 6, 7, p. 201 (*Grammoceras quadratum*); *Suppl.*, p. cxliv
- quadratus*, *Ammonites*, cxliv; (*Hildoceras*), 202
- quadrifida**, *Sonninia*, *Pl.* 91, *figs.* 1-3; pp. 366, 384, 394
- quadrifida* stock, 364
- Quarrymen's terms**, 48
- Quenstedt**, Professor F. A. von, 3, 17, 18, 22, 23, 31, 35, 36, 83, 85, 98, 102, 143, 149, 155, 156, 170, 174, 184, 188, 189, 190, 192, 195, 196, 197, 198, 200, 203, 205, 215, 229, 230, 237, 238, 239, 240, 241, 243, 244, 246, 248, 252, 255, 259, 293, 309, 310, 315, vii, viii, xxviii, xxxiv, xxxv, xxxvi, xl, xli, liii, lv, lix, lx, cxxxii, cxxxiv, cxlvii, clii, clx, clxxiii, clxxiv, clxxv, clxxxiii; opinion on *Lias-Oolite* division, 3; on *A. Murchisonæ*, 16; on *Am. Murchisonæ acutus*, 24; and *A. discoideus*, 99; on *Am. radians*, 156; confusion about *opalinus*, xxxv; and *A. Murchisonæ obtusus*, lxx
- Radial curve**, ii, cxci; hypostrophic character of, lxxii; features of, cci
- Radial line**, ii; caduceiform, lxxiv; like Greek bow, lxxix; subfalcate, lxxix; very angulate (series), ci; and rostration, cvi
- Radial lines** figured, xxxiv; evolution of various forms of, lxxiv; figures showing development of, lxxviii, lxxx; tables of, clxiii, clxv, clxvii, cxevi
- radians**, *Ammonites*, 50, 127, 143, 169, 184, 189, 190, 204, 205, 248, 252, cxlvii, clxxi, clxxviii, clxxx, clxxxi, clxxxiii, clxxxiv; synopsis of species to which the trivial name *radians* has been given, 188-190
- radians**, *Dumortieria*, *Pl.* 42, *figs.* 8-10, p. 247; *Fig.* 2, p. 187 (*Nautilus radians*); *Suppl.*, *Pl.* 22, *figs.* 31-33; *Fig.* 175, p. cxevi; p. clxxxix
- radians*, *Dumortieria*, *Pl.* 40, *figs.* 4-6, see *regularis*, *D.*; *Pl.* 40, *figs.* 7, 8, *psamminum*, *Catullocceras*; *Pl.* 42, *figs.* 1, 2, *sp. D.*; *Pl.* 42, *figs.* 3-5, *penexigua*, *D.*; *Pl.* 42, *figs.* 6, 7, *signata*, *D.*; *Pl.* 42, *figs.* 11, 12, *metita*, *D.*; *Pl.* 43, *figs.* 1-4, *sp., D.*; p. 247, see spp. above

- \**radians*, *Grammoceras*, fig. 3, p. 187; see sp.  
**Dumortieria**.  
*radians*, *Grammoceras*, 12, 45, 46, 143  
*radians*, *Harpoceras*, 170, 189, 204, 205, cxlvii, cxlviii, clii  
 \**radians*, *Nautilus*, fig. 2, p. 187; see *radians*,  
**Dumortieria**  
*radians*, *Nautilus*, 186, 188, 248  
*radians amalthei*, *Ammonites*, 189  
*radians compressus*, *Ammonites*, 143, 155, 188, 189, 190, vii  
*radians costula*, *Ammonites*, 188, 237, 238  
*radians depressus*, *Ammonites*, 170, 174, 188, 190, 205, 248, cxxxii, cxlvii  
*radians gigas*, *Ammonites*, 190, 205, vii  
*radians numismalis*, *Ammonites*, 189  
*radians quadratus*, *Ammonites*, 190, 201, 203  
*radians*, var. *exigua*, *Dumortieria*, Pl. 43, figs. 11, 12, see *exigua*, D.; Pl. 44, figs. 1-3, *lata*, D.; p. 252, see spp. above  
*radians*, var. *exigua*, *Dumortieria*, clxxxiii  
 Radiate, see radius; also anguli-, biarci, falci-, flexi-, gammi-, prorsi-, recti-, rursi-, subfalci-, torti-, versi-, v-scripti-radiate  
 Radicals, of *Ammonite* branches, 270  
 Radii, how used, 57; sigmoidal, transitional, straight, 112; annular, subannular, 267  
*radiosa*, *Dumortieria*, Pl. 30, fig. 18, see **subfasciata**, D.; Pl. 42, fig. 13-15; Pl. 43, figs. 5-7, see **diphyes**, D.; p. 253, see spp. above  
*radiosa*, *Dumortieria*, clxxx, clxxxi; Maseke on, clxxx  
*radiosa*, var. *gundershofensis*, *Dumortieria*, Pl. 45, figs. 13, 14, see **inclusa**, D.; p. 254, see **inclusa**, D., **subfasciata**, D.  
*radiosa* var. *gundershofensis*, *Dumortieria*, clxxx, clxxxi  
*radius*, *Ammonites*, 248, 253, clxxviii, clxxix, clxxx; Maseke on, clxxx  
*radius*, *Harpoceras*, 253  
 Radius, 57, iii; see also anguliradius, costa, costistria, flexiradius, prorsiradius, rectiradius, rursiradius, stria, strii-costa, versiradius  
 Ragstones, Middle, Lower, Upper, ceix  
 Ramesveram, 454  
 Ramsay, Sir A. C., on Wotton-under-Edge, 49  
 Ramsayi, *Trigonia*, 44  
 Recession of inner margin, 36  
**reclinans**, *Sonninia*, Pl. 49, figs. 16, 17; Pl. 65, figs. 3, 4 (*S. crassispinata*); Pl. 98, fig. 7; Pl. 103, fig. 21; pp. 390, 421  
 Reclined ribs, 280  
**recticostata**, *Darellella*, Suppl., Pl. 17, figs. 10-12, p. cvii  
 Rectiradiate (*Pseudogrammoceras*), clii; (series of *Dumortieria*), clxxii  
 Rectiradius, iii  
 Recurved bifurcate ribbing, 124  
 Red Beds, date of, cevi  
 Reduced figures, need for care in comparison with those of natural size, 333  
**reflua**, *Crickia*, Suppl., Pl. 11, figs. 16-18; Fig. in text, 29, p. lxxiii  
**reformata**, *Sonninia*, Pl. 89, figs. 6-8; pp. 391, 434  
**regale**, *Pseudogrammoceras*, Suppl., Fig. 134, p. clxvii; Fig. 138, p. cxlvi; p. cxlv  
 Regleyi, *Ammonites*, 273, 283; *Cosmoceras*, 273  
**Regleyi**, *Tmetoceras*, Pl. 48, figs. 8-10, p. 273 (*T. scissum*); Suppl., p. clxxi  
 Regulari-ornate, iv, viii  
**regularis**, *Dumortieria*, Pl. 41, figs. 4-6, p. 248 (*Dum. radians*); Suppl., Fig. 174, p. cxcvi; p. clxxviii  
**regularis**, *Sonninia*, Pl. 64, figs. 1-3 (*S. marginata*); Pl. 96, figs. 3-5; pp. 385, 395  
 Reinecke, 35, 53, 186, 188, 196, 237, 238, 248, 249, 250, xxxiv, xxxvi, xl, xli, xliii, cxlviii, clxxv; collection, 187; specimens, xl  
**renovata**, *Sonninia*, Pl. 93, figs. 1-6; Figs. in text, 28, p. 391; 54, p. 430; 80, p. 443; p. 433  
 renovata, *Sonninia*, cc  
 Renovate, series, 453; *Sonninia*, 448; species, xxxvi, xlvi; stage, species, xlii  
**renovatum**, *Cypholloceras*, Pl. 14, figs. 7-9, p. 53 (*Lioceras*, sp.); Suppl., Pl. 10, fig. 5; p. xlvi  
**replicatum**, *Pseudolioceras*, Pl. 20, figs. 9, 10, p. 87 (*P. Beyrichi*); Suppl., Fig. 161, p. clxvii; p. clx  
 Representation, morphic, ceiii  
 Résumé of genera, 122-125

- Retrogression, 308; in development, 289; characters of, 289; the reversal of progression, 290; law of, latest acquired characters lost first, 294; in Zuercheria, 299; illustrated in crassa stock, 348; law of, relating to compression of whorls, 348
- Retrosiphonata, 126
- Reversion, 139; in development, 159
- revirescens, *Sonninia*, Pl. 70, fig. 1; Pl. 100, fig. 9; Figs. in text, 19, p. 389; 45, p. 416; 71, p. 443; pp. 324, 417
- Reynès, P., vii, viii, ix, excvii
- Reynesella, Suppl., p. cix; *inops*, *juncta*, *lineata*, *piodes*, *rodburgensis*
- Reynesella, from Hugia, cxi; classification, excviii
- Reynesia, Suppl., p. ciii; *amœna*, *benigna*, *cœla*, *furellata*, *intermedia*, *laxa*, *lepida*
- Reynesia, classification, excviii
- Rhæboceras, Suppl., p. lxxii; *tolutarium*, *tortum*
- Rhæboceras, from Crickia, lxxiii; classification, excviii
- rheumatisans, Ammonites, 109, vii, x
- rhodanica, *Dumortieria*, Suppl., p. clxxix
- rhodanica, *Dumortieria*, 248
- Rhone basin, xiii; *Grammoceras* in, 168
- Rhynchonella, 47, 165
- Rhynchonellæ, 52
- Rhynchonella ringens beds, date of, cvii
- Ribs, primary, 16; secondary, 16; and striæ=radii, 57; v-shaped, 57, 69, 73; changes of, 134; arcuate, 142, 158; subarcuate, 158; direct, 231; subdirect, 231; reclined, 280; falciform, 73, 294; scythe-shaped, 294; sickle-shaped, 294; undulate, 307; duplicated, homologous to spines, 345
- Ribbing, types of, 124
- Richardson, L., lxvi, cxlix, clxx, clxxix exci
- ringens, *Rhynchonella*, 8, 9; beds, date of, cvii
- Roadstone, cxix; date of, cxi
- Robin Hood's Bay, 175
- Robinswood Hill, clxx
- robustum, *Graphoceras*, Suppl., Pl. 15, figs. 9-11, p. xc
- robustum, *Phymatoceras*, xxx
- robustus, Ammonites, vii, x
- Rodborough Hill, 90, 94, 96, 100, cx
- rodburgensis, *Reynesella*?, Suppl., Pl. 17, figs. 1-3, p. cx
- Roman province, xiv
- Romani, Ammonites, 305, 306; *Dorsetensia*, 307, 310
- Rostration, excix; increase of, influence on shape of radial line, cxi; progressive decline of, lxxx; degree of, cxi
- Rostrum, projection of, cxi
- rotabilis, *Braunsella*?, Suppl., Pl. 17, figs. 7-9; p. cii
- Rubby Oolite, 3
- rubescens, *Lytoceras*, 165
- rudidiscites, *Hyperlioceras*, Pl. 18, fig. 1; Pl. 17, figs. 3, 4; p. 94 (*H. discites*); Suppl., Fig. 94, p. clxv; p. cxxiv
- rudidiscites, *Hyperlioceras*, ccii
- rudis, *Ludwigella*, Pl. 15, figs. 11-13; Pl. A, fig. 7, p. 103 (*Ludwigia rudis*); Suppl., Fig. 47 in text, p. lxxxv
- rudis*, *Ludwigia*, Pl. 15, figs. 11-13, see *rudis*, *Ludwigella*; Pl. 15, figs. 14, 15, *subrudis*, L.; Pl. 15, figs. 16, 17, *angulifera*, *Braunsina*; p. 103, see spp. above
- rudis, *Ludwigia*, lxxxv, ci
- rugosa, *Ludwigella*, Suppl., Pl. 20, figs. 34-36; p. xc
- rugosus, *Æcotraustes*, Pl. 21, figs. 1, 2; Suppl., Fig. 189, p. cxevi; p. cxci
- Rursicostate (series *Fontannesia*), clxxxix
- Rursiradiate, iii; group, xxiii
- Rursiradius, iii
- Rursi-subflexiradiate, x
- Rursum, iii
- rustica, *Welschia*, Suppl., Pl. 4, figs. 16-18; p. lii
- rustica, *Dumortieria*, Pl. 45, figs. 4, 5, 10-12; p. 259 (*D. subundulata*); p. clxxxvi
- Rutland, 91
- Saddle, siphonal, 217
- Saddles and lobes, 219
- Sæmanni, Ammonites, 203, cxlix, eli
- Sæmanni*, *Grammoceras*, Pl. 34, figs. 1, 2, see *pachu*, *Pseudogrammoceras*; Pl. 36, figs. 6-8, see *thrasu*, *Pseudogrammoceras*; p. 203, see spp. above
- Sæmanni, *Grammoceras*, cxlv, eli
- Sæmanni, *Hildoceras*, 203
- sæmanni, *Pseudogrammoceras*, Suppl., Fig. 145; p. cxlix

- St. Quentin, xvii  
 Sand beds, date of, ceviii  
 Sand Rock, 251  
 Sandford Lane, 65, 374, lxxxvi, lxxxvii, lxxxviii, xciv, xcvii; strata of, cevi, cevii  
 Sands, 173; section of [Yeovil], 5; thickness at different places, 6; of Inferior Oolite, 50; at Sodbury, 166; varying date of, comparative table, 167; Cotteswold, xii; yellow, xxxv; and Tmetoceras, clxx; and opalinoid Ammonites, clxxxii; dates of various, ceviii; see Blue, Bridport, Cotteswold, Grey, Harford, Midford, Yellow, Yeovil Sands  
 Sandy ferruginous beds, 30, 42, 49; for Tmetoceras, clxx; date of, cevii  
 Sandy ferruginous Limestone, 44, 168, xxxv  
 Sandy ferruginous Oolite, 275  
 sauzei, Ammonites, 63, 454; Emileia, hemera, cev; hemera, vi; hemera, strata of, cevii  
 Sauzei-Kalke, 453  
 Sauzei-zone, 4, 8, 63, 292, 316; thickness of, 10; reasons for term, 292  
 Sauzei-Sowerbyi zone, 316  
 Sayni, Witchellia, 375  
 scalpta, *Sonninia*, Pl. 87, figs. 1-3; pp. 376, 385  
 Scaphitoid appearance, 403  
 sceleta, *Canavarella*?, Suppl., Pl. 22, figs. 19-21; p. cxxix  
 Schlotheimia, 267; Ungulata  
 Schlenbach, 87, 88, 228, 229  
 Schlenbachia, cci  
 Schmidt, 227  
 Schuchert, C., Brachiopoda, cxcix  
 Schwarzer Jura, 3  
 Seissi hemera, vi; strata of, xxxv, cevii  
 scissum, *Simoceras*, 273  
 scissum, *Tmetoceras*, Pl. 48, figs. 4-7, p. 273; Suppl., p. clxx  
 scissum, *Tmetoceras*, Pl. 48, figs. 1, 2, see *circulare*, T.; Pl. 48, figs. 8-10, *Regleyi*, T.; p. 273, see spp. above  
 scissum, *Tmetoceras*, xxxv, clxxi; hemera, cev  
 scissus, Ammonites, 273; Haug on, 274  
 Scotland, 19  
 Seroff, date of, cevi  
 sculpta, *Haugia*, Pl. 26, figs. 1, 2, p. 156 (*Haugia eseri*); Suppl., p. xxix  
 Scythe-shaped ribs, 294  
 Secondary ribs, 16  
 Sections, at Babylon Hill, 5; Bradford Abbas, 5; Stroud Hill, 7; Osborne, 8; Wyke Quarry, 8; Haresfield Hill, 43; Frocester Hill (Coaley Peak), 44; Coaley Wood, 45; Nibley Knoll, 46; Stinchcombe, 47; Burton Bradstock, 47; Northampton District (Sharpe), 47; Old Duston Stonepit (Sharpe), 48; Cotteswolds, analysis of, 49; Buckholt Wood, 164; Little Sodbury, 164; Lyncombe Cutting (Bath), 165; Midford Sands, 165; White Lackington, 165; correlation of (Table), 166; Dundry, 292, 293; correction of, 316; see also Geological details  
 Seebach, 173, 211, 228, 246, 253, clxxxviii, clxxx  
 semicostata, *Darellia*, Pl. 12, figs. 10, 11, p. 34 (*Lioceras decipiens* var. *intermedium*?); Suppl., Pl. 18, fig. 30; Fig. 73, p. clxxv; p. cxiii  
 semilenis, *Braunsella*, Suppl., Pl. 17, figs. 19-21; p. cii  
 semipolatum, *Hildoceras*, Pl. 22, figs. 30, 31; Pl. A, fig. 28; p. 112 (*Hildoceras bifrons* var.); Suppl., p. clvi  
 semispinata, *Sonninia*, Pl. 77, figs. 1, 2; Pl. 103, fig. 15; pp. 343, 389, 416  
 senescens, *Polymorphites*, Pl. 48 figs. 13-15; p. 268  
 Senility, atavic, 357  
 Septa, how to develop and trace, 380; abnormalities, 381; differences between, 382; terms for, v; see also densiseptate, inornatilobate, ornatilobate, pauciseptate  
 Septal morphogenesis, ccii  
 Septicarina, iv; and degeneration, clvii; (series of *Pseudogrammoceras* without) cliii  
 Septicarinata, clvi; (series), cxix; (*gammiradiata*), cxliii  
 Septituberculate, iv  
 Septum, in carina, clv  
 Sequence of phenomena, cxcix  
 Series, ascending, 200, 207  
 serpentinum, *Grammoceras*, 158  
 serpentinus, Ammonites, 13, 50, 112  
 Serpulæ, 455  
 serrodens, Ammonites, 119, 229, 230  
 serrodens, *Hudlestonia*, Pl. 38, figs. 9-12; p. 229  
 serrodens, *Pelecoceras*, 165

- Sessile, 405  
 Sevenhampton, lxvi  
 Seven Sisters, strata of, cevii  
 Sharpe, S., 48, 52; on Northampton Oolite, 47; on Am. Murchisonæ, 53  
 Shepton Beauchamp, xiv, xix, xx, xxi, xxiv, xxv, xxvi, xxvii, cli  
 Shepton Mallet, cxlvi  
 Sherborne, 19, 28, 31, 32, 40, 61, 65, 90, 97, 106, 108, 120, 121, 275, 292, 305, 307, 309, 1, liv, lviii, lix, lxi, lxxi, lxxvii, lxxi, lxxii, lxxiii, lxxxv, lxxxvi, lxxxvii, lxxxviii, xciv, xcvi, xc; Ammonites of disused quarry at, 292; excavations at, and Mr. Hudleston, 374; strata of, cevi, cevii  
 Shire, note on, 359  
 Sickle-shaped ribs, 294  
 sigalœn, *Lytoceras*, cc  
 Sigmoidal ribbing, 124  
 Signalberg, 258  
*signata*, *Dumortieria*, Pl. 42, figs. 6, 7, p. 248 (Dun. radians); *Suppl.*, fig. 176, p. cxevi; p. clxxxix  
*similis*, *Brasilia*, Pl. 15, figs. 1, 2; Pl. A, fig. 13; p. 31 (*Lioceras decipiens* var. *simile*); *Suppl.*, Pl. 11, fig. 36; p. lxxxii  
*Simoceras*, 269; *Dumortieri*, *scissum*  
*simplex*, *Sonninia*, Pl. 70, figs. 2, 3; Pl. 103, fig. 11; pp. 326, 390, 423  
*simplex*, *Sonninia*, Pl. 70, fig. 4, see sp., *Sonninia simplex*, *Sonninia*, 353, 439  
*simplex*, *Terebratula*, found outside Cottswolds, 8  
 simplification, stages of, excix  
 Simpson, 85, 203  
*Simpsoni*, *Ammonites*, 226  
 Sinon, *Harpoceras*, 227  
 Sinon, *Hudlestonia*, Pl. 38, figs. 13-16; p. 227  
 Sinon, *Ludwigia*, 227  
 Sinon, *Pelecoceras*, 175  
 Siphonal lobe, augmentation of branches of, how caused, 217  
 Size, acme of, cc  
 Skeleton lobes, table (VIII) of, 443  
 Skye, Isle of, lxx  
 Slate, 48  
 Smith, J. P., cxcix  
 Smith, W., 242  
 Smooth evolute stage, examples of, 289  
 Smooth *Sonninia*, 448  
 Snowhill Clay, date of, cevii  
 Snuff-Boxes, cevii  
 Sodbury, 163, 173, 209, 251, 252, clxxi; strata of, ceviii; see Little Sodbury  
*solaris*, *Ammonites*, 241, clxxiv  
*solaris*, *Dumortieria*, clxxiv  
 Solid carina, 81, iv; see carina  
 Solliès-Pont, 294  
 Somerset, 7, 9, 10, 19, 40, 50, 51, 55, 71, 73, 75, 90, 97, 103, 114, 117, 120, 124, 168, 173, 175, 208, 214, 220, 251, 257, 266, 275, 281, 305, xiv, xv, xix, xxii, xxiv-xxvii, xlvi, liii, lvii, lx, lxvii, lxxiv, lxxxvii, lxxxvi, xevi, xevii, eix, cxviii, cxxv, cxxviii, cxliv, cxlviii, cli, clxxii, clxxiv, clxxv, clxxx, clxxxv, exe, exciii, exciv; not to add shire, 359; strata of, cevi, cevii, ceviii, ccix  
 Sommerseatas, 359  
*Sonninia*, p. 313; *Suppl.*, p. cxcii; *abnormis*, *acanthodes*, *alternata*, *arenata*, *attrita*, *boweri*, *brevispinata*, *biplicata*, *buckmanni*, *camura*, *contusa*, *costata*, *costigera*, *crassa*, *crassibullata*, *crassicostata*, *crassiformis*, *crassinuda*, *crassispinata*, *cymatera*, *decora*, *decorata*, *densicostata*, *diversa*, *dominans*, *dominata*, *dominatrix*, *dominica*, *dundriensis*, *duplicata*, *euromphalica*, *fissilobata*, *gibbera*, *inæqua*, *insignoides*, *irregularis*, *lævigata*, *loculosa*, *locuples*, *magnispinata*, *marginata*, *modesta*, *multicostata*, *multispinata*, *mutans*, *nodata*, *nuda*, *omphalica*, *obtusiformis*, *ovalis*, *palmata*, *papilionacea*, *parvicostata*, *paucinodata*, *plicata*, *polyacanthus*, *ptycta*, *pustulifera*, *quadrifida*, *reclinans*, *reformata*, *regularis*, *renovata*, *revirescens*, *scalpta*, *semispinata*, *simplex*, *sowerbyi*, sp., *spinea*, *spini-costata*, *spinifera*, *spinigera*, *spinosa*, *subcostata*, *subdecorata*, *subirregularis*, *submarginata*, *subsimplex*, *subspinosa*, *substriata*, *sulcata*, *tridactyla*, *umbilicata*, *zurcheri*  
*Sonninia*, 13, 14, 128, 265, 286, 287, cciii; descent of, 110; allied to *Pleuroceras* and *Amaltheus*, 110; from *Haugia*, 144; a cryptogenetic series, 314; spp. illustrate retrogression, 315; horizon of, at Dundry, 316; order of changes in retrogression, 316; groups of,

- how divided, 316; costata stock, 336; magnispinata stock, 341; biplicata stock, 344; crassa stock, 347; submarginata stock, 328; acanthodes stock, 331; and Dumortieria grammoceroïdes, 339; spinous species distinguished, 349; subdecorata stock, 357; omphalica stock, 362; quadrifida stock, 364; paucinodata stock, 368; species of different stocks, 372; revision, 379; and Hammatoceras, comparison of, 379; detailed classification of, 392; species innominatæ, 438; summary, 441; numerical details of, 441; skeleton outlines of lobes (Table VIII), 443; remarks on classification of, 444; analysis of species of, according to ornament, 447; how to analyse and identify species of, 448; further generic division of, required, 450; characters of different series in, 450; the species of Concauum zone, all new, 451; tuberculate core of, iv; likeness to Fontannesia, clxxxvii; classification, cxviii
- Sonniniæ, revision of, new spp. of, 379; outline classification, 384-391; genealogical table, 445; divisions (ornament), 447; morphic equivalents (Table X), 449; generic subdivision possible, 450; migration of, 452; doubtful occurrence of, in Murchisonæ zone of Normandy, 452; extra-European spp. of, 453; dwarf, cxiii; hemera, strata of, cxvii; sp. hemera, vi, cv
- Sonninian Age, cv
- Sonniniæ, 287, 293, 299, 302, 313, xiv; revision, 379; additions, cxcii; origin of, 288; geological position of, 292; literature on, 293; classification, cxviii
- South America, 258, clxx; correspondence of faunal sequence in Europe and, 454
- South Cotteswolds, 163
- South Dorset, 324
- South Dorset coast, stratal succession, xxxv
- South Kensington Museum, 17
- South Petherton, 183, 184
- South Somerset, 61
- Sowerby, J., & J. D. C., 17, 56, 63, 149, 173, 174, vii, viii, xxv, lxx, lxxxvi, cxxxi
- Sowerbyi, Ammonites, 9, 13, 63, 315; group of, and Amaltheus, 130; remarks on the type specimen, 342; confusion concerning name of, 342
- Sowerby group, 143
- Sowerbyi, Hammatoceras, 13, 128, 287, 313, 342
- Sowerbyi, Harpoceras, 341, 342
- \*Sowerbyi, Sonninia, Pl. 49, figs. 10-13
- Sowerbyi, Sonninia, 110, 315, 450
- Sowerbyi insignoides, Ammonites, 315
- Sowerbyi ovalis, Ammonites, 315
- Sowerbyi-zone, 4, 6, 8, 9, 63, 291; at Halfway House, thickness of, fossils of, 10; suggestions concerning, 292; and Concauum zone, 342
- sp., Canavarina?, Pl. 13, figs. 4, 5, p. 35 (Lioceras opalinum); Suppl., Fig. 133, p. clxvii; p. clxiii
- sp., Cosmogyria, Suppl., Pl. 14, figs. 11, 12; p. liv
- sp., Cotteswoldia, Pl. 31, figs. 13, 14, p. 179 (Grammoceras subserrodens); Suppl., Fig. 110, p. clxv; p. cxxxv
- sp. A., Dorsetensia, Pl. 52, figs. 1-3, p. 304, see Lennieri, D.
- sp. B., Dorsetensia, Pl. 52, figs. 4-7, p. 304
- sp., Dorsetensia, cxcii
- \*sp., Dumortieria, Fig. 3, p. 187 [Foreign]
- sp., Dumortieria, Pl. 37, figs. 18, 19, p. 245, see costula, D.
- sp., Dumortieria, Pl. 45, figs. 15, 16, p. 241 (D. Levesquei); p. clxxvi
- sp., Dumortieria, Pl. 44, figs. 4-6, p. 255 (D. Moorei); Suppl., Fig. 182, p. cxevi; p. clxxxiii
- sp., Dumortieria, Pl. 43, figs. 1-4, p. 251 (Dum. radians); p. clxxxiv
- sp., Dumortieria, Pl. 42, figs. 1, 2 (Dum. radians) p. clxxx
- sp., Dumortieria, clxxv
- sp., Grammoceras, Pl. 32, figs. 11, 12, p. 191, see arcuata, Walkeria
- sp. A., Grammoceras, Pl. 34, fig. 12, p. 169 (G. toarcense); Suppl., p. cxxxii
- sp., Grammoceras, p. cxxxix
- sp., Harpoceras, cxii
- sp., Haugia, Suppl., p. xxix
- sp., Hyattina, Pl. 4, fig. 7, p. 22 (Lioceras bradfordense); Suppl., Pl. 17, fig. 29; p. cxxx
- sp., Lioceras, Pl. 14, figs. 7-9; see renovatum, Cypholioceras
- sp., Lioceras, Pl. 14, fig. 12, p. 53 (L. opalinum var. comptum); Suppl., Pl. 10, fig. 9; p. xlii
- sp., Lioceras, xlvi

- sp., *Ludwigia*, Pl. 23, figs. 2-4, p. 107, see sp., *Witchellia*; Pl. 23, figs. 9, 10, p. 107, see *Witchelli*, *Brodiceras*
- sp., *Ludwigia*, xxxiii
- sp. A., *Platygraphoceras*, Pl. 15, figs. 9, 10, p. 76 (*Lioceras apertum*); Suppl., Fig. 56 in text, p. xciv
- sp. A., *Pleydellia*, Pl. 30, figs. 11, 12, p. 198 (*Grammoceras subcomptum*); Suppl., Fig. 118, p. clxvii; p. cxxxviii
- sp. B., *Pleydellia*, Pl. 31, figs. 7-9, p. 179 (*Grammoceras subserrodens*); Suppl., Fig. 120, p. clxvii; p. cxxxix
- sp., *Pseudogrammoceras*, Suppl., p. clii
- sp., *Pseudogrammoceras*?, Pl. 29, figs. 6, 7, p. 182 (*Grammoceras doerntense*); Suppl., Fig. 153, p. cliv
- \*sp., *Pseudographoceras*?, Suppl., p. xci [Foreign]
- sp., *Pseudographoceras*, xcii
- sp., *Sonninia*, Pl. 72, figs. 1, 2, p. 439; Pl. 79, figs. 7, 8, p. 439; Pl. 89, figs. 9, 10, p. 439; Pl. 67 figs. 1, 2, p. 438 (*S. dominans*); Pl. 103, fig. 24 (*S. aff. dominans*); Pl. 67, figs. 3, 5; Pl. 103, fig. 20, p. 438; Pl. 70, fig. 4, p. 439 (*S. simplex*); Pl. 95, figs. 9, 10, p. 440; Pl. 97, fig. 5, p. 440; Pl. 103, fig. 19, p. 440
- sp. *Sonninia*, Pl. 22, fig. 34; Pl. 23, figs. 7, 8, see aff. *Buckmanni*, S.; Pl. 23, figs. 5, 6, see *dundriensis*, *Sonninia*; Pl. 85, figs. 7, 8, see *obtusiformis*?, S.; Pl. 78, figs. 6-9; Pl. 88, fig. 4; see *subirregularis*, S.
- sp., *Sonninia*, exciii
- sp., *Walkeria*, Pl. 30, fig. 10, p. 199 (*Grammoceras lotharingicum*); Suppl., Fig. 124, p. clxvii; p. cxl
- sp., *Witchellia*, Pl. 23, figs. 2-4, p. 107 (*Ludwigia* sp.); Suppl., p. cxcii
- sparsicosta*, *Dumortieria*, Pl. 45, figs. 17-20, p. 239
- Specific characters of *Lioceras*, xxxvi
- Specific distinction, excix
- Specific descriptions, interpretation of, cciii
- Specific development, and difference in description, xciv
- Species, additional, clxi
- Species, new, protests against, cause of trouble, 379
- Sphaeroceras*, 140, ccii; *brongniarti*, *gervillii*, *wrighti*
- Sphaeroceratoid*, ccii
- sphaeroidalis*, *Terebratula*, 5
- Spina*, iii
- \**spinatum*, *Paltopleuroceras*, Pl. 49, fig. 7, p. 295
- spinatum*, *Pleuroceras*, Pl. 49, fig. 7, see *spinatum*, *Paltopleuroceras*
- spinatum*, *Pleuroceras*, 241, 287, 291, 295
- Spinatum* zone, 133, 163, 283, 291
- spinea*, *Sonninia*, Pl. 86, figs. 4-6; Figs. in text, 12, p. 386; 38, p. 406; 64, p. 443; pp. 387, 405
- Spines*, 405; see also *bullae*, *nodus*, *nonseptituberculate*, *papilla*, *septituberculate*, *tuberculate*, *spina*; hollow as compared to solid, 314; strongly marked ribs homologous to, 345; aborted, 342; furcation of, note on, 378; how to preserve, 413
- Spinicostae*, 357
- spinicostata*, *Sonninia*, Pl. 73, figs. 4-6; pp. 337, 387, 405
- Spinicostate*, 405
- spinifera*, *Sonninia*, Pl. 50, figs. 14, 15; Pl. 74, figs. 4-6 (*S. spinigera*); Pl. 100, figs. 1-4; pp. 335, 390, 418
- spinigera*, *Sonninia*, Pl. 74, figs. 4-6, see *spinifera*, S.
- spinosa*, *Rhynchonella*, 165
- spinosa*, *Sonninia*, Pl. 81, figs. 7-9; pp. 365, 384
- Spinous*, 405
- Spiral angle*, 135, 137
- Spirula*, 454, 455
- Spissicostate* (series of *Dumortieria*), clxxix
- Spissicostation*, clxxii
- Sports*, 289
- Spontaneous variation*, 289
- Stage of atavie senility*, 357
- Stage*, *Aalenian*, *anagenetic* *costate*, *arietan*, *Bajocian*, *Bathonian*, *bispinous*, *catagenetic* *costate*, *globose*, *goniatite*, *grammoceran*, *lioceratan*, *multispinous*, *nodate*, *parvituberculate*, *paucicostate*, *phylogerontic*, *postnodate*, *renovate*, *smooth-evolute*, *striate*, *Toarcian*, *tuberculate*, *unispinous*
- Stages*, ccv; omission of, from ontogenetic record, 289; dissimilar, elimination of, 290
- Stahl*, 241, 242
- Stanley*, 279
- Standish Beacon*, xxxiii, xlv

- Steinmann, Dr. G., 453  
**steinmanni**, *Canavarina*, *Suppl.*, **Fig. 130**, p. cxlii  
 Steinmanni, *Harpoceras*, cxlii  
 stellaris, *Ammonites*, 226  
 Stenogyral, ii, excvii  
 Stephanoceras, 14, 45, 46, 47, 129, 271; *blagdeni*,  
*braikenridgii*, *brodiei*, *bullatum*, *humphriesi-*  
*anum*, *platystomum*, *punctum*, *subcoronatum*,  
*zigzag*; zone, 4; and *pettos*-*Blagdeni* radical,  
 271; and *Parkinsonia*, common origin of,  
 271; polygenetic origin of, 272; depressed  
 band on middle of abdomen of, 272  
 Stephanocerata, not one group, 272  
 Stephanocertinae, 14  
 Stephanoceratites zone, 4  
 Stephens, Darell, 237, 242, 245, 298, 340, 359,  
 362, 377, lxiv, lxxix, lxxxiv, xcvii, cxi, cxii,  
 cxvi, cxx, cxxiv, clxxviii; collection, 292; see  
 Darell, Darell Stephens  
 Stephensi, *Rhynchonella*, xxxvii  
**stephensi**, *Vacekia*, *Suppl.*, **Pl. 10**, **figs. 17-19**;  
**Fig. 156**, p. clxvii; **Fig. 162**, p. clvii  
 Stepheoceras, cc; tuberculate core of, iv  
**stigosum**, *Graphoceras*, **Pl. 9**, **figs. 5, 6**, p. 68  
 (*Lioceras concavum*, var. *v-scriptum*); *Suppl.*,  
**Fig. 59** in text, p. xcvii  
**aff. stigosum**, *Graphoceras*, **Pl. 9**, **figs. 8-10**,  
 p. 56 (*Lioceras concavum*); p. xcvii  
 Stinchcombe, section of, 47  
 Stinchcombe Hill, 55, 86, 158, 173, 176, 208, 209,  
 213, 239, 279, xxix, xxxix, cxlviii, cxlix, clii,  
 clvi, clx  
 Stoford, 19, 61, 71, 75, 214, 257, 266, xxxviii,  
 lxvii, lxxiv, lxxvii, lxxxviii, xcvi, ci, cxviii,  
 clxxv, clxxxv, cxc; strata of, cviii  
 Stoke Knap, 26, 40, 51, 399, 401, xxvii, xlvi, lii,  
 lx, lxviii, lxxi, lxxv, lxxviii, lxxxiii, lxxxvi,  
 lxxxvii, lxxxviii, lxxxix, xc, xcii, xciv, xcvi,  
 civ, cvi, cviii, cix, cx, cxii, cxiv, cxvi, cxxviii,  
 cxxix, clvii, cxcii; sands at, 51; species from  
 sands at, 52; strata of, cviii  
**Stokeia**, *Suppl.*, p. cxxvii; *marmorea*, *subacuta*  
 Stokeia, classification, excviii  
 Strangwaysi, *Harpoceras*, note concerning original  
 specimen, 138  
 Strasburg Museum, 264  
 Strata on Dorset Coast, thickness of, clxxxiii  
 Stratal succession, xxxv  
 Stratigraphical position, ccvi  
 Stratigraphical terms, ccv  
 Stria, iii  
 Striae and radii, 57  
 striaries, *Agassicerias*, 226; *Ammonites*, 289  
 striata, *Trigonia*, 46  
 Striate *Ammonites*, xli  
 Striate (series of *Dumortieria*), clxxx  
 Striate species, xxxvi  
 Striate stage, examples of, 289; species, xl  
 Striation, cc  
 Striatuli hemera, vi, xii, cliv; strata of, cviii  
*striatulocostata*, *Dumortieria*, *Pl. 37*, **figs. 16, 17**,  
 see **yeovilensis**, **D.**; *Pl. 40*, **figs. 1, 2**, **externi-**  
**costata**, **D.**; *Pl. 40*, **figs. 3-8**, **mutans**, **D.**; *Pl.*  
*40*, **figs. 10-12**, **declinans**, **D.**; p. 243, see spp.  
 above  
*striatulocostata*, *Dumortieria*, clxxvii, clxxviii  
*striatulo-costatus*, *Ammonites*, 237, 255, clxxv  
 Striatulum beds, 50, 51, 164, 165; at Midford,  
 113; absent from Haresfield, 166; of York-  
 shire, 188  
**striatulum**, *Grammoceras*, **Pl. 26**, **figs. 8 10**; **Pl.**  
**28**, **figs. 18, 19**; p. 173; *Suppl.*, p. cxxxii  
*striatulum*, *Grammoceras*, *Pl. 28*, **figs. 16, 17**, see  
**penestriatulum**, **G.**; *Pl. 28*, **figs. 20, 21**, **are-**  
**nacea**, *Canavarella*; p. 173, see spp. above  
*striatulum*, *Grammoceras*, 12, 44, 45, 46, 49, 50,  
 158, 164, 165, 173, 222, xii, cxxix, cxxxii; in  
 Lias and Inferior Oolite, how mistake arose,  
 175; position in regard to sands, 175; mis-  
 take for *Dumortieria*, xciv; (hemera), ccv  
 Striatulum group, 163  
*striatulum*, *Harpoceras*, 45, 170, 174, 182  
 Striatulum subzone, 43, 45, 46, 49, 50, 52; cor-  
 rection, 166  
*striatulum*, var. *comptum*, *Harpoceras*, 170  
*striatulus*, *Ammonites*, 49, 173, 174, 252; (*Harmo-*  
*ceras*), 174  
 Striatulus shales, 167, 168  
*striatulus*, *Ammonites*, range of, in *Cotteswolds*,  
 49  
**striatum**, *Lioceras*, **Pl. 13**, **fig. 6**, p. 35 (*L. opa-*  
*linum*); **Pl. 13**, **fig. 12**, p. 54 (*L. opalinum*  
 var. *comptum*); *Suppl.*, **Pl. 10**, **fig. 10**; p.  
 xlii  
*striatum*, *Liparoceras*, 287; and modifying action,  
 289

- Strickland, H. E., and rules of nomenclature, 14
- Strigoceras, *cei*; *trifurcatum*, *truellii*
- Striicosta, *iii*
- Strophogyria**, *Suppl.*, p. **lxii**; *agriæ*, *cosmia*, *pinax*
- Strophogyria, classification, *excviii*
- Stroud, 64, 90, 91, 94, 96, 100, 229, 231, 239, 242, 245, 251, 252, 253, 258, 275, 279, 281, *xxvi*, *xxvii*, *xlii*, *civ*, *cx*, *cxxx*, *cxlix*, *clxi*, *clxix*, *clxx*, *clxxi*, *clxxvii*, *clxxxix*
- Stroud Hill, section of, 7
- Stroud Valley, 175
- Struckmanni, Ammonites, 206, *cxlviii*; (? Harpoceras), 205
- Struckmanni hemera, *vi*, *cliv*; strata of, *ceviii*
- struckmanni**, **Pseudogrammoceras**, p. 206 (*Grammoceras fallaciosum* var. *Struckmanni*); *Suppl.*, **Fig. 143**, p. *clxvii*; p. *cxlviii*
- Struckmanni, *Pseudogrammoceras* (hemera), *cev*
- Stubbington, F., 214
- Stürtz, *cxlviii*
- sub-, use of, *excvii*
- subacuta**, **Manselia**, *Suppl.*, Pl. 13, figs. 4-6, p. *lviii*
- subacuta**, **Stokeia**, *Suppl.*, Pl. 17, figs. 10-12; p. *cxxxviii*
- Subalticarinata, *cvi*, *cxi*; (series), *cxi*, *cxii*, *cxiv*
- subangulata, *Rhynchonella*, 8, 43
- Subangustumbilicate, *excvii*
- Subannular radii, 267
- subaratum**, **Catullocheras**, Pl. 39, figs. 1, 2 (*Dumortieria arata*); p. 280 (*Catullocheras aratum*); *Suppl.*, p. *clxxii*
- subaratum, *Catullocheras*, *clxxii*
- Subarcuate ribbing, 125; ribs, 158
- Subarcuate (series), *cix*
- subcandida**, **Cotteswoldia**, Pl. 32, figs. 7, 8, p. 192 (*Grammoceras aalense*); *Suppl.*, **Fig. 108**, p. *clxv*; p. *cxxxxv*
- Subcarinate (series), *xcvi*
- subcarinatum, *Phylloceras*, 119
- subcarinatus, Ammonites, 119
- subcaeva, **Hyattia**, *Suppl.*, **Fig. 13** in text, p. *lvi*
- subcompta?, **Pleydellia**?, Pl. 30, figs. 13, 14; p. 198 (*Grammoceras subcomptum*); *Suppl.*, **Fig. 117**, p. *clxvii*; p. *cxxxxviii*
- subcomptum*, *Grammoceras*, Pl. 30, figs. 11-14, p. 198, see **subcompta**, **Pleydellia**
- subcomptum, *Grammoceras*, *cxxxxviii*
- subcomptum, *Harpoceras*, 198, 248
- Subconcaumbilicate, *v*
- subcontractus, *Macrocephalites*, hemera, *cev*
- subcornuta**, **Apedogyria**, *Suppl.*, Pl. 14, figs. 13-15; p. *lx*
- subcoronatum, *Stephanoceras*, 272
- subcostata**, **Sonninia**, Pl. 71, figs. 4, 5; Pl. 103, **fig. 6**; pp. 330, 387, 415
- Subcostate, *Sonninia*, 448
- Subcostate species, *xxxvi*
- Subcostation, *cc*
- subcostosum**, **Lioceras**, Pl. 20, figs. 11, 12, p. 102 (*Ludwigia costosa*); *Suppl.*, Pl. 6, figs. 5-7; p. *xxxvii*
- Suberassicarinata (series), *cxxi*
- Suberassicostate, *ix*
- Suberassornate, *x*
- subdecorata beds, date of, *cevii*
- subdecorata, *Rhynchonella*, 8
- subdecorata**, **Sonninia**, Pl. 84, figs. 9-11; **Figs. in text**, 16, p. 388; 42, p. 412; 68, p. 443; pp. 361, 412
- subdecorata stock, 357; distinction of species in, 357; ontogenetic stages of, described, 358
- Subdirect ribs, 231
- subdiscoideum**, **Deltoidoceras**, Pl. 19, figs. 5, 6; Pl. 20, figs. 1, 2; p. 100 (*Hyperlioceras subdiscoideum*); *Suppl.*, **Fig. 82**, p. *clxv*; p. *cxviii*
- subdiscoideum*, *Hyperlioceras*, Pl. 19, figs. 5, 6; Pl. 20, figs. 1, 2, p. 100, see **subdiscoideum**, **Deltoidoceras**
- subdiscoideum, *Hyperlioceras*, *cxviii*
- subexcentrica**, **Dumortieria**, Pl. 30, **fig. 19**; Pl. 44, figs. 7, 8, p. 255 (*Dumortieria Moorei*); *Suppl.*, **Fig. 180**, p. *cx cvi*; p. *clxxxii*
- subfalcata**, **Manselia**, *Suppl.*, Pl. 11, figs. 25-27; **Fig. 15** in text, p. *lviii*
- Subfalcate to subarcuate (series), *cix*
- Subfalciradiata (series), *lxxix*, *cxv*, *clvii*
- subfallaciosum**, **Pseudogrammoceras**, Pl. 33, figs. 17, 18; p. 204 (*Grammoceras fallaciosum*); *Suppl.*, **Fig. 141**, p. *clxvii*; p. *cxlvii*
- Sub-family, 14, *excviii*
- subfasciata**, **Dumortieria**, Pl. 30, **fig. 18** (*Dum. radiosa*); p. 254 (*Dum. radiosa*, var. *gundershofensis*); *Suppl.*, **Fig. 177**, p. *cx cv*; **Fig. 178**, p. *clxxxii*

- Subflexicostate (series, Fontannesia), exc  
 Subflexiradiate (series of Dumortieria), clxxxiv ;  
 (Pseudogrammoceras series), cxlvi  
 subfurcatum, Cosmoceras, 10  
**subglabra**, Walkeria, Pl. 13, figs. 7-10, p. 35  
 (Lioceras opalinum) ; Figs. 125, 126, p.  
 clxvii ; p. cxli  
 Sub-groups, generic, 15  
 Subirregulariornate, x  
**subirregularis**, Sonninia, Pl. 77, figs. 6-9 (S. sp.) ;  
 Pl. 88, fig. 4 (S. sp.) ; Pl. 98, figs. 4, 5 ; Figs.  
 in text, 24, p. 390 ; 50, p. 424 ; 76, p. 443 ; p.  
 426  
 Sublatumbilicate, cii, excvii ; (series), cii  
 Subleptogyral, excvii  
**subleve**, Hyperlioceras, Pl. 17, fig. 5 ; Pl. 18, fig.  
 3 ; p. 94 (H. discites) ; Suppl., Fig. 93, p.  
 clxv ; p. cxliii  
**sublineata**, Brasilia, Pl. 8, figs. 5, 6 ; p. 72 (Lio-  
 ceras concavum var.) ; Suppl., Fig. 40 in text,  
 p. lxxx  
 sublineatum, Lytoceras, 45, 46  
**submarginata**, Sonninia, Pl. 71, figs. 1-3 ; pp. 329,  
 387, 406  
 Submarginata stock, 328  
 submaxillata, Terebratula, 43  
**subobsoleta**, Ludwigella, Suppl., Pl. 19, figs. 4-6 ;  
 p. lxxxviii  
 Subornate, iv, ix  
**subornatum**, Dissoroceras, Suppl., Fig. 77 ; p.  
 cxv  
 Subpachygyral, excvii  
 subplanatum, Harpoceras, 38, 216, 217  
 Subpaucicostate, ix ; (series), xcv  
 Subplatygyral, excvii  
**subquadrata**, Braunsina ?, Suppl., Pl. 20, figs. 10-  
 12 ; p. ci  
*subquadratum*, Grammoceras, Pl. 36, figs. 3-5, p.  
 202, see **subquadratum**, Pseudogrammoceras  
 subquadratum, Grammoceras, cxlv  
**subquadratum**, Pseudogrammoceras ; Pl. 36, figs.  
 3-5, p. 202 (Grammoceras subquadratum) ;  
 Suppl., Fig. 135, p. clxvii ; p. cxlv  
 subradiatus, Ammonites, 13, 20  
 Subrecticostate (series Fontannesia), exc  
**subrudis**, Ludwigella, Pl. 15, figs. 14, 15 ; Suppl.,  
 Fig. 52 in text, p. lxxxvii  
 Subrursiradiate, x  
**subsectum**, Deltotoceras, Pl. 19, figs. 3, 4 ; p. 98  
 (Hyperlioceras discoideum) ; Suppl., Fig. 86,  
 p. clxv ; p. cxxi  
 subserrodens, Amaltheus, 179, cxliii  
*subserrodens*, Grammoceras, Pl. 31, figs. 5, 6, 10-  
 12, venustula, Canavarina ; Pl. 31, figs. 7-9,  
 sp., Pleydellia ; Pl. 31, figs. 13, 14, sp., Cottes-  
 woldia ; p. 179 see spp. above  
 subserrodens, 222, 223, cxxxv ; Grammoceras,  
 cxxxix, cxliii  
**subsimplex**, Sonninia, Pl. 95, figs. 6-8 ; Figs. in  
 text, 25, p. 390 ; 51, p. 424 ; 77, p. 443 ; p.  
 427  
 subsimplex, Sonninia, 328  
**subsularis**, Dumortieria, Pl. 37, figs. 6-8 ; p. 241  
 (Dum. Levesquei) ; p. clxxiv  
**subspinatum**, Haplopleuroceras, Pl. 49, figs. 5, 6 ;  
 Pl. 51, figs. 1-10, 11-13 ; p. 300  
 subspinatum, Haplopleuroceras, 287, 303  
 subspinatum, Plenroceras, 300  
 subspinatus, Amaltheus, 300  
**subspinosa**, Sonninia, Pl. 49, figs. 8, 9 ; Pl. 84,  
 figs. 4-6 ; pp. 358, 387, 412  
 subspinosa, Sonninia, 287  
 Subspissicostate, Biarciradiata, cxi  
 Subspissicostate (series), xcvi, cxi  
 Sub-stages, tuberculated, 405  
 Substenogyral, excvii  
**substriata**, Sonninia, Pl. 70, figs. 6, 7 ; Pl. 71, figs.  
 6-8 ; pp. 330, 387, 406  
 substriata, Sonninia, 353  
**substriatum**, Ancolloceras, Suppl., Pl. 6, figs. 14-  
 16 ; p. xlvi  
**subtabulata**, Cosmogyrria, Suppl., Pl. 4, figs. 13-  
 15b ; p. liii  
 Subtabulate, cvi ; (series), ciii  
**subtecta**, Dorsetensia, Pl. 54, figs. 3-5 ; Pl. 55,  
 figs. 1, 2 ; p. 309  
 Subtriangularia, cxvii  
 Sub-tribe, 15  
 Subtuberculate, ix  
**subundulata**, Dumortieria, Pl. 45, figs. 1-3 ; p.  
 259 ; p. clxxxvi  
*subundulata*, Dumortieria, Pl. 43, figs. 8-10, see  
*latescens*, D. ; Pl. 44, figs. 10-12, *munda*, D. ;  
 Pl. 45, figs. 4, 5, 10-12, *rustica*, D. ; Pl. 45,  
 figs. 6, 7, *exacta*, D. ; Pl. 45, figs. 8, 9, *Brancoi*,  
 D. ; p. 259, see spp. above

subundulata, Dumortieria, clxxxv, clxxxvii; Haug's criticism of a specimen, 261  
 Subundulata series, clxxxiv, clxxxv  
 subundulata, var. externicompta, Dumortieria, 259  
 subundulata, var. externicostata, Dumortieria, 243, 259, clxxxvii  
 subundulata, var. striatulocostata, Dumortieria, 243  
 subundulatum, Harpoceras, clxxxvi  
 subundulatum, var. externecomptum, Harpoceras, 259, clxxxv  
 subundulatum, var. externe-costatum, Harpoceras, 243, 259, clxxxvii  
 subundulatum, var. externepunctum, Harpoceras, 196, 260  
 Sub-zone, 2, 10; striatum, variabilis, 46  
 suevica, Dumortieria, 252  
 sulcata, Lillia, Pl. 22, figs. 32, 33; Pl. 23, fig. 1, p. 109, see sulcata, Sonninia  
 sulcata, Lillia, exciii  
 sulcata, Sonninia, Pl. 22, figs. 32, 33; Pl. 23, fig. 1; p. 109 (Lillia sulcata); Suppl., p. exciii  
 sulcata, Sonninia, xiv  
 Sulcate, iv  
 Super-family, cxeviii  
 superba, Cotteswoldia, Pl. 32, figs. 1, 2; p. 192 (Grammoceras aalense); Suppl., Fig. 107, p. clxv; p. cxxxiv  
 Sutner, 267  
 Sutneri, Ammonites, 82; Parkinsonia, 272; Tmetoceras, 282, 285  
 \*Sutneri?, Witchellia, Pl. 49, figs. 14-17  
 Sutneri, Witchellia, 304  
 Suture, reasons for development in complication, 134  
 Suture-line, excix; and lobes, 134; stretching of, 180; development of, 217; as criterion of affinity, i; importance of, i; oblique lobes, clxix; characters of, cc  
 Swabia, 238, 258, xvii  
 Swabian Alps, 49  
 Symonsbury, xxxvii, lviii  
 Symonsbury Hill, 274

Tables:

- Table I.—Varieties of *Lioc. concavum*, 74
- Table II.—Genealogical, 131

Table III.—Hildoceratidæ, 132  
 Table IV.—The Grammocerata, 221  
 Table V.—The Polymorphidæ, 282, 283  
 Table VI.—Relationship of Amaltheidæ, 291  
 Table VII.—Genealogy of Dorsetensia, 312  
 Table VIII.—Sonniniæ, skeleton lobes of, 443  
 Table IX.—Sonniniæ, genealogical, 445  
 Table X.—Morphic equivalents, 449  
 Suppl. Table I.—Radial lines, Hildoceratidæ, clxiii  
 Suppl. Table II.—Radial lines, Hildoceratidæ, clxv  
 Suppl. Table III.—Radial lines, Hildoceratidæ, clxvii  
 Suppl. Table IV.—Radial lines, Polymorphidæ, Oppedidæ, cxevi  
 Suppl. Table.—Correlation of deposits, *cevi*  
 tabulata, Dumortieria, Suppl., Pl. 22, figs. 25-27; p. clxxxv  
 tabulatum, Dissoroceras, Pl. 21, figs. 5, 6; p. 104 (Ludwigia Lucyi); Suppl., Fig. 76, p. cxlv; p. cxv  
 Tabulate, iv; see penetabulate, subtabulate  
 Tabulate and penetabulate, cvi  
 Tabulate periphery described, cv  
 Tabulation of area, cvi  
 Taehygenesis, ceii; in decline of certain features, cxxxvii  
 Tate and Blake, 13, 61  
 Taylori and Cosmoceras, Haug location of, criticism on, 270  
 tecta, Dorsetensia, Pl. 56, figs. 2-5, p. 311  
 tenerum, Toxolioceras, Suppl., Fig. 98, p. cxxvii  
 Tenuia, cxlvi  
 tenuis, Ludwigella, Suppl., Pl. 20, figs. 37-39; p. lxxxvii  
 Terebratula, 47  
 Terminal lobule, 364  
 Terminals (of stocks), xcix  
 Terms, see acme, alticarina, anagenesis, anaplasia, anguliradiata, anguliradius, angustilobate, angustumbilicate, annular, arcuate, bispinous, bitabulate, bituberculation, brachysceles, brephic, bulla, bullicostæ, bullicostate, caduceiform, carinati-bisulcate, carinati-convex, carinatisulcate, carinatitabulate, catabatic, catagenesis, cataplasia, coiling in, coiling out, concave, concavifastigate, concavumbilicate,

- concentric, concentricatumbilicate, concentricumbilicate, conch, convex, convexifastigate, costa, costistria, crassicarinate, crassicostate, crassornate, craterumbilicate, cruciform, deltiradiate, deltoid, densicostate, densisept, direct, distincticarinate,  $\eta$ , earlier inheritance, ectobrachysceles, endobrachysceles, epacme, ephobic, equicellate, equipoised, excentric coiling, excentricatumbilicate, excentricumbilicate, extreme, extreme-latumbilicate, extreme-pachygyral, falcate, falciform, falciradiate, fastigate, flexicostate, flexiradius, gammiradiate, gerontic, gradumbilicate, hemera, hollow-carina, homœomorph, homœomorphous, homœomorphous, hypostrophic, inæquiorate, incoiling, inornatilobate, interlobular, intra-axial, irregulari-ornate, isosceloid, L, l, lævigata, lævigatilibulate, latangulate, latilobate, latisept, latumbilicate, leptogyral, lithic, magnilobate, metaplasia, morphanagenesis, morphic equivalents, m. prefiguration, m. representation, morpho-, morphogenesis, morphogeny, morphological equivalents, etc. = morphic, multispinous, multituberculation, neanic, nodicostæ, nodicostate, nodus, nonsepticarina, nonseptituberculate, nontuberculate, oligogyral, ornatilobate, outcoiling, pachygyral, palmate, papilla, paracme, parvicarinate, partition-band, parvicarina, parvicostate, parvilobate, parviornate, parvituberculate, paucicostate, pauciseptate, pedigerous, penatubulate, per-, perangustumbilicate, perlatumbilicate, perleptogyral, perpachygyral, perplatygyral, perstenogyral, phylembryonic, phylephobic, phylhypostrophic, phyllobrephic, phyllocatabatic, phylogerontic, phyloneanic, planate, planifastigate, platygyral, pœcilmorphy, polygyral, postnodate, prorsicostate, prorsiradiate, prorsiradius, radial curve, r. line, radius, reclined ribs, rectiradiate, rectiradius, regulariornate, rursicostate, rursiradiate, rursiradius, rursisubflexiradiate, septicarina, septituberculate, sessile, solid carina, spina, spinicostæ, spissicostate, stria, striicosta, subalticarinate, subangustumbilicate, subannular, subarcuate, subcarinate, subconcaumbilicate, subcostate, subcrassicarinate, subcrassicostate, subcrassornate, subdirect, subfalcate, subfalciradiate, subflexicostate, subflexiradiate, subirregulariornate, sublatumbilicate, subleptogyral, subornate, subpachygyral, subpaucicostate, subplatygyral, subrecticostate, subrursiradiate, subspissicostate, substenogyral, subtabulate, subtuberculate, tabulate, tachygenesis, to, tortiradiate, tortiradius, tuberculate, ultra-axial, umbilicus concentric, u. excentric, undulate, unispinous, unituberculate, ventrally inclined, ventrally projected, versiradiate, versiradius, v-script, v-shaped
- Terms, quarrymen's, 48  
 Terms of auxology, 357  
 Terms, technical, exevii; hemeral, ccv; stratigraphical, ccv  
 Tessonianus, Ammonites, 309, 310  
 Test-ornament, excix; characters of, cc  
 Tetrabranchiata, 126  
 Thiolière, 273, 277  
 Thompson, Beeby, 40, 53, xviii; on Am. bifrons, 48; on Am. opalinus, 52; and *Lioceras comptum*, 55; on Northampton strata, xv; and *Lioceras Thompsoni*, xl  
**thompsoni, *Lioceras*, Suppl., Pl. 7, figs. 13-16; p. xl**  
 Thone, 5  
 Thouars, 172  
 Thouarsense, *Grammoceras*, 170  
 Thouarsensis, Ammonites, 169, 170, cxxxii  
 Thuringia, *Grammoceras* in, 169  
**thrasu, *Pseudogrammoceras*, Pl. 36, figs. 6-8; Suppl., Fig. 136; p. cxlv**  
 Tilly-sur-Seulles, clxxiv  
 tirolense, *Phymatoceras*, xxx  
 tirolensis, Ammonites, 109, vii, x, xi  
 tirolensis, Am. (Dum.), need for new name for, xxx  
 Title, explanation of, cciv  
**Tmetoceras, p. 269; Suppl., p. clix; circulare, hollandæ, regleyi, scissum, sutneri**  
*Tmetoceras*, clxix; from allies, 267; classification, exeviii  
 to = passing on to become, 341, 342  
*toarcense, Grammoceras*, Pl. 34, fig. 12, see **sp. A. Grammoceras**; Pl. 28, figs. 4, 5, see **audax, G.**; Pl. 28, figs. 7-13, **toarciense, G.**; p. 169, see spp. above

- toarcense, *Grammoceras*, 165, 221, 222, 305, cxxxi, cxxxii; and *Orbigny*, connection between, table, 183; in Lias and Inf. Oolite, how mistake arose, 175
- toarcense-striatulum, note on term, cxlvi
- toarcense-striatulum*, *Grammoceras*, Pl. 28, figs. 14, 15, p. 173, see **explicatum**, **Pseudogrammoceras**
- toarcense-striatulum, *Grammoceras*, 165, cxlvi
- toarcensis, *Ammonites*, 172; Lima, 172
- Toarcian, 220; value of term, 173; stage, ccv
- Toarcien, equivalents of, 173
- toarciense, *Grammoceras*, Pl. 28, figs. 7-13, p. 169 (G. toarcense); p. cxxxii
- toarciensis, note on word, 173
- Toarcium, 172
- tolutarium**, *Rhæboceras*, Suppl., Pl. 11, figs. 4-6; p. lxxiii
- tolutarius, *Ammonites*, lxxii, lxxiii
- toma, *Canavarella*, Suppl., Pl. 22, figs. 16-18; p. cxxix
- torquata, *Denckmannia*, Suppl., Pl. 3, figs. 4-6; p. xix
- torquata, *Denckmannia*, ix
- Tortiradiæ (series), lxxiv
- Tortiradius, position of, in regard to other forms of radii, lxxiv
- tortiva, *Fontannesia*, Pl. 47, figs. 8, 9; p. 262 (*Dinnortiera grammoceroïdes*); p. cxc
- tortum, *Rhæboceras*, Suppl., Pl. 11, figs. 1-3; Fig. 28 in text; p. lxxii
- torulosum, *Lytoceras*, 50, 51, 52
- torulosus, *Ammonites*, 45, 49; zone of, 49
- Torulosis* bett, 2
- Toulon, 294, 295, 299
- toxeres, *Darellia*, Suppl., Pl. 18, figs. 13-15; p. cxiii
- Toxolioceras**, Suppl., p. cxxvi; **incisum**, **mundum**, **tenerum**, **walkeri**; classification, cxviii
- Transverse ornament, cc
- Trent, 114, 175, 281, xiv
- Triangle, inverted, 360
- Triangles, proportional, cxvii
- triangulare, *Deltotoceras*, Fig. 84, p. cxx
- Tribe 14
- trichina, *Manselia*, Suppl., Pl. 10, figs. 14-16, p. lix
- tridactyla, *Sonninia*, Pl. 101, figs. 1-3; pp. 384, 393
- trifoliatum, *Phylloceras*, 301
- trifureatum, *Strigoceras*, cci
- Trigonia-grit, Lower, ccix; for *Lioceras concavum*, 62; and *Fontannesia*, cxc; date of, cxvii
- Trigonia-grit, Upper, 7, ccix; age of, 91; date of, cxi
- Trigonia grits and Dorset Cephalopod bed, 3
- Trigonia navis, zone of, 49; beds, 258
- Trimarginate, 132
- trimarginatum, *Harpoceras*, 13
- trimarginatus, *Ammonites*, 127, 129
- Trinomial nomenclature, remarks on, 315
- Tropiditæ, 14
- Tropidoceras, 13, 14, 127
- Trotternish, lxx
- Truelli, *Ammonites*, confounded with *Hyperlioceras discoïdeum*, 92, 99
- Truelli hemera, vi; strata of, cxi
- truelli, *Strigoceras*, cci; hemera, ccv
- tuberata, *Kiliania*, Suppl., Pl. 15, figs. 1-3; p. lxvi
- tuberculata, *Ludwigia*, Pl. 3, figs. 4, 5; Pl. A, fig. 2; p. 17 (*Ludwigia Murchisonæ*, var. *obtusa*); Suppl., Pl. 11, fig. 30; p. lxix
- Tuberculate, iv
- Tuberculate *Sonniniæ*, 447
- Tuberculate costate *Sonniniæ*, 447
- Tuberculate stage, 405; in *Grammoceras*, cxxxi
- Tuberculation, iii
- tumefacta, *Denckmannia*, Suppl., Pl. 1, figs. 7-10; p. xix
- tumefacta, *Denckmannia*, ix
- tumidus, *Spirifer*, 258
- Turbo, 46
- turgidus, *Amaltheus*, 291
- Turrilites, 381
- Tutcher, J. W., and Dundry specimen, 434; and *Brasilina Tutcheri*, lxxxiii, lxxxiv; and *Fontannesia* at Dundry, clxxxviii, cxc; and photographs, cxcii
- Tutcheri**, *Brasilina*, Suppl., Figs. 44, 45 in text, p. lxxxiii (? Suppl., Pl. 10, figs. 35-37, p. cxxx)
- Type-species, cxi
- Typical series (*Fontannesia*), clxxxviii
- Ubaldo, 294

- \***Ualdi, Zurcheria**, p. 298 [Foreign]  
 Ualdi, Zurcheria, 291, 293, 294, 295, 297  
 Ultra-axial, 369  
 ultramontanum, Phylloceras, 301  
 Umbilical catagensis, ceii  
 Umbilical closing, ceii  
 umbilicata, Ludwiginia, Suppl., Fig 18 in text, p. lxi  
 umbilicata, Sonninia, Pl. 84, figs. 1-3; pp. 385, 397  
 Umbilicate species, clxxxiii  
 Umbilicate (series of Cottswoldia), cxxxv; see also Augustumbilicate, concavumbilicate, concentumbilicate, concentri-latumbilicate, craterumbilicate, excentrumbilicate, excentri-latumbilicate, gradumbilicate, latumbilicate, subconcavumbilicate  
 Umbilication, excix, cei; renewal of, in age, 140  
 Umbilicus, changes in, 36; expansion of, 140, 312—Hyatt's explanation of, 312; concentric, 323; excentric, 323; comparison of dimensions of, in modesta and simplex, 327; comparative measurements in nuda, simplex, substriata, 353; terms for, iv; change of, with age, v; expansion of, v, exliv; expansion of, hypostrophic, lxxii; progressive decline of, lxxxix; relative time of expansion of, exliv; expansion of, remarks on, exliv; opening out, ceii; a character of distinction, ceiv  
 Umbria, 220  
 uncinatum, Lioceras, Suppl., Pl. 5, figs. 7-11; p. xxxvi  
 uncum, Lioceras, Suppl., Pl. 6, figs. 8-10; p. xxxvii  
 undatum, Cylicoceras, Suppl., Pl. 5, figs. 5, 6; p. 1  
 Undulate ribs, 307  
 undulatum, Graphoceras, Pl. 10, fig. 9; Pl. A, fig. 19; p. 56 (Lioceras concavum); p. xcvi  
 undulatum, Lioceras, Suppl., Pl. 9, figs. 1-3 (13, 14?); p. xxxix  
 undulatus, Ammonites, 241, 242, 246  
 Unispinous stage, 288; examples of, 289  
 Unituberculation, ce  
 Upper beds, ceix  
 Upper Inferior Oolite, cev  
 Upper Freestone, 7  
 Upper Leda-ovum beds, date of, xv  
 Upper Lias, see Lias, upper  
 Upper Lias Cephalopoda Bed, 175  
 Upper Lias Sands, 175  
 Upton, Charles, 286, li, lxiii, cl, clxi, clxxxix; prior use of Dumortieria, 286; his hints on photography, 380; and Dumortieria, clxix  
 Uptonia, clxix, clxxxviii  
 Vacek, Dr. M., 35, 53, 64, 83, 96, 155, 156, 176, 191, 238, 266, 269, 270, 273, 277, 294, 295, 297, 298, xxxvi; on Harp. opalinum, 54; on Lias and Oolite, 64; and Pseudographoceras sp., xciii  
**Vacekia, Suppl., p. clvi; Stephensi**  
 Vacekia, from Pseudolioceras, clviii; classification, excviii  
 Valdani, Ammonites, 289  
 variable, Hammatoceras, 146  
 variable, Harpoceras, 146, 149, 211, vii, x, xxi, xxiii; remarks on discrepancies in Wright's figure of (by Mr. Crick), 146  
 variabilis, Ammonites, 50, 153, 226, vii, x, xxiii, xxvii; Ammonites, as type of Hangia, 45; (jugosa), Ammonites, 212; beds, 164, 167; group, xxiii  
 variabilis, Haugia, Pl. A, fig. 34; p. 146; Suppl., p. xxiii  
 aff. variabilis, Haugia, Pl. 25, fig. 2; Suppl., p. xxiii; p. 146 (H. variabilis)  
 variabilis, Haugia, Pl. 23, figs. 11, 12, see jugosa, H.; Pl. 23, figs. 14, 15, grandis, H.; Pl. 25, fig. 2, aff. variabilis, H.; p. 146, see spp. above  
 variabilis, Haugia, 45, 142, x, xxi, xxiii, xxv, xxvi; and H. jugosa, comparative dimensions, 150; and Grammoceras dispansum, comparison of, 212; (hemera), cev  
 Variabilis hemera, vi, xii, xv, cliv; strata of, ceix; variabilis, Rhynchonella, 48  
 Variabilis subzone, 45, 46, 50, 148  
 variabilis, var. dispansus, Ammonites, 211  
 Variation, normal and abnormal, 289  
 Variation as specific and generic, excix  
 Variety of form (pæcilomorphy), excix  
 Vaughan, Dr., and Harpoceras nitescens, cxxxi; and Dumortieria, clxix; and Catullocheras Leesbergi, clxxi  
 Vendée, cxxxiv, clxxxviii, clxxx

- Veneris, Parkinsonia, 272  
 Ventral area, development of, 280, 299  
 Ventrally inclined, 231  
 Ventrally projected, 231  
 venustula. Canavarina, Pl. 31, figs. 5, 6, 10-12?, p. 179 (Grammoceras subserrodens); Suppl., Figs. 131, 132, p. clxvii; p. cxliii  
 Vermiceras, 267; Conybearii  
 Vernosæ, Catulloceras, 232, 233, 234; Dumortieria, 161, 234; Polymorphites, 264, 267, 276, 283, 284, 285; and Polymorphites, Haug's opinion on, 268  
 Verpillière, see la Verpillière  
 Versiradiate, x  
 Versiradius, iii  
 Versum, iii  
 Versicostate (series Fontannesia), exci  
 vibrata, Ludwigella, Suppl., Pl. 19, figs. 13-15; p. lxxxviii  
 vitiosum, Cypholloceras, Suppl., Pl. 5, figs. 1, 2; p. xlv  
 vittatum, Pleuroceras, 291  
 Voltzii, Astarte, 5  
 V-script genera, from Braunsella, cii  
 V-script line, in earlier species, cvi  
 V-scriptiradiate (series), xci  
 v-scriptum, Graphoceras, Pl. 10, figs. 5, 6; Pl. A, fig. 16; p. 68 (Lioceras concavum var. v-scriptum); Suppl., Pl. 15, fig. 18; Fig. 58 in text. p. xcvi  
 v-scriptum, Lioceras, 69  
 V-shaped radii, 57; ribbing, 124; ribs, 57, 69, 73, 75  
 Waagen, Dr. W., 13, 14, 83, 91, 94, 96, 98, 151, 158, 272, 287, 292, 293, 328, 376, exxii, exciv, excv; and Harpoceras, 13, 14, 143; on Gryphite grit, 91, 96  
 Waagenia, 13, 313  
 Wæhneroceras, 267  
 Waldheimiæ, 52  
 Walford, E. A., on Otley Hill, 40, 52; on Am. Murchisonæ, 53  
 Walker, J. F., 94, xxxix, lxxv; and Walkeria, exxxix  
 Walkeri, Hyperlioceras, Pl. 16, figs. 1, 2, see Walkeri, Toxolloceras; Pl. 16, figs. 3-6, polita, Darellia; Pl. 16, figs. 7-9, piodes, Reynesella; Pl. 16, figs. 10, 11, cæla, Reynesia; p. 92, see spp. above  
 Walkeri, Hyperlioceras, 301, civ, cix, cxiv, exxvi  
 Walkeri, Toxolloceras, Pl. 16, figs. 1, 2, p. 92 (Hyperlioceras Walkeri); Suppl., Pl. 18, figs. 1-3, 22; p. exxvi  
 Walkeria, Suppl., p. exxxix; arcuata, burtonensis, delicata, lotharingica, sp., subglabra  
 Walkeria, classification, exeviii  
 Walther, Dr. Johannes, criticisms of his dispersal theory, 454  
 Welsch, Jules, and Welschia, li  
 Welschia, Suppl., p. li; obtusiformis, pagana, rustica  
 Welschia, from Cosmogoria, liii; from Hyattia, lv; from Kiliania, lxiv; from Ludwigia, lxix; from Brasilia, lxxx; classification, exeviii  
 Wentzen, 96  
 Werthi, Ammonites, vii, xi, xxvii  
 White bed below Ironshot, 293  
 White Ironshot, Lower, date of, cevii; Upper, date of, cevii  
 White Lackington, 175, 213, 219, 220, 231, 265, 281, xxv, cxlviii; section, 165  
 White Oolite, 5  
 White stone, date of, cevi  
 Whitehall Farm, xxviii  
 Whittington, lxvi  
 Whorl, contraction of, in age, 130  
 Whorl-shape, excix; characters of, cc  
 Whorl, see also leptogyral, oligogyral, pachygyral, platygyral, polygyral, stenogyral  
 Whorls, relatively stout (series with), cxiv  
 Wick, 305  
 Wild Bed, xxxv; date of, cevii  
 Wilson, E., 278, 342, 399, xxvi, xxix, lv, lxxix, xevii, e, cii, cix, cxiii, cxix, cxlxxxv; and Dundry, Ammonites, 63; and Ludwigia rudis, 103; sends specimens, 168, 173; gave figured specimen, 401; and Hyattia Wilsoni, lvi; see Buckman & Wilson  
 Wilsoni, Hyattia, Suppl., Pl. 12, figs. 4-9; p. lvi  
 Wilton-shire, 359  
 Wiltshire, Dr. T., and Wiltshireia, lxxviii  
 Wiltshireia, Suppl., p. lxxviii; gigantea  
 Wiltshireia, from Lueya, lxxiv; from Ludwigia, lxix; classification, exeviii  
 Winwood, Rev. H. H., 165  
 Wistley Hill, cxxi

- Witchell, E., 6, 42, 66, 78, 90, 91, 94, 100, 107 ;  
on Stroud Hill, 6 ; on Little Sodbury, 40 ;  
on sandy ferruginous limestones, 44 ; and  
Witchellia, 82 ; on Gryphite-grit, 90, 94, 100 ;  
and Brodieia Witchelli, xxxiii
- Witchell, Mrs. E., 66
- Witchelli, Brodiceras, Pl. 23, figs. 9, 10 ; p. 107**  
(Ludwigia sp.) ; p. xxxiii (Brodieia ? Wit-  
chelli
- Witchelli, Brodieia, Pl. 23, figs. 9, 10, Suppl., p.*  
*xxxiii ; see Witchelli, Brodiceras*
- Witchellia, as new genus, 82 ; Suppl., p. cxcii ;**  
laeviuscula, sayni, sp., \*sutneri
- Witchellia, 117, 287, 290, 292, 314 ; and Dundry,  
292, 293 ; from Dorsetensia, 303 ; characters  
of, 303 ; from Sonnina, 314 ; beds, ceix
- Witchellia hemera, strata of, cevi
- Witchellia sp. hemera, vi, cev
- Witshireia, Suppl., Pl. 11, fig. 31, misprint, see*  
**Wiltshireia**
- Woodward, H. B., 112, 446 ; on Am. opalinus, 50 ;  
and use of double names, 222
- Worcestershire, elvi, elxi
- Wotton-under-Edge, 157, 173, 175, 182, 208, 213,  
242, 247, 279, cxxxii, cl, clxxxiii
- Wright, Dr. T., 35, 44, 49, 80, 114, 119, 146, 147,  
148, 149, 150, 170, 172, 175, 176, 178, 182,  
189, 192, 193, 197, 204, 205, 206, 207, 215,  
232, 238, 254, 255, 287, 296, vii, viii, x, xvi,  
xxi, xxiii, xxiv, xxxvi, xlii, xlvi, lxxxix, cxxxi,  
cxl, cxlv, cxlvii, cxlviii, cxlix, elii, eliii,  
elxxxii, ce ; on Lias Ammonites, 4, 6, 10, 37,  
55 ; Frocester Hill, 3 ; on Leekhampton Hill,  
7 ; Harpoceras, 11 ; on genus Harpoceras, 13 ;  
on A. Murelisonæ, 19 ; on Lioceras opalinum,  
22 ; on Inferior Oolite, 41, 42 ; on line between  
Lias and Oolite, 44 ; on Nautilus comptus, 53 ;  
on Am. concavus, d'Orb., 60, 86 ; on Gryphite-  
grit, 91 ; on A. bifrons in Cotteswold Sands,  
113 ; on A. variabilis, 143 ; on A. dispansus,  
145 ; and opalinum-zone, 220 ; and Harp.  
aalense, 256 ; and specimen of Ludwigella  
glevensis, lxxxix ; and Harpoceras radians,  
cxlv ; remarks on A. Moorei, clxxxii
- \*Wrighti, Lytoceras, nom. nov., 44**
- Wrighti, Lytoceras, 45, ce ; Sphaeroceras, 120
- Würtenberger, 272
- Württenbergeri, Ammonites, 85
- Wyke Quarry, 62, 120. lxxxv ; section at, 8
- Yate, 40
- Yellow Sands, xxxv ; date of, ceviii ; at Midford,  
position of, 113
- Yellow and blue sands, date of, ceviii
- Yellow and grey sands, 167, 229 ; beds of, 168 ;  
below Dogger, date of, ceviii
- Yellow micaceous sands, 167
- Yeovil, 6, 52, 97, 106, 237, xxxviii, elxxii, elxix,  
elxxiv ; absence of Opalinum beds, 52 ; mis-  
taken use of the name in labelling fossils, 106 ;  
and Ilminster, lxxxvi ; strata of, ceviii
- Yeovil Junction, 245, clxxxiii ; strata at, 6 ; may  
denote specimens from Dorset and Somerset,  
247
- Yeovil Sands, 3, 47, 166 ; characters of, fossils  
of, 6 ; doubts about correlation with Cottes-  
wold Sands, 50 ; and Cotteswold, discrepancy  
of Am. fauna in, 52 ; base, 165 ; beds of, 166,  
168 ; date of, ceviii, ceix
- yeovilensis, Dumortieria, Pl. 37, figs. 16, 17, p.**  
**243 (D. striatulo-costata) ; Suppl., Fig. 172,**  
**p. cxevi ; p. clxxxviii**
- Yorkshire, 86, 173, 175, 188, 202, 228, 239, xc ;  
Dogger, 167 ; strata, 167 ; yellow and grey  
sands, 167 ; sands on horizon of Dumortieria  
beds, 167 ; strata of, ceviii, ceix
- Young & Bird, 38, elviii
- Zieten, 17, 35, 169, 188, 192, 197, 215, 216, 227,  
241, 252, 254, xl, lv, clxxxii
- Zigzag beds, cevi
- Zigzag hemera, vi ; strata of, cevi
- zigzag, Stephanoceras, possible descendants of,  
272 ; characters of adult of, 272
- zigzag, Zigzagiceras, hemera, cev
- Zio, Harpoceras, 13
- ziphus, Ammonites, 289 ; unispinous stage, sepa-  
rating progressive and retrogressive costate  
stages, 290
- Zittel, Dr. K. A., 268, 269, 287 ; classification,  
126 ; on Harpoceras, 128 ; and Oxynoticeras,  
225
- Zitteli, Harpoceras, 158 ; Polymorphites, 266, 267,  
268, 270, 276, 282, 284, 285
- Zoological series, development, cxcix

- Zonal Ammonites mixed, 7
- Zone, erroneous ideas concerning species in a, 446 ;  
 species of a, not necessarily contemporaneous ;  
 immense time to deposit, 446 ; commune,  
 bifrons, concavum, falciferum, Harpoceras,  
 henleyi, humphriesianum, ibex, jamesoni,  
 jurensis (e), margaritatus, murchisonæ, opa-  
 linum (us), parkinsoni, Posidonomya Bronni,  
 sauzei, sowerbyi, spinatum, Stephanoceras,  
 Stephanoceratites, Trigonina navis, torulosus
- Zones, and sub-zones, 2 ; Opper, 49 ; and beds, 166 ;  
 coalesced, 274
- Zurcher and Zurcheria, 293
- Zurcheri, Somminia, and Fontannesia, etc
- Zurcheria**, p. 293 ; **Suppl.**, p. cxcii ; **inconstans**,  
**parvispinata**, **pertinax**, **pugnax**, **\*ubaldi**
- Zurcheria, 287, 314, 436, etc ; Foreign species of,  
 described, 298 ; from Haplopleuroceras, 300 ;  
 from Somminia, 314 ; classification, etcviii

Palæontographical Society, 1907.

A MONOGRAPH

OF THE

CRETACEOUS LAMELLIBRANCHIA

OF

ENGLAND.

BY

HENRY WOODS, M.A.

UNIVERSITY LECTURER IN PALÆOZOLOGY, CAMBRIDGE.

VOL. II. PART IV.

CYPRINIDÆ, ISOCARDIIDÆ, LUCINIDÆ, CORBIDÆ, UNICARDIIDÆ,  
TELLINIDÆ, MACTRIDÆ, AND VENERIDÆ.

PAGES 133—180; PLATES XX—XXVII.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1907.

PRINTED BY ADLARD AND SON, LONDON AND DORKING.

CYPRINA SEDGWICKI (*Walker*), 1866. Plate XIX, fig. 14. Plate XX, figs. 1–5.

1866. SPHÆRA SEDGWICKII, *J. F. Walker*. Ann. Mag. Nat. Hist., ser. 3, vol. xviii, p. 386, pl. xiii, figs. 1, 2.  
 1867. CYPRINA ANGULATA, var., *H. G. Seeley*. Ibid., ser. 3, vol. xx, p. 27.  
 1875. — SEDGWICKII, *W. Keeping* in *T. G. Bonney*. 'Cambridgeshire Geology,' p. 68.  
 1883. — — *W. Keeping*. Foss., etc., Neoc. Upware and Brickhill, p. 123, pl. vi, fig. 12.

*Description*.—Shell more or less oval, sometimes sub-triangular, rounded, inflated, slightly or moderately inequilateral; length as a rule not greatly exceeding the height. Lunular margin of moderate length, concave. Anterior margin rounded, passing gradually into the convex ventral margin. Postero-dorsal margin moderately convex. Umbones prominent, broad, curved inward and forward. Carina absent or indistinct. Postero-dorsal region convex, rounded. Lunule large, ovate, bounded by a faint groove. Escutcheon long, bounded by a more or less distinct carina. Ornamentation consists of growth-lines.

*Measurements* :

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	
Length .	39	38	37	37	34	32	31	27	23	mm.
Height .	34	31	31	32	31	26·5	27	24	20	,,
Thickness	29	25	26·5			23	24			,,
	(1–9) Lower Greensand, Upware.									

*Affinities*.—This species is closely related to, and may perhaps be only a local variety of *C. Saussuri* (see above). The chief points in which it differs from the latter are (1) the carina is absent or indistinct, (2) the posterior margin is relatively higher, (3) the valves are usually more inflated, (4) the shell is usually less triangular in outline and less inequilateral.

*Remarks*.—The examples of *C. Sedgwicki* vary in relative height and length, and consequently in outline. The longer forms approach *C. Saussuri* more nearly than the shorter forms.

This species was placed in the genus *Sphæra* by Mr. J. F. Walker, but was subsequently referred to *Cyprina* by Seeley and by W. Keeping.

*Type*.—From Potton, in Mr. J. F. Walker's collection.

*Distribution*.—Lower Greensand of Upware and Potton.

CYPRINA OBTUSA, *Keeping*, 1883. Plate XX, fig. 6.

1883. CYPRINA OBTUSA, *W. Keeping*. Foss., etc., Neoc. Upware and Brickhill, p. 124, pl. vi, fig. 13.

*Remarks.*—*C. obtusa*, of which I have seen two specimens only, closely resembles some forms of *C. Saussuri*, but differs in having narrower and less curved umbones. It also resembles the more elongate forms of *C. Sedgwicki*.

*Type.*—In the Sedgwick Museum.

*Distribution.*—Lower Greensand of Upware.

CYPRINA CUNEATA, *Sowerby*, 1836. Plate XX, figs. 7–12.

1836. CYPRINA CUNEATA, *J. de C. Sowerby*. Trans. Geol. Soc., ser. 2, vol. iv, pp. 240, 341, pl. xvi, fig. 19.
1849. — TRIANGULARIS, *T. Brown*. Foss. Conch., p. 207, pl. lxxxv, fig. 2.
1850. — CUNEATA, *A. d'Orbigny*. Prodr. de Pal., vol. ii, p. 161.
1854. — — *J. Morris*. Cat. Brit. Foss., ed. 2, p. 199.
1865. — — *F. J. Pietet and G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4) p. 230.
1870. — — *F. Stoliczka*. Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 193 [*Anisocardia (Feniella)*].

*Description.*—Shell of small or moderate size, triangular, convex with flattened sides, carinate, considerably inequilateral. Lunular margin long, concave. Anterior margin regularly rounded. Ventral margin only slightly curved, sometimes with the posterior part concave. Posterior margin short, truncated, almost straight, nearly parallel to the height of the shell, forming a right angle with the ventral margin and an obtuse angle with the long postero-dorsal margin. Umbones prominent, high, curved considerably inward and forward. A distinct, but rounded, carina extends in a gentle curve from the umbo to the postero-ventral angle. In front of the carina the shell is sometimes slightly concave. Postero-dorsal area narrow, sloping steeply except near the posterior margin. Lunular region deep, indistinctly limited. Escutcheon elongate, bounded by a small carina. Ornamentation consists of very fine growth-lines at regular intervals.

*Measurements:*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Length .	48	36	35	31	29	26.5	26	26	23	20 mm.
Height .	40	29	29	26	24	20.5	21	19.5	20	16 „

(1–10) Blackdown.

*Affinities.*—The differences between *C. Saussuri* and this species are given above (p. 132).

The form from the Meule de Braquegnies which was referred to *C. angulata*,

Sowerby, by Briart and Cornet,<sup>1</sup> appears to be more nearly related to *C. cuneata* than to *C. angulata*.

*C. securiformis*, Sharpe,<sup>2</sup> is similar to *C. cuneata*, but its ventral margin has a much greater curvature.

*C. cuneata* is mentioned by Stoliczka as a typical example of the sub-genus *Veniella*, Stoliczka.<sup>3</sup> The anterior right cardinal tooth, however, does not appear to be so strongly developed as in the type of *Veniella*.

*Types*.—The types came from Blackdown, but cannot now be found.

*Distribution*.—Upper Greensand (zone of *Schlawbachia rostrata*) of Blackdown and Haldon. Upper Greensand (Meÿer's Bed 2) of Weston Mouth (Devon).

CYPRINA CLAXBIENSIS, sp. nov. Plate XXI, fig. 2; Plate XXIV, fig. 1.

*Description*.—Shell large, stout, oval, rather elongate, considerably inequilateral, moderately convex. Antero-dorsal margin short, straight or slightly concave. Anterior margin well rounded, passing gradually into the convex ventral margin. Posterior margin oblique, sub-truncate, more or less rounded. Postero-dorsal margin rather long, slightly convex. Umbones broad, curved anteriorly, with a rounded carina extending to the postero-ventral extremity, and limiting a flattened or somewhat convex postero-dorsal area which slopes rapidly to the postero-dorsal margin, but more gradually to the posterior margin. Lumular region excavated, not limited. Ornamentation consists of small concentric ribs.

Hinge: in the right valve the anterior cardinal is conical, larger than the median cardinal, and placed below and separated from the latter; the posterior cardinal is oblique, laminar, and divided by a furrow. In the left valve the anterior and median cardinals are stout, the posterior cardinal is oblique and laminar.

*Measurements (approximate)* :

	(1)	(2)	(3)
Length . . . . .	99	80	74 mm.
Height . . . . .	75	64	56 ,,

*Affinities*.—This species resembles *C. Constanti*, Dollfus,<sup>4</sup> from the Kimeridgian,

<sup>1</sup> Meule de Braquegnies ('Mém. cour. et Mém. des. Sav. étrangers,' vol. xxxiv, 1867), p. 68, pl. viii, figs. 26—28.

<sup>2</sup> 'Quart. Journ. Geol. Soc.,' vol. vi (1850), p. 182, pl. xxii, figs. 1—3. *C. globosa*, Sharpe (Ibid., p. 182, pl. xv, fig. 1) is recorded by Morris from Blackdown, but I have seen no example of it.

<sup>3</sup> 'Palæont. Indica, Cret. Fauna S. India,' vol. iii (1870), p. 189. See also Meek, 'Invert. Cret. and Tert. Foss. U. Missouri' (1876), pp. 147—152.

<sup>4</sup> 'Faune Kimmérid. du Cap de la Hève' (1863), p. 65, pl. x, figs. 6—8. De Loriol and Pellat, 'Mon. Étages supér. Jurass. de Boulogne-sur-Mer' (1874), p. 42, pl. xii, fig. 14.

but is much larger and stouter, and the lunular region is more deeply excavated; also the umbones appear to have a greater anterior curvature.

*Type*.—From Benniworth Haven, in the Sedgwick Museum.

*Distribution*.—Claxby Ironstone (zone of *Belemnites lateralis*) of Benniworth Haven and Donnington.

CYPRINA TEALBIENSIS, sp. nov. Plate XX, fig. 13*a, b*.

*Description*.—Shell very thick, large, elongate, oval, regularly convex, very inequilateral. Antero-dorsal margin concave. Anterior margin rounded, curving rapidly, passing gradually into the ventral margin. Posterior margin rounded, forming an obtuse angle with the long, slightly convex postero-dorsal margin. Umbones broad, anterior, curved inward. A faint carina extends from the umbo to the posterior end. Lunular region deep. Escutcheon large, deep, limited by a strong carina. Ornamentation consists of growth-ridges.

*Measurements* :

	(1)	(2)
Length . . . . .	105	62 mm.
Height . . . . .	82	49 „

(1, 2) Tealby Limestone.

*Affinities*.—In its elongate form, and deep, carinate escutcheon this species resembles *C. boloniensis*, de Loriol,<sup>1</sup> from the Portlandian.

*Remarks*.—There are two specimens in the Sedgwick Museum and one in the British Museum. The hinge has not been seen.

*Distribution*.—Tealby Limestone of Walesby and Claxby, Lincolnshire.

CYPRINA, sp. Plate XXI, fig. 3.

A large *Cyprina* from the Tealby Limestone of Claxby is known by a right and a left valve, now in the Sedgwick Museum, and appears to belong to a distinct species. It shows some resemblance to *C. angulata*, Sowerby (see page 141), but differs from that species in the greater ventral slope of the postero-dorsal margin; the greater obliquity of the posterior margin; the smaller curvature of the umbones; the longer and less concave antero-dorsal margin; and in the absence of a carina cutting off a postero-dorsal area. The surface of the shell is imperfectly preserved, but in places there is evidence of well-marked growth-ridges. Length, 92 mm. Height, 80 mm.

<sup>1</sup> De Loriol and Pellat, 'Portlandien de Boulogne-sur-Mer' (1866), p. 54, pl. v, fig. 9.

CYPRINA, sp. Plate XX, fig. 14.

A few specimens of a small *Cyprina*, with the shell imperfectly preserved, have been found in the Speeton Clay (D, 1).

CYPRINA ANGLICA, sp. nov. Plate XX, figs. 15, 16. Plate XXI, fig. 1*a*, *b*.

*Description*.—Shell of moderate size, oval, inflated, very inequilateral. Anterior margin rounded, forming a continuous curve with the convex ventral margin. Posterior margin less convex than the anterior, sometimes slightly truncated, more or less oblique, usually curving gradually to join the ventral margin. Postero-dorsal margin long, slightly convex. Antero-dorsal margin short, nearly straight. Umbones broad, anterior, curving inward and forward. Postero-dorsal part of shell slightly compressed; carina absent or indistinct. Lunule ovate, depressed, more or less distinctly limited. Ornamentation consists of growth-lines.

*Measurements* :

	(1)	(2)	(3)	(4)	(5)	(6)
Length	42	41	38	32	27	21 mm.
Height	35	33	31	24	20	14·5 „
Thickness	28	26·5	24	16·5	14·5	9·5 „

(1–6) Crackers, Atherfield.

*Affinities*.—*C. anglica* does not appear to be closely related to any other English species. Externally it shows some resemblance to *C. angulata*, Sowerby (see below), but is of much smaller size, more elongate, with a more or less distinctly limited lunule, and either without a carina or with an indistinct carina near the umbones.

*Remarks*.—Nearly all the specimens show the two valves united, so that the hinge and pallial line do not appear to have been seen by previous workers; this probably accounts for the fact that in several collections the species has been referred to the genus *Venus*. A left valve, from which I have removed the matrix, shows that the hinge agrees with *Cyprina*, and that there is no pallial sinus.

*Type*.—In the Sedgwick Museum, Cambridge.

*Distribution*.—Lower Greensand (Crackers) of Atherfield. Atherfield Beds of Peasemarsk.

CYPRINA (VENILICARDIA) PROTENSA, sp. nov. Plate XXI, figs. 4–7. Text-figs. 20, 21.

1845. CYPRINA ANGULATA, *E. Forbes*. Quart. Journ. Geol. Soc., vol. i, p. 240  
(*partim*).

*Description.*—Shell large, oval, convex, moderately inequilateral, anterior part produced. Antero-dorsal margin concave. Anterior margin rounded, passing gradually into the convex ventral margin which curves upward to join the posterior margin. Posterior margin rounded, sometimes forming a large and rounded angle with the ventral margin, but sometimes passing into it gradually. Postero-dorsal margin convex. Postero-dorsal part of valves compressed, sometimes limited by an indistinct carina. Umbones prominent, curving forward and inward. Lunule indistinctly limited. Escutcheon narrow, deep, with a sharp edge. Ornamentation consists of growth-lines.

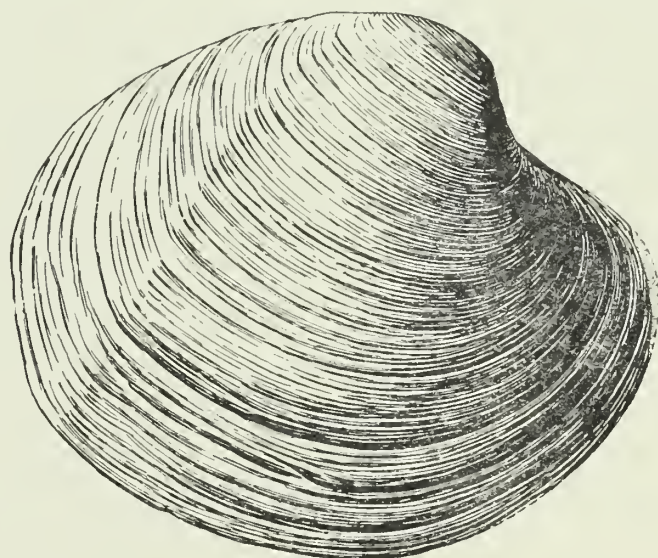


FIG. 20.—*Cyprina* (*Venilicardia*) *protensa*, sp. nov. Lower Greensand (*Perna*-bed), Atherfield. Sedgwick Museum. Right valve.  $\times \frac{1}{2}$ .

*Measurements:*

	(1)	(2)	(3)	(4)	(5)	(6)
Length	106	105	103	99	75	49 mm.
Height	84	89	91	88	60	40 „

(1—5) *Perna*-bed, Atherfield.

(6) Crackers, Atherfield.

*Affinities.*—The characters which distinguish this species from *C. angulata*, Sowerby, are: the umbones are less anterior and the shell is less inequilateral; the umbonal part of the shell is relatively smaller; the carina is less distinct; the anterior part of the shell is more produced; the posterior part is more rounded; the ventral margin has a greater curvature; the shell is less inflated, so that the marginal parts of the valves meet at a smaller angle. The anterior part of the shell resembles that of *C. truncata*, but the posterior part is more rounded, and

the postero-dorsal margin has a greater ventral slope. *C. protensa* belongs to the sub-genus *Venilicardia*, Stoliczka.<sup>1</sup>

*Type*.—In the Sedgwick Museum; from the *Perna*-bed of Atherfield.

*Distribution*.—Lower Greensand: *Perna*-bed of Atherfield and Sandown.

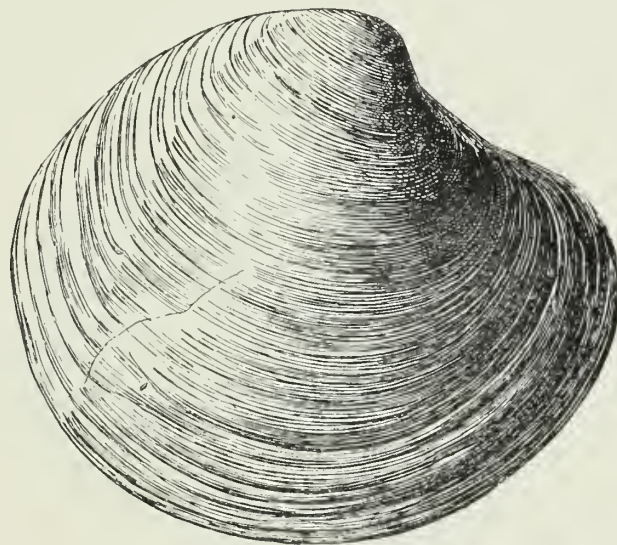


FIG. 21.—*Cyprina (Venilicardia) protensa*, sp. nov. Lower Greensand (*Perna*-bed), Atherfield. Sedgwick Museum. Right valve.  $\times \frac{1}{4}$ .

Crackers of Atherfield. Ferruginous Sands of Shanklin (Meÿer Collection).  
Atherfield Beds of Peasmarsh.

CYPRINA SOWERBYI, *d'Orbigny*, 1850. Plate XXI, figs. 8, 9. Text-fig. 22.

1836. CYPRINA ANGULATA, *J. de C. Sowerby*. Trans. Geol. Soc., ser. 2, vol. iv,  
p. 128.  
1845. — — — *E. Forbes*. Quart. Journ. Geol. Soc., vol. i, p. 240  
(*partim*).  
1850. — — — SOWERBYI, *A. d'Orbigny*. Prodr. de Pal., vol. ii, p. 78.  
1854. — — — ANGULATA, *J. Morris*. Cat. Brit. Foss., ed. 2, p. 199 (*partim*).

*Measurements* :

	(1)	(2)	(3)	(4)
Length	71	64	59	55 mm.
Height	60	51	52	48 „

(1, 2, 4) Hythe Beds, Hythe.

(3) Lower Greensand, near Atherfield.

<sup>1</sup> 'Palaeont. Indica, Cret. Fauna S. India,' vol. iii (1870), p. 190.

*Remarks.*—Internal casts of *Cyprina* are found commonly in the Hythe Beds of Hythe, etc. Those from the “rag” have their original form well preserved, but the specimens found in the softer greensand beds are more or less crushed. One example of the same species with the shell preserved has been obtained from the Lower Greensand between Atherfield and Blackgang. The form of the shell

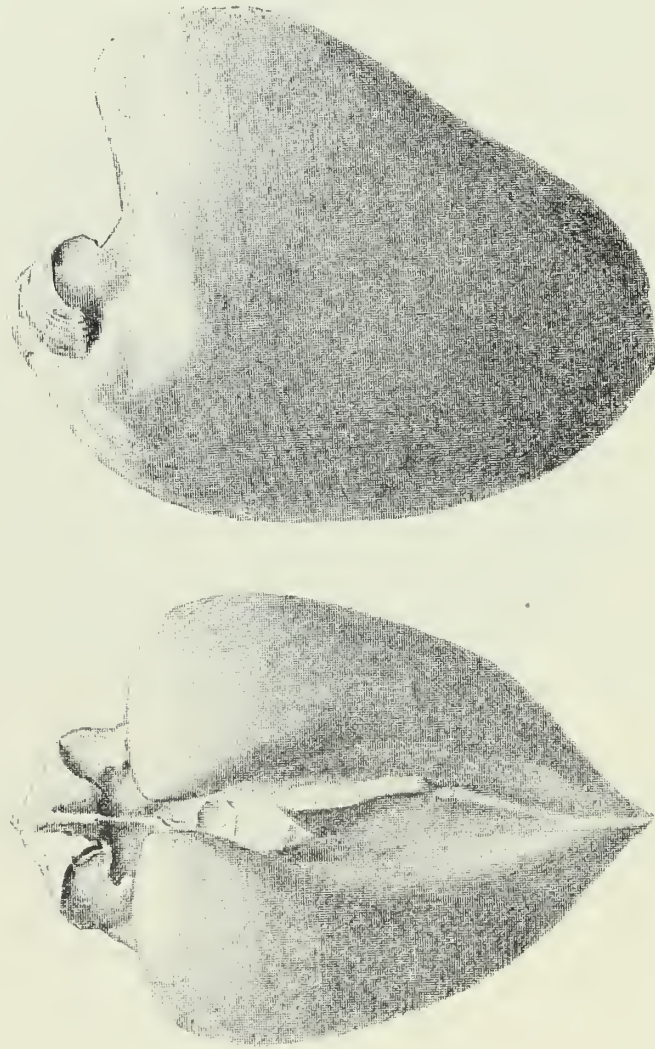


FIG. 22.—*Cyprina Sowerbyi*, d'Orb. Lower Greensand, Parham Park. British Museum, No. 5933. Internal cast. Left valve, and dorsal view of both valves.  $\times \frac{1}{2}$ .

resembles that of *C. lincolata* (see below), but the anterior curvature of the umbones is considerably less, and the postero-dorsal margin of the shell is less convex. It is difficult to determine satisfactorily the affinities of this species until more specimens with the shell have been obtained. It may be identical with the form from the Upper Aptian of Ste. Croix and the Perte-du-Rhône referred by

Pietet and Roux<sup>1</sup> to *C. erygensis*, Leymerie, and by Pietet and Campicche<sup>2</sup> to *C. angulata*, Sowerby. English examples were identified with *C. angulata* by J. de C. Sowerby, Forbes, and Morris, but were regarded by d'Orbigny as belonging to a distinct species which he named *C. Sowerbyi*, and mentioned as types the specimens collected by Fitton from the Hythe Beds near Folkestone. *C. Sowerbyi* also resembles *C. neocomiensis*, d'Orbigny.<sup>3</sup>

*Distribution*.—Hythe Beds of Hythe. Sandgate Beds of Parham Park. Lower Greensand between Atherfield and Blackgang.

CYPRINA (VENILICARDIA) ANGULATA (*Sowerby*), 1814. Plate XXII, figs. 1—4.  
Text-figs. 23, 24.

- |           |                   |                     |  |
|-----------|-------------------|---------------------|--|
| 1814.     | VENUS ANGULATA,   | <i>J. Sowerby</i> . | Min. Conch., vol. i, p. 145, pl. lxxv.   |
| 1828.     | CYPRINA ANGULATA, | <i>J. Fleming</i> . | Hist. Brit. Animals, p. 444.   |
| 1836.     | —                 | —                   | <i>J. de C. Sowerby</i> . Trans. Geol. Soc., ser. 2, vol. iv, p. 240.  |
| 1850.     | —                 | —                   | <i>A. d'Orbigny</i> . Prodr. de Pal., vol. ii, p. 161.   |
| 1854.     | —                 | —                   | <i>J. Morris</i> . Cat. Brit. Foss., ed. 2, p. 199 ( <i>partim</i> ).  |
| 1870.     | —                 | —                   | <i>F. Stoliczka</i> . Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 193.   |
| Non 1868. | —                 | —                   | <i>A. Briart and F. L. Cornet</i> . Meule de Bracquegnies (Mém. cour. et Mém. des Sav. étrangers, vol. xxxiv), p. 68, pl. viii, figs. 26—28. |

*Description*.—Shell large, sub-quadrate, rounded, very inequilateral, moderately inflated. Anterior margin rounded, passing quickly into the ventral margin, with which it forms a regular and continuous curve. Posterior margin more or less truncated, slightly or moderately convex, usually oblique, and forming an obtuse angle with the postero-dorsal margin. Umbones large, broad, anterior. A more or less distinct carina passes from the umbo to the postero-ventral angle, cutting off a postero-dorsal area, which slopes rather rapidly to the posterior margin. Lanular region more or less depressed, not limited. Escutcheon narrow, deep, limited by a sharp carina.

Ornamentation consists of growth-lines.

In the right valve the posterior cardinal tooth is large and divided; the median cardinal is smaller than the anterior cardinal, and in most forms adjoins

<sup>1</sup> Pietet and Roux, 'Moll. Foss. Grès verts de Genève' (1852), p. 444, pl. xxxiv, fig. 1.

<sup>2</sup> 'Terr. Crét. de Ste. Croix' (1865), p. 221.

<sup>3</sup> 'Pal. Franç. Terr. Crét.,' vol. iii (1847), pp. 98, 759, pl. cclxxi. Afterwards referred to *C. bernensis*, Leymerie, see d'Orbigny, 'Prodr. de Pal.,' vol. ii (1850), p. 77.

the postero-dorsal side of the latter, but in examples in which the umbones are more anterior in position the median cardinal is dorsal to the anterior cardinal, and is almost continuous dorsally with the posterior cardinal tooth.

*Measurements :*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Length .	103	. 104	. 99	. 98	. 96	. 89	. 87	. 82 mm.
Height .	92	. 90	. 86	. 86	. 86	. 79	. 79	. 70 „

(1—8) Blackdown.

*Affinities.*—Specimens of *Cyprina* from the Aptian and Gault of the Perte du Rhône and Ste. Croix were referred by Pictet, Roux, and Renevier, to *C. eryensis*, Leymerie, but were subsequently identified with *C. angulata* by Pictet, Renevier,

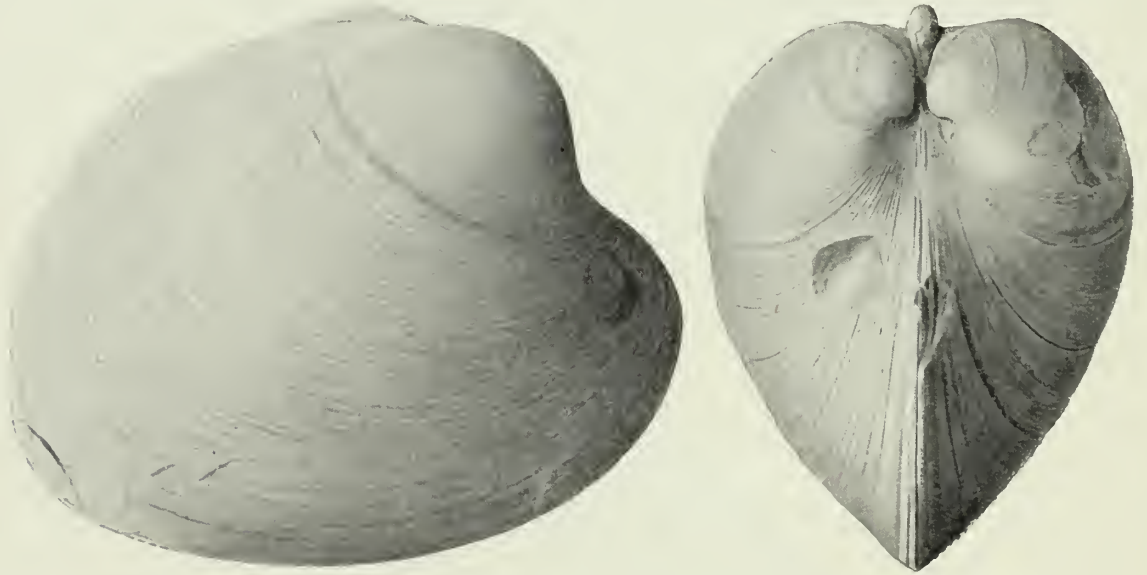


FIG. 23.—*Cyprina (Venilicardia) angulata* (Sow.). Upper Greensand, Blackdown. Museum of Practical Geology, No. 18698. Right valve, and anterior view of both valves.  $\times \frac{1}{2}$ .

and Campiche.<sup>1</sup> Pictet and Campiche, after an examination of specimens from the Gault of Nièvre and Yonne, came to the conclusion that *C. eryensis*, as described and figured by Leymerie<sup>2</sup> and d'Orbigny,<sup>3</sup> must be regarded as a synonym of *C. angulata*. I have had no opportunity of comparing French specimens with examples from Blackdown, but so far as I can judge from the figures of *C. eryensis* there appear to be some differences, consequently I do not at present feel justified in including *C. eryensis* as a synonym of *C. angulata*.

<sup>1</sup> Pictet and Roux, 'Moll. Foss. Grès verts de Genève' (1852), p. 444, pl. xxxiv, fig. 1. Pictet and Renevier, 'Foss. Terr. Aptien' ('Matér. Pal. Suisse,' ser. 1, 1856-58), pp. 75, 177. Pictet and Campiche, 'Terr. Crét. Ste. Croix' ('Matér. Pal. Suisse,' ser. 4, 1865), p. 221.

<sup>2</sup> 'Mém. Soc. géol. de France,' vol. v (1842), pp. 5, 25, pl. iv, figs. 6, 7.

<sup>3</sup> 'Pal. Franç. Terr. Crét.,' vol. iii (1844), p. 102, pl. cclxxiv.

*C. angulata* of Briart and Cornet appears to be closely related to *C. cuneata*, Sowerby (see p. 134).

*C. (Venilicardia) Jukesi*, de Loriol,<sup>1</sup> from the Gault of Cosne, resembles some forms of *C. angulata*.<sup>2</sup>

*Remarks.*—*C. angulata* varies in its relative height and length, and in the position of the umbones. The shell is usually stout, but occasionally rather thin. Sowerby gives a good figure of *C. angulata*, except that the teeth, as pointed out by Stoliczka, are not correctly drawn.<sup>3</sup>

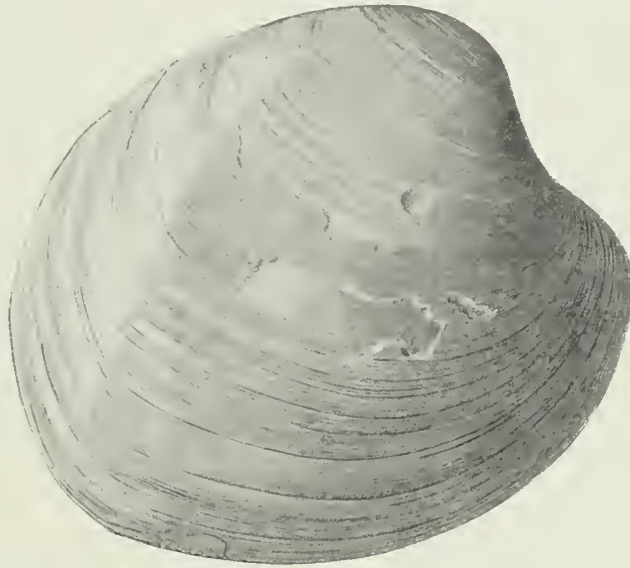


FIG. 24.—*Cyprina (Venilicardia) angulata* (Sow.). Upper Greensand, Blackdown. Sedgwick Museum. Right valve  $\times \frac{1}{2}$ . The hinge of this specimen is shown on Plate XXII, fig. 2.

*Types.*—From the Upper Greensand of Blackdown, in the British Museum.

*Distribution.*—Upper Greensand (zone of *Schlenbachia rostrata*) of Blackdown and Haldon. Recorded by Jukes-Browne from the Lower Gault of Wiltshire, and from the Upper Greensand of the Isle of Wight.

CYPRINA (VENILICARDIA) LINEOLATA (Sowerby), 1813. Plate XXII, figs. 5—8.  
Plate XXIII, figs. 1, 2.

1811. VENUS CASTRENSIS, J. Parkinson. Organic Remains, vol. iii, p. 187 (non *V. castrensis*, L.).

<sup>1</sup> 'Gault de Cosne' (1882), p. 68, pl. ix, fig. 1.

<sup>2</sup> Morris records *Cyprina globosa*, Sharpe, from the Greensand of Blackdown, but I have not seen any specimen from that locality. Morris, 'Cat. Brit. Foss.,' ed. 2 (1854), p. 199. Sharpe, 'Quart. Journ. Geol. Soc.,' vol. vi (1850), p. 182, pl. xv, fig. 1.

<sup>3</sup> From the remark on Sowerby's figure made by Briart and Cornet (p. 69) I can only conclude that they had not seen specimens of *C. angulata*.

1813. VENUS LINEOLATA, *J. Sowerby*. Min. Conch., vol. i, p. 57, pl. xx (upper figure).
1828. — — *J. Fleming*. Hist. Brit. Animals, p. 449.
1836. CYPRINA ROSTRATA, *J. de C. Sowerby*. Trans. Geol. Soc., ser. 2, vol. iv, pp. 240, 341, pl. xvii, fig. 1.
1836. CYTHEREA LINEOLATA, *Sowerby*. Ibid., p. 240.
1850. CYPRINA ROSTRATA, *A. d'Orbigny*. Prodr. de Pal., vol. ii, p. 161.
1854. — — *J. Morris*. Cat. Brit. Foss., ed. 2, p. 199.
1854. CYTHEREA LINEOLATA, *Morris*. Ibid., p. 200.
1865. CYPRINA ROSTRATA, *F. J. Pictet* and *G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), pp. 222, 229.
1870. — — *F. Stoliezka*. Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 193 (*Venilicardia*).
1907. — LINEOLATA, *R. B. Newton*. Proc. Malacol. Soc., vol. vii, p. 284, pl. xxiv, fig. 14.
- Non 1844. — — *A. d'Orbigny*. Pal. Franç. Terr. Crét., vol. iii, p. 98, pl. celxxi (*Cyprina neocomiensis*, d'Orbigny, Ibid., p. 759).

*Measurements :*

	(1)	(2)	(3)	(4)
Length .	71	67	66	52 mm.
Height .	61	60	58	43 „

(1—4) Blackdown.

*Affinities.*—This species differs from *C. angulata* in its more prominent and more strongly curved umbones, in the shorter posterior margin and the greater slope of the postero-dorsal margin, and in the more deeply depressed lunular region. The hinge also differs: in the right valve the median cardinal tooth is distinctly separated from the anterior cardinal and is dorsal to the latter and continuous with the posterior cardinal tooth; the latter is either undivided or the division is indistinctly shown.

*Remarks.*—*C. lineolata* varies considerably in the prominence and curvature of the umbones, and, as a result, in the outline of the shell. An extreme form was figured by *J. de C. Sowerby* as the type of *C. rostrata*; in specimens in which the umbones are less prominent and their anterior curvature less pronounced the outline of the shell becomes less triangular, and in some cases approaches that of *C. angulata*, but the differences in the hinge of the right valve and the greater depth of the lunular region appear to be present in all specimens. The average size of this species is considerably less than that of *C. angulata*.

The type of *Venus lineolata*, *Sowerby* (*V. castrensis*, *Parkinson*), from Blackdown, agrees with the normal forms of *C. rostrata*, except for the presence of

numerous W-shaped markings on the surface. These appear to be due to the structure of the shell (possibly connected with colour markings), since they are seen only in specimens which are somewhat decorticated, and are in some cases present on one valve but not on the other, or are seen on the dorsal but not on the ventral part of a valve.

Stoliczka<sup>1</sup> thought that *Venus lineolata* was probably identical with *Cytherea plana*, Sowerby, but the hinge and pallial line of the former prove conclusively that it belongs to the genus *Cyprina*.

*Types*.—From Blackdown; *Venus lineolata* in the British Museum; *C. rostrata* in the Bristol Museum.

*Distribution*.—Upper Greensand (zone of *Schlenbachia rostrata*) of Blackdown.

CYPRINA (VENILICARDIA) TRUNCATA (*Sowerby*), 1836. Plate XXIII, fig. 3.

1836. VENUS? TRUNCATA, *J. de C. Sowerby*. Trans. Geol. Soc., ser. 2, vol. iv, pp. 242, 341, pl. xvii, fig. 3.
1850. — SUBTRUNCATA, *A. d'Orbigny*. Prodr. de Pal., vol. ii, p. 159.
1854. CYTHEREA TRUNCATA, *J. Morris*. Cat. Brit. Foss., ed. 2, p. 201.
1865. VENUS SUBTRUNCATA, *F. J. Pictet and G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 190.
- 1870 — — *F. Stoliczka*. Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 161 (*Caryatis*).

*Affinities*.—*C. truncata* is closely allied to, and probably only a variety of *C. angulata*. The shell is thinner, the posterior margin higher, and the anterior part more produced than in *C. angulata*.

This species, or variety, has hitherto been referred to *Venus* or *Cytherea*, but a specimen showing the hinge and pallial line proves that it is a *Cyprina*. The hinge agrees with that of *C. angulata*.

An example collected by the late Rev. W. Downes (Plate XXIII, fig. 4) is more elongated and more inflated than the type of *C. truncata*, but agrees in other respects, and is probably only an individual variation.

*Type*.—From Blackdown; in the Bristol Museum.

*Distribution*.—Upper Greensand (zone of *Schlenbachia rostrata*) of Blackdown.

CYPRINA LIGERIENSIS, *d'Orbigny*, 1844.

Internal casts of a large *Cyprina* have been found in the Cenomanian Sandstone of Wilmington,<sup>2</sup> Devon, and in the cherty blocks in the Eocene Gravel

<sup>1</sup> 'Cret. Fauna S. India,' vol. iii (1870), pp. 160, 169.

<sup>2</sup> Jukes-Browne, 'Cret. Rocks of Britain,' vol. ii (1903), p. 129.

(derived from the Upper Greensand) of Aller Vale near Torquay. They have been identified with *C. ligeriensis*, d'Orbigny,<sup>1</sup> by Mr. Jukes-Browne, who has compared them with examples of that species from the Cenomanian of Vimoutiers and Orbiquet, and states that the agreement is very close. The English specimens also resemble *C. Noueliana*, d'Orbigny,<sup>2</sup> of which a cast only is figured by d'Orbigny, and was at first regarded as *C. ligeriensis*. An example from Wilmington is in the Sedgwick Museum. Others from Aller Vale are in the Torquay Museum and in the Sedgwick Museum.

CYPRINA (VENILICARDIA ?) QUADRATA, *d'Orbigny*, 1844. Plate XXIII, figs. 6—9.

1840. ISOCARDIA CRETACEA, *H. B. Geinitz*. Char. d. Schicht. u. Petref. des sächs. Kreidegeb., pt. 2, p. 53, pl. xi, figs. 6, 7 (*non* Goldfuss).
1844. CYPRINA QUADRATA, *A. d'Orbigny*. Pal. Franç. Terr. Crét., vol. iii, p. 104, pl. cclxxvi.
1850. — — — — — Prodr. de Pal., vol. ii, p. 161.
- — — — — *H. B. Geinitz*. Das Quadersandst. oder Kreidegeb. in Deutschland, p. 156.
1865. — — — — — *F. J. Pictet and G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 225, pl. cxv, figs. 3—5.
1870. — — — — — *F. Stoliczka*. Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 193.
1873. — — — — — *H. B. Geinitz*. Das Elbthalgeb. in Sachsen (Palæontographica, vol. xx, pt. 2), p. 62, pl. xvii, figs. 14—16.
- ? 1877. — — — — — *A. Fritsch*. Stud. im Gebiete der böhm. Kreideformat. II Weissenberg. u. Malnitz. Schicht., p. 116, fig. 76.
- ? 1883. — — — — — Ibid., III Iverschicht., p. 100, fig. 65.
1895. — — — — — *E. Tiessen*. Zeitschr. d. deutsch. geol. Gesellsch., vol. xlvii, p. 486.
1897. ARCTICA — — — — — *H. Woods*. Quart. Journ. Geol. Soc., vol. liii, p. 390, pl. xxvii, fig. 25, pl. xxviii, fig. 1.

*Description*.—Shell sub-rhomboidal, much inflated, rather strongly carinate, very inequilateral; length somewhat greater than height. Anterior margin rounded, passing gradually into the slightly curved ventral margin. Posterior

<sup>1</sup> 'Pal. Franç. Terr. Crét.,' vol. iii (1844), p. 103, pl. cclxxv, figs. 1, 2; 'Prodr. de Pal.,' vol. ii (1850), p. 161; Guéranger, 'Album Paléont. de la Sarthe,' 1867, p. 13, pl. xvii, figs. 1, 5.

<sup>2</sup> *Op. cit.* (1844), pl. cclxxv, figs. 3, 4; *op. cit.* (1850), p. 195.

margin truncated, high. Postero-dorsal region flattened. Umbones prominent, anterior, curved inwards. Lunular region excavated. Ornamentation consists of concentric striæ.

*Measurements :*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Length .	54	46	37	35	26	23	46	40	20	45	58 mm.
Height .	46	41	34	31	24	19	39	33	15	38	52 „

(1—6) Gault, Folkestone.

(7—9) Rye Hill Sand, Warminster.

(10) Chloritic Marl, Maiden Bradley.

(11) Base of Chalk, Chard.

*Affinities.*—In *C. ligeriensis*, d'Orbigny,<sup>1</sup> the umbones are less anterior in position, and the angle between the posterior and the dorsal margins is larger than in *C. quadrata*.

*C. regularis*, d'Orbigny,<sup>2</sup> is distinguished from *C. quadrata* by its less inequilateral and more regularly globose shell, by its less incurved umbones, and the smaller truncation of the posterior end.

*C. crassicornis* (Agassiz)<sup>3</sup> possesses a relatively higher and less inequilateral shell, with more prominent umbones, which are not so much curved anteriorly as in *C. quadrata*.

*Remarks.*—The specimens from the Gault have the shell more or less perfectly preserved, but most of the examples from higher beds are, like the type, in the form of internal casts. The specimens found in the Chalk Rock are rather imperfect, but do not appear to differ specifically from those found at lower horizons.

*Type.*—The locality of the type is not given by d'Orbigny, but he records specimens from the Cenomanian of Villers (Calvados), Rouen, St. Calais (Sarthe), etc.

*Distribution.*—Upper Gault of Folkestone. Upper Greensand (zone of *Schlanbachia rostrata*) of Devizes (*vide* Jukes-Browne). Rye Hill Sand of Warminster. Base of the Chalk of Chard. Chloritic Marl of Maiden Bradley and the Isle of Wight. Chalk Rock of Morgan's Hill near Devizes, Cuckhamsley, and Luton.

<sup>1</sup> 'Pal. Franç. Terr. Crét.', vol. iii (1844), p. 103, pl. cclxxv, figs. 1, 2 (not 3, 4).

<sup>2</sup> *Ibid.*, p. 100, pl. cclxxii, figs. 3—6; Pictet and Campiche, 'Foss. Terr. Crét. Ste. Croix' (1865), p. 224, pl. cxv, figs. 1, 2.

<sup>3</sup> 'Études crit. Moll. Foss., Myes' (1842), p. 36, pl. viii f, figs. 5—10; Pictet and Campiche, 'Terr. Crét. Ste. Croix' ('Matér. Pal. Suisse,' ser. 4, 1865), p. 226, pl. cxv, figs. 6—8.

*Genus*—TRAPEZIUM, *Megerle v. Mühlfeldt*, 1811.  
(‘Naturf. Freunde zu Berlin Mag.,’ vol. v, p. 68.)

TRAPEZIUM? ARCADIFORME (*Keeping*), 1883. Plate XXIII, figs. 10, 11.

1883. CYPRICARDIA ARCADIFORMIS, *W. Keeping*. Foss. etc., Neoc. Upware and Brickhill, p. 120, pl. vi, fig. 6.

*Description*.—Shell trapezoidal, inflated; length much greater than height. Dorsal and ventral margins nearly straight and nearly parallel. Posterior margin oblique, straight or slightly curved, forming an obtuse angle with the dorsal margin and an acute but rounded angle with the ventral margin. Anterior margin rounded. Umbones near the anterior end, much curved, with a strong, rounded keel extending to the postero-ventral angle. The part in front of the keel is slightly concave, giving a faint sinuosity to the ventral margin of the valve. The triangular part dorsal to the keel is compressed and flattened, and slopes steeply to the margin. Lunule cordate. Hinge not seen.

Ornamentation consists of small, rounded radial ribs, and, at intervals, strong concentric laminar ridges; both ribs and ridges are indistinct on the part dorsal to the keel. Length 21 mm.; height 12.5 mm.; thickness, 13 mm.

*Affinities*.—This species is more elongate, and the carina is more angular than in *T. squamosum* (see below).

*Remarks*.—The only examples seen are the type and a specimen in Mr. J. F. Walker’s collection.

*Type*.—The type is in the Sedgwick Museum.

*Distribution*.—Lower Greensand, Upware.

TRAPEZIUM? SQUAMOSUM (*Keeping*), 1883. Plate XXIII, figs. 12—15.

1883. CYPRICARDIA SQUAMOSA, *W. Keeping*. Foss., etc., Neoc. Upware and Brickhill, p. 120, pl. vi, fig. 5.

*Description*.—Shell rounded-oblong, much inflated, highest near the posterior end. Dorsal margin nearly straight; the posterior forms a regular curve, which passes into the slightly concave ventral margin. Dorsal part of anterior margin concave, ventral part rounded. Umbones prominent, anterior, much curved. A broad, rounded ridge extends from the umbo to the postero-ventral extremity and divides the shell into two parts. The part in front of the ridge is slightly concave, the part above is larger and convex. Lunule cordate.

Ornamentation consists of small radial ribs, and, at rather distant intervals,

strong concentric lamellæ. The ornamentation is indistinct on the part above the rounded ridge. Margin of valve crenulate.

*Measurements :*

	(1)	(2)	(3)	(4)
Length . . .	15·5	14	13·5	12·5 mm.
Height . . .	12	11	11	10 „
Thickness . .	10	10	10·5	9 „

(1—4) Lower Greensand, Upware.

*Affinities.*—Keeping compared this species with *Cardita neocomiensis*, d'Orbigny, to which it shows some resemblance in general form. But the faint radial ribs and strong concentric lamellæ, as well as the character of the hinge, so far as it can be made out, seem to connect this species with *Trapezium* rather than with *Cardita*.

*Type.*—In the Sedgwick Museum.

*Distribution.*—Lower Greensand, Upware.

TRAPEZIUM ? sp. Plate XXIII, fig. 16.

1883. *CYPRICARDIA STRIATA*, W. Keeping. Foss., etc., Neoc. Upware and Brickhill, p. 119.

An imperfect left valve from the Lower Greensand of Upware, in the Sedgwick Museum, was identified by W. Keeping with *Cypricardia striata* (Geinitz)<sup>1</sup> from the Cenomanian of Saxony. The ribs are fewer in number than in the examples of *C. striata* figured by Geinitz.

TRAPEZIUM TRAPEZOIDALE (*Römer*), 1841. Plate XXIII, figs. 17—19.

1841.	<i>CRASSATELLA TRAPEZOIDALIS</i> , F. A. Römer.	Die Verstein. d. nord-deutsch. Kreidegeb., p. 74, pl. ix, fig. 22.
? 1847.	—	A. d'Archiac. Mém. Soc. géol. de France, ser. 2, vol. ii, p. 302.
1850.	<i>CYPRINA</i>	H. B. Geinitz. Das Quadersandst. oder Kreidegeb. in Deutschland, p. 158 ( <i>partim</i> ).
1854.	<i>CYPRICARDIA</i>	A. d'Orbigny. Prodr. de Pal., vol. ii, p. 240.

<sup>1</sup> 'Char. d. Schicht. u. Petref. des sächs. Kreidegeb.,' pt. 2 (1840), p. 52, pl. x, fig. 3. *Modiola carditoïdes*, Geinitz, 'Das Elbthalgeb. in Sachsen' ('Palæontographica,' vol. xx, pt. 1, 1873), p. 218, pl. xlviii, figs. 11—13; pl. xlix, figs. 19, 20.

1873. CYPRINA TRAPEZOIDALIS, *H. B. Geinitz*. Das Elbthalgeb. in Sachsen (Palæontographica, vol. xx, pt. 1), p. 229, pl. 1, fig. 6 (? 5).
1889. CYPRICARDIA — *E. Holzjffel*. Die Mollusk. Aachen. Kreide (Palæontographica, vol. xxxv), p. 179.
1897. TRAPEZIUM TRAPEZOIDALE, *H. Woods*. Quart. Journ. Geol. Soc., vol. liii, p. 391, pl. xxviii, figs. 9, 10.
1901. CYPRICARDIA TRAPEZOIDALIS, *F. Sturm*. Jahrb. d. k. preussisch. geol. Landesanst. für 1900, vol. xxi, p. 80, pl. vii, fig. 5.
1902. — — *A. Wolle mann*. Lüneburg. Kreide (Abhandl. d. k. preussisch. geol. Landesanst. N. F., Heft. 37), p. 78, pl. ii, fig. 3; pl. iii, fig. 1.

*Description*.—Shell trapezoidal, rounded, inflated. Ventral margin slightly curved, roughly parallel to the dorsal margin, and passing gradually into the rounded anterior margin. Posterior margin oblique, forming an obtuse angle with the dorsal margin and an acute angle with the ventral margin. Umbones near the anterior end, much curved. A sharp, gently curving carina extends from the umbo to the posterior angle and cuts off a triangular and slightly concave area.

Ornamentation consists of fine concentric lines.

*Measurements* :

	(1)	(2)	(3)
Length . . .	25	23	21 mm.
Height . . .	17	14	14 „
Thickness . . .	16	15	15 „

(1—3) Chalk Rock, Cuckhamsley.

*Affinities*.—Wolle mann considers that *Trapezium galicianum* (Favre)<sup>1</sup> is not distinct from this species, but is founded on an older example than the type of *T. trapezoidale*. According to Wolle mann, various changes in the form of the shell take place during growth. Thus, in the older specimens the valves become more convex, the length relatively less, the posterior margin less oblique, the ventral margin more curved, the outline less trapezoidal, and the umbones less curved. This view is probably correct, but none of the English examples which I have seen pass beyond the stage represented by Römer's type.

In *Trapezium tricarinatum* (Römer)<sup>2</sup> the umbones are less anterior in position than in *T. trapezoidale*.

<sup>1</sup> 'Moll. Foss. de la Craie de Lemberg' (1869), p. 109, pl. xii, fig. 3.

<sup>2</sup> 'Die Verstein. d. nord-deutsch. Kreidegeb.' (1841), p. 74, pl. ix, fig. 23.

*Remarks.*—This species occurs in the Chalk Rock, but is not common. All the specimens seen are casts, but one shows a fragment of shell.

*Type.*—The type is stated by Römer to have come from the Pläner-kalk of Strehlen (Dresden), but Geinitz says that he has never found the species at that locality.

*Distribution.*—Chalk Rock of Dover, Cuckhamsley, Aston Rowant, Princes Risborough, Thickthorn Hill (Bledlow), and Luton railway cutting.

*Family*—ISOCARDIIDÆ, Gray.

*Genus*—ISOCARDIA, Lamarck, 1799.

(‘Mém. Soc. Hist. Nat. Paris,’ p. 86.)

ISOCARDIA SIMILIS, Sowerby, 1826. Text-fig. 25.

- |       |                    |                          |   |
|-------|--------------------|--------------------------|---|
| 1826. | ISOCARDIA SIMILIS, | <i>J. de C. Sowerby.</i> | Min. Conch., vol. vi, p. 27, pl. dxvi,<br>fig. 1.   |
| 1850. | —                  | —                        | <i>A. d'Orbigny.</i> Prodr. de Pal., vol. ii, p. 163.   |
| 1854. | —                  | —                        | <i>J. Morris.</i> Cat. Brit. Foss., ed. 2, p. 204.  |
| 1865. | —                  | —                        | <i>F. J. Pictet and G. Campiche.</i> Foss. Terr. Crét. Ste.<br>Croix (Matér. Pal. Suisse, ser. 4),<br>p. 240. |
| 1870. | —                  | —                        | <i>F. Stoliczka.</i> Palæont. Indica, Cret. Fauna S. India,<br>vol. iii, pp. 188, 194.                        |

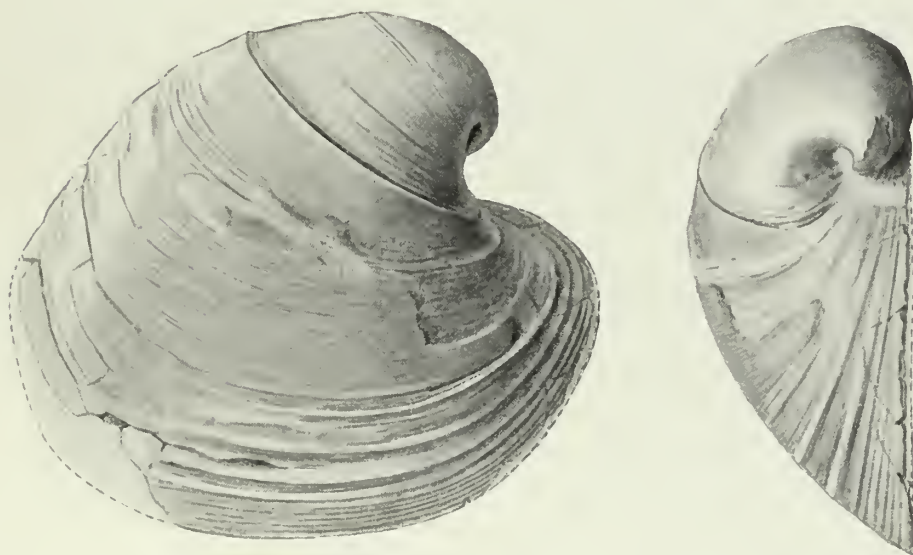


FIG. 25.—*Isocardia similis*, Sowerby. Lower Greensand, near Sandgate. Right valve, and anterior view. British Museum (Nat. Hist.). The Type. Natural size.

*Description.*—Shell convex, oval, longer than high. Antero-dorsal margin short. Anterior margin produced, somewhat pointed, rounded, curving rapidly to join the slightly convex ventral margin. Posterior margin short, somewhat truncated. Postero-dorsal margin long, convex, with a considerable ventral slope. Umbo prominent, recurved. Lunular region deep. A faint carina extends from the umbo to the postero-ventral extremity. Ornamentation consists of growth-lines. Length 78 mm. Height 70 mm.

*Remarks.*—The type, a right valve, now in the British Museum, is the only undoubted example of this species which I have seen. From the nature of the matrix there seems no doubt that this specimen comes from the *mammilatum* zone. The hinge cannot be made out satisfactorily, but the form of the shell agrees closely with that typical of *Isocardia*.

*Distribution.*—Lower Greensand (zone of *Douvilleiceras mammilatum*) near Sandgate.<sup>1</sup>

*Family*—LUCINIDÆ, *Fleming*.

*Genus*—LUCINA, *J. G. Bruguière*, 1797.

(‘Encyc. Méth., Vers,’ pl. cclxxxiv. Lamarek, ‘Mém. Soc. Hist. Nat. Paris,’ 1799, p. 84.)

LUCINA, sp. Plate XXIV, figs. 2, 3.

Internal casts of a *Lucina* have been obtained from the Spilsby Sandstone (zone of *Belemnites lateralis*) of Donnington and Claxby. A right valve with the shell preserved was found by Mr. Lamplugh in the Spilsby Sandstone at Holton and probably belongs to the same species as the casts. The shell bears numerous small concentric ridges.

LUCINA, sp. Plate XXIV, figs. 4, 5.

Some internal casts and a portion of an external cast of *Lucina* have been

<sup>1</sup> *Isocardia? ornata*, Forbes, ‘Quart. Journ. Geol. Soc.,’ vol. i (1845), p. 242, pl. ii, fig. 10, is known only by the imperfect type specimen which is now in the Museum of the Geological Society (No. 2150), and was obtained from the Lower Greensand of Atherfield. It was referred to *Opis* by d’Orbigny, ‘Prodr. de Pal.,’ vol. ii (1850), p. 118.

*Isocardia cryptoceras*, d’Orbigny, has been recorded by Barrois from the Upper Greensand near Devizes. See ‘Terrain Crét. supér. de l’Angleterre et de l’Irlande’ (1876), p. 61.

found in the Lower Greensand<sup>1</sup> of Blackgang, Shanklin, and Parham Park. The outline is nearly circular and the convexity small or moderate. The ornamentation consists of concentric ribs and flat interspaces.

LUCINA, sp. Plate XXIV, fig. 6.

A specimen with the two valves united was obtained by the late C. J. A. Meÿer from the Lower Greensand (Ferruginous Sands) of Shanklin, and appears to belong to a distinct species. The shell is regularly convex, slightly higher than long, and the lunule is deeply depressed. The ornamentation consists of numerous, small, regular, concentric ribs.

LUCINA ? SCULPTA, *Phillips*, 1829. Plate XXIV, figs. 7—9.

1829.	LUCINA SCULPTA,	<i>J. Phillips.</i>	Geol. Yorks., pp. 122, 170, pl. ii, fig. 15 (p. 252, ed. 3).
1844.	—	—	<i>A. d'Orbigny.</i> Pal. Franç. Terr. Crét., vol. iii, p. 118, pl. cclxxxiii, figs. 1—4.
1850.	—	—	<i>E. Eichwald.</i> Zeitschr. d. deutsch. geol. Gesellsch., vol. ii, p. 471.
—	—	—	<i>A. d'Orbigny.</i> Prodr. de Pal., vol. ii, p. 118.
1854.	—	—	<i>J. Morris.</i> Cat. Brit. Foss., ed. 2, p. 208.
1862.	—	—	<i>J. G. Chenu.</i> Man. de Conchyl., vol. ii, p. 119, fig. 571.
1866.	—	—	<i>F. J. Pictet and G. Campiche.</i> Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 291.
1871.	—	—	<i>F. Stoliczka.</i> Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 252.
1906.	—	—	<i>A. Wollemani.</i> Die Biv. u. Gastrop. norddeutsch. Gaults, p. 277.

*Description.*—Shell very convex, higher than long, with angular outline. Antero-dorsal margin long, concave. Postero-dorsal margin long, convex. Angles occur at the ventral limit of the lunule, at the junction of the anterior and ventral margins, near the posterior part of the ventral margin, and at the ventral limit and the middle of the escutcheon. Umbones high, prominent, sharp, curved

<sup>1</sup> *Lucina arduennensis*, d'Orbigny, and *L. Dupiniana*, d'Orbigny, have been recorded by Topley from the Lower Greensand of the Weald. I have not seen any specimens which could be identified with those species. Two imperfect left valves from the Lower Greensand of Atherfield, now in the Museum of the Geological Society, were referred by Forbes to *L. globiformis*, Leymerie. Without better specimens it is difficult to determine the genus to which Forbes' specimens belong. See Forbes, 'Quart. Journ. Geol. Soc.,' vol. i. (1845), p. 240; Leymerie, 'Mém. Soc. géol. de France,' vol. v (1842), p. 4, pl. iii, fig. 8.

anteriorly. Ridges extend from the umbo to the angles at the margin of the valve; the parts between the ridges are flattened. Lunule large, ovate, divided into an inner and an outer part by a ridge. Escutcheon very large, consisting of a median lanceolate part which is much depressed and separated by a sharp edge from a large concave outer portion.

Ornamentation consists of broad concentric ridges which run parallel to the margin of the valve and end abruptly at the lunule and escutcheon. Very fine, sometimes indistinct, ribs occur on the ridges and interspaces.

*Affinities.*—*Lucina sculpta* is quite unlike any other Cretaceous species. Its angular outline and large concave escutcheon give it an unusual appearance. Externally it shows some resemblance to some species of *Thyasira*,<sup>1</sup> but the hinge and adductor impressions are at present unknown. Stoliczka regarded it as probably a true *Lucina*.

*Remarks.*—I have seen only four specimens, of which three are in the British Museum and one is in the Museum of Practical Geology.

*Type.*—The type cannot be found. It is stated to have come from the Specton Clay (? zone of *Belemnites minimus*).

*Distribution.*—Lower Gault (Bed vi) of Folkestone.

LUCINA TENERA (*Sowerby*), 1836. Plate XXIV, figs. 10—14.

1836. VENUS ? TENERA, *J. de C. Sowerby*. Trans. Geol. Soc., ser. 2, vol. iv, pp. 114, 335, pl. xi, fig. 7.
1854. — — *J. Morris*. Cat. Brit. Foss., ed. 2, p. 231.
1865. — — (? LUCINA), *F. J. Pictet and G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 189.
1870. — — (? CARYATIS), *F. Stoliczka*. Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 160.
1875. LUCINA — *A. J. Jukes-Browne*. Quart. Journ. Geol. Soc., vol. xxxi, p. 300, pl. xv, figs. 10—12.

*Description.*—Shell oval, moderately convex, longer than high, inequilateral, the anterior part longer and higher than the posterior part. Anterior margin regularly rounded, passing gradually into the curved ventral margin. Posterior margin somewhat truncated, forming an obtuse angle with the postero-dorsal margin. Umbones of moderate size with a slight forward curvature. Lunule elongate, depressed, limited by a carina. Escutcheon large, not distinctly limited.

<sup>1</sup> *Arinus*, Sowerby; *Cryptodon*, Turton.

Ornamentation consists of numerous, regular, strong, concentric ribs which become smaller near the antero-dorsal and postero-dorsal margins.

*Measurements :*

	(1)	(2)	(3)	(4)	(5)
Length .	15	14	13	12.5	9 mm.
Height .	14	12	11	11	7.5 „
Thickness	8	7	6.5	—	4.5 „

(1—5) Gault, Folkestone.

*Affinities.*—In form and ornamentation this species resembles *L. Sanctæ-Crucis*, Pictet and Campiche,<sup>1</sup> but is much smaller and relatively longer.

*Type.*—The type came from the Gault of Folkestone, but cannot now be found. The specimens figured by Jukes-Browne are in the Sedgwick Museum, Cambridge.

*Distribution.*—Gault of Folkestone and Black Ven. Cambridge Greensand. Upper Greensand (zone of *Schlanbachia rostrata*) of Devizes.

LUCINA DOWNESI, sp. nov. Plate XXIV, figs. 15 *a—c*.

*Description.*—Shell oval or nearly orbicular, moderately convex, slightly inequilateral, longer than high, postero-dorsal part compressed. Anterior and ventral margins rounded. Posterior margin less convex than the anterior, forming an obtuse angle with the convex postero-dorsal margin. Umbones of moderate size. Lunule elongate. Ornamentation consists of numerous regular, concentric, lamellar ribs separated by broad, flat interspaces with fine concentric ribs.

*Measurements :*

	(1)	(2)
Length .	32	26 mm.
Height .	28.5	24 „
Thickness .	14	— „

(1, 2) Blackdown.

*Affinities.*—This species resembles *L. Cornueliana*, d'Orbigny,<sup>2</sup> from the Neocomian, but the umbones are less prominent and the shell is less inequilateral. It is also similar to *L. subnumismalis*, d'Orbigny,<sup>3</sup> from the Aachen Greensand, but the ribs are more numerous and the antero-dorsal margin has a greater

<sup>1</sup> "Terr. Crét. Ste. Croix" ('Matér. Pal. Suisse,' ser. 4, 1866), p. 289, pl. cxxii, fig. 8.

<sup>2</sup> 'Pal. Franç. Terr. Crét.,' vol. iii (1844), p. 116, pl. cclxxxi, figs. 3—5.

<sup>3</sup> Holzapfel, "Die Mollusk. Aachen. Kreide" ('Palæontographica,' vol. xxxv, 1889), p. 187, pl. xix, figs. 1—3. Ravn, 'Mollusk. i Danmarks Kridtafl. I. Lamellibr.' (1902), p. 129, pl. iv, fig. 21.

ventral slope. The ribs are more numerous than in *Lucina Nereis*, d'Orbigny,<sup>1</sup> from the Cenomanian.

*Distribution*.—Upper Greensand (zone of *Schlowbachia rostrata*) of Blackdown. Upper Greensand near Lyme Regis.

LUCINA PISUM, *Sowerby*, 1836. Plate XXIV, figs. 16—19.

1836.	LUCINA PISUM,	<i>J. de C. Sowerby</i> .	Trans. Geol. Soc., ser. 2, vol. iv, pp. 241, 341, pl. xvi, fig. 14.
1850.	—	—	<i>A. d'Orbigny</i> . Prodr. de Pal., vol. ii, p. 162.
1854.	—	—	<i>J. Morris</i> . Cat. Brit. Foss., ed. 2, p. 208.
1871.	—	—	<i>F. Stoliczka</i> . Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 252.
Non 1844.	—	—	<i>A. d'Orbigny</i> . Pal. Franç. Terr. Crét., vol. iii, pl. cclxxxii, figs. 3—5 ( <i>L. Cornueliana</i> , p. 116).
?—1868.	—	—	<i>A. Briart and F. L. Cornet</i> . Meuse de Braquegnies (Mém. cour. et Mém. des Sav. étrangers, vol. xxxiv), p. 69, pl. viii, figs. 18—21.

*Description*.—Shell small, very convex, with nearly circular outline, slightly inequilateral; length and height nearly equal. Anterior and ventral margins forming a regular curve; posterior margin slightly truncated, forming an obtuse angle with the postero-dorsal margin. Umbones rather large. Lunule ovate, broad, depressed. Esentcheon indistinctly limited. Ornamentation consists of concentric ribs, with growth-rings at intervals.

*Measurements* :

	(1)	(2)	(3)
Length . . .	5	4.5	4 mm.
Height . . .	4.9	4.3	4 „
Thickness . . .	3.5	3	2.9 „

(1—3) Blackdown.

*Remarks*.—The form referred to *L. pisum* by Briart and Cornet is much larger than the English examples of that species, and also differs in its relatively longer and more compressed shell.

*Type*.—From Blackdown; in the Bristol Museum.

*Distribution*.—Upper Greensand (zone of *Schlowbachia rostrata*) of Blackdown.

<sup>1</sup> 'Prodr. de Pal.,' vol. ii (1850), p. 162. Guéranger, 'Album Paléont. de la Sarthe' (1867), p. 12, pl. xv, fig. 15. The hinge figured by Guéranger does not agree with *Lucina*. Stoliczka suggests that this species belongs to *Cyprimeria*, see 'Palæont. Indica, Cret. Fauna S. India' (1871), pp. 164, 253.

## Family—CORBIDÆ, Dall.

Genus—CORBICELLA, J. Morris and J. Lycett, 1853.

('Moll. Great Ool.,' pt. ii, p. 94.)

CORBICELLA CLAXBIENSIS, sp. nov. Plate XXIV, figs. 20—23.

*Description*.—Shell oval, regularly convex, slightly inequilateral, anterior part rather larger than the posterior part, length equal to nearly  $1\frac{1}{2}$  times the height. Anterior margin rounded. Ventral margin convex, curving rapidly to join the posterior margin which forms an angle with the nearly straight postero-dorsal margin. Umbones broad, inconspicuous, scarcely curved, close together. Surface of shell smooth except for growth-lines.

*Measurements* :

	(1)	(2)	(3)	(4)
Length	. 38	. 37	. 30	. 27 mm.
Height	. 26	. 25	. 21	. 19 ,,

(1—4) Claxby Ironstone, Benniworth Haven.

*Remarks*.—The genus *Corbicella* does not appear to have been recognised in deposits of Cretaceous age, but since it is present in the Portlandian its occurrence in the lower part of the Speeton Series of Lincolnshire causes no surprise.

*C. claxbiensis* is similar in outline to some forms of *C. Pellati*, de Loriol,<sup>1</sup> from the Portlandian.

*Type*.—In the Sedgwick Museum, Cambridge.

*Distribution*.—Spilsby Sandstone (zone of *Belemnites lateralis*) of Claxby and Donnington. Claxby Ironstone (zone of *B. lateralis*) of Benniworth Haven.

Genus—SPHÆRA, J. Sowerby, 1822.

('Min. Conch.,' vol. iv, p. 41.)

SPHÆRA CORRUGATA, Sowerby, 1822. Plate XXIV, fig. 24; Plate XXV, figs. 1, 2; text-fig. 26.

1822. SPHÆRA CORRUGATA, J. Sowerby. Min. Conch., vol. iv, p. 42, pl. cccxxxv.

1842. VENUS CORDIFORMIS, A. Leymerie. Mém. Soc. géol. de France, ser. 2, vol. v, p. 5, pl. v, fig. 8.

<sup>1</sup> De Loriol and Pellat, 'Jurass. de Boulogne-sur-mer' (1875), p. 67, pl. xiv, fig. 12.

1842. *CARDIUM GALLOPROVINCIALE*, *P. Matheron*. Catal. Foss. du Départ. des Bouches-du-Rhône, p. 155, pl. xvii, figs. 1, 2.
1844. *CORBIS CORDIFORMIS*, *A. d'Orbigny*. Pal. Franç. Terr. Crét., vol. iii, p. 111, pl. cclxxix.
1845. — *CORRUGATA*, *E. Forbes*. Quart. Journ. Geol. Soc., vol. i, p. 239.
1850. — — *d'Orbigny*. Prodr. de Pal., vol. ii, p. 78.
1854. *SPILERA* — *J. Morris*. Cat. Brit. Foss., ed. 2, p. 224.
1855. *CORBIS* — *G. Cotteau*. Moll. Foss. de l'Yonne, p. 80.
1856. — — *F. J. Pictet and E. Renavier*. Foss. Terr. Aptien (Matér. Pal. Suisse, ser. 1), p. 76, pl. viii, fig. 3.
1859. — *CORDIFORMIS*, *J. Vilanova-y-Piera*. Mem. geog.-agric. de Castellon, pl. iii, fig. 13.
1865. — *CORRUGATA*, *H. Coquand*. Mon. Aptien de l'Espagne, p. 116.
1866. *FIMBERIA* — *F. J. Pictet and G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 279.
1869. *PALÆOCORBIS CORDIFORMIS*, *T. A. Conrad*. Amer. Journ. Conch., vol. v, p. 101.
1871. *SPILERA CORRUGATA*, *F. Stoliczka*. Palæont. Indica, Cret. Fauna S. India, vol. iii, pp. 247, 252.
- ? 1877. *CORBIS* cf. *CORRUGATA*, *G. Böhm*. Zeitschr. d. deutsch. geol. Gesellsch., vol. xxix, p. 240.
1897. — *CORRUGATA*, *K. Gerhardt*. Neues Jahrb. für Min., etc., Beil.-Bd. xi, p. 186.
1899. *FIMBERIA* — *A. Wollemaun*. Zeitschr. der deutsch. geol. Gesellsch., vol. li, p. 592.

*Description*.—Shell large, stout, inflated, subglobular, slightly inequilateral, height and length nearly equal. Anterior margin rounded, forming an angle with the hinge-margin, and passing gradually into the ventral margin with which it forms a regular curve. The ventral margin curves rapidly towards the posterior margin, which makes an obtuse angle with the hinge-margin. Lunule flattened or depressed, with a swollen lower margin which is separated from the rest of the valve by a furrow. Esentecheon triangular, limited by a furrow which passes from the umbo to the posterior margin. Umbones large, prominent, curved anteriorly. Ornamentation consists of broad, strong, unequal, concentric ridges which are more numerous on the middle than on the anterior and posterior parts of the shell. The concentric ridges are crossed by numerous, small, radial ribs.

*Measurements* :

	(1)	(2)	(3)	(4)
Length	95	84	80	70 mm.
Height	93	83	77	68 ..

(1—4) Lower Greensand, Atherfield.

*Remarks.*—This species is the type of the genus *Sphæra*. It is fairly common in the *Perna*-bed of the Isle of Wight. A young example is figured by d'Orbigny.

*Type.*—The type was obtained by Professor Sedgwick from the *Perna*-bed of Sandown, but cannot now be found.

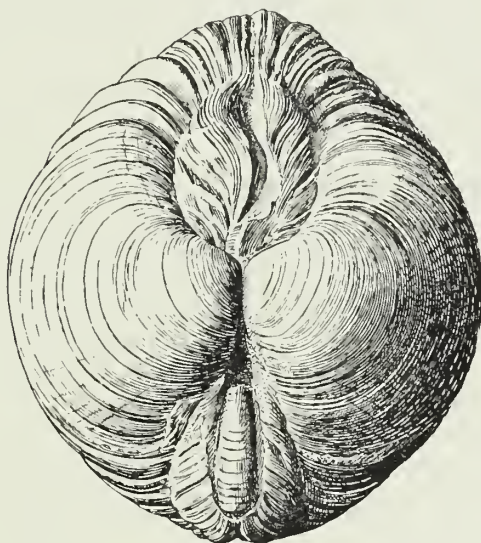


FIG. 26.—*Sphæra corrugata*, Sow. Lower Greensand, near Hythe. Museum of Practical Geology, No. 19716. Dorsal view.  $\times \frac{1}{5}$ .

*Distribution.*—Lower Greensand (*Perna*-bed and Crackers) of Atherfield; also recorded by Fitton from Beds viii and xiv. Hythe Beds of Hythe and Maidstone. Recorded by Topley from the Atherfield Beds of Peasmarsh and Shalford; the Hythe Beds of Lymepe; and the Sandgate Beds of Sandgate.<sup>1</sup>

SPHÆRA, sp. Plate XXV, fig. 3.

A small specimen from the Chalk Marl of Chard appears to belong to a distinct species. It is much smaller than *S. corrugata*, also relatively longer, more oval in outline, and less inflated. The escutcheon is not defined, the lunule is small or absent, and the antero-dorsal margins are thick and prominent. The concentric ridges resemble those of *S. corrugata*, but the radial ribs are more distinct. Length 16.5 mm.; height 14 mm.; thickness 12.5 mm.

<sup>1</sup> The type of *Corbis? fibrosa*, Forbes, from Peasmarsh, is in the Museum of the Geological Society (R 2154), but is too imperfect for determination. Forbes, 'Quart. Journ. Geol. Soc.,' vol. i (1845), p. 239.

*Genus*—MUTIELLA, *Stoliczka*, 1871.

(‘*Palæont. Indica, Cret. Fauna S. India,*’ p. 247.)

MUTIELLA ? CANALICULATA (*Sowerby*), 1836. Plate XXV, figs. 4—6.

1836. PETRICOLA CANALICULATA, *J. de C. Sowerby*. *Trans. Geol. Soc.*, ser. 2, vol. iv, pp. 241, 341, pl. xvi, fig. 11.
- — NUCIFORMIS, *Sowerby*. *Ibid.*, pp. 241, 341, pl. xvi, fig. 10.
1850. CARDIUM CANALICULATUM, *A. d'Orbigny*. *Prodr. de Pal.*, vol. ii, p. 163.
- — NUCIFORME, *d'Orbigny*. *Ibid.*, p. 163.
1854. PETRICOLA ? CANALICULATA, *J. Morris*. *Cat. Brit. Foss.*, ed. 2, p. 220.
- — NUCIFORMIS, *Morris*. *Ibid.*, p. 220.
1866. CARDIUM CANALICULATUM, *F. J. Pictet and G. Campiche*. *Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4)*, p. 270.
- 1865-66. PETRICOLA NUCIFORMIS, *Pictet and Campiche*. *Ibid.*, pp. 163, 276.
1870. — CANALICULATA (CARDIUM), *F. Stoliczka*. *Palæont. Indica, Cret. Fauna S. India*, vol. iii, p. 141.
- — NUCIFORMIS (? CORBIS), *Stoliczka*. *Ibid.*, p. 141.

*Description*.—Shell inflated, outline more or less orbicular, inequilateral, length and height equal. Margins rounded. Anterior margin less convex than the posterior margin. The latter makes an obtuse angle with postero-dorsal margin and curves rapidly to join the ventral margin. The margin in front of the umbo expands. Umbones large, contiguous, curving inward and forward. No lunule.

Ornamentation consists of numerous, regular, radial ribs, separated by narrow furrows, and crossed by narrow concentric ridges which are more prominent on the posterior part of the shell than elsewhere. Inner margins of the valves crenulate.

There are two cardinal teeth in the left valve and one in the right. Behind the umbo a long, nearly straight, sharp ridge forms the inner margin of the ligament groove.

*Measurements* :

	(1)	(2)	(3)	(4)	
Length	20·5	19	17	14·5	10 mm.
Height	20·5	19	17	14·5	10 „

(1—4) Blackdown.

*Affinities*.—The generic position of this species has been for a long time a matter of doubt, but no one appears to have accepted *Sowerby*'s view. The

species is rare, and the opinions expressed by various authors appear to have been based entirely on the figures given by Sowerby.

The hinge is similar to that of *Mutiella coarctata* (Zittel),<sup>1</sup> but shows some points of difference: thus the transverse corrugations or teeth on the expanded anterior margin appear to be absent, and the terminal posterior lateral tooth cannot be recognised with certainty. The points of resemblance, however, and the similarity in the form of the shell and the character of the ornamentation seem sufficient to justify the assignment of this species either to *Mutiella* or to a closely allied genus.

From the figures given by Sowerby, *Petricola nuciformis* appears to differ considerably from *P. canaliculata*, but after an examination of the type of the former I am led to the conclusion that it is not specifically distinct from the latter; it differs only in being more inequilateral, and the apparent difference in the ornamentation is due to the imperfect preservation of the surface of the shell in *P. nuciformis*.

*Types*.—From Blackdown. The type of *Petricola canaliculata* cannot be found. The type of *P. nuciformis* is in the Bristol Museum.

*Distribution*.—Upper Greensand (zone of *Schlowbachia rostrata*) of Blackdown, and Peak Hill, near Sidmouth.

#### MUTIELLA ROTUNDATA (*d'Orbigny*), 1844.

1844. CORBIS ROTUNDATA, *A. d'Orbigny*. Pal. Franç. Terr. Crét., vol. iii, p. 113, pl. cclxxx, figs. 1-4.  
 1850. — — — — — Prodr. de Pal., vol. ii, p. 162.  
 1867. — — — *E. Guéranger*. Album Paléont. de la Sarthe, p. 15, pl. xix, figs. 10, 11.  
 1870. — — — *F. Römer*. Geol. v. Oberschles., p. 340.  
 1871. MUTIELLA ROTUNDATA, *F. Stoliczka*. Palæont. Indica, Cret Fauna S. India, vol. iii, pp. 247, 252.  
 1896. CORBIS ROTUNDATA, *A. J. Jukes-Browne and W. Hill*. Quart. Journ. Geol. Soc., vol. lii, p. 153.

A portion of a right valve of *Mutiella rotundata* from the Cenomanian (Bed 11) of Dunscombe, South Devon, was found and determined by the late C. J. A. Meÿer. An internal cast was collected from Bed 10 of Beer Head by Mr. Jukes-Browne, who also records the species from the Chloritic Marl of Maiden Bradley,

<sup>1</sup> *Fimbria coarctata*, Zittel, 'Die Biv. d. Gosaugeb.,' pt. i (1864), p. 44, pl. vii, fig. 5. Referred by Stoliczka, and subsequently by Zittel and by G. Müller, to the genus *Mutiella*. Compare also the hinge of *Mutiella rotundata* figured by Guéranger, 'Album Paléont. de la Sarthe' (1867), pl. xix, fig. 11.

and the Chalk Marl of Chard. The specimens seen are not sufficiently perfect for figuring.

*M. rotundata* is the type of the genus *Mutiella*. In France this species is found in the Cenomanian of Le Mans, Sarthe, Rouen, etc.<sup>1</sup>

Family—UNICARDIIDÆ, *Fischer*.

Genus—UNICARDIUM, *A. d'Orbigny*, 1849.

(‘*Prodr. de Pal.*,’ vol. i, p. 218.)

UNICARDIUM CLAXBIENSE, sp. nov. Plate XXV, figs. 7 *a*, *b*.

*Description*.—Shell large, oval, inflated, with somewhat flattened sides, very inequilateral; anterior part much longer than posterior part. Anterior margin well rounded, passing gradually into the antero-dorsal margin, and into the ventral margin, which is only slightly curved. Posterior margin truncated. Umbones broad, curved inward and slightly forward. In front of the umbones the shell is depressed.

Ornamentation consists of narrow, sharp, prominent, somewhat irregular concentric ribs separated by relatively broad, concave interspaces.

*Measurements* :

	(1)	(2)
Length . . . . .	52	40 mm.
Height . . . . .	45	34 „

(1, 2) Benniworth Haven.

*Affinities*.—In this species the umbones are not so high and the posterior part of the shell is longer than in *U. heteroclitum* (d’Orbigny)<sup>2</sup>; also the ribs appear to be narrow and sharper.

*Type*.—In the Sedgwick Museum, Cambridge.

*Distribution*.—Claxby Ironstone (zone of *Belemnites lateralis*) of Benniworth Haven, Lincolnshire.

<sup>1</sup> *Corbis*? *Morisoni*, Woods, from the Chalk Roek of Cuckhamsley, is at present known by two imperfect valves only. The hinge cannot be seen, and the generic position of the species is still uncertain. See Woods, ‘*Quart. Journ. Geol. Soc.*,’ vol. liii, p. 392, pl. xxviii, figs. 13, 14.

<sup>2</sup> In Murchison, de Verneuil and de Keyserling, ‘*Géol. Russie de l’Europe*,’ vol. ii (1845), p. 460, pl. xxxix, figs. 9, 10. D’Orbigny, ‘*Prodr. de Pal.*,’ vol. i (1849), p. 367. Eichwald, ‘*Lethæa Rossica*,’ vol. ii (1868), p. 647. Two examples of *U. heteroclitum* from the Lower Volgian, near Moscow, are in Mr. Lamplugh’s collection.

UNICARDIUM VECTENSE, sp. nov. Plate. XXV, figs. 8—11.

*Description.*—Shell thin, much inflated, oval or slightly subquadrate, inequilateral, the anterior part rather larger than the posterior part; length a little greater than height. Antero-dorsal margin short, nearly straight. Anterior margin rounded, making an obtuse angle with the antero-dorsal margin, and curving rapidly to join the moderately convex ventral margin. Posterior margin rounded, slightly truncated. Postero-dorsal margin slightly convex. Umbones prominent, contiguous, curving inward and forward. Ornamentation consists of numerous, strong, somewhat irregular, concentric ribs. Ligament in a long, narrow groove. Teeth absent or poorly developed.

*Measurements:*

	(1)	(2)	(3)	(4)
Length .	20	18	16	12 mm.
Height .	19	17	15	11·2 „

(1—4) Crackers, Atherfield.

*Affinities.*—The shell is relatively higher, the umbones more prominent, and the ribs rather stronger than in *U. Ebraji*, de Loriol.<sup>1</sup>

*Distribution.*—Lower Greensand: Crackers of Atherfield, *Perna*-bed of Sandown, and Ferruginous Sands of Shanklin.

UNICARDIUM, sp. Plate XXV, fig. 12.

A specimen of *Unicardium* from the Upper Greensand of South Devon<sup>2</sup> was collected by Sir H. T. De la Beche and is now in the Museum of the Geological Society, No. 1580. It resembles *U. vectense*, but the umbones are not so prominent and the ribs are smaller, more numerous, and more regular.

UNICARDIUM? GAULTINUM (*Pictet and Roux*), 1852.

1852. CORBIS GAULTINA, *F. J. Pictet and W. Roux*. Moll. Foss. Grès verts de Genève, p. 448, pl. xxxiv, fig. 4.
1866. FIMBRIA — *F. J. Pictet and G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 282, pl. cxxii, figs. 3, 4.
1871. — — *F. Stoliczka*. Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 252.
1875. CORBIS — *A. J. Jukes-Browne*. Quart. Journ. Geol. Soc., vol. xxxi, p. 300, pl. xv, fig. 9.

<sup>1</sup> 'Gault de Cosne' (1882), p. 70, pl. viii, figs. 13-16.

<sup>2</sup> Probably from near Sidmouth or Blackdown.

Two internal casts from the Cambridge Greensand (derived from the Gault) were identified by Mr. Jukes-Browne as *Corbis gaultina*, Pictet and Roux. The specimens are in the Sedgwick Museum, and no other examples appear to have been found. The type of *C. gaultina* came from the Gault of Saxonet. In external form this species agrees closely with *Unicardium*, but the hinge is unknown, so that the generic position cannot be determined with certainty.

UNICARDIUM RINGMERIENSE (*Mantell*), 1822. Plate XXV, figs. 13, 14.

1822. VENUS? RINGMERIENSIS, *G. Mantell*. Foss. S. Downs, p. 126, pl. xxv, fig. 5.  
 1850. PANOPÆA — *A. d'Orbigny*. Prodr. de Pal., vol. ii, p. 157.  
 1854. UNICARDIUM RINGMERIENSE, *J. Morris*. Cat. Brit. Foss., ed. 2, p. 229.  
 1865. CARDIUM — *F. J. Pictet and G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 195.  
 Nov 1850. ARCA RINGMERENSIS, *H. B. Geinitz*. Das Quadersandst. oder Kreidegeb. in Deutschland, p. 162.  
 — 1872. MUTIELLA RINGMERENSIS, *H. B. Geinitz*. Das Elbthalgeb. in Sachsen (Palæontographica, vol. xx, pt. 2), p. 61, pl. xvi, figs. 11–13.  
 — 1877. — — *A. Fritsch*. Stud. im Gebiete der böhm. Kreideformat. II Weissenberg. u. Malnitz. Schicht., p. 115, fig. 75.  
 — 1883. — — *Fritsch*. Ibid. III Isernschicht., p. 100, fig. 64.  
 — 1889. — — *Fritsch*. Ibid. IV Teplitz. Schicht., p. 78.  
 — 1897. — — *Fritsch*. Ibid. VI Chlomek. Schicht., p. 54, fig. 59.

*Description*.—Shell subquadrate, rounded, inflated, antero-dorsal part compressed, length rather greater than height, inequilateral, anterior part larger than the posterior part. Antero-dorsal margin nearly straight. Anterior margin moderately convex, making an obtuse angle with the antero-dorsal margin and curving rapidly near the ventral margin. The latter is moderately convex and curves upward to join the posterior margin, which is slightly curved, and forms an obtuse angle with the postero-dorsal margin. Umbones large, prominent, contiguous, curving forward. Ornamentation consists of strong, narrow, concentric ridges.

*Measurements* :

	(1)	(2)
Length . . . . .	42	36 mm.
Height . . . . .	38	34 „

(1) Chalk Marl, Tiferleigh.

(2) Chalk Marl, Chardstock.

*Remarks.*—The specimens from the Pläner-kalk of Strehlen which were referred to this species by Geinitz appear to be related to *Mutiella coarctata* (Zittel).<sup>1</sup>

*Type.*—The type came from the Chalk Marl of Middleham, but cannot now be found.

*Distribution.*—Upper Greensand (zone of *Schlœnbachia rostrata*) of Devizes. Base of Chalk Marl of Titherleigh and Chardstock. Chalk Marl of Middleham and Ringmer.

[Systematic position not determined.]

*Genus*—THETIRONIA, F. Stoliczka, 1870.

(‘Palæont. Indica, Cret. Fauna S. India,’ vol. iii, p. 158. *Thetis*, J. de C. Sowerby, ‘Min. Conch.,’ vol. vi, 1826, p. 19. Non *Thetis*, Oken, 1815. Syn. *Fimbriella*, Stoliczka, op. cit., p. 246.)

The genus *Thetironia* [*Thetis*] has been placed in the family Veneridæ by Deshayes, d’Orbigny, Chem, Stoliczka, Zittel, Fischer, Dall, and other authors, on account of the presence of the acutely angular line which has often been regarded as a pallial sinus. This angular line appears as a deep groove on internal casts, and must consequently have been a prominent rib on the interior of the shell. In its position and rib-like form it is quite unlike the pallial sinus of any lamellibranch,<sup>2</sup> and it seems to be a structure of an entirely different nature, probably serving, as was suggested by S. P. Woodward<sup>3</sup> merely to strengthen the thin shell. *Thetironia* is further distinguished from the Veneridæ by its hinge, which is of quite a different type (see Plate XXVI, figs. 10 b, 14). Stoliczka, in referring this genus to the Veneridæ and sub-family Dosiniinæ, says: “There can be little doubt that all the external characters indicate a close approach to the recent *Clementia*”; the hinge, however, which seems to have been unknown to Stoliczka, shows that this view of the relationship of *Thetironia* cannot be maintained.

A concentric ridge seen near the ventral margin on some internal casts of *Thetironia* has been regarded by some authors as evidence of a simple pallial line; but the presence in some specimens of several similar ridges at different distances from the margin suggests that they are really of the nature of growth-rings (see Plate XXVI, fig. 6).

*Thetironia* was identified with *Poromya* by S. P. Woodward (1854) and by H.

<sup>1</sup> G. Müller, ‘Mollusk. Untersen. v. Braunschweig u. Ilse’ (1898), p. 60.

<sup>2</sup> De Loriol compared it with *Lucinopsis*, but the differences between the pallial sinus of that genus and the angular rib of *Thetironia* are considerable.

<sup>3</sup> ‘Manual of the Mollusca,’ ed. 1 (1854), p. 319; ed. 3 (1875), p. 491. Woodward says, “umbones strengthened inside by a posterior lamina.”

and A. Adams (1858). Deshayes (1858), and Pietet and Campiche (1865), though considering them allied forms, did not regard them as generically identical. The latter authors had little confidence in the suggested relationship of *Thetironia* to *Venus*, but in the absence of specimens furnishing decisive evidence they left the former genus in the family Veneridæ. In its external form and thin shell *Thetironia* shows some resemblance to *Poromya*, but the conspicuous internal ligament found in the latter is absent in the former.

In a systematic list of Mollusca, J. E. Gray<sup>1</sup> placed *Thetironia* in the Lucinidæ, but gave no reasons for assigning it to that family. Although elongate markings do occur in the interior of some species of *Lucina*, they show but little resemblance to the angular rib of *Thetironia*. Further, the hinge is unlike that typical of *Lucina*; for although in some few species (*e. g.* *L. gibba*, *L. pennsylvanica*) in which the umbones have a considerable anterior curvature, the positions of the cardinal teeth become somewhat similar to those in *Thetironia*, yet this is clearly a secondary character due to torsion and cannot be taken as evidence of any affinity between *Lucina* and *Thetironia*.

The hinge in some of the Corbidæ, such as *Sphæriola*, *Gonodon*, and *Mutiella* resembles that of *Thetironia*, but is far stouter, and the shell is much thicker. The hinge in *Unicardium* also is somewhat similar to that of *Thetironia*, since lateral teeth are absent, but the cardinals are less developed. *Unicardium*, however, differs from *Thetironia* in the character of its ornamentation and in the form of the shell.

In both form and position the teeth of *Thetironia* show a striking resemblance to the cardinal teeth of the Cardiidæ (especially to *Protocardia*), and the hinge-margin in front of the umbo expands in a similar way; some further resemblance is seen in the position and prominence of the external ligament, and in the general form of the shell, which is similar to that of the nearly smooth *Cardium* (*Serripes*) *grœnlandicum*, Chemnitz.<sup>2</sup> The greater development of ornamentation on the posterior part than on the remainder of the shell in *Thetironia* is also suggestive of some forms of *Protocardia*. The position of the cardinal teeth in the Cardiidæ is practically constant and is a character of systematic importance; so that the close resemblance between these teeth in *Thetironia* and in the Cardiidæ seems to indicate a real relationship. Opposed to this, however, is the absence of lateral teeth<sup>3</sup> in *Thetironia*; but although these teeth are usually found in the Cardiidæ,

<sup>1</sup> 'Synopsis Brit. Mus.,' ed. 44 (1842), p. 91.

<sup>2</sup> Although d'Orbigny placed *Thetironia* in the Veneridæ, he recognised that in some respects it clearly resembles *Cardium*. See 'Pal. Franç. Terr. Crét.,' vol. iii (1846), p. 451.

<sup>3</sup> In the 'Additions and Corrections' to his Monograph Stoliczka states that in *Thetironia ignobilis* there are two cardinals and a minute posterior lateral in the right valve, and three cardinals in the left valve. 'Paleont. Indica, Cret. Fauna S. Indica' (1871), p. 485.

yet they are occasionally absent. Other differences are seen in the very thin and punctate shell, and in the internal rib.

Nothing closely resembling the internal rib of *Thetironia* seems to be known in any other lamellibranch. But in some Jurassic and Cretaceous<sup>1</sup> species of *Protocardia* a rib, either single or  $\Lambda$ -shaped, is found at the inner boundary of the posterior area; this, however, differs from the rib of *Thetironia*, in that it reaches the margin of the valve and is not continued anteriorly to the neighbourhood of the anterior adductor.

It seems, therefore, that although *Thetironia* resembles the *Cardiidae* in several respects, yet the points of difference are too great to allow of its being included in that family.

THETIRONIA MINOR (*Sowerby*), 1826. Plate XXV, figs. 15 *a-c*; Plate XXVI, figs. 1—8.

1822. VENUS, *G. Mantell*. Foss. S. Downs, p. 73.
1826. THETIS MINOR, *J. de C. Sowerby*. Min. Conch., vol. vi, p. 21, pl. dxiii, figs. 6 (? 5).
1829. — — — *M. J. L. DeFrance*. Dict. Sci. Nat., vol. liv, p. 275.
1841. — — — *SOWERBY, F. A. Römer*. Die Verstein. d. nord-deutsch. Kreidegeb. p. 72 (*partim*).
1845. — — — var.  $\alpha$  minor, var.  $\beta$ . major. *E. Forbes*. Quart. Journ. Geol. Soc., vol. i, p. 242.
1846. — — — LÆVIGATA, *A. d'Orbigny*. Pal. Franç. Terr. Crét., vol. iii, p. 452, pl. cclxxxvii, figs. 1—3.
- 1832-53. — — — MINOR, *G. P. Deshayes*. Traité Élément. Conchyl., vol. i, p. 575, pl. xxii, figs. 3, 4.
1854. — — — *J. Morris*. Cat. Brit. Foss., ed. 2, p. 227.
- — — *S. P. Woodward*. Manual of the Mollusca, fig. 221 (on p. 318).
1865. — — — *F. J. Pictet and G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 202, pl. cxii, fig. 4.
1870. — — — LÆVIGATA, *Pictet and Campiche*. Ibid., p. 203, pl. cxii, figs. 2, 3.
- — — THETIRONIA MINOR, *F. Stoliczka*. Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 158.
1884. THETIS MINOR, *O. Weerth*. Die Fauna des Neocom. im Teutoburg. Walde (Palæont. Abhandl., vol. ii), p. 41, pl. ix, figs. 5, 6.
1898. — — — LÆVIGATA, *E. G. Skeat and V. Madsen*. Jur. Neoc. and Gault Boulders in Denmark, p. 176, pl. vi, figs. 7—9.

<sup>1</sup> Part of this rib is seen in a figure given by Pictet and Campiche, 'Terr. Crét. Ste. Croix' ('Matér. Pal. Suisse,' ser. 4, 1866), pl. cxxi, fig. 7*a*.

1895.	THETIS MINOR,	<i>F. Vogel.</i>	Holländisch. Kreide, p. 58.
1900	—	—	<i>A. Wollemani.</i> Die Biv. u. Gastrop. d. deutsch. u. holländ. Neocoms, p. 118.
Non 1846.	—	—	<i>A. d'Orbigny.</i> Pal. Franç. Terr. Crét., vol. iii, p. 453, pl. cclxxxvii, figs. 4—7.
— 1850.	—	—	<i>d'Orbigny.</i> Prodr. de Pal., vol. ii, p. 136.
— 1868.	—	—	<i>E. v. Eichwald.</i> Lethæa Rossica, vol. ii, p. 707, pl. xxvi, fig. 6.

*Description.*—Shell oval, rounded, convex, slightly (sometimes moderately) inequilateral; length rather greater than height. Margins forming nearly regular curves; anterior margin less convex than the posterior, making a rounded angle where it meets the nearly straight antero-dorsal margin. Umbones prominent, rather broad, close together, more or less curved forward. Lunular region depressed, not limited. Postero-dorsal region sometimes slightly compressed.

Ornamentation consists of slightly-raised concentric lines at regular intervals with less distinct lines between; and of regular rows of radial pits, which on the posterior part of the shell are replaced by rows of short spiny projections or minute tubercles.

A long, acutely angular rib extends from the level of the posterior adductor to near the umbo. The front part of this rib is continued to near the anterior adductor, but is less prominent than the angular part; at first it curves ventrally, and afterwards dorsally, the last part being somewhat angular.

*Measurements:*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Length	31	30	27	26·5	25	23	30	26	20	17·5	17 mm.
Height	28·5	29	25	25	24	21·5	27	23·5	18	16·5	16 „

(1—6) Crackers, Atherfield.

(7—11) Internal casts, Lower Greensand, Shanklin.

*Affinities.*—Pictet and Campiche separated, but with considerable hesitation, the examples of *Thetironia* found in the Crackers of Atherfield from those found in the Ferruginous Rock of Shanklin. The former they referred to *T. lævigata*, d'Orbigny (*non* Sowerby); whilst the latter are typical of *T. minor*. There is, as stated by those authors, considerable difficulty in comparing specimens from the two localities owing to their different states of preservation. Those from Atherfield have the shell well preserved in nearly all cases, although not uncommonly the original form has been somewhat modified by crushing. The specimens from Shanklin, on the other hand, are nearly always casts, but owing to the hardness of the rock they retain their original form more perfectly.

Pictet and Campiche thought that the Atherfield form was less convex and

more inequilateral than the Shanklin form. After comparing a considerable number of specimens I find that those from Atherfield are, as a rule, slightly less convex; but the more inequilateral character is not constant; specimens of the *same size* are commonly quite as nearly equilateral, but the inequilateral character becomes more marked with age. Since larger forms are more common at Atherfield than at Shanklin, one may at first sight get the impression that there is a real difference in the inequilateral character. I have not seen any specimen from Atherfield so inequilateral as the form figured by Pictet and Campiche appears to be, and I think it is probable that their specimen was somewhat distorted by crushing.

*T. genevensis*, Pictet and Roux,<sup>1</sup> is distinguished from *T. minor* by the height and length being equal, by its more nearly equilateral form, and by a difference in the curvature of the rib in front of the angular part.

*Remarks.*—*Thetironia* has been recorded by Phillips and Judd from the Speeton Clay, but I have not seen any examples from that deposit. In some collections from Speeton specimens of *Cyprina* have been identified as *Thetironia*.

*Type.*—Fig. 6, Lower Greensand of Shanklin; in the British Museum. The original of fig. 5 from near Lyme Regis has not been seen.

*Distribution.*—Lower Greensand: Crackers of Atherfield; also recorded by Fitton from the *Perna*-bed and Beds vi, viii, ix, x, xiii, and xiv between Atherfield and Blackgang Chine. Ferruginous Sands of Shanklin. Atherfield Beds of East Shalford. Hythe Beds of Hythe. Sandgate Beds of Sandgate, etc. Folkestone Beds of Folkestone.

THETIRONIA LEVIGATA (*Sowerby*), 1818. Plate XXVI, figs. 9—14.

1818. CORBULA LEVIGATA, *J. Sowerby*. Min. Conch., vol. iii, p. 14, pl. ccix, figs. 1, 2.  
 1826. THETIS MAJOR, *J. de C. Sowerby*. Ibid., vol. vi, p. 20, pl. dxiii, figs. 1—4.  
 1829. — — *M. J. L. DeFrance*. Dict. Sci. Nat., vol. liv, p. 276.  
 1850. UNICARDIUM LEVIGATUM, *A. d'Orbigny*. Prodr. de Pal., vol. ii, p. 163.  
 1854. THETIS LEVIGATA, *J. Morris*. Cat. Brit. Foss., ed. 2, p. 227.  
 — — MAJOR, *Morris*. Ibid., ed. 2, p. 227.  
 1862. — — *J. G. Chew*. Manuel de Conchyl., vol. ii, p. 90, fig. 405.  
 1865. — — *F. J. Pictet and G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), pp. 209, 210, pl. cxii, fig. 5.

<sup>1</sup> Pictet and Roux, 'Moll. Foss. Grès verts de Genève' (1852), p. 420, pl. xxx, fig. 2. Pictet and Campiche, 'Terr. Crét. de Ste. Croix' (1865), p. 206, pl. cxii, fig. 7. Barrois records *T. genevensis* from the Upper Greensand of Lulworth, but I have not seen any specimens; see Barrois, 'Terr. Crét. Supér. de l'Angleterre,' etc. (1876), p. 90.

- ? 1868. THETIS MAJOR, *A. Briart and F. L. Cornet*. Meule de Bracquagnies (Mém. cour. et Mém. des Sav. étrangers, vol. xxxiv), p. 83, pl. vii, figs. 14, 15.
1871. FIMBRIELLA LÆVIGATA, *F. Stoliczka*. Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 246.
1882. THETIS MAJOR, *P. de Loriol*. Gault de Cosne, p. 61, pl. viii, figs. 6—8.
- ? 1874. — — *W. Dames*. Zeitschr. d. deutsch. geol. Gesellsch., vol. xxvi, p. 766, pl. xxi, fig. 4.
1885. — — *F. Nötling*. Die Fauna d. baltisch. Cenoman. (Palæont. Abhandl., vol. ii), p. 29, pl. v, fig. 6.
- Nov 1845. — SOWERBII var.  $\beta$  MAJOR, *E. Forbes*. Quart. Journ. Geol. Soc., vol. i, p. 242.
- 1846. — MAJOR, *A. d'Orbigny*. Pal. Franç. Terr. Crét., vol. iii, p. 454, vol. cccxxxvii, figs. 8—10.
- — — LÆVIGATA, *d'Orbigny*. Ibid., vol. iii, p. 452, pl. cccxxxvii, figs. 1—3.
- 1850. — — *d'Orbigny*. Prodr. de Pal., vol. ii, p. 118.
- — — MAJOR, *d'Orbigny*. Ibid., vol. ii, p. 160.
- ? — 1852. — SOWERBYI, *R. Kner*. Denkschr. d. k. Akad. Wissensch. Wien, Math.-nat. Cl., vol. iii, p. 311, pl. xvi, fig. 21.
- ? — 1868. — MAJOR, *E. v. Eichwald*. Lethæa Rossica, vol. ii, p. 708.

*Measurements :*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Length .	47	42	41	39	30·5	29·5	22·5	22	13 mm.
Height .	43	40	39	37	27	28	21	22	13 ,,

(1—9) Blackdown.

*Affinities.*—This species is closely allied to *T. minor*, with which it was united by Römer under the name *T. Sowerbii*, but it possesses relatively higher and narrower umbones than *T. minor*. *T. lævigata* is commonly of larger size than *T. minor*, and as in the case of the latter, the large forms are more inequilateral than the small forms. A rather small example was figured by Sowerby as *Corbula lævigata*, and was taken by Stoliczka as the type of a new genus *Fimbriella*, but it proves to be, as was suggested by Pictet and Campiche, an example of *T. major*.

The hinge can be seen in some specimens from Blackdown (Plate XXVI, figs. 10*b*, 14). It consists of two small conical or tubercular teeth just below the umbo of each valve. In the right valve the teeth are placed one above the other, but the dorsal tooth is slightly in front of the ventral and rather smaller than the latter. In the left valve the teeth are side by side, nearly on the same level, and the anterior tooth is rather larger than the posterior. Lateral teeth are absent. The external ligament is short and prominent.

*Types.*—The type of *Corbula lævigata*, from Blackdown, and the types of *Thetis major*, from Blackdown and Devizes, are in the British Museum. *T. major* is the type of the genus *Thetis*, Sowerby.

*Distribution.*—Gault of Black Ven. Upper Greensand (zone of *Schambachia rostrata*) of Blackdown, Potterne, Devizes, and near Lyme Regis. Recorded by Price from the Gault of Folkestone.

*Family*—TELLINIDÆ, *Deshayes*.

*Genus*—TELLINA, *Linnaeus*.

(‘Syst. Nat.’ ed. 10, 1758, p. 674; ed. 12, 1767, p. 1116.)

TELLINA CARTERONI, *d’Orbigny*, 1845. Plate XXVI, figs. 15, 16.

1842. TELLINA ? vel PSAMMOBIA ? ANGULATA, *Deshayes* in *A. Leymerie*. Mem. Soc. géol. de France, vol. v, pp. 3, 24, pl. iii, fig. 6 (non *T. angulata*, L.).
1845. — ANGULATA ?, *E. Forbes*. Quart. Journ. Geol. Soc., vol. i, p. 239.
- TELLINA CARTERONI, *A. d’Orbigny*. Pal. Franç. Terr. Crét., vol. iii, p. 420, pl. cccxxx, figs. 1, 2.
1850. — — *d’Orbigny*. Prodr. de Pal., vol. ii, p. 75.
1861. — — *P. de Loriol*. Anim. Invert. Foss. Mt. Salève, p. 59, pl. vii, fig. 2.
1865. — — *F. J. Pictet and G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 134.
1870. — — *F. Stoliczka*. Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 123.
1884. — — *O. Weerth*. Die Fauna des Neocom. im Teutoburg. Walde (Palæont. Abhandl., vol. ii), p. 41.
1895. — — *G. Maas*. Zeitschr. d. deutsch. geol. Gesellsch., vol. xlvii, p. 257.
1900. — — *A. Wolle mann*. Die Biv. u. Gastrop. d. deutsch. u. holländ. Neocoms, p. 121.

*Description.*—Shell elongate, much compressed, inequilateral, length equal to more than twice the height. Anterior margin rounded, curving rapidly to join the slightly curved ventral margin. Posterior margin oblique, forming an angle with the ventral margin. A shallow furrow passes from the umbo to the middle of the ventral margin. Umbones small, curved forward. A sharp carina extends in a curve from the umbo to the postero-ventral angle, and cuts off a narrow, flattened, postero-dorsal area. Ornamentation consists of fine radial ribs on the anterior and posterior parts of the valves, especially just in front of the carina; growth-lines distinct.

*Measurements :*

	(1)	(2)	(3)	(4)
Length	39·2	39	38	36 mm.
Height	17	16	16·5	15·2 „

(1—4) Crackers, Atherfield.

*Affinities.*—The English specimens differ from the figure of *T. Carteroni* given by d'Orbigny in the greater curvature of the carina, the narrower postero-dorsal area, and the greater upward bend of the anterior end of the shell. Professor Boule has kindly examined the specimen figured by d'Orbigny, and states that the carina is more curved and the postero-dorsal area narrower than represented in the figure; also the anterior part has been restored. Professor Boule has also compared a photograph of a specimen from Atherfield with d'Orbigny's specimen and considers that they do not differ specifically. Pietet and Campiche were able to compare English with French specimens, and the principal difference which they noted was the occurrence of fine radial ribs on the posterior part of the shell in English specimens; but I find that those ribs are indistinct or absent in specimens which are not quite perfectly preserved.

The figure of *T. angulata* given by Deshayes appears to differ from *T. Carteroni* in its more elongate form and the greater length of the anterior region, but these differences are probably due to the imperfection of the specimen. Previous writers have not regarded it as distinct from d'Orbigny's *T. Carteroni*.

Stoliczka regarded *T. Carteroni* as a typical *Tellina*. It resembles closely the sub-genus *Phylloda*, Schumacher.

One specimen from Atherfield (Plate XXVI, fig. 17) differs from the other examples of this species in the occurrence of strong radial ribs on the posterior part of the shell. It may be only a variety of *T. Carteroni*.

*Type.*—From the Neocomian of Vendevre; the original cannot be found. The specimen figured by d'Orbigny came from Marolles.

*Distribution.*—Lower Greensand (Crackers) of Atherfield. Atherfield Beds of East Shalford.

TELLINA STRIATULOIDES, *Stoliczka*, 1870. Plate XXVI, figs. 18, 19; Plate XXVII, fig. 1.

1824. TELLINA STRIATULA, *J. de C. Sowerby*. Min. Conch., vol. v, p. 79, pl. cccclvi, fig. 1 (non *T. striatula*, *Olivi*, *Bolten*, *Lamarek*).
1850. — — — *A. d'Orbigny*. Prodr. de Pal., vol. ii, p. 159.
1854. — — — *J. Morris*. Cat. Brit. Foss., ed. 2, p. 226.

1865. *TELLINA STRIATULA*, *F. J. Pictet and G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 139.
1870. — (*TELLINELLA*) *STRIATULOIDES*, *F. Stoliczka*. Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 123.

*Description*.—Shell elongate-oval, compressed, inequilateral; length equal to about twice the height; the anterior part longer than the posterior part. Anterior margin rounded. Ventral margin slightly curved, making an angle with the posterior margin. Posterior margin oblique, curved near the postero-ventral angle, and forming an obtuse angle with the postero-dorsal margin. Umbones inconspicuous, only slightly curved. A rounded carina extends in a nearly straight line from the umbo to the postero-ventral angle, and cuts off a flattened postero-dorsal area. Ornamentation consists of small radial ribs on the postero-dorsal area and on the part just in front of the carina; also on a small part of the shell near the anterior margin. Fine concentric lines are also present, and are more distinct on the anterior and posterior parts of the shell than elsewhere. Pallial sinus relatively small, somewhat angular.

*Measurements* :

	(1)	(2)
Length	. 30	. 27 mm.
Height	. 14.5	. 13.2 ,,

(1—2) Blackdown.

*Affinities*.—Stoliczka placed this species in the sub-genus *Tellinella*, with which it agrees closely in external form, but the oblique cardinal teeth resemble more closely those of the sub-genus *Palaemora*.

*Type*.—From Blackdown; in the British Museum.

*Distribution*.—Upper Greensand (zone of *Schlaenbachia rostrata*) of Blackdown and Haldon. Recorded by Jukes-Browne from the higher part of the zone of *Pecten asper* in North Dorset.

*Section*—*PALEOMERA*, *F. Stoliczka*, 1870.

(‘Palæont. Indica, Cret. Fauna S. India,’ vol. iii, p. 116.)

*TELLINA (PALEOMERA) INÆQUALIS*, *Sowerby*, 1824. Plate XXVII, figs. 2—8.

1824. *TELLINA INÆQUALIS*, *J. de C. Sowerby*. Min. Conch., vol. v, p. 80, pl. cccclvi, fig. 2.
1850. *ARCOPAGIA* — *A. d'Orbigny*. Prodr. de Pal., vol. ii, p. 158 (*partim*).
1854. *TELLINA* — *J. Morris*. Cat. Brit. Foss., ed. 2, p. 226.

- ? 1868. *TELLINA INÆQUALIS*, A. Briart and F. L. Cornet. Meule de Bracquegnies (Mém. cour. et Mém. des Sav. étrangers, vol. xxxiv), p. 77, pl. viii, figs. 24, 25.
1870. *ARCOPAGIA* — (LINEARIA), F. Stoliczka. Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 124.
- Non 1845. *TELLINA* — ?, E. Forbes. Quart. Journ. Geol. Soc., vol. i, p. 239.

*Description.*—Shell oval, moderately inequilateral; length rather more than  $1\frac{1}{2}$  times the height; left valve less convex than the right. Anterior part of valves rounded. Posterior margin convex, subtruncate, more or less oblique, forming a blunt angle with the ventral margin. A slight carina extends from the umbo to the postero-ventral angle and cuts off a flattened postero-dorsal area. Umbones moderately prominent. Pallial sinus large, rounded. Postero-dorsal area ornamented with small radial ribs; the remainder of the shell smooth except for growth-lines.

*Measurements:*

	(1)	(2)	(3)	(4)	(5)	(6)
Length . . .	29	28	27	26	23·5	18 mm.
Height . . .	18·5	18	17	16·5	14·5	11 „
Thickness . . .	9	7·5	8	7·25	6·5	— „

(1—6) Blackdown.

*Affinities.*—*T. strigata* Goldfuss,<sup>1</sup> from the Aachen Greensand, is similar in form to *T. inæqualis*, but possesses fine radial ornamentation over the entire surface of the shell. *T. Royana*, d'Orbigny,<sup>2</sup> is also similar in form, but appears to be more nearly equilateral and without radial ribs.

A species of *Tellina* found in the Meule de Bracquegnies was referred to *T. inæqualis* by Briart and Cornet, but it appears to differ in some respects from the latter. The specimens which I have seen from Bracquegnies are not sufficiently well preserved to enable me to express a definite opinion as to their relationship to *T. inæqualis*.

*Type.*—From the Upper Greensand of Blackdown; in the British Museum.

*Distribution.*—Upper Greensand (zone of *Schlanbachia rostrata*) of Blackdown and Haldon. Recorded by Jukes-Browne from the Upper Greensand of Devizes and the Isle of Wight.

<sup>1</sup> 'Petref. Germ.,' vol. ii (1840), p. 234, pl. cxlvii, fig. 18. Holzapfel, 'Die Mollusk. Aachen. Kreide' (Palæontographica, vol. xxxv, 1889), p. 159, pl. xi, figs. 6–10. This species is the type of the sub-genus or section *Pakamera*, Stoliczka, 1870.

<sup>2</sup> 'Pal. Franç. Terr. Crét.,' vol. iii (1845), p. 422, pl. cccclxxx, figs. 9–11.

*Sub-genus*—LINEARIA, *T. A. Conrad*, 1860.

(‘*Journ. Acad. Nat. Sci. Philad.*,’ ser. 2, vol. iv, p. 279, and ‘*Amer. Journ. Conch.*,’ vol. vi [1870], p. 73.)

TELLINA (LINEARIA), sp. Plate XXVII, fig. 9.

*Description*.—Shell oval, moderately convex with flattened sides, nearly equilateral. Anterior margin rounded. Ventral margin slightly convex. Posterior margin slightly truncated, rounded. Umbones inconspicuous. Postero-dorsal region slightly compressed, but not limited by a carina.

Ornamentation consists of numerous, strong, regular, concentric ribs separated by narrow grooves; and a few small radial ribs on the anterior and posterior parts, those on the latter sometimes not reaching the margin. Length 16·5 mm.; height 10·5 mm.

*Affinities*.—This species, of which only a few examples have been seen, is closely allied to, if not identical with, *T. Rauliniana* (d’Orbigny),<sup>1</sup> but the posterior ribs are less prominent. The shell is less elongate than is d’Orbigny’s type, but scarcely differs in this respect from the example figured by Pictet and Campiche. It is more elongate and has the postero-dorsal region less flattened than in *T. subconcentrica* (d’Orbigny).<sup>2</sup> *T. subhercynica*, Maas, is another similar form.

*Distribution*.—Lower Greensand (Crackers) of Atherfield. Atherfield Beds of East Shalford.<sup>3</sup>

TELLINA (LINEARIA) SUBTENUISTRIATA, *d’Orbigny*, 1850. Plate XXVII, figs. 10—13.

1836. AMPHIDESMA ? TENUISTRIATUM, *J. de C. Sowerby*. *Trans. Geol. Soc.*, ser. 2, vol. iv, pp. 239, 341, pl. xvi, fig. 7.
1850. TELLINA SUBTENUISTRIATA, *A. d’Orbigny*. *Prodr. de Pal.*, vol. ii, p. 159 (non *T. tenuistriata*, Deshayes, 1824).
1854. AMPHIDESMA ? TENUISTRIATUM, *J. Morris*. *Cat. Brit. Foss.*, ed. 2, p. 183.

<sup>1</sup> For references see p. 176, footnotes 1 and 2.

<sup>2</sup> Some specimens from the Folkestone Beds of Folkestone agree in form with *T. subconcentrica*, but owing to the imperfect preservation of the surface the character of the ornamentation cannot be made out satisfactorily.

<sup>3</sup> It is possible that *Tellina equalis*, Mantell (*nom. nud.*), from the Lower Greensand of Parham, may be the form described above. Mantell, ‘*Trans. Geol. Soc.*,’ ser. 2, vol. iii (1829), p. 211.

1865. *TELLINA SUBTENUISTRIATA*, *F. J. Pictet and G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), pp. 132, 138.
1870. *AMPHIDESMA TENUISTRIATUM*, *F. Stoliczka*. Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 111 (? *Thracia* or *Tellina*).

*Description*.—Shell oval, of moderate convexity, nearly equilateral. Anterior margin rounded; ventral margin moderately convex; posterior margin truncated, more or less oblique, forming a blunt angle with the ventral margin, and an obtuse angle with the postero-dorsal margin. Umbones rather broad, scarcely curved. Postero-dorsal part of shell compressed and flattened.

Ornamentation consists of numerous strong, regular, concentric ribs, and of a few small radial ribs on the anterior part, and of a larger number on the postero-dorsal region and the part just in front of it.

*Measurements* :

	(1)	(2)	(3)	(4)
Length . . .	19	18	17	13 mm.
Height . . .	13·5	13	11·5	9 „

(1—4) Blackdown.

*Affinities*.—This species resembles *Tellina Rauliniana* (d'Orbigny),<sup>1</sup> but possesses a relatively shorter and higher shell, with a more convex ventral margin and more numerous radial ribs. In form it approaches more nearly the examples from the Gault of the Perte du Rhône figured by Pictet and Campiche,<sup>2</sup> but in the latter the posterior extremity is more angular and the posterior ribs more prominent and limited to the postero-dorsal region.

*T. subtenuistriata* also resembles *T. subconcentrica* (d'Orbigny),<sup>3</sup> but is more nearly equilateral and the ventral border is more convex.

It differs from the species from the Lower Greensand described above in the flattened postero-dorsal region, the more angular posterior extremity, the smaller apical angle, the larger curvature of the ventral margin, and greater relative height. *T. subhercynica*, Maas,<sup>4</sup> is another similar form.

*Remarks*.—The type is somewhat imperfectly preserved, but the radial ribs on the anterior and posterior parts, which are not shown in Sowerby's figure, can be made out satisfactorily. The size of the apical angle and the outline of the shell vary in different examples.

<sup>1</sup> 'Pal. Franç. Terr. Crét.,' vol. iii (1845), p. 411, pl. cclxxviii, figs. 7-10.

<sup>2</sup> Pictet and Campiche, 'Terr. Crét. Ste. Croix' (1865), p. 141, pl. cix, figs. 1-3.

<sup>3</sup> Op. cit., p. 410, pl. cclxxviii, figs. 1-6, and 'Prodr. de Pal.,' vol. iii (1850), p. 75. Pictet and Renevier, 'Foss. Terr. Aptien' (Matér. Pal. Suisse, ser. I, 1856), p. 69, pl. vii, fig. 7.

<sup>4</sup> 'Zeitschr. der deutsch. geol. Gesellsch.,' vol. xlvii (1895), p. 258, pl. vi, figs. 3, 4.

*Type*.—From Blackdown; in the Bristol Museum.

*Distribution*.—Upper Greensand (zone of *Schlenbachia rostrata*) of Blackdown.

TELLINA (LINEARIA) sp. Plate XXVII, figs. 14—16.

*Description*.—Shell oval, moderately convex, with flattened sides, nearly equilateral. Anterior and posterior margins rounded. Ventral margin only slightly curved, and nearly parallel with the dorsal margin. Umbones broad, nearly median. Postero-dorsal part of valve flattened, rather large, limited by a faint carina.

Ornamentation consists of numerous small, regular, concentric ribs, and numerous small radial ribs on the postero-dorsal area and near the anterior end.

*Measurements* :

	(1)	(2)	(3)	
Length	. 17	. 15	. 14	mm.
Height	. 12	. 10	. 9.5	„

(1—3) Blackdown.

*Affinities*.—This species resembles *T. Rauliniana* (d'Orbigny), but the radial ribs are much more numerous. It is also similar to the form from the Lower Greensand described above, and to *T. subhercynica*, Maas.

*Distribution*.—Upper Greensand (zone of *Schlenbachia rostrata*) of Blackdown.

*Family*—MACTRIDÆ, Gray.

*Genus*—MACTRA, Linnæus, 1767.

(‘Syst. Nat.’ ed. 12, vol. i, p. 1125.)

MACTRA, sp. Plate XXVII, figs. 17, 18.

A few specimens which resemble *Mactra* externally, but of which the hinge has not been seen, were found in the Lower Greensand (Ferruginous Sands) of Shanklin by the late C. J. A. Meÿer. They are rather larger and relatively higher than *M. angulata*, and the carina is less distinct. The surface of the shell is ornamented with small concentric ribs.

MACTRA ANGULATA, Sowerby, 1836. Plate XXVII, figs. 19—23.

1836. MACTRA ? ANGULATA, J. de C. Sowerby. Trans. Geol. Soc., ser. 2, vol. iv, pp. 241, 341, pl. xvi, fig. 9.

1850. MACTRA ANGULATA, A. d'Orbigny. Prodr. de Pal., vol. ii, p. 158.

1854.	MACTRA	ANGULATA,	<i>J. Morris.</i>	Cat. Brit. Foss., ed. 2, p. 209.
1865.	—	—	<i>F. J. Pictet and G. Campiche.</i>	Foss. Terr. Crét. Ste. Croix (Mater. Pal. Suisse, ser. 4), p. 129.
1870.	—	—	<i>F. Stoliczka.</i>	Palæont. Indica, Cret. Fauna S. India, vol. iii, pp. 55, 56.
Non 1851.	—	—	<i>J. Müller.</i>	Petref. der Aachen. Kreidef., pt. 2, p. 66 (= <i>M. Bosquetiana</i> , Stoliczka).
—	1901.	—	<i>F. Sturm.</i>	Jahrb. d. k. preuss. geol. Landesanst. für. 1900, vol. xxi, p. 84, pl. viii, fig. 1.

*Description.*—Shell small, convex, subtriangular, slightly inequilateral, with the antero- and postero-dorsal parts bending rapidly to the margins. Antero-dorsal margin long. Anterior margin rounded. Ventral margin convex, forming an angle with the posterior margin, which is truncated, oblique, and slightly convex. Umbones prominent, pointed, curved inwards, with a carina which extends in a gentle curve to the postero-ventral angle. Ornamentation consists of fine concentric ribs, which become fewer and stronger near the antero-dorsal and postero-dorsal margin.

*Measurements :*

	(1)	(2)	(3)	(4)
Length	14	13	10	8 mm.
Height	12	10·5	8	7 „

(1—4) Blackdown.

*Affinities.*—In form and ornamentation *M. angulata* resembles *M. Warrenana*, Meek and Hayden,<sup>1</sup> but the latter is of larger size and the umbones show a distinct anterior curvature.

A species found in the Aachen Greensand, now known as *M. Bosquetiana*, Stoliczka, was identified with *M. angulata* by Müller, but is distinguished from the latter, as Stoliczka pointed out, by its greater length, smaller convexity, rounded posterior margin, and other characters.

*Type.*—From Blackdown ; in the Bristol Museum.

*Distribution.*—Upper Greensand (zone of *Schlaenbachia rostrata*) of Blackdown and Haldon. Recorded by Barrois from the Upper Greensand of Lulworth and by Jukes-Browne from the equivalent of the Blackdown Beds at Sidmouth.

<sup>1</sup> Meek, 'Invert. Cret. and Tert. Foss. U. Missouri' (1876), p. 208, pl. xxx, fig. 7. Whiteaves, 'Mesozoic Foss.' (Geol. Surv. Canada), vol. i (1879), p. 142, pl. xvii, fig. 9, pl. xix, fig. 3.

Family—VENERIDÆ, *Leach.*

Genus—PTYCHOMYA, *L. Agassiz*, 1842.

(*Études crit. Moll. Foss.*; *Myes*, p. xviii, pl. xi, figs. 3, 4.)

PTYCHOMYA ROBINALDINA (*d'Orbigny*), 1844. Plate XXVII, figs. 24—26.

- |          |                          |                      |  |
|----------|--------------------------|----------------------|--|
| 1842-45. | PTYCHOMYA PLANA,         | <i>L. Agassiz.</i>   | <i>Études crit. Moll. Foss.</i> ; <i>Myes</i> , p. xviii (1845), pl. xi, figs. 3, 4 (1842).  |
| 1844.    | CRASSATELLA ROBINALDINA, | <i>A. d'Orbigny.</i> | <i>Pal. Franç. Terr. Crét.</i> , vol. iii, p. 75, pl. cclxiv, figs. 10—13.   |
| 1845.    | —                        | —                    | <i>E. Forbes.</i> <i>Quart. Journ. Geol. Soc.</i> , vol. i, p. 241.  |
| 1850.    | —                        | —                    | <i>d'Orbigny.</i> <i>Prodr. de Pal.</i> , vol. ii, p. 77.  |
| 1854.    | —                        | —                    | <i>J. Morris.</i> <i>Cat. Brit. Foss.</i> , ed. 2, p. 196.   |
| 1855.    | —                        | —                    | <i>G. Cotteau.</i> <i>Moll. Foss. de l'Yonne</i> , p. 71.  |
| 1866.    | PTYCHOMYA                | —                    | <i>F. J. Pictet and G. Campiche.</i> <i>Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4)</i> , p. 352, pl. cxxvii, figs. 2—6. |
| 1869.    | RADIOCONCHA              | —                    | <i>T. A. Conrad.</i> <i>Amer. Journ. Conch.</i> , vol. v, p. 47.   |

*Description.*—Shell oval-oblong, elongate, convex, but with flattened sides, very inequilateral, anterior part rather higher than the posterior part. Anterior margin regularly rounded. Ventral margin only slightly curved, nearly parallel to the dorsal margin. Posterior margin oblique, forming an acute angle with the ventral margin and an obtuse angle with the slightly curved postero-dorsal margin. Umbones inconspicuous. On the postero-dorsal side of a line from the umbone to the posterior extremity the shell is flattened. Lunule narrow, elongate.

Ornamentation consists of strong radial ribs, which are sometimes more or less nodose. Those on the posterior part of the shell are stronger and separated by broader furrows than those on the anterior part. The ribs which reach the posterior margin start from the umbo; the others start from a line between the umbo and a point on the opposite margin which is about a quarter of the distance from the anterior to the posterior end. In front of this line the ribs form a considerable curve; behind it they are only slightly curved; the ribs meet at an acute angle at the line mentioned forming either a  $\Lambda$  throughout or a chevron  $M$ , on the ventral part. The postero-dorsal margin is ornamented with strong nodose ridges.

*Measurements :*

	(1)	(2)	(3)
Length . . .	80	70	69 mm.
Height . . .	44	39	36 „

(1—3), *Perna*-bed, Atherfield.

*Affinities.*—Forbes states that English examples of this species were identified by comparison with French specimens. I have not seen any foreign examples of *P. Robinaldina*, but the English specimens appear to differ from those figured by d'Orbigny and by Pictet and Campiche in their greater convexity and larger size, in the more acute angle which the ribs make at the dorso-ventral line, and in the somewhat less anterior position of that line. In all these respects the English examples approach more nearly to *P. neocomiensis* (de Loriol),<sup>1</sup> but differ from that species in their more elongate form. It seems, however, not unlikely that a large number of specimens might show that *P. Robinaldina* and *P. neocomiensis* are not specifically distinct. In connection with this, attention may be called to *Nucula* (*Acila*) *bivirgata*, Sowerby, in which the ornamentation is somewhat similar and shows considerable variation.

The genus *Ptychomya* was placed in the Crassatellitidæ by Pictet and Campiche and by Stoliczka. Its resemblance to *Circe* (*Crista*) was pointed out and fully discussed by Dames,<sup>2</sup> whose view of its systematic position is accepted by Fischer.

*Remarks.*—The date of the plate on which Agassiz figured *Ptychomya plana* is earlier, but the text relating to it is later than d'Orbigny's figure and description of *Crassatella Robinaldina*. Since the specimen figured by Agassiz is rather unsatisfactory and d'Orbigny's name has been used by nearly all writers it seems desirable to retain the latter.

*Distribution.*—Lower Greensand (*Perna*-bed) of Atherfield. Ferruginous Sands of Shanklin. Hythe Beds of Hythe, Lympne, and Maidstone.

<sup>1</sup> Pictet and Campiche, "Terr. Crét. Ste. Croix" ('Matér. Pal. Suisse,' ser. 4, 1866), p. 355, pl. cxxvii, figs. 9—12.

<sup>2</sup> 'Zeitschr. d. deutsch. geol. Gesellsch.,' vol. xxv (1873), p. 374, pl. xii, figs. 1—4.

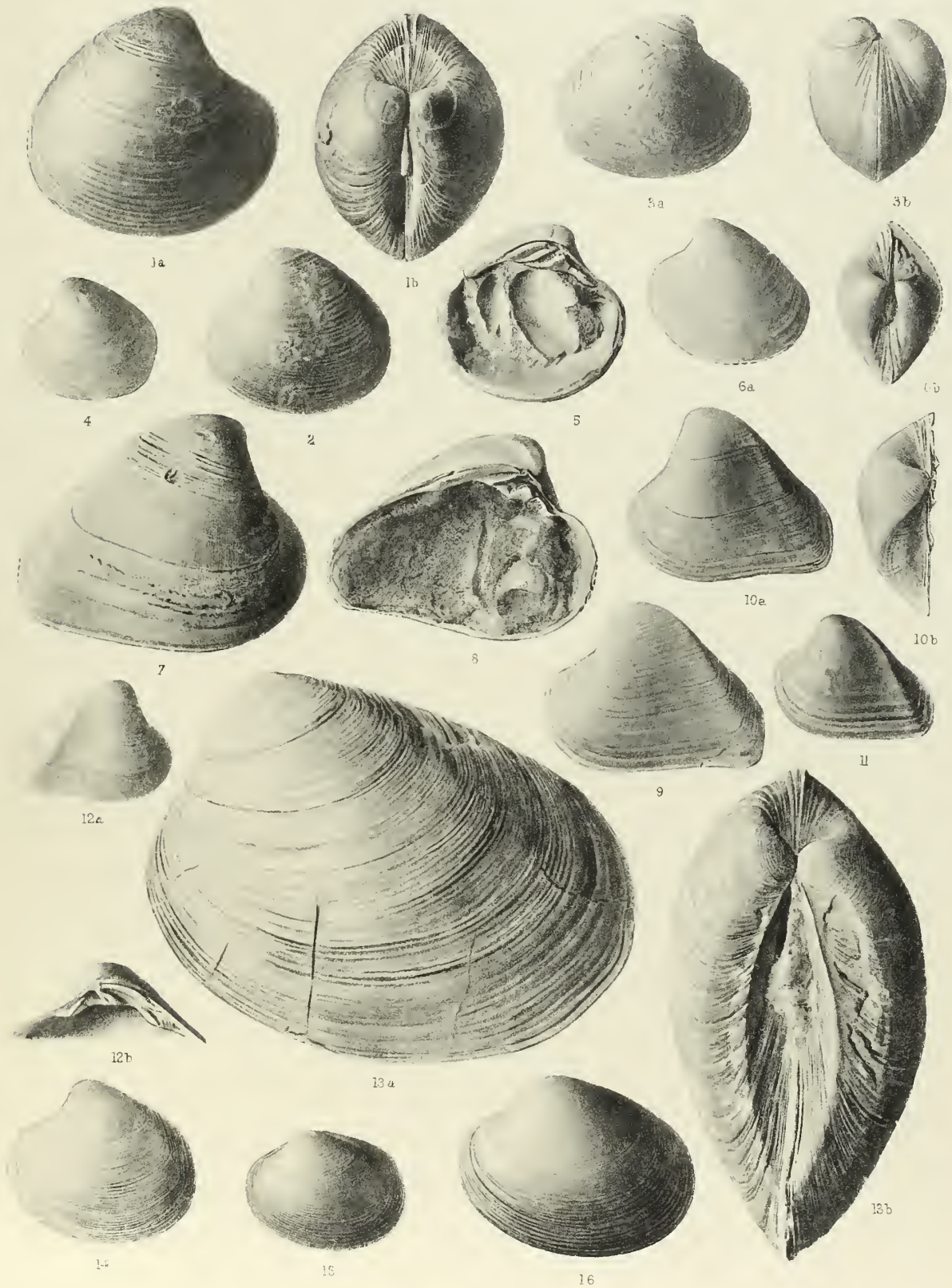


PLATE XX.

CYPRINA (*continued*).

FIGS.

- 1-5. *C. Sedgwicki* (Walker). Lower Greensand. (P. 133.)
1. Potton. The Type. Mr. Walker's Collection. *a*, right valve; *b*, dorsal view of both valves.
  - 2-5. Upware. Sedgwick Museum. 2, 4, 5, left valves. 3 *a*, right valve; 3 *b*, anterior view of 3 *a*.
6. *C. obtusa*, Keeping. Lower Greensand, Upware. Sedgwick Museum. The Type. *a*, left valve; *b*, dorsal view. (P. 133.)
- 7-12. *C. cuneata*, Sow. Upper Greensand, Blackdown. (P. 134.)
7. British Museum, L 17066. Right valve.
  8. British Museum, L 17066. Left valve.
  - 9, 10. Sedgwick Museum. Left valves. 10 *b*, dorsal view of 10 *a*.
  11. British Museum, L 17066. Left valve.
  - 12 *a*. British Museum, L 17066. Right valve. 12 *b*, hinge,  $\times 1\frac{1}{2}$ .
13. *C. tealbiensis*, Woods. Tealby Limestone, Claxby. British Museum, No. 49985. *a*, left valve,  $\times \frac{3}{4}$ ; *b*, dorsal view of both valves,  $\times \frac{3}{4}$ . (P. 136).
14. *C.* sp. Speeton Clay, Speeton. Sedgwick Museum. Left valve. (P. 137.)
- 15, 16. *C. anglica*, Woods. Lower Greensand (Crackers), Atherfield. Sedgwick Museum. Left valves. (P. 137.)



CRETACEOUS LAMELLIBRANCHIA.





PLATE XXI.

CYPRINA (*continued*).

FIGS.

1. *C. anglica*, Woods. Lower Greensand (Crackers), Atherfield. Sedgwick Museum. *a*, right valve; *b*, dorsal view. (P. 137).
2. *C. claxbiensis*, Woods. Claxby Ironstone, Benniworth Haven. Sedgwick Museum. Left valve. (P. 135.)
3. *C.* sp. Tealby Limestone, Claxby. Sedgwick Museum. Left valve,  $\times \frac{3}{4}$ . (P. 136.)
- 4-7. *C. (Venilicardia) protensa*, Woods. Lower Greensand, Atherfield. See also Text-figures 20, 21. (P. 137.)
  4. *Perna*-bed. Sedgwick Museum. *a*, left valve,  $\times \frac{3}{4}$ ; *b*, dorsal view,  $\times \frac{3}{4}$ .
  5. *Perna*-bed. Museum of Practical Geology, No. 16744. Hinge of left valve.
  6. *Perna*-bed. British Museum, L 432. Hinge of right valve,  $\times \frac{3}{4}$ .
  7. Crackers. British Museum, L 6304. A small specimen. Right valve.
- 8, 9. *C. Sowerbyi*, d'Orb. See also Text-figure 22. (P. 139.)
  8. Hythe Beds, Hythe. Sedgwick Museum. Internal cast of right valve.
  9. Lower Greensand, between Atherfield and Blackgang. York Museum. Left valve.



CRETACEOUS LAMELLIBRANCHIA.





PLATE XXII.

CYPRINA (*continued*).

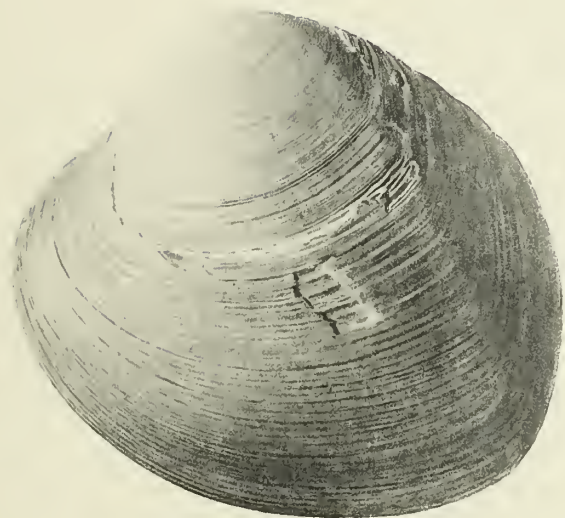
FIGS.

1-4. *C. (Venilicardia) angulata* (Sow.). Upper Greensand, Blackdown. See also Text-figures 23, 24. (P. 141.)

1. Sedgwick Museum. Left valve,  $\times \frac{3}{4}$ .
2. Sedgwick Museum. Hinge of right valve,  $\times \frac{3}{4}$ .
3. York Museum. Hinge of left valve.
4. Museum of the Geological Society. Hinge of right valve of a specimen with the umbones more anterior than usual.  $\times \frac{3}{4}$ .

5-8. *C. (Venilicardia) lineolata* (Sow.). Upper Greensand, Blackdown. Sedgwick Museum. (P. 143.)

- 5 *a*, left valve; 5 *b*, anterior view.
- 6 *a*, right valve; 6 *b*, hinge of the same.
7. Hinge of left valve.
8. Right valve.



1



2



3



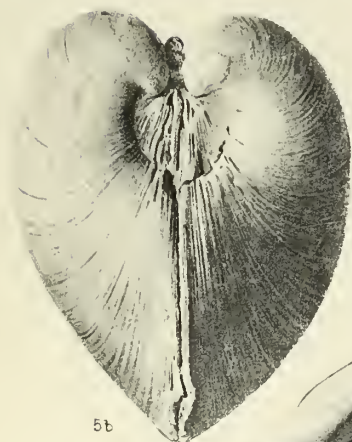
5a



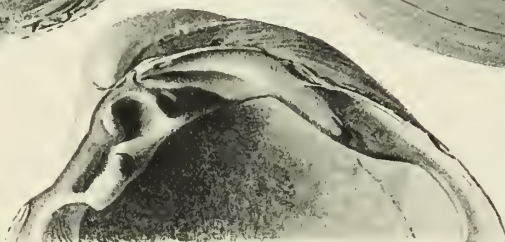
4



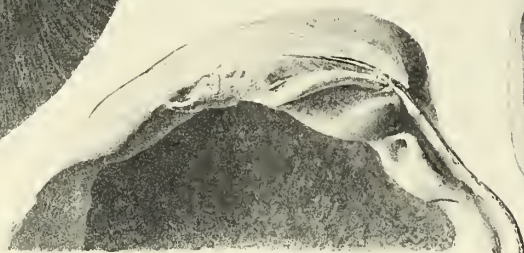
6a



5b



6b



7



8

CRETACEOUS LAMELLIBRANCHIA





PLATE XXIII.

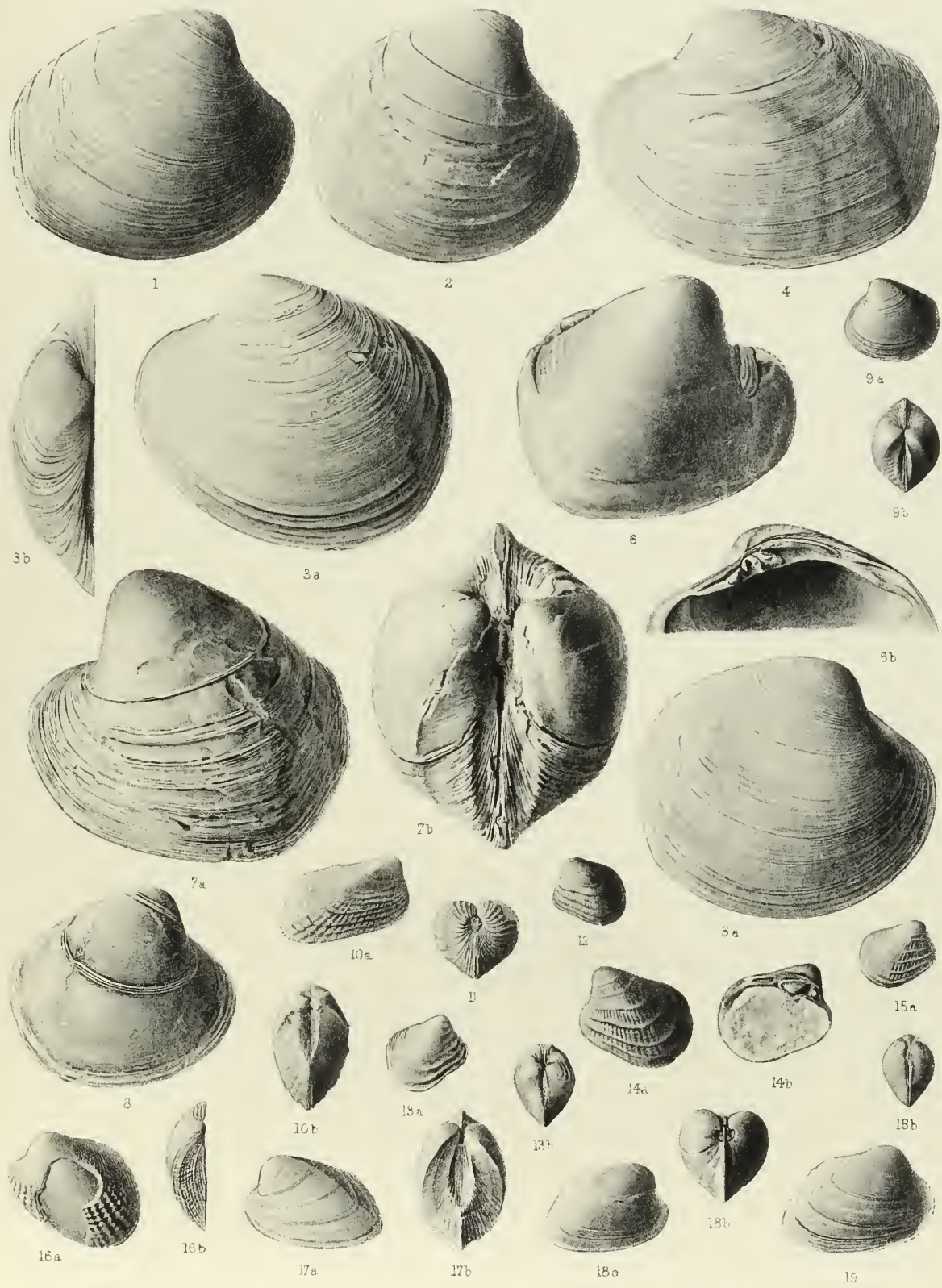
CYPRINA (*continued*).

FIGS.

- 1, 2. *C. (Venilicardia) lineolata* (Sow.). Upper Greensand, Blackdown. Sedgwick Museum. Right valves. 2, a short form. (P. 143.)
3. *C. (Venilicardia) truncata* (Sow.). Upper Greensand, Blackdown. The Type. Bristol Museum. *a*, left valve; *b*, dorsal view of the same. (P. 145.)
4. *C. (Venilicardia) truncata?* (Sow.). Upper Greensand, Blackdown. Exeter Museum. Left valve. Probably an elongate variety of *C. truncata*. (P. 145.)
5. *C. (Venilicardia) truncata?* (Sow.). Upper Greensand, Blackdown. Sedgwick Museum. *a*, right valve; *b*, hinge. Probably a short variety of *C. truncata*. (P. 145.)
- 6-9. *C. quadrata*, d'Orb. Gault, Folkestone, except fig. 6. (P. 146.)
6. Upper Greensand, Warminster. Sedgwick Museum. Internal cast. Right valve.
7. Sedgwick Museum. *a*, left valve; *b*, dorsal view.
8. British Museum, L 9183. Right valve, decorticated.
9. Sedgwick Museum. *a*, left valve; *b*, dorsal view.

Genus—TRAPEZIUM, *v. Mühlfeldt*.

- 10, 11. *T. ? arcadiforme* (Keep.). Lower Greensand, Upware. (P. 148.)
10. The Type. Sedgwick Museum. *a*, right valve; *b*, dorsal view.
11. Mr. Walker's Collection. Anterior view.
- 12-15. *T. ? squamosum* (Keep.). Lower Greensand, Upware. Sedgwick Museum, except fig. 14. (P. 148.)
12. Left valve.
- 13 *a*, right valve; *b*, dorsal view.
14. Mr. Walker's Collection. *a*, left valve,  $\times 1\frac{1}{2}$ ; *b*, interior of same,  $\times 1\frac{1}{2}$ .
- 15 *a*, right valve; *b*, dorsal view.
16. *T. ?* sp. Lower Greensand, Upware. Sedgwick Museum. *a*, left valve; *b*, dorsal view. (P. 149.)
- 17-19. *T. trapezoidale* (Röm.). Chalk Rock, Cuckhamsley. Sedgwick Museum. (P. 149.)
- 17 *a*, left valve; *b*, dorsal view.
- 18 *a*, right valve; *b*, anterior view.
19. Right valve.



CRETACEOUS LAMELLIBRANCHIA.





PLATE XXIV.

FIGS.

1. *Cyprina claxbiensis*, Woods. Claxby Ironstone, Donnington. Sedgwick Museum. Hinge of right valve. (P. 135.)

Genus—LUCINA, *Bruguère*.

- 2, 3. *L.* sp. Spilsby Sandstone. 2, internal cast of right valve, Donnington. Sedgwick Museum. 3, right valve, Holton, Mr. Lamplugh's Collection. (P. 152.)

- 4, 5. *L.* sp. Lower Greensand. (P. 152.)

4. Near Atherfield. Museum of Practical Geology, No. 19719. Internal cast. *a*, right valve; *b*, dorsal view.

5. Sandgate Beds, Parham Park. Museum of the Geological Society, No. 2149. Internal cast of left valve.

6. *L.* sp. Lower Greensand (Ferruginous Sands), Shanklin. Sedgwick Museum, Cambridge. *a*, left valve; *b*, dorsal view. (P. 153.)

- 7-9. *L.* ? *sculpta*, Phill. Gault, Folkestone. (P. 153.)

7. Museum of Practical Geology, No. 19761. Right valve,  $\times 1\frac{1}{2}$ .

8. British Museum, No. L 4990. *a*, part of right valve; *b*, dorsal view of both valves.

9. British Museum, No. L 4990. Left valve.

- 10-14. *L. tenera* (Sow.). Gault, Folkestone. (P. 154.)

10. Sedgwick Museum. *a*, left valve,  $\times 1\frac{1}{2}$ ; *b*, portion near middle of valve,  $\times 8$ .

11. Sedgwick Museum. Right valve,  $\times 1\frac{1}{2}$ .

12. British Museum, No. L 4977. *a*, left valve; *b*, dorsal view; *c*, portion near middle of valve,  $\times 8$ .

13. British Museum, No. L 4977. *a*, left valve,  $\times 1\frac{1}{2}$ ; *b*, anterior view,  $\times 1\frac{1}{2}$ .

14. British Museum, No. L 4977. Right valve,  $\times 1\frac{1}{2}$ .

15. *L. Dornesi*, Woods. Upper Greensand, Blackdown. Museum of Practical Geology, No. 19771. *a*, left valve; *b*, dorsal view; *c*, portion near middle of valve,  $\times 6$ . (P. 155.)

- 16-19. *L. pisum*, Sow. Upper Greensand, Blackdown. Sedgwick Museum, Cambridge. 16-18, right valves; 18 *b*, dorsal view; 19, left valve. All  $\times 3$ . (P. 156.)

Genus—CORBICELLA, *Morris and Lycett*.

- 20-23. *C. claxbiensis*, Woods. Claxby Ironstone, Benniworth Haven. Sedgwick Museum, Cambridge. (P. 157.)

20 *a*, left valve; *b*, dorsal view of the same.

21. Right valve.

22. Hinge of right valve,  $\times 1\frac{1}{2}$ .

23. Left valve.

Genus—SPHÆRA, *Sowerby*.

24. *S. corrugata*, Sow. Lower Greensand (Crackers), Atherfield. Sedgwick Museum. Left valve. See also text-figure 26. (P. 157.)



CRETACEOUS LAMELLIBRANCHIA.





PLATE XXV.

SPIPERA (*continued*).

FIGS.

- 1, 2. *S. corrugata*, Sow. Lower Greensand, Atherfield. (P. 157.)  
1. Crackers, Atherfield. Sedgwick Museum. Right valve.  
2. *Perna*-bed, Atherfield. British Museum, No. 50349. Hinge of right valve,  $\times \frac{3}{4}$ .
3. *S.* sp. Base of Chalk Marl, Chard. Museum of Practical Geology, No. 7899. *a*, right valve; *b*, dorsal view. (P. 159.)

Genus—MUTIELLA, *Stoliczka*.

- 4–6. *M.* ? *canaliculata* (Sow.). Upper Greensand, Blackdown. Sedgwick Museum. (P. 160.)  
4 *a*, left valve; *b*, interior of same; *c*, dorsal view; *d*, portion of anterior part,  $\times 4$ .  
5 *a*, left valve,  $\times 1\frac{1}{2}$ ; *b*, anterior view of same,  $\times 1\frac{1}{2}$ ; *c*, hinge,  $\times 2$ .  
6 *a*, right valve; *b*, anterior view of same; *c*, hinge,  $\times 2$ .

Genus—UNICARDIUM, *d'Orbigny*.

7. *U. clarbiense*, Woods. Claxby Ironstone, Benniworth Haven. Sedgwick Museum. *a*, left valve; *b*, dorsal view of the same. (P. 162.)
- 8–11. *U. rectense*, Woods. Lower Greensand (Crackers), Atherfield. Sedgwick Museum. (P. 163.)  
8 *a*, left valve; *b*, dorsal view; *c*, portion near the mid-ventral margin,  $\times 3$ .  
9. Left valve.  
10. Hinge of right valve,  $\times 1\frac{1}{2}$ .  
11 *a*, right valve; *b*, anterior view.
12. *U.* sp. Upper Greensand, South Devon. Museum of the Geological Society, No. 1580. *a*, right valve; *b*, dorsal view; *c*, portion near the middle of the anterior half,  $\times 8$ . (P. 163.)
- 13, 14. *U. ringmeriense* (Mant.). Base of Chalk Marl. (P. 164.)  
13. Titherleigh. Sedgwick Museum. Left valve.  
14. Chardstock. Museum of Practical Geology, No. 19803. *a*, right valve; *b*, dorsal view.

Genus—THETIRONIA, *Stoliczka*.

15. *T. minor* (Sow.). Lower Greensand (Crackers), Atherfield. Sedgwick Museum. 15 *a*, right valve; *b*, portion near the mid-ventral margin,  $\times 6$ ; *c*, portion near the postero-dorsal margin,  $\times 6$ . (P. 167.)



CRETACEOUS LAMELLIBRANCHIA





PLATE XXVI.

THETIRONIA (*continued*).

FIGS.

- 1-8. *T. minor* (Sow.). Lower Greensand. Sedgwick Museum. 1-5, Crackers, Atherfield. 6, near Atherfield. 7, 8, Ferruginous rock, Shanklin. (P. 167.)
1. Right valve.
  - 2 *a*, right valve; *b*, anterior view.
  3. Right valve.
  - 4 *a*, left valve; *b*, dorsal view.
  5. Left valve.
  6. Internal cast of right valve.
  7. Internal cast. *a*, left valve; *b*, dorsal view.
  8. Internal cast of right valve.
- 9-14. *T. laevigata* (Sow.). Upper Greensand, Blackdown. (P. 169.)
9. Sedgwick Museum. Left valve.
  10. Sedgwick Museum. *a*, right valve; *b*, hinge of left valve of the same specimen,  $\times 1\frac{1}{2}$ .
  11. Museum of Practical Geology, No. 19783. Dorsal view.
  12. Sedgwick Museum. Left valve.
  13. Museum of Practical Geology, No. 19780. *a*, right valve; *b*, portion near the posterior margin,  $\times 6$ .
  14. Sedgwick Museum. Hinge of right valve,  $\times 1\frac{1}{2}$ .
- Genus*—TELLINA, *Linnaeus*.
- 15, 16. *T. Carteroni*, d'Orb. Lower Greensand (Crackers), Atherfield. Sedgwick Museum, Cambridge. (P. 171.)
- 15 *a*, right valve; *b*, portion near the anterior margin,  $\times 3$ ; *c*, portion near the posterior margin,  $\times 3$ .
  - 16 *a*, left valve; *b*, dorsal view of the same; *c*, hinge of the same,  $\times 1\frac{1}{2}$ .
17. *T.* sp. Lower Greensand (Crackers), Atherfield. Sedgwick Museum. Right valve. (P. 172.)
- 18, 19. *T. striatuloides*, Stol. Upper Greensand, Blackdown. (P. 172.)
18. Sedgwick Museum. *a*, left valve; *b*, posterior part,  $\times 3$ .
  19. Sedgwick Museum. Interior of right valve.



CRETACEOUS LAMELLIBRANCHIA.





PLATE XXVII.

TELLINA (*continued*).

Figs.

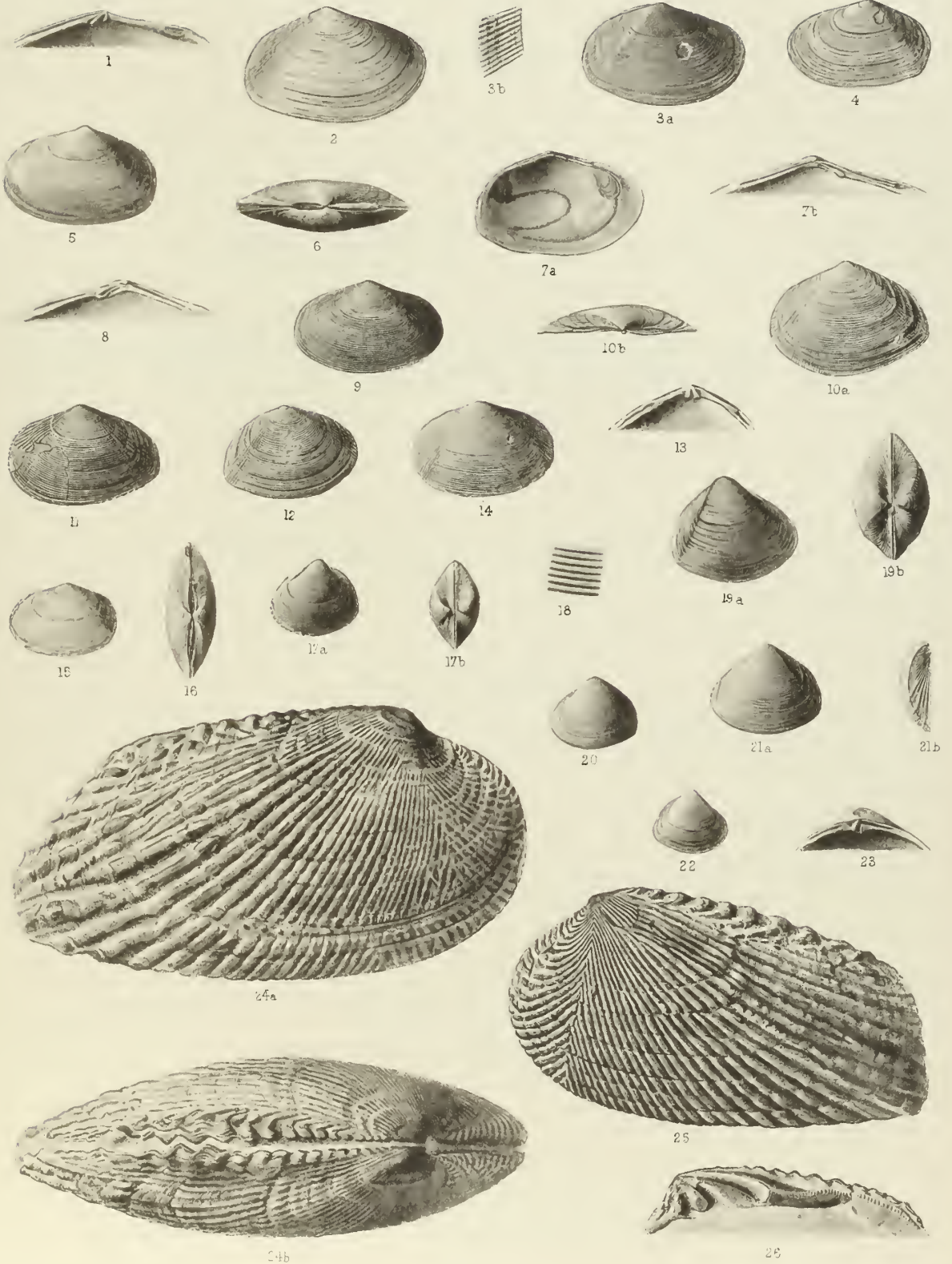
1. *T. striatuloides*, Stol. Upper Greensand, Blackdown. British Museum, No. L 16829. Hinge of right valve,  $\times 2$ . (P. 172.)
- 2-8. *T. (Palæomæra) inæqualis*, Sow. Upper Greensand, Blackdown. Sedgwick Museum, except fig. 8. (P. 173.)
  2. Right valve.
  - 3 *a*, right valve; *b*, part of postero-dorsal area,  $\times 4$ .
  - 4, 5. Left valves.
  6. Dorsal view.
  - 7 *a*, interior of left valve; *b*, hinge of same,  $\times 2$ .
  8. British Museum, No. L 17129. Hinge of right valve,  $\times 2$ .
9. *T. (Linearia)*, sp. Lower Greensand (Crackers), Atherfield. British Museum, No. 48626. Left valve,  $\times 1\frac{1}{2}$ . (P. 175.)
- 10-13. *T. (Linearia) subtenuistriata*, d'Orb. Upper Greensand, Blackdown. (P. 175.)
  10. British Museum, No. L 7129. *a*, left valve,  $\times 1\frac{1}{2}$ ; *b*, dorsal view,  $\times 1\frac{1}{2}$ .
  11. Sedgwick Museum. Left valve,  $\times 1\frac{1}{2}$ .
  12. British Museum, No. L 17129. Right valve,  $\times 1\frac{1}{2}$ .
  13. British Museum, No. L 17129. Hinge of right valve,  $\times 2$ .
- 14-16. *T. (Linearia)*, sp. Upper Greensand, Blackdown. British Museum, No. L 17129. (P. 177.)
  14. Right valve,  $\times 1\frac{1}{2}$ .
  15. Left valve.
  16. Dorsal view,  $\times 1\frac{1}{2}$ .

Genus—*MACTRA*, *Linnaeus*.

- 17, 18. *M.* sp. Lower Greensand (Ferruginous Sands), Shanklin. Sedgwick Museum. 17 *a*, left valve; 17 *b*, dorsal view. 18, portion near the middle of valve,  $\times 6$ . (P. 177.)
- 19-23. *M. angulata*, Sow. Upper Greensand, Blackdown. (P. 177.)
  19. Museum of Practical Geology, No. 20714. *a*, right valve,  $\times 1\frac{1}{2}$ ; *b*, dorsal view,  $\times 1\frac{1}{2}$ .
  20. Sedgwick Museum. Left valve,  $\times 1\frac{1}{2}$ .
  21. Sedgwick Museum. *a*, left valve,  $\times 1\frac{1}{2}$ ; *b*, posterior view of same,  $\times 1\frac{1}{2}$ .
  22. Sedgwick Museum. Right valve.
  23. Museum of Practical Geology, No. 20717. Hinge of left valve,  $\times 3$ .

Genus—*PTYCHOMYA*, *Agassiz*.

- 24-26. *P. Robinaldina* (d'Orb.). Lower Greensand. Sedgwick Museum. (P. 179.)
  24. *Perna*-bed, Atherfield. *a*, right valve; *b*, dorsal view.
  25. *Perna*-bed, Atherfield. Left valve.
  26. Ferruginous Sands, Shanklin. Hinge of right valve.



CRETACEOUS LAMELLIBRANCHIA.



Palæontographical Society, 1907.

A MONOGRAPH

ON THE

BRITISH FOSSIL

ECHINODERMATA

FROM

THE CRETACEOUS FORMATIONS.

VOLUME SECOND.

THE ASTEROIDEA AND OPHIUROIDEA.

BY

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

PART FOURTH.

PAGES 91—132; PLATES XXVII—XXIX.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1907.

PRINTED BY ADLARD AND SON, LONDON AND DORKING.

## FAMILY UNCERTAIN.

*Genus*—ARTHRASTER, *Forbes*, 1848.

Arms stout and long. Radialia, marginalia, and ventro-lateralial form an alternating series of seven very completely articulating similar ossicles, which fit so closely as to leave no conspicuous interstices. Each ossicle consists of an oblong and flattened base with a surmounting ridge. Ventro-lateral plates on actinal surface of disc small and mammiform. Ossicles on abactinal surface of disc hemispheroid with a crenulated edge. All the ossicles possess, as ornament, hemispherical granular prominences.

1. ARTHRASTER DIXONI, *Forbes*. Pl. XVIII, figs. 1 and 1 *a*; Pl. XXIX, figs. 11 and 11 *a*.

ARTHRASTER DIXONI, *Forbes*, 1848. Mem. Geol. Surv. Gt. Brit., vol. ii, p. 467.

— — *Forbes*, 1850. In Dixon's Geology of Sussex, p. 336, pl. xxiii, fig. 1.

— — *Dujardin et Hupé*, 1862. Hist. Nat. Zooph. Échin. (Suites à Buffon), p. 437.

— — *Forbes*, 1878. In Dixon's Geology of Sussex (new ed., Jones), pp. 369 and 370, pl. xxiii, fig. 1.

*Specific Characters*.—Dorsal ridge of all of the arm ossicles well rounded. No spines present except on the adambulacral plates.

*Material*.—The best example of this very peculiar starfish is preserved in the British Museum of Natural History, Dixon Coll., 47000. The specimen consists of the remains of four arms, only one of which is at all well preserved. It is the type described by Forbes, and is figured in this Monograph on Pl. XVIII. A well-preserved fragment of an arm is also in the possession of Dr. Rowe, of Margate. I have referred two fragmentary specimens presented to the British Museum (E 5023 and E 5024) by Mr. W. McPherson, F.G.S., to this species (*vide infra*).

*Description*.—A section of the arm is similar at all points. It shows seven ossicles, namely, a radial, the pairs of supero- and infero-marginalia, and a pair of ventro-lateralial. These ossicles all alternate in series, and they closely fit the corresponding neighbouring plates in their respective series. The edges of the plates possess articulations which assist in forming this close union. All the plates

are generally similar in appearance. They differ, however, in measurements as detailed below.

Breadth of radialia	.	.	.	.	8.2 mm.
Length „ „	.	.	.	.	3.5 „
Breadth of supero-marginalia	.	.	.	.	6.2 „
Length „ „	.	.	.	.	3.5 „
Breadth of infero-marginalia	.	.	.	.	5.9 „
Length „ „	.	.	.	.	3.5 „
Breadth of ventro-lateralialia	.	.	.	.	4.5 „
Length „ „	.	.	.	.	3.5 „

It will thus be seen that the breadth of the plates diminishes as we proceed ventralwards. The ridges, also, on the plates, become more rounded in the same direction.

The ornament of the plates consists of hemispherical granular prominences of moderate size. They appear to have been especially prominent at the base of the ridge. No spine-pits are present.

The height of the ray is 16.5 mm., and the breadth is about the same. Post-mortem contraction has brought the ventro-lateralialia of opposite sides into close approximation, in some cases totally obliterating the ambulacral groove. Along one or two of the arms some of the adambulacrals are still visible. They are 1.8 mm. broad and 1.2 mm. long. The portion of the plate nearest the ambulacral groove is depressed, giving the plate a two-storied appearance.

A few robust, rhomboidal, smallish ventro-lateralialia are present at the base of the arm. Their breadth is 1.8 mm. They are mammiform. A few similar plates also enter the base of the arm.

The two collections of isolated ossicles presented by Mr. McPherson referred to above are very interesting. Each specimen consists of a single ossicle simulating one of the abactinal bulbiform ossicles of *Pentaceros*, but possessing the distinct *Arthraster* ornament, associated with plates which exactly match the ventro-lateralialia of *A. Dixoni* and other plates which resemble the arm plates of this species except that the surmounting ridge is not so high. There is no doubt that the plates are those of a species of *Arthraster*. I have little hesitation, in spite of their occurrence in the Upper Chalk, in referring the ossicles to *A. Dixoni*, especially as it is a matter of common experience that species of Chalk starfish have a wide stratigraphical range.

*Locality and Stratigraphical Position.*—Forbes' type is from the Lower Chalk, Balcombe, Sussex. The specimen in the possession of Dr. Rowe was collected in the zone of *Terebratulina gracilis* in Devon. The specimens presented to the British Museum by Mr. McPherson are from the *Marsupites* zone, Brighton.

*Remarks.*—Forbes compared the genus *Arthraster* with the modern genus *Ophidiaster*. The larger amount of material known since that time does not allow us to recognise such affinity.

Valette (see above, p. 81) has described certain isolated plates, which are similar in form and size, as belonging to the genus *Arthraster*, and has called the species *A. senonensis*. These plates are smooth and show no trace of the surmounting longitudinal ridge or ornament which is so characteristic of *Arthraster*. Dom Aurélien Valette kindly lent these plates to Dr. Bather in order that I might examine them. I am therefore enabled to state that the plates are those of *Pycinaster angustatus*.

2. ARTHRASTER CRISTATUS, n. sp. Pl. XXIX, figs. 10, 10 *a*, 10 *b*.

*Specific Characters.*—Ridges of the radialia and supero-marginalia cristate. Upper surface of the ridge of all arm-ossicles possessing lipped pits formerly occupied by small spines.

*Material.*—The specimen figured on Pl. XXIX was restored by Dr. Blackmore, of Salisbury, from a number of isolated ossicles in his collection which were found in a single mass of chalk. These ossicles are the only material known of the species.

*Description.*—The dimensions of the ossicles are as follow :

Breadth of radialia . . . . .	5·4 mm.
Length „ „ . . . . .	3·2 „
Breadth of supero-marginalia . . . . .	4·8 „
Length „ „ . . . . .	3·2 „
Breadth of infero-marginalia . . . . .	4·2 „
Length „ „ . . . . .	3·2 „
Breadth of ventro-lateralia . . . . .	3·8 „
Length „ „ . . . . .	3·2 „

Just as in *A. Dixoni* the breadth of the plates diminishes ventralwards, and the ridges on the plates become more rounded in the same direction. The cristate ridges of the more dorsal plates are, however, very characteristic of the species, as are also the lipped pits on the summit of the ridges. The pits were formerly occupied by small spines. The base of the ridges of the plates possesses the granular hemispherical prominences, such as are also met with in *A. Dixoni* and characterise the genus.

*Locality and Stratigraphical Position.*—Micheldever, Hants. Zone of *Micraster cor-anguinum*.

ADDENDUM (to *Phanerozouate Asteroids*).

Further investigation, as a result of the privilege of investigating the fine collection of Chalk Asteroids in the possession of Dr. Blackmore, of Salisbury, has enabled me to describe several new species belonging to genera which have been dealt with in previous pages. Some of these species had been recognised but not described by Dr. Blackmore, to whom I am indebted for very many valuable suggestions.

*Family*—PENTAGONASTERIDÆ, *Perrier*, 1884. (See p. 3.)

*Genus*—NYMPHASTER, *Sladen*, 1885. (See p. 14.)

5. NYMPHASTER RUGOSUS, n. sp. Pl. XXIX, figs. 7, 7 a.

*Specific Characters*.—All marginalia covered with granular prominences, which are closely crowded, and in no case arranged in a linear series. No spine-pits on the marginalia. Margin of disc lunate.

*Material*.—Two specimens are known of this species. They are preserved in the British Museum (Nat. Hist.), and bear the registered numbers 57516 (purchased of W. Griffiths) and 76002 (Capron Coll.). Both specimens are imperfect. The first-named specimen is figured Pl. XXIX, fig. 7, and is taken as the type.

*Description*.—The two specimens show the disc to have been small. The minor radius in the specimen 57516 measures about 11 mm. The arms are broken off short in both specimens, and therefore it is not possible to give the major radius.

There are about eight infero-marginalia in each interbrachial arc. These are all approximately equal in size, being 2·7 mm. long and 1·8 mm. broad. In shape they are oblong.

The margin of the disc is lunate. It is this character and the character of the granular prominences which distinguish the species from *N. radiatus*.

*Locality and Stratigraphical Position*.—Lower Chalk, Dover and Folkestone.

*Genus*—PYCINASTER,<sup>1</sup> nom. nov.

PYCINASTER, *Sladen*, 1891 (see p. 21), non *Pomel*, 1883. Classif. méthod. Echin., p. 42.

1. PYCINASTER ANGUSTATUS, *Sladen* sp. (see p. 21). Pl. IX, figs. 1 *a*, 1 *b*; Pl. XXI, figs. 2, 2 *a*; Pl. XXV, fig. 7; Pl. XXVI, figs. 4, 4 *a*, 4 *b*.

This species appears to be quite common in the Upper Chalk. An exceedingly well-preserved specimen is in the collection of Dr. Blackmore, of Salisbury.

The following specimens, which belong to the genus *Pycinaster*, and probably to this species, have been erroneously ascribed by me to other genera and species in Part III of this volume (pp. 67–90).

The single specimen described on p. 73 as a new species, *Pentagonaster robustus*, is probably an immature form of this species. A collection of five ossicles described (p. 89) as *Pentaceros*, sp., and the specimen figured on Pl. XXVI as *Calliderma mosaicum*, also belong to the species. The latter specimen should be described as from the Upper Chalk.

Dom Aurélien Valette has courteously enabled me to examine the syn-types of his *Arthraster senonensis* ('Bull. Soc. Sci. Yonne,' 1902, p. 23). They prove to be marginals of *Pycinaster angustatus*. Four ossicles referred by him to his *Pentaceros senonensis* (*vide infra*) also belong to the present species.

2. PYCINASTER SENONENSIS, *Valette*, sp. Pl. XXVI, figs. 1, 1 *a*, 1 *b*; Pl. XXIX, figs. 6, 6 *a*.

PENTACEROS SENONENSIS, *Valette*, 1902. Bull. Soc. Sci. Yonne, vol. lvi, pp. 17, 18, figs. 1, 2 (non 3–7).

— PUNCTATUS, *Spencer*, 1905. Antea, p. 88.

Dr. Blackmore's material enables me definitely to ascribe this species to *Pycinaster*, and to add the following new diagnosis and details:

*Specific Characters*.—Body of large size. Breadth of marginalia more than twice their thickness. All marginalia smooth or with very shallow hexagonal spine-pits.

*Description*.—The marginalia may be as much as 20 mm. high. They appear to be distinguished from the marginalia of *P. angustatus*, not only by their

<sup>1</sup> Πυκνός, compact, Homeric form of πυκρός. Dom Aurélien Valette kindly pointed out the prior use of *Pycinaster* to Dr. F. A. Bather, who suggests the above emendation.

magnitude, but also by the manner in which the upper surface is turned over so as to make the ossicle **ƒ**-shaped (compare Text-fig. 23, p. 119).

Associated with these marginalia are found rounded, smooth ossicles, which are correspondingly large, being as much as 12 mm. in diameter, and which are undoubtedly ossicles from the abactinal surface of the disc. Their size and form (see Pl. XXIX, fig. 6) render them liable to be mistaken for ossicles of *Stauranderaster* (see p. 125). They do not, however, possess spine-pits, and species of *Stauranderaster* which do not possess spine-pits are very distinct, having nodular abactinal ossicles of a very characteristic appearance (compare *S. coronatus*, Pl. XXIV, fig. 2). There appears therefore to be no doubt that these ossicles should be referred to the genus *Pycinaster*, and probably to *P. punctatus*. The base of the abactinal ossicles of *P. angustatus* is produced, as also in *P. crassus* (Pl. XXIX, fig. 4*a*), and quite different from the flattened base of these ossicles.

*Remarks.*—It might be urged that the differences which separate these ossicles from those ascribed to *P. angustatus*, are not sufficient warrant for a new species. I regard the differences, however, given above as important, and though several well-preserved specimens of *P. angustatus* are known, none approaches the large size which *P. punctatus* must have attained. On p. 81, *Pentaceros senonensis*, Valette, was regarded as probably identical with *P. Boysii*. Examination of the original specimens, which I owe to the courtesy of Dom Aurélien, shows that they belong to four different species: *Stauranderaster coronatus*, *S. argus*, *Pycinaster angustatus*, and my "*Pentaceros punctatus*." The last species is represented by two dorsal ossicles from Les Clérimois (figs. 1 and 2). With the concurrence of Dom Aurélien, I therefore take the original of his fig. 1 as type.

*Locality and Stratigraphical Position.*—The specimens in the possession of Dr. Blackmore are from East Harnham, Wilts., zone of *Actinocamax quadratus*.

### 3. PYCINASTER CRASSUS, n. sp. Pl. XXIX, figs. 1, 2, 2*a*, 3, 3*a*, 4, 4*a*, 5.

*Specific Characters.*—Body of large size. Height of marginalia not twice their thickness. Median marginalia smooth. More distal marginalia with prominent mammilations.

*Material.*—There are about eight fragmentary specimens of this species in the British Museum (Nat. Hist.). The specimen registered E. 2576 (Mantell Coll.) shows considerable portions of the actinal surface, and that registered 35498 (Taylor Coll.) the dorsal view of a well-preserved portion of one arm. Both these are figured on Pl. XXIX. Another specimen, registered E. 2628 (Mantell Coll.), shows a portion of the abactinal surface of the disc. The other specimens are

mostly collections of isolated plates. The specimen registered 35498 is taken as the type.

*Description.*—The abactinal surface of the disc appears to have been covered with a number of plates of generally uniform size, with an average diameter of about 3·8 mm. A few plates exceed this size, but in no case are they as large as the corresponding plates in *P. punctatus*.

No specimen is sufficiently well preserved to give the proportionate lengths of the major and minor radii, but there is no doubt that the arms were considerably produced. A row of hexagonal tabulate radialia are present throughout the greater portion of the arm. The breadth of the arm at the base in the specimen registered E. 2576 is about 22 mm. This specimen, however, judging by the dimensions of the marginal plates, does not by any means appear to have attained the usual size of the species. The length of its minor radius is 18·5 mm.

The median supero-marginalia are quite smooth and are distinguished from those of all other species of the genus by their thickness (Text-fig. 24 *a*). In full-grown specimens they appear to be 18 mm. in breadth, 6 mm. in length, and 10 mm. in thickness. More distally the supero-marginalia acquire large mammillate rugosities.

The infero-marginalia are similar in character to the superior series.

Two rows of ventro-lateralialia enter the base of the arm. Most of the ventro-lateralialia appear to have been rhomboidal in shape and of uniform size. They possess very shallow hexagonal fittings indicating the former possession of granules.

*Locality and Stratigraphical Position.*—Upper Chalk, Kent.

*Genus*—METOPASTER, *Sladen*. (See p. 30.)

9. METOPASTER QUADRATUS, n. sp. Text-figs. 1, 2, p. 98.

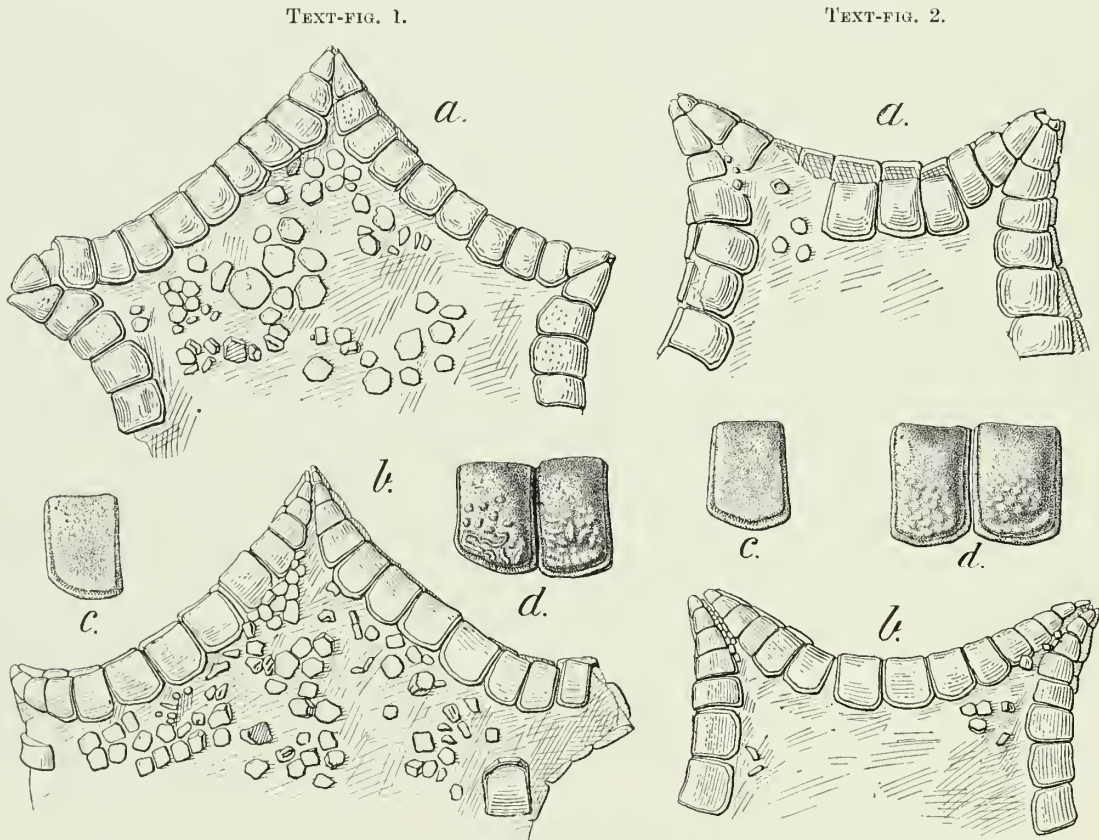
*Specific Characters.*—Marginal plates in interbrachial areas almost square. Raised area on marginal plates without spine-pits. Supero-marginal plates rugose on interior surface. Ultimate supero-marginal plates may or may not be the largest of the series, variation in this respect being especially marked. Abactinal plates of disc with distinct stellate marking.

*Material.*—There are three fairly perfect and four fragmentary specimens of this species in the collection of Dr. Blackmore, of Salisbury. Two of these are figured in Text-figs. 1, 2. The species was discovered by Dr. Blackmore, who suggested the specific name "*quadratus*" on account of the characteristic shape

of the majority of the marginal plates. The type is the specimen figured in Text-fig. 2.

*Description.*—The abactinal area of the disc is covered with hexagonal plates, which have a distinctly stellate appearance on their upper surface.

The arms are distinctly produced. In the specimen figured in Text-fig. 1,  $R : r :: 41 \text{ mm.} : 28 \text{ mm.}$  In the specimen figured in Text-fig. 2,  $R : r :: 41 \text{ mm.} :$



TEXT-FIG. 1.—*a*, Abactinal view of a specimen of *M. quadratus*, nat. size; *b*, actinal view of the same specimen; *c*, view of infero-marginal plate magnified two diameters; *d*, view of two supero-marginal plates magnified two diameters.

TEXT-FIG. 2.—*a*, Abactinal view of another specimen of *M. quadratus*, nat. size; *b*, actinal view of the same specimen; *c*, view of infero-marginal plate magnified two diameters; *d*, view of two supero-marginal plates magnified two diameters.

30 mm. The length of the side in the first-named specimen is 51 mm., in the second-named specimen 56 mm.

The supero-marginalia are either five or six in number, counting from the median inter-radial line to the extremity of the arm. In the inter-brachial area they are distinctly quadrate in character, and are from 7 to 8 mm. in width and from 6 to 7 mm. long.

The terminal paired supero-marginalia present very curious features. In the specimen figured in Text-fig. 1 some of these plates are large and tri-

angular, just as in a typical *Metopaster*. Other terminal plates are, however, small and approximate to those characteristic generally of *Asteroidea*. The specimen figured in Text-fig. 2 presents no terminal plate which has a resemblance to those typical of *Metopaster*. In all other respects the specimens are almost exactly similar to one another.

The infero-marginalia are smooth and slightly concave in the centre. They are eight in number.

The actinal area of the disc is covered with sub-equal plates, which are four-sided in the inter-radial regions and tend to become hexagonal radially.

*Locality and Stratigraphical Position.*—Zone of *Actinocamax quadratus*, East Harnham, Salisbury.

*Remarks.*—The ornament of this species is identical with that of *M. uncatus*. The important differences between the species lie in the shape of the marginal plates, the character of the terminal supero-marginalia which show their especial peculiarities in all the specimens, and the ornament of the abactinal plates of the disc.

*Family*—PENTACEROTIDÆ (*Gray*), *emend. Perrier*, 1884. (See p. 76.)

*Genus*—STAURANDERASTER, novum. (See p. 125.)

12. S. ARGUS, n. sp. Pl. XXV, figs. 6, 6 *a*; Pl. XXIX, figs. 8, 8 *a*, 9, 9 *a*.

*Specific Characters.*—Ossicles ocellato-punctate. Surface of ossicles very rarely truncate. If truncate, the flattened surface is not striated so as to simulate the asteroid madreporite.

*Material.*—Only very fragmentary specimens of this species are known. The best preserved specimen is in the collection of Dr. Blackmore, of Salisbury, and is figured on Pl. XXIX. Dr. Blackmore also possesses other specimens belonging to this species. Two specimens of the species are also preserved in the British Museum (Nat. Hist.), and bear the registered numbers E. 5019 and E. 2566 respectively. The first-named specimen was presented by Mr. W. McPherson. The second specimen was originally figured by Forbes in Dixon's 'Geology of Sussex,' pl. xxi, fig. 16, as a "fragment of an *Oreaster*." In Part III of this Monograph it was figured under my direction (Pl. XXV, figs. 6, 6 *a*) as Genus (?), Sp. (?). I have now isolated two or three ossicles from the specimen, and they are figured on Pl. XXIX, fig. 9. They show that the ossicles as originally figured merely present their interior aspect. The specimen E. 5019 is taken as the type.

*Description.*—The state of preservation of the fragmentary specimens of this species only allows adequate description of the ossicles of the disc. These are very uniform in character, and only differ from those of *Stauranderaster ocellatus* in the absence of the truncated summit with madreporiform striations. The largest ossicle measures about 6 mm. in diameter.

The isolated ossicles figured on Pl. XXIX show the characteristic shape of marginal ossicles belonging to the genus *Stauranderaster* (see p. 120), and assist us in ascribing not only this species, but also *S. ocellatus*, to which the species is closely allied, to that genus.

*Locality and Stratigraphical Position.*—The specimen presented to the British Museum (Nat. Hist.) by Mr. W. McPherson, is from the *Marsupites* zone at Brighton. The specimens in the collection of Dr. Blackmore are from Micheldever, Hants (zone of *Micraster cor-anguinum*).

*Order*—CRYPTOZONIA, *Sladen*, 1886.

*Family*—LINCKIIDÆ, *Perrier*, 1875.

Cryptozonate Asteroidea, with comparatively well-developed marginal plates, always contingent. Disc small, rays long and cylindrical. Abactinal skeleton tessellate. Tegumentary developments granulate, superambulacral plates usually present. Pedicellariæ (rarely present) excavate or foraminate.

*Genus*—LINCKIA, *Nardo*, 1834.

LINCKIA, *Nardo*, 1834. De Asteriis, Oken's Isis, p. 717.

OPHIDIASTER (pars), *Müller and Troschel*, 1890. Monatsber k. preuss. Akad. Wiss. Berlin, p. 103.

LINCKIA, *Gray*, 1841. Ann. Mag. Nat. Hist., vol. vi, p. 284.

ACALIA (sub. gen.), *Gray*, 1841. Tom. cit., p. 285.

Arms more or less cylindrical. Dorsal plates small, not arranged regularly in longitudinal series. Two or three rows of granules on the adambulacral plates. Superambulacral plates present. Papular areas distributed irregularly between the dorsal plates.

1. LINCKIA, ? sp. Pl. XXVII, figs. 1, 1 a.

*Material.*—A distorted specimen, which very probably belongs to the genus *Linckia*, is preserved in the British Museum (Nat. Hist.) (E. 5055, Capron Coll.).

*Description.*—The disc is small and very much distorted. The ventral aspect of one arm is the only portion of the star-fish which affords much opportunity for description. The arm is about 18 mm. long and 4 mm. broad, and possesses the cylindrical characteristic shape of the genus. It is composed of a large number of square ossicles, which are superposed in the cross-section of the arm, so far as it can be seen. They possess no spines, but a regular granulation appears to run lineally across their breadth.

*Remarks.*—This specimen is not sufficiently well preserved to ascribe it to a definite species of the genus.

*Stratigraphical Position.*—Lower Chalk.

## CRETACEOUS OPHIUROIDEA.

*Order*—ZYGOPHIURÆ, *Bell* (1892).

Ophiuroidea, in which the movement of the ossicles on one another is limited by the development of lateral processes and pits. Superior, inferior, and lateral spine-bearing arm-plates are always present. The arms are simple and cannot coil round straight rods.

*Family*—OPHIOLEPIDIDÆ.

Zygophiuræ with oral papillæ from three to six, of which the last may be infradental. Arm incisures on the disc. Dental papillæ absent.

*Genus*—OPHIURA, *Lamarck*, 1801.

- OPHIURA, *Lamarck*. *Histoire Naturelle des Animaux sans Vertebres*, vol. ii.  
 OPHIOLEPIS, *Müller and Troschel*, 1842. *System der Asteriden* (Braunschweig).  
 OPHIOGLYPHA, *Lyman*, 1865. (Ophiuridæ and Astrophytidæ) *Ill. Cat. Mus. Comp. Zool. Harvard*, Nos. i, viii; 1882, *Rep. Challenger Zool.*, vol. v.  
 — *Verrill*, 1899. *Report on the Ophiuroidea collected by the Bahama Expedition in 1893*; Iowa City, *Bull. Labor. Nat. Hist.*, p. 4.

Disc covered with plates or scales which are for the most part swollen. Radial shields naked and swollen. Teeth. The inner mouth-papillæ long but

becoming smaller and shorter towards the distal oral region, where they are almost hidden by the scales of the mouth-tentacles. Arm-spines smooth and short, seldom longer than an arm-segment. Tentacle-scales numerous. The innermost pair of tentacle-pores narrow, surrounded by numerous tentacle-scales, and opening obliquely into the oral slits. In the back of the disc, where the arm joins it, a notch usually edged with papillæ. Two genital slits arise from the sides of the mouth-shields.

The following species are placed provisionally in this genus, to which the known characters would approximate them. The evidence, however, in every case is incomplete.

1. *OPHIURA SERRATA*, *Roemer*. Pl. XXVII, figs. 3, 3 *a*, 3 *b*, 3 *c*, 3 *d*, 3 *e*.

- OPHIURA SERRATA*, *Roemer*, *F. A.*, 1841. Die Versteinerungen norddeutsch. Kreidegeb., p. 28, pl. vi, fig. 23.  
 — — *Forbes*, 1843. Proc. Geol. Soc., vol. iv, p. 234, fig. 2.  
 — — *Reuss*, 1845-6. Die Verstein. böhm. Kreideform., vol. ii, p. 58, pl. xx, fig. 26.  
 — — *Forbes*, 1850. In Dixon's Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex, p. 337, pl. xxiii, figs. 2, 3, 3 *a*, 3 *b*.  
 — — *Morris*, 1854. Cat. Brit. Foss., ed. 2, p. 84.  
 — — *Forbes*, 1878. In Dixon's Geology of Sussex (new edition, Jones), p. 369, pl. xxiii, figs. 2, 3, 3 *a*, 3 *b*.

*Specific Characters*.—Conspicuous pear-shaped radials. Remainder of dorsal surface of disc covered with scales. Upper arm-plates occupying great proportionate width of arm. Six, occasionally seven?, spines on each side of arm-segment.

*Material*.—Only two fragments of arms were originally available for description by Roemer. The specimens described by Forbes were more nearly complete, one specimen showing a considerable portion of the disc and the proximal portion of four arms (figured on Pl. XXVII of this Monograph), now in the British Museum (Nat. Hist.), and bearing the registered number E. 5043 (Dixon Coll.). There are fragments of arms in several collections which can apparently be ascribed to this species.

*Description*.—The disc is 15 mm. in diameter. Almost the whole of the dorsal covering has disappeared in the specimen figured, thus exposing the inner surface of the mouth-plates. The jaws (oral angle plates) are clearly seen. They are long and slender and do not meet inter-radially. The grooves for the water

vascular canal and for the nerve-ring; and the depressions for the first mouth-tentacle and the entrance to the branch of the water vascular system are clearly shown. Fragments of the scaly covering of the disc are seen scattered over the disc. The peristomial plates are not recognisable, as is also the case in modern species of *Ophiura*. The arms are 3 mm. wide at the base. The upper arm-plates near the disc are broad. Six (or seven?) spines, which are in length about a third of the length of the arm-segment, are present.

The vertebral ossicles are figured on Pl. XXVII, figs. 3 *c*, 3 *d*, 3 *e*. They show the typical Ophiurid structure as displayed by modern species of Zygophiurids.

*Locality and Stratigraphical Position.*—Upper Chalk, Bromley, Kent.

2. OPHIURA FITCHII, n. sp., *ex Forbes*, MS. Pl. XXVII, figs. 2, 2 *a*, 2 *b*.

*Specific Characters.*—Body large and stoutly built. Disc covered with large swollen plates. Radials contiguous, large, kidney-shaped. Upper and lower arm-plates small.

*Material.*—An external cast in flint, the sole remains of this species, is preserved in the Norwich Museum (No. 2294).

*Description.*—Very little can be made out concerning the structure of this ophiurid. The disc appears to have been surrounded with a circlet of large radials. It has a diameter of about 16 mm.

A plasticine mould of the lower portion of the cast is figured on Pl. XXVII, fig. 2 *a*. The jaws (oral angle plates) are distinctly seen. They were long and slender, and similar in form to those of *O. serrata*. Similarly a peristomial plate is not visible. The inter-radial rounded buccal shield is clearly seen. The arm is 4.5 mm. broad at the base. The impression of the cast of the arm appears to indicate that both upper and lower arm-plates were small, as the side arm-plates appear to meet in the dorsal and ventral median lines.

*Locality and Stratigraphical Position.*—From flint gravel, Mousehold, Norwich.

3. OPHIURA PARVISENTUM, n. sp. Pl. XXVII, figs. 4, 4 *a*.

*Specific Characters.*—Disc covered with small plates, radials inconspicuous. Proximal upper arm-plates only occupying about one third of dorsal surface of arm. Five spines on each side of arm-segment.

*Material.*—There is only one specimen of this species. This is preserved in the British Museum (Nat. Hist.), and bears the registered number E. 5052 (purchased of Simmons).

*Description.*—The disc is about 15 mm. in diameter. It is covered with a large number of small plates, which are rather scattered. The arms are 3 mm. broad at the base. The upper arm-plate is much narrower than in *O. serrata*. There are five spines, about three quarters the length of an arm-segment, on each side of the arm.

*Locality and Stratigraphical Position.*—Upper Chalk, Bromley, Kent.

*Genus*—OPHIOTITANOS,<sup>1</sup> novum.

Disc covered with plates which are small and sub-equal. Radial shields small, triangular, naked, scarcely swollen. Arm-spines small. Mouth-shields large. Side mouth-shields small, widely separated.

1. OPHIOTITANOS TENUIS, n. sp. Pl. XXVIII, figs. 1, 1 a, 2, 2 a.

Proximal upper arm-plates longer than broad. Spines very short, five in number. Disc, with the exception of the radial plates, covered with an extensive granulation.

*Material.*—The material for the description of this species consists of several specimens in the British Museum (Nat. Hist.), The specimen E. 5056, which is the type, is figured on Pl. XXVIII, fig. 1, and the specimen E. 5057 on Pl. XXVIII, fig. 2. There are also specimens registered E. 5058, E. 5059, 57512. All are in a fair state of preservation. The first four specimens are from the Capron Coll., and the latter specimen was purchased from W. Griffiths. There are further examples of the species in the Sedgwick Museum, Cambridge.

*Description.*—The disc is flat on the dorsal surface, and its diameter in the largest specimen is 4.7 mm. Each pair of radial shields is separated by three ornamented plates.

The mouth-shields are almost oval in shape. The side mouth-shields are small, and lie widely separated on the outer edges of the mouth-shields. There

<sup>1</sup> *Tirareg* = chalk.

is a large number of granules in the oral region, but the tips of the jaws (oral angle plates) can be seen just above the mouth-shields. There appear to be five (or six) squarish mouth-papillæ.

The first under arm-plate is small and with rounded edges. Distally the under arm-plates are at first almost square, then roughly pentagonal, and finally triangular, with the apex pointing towards the disc. The side arm-plates meet below at about the seventeenth arm-plate. The upper arm-plates are at first hexagonal, but rapidly become roughly triangular. They are tumid in appearance and have a rounded base. They rapidly become smaller, and allow the arm-plates to meet dorsally.

There are on each arm-segment five small smooth spines considerably shorter than the length of a segment.

There appear to be two tentacle-scales, but the exact number is rather difficult to determine.

*Locality and Stratigraphical Position.*—Lower Chalk, Folkestone and Dover.

2. OPHIOTITANOS LÆVIS, n. sp. Pl. XXVIII, figs. 3, 3 a, 4, 4 a.

*Specific Characters.*—Spines longer than arm-segments. Upper arm-plates broader than long. Plates of dorsal surface of disc not hidden by granules.

*Material.*—Only one specimen is known. This is preserved in the British Museum (Nat. Hist.), no. E. 5053 (purchased of Mr. Griffiths), and shows the dorsal aspect.

*Description.*—The diameter of the disc is 4.8 mm., being thus about the same size as *Ophiotitanos tenuis*. The arm is, however, not so broad at the base, measuring here only 1.5 mm. across. The specific characters given above separate it sharply from this last-named species. I have not been able to determine the number of spines on each arm-segment.

*Locality and Stratigraphical Position.*—Lower Chalk, Dover.

*Remarks.*—A small specimen upon the slab, no. E. 5058 (Pl. XXVIII, figs. 4, 4 a), may be a young member of this species, as it possesses a strong general resemblance to the above. It is peculiar in having only four arms, probably an abnormality. As explained on p. 111, *Ophioglypha bridgerensis*, Meek, is very similar in appearance to this species.

3. *OPHIOTITANOS MAGNUS*, n. sp. Pl. XXVIII, figs. 5, 5 a; Pl. XXIX, fig. 13.

*Specific Characters.*—Proximal upper arm-plates broader than long. Spines very short, seven spines on each arm-segment. Disc, with the exception of the radial plates, covered with an extensive granulation.

*Material.*—There are several specimens belonging to this species in the British Museum (Nat. Hist.) and in the Sedgwick Museum at Cambridge. The specimens in the British Museum bear the registered numbers E. 5060 (Capron Coll.), E. 5050, E. 370, and E. 371 (all from J. Starkie Gardner Coll.). The first-named specimen, which shows the ventral aspect, is figured on Pl. XXVIII as the type. A specimen from the Sedgwick Museum showing the dorsal aspect is figured on Pl. XXIX.

*Description.*—This species is the largest of all the known Chalk Ophiuroids, the diameter of the disc being about 37 mm., and the breadth of the arm at the base 5 mm. There appear to have been two tentacle-scales.

*Remarks.*—Portions of the arm of this species are very similar in form to those of *Ophiura serrata*. Unless the disc is present it is difficult to separate this species from that form.

*Locality and Stratigraphical Position.*—Lower Chalk.

#### *Sub-order*—NECTOPHIURÆ.

Spines situated at an angle to the arm.

#### *Family*—AMPHIURIDÆ, *Ljungman*, 1867.

Zygophiuræ with oral papillæ from one to five, of which the last is generally infradental. Arms inserted on ventral side of disc. Dental papillæ absent.

#### *Genus*—AMPHIURA, *Forbes*, 1842.

Disc small, delicate, covered with naked overlapping scales, and furnished with uncovered radial shields. Teeth. Mouth-angles small and narrow. Arms long, slender, even, and more or less flattened. Arm-spines short and regular.

1. *AMPHIURA CRETACEA*, n. sp. Pl. XXVIII, figs. 6, 6 a.

*Specific Characters.*—Five (or six) mouth-papillæ. Two tentacle-scales. Five arm-spines. Mouth-shields triangular in shape with a curved convex base, a fair proportion of the jaws (oral angle plates) showing on the ventral surface.

*Material.*—The one specimen known of this species is preserved in the British Museum (Nat. Hist.), no. E. 5059 (Capron Coll.).

*Description.*—The disc is 3 mm. in diameter.

There are five (or six) moderately stout blunt mouth-papillæ on either side of the mouth-angle, and a triangular papilla situated infradentally. The side mouth-shields are long and narrow, with proximal and distal sides parallel. They meet in the middle. The extremities of the jaws are very obvious above these.

The arms are long and slender, and are 2 mm. broad at base. The width of arm close to disc is 1.6 mm. The first under arm-plate is small, with slight re-entering sides and a prominent median groove. The remaining under arm-plates have a pointed proximal apex, and their sides are re-enteringly curved. The distal side is convex. The side arm-plates meet proximally on the under surface in the middle line.

The five stout tapering spines are rather longer than a joint of the arm, and are situated on a proximal ridge.

*Locality and Stratigraphical Position.*—Lower Chalk, Folkestone.

## CRETACEOUS ASTEROIDEA AND OPHIUROIDEA FROM EXTRA-BRITISH LOCALITIES.

The following are the principal species from extra-British localities which have not been mentioned in the previous portions of the Monograph. It will be seen that where accurate information is available, these species are almost entirely identical with British species.

*ASTERIAS QUINQUELOBA*, *Goldfuss*, 1826. 'Petrefacta Germaniæ,' p. 209, pl. lxiii, figs. 5 a—u.

The illustrations given of this species are very beautiful and accurate, and enable one to identify the ossicles ascribed to it as a mixture of ossicles of

*Metopaster Parkinsoni* (*a—p*), *Stauranderaster ocellatus* (*q—r*), and *Pentagonaster megaloplax* (*s—u*).

Various German writers have utilised the description of Goldfuss and this specific name for the identification of isolated ossicles—*e. g.* in Roemer, 1841, 'Die Verstein. norddeutsch. Kreidegeb.,' pl. vi, fig. 20, the ossicles ascribed to *A. quinqueloba* are really ossicles of *P. megaloplax*; while in Reuss, 1845—6, 'Verstein. böhm. Kreideform.,' p. 58, pl. xliii, figs. 15—20, and in Geinitz, 1872—5, 'Palæontographica,' vol. xx, pt. 2, pl. vi, fig. 7, the ossicles ascribed to *A. quinqueloba* are really ossicles of *M. Parkinsoni*.

Since the name *quinqueloba* is prior to all the other names mentioned above, it must be used instead of one of them. The simplest course appears to be to limit it in the sense of Roemer, by fixing on the specimen represented in Goldfuss's plate lxiii, fig. 5 *t, u*, as type of *Asterias quinqueloba*. The result of this is to replace the name *Pentagonaster megaloplax*, Sladen (antea p. 27, Pl. IV, figs. 2—4, Pl. XIII, figs. 1 *a, 1 b*), by *Pentagonaster quinqueloba* (Goldfuss).

ASTERIAS JURENSIS, Münster, 1826. In Goldfuss, 'Petrefacta Germaniæ,' p. 210, pl. lxiii, figs. 6 *a—h*.

Figs. 6 *a—e* represent a fragment and isolated ossicles which closely resemble *Calliderma Smithiæ*, and figs. 6 *f—h* represent isolated ossicles bearing an equally strong resemblance to *Stauranderaster Boysii*. The species, however, is said to be "e calcareo jurassi Wurthembergia et Baruthino," whereas *C. Smithiæ* and *S. Boysii* are typical Cretaceous species, and have not in any other work been described from Jurassic rocks. Without seeing the original specimens no one should assert that Münster was so far mistaken as to the horizon and locality of the fossils before him. We can only suspend judgment.

ASTERIAS TABULATA, Goldfuss, 1826. 'Petrefacta Germaniæ,' p. 210, pl. lxiii, figs. 7 *a—g*.

Figs. 7 *a—b* are illustrations of isolated ossicles of *Stauranderaster argus* which are found in the Upper Chalk (zone of *Micraster. cor-anguinum*). I am unable to recognise the illustrations of the remaining ossicles as appertaining to any English Cretaceous species. The plates are said to be "e stratis argillaceis superioribus calcarei jurassi Baruthini." It is just possible that the locality and stratigraphical horizon are wrongly given in the case of *a* and *b*, and the name *Asterias tabulata* should be restricted to figs. *c—g*, one of those specimens being taken as type.

ASTERIAS SCHULZII, *Cotta*.

This is described and figured in Roemer, 1841, 'Die Verstein. Norddeutsch. Kreidegeb.,' p. 28, pl. vi, fig. 21, as follows: "Fünfeckig mit fünf kurzen Strahlen, unten vertieft und in der Mitte mit fünf Erhabenheiten; der vorstehende Rand gewölbt und zwischen je zwei Strahlenspitzen mit etwa 45 schmalen Täfelchen besetzt."

The description reads as if the specimen belonged to the genus *Stauranderaster*, but neither this nor the figure given is much aid in the exact identification of the species.

A cast of a fossil Asteroid is ascribed to the same species under the name of *Stellaster Schulzii*, by Geinitz, 'Palæontographica,' vol. xx, pt. 2, pl. v, figs. 3, 4. This cast, however, looks like a cast of a species of either *Calliderma* or *Nymphaster*.

ASTERIAS? DUNKERI, *Roemer*, 1841. 'Die Verstein. norddeutsch. Kreidegeb.,' p. 27.

This species is described as follows: "Die Flächentäfelchen sind länger als breit, 4—6 eckig, schrägrandig fein gekörnt und nahe am obern Rande durchbohrt." Only isolated plates were known. I am unable to identify the species with other known Asteroids. The illustration given is not very clear.

According to Roemer, these isolated plates were described by Dunker and Koch, 1837, 'Norddeutsch. Oolithgeb.,' as plates of *Cidaris variabilis*.

CŒLASTER COULONI, *Agassiz*, 1836. 'Mém. Soc. Sci. Nat. Neuchatel,' vol. i, p. 191.

No figure was given of this species by Agassiz. A fossil Asteroid figured by Fritel, 'Le Naturaliste,' vol. xvi, 1902, p. 79, as this species, appears to be somewhat like *Nymphaster marginatus*.

CUPULASTER PAUPER, *Frič*, 1893. 'Arch. Landesdf. Böhmen,' ix, no. 1, p. 112.

This species is named from a specimen 3 mm. in diameter, which so obviously presents the large terminal plates which are common to all very young forms of starfish, that it is useless to speculate as to its identity.

*Locality and Stratigraphical Position.* — Cretaceous (Priesener Schichten), Waldek, near Bensen, Bohemia.

GONIASTER MARGINATUS, *Reuss*, 1845—6. ‘Verstein. böhm. Kreideform.’ p. 58, pl. 43, figs. 21—32.

The illustrations of the isolated ossicles described as this species bear strong resemblance to those of *M. Parkinsoni*.

GONIASTER MAMMILLATA, *Gabb*, described by *Clark*, 1892, in ‘Bull. U.S. Geological Survey,’ no. 97, p. 32.

“*Determinative Characters.*—Body pentagonal, provided with a dorsal and a ventral row of marginal plates that are narrower than high, and distinctly tumid on their outer surface. Only detached marginal plates preserved.”

*Remarks.*—The isolated plates undoubtedly belong to a species of *Pycinaster* and bear a strong resemblance to those of *Pycinaster angustatus*.

“*Locality and Geological Position.*—Yellow Limestone of the middle marl bed of the Cretaceous from Vincentown, New Jersey.”

PENTACEROS DILATATUS, *S. Meunier*, 1906. ‘Le Naturaliste,’ (2), vol. xx, p. 117.

The specimen described under this name is an external cast in flint, of which a plaster cast has been presented to the British Museum (Nat. Hist.), E. 13075. Owing to the courtesy of Professor Stanislas Meunier I have been able to examine the original specimen. It shows a well-preserved impression of the abactinal surface. The ossicles of the disc are rhomboidal or hexagonal, contiguous, of almost uniform size, about 2 mm. in diameter. The specimen, therefore, cannot be placed in the genus *Pentaceros*, and its appearance, measurements, and type of ornament enable me to ascribe it to *Pentagonaster obtusus*.

OPHIOGLYPHA BRIDGERENSIS, *Meek*, described and figured by *Clark*, 1892. ‘Bull. U.S. Geological Survey,’ no. 97, p. 29.

‘*Determinative Characters.*—Disc composed of numerous small imbricating plates. Upper arm-plates wider than long, the outer angles sharp and expanding between the side arm-plates, which are slightly smaller. Under arm-plates long and nearly rectangular in shape.

“*Dimensions*.—Diameter of disc 6 mm. Length of arm 20 mm. Width of arm near disc 1·25 mm.”

*Remarks*.—The figures given and dimensions of this species appear to me to indicate that it closely resembles *Ophiotitanos lævis*. The upper arm-plates are described as hexagonal, and the more proximal upper arm-plates of the British species present this appearance.

*Locality and Stratigraphical Position*.—Cretaceous, Fort Ellis, Montana.

OPHIOGLYPHA TEXANA, *Clark*, 1892. ‘Bull. U.S. Geol. Survey,’ no. 97, p. 30.

“*Determinative Characters*.—Disc round; composition indistinct. Arms long, with wedge-shaped under arm-plates about as wide as long; upper arm-plates about twice as wide as long.

“*Dimensions*.—Diameter of disc 15 mm. Length of arm 50 mm. Width of arm at disc 2 mm.”

*Remarks*.—It is difficult to identify this with a British species, but the illustrations appear to indicate that it is somewhat similar to *Amphiura cretacea*.

*Locality and Stratigraphical Position*.—Cretaceous, six miles north of Fort Worth.

OPHIURA GRANULOSA, *Roemer*, 1841. ‘Die Verstein. norddeutsch. Kreidegeb.’ p. 28, pl. vi, fig. 22.

This species is described as follows :

“Die Arme sind walsenförmig und bestehen aus gewölbten, seitlich durch ein Furche getrennten, deutlich gekörnten Seitenschildchen; wo sich deren vier berühren liegt ein kleines, dreieckiges Schildchen dazwischen.”

*Remarks*.—The small fragment of the arm figured shows it to be a portion of the distal extremity—quite possibly the distal extremity of some species of *Ophiotitanos*.

*Locality and Stratigraphical Position*.—Lower Chalk, Lindener Berg, near Hanover.

OPIHURA ? PULCHERRIMA, *Průč*, 1893. 'Arch. Landesdf. Böhmen,' vol. ix, no. 1, p. 113.

*Remarks.*—No description is given. The figure does not show any resemblance of this species to other known forms, but the specimen was obviously imperfect. The upper arm-plates appear to be V-shaped.

*Locality and Stratigraphical Position.*—Cretaceous (Priesener Schichten), Waldek, near Bensen, Bohemia.

STELLASTER ALBENSIS, *Geinitz*, 1872—5. 'Palæontographica,' vol. xx, pt. 2, p. 16, pl. vi, fig. 3.

*Remarks.*—This species is only known from a cast from the Quadersandstein. In the absence of determinative characters it is impossible to say whether it is identical with or differs from more fully described species.

STELLASTER COOMBI, *Forbes*, sp., in *Geinitz*, 1872—5, 'Palæontographica,' vol. xx, pt. 2, p. 17, pl. vi, figs. 4—6.

The specimens illustrated here as *S. Coombii* certainly do not belong to Forbes' species of that name. They appear to be ossicles of various species, but I am unable to identify them from the figures given.

#### SPECIFIC AND GENERIC CHARACTERS IN CHALK ASTEROIDEA.

When I commenced this account of Cretaceous Asteroids I endeavoured, so far as possible, to follow the generic classification of previous authors and especially to preserve the continuity of Mr. Sladen's work. More recent work, however, has led me to believe that the shape of the marginal plates, together with their ornament, affords the best determinative generic and specific characters, and further enables us to identify almost all Cretaceous starfishes from single isolated plates.

Some necessary revision as to nomenclature in both genera and species is given below, together with an illustrated key-table, which it is hoped will enable zonal collectors to identify the isolated asteroid plates which are commonly met with in

almost all exposures. Up to the present our knowledge of the zonal occurrence of these forms has been limited, as complete specimens of starfishes are exceedingly rare. There appears to be no reason now, however, why our knowledge of the zonal distribution of these forms should not become as nearly complete as it is, for example, in the case of Echinoids.

I must thank Dr. Blackmore, of Salisbury, for his invaluable suggestions to me concerning this means of identification.

*Ornament.*—The ornament of starfishes consists of calcareous pieces, which may be spinous in form, or scaly, or granular. These may occur :

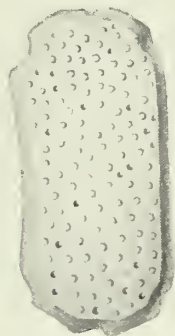
(1) Embedded in the living tissues outside the general body-plates, but not in contact with the plates themselves. On the death of the animal they become dispersed on the disintegration of the living tissues, and such ornament is therefore rarely visible in fossil specimens.

(2) Articulated to the plates. In this case they are situated :

- (a) Either in a depression of the plate ;
- (b) Or in a depression upon a raised eminence of the plate. Occasionally in this latter case the depression may be excavate in the centre in order to allow a strong muscular attachment. In this case the eminence may simulate the perforate tubercle of an Echinoid such as *Cidaris*.



TEXT-FIG. 3.—Isolated marginal of *Nymphaster Coombii*, showing spines and spine-pits.



TEXT-FIG. 4.—Isolated marginal of *Stauranderaster bulbiferus*, showing the "pustulate" type of ornament.

In almost all cases in Cretaceous Asteroids the ornament is of the type 2 *a*.

Generally the movable articulated pieces have disappeared, but in such cases the depression on the plate which they formerly occupied is readily visible (compare Text-fig. 3).

I purpose to call all such movable articulated pieces, whether they are spinous or granular in character, "spines," and, at the suggestion of Dr. Bather, the depressions on the plate "spine-pits."

The character of the spine-pits appears to be constant in character in each individual species.

Thus, *e. g.* in *N. Coombii* (Text-fig. 3) they show a coarse honeycomb structure, uniform in character over the whole of the plate. In *Stauranderaster bulbiferus* (Text-fig. 4) the spine-pits are circular and widely spaced. This latter type is interesting, as it apparently occurs only in the genera *Metopaster* and *Stauranderaster*. The spine is very small, and barely projects over the edge of the deep

spine-pit, thus giving the plates an embossed appearance. This type of ornament I call the "pustulate" type.

In previous portions of this Monograph both Mr. Sladen and myself have assumed that if no spine-pits are present on a plate they have been weathered

away. It now appears that the absence of spine-pits is such a constant character in certain species that this supposition can no longer be held, and the absence of spine-pits indicates an original absence of spines, or, at any rate, spines articulated to the plates. In support of such a conclusion it can be urged that, generally speaking, Chalk fossils are but little weathered, and that there is evidence derived from a study of recent forms.

*Pedicellariæ*.—As can readily be understood, only pedicellariæ which are articulated in depressions of the plate are preserved in Cretaceous Asteroids. Purse-like, valvate pedicellariæ (Text-fig. 5) of a generalised type are common to many genera. More specialised pedicel-

lariæ, however, peculiar to the genera *Metopaster* and *Pycinaster* are also met with (Text-fig. 7).

TEXT-FIG. 5.—Pedicellaria of *Nymphaster oligoplax*.



TEXT-FIG. 6.—Three pedicellaria from *Pentagonaster quinqueloba* on the right. A pedicellaria from *Hadranderaster abbreviatus* on the left.



TEXT-FIG. 7.—A pedicellaria from *Metopaster Parkinsoni* in the centre, on the left a pedicellaria of *Pycinaster senonensis*, on the right a pedicellaria of *Stauranderaster coronatus*.

#### KEY-TABLE FOR THE IDENTIFICATION OF CRETACEOUS ASTEROIDS.

The following key-table is based on the shape of the marginal plates and the character of the spine-pits on them. Generally speaking both superior and inferior series are similar in these respects, but when otherwise a note is made in the table.

A short description is also given of various plates which cannot be adequately treated in the table.

All the plates figured in the table are magnified 4 diameters.

It is convenient to consider the Chalk (Cenomanian-Senonian) species separately from the Upper Greensand forms. No Cretaceous Asteroidea have been described from below this horizon.

## CHALK (CENOMANIAN-SENONIAN) SPECIES.

## I.—Marginals four-sided, with sides rectilinear or almost rectilinear; broad.

- A. Without a rabbit-edge. *Calliderma*, *Nymphaster*, *Pentagonaster*.  
 B. With a rabbit-edge. *Metopaster*, *Mitraster*.  
 C. With a distinct ridge. *Arthraster*.

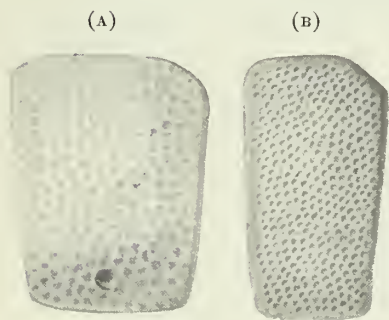
II.—Marginals either hexagonal or rounded; very thick. *Hadrauderaster*.III.—Marginals wedge-shaped, high, spine-pits very shallow or absent. *Pycinaster*.IV.—Marginals breast-plate-shaped. *Stauranderaster*.

## V.—Miscellaneous plates.

## I.—Marginals four-sided, with sides rectilinear or almost rectilinear. Pedicellariæ when present of a simple bi-valvate character.

- A. Without a rabbit-edge. *Calliderma*, *Nymphaster*, *Pentagonaster*.

## 1. Spine-pits shallow, hexagonal, giving a honeycomb appearance.



TEXT-FIG. 8.

- a. Honeycomb medium or fine. *C. Smithiæ* (see p. 123).  
 Text-fig. 8 A.—Variety with medium-sized spine-pits  
 (see p. 123).  
 Text-fig. 8 B.—Variety with fine spine-pits (see  
 p. 123).

- b. Honeycomb coarse. *N. Coombii*. Text-fig. 3, p. 113.



TEXT-FIG. 9.

- c. Honeycomb confined to a portion of the plate (or absent). *P. obtusus*. Text-fig. 9.

2. Spine-pits shallow, circular, circles variable in size, adjoining.



TEXT-FIG. 10.

One species, *C. latum*. Text-fig. 10.

3. Spine-pits deep, circular, not adjoining.



TEXT-FIG. 11.



TEXT-FIG. 12.

a. Spine-pits coarse. *N. marginatus*. Text-fig. 11.

b. Spine-pits fine, not on margin. *N. oligoplax*. Text-fig. 12.



TEXT-FIG. 13.

c. Spine-pits fine, uniformly over the whole of plate. *P. lunatus*.  
Text-fig. 13.

4. Spine-pits on outer edge of plate with raised margins.



TEXT-FIG. 14.

One species, *P. quinqueloba* (see p. 108). Text-fig. 14.

5. No spine-pits present.

(A) (B)



TEXT-FIG. 15.



TEXT-FIG. 16.

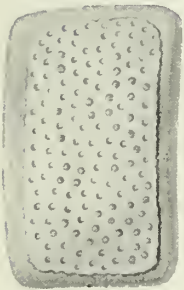
a. Proximal marginalia almost smooth; distal with granular rugosities arranged in a linear series. *N. radiatus*. Text-fig. 15, (A) proximal marginal, (B) distal marginal.

b. Marginalia with rugosities not arranged in linear series. *N. rugosus*. Text-fig. 16.

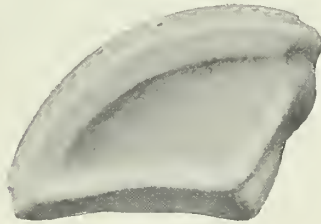
B. Marginals with a rabbit-edge. Rabbit-edge covered with small spine-pits. Pedicellariæ when present "winged" (see Text-fig. 7).

1. Spine-pits on central raised area.

(A)



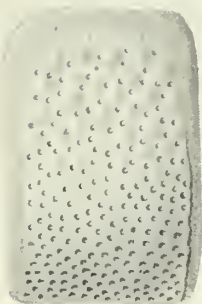
(B)



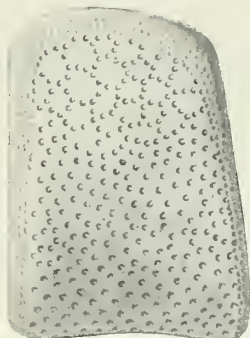
TEXT-FIG. 17.

a. Central raised area smooth on both superior and inferior marginalia. Spine-pits on infero-marginalia uniformly situated. *M. Parkinsoni*. Text-fig. 17, (A) outer view of marginal, (B) side view of marginal.

(A)



(B)



TEXT-FIG. 18.

b. Central raised area of supero-marginalia rugose; that of infero-marginalia smooth, with spine-pits in form of network. *M. Hunteri*. Text-fig. 18, (A) supero-marginal, (B) infero-marginal.

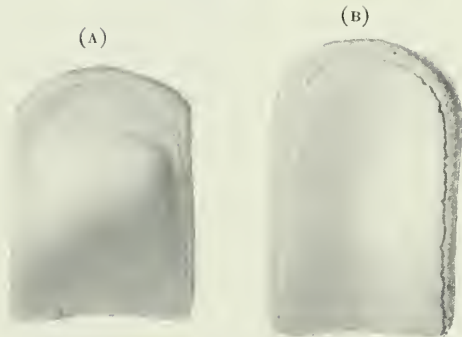
c. Central raised area of supero-marginalia smooth in young, rugose in mature individuals. Lower Chalk form. *M. cornutus* (see p. 124).

## 2. No spine-pits on central raised area.



TEXT-FIG. 19.

a. Rugosities present on greater portion of surface of supero-marginalia. *M. rugatus*. Text-fig. 19, (A) supero-marginal, (B) infero-marginal.

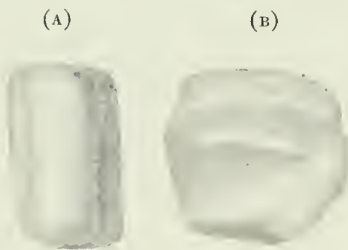


TEXT-FIG. 20.

b. Rugosities confined to inner edge of supero-marginalia or absent; outer portion of plate tumid. a. Plates oblong. *M. uncatus*. Text-fig. 20, (A) supero-marginal, (B) infero-marginal. β. Plates square. *M. quadratus*.

c. No rugosities present on the supero-marginalia which are not tumid on their outer portion. *M. compactus*. See Pl. XXVI, fig. 3b.

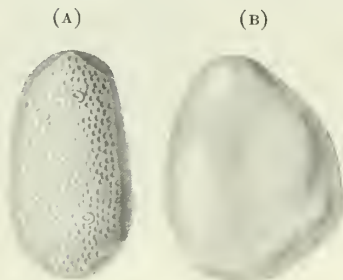
N.B.—The infero-marginalia of the above species are difficult to distinguish except by their dimensions. The reader is advised to refer to the detailed description for these.

c. Marginalia with a distinct ridge which has granular elevations along its base. *Arthraster*.

TEXT-FIG. 21.

1. Upper surface of ridge smooth. *A. Dixoni*. Text-fig. 21, (A) outer view of marginal, (B) side view of marginal.

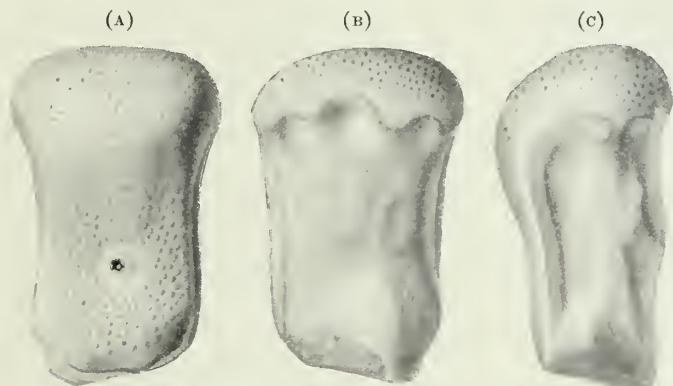
2. Upper surface of ridge with spine-pits. *A. cristatus*. See Pl. XXIX, fig. 10.

II.—Plates either hexagonal or rounded; very thick. Spine-pits form a distinct, fine honeycomb marking. *Hadrandraster* (see p. 125).

TEXT-FIG. 22.

There is only one species. *H. abbreviatus*. Text-fig. 22, (A) outer view of marginal, (B) side view of marginal.

III.—Marginals generally wedge-shaped, high, spine-pits very shallow or absent.  
 Pedicellariæ when present with five valves round a deep central depression. *Pycinaster*.



TEXT-FIG. 23.

1. Plates of maximum height, 10 mm. *P. angustatus*. See Pl. IX, fig. 1 a.
2. Plates of maximum height, 20 mm.,  $\Gamma$ -shaped in profile. *P. senonensis*. Text-fig. 23, (A) outer view of marginal, (B) interior view of marginal, (C) side view.

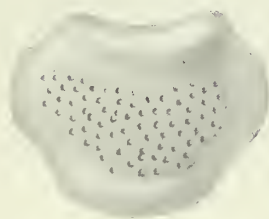


TEXT-FIG. 24.

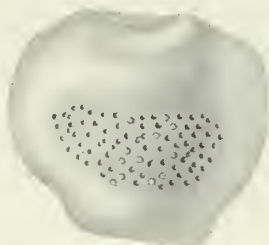
3. Plates very thick, often oblong, not wedge-shaped. *P. crassus*. Pl. XXIX, fig. 3, exterior view of marginal. Text-fig. 24, side view of marginal.

IV.—Marginal plates breast-plate-shaped. *Stauranderaster* (see p. 125).

A. With spine-pits.

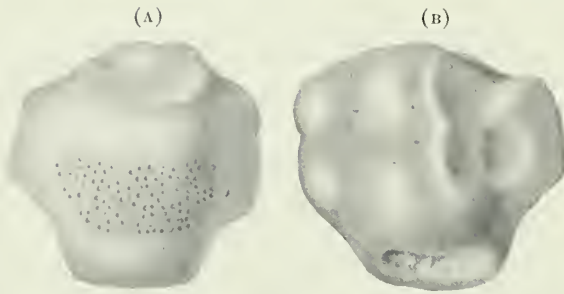


TEXT-FIG. 25.



TEXT-FIG. 26.

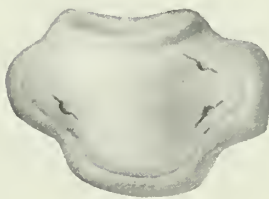
1. Spine-pits fairly coarse. *S. bulbiferus* (commonly occurring). Text-fig. 25.
2. Spine-pits medium. *S. bipunctatus* (only one specimen known). Text-fig. 26.



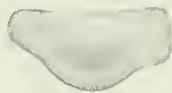
TEXT-FIG. 27.

3. Spine-pits fine. *S. Boysi*. Text-fig. 27, (A) outer view of marginal, (B) interior view of marginal.

B. Without spine-pits.



TEXT-FIG. 28.



TEXT-FIG. 29.

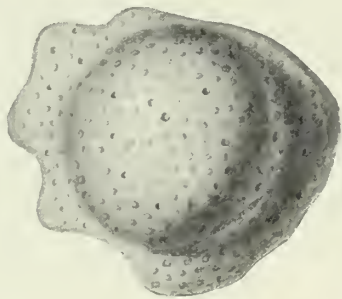
1. Maximum size about 7 mm. *S. coronatus*. Text-fig. 28.
2. Maximum size about 2.5 mm. *S. squamatus*.
3. Maximum size about 2.5 mm. *S. pistilliferus*. Text-fig. 29.

N.B.—It is impossible to distinguish isolated marginalia of these two species. Compare V, 3 (p. 121).

V.—The collector may also come into possession of the following plates :

1. Large triangular plates having the characteristic ornament of *Metopaster*. These are the ultimate supero-marginalia which characterise the genus. See *e. g.* Pl. XVI, fig. 2 *a*.

2. Large hemispherical plates with a flattened base. These are met with in the following species :



TEXT-FIG. 30.

A. With spine-pits.

*Stauranderaster bulbiferus*, *S. Boysi*, and ? *S. bipunctatus*. These are distinguished from one another by their spine-pits, which are of the same character as those met with in the marginalia. Text-fig. 30 = a primary inter-radial of *S. bulbiferus*.

B. Without spine-pits.

*Pycinaster senonensis*, distinguished by the smooth surface, Pl. XXIX, fig. 6.

*Arthraster Dixoni*, distinguished by the rugose surface, Pl. XXIX, fig. 11.

3. Nodular plates with an excavate margin met with in the following species :
- A. With flattened base, from 7—9 mm. in diameter, *S. coronatus*, Pl. XXIV, fig. 2.
- „        „        „        3—4 mm.        „        *S. squamatus*, Pl. XXV, fig. 3.
- B. With produced base, *S. pistilliferus*, Pl. XXV, fig. 5.

4. Oblong or almost oblong plates having the characteristic ornament of *S. bulbiferus*. These are the more distal marginals, or in some cases the ventro-lateralia of this species. Generally the marginals are indented at the corners, and their shape can be decided from the characteristic breast-plate form.



TEXT-FIG. 31.

Text-fig. 4, p. 113.—Outer view of plate.  
Text-fig. 31.—Side view of plate.

5. Irregularly rounded or polygonal plates with ocellate depressions having a raised ridge.



TEXT-FIG. 32.

- A. Without madreporiform markings on summit. *S. argus*. Pl. XXIX, fig. 8 a.
- B. With madreporiform markings on summit. *S. ocellatus*. Text-fig. 32.

6. One specimen of *Astropecten*? sp. and *Linckia* sp.? respectively have also been described, see pp. 90 and 100.

#### UPPER GREENSAND FORMS.

The genus *Comptonia* appears to be characteristic of this horizon. The plates are very similar in shape to those of *Calliderma*, except that they are more rounded in profile. Unfortunately, no specimen at present known shows the ornament of the marginalia.

I have also met with *C. Smithia* and *P. punctatus* from this horizon. They are readily distinguished by the characters which have already been given in the key-table.

## NOTES ON THE KEY-TABLE.

*Genera*—CALLIDERMA, NYMPHASTER, PENTAGONASTER.

The following are the chief distinctive characters which separate these three genera in recent forms.

CALLIDERMA.	PENTAGONASTER.	NYMPHASTER.
1. Arms well produced.	Arms slightly produced.	As in <i>Calliderma</i> .
2. Abactinal area covered with closely fitting plates.	As in <i>Calliderma</i> .	Abactinal area covered with paxillæ, which are not closely fitting in the radial areas.
3. Ventro-lateral and infero-marginal plates with prominent spines.	Ventro-lateral and infero-marginal plates without prominent spines.	As in <i>Pentagonaster</i> .
4. Armature of the adambulacral plates consisting of 14–16 small spines arranged uniserially, with three or four rows of larger spines arranged rather irregularly.	Armature of the adambulacral plates arranged in longitudinal series. Series on the whole uniform in character.	As in <i>Pentagonaster</i> .

The fossil species of *Calliderma* possess the characters numbered 1 and 2, but differ to a greater or less extent in characters 3 and 4, in which they resemble *Pentagonaster*. The genus *Calliderma* was, however, founded by Gray on one species—*C. emma*. No other recent species has been assigned to the genus. It is difficult, therefore, to say how far the distinctive characters of the Cretaceous genera should have generic value. The question is debated by Mr. Sladen on p. 5 of this Monograph, and the very striking general resemblance of the fossil species to the recent *C. emma* influenced him in his decision to group them under this genus. There appears no great reason to dispute this assignment, but I am in more doubt as to the systematic position of the species which have been placed in the genera *Pentagonaster* and *Nymphaster*. It will be seen that as the fossil species of *Calliderma* resemble *Pentagonaster* in characters 3 and 4, the only distinctive character which remains between the two genera is the length of the

arm. Two of the fossil species of *Pentagonaster*, namely *P. lunatus* and *obtusus*, have all arms which are well produced (the arms in the specimen of *P. lunatus* figured on Pl. IV, fig. 1, are broken off short). The third and remaining species, *P. quinqueloba*, is usually much more pentagonal in shape, although a specimen in the possession of Dr. Blackmore has a major radius at least twice the magnitude of that of the minor radius.

The species assigned to the genus *Nymphaster* by Sladen were so assigned because their structure and character, so far as they could be made out from the fragmentary condition of the fossils, appeared to warrant their inclusion in the genus *Nymphaster* (see p. 15).

It appears to me that these species have the same generalised characters as those assigned to the genera *Calliderma* and *Pentagonaster*. The distinctive character of the genus *Nymphaster* is the possession of paxillæ on the abactinal plates. No fossil species is sufficiently well preserved to show whether these were absent or present, and it is impossible therefore to confirm or deny Sladen's suggestion.

It will be seen from the above that there is no certain evidence which entitles us to distribute the Cretaceous species amongst the three genera, and it may be the task of a future observer to place them in one new genus. I have, however, in order to secure uniformity, utilised all these generic names even for the description of new species. The following species also appear to require revision.

*Calliderma Smithiæ*, *C. mosaicum*.

After examination of the fairly numerous specimens of the fossils assigned to these species in the British Museum (Nat. Hist.) I cannot confirm the specific distinctions made by Sladen on pp. 10 and 11 of this Monograph. All the characters mentioned vary greatly in individual specimens. The ornament, however, is common in character to both species, and I should prefer to unite them in one species, namely, *C. Smithiæ*, as this has prior place in the original account given by Forbes.

The specimens figured on Pl. VII, figs. 1 and 2, and stated by Sladen to be in his opinion doubtful examples of *N. Coombii* (p. 17), should in my opinion be assigned to *C. Smithiæ*, as should also the specimen figured on Pl. XIX, fig. 3. These examples possess a finer type of honeycomb structures on their marginalia than is usually met with in *C. Smithiæ*, and they may, therefore, be a distinct variety of this species (see Text-fig. 8).

A specimen preserved in the British Museum (Nat. Hist.) E. 5063, was figured by Sladen on Pl. V, fig. 1 *a*, of this Monograph as *Tomidaster sulcatus*. Apparently it was the intention of Sladen to make a new genus and species for the reception

of this fossil. The dimensions of the marginalia, compared with the minor radius and the ornament, are precisely the same as in *C. Smithia*, from which the specimen only differs in the possession of numerous valvate pedicellariæ. In view of the somewhat freakish way in which pedicellariæ occur in starfishes, it does not appear to me that this character alone entitles us to make a specific or generic distinction on behalf of this specimen.

There is another specimen also in the collection of the British Museum (E. 1116) which has similarly numerous valvate pedicellariæ, but which shows the abactinal aspect. In all other respects the specimen cannot be distinguished from a specimen of *C. Smithia*.

*Genus*—METOPASTER.

In the key-table I have only distinguished four species of *Metopaster*, namely, *M. Parkinsoni*, *M. uncatas*, *M. quadratus*, and *M. cornutus*, the latter being a doubtful species. If one examines collections of Cretaceous Asteroids, one finds that practically all the specimens have been rightly assigned to these species. Specimens which could be assigned to the species *M. Mantelli*, *M. Bowerbanki*, *M. zonatus*, *M. subluuatus*, *M. cingulatus* (see pp. 38-55), are very rarely met with.

The very considerable variation which occurs in undoubted specimens of



TEXT-FIG. 33.—Marginal of *Metopaster Parkinsoni*, showing a more scattered type of ornament than that usually met with.

*M. Parkinsoni* in the number of the supero-marginalia, their form, amount of ornament, and the shape of the ultimate plates of this series, makes specific characters founded solely upon these characters of doubtful validity, particularly as such variations occur even in an individual specimen, and it is upon a rather extreme variation of these characters occurring in very few specimens that this large number of species have been described. On the

other hand, the presence or absence of spine-pits on the raised central area of the plate is a constant character in species of *Metopaster*. Two specimens figured in the Monograph appear to belie this statement. The specimen figured on Pl. X, fig. 4a, shows no spine-pits on its infero-marginalia, but is figured as *M. Parkinsoni*. I have isolated a dorsal ossicle, which shows the specimen undoubtedly to belong to *M. uncatas*. The specimen figured on Pl. XI, fig. 3a, as *M. uncatas*, shows spine-pits on its supero-marginalia in one inter-radius only. After very careful examination of this specimen, I have come to the conclusion that this inter-radius—the right-hand upper inter-radius of the figure—has been added by a dealer from a collection of ossicles of *M. Parkinsoni* to an imperfect specimen of *M. uncatas*.

*Genus*—STAUANDERASTER,<sup>1</sup> novum.

PENTACEROS (pars). Pp. 76–89 of this Monograph.

The species *bulbiferus*, *Boysii*, *coronatus*, *ocellatus*, *bispinosus*, *pistilliferus*, and *squamatus* (pp. 76–89 of this Monograph), which have been formerly placed in the genus *Pentaceros*, together with the new species *argus* (p. 99), should, I think, now be ascribed to a new genus. The plates of these species are breast-plate-shaped, at times almost cross-shaped, and bear a characteristic type of ornament (see p. 113). In both these respects and in the absence of papular areas the species differ widely from species of recent *Pentaceros*, with which the only feature they have in common is the circlet of raised plates on the abactinal surface of the disc.

The type species of the new genus is *Stauranderaster Boysii*, and its diagnostic characters are :

Arms high, well produced, marginalia breast-plate-shaped, generally with a rabbet-edge free from ornament, and a raised interior area, either smooth or with ornament of an embossed type. A circlet of swollen plates present on the abactinal surface of the disc.

This genus, with the following genus, may be placed provisionally in the family Pentacerotidæ.

*Genus*—HADRANDERASTER,<sup>2</sup> novum.

PENTACEROS (pars), p. 86 of this Monograph.

The species described as *Pentaceros abbreviatus* on p. 86 of this Monograph differs so considerably in the shape of its marginalia and their ornament from the species of *Stauranderaster* and recent species of *Pentaceros* that I have placed it in a new genus.

The type species is *Hadranderaster abbreviatus*, and the diagnostic characters of the new genus are :

Arms high, well produced, marginalia either hexagonal or rounded, very thick, ornament spread uniformly over the surface of the plate. Pedicellaria bi-valvate.

<sup>1</sup> *σταυρός* = a cross, *ἄνδηρον* = a raised garden border.

<sup>2</sup> *ἀδρός* = stout, *ἄνδηρον* = a raised garden border.

## GENERAL CHARACTERISTICS OF CRETACEOUS ASTEROIDEA AND OPHIUROIDEA.

The majority of Cretaceous starfishes belong to the Phanerozontate forms included in the families *Pentagonasteridæ* and *Pentacerotidæ*. Modern forms of the genera of these families are widely distributed geographically, but, generally speaking, they are characteristic of warmer waters than those of the English Channel of to-day.

The Chalk starfishes are specialised types which, although approximating to, are not identical with, modern genera. The differences, at any rate in some cases, appear to be distinctly physiologically advantageous.

*Metopaster* and *Mitraster*, the most abundant of all Chalk starfishes, possess not only a specialised type of ornament but also characteristic massive plates. The arms tend to become shortened and the disc correspondingly enlarged.

The Chalk species of the *Pentacerotidæ* differ from the modern forms, inasmuch as they are more strongly built; the abactinal areas are not reticulate, and all species possess intermarginalia which cause the characteristically deep body of these forms.

The Chalk is a deposit formed in seas which were sufficiently distant from land to avoid any great admixture of clay or sand. *Globigerina* and other forms of pelagic Foraminifera floated in abundance on the surface of the sea, which, because of its temperature, must have been exceedingly favourable to prolific forms. In the circumstances there must have been an abundance of food for starfishes, and we find, therefore, that the long-armed, comparatively active *Astropectinidæ*, which were so characteristic of the Jurassic shallow water deposits, are displaced by more sedentary forms which tend to specialise, so as to obtain, by the enlargement of the disc or development of intermarginalia, the largest possible space for their digestive organs.

The irregular Echinoids which are so characteristic of the Cretaceous seas are similarly sedentary forms.

The fossil Ophiuroidea also closely resemble modern forms. The isolated vertebral ossicles of *O. serrata*, figured Pl. XXVII, figs. 3 *c*, 3 *d*, 3 *e*, cannot be distinguished from the ossicles of recent Ophiuroids. Complete specimens of Ophiuroidea and Asteroidea are rare, but isolated plates are very numerous in the Upper Chalk. They are, on the contrary, rare in the Lower Chalk, according to experienced collectors, as, for example, Mr. Dibley.

The following starfishes are found in the zones indicated. The list is compiled

from the papers of Dr. Rowe ('Proc. Geol. Assoc.' vols. xvi, xvii), and also from notes furnished by Dr. H. P. Blackmore and Mr. T. H. Withers.

	Zone of <i>Ostrea-lunata</i> .	Zone of <i>Belemnitella macronata</i> .	Zone of <i>Actinocamax quadratus</i> .	Zone of <i>Marsupites</i> .	Zone of <i>Micraster cor-anginan</i> .	Zone of <i>M. cortestudinarium</i> .	Zone of <i>Holaster planus</i> .	Zone of <i>Terebratula gracilis</i> .	Zone of <i>Rhynchonella Cuvieri</i> .	Zone of <i>Holaster subglobosus</i> .	Zone of <i>Ammonites varians</i> .
<i>Nymphaster Coombei</i> , Forbes . . .	...	...	...	...	...	...	...	...	×	...	...
— <i>oligoplax</i> , Sladen . . .	...	...	...	...	×	...	...	...	...	...	...
<i>Pentagonaster quinqueloba</i> , Goldfuss . . .	...	×	×	×	×	...	...	...	...	...	...
— <i>obtusus</i> , Forbes . . .	...	...	×	×	...	...	...	...	...	...	...
<i>Metopaster Parkinsoni</i> , Forbes . . .	...	...	×	...	×	×	×	×	...	...	...
— <i>uncatus</i> , Forbes . . .	...	...	...	×	×	×	...	...	...	...	...
— <i>quadratus</i> , n. sp. . . .	...	...	×	...	...	...	...	...	...	...	...
— <i>cornutus</i> , Sladen . . .	...	...	...	...	...	...	...	...	×	...	...
<i>Mitraster Hunteri</i> , Forbes . . .	...	×	...	...	×	...	...	...	...	...	...
— <i>rugatus</i> , Forbes . . .	...	×	×	...	×	...	...	...	...	...	...
<i>Pycinaster angustatus</i> , Forbes . . .	...	×	×	×	×	...	...	...	...	...	...
— <i>senonensis</i> , Valette . . .	...	...	×	...	...	...	...	...	...	...	...
<i>Stauranderaster bulbiferus</i> , Forbes . . .	...	×	×	×	×	×	...	...	...	...	...
— <i>Boysi</i> , Forbes . . .	...	...	×	...	...	...	...	...	...	...	...
— <i>ocellatus</i> , Forbes . . .	...	×	×	×	×	...	...	...	...	...	...
— <i>pistilliferus</i> , Forbes . . .	...	×	×	...	...	...	×	...	...	...	...
— <i>argus</i> , n. sp. . . .	...	...	...	...	×	...	...	...	...	...	...
<i>Arthraster Dixoni</i> , Forbes . . .	...	...	...	×	...	...	...	×	...	...	...
„ <i>cristatus</i> , n. sp. . . .	...	...	...	...	×	...	...	...	...	...	...

THE PHYLOGENY OF THE CRETACEOUS ASTEROIDEA.

If we examine the various species of a genus or group of related genera of Cretaceous Asteroids, we find that there is a similar transition from smooth to spinous forms through an intermediate form, to that which has been observed in Ammonites and Brachiopods.

Both in Ammonites and Brachiopods single specimens show the whole life-history of the individual, for the shell of the animal is not materially altered in character after it has once been formed. It is therefore possible to show, *e. g.*, that the character of the ornament of the shell of an Ammonite was smooth in its infancy, costate in its adolescence, spinous in the adult, and it has also been shown that this life-history depicted by the individual is an epitome of the phylogenetic history of the species (Buckman, 'Mon. Ammon. Inf. Oolite,' Pal. Soc., 1905, p. cc). Similar observations have been made with regard to Brachiopods (Buckman, 'Quart. Journ. Geol. Soc.,' vol. lxiii, 1907, p. 338); primitively the Brachiopod shell is smooth externally, more advanced forms are progressively costate and then spinous. Occasionally species may regress towards a primitive



form, which was the ancestor of these two groups, early gave rise to two offshoots, one of which includes the *Metopaster* species, the other the *Mitraster* species. Both genera retained evidence of common ancestry by the possession of similar ornament of the specialised "pustulate" type, and by the similar appearance of their ultimate supero-marginalia, which, instead of being smaller than the rest of the superior marginal series, are as large or larger than these. *M. cornutus*, which is the only species found in the lower zones of the chalk (Turonian), shows that early specialisation set in. This form is spinous without rugosities when young (see p. 55, Pl. XIV, fig. 5), but older specimens (see Pl. XXIX, fig. 12) acquire rugosities.

The species of *Metopaster*, *M. quadratus* and *M. uncatius*, have lost all spines from the raised central area of their supero-marginalia, and, instead, possess rugosities. The raised central areas of the infero-marginalia possess neither spines nor rugosities, but are quite smooth. *M. quadratus* has also acquired, as a frequent variation, a primitive type of ultimate supero-marginalia (see p. 98). The type of ornament shows the species to be highly specialised, and this fact, together with its occurrence in the higher zones of the Chalk, affords us an explanation of the remarkable peculiarity of the terminal supero-marginalia on the supposition that it is a catagenetic tendency.

The species of *Mitraster* show even more decided evidence of the three phases—spinous, rugose, smooth. These alterations only occur on the raised central area of the supero-marginalia. The infero-marginalia appear to pass directly from the spinous to the smooth stage without the intervention of a rugose stage.

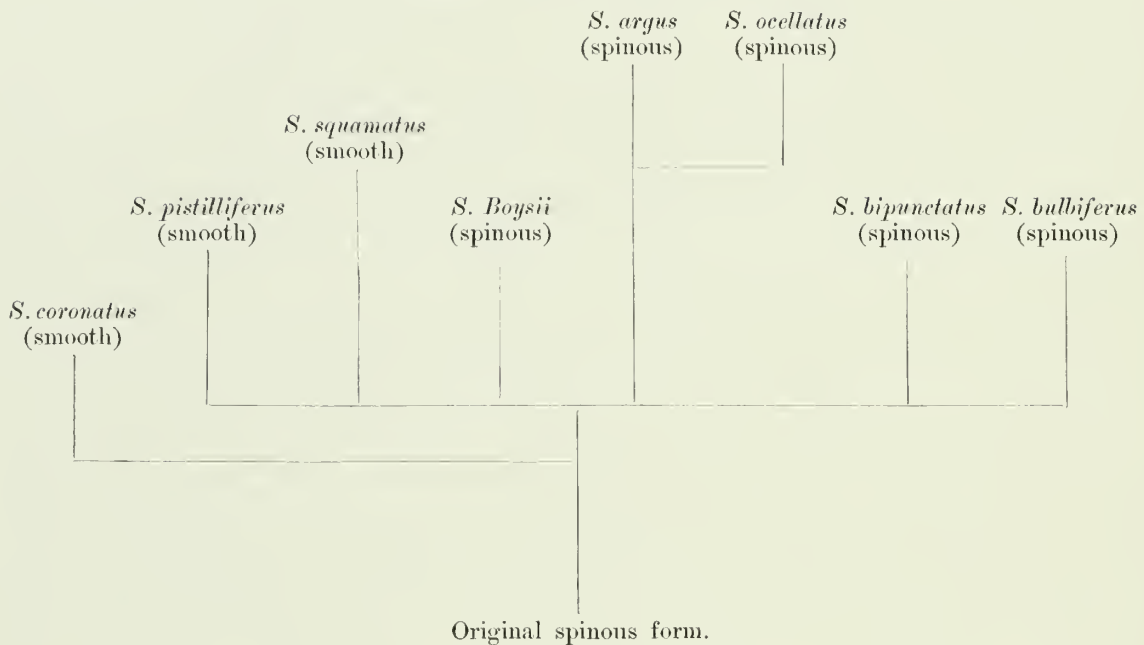
#### *Genera*—CALLIDERMA, NYMPHASTER, AND PENTAGONASTER.

This group tends to become smooth both in the Senonian and in the Turonian-Cenomanian.

Turonian-Cenomanian forms include *C. Smithia*, *C. latum*, *N. Coombii*, *N. oligoplas*, and *N. marginatus*, which are spinous; *N. rugosus*, which is rugose; *N. radiatus*, which is smooth on the older proximal plates, but rugose on the younger distal plates.

Senonian forms include *P. quinqueloba* and *P. lunatus*, which are spinous; *P. obtusus*, which very often possesses marginalia which have lost the majority of the spines and are almost smooth.

## Genus—STAUANDERASTER.



The left-hand stem and branches of the diagram above are occupied by the generalised species which have long tapering arms. They show the transition from spinous to smooth forms. The spinous form of these species is *S. Boysii*. In the lower zones of the Chalk one species (*S. coronatus*) appears. This has neither spines nor rugosities on the majority of its marginalia, although a few distal marginalia are rugose. *S. squamatus*, which is almost identical in character with *S. coronatus*, except that it is of smaller size, and *S. pistilliferus* (arms not known) are the smooth forms which characterise the upper or middle zones of the Chalk.

The right-hand stem and branches are occupied by various specialised forms from the upper and middle zones of the Chalk. *S. bulbiferus* shows a specialisation in the bulbiform character of the extremity of its arms, and *S. bipunctatus* in the character of the spines on the ventro-lateralia. *S. ocellatus* and *S. argus* are specialised in the peculiar nature of their armature. All these forms are spinous, their specialisation lying in other directions.

## Genus—HADRANDERASTER.

The majority of the plates on this form are spinous, although a few distal plates are smooth, probably indicating a catagenetic tendency in this direction.

*Genus*—PYCINASTER.

Spines are very feebly developed in this genus. The spine-pits when present are very shallow, and often they are absent altogether. Spine-pits are often visible on the actinal plates after they have disappeared from the abactinal series.

*P. crassus* possesses rugosities on the distal marginalia.

*Genus*—ARTHRASTER.

*A. cristatus* possesses both spines and rugosities; *A. Dixoni* is rugose without spines.

Speculation as to phylogeny in these latter three genera, in view of the state of our knowledge, would be valueless.

## GLOSSARY.

The following glossary and diagram (Text-fig. 34) is added to aid the geologist who has but little acquaintance with modern zoological terms.

*Abactinal*.—Applied to the surface which is uppermost when the starfish walks on its tube feet; the term “dorsal” is used by some authors in the same sense.

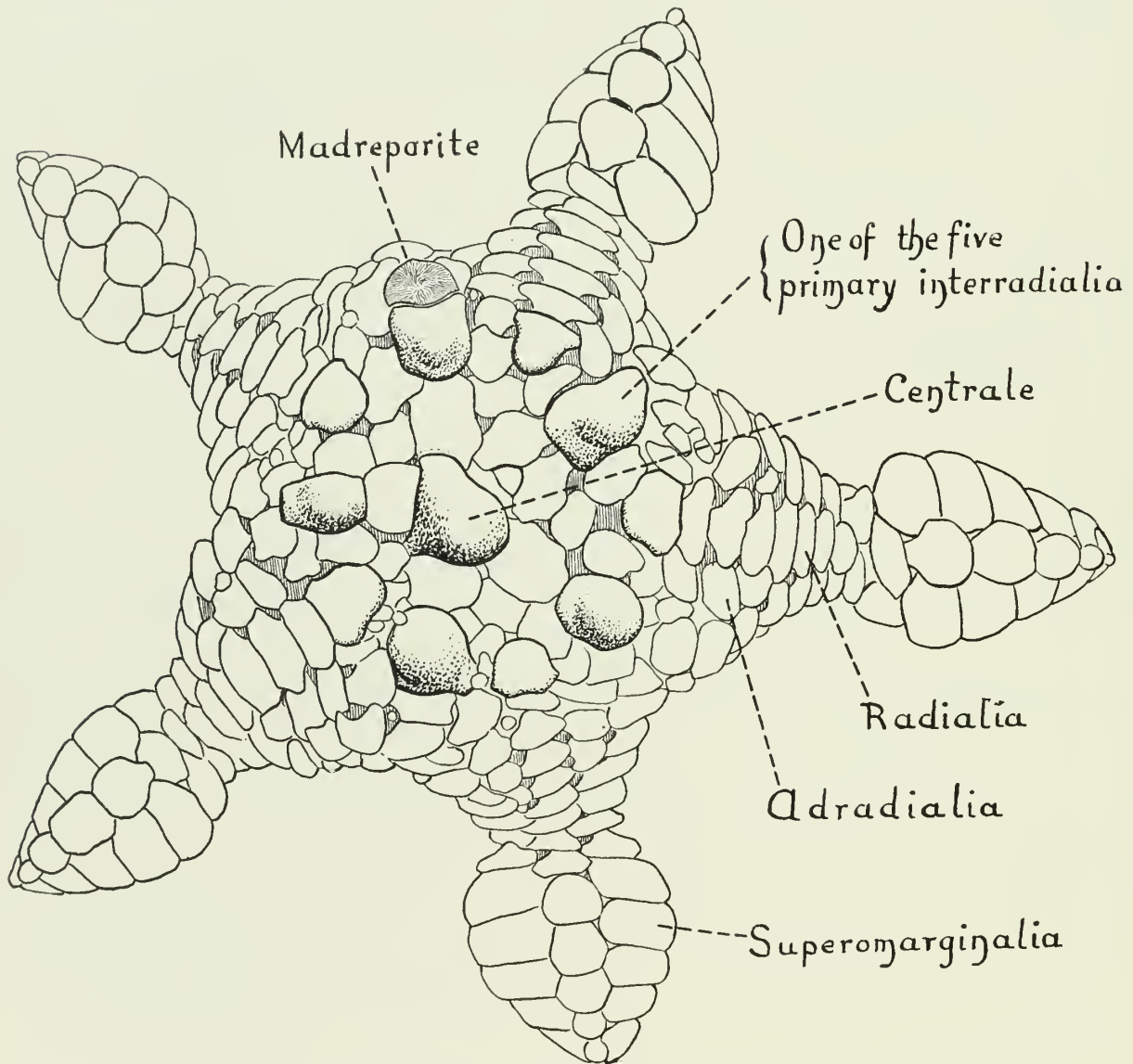
*Actinal*.—Applied to the surface which is undermost when the starfish walks. On this surface are situated the mouth and the ambulacral grooves. The term is used synonymously with “ventral” by some authors.

*Adambulacralia* or *Adambulacral Plates*.—The ossicles which are adjacent to the ambulacral ossicles. In the order “Phanerozonia,” to which the great majority of Chalk Asteroids belong, these ossicles are visible on the actinal surface, bordering the ambulacral groove and hiding the ambulacral ossicles. Adambulacralia may be recognised by their prominent armature of spines.

*Adradialia*.—Ossicles situated on either side of the radialia (*q. v.*).

*Ambulacral*.—The ambulacral groove is the groove stretching from the mouth to the extremities of the arm. It is formed by the ambulacral ossicles, which meet in the middle so as to form an arch. The tube feet project through the arch and into the groove.

*Centrale*.—The most central ossicle on the abactinal surface of the disc. This ossicle, together with five ossicles situated inter-radially and called the “Primary Inter-radialia,” are especially prominent in the young form, in which they often occupy almost the whole of the abactinal surface. Generally speaking



TEXT-FIG. 34.—Abactinal view of a specimen of *Stauranderaster bulbiferus*, natural size, slightly restored from the specimen from Charlton, Kent, registered E. 4344 in the British Museum (Nat. Hist.).

they can be distinguished in the adult form by their larger size, and occasionally they are especially prominent, as in species of *Stauranderaster* (Text-fig. 34) and of the recent genus *Pentaceros*.

*Marginalia*.—In adult forms of the order “Phanerozonia,” which includes



PLATE XXVII.

LINCKIA SP., n. sp. (Page 100.)

*From the Lower Chalk.*

FIG.

1. Actinal aspect; natural size. (Coll. Brit. Mus., E. 5055.)
  - a. Actinal aspect of portion of arm; magnified 4 diameters.

OPHIURA FITCHII, n. sp., *ex Forbes*, MS. (Page 103.)

*From the Flint Gravel.*

2. Actinal aspect, natural size. (Coll. Norwich Mus.)
  - a. Cast of actinal aspect in region of mouth; magnified 4 diameters.
  - b. Abactinal aspect; natural size.

OPHIURA SERRATA, *Roemer*. (Page 102.)

*From the Upper Chalk.*

3. Abactinal aspect; natural size. (Coll. Brit. Mus., E. 5043.)
  - a. Abactinal aspect of segment of disc and two arms; magnified 4 diameters.
  - b. Abactinal view of two isolated vertebral ossicles of another specimen; magnified 9 diameters. (Coll. Brit. Mus., E. 5046.)
  - c. Side view of the same ossicles; magnified 9 diameters.
  - d. Anterior view of the same ossicles; magnified 9 diameters.
  - e. Posterior view of the same ossicles; magnified 9 diameters.

OPHIURA PARVISENTUM, n. sp. (Page 103.)

*From the Upper Chalk.*

4. Abactinal aspect of type specimen; natural size. (Coll. Brit. Mus., E. 5052.)
  - a. Abactinal aspect of portion of one arm; magnified 6 diameters.

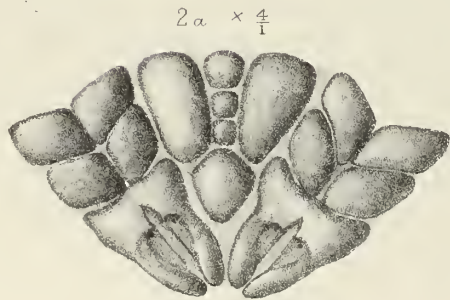
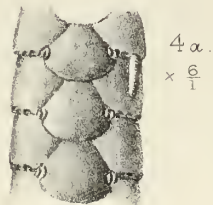
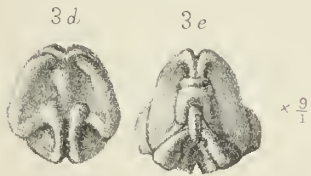
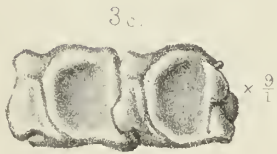
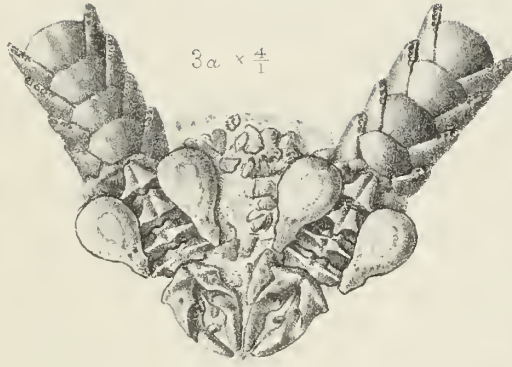
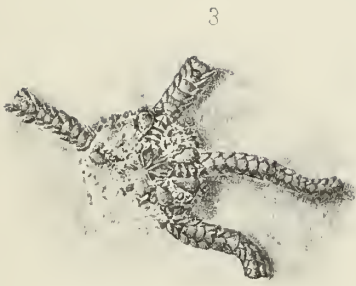






PLATE XXVIII.

OPIHOTITANOS TENUIS, n. sp. (Page 104.)

*From the Lower Chalk.*

FIG.

1. Abactinal aspect of type specimen; natural size. (Coll. Brit. Mus., E. 5056.)
  - a. Abactinal aspect of a segment of disc and two arms; magnified 8 diameters (slightly restored).
2. Actinal aspect of another example; natural size. (Coll. Brit. Mus., E. 5057.)
  - a. Actinal aspect of a segment of disc and two arms; magnified 8 diameters (slightly restored).

OPIHOTITANOS LEVIS, n. sp. (Page 105.)

*From the Lower Chalk.*

3. Abactinal aspect; natural size. (Coll. Brit. Mus., E. 5053.)
  - a. Abactinal aspect of a segment of disc and two arms; magnified 8 diameters (slightly restored).
4. Abactinal aspect of another small example. (Coll. Brit. Mus., E. 5058.)
  - a. Abactinal aspect of a segment of disc and one arm; magnified 10 diameters (slightly restored).

OPIHOTITANOS MAGNUS, n. sp. (Page 106.)

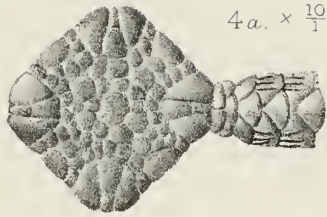
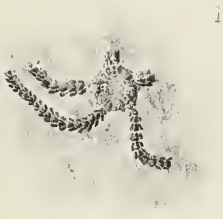
*From the Lower Chalk.*

5. Actinal aspect of type specimen; natural size. (Coll. Brit. Mus., E. 5060.)
  - a. Actinal aspect of portion of arm; magnified 4 diameters (slightly restored).

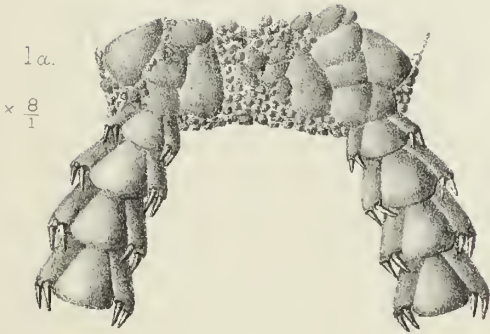
AMPHIURA CRETACEA, n. sp. (Page 107.)

*From the Lower Chalk.*

6. Actinal aspect of type specimen; natural size. (Coll. Brit. Mus., E. 5059.)
  - a. Actinal aspect of a segment of disc and two arms; magnified 10 diameters (slightly restored).



4a.  $\times \frac{10}{1}$

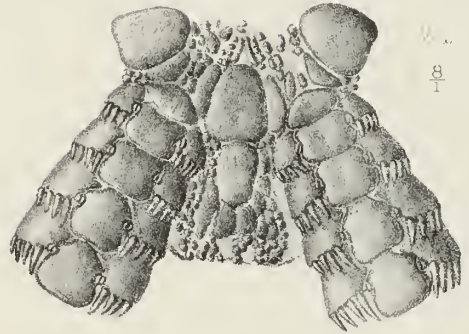


1a.

$\times \frac{10}{1}$



4.



3a.

$\times \frac{10}{1}$



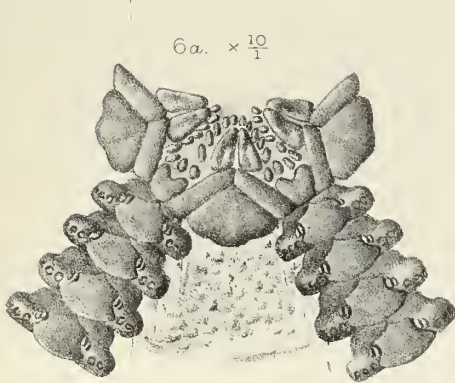
5.



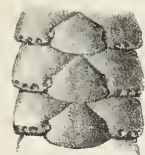
6.



3.



6a.  $\times \frac{10}{1}$



5a.

$\times \frac{4}{1}$



3a.

$\times \frac{10}{1}$





PLATE XXIX.

PYCINASTER CRASSUS, n. sp. (Page 96.)

*From the Upper Chalk.*

FIG.

1. Actinal aspect of a small specimen; natural size. (Coll. Brit. Mus., E. 2576.)
2. Abactinal aspect of surface of arm of type specimen; natural size. (Coll. Brit. Mus., 35498.)
  - a. Supero-marginal plate; magnified 3 diameters.
3. Supero-marginal plate; natural size. (Coll. Brit. Mus., E. 2631.)
  - a. Side view of same ossicle; natural size.
4. Isolated ventro-lateral plate; magnified 2 diameters. (Coll. Brit. Mus., E. 2632.)
  - a. Isolated plate from abactinal surface of disc; magnified 2 diameters.
5. Madreporite; natural size. (Coll. Brit. Mus., E. 2628.)

PYCINASTER SENONENSIS, *Valette*, sp. (Page 95.)

*From the Upper Chalk.*

6. Outer view of abactinal ossicle of disc; natural size. (Dr. Blackmore's Collection.)
  - a. Side view of same ossicle; natural size.

NYMPHASTER RUGOSUS, n. sp. (Page 94.)

*From the Lower Chalk.*

7. Actinal aspect; natural size. (Coll. Brit. Mus., 57516.)
  - a. Infero-marginal plate; magnified 6 diameters.

STAUANDERASTER ARGUS, n. sp. (Page 99.)

*From the Upper Chalk.*

8. Actinal aspect; natural size. (Dr. Blackmore's Collection.)
  - a. One of the ventro-lateral plates; magnified 2 diameters.
9. Inner view of three ossicles isolated from a specimen in the British Museum; figured by Forbes; magnified 2 diameters. E. 2566. [See also Plate XXV, fig. 6.]
  - a. Outer view of same ossicles; magnified 2 diameters.

ARTHRASTER CRISTATUS, n. sp. (Page 93.)

*From the Upper Chalk.*

10. Side view of segment of arm, restored; natural size. (Dr. Blackmore's Collection.)
  - a. Outer view of a radiale; magnified 4 diameters.
  - b. Side view of same ossicle; magnified 4 diameters.

ARTHRASTER DIXONI, *Forbes*, sp. (Page 91.)

*From the Upper Chalk.*

11. Ossicle from abactinal surface of disc; natural size. (Coll. Brit. Mus., E. 5024.)
  - a. The same ossicle; magnified 3 diameters.

METOPASTER CORNUTUS, *Sladen*, sp. (Page 117.)

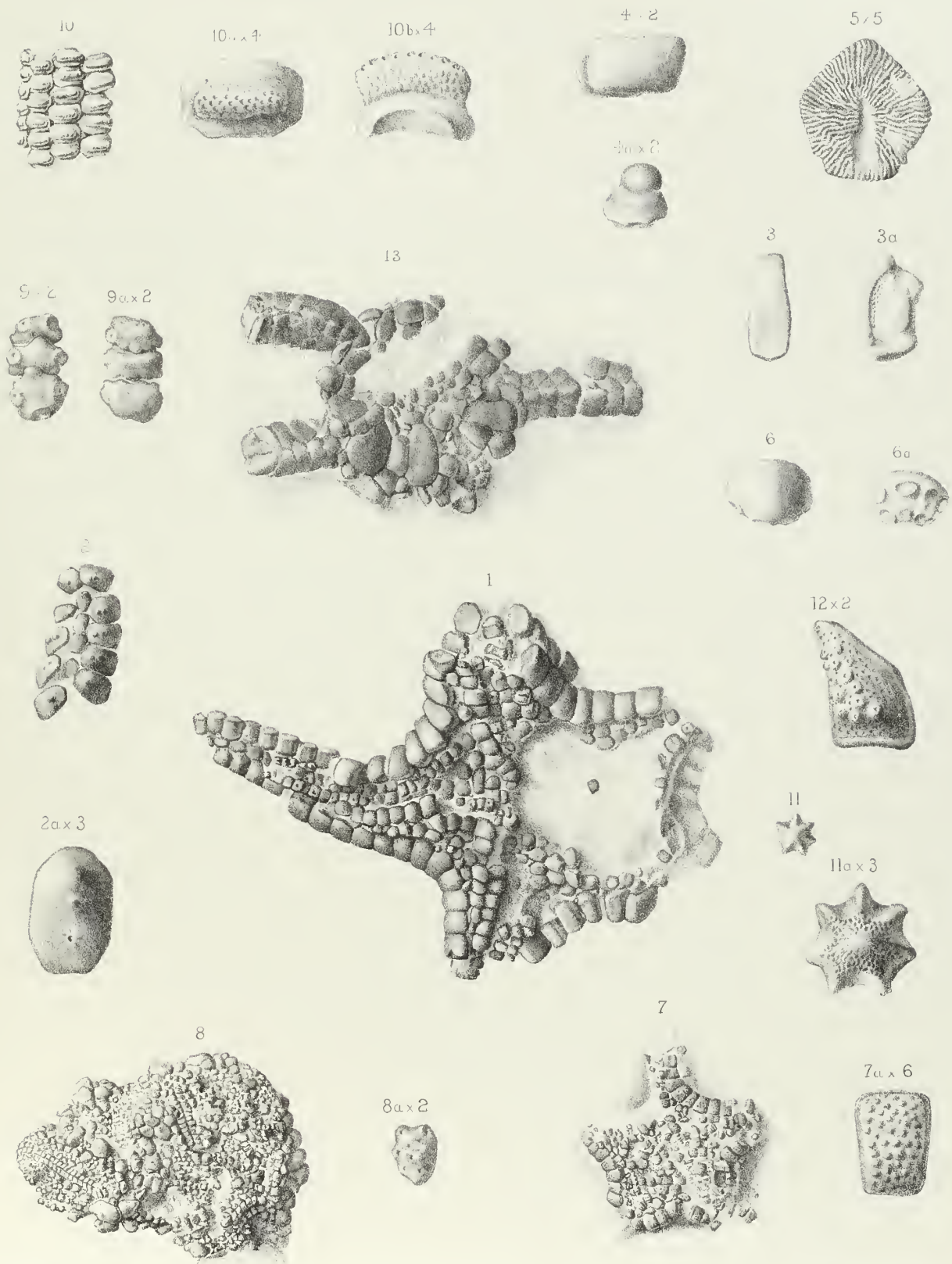
*From the Upper Chalk.*

12. Ultimate supero-marginal plate of adult specimen; magnified 2 diameters. (Dr. Rowe's Collection.)

OPHIOTITANOS MAGNUS, n. sp. (Page 106.)

*From the Lower Chalk.*

13. Abactinal aspect; magnified 2 diameters. (Coll. Sedgwick Mus., Cambridge.)



W. S. ... del. et lith.

W. S. ... del. et lith.

CRETACEOUS ASTEROIDEA



THE  
PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCLVII.

VOLUME FOR 1907.

LONDON

MDCCCVII.



A MONOGRAPH  
OF  
BRITISH CONULARIÆ.

BY  
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LONDON:  
PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.  
1907.

PRINTED BY ADLARD AND SON, LONDON AND DORKING.

# THE BRITISH CONULARIÆ.

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## INTRODUCTION.

THE interest attaching to the systematic position of the genus *Conularia*, together with the absence of a general account of the British species, induced me to undertake the work for this monograph, which has been carried out during the last two years at the Sedgwick Museum, Cambridge, and the British Museum (Natural History), London. During its progress I have examined specimens from the Geological Survey Collections in London, Edinburgh, and Dublin, from the British Museum (Natural History), from the Sedgwick Museum, Cambridge, from Mrs. Gray's Collection of Girvan Fossils, and from other sources. I also worked at the Vetenskaps-Akademi, Stockholm, where I was enabled, by the kindness of Professor Holm, to inspect a number of Swedish specimens and compare them with the British forms.

In conclusion I should like to express my best thanks to the officials of the museums in which I have worked for their unfailing courtesy and kindness, and especially to Mr. H. Woods, at whose suggestion I undertook the monograph, and who has given me the most valuable help and guidance throughout.

---

## HISTORY.

The first reference to *Conularia* is found in the 'History of Rutherglen and Kilbride,'<sup>1</sup> where the author refers to a "curious fossil," the class of which had not been determined. "The specimens are in casts of ironstone, sometimes found inclosed in ironstone like a nucleus." No locality is given, but the shell is figured. In 1818 Sowerby<sup>2</sup> gave a diagnosis of the genus *Conularia*, which "Mr. Miller, of Bristol, has very properly instituted for the reception of a four-sided fossil,

<sup>1</sup> Ure, 'History of Rutherglen and Kilbride' (1793), pp. 330, 331, pl. xx, fig. 7.

Sowerby, 'Min. Conch.,' vol. iii (1818), p. 107, pl. 260, figs. 1—6.

somewhat resembling an *Orthocera*, but furnished with imperforate septa, and an inflexion of the lip that nearly closes the mouth." He also described and figured two species, *C. quadrisulcata* and *C. teres*. The former was founded on specimens from "Transition Limestone" (fig. 4), "Bristol Limestone about the Hotwells" (fig. 5), "Transition Limestone that contains mica from near Keswick" (fig. 3), and "Tronhie Bank near Glasgow" (fig. 6), and is now known to include three different species, while the latter was doubted at the first by its author, and was soon afterwards recognised to be an *Orthoceras*.

In 1828 we find the species *C. sowerbyi* attributed by de Blainville<sup>1</sup> to Defrance, with a reference to the 'Dictionnaire des Sciences Naturelles.' De Blainville reproduced all Sowerby's six figures, and gave no description; as all attempts to find any account of *C. sowerbyi* in the 'Dictionnaire' have proved unsuccessful, Defrance's right to the species seems to be very doubtful.

In 1839 Sowerby<sup>2</sup> described and figured a Wenlock Limestone form under the original name, *C. quadrisulcata*, mentioning, however, that it might be found possible to separate this from the Carboniferous Limestone species, in which case Defrance's name should be adopted for the former. The next new species was found in Ireland, co. Tyrone, and was described and figured by Portlock<sup>3</sup> under the name *C. elongata*, together with two other species named respectively "*C. quadrisulcata*, Sow. var. *carb.*" and "*C. quadrisulcata*, Sow. var. *sil.*" The two figured specimens of the latter belong to two distinct species. The next important reference to the genus is in the 'Géologie de la Russie d'Europe,'<sup>4</sup> where de Verneuil, in the Palæontological Section, definitely restricted Sowerby's name, *C. quadrisulcata*, to the Carboniferous species and adopted Defrance's name, *C. sowerbyi*, for the Silurian species, distinguished by its greater size, compressed form and continuous transverse folds. The description is accompanied by a clear figure, and since this is the first time that the two forms are definitely separated and named, the species *C. sowerbyi* should be assigned to de Verneuil.

In 1847 Sandberger<sup>5</sup> published an important monograph on Palæozoic Pteropods, in which he described and figured fourteen species, including among them the three known British forms, but giving to them new and more descriptive names, which, however, have not been adopted. He also gave a general description of the genus, and a list of those characters upon which he based his specific distinctions. In 1855 M'Coy<sup>6</sup> attempted to clear up the confusion in nomencla-

<sup>1</sup> De Blainville, 'Malacol.' (1828), p. 377, pl. xiv, figs. 2 *c—e*.

<sup>2</sup> Sowerby in Murchison, 'Silur. Syst.' (1839), p. 627, pl. xii, fig. 22.

<sup>3</sup> Portlock, 'Report, Geol. Londonderry' (1843), p. 393, pl. xxix a.

<sup>4</sup> De Verneuil in Murchison, de Verneuil and de Keyserling, 'Géol. de la Russie d'Europe' (1845), vol. ii, "Paléont.," p. 348, pl. xxiv, fig. 5.

<sup>5</sup> F. Sandberger, "Pteropoda der ersten Erdbildungs-Epoche: Conularia und Coleoprion," 'Neues Jahrb. für Min., etc.,' 1847, p. 8.

<sup>6</sup> F. M'Coy in Sedgwick's 'Synops. Brit. Palæoz. Rocks' (1855), pp. 287, 520.

ture by substituting Sandberger's name, *C. cancellata*, for the *C. sowerbyi* of doubtful origin, and by restricting *C. quadrisulcata* to the Carboniferous species, as had already been done by de Verneuil. In the Appendix<sup>1</sup> to the same work Salter described and figured a new Upper Silurian species, *C. subtilis*, which is also referred to by M'Coy in the text. In 1866 Salter<sup>2</sup> described and figured four species, *C. lavigata*, *C. homfragi*, *C. margaritifera*, and *C. corium*. In 1867 the most important work upon this genus appeared in Barrande's 'Monograph of Palæozoic Pteropods,'<sup>3</sup> in which he described and figured twenty-seven Bohemian species, giving also a general account of the genus, details of structure, and the horizontal and vertical distribution. In 1873 Salter<sup>4</sup> catalogued, without description or figures, two new species in the Woodwardian Museum, Cambridge, under the names *C. clavus* and *C. bifasciata*. The former, belonging to the Fletcher Collection (reg. no. a. 878) is said to come from the Wenlock Limestone near Dudley, and was described and figured by Cowper Reed<sup>5</sup> in 1902. As, however, both in character and preservation, the fossil is identical with small specimens of *C. quadrisulcata* from the ironstone nodules of the Coal Measures, and is totally unlike any fossil I have seen from the Wenlock Limestone, I am of opinion that a wrong horizon has led to the institution of a false species, which must therefore be abandoned. With regard to *C. bifasciata*, also described and figured by Cowper Reed,<sup>5</sup> the species was unrecognisable from Salter's note, and the same form in Sweden was described and figured eleven years later by Lindström,<sup>6</sup> under the name *C. aspersa*; Lindström's name, and not Salter's, should therefore be adopted for the species. Another new species was added to the list in 1875 by Hicks,<sup>7</sup> who described and figured a somewhat doubtful form from the Lower Ordovician of South Wales under the name *C. llanvirnensis*. Three years later we find a reference by Etheridge<sup>8</sup> to some fragments of a new species from the Lower Carboniferous of Scotland, and these fragments undoubtedly belong to the new species, *C. tenuis*, described subsequently. In 1884, in the important monograph to which reference has already been made, Lindström described and figured five species from Gotland, and in 1893 Holm<sup>9</sup> completed the description of the Swedish members of the family. In addition to the description of nine new

<sup>1</sup> *Loc. cit.*, Appendix A, p. vi, and p. 287, pl. 1.L, fig. 24.

<sup>2</sup> J. W. Salter in Ramsay's 'Geol. North Wales,' Mem. Geol. Surv., vol. iii, ed. 1 (1866), pp. 354, 355; ed. 2 (1881), pp. 562, 563, pls. x, xi A.

<sup>3</sup> J. Barrande, 'Syst. Silur. du Centre de la Bohême' (1867), vol. iii.

<sup>4</sup> J. W. Salter, 'Catal. Cambr. and Silur. Foss. Geol. Mus. Cambr.' (1873), pp. 153, 171.

<sup>5</sup> F. R. C. Reed, 'Geol. Mag.' [4], vol. ix (1902), p. 123.

<sup>6</sup> G. Lindström, "Silur. Gastr. and Pterop. Gotland," 'K. Svenska Vet.-Akad. Handl.,' vol. xix, no. 6 (1884), pp. 39—47, pls. i, vii, xix.

<sup>7</sup> H. Hicks, 'Quart. Journ. Geol. Soc.,' vol. xxxi (1875), p. 189, pl. xi, figs. 5, 6.

<sup>8</sup> R. Etheridge, jun., 'Quart. Journ. Geol. Soc.,' vol. xxxiv (1878), p. 19.

<sup>9</sup> G. Holm, "Hyolithidæ och Conulariidæ," 'Sver. Geol. Undersök.' (1893), ser. C, no. 112.

species the author gave a complete list of the species known at the time with tables of vertical distribution in the different countries, and also made the first attempt at a natural classification.

### GENERAL MORPHOLOGY.

(1) *Form of the Shell.*—The shell is always in the form of a straight four-sided pyramid. The few cases among British species in which a slight curvature is seen, are probably due to accident. The tapering of the shell is generally uniform, though there are several exceptions in which the sides become nearly parallel towards the aperture while converging more rapidly in the apical portion, *e. g.* *C. subtilis* (Plate IV, fig. 8).

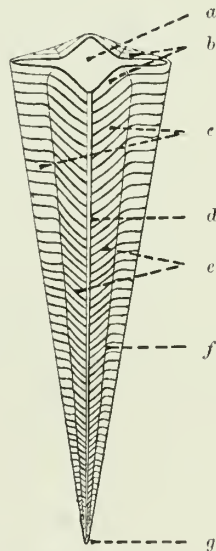


FIG. 1.—Diagram of *Conularia*. *a.* Aperture. *b.* Apertural lobes. *c.* Faces of the pyramid. *d.* Marginal groove. *e.* Transverse ridges. *f.* Facial groove. *g.* Apex.

(2) *Cross-Section.*—The section of the shell at right angles to the long axis varies considerably. Very frequently deformation has taken place, but is not easy to detect, as a square is converted to a rhomb, without any distortion in the shell itself. Hence the observed cross-section is often misleading, though there are certain characters in the ornamentation which throw light upon the natural form (see “Ornamentation,” p. 8).

In the majority of cases the transverse section is a square in which the sides are either straight lines as in *C. quadrisulcata* and *C. hispida* (Pl. III, fig. 10), or slightly convex curves as in *C. crassa* and *C. globosa* (Pl. IV, fig. 5, and Pl. III, fig. 7 *b*).

In a considerable number of cases the cross-section is in the form of a more or less flattened rhomb, in which :

- (i) The sides are straight or slightly concave throughout the length of the shell, *e. g.* *C. laevigata*.
- (ii) The straight lines are replaced towards the apex by convex curves, while the shorter axis becomes still more diminished, giving rise to a flattened ellipse or figure  $\infty$ , *e. g.* *C. sowerbyi*, *C. vesicularis* (Pl. V, fig. 4 *b*).
- (iii) The straight lines are replaced by convex curves throughout, giving rise to an ellipse, *e. g.* *C. complanata* (Pl. IV, fig. 13).

In one somewhat doubtful case the sides appear to be equal in pairs, giving rise to a rectangle, *e. g.* *C. punctata* (Pl. I, fig. 10 *b*).

(3) *Faces of the Pyramid*.—Except in the doubtful cases of *C. laevigata* and *C. punctata* among British species, the faces of the pyramids are equal, and similar elongated triangles, with surfaces either plane or with the modifications mentioned above. The apical angle of the face can frequently be measured, even when the specimen is very imperfect. It is usually found to have a fairly constant value for a species, and is therefore of considerable specific importance. It is not readily affected by compression of the shell, as is the case with the apical angle of the pyramid, hence the values given are generally reliable. When the shell tends to become prismatic towards the aperture, the angle of the face becomes correspondingly less.

(4) *Longitudinal Grooves and Ridges*.—The faces are separated from one another in all cases by straight, well-marked, longitudinal grooves, which run down the angles of the pyramid. These “marginal grooves” vary greatly in character, but are very constant for a species. In all the earliest forms they are smooth, deep, and with a tendency for the edges to become prominent, as in *C. coronata* (Pl. III, fig. 1 *a*) and *C. homfrayi*. In the later ornamented types the ornamentation of the faces may be continued across the grooves without change in direction, as in *C. sowerbyi* (Pl. V, fig. 10 *a*); or it may change its direction at the edges, and cease at the base, as in *C. quadrisulcata* (Pl. III, fig. 2); or it may cease abruptly at the edge, leaving a smooth groove, as in *C. brevicornuta* (Pl. V, fig. 13).

In shape also there are all stages, from a sharp, well-defined groove, such as is seen in *C. hispida* (Pl. III, fig. 9 *a*); to the wide, shallow undulation seen in *C. crassa* (Pl. IV, fig. 4 *a*).

On the surface of the face itself longitudinal grooves are sometimes seen. In the earlier smooth forms these “facial grooves” are constant, well marked, and frequently resemble the marginal grooves in having prominent, raised edges (*e. g.* *C. coronata*, Pl. III, fig. 1 *a*); but in most of the later species, if present at all, they appear as narrow depressions, or frequently as fine cracks, marking the line of weakness, along which the transverse ridges are bent. They are always central or

sub-central, according to the position of this bend. In *C. microscopica* (Pl. II, figs. 6, 7), they are unusually deep and constant. Secondary facial grooves, dividing again the half faces, are only seen in the early smooth forms.

In three species the centres of the faces are marked by fine, internal, longitudinal ridges, the internal septa of Lindström.<sup>1</sup> In British forms they are in pairs in *C. punctata* (Pl. I, figs. 10 *a*, 11) and *C. aspersa* (Pl. I, figs. 5, 6 *b*), and single in *C. tenuis* (Pl. II, fig. 2). They appear to be fine, biconvex ridges on the inner surface of the shell. As the result of compression, and owing to the thinness of the shell, in the two latter species they are often seen as raised ridges on the outer surface; in *C. aspersa* these ridges are usually accompanied by a black stain, probably indicating the position of some important anatomical structure (Pl. I, figs. 6 *b*, 9 *c*).

(5) *Aperture and Apex of Shell*.—The aperture of the shell is not commonly preserved, though many perfect examples are known, especially among specimens from ironstone concretions. Each face terminates in a roughly triangular lobe, on which the general ornamentation of the face is continued. Generally these lobes are short and rigid and bent down at right angles to the axis of the shell, partially closing the aperture, as in *C. quadrisulcata* and *C. sowerbyi* (Pl. III, fig. 6; Pl. V, fig. 8); but in *C. aspersa* they are long, and meet, forming an elevated cone (Pl. I, fig. 5); in this species the shell is very thin, and the apertural lobes were probably not rigid.

In the greater number of specimens the delicate apical portion of the shell is not preserved, but examples are found in some species where the pyramid tapers to a fine point. It is generally difficult to make out whether this end was closed or open; but in one species there seems good evidence that the latter state prevailed. *C. tenuis* is found in a good state of preservation in the hard, shaly Calciferous Sandstone of Glencartholm, Dumfriesshire, and on slabs of this rock examples are found in clusters, varying in number from two to as many as sixteen (Pl. II, fig. 1). The size of the individuals of the cluster varies, some being quite small and some full grown. They must have been connected with one another or with some foreign body by their apices, which must therefore have been pierced during some part of the life of the animal. I have found no trace of this fixed condition in any other species, nor have I found any reference to it in published works, except in a short article by Ruedemann,<sup>2</sup> entitled "Note on a Sessile Conularian." He describes this form as a typical Conularian, in which the delicate pyramid base is inserted in a chitinous cup, which by means of suction acted as a temporary organ of attachment. The attachment in the case of *C. tenuis* can hardly have been temporary, and from the size of the individuals must have been an adult character.

In a large number of species, instead of tapering to a fine point the pyramid is

<sup>1</sup> G. Lindström, 'Silur. Gastrop. Gotland,' p. 46.

<sup>2</sup> 'American Geologist,' vol. xvii (1896), p. 158.

found ending in a more or less convex septum, which Sowerby noticed as long ago as 1839 (*loc. cit.*), and which gave rise to the idea that the genus should be placed in the Cephalopods (Pl. V, figs. 12 *a*, 14 *a*). The septum consists of a very thin shell, which appears to be continuous with the inner layer of the test. It is quite unornamented, the striæ which are often seen parallel with the longer axis being probably due to compression (Pl. V, fig. 7 *b*). The position at which it is found varies considerably, for it is sometimes close to the apex, where it only measures about 10 mm. across, while in other cases, in specimens of about the same size, it has a length of 25 mm. or more. Probably, therefore, the apical part of the shell is divided up by a series of septa, of which only the lowest is usually seen. In the Birmingham University Museum, however, there is a specimen which shows a second septum arching away about 6 mm. above the first. The existence of a siphuncle in these septa has been suggested at various times by different writers,<sup>1</sup> but never with any great certainty. The septa are frequently much broken, but I have seen several perfect ones. On only one of these (Pl. V, fig. 1 *b*) have I observed anything like a siphuncle, and here, though the small central tube is very well defined, it appears to be closed, and may be an abortive survival of a once functional structure, or a scar left by the growth of the septum.

In all probability the chambers thus successively cut off at the apex remained quite empty, and the apical ones may even have been lost in the lifetime of the animal; after this had taken place the apical end of the shell must have been closed. But in some species, where the shell is exceptionally thin, septa appear to be unknown. Possibly in all these cases—certainly in *C. tenuis*—the shell remained open at the apex, and was fixed to some foreign body.

(6) *Orientation*.—In total ignorance of the nature of the soft parts of the animal, any distinction between dorsal and ventral sides must be merely an arbitrary one. Salter writes, in 1855<sup>2</sup>: “If we consider, as it seems to me we ought to do, that in this compressed species the two opposite angles of the flatter sides are the dorsal and ventral ones, we shall then, I think, have a character by which we may be able to trace these parts in the squarer species and in some which are probably compressed laterally. For I find that the line where the usual transverse ribs are bent or broken at about the middle of each lobe is not really in the middle in all cases, but is nearer the dorsal and ventral angles than the lateral ones; and again, the two lobes which form the dorsal side are sometimes wider than those two which form the ventral face.”

But this attempt at orientation seems to me to be of little value. The “squarer species” are, in all cases which I have observed, symmetrical, and as the

<sup>1</sup> Ruedemann, ‘American Geologist,’ vol. xviii (1896), p. 65; Sowerby, *loc. cit.* (1839); Hall, ‘Palæont. New York,’ vol. i (1847), p. 222, pl. lix, fig. 4 *e*.

<sup>2</sup> Sedgwick, ‘Synopsis of Brit. Palæoz. Rocks,’ Appendix A, p. v.

position of the shell in life was probably upright, it is difficult, without the soft parts, to distinguish dorsal and ventral sides. In describing the compressed forms I have used the terms "central" and "lateral" marginal grooves for the sake of convenience for expressing, respectively, those at the extremities of the short and long diameters of the cross-section.

(7) *Ornamentation*.—A small number of the earlier members of the genus have smooth shells, but the majority show a very delicate and beautiful ornamentation, differing greatly in different species, although usually constant for each species. Among British forms this ornamentation is essentially a transverse one, though in some foreign species a longitudinal direction prevails (*e. g.* *C. scalaris*, Holm).

Each face is typically crossed by a series of ridges, separated by furrows, and bent up regularly along a central or subcentral line, so as to form a succession of chevrons opening towards the apex. The angle of the chevron varies from  $180^\circ$  to little over  $90^\circ$ . Very usually the angle increases in size from the apex towards the aperture, but in any one species is fairly constant for the central part of the shell. The straight sides of the chevron may be replaced by simple or compound curves. The two sides of the chevron are symmetrical in those species having a square cross-section (Pl. III, fig. 9*a*), but where a compressed form is the natural one the ridges very frequently fall away more sharply to the lateral than to the central marginal grooves. With this character is often found a shifting of the points of the chevrons towards the central marginal groove (Pl. V, figs. 1*a*, 7*a*). These features often afford a clue to the natural cross-section, when the latter cannot be directly observed. The ridges vary in width from coarse bars, nearly 1 mm. wide, as seen in *C. crassa* (Pl. IV, fig. 4*a*), to the finest striæ, invisible except under the microscope, as in *C. microscopica* (Pl. II, fig. 9). In an individual example the ridges usually become finer and more crowded at the apex, and often again at the aperture, but for the centre of the shell a fairly constant spacing is maintained in any one species.

The details of ornamentation vary enormously. The ridges are sometimes quite smooth, but more frequently the summits are studded with fine tubercles, round, or less commonly elongated, triangular, etc. The tubercles may be prolonged as fine points on to the intervening furrow, as in *C. hispida* (Pl. III, figs. 9*b*, 11); or may be confined to the ridges, as in *C. globosa* (Pl. III, fig. 7*a*). In a considerable number of species a well-marked longitudinal striation is seen in the furrows between the ridges; this is usually finer than the main transverse ridging (Pl. V, figs. 2*a*, 12*b*).

In a few cases the transverse ridges are represented by rows of tubercles, arranged regularly across the shell, as in *C. aspersa* and *C. punctata* (Pl. I, figs. 7, 8*b*, 9*a*, 12*a*).

(8) *Structure of the Shell*.—The shell in the British species is always very thin, rarely exceeding 1 mm. in thickness, and often very much less. It appears to

have consisted essentially of some chitinous material, impregnated sometimes with a certain amount of lime. In the greater number of species the shell is made up of two distinct layers; the outer is usually dark-coloured, semi-transparent, and highly ornamented; the inner is of a paler colour, more opaque, thinner, and nearly smooth (Plate V, fig. 10 *b*). In such transverse sections as I have been able to obtain this division is not well marked, but the two layers are often clearly seen where the outer is partially flaked off. In some species where the shell is exceptionally thin it is apparently quite homogeneous. The structure of the shell is best seen in some specimens of *C. quadrisulcata* from the ironstone nodules of the Coal Measures.

(9) *Preservation of the Shell*.—The shells are preserved in limestones, sandstones, shales, slates, and ironstone nodules. They are always liable to compression, the result being in some cases actual contact between the upper and under faces. When the specimens are large they are seldom perfect, the apertural part being broken away more often even than the apical portion. Frequently also only one or two faces are preserved. Sometimes the different layers of the shell are seen in an excellent state of preservation, especially in specimens from the ironstone nodules; but more often the outer layer is considerably damaged, and along the summits of the ridges the shell may be entirely gone, little isolated portions remaining in the furrows (Pl. III, fig. 4 *b*). Lastly, in a large number of cases no shell is preserved, and the fossil is in the form of either an external or an internal cast.

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## DISTRIBUTION OF THE GENUS.

*Conularia*, though never really common, is found distributed through the British rocks from the Upper Cambrian to the Upper Carboniferous. During this period the maximum development was reached in Middle and Upper Ordovician and Silurian times, when twenty-two out of the thirty British species occurred. Above this horizon the number of species diminishes, five appearing in the Carboniferous rocks, only one of which survives in Upper Carboniferous times. Examples are found in the Budleigh Salterton Pebble Bed, but these are all derived. [See Table on p. 10.]

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## ZOOLOGICAL AFFINITIES.

The position in the animal kingdom in which the genus *Conularia* should be placed, has been a subject of contention from the time when Sowerby wrote, in 1821, that "it may perhaps belong to that family of Lamarek's order of shelly animals—'Crassipedes'—which inhabit tubes, and contains *Teredo* and some other tubiform shells, whose tubes are sometimes jointed."<sup>1</sup> Very soon after this, and

<sup>1</sup> Sowerby, 'Min. Conch.,' vol. iii (1821), p. 107.

TABLE OF DISTRIBUTION OF BRITISH SPECIES.

Species.	Tremadoc.	Ordovician.			Silurian.			Devonian.	Lower Carboniferous.	Upper Carboniferous.
		Arenig.	Llandeflo.	Bala.	Llandoverly.	Wenlock.	Ludlow.			
<i>Conularia homfrayi</i> , Salt. ....	×	..	..	..	..	..	..	..	..	..
.. <i>llanvirnensis</i> , Hicks .....	..	×	×	..	..	..	..	..	..	..
.. <i>corium</i> , Salt. ....	..	..	×	..	..	..	..	..	..	..
.. <i>linnarssoni</i> , Hohn. ....	..	..	×	..	..	..	..	..	..	..
.. sp. ( <i>margaritifera</i> ?) .....	..	..	×	..	..	..	..	..	..	..
.. <i>coronata</i> , n. sp. ....	..	..	×	..	..	..	..	..	..	..
.. sp. ....	..	..	×	..	..	..	..	..	..	..
.. sp. ....	..	..	×	..	..	..	..	..	..	..
.. <i>elongata</i> , Portl. ....	..	..	..	×	..	..	..	..	..	..
.. <i>lævigata</i> , Salt. ....	..	..	..	×	..	..	..	..	..	..
.. <i>plicata</i> , n. sp. ....	..	..	..	×	..	..	..	..	..	..
.. <i>planiseptata</i> , n. sp. ....	..	..	..	×	×	..	..	..	..	..
.. <i>reticularis</i> , n. sp. ....	..	..	..	×	..	..	..	..	..	..
.. <i>hispida</i> , n. sp. ....	..	..	..	×	..	×	..	..	..	..
.. sp., cf. <i>aspera</i> .....	..	..	..	×	..	..	..	..	..	..
.. <i>punctata</i> , n. sp. ....	..	..	..	..	×	..	..	..	..	..
.. <i>soverbyi</i> , de Vern. ....	..	..	..	×	×	×	..	..	..	..
.. <i>breviconveta</i> , n. sp. ....	..	..	..	..	..	×	..	..	..	..
.. <i>triangularis</i> , n. sp. ....	..	..	..	..	..	×	..	..	..	..
.. <i>crassa</i> , n. sp. ....	..	..	..	..	..	×	..	..	..	..
.. <i>microscopica</i> , n. sp. ....	..	..	..	..	..	×	..	..	..	..
.. sp. ....	..	..	..	..	..	×	..	..	..	..
.. <i>aspera</i> , Lindstr. ....	..	..	..	..	..	..	×	..	..	..
.. <i>subtilis</i> , Salt. ....	..	..	..	..	..	..	×	..	..	..
.. <i>hastata</i> , n. sp. ....	..	..	..	..	..	..	×	..	..	..
.. <i>deftericosta</i> , Sandb. ? .....	..	..	..	..	..	..	..	×	..	..
.. <i>quadrisulcata</i> , Sow. ....	..	..	..	..	..	..	..	×	×	×
.. <i>complanata</i> , n. sp. ....	..	..	..	..	..	..	..	?	×	..
.. <i>elegans</i> , n. sp. ....	..	..	..	..	..	..	..	..	×	..
.. <i>tenuis</i> , n. sp. ....	..	..	..	..	..	..	..	..	×	..
.. <i>globosa</i> , n. sp. ....	..	..	..	..	..	..	..	..	×	..

until 1842, the genus was generally associated with the Cephalopods, but in that year the Pteropodian nature of the shell was suggested by d'Archiac and de Verneuil,<sup>1</sup> although no reasons were given for this opinion. From that time forward we generally find *Conularia* styled a "Palæozoic Pteropod," de Koninck, Sandberger, Brom, Roemer, d'Orbigny, M'Coy, Eichwald, Barrande, and most other writers adopting this view. A few authors—Portlock, Geinitz, and Dana—still retained *Conularia* among the Cephalopods, Dana considering it to be the shell of a Dibranh Cephalopod. The question was not, however, allowed to rest for long. Opponents to the Pteropodian theory soon appeared: Haeckel<sup>2</sup> considered it most improbable, and Dr. M. Neumayr<sup>3</sup> refuted it in the strongest terms. He expressed the greatest

<sup>1</sup> 'Trans. Geol. Soc.,' [2], vol. vi, p. 325.

<sup>2</sup> E. Haeckel, 'Morphologie,' vol. ii, p. 113.

<sup>3</sup> M. Neumayr, "Zur Kenntniss der Fauna des untersten Lias in den Nordalpen," 'Abhandl. k. k. geol. Reichsanst.,' vol. vii, pt. 5 (1874), p. 18.

surprise that a theory, not possessing even the appearance of probability, should have been accepted as a fact without any kind of proof. He considered the determination of the systematic position of *Conularia* to be a matter of great difficulty, but suggested that it is most probably allied to the Palæozoic Capulidæ.

In 1881 von Ihering<sup>1</sup> placed *Conularia* with the other so-called Palæozoic Pteropods in the class with which it was first associated. He considered that these simple chambered shells constitute the earliest and most primitive group of Cephalopods, allied to the Orthoceratidæ, and named by him, on account of the thinness of the shell, "Leptoceratiten." From this group, according to von Ihering, arise on the one side the Tetrabranchs as a small offshoot, and on the other the Dibbranchs (in which he included the Ammonites) as the main branch.

Lindström,<sup>2</sup> in 1884, criticised these conclusions. He stated that in his opinion the external similarity of some species of *Clio* (or *Cliodora*) to a Conularian shell was most striking; that the internal longitudinal septa found in a few species (*e. g. C. aspersa*) were homologous to similar structures found in *Clio*, *Styliola*, etc.; that the typical ornamentation of a Conularian was approached in some species of *Clio*; and finally, that among living Pteropods forms differed sufficiently widely to make any discussion of close correspondence unnecessary. He therefore retained the genus with the Pteropods.

In 1889 Pelseneer<sup>3</sup> endeavoured to prove that the "Prétendus Ptéropodes Primaires" had no connection with the modern Pteropods. He based his conclusions on: (1) The form and character of the Conularian shell, and (2) the probable origin of the Pteropods. Although his arguments were answered, each in turn, by C. Wiman<sup>4</sup> in 1894, it appears to me that his deductions as to the affinities of modern Pteropods cannot be refuted.<sup>5</sup>

After prolonged study Pelseneer has come to the conclusion that the Pteropods are not a primitive, but a highly specialised group, derived from two different sources: (1) the Thecosomatous Pteropods (with which *Conularia* was associated) from Bulloidea-like Opisthobranchs, and (2) the Gymnosomatous Pteropods from Aplysioidea-like Opisthobranchs.

The evidence for the highly specialised nature of the Pteropods is seen in their marked asymmetry, and the great concentration of their nervous system; and in their embryology. As the embryo is even more asymmetrical than the adult, they must be derived from ancestors already highly specialised, and the apparent symmetry is acquired by adaptation to natatory habits.

<sup>1</sup> H. von Ihering, 'Neues Jahrb. für Min., etc.' (1881), vol. i, p. 87.

<sup>2</sup> G. Lindström, 'Silur. Gastrop. and Pterop. of Gotland' (1884), pp. 39, 40.

<sup>3</sup> P. Pelseneer, 'Bull. Soc. Belge de Géol., etc.,' vol. iii (1889), Mem., pp. 126—136.

<sup>4</sup> C. Wiman, 'Bull. Geol. Inst. Upsala,' vol. ii (1895), pp. 114—116.

<sup>5</sup> See also Pelseneer, 'Rep. Challenger Expedition,' vol. xxiii, pt. iii (Anatomy), pp. 75—96.

Pelseneer, therefore, has given up entirely the use of the term "Pteropoda"<sup>1</sup> in zoological nomenclature, and has included the three families of "Thecosomatous Pteropods," with a number of other Gastropod families, in his *Tribe* Bullomorpha, *Sub-order* Tectibranchiata, *Order* Opisthobranchiata.

This consignment of the Pteropods to the Opisthobranch Gastropods (themselves highly specialised members of the class) makes it impossible to regard them as a primitive group represented in the earliest Palaeozoic rocks. It appears, therefore, that on zoological evidence the inclusion of *Conularia* among the Pteropods must be abandoned.

But the conclusion that *Conularia* is not a Pteropod, does little to facilitate the assignment to its natural position. In considering the question attention may be drawn to the following characters of the shell, which appear to be beyond doubt :

- (1) The shell in many cases reached a length of between 100 and 200 mm.
- (2) The shell was in most cases very thin, and usually consisted of at least two distinct layers.
- (3) In at least one species the apical end of the shell was open, and organic attachment to foreign bodies was thus effected.
- (4) In the larger number of species the apical part of the shell was divided up by thin imperforate septa, and the sharply pointed apex was very probably cast during lifetime.
- (5) The aperture of the shell was partially closed by infolding lobes.

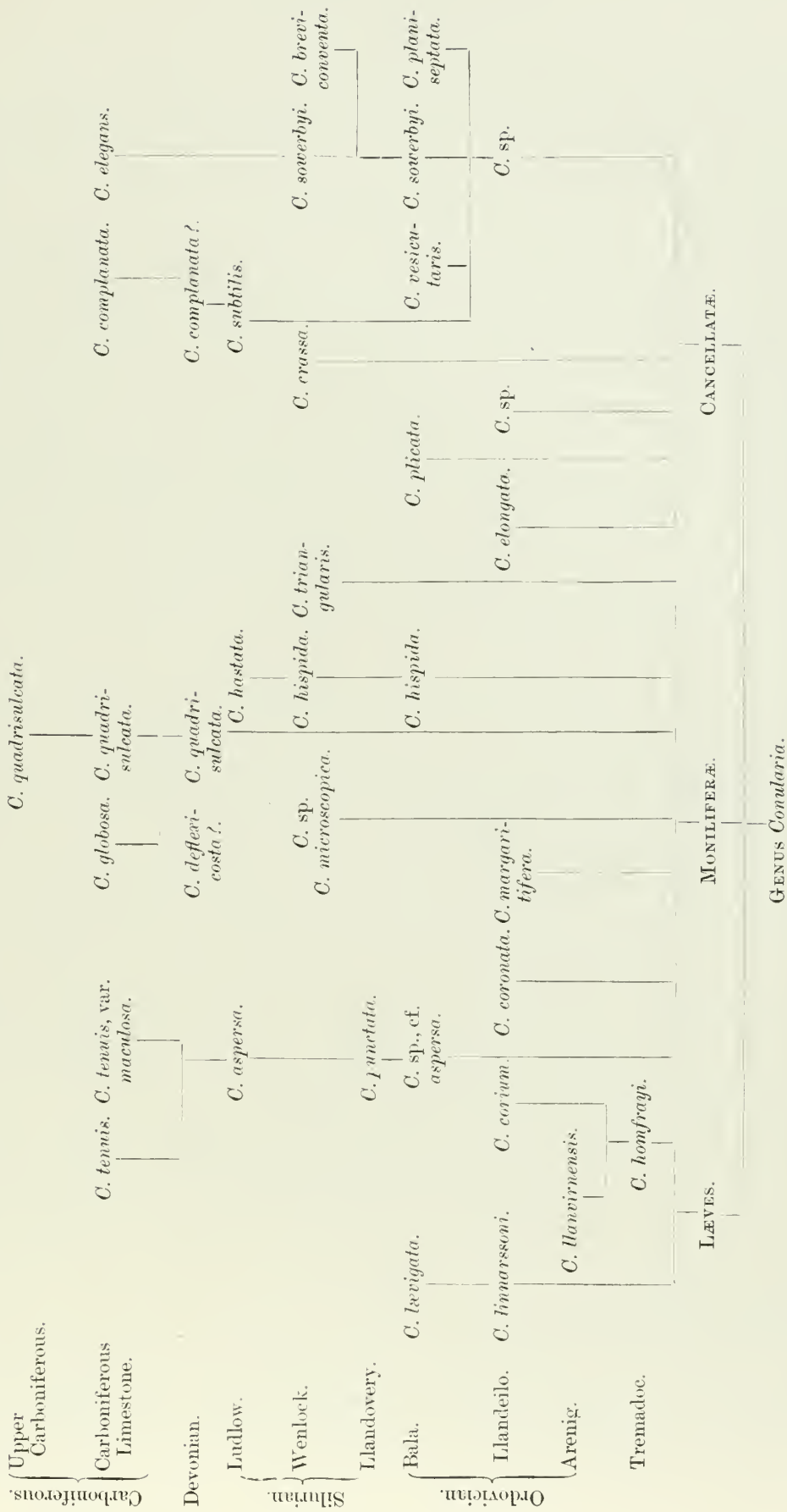
These peculiar and varied characters seem to indicate that *Conularia* is a Mollusc, but do not point to a close relationship with any of the main groups. It appears to resemble the primitive Cephalopods more closely than any other forms, and perhaps we should follow von Ihering in placing the genus in this group. But the differences between it and the earliest Orthoceratidæ are so great that I should prefer to regard *Conularia* as a member of an extinct group, equivalent to the Cephalopods, and derived with them from the same simple shelled ancestor.

## CLASSIFICATION.

I have adopted Holm's method of classification as being useful, although perhaps it is not of much value phylogenetically. The method is not altogether satisfactory, as in following it some species which are probably closely allied appear in altogether different sections. For instance, *C. elongata*, in the broad, rounded, and horizontal transverse ridges, resembles *C. linnarssoni*, but by virtue of the sharper definition of these and the fine longitudinal ornamentation it must be placed with the *Cancellatæ*, not with *Lares*. Again, no hard and fast line can be drawn between the *Moniliferæ* and the *Cancellatæ*, *C. crassa*, *C. plicata*, etc., forming a transition between the two. Holm's section, *Longitudinales*, is unrepresented in British rocks.

<sup>1</sup> E. R. Lankester, 'Treatise on Zoology,' pt. v, Mollusca by Pelseneer (1906).

TABLE OF DISTRIBUTION OF BRITISH SPECIES OF CONULARIA ARRANGED ACCORDING TO HOLM'S CLASSIFICATION.



GENUS *Conularia*.

## SYSTEMATIC ACCOUNT OF BRITISH SPECIES.

*Family* CONULARIIDÆ.*Genus* **CONULARIA**, Sowerby 1818 [ex Miller MS.]

*Diagnosis*.—Shell a four-sided, elongated pyramid—nearly always straight. Cross-section a square, rhomb, rectangle or rhomboid, or the corresponding figures where the straight lines are replaced by curves. Faces of the pyramid flat, convex or concave; all equal or equal only in opposite pairs. Angles of the pyramid marked by straight grooves. Aperture partially closed by infolding lobes, apex sharply tapering; apical part of shell divided up into a few compartments by thin convex, probably imperforate septa. Shell smooth, or ornamented with a series of ridges, sometimes longitudinal, more often transverse. Shell very thin, formed of chitin, more or less impregnated with lime.

*Section I.—LÆVES.*

Shell without transverse ornamentation, except growth-lines.

(A) Shell large, very thin; marginal and facial grooves well marked; growth-lines irregular and often imperceptible.

(i) Shell smooth, except for a single ridge down the centre of the face.

*C. llanvirnensis*, Hicks.

(ii) Shell with a well-marked central facial groove, flanked by two very faint secondary grooves; tapering of shell very gradual.

*C. corium*, Salter.

(iii) Marginal and central facial grooves bounded by prominent edges; tapering of shell more rapid.

*C. homfrayi*, Salter.

(B) Shell small; growth-lines strongly marked.

(i) Marginal and central facial grooves strongly marked and usually with prominent edges. Growth-lines horizontal. *C. linnarssoni*, Holm.

(ii) Facial grooves absent; growth-lines gently arched across the face.

*C. lavigata*, Salter.

**Conularia llanvirnensis**, Hicks.

1875. *Conularia llanvirnensis*, H. Hicks, Quart. Journ. Geol. Soc., vol. xxxi, p. 189, pl. xi, figs. 5, 6.

*Diagnosis*.—Shell large, very thin, tapering uniformly; cross-section unknown. Faces flat, apical angle of face 5°—6°. Marginal groove unknown; strong central

ridge (?). Aperture unknown; apex pointed; apical septa unknown. Ornamentation absent; lines of growth indistinct.

*Dimensions*.—Length 150—180 mm. Width of face 30 mm.

*Description*.—This shell is found in a bad state of preservation in the Upper Arenig and Lower Llandeilo rocks of South Wales. It seems to be of a somewhat doubtful nature. The “strong central ridge,” mentioned by Hicks, is only occasionally seen, and then appears to be merely a line of weakness, along which the shell has yielded. There seem, indeed, to be few characters in proof of its generic position, and those features by which it is distinguished from *C. corium* are of a negative kind. However, until better specimens are obtained, which may prove or disprove its right to specific distinction, I have retained *C. llanvirnensis* as a separate species.

*Horizon and Locality*.—Upper Arenig: Llanvirn.

*Type*.—Sedgwick Museum, Cambridge (reg. nos. 19, 20).

### **Conularia corium**, Salter.

1866. *Conularia corium*, J. W. Salter, in Ramsay's Geol. N. Wales, Mem. Geol. Surv., vol. iii, ed. 1, p. 355, pl. xi A, fig. 11 (also ed. 2, 1881, p. 563).

*Diagnosis*.—Shell large, very thin, tapering uniformly; cross-section unknown. Faces equal, slightly convex apically, concave aperturally; apical angle  $4^{\circ}$ — $5^{\circ}$ . Marginal grooves narrow and straight, tending to become prominent towards the aperture. Central facial grooves well marked; secondary grooves on either side faint, converging slowly. Aperture, apex, and apical septa unknown. Ornamentation absent.

*Dimensions*.—Length about 250 mm. (?) Width of face over 30 mm.

*Description*.—This species was described by Salter in 1866, and still at the present time very few examples are known. Hence little can be added to his description. No specimen that I have seen, is nearly perfect, and all are badly preserved. The secondary facial grooves, about 7 mm. apart at the apertural end, slowly approach one another towards the apex. They are very faint along their whole course, and die away before reaching the apex.

*Affinities*.—Salter compared this species with *C. pyramidata* of the May Sandstone (Ordovician), but it differs from this in having the faces equal, a smaller apical angle, and a smooth shell. Of British species, it is undoubtedly closely allied to *C. homfrayi*, from which it is distinguished by the slow rate of tapering and the simple nature of the marginal and central grooves.

*Horizon and Locality*.—Lower Llandeilo; Tyobry, Penrhyn.

*Type*.—Museum of Practical Geology (reg. nos. 16173, 16174).

**Conularia homfrayi**, Salter.

1866. *Conularia homfrayi*, J. W. Salter, in Ramsay's Geol. N. Wales, Mem. Geol. Surv., vol. iii, ed. 1, p. 354, pl. x, figs. 11—13 (also ed. 2, 1881, p. 562).

*Diagnosis*.—Shell large, thin, tapering uniformly; cross-section unknown. Faces flat, apical angle  $7^{\circ}$ — $10^{\circ}$  (?). Marginal grooves well marked, edges prominent. Central facial grooves strong, with prominent edges, and flanked by faint secondary grooves. Aperture imperfectly preserved, lobes apparently blunt and not inflected; apex sharply pointed; septa unknown. Ornamentation absent.

*Dimensions*.—Length 110 mm. Width of face 25 mm.

*Description*.—This species is represented by fairly numerous examples, but most are fragmentary and imperfectly preserved. The rocks in which they occur have usually undergone cleavage, and the fossils are sometimes broadened and sometimes greatly drawn out, so that the apical angle of the face cannot be relied on as representing the true angle. The facial ridges and grooves are also difficult to make out for the same reason. The central groove is quite definite, and there appears to be a faint groove close to it on each side.

*Affinities*.—This, the earliest of British *Conularia*, is most nearly allied to *C. corium*, which is found at a slightly higher horizon. It is distinguished from the latter by its smaller size, more rapid tapering, and by the raised edges of the marginal and central grooves.

*Horizon and Localities*.—Upper Tremadoc: Garth Hill; Tu-hwnt-yr-bwlech; etc.

*Type*.—Sedgwick Museum, Cambridge (reg. no. 7).

**Conularia linnarssoni**, Holm. Plate I, figs. 1—4.

1843. *Conularia quadrisulcata*, var. Silurian, J. Portlock, Rept. Geol. Londonderry, p. 393, pl. xxix a, fig. 3.

1893. *Conularia linnarssoni*, G. Holm, Hyolithidæ och Conulariidæ, p. 130, pl. iv, figs. 38—40.

*Diagnosis*.—Shell small, tapering uniformly; cross section-square. Faces equal, flat, apical angle  $16^{\circ}$ — $20^{\circ}$ . Marginal grooves well marked, base rounded, edges smooth and prominent. Facial grooves strong, central; edges sometimes prominent. Aperture unknown; apex sharply pointed; apical septa unknown. Ornamentation absent. Growth-lines strongly marked, regular, horizontal, ending abruptly on either side of the marginal groove, leaving a smooth edge; at the central grooves replaced by fine striæ, bent down towards the apex, and meeting at an angle at base of the groove. Occasionally the growth-lines are hardly visible, and the shell is then quite smooth.

*Dimensions*.—Length, 50—60 mm. Width of face, 15 mm.

*Description*.—This species was instituted by Holm for the reception of a small specimen from the Chasmopskalk (= Llandeilo) of Ålleberg, Vestergötland. Its existence in Britain has not, until now, been recorded, but there are nearly thirty examples in Mrs. Gray's Girvan Collection. Portlock's *C. quadrisulcata*, var. Silurian (Mus. Praet. Geol., reg. no. 12645), is also, undoubtedly, an example of this species, which is therefore represented in both Scotland and Ireland.

Some of the Scottish specimens are quite well preserved; most are flattened, but one (Pl. I, fig. 1), shows approximately a square cross-section, and this is probably the natural form, though Holm's type from Ålleberg is slightly compressed. In the latter specimen also there appears to be a slight inequality between the pairs of faces, but this is not noticeable in the British forms. In close juxtaposition with the examples from Craighead there occur, in more than one case, rods covered with a shell exactly similar to that of the *Conularia*, and tapering from a width of 3 mm. to that of 1 mm. I have seen none actually attached to the *Conularia*, but I think it highly probable that they constitute the apical end of the shell, which was drawn out to a considerable length, and was probably attached to some foreign substance. The longest has a length of 25 mm.

*Affinities*.—This species is quite different from any other British form. It resembles, in some characters, the Swedish *C. larvis* (Lindström), but is readily distinguished by the horizontal growth-lines.

*Horizon and Locality*.—Llandeilo: Craighead, Ardmillan, and Baleletchie, Girvan. Lower Silurian: Desertcreat, Co. Tyrone.

*Type*.—Geological Survey Collection, Stockholm.

### **Conularia lævigata, Salter.**

1866. *Conularia lævigata*, J. W. Salter, in Ramsay's Geol. N. Wales, Mem. Geol. Surv., vol. iii, ed. 1, p. 354, woodc. 19 (also ed. 2, 1881, p. 562).

*Diagnosis*.—Shell small, tapering uniformly; cross-section rhombic (?). The faces meeting at one acute angle slightly smaller than the other pair; slightly convex apically and concave aperturally; apical angle  $7^{\circ}$ — $8^{\circ}$ . Marginal grooves shallow, rounded; facial grooves absent. Aperture, apex, and apical septa unknown. Ornamentation absent, except for gently curved irregular lines of growth.

*Dimensions*.—Length 40—50 mm. Width of face 14—15 mm.

*Description*.—Only the type specimen of this species is known. It is somewhat doubtful whether the inequality of the sides referred to by Salter is not due to accident, and the course of the growth-lines (*i. e.* rising to a maximum at the angle where the smaller sides meet) may also be a secondary character.

*Affinities*.—This species differs from the other smooth types in the absence of

facial grooves and in the course of the growth-lines. It is possible, in the absence of any other examples, that the specimen should be regarded as an ornamented shell, which is smooth as the result of bad preservation.

*Horizon and Locality.*—Caradoc: Llwyn-yr-hwch, Beddgelert, N. Wales.

*Type.*—Museum of Practical Geology (reg. no. 12657).

*Section II.—MONILIFERÆ.*

Ornamentation consisting exclusively of transverse ridges or of tubercles arranged in transverse rows, without finer longitudinal ridges.

(A) Internal raised longitudinal ribs ("septa" of Lindström, *loc. cit.*) present down the centre of each face.

(a) Ornamentation extremely fine; hardly visible without a lens.

(i) Septa in pairs down the centre of each face. Faces equal.  
Tubercles round and distinct. *C. aspersa*, Lindström.

(ii) Septa in pairs down the centre of each face. Faces equal in opposite pairs. Tubercles more or less confluent in longitudinal rows. *C. punctata*, sp. nov.

(iii) Septa in pairs down the centre of each face, and also singly at the angles of the pyramid (?). *C. sp. cf. aspersa*.

(b) Ornamentation coarse. Septa singly down the centre of each face.

(i) Transverse ridges quite smooth. *C. tenuis*, sp. nov.

(ii) Ridges finely tuberculated. *C. tenuis*, var. *maculosa*.

(B) No internal longitudinal ribs present.

(a) Ornamentation very fine, just visible to the naked eye or only visible with a lens.

(†) Marginal and facial grooves with prominent edges.

(i) Shell large; ridges fine and regular, festooned across each half face. *C. coronata*, sp. nov.

(ii) Shell small; ridges form a sigmoidal curve from the facial groove down to the marginal groove.

*C. sp. (margaritifera ?)*.

(++) Marginal and facial grooves simple.

(i) Shell small; ornamentation only seen under microscope.

*C. microscopica*, sp. nov.

(ii) Shell small; ornamentation just visible to naked eye.

*C. sp.*

(b) Ornamentation visible to naked eye.

(†) Tubercles round; confined to the ridges.

(i) Ridges coarse, turning up at an angle in the marginal grooves; faces flat. *C. quadrisulcata*, Sowerby.

- (ii) Ridges fine, turning up at an angle in the marginal groove, and curving across the face. *C. deflexicosta*, Sandberger.
- (iii) Ridges fine and closely packed; faces convex.

*C. globosa*, sp. nov.

(††) Tubercles prolonged as sharp projections on to the furrow above.

(i) Tubercles oval; projections fine, curving, hair-like, and irregular in length. *C. hispida*, sp. nov.

(ii) Tubercles short, blunt, triangular. Ridges fine, and closely packed. *C. triangularis*, sp. nov.

(iii) Tubercles prolonged upwards as sharp, straight lamellæ, extending nearly across the furrow.

*C. hastata*, sp. nov.

**Conularia aspersa**, Lindström. Plate I, figs. 5—9.

1873. *Conularia bifasciata*, J. W. Salter, Catal. Cambr. Silur. Foss. Woodw. Mus., p. 171 (*a.* 926).

1884. *Conularia aspersa*, G. Lindström, Silur. Gastrop. Gotland, p. 46.

1902. *Conularia bifasciata*, F. R. C. Reed, Geol. Mag. [4], vol. ix, p. 123.

*Diagnosis*.—Shell large, very thin; tapering uniformly. Cross-section probably square. Faces equal, flat; apical angle about 20°. Marginal grooves shallow, inconspicuous; central facial groove faint and inconstant, flanked by a pair of fine internal ribs, converging from 3 mm. to less than .25 mm. at the apex, marked on the exterior by fine black lines. Aperture nearly closed by four triangular lobes, forming an elevated cone; apex sharply pointed; apical septa unknown. Ornamentation inconspicuous; ridges fine, closely packed (40—100 in 5 mm.); arched gently across each face, meeting at a wide angle and without break in the marginal grooves and undisturbed by the central ribs; studded with small round tubercles. Furrows smooth. Growth-lines follow the course of the ridges.

*Dimensions*.—Length at least 120 mm. Width of face, 35 mm.

*Description*.—The British species, which is common in the Lower Ludlow Flags of Shropshire, is undoubtedly the same as the species from Gotland described by Lindström (Pl. I. fig. 8 *a*). I have examined a large number of the Swedish forms, and find that they are quite indistinguishable from the British specimens, except for the fact that as a rule the ornamentation is better preserved. Salter's name, *bifasciata*, is the earlier, but in the 'Catal. Cambr. and Silur. Foss.' no description or figure is given, so that it can only be regarded as a MS. name and Lindström's name, *aspersa*, must be adopted.

The "internal septa" of Lindström are well seen in almost every example,

appearing either as black lines, flush with the surface, or as shelly ridges, rendered prominent on the outside by the compression of the shell. Often the shell is entirely flattened, so that the "septa" from the under faces are seen through the shell of the upper face (Pl. I, fig. 6 *a*).

The ornamentation varies considerably, both in coarseness and in the arrangement of the tubercles. The transverse ridges may be only about 40 per 5 mm., or may be as many as 100. Again the same variety in arrangement is seen as is described by Lindström for *C. bilineata*—*i. e.* the tubercles are sometimes close together, forming a very definite tubereulated ridge (Pl. I, fig. 6 *c*), while in other cases they are about equally spaced, laterally and vertically, and the actual ridges are hardly seen (Pl. I, fig. 7); again, in the same specimen the tubercles are sometimes round, sometimes distinctly elongated (Pl. I, fig. 9 *c*).

*Affinities.*—This species, together with *C. punctata* and *C. sp. cf. aspersa*, form a well-defined group, characterised by the presence of the paired "septa." They are readily distinguished by this from all other forms, and are possibly related to *C. tenuis* from the Carboniferous rocks, which shows the single central "septum." The type of ornamentation is that seen in *C. exquisita*, Barrande.

*Horizon and Locality.*—Lower Ludlow Shales: Church Hill, Leintwardine; Bow Bridge, etc. Silurian: Gotland.

*Type.*—Vetenskaps Akademi, Stockholm.

### **Conularia punctata**, sp. nov. Plate I, figs. 10—12.

*Diagnosis.*—Shell of medium size, moderately thick, tapering uniformly. Cross-section oblong, with the shorter diameter four-fifths of the longer. Faces equal in pairs, flat; apical angles about 14° and 10° respectively (?). Marginal grooves wide and shallow; centre of face marked by a pair of internal ribs converging towards the apex. Aperture, apex, and apical septa unknown. Ornamentation inconspicuous; ridges fine, closely packed (40 in 5 mm. in adult shell), arched across the face, and undisturbed by the central ribs; studded with small tubercles which tend to blend with those above and below, giving rise to vertical as well as transverse striation. Furrows very narrow.

*Dimensions.*—Length of one incomplete portion, 50 mm. Width of face, 32 mm.

*Description.*—There are only four examples of this species, all in Mrs. Gray's collection of Girvan fossils, and none are perfect. One small example (Pl. I, fig. 10 *a*) shows four faces at right angles to one another, and one pair appear to be distinctly shorter than the other pair (Pl. I, fig. 10 *b*). This is the only specimen in which the cross-section can be directly ascertained, and this may be misleading, as the preservation is not good. The longitudinal "septa" are well seen, both as black lines on the exterior (Pl. I, fig. 10 *a*), and as projecting ribs on the inner face (Pl. I, fig. 11). They appear to be solid cores between the two

layers of the shell, ridging up the inner layer only (Pl. I, fig. 11). The ornamentation appears to be almost intermediate between that of *C. aspersa*, Lindström, and that of *C. curta*, Sandberger. In the young shell the longitudinal ridges are almost stronger than the transverse (Pl. I, fig. 10 *c*), but in the adult both are equally strong (Pl. I, figs. 12 *a*, 12 *b*). The furrows are only fine grooves between neighbouring ridges. The shell is fairly thick, and consists of two distinct layers.

*Affinities*.—This species is closely related to *C. sp. cf. aspersa* from the Bala, and to *C. aspersa* from the Ludlow. It is distinguished from both by the form of the transverse section, by the small angles of the faces, and by the ornamentation.

*Horizon and Locality*.—Middle and Upper Llandovery: Woodland Point and Penkill, Girvan.

*Type*.—Mrs. Gray's Collection.

**Conularia** sp. cf. **aspersa**, Lindström. Plate I, figs. 13—14.

In the highest Bala rocks of Thraive Glen, Girvan, and at the same horizon at Horderley, incomplete fragments of a Conularian are found. Although specimens are fairly numerous, only one (Pl. I, fig. 13) gives any detail of the form of the shell. This specimen, so far as can be ascertained, is the external cast of one face, which tapers uniformly at an angle of about 25°. The internal longitudinal "septa," so characteristic of *C. aspersa*, are also found here, and from the figured specimen appear to be present, not only in pairs down the centres of the faces, but also at the angles of the pyramid (Pl. I, fig. 13 *a*). This appearance may, however, be misleading, and cannot be confirmed from other specimens, as these, though showing the septa, are all very incomplete and broken. No shell is preserved, but the ornamentation is well seen in the casts, and closely resembles that of *C. aspersa* (Pl. I, fig. 13 *b*). It varies much in coarseness with the size of the shell (*cf.* Pl. I, figs. 13 *b* and 14 *a*). This species is closely allied to *C. punctata* and to *C. aspersa*, from both of which it may provisionally be distinguished by the presence of the "septa" at the angles of the pyramid.

The figured specimen is in Mrs. Gray's Collection, and comes from the Starfish Bed, Girvan.

**Conularia tenuis**, sp. nov. Plate II, figs. 1—3.

1878. *Conularia*, sp. ind., R. Etheridge, jun., Quart. Journ. Geol. Soc., vol. xxxiv, p. 19.

*Diagnosis*.—Shell large, very thin, tapering uniformly; cross-section square. Faces equal, flat; apical angle 10°—14°. Marginal grooves shallow and incon-

spicuous; centre of face marked by a conspicuous longitudinal internal "septum." Aperture slightly contracted; lobes broad and rounded; apex tapers to a sharp point; apical septa unknown. Ornamentation highly characteristic. Ridges fine, perfectly smooth, well spaced (5—6 in 5 mm.), forming an average angle of  $132^{\circ}$  along the central rib. Furrows smooth or irregularly wrinkled.

*Dimensions.*—Length at least 180 mm. Greatest width of face seen, 20 mm.

*Description.*—It is certainly this species to which R. Etheridge refers, *loc. cit.*, but his specimens seem to have been very fragmentary, and he therefore gave no name and no figure. Over seventy specimens have come under my notice, and the species seems to be one of the best marked as well as one of the most interesting known. At present it has only been found in the dark grey cement stone in the Lower Carboniferous of Scotland, where it is always completely flattened. From the equality of the faces, and the symmetry between the halves of each face, it may be inferred that the cross-section was square. The most characteristic feature of the shell is the strong median rib which is seen down the centre of each face. This rib is of the same nature as the internal "septum" seen in *C. aspersa*, but as the shells are always flattened, the rib becomes conspicuous upon the outer surface. More often than not a complicated network is seen, for owing to the thinness of the shell and the compression which has occurred, the transverse and longitudinal ridges of the two under faces are also prominent upon the outer surface (Pl. II, fig. 2). The ridges are smooth, glossy, and rounded, and are generally well preserved. In the furrows the very thin shell is often seen to be wrinkled (Pl. II, fig. 3).

The most remarkable feature of this species is the close association of several individuals, which has not, to my knowledge, been recorded for any other species. Pl. II, fig. 1, shows at least sixteen specimens of varying sizes, attached at their apices, and radiating from a centre. This is the most nearly perfect, though not the only example, I have seen. In the British Museum (Nat. Hist.) is a slab with three large specimens and a fourth fragment radiating from a centre (no. G. 17662) and another with at least seven small individuals showing radial arrangement (no. 17664). There is no sign of specialisation among the individuals, and the arrangement was, therefore, probably not of the nature of a true colony, but merely an association of separate individuals.

*Affinities.*—This species is quite unlike any other, owing to the thinness of the shell, the central internal longitudinal rib, and the smoothness of the transverse ridges. It is possibly allied to *C. aspersa*.

*Horizon and Localities.*—Calciferous Sandstone: Glencartholm, Eskdale; Water of Leith; Woodhall Mill.

*Type.*—Geological Survey Museum, Edinburgh.

**Conularia tenuis**, var. **maculosa**, nov. Plate II, fig. 4.

Five specimens of the seventy-two which I have examined differ from the majority in having the ridges slightly wider, and their summits ornamented with a row of small round tubercles (Pl. II, fig. 4). The latter are exceedingly well marked over the whole of the shell in the specimens in which they occur, and as in the common type there is not the least trace of tuberculation, these few examples constitute a well-marked variety. In all other characters they agree with the normal type, except, perhaps, that the ridges form a curve across the face rather than a sharp angle along the central ridge; but this difference is not strongly marked.

**Conularia coronata**, sp. nov. Plate III, fig. 1.

*Diagnosis*.—Shell large, very thin, non-calcareous; tapering uniformly; cross-section a flattened rhomb (?); faces equal, flat; apical angle about  $15^{\circ}$ . Marginal grooves well defined; edges becoming prominent towards the aperture. Similar grooves with raised edges marking the centres of the faces; half-faces again subdivided by fine secondary grooves. Aperture unknown; apex pointed; apical septa not seen. Ornamentation inconspicuous—only seen with a lens. Ridges very fine, regular (75 in 5 mm.), forming a series of festoons across the face, rising irregularly at the marginal and central grooves, and falling in shallow arcs between; growth-lines following the course of the ridges. Ridges broken up by vertical striations; furrows smooth.

*Dimensions*.—Length of largest specimen (incomplete), 107 mm. Greatest width of face, 32 mm.

*Description*.—Only two examples of this species are known, and each shows a greatly crumpled and wrinkled surface, pointing to a very thin, probably non-calcareous test. Plate III, fig. 1, shows the more nearly perfect of the two, but this also has only three faces preserved, is greatly compressed, and slightly deformed, so that the cross-section is doubtful. The prominent raised edges of the marginal and central grooves, so well seen in this species, are of frequent occurrence among the earlier Conulariæ, but are never seen in the later forms. The fine and beautifully regular ornamentation is best seen on the raised edges of the grooves (Plate III, fig. 1 *b*), where the test is less wrinkled, but can be traced across the crumpled surface of each face. The course of the ridges is somewhat irregular; they rise at each marginal and central groove, but the height to which they rise and the sharpness of the curves formed vary considerably on the different faces. The ridges appear to be broken up by a very fine cross-striation, of which there is no trace in the furrows.

*Affinities*.—This species resembles the early smooth types superficially, but is

readily distinguished from them by the large angle and the fine and regular ornamentation. It comes very close to a Bohemian species, *C. insignis*, Barrande, from which it differs in having (1) a smaller apical angle, (2) a finer ornamentation, (3) more prominent marginal and facial grooves. It is also very like *C. sosia*, Barrande, but here again all the grooves are simple, and the course of the ridges is different.

*Horizon and Localities*.—Lower Llandeilo: Ritton Castle, Salop; Llandrindod, Radnorshire.

*Type*.—British Museum (Nat. Hist.) (reg. no. G. 17660).

**Conularia** sp. (*margaritifera*, Salter ?). Plate II, fig. 5.

(?) 1866. *Conularia margaritifera*, J. W. Salter, in Ramsay's Geol. N. Wales, Mem. Geol. Surv., vol. iii, ed. 1, p. 355, pl. xi a, fig. 12, and ed. 2 (1881), p. 563.

1906. *Conularia doveri*, J. Postlethwaite, Geol. English Lake District, ed. 2, p. 27, pl. v, fig. 16.

*Diagnosis*.—Shell small, tapering more rapidly towards the apex. Cross-section probably rhombic. Faces equal, flat; apical angle about 20°, nearer the aperture 14°. Marginal grooves well defined, of medium depth; facial grooves central, fine apically, broader and more prominent towards the aperture. Aperture unknown; apex sharply pointed; apical septa unknown. Ornamentation inconspicuous; ridges fine (30—50 in 5 mm.), tuberculated, forming a strongly sigmoidal curve across each half face; angle 120°—130°.

*Dimensions*.—Length probably about 40 mm. Width of face about 9 mm (?).

*Description*.—The specimen upon which Salter based the species *margaritifera* was described by him as “only a fragment of one segment.” If, as I am inclined to believe, this fragment is only half the face, and the “sub-central sulcus” is the result of accident, the specimen from the Skiddaw Slates probably belongs to the same species; but more material is needed to prove the point. The latter is imperfect, but fairly well preserved, and shows well the fine sigmoidal ridges (Pl. II, fig. 5 b), and the marginal and facial grooves.

*Affinities*.—The species has, in common with *C. coronata*, the prominent grooves and fine curved ridges, but is readily distinguished by the smaller size, coarser ornamentation, and the direction of the ridges.

*Horizons and Localities*.—Skiddaw Slates: Brunstock Scar. (?) Llandeilo: Dow Hill, Girvan. Lower Llandeilo: Ty Obry.

*Type*.—Sedgwick Museum, Cambridge, and Museum of Practical Geology (reg. nos. 16175, 16176 ?).

**Conularia microscopica**, sp. nov. Plate II, figs. 6—9.

*Diagnosis*.—Shell very small, non-calcareous; tapering uniformly; cross-section square. Faces equal, flat; apical angle 10°—12°. Marginal grooves deep, well

defined; edges sharp and base rounded. Facial grooves deep, straight, central. Aperture unknown; apex sharply pointed; apical septa unknown. Ornamentation only seen under microscope. Ridges very fine and closely tuberculated (250—300 in 5 mm.), forming an angle of  $145^{\circ}$ — $150^{\circ}$  along the facial grooves, ceasing abruptly at the marginal grooves. Growth-lines following the same course as the ridges, and visible to the naked eye.

*Dimensions*.—Length, 20—30 mm. Greatest width of one face, 5 mm.

*Description*.—This small shell appears perfectly smooth when seen with the naked eye, but under high magnification the very fine, and often well preserved, ornamentation is well seen (Pl. II, fig. 9). The vertical striation, seen on the ridges, does not appear to extend to the furrows. The marginal and central grooves are quite smooth.

*Affinities*.—Some specimens of this shell might be mistaken for the smoother examples of *C. linnarssoni*, but under the microscope the ornamentation distinguishes it from that and all other forms. It is probably allied to *C. coronata*.

*Horizon and Locality*.—Wenlock Shale: Buildwas.

*Type*.—Museum of Practical Geology (reg. no. 12628).

### **Conularia** sp. Plate II, fig. 10.

*Diagnosis*.—Shell small, tapering uniformly; cross-section square. Faces equal, flat; apical angle  $15^{\circ}$ . Marginal grooves well defined, rounded, fairly deep. Facial grooves central, fine. Aperture, apex, and apical septa unknown. Ornamentation inconspicuous; ridges fine and close (25 in 5 mm.) forming an angle of  $130^{\circ}$  along the facial groove. Ridges nearly as wide as the furrows; tuberculated; furrows smooth.

*Dimensions*.—Length, 25 mm. ? Width of face, 7 mm.

*Description*.—There is only one example of this small form, and as the preservation is not very good, and only one complete face is seen, I have not named it as a separate species. The most marked characters are the square cross-section, rounded marginal grooves (Pl. II, fig. 10 *b*), and fine ridges symmetrically disposed along the facial grooves. The finer ornamentation is almost obliterated, but the ridges appear to be tuberculated (Pl. II, fig. 10 *c*).

*Affinities*.—This species is nearly allied to *C. microscopica*, from which it is distinguished by the much coarser ornamentation.

*Horizon and Locality*.—Wenlock Limestone: Ledbury.

*Type*.—British Museum (Nat. Hist.) (reg. no. G. 11798).

### **Conularia quadrisulcata**, Sowerby. Plate III, figs. 2—6.

1821. *Conularia quadrisulcata*, Sowerby, Min. Conch., vol. iii, p. 107, pl. 260, figs. 5, 6.

1840. *Conularia quadrisulcata*, J. Prestwich, Trans. Geol. Soc. [2], vol. v, p. 442, pl. xl, fig. 2.

1843. *Conularia quadrisulcata*, J. Portlock, Rept. Geol. Londonderry, p. 393, pl. xxix A, figs. 4, 5.  
 1847. *Conularia tubericosta*, F. Sandberger, Neues Jahrb. für Mineral. etc., p. 21, pl. i, fig. 12.  
 1855. *Conularia quadrisulcata*, F. M'Coy in Sedgwick's Synops. Brit. Palæoz. Rocks, p. 520.  
 1873. *Conularia clavus*, J. W. Salter, Catal. Camb. Silur. Foss. Woodw. Mus., p. 153.  
 1902. *Conularia clavus*, F. R. C. Reed, Geol. Mag. [4], vol. ix, p. 122.

*Diagnosis.*—Shell varies much in size and tapers uniformly; cross-section square. Faces equal, flat; apical angle about  $14^{\circ}$ . Marginal grooves well marked, with angular base and edges; facial grooves inconstant. Aperture partially closed by four short lobes bent down at right angles to the axis; apex sharply pointed; apical septa rarely seen, gently convex. Ornamentation increasing in coarseness with the increase in the size of the specimen. Ridges well defined; in medium-sized specimen (Pl. III, fig. 2) 8—10 in 5 mm.; forming an average angle of  $140^{\circ}$  across the face; studded with small round tubercles. Furrows smooth.

*Dimensions.*—The largest specimen is calculated to be over 200 mm. in length. Greatest width of face, 36 mm.

*Description.*—The name *quadrisulcata* was the first specific name given by Sowerby, and is generally recognised to have included more than one form from more than one horizon. In 1845 the name was restricted by de Verneuil to the Carboniferous form, and since that time it has been applied indiscriminately to most Carboniferous species; but even when restricted the species is a very variable one. The Coal Measure forms, from their state of preservation and general appearance, would seem to be quite distinct from the larger limestone specimens, but when details are preserved on the latter they are found to shade quite insensibly into the former. The size varies immensely; probably the smallest shells are not full grown. On the whole the Coal Measure examples are small, few exceeding a length of 60—70 mm., and none reaching the large size of the Carboniferous Limestone forms. The appearance of the ornamentation varies greatly according to the state of preservation. In specimens from a coarse limestone no shell is seen, and the ridges appear broad and rough, with only a faint indication of tuberculation (Pl. III, fig. 2), while specimens from the ironstone nodules of the Coal Measures show a delicate ornamentation beautifully preserved. In the latter two distinct layers of shell may be seen. The innermost is very thin, light-coloured, opaque, and little ornamented (Pl. III, fig. 4*b*). Outside this is the thicker layer, which is most often seen, and which in the ironstone specimens is dark brown to black, semi-transparent, and with a resinous lustre. This, when perfectly preserved, shows beautiful rounded tubercles on the summits of the ridges, with tiny projections passing from them to the base of the ridge in the direction of the aperture; the furrows are quite smooth (Pl. III, fig. 5). Occasionally, as the result of secondary action, the furrows are thrown into a series of irregular interlocking folds or corrugations, which at times assume a more or less regular arrangement, giving the effect of a normal longitudinal striation

(observed in other species, but not so frequently). The arrangement of the ridges in the marginal groove is very characteristic; on the edges they turn up abruptly towards the aperture, and meet, or alternate, with those of the adjacent face at the base (Pl. III, fig. 2). Sometimes the ridges bifurcate on the edge.

*Affinities.*—This species is quite unlike any other British form. The coarser specimens from the limestone sometimes slightly resemble specimens of *C. crassa*, but they are readily distinguished by the ornamentation of the marginal grooves.

*Horizons and Localities.*—Upper Devonian: Frankmarsh, N. Devon (rare). Carboniferous Limestone: Yorkshire, Derbyshire, Staffordshire, Dublin, Glasgow, etc. Coal Measures: Coalbrookdale, etc.

### **Conularia deflexicosta**, Sandberger (?).

1847. *Conularia deflexicosta*, F. Sandberger, Neues Jahrb. für Min., etc., p. 16, pl. i, fig. 6.

1896. *Conularia deflexicosta*, G. F. Whidborne, Devon. Fauna S. England, vol. iii, p. 35, pl. iv, fig. 13.

*Remarks.*—In the monograph referred to above Whidborne described a very imperfect specimen of a Conularian from Pilton, and referred it, “presumptively,” to Sandberger’s species, *C. deflexicosta*. I have not seen any other similar specimens, so that the occurrence of this species in Britain remains doubtful. The ridges appear to be tuberculated and the furrows smooth, so that the species must be placed in the section Moniliferæ.

### **Conularia globosa**, sp. nov. Pl. III, figs. 7, 8.

*Diagnosis.*—Shell of medium size, tapering uniformly; cross-section a square with the sides convex. Faces equal, gently convex; apical angle  $7^{\circ}$ — $8^{\circ}$ . Marginal grooves of medium depth and with rounded base. Facial grooves central, faint, only seen in young specimens. Aperture unknown. Apical septum deeply convex, with circular transverse section. Ornamentation fine. Ridges prominent, crowded (25—35 in 5 mm.), forming a very wide angle or broad curve across the face, and continuous across the marginal groove, making an angle of about  $140^{\circ}$  in its base; closely studded with small round tubercles. Furrows smooth.

*Dimensions*—Length about 100 mm. Greatest width of face, 19 mm.

*Description.*—Of the two specimens known, one (Pl. III, fig. 8) appears to be quite a young form. Each shows the true cross-section, and the characteristic deeply convex septum. The ridges are very close together, especially towards the aperture; they are for the most part regular, but in places anastomose, and vary their course. The tubercles are well preserved over the whole shell, and no sign of ornamentation is seen in the furrows (Pl. III, fig. 7 *d*).

*Affinities.*—This species is most nearly allied to *C. quadrisulcata*, from which it is distinguished by the convex faces, the deeply convex septum, and the fine ornamentation.

*Horizon and Localities.*—Carboniferous Limestone: Avon Gorge and Tortworth.  
*Type.*—Museum of Practical Geology (reg. no. 11909).

**Conularia hispida**, sp. nov. Plate III, figs. 9—11.

*Diagnosis.*—Shell of medium size, thin; tapering uniformly; cross-section square. Faces equal, flat; apical angle  $10^{\circ}$ — $12^{\circ}$ . Marginal grooves deep and narrow; base and sides rounded. Facial groove fine, central. Aperture, apex, and apical septa unknown. Ornamentation fine; transverse ridges (8—24 in 5 mm.), forming an angle of  $130^{\circ}$ — $145^{\circ}$  along the central groove; closely studded with small pear-shaped tubercles, which are prolonged upwards as fine projections about half way across the furrow; the other half quite smooth.

*Dimensions.*—Length about 140 mm. Greatest width of face, 25 mm.

*Description.*—This shell is usually found somewhat compressed, but one specimen from Ledbury gives a truly square cross-section (Pl. III, fig. 10). The state of preservation is good and the characteristic ornamentation is well seen. The ridges (average, 14 in 5 mm.) are more closely packed near the apex, and pass without a break across the marginal grooves. Down the centre of each face the shell is puckered into little short folds, which follow the course of the ridges, and die out before reaching the marginal grooves. The little pear-shaped tubercles (45—50 in 5 mm.) are often much worn down and nearly obliterated, but when well preserved are seen slightly clasping the ridge, and tapering upwards into fine points (Pl. III, fig. 11). The upper half of each furrow is quite smooth.

*Affinities.*—This species is readily distinguished from any other by its unique ornamentation.

*Horizon and Localities.*—Wenlock Limestone: Dudley; Ledbury. Highest Bala: Thraive Glen, Girvan.

*Type.*—British Museum (Nat. Hist.) (reg. no. G. 10041).

**Conularia triangularis**, sp. nov. Plate III, fig. 12.

*Diagnosis.*—Shell of medium size; tapering uniformly; cross-section square. Faces equal, flat; apical angle  $12^{\circ}$ . Marginal grooves of medium depth and with rounded base. Facial groove fine, central. Aperture, apex, and apical septa unknown. Ornamentation inconspicuous; transverse ridges fine, closely packed (50 in 5 mm.), forming an angle of  $135^{\circ}$ — $145^{\circ}$  along the central groove, studded with small, closely-packed, triangular tubercles.

*Dimensions*.—Length at least 60 mm. Greatest width of face, 14 mm.

*Description*.—Only one example of this species is known, but its characters are so well marked as to justify its separation as a new species. The shell is well preserved, and has undergone only very slight deformation. This has resulted in three of the faces being slightly ridged down their centres, but the fourth shows a fine groove, which is probably the natural condition. The marginal grooves are also probably a trifle deepened, but in places show a gentle, rounded base with the ornamentation continuing across undisturbed (Pl. III, fig. 12 *c*). The transverse ridges are so crowded as to be hardly visible to the naked eye. They are studded with close-set tubercles, rounded below, but on the upper side prolonged into blunt points, which cross the furrow above (Pl. III, fig. 12 *d*). The tubercles are for the most part reduced to small triangular hollows.

*Affinities*.—This species is readily distinguished from all others by the fine, close-set ridges and the triangular tubercles.

*Horizon and Locality*.—Wenlock Limestone: Dudley.

*Type*.—British Museum (Nat. Hist.) (reg. no. 866).

**Conularia hastata**, sp. nov. Plate IV, fig. 1.

*Diagnosis*.—Shell of medium size, tapering uniformly; cross-section probably square. Faces equal (?), flat; apical angle about  $18^\circ$ . Marginal grooves slight; base angular; facial groove fine and central. Aperture, apex, and apical septa unknown. Ornamentation fine; ridges prominent, closely packed (20—25 in 5 mm.), forming a broad curve across the face, flat in the centre, and falling to the marginal grooves, where they meet the ridges of the adjacent side at an angle of nearly  $90^\circ$ . Studded with very small, round, distant tubercles, from which fine, sharp lamellæ extend upwards across the furrow.

*Dimensions*.—Length, 60—70 mm. Greatest width of face, 17 mm.

*Description*.—There are six specimens of this species in the Survey Collection at Edinburgh, all from the same locality. None are at all perfect, and no cross-section can therefore be obtained directly. The only evidence as to its form is that afforded by the course of the ridges. The latter are, in most cases, very nearly symmetrical upon each half of the face, which is usually only the case with square specimens. However, this is not a certain test, and the natural form may have been flattened. The ornamentation is very constant for all the specimens. The ridges vary very little in distribution from apex to aperture, and down the whole length of the shell they are fine, closely packed and very well defined, and the little vertical striæ are usually clearly seen, especially in the external casts (Pl. IV, fig. 1 *d*).

*Affinities*.—This shell slightly resembles *C. hispida* and *C. triangularis*, but is easily distinguished from both.

*Horizon and Locality.*—Upper Ludlow : River Esk below Henshaw Burn.

*Type.*—Geological Survey Museum, Edinburgh (reg. no. 4623).

*Section III.—CANCELLATÆ.*

Ornamentation cancellated, with coarser transverse main ridges, forming obtuse angles across the faces, and finer and lower longitudinal ridges connecting the former. Ornamentation visible to naked eye.

(A) Transverse section square. Longitudinal ridges feeble and inconstant.

(i) Ridges coarse, irregular, almost horizontal. Central facial groove strong. *C. elongata*, Portlock.

(ii) Shell small; ridges and tubercles fine; longitudinal ridges chiefly marked on either side of the marginal grooves.

*C. plicata*, sp. nov.

(iii) Shell large; ridges and tubercles very coarse; marginal grooves very wide and shallow. *C. crassa*, sp. nov.

(iv) Marginal grooves with rounded base and prominent, smooth, rounded edges. *C.* sp.

(B) Transverse section rhombic or elliptical.

(a) Longitudinal ridges faint and inconstant; tapering more rapid at the apex.

(i) Facial groove well marked, often sub-central; average angle of ridges  $130^{\circ}$ . Ridges fall more sharply to the "lateral" than to the "central" marginal grooves. *C. subtilis*, Salter.

(ii) Sides nearly parallel towards the aperture; cross-section elliptical; facial groove absent; average angle of ridges  $150^{\circ}$ .

*C. complanata*, sp. nov.

(b) Longitudinal ridges strongly marked over the whole shell.

(i) Shell small; apical angle of face  $17^{\circ}$ — $20^{\circ}$ ; apical septa flat; ridges nearly horizontal across the "central" marginal groove, bent down sharply to the "lateral" grooves; longitudinal bars separated. *C. planiseptata*, sp. nov.

(ii) Shell of medium size; apical angle of face  $10^{\circ}$ — $11^{\circ}$ ; apical septa convex; ridges meet at an angle in the marginal grooves; transverse and longitudinal bars prominent, and equally spaced. *C. vesicularis*, sp. nov.

(iii) Shell large; apical angle of face  $10^{\circ}$ — $12^{\circ}$ ; apical septa convex; ridges nearly horizontal across the central marginal groove; the longitudinal ridges twice as numerous as the transverse, rounded and in contact laterally.

*C. sowerbyi*, de Verneuil.

- (iv) Shell large; apical angle of face  $16^{\circ}$ — $20^{\circ}$ ; apical septa convex; ridges cease at the edges of the marginal grooves, which are smooth and narrow. Ornamentation as in *C. sowerbyi*, but coarser. *C. brevicouventa*, sp. nov.
- (v) Shell small; apical angle of face  $8^{\circ}$ — $10^{\circ}$ ; apical septa convex; ridges nearly horizontal across the central marginal groove; ornamentation fine; longitudinal ridges numerous, sharply defined, not in contact laterally. *C. elegans*, sp. nov.

**Conularia elongata**, Portlock.

1843. *Conularia elongata*, J. Portlock, Rept. Geol. Londonderry, p. 393, pl. xxix A, fig. 2.

1847. *Conularia pectini-costata*, F. Sandberger, Neues Jahrb. für Min., etc., p. 17, pl. i, fig. 7.

*Diagnosis*.—Shell small, tapering uniformly; cross-section square. Faces equal, slightly concave; apical angle about  $10^{\circ}$ . Marginal grooves wide and very shallow. Facial groove strong, central. Aperture, apex, and apical septa unknown. Ornamentation coarse; transverse ridges irregular (8 in 5 mm.), passing horizontally across the face; interrupted by the facial groove, but continuous across the marginal groove, in which they arch down towards the apex. Furrows crossed by fine, regular, longitudinal striæ (20—30 in 5 mm).

*Dimensions*.—Length about 40 mm. Greatest width of face, 10 mm.

*Description*.—The type specimen still remains the only known example of this species. The shell is not preserved, but the ornamentation is fairly well seen. The ridges are irregular and thickened by friction, so that they appear over most of the shell more like the rounded growth-lines of *C. limarssoni*, but towards the aperture they are finer, and as many as 15 in 5 mm., and the longitudinal striation of the furrows is seen to extend to the ridges.

*Affinities*.—This species resembles *C. limarssoni* in the strongly marked central facial groove and the horizontal transverse folds, but is readily distinguished by the cancellated ornamentation and the small angle of the face.

*Horizon and Locality*.—Caradoc (?): Desertcreat.

*Type*.—Museum of Practical Geology (reg. no. 12642).

**Conularia plicata**, sp. nov. Plate IV, figs. 2, 3.

*Diagnosis*.—Shell of medium size, tapering uniformly; cross-section square. Faces equal, flat; apical angle  $16^{\circ}$ — $17^{\circ}$ . Marginal grooves of medium depth and width; facial grooves absent. Aperture partially closed by short blunt triangular lobes, at right angles to the main axis. Apex sharply pointed; apical septa unknown. Ornamentation fine; ridges far apart (9—12 in 5 mm.), forming broad,

simple curves across the face, continuous across the marginal groove, studded with small, round, well-spaced tubercles. Furrows marked by secondary transverse ridges and faint longitudinal striations—the latter especially marked close to the marginal grooves.

*Dimensions.*—Length sometimes as much as 70 mm., usually 20—30 mm. Greatest width of face, 20 mm.

*Description.*—This is a well-marked species, of which there are several examples in Mrs. Gray's Collection. The most characteristic features are the broad sweeping curves which the ridges make across the face, the secondary transverse ridges, and the small distant tubercles.

*Affinities.*—This species is easily distinguished from other cancellate forms by the square cross-section and fine curved ridges. With *C. crassa* it forms a transition between the Moniliferæ and the Cancellatæ.

*Horizon and Locality.*—Upper Bala (Starfish Bed): Girvan.

*Type.*—Mrs. Gray's Collection.

**Conularia crassa**, sp. nov. Plate IV, figs. 4—6.

*Diagnosis.*—Shell large, tapering uniformly; cross-section a square, with the sides gently convex. Faces equal, convex; apical angle about  $16^\circ$ . Marginal grooves very shallow, wide; facial groove hardly perceptible. Aperture, apex, and apical septa unknown. Ornamentation coarse; transverse ridges strong, widely separated (5—6 in 5 mm.), forming an angle of about  $140^\circ$  down the centre of the face, studded with large rounded, distant tubercles (8 in 5 mm.).

*Dimensions.*—Length at least 120 mm. Greatest width of face, 24 mm.

*Description.*—Examples of this species are found in a fairly good state of preservation, often retaining a considerable portion of the shell. They have usually undergone flattening, so that the cross-section is obscure, but one specimen (Pl. IV, fig. 5) shows a broad ellipse, which appears to have been derived from a square, the sides of which are replaced by gently convex curves. The most marked character of the species is the exceedingly wide and shallow marginal grooves, which are of the nature of gentle undulations, without any well-marked boundaries. The ornamentation is continued across them without any break. The appearance of the ridges varies with the state of preservation. Sometimes the blunt, rounded tubercles are clearly seen; but more often they appear flattened and pierced in the centre (Pl. IV, fig. 6*b*); or, again, only a raised, wavy ridge may be seen (Pl. IV, fig. 4*b*); or, lastly, the tubercles may be worn away and represented by hollows, between which little portions of the shell still remain. The furrows are crossed by very slight, inconspicuous and inconstant vertical undulations.

The specimen seen in Pl. IV, fig. 4 *a* shows a curious smooth portion of shell just below the fracture. On each side it appears to be quite continuous with the inner less-decorated layer of the shell. In this character, and in its texture, it is quite similar to the apical septa found in so many species. On each side the transverse ridges appear undisturbed, but above their course is very irregular for over 20 mm. The probable explanation of this is, that the shell was injured during the life of the animal, and the injury was repaired by the growth of the inner layer.

*Affinities.*—This species is readily distinguished from other British forms by the very coarse ornamentation and the wide, shallow, marginal grooves. In general characters it resembles *C. alundica*, Holm, but the ornamentation is much coarser, the angle of the face larger, and that of the ridges smaller than in the Swedish species.

*Horizon and Locality.*—Wenlock Limestone: Dudley.

*Type.*—British Museum (Nat. Hist.) (reg. no. G. 6271).

### **Conularia sp.**

*Description.*—Several fragmentary specimens occur in the Llandeilo rocks of Balcleachie and Dowhill, which should probably be placed in a distinct species, but as there is no example which is at all complete I merely note the characteristic features: Marginal grooves well marked with rounded base, and prominent rounded edges; facial grooves absent. Faces equal, flat; apical angle  $10^{\circ}$ — $11^{\circ}$ . Apex sharply pointed. Ornamentation fairly coarse; ridges (10—12 in 5 mm.), forming a sharp curve ( $\equiv$  angle of  $135^{\circ}$ ) across the face, bending up again and ceasing abruptly at the prominent edges of the marginal grooves; smooth near the apex, but finely tuberculated higher up. Furrows slightly striated.

*Dimensions.*—Length, 30 mm. Greatest width, 7 mm.

All specimens are in Mrs. Gray's Collection.

### **Conularia subtilis, Salter. Plate IV, figs. 7—11.**

1821. *Conularia quadrifulcata*, Sowerby, Min. Conch., vol. iii, pl. 260, fig. 3.

1855. *Conularia subtilis*, J. W. Salter, Appendix A to Sedgwick's Synops. Brit. Palæoz. Rocks, p. vi.

1855. *Conularia subtilis*, F. M'Coy, in Sedgwick's *op. cit.*, p. 288, pl. i, L, fig. 24.

*Diagnosis.*—Shell of medium size, tapering slightly more rapidly at the apex. Cross-section rhombic; diagonals often nearly equal. Faces equal, slightly convex apically and concave aperturally; average apical angle  $13^{\circ}$ . Marginal grooves narrow, inconspicuous; facial groove fine; central or slightly nearer the "central"

marginal groove. Aperture, apex, and apical septa unknown. Ornamentation fine; ridges narrow (10—40 in 5 mm.), forming an average angle of  $130^\circ$  along the facial groove, and falling more sharply to the “lateral” than to the “central” marginal grooves; studded with small, close-set, rounded or slightly elongated tubercles, which tend to be prolonged upwards and downwards into little points (Pl. IV, fig. 10 *b*). Striation of furrows slight or absent.

*Dimensions*.—Length about 80 mm. Greatest width of face 17 mm.

*Description*.—Salter's type specimen of *Conularia subtilis* comes from the Kirby Moor flags of the Kendal district, and its preservation is as bad as that of most of the other fossils from this locality. No shell is seen, and the ornamentation is blurred or almost obliterated. From finer grained rocks at the same horizon other specimens, which I believe to be of the same species, are found in a much better state of preservation, although these naturally do not agree in every way with Salter's description. Fig. 7 shows a specimen from Monmouthshire, on the lower half of which the ornamentation closely resembles that of the Benson Knot specimens, while on the upper half the fine and delicate ornamentation, characteristic of well-preserved examples, is well seen. The examination of a number of specimens shows that the inequality of the faces, noted by Salter, is not of general occurrence, and I believe that the shell, in its natural condition, was equal sided. The cross-section is sometimes nearly square, and then the want of symmetry between the two halves of each face is less marked. The ornamentation varies greatly, even on the same specimen. In places the little tubercles appear elongated, and clasp the raised ridge, giving the appearance of little rings threaded upon it (Pl. IV, fig. 10 *a*). In another part of the same shell they are prolonged up and down into the furrows as little short, pointed projections (Pl. IV, fig. 10 *b*), while sometimes, again, they appear as little, simple, round tubercles (Pl. IV, fig. 9 *b*). Usually there is no definite longitudinal ridging of the furrows, but sometimes it is slightly, sometimes even strongly, developed. One specimen from Deerhope, Pentland Hills, shows distinct ornamentation. The tubercles are much smaller, and are prolonged downwards towards the apex, as long, fine points extending across the furrow (Pl. IV, fig. 11). The Scottish specimen represented in the last-mentioned figure should perhaps be placed apart as a definite variety, as, together with the difference in ornamentation, the apical angle of the face is large, about  $20^\circ$ , and the tapering appears uniform. The ridges also on adjacent half faces are almost horizontal across the “central” marginal groove, falling sharply to the “lateral” grooves.

*Affinities*.—This species in some ways resembles *C. hispida* and *C. hastata*, from which it is distinguished by the rhombic cross-section and sub-central facial groove. Other specimens resemble more closely *C. sowerbyi*, and coarse specimens are sometimes hard to distinguish, but the form of the pyramid and the course of the ridges are generally sufficiently characteristic.

*Horizon and Localities.*—Upper Ludlow: Brigsteer; Benson Knot; Underbarrow; Usk, Monmouthshire; Whitcliff, Ludlow; etc.

*Type.*—Sedgwick Museum, Cambridge (reg. no. *b* 59).

**Conularia complanata**, sp. nov. Plate IV, figs. 12—14.

*Diagnosis.*—Shell large, tapering more rapidly near the apex. Cross-section an ellipse. Faces equal, gently convex; apical angle about  $15^\circ$ , but the sides nearly parallel, except towards the apex. Marginal grooves shallow, with angular base; facial grooves absent. Aperture unknown; apical septum convex, shallow. Ornamentation fine; ridges low (17 in 5 mm.), forming an angle of about  $160^\circ$  towards the aperture, diminishing to  $140^\circ$  towards the apex; studded with small, round, prominent tubercles. Furrows smooth, or more often slightly striated.

*Dimensions.*—Length about 150 mm. Greatest width of face, 25 mm.

*Description.*—In Carboniferous rocks the species is comparatively abundant, but its preservation is nearly always bad. The shell often reaches a large size, and the prismatic form towards the aperture is well seen. The spacing of the ridges is very uniform for the greater part of the shell, but near to the aperture the ridges become very crowded. There is an imperfect specimen from the Devonian of Padstow, Cornwall, which may belong to this species (British Museum [Nat. Hist.], G. 8229).

*Affinities.*—This species resembles most closely *C. subtilis*, from which it is distinguished by the large size, the absence of the facial groove, and the wide angle of the transverse ridges.

There is a specimen in the British Museum (Nat. Hist.), reg. no. G. 9030, from the Carboniferous Limestone of Stonyhurst, Lancashire, which differs from the foregoing in some important points, but the preservation is so bad and the specimen so imperfect that no satisfactory diagnosis can be given. The characters which can be determined are: Marginal grooves very shallow. Ornamentation fine; ridges very narrow, evenly spaced (14 in 5 mm.), forming at the aperture broad curves, which give place towards the apex to perfectly straight horizontal lines. Ridges appear to be tuberculated with widely separated round tubercles; furrows smooth. Length of portion, 82 mm.

*Horizons and Localities.*—Devonian: Padstow, Cornwall (?). Carboniferous Limestone: Bristol; Oretton and Farlow, Salop, etc.

*Type.*—British Museum (Nat. Hist.) (reg. no. G. 17666).

**Conularia planiseptata**, sp. nov. Plate V, figs. 1, 2.

*Diagnosis.*—Shell small, tapering uniformly, or slightly more rapidly near the apex. Cross-section rhombic or elliptical, with the longer diameter more than

double the shorter. Faces equal, slightly convex; apical angle  $17^{\circ}$ — $20^{\circ}$ . Marginal groove of medium depth, base rounded; facial grooves absent. Apical septum flat. Ornamentation fine; ridges fairly close (average 18 in 5 mm.), forming an angle of  $145^{\circ}$  across the face; point of angulation nearer to the "central" than to the "lateral" marginal groove; ridges continuous across the grooves, at the base of which they form an angle of almost  $180^{\circ}$ ; studded with small, rounded, widely separated tubercles. Furrows crossed by narrow, well-defined vertical bars.

*Dimensions*.—Length, 40—50 mm. Greatest width of face, 16 mm.

*Description*.—Well-preserved examples of this small species are obtained from Thraive Glen, but those from Woodland Point are all somewhat fragmentary. The figured specimen shows a nearly perfect apical septum, which, unlike the septa of most species, is quite flat; and since the surface is quite unwrinkled, this must be the natural form. The small oblong projection in the centre is very suggestive of some sort of siphuncle (Pl. V, fig. 1*b*). I have not seen anything resembling this in any other example, even where the septa are nearly perfect. In this specimen the central tube appears to be closed, and may very likely be only a scar left by the final completion of the septum.

*Affinities*.—This species resembles most closely *C. vesicularis*, from which it is distinguished by the large angle of the face, the flat apical septum, and slight differences in the ornamentation.

*Horizons and Localities*.—Upper Bala and Middle Llandovery: Thraive Glen and Woodland Point, Girvan.

*Type*.—Mrs. Gray's Collection.

### **Conularia vesicularis**, sp. nov. Plate V, figs. 3—6.

*Diagnosis*.—Shell of medium size, tapering uniformly. Cross-section at the aperture a rhomb with diameters nearly equal, at the apex an ellipse or the figure  $\infty$ . Faces equal, flat, convex, or gently concave near the aperture; apical angle  $10^{\circ}$ — $11^{\circ}$ . Marginal grooves of medium depth; facial grooves absent. Apical septa convex. Ornamentation fine; ridges moderately close (average 17 in 5 mm.), forming an angle of  $140^{\circ}$  across the face; the point of angulation slightly nearer to the "central" than to the "lateral" marginal groove; ridges continuous across the marginal grooves and forming an angle at the base of about  $150^{\circ}$ . Ridges studded with rounded tubercles; furrows crossed by prominent bars.

*Dimensions*.—Length about 90 mm. Greatest width of face, 14 mm.

*Description*.—This species is of widespread occurrence in the uppermost Ordovician rocks. Specimens are not usually well preserved and no aperture is known. The "central" marginal groove is usually deeply sunken towards the

apex, and the faces strongly convex, thus giving an  $\infty$ -shaped cross-section (Pl. V, fig. 4 *b*). Towards the aperture the "central" marginal grooves become much more prominent, the faces become slightly concave, and the cross-section approaches a square (Pl. V, fig. 4 *a*).

The ridges are generally fine and well-marked. The tubercles are very often worn down, and the circular hollows in the furrows are then strongly marked (Pl. V, fig. 6 *b*). Frequently the shell is removed entirely, and a very characteristic appearance is then obtained. Ridges and vertical bars are replaced by grooves, and the furrows appear to be filled with rows of gently hollowed tubercles (Pl. V, fig. 6 *c*). I have not observed this appearance in any other species.

*Affinities.*—This species is closely allied to *C. sowerbyi* and to *C. planiseptata*. It is distinguished from the latter by the slow rate of tapering, and from the former by the smaller size, and by the characteristic ornamentation.

*Horizon and Localities.*—Caradoc: Acton Scott; Tynwyd; Cardington; etc.

*Type.*—Museum of Practical Geology (reg. no. 12647).

### **Conularia sowerbyi**, de Verneuil. Plate V, figs. 7—11.

1821. *Conularia quadrisulcata*, Sowerby, Min. Conch., vol. iii, pl. 260, fig. 4.  
 1828. *Conularia sowerbyi*, Defrance, MS.  
 1839. *Conularia quadrisulcata*, Sowerby, in Murchison's Silur. Syst., pl. xii, fig. 22.  
 1845. *Conularia sowerbyi*, de Verneuil, in Murchison, de Verneuil, and de Keyserling, Géol. de la Russie d'Europe, vol. ii, p. 348, pl. xxiv, fig. 5.  
 1847. *Conularia cancellata*, F. Sandberger, Neues Jahrb. für Min., etc., p. 20, pl. i, fig. 11.  
 1855. *Conularia cancellata*, F. M'Coy, in Sedgwick's Synops. Brit. Palæoz. Rocks, p. 287.  
 1859. *Conularia sowerbyi*, Sowerby, in Murchison's Siluria, ed. 3, p. 550, pl. xxv, fig. 10.

*Diagnosis.*—Shell large, tapering uniformly; cross-section rhombic near the aperture, elliptical near the apex. Faces equal, gently convex, apical angle  $10^{\circ}$ — $12^{\circ}$ . Marginal grooves shallow, broad; facial grooves inconstant. Lobes of the aperture short and triangular; apex closed by a convex septum. Ornamentation fairly coarse; transverse ridges well marked (average 12 in 5 mm., more crowded at the apex and the aperture), forming an average angle of  $147^{\circ}$ . Ridges closely set with rounded tubercles. Longitudinal bars in the furrows twice as numerous as the transverse ridges, rounded, and in contact laterally. Ornamentation continuous across the marginal grooves.

*Dimensions.*—Length about 120 mm. Greatest width of face, 33 mm.

*Description.*—This species is the commonest of British Conulariæ. It is found usually preserved in limestone, and has, therefore, undergone less crushing than many. At the aperture the cross-section is a rhomb with the longer diameter

rather less than twice the shorter (about 5:3), but at the apex the shell almost invariably appears more flattened, and the cross-section takes the form of an ellipse with the longer diameter more than twice the shorter. The apical angles of the faces vary in different specimens, but the measurements are not always trustworthy, and the greater number give values between  $10^{\circ}$ — $12^{\circ}$ .

The apertural lobes are not usually seen, though there are several specimens known which show them in a more or less nearly complete state. They are short, with gently rounded apices, and bend down at right angles to the axis of the shell (Pl. V, fig. 8). In almost all cases the shell is closed at the apical end by a gently convex septum (Pl. V, figs. 7*b* and 9), and rarely, if ever, does it taper to a sharp point. The septum occurs at varying distances from the aperture, and this fact points to the probability of the existence of more than one such partition in the length of the shell. Indeed, in one specimen, from the Museum of Birmingham University, 6 mm. above the terminal septum the shell is broken away, and another and quite similar septum is seen, passing inwards parallel to the other, and apparently continuous with the thin inner layer of the shell. The ornamentation is of the typical cancellate type. The point of angulation of the transverse folds is perceptibly nearer to the "central" than to the "lateral" marginal grooves, and the ridges meeting in the "central" groove from adjacent faces form an angle approaching  $180^{\circ}$ . In the apical half of the shell the ridges form straight-sided chevrons across the face, but towards the aperture there is a marked increase in the size of the angle, and the straight lines are replaced by broad, compound curves, at first concave, then convex to the aperture as they pass down from the point of angulation to the marginal groove.

The tubercles on the ridges are sometimes well preserved, but more often are reduced by friction to small rounded hollows; still more frequently the ridges are worn down to coarse, rough projections, and in the furrows between these the shell is well preserved, and the close and regular vertical striation is clearly seen. If the outer layer of the shell is removed, the thin yellowish under-layer is exposed, ornamented in the same way as the outer, but much less strongly (Pl. V, fig. 10*b*).

*Affinities.*—This shell is the commonest British representative of a type that is widely spread all over the globe. It is very similar to the Bohemian species, *C. proteica*, Barrande, and to the Swedish *C. cancellata*, Lindström, but it is doubtful whether it is identical with either of these. Species with strongly cancellated ornamentation appear to have flourished in highest Ordovician and Silurian times, and during this period gave rise to local types (*C. planiseptata*, *vesicularis*, *breviconventa*), which cannot be identified with species of other countries. Lindström's species, *C. cancellata*, ranging from the Brachiopodskiffer to the highest Silurian of Gotland, may possibly in the same way include more than one local species, but I was not able to identify any with the British forms.

*Horizons and Localities.*—Wenlock Limestone: Malvern; Ledbury; Dudley; etc. Upper Ludlow: Underbarrow; etc.

*Type.*—Unknown.

**Conularia breviconventa**, sp. nov. Plate V, figs. 12, 13.

*Diagnosis.*—Shell of medium size, tapering uniformly; cross-section a flattened rhomb. Faces equal, flat. Apical angle  $16^{\circ}$ — $20^{\circ}$ . Marginal grooves narrow, of medium depth; facial grooves inconstant. Aperture unknown; apex closed by a convex septum. Ornamentation coarse; ridges, on an average, 6 in 5 mm. for the centre of the shell, closer at the aperture and the apex, forming an average angle of  $130^{\circ}$ . Ornamentation of the typical cancellate type with close-set tubercles, ceasing at the edge of the marginal groove.

*Dimensions.*—Length about 70 mm.; greatest width of face, 20 mm.

*Description.*—This species is not nearly so common as the preceding one, but occurs with it at Dudley and other places. The shell generally appears to be compressed, as is seen by the fine wrinkles along the septum; hence the observed transverse section may not be the true one. The angle of the face is always considerably larger than in *C. sowerbyi*. The marginal grooves are markedly different, being narrow, well-defined, and apparently with smooth base. The detailed ornamentation is the same as in *C. sowerbyi*, but is, on the whole, much coarser; the angle of the ridges is smaller, and increases very little towards the aperture, the ridges themselves are more sharply defined, and, if curved at all, form simple arcs concave to the aperture.

*Affinities.*—This species closely resembles the commoner form, *C. sowerbyi*, but is distinguished by the coarser ornamentation, by the much larger facial angle, and by the smooth, narrow, marginal grooves, in which the ornamentation of the rest of the shell is absent. It very closely resembles *C. trentonensis*, Hall, in the wide facial angle and coarse ornamentation.

*Horizon and Locality.*—Wenlock Limestone: Mayhill; Dudley; etc.

*Type.*—British Museum (Nat. Hist.) (reg. no. G. 17667).

**Conularia elegans**, sp. nov. Plate V, fig. 14.

*Diagnosis.*—Shell small, tapering uniformly; cross-section rhombic. Faces equal, slightly convex; apical angle  $8^{\circ}$ — $10^{\circ}$ . Marginal grooves narrow, sharply defined; facial grooves absent. Aperture unknown; apical septum slightly convex. Ornamentation fine; ridges regular, narrow, crowded (20—25 in 5 mm.) forming an angle of about  $140^{\circ}$  across the face. Furrows crossed by fine, regular, well-marked striations, which in places are seen to extend to the ridges.

*Dimensions.*—Length about 60 mm. Greatest width of face, 12 mm.

*Description.*—The figured specimen, although very imperfect, shows a considerable amount of shell in a good state of preservation. The septum is finely wrinkled parallel to its long axis, which indicates that the specimen is compressed; but the ridges, meeting at a broad angle in the “central” marginal groove, and falling away more sharply towards the sides, indicate that the natural form is a rhomb, and not a square. The ridges are very regularly spaced through the whole length of shell, and are for the most part smooth. However, in a few places, the striations of the furrows appear to extend to the ridges, forming slight tubercles, which have probably been worn down over the rest of the shell.

*Affinities.*—This small species is quite distinct from the other cancellate types. It resembles *C. planiseptata* more closely than any other form, but is readily distinguished by the slow rate of tapering, the fine ornamentation, and the nearly smooth ridges.

*Horizon and Locality.*—Carboniferous Limestone: Farlow, Salop.

*Type.*—British Museum (Nat. Hist.) (reg. no. G. 17665).

### **Conularia, sp.**

*Remarks.*—In the Llandeilo rocks of Craighead and Ardmillan fragments of a cancellate *Conularia* are found, which probably belong to a separate species, but on account of the very imperfect condition of the shells it is impossible to give a definite diagnosis. The transverse section is probably a very much flattened rhomb, for the faces show a great want of symmetry, the ridges forming a straight line across the “central” marginal groove. The marginal grooves are wide, but well-defined, and the ornamentation, which is markedly cancellate, is continuous across the grooves. The longitudinal bars in the furrows are well separated, as in *C. planiseptata*.

INDEX OF SPECIES OF CONULARIA.

Specific Name.	Pages.	Plates and Figs.
<i>aspersa</i>	3, 6, 8, 11, 18, <b>19</b> , 20, 21, 22	I, 5—9
sp. cf. <i>aspersa</i>	<b>21</b>	I, 13, 14
<i>bifasciata</i>	3, 19	
<i>bilineata</i>	20	
<i>breviconventa</i>	5, 31, 38, <b>39</b>	V, 12, 13
<i>cancellata</i>	3, 37, 38	
<i>clavus</i>	3, 26	
<i>complanata</i>	3, 5, 30, <b>35</b>	IV, 12—14
<i>corium</i>	3, 14, <b>15</b>	
<i>coronata</i>	5, 16, 18, <b>23</b> , 24, 25	III, 1
<i>crassa</i>	4, 5, 8, 12, 27, 30, <b>32</b>	IV, 4—6
<i>deflexicosta</i>	19, <b>27</b>	
<i>doveri</i>	24	
<i>elegans</i>	31, <b>39</b>	V, 14
<i>elongata</i>	2, 12, 30, <b>31</b>	
<i>exquisita</i>	20	
<i>globosa</i>	4, 8, 19, <b>27</b>	III, 7—8
<i>hiastata</i>	19, <b>29</b> , 34	IV, 1
<i>homfrayi</i>	3, 5, 14, 15, <b>16</b>	
<i>hispidata</i>	4, 5, 8, 19, <b>28</b> , 29, 34	III, 9—11
<i>insignis</i>	24	
<i>laevigata</i>	3, 5, 14, <b>17</b>	
<i>laevis</i>	17	
<i>linnarssoni</i>	12, 14, <b>16</b> , 25, 31	I, 1—4
<i>llanvirnensis</i>	3, <b>14</b>	
<i>margaritifera</i>	3, 18, <b>24</b>	II, 5
<i>microscopica</i>	6, 8, 18, <b>24</b> , 25	II, 6—9
<i>calandica</i>	33	
<i>planiseptata</i>	30, <b>35</b> , 37, 38, 40	V, 1—2
<i>plicata</i>	12, 30, <b>31</b>	IV, 2—3
<i>proteica</i>	38	
<i>punctata</i>	5, 6, 8, 18, <b>20</b> , 21	I, 10—12
<i>pyramidata</i>	15	
<i>quadrisulcata</i>	2, 3, 4, 5, 6, 9, 18, <b>25</b> , 28, 33, 37	III, 2—6
<i>scalaris</i>	8	
<i>sosia</i>	24	
<i>sowerbyi</i>	2, 3, 5, 6, 30, 34, <b>37</b> , 39	V, 7—11
<i>subtilis</i>	3, 4, 30, <b>33</b> , 34, 35	IV, 7—11
<i>tenuis</i>	3, 6, 7, 18, 20, <b>21</b>	II, 1—3
<i>tenuis</i> var. <i>maculosa</i>	<b>23</b>	II, 4
<i>teres</i>	2	
<i>trentonensis</i>	39	
<i>triangularis</i>	3, 19, <b>28</b> , 29	III, 12
<i>tubericosta</i>	26	
<i>vesicularis</i>	5, 30, <b>36</b> , 38	V, 3—6

The names printed in italics either refer to foreign species or are synonyms. The numeral in black type indicates the page on which the specific diagnosis occurs.





## EXPLANATION OF THE PLATES.

All the figures are of natural size unless the amount of enlargement is stated. Owing to the very great difference between the coarse and fine species I have found it impossible to make all magnifications of details the same. The magnifications are all 2, 5, 10, or multiples of 10, and when possible a 10 magnification is given for comparison.

### PLATE I.

FIGS.		PAGE
1—4.	<i>Conularia linnarssoni</i> , Holm Mrs. Gray's Collection . . . . .	16
	1. Specimen from Llandeilo Beds, Balclatchie. Uncrushed, showing a square cross-section. × 2.	
	2. Small flattened specimen from the same locality. Shell almost smooth. × 2.	
	3. Marginal groove. × 20.	
	4. Facial groove showing striations. × 20.	
5—9.	<i>Conularia aspersa</i> , Lindström . . . . .	19
	5. Specimen from the Lower Ludlow of Church Hill, showing the apertural cone. British Museum (Nat. Hist.), no. 5373.	
	6 <i>a</i> . Large imperfect specimen from the same locality, compressed so as to show the "septa" from the under faces. 6 <i>b</i> . Portion of shell with "septa." × 5. 6 <i>c</i> . Ornamentation. × 40. British Museum (Nat. Hist.), no. G. 4603.	
	7. Ornamentation of another specimen from the same locality. × 40. British Museum (Nat. Hist.), no. G. 4604.	
	8 <i>a</i> . Specimen from the Silurian of Gotland. 8 <i>b</i> . Ornamentation. × 40. Vetenskaps Akademi, Stockholm.	
	9 <i>a, b, c</i> . Ornamentation of other Swedish specimens. × 40.	
10—12.	<i>Conularia punctata</i> , sp. nov. Mrs. Gray's Collection . . . . .	20
	10 <i>a</i> . Small specimen from the Upper Llandovery of Penkill, uncrushed.	
	10 <i>b</i> . Cross-section of shell. 10 <i>c</i> . Ornamentation above fracture. × 20.	
	11. Portion of the inner surface of the shell of another specimen, showing the septa projecting inwards only. × 10.	
	12 <i>a</i> . Ornamentation of a larger specimen. × 20. 12 <i>b</i> . External cast of the same. × 20.	
13, 14.	<i>Conularia</i> sp., cf. <i>aspersa</i> , Lindström Mrs. Gray's Collection . . . . .	21
	13 <i>a</i> . External cast of large specimen from the Starfish Bed (Upper Bala), Girvan, showing one face. 13 <i>b</i> . Ornamentation. × 20.	
	14 <i>a</i> . Ornamentation of a small specimen from the same locality. × 20.	
	14 <i>b</i> . The same. × 40.	

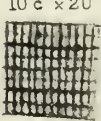
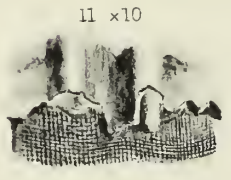
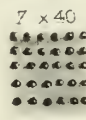
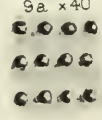
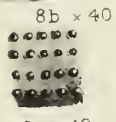
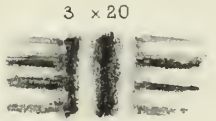
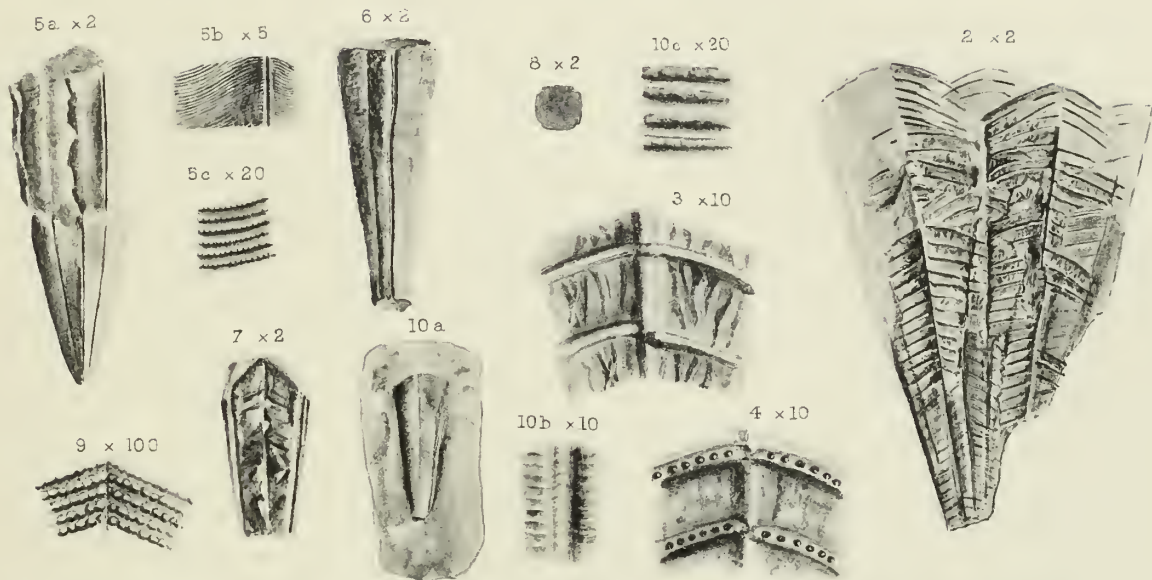






PLATE II.

FIGS.		PAGE
1—3.	<i>Conularia tenuis</i> , sp. nov. . . . .	21
	1. Slab of Calciferous Sandstone from Glencartholm, showing numerous specimens attached by their apices. Geological Survey Museum, Edinburgh, no. 1.	
	2. Compressed specimen from the same locality, showing the thinness of the shell. × 2. British Museum (Nat. Hist.), no. G. 17661.	
	3. Ornamentation of another specimen. × 10.	
4.	<i>Conularia tenuis</i> , var. <i>maculosa</i> , nov. British Museum (Nat. Hist.), no. G. 17663. Ornamentation. × 10 . . . . .	23
5.	<i>Conularia</i> , sp. ( <i>margaritifera</i> Salter ?). Sedgwick Museum, Cambridge . . . . .	24
	5 <i>a.</i> Small specimen from the Skiddaw Slates, Brunstock Scar. × 2. 5 <i>b.</i> Small portion of the shell by the central facial groove, showing the fine ornamentation. × 5. 5 <i>c.</i> Ornamentation. × 20.	
6—9.	<i>Conularia microscopica</i> , sp. nov. . . . .	24
	6. Specimen nearly complete and uncrushed from the Wenlock Shale of Buildwas. × 2. Museum of Practical Geology, no. 12628.	
	7. Imperfect flattened specimen from the same locality, showing the crumpled shell. × 2. British Museum (Nat. Hist.), no. G. 17668.	
	8. Cross-section near apex of another specimen. × 2.	
	9. Ornamentation. × 100.	
10.	<i>Conularia</i> , sp. British Museum (Nat. Hist.), no. G. 11798 . . . . .	25
	10 <i>a.</i> Specimen from the Wenlock Limestone of Ledbury showing one face. 10 <i>b.</i> Marginal groove. × 10. 10 <i>c.</i> Ornamentation. × 20.	



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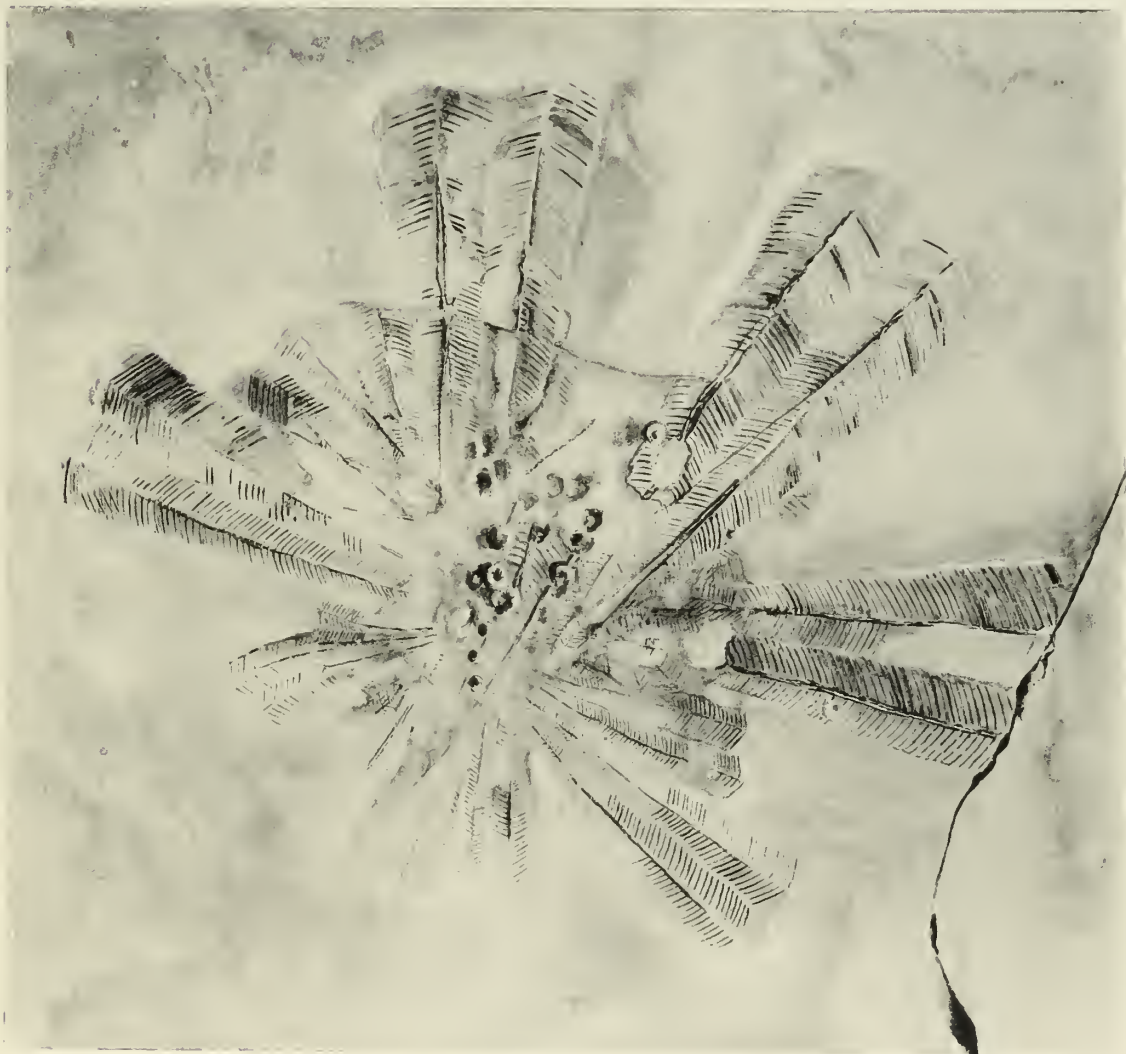






PLATE III.

FIGS.	PAGE
1. <i>Conularia coronata</i> , sp. nov. British Museum (Nat. Hist.), no. G. 17660 . . . . .	23
1 <i>a.</i> Compressed specimen from the Lower Llandeilo Rocks of Ritton Castle, showing one nearly complete face and one half face. 1 <i>b.</i> Marginal groove. × 5. 1 <i>c.</i> Ornamentation. × 20.	
2—6. <i>Conularia quadriseleata</i> , Sowerby . . . . .	25
2. Specimen from the Carboniferous Limestone of Staffordshire in the private collection of Sir Thomas Wardle.	
3. Flattened specimen from the Coal Measures, Salop. British Museum (Nat. Hist.), no. 3448.	
4 <i>a.</i> Specimen from Carluke, Glasgow. Museum of Practical Geology, no. 11903. 4 <i>b.</i> Ornamentation near the apex. × 20.	
5. Ornamentation of a specimen from the Coal Measures, Coalbrookdale. × 20.	
6. Aperture of a small specimen from Coalbrookdale. × 2.	
7, 8. <i>Conularia globosa</i> , sp. nov. Museum of Practical Geology . . . . .	27
7 <i>a.</i> Specimen from the Carboniferous Limestone of Avon Gorge. 7 <i>b.</i> Cross-section just below fracture. 7 <i>c.</i> Cross-section of septum. 7 <i>d.</i> Ornamentation. × 20. (No. 11909.)	
8. Young specimen from the same horizon at Tortworth. (No. 11911.)	
9—11. <i>Conularia hispida</i> , sp. nov. . . . .	28
9 <i>a.</i> Specimen from the Wenlock Limestone near Dudley. 9 <i>b.</i> Ornamentation. × 10. British Museum (Nat. Hist.), no. G. 10041.	
10. Cross-section of another specimen from Ledbury. British Museum (Nat. Hist.), no. G. 11796.	
11. Ornamentation of a specimen from the Upper Bala of Thraive Glen, Girvan, showing the pear-shaped tubercles. × 20. Mrs. Gray's Collection.	
12. <i>Conularia triangularis</i> , sp. nov. British Museum (Nat. Hist.), no. 866 . . . . .	28
12 <i>a.</i> Imperfect specimen from the Wenlock Limestone of Dudley. 12 <i>b.</i> Cross-section. 12 <i>c.</i> Marginal groove. × 10. 12 <i>d.</i> Ornamentation. × 20.	

1a

9a

7a x 20

7a

11 x 20

9b x 10

7b

10

8

7c

1c x 20

5 x 20

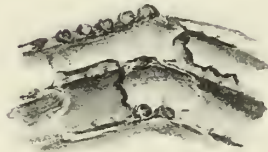
6 x 2

1b x 5

4b x 20

2

12c x 10



3

12a

4a

12d x 20

12b

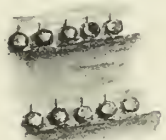
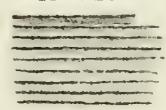
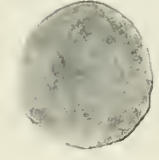
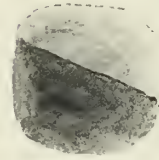
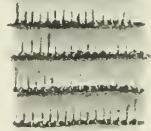
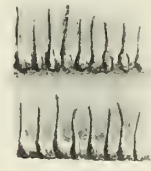






PLATE IV.

FIGS.		PAGE
1.	<i>Conularia hastata</i> , sp. nov. Geological Survey Museum, Edinburgh	29
	1 <i>a.</i> Specimen showing one face, from the Upper Ludlow, R. Esk below Henshaw Burn. (Reg. no. 4623.) 1 <i>b.</i> Ornamentation. $\times 10$ . 1 <i>c.</i> Ornamentation. $\times 20$ . 1 <i>d.</i> External cast of ornamentation. $\times 20$ .	
2, 3.	<i>Conularia plicata</i> , sp. nov. Mrs. Gray's Collection . . . . .	31
	2 <i>a.</i> Uncrushed specimen with square cross-section from the Starfish Bed (Upper Bala), Girvan. 2 <i>b.</i> Marginal groove. $\times 10$ .	
	3 <i>a.</i> Flattened specimen from the same locality. 3 <i>b.</i> Ornamentation. $\times 10$ .	
4—6.	<i>Conularia crassa</i> , sp. nov. . . . .	32
	4 <i>a.</i> Large specimen from the Wenlock Limestone of Dudley. British Museum (Nat. Hist.), no. G. 6271. 4 <i>b.</i> Ornamentation. $\times 5$ .	
	5. Cross-section of a slightly compressed specimen from the same locality. Museum of Practical Geology, no. 12510.	
	6 <i>a.</i> Small specimen from the same locality. British Museum (Nat. Hist.), no. 47832. 6 <i>b.</i> Ornamentation. $\times 5$ .	
7—11.	<i>Conularia subtilis</i> , Salter . . . . .	33
	7 <i>a.</i> Specimen from the Upper Ludlow, Usk, Monmouthshire. 7 <i>b.</i> Ornamentation above the fracture. $\times 10$ . 7 <i>c.</i> The same. $\times 20$ . British Museum (Nat. Hist.), no. G. 4602.	
	8. Specimen from the same horizon at Benson Knot. Sedgwick Museum, Cambridge, reg. no. G. 14.	
	9 <i>a.</i> Flattened specimen from the same horizon at Bradnor Hill, Kington. 9 <i>b.</i> Ornamentation. $\times 20$ . Museum of Practical Geology, no. 12497.	
	10 <i>a, b.</i> Ornamentation of different parts of the same shell from the Whitcliff, Ludlow. $\times 20$ .	
	11. Ornamentation of specimen from Deerhope, Pentland Hills. $\times 20$ . British Museum (Nat. Hist.), no. G. 8744.	
12—14.	<i>Conularia complanata</i> , sp. nov. . . . .	35
	12. Imperfect specimen from the Carboniferous Limestone of Farlow, Salop. British Museum (Nat. Hist.), no. G. 17666.	
	13. Cross-section of another specimen from the same horizon.	
	14 <i>a.</i> Ornamentation of another specimen. $\times 10$ . 14 <i>b.</i> The same. $\times 20$ .	

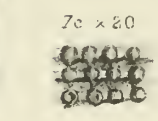
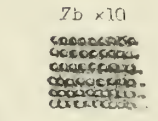
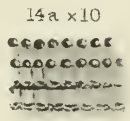
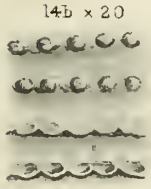
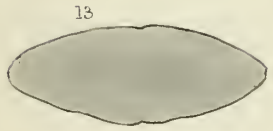
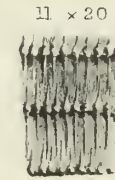
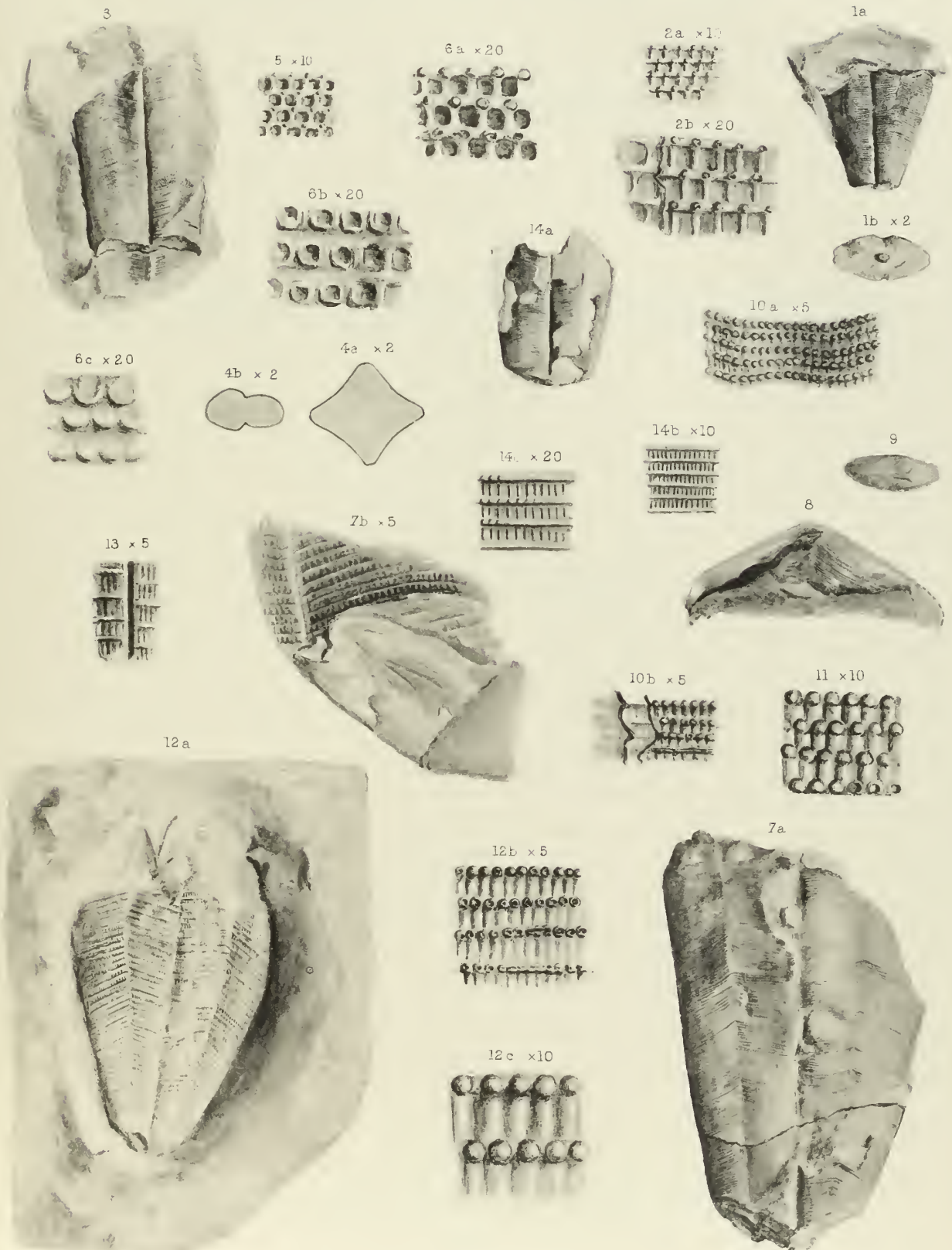






PLATE V.

FIGS.		PAGE
1, 2.	<i>Conularia planiseptata</i> , sp. nov. Mrs. Gray's Collection .	35
	1 <i>a.</i> Specimen from the Upper Bala of Thraive Glen. 1 <i>b.</i> Apical septum, showing siphuncle (?). × 2.	
	2 <i>a.</i> Ornamentation of another specimen from the same locality. × 10. 2 <i>b.</i> The same. × 20.	
3—6.	<i>Conularia vesicularis</i> , sp. nov. . . . .	36
	3. Imperfect specimen from the Bala of Acton Scott. Museum of Practical Geology, no. 12647.	
	4 <i>a.</i> Cross-section of another specimen at the aperture. × 2. 4 <i>b.</i> The same at the apex. × 2.	
	5. Ornamentation. × 10.	
	6. Different appearances of ornamentation. × 20. 6 <i>a.</i> Ridges well preserved. 6 <i>b.</i> Ridges worn, and rounded hollows prominent. 6 <i>c.</i> Shell all removed, and internal cast left.	
7—11.	<i>Conularia sowerbyi</i> , de Verneuil . . . . .	37
	7 <i>a.</i> Specimen from the Wenlock Limestone of Dudley, ending in a broken apical septum. 7 <i>b.</i> Portion of broken apical septum. × 5. British Museum (Nat. Hist.), no. 6327.	
	8. Imperfect aperture of another specimen. Museum of Practical Geology, no. 12504.	
	9. Complete apical septum of another specimen. Museum of Practical Geology, no. 11799.	
	10 <i>a.</i> Marginal groove. × 5. 10 <i>b.</i> Portion showing inner layer of shell. × 5.	
	11. Ornamentation. × 10.	
12, 13.	<i>Conularia breviconventa</i> , sp. nov. . . . .	39
	12 <i>a.</i> Specimen from the Wenlock Limestone of Dudley. 12 <i>b.</i> Ornamentation. × 5. 12 <i>c.</i> The same. × 10. British Museum (Nat. Hist.), no. G. 17667.	
	13. Marginal groove of another specimen. × 5.	
14.	<i>Conularia elegans</i> , sp. nov. British Museum (Nat. Hist.), no. G. 17665 . . . . .	39
	14 <i>a.</i> Small specimen from the Carboniferous Limestone of Farlow, Salop. 14 <i>b.</i> Ornamentation. × 10. 14 <i>c.</i> The same. × 20.	





Palæontographical Society, 1907.

A MONOGRAPH

OF THE

BRITISH CAMBRIAN TRILOBITES.

BY

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PART II.

PAGES 29—48; PLATES III, IV.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1907.

PRINTED BY ADLARD AND SON, LONDON AND DORKING.

to represent the second segment; terminates in a blunt point. Lateral lobes considerably narrowed behind the axis, where they are confluent with one another.

Head- and tail-shields (judging from a distorted specimen) about 4—4·5 mm. long and wide.

Since the above description was printed I have found a less distorted specimen, from Dwrrhyd, near Solva, in the Oxford University Museum. It shows that the second segment of the axis of the tail was perfectly defined posteriorly by a furrow in the position of the crack which crosses the axis in the specimen represented in Plate II, fig. 24. The head- and tail-shields are about 4 mm. long and 5·5 mm. wide.

Our specimens are slightly smaller than those described by Brögger, and the head is somewhat less quadrate than in his figures. Matthew makes the same remarks about the American form, which he refers to *Agnostus parvifrons*, var. *truncatus*, and which he identifies, with some doubt, with Brögger's species.

*Horizon and Localities.*—Menevian: Solva; Dwrrhyd, near Solva.

#### *Section LONGIFRONTES (addendum).*

Since the first part of this monograph was published I have found, amongst the specimens collected by Mr. Rhodes for the Geological Survey, and at present deposited in the Museum of Birmingham University, several heads and tails of Brögger's *A. incertus*, of which accordingly I append a description.

#### 26. *Agnostus incertus*, Brögger. Plate III, figs. 1—3.

1879. *Agnostus incertus*, Brögger, *Nyt Mag. for Naturv.*, vol. xxiv, p. 70, pl. vi, fig. 4 *a, b*.

1880. *Agnostus incertus*, Tullberg, *Agnostus-arterna*, p. 19, pl. i, fig. 6 *a, b*.

Head rounded in front, with a narrow margin. Glabella narrow, bilobed; anterior lobe obtusely pointed in front; posterior lobe long, nearly parallel-sided, but with two scarcely visible lateral impressions on each side, elevated posteriorly. Cheeks somewhat narrowed in front of the glabella, where they are separated by a furrow.

Tail sub-quadrate, with a narrow margin, which bears a minute spine on each side. Axis broad and elevated in front, somewhat abruptly constricted behind, and produced into a depressed and narrow point wedged between the lateral lobes; segmentation indicated only by two short grooves on each side of the elevated anterior portion; in the space between these grooves is a prominent

median tubercle. Lateral lobes very slightly narrowed posteriorly, and separated behind the axis by a furrow.

Head- and tail-shields 5—6 mm. long and wide.

The heads are, unfortunately, not complete, and do not show the hinder portion. According to Tullberg, the posterior lobe of the glabella bears a median tubercle, and the basal lobes are triangular and confluent behind. In Brögger's and Tullberg's figures the anterior lobe is represented as much more acute in front than in our specimens; but this is probably owing to the somewhat imperfect preservation of the British specimens, and the fact that they are without the test. The tail agrees exactly with the Scandinavian form.

Amongst British species the nearest ally is *A. exaratus*, Grönwall. In that species, however, the axial furrows are much deeper, both in the head and in the tail. The axis of the tail, moreover, although it is produced into a depressed point, is not so suddenly constricted as in *A. incertus*, nor is the pointed termination so long. The segmentation of the axis is even less distinct than in the latter species.

*Horizon and Locality.*—Cambrian: from “supplementary stream seven chains south-west of Neves Castle” [Shropshire] “four yards below *Paradoxides* Bed, irregular brecciated bed in crushed shales.” In Scandinavia this species occurs in the *Paradoxides* zone.

Genus **MICRODISCUS**, Salter (*nou* Emmons).

(? *Pemphigaspis*, Hall.)

The genus *Microdiscus* was first established by Emmons<sup>1</sup> in 1855 for a small trilobite, to which he gave the name *M. quadricostatus*. In 1864 Salter<sup>2</sup> referred to the same genus the British form which has ever since been known as *M. punctatus*; and, in practice, it is Salter's species which is now universally taken as the type. Unfortunately, however, it does not belong to the same genus as Emmons's specimen, and consequently the name proposed by Emmons has entirely lost its original significance. As long ago as 1861 it was pointed out by Barrande<sup>3</sup> that *M. quadricostatus* resembles the young of *Trinuclerus*, and that Emmons was probably in error in considering it more ancient than the rest of his Taconic trilobites. Walcott<sup>4</sup> has since made a similar observation, and states that

<sup>1</sup> American Geology, vol. i, pt. 2 (1855), p. 116, pl. i, fig. 8.

<sup>2</sup> Quart. Journ. Geol. Soc., vol. xx (1864), p. 237.

<sup>3</sup> Bull. Soc. Géol. France, ser. 2, vol. xviii (1861), p. 280, pl. v, fig. 13. Barrande reproduces Emmons's figure and description.

<sup>4</sup> Bull. U. S. Geol. Surv., no. 30 (1886), p. 152.

the shales from which Emmons's specimen was obtained, belong to the Hudson River group, which is of Ordovician age. The figure given by Emmons is sufficiently clear to show that his specimen was one of the Trinucleidæ, for the tail, thorax, and glabella are all of the same type as in *Trinucleus* and *Ampyx*. In the number of thoracic segments and the form of the head-shield, as shown in the figure, the specimen undoubtedly presents immature characters, and, as *Trinucleus concentricus* is abundant at the same horizon, it is probably the young of that species. It cannot, therefore, stand as the type of a genus; and if it did, it is not the genus to which the species usually referred to *Microdiscus* belong. How far the continuous usage of nearly forty years may override the strict rules of nomenclature is a matter of personal opinion, but it would certainly be premature at present to substitute another name; for, as Walcott has pointed out, *Pemphigaspis bullata*, Hall,<sup>1</sup> is closely related to the reputed *Microdiscus*, and probably belongs to the same genus. Should this prove to be the case, *Pemphigaspis* is the name which ought to be employed. Until, however, Hall's species is more completely known, the matter remains uncertain, and for the present, therefore, I follow other writers in using the name *Microdiscus* in Salter's sense, with *M. punctatus*, Salter, as the type.

The genus is usually distinguished from *Agnostus* by the facts that it possesses three or four thoracic segments, and that the axis and sometimes the lateral lobes of the tail are divided into a number of segments. It is less easy to give any constant character which will invariably distinguish between the heads. In *Agnostus* the glabella is usually divided into a small anterior and a long posterior lobe; in *Microdiscus* it is either smooth or more or less distinctly divided into several segments of approximately equal length, and if the divisions tend to become obsolete, it is in the anterior part of the glabella that they first disappear. The basal lobes characteristic of *Agnostus* are absent in *Microdiscus*, or are represented only by very obscure elevations in the axial furrows. In *Microdiscus* the margin of the head is often beaded, punctate, or ornamented with tubercles; in *Agnostus* it is smooth.

It is often stated that the thorax of *Microdiscus* consists of four segments. Both *M. punctatus*, Salter, and *M. speciosus*, Ford,<sup>2</sup> were originally described as possessing four thoracic segments. Ford,<sup>3</sup> however, subsequently showed that in *M. speciosus* the number of segments is really three; and an examination of a large series of specimens of *M. punctatus* proves that in that species also there are only three. In *M. punctatus* each of the pleural segments is deeply grooved: there is also a strongly marked groove near the posterior margin of the head, and another near the anterior margin of the tail. There are thus five deep furrows

<sup>1</sup> Sixteenth Ann. Rep. N. Y. State Cab. Nat. Hist. (1863), p. 221, pl. v a, figs. 3—5.

<sup>2</sup> Amer. Journ. Sci., ser. 3, vol. vi (1873), p. 137.

<sup>3</sup> Ibid., vol. xiii (1877), p. 141.

with four strong ridges between them, and possibly Salter may have counted the number of ridges. Examination with a microscope, however, shows that the dividing lines between the head, the thoracic segments, and the tail lie along these ridges, and that the first and last grooves belong to the head and tail respectively.

According to Matthew,<sup>1</sup> the number of thoracic segments varies from two to four.

### 1. *Microdiscus lobatus* (Hall). Plate III, figs. 4—6.

1847. *Agnostus lobatus*, Hall, Pal. New York, vol. i, p. 258, pl. lxxvii, fig. 5 *a—f*.

1858. *Agnostus lobatus*, Rogers, Geol. Surv. Pennsylvania, vol. ii, p. 820, fig. 614 (1—4).

1873. *Microdiscus lobatus*, Ford, Amer. Journ. Sci., ser. 3, vol. vi, p. 135, footnote.

1886. *Microdiscus lobatus*, Walcott, Bull. U. S. Geol. Surv., no. 30, p. 156, pl. xvi, figs. 1, 1 *a*, 1 *b*.

1888. *Microdiscus lobatus*, Shaler and Foerste, Bull. Mus. Comp. Zool. Harvard, vol. xvi, p. 36, pl. ii, fig. 13.

1890. *Microdiscus lobatus*, Walcott, Tenth Ann. Rep. U. S. Geol. Surv., p. 632, pl. lxxxi, figs. 4, 4 *a*, 4 *b*.

Head forming rather more than a semicircle, with a broad margin. Glabella nearly cylindrical, rounded in front, elevated above the cheeks, reaching forward to the wide marginal groove; occipital furrow deep, sometimes two weaker transverse furrows dividing the glabella in front of the occipital furrow into three approximately equal lobes; occipital ring strong, elevated in the middle into an ill-defined tubercle. Cheeks small, semilunar, convex. Margin very broad in front of the glabella, narrowing towards the sides, expanded again at the genal angles, continuous with the flattened space behind the cheeks; consisting, in front, of a broad groove with an external raised rim, the rim dying out towards the side of the head, where the margin becomes flat; slightly upturned again at the genal angle; in the anterior groove a row of small punctæ is sometimes indistinctly visible.

Head-shield 1.5 mm. long, 2 mm. wide.

The cylindrical glabella and broad margin distinguish this form very easily from all the other known British species. It was discovered by Mr. E. S. Cobbold in an exposure of limestone 200 yards south of Comley Quarry, and it is to him that I am indebted for bringing it to my notice. Although he examined a large amount of material, and obtained some ten or twelve specimens, they all appear to be heads. According to Walcott, the axis of the tail in *M. lobatus* is marked by three well-defined transverse furrows, and the lateral lobes by three principal furrows and three slight furrows (presumably intermediate).

There appears to be a considerable amount of variation in the American

<sup>1</sup> Trans. N. Y. Acad. Sci., vol. xv (1896), p. 235.

specimens. Hall, and Shaler and Foerste represent the glabella as reaching to the anterior margin, which in Shaler and Foerste's figure is much broader in front of the glabella than at the sides (as in the Comley form). In Walcott's figures the glabella does not reach the margin, and the margin is not expanded in front. In one of Hall's figures the glabella is cylindrical, in another it is narrowest in front; in Shaler and Foerste's figure it is constricted in the middle; in one of Walcott's figures it is conical, in the other it is a little narrowed at the middle lobe. The occipital furrow appears always to be strong, but the fainter transverse furrows are only occasionally seen—the greater number of examples, according to Walcott, are without them. Walcott remarks on the variability in the outline of the head and in the form of the glabella.

*Horizon and Locality.*—Cambrian: limestone beds 200 yards south of Comley Quarry, Shropshire. In America the species belongs to the *Olenellus* zone.

## 2. *Microdiscus speciosus*, Ford. Plate III, fig. 7.

1873. *Microdiscus speciosus*, Ford, Amer. Journ. Sci., ser. 3, vol. vi, p. 137, fig. 2 *a, b*.

1877. *Microdiscus speciosus*, Ford, loc. cit., vol. xiii, p. 141.

1886. *Microdiscus speciosus*, Walcott, Bull. U. S. Geol. Surv., no. 30, p. 154, pl. xvi, figs. 3, 3 *a—c*.

1890. *Microdiscus speciosus*, Walcott, Tenth Ann. Rep. U. S. Geol. Surv., p. 632, pl. lxxxi, figs 5, 5 *a—c*.

1896. *Microdiscus speciosus*, Matthew, Trans. N. Y. Acad. Sci., vol. xv, p. 236, pl. xvii, fig. 6.

Head convex, semi-elliptical, somewhat acute in front, and obliquely rounded at the genal angles, with a narrow margin. Glabella conical, forming about one third of the whole width, elevated above the cheeks, and separated from them by distinct but not very deep axial furrows, reaching forward nearly to the anterior margin, and projecting slightly backwards beyond the posterior margin, without any sign of occipital or glabellar furrows. Cheeks sloping downwards from the glabella to the margin, wide posteriorly, narrowing forwards, confluent in front of the glabella, surrounded posteriorly as well as round the sides and front by a marginal groove and rim. Margin narrow, slightly expanded in front, consisting of a groove and an external raised rim, both of which are continued behind the cheeks to the glabella, with six or seven distant tubercles upon the rim on each side, and one behind the cheeks.

Head-shield 8 mm. long, 9 mm. wide.

The specimen here described, the only one yet known in Britain, was found, with *M. lobatus*, by Mr. E. S. Cobbold in an exposure of limestone 200 yards south of Comley Quarry. It agrees in every particular with the figure and description given by Ford of the head of *M. speciosus*, and it closely resembles Walcott's fig. 3 *c* in 'Bull. U. S. Geol. Surv.,' no. 30, pl. xvi, although in that figure the glabella

is somewhat shorter. It is larger than is usually the case in this species, but some of the specimens mentioned by Ford exceed it in length. According to Matthew, *M. speciosus* has three pairs of broadly but distinctly impressed furrows on the sides of the glabella, and also a pair of sharply cut occipital furrows, but on many heads of adult examples all these furrows are quite obliterated. As the tail will no doubt be found some time, I quote Ford's description :

“Pygidium as long as the head and of nearly the same shape, but slightly narrower, taking the extreme measurements, and more rapidly tapering; gracefully curved in outline. Marginal rim distinct all round, widest anteriorly, distinctly raised or thickened at the edge. Axis conical, sometimes acutely so, long and slender, extending very nearly to the margin, divided by faint cross furrows directed slightly backward into eleven rings or segments. Side-lobes highly convex and without furrows. The axis and side-lobes appear to overhang the marginal rim at the posterior extremity, giving the border the appearance of being only about half as wide behind as it is in front.

“The entire surface is finely punctate. In one specimen of the pygidium, out of a large number of perfect specimens examined, there appears to be a twelfth ring in the axis.”

*Horizon and Locality.*—Cambrian: limestone beds 200 yards S. of Comley Quarry, Shropshire. In America the species belongs to the *Olenellus* zone.

### 3. *Microdiscus* sp. Plate III, fig. 8.

A small tail found by Mr. E. S. Cobbold in the *Olenellus* band of Comley Quarry is too imperfect to identify with certainty; but as it is certainly different from any species hitherto recognised in Britain, it is of sufficient interest to be described and figured. It is an internal cast, without test.

Tail semi-elliptical. Axis broad, conical, prominent, reaching nearly to the posterior margin, distinctly segmented, four rings being visible on the portion preserved. Lateral lobes narrow, smooth, sloping downwards rather steeply from the axis. Margin, or doublure, broad and concave (on the cast).

Length 2·8 mm.; width about 3 mm.

It agrees very closely with the tail of *M. helena*, Walcott,<sup>1</sup> from which, indeed, it appears to differ only in the width and concavity of the margin. The Comley specimen, however, is an internal cast, and the apparent margin seems to be the impression of the doublure. The difference, therefore, is probably apparent rather than real.

*Horizon and Locality.*—*Olenellus* limestone: Comley Quarry, Shropshire.

<sup>1</sup> Tenth Ann. Rep. U. S. Geol. Surv. (1890), p. 632, pl. lxxxi, figs. 1, 1 a.

4. *Microdiscus sculptus*, Hicks. Plate III, figs. 9, 10.

1871. *Microdiscus sculptus*, Hicks, Quart. Journ. Geol. Soc., vol. xxvii, p. 400, pl. xvi, figs. 9, 9 a, 10, 10 a.

Head semicircular or semi-elliptical, marginate. Glabella conical, about one third as wide and rather more than half as long as the head, bounded by well-marked axial furrows. Checks about as wide as the glabella posteriorly, nearly uniform in width, separated in front of the glabella by a groove; occipital furrow deep. Margin very broad in front, narrowing rapidly to the genal angles, ornamented in front by a row of rather large tubercles.

Thorax of three segments. Axis forming about one third of the width. Pleuræ deeply grooved, bent downwards at the tips.

Tail semicircular or semi-elliptical, marginate. Axis about a quarter the width of the whole tail in front, prominent, conical, not quite reaching to the margin, divided into six rings besides the articular ring and the terminal portion, some of the rings with a pair of small tubercles. Lateral lobes with five distinct furrows separating rounded ribs; the first furrow nearly at right angles to the axial line; the last very close to the axis and almost parallel with it. Margin narrow, flat.

Total length of entire but compressed specimen, 8.5 mm.; width 3 mm.

The only specimen known which shows the head and thorax is, unfortunately, very imperfectly preserved, and is, apparently, much compressed. In an undistorted specimen the outline of the head and tail would probably be semicircular. It is impossible to say whether a neck-spine was present, and very difficult to determine the number of thoracic segments. Hicks's figure shows four; but in front of the tail there are only four grooves, and of these the first, I think, is the occipital furrow of the head. In that case the remaining three are the pleural grooves, and there cannot be more than three thoracic segments. It is, however, possible that there may be no occipital furrow, and that the front groove may belong to the thorax.

There is little chance of confounding *M. sculptus* with any other British species. The head, however, in its general appearance is a little like the head of *M. punctatus*. It is, unfortunately, very imperfectly preserved in the only complete specimen yet known; but the glabella and cheeks appear to differ in no important respect from those of *M. punctatus*. The principal distinction lies in the margin, which is broader in front and appears to be narrower at the sides than in that species. Moreover, in the former it is ornamented by a row of rather large tubercles; in the latter it is crenulated throughout, the beads being very much smaller and less elevated than the tubercles of *M. sculptus*. The tail is the most characteristic portion. In *M. lobatus*, also, there are well-marked ribs upon the axis and lateral

lobes, but the number of these is smaller. In *M. speciosus* the segmentation of the axis is faint and the lateral lobes are without furrows. In *M. punctatus* the axis is divided into many rings, but the lateral lobes are without ribs.

Of foreign species the most closely related is *M. dawsoni*, Hartt.<sup>1</sup> The tail, indeed, seems to be almost indistinguishable, and the ornamentation of the margin of the head is very similar. The glabella, however, in *M. dawsoni*, is represented both by Walcott<sup>2</sup> and Matthew<sup>3</sup> as extending to the anterior margin; in *M. sculptus* it is not much more than half as long as the head. According to Matthew, *M. dawsoni* has only two thoracic segments; *M. sculptus* has at least three. It is clear, therefore, that the two forms must be specifically distinct.

*Types*.—Both of Hicks's types are in the Sedgwick Museum, Cambridge, and are re-figured on Plate III.

*Horizon and Locality*.—Harlech Series: near Nun's Well, St. David's; West of Porth Clais, St. David's.

##### 5. *Microdiscus punctatus*, Salter. Plate III, figs. 11—17.

1864. *Microdiscus punctatus*, Salter, Quart. Journ. Geol. Soc., vol. xx, p. 237, pl. xiii, fig. 11 *a, b, c*.

1878. *Microdiscus punctatus*, Whiteaves, Amer. Journ. Sci., ser. 3, vol. xvi, p. 225.

1882. *Microdiscus scanicus*, Linnarsson, De undre Paradoxideslagren vid Andrarum, p. 29, pl. iv, figs. 17, 18.

1882. *Microdiscus eucentrus*, Linnarsson, *ibid.*, p. 30, pl. iv, figs. 19, 20.

1884. *Microdiscus punctatus*, Walcott, Bull. U. S. Geol. Surv., no. 10, p. 24, pl. ii, figs. 1, 1 *a—c*.

1886. *Microdiscus punctatus*, var. *pulchellus*, Matthew, Proc. and Trans. Roy. Soc. Can., vol. iii, sect. 4, p. 74, pl. vii, fig. 12 *a, b, c*.

1896. *Microdiscus pulchellus*, Matthew, Trans. N. Y. Acad. Sci., vol. xv, p. 242, pl. xvii, fig. 8 *a—f*.

1896. *Microdiscus punctatus*, Matthew, *ibid.*, p. 244.

1902. *Microdiscus scanicus*, Grönwall, Bornholms Paradoxideslag, p. 79.

1902. *Microdiscus scanicus*, f. *eucentra*, Grönwall, *ibid.*, p. 79, pl. i, fig. 20.

Head semi-elliptical, marginate. Glabella narrow, about two thirds the length of the head, cylindro-conical, with two slight lateral impressions on each side, separated from the cheeks by deep axial furrows; no definite neck-furrow; produced posteriorly into a strong occipital spine which rises upwards and backwards at an angle of about 45°; obscure traces of basal lobes sometimes visible. Cheeks very convex, less prominent than the glabella posteriorly, but elevated above it in front; divided in front of the glabella by a groove which is narrow and but slightly impressed on the outer surface of the test, broad and deep on the internal cast; a strong occipital furrow close to the posterior margin; external surface of the test finely punctate, internal casts nearly smooth. Margin

<sup>1</sup> J. W. Dawson's *Acadian Geology*, 2nd ed. (1868), p. 654, fig. 228.

<sup>2</sup> Bull. U. S. Geol. Surv., no. 10 (1884), p. 23, pl. ii, figs. 3, 3 *a*.

<sup>3</sup> Trans. N. Y. Acad. Sci., vol. xv (1896), p. 240, pl. xvii, fig. 5 *a—c*.

widest in front, somewhat narrower at the sides, slightly produced at the genal angles; smooth on the outer surface, marked on internal casts by close-set transverse impressions which divide it into a row of beads.

Thorax of three segments. Axis narrow, only about half as wide as the pleuræ. Pleuræ straight, bent downwards at the tips, with a broad groove; pointed; the points in the first segment directed backwards, in the other two segments forwards.

Tail semi-elliptical, with the anterior angles truncated, marginate. Axis narrow, forming about one fifth of the total width in front, tapering gradually, divided into a number of rings, of which eight or nine are usually distinct, reaching nearly to the posterior margin, separated from the lateral lobes by very deep axial furrows. Lateral lobes with a broad, deep groove in front, but otherwise without furrows or ribs, wide in front, very narrow behind the axis, where they are confluent with each other; test perforate, or punctate both externally and internally. Margin narrow, nearly equal in width throughout.

Head- and tail-shields about 3 mm. long and 4 mm. broad in specimens of average size.

There are important differences between the exterior and the interior of the test of this species, and consequently the external moulds differ in several respects from the internal casts. These differences are well shown in the series of specimens in the Sedgwick Museum and in other collections. In the moulds which show the exterior of the test, the furrow in front of the glabella (which appears in the mould as a ridge) is a narrow and not very strongly impressed line; in the internal casts it is a deep and broad groove. In the actual tests there must therefore have been a strong interior ridge in this position. In correspondence with this difference the cheeks in the moulds appear to be nearly of uniform width throughout, while in the casts they narrow forwards. In the external moulds the impressions on the sides of the glabella are less distinct than in the internal casts. The margin of the head in external moulds is smooth, in internal casts it is erenulate. The test of the head was finely punctate externally; in internal casts the surface is nearly smooth. The test of the tail was either perforate or punctate both on the exterior and interior surfaces. External moulds therefore show small eminences projecting inwards, indicating that the tail was punctate, while internal casts show similar eminences projecting outwards, suggesting that the tail was tuberculate. In both cases, and especially in the internal casts, the ornamentation is often indistinct and the surface nearly smooth.

In young forms the lateral impressions on the sides of the glabella are much more strongly marked than in the adult, and distinct lateral lobes may sometimes be recognised. The neck-spine also is shorter, and there are fewer rings on the axis of the tail.

On account of the differences between the exterior and interior of the test, and between the young and the adult, there is considerable variety in the appearance of different specimens, and but for the large series obtained from South Wales, some of the variations due to age or to the mode of preservation might be supposed to constitute distinct species. So far as I have observed, however, there is no other species in Great Britain which has a narrow many-ringed axis to the tail and unribbed lateral lobes. The head of *M. sculptus*, in the imperfect condition of the only complete specimen known, is in general shape not unlike an imperfect head of *M. punctatus*, but in the former species the margin shows a row of rather large tubercles in front, which offers little resemblance to the fine crenulation on the under surface of the margin in *M. punctatus*. The species from Comley are so distinct that there is no possibility of confounding them with this form.

In consequence partly of the variations here described, and partly of the brevity of Salter's description and the inadequacy of his figures, forms which appear to be identical with our *M. punctatus* have been recorded under other names both in Scandinavia and in North America.

The Swedish specimens described by Linnarsson as *M. scanicus* and *M. eucentrus* appear to be the same form under different conditions of preservation, and seem to be indistinguishable from the British species. *M. scanicus* is represented by Linnarsson without a neck-spine, but he remarks that some indistinct impressions seem to show indications of such a spine. In our own specimens the spine is often lost, and the glabella appears to end bluntly. Linnarsson also states that there is no definite ornamentation on the cheeks, and the margin of the head is smooth, that the furrow in front of the glabella is narrower than in *M. punctatus*, and the cheeks not so much contracted forwards. The punctation on the cheeks of *M. punctatus* is generally somewhat indistinct, and often quite invisible, and in the other characters mentioned Linnarsson's description agrees with the external moulds of *M. punctatus*. Moreover, according to Grönwall the stone-casts of *M. scanicus* show a weak crenulation of the margin. The other Swedish form, described by Linnarsson as *M. eucentrus*, is believed by Grönwall to be merely a time mutation of *M. scanicus*, and does not differ from the ordinary internal casts of *M. punctatus*.

The form described by Walcott in 1884 as *M. punctatus* is also probably identical with the British species. It is true that the figures of the head which he gives indicate considerable differences. The occipital spine is represented as very short and obtuse, and the margin is ornamented with a row of rather distant tubercles. In these respects, however, the figure scarcely agrees with the description; for Walcott states that the occipital spine in medium-sized specimens is as long as the glabella, and that the marginal groove is marked by numerous short furrows at right angles to the margin. The description, indeed, agrees completely with our Welsh specimens, and judging from it alone I should have little hesitation

in regarding the two forms as identical. According to Walcott, Salter's figures differ from the American specimens in having a longer and more slender spine, and a punctate surface to the head and pygidium. Salter's fig. 11 *b* shows the spine longer than it usually is, and Walcott himself in his description states that the surface of the American form is finely punctate.

There can now be little doubt that the species described and figured by Matthew in 1886 as *M. punctatus*, Salter, var. *pulchellus*, Hartt, and in 1896 as *M. pulchellus*, Hartt, is identical with *M. punctatus*. The characters on which he relies to distinguish the American form are the smaller and more erect occipital spine, the larger number of rings on the pygidial axis, and the fact that the tail is tuberculate instead of punctate. The spine in the Welsh form varies considerably in length, and is often flattened down upon the thorax or broken away altogether; but external moulds show that it rose from the plane of the head at a considerable angle, and it is not usually any longer than in Matthew's figure. The number of rings on the axis is understated by Salter. In most well-preserved specimens of the usual size eight or nine rings are quite distinct, and there may be indications of others. Owing to the increasing vagueness of the annulations towards the end of the axis the precise number of rings which can be counted is a character of little value. As regards the ornamentation of the tail, it has been shown above that owing to the peculiar structure of the test internal casts are often tuberculate.

The form referred by Whiteaves to *M. punctatus* appears to be the same as Matthew's *M. pulchellus*. He states that the species has been observed "on the Kennebecasis River, N.B., where it was collected by Mr. G. F. Matthew." This is one of Matthew's localities for *M. pulchellus*.

From a somewhat higher horizon than *M. pulchellus* Matthew describes another form, which is distinguished by possessing a punctate tail, and which he therefore identifies with *M. punctatus*, Salter. In one locality, however, from this same horizon, specimens have been obtained with tuberculate tails. The difference is probably due to the mode of preservation, the punctate specimens showing the exterior surface of the test and the tuberculate specimens showing the interior.

*Types*.—The original of Salter's fig. 11 *c* is in the Sedgwick Museum, Cambridge; some artificial casts of his fig. 11 *a* are in the British Museum. Salter states that there are four thoracic segments; but the type specimen (re-figured in Plate III, fig. 11) possesses only three. In this specimen, which is an internal cast, the surface of the tail is tuberculate.

*Horizon and Localities*.—Menevian: Porth-y-rhaw and Nine Wells, near St. David's; Dwr-rhyd, near Solva; Tyddyngwladys, Upper Mawddach; Waterfall Valley, Maentwrog.

*Family SHUMARDIIDÆ.*

The genus *Shumardia* has by some writers been placed in the family Agnostidæ. Moberg,<sup>1</sup> however, in 1890 pointed out that it presents scarcely any resemblance to *Agnostus*, except in the absence of eyes and facial sutures, and he concluded that it belongs rather to the Olenidæ. At a later date Pompeckj<sup>2</sup> considered it to be most closely related to *Conocoryphe*; while Reed,<sup>3</sup> like Moberg, included it in the Olenidæ. In the absence of eyes and the marginal position of the facial suture it resembles the Conocoryphidæ; but it differs in the form of the glabella, the small number of thoracic segments, the structure of the pleuræ, and the comparatively large size of the tail. Its stratigraphical position, also, would be remarkable for a member of that family.

Some authorities have supposed that it may be the young of one or other of the genera which are found associated with it; but the large number of specimens which have now been found, in widely separated localities, and the entire absence of forms intermediate between it and any other recognised genus, render this view highly improbable. If it be a larva the change to the adult form must have been as abrupt and almost as striking as the change from the chrysalis to the butterfly; and of such violent metamorphosis we have no evidence in trilobites.

It is an aberrant genus, the affinities of which are not yet determined; and for the present it is most convenient to place it in a family of its own.

*Genus SHUMARDIA*, Billings.1. *Shumardia pusilla* (Sars). Plate III, figs. 18—20; Plate IV, figs. 1—4.

1835. *Battus pusillus*, Sars, *Oakens Isis*, 1835, col. 334, pl. viii, fig. 2 *a, b*.  
 1838. *Trilobites pusillus*, Boeck, *Keilhau's Gæa Norv.*, p. 144.  
 1865. *Agnostus (Olenus?) pusillus*, Kjerulf, *Veiviser ved geol. excursioner i Christiania omegn*, p. 2, and p. 3, fig. 10.  
 1874. *Conophrys salopiensis*, Callaway, *Quart. Journ. Geol. Soc.*, vol. xxx, p. 196.  
 1877. *Conophrys salopiensis*, Callaway, *loc. cit.*, vol. xxxiii, p. 667, pl. xxiv, fig. 7.  
 1882. *Conophrys pusilla*, Brögger, *Die Silur. Etagen 2 und 3*, p. 125, pl. xii, fig. 9.  
 1890. *Shumardia pusilla*, Moberg, *Om en afdelning inom Ölands Dictyonemaskiffer*, p. 4, figs. *a—c*.  
 1902.<sup>?</sup> *Shumardia miqueli*, Pompeckj, *Neues Jahrb.*, 1902, vol. i, p. 5, fig. 2 *a, b*.  
 1902. *Shumardia bottnica*, Wiman, *Bull. Geol. Inst. Upsala*, vol. vi, p. 65, pl. iii, figs. 35—38.  
 1902. *Acanthopleurella grindrodi*, Groom, *Geol. Mag.*, new series, decade iv, vol. ix, p. 70, with 4 figs. (a young form).  
 1906. *Shumardia pusilla*, Moberg and Segerberg, *Ceratopygeregionen*, p. 80, pl. iv, figs. 10—12.  
 1906. *Shumardia bottnica*, Moberg and Segerberg, *ibid.*, p. 81, pl. iv, figs. 13—16.

<sup>1</sup> Om en afdelning inom Ölands Dictyonemaskiffer, p. 7.

<sup>2</sup> Neues Jahrb., 1902, vol. i, p. 7.

<sup>3</sup> Trilobites of the Girvan District, Palæont. Soc., 1903, p. 42.

As Mr. Raw has devoted a considerable amount of time to the study of this form, I quote his description and notes from the manuscript which he has supplied to me.

“Body convex, deeply trilobed. Head without free cheeks. Thorax of six segments and tail of four, both ornamented with lines of tubercles. Surface otherwise smooth. General shape ovate, the greatest width being the back of the head-shield, which, in adults of 4 mm. in length, measures 2.5 mm.; younger individuals are relatively broader (*e.g.* in a very perfect individual of 3 mm. the width is 2.2 mm., and a larval form of 1 mm. has a head 0.8 mm. broad).

“Head roughly half a hemisphere, but somewhat trapezoidal in outline. Glabella strongly arched behind, flatter in front; at its middle and narrowest part about one third the greatest width of the head, somewhat broader in the neck-segment, and also broader in front, where two eye-like lobes are outlined by furrows behind them. Axial furrows particularly deep up to and round these lobes, in front of them narrow, shallow, and straight, meeting at a blunt angle well above the anterior border. Neck-segment well defined in front by a transverse furrow over the glabella, rounded, and projecting behind. Halfway between the neck furrow and the eye-like lobes a faint lateral furrow is sometimes seen on either side of the glabella near the bottom of the axial furrows. Cheeks at the sides strongly arched and bent down all round, in front continuing the curvature of the glabella; bounded behind by the occipital furrow (the hinder edge of which forms a barely perceptible rim), running at first straight out from the neck-segment, then downwards and backwards to the sharp genal angles, which were perhaps furnished with a fine spine.

“Thorax of six segments. Axis broad, in front half as wide again as the pleuræ, markedly tapering behind. Pleuræ running straight out, their ends, except in the fourth segment, thin and faceted, sharply bent down and back and obliquely truncated behind. Fourth segment stronger than the rest, its pleuræ prolonged into spines projecting backwards and inwards and as long as the thorax and tail combined. Axial part of each segment forming a prominent ring rising behind into a tuberculate crest; each pleura rising along its centre into a prominent tuberculated ridge, which descends gently to the front of the segment but is separated from the posterior margin by a furrow.

“Tail subquadrate or semicircular, straight or a little emarginate behind; surrounded by a prominent rim which touches the axis behind; segments, four in number, conspicuous both on the axis and the limb, ridged like those of the thorax, and like them provided with rows of tubercles; the rim also is similarly tuberculated. Axis prominent, bluntly tapering, about the same width as the limbs on either side.

“This description is based on external and internal moulds collected from the Shinton Shales by Mr. Rhodes for the Geological Survey, kindly lent by the Director.

“Many specimens are found inrolled. In this case the spines on the fourth segment lie back in the plane of the tail, the last three segments thus taking little part in the rolling. In agreement with this it can be seen that the skin is more deeply infolded at the joints in front of the fourth segment than behind. The folds in front of the fourth segment are in consequence often broken away.

“Dimensions of a perfect specimen collected by Mr. Rhodes. Length: total, 2.9 mm.; head, 1.03 mm.; thorax, 1.2 mm.; tail, 0.67 mm. Breadth: head, 2.2 mm.; tail, 1.5 mm.

“*Development*.—Among the material from the Shineton Shales, collected by Mr. Rhodes for the Geological Survey, are two individuals, one 1 mm. (R. R. 2286) and the other 1.5 mm. (R. R. 2296) long. In these the head is semicircular in outline, with the same features as the above though less strongly marked, and with a faint groove (as in *S. granulosa*, Billings) running from the apex of the glabella up to but not across the anterior border. The thorax in these specimens is of four segments, the last three of which, and possibly all, end in long spines, of which the fourth is the strongest. The tails are somewhat indistinct, but are very similar to those of the adult. These specimens are almost certainly young forms of the same species, and they agree very closely with the specimens described by Dr. Groom from Malvern under the name of *Acanthopleurella grindrodi*, the apparent absence of the frontal limb in the Malvern specimens being probably the result of inrolling.

“*Affinities*.—The Shineton form was described by Callaway in 1877 under the name *Conophrys salopiensis*, but seems to be identical with the Scandinavian species *S. pusilla*. Brögger in 1882 pointed out its close relationship and probable identity with Sars' *Battus pusillus*, which he accordingly named *Conophrys pusilla* and of which he figured the head. This belongs, apparently, to an older individual than the best of the Shineton specimens. It is larger and more trapezoidal in outline, the differences being of the same kind as those between the large and small forms described above. Moberg in 1890 figured both the head and tail of the species and referred them to Billings' genus *Shumardia*.

“*S. miqueli*, Pompeckj, is very probably identical with *S. pusilla*. The head-shield in this form seems to be slightly distorted by cleavage; and the small tail, of the same shape as in *S. pusilla*, has only three segments and does not show the rim, which may, however, be broken away.

“The head-shield of *S. bottnica*, Wiman, as Wiman himself observes, agrees exactly with that of *S. pusilla*, and the single pygidium may well be that of a young form of the same species. The head-shields of *S. aelandica*, Moberg,<sup>1</sup> and *S. dicksoni*, Moberg,<sup>2</sup> are also almost identical, but while the tail of the former is not far removed, that of the latter is widely different.

<sup>1</sup> Geol. För. Stockholm Förh., vol. xxii (1900), p. 357, pl. xiv, figs. 4–6; Ceratopygeregionen (1906), p. 79, pl. iv, figs. 7–9.

<sup>2</sup> Ceratopygeregionen (1906), p. 81, pl. iv, figs. 17–22.

“From the type species of the genus, the *Shumardia granulosa* of Billings,<sup>1</sup> *S. pusilla* is distinguished by its more quadrate tail, and by the absence, in the adult, of the groove from the apex of the glabella over the frontal limb.

“*Shumardia scotica*, Reed<sup>2</sup> (from the Bala beds of Whitehouse Bay), is readily distinguished. Thanks to the kindness of Mrs. Gray the writer has had the privilege of examining the type specimens. The proportions are noticeably different, a line across the glabella at the back of the lateral lobes dividing it into two equal parts, whereas in *S. pusilla* a similar measurement gives 15 : 23 as the proportion of front to back. The lateral lobes are more prominent and better defined on their inner sides, while the furrows round the front of the glabella are deeper. The prominent tubercle on the neck-segment (apparently a backwardly directed spine), and the strong posterior furrow on the cheek also distinguish it. The genal angles are not sufficiently disclosed to show their form.”

To the above observations by Mr. Raw I have only to add the following notes :

The tubercles on the thorax and tail are most clearly seen on external moulds, and are often indistinct or even invisible on internal casts. The ridges on the tail are not always well shown, and this is especially the case with the fine intermediate ridges which correspond with the raised edges of the pleuræ in the thorax. The long spine of the fourth segment is often buried in the matrix, and requires careful development to disclose it. It may be remarked that even in the Shineton specimens, which are usually well preserved, Callaway does not appear to have observed it. It should, indeed, always be borne in mind, in dealing with specimens of this genus, that the margins of the head and tail and the ends of the pleuræ are very commonly concealed.

Specimens precisely similar to those from Shineton occur at several localities near Arenig. The very fine example shown in Plate III, fig. 20, for the loan of which I am indebted to Mr. G. J. Williams, was found by him at Annodd Bwll in that district. It is one of the largest that I have seen, measuring 4 mm. from head to tail.

*Horizon and Localities.*—Upper Tremadoc : Shineton (in the Shineton Shales) ; Annodd Bwll, and other localities near Arenig ; Malvern.

1a. *Shumardia pusilla*, var. *morvensis*, var. nov. Plate IV, fig. 5.

The specimens of *Shumardia* found at Penmorfa closely resemble those from Shineton, and must, I think, be referred to the same species ; but they present certain small differences which, although minute, appear to be constant, and thus constitute a distinct variety.

<sup>1</sup> Palæozoic Fossils, vol. i (1865), p. 92, fig. 83, *a*, *b*.

<sup>2</sup> Trilobites of the Girvan District, Palæont. Soc., 1903, p. 42, pl. iv, fig. 12.

The genal angles in this form are considerably produced; there is a distinct margin to the head, and the glabella is bounded in front by furrows much deeper and stronger than in the typical form. The last character is probably the only one of importance. It is by no means unlikely that the Shingleton form may also possess a margin, and that the genal angles may be produced; but the border of the head is nearly always concealed, and only doubtful indications of these structures can be seen.

All the specimens from Penmorfa show the deep furrows in front of the glabella, and specimens with the same character also occur at Arenig. Mr. Fearnside tells me that the two forms may belong to slightly different horizons. They occur in material of rather different character, and apparently are never found in the same block.

*S. nericensis* Wiman<sup>1</sup> also shows a distinct margin to the head, and the genal angles are much produced. But in the absence of any information as to the character of the furrows in front of the glabella, I should hesitate to refer the Penmorfa form to that species. The very small size of Wiman's figured specimens is remarkable.

*Horizon and Localities.*—Upper Tremadoc: Penmorfa; Ceunant-y-garreg-ddu and Annodd Bwll, near Arenig.

## 2. *Shumardia* sp.

At Ty'n-y-Ilan, near Penmorfa, both Professor Hughes and Mr. W. G. Fearnside have found remains of *Shumardia* in beds which appear to be of Lower Tremadoc age. The specimens, though numerous, are too imperfect for identification or description. They show the general form and characteristic glabella of *Shumardia*; but as they occur at a lower horizon they are probably distinct from the Upper Tremadoc form.

### *Family* TRINUCLEIDÆ.

The inclusion of the genus *Orometopus* in the Trinucleidæ entails some alteration in the usual definition of that family. *Orometopus* possesses well-developed compound eyes, free cheeks of considerable size, and (in some cases at least) more than six thoracic segments; and the course of the facial suture proves that the genus belongs to Beecher's Opisthoparia. Nevertheless, as the very beautiful examples figured on Plate IV clearly indicate, its affinities are with *Trinucleus* and *Ampyx*. The clavate glabella, the horizontal grooved pleuræ, and

<sup>1</sup> Arkiv. f. Zool., vol. ii, no. 11 (1905), p. 14, pl. i, figs. 13—15.

the broad triangular tail, are characters which it shares with those genera, and which differentiate it from other families. It is the earliest known genus of the Trinucleidæ, and must therefore be looked upon as the primitive form; and the conclusion is inevitable that in the later genera the absence of compound eyes and the supposed marginal position of the facial suture are degenerative characters. It is, indeed, no longer improbable that the ocelli which occur on the middle of the cheeks in some species of *Trinucleus* and *Ampyx* may represent the normal eyes, and that the lines which Salter<sup>1</sup> and McCoy<sup>2</sup> observed running from these ocelli to the margins may be the fused facial sutures, as they supposed. If this be so the Trinucleidæ can scarcely be included in Beecher's Hypoparia. If, on the other hand, as Loven,<sup>3</sup> Barrande,<sup>4</sup> and Beecher<sup>5</sup> contend, the true facial suture in *Trinucleus* is marginal, then *Trinucleus* itself may be placed in the Hypoparia; but as it is derived from an Opisthoparian ancestor, the genetic value of Beecher's classification becomes extremely doubtful.

As Mr. Raw proposes to discuss in detail the affinities of *Orometopus* in a forthcoming paper, it is unnecessary for me to say more upon the subject here. It may, however, be noted that in the young *Trinuclei* figured by Barrande a small lobe is cut off at the internal angles of the cheeks, as in the adult *Orometopus*.

*Genus* **OROMETOPUS**, Brögger.

The type species of this genus is *Orometopus elatifrons* (Ang.), which was described by Angelin from an imperfect cranidium, and was referred by him, with doubt, to his genus *Holometopus*. Brögger in 1882 gave a fuller description and more perfect figure; and, recognising that it did not belong to *Holometopus*, he subsequently proposed the name *Orometopus*.<sup>6</sup> Moberg has recently given fresh figures of the same form. In all these cases, with the exception of the tail doubtfully ascribed by Moberg to this species, the writers appear to have had before them only the cranidium. The very fine examples from Shineton now enable us to give a complete description. The specimen figured in Plate IV, fig. 8, showing the cranidium and thorax, was collected by Mr. Rhodes for the Geological Survey; while that represented in fig. 9, showing the tail, thorax, free cheek, and part of the cranidium, was found by Mr. E. S. Cobbold, to whom I am greatly indebted for the loan of the specimen. The specimens of the second species here described

<sup>1</sup> Quart. Journ. Geol. Soc., vol. iii (1847), p. 251.

<sup>2</sup> Synopsis Sil. Foss. Ireland (1846), p. 56; Ann. & Mag. Nat. Hist., ser. 2, vol. iv (1849), p. 410.

<sup>3</sup> Öfv. k. Vet. Akad. Förh. Stockholm, vol. ii (1845), p. 104.

<sup>4</sup> Systême Silurien, vol. i (1852), p. 615.

<sup>5</sup> Amer. Journ. Sci., ser. 3, vol. xlix (1895), p. 307.

<sup>6</sup> Nyt Mag. f. Naturv., vol. xxxv (1896), p. 68, note.

I owe to the kindness of Mr. Fearnside. It appears to be the form originally described by Salter as *Ampyx prænuntius*.

Briefly, the genus resembles *Ampyx*, except in the following characters: The glabella is not so large and does not reach to the frontal margin; well-developed compound eyes are present; there is a facial suture, which is marginal in front, runs backwards to the eyes, and thence outwards and backwards to the posterior margin; the head is surrounded by a raised marginal rim; and the number of thoracic segments is usually more than six. It is in the characters of the tail and the thoracic pleuræ that the resemblance to *Ampyx* and *Trinucleus* is most striking, while the presence of eyes and of a facial suture constitute the most important differences.

1. **Orometopus elatifrons** (Angelin). Plate IV, figs. 6—10.

1854. *Holometopus? elatifrons*, Angelin, Pal. Scand., p. 90, pl. xli, figs. 17, 17 a.

1882. *Holometopus? elatifrons*, Brögger, Die Silur. Etagen 2 und 3, p. 128, pl. iii, fig. 13.

1896. *Orometopus elatifrons*, Brögger, Nyt Mag. f. Naturv., vol. xxxv, p. 68, note.

1906. *Orometopus elatifrons*, Moberg and Segerberg, Ceratopygeregionen, p. 99, pl. vii, fig. 3 (? non fig. 4, 5).

As this is another form to which Mr. Raw has devoted much careful study I quote his manuscript description:

“General form approximately circular.

“Head crescentic, slightly angulated in front, extremely broad; posterior and lateral angles continued into long, somewhat diverging genal spines. Glabella prominent, broadest about the mid-length of the shield, narrowing behind, where it is strongly arched into a keel and continued as a strong spine over the neck-segment and the anterior segments of the thorax, slightly narrowing in front where it is rounded and descends gently to the broad marginal furrow. Neck-segment well defined, narrow, bowing out behind under the spine. At a distance in front of the neck-segment about equal to its width, faint, short furrows, inclining up to the back, indent the sides of the glabella, and there are, perhaps, indications of another pair at an equal distance in front. Axial furrows well defined, ending in front in two rounded pits on either side of the glabella at about a quarter the length of the head-shield from the front. Posterior furrows on the cheeks broadening outwards and ending in two marked depressions. Cheeks rising towards a sharp marginal ridge, bevelled outside; ornamented externally, except in the furrows, with a network of narrow ridges surrounding pits, or in moulds of the inner surface with scattered pits. From the sides of the glabella at its broadest part elevated eye-lines run outwards and somewhat back-

wards across the cheeks to the eyes, whose distance apart is half the distance between the ends of the fixed cheeks. From the same points at the sides of the glabella broad, shallow furrows run obliquely backwards, cutting off triangular areas which rise towards the neck-segment into prominent elevations on either side. Palpebral lobes fairly elevated. Eyes small, about sixteen facets only being seen in a rather small but adult individual. Anterior part of the facial suture bowed outwards, cutting the raised rim in front of the eye, continuous with its fellow of the other side as a gentle curve on the bevelled front of the shield; posterior part running outwards and cutting the posterior margin after circumscribing the ends of the fixed cheeks.

“Thorax of eight segments,<sup>1</sup> broad and short, narrowing behind, the lateral margins forming part of a circle. Axis prominent, one quarter the width of the whole thorax. Segments short; axial parts forming prominent, rounded, backwardly bowing rings; pleuræ straight, long, hollowed almost symmetrically, their ends in the first segments more pointed, in the hinder segments abruptly bent downwards and truncated.

“Tail short, triangular, margin bent downwards. Axis broad, extending to the edge of the upper surface, of four distinct segments. On the limb only the first segment is clearly indicated.

“Associated on the same slab (R. R. 2294) with three individuals of *Orometopus* is a doublure of corresponding size with hypostome attached, which almost certainly belongs to this species. The doublure is convex, moderately broad, and has no suture across it (unless along the median line). It is ornamented with longitudinal raised lines, of which there is a second set regularly intercalated in front. Attached to one side of it is a fragment of the impression of the skin of the cheek regularly ornamented. The hypostome is transversely oblong or oval and, except for the curved anterior margin, which extends as small wings beyond the sides, is polygonal, of sub-equal sides, its posterior margin being made of three and its lateral margins of one each. Its greater part consists of a transversely oval convexity bordered by a shallow furrow deepening into two hollows at the sides. Outside this furrow, except at the extreme front, is a narrow, slightly convex rim. The surface is ornamented by fine raised lines.

“Dimensions of the specimen (R. R. 2294), Plate IV, fig. 8 :

	Total.	Cranidium.	Thorax.	Tail.
Length . . .	5·1	2·2	2·3	0·75 mm.
Breadth . . .	5·8	5·4	4·4	2·7 mm.

The specimen lacks the free cheeks and tail, which are calculated from material kindly lent by Mr. E. S. Cobbold. The total breadth is measured to the edges

<sup>1</sup> “In the Survey specimen R. R. 2294 there are eight segments. In Mr. Cobbold’s specimen also there are eight; but the head being separated from the trunk by a space, it is just possible that there may have been nine in that specimen.”

of the restored free cheeks along the line of the inner parts of the back of the fixed cheeks.

“The form here described differs somewhat from Brögger’s and Moberg’s figures and descriptions of the species. In these the anterior part of the glabella appears round and well defined, seeming to rise abruptly from the frontal limb, while in the Shineton form the anterior part of the glabella is low, descending gently to the front. Again, neither Brögger nor Moberg mentions the prominent pits which limit the extent of the axial furrows in front. The writer is assured, however, by the author of this monograph, who has seen Scandinavian specimens, that it is identical with that species.

“It may be remarked here that the detached tails figured by Moberg probably do not belong to this genus.”

The fact that I have seen Scandinavian specimens does not entitle me to express an opinion without giving the reasons upon which that opinion is based; nor would I venture positively to assert the identity of the British and Scandinavian forms until we know more about the latter than we do at present, for it sometimes happens in Trilobites that specific distinctions lie not in the head but in the tail and thorax. I do not think, however, that the differences pointed out by Mr. Raw are sufficient to characterise a new species. The pits at the anterior ends of the axial furrows have no diagnostic value, for they are common in *Ampyx*, *Trinucleus*, *Calymene*, and other genera, but are not usually visible except in well-preserved specimens. A more important difference is the comparative flatness of the glabella in the Shineton specimens. These, however, occur in shale, while the Scandinavian specimens are found in calcareous beds; and it is very common to find forms preserved in shale with very much flatter and less prominent glabellas than the same species in a limestone band. It is, then, to differences in the mode of preservation that I attribute the differences between the British and Scandinavian specimens.

*Horizon and Localities.*—Upper Tremadoc: Shineton; Arenig? Most of the specimens of *Orometopus* from the Arenig district are specifically indeterminable. *O. prænuntius* undoubtedly occurs, but some of the specimens may belong to *O. elatifrons*.

## 2. *Orometopus prænuntius* (Salter). Plate IV, fig. 11.

1866. *Ampyx prænuntius*, Salter, Mem. Geol. Surv., vol. iii, p. 321, pl. viii, fig. 5.

General form depressed, circular.

Head semicircular, with the genal angles produced into long spines. Glabella subquadrate, wide in front, narrower behind, about three quarters the length and



PLATE III.

FIG.		PAGE.
	<b>Agnostus incertus</b> , Brögger.	29
1, 2.	Heads. Cambrian; Neves Castle. Collected by Mr. Rhodes. Geological Survey, R. R. 2453 (fig. 1), R. R. 2446 (fig. 2).	
3.	Tail. Cambrian; Neves Castle. Collected by Mr. Rhodes. Geological Survey, R. R. 2455.	
	<b>Microdiscus lobatus</b> (Hall).	32
4-6.	Heads. Cambrian; Comley. Collected by Mr. E. S. Cobbold. Sedgwick Museum. The specimen represented in fig. 4 shows two furrows across the glabella in front of the occipital furrow; in the other two specimens no such furrows are visible. Fig. 5 <i>a</i> is a side view of the specimen represented in fig. 5.	
	<b>Microdiscus speciosus</b> , Ford.	33
7.	Head. Cambrian; Comley. Collected by Mr. E. S. Cobbold. Sedgwick Museum.	
	<b>Microdiscus</b> , sp.	34
8.	Tail. Olenellus zone; Comley Quarry. Collected by Mr. E. S. Cobbold. Sedgwick Museum.	
	<b>Microdiscus sculptus</b> , Hicks.	35
9.	Hicks's type; an entire but very poorly preserved specimen. Harlech Series; Nun's Well, St. David's. (Figured by Hicks, Quart. Journ. Geol. Soc., vol. xxvii, pl. xvi, fig. 9, 9 <i>a</i> .)	
10.	Tail. Harlech Series; Nun's Well, St. David's. Sedgwick Museum. (Figured by Hicks, <i>ibid.</i> , pl. xvi, fig. 10, 10 <i>a</i> .)	
	<b>Microdiscus punctatus</b> , Salter.	36
11.	One of Salter's figured specimens. An internal cast; the neck-spine has been pressed down upon the thorax and has since been broken away; its impression appears upon the axial rings. Menevian; Porth-y-rhaw, St. David's. Sedgwick Museum. (Figured by Salter, Quart. Journ. Geol. Soc., vol. xx, pl. xiii, fig. 11 <i>c</i> .)	
12.	Internal cast; 12 <i>a</i> , side view of head of the same specimen. The neck-spine is broken off, but is restored in outline in the side view. Menevian; near Nine Wells, St. David's. Mr. G. J. Williams' Collection.	
13.	Internal cast of head, showing in the surrounding matrix the impression of the upturned neck-spine. Menevian; Dwrrhyd, near Solva. Oxford University Museum.	
14.	Head. An artificial cast of a natural external mould. Except where a small portion of the test remains in the mould the margin is not crenulated. Menevian; near Nine Wells, St. David's. Sedgwick Museum.	
15.	Head of a young individual; internal cast. Menevian; near Nine Wells, St. David's. Sedgwick Museum.	
16.	Tail and thoracic segments; internal cast. Menevian; near Nine Wells, St. David's. Sedgwick Museum.	
17.	Tail, internal cast; 17 <i>a</i> , external mould of the same individual. The actual test is not present in either. Both are covered with tubercles, showing that the test itself was punctate, or else perforate both internally and externally. Menevian; Dwrrhyd, near Solva. Oxford University Museum.	
	<b>Shumardia pusilla</b> (Sars).	40
18.	Internal cast. Shineton Shales; Shineton. Collected by Mr. Rhodes. Geological Survey, R. R. 2266.	
19.	External mould. Shineton Shales; Shineton. Collected by Mr. Rhodes. Geological Survey, R. R. 2282.	
20.	Internal cast. Upper Tremadoc; Amnodd Bwll, Arenig. Mr. G. J. Williams' Collection.	

The small outlines, filled in with a flat shade and placed by the side of the enlarged figures, show the actual size of the specimens.



*Agnostus, Microdiscus, Shumardia.*





PLATE IV.

FIG.		PAGE.
	<b>Shumardia pusilla</b> (Sars).	40
1.	An inrolled specimen: head, with the exception of the doublure, removed, thus exposing the interior of the tail. Shineton Shales; Shineton. Collected by Mr. Rhodes. Geological Survey, R. R. 2282.	
2.	Young. Shineton Shales; Shineton. Collected by Mr. Rhodes. Geological Survey, R. R. 2296.	
3.	Young. Bronsil Shales (Tremadoc); South Malverns. Oxford University Museum. (Figured by Groom as <i>Acanthopleurella Grindrodi</i> , Geol. Mag., 1902, p. 72, fig. 3.)	
4.	Young. Shineton Shales; Shineton. Collected by Mr. Rhodes. Geological Survey, R. R. 2286.	
	<b>Shumardia pusilla</b> , var. <b>morvensis</b> , var. nov.	43
5.	Internal cast. Upper Tremadoc; Penmorfa. Collected by Mr. W. G. Fearnside. Sedgwick Museum.	
	<b>Orometopus elatifrons</b> (Angelin).	46
6.	Cranidium. Shineton Shales; Shineton. Collected by Mr. E. S. Cobbold. Sedgwick Museum.	
7.	An imperfect cranidium, showing in the matrix the impression of the neck-spine. Shineton Shales; Shineton. Collected by Mr. Rhodes. Geological Survey, R. R. 2294.	
8.	Cranidium and thorax. Shineton Shales; Shineton. Collected by Mr. Rhodes. Geological Survey, R. R. 2294.	
9.	The most complete specimen known; an external mould. Shineton Shales; Shineton. Collected by Mr. E. S. Cobbold. Sedgwick Museum.	
10.	Hypostome and doublure. Shineton Shales; Shineton. Collected by Mr. Rhodes. Geological Survey, R. R. 2294.	
	<b>Orometopus prænuntius</b> (Salter).	48
11.	An entire but somewhat compressed specimen. Upper Tremadoc; Penmorfa. Collected by Mr. W. G. Fearnside. Sedgwick Museum.	

The small outlines, filled in with a flat shade and placed by the side of the enlarged figures, show the actual size of the specimens.



1 x 10



2 x 20



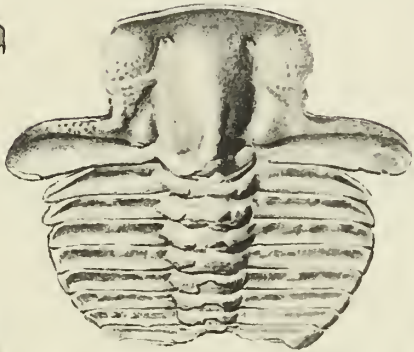
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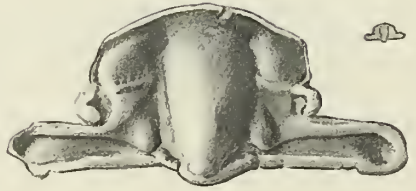
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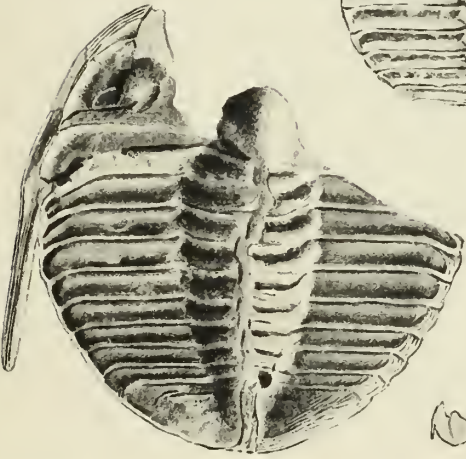
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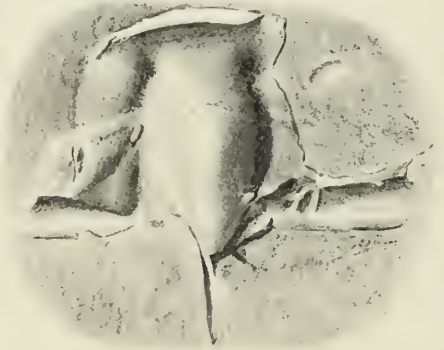
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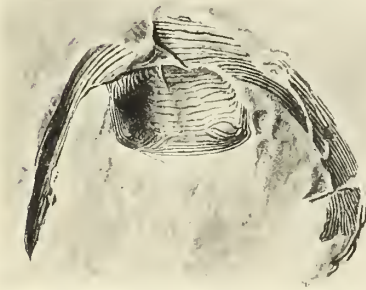
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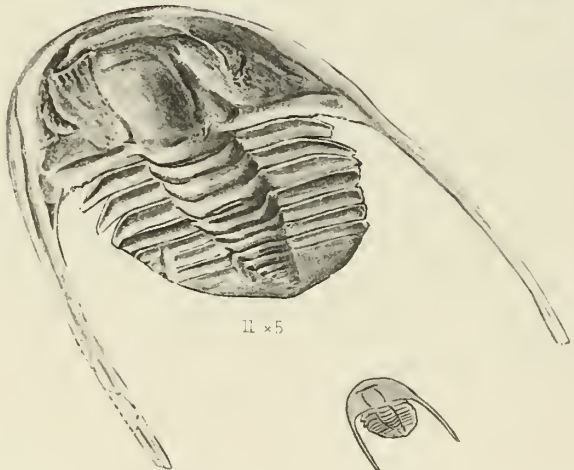
8 x 10



9 x 10



10 x 10



11 x 5

Shumardia, Prometopus.



Palaëontographical Society, 1907.

A MONOGRAPH

OF

BRITISH GRAPTOLITES.

BY

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PART VI.

PAGES xcvi—cxx, 217—272; PLATES XXVIII—XXXI.

LONDON:

PRINTED FOR THE PALEONTOGRAPHICAL SOCIETY.

1907.

PRINTED BY ADLARD AND SON, LONDON AND DORKING.

Rhabdophora in time necessarily gives to the collective Graptolitic fauna of each of the subsystems or major formations of the Lower Palæozoic rocks a special and distinctive aspect that renders it capable of immediate identification all over the world. The Arenig division is recognisable at a glance by its crowds of Phyllograptidæ and Dichograptidæ; the Bala, by the absence of these families and the presence of multitudes of Dicellograptæ and Diplograptæ; the Valentian, by the absence of the former and the presence of the latter in association with Monograptidæ; and the higher Silurians by the absence of the Diplograptidæ and the presence of Monograptidæ alone."

(8) "The further restriction in time and vertical extension of the species and varieties of the Rhabdophora places in our hands the material available for a more minute subdivision of the formations of the Lower Palæozoic rocks than has hitherto been attempted. These subdivisions, or Graptolite horizons, answer roughly to the Ammonite zones of the Jurassic rocks of Europe, and will, in all probability, prove of equal value in the correlation of widely separated deposits." At present the following zones are recognisable, many of them of extraordinary geographical range :

*Upper Cambrian.*

1. Zone of *Bryograptus Callareii*.

*Lower Ordovician.*

2. Zone of *Tetragraptus bryonoides*.
3. Zone of *Didymograptus bifidus*.
4. Zone of *Didymograptus Murchisoni*.

*Upper Ordovician.*

5. Zone of *Cænograptus gracilis*.
6. Zone of *Dicranograptus Clingani*.
7. Zone of *Pleurograptus linearis*.
8. Zone of *Dicellograptus complanatus*.
9. Zone of *Dicellograptus anceps*.

*Silurian System.*

10. Zone of *Diplograptus acuminatus*.
11. Zone of *Diplograptus vesiculosus*.
12. Zone of *Monograptus gregarius*.
13. Zone of *Monograptus spinigerus*.
14. Zone of *Rastrites maximus*.
15. Zone of *Monograptus exiguus*.
16. Zone of *Cyrtograptus Grayæ*.

(Wenlock-Ludlow Series.)

17. Zone of *Cyrtograptus Murchisoni*.
18. Zone of *Cyrtograptus Linnarssoni*.
19. Zone of *Monograptus testis*.
20. Zone of *Monograptus Nilssoni*.

(A table is given showing the Geographical Range of these zones.)

(9) "The several zones common to two or more regions occupy invariably the same relative position with respect to each other and the same vertical place in the ascending series of formations. Hence we have no choice but to regard them as homotaxially or synchronologically identical."

(10) "In the face of these results, the host of proofs formerly supposed to be afforded by the abnormalities of the vertical distribution of the Graptolithina, in favour of the doctrines of migration and colonies, vanish. We have at present no evidence to show that any Graptolite group, or even a single species or variety, made its appearance at an earlier date in one region than in another; and, as a consequence, the place of its origin and the direction of its extension in space are at present equally incapable of recognition. The Graptolite appears to be as restricted in its vertical range, and as widely extended in its horizontal distribution, as any known form of life hitherto recognised as existent in Palæozoic times. It is one of the most suitable of fossils for the purposes of the working geologist and systematist; its short vertical range affording elements for the subdivision of the accepted Lower Palæozoic formations into their component zones; its wide horizontal distribution allowing of the exact parallelism of synchronous deposits in areas now geographically separated; and its universal dissemination rendering it easy of collection and study."

1880.

*Tullberg*,  
"Några *Didymograptus*-arter vid Kiviks-Esperöd," 'Geol. Fören. Förh.,' bd. 5.

Three papers by Tullberg appeared in the year 1880. In the first he describes and figures five new species of *Didymograptus* from the Lower Graptolite shales at Kiviks-Esperöd: *D. balticus*, *D. vacillans*, *D. pusillus*, *D. filiformis*, and *D. suecicus*.

1880.

*Tullberg*.  
"Tvenne nya graptolitslägten," 'Geol. Fören. Förh.,' bd. 5.

In a second paper he describes two new genera and species of Graptolites: (1) *Lonchograptus ovatus* from the *Didymog. geminus* zone and *Janograptus laxatus* from the *D. mucronatus* zone at Fågelsång.

1880.

*Tullberg*,  
"Lagerföljden vid Röstänga," 'Geol. Fören. Förh.,' bd. 5.

Tullberg's third paper is entirely stratigraphical, and is preliminary to his great work—the "Skånes Graptoliter." He recognises several graptolite zones in the Silurian *Cyrtograptus*, *Retiolites* and *Lobiferus*-skiffer, and also in the beds belonging to the Ordovician. He correlates these with the zones previously worked out in Britain by Lapworth.

1880.

Törnquist,  
 "Studier öfver *Retiolites*," 'Geol. Fören. Förh.,' bd. 5.

A most important paper by Törnquist bearing on the structure of *Retiolites* appeared in 1880. By means of sections, transverse and longitudinal, he was able to elucidate many points which Linnarsson, Barrande, Hall and others had left unsettled. His materials consisted not only of specimens of the true *Retiolites*, but also of another form,

which was separated later by Tullberg as a distinct genus—*Stomatograptus*.

*Structure*.—The main result arrived at by Törnquist is that the polypary in these genera consists of two different elements: (1) "the outer polyparium or periderm, consisting of the reticulate skin, with its parietal and apertural threads, strands, and two virgulas; (2) the inner polyparium, with smooth and thinner walls."

The inner polyparium is very similar to that of a diprionidian Graptolite, and possesses distinct intertheal walls of a trough-like shape. The thecæ arise from an extremely narrow common canal, and open outward and upward.

This inner polyparium was presumably attached to the outer in such a way that "the free wide thecal apertures of the former are fastened to the parietal threads of the latter."

The network-like periderm, which may have been covered by a thin skin, is not in close contact with the inner polyparium, and the space between the two Törnquist calls the "parietal canal."

## CHAPTER IV.

1881 to 1907.

1881.

Törnquist,  
 "Om några graptolitarter från Dalarna," 'Geol. Fören. Förh.,' bd. 5.

Törnquist, in the year 1881, described and figured five new species of *Monograptus* from the *Retiolites* shales of Dalarna. These are *M. cultellus*, *M. nodifer*, *M. crenulatus*, *M. continens*, and *M. sartorius*. In addition to these he figures and describes specimens of *Diplog. folium*, *D. pristis*, and *Monog. priodon*.

1881.

Linnarsson,  
 "Graptolitskiffrar med *Monograptus turriculatus* vid Klubbudden nära Motala," 'Geol. Fören. Förh.,' bd. 5.

The same year Linnarsson described a number of Graptolites from Klubbudd in beds which he considers answer in stratigraphical position to the Lower Gala of Scotland. Four of his species are given as new, viz.: *Monog. rhyncophorus*, *M. dextrorsus*, *M. tortilis*, and *M. resurgens*. The other species described and figured by Linnarsson are: *M. jaculum*, *M. priodon*, *M. cf. crassus*, *M. cf. lobifer*, *M. runcinatus*, *M. turriculatus*, *Rastrites Linnæi*, *Diplograptus palmeus*, and *Retiolites perlatus*?

1881.  
*Holm*,  
 "Tvenne nya slägten  
 af familjen Dichograp-  
 tidæ," 'Öfvers. K.  
 Vetenskaps Akad. För-  
 handl.,' no. 9.

Two new genera were founded by Holm in 1881 for certain forms of Dichograptidæ with four primary stipes: **Holograptus**. His genus (1) (type *H. expansus*) includes those species in which the four primary stipes branch irregularly and on both sides. The type species occurs in the *Phyllograptus* shales of Vestergötland.

In his genus (2) **Trochograptus** (type *T. diffusus*) the four primary stipes give off branches on one side only at fairly regular intervals, and these may branch again in their turn.

Holm shows that the so-called "funicle" bears cells in *T. diffusus*, and is not non-celluliferous, as originally supposed.

1881.  
*Holm*,  
 "Pterograptus, ett nytt  
 graptolitslägte,"  
 'Öfvers. K. Vetenskaps  
 Akad. Förhandl.,' no. 4.

In 1881 Holm described a third genus, namely, **Pterograptus**, with its species *P. elegans*.

He again discusses the question of the celluliferous or non-celluliferous character of the "funicle" in Graptolites. He thinks it not improbable that the "funicle" will prove to be always celluliferous, even in the case of *Cænograptus gracilis*.

1881.  
*Barrois*,  
 "Sur le Terrain Silu-  
 rien superieur de la  
 presqu'île de Crozon,"  
 'Ann. Soc. Géol. du  
 Nord,' vol. vii.

Barrois notices the occurrence of *Monog. colonus*, *M. Sedgwickii*, *M. priodon*, and *M. Hisingeri* in the Ampelite Shales of Crozon. A previous record of the existence of Graptolites at this horizon had been made by M. Guillier.

1881.  
*Keeping*,  
 "The Geology of Cen-  
 tral Wales," 'Quart.  
 Journ. Geol. Soc.,'  
 vol. xxxvii.

In 1881 Keeping made known the existence of various graptolitiferous horizons in the Silurian of Central Wales, and utilised the Graptolites for the purpose of working out the geological succession in that region.

In addition to the Rhabdophora collected by him, Keeping found a number of Cladophora, most of them new to science.

1881.  
*Lapworth*,  
 Ibid. Appendix "On  
 some New Species of  
 Cladophora," 'Quart.  
 Journ. Geol. Soc.,'  
 vol. xxxvii.

In an appendix to this paper, Lapworth described and figured seven new species of Cladophora discovered by Keeping. These are: *Dictyonema venustum*, *D. delicatulum*, *D. corrugatellum*, *Calyptograptus? plumosus*, *C.? digitatus*, *Acanthograptus ramosus*, and *Odontocaulis Keepingii*.

A new genus **Odontocaulis** is also described and figured.

1882.  
*Brögger*,  
 'Die Silurischen  
 Etagen 2 und 3.'

Brögger, in a classic work on "Die Silurischen Etagen 2 und 3," described and figured two new species of *Bryograptus* from Norway: *Bryograptus ramosus* and *B. retroflexus*. He also re-figured Kjerulf's *Grapt. tenuis* (*Bryog. Kjerulfi*, Lapw.).

Brögger also figured Norwegian specimens of *Dictyograptus flabelliformis*

(Eichwald), and discussed the structure of this genus in considerable detail. He shows that the polypary originates from a sicula, is basket-shaped, that the branches bear cells along their whole length on their inner side, and that *Dictyonema* "is therefore much more closely allied to the true Rhabdophora than is usually supposed."

One of the forms described by Kjerulf as *Dictyonema norvegicum* is regarded as a mutation of *D. flabelliformis*. The others are identical with it, while another variety, var. **conferta**, had been recognised by Linnarsson (MS). Many other species of Graptolites found in Norway are recorded, and their synonymies given, but no descriptions or figures.

He corrects previous views as to the age of the *Bryograptus* beds, and shows that they occur in the upper part of the *Dictyonema* beds, in the passage beds between Etagen 2 and 3.

1882. A paper of decided importance was published by Tullberg in this year. Considerable differences of opinion had arisen as to the exact nature of the species figured and described in Hisinger's 'Lethæa Suecica,' which was issued as far back as 1837-40. It had become impossible to identify many of his forms until they had been re-figured and re-described in the light of modern knowledge. This much-needed revision was undertaken by Tullberg in this paper.

Tullberg,  
"On the Graptolites described by Hisinger," 'Bihang K. Vetenskaps Akad. Handl.,' bd. 6, no. 13.

The paper commences with an excellent historical account of the work of the older Swedish palæontologists and of the part that each played in developing our knowledge of the nature of Graptolites. Eight species of Graptolites are described and figured, and in each case Hisinger's original type specimens are re-drawn and re-described. The species include *Climacograptus scalaris*, *Diplograptus pristis*, *Diplog. teretiusculus*, *Monograptus sagittarius*, *M. convolutus*, *Cephalograptus folium*, *Didymog. geminus* and *Dictyonema flabelliforme*.

1882. Four new species of Swedish Graptolites were described and figured in 1882 by Kurek from the *M. cyphus* beds at Bollerup, Scania. These were *Monograptus revolutus*, *Diplog. longissimus*, *Cephalog. ovatoelongatus* and *Climacog. undulatus*, and two associated forms are compared with *Dimorphog. Swanstoni* and *M. cyphus* respectively. The figures are good and the structure well represented.

Kurek,  
"Några nya Graptolitarter från Skåne," 'Geol. Fören. Förl.,' bd. 6.

1882. Some very interesting forms of Dichograptids from Christiania were described by Herrmann in 1882, which illustrate well the powers of variation of one species as regards the number of its branches. In a new species described by him as *Loganograptus Kjerulfi*, he notes every gradation from forms with five stipes to those with twelve and perhaps

Herrmann,  
"Vorläufige Mitteilung über eine neue Graptolitenart," 'Nyt Mag. for Naturvid.,' bd. xxvii.

sixteen. All these are characterised by a large disc, the development of which he traces.

Two specimens of a form doubtfully referred to *Dichograptus Milesi* are figured, and fragments of *Dendrograptus* (?), *Pleurograptus* (?), and *Cenograptus* (?).

1882. A paper by Hopkinson on the "Morphology of the Rhabdophora," previously read before the British Association in 1881, was published in full in the early part of 1882. In this paper he figures and describes a specimen of *Tetra-graptus serra*, indicating the presence of an internal ridge and constriction at the base of each hydrotheca.

Hopkinson,  
"On some Points in the Morphology of the Rhabdophora or true Graptolites," 'Ann. Mag. Nat. Hist.,' ser. 5, vol. ix.

He concludes (1) "that in certain Graptolites the calyces seem to be completely cut off from their supporting perisarc, this appearance being due to a constriction, or the presence of a partially dividing ridge," and (2) that "in these same forms there are at least constrictions in the perisarc, dividing it into sections, from each of which a calycele is produced."

He holds that these phenomena show that the calyces of the Graptolites are true hydrothecæ, and that the Graptolites are the "Palæozoic representatives of the recent Hydrophora."

Three stratigraphical papers in which Graptolites are referred to also appeared during the year 1882.

1882. The first was by Marr, who gave a generalised account of his visit to the classic localities of the Cambrian and Silurian rocks of Scandinavia, summarised the discoveries of the Scandinavian geologists, and correlated anew the fossil-bearing formations with the British and Bohemian deposits. He notes the Graptolite zones previously correlated by earlier observers, and gives a full list of the Graptolites from the

Marr,  
"On the Cambrian and Silurian Rocks of Scandinavia," 'Quart. Journ. Geol. Soc.,' vol. xxxviii.

*Retiolites* beds of Bornholm.

The second was by Schmidt, who gave a description of the "Silurian (and Cambrian) Strata of the Baltic Provinces of Russia," and their successive fossiliferous zones as developed by himself during a lifetime of research. He compares them with those of Scandinavia and the British Isles and fixes the exact horizons of *Dictyonema* and *Phyllograptus* in the sequence in the Baltic Provinces.

1882. Schmidt,  
"On the Silurian (and Cambrian) Strata of the Baltic Provinces of Russia," 'Quart. Journ. Geol. Soc.,' vol. xxxviii.

The third was by Lapworth, on "The Girvan Succession in South Scotland," in which the value and reliability of the Graptolites as "zone fossils" were again demonstrated, by the discovery in the Girvan district of the same series of Graptolitic zones in the same order as in the previously described Moffat area, notwithstanding the great differences between

1882. Lapworth,  
"On the Girvan Succession," 'Quart. Journ. Geol. Soc.,' vol. xxxviii.

the two regions as respects the thickness, lithology, and palæontological features of the formations present.

1882.

*Tullberg,*

“Skånes Graptoliter,”

‘Sver. Geol. Unders.,’

ser. C, no. 50.

In this year also Tullberg brought out the first part of his great work on the “Skånes Graptoliter.” In this part of his paper Tullberg divided the whole of the Cambrian and Silurian Beds of Scania into successive zones, the majority being characterised by distinctive Graptolites.

The zoning of the strata containing Graptolites is even more detailed than that by Lapworth in his Moffat paper, and the result of Tullberg’s work not only added to the proof of the value and utility of Graptolites as zone indices, and as a means of correlating synchronous deposits in countries geographically distant, but pointed the way to a closely detailed correlation of the British and Scandinavian deposits.

1883.

*Tullberg,*

“Skånes Graptoliter,”

‘Sver. Geol. Unders.,’

ser. C, no. 55.

In the second part of this work, published the following year, Tullberg dealt with the classification of the Graptolites in general, and the various species found in the *Cyrtograptus* and *Cardiola* shales in particular.

*Classification.*—A modification of Lapworth’s classification is suggested. Nine families are recognised. Six of these—Dietyograptidæ, Dichograptidæ, Nemagraptidæ, Monoprionidæ, Mono-diprionidæ, and Diprionidæ—are grouped together under the Class **Monophyontes**; one—Heteroprionidæ (including the single genus *Dimorphograptus*)—under the Class **Mono-Amphyontes**; and two—the Glossograptidæ and Retiolitidæ—under the Class **Amphiphyontes**.

Under the family Dichograptidæ Tullberg includes not only the true Dichograptids, but also *Pleurograptus*, *Cladograptus*, and *Phyllograptus*. The family Retiolitidæ is left unchanged, and contains *Trigonograptus* and *Clathrograptus*, in addition to *Retiolites* and a new genus **Stomatograptus**.

The genus *Monograptus* the author divides into six groups, according to the general form of the polypary and the shape of the thecæ, and for these he proposes names—*i. e.* (1) Leptopodes (*M. Nilssoni*, etc.), (2) Orthopodes (*M. Hisingeri*), (3) Helicopodes (*M. convolutus*, etc.), (4) Opisopodes (*M. lobifer*, etc.), (5) Kamtopodes (*M. testis*, etc.), (6) Prosopodes (*M. colonus*, etc.). These groups, it will be seen, correspond fairly closely with those suggested by Lapworth. (‘Scottish Monograptidæ,’ 1876.)

*Description of Species.*—A large part of this paper is devoted to the description of the Scanian species, many of which are new. These are admirably figured in two plates, and include:

*Leptopodes.*—*Monograptus Nilssoni*.

*Orthopodes.*—*M. Hisingeri*, *M. comarinus*, *M. personatus*, *M. Linnarssoni*, *M. spinulosus*, *M. speciosus*.

*Opisopodes*.—*M. priodon*, *M. Flemingii*, *M. riccartonensis*, *M. nodifer*, *M. sartorius*, *M. scanicus*, *M. capillaceus*, *M. flexuosus*, *M. retroflexus*.

*Kamptopodes*.—*M. testis*, *M. bohemicus*.

*Prosopodes*.—*M. dubius*, *M. colonus*, *M. cultellus*, *M. uncinatus*.

*Cyrtograptus*.—*C. Grayi*, *C. spiralis*, *C. Murchisoni*, var. **crassiusculus**, *C. Carruthersi*, and the new species: *C. dubius*, *C. Lapworthi*, *C. pulchellus*, *C. flaccidus*, *C. moniliformis*, *C. rigidus*, *C. Lundgreni*.

*Retiolites Geinitzianus* and the new genus **Stomatograptus** with its species *S. Törnquisti* are also described and figured. This last genus, originally described by Törnquist as a *Retiolites*, is characterised by the presence of large pores on the sides of the polypary by means of which the "lateral canals are in connection with the exterior."

*Structure*.—A detailed account of the structure of *Retiolites* is given, which in some respects marks an advance on the results already arrived at by Törnquist, but no figures are given illustrating the points of structure described.

1883.

*Törnquist*,  
"Bergbygnaden inom  
Siljansområdet i  
Dalarne," 'Sver. Geol.  
Unders.,' ser. C, no. 57.

A stratigraphical paper was also published by Törnquist during the year, which was the forerunner of a series of papers by him entitled "Siljansområdets Graptoliter." In this memoir the various zones of the *Rastrites* and *Retiolites* shales are given and correlated with those abroad.

1883-84.

*Postlethwaite*,  
"Graptolites of the  
Skiddaw Slates,"  
'Trans. Cumb. Assoc.  
for Advancement of  
Literature and Science,'  
vol. viii.

In 1883-84 Postlethwaite published a paper in which he dealt with the structure, classification, reproduction, and state of preservation of the Graptolites found in the Skiddaw Slates, and gave a complete list of the forty species already obtained from these beds.

He figures a few of the most typical species, and among them a new form of *Tetragraptus*, which was subsequently described by Elles (in 1898) as *Tetrag. Postlethwaitii*.

1884.

*Spencer*,  
'Niagara Fossils,' pt. i;  
"Graptolitidæ of the  
Upper Silurian Sys-  
tem," 'Bull. Mus. of  
the Univ. of Missouri.'

Dr. Spencer, who had previously described (in 1878) three new genera and nine new species of Dendroid Graptolites from the Niagara formation, but had given no figures of these new forms, figured and re-described them in a paper published in 1884; and in addition one new genus and twenty-two new species, making a total of thirty species and four genera. A brief account is given by him of the distribution, zoological affinities, structure, reproduction, and classification of the Graptolites. The descriptions are brief and the figures poor.

*Description of Species*.—The species described are *Phyllograptus* ? **dubius**, *Retiolites venosus*, *Dendrograptus ramosus*, *D. simplex*, *D. Dawsoni*, *D. frondosus*, *D. prægracilis*, *D. spinosus*, *D.* (s.g. **Chanograptus**) **novellus**, *Callograptus Niagarensis*, *C. Granti*, *C. multicaulis*, *C. minutus*; *Dictyonema retiforme*, *D. gracile*, *D.*

**expansum**, *D. Websteri*, *D. tenellum*, *D. splendens*, *D. pergracile*; *Calyptograptus cyathiformis*, *C. subretiformis*, *C. micronematoides*, *C. ? radiatus*, *Rhizograptus bulbosus*, *Acanthograptus Granti*, *A. pulcher*; *Inocaulis plumulosus*, *I. bellus*, *I. divaricatus*, *I. problematicus*, *I. diffusus*, *I. cervicornis*, *I. phycoides*, *I. ramulosus*; *Thamnograptus bartonensis*, *T. multiformis* (not a *Thamnograptus*), *Ptilograptus foliaceus*; **Cyclograptus n.g.**, *C. rotadentacus*.

The new species are mainly founded on the features presented by their general outlines.

1885.

Herrmann,

“Die Graptolithen-familie Dichograptidæ, Lapw.,” ‘Nyt Mag. for Naturvid.,’ bd. xxix.

In the year 1885 Herrmann published a monograph on the family of the Dichograptidæ. This work is valuable as giving a fairly complete summary of our knowledge of the Graptolites in general, and of the Dichograptidæ in particular, at the time it was written.

*Classification.*—The family Dichograptidæ includes, according to Herrmann, sixteen genera, which he groups as follows: 1, *Didymograptus*; 1a, *Trichograptus*; 1b, *Bryograptus*; 1c, *Pterograptus*; 1d, *Pleurograptus*; 2, *Janograptus*; 3, *Tetragraptus*; 3a, *Schizograptus*; 3b, *Trochograptus*; 3c, *Ctenograptus*; 3d, Type Gr. *Richardsoni*; 3e, *Holograptus*; 3f, *Goniograptus*; 4, *Dichograptus*; 4a, *Clematograptus*; 5, *Clonograptus*.

He gives all the previously described species of each genus, and transfers some species from genera in which they had been placed by previous authors to other genera. The only new species described by Herrmann is *Pterograptus ? dilaceratus*, from the *Phyllograptus* shales of Norway.

*Organisation.*—In a chapter dealing with the organisation and economy of the Graptolites, the sicula is described, and its function as an organ of attachment denied. The question of the “angle of divergence” of the stipes is discussed in much detail, and Herrmann suggests, for the first time, the employment of the ventral instead of the dorsal angle as the conventional “angle of divergence,” a plan which has since been generally adopted by Graptolithologists. He considers that the Graptolites probably lived with the sicula below and the branches growing upwards. He supports Holm’s opinion that in some cases, at any rate, the “funiele” bears thecae; and gives additional examples. He deals with the function and development of the central disc at considerable length; attaches considerable importance to Hopkinson’s discovery of an apparent dividing septum between the theca and common canal, and agrees with him that it places the “hydrothecal” nature of the cells beyond doubt.

1885.

Roemer,

“Lethæa erratica,”  
‘Palæont. Abh. v.  
Dames und Kayser,’  
bd. ii, heft 5.

Roemer describes and figures several species of Graptolites from the greenish-grey Graptolithen-Gestein of North Germany. These are: *M. ludensis*, *M. testis*, *M. scanicus*, *Retiolites Geinitzianns*, and two unidentified species of *Mono-graptus*.

1885.  
*Dawson,*  
 "Graptolites of the  
 Quebec Group," 'Red-  
 path Museum Report,'  
 January.

In a short note referring to "Graptolites of the Quebec Group," collected by Mr. Richardson for the Montreal Museum, Dawson describes a new species of *Dictyonema* (*D. delicatulum*) from the Point Levis at Fort, No 2, and records the occurrence of *D. sociale* in the black shales of Matane.

1886.  
*Lapworth,*  
 "Preliminary Report on  
 some Graptolites from  
 the Lower Palæozoic  
 Rocks on the South of  
 the River St. Lawrence,  
 etc.," 'Trans. Roy. Soc.  
 Canada,' sect. 4.

In the following year Lapworth published a "Preliminary Report on some Graptolites" forwarded to him by the Canadian Survey from the Lower Palæozoic Rocks on the south side of the St. Lawrence—from Cape Rosier to Tartigo River, from the north shore of the Island of Orleans, one mile above Cape Rouge, and from the Cove Fields, Quebec.

He gives detailed lists of Graptolites from a large number of Canadian localities, arranges them in stratigraphical order, and correlates the containing beds with the graptolite bearing formations of America, Britain, and Europe.

He recognises the existence in Canada of two main faunas, each divided into two sub-faunas :

(A) Quebec or Calciferous—Chazy Fauna :

Sub-fauna 1.—Cape Rosier (and Barrasois River) Zone of Calciferous age=  
 Tremadoc rocks and *Dictyonema* beds.

Sub-fauna 2.—St. Anne River Zone=Arenig.

(B) Trentonian, Marsonin River (or Norman's Kill) fauna :

Sub-fauna 1.—*Carnograptus* zone of Griffin Cove and Marsouin River=  
 Middle Llandeilo and Glenkiln.

Sub-fauna 2.—Cove Fields and Orleans Island Zone=Highest Llandeilo or  
 Lowest Caradoc.

1887.  
*Törnquist,*  
 "Anteckningar om de  
 äldre Paleozoiska leden  
 i Ostthüringen och  
 Voigtland," 'Geol.  
 Fören. Förh.' bd. ix,  
 häft 7.

Törnquist, in a paper on the "Older Palæozoic Rocks of Ostthüringia and Voigtland," classified and described their Graptolite zones, and correlated them with those of Scandinavia and Britain. He recognises three main horizons: (a) Lower *Rastrites* shales, (b) Upper *Rastrites* shales, and (c) *Retiolites* shales. In an appendix to this paper he describes and figures three new species: (1) *Rastrites phleoides*, (2) *Cyrtograptus radians*, and (3) *Retiolites macilentus*.

1888.  
*Marr & Nicholson,*  
 "The Stockdale  
 Shales," 'Quart. Journ.  
 Geol. Soc.,' vol. xliv.

In 1888 a very important paper from the stratigraphical aspect of graptolithic literature was published by Marr and Nicholson. They divide the whole of the Stockdale Shales of the Lake District into their component zones, the majority of these being distinguished by special Graptolites. They demonstrate the presence in the Stockdale Shales of the same Graptolite zones

as those in the Birkhill and Gala beds of South Scotland in the same order of sequence, and parallel them with those of many other districts, British and Foreign.

1889.

*Marr,*

“Notes on the Lower Palæozoic Rocks of the Fichtelgebirge,” ‘*Geol. Mag.*,’ dec. 3, vol. vi.

In the following year Marr gave a revised list of the Frankenwald and Thüringerwald Graptolites preserved in the Dresden Museum. This list is of special interest, as many of these forms are the originals of the figures on the plates of Geinitz’s work, ‘*Die Graptolithen*,’ 1852. Marr also made known the presence of Graptolites in the representatives of the Wenlock formation in Thuringia and

the neighbouring parts of Bavaria.

1889.

*De Rouville,*

“Note sur un nouvel Horizon de Graptolites dans le Silurien de Cabrières,” ‘*Bull. Soc. Géol. de France*,’ t. xviii.

De Rouville made known the presence of Graptolites in a rich Arenig fauna discovered near Cabrières. No specific names of Graptolites are given.

1889.

*Lapworth,*

“On the Ballantræ Rocks of S. Scotland and their place in the Upland Sequence,” ‘*Geol. Mag.*,’ dec. 3, vol. vi.

The same year Lapworth, after pointing out the systematic importance of the existence of a typical Arenig fauna in the Ballantræ Rocks of South Scotland, the discovery of which had been made known by him in 1886 (Jukes-Browne, ‘*Historical Geology*,’ 1st Edition), gave a generalised account of his conclusions respecting the structure and sequence throughout the Southern Uplands, and paralleled in tabulated form their graptolite bearing formations with their equivalents in England and Wales.

1889.

*Jaekel,*

“Ueber das Alter des sogenannten Graptolithengesteins mit besonderer Berücksichtigung der in demselben enthaltenen Graptolithen,” ‘*Zeitschr. deutsch. geol. Gesell.*,’ bd. xli.

A paper on the fauna of the Graptolithengestein of the German Drift erratics, with special relation to their Graptolites, was published by Jaekel in 1889 (compare the subsequent memoir by Jahn).

Several Graptolite species are described and figured, and it is proposed to divide the genus *Monograptus* into two new groups or genera—**Pristiograptus** and **Pomatograptus**, a similar division being regarded as probably equally applicable to the two- and many-rowed forms of Graptolites.

*Pristiograptus* is characterised by a straight or convexly curved polypary, cylindrical cells in contact throughout, having their apertures occupying the whole of the upper end of the cell, and their apertural processes, if present, occurring as spines on the lower edge of the aperture.

In *Pomatograptus* the polypary is straight or concavely curved, the cells free at their outer end, while the aperture is small and protected by a roof-like process arising from the upper part of the cell.

Under the name *Pristiograptus* the author describes *P. bohemicus*, *P. Roemeri*?, *P. Nilssoni*, *P. colonus*, *P. testis*, and a new species *P. frequens*. Under the name *Pomatograptus*, he describes *P. priodon*, *P. Becki*, *P. Barrantei*, and a new form, *P. micropoma*.

The structure of *Retiolites* is also described.

*Mode of Life.*—In discussing the mode of life of the Graptolites, Jaekel returns to the idea of their rooted attachment to the floor of the sea, and also revives the opinion of Hall that all single Graptolites “usually described under the name *Monograptus*” are torn-off pieces of larger colonies. He maintains that the narrow end is never complete, and never shows well-developed cells.

*Affinities.*—Jaekel agrees with Neumayr that the Graptolites should be placed in a special class, which might be compared with the Corals.

1890.  
Holm,  
“Gotlands Graptoliter,”  
‘Bihang K. Svenska  
Vet.-Akad. Handl.,’ bd.  
xvi, af. 4, no. 7.

During this year, a brilliant paper on the minute structure of the Graptolites was published by the Swedish palæontologist, Holm.

Previous researchers had attempted to isolate the Graptolite from the rock in which it was imbedded, but the process was brought to great perfection by Holm, and the value of the results thus obtained can hardly be over-estimated. In this paper (“Gotlands Graptoliter”) Holm gives the results of his investigations of the structure of *Dictyonema*, *Monograptus dubius*, *Retiolites*, and *Stomatograptus*.

*Dictyonema cervicorne.* The structure of a branch of *Dictyonema* is worked out in this new species. The thecæ are turned inwards. From one side of the thecæ, alternately on the left- and right-hand side, there grows out a “bird-nest”-like theca, which Holm terms a “bitheca” (? gonangium). Between each pair of thecæ there is one dissepiment. Holm points out that the forms referred to the genus *Dictyonema* are both siculate and non-siculate, and holds that it may be found necessary in the future to sub-divide this genus.

*M. priodon* and *M. sub-conicus* are recorded from Gothland, and *M. Flemingii* (which he regards as only a mutation of *M. priodon*) and *M. dubius* are figured. The structure of the latter species is very accurately represented.

*Retiolites Geinätzianus.* The isolation methods adopted by Holm also enabled him to give a far more complete description, and a more detailed and perfect figure of the structure of *Retiolites* than had hitherto been possible. The nature of the outer net-like periderm is more particularly elucidated, as well as the relations between the straight and zigzag “virgulas,” and “threads” of the skeleton generally.

*Stomatograptus Törnuquisti.* Many further points of structure, obscure in

*Retiolites*, are cleared up by Holm's development of specimens of *Stomatograptus* (*S. Törnquisti*). This genus he considers to be more distinct from *Retiolites* than was previously supposed, for in *Stomatograptus*, in addition to the "pores," the form of the apertures is different. He proves that the periderm in this genus, as in other Graptolites, is composed of three layers; "the outer and inner are smooth and without spaces, while the middle one is formed of a network of chitinous threads."

*Retiolites nassa*. Another interesting form, *Retiolites nassa* (later made the type of a new genus—*Gothograptus*—by Frech.), is shortly described. This form bears the same relation to the Retiolitidæ that *Climacograptus* does to the Diplograptidæ.

1890.

Törnquist,  
"Siljansområdets  
Graptoliter," i,  
'Lunds Univ. Års-  
skrift,' bd. xxvi.

In 1890 Törnquist brought out the first part of his "Siljansområdets Graptoliter." In this paper several species of Graptolites (some new) are carefully described and figured. The author recites concisely his own views on the structure of *Retiolites*, and discusses Tullberg's opinions on the subject.

*Description of Species.*—*Retiolites Geinitzianus*, *R. cfr. perlatus*, and *R. obesus* are described and figured, and he thinks that, when better material is obtained, the last species will form the type of a new genus. He refers the species described by Suess ('Böhmische Graptolithen,' 1851) as *R. grandis*, to the genus *Stomatograptus*. In addition, he figures *Lasiograptus margaritatus*, *Dichog. octobrachiatus*, *Clonograptus robustus* (allied to *Gr. ramulus*, Hall), *Tetragraptus serra*, *Tetrag. curvatus*, *Didymograptus minutus*, *D. gracilis*, and *D. decens*. In his description of *D. minutus*, he notes the long thread extending from the apex of the sicula, and thinks that this might correspond more nearly to the virgula in the genera *Diplograptus* and *Monograptus*. He suggests that the genus *Didymograptus* should be made the type of a new family—the Didymograptidæ—distinct from that of the Dichograptidæ on account of apparent differences in the development of the branches.

The other species described in the paper are *Dicellograptus anceps*, *Phyllograptus densus*, *Climacograptus scalaris*, *C. internexus*, and a form which the author thinks further research will prove to be a distinct species, and for which he suggests a name, *C. phrygionius*; *Diplograptus pristis*, *D. truncatus*, *D. palmeus*, a new species, *D. bellulus*, *Cephalograptus folium* and *C. cometa*.

In most of the specimens the sicula and its relations to the proximal thecæ are carefully figured.

1890.

Malaise,  
"Sur les Graptolites  
de Belgique," 'Bull.  
Acad. Roy. de Bel-  
gique,' ser. 3, vol. xx.

Malaise in 1890 summarised his work among the graptolite bearing Palæozoic rocks in Belgium, and correlated the zones with those of Britain. He recognises in Belgium four successive chronological groups of Graptolites, viz. those of the Arenig, Bala, Llandovery, and Wenlock-Ludlow, but

the presence of two others, *i.e.* the *Dictyonema sociale* zone and that of the Llandeilo, he regards as yet problematical.

1890.

*Dodge,*

“Some Silurian Graptolites from Northern Maine,” ‘*Amer. Journ. Sci.*,’ vol. xl.

Dodge described a few species of Graptolites found by himself in Maine in beds of Norman’s Kill age. They include *Helicograptus gracilis*, *Dicellograptus* sp., *Diplograptus* sp., *Cryptograptus marcidus*, and *Glossograptus spinulosus*.

1890.

*Gurley,*

“Geological Age of the Graptolite Shales of Arkansas and some new Species of Graptolites,” ‘*Ann. Rep. Geol. Surv. Arkansas*’

The geological age of the Graptolite shales of Arkansas is discussed by Gurley in a paper published in 1890. He recognises two horizons—the Trenton and the Calciferous. The latter, he considers, corresponds to the Point Levis beds, the former to the upper part of the Norman’s Kill fauna. The stratum marked out by the latter distinctive fauna is termed by him the “*Dicellograptus* zone,” and is divided into (a) Lower *Dicellograptus* sub-zone with *Carnograptus gracilis*, and (b) Upper *Dicellograptus* sub-zone without *Carnog. gracilis*. The Arkansas fauna thus corresponds to that of the Upper Zone. He describes four new forms: *Dicranograptus arkansasensis*, *Dicranog. Nicholsoni* var. *parvangulus*, *Diplog. trifidus*, and *Dictyonema obovatum*. Only two of the species are figured.

A complete list of the Graptolites obtained from Arkansas is also given.

1890.

*Getz,*

“Graptolitförende skifferzoner i det Trondhjemske,” ‘*Nyt Mag. for Naturvid.*,’ bd. xxxi.

In 1890 Getz described a few specimens obtained (mainly by Herrmann) from two distinct Graptolite horizons in the Trondhjem district, corresponding the one to Upper Glenklin or Lower Hartfell, and the other to the Birkhill. The Graptolites are poorly preserved owing to the cleavage of the beds, and it is impossible to identify more than *Dicranograptus ramosus* and *Climacog. bicornis*, but the author records in addition a species of *Didymograptus*, *Diplograptus*, and *Dicellograptus* from the lower horizon. From the Upper Birkhill zone he figures *M. cfr. concolatus*, *Monograptus Halli* and *Rastrites* sp.

1890.

*Nicholson, H. O.,*

“Note on the Occurrence of *Trigonograptus ensiformis*, etc.,” ‘*Geol. Mag.*,’ dec. 3, vol. vii.

The same year H. O. Nicholson recorded the existence of *Trigonograptus ensiformis* in the Ellergill Beds of the Lake District, and also described a new variety of *Didymograptus* under the name *D. r-fractus* var. **volucer**.

1890.

*Geinitz,*

‘*Die Graptolithen des k. Mineralog. Mus. in Dresden.*’

Geinitz, in a paper published in this year, revised the fine collection of Graptolites in the Dresden Museum, and gave descriptions and figures of some of the species identified. He retains all the genera and species of Graptolites originally described by him, with the exception of *Nereograptus*. Very

brief (if any) descriptions of the forms illustrated are given, and the figures are mainly copies from the illustrations to his 'Graptolithen,' 1852, or from other authors; but the synonymy of each species is given fully. The species referred to are: *Monograptus sagittarius*, *M. Hisingeri*, *M. nuntius*, *M. Nilssoni*, *M. Salteri*, *M. tenuis*, *M. bohemicus*, *M. latus*, *M. virgulatus*, *M. Barrandei*, *M. colonus*, *M. frequens*, *M. testis*, *M. priodon*, *M. millipeda*, *M. Becki*, *M. Halli*, *M. Flemingi*, *M. clintonensis*, *M. Sedgwickii*, *M. convolutus*, *M. turriculatus*, *M. proteus*, *M. peregrinus*, *M. Linnæi*, *M. gemmatus*; *Cyrtograptus Murchisoni*, *C. radians*; *Pterograptus dilaceratus* (which he regards as identical with *Cænog. gracilis*); *Didymograptus Murchisoni* and *D. Forchhammeri*; *Tetragraptus serra* and *T. fruticosus*; *Diplograptus ovatus*, *D. palmeus*, *D. folium*, *D. cometa*, *D. foliaceus*, *D. teretiusculus*, *D. pristis*, *D. secalinus*, *D. mucronatus*, *D. Swanstoni*; *Phyllograptus* *cf.* *angustifolius*; *Triplograptus Nereitarum*; *Retiolites Geinitzianus*. Geinitz's views appear to have undergone but little change since 1862, and he refuses to accept such genera as *Rastrites*, *Dicellograptus*, *Dimorphograptus*, *Climacograptus*, etc.

1891.

Hall, T. S.,

"On a new Species of  
*Dictyonema*," 'Proc.  
Roy. Soc. Vict.,' n.s.,  
vol. iv.

In 1891 T. S. Hall described a new species of *Dictyonema*—*D. grande* from the Lancefield beds of Australia.

1891.

Björlykke,

"Graptolitförende  
Skifere i v. Gausdal,"  
'Norges Geol. Undersög-  
gelse Aarbog,' no. 1.

In 1891 Björlykke gave brief descriptions and sketch-figures of some species of *Didymograptus*, etc., found by himself in Western Gausdal. These include *D. geminus*, *D. cf. nitidus* or *balticus*, *D. cf. euodus*, *D. hirundo* or *patulus*, *D. pusillus*, *Diplog. teretiusculus*, *Climacograptus* sp., *Pterograptus elegans*, and *Tetragraptus bryonoides*.

1891.

Matthew,

"On a new Horizon in  
the St. John's Group,"  
'Canad. Record of  
Science.'

Matthew during this year recorded the discovery of *Dictyonema flabelliforme* in the St. John's Group. He discusses the importance of this fossil as a zone index in Europe.

He considers that *Dictyonema* was a free, floating organism, and "began life as a *Bryograptus*."

1891.

Pritchard,

"On a new Species of  
the Graptolitidæ—*Tem-  
nograptus magnificus*,"  
'Proc. Roy. Soc. Vict.'

During the same year Pritchard recorded what he considered to be a new species of *Temnograptus* from Australian deposits, under the name *T. magnificus*.

1891.

Gurley,

"On some recent  
Graptolitic Literature,"  
'Amer. Geol.,' vol. viii.

A general review of Jaekel's, Geinitz's, Törnquist's, and Holm's papers issued during the previous two years, was published by Gurley in the 'American Geologist' for 1891.

1891. Two questions of synonymy were discussed by Moberg in 1891. The first deals with *Dictyonema* and *Dictyograptus*, and Moberg urges the adoption of the latter name for the same reason as that given by Hopkinson and Lapworth, namely, that *Dictyonema* is an "old-established name for a genus of plants." The second deals with *Didymog. caluceus* or *D. gibberulus*. As Salter's name, *D. caduceus*, has been used for two species, and it is impossible to say to which of the two the original name corresponded, Moberg agrees with Nicholson that it can no longer stand, and he proposes the general adoption of Nicholson's specific name, *D. gibberulus*.

1892. Numerous papers dealing with Graptolites appeared in 1892, the majority of them being by Swedish writers. *Törnquist*, 'Siljansområdets Graptoliter,' pt. ii. Another part of Törnquist's great work on the "Siljansområdets Graptoliter" was published during this year. It deals wholly with the Monograptidæ. The author discusses the three genera usually included under this family—viz. *Cyrtograptus*, *Rastrites*, and *Monograptus*, and classifies the various species belonging to the last-named genus, rejecting Jaekel's division of *Monograptus* into *Pomatograptus* and *Pristiograptus*.

Törnquist's classification is based on the principle adopted by Lapworth (1876)—namely, on the form of the polypary and the form of the thecæ, but it is far more detailed. The proposed divisions are as follows:

(A) Thecæ tube-like, of prismatic form, with upper walls in contact throughout.

(1) Rhabdosome narrow, flexible; type *M. Nilssoni*.

(2) Rhabdosome wide, rigid; type *M. Hisingeri*.

(B) Upper wall of theca partly free.

(1) Rhabdosome straight or curved.

(a) Theca with only a narrow border near the aperture free; apertures hook-shaped, pressed into the polypary (*M. crenulatus*, etc.).

(b) Upper wall of theca prolonged into a lip-shape, type *M. priodon*.

(c) Outer part of theca bent round and grown to the lower walls (*M. lobiferus*).

(d) Free part of theca bent round in a loop shape (*M. sartorius*).

(e) Free part of theca bent double into an S-shape (*M. nodifer*).

(f) Upper free wall of theca passing over without a boundary into the lower wall of the theca above (*M. runcinatus*).

(g) Upper wall of theca prolonged into a long spine (*M. Sedgwickii*).

(2) Polypary spirally curved.

(a) Theca growing out centripetally (*M. discus*, etc.).

The main part of the paper is occupied with careful descriptions illustrated by excellent figures, of numerous species of *Monograptus*, etc., some of the species

being new. The following are described: *Rastrites peregrinus*, *R. hybridus*, *Monograptus gregarius*, *M. limatulus*, *M. leptotheca*, *M. crenulatus*, *M. continens*, *M. priodon* (Törnquist discusses and criticises the view of Jaekel as to the structure of the theca in this species), *M. cygneus*, *M. cultellus*, *M. lobiferus*, *M. cfr. Becki*, *M. singularis*, *M. sartorius*, *M. ansulosus*, *M. cfr. dextrorsus*, *M. exiguus*, *M. nodifer*, *M. runcinatus*, *M. Sedgwicki*, *M. convolutus*, *M. spiralis*, var. *subconicus*, *M. turriculatus*, *M. discus*, *M. proteus*, *M. flagellaris*. In all the illustrations great attention is paid to the correct figuring of the proximal end.

1892.

Törnquist,  
"Ett inlägg i en  
synonymifråga," 'Geol.  
Fören. Förh.,' bd. xiv.

The proposal of Moberg to adopt Hopkinson's and Lapworth's suggested name of *Dictyograptus* in place of *Dictyonema* was discussed and criticised by Törnquist in 1892. He considers that the fact that "*Dictyonema*" is an old-established name for a genus of plants is not a sufficient

reason for its rejection.

1892?.

James,  
"Manual of Palæon-  
tology of the Cincinnati  
Group, pt. 2,  
Coelenterata."

In 1892 (?) James published the second part of his Manual on the Palæontology of the Cincinnati Group dealing with the Coelenterata.

*Classification.*—James considers that in the sub-class Hydroida there is only one order—the Thecophora—and that this includes the two genera *Dendrograptus* and *Dictyonema*.

Under the genus *Dendrograptus* (which according to James includes *Buthotrephis*, Hall, pars, and *Psilophyton*, Lesqx.) he describes *D. gracillimum*, Lesqx., *D. tenuiramosus*. The genus also includes *D. arbusculum*, Ulrich (= *D. irregulare*, Hall).

According to the author the sub-class Graptoloidea comprises seven genera: (1) *Graptolithus*; (2) *Diplograptus*, including the two species *D. spinulosus* and *D. Whitfieldii*; (3) *Climacograptus* with its species *C. typicalis* and *C. bicornis*; (4) *Dicranograptus*, type *D. ramosus*; (5) *Megalograptus* (*M. Welchi* being entirely distinct from any other known Graptolite); (6) *Inocaulis*; and (7) *Dawsonia* (*Lockeia*), *D. siliquaria*.

1892.

Jahn,  
"Vorläufiger Bericht  
über die Dendroiden  
des böhmischen Silur,"  
'K. Akad. Wiss. Wien,  
Mathem. Naturw.  
Classe,' bd. ci, heft 7.

In 1892 Jahn published a preliminary report of his investigations among the Dendroidea of the Silurian Rocks of Bohemia. He discusses the history of our knowledge of the genus *Dictyonema* up to the year 1875, but ignores the more recent work. He considers that many species have been included under this genus which really belong to other genera, and he suggests that *Desmograptus*, regarded by Hopkinson and Lapworth as a sub-genus of *Dictyonema*,

should be regarded as a distinct genus. He also proposes a new genus—**Damesograptus**. Jahn names eight new species of Dendroidea, mainly from Stage E. e. 2 in Bohemia, but gives no descriptions or figures. These are *Callograptus tenuissimus*, *Callog. bohemicus*, *Callog. palmeus*, *Desmograptus*

**giganteus**, *Desmog.* **diffusus**, *Desmog.* **bohemicus**, *Desmog.* **frondescens**, *Dictyonema* **Barrandei**. Owing to the absence either of descriptions or figures none of these forms can be identified.

1892.  
Barrois,  
"Mémoire sur la Dis-  
tribution des Grapto-  
lites en France," 'Ann.  
Soc. Géol. du Nord,'  
t. xx.

A most important paper by Barrois appeared in 1892 dealing with the Distribution of Graptolites in France. In this paper Barrois collected together all the scattered information obtained by himself and others for many past years as to the occurrence of Graptolites in France. In addition to recording all such Graptolite species as had been discovered and identified, several species are fully described by him,

but no figures are given.

In Languedoc three horizons are recognisable. From the lowest (Arenig) the following species are described: *Didymog. balticus*, *D. v-fractus*, *D. pennatulus*, *D. nitidus*, *D. bifidus*, *D. indentus*, *D. Escoti*, *Tetrag. serra* and *T. quadribra-  
chiatus*; from the middle one (Llandeilo) only *D. euodus*; from the highest (Wenlock Shales) *M. priodon*, *M. bohemicus*, *M. colonus*, *M. Roemeri*, *M. Nilssoni*.

From the Pyrenees the Graptolites are mainly of Birkhill-Tarannon age, and the following species are described: *Monog. Becki*, *M. priodon*, *M. attenuatus*, *M. crispus*, *M. proteus*, *M. Barrandei*, *M. spiralis*, *M. communis*, *M. nodifer*, *M. sartorius*, *M. runcinatus*, *M. Salteri*, *M. crassus*, *M. Halli* (?), *M. Roemeri*, *M. riccartonensis*, *M. comerinus*, *M. basilicus*, *M. Nilssoni*, *M. concinnus*, *M. discus*, *M. Lapworthi*, *Cyrtog. Murchisoni*, *Cyrtog. Grayi*, *Retiolites Geinitzianus*, *R. perlatus*.

From the Ardennes, Graptolites of Cambrian, Arenig, Caradoc, Lower Llandovery, Tarannon, Wenlock and L. Ludlow age are recorded. From Normandy only Wenlock fossils are known.

In Brittany, *Didymog. Murchisoni*, *D. euodus*, *D. nanus*, *D. furcillatus* are described from Angers, while *Diplog. foliaceus* and *D. angustifolius* represent the Glenkiln horizon. The Llandovery strata of Anjou contain *Monog. spiralis*, *M. crenularis*, *M. lobiferus*, *M. sublobiferus*, *M. Sedgwickii*, *M. cyphus*, *M. Olingani*, *Climacog. normalis*, *Cephalog. folium*, *Diplog. Hughesi*, *Rastrites peregrinus*, and *R. Linnæi*.

The Ampelite schists of Western France are shown by their fossils to be of Tarannon-Wenlock age, and the Ampelite limestones to occupy a somewhat higher horizon.

1892.  
Gürich,  
"Ueber die Zellenöff-  
nung von *Monograptus*  
*priodon*," 'Sitzungs-  
bericht d. Schles.  
Gesell., Naturw. Sect.,  
Breslau.'

Gürich, in a paper published during this year, discussed Jaekel's proposed division of the genus *Monograptus* into *Pomatograptus* and *Pristiograptus*, and suggested that for the two groups typified by these names the titles of (a) *Monograpti reversi*, and (b) *Monograpti erecti*, should be substituted, as the "question of their systematic relationships was as yet not ripe for decision." He gives a "schematic

representation of the conjectural connection of the *Monograpti reversi* and *M. erecti* with a hypothetical disc."

1892.

Moberg,

"Om skifferna med  
*Clonograptus tenellus*,  
dess Fauna och Geolo-  
giska Alder,"  
'Geol. Fören. Förh.,'  
bd. xiv.

In 1892 Moberg described the fauna of the *Clonograptus* Beds of Sweden, and added two new species. He discusses briefly the various genera included in the family of the Dichograptidæ, and points out that nearly all these genera are founded on the somewhat unsatisfactory character of differences in the mode of branching, and are as a rule typified by only one species. He refers his new species doubtfully to *Bryograptus*.

*Clonograptus tenellus* is fully described, and a variety of it—var. **hians**—is proposed. The new species are: *Bryograptus?* **hunnebergensis**, and *Bryo.?* **sarmmentosus**. The author discusses at length the resemblances and differences between *Clonograptus* and *Bryograptus*, and points out that it is probable that *Didymograptus* was developed from the latter genus.

Moberg also enters fully into the question of the age of the *Clonograptus tenellus* beds.

1892.

Moberg,

"Om några nya Grap-  
toliter från Skånes  
Undre Graptolits-  
kiffer," 'Geol. Fören.  
Förh.,' bd. xiv.

In a second paper published during the same year Moberg described two new genera of Dichograptidæ from the Lower Graptolite shales of Scania. One of these is **Mæandrograptus**, with its species *M. Schmalenseei*, a form intermediate between *Didymograptus* and *Dicellograptus*, the "sicula giving rise directly (near its broader end and on the same side) to many thecæ."

The structure of the proximal end of *Didymog. gibberulus* is also worked out by Moberg with great care, and on account of its peculiarities he suggests that the species should be made the type of a new genus **Isograptus**.

In addition to the two new genera, he describes and figures a new species of *Azygograptus* (*A. suecicus*).

1892.

Moberg,

Referat von G. F.  
Matthew "On a new  
Horizon in the St.  
John's Group," 'Geol.  
Fören. Förh.,' bd. xiv.

A third paper published by Moberg during this year consists of a review of Matthew's paper "On a New Horizon in the St. John's Group." He gives a summary of Matthew's results and compares them with the occurrence of the *Dictyonema* and *Bryograptus* beds in Sweden.

1893.

Moberg,

"En *Monograptus*  
försedd med discus,"  
'Geol. Fören. Förh.,'  
bd. xv.

In 1893 Moberg described a very curious species of *Monograptus*—*M. pala*—provided with a disc at the proximal end. The presence of a disc had not been previously observed in *Monograptus*.

During this same year, also, several important papers were published dealing with the details of the structure of *Diplograptus* and *Monograptus*.

1893.  
Törnquist,  
"Observations on the  
Structure of some  
Diprionidæ," 'Lunds  
Univ. Årsskrift,'  
bd. xxix.

The first paper was one by Törnquist, "On the Structure of some Diprionidæ." By means of transverse and longitudinal sections of specimens preserved in iron pyrites he worked out many details of structures previously obscure. Like Moberg he distinguishes carefully between the two aspects of the polypary. For these he adopts the terms "obverse" (in which the sicula is completely visible) and "reverse" (in which the sicula is partly concealed from view). The row of thecae which contains the first theca is called by him the "primordial" series, and the other the "second" series.

As regards the development of the first theca he shows that the sicula gives rise (on the left side in the obverse aspect) to a small lobe which develops into a conical space similar to that of the sicula, but "shorter, and communicating with the common cavity of the rhabdosoma." This he distinguishes as the "connecting canal." "Surrounding not only both sides of the sicula, but also its reverse wall," there is an undivided space which he calls the "biserial chamber." The structure of the median septum as respects its complete or incomplete nature, as shown in certain species, is also worked out. In all cases the author apparently implies that each theca is developed from the theca immediately below belonging to the same series.

These details are worked out in the case of *Climacog. scalaris*, *C. internexus*, *Diplog. bellulus*, *D. palmeus*, and *Cephalog. cometa*.

1893.  
Wiman,  
"Ueber Diplograpti-  
dæ," 'Bull. of the Geol.  
Instit. of Upsala,' no. 2,  
vol. i.

The structure of *Diplograptus* was still further elucidated by Wiman during the same year. He obtained his results by carrying out the methods previously employed by Holm in the case of *Dictyonema* and *Retiolites*, namely, of completely isolating the specimen from the matrix.

The most important discoveries made known by Wiman in this paper are with reference to the sicula and the virgula.

The sicula is shown to consist of two parts: (*a*) a proximal cup-like portion similar in structure to an ordinary theca and possessing growth lines, and (*b*) "a distal portion consisting of coarse, longitudinal branching or anastomosing thickenings or threads." The apertural spines (two in number) of the sicula are also described, and are shown to be flat, not cylindrical. The bilateral symmetry of the sicula thus produced reminds one of a "Bryozoan rather than a modern Hydroid polypary."

The relations of the virgula, as then accepted, are fully discussed, and it is shown to consist of two distinct and separate parts, the distal part (or virgula proper as now understood), having its origin in the union of the longitudinal lines of the distal portion of the sicula.

As regards the development of the proximal thecæ, Wiman agrees in the main with Törnquist's observations, but differs in the interpretation of the facts. He regards the "connecting canal" as merely a bud which develops into the proximal part of the first theca. In the special form of *Diplograptus* figured by Wiman in illustration, the second theca develops directly from the first theca, and each subsequent theca "develops from the next more proximally situated theca of the opposite side." There is, therefore, no special structure such as a common canal to give origin to the theca in this species, nor is there any double longitudinal septum.

1893.

Wiman,

"Ueber *Monograptus*,  
Geinitz," 'Bull. of the  
Geol. Institut. of Upsala,'  
no. 2, vol. i.

This important paper was followed a few months later by another by the same author on the structure of *Monograptus*. The structural details described in this paper are worked out in specimens of *M. dubius*.

The sicula in this *Monograptus* is shown to be essentially similar in structure to that in *Diplograptus*; the mode of development of the virgula is also similar.

The growth lines at the point of origin of the first theca show a very marked discontinuity; the passage between sicula and theca is wider than in *Diplograptus*, and the first theca arises from the left side in the obverse aspect. This first theca does not grow downward at first and then curve upward as in *Diplograptus*, but grows upward at once. Each subsequent theca develops from the one immediately below, and not from a common canal. Wiman observes the same zig-zag-like union of the growth lines on the thecæ as noted in the case of *Diplograptus*.

1893.

Lake and Groom,

"On the Llandovery  
and Associated Rocks  
of Corwen," 'Quart.  
Journ. Geol. Soc.,'  
vol. xlix.

In 1893 Lake and Groom noted the occurrence of the upper part of the *Monog. gregarius* zone (Lower Birkhill) in the Corwen district of North Wales.

1893.

Sollas,

"On the Minute Struc-  
ture of the Skeleton of  
*Monog. priodon*," 'Geol.  
Mag.,' dec. 3, vol. x.

A short note on the structure of the skeleton of *Monograptus priodon* was published by Sollas in 1893. By means of transverse sections he was able to recognise in British specimens the three layers (comp. Richter, 1871): "an outer and inner, which are very thin, separated by a space now filled with calcite, and a thicker middle layer." He notices

also and explains the thickening of the wall of the theca near its inner opening into the common canal and also along the free edges of the theca, but points out that this is caused "partly by an enlargement of the space between the layers, and partly by a thickening of the middle layer."

"The virgula," he holds, "would appear to possess no independent existence; it seems to be merely a thickening of the middle layer."

1893.

*Hall, T. S.,*

“Note on the Distribution of the Graptolitidæ in the Rocks of Castlemaine,” ‘Australian Assoc. for the Advance. of Science.’

T. S. Hall in this year contributed a short note on the “Distribution of the Graptolitidæ in the Rocks of Castlemaine.”

The zones which he recognises from below upward are as follows: (1) *Tetragraptus fruticosus* with *Tetrag. quadribrachiatus* and *Phyllog. typus*, etc.; (2) *Didymograptus bifidus*; (3) *Didymog. caduceus* and *Phyllog. typus*; (4) *Didymog. caduceus* without *Phyllog. typus*; (5) *Loganograptus Loganii* occurs at a high horizon, and probably occupies a fifth zone.

1893.

*Barrois,*

“Sur le *Rouvilligraptus Richardsoni* de Cabrières,” ‘Ann. Soc. Géol. du Nord,’ t. 21.

The same year Barrois described and figured a specimen of *Graptolithus Richardsoni*, from Cabrières, and suggested the generic name of **Rouvilligraptus** for species of this type.

1894.

*Perner,*

‘Études sur les Graptolites de Bohême,’ pt. i.

In 1894 Perner published the first part of his extensive work on the “Graptolites de Bohême,” a memoir in which he revised and carried on the Graptolite work so brilliantly begun by Barrande in 1851. This first part is devoted mainly to the study and description of the minute structure of the Graptolite skeleton.

An early section of the paper is devoted in part to a defence of Jaekel’s work and his division of the genus *Monograptus* into *Pomatograptus* and *Pristiograptus*, and in part to a study of the thecal wall and its ornaments.

The greater portion of the memoir is, however, devoted to an account of the microscopic structure of the skeleton in *Monograptus*. Perner recognises four distinct layers (in distinction to the three described by previous observers): (1) the epidermic layer, (2) the black layer, (3) the layer with coigns, and (4) the layer with “colonnettes,” all of which are described in detail.

Perner shows that the virgula or “solid axis” does not lie in the dorsal sinus, as was believed by Barrande, but occurs in the third layer, under the black layer. It was very thin and elastic, but hardly ever loses its continuity in the fossil.

After giving an account of the structure of *Retiolites* as worked out by Holm and other Swedish authors, Perner concludes with a description of the microscopical structure of the skeleton.

1894.

*Pritchard,*

“Notes on some Lancefield Graptolites,” ‘Proc. Roy. Soc. Vict.’ n.s., vol. vii.

In 1894 Pritchard gave a description of a few forms of Graptolites from the Lancefield Beds of Victoria. He also records *Clonograptus flexilis* and *Tetragraptus quadribrachiatus* from the Lancefield locality.

1894.

Marr,

“Notes on the Skiddaw  
Slates,” ‘Geol. Mag.,’  
dec. 4, vol. I.

An important paper, dealing with the range and distribution of Graptolites in Britain, was published in 1894 by Marr, who gave a complete list of the Graptolites hitherto found in the Skiddaw Slates. He divides the Skiddaw Slates for the first time into the following horizons :

- (2)  $\left\{ \begin{array}{l} (d) \text{ Millburn Beds—Uppermost Arenig or Llandeilo (Lower).} \\ (c) \text{ Ellergill Beds, characterised by } \textit{Didymog. fasciculatus}, \textit{Azygog.} \\ \textit{caelebs}, \textit{Trigonograptus}, \textit{etc.} \\ (b) \text{ Tetragraptus Beds } \left\{ \begin{array}{l} \text{Upper, with } \textit{Didymog. nutus}. \\ \text{Lower.} \end{array} \right. \\ (a) \text{ Dichograptus Beds.} \end{array} \right.$

(1) *Bryograptus* Beds = Tremadoc Slates.

This paper and its zonal divisions formed the geological foundation for most of the subsequent graptolitic literature concerning the fossils of the Skiddaw Slates.

In this paper the author figures from the *Bryograptus* Beds specimens of *Bryograptus ramosus* and *Bryo. Callavei*?

1894.

Hall, T. S.,

“Note on the Distribu-  
tion of the Graptolitidæ  
in the Rocks of Castle-  
maine,” ‘Australian  
Assoc. for the Advance-  
ment of Science,’

Hall, in 1894, published a more detailed account of the Graptolite zones of Castlemaine.

He argues in favour of the distinctness of the genera *Goniograptus* and *Loganograptus*, and points out that the auriferous bands of the colony begin above the base of the *T. fruticosus* zone, and range as high as the beds with *Phyllograptus*.

1894.

Lundgren,

‘Geol. Fören. Förh.,’  
bd. xvi, heft 4.

Three letters dealing with the controversy on the terminology—*Dictyonema* or *Dictyograptus*—appeared in 1894.

In the first of these Lundgren considers that on the strict ground of priority Salter’s name, *Graptopora*, should be substituted for *Dictyonema*, but thinks that it is unnecessary to adhere so rigorously to the laws of priority, and that in this case it would be mere pedantry to change a name so well established for a genus characteristic of so widespread an horizon.

1894.

Moberg,

“*Dictyonema* contra  
*Dictyograptus*,” ‘Geol.  
Fören. Förh.,’ bd. xvi.

In the second, Moberg enters into the question in considerable detail, and replies to the arguments brought forward, adopting “Hopkinson’s name of *Dictyograptus*, on the ground that I find it to be the oldest name in the list of synonymies which is free from objections.”

1894.

Törnquist,

“*Dictyonema* contra  
*Dictyograptus*,” ‘Geol.  
Fören. Förh.,’ bd. xvi.

The third and final communication on the subject was a letter written by Törnquist, who confines himself to the argument that the use of *Dictyonema* as the generic name of both a plant and an animal is quite in accordance with the rules laid down by the German Zoological Society.

1894.  
*Törnquist,*  
 "Några anmärkingar  
 om Graptoliternas Ter-  
 minologi," 'Geol.  
 Fören. Förh.,' bd. xvi.

In a paper published during the same year Törnquist discussed some of the points in which he differs from Wiman as to the structure of *Diplograptus*. He controverts Wiman's statement that a "double longitudinal septum does not exist," as in most species of *Diplograptus* it certainly is present, either in a complete or incomplete form, "though in no known case does it extend to the extreme proximal part of the polypary."

He also discusses in detail Wiman's statement that there is no "common canal," and that the "connecting canal" is only part of the first theca. According to Wiman the whole rhabdosome consists of thecæ only (excluding the virgula and sicula), and Törnquist discusses whether this complete change in the nomenclature previously adopted is justified.

Törnquist also urges that the question depends entirely on what significance is attached to the word "theca," and he objects, in the third place, to Wiman's statement that because the sicula gives rise to only one bud, therefore *Diplograptus* is "monoprionidian."

1895.  
*Holm,*  
 "Om *Didymograptus,*  
*Tetragraptus,* och  
*Phyllograptus,*" 'Geol.  
 Fören. Förh.,' bd. xvii.

Two papers of first-rate importance, dealing with the structure of the Graptolites, were published in 1895.

The first was by Holm, "On the Structure of *Didymograptus,* *Tetragraptus,* and *Phyllograptus.*" The important results arrived at by him were due largely to the extreme skill with which he was able to isolate specimens from the matrix.

The first conclusion arrived at is, that "in the main, a complete conformity exists in the first stages of development of the polypary, both in the genera *Didymograptus,* *Tetragraptus,* and *Phyllograptus,* and in the family of the Diplograptidæ." In all these the sicula gives rise to one bud only on one side (left), and "from this bud is developed partly the second theca, partly the 'connecting canal,' which connects both halves of the polypary, and which in the first place gives origin to the third theca, and partly also the common canal, which connects the second theca with the succeeding ones." In the Monograptidæ, which Holm regards as degenerate from the Diplograptidæ, the "connecting canal" is entirely absent.

He agrees with Wiman that the sicula consists of two parts, but he differs in regarding the pointed end (initial part) as the original and oldest portion from which the apertural part was developed. This apertural part, having the same function as a theca, "might therefore be considered justly as the first theca of the polypary." He uses throughout the terms first, second, and third theca, but holds that the old name "sicula" is, nevertheless, a "convenient and significant one," and should be retained. Referring to the common canal, he writes: "The common canal, by which all the cells of the polypary are connected with one

Genus **DIPLOGRAPTUS**, M'Coy.

1850. *Diplograpsis*, M'Coy, Ann. Mag. Nat. Hist. [5], vol. vi, p. 270.

1854. *Diplograpsus*, M'Coy, Brit. Pal. Foss., p. 3.

*Polypary* bilaterally symmetrical; rectangular, sub-cylindrical, concavo-convex, or tabular in section; biserial throughout; test continuous.

*Thecæ* sub-prismatic or sub-cylindrical tubes, ventral walls typically inclined and more or less straight; apertural margins even or undulated.

The polypary in *Diplograptus* varies much in size, ranging from a few millimetres to many centimetres in length; it may be narrow or broad, when broad attaining its maximum width either gradually or within a short distance of the proximal end.

The sicula as a general rule is visible only in the obverse aspect of the polypary, and its apex is more or less embraced and completely concealed by the bases of the early thecæ.

The polypary in *Diplograptus* presents greater difficulties of description and interpretation, perhaps, than that in any other genus. These are due not only to the differences in the outline and transverse section of the original and uncompressed polypary in the different species, but also to the diversity in the original form of their thecæ; and these differences are complicated by the fact that British examples are usually compressed to mere films.

So far as may be inferred from such specimens of *Diplograptus* as have hitherto been met with preserved in relief or sub-relief, the original *distinctions* among the various groups and species were those connected with (1) the general outline of the polypary, and (2) its transverse section; (3) the general form of the theca, (4) the shape of its apertural margin, and (5) its ornaments. These primary distinctions may all undergo accidental modifications during the process of compression in the rock, giving origin to secondary *appearances*, which vary with the direction and the amount of compression.

The *general outline of the polypary*, in the majority of forms belonging to *Diplograptus*, resembles that in *Climacograptus*, being as a rule parallel-sided, or tapering towards the proximal extremity; but there are almost all gradations, from parallel-sided to fusiform, foliate, and even wedge-shaped.

The polypary appears to have been in no case quite cylindrical as in *Climacograptus*, but was somewhat concavo-convex, the concave side being narrower than the convex. In the majority of forms, however, the departure from symmetry was apparently but slight.

As respects the distinctions in the *form of the transverse section* of the polypary, there is a first group of species—of which *Diplograptus quadrimucronatus*, Hall,

may be regarded as the type—in which the form of the transverse section varied from square (*D. quadrimucronatus*) to quadrangular with rounded angles (*D. calcaratus*, etc.). This group was erected into a sub-genus by Lapworth in 1873, under the title of *Orthograptus*.

In a second group the form of the transverse section of the polypary was sub-circular or elliptical. This group—which is typified by *Diplog. tamariscus*, Nieh.—constitutes the sub-genus *Glyptograptus*, Lapworth.

In a third group the transverse section was distinctly concavo-convex, and the appearances presented by compressed forms show a combination of those found separate in *Climacograptus* and *Orthograptus*. This group, which includes such forms as *Diplog. foliaceus*, Murch., may be distinguished as the sub-genus *Mesograptus* (nov.) The extreme species of this group, in which the concavo-convexity of the polypary is most pronounced, have been sometimes separated off to form the sub-genus *Amplexograptus* (*Diplog. perexcavatus*, Lapw.).

Finally, there is a fourth group, in which the transverse section of the uncompressed polypary was flattened from obverse to reverse. The majority of the species of this group—which also exhibit a tendency to become more or less foliiform in outline, and are typified by *Diplog. folium*, His.—are generally united under the sub-generic title *Petalograptus*, Suess. The extreme forms of the group, in which the polypary has a wedge-like outline, are typified by *Diplog. cometa*, Geinitz, and constitute Hopkinson's sub-genus *Cephalograptus*.

As regards the distinctions in the *original shapes of the thecæ* in the genus *Diplograptus*, we find at the one extreme, in the sub-genus *Petalograptus*, the thecæ in the form of long cylindrical and but slightly flattened tubes of equal width throughout, recalling those of the much older genus *Phyllograptus*, Hall. In the typical forms of the sub-genus *Glyptograptus* the theca is shorter and stouter, and the middle third of its ventral wall impressed to form a distinct "excavation" as in the genus *Climacograptus*; but the free edge is inclined instead of being vertical, the sigmoid ventral curve is flowing rather than sharp, and the "excavation" is wide instead of deep. In the sub-genus *Mesograptus* the earlier thecæ, as a rule, resemble those of *Climacograptus* and the later ones those of *Orthograptus*; but in the obverse aspect of the forms ranged under *Amplexograptus* the "excavation" in all the thecæ is characteristically wide and deep, as in *Climacograptus*. In most of the forms grouped under *Orthograptus* the general form of the theca is that of a subquadrangular sac, expanding above and pressed inwards below; but occasionally the ventro-dorsal narrowing of the theca is carried so far throughout that the "excavation," as such, seems almost to disappear, while the curvature of the ventral wall is at the same time so much reduced that in extreme forms of this sub-genus, such as *Orthog. quadrimucronatus*, the thecæ approximate in shape to flattened rectangular prisms.

As respects the *original shape of the edge of the thecal aperture and its*

appearances after compression, the simplest types are seen in *Petalograptus*, in which the edge was even and devoid of ornament; so that the *denticle* (Nich.), —*i.e.* the apparent corner or angle constituted in compressed forms by the meeting of the apparent profile of the apertural margin and the apparent profile of the free edge of the theca—becomes almost rectangular. In *Glyptograptus* the outline of the apertural edge was somewhat undulate, so that the denticle becomes either sharp and inclined (*cusplate*) (Fig. 171 *b*), or rounded and re-curved (*rostrate*) (Fig. 171 *d*), according to the direction of compression. In the sub-genus *Orthograptus* the undulation of the apertural margin was in many forms so pronounced as to give origin to two well-marked elevations or lobes lying between three depressions, so that the aperture somewhat resembled in shape the lip of a jug. As the apertural edge itself often had a distinct thickening or flange we are presented, in compressed specimens belonging to this sub-genus, with a great variety of appearances, due, some to the original distinctions in the forms of the polypary and theca, and some to the different directions in which the compression has been effected. The apparent profile of the apertural margin of the theca may appear straight, undulate, lobate, notched or broadly-rounded in outline; horizontal, inclined or everted in direction; and the denticle cusplate, rostrate or mucronate in shape. In the extreme forms of the sub-genus the apertural lobes are prolonged into distinct spines, sometimes of great length and stiffness.

The views in which the compressed polyparies and theca are presented are varied. In all the flattened examples of species belonging to the genus *Diplograptus* the commonest view shown is the profile (or, better, *bi-profile*) view (Fig. 145 *f*), in which the septal groove, if present, runs down the middle of the symmetrically compressed polypary. In this view, in the majority of cases, it is impossible to determine whether the obverse or the reverse aspect is presented. The *scalariform* (or true ventral) view so commonly found in *Climacograptus* is exceedingly rare. In the sub-genus *Petalograptus* this bi-profile view is almost the only one met with. In *Glyptograptus* the bi-profile view (here with “excavations”) is characteristic (Fig. 171 *b*); but a common one is the *sub-scalariform*, quarter-face, or oblique view (Fig. 167 *a*), in which the apertural margin shows for three quarters of its width on one side of the polypary, and for one quarter on the other. In *Mesograptus*, as a general rule, the views vary in different parts of the same polypary, and in the sub-group *Amplexograptus* we find two bi-profile views—an obverse aspect (Fig. 184 *c*), in which the polypary and theca resemble those of *Climacograptus*, and a reverse aspect (Fig. 184 *d*), in which they resemble those of *Orthograptus* or *Glyptograptus*. In the sub-genus *Orthograptus* the bi-profile view (Fig. 154 *b*) is the dominant one, but the most characteristic is the quarter-face or sub-scalariform view (Fig. 161 *d*), in which, as in *O. vulgatus*, the denticles often show as cusplate on one of the lateral edges and rostrate on the other, or, as in *O. quadrimucronatus*,

the apertural margins of the thecæ transgress from one edge as narrow slits for the whole of their depth upon the body of the polypary (Fig. 145 c). Sometimes, as in *O. vesiculosus*, the thickened apertural margins of the row of thecæ upon the opposite edge show through the test of the compressed polypary from the buried face below, and there is presented what at first sight appears to be a bi-scalari-form view (Pl. XXVIII, fig. 8 c).

*Classification.*—The major classification of the British forms of *Diplograptus* adopted here follows essentially on the lines of that suggested by Lapworth in 1873; the minor grouping corresponds with that already employed by us in the case of the genus *Climacograptus* (p. 183).

A.—*Diplograpti* in which the polypary was almost square or quadrangular in transverse section.

= *Orthograptus*, Lapworth.

*Group I.*—*Orthograpti* in which the thecæ were practically rectangular in section, and the apertural margin lobate, often spinose; excavation fairly distinct.

Type *Orthog. quadrimucronatus*.  
*O. quadrimucronatus*.  
 var. *spinigerus*.  
*O. Pageanus*.  
 var. *micracanthus*.  
 var. *abnormispinosus*.  
*O. Whitfieldi*.  
*O. insectiformis*.  
*O. vesiculosus*.  
 var. *penna*.  
*O. mutabilis*.  
*O. bellulus*.

*Group II.*—*Orthograpti* in which the thecæ were almost semi-circular in section, and the apertural margin plain or but slightly lobate; excavation inconspicuous.

Type *Orthog. truncatus*.  
*O. truncatus*.  
 var. *abbreviatus*.  
 var. *intermedius*.  
 var. *pauperatus*.  
 var. *socialis*.

*Group III.*—*Orthograpti* in which the thecæ were sub-rectangular in section, and the apertural margins strongly lobate; excavation distinct.

*O. cyperoides*.  
 Type *Orthog. calcaratus*.  
*O. calcaratus*.  
 var. *basilicus*.  
 var. *vulgatus*.  
 var. *acutus*.  
 var. *priscus*.  
*O. rugosus*.  
 var. *apiculatus*.

B.—*Diplograpti* in which the polypary was almost circular or elliptical in section.  
= *Glyptograptus*, Lapworth.

*Group I.*—*Glyptograpti* in which the axis of the theca was straight, the thecæ semi-circular in section, and the apertural margins undulate; excavations wide and deep.

Type *Glyptog. tamariscus*.  
*G. tamariscus*.  
var. *incertus*.  
*G. serratus*.  
var. *barbatus*.  
*G. teretiunculus*.  
var. *euglyphus*.  
var. *siccatus*.  
*G. dentatus*.  
var. *appendiculatus*.

*Group II.*—*Glyptograpti* in which the axis of the theca was twisted, the thecæ semi-circular in section, and the apertural margins undulate; excavations very distinct.

Type *Glyptog. sinuatus*.  
*G. sinuatus*.  
*G. persculptus*.

C.—*Diplograpti* in which the polypary was conspicuously concavo-convex in transverse section.

= *Mesograptus*, nov.

*Group I.*—*Mesograpti* in which the thecæ were semi-circular in section and the apertural margins somewhat undulating; excavations deep and conspicuous in proximal region of polypary only.

Type *Mesog. foliaceus*.  
*M. foliaceus*.  
*M. multidentis*.  
var. *compactus*.  
*M. modestus*.  
var. *parvulus*.  
var. *diminutus*.  
*M. magnus*.

*Group II.*—*Mesograpti* in which the thecæ were semi-circular in section, and the apertural margins undulate; excavations deep and conspicuous in the obverse aspect throughout.

(= *Auipleurograptus*.)  
*A. peræcaratus*.  
*A. confertus*.  
*A. cœlatus*.  
*A. arctus*.

D.—*Diplograpti* in which the polypary was tabular in transverse section.  
= *Petalograptus*, Suess.

*Group I.*—*Petalograpti* in which the thecæ were typically curved, circular

Type *Petalog. folium*.  
*P. folium*.

in section, and the apertural margins even and oblique.

*P. palmeus.*  
var. *tenuis.*  
var. *lata.*  
var. *ovato-elongatus.*

*P. minor.*  
? *P. phylloides.*  
*P. altissimus.*

Group II.—*Petalograpti* in which the thecæ were approximately straight, circular in section, and with even apertural margins.

(= *Cephalograptus.*)  
Type *Cephalog. cometa.*  
*C. cometa.*  
*C. petalum.*  
*C. acuminatus.*

It will be obvious from a study of the characters of the specific forms included in these sub-genera in the following pages that the divisions recognised are separated from each other by no hard and fast lines. The typical species in each "sub-genus" are no doubt distinct as such, but there are so many divergences from them in different directions within the sub-genus that there seems to be an almost insensible passage from one into the other. Not only so, but some of the more typical forms of the various sub-genera recall forms belonging to other groups which have long since generally been accorded a distinct generic rank.

All the species included in the sub-genus *Petalograptus* strikingly suggest in the outlines of their polypary and thecæ the much older genus *Phyllograptus*, but shade gradually in their outward aspect into those species of *Orthograptus* grouped around *O. truncatus*. Most of the forms united under *Glyptograptus* agree with those of the genus *Climacograptus* in the approximately cylindrical form of the polypary, but some (*G. sinuatus*, etc.) recall the *Dicrauograptidæ* in the characters of their thecæ, while others, again (*G. dentatus*, etc.), seem to grade into those *Orthograpti* typified by *O. calcaratus*.

The *Mesograpti* pass on the one hand through *M. foliaceus* into the *Orthograpti* typified by *O. calcaratus*, while on the other hand such extreme forms as *M. perreacatus* appear to lead into the *Climacograpti*. In the *Orthograpti*, in addition to the gradations noted above we find forms grouped around *O. quadrimucronatus*, shading almost imperceptibly into the family of the *Glossograptidæ*.

#### Sub-genus **Orthograptus**, Lapworth.

1873. *Orthograptus*, Lapworth, Classification of the Rhabdophora, Geol. Mag., vol. x, p. 500.

Within the sub-genus *Orthograptus* there is a certain amount of variation, not only in the form of the polypary itself, but also in that of the thecæ. Broadly

speaking, it may be said that the polypary was typically square in transverse section, and the thecæ in the shape of more or less flattened rectangular prisms with undulate or lobate apertural margins (*O. quadrimucronatus*). The polypary, however, in some species tends to lose its angularity, and to be sub-rectangular rather than square in transverse section; the thecæ are also less rectangular in form, at the same time that the apertural margin is more strongly lobate (*O. calcaratus*). In others a somewhat intermediate variation is brought about by the gradual flattening of the polypary, while the thecæ become more semi-circular in section, and the lobate character of the apertural margin diminishes to insignificance (*O. truncatus*).

## GROUP I.

*Orthograpti*, in which the thecæ were practically rectangular in section, and the apertural margin lobate and often spinose; excavation fairly distinct.

**Diplograptus (Orthograptus) quadrimucronatus** (Hall). Plate XXVIII, figs. 1 *a—d*.

1865. *Graptolithus quadrimucronatus*, Hall, Grapt. of Quebec Group, p. 144, pl. xiii, figs. 1--10.  
 1867. *Diplograptus quadrimucronatus*, Nicholson, Geol. Mag., vol. v, p. 111.  
 1876. *Diplograptus aculeatus*, Lapworth, Cat. West. Scott. Foss., pl. iv, fig. 44.  
 1877. *Diplograptus quadrimucronatus*, Lapworth, Grapt. Co. Down, p. 133, pl. vi, fig. 20.

Polypary 7 cm. or more in length, widening gradually within 2 cm. from 1.5 mm. to a breadth of about 3 mm., which is then maintained. Sicula 1.5 mm. in length, free on one side for a short fraction of length; lateral spines present, but rarely preserved. Thecæ twelve to eight in 10 mm., rectangular prisms having a length of 2 mm., and overlapping one third to one half their extent; apertural margins slightly lobate, both outer angles furnished with stiff projecting spines.

FIGS. 145 *a* and *b*.—*Orthograptus quadrimucronatus* (Hall).



- a*. Young specimen showing full length of sicula. On same slab as Pl. XXVIII, fig. 1 *d*.  
*b*. Proximal end of adult specimen showing extra spines on proximal theca. Enlargement of part of Pl. XXVIII, fig. 1 *b*.

*Description*.—The polypary, which is characteristically stiff and rigid, is often of considerable length. The increase in breadth all takes place in the proximal region of the polypary, so that for the greater part of its length the margins are practically parallel.

In the symmetrical profile view the thecæ have a general inclination of about 20°; but, like most of the forms in this group, this species presents itself under several distinct views after compression. The most characteristic is the sub-scalariform view (Fig. 145 *c*), in which the apertural spines belonging

to one vertical row on each side are shown to their full length, and the edge of the apertural margin is exhibited almost to its full extent, occupying nearly one half the breadth of the body of the polypary. The commonest view, however,

FIGS. 145 c, d, e, f.—*Orthograptus quadrimucronatus* (Hall).



- c. Distal thecae. Sub-scalariform view, showing full length of apertural spines. Enlargement of part of Pl. XXVIII, fig. 1 a.
- d. Sub-scalariform view, showing variations in apparent length and position of apertural spines. Mount Benger Burn, S. Scotland, Hartfell Shales. Coll. Lapworth.
- e. Sub-scalariform view, showing further variations in the shape of the apertural margin. On same slab as Fig. 145 d.
- f. Bi-profile view, in which apertural margin appears inclined, and spines are almost invisible. Enlargement of part of Pl. XXVIII, fig. 1 c.

is the bi-profile (Fig. 146), in which the lobation of the apertural edge causes the visible part of the apertural margin to appear sometimes broadly rounded or notched, while the apertural spines are greatly foreshortened or quite invisible. What seems to be a variation of this view is sometimes presented when the foreshortened apertural margin appears as if inclined, and the spine is, as a rule, invisible (Fig. 145 f). The apertural spines are stout, and may measure as much as 1.5 or 2 mm. in length; their apparent direction is, however, varied by compression, and may appear horizontal, downward or upward.

The basal thecae, which are small, bear, in addition to the usual pair of apertural spines, a short (? mesial) spine or spur, which is, however, very rarely shown (Fig. 145 b).

*Affinities.*—*O. quadrimucronatus* is related in form to the other spinose members of the group, such as *O. Whitfieldi*, from which it differs in the form of the polypary, and in the length and direction of the spines. It also presents certain close resemblances to the forms grouped in the family of the *Glossograptidæ*.

*Horizon and Localities.*—Hartfell Shales (*Pleurog. linearis* zone).

*S. Scotland:* Dobb's Linn; Hartfell; Mount Benger Burn, etc.

*Associates, etc.*—*Orthog. quadrimucronatus* is not an uncommon fossil in the Hartfell Shales of S. Scotland, where it occurs in the zone of *Pleurog. linearis* associated with the zone fossil, and with *Orthog. truncatus*, var. *pauperatus*, and other forms. The specimens from Mount Benger Burn are generally narrower than those from other localities, and the thecae are somewhat more closely set.

*Collections.*—Lapworth, British Museum (Natural History), Geological Survey of Scotland, and the Authors.

Var. **spinigerus**, Lapworth. Plate XXVIII, figs. 2 *a—d*.

1876. *Diplograptus quadrimucronatus* var. *spinigerus*, Lapworth, Cat. West. Scott. Foss., pl. ii, fig. 43.

In addition to the typical form already described, there occurs a second form of *Orthog. quadrimucronatus*, which appears to be sufficiently distinct to be classed as a variety. It occurs on the same horizon as *O. quadrimucronatus*, but is usually larger, and has abnormally developed spines on the thecæ about 8 mm. from the proximal end, this position corresponding apparently with the tenth thecal pair. These thecæ are each furnished typically with a pair of long curved spines having a length of 5 mm. or more, and which are remarkably conspicuous in compressed specimens. Occasionally also spines of corresponding abnormal length are developed on the thecæ lying immediately below (ninth pair), and also on the fourteenth pair (Pl. XXVIII, fig. 2 *b*), but as a rule they are confined to the tenth pair alone.

FIG. 146.—*Orthograptus quadrimucronatus*, var. *spinigerus*, Lapw.



Distal thecæ as seen in bi-profile view, showing the rounded form of the apertural margin in compressed examples. Enlargement of part of Pl. XXVIII, fig. 2 *c*.

In this variety, also, the thecæ usually number ten to eight in 10 mm., but occasionally, as in those from Mount Benger Burn, the thecæ are a little more closely set.

*Horizon and Localities.*—Hartfell Shales (zone of *Pleurog. linearis*).

*S. Scotland:* Hartfell; Mount Benger Burn.

*Collections.*—Lapworth and the Authors.

**Diplograptus (Orthograptus) Pageanus**, Lapworth. Plate XXVIII, figs. 3 *a—c*.

1873. *Diplograptus Pageanus*, Lapworth, *nom. nudum*, Geol. Mag., vol. ix, p. 134.

Polypary relatively short, 2.5—4 cm. in length, typically somewhat fusiform in shape; widening from 2 mm. to a maximum breadth of 4.5 mm. within 1 cm. of the proximal end, but diminishing again distally to a breadth

FIG. 147.—*Orthograptus Pageanus*, Lapw.



Proximal end showing spinose nature of the thecæ. Enlargement of part of Pl. XXVIII, fig. 3 *a*.

not exceeding 3 mm. Thecæ sixteen to twelve in 10 mm. of the *Orthograptus* type, furnished with long horizontal and somewhat flexed spines.

*Description.*—Although the more typical examples of the species are sub-fusiform in shape some examples show little or no tendency to narrow towards the distal extremity of the polypary.

The virgula is always very conspicuous, and is stiff and wire-like.

All the thecæ are provided with conspicuous spines, but those on the basal thecæ are specially long and may measure as much as 4 mm. The apertural margins of the thecæ are conspicuously lobate and approximate to those of *Orthog. calcaratus*.

*Affinities*.—*O. Pageanus* is undoubtedly closely allied to *O. quadrimucronatus*, but differs from it in being shorter and broader, and having more closely set thecæ, which are also somewhat different in form and ornament.

*Horizon and Localities*.—Hartfell Shales (zone of *Dicranog. Clingani*).

*S. Scotland*: Hartfell; Auchenacat Burn.

*Collection*.—Lapworth.

Var. **micracanthus**, var. nov. Plate XXVIII, figs. 4 *a—c*.

Associated with *O. Pageanus* there occurs a shorter and narrower form which is sufficiently distinct to rank as a variety.

FIG. 118.—*Orthograptus Pageanus*, var. *micracanthus*, nov.



Proximal end, showing origin of septal groove. Enlargement of part of Pl. XXVIII, fig. 4 *b*.

This form never exceeds 3 cm. in length. The polypary widens rapidly from a broadly truncate base, attaining its maximum breadth of 2.5 or 3 mm. within 5 mm. of the proximal end, and this is maintained for the remainder of its length.

*Horizon and Localities*.—Hartfell Shales (zone of *Dicranog. Clingani*).

*S. Scotland*: Hartfell; Dobb's Linn.

*Associates, etc.*—Var. *micracanthus* is fairly common in the zone of *Dicranog. Clingani*, where it occurs associated with *Orthog. calcaratus* and other forms.

*Collections*.—Lapworth and the Authors.

Var. **abnormispinosus**, var. nov. Plate XXVIII, fig. 5 *a*.

A second variety, which may be appropriately named *abnormispinosus*, bears precisely the same relationship to *O. Pageanus* var. *micracanthus* that *O. quadrimucronatus* var. *spinigerus* does to its typical species. It occurs in the zone of *Dicranog. Clingani*. This variety never appears to exceed 2.5 cm. in length, and has abnormally developed spines on the eighth or ninth thecal pair, or more rarely on a few other thecæ also. It widens gradually throughout its length, attaining its maximum breadth of 3 mm. close to the distal extremity. The thecæ are somewhat less closely set than in *O. Pageanus*, being fourteen to ten in 10 mm.

A flattened tube, which probably contains the virgula, is a conspicuous feature of the polypary beyond its distal extremity.

*Horizon and Locality.*—Hartfell Shales (zone of *Dicranog. Olingau*).

*S. Scotland*: Hartfell.

*Collections.*—Lapworth, and Geological Survey of Scotland.

**Diplograptus (Orthograptus) Whitfieldi** (Hall). Plate XXVIII, figs. 6 *a—d*.

1859. *Graptolithus Whitfieldi*, Hall, Pal. New York, vol. iii, p. 516, figs. 1, 2.

1867. *Diplograptus Whitfieldi*, Nicholson, Geol. Mag., vol. iv, p. 3, pl. vii, figs. 4, 4 *a*.

1868. *Diplograptus Whitfieldi*, Carruthers, Geol. Mag., vol. v, p. 131, pl. v, figs. 3 *b*, 3 *c*.

1876. *Diplograptus Whitfieldi*, Lapworth, Cat. West. Scott. Foss., pl. ii, fig. 45.

1877. *Diplograptus Whitfieldi*, Lapworth, Grapt. Co. Down, p. 134, pl. vi, fig. 21.

Polypary short, not exceeding 2 cm. in length and 3 mm. in breadth (exclusive of spines), usually both shorter and somewhat narrower. Sicula 1 mm. long, generally obscure, virgella conspicuous. Thecae twelve in 10 mm., having a length of 1.5—2 mm. and overlapping one third to one half their extent. Apertural margins sub-lobate, bearing slender, stiff spines, in most cases directed upward.

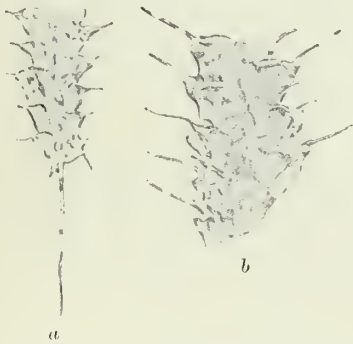
*Description.*—The polypary varies considerably in its dimensions with age, but is always short and relatively broad in proportion to its length; on the whole, the specimens of commonest occurrence average 1.5 cm. in length and about 2 mm. in breadth; larger specimens are rare.

Th. 1<sup>1</sup> originates basally, and th. 1<sup>2</sup> crosses the sicula almost horizontally so that the proximal end has a very symmetrical appearance. The virgella is usually long (4 mm.), and the two basal thecae have apertural spines, while th. 1<sup>1</sup> appears to have a mesial one in addition. The thecae are of the general *Orthograptus* type; in profile view they have an average inclination of about 30°. The apertural margins are sub-lobate, and from their outer angles the slender stiff spines project; these are commonly

about 1 mm. in length, but in very well preserved specimens they have been noted as having a length of 2 mm. or even more; they are usually straight and have an upward and outward tendency, though this is not invariable.

*Affinities.*—*Orthograptus Whitfieldi* has certain affinities with all the other spinose *Orthograpti*. It should, however, be easily distinguished from them by the stiff,

FIGS. 149 *a* and *b*.—*Orthograptus Whitfieldi* (Hall).



*a*. Proximal end, showing long virgella. Enlargement of part of Pl. XXVIII, fig. 6 *b*.

*b*. Distal theca, showing apertural spines and form of apertural margin. Enlargement of part of Pl. XXVIII, fig. 6 *c*.

slender nature of the spines; from such a species as *Orthog. quadrimucronatus* it differs in the more upward direction of its spines and their greater length relatively to the length of the polypary.

In the general characters of the thecæ and ornaments *O. Whitfieldi* bears a certain resemblance to the Glossograptidæ.

*Horizon and Localities.*—Glenkiln Shales, and equivalents.

*S. Scotland:* Glenkiln Burn; Beleraig Burn; Dobb's Linn, etc. *N. Wales:* Tiddyndiewm; Pensiflog. *Central Wales:* Builth Road.

*Associates, etc.*—*Orthog. Whitfieldi* is fairly common in a fragmentary condition wherever the Glenkiln Shales are found. It is usually associated with *Nemag. gracilis*, *Dicellog. sextans*, *Climacog. Scharenbergi*, *Amplexog. perexcavatus* and other forms. Complete specimens are rare.

*Collections.*—Geological Survey of Scotland, Lapworth, and the Authors.

### **Diplograptus (Orthograptus) insectiformis**, Nicholson. Plate XXVIII, figs. 7a—c.

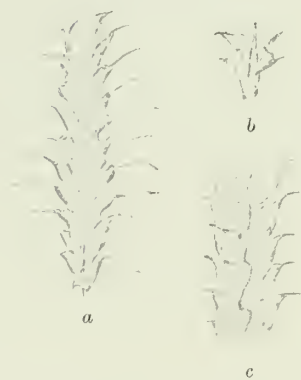
1869. *Diplograptus insectiformis*, Nicholson, Ann. Mag. Nat. Hist. [4], vol. iv, p. 237, pl. xi, fig. 13.

1876. *Diplograptus insectiformis*, Lapworth, Cat. West. Scott. Foss., pl. ii, fig. 40.

1877. *Diplograptus insectiformis*, Lapworth, Grapt. Co. Down, pl. vi, fig. 15.

Polypary typically small, not exceeding 1 cm. in length, with an average breadth of 1.5 mm. attained by gradual widening from the proximal end. Sicular relatively large. Thecæ twelve to ten in 10 mm., of the general *Orthograptus* type, but slender, with a length of 1.5 mm. overlapping one half to two thirds of their extent; apertural margins slightly lobate, prolonged into delicate flexed spines.

FIGS. 150 a, b and c.—*Orthograptus insectiformis*, Nich.



- a. Proximal end, reverse aspect, showing sicular and long apertural spines. Dobb's Linn, Lower Birkhill Shales (zone of *M. gregarius*). Coll. Elles.  
 b. Young specimen, obverse aspect, showing full length of sicular. Ibid.  
 c. Distal thecæ, sub-scalariform view. Enlargement of part of Pl. XXVIII, fig. 7 b.

*Description.*—The polypary in *Orthog. insectiformis* is usually small, and it has a characteristic gregarious habit. Occasionally, however, solitary specimens are found which are usually somewhat larger; these may have a length of 2 cm. and a breadth of 2 mm.

The sicular is relatively large, measuring fully 2 mm. in length; it reaches up to the level of the aperture of th. 2<sup>2</sup>. Th. 1<sup>1</sup> grows straight upward and outward from near its aperture; th. 1<sup>2</sup> grows obliquely from it so as to leave the sicular free for fully one third its length on one side. The septum is incomplete, there being no sign of it in the reverse aspect of the polypary.

*Affinities.*—The only other spined Diplograptid with which *O. insectiformis*

might be confused is *Cl. innotatus*; in this species, however, the characters of the thecae are quite different, while the spine is not apertural, but mesial in position.

*Horizon and Localities.*—Llandoverly (Birkhill Shales), zone of *Monog. gregarius*.  
*S. Scotland*: Dobb's Linn. *Ireland*: Ballygrot (?).

*Associates, etc.*—*Orthog. insectiformis* is a somewhat rare fossil in the Birkhill Shales of S. Scotland, where it occurs in the zone of *Monog. gregarius* with *Cl. Törnquisti* and *M. gregarius*.

*Collections.*—The Geological Survey of Scotland, British Museum (Natural History), Lapworth, and the Authors.

**Diplograptus (Orthograptus) vesiculosus, Nich.** Plate XXVIII, figs. 8 *a—d*.

1868. *Diplograptus vesiculosus*, Nicholson, Ann. Mag. Nat. Hist. [4], vol. i, pl. iii, fig. 11.  
 1869. *Diplograptus vesiculosus*, Nicholson, Ann. Mag. Nat. Hist. [4], vol. iv, p. 237, pl. xi, figs. 14, 15.  
 1874. *Diplograptus vesiculosus*, Dairon, Trans. Geol. Soc. Glasgow, p. 183, pl. i, fig. 20.  
 1876. *Diplograptus vesiculosus*, Lapworth, Cat. West. Scott. Foss., pl. ii, fig. 41.  
 1877. *Diplograptus vesiculosus*, Lapworth, Grapt. Co. Down, pl. vi, fig. 19.

Polypary robust, from 3—6 cm. in length with a uniform breadth of 3—4 mm., and having a characteristic vesicle prolonged beyond the distal extremity. Sicula very large, with long and conspicuous virgella. Thecae broad, ten to eight in 10 mm., of the general *Orthograptus* type, expanding towards aperture, with a length of 2 mm., and overlapping for one half their extent. Apertural margins but slightly lobate, wide.

*Description.*—*O. vesiculosus* is broad even in its initial stages. Its most conspicuous feature is the presence of a tubular membranous body within the polypary;

Figs. 151 *a—c.*—*Orthograptus vesiculosus*, Nicholson.



Various stages in the development of the young polypary, showing great length of sicula and origin of th. 1<sup>l</sup>.  
*a.* Dobb's Linn, Lower Birkhill Shales. Coll. Lapworth.  
*b.* Ibid.  
*c.* On same slab as 150 *a*.

which expands, on leaving the distal extremity, into a large fusiform, ovate or cylindrical vesicle, with an acuminate apex, which is bounded by strong filiform margins; sometimes it emerges from the polypary quite small, and gradually swells out and then again diminishes in size; at other times it begins to distend before leaving the polypary, and is clearly visible inside it, but it always attains its maximum size outside, and may be as much as 5 cm. in length, with a breadth of 1 cm. What appears to be the virgula may frequently be detected running through it. This membranous tube appears to originate as a film surrounding the sicula and is present from the earliest stages of growth of the polypary (see Figs. 151 *a—f*).

Figs. 151 *d-f*.—*Orthograptus vesiculosus*, Nicholson.



Various stages in the development of the young polypary, showing great length of sicula and origin of th. 1<sup>1</sup>.  
*d*. On same slab as 150*b*.  
*e*. Dobb's Linn. Coll. H. M. Geological Survey, Edinburgh.  
*f*. Beleraig Burn. Coll. Wood.

The sicula appears to be at least 6 mm. in length, but it is hard to determine this with accuracy, either because it passes so gradually into the virgula, or else because it is enclosed in the membrane which later expands into the vesicle. In any case it can only be detected in young individuals, since the apex is concealed by the thecæ in all adult forms and is only partially visible even on the obverse side. The virgella in some Irish specimens measures 1.2 cm. in length, but in Scottish and English specimens it is as a rule considerably shorter, though in one Scottish specimen it measures 1.3 cm. Th. 1<sup>1</sup> originates about 3—4 mm. above the aperture of the sicula and grows downward below it before bending upward and outward; th. 1<sup>2</sup> crosses the sicula nearly horizontally, so as to conceal it almost completely in the reverse aspect. The septum is developed after two pairs of thecæ have arisen, and seems to be complete. Compressed, pseudo-“biscalariform” views (Pl. XXVIII, fig. 8*c*) of the polypary are of common occurrence and characteristic of the species. It is only rarely that the thecal tubes are clearly seen; they have a general inclination of 20°—25°, and a length of 2 mm., and are overlapped for one half of this. They are broad for their length and have wide apertures, occupying about one half of the total breadth of the polypary.

*Affinities*.—*O. vesiculosus* differs from its variety var. *penna*, to which it is very closely allied, in being a longer form and in having a larger and more conspicuous vesicle. It is also allied in some aspects to *Mesog. modestus*, but differs from that species in the possession of a vesicle and in having larger thecæ.

*Horizon and Localities*.—Llandoverly (Birkhill Shales) (zone of *O. vesiculosus*).

*S. Scotland*: Dobb's Linn; Frenchland Burn; Beleraig, etc. *Ireland*: Coalpit Bay, Donaghadee; Little River, Pomeroy, Co. Tyrone. *Lake District*: Skelgill.

*Associates, etc.*—*O. vesiculosus* is usually a fairly abundant fossil wherever the Lower Birkhill Shales or their equivalents are developed. Some very fine Irish specimens from Donaghadee are in the possession of Mr. Swanston, of Belfast, and in the Museum of the Belfast Natural History Society. A few specimens only are known from the Lake District and they are mostly small and poor. The species occurs in Scotland and Ireland associated with *Monog. tenuis*, *Mesog. modestus*, *Climacog. medius* and various *Dimorphograpti*, including *D. confertus*, and *D. Swanstoni*.

*Collections*.—Swanston, Museum of Belfast Natural History Society, Geological Survey of Scotland, Sedgwick Museum, Lapworth, and the Authors.

Var. **penna**, Hopk. Plate XXVIII, figs. 9 *a—c*.

1869. *Diplograpsus penna*, Hopkinson, Journ. Quekett Micros. Club, vol. i, p. 159, pl. viii, fig. 12.

1872. *Diplograptus penna*, Hopkinson, Geol. Mag., vol. ix, p. 505, pl. xii, fig. 6.

In addition to the typical form of *O. vesiculosus* there occurs on the same horizon a closely allied, though smaller and narrower form, which appears to be that originally described by Hopkinson as *Diplog. penna*. We believe it to be a variety of *O. vesiculosus*.

This variety rarely measures more than 3 em. in length, and seems never to exceed 2·5 mm. in breadth, while the vesicle is commonly thinner and more dilated nearer to its distal extremity than is the case in the typical form. The thecæ are practically identical with those of *O. vesiculosus*.

*Horizon and Localities.*—Llandoverly (Birkhill Shales) (zone of *O. vesiculosus*).

*S. Scotland:* Frenchland Burn; Dobb's Linn; Beleraig. *Lake District:* Skelgill; Keisley.

*Associates, etc.*—Var. *penna* occurs somewhat sparingly in S. Scotland with the same associates as the typical species; it occurs, however, in some abundance at Keisley, where it has been found by Dr. Marr associated with *Dimorphog. confertus*.

*Collections.*—Marr, Sedgwick Museum, and the Authors.

**Diplograptus (Orthograptus) bellulus**, Törnquist. Plate XXIX, figs. 2 *a—c*.

1890. *Diplograptus bellulus*, Törnquist, Siljansomr. Graptol., Acta Univ. Lund., vol. xxvi, p. 28, pl. i, figs. 25—29.

1893. *Diplograptus bellulus*, Törnquist, Structure Diprionidæ, Acta Univ. Lund., vol. xxix, p. 10, figs. 42—44.

1897. *Diplograptus bellulus*, Törnquist, Diplog. and Heteroprionidæ of Scanian Rastrites Beds, Kongl. Fysiogr. Sällsk. i Lund Handl., vol. viii, p. 17, pl. ii, figs. 20—25.

Polypary short and somewhat robust, not exceeding 2 em. in length, and widening quickly to its maximum breadth of 2 mm. Sicula small, with very long virgella 8 mm. in extent. No septum. Thecæ fourteen to ten in 10 mm., walls showing slight sigmoid curvature in subprofile view, having a length of 2 mm., and overlapping one half their extent; apertural margins slightly undulate, wide.

*Description.*—The polypary shows an unusual degree of concavo-convexity for this group, and is short and distinctly wide for its length, which rarely exceeds 1·5 em., and widens quickly from ·8 mm. to its maximum breadth of 2 mm. (relief). The sicula does not measure more than ·5 mm., but the virgella

is often prolonged for 8 mm. or more; it is, however, rarely completely preserved. The overlap of the thecae is less in the initial than in the distal portion of the polypary, and the apertural margins appear to be everted in specimens preserved in relief. No septum is visible in either aspect.

FIGS. 152 *a*, *b*, and *c*.—*Orthograptus bellulus*, Törnq.



- a*. Proximal end, showing long virgella. Beleraig Burn, Birkhill Shales. Coll. Wood.  
*b*. Proximal end, showing form of thecae. Dobb's Linn., Birkhill Shales (*M. Clingani* beds). Coll. Lapworth.  
*c*. Proximal end in relief, showing small portion of sicula. Note absence of septal groove. Skelgill, Skelgill Shales. Coll. Sedgwick Museum.

*Affinities*.—In the increase in the concavo-convexity of the polypary *O. bellulus* approaches the *Mesograpti*; indeed, distal fragments of *Orthog. bellulus* closely resemble *Mesog. modestus* in their general characters, but have the thecae much more closely set; the long virgella and characters of the thecae in the proximal region are, however, sufficient to distinguish it when the complete specimen is seen.

*Horizon and Localities*.—Llandovery (Upper Birkhill Shales) (zones of *M. convolutus* and *M. spinigerus*).

*S. Scotland*: Dobb's Linn; Beleraig Burn, etc. *Lake District*: Skelgill. *Wales*: Llanystwmdwy; Rhayader; Llanbrynmair.

*Associates, etc.*—*O. bellulus* is a fairly common fossil in the Upper Birkhill Shales of S. Scotland, where it occurs associated with *Monog. spinigerus*, *M. convolutus*, *M. Clingani*, *M. lobiferus*, *Cephalog. cometa*, *C. petalum* and other forms. It also

occurs with a similar fauna at Skelgill.

*Collections*.—Sedgwick Museum, British Museum (Natural History), Fearn-sides, Lapworth, and the Authors.

***Diplograptus (Orthograptus) mutabilis*, sp. nov.** Plate XXIX, figs. 1 *a*—*d*.

Polypary large, 4—5 cm. in length, widening rapidly from origin till the maximum breadth 3—3.5 mm. is attained, thence margins sub-parallel. Sicula large. Thecae twelve to nine in 10 mm., overlapping one half to two thirds their length, apertural margins slightly lobate, with fairly conspicuous rim or flange.

*Description*.—The polypary is widest close to the proximal end, the increase taking place within 1 cm. of the proximal end, and attaining a breadth of 3—3.5 mm. from an initial width of 1.5 mm.; subsequently there is slight diminution, and the ventral margins are then almost straight and parallel for the

remainder of their length. The sicula has a length of 2 mm., and has a slender virgella 1 mm. in extent. Th. 1<sup>1</sup> appears to originate near its aperture and to grow

FIGS. 153 a, b, and c.—*Orthograptus mutabilis*, nov.



- a. Obverse aspect, showing portion of sicula. Dobb's Linn, Birkhill Shales. Coll. Lapworth.  
 b. Reverse aspect; specimen somewhat distorted, giving different appearances in the form of the apertural margins. Dobb's Linn, Birkhill Shales (zone of *M. cyphus*). Coll. Elles.  
 c. Distal thecae, sub-scalariform view. Ibid.

at once outward and upward; from it th. 1<sup>2</sup> develops in the normal manner, and neither the aperture of th. 1<sup>1</sup> nor that of th. 1<sup>2</sup> reach the level of the apex of the sicula; th. 2<sup>1</sup> develops from th. 1<sup>2</sup>, but thereafter, with the growth of the septum the thecae develop in a linear manner.

In profile view the thecae are seen to have a general inclination of about 25°; the angle is, however, larger where the polypary is widest, and the thecae more conspicuously curved outward. The apertural margin is everted and somewhat rostrate.

*Affinities*.—*O. mutabilis* shows considerable resemblance to the *Petalograpti* in

its proximal region, where the thecae are long and curved; the distal part of the polypary, however, is that characteristic of an *Orthograptus*. From other *Orthograpti* the form of the polypary should be sufficient to distinguish it.

*Horizon and Localities*.—Llandovery (Birkhill Shales), Zone of *M. gregarius* (sub-zone *M. cyphus*).

*S. Scotland*: Dobb's Linn; Frenchland Burn, etc.

*Associates, etc.*—*Orthog. mutabilis* is particularly abundant at Dobb's Linn in a band at the base of the zone of *M. gregarius* seen at the head of the Long Burn, where it occurs associated with *Monog. gregarius*, *M. cyphus*, *M. tenuis*, *Diplog. tamariscus*, *Cl. rectangularis*, *Cl. Törnquisti*, etc.

*Collections*.—Lapworth and the Authors.

## GROUP II.

*Orthograpti* in which the thecae were almost semi-circular in section, and the apertural margin plain or but slightly lobate; excavation inconspicuous.

**Diplograptus (Orthograptus) truncatus**, Lapw. Plate XXIX, figs. 3 a—e.

1877. *Diplograptus truncatus*, Lapworth, Grapt. Co. Down, p. 133, pl. vi, fig. 17.

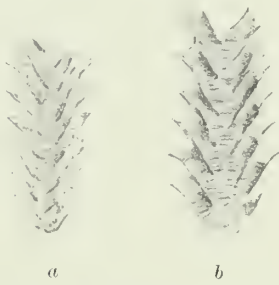
Polypary characteristically fusiform, 6 cm. or more in length, increasing rapidly in width until maximum of 4 mm. is attained; proximal end broadly rounded.

Sicula 2.5 mm. in length, with short but conspicuous virgella, and with

spines on the two proximal thecae. Thecae thirteen to ten in 10 mm., having a length of 2 mm., and widening somewhat abruptly at the edge of the aperture, overlapping one half to two thirds of the total length. Apertural margin slightly undulate, everted in bi-profile view.

*Description.*—The polypary varies in size with age, but always attains considerable width. It is 1 mm. wide at origin, and, increasing at first rapidly and then more gradually, attains the maximum breadth at the distance of about 1.5 cm. from the proximal end; it may, however, diminish again distally, giving the characteristic fusiform appearance.

FIGS. 151 *a* and *b*. *Orthograptus truncatus*, Lapw.



*a*. Incomplete proximal end in full relief. Myoch Bay, Girvan; Hartfell Shales. Coll. Mrs. Gray.  
*b*. Distal thecae of same specimen, showing characteristic bi-profile view of thecae, and growth lines.

The sicula is long and slender, measuring 2.5 mm. in length, but this is only determinable in young specimens, since its apex is entirely concealed in the adult. Th. 1<sup>1</sup> originates a little distance above the aperture of the sicula, but quickly embraces it; it grows down below the level of the aperture, but then bends abruptly round to grow upward and outward, giving off a spine where change in direction of growth takes place (see Figs. 155 *a—c*); th. 1<sup>2</sup>, which is also furnished with a mesial spine, develops from th. 1<sup>1</sup>, and grows across the sicula in such a manner as to conceal it completely from view in the reverse aspect of the polypary; th. 2<sup>1</sup> appears to

cross in front of the sicula, which is, therefore, eventually almost concealed in the obverse aspect also. The sicula itself is not entirely concealed till three thecae have developed on each side. No septum makes its appearance till at least four thecae have developed on each side, and it is doubtful if it is ever complete, for it is, as a rule, invisible in the reverse aspect of the polypary, and the thecae appear to develop alternately throughout.

In the Scottish specimens the virgella commonly has a length of about 1 mm., but in specimens from Shropshire this dimension is considerably exceeded.

The thecae have an average length of 2 to 3 mm., widening throughout, but somewhat abruptly immediately under the apertural margin. In the common bi-profile view they appear to have a general inclination of 35° to 40°, and the apertural margins are typically everted, and transgress slightly upon the wall of the theca immediately above, while the overlapping of the cells is particularly clear and—owing, perhaps, to the tenuity of the periderm—growth lines are usually well marked. The distal prolongation of the virgula is characteristically short and inconspicuous.

*Affinities.*—*Orthograptus truncatus* is, apparently, allied to *O. calcaratus* and its varieties, with which it is commonly associated; it should, however, be readily separated on account of the more distinct eversion of the apertural margins in

bi-profile view, by the position of the spines on the proximal pair of thecae, and by the absence or shortness of the distal prolongation of the virgula.

*Horizons and Localities.*—Lower Hartfell Shales (zones of *Dicranog. Clingani* and *Pleurog. linearis*). Harnage Shales. Whittery Ash.

*S. Scotland*: Hartfell; Dobb's Linn; Myoch Bay, etc., etc. *N. Ireland*: Ballygrot. *N. Wales*: Conway; Llanystwmdwy, near Criccieth. *Shropshire*: Cound Moor Quarry; Whittery Dingle, Soudley.

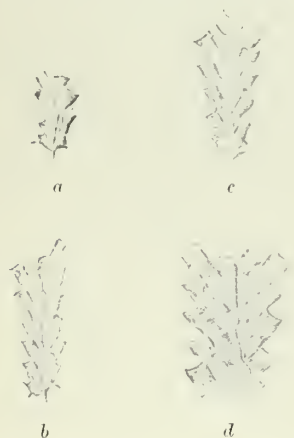
*Associates, etc.*—*Orthog. truncatus* is a common fossil wherever the Graptolitic facies of the Bala-Caradoc rocks is developed, and is especially abundant in the middle zones. It makes its first appearance in S. Scotland in the zone of *Dicranog. Clingani*, where it swarms in association with the zone fossil, *O. calcaratus* var. *basilicus*, *Dicellog. Morrisi*, *Cl. caudatus*, *Dicellog. Forchhammeri*, and other forms. It is abundant also in the *P. linearis* zone.

*Collections.*—Sedgwick Museum, Fearnside, Lapworth, and the Authors.

In addition to the typical *Orthog. truncatus* there are certain other forms which, while agreeing with it in the general type of theca, differ from it in the size and shape of the polypary, and in minor thecal characters. Some of these occur in association with the typical species, others upon horizons of somewhat earlier and later geological date. They are here distinguished as separate varieties.

Var. **abbreviatus**, var. nov. Plate XXIX, figs. 6 *a—c*.

FIGS. 155 *a, b, c, and d.*—*Orthograptus truncatus*, var. *abbreviatus*, nov.



- a.* Fragment, obverse aspect, showing sicula. Dobb's Linn, Upper Hartfell Shales (zone of *Dicellog. anceps*). Coll. Sedgwick Museum.  
*b.* Obverse aspect of more complete specimen on same slab.  
*c.* Reverse aspect of another specimen on same slab.  
*d.* Distal theca of another specimen on same slab.

This variety is especially abundant in the Upper Hartfell Shales. It is a small form, which appears never to exceed 2 cm. in length. It has a maximum breadth of 3 mm., so that it is relatively wide; very frequently this maximum breadth is attained a considerable distance from the distal extremity, and diminishes distally, giving a sub-fusiform appearance to the polypary as a whole similar to that typical of *O. truncatus* itself. The thecae are, in most respects, like those of the typical form, but widen even more conspicuously towards the apertural margin. The specimens are, as a rule, well preserved, so that details of the structure of the proximal end are clearly seen.

*Horizons and Localities.*—Upper Hartfell Shales and Lower Birkhill Shales (zones of *Dicellog. complanatus*, *D. anceps*, *Cephalog. acuminatus*, and *Diplog. vesiculosus*).

*S. Scotland*: Dobb's Linn; Hartfell, Belcraig,

etc. *N. Ireland*: Pomeroy Tirnaskea. *N. Wales*: Deganŵy Quarry; Conway Castle.

*Associates, etc.*—Var. *abbreviatus* is especially characteristic of the highest beds of the Hartfell Shales (*Dicellog. anceps* zone), where it occurs in great abundance associated with *Dicellog. anceps*, var. *ornatus*, *Cl. supernus*, and *Retiolites* sp. A few specimens have also been found in the zone of *Dicellog. complanatus*, associated with the zone fossil, *Orthog. truncatus* var. *socialis*, and *Climacog. miserabilis*. The Birkhill specimens are generally a little smaller than those from the Hartfell Shales.

*Collections.*—Lapworth and the Authors.

Var. **intermedius**, var. nov. Plate XXIX, figs. 4 *a—e*.

FIGS. 156 *a* and *b*.—*Orthograptus truncatus*, var. *intermedius*, nov.



*a*. Proximal end, reverse aspect. Enlargement of part of Pl. XXIX, fig. 4 *c*.  
*b*. Distal thecae. Enlargement of part of Pl. XXIX, fig. 4 *b*.

Another common variety of *O. truncatus*, which is, however, characteristic of the Lower Hartfell Shales, is here distinguished as var. *intermedius*. It attains a great length, commonly measuring 8—13 cm. or more, and has an average breadth not exceeding 2.5 mm., which is attained within the first 2 cm., so that the polypary is parallel-sided for the greater portion of its length.

The thecae are somewhat intermediate in character between those of *O. truncatus* and those of *Glyptograptus*. They measure fourteen to ten in 10 mm., and overlap one half their extent; in common profile view they are inclined at a lower angle with respect to the axis of the polypary, and the apertural margins are less conspicuously everted than in the typical form.

*Horizon and Localities.*—Lower Hartfell Shales (zones of *Climacog. Wilsoni* and *Dicranog. Clingani*). Upper Glenkiln Shales (?).

*S. Scotland*: Hartfell; Dobb's Linn, etc.

*Associates, etc.*—Var. *intermedius* is especially characteristic of the zone of *Cl. Wilsoni*, and also occurs in the zone of *Dicranog. Clingani*; it is very rare in the higher Glenkiln Shales. In the lower zone of the Hartfell Shales it occurs associated with *Orthog. calcaratus*, var. *vulgatus*, *Cl. tridentatus*, *Cl. Scharenbergi*, and *Dicranog. Nicholsoni*, and on the higher, with *Dicranog. Clingani*, *Leptog. flaccidus*, *Orthog. calcaratus*, var. *basiliens*, and other forms.

*Collections.*—Sedgwick Museum, Lapworth, and the Authors.

Var. **pauperatus**, var. nov. Plate XXIX, figs. 5 *a—d*.

Another common variety of *Orthog. truncatus* is a short and narrow form which is practically confined to the zones of *Dicranog. Clingani* and *Pleurog. linearis*, and which has been appropriately termed *pauperatus*. In this the length is occasionally as much as 4—6 cm., but smaller forms are far commoner, and no specimens exceed 2 mm. in breadth in Lapworth's Collection. This width is attained within 5 mm. of the proximal end, so that the polypary is characteristically narrow. The thecæ number fourteen to twelve in 10 mm., and they never overlap for more than half their length.

*Horizon and Localities.*—Hartfell Shales (zones of *Dicranog. Clingani* and *Pleurog. linearis*).

*S. Scotland*: Dobb's Linn; Hartfell, etc. *Ireland*: Ballygrot.

*Associates, etc.*—Var. *pauperatus* appears to be especially characteristic of the zone of *Dicranog. Clingani*, though it also ranges up into the zone of *Pl. linearis*. It is commonly associated with *Diplog. calcaratus* var. *basilicus* and crowds of *Corymoides*.

*Collections.*—Sedgwick Museum, Lapworth, and the Authors.

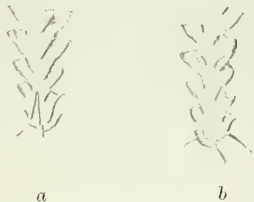
Var. **socialis**, Lapworth. Plate XXIX, figs. 7 *a—e*.

1880. *Diplograptus socialis*, Lapworth, Ann. Mag. Nat. Hist. [5], vol. v, p. 166, pl. iv, figs. 13 *a—e*.

A still smaller variety of *Orthog. truncatus*, which has all the aspects of a starved or dwarfed form, is especially characteristic of the zone of *Dicellog. complanatus* in the Upper Hartfell Shales.

The polypary never exceeds 1.5 cm. in length, and forms of less than 1 cm. are of commoner occurrence, while the average breadth is only 1.5 mm. The

FIGS. 157 *a* and *b*—*Orthograptus truncatus*, var. *socialis*, Lapw.



*a*. Proximal end, reverse aspect, but upper part of specimen removed so as to show the interior of the obverse side and hence the sicula. Coalpit Bay, Co. Down; Birkhill Shales (zone of *Dicellog. complanatus*). Coll. Lapworth.

*b*. Similar part of the obverse side of another specimen on same slab.

thecæ number fourteen to twelve in 10 mm.; they have a general inclination in profile view of 45°, have a length of about 1.5 mm., and overlap one third to one half their extent; their apertural margins are like those of the typical form but somewhat less everted in profile view.

The sicula is long (2 mm.), and is free on one side for a small fraction of its length; th. 1<sup>1</sup> originates near the aperture and grows at once upward and outward, giving off a spine some little distance below the aperture; th. 1<sup>2</sup> crosses the sicula obliquely and gives off a spine where direct upward growth

FIGS. 157 *c* and *d*.—*Orthograptus truncatus*, var. *socialis*, Lapw.



*c*. Complete specimen on same slab as figs. 157 *a* and *b*.  
*d*. Distal thecae of another specimen from same locality.

commences; both the spines are about 1 mm. in length. All the thecae are markedly alternate in their arrangement, and though in the obverse aspect there appears to be a septum, it must be incomplete, for it is always invisible in the reverse aspect of the polypary. Many of the thecae show beautiful growth lines on their walls.

*Horizon and Localities*.—Upper Hartfell Shales (*Dicellogr. complanatus* zone).

*S. Scotland*: Dobb's Linn; Shalloch Mill, etc.

*Ireland*: Coalpit Bay, Donaghadee.

*Associates, etc.*—Var. *socialis* is a common fossil at Dobb's Linn in the fossiliferous band in the Barren Mudstones known as the zone of *Dicellograptus complanatus*, where it occurs associated with *D. complanatus* and *Climacog. miserabilis*. It occurs with similar associates in the Girvan country, and in the North of Ireland, where it is extremely well preserved.

*Collections*.—Sedgwick Museum, Lapworth, and the Authors.

### **Diplograptus (Orthograptus) cyperoides**, Törnquist.

1897. *Diplograptus cyperoides*, Törnquist, Kongl. Fysiogr. Sällsk. i Lund Handl., vol. viii, p. 16, pl. ii, figs. 30—32.

Polypary very small and slender, rarely exceeding 7 mm. in length, and having a maximum breadth of 1 mm. Sicula very long. Thecae twelve in 10 mm.; narrow tubes, with slight overlap; apertural margins slightly undulate, occupying about one quarter of total width in bi-profile view.

*Description*.—The polypary is very small, but is characterised by the relatively

FIGS. 158 *a* and *b*.—*Orthograptus cyperoides*, Törnq.



*a*. Proximal end, obverse aspect, showing long sicula. Dobb's Linn, Long Cliff; Birkhill Shales (zone of *M. gregarius*). Coll. Elles.  
*b*. Specimen in relief, showing complete but shorter sicula, and septal groove. Llanystwmdwy, near Criccieth; Llandovery Beds (zone of *M. fimbriatus*). Coll. Fearnside.

great length of the sicula, which may reach 3 mm. Th. 1<sup>1</sup> is slightly longer than any theca subsequently developed; it has a length of 2 mm., and, originating near the aperture of the sicula, grows straight upward and outward; th. 1<sup>2</sup> grows from it in such a manner that the sicula is left free for a considerable fraction of its length on one side. The aperture of th. 3<sup>1</sup> is on a level with the apex of the sicula. The remaining thecae, usually five or six in each thecal series, have an average length of 1 mm., are seen in bi-profile view to have an overlap of one third to one half their length, and to have their apertural margins slightly everted. There

appears to be an indication of the presence of a partial septum in some of the specimens.

*Affinities.*—The small size of *Orthog. cyperoides*, and its relatively enormous sicula, make it quite easy to recognise and distinguish it from all other *Diplograpti* at present known. In the general characters of the polypary and the thecae it stands midway between the *Orthograpti*, on the one hand, and the *Petalograpti* on the other.

*Horizon and Localities.*—Llandovery (Upper Birkhill Shales). Zones of *Monog. gregarius* and *M. convolutus* (including band with *Cephalog. cometa*).

*S. Scotland*: Dobb's Linn (Main Cliff and Long Linn); Beleraig. *N. Wales*: Llanystwmdwy, near Criccieth.

*Associates, etc.*—The Scottish specimens of *O. cyperoides* agree very well with the description given by Törnquist for his species, except that there appears to be a trace of a septum in some specimens. Those from the zone of *Monog. gregarius* are commonly associated with the zone fossil, *M. triangulatus* and *Cl. Törnquisti*; while those from the higher zone of *Monog. convolutus* occur with *M. convolutus*, *Orthog. bellulus*, and various *Petalograpti*. The Welsh specimens, collected by Fearnside, show some slight differences from the Swedish specimens, in that the sicula is slightly shorter, and the polypary always appears to possess a partial septum. These forms occur, too, at a somewhat lower horizon than those from S. Scotland, being characteristically associated with *Monog. fimbriatus*.

*Collections.*—Fearnside and the Authors.

### GROUP III.

*Orthograpti* in which the thecae were sub-rectangular in section and the apertural margins strongly lobate; excavation distinct.

**Diplograptus (Orthograptus) calcaratus**, Lapworth. Plate XXX, figs. 1 *a—c*.

1876. *Diplograptus foliaceus*, var. *calcaratus*, Lapworth, Cat. West. Scott. Foss., pl. i, fig. 30.

Polypary robust, 8 to 10 cm. in length, wide at origin, attaining maximum breadth of 2.5 to 3.5 mm. Virgular tube stout and prolonged. Virgella conspicuous; basal thecae adorned with long, stout spines. Thecae ten to eight in 10 mm., 2.5 mm. in length, overlap not exceeding one half; apertural margin strongly lobate, appearing rounded, concave, inclined, or everted in the various views.

*Description.*—The polypary in *Orthog. calcaratus* often reaches a considerable length; its maximum width, which varies from 2.5 to 3.5 mm. in different speci-

Figs. 159 *a* and *b*.—*Orthograptus calcaratus*, Lapw.

- a*. Proximal end in full relief, showing origin of septal groove. Dobb's Linn, Lower Hartfell Shales (zone of *Dicranog. Clingani*). Coll. Lapworth.
- b*. Proximal end of a compressed specimen, showing long virgella with its membrane and thecal spines. Hartfell Spa, Lower Hartfell Shales. Coll. Elles.

insensibly into the sacculate portion of the free edge (Fig. 159 *a*); in sub-scalariform views, however, the denticle is always clearly defined and strongly mucronate, and there is an appearance of constriction immediately below the

Fig. 159 *c*.—*Orthograptus calcaratus*, Lapw.

- c*. Distal theca. Enlargement of part of Pl. XXX, fig. 1 *c*.

apertural edge (Fig. 159 *c*). This apertural margin in specimens preserved in semi-relief is strongly lobate. It is first notched interiorly, and then rises to a broad lobe to become again depressed at its extreme median outer limit, so that the mouth of the theca resembles in form the lip of a jug. After compression this apertural margin may appear horizontal, inclined, or somewhat everted, and rostrate or cusped. These features are, however, usually more clearly seen in examples of the varieties of this species, especially in var. *vulgatus* (see Figs. 160 *a—d*).

The initial thecae are provided with long, stout spines, which may measure fully 7 mm. in length. In some cases, indeed, these thecae have lost their original form, and have become entirely modified to spines. The virgella is very conspicuous, and may be as much as 11 mm. in length; it is partially surrounded by a membrane similar to that noticed in the case of *Olimacog. caudatus*. The long virgella and spines of the initial thecae give a characteristic appearance to the proximal end of this species. Another conspicuous feature is the broad rod-like or tube-like structure which runs through the polypary, and is continued beyond the distal extremity. This may be the virgula, but it seems more likely that it is a structure which contains the virgula. The septum appears to develop between th. 5<sup>1</sup> and th. 5<sup>2</sup>.

In bi-profile view the thecae have a general inclination of about 30°, the impressed portion of the ventral wall passing

*Affinities*.—*O. calcaratus* may as a rule be readily distinguished from all other *Orthograpti* by the long virgella and large spines belonging to the basal thecae.

*Horizon and Localities.*—Lower Hartfell Shales (particularly zone of *Dicranog. Clingani*).

*S. Scotland*: Dobb's Linn, Hartfell; etc. *Ireland*: Carnalea.

*Associates, etc.*—*O. calcaratus* is a common fossil in the Lower Hartfell Shales in the zone of *Dicranog. Clingani*, where it occurs associated with *Climacog. bicornis*, *Dicranog. ramosus*, etc. Some individuals are also found in the underlying zone of *Climacog. Wilsoni*, but they are of rare occurrence.

*Collections.*—Sedgwick Museum, Lapworth, and the Authors.

Var. **vulgatus**, Lapworth MS. Plate XXX, figs. 5 *a—d*.

1895. ? *Diplograptus foliaceus* var. *vulgatus*, Perner, Grapt. de Bohême, pt. ii, p. 29, pl. viii, figs. 5*a—c*.

A well-marked variety of *Orthog. calcaratus*, which occurs abundantly in the Lower Hartfell Shales, has been appropriately termed var. *vulgatus*. It differs from the more typical form in three particulars:

FIGS. 160 *a—c.*—*Orthograptus calcaratus*, var. *vulgatus*, Lapw. MS.



*a.* Proximal end in sub-relief, obverse side as seen in sub-scalariform view. Note sicula and origin of septum. Dobb's Linn, Lower Hartfell Shales (zone of *Climacog. Wilsoni*). Coll. Lapworth.

*b.* Obverse aspect, bi-profile view. Hartfell, Lower Hartfell Shales. Coll. Elles.

*c.* Reverse aspect preserved as an impression, showing origin of septum. Hartfell Spa, Lower Hartfell Shales. Coll. Geological Survey of Scotland.

(1) In the absence of the extraordinary development of basal spines;

(2) In the more abrupt widening and general coarseness of the polypary;

(3) In the more everted character of the apertural margin in sub-scalariform view.

The polypary attains about the same length as that of *Orthog. calcaratus*, but widens more abruptly, and has in general a more coarse appearance; the widening from 1 mm. to 3 mm. takes place within 1 cm. of the proximal end. The tubular structure which probably contains the virgula is even broader than in *O. calcaratus* as a general rule, but is occasionally seen to be quite narrow, when it is probably the virgula itself.

The thecæ are about the same in number as in the typical form, but there is a tendency to more distinct eversion of the apertural margin, accompanied by convexity of the margin itself. This, as has been explained earlier, is probably due to the more undulating character of the apertural margin itself.

Small basal spines similar in position to those of *Orthog. calcaratus* are developed as a rule, but they are always relatively inconspicuous.

*Horizon and Localities.*—Lower Hartfell Shales, *Dicranograptus* Shales.

*S. Scotland*: Hartfell; Dobb's Linn, etc. *Wales*: Conway Railway Cutting;

Llanystwmdwy, near Criccieth; Spittal Road Railway Cutting, Pembrokeshire, etc.  
*Ireland*: Carnalea, Co. Down; Coalpit Bay, Co. Down.

FIG. 160 d.—*Orthograptus calcaratus*, var. *vulgatus*, Lapw. MS.



d

d. Distal thecae as seen in sub-scalariform view. Enlargement of part of same specimen as Fig. 160 b.

*Associates, etc.*—Var. *vulgatus* seems to be a very abundant fossil in the Lower Hartfell Shales of South Scotland, where it occurs typically in the zone of *Climacog. Wilsoni*, and is associated with *Climacog. bicornis*, *Orthog. truncatus*, var. *intermedius*, and *Dicranog. Nicholsoni*. It ranges up into the zone of *Dicranog. Clingani*, where it occurs with *Orthog. truncatus* and var. *pauperatus*, and a few examples are found in still higher beds. It has not yet been discovered with certainty in the Upper Glenkiln Beds of S. Scotland, but in both N. and S. Wales it appears to occur at this horizon associated with *Dicranog. brevicaulis*, *Mesog. multidentis*, and other forms.

*Collections.*—Sedgwick Museum, Geol. Surveys of England and Scotland, Fearnside, Lapworth, and the Authors.

Var. **acutus**, Lapworth MS. Plate XXX, figs. 3 a—c.

Another variety, somewhat resembling var. *vulgatus* in the form of the polypary and in the absence of large basal spines, is especially characteristic of the Glenkiln Shales and their equivalents. The polypary widens rapidly from 1 mm. to 4 mm. within 1.5 em. of the proximal end, and the thecae number twelve to nine in 10 mm. instead of ten to eight as in the typical form. They appear to be inclined at a higher angle also, and the apertural margins have a distinct flange and are more incurved and everted in bi-profile view than those of either var. *vulgatus* or *O. calcaratus*.

FIG. 161.—*Orthograptus calcaratus*, var. *acutus*, Lapw. MS.



Distal thecae, sub-scalariform view. Enlargement of part of Pl. XXX, fig. 3 b.

*Horizons and Localities.*—Glenkiln Shales; *Dicranograptus* Shales.

*S. Scotland*: Birnock, Leadhills, etc. *S. Wales*: Spittal Road Railway Cutting, near Clarboston Road; Drefach, Mydrim; Dewi Fawr. *N. Wales*: Conway Cutting.

*Associates, etc.*—Var. *acutus* occurs in the Glenkiln Shales, associated with *Dicellog. sextans*, *D. divaricatus*, *D. intortus*, *Didymog. superstes*, *Cryptog. tricornis*, and other forms. It also occurs in the *Dicranograptus* Shales, associated with *Dicellog. sextans*, *Dicranog. brevicaulis*, and *Mesog. multidentis*.

*Collections.*—Geological Surveys of England and Scotland, Lapworth, and the Authors.

Var. **basilicus**, Lapworth. Plate XXX, figs. 2 *a*—*d*.

1873. *Orthograptus basilicus*, Lapworth, *nom. nudum*, Geol. Mag., vol. x, p. 134.

Another variety of *Orthog. calcaratus* is of common occurrence in the Lower Hartfell Shales. Like the foregoing varieties, var. *basilicus* is distinguished from the typical form by the absence of prominent basal spines. It is a narrower and

Figs. 162 *a* and *b*.—*Orthograptus calcaratus*, var. *basilicus*, Lapw.



*a*. Sicula and theca 1<sup>1</sup>. On same slab as Pl. XXX, figs. 2 *c* and 2 *d*.  
*b*. Proximal end of adult example, obverse view. Enlargement of part of Pl. XXX, fig. 2 *d*.

more compact form than either var. *vulgatus* or var. *acutus*, and the thecæ project less from the margin of the polypary. The average breadth does not exceed 2.5 mm., and this is attained somewhat rapidly from an initial breadth of about 1 mm. within 1 cm. of the proximal end. The thecæ number eleven to nine in 10 mm; they have an average length of 3 mm., and overlap one half their extent; the basal thecæ have small spines only. The sicula is 2 mm. in length. The septal groove seems to originate between th. 4<sup>1</sup> and th. 3<sup>2</sup>.

*Horizon and Localities*.—Lower Hartfell Shales (zones of *Dicranog. Clingani* and *Pleurog. linearis*).

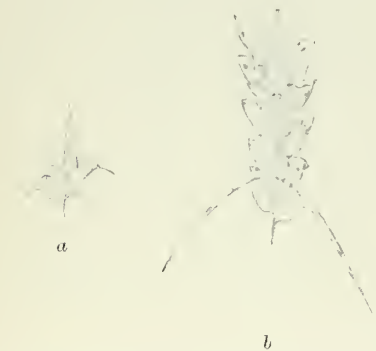
*S. Scotland*: Dobb's Linn; Hartfell, etc.

*Associates, etc.*—Var. *basilicus* occurs in fair abundance in the zones of *Dicranog. Clingani* and *Pleurog. linearis*, associated with the zone fossils, *Orthog. truncatus*, var. *pauperatus*, and other forms.

*Collections*.—Sedgwick Museum, Geol. Survey of Scotland, Lapworth, and the Authors.

Var. **tenuicornis**, var. nov. Plate XXX, figs. 4 *a*—*c*.

Figs. 163 *a* and *b*. *Orthograptus calcaratus*, var. *tenuicornis*, nov.



*a*. Sicula and thecæ 1<sup>1</sup> and 1<sup>2</sup>. On same slab as Pl. XXX, figs. 4 *a* and *b*.  
*b*. Proximal end of adult specimen. Enlargement of part of Pl. XXX, fig. 4 *a*.

This variety is closely allied in thecal characters to the type. The basal thecæ are furnished with two long, slender, apertural spines, which may have a length of fully 7 mm., but the virgella is short and inconspicuous. The virgular tube also is generally very slender, while the general form of the polypary recalls that of var. *vulgatus* rather than that of *Orthog. calcaratus* itself.

*Horizon and Locality*.—Lower Hartfell Shales.

*S. Scotland*: Morroch Bay, two miles south of Portpatrick.

*Collection*.—Geological Survey of Scotland.

Var. *priscus*, var. nov. Plate XXX, figs. 6 *a—c*.

1875. *Diplograptus foliaceus*, Lapworth, Quart. Journ. Geol. Soc., vol. xxxi, p. 657, pl. xxxv, figs. 7 *a—7 g*.

Another form, which may provisionally be regarded as a variety of *Orthog. calcaratus*, occurs in abundance in the Llandeilo rocks of S. Wales.

It is very long—occasionally reaching 12 cm. in length—and widens gradually to 5 mm. from 2.5 mm. at the proximal extremity, which is broad and abrupt; the ventral margins are, however, parallel for the greater portion of their length. The sicula is embedded and has a stout and short virgella; the two proximal thecæ are adorned with small, but conspicuous, apertural spines.

FIG. 164.—*Orthograptus calcaratus*, var. *priscus*, nov.



Distal thecæ. Enlargement of part of Pl. XXX, fig. 6 *a*.

The thecæ number fourteen to ten in 10 mm.; they have a length of about 3 mm. and overlap one half to two thirds of their extent. They are, as it were, somewhat pressed inwards towards the axis of the polypary, so that in bi-profile view the apertural margin projects but slightly from the ventral edge. In sub-scalariform views, however, there is presented a well-marked sub-mucronate denticle.

*Remarks.*—Var. *priscus* is the Llandeilo form that was referred by Lapworth in 1875 to *Diplog. foliaceus*, Murch., and which at that time (*supra*, p. 657) appeared to him to be identical with the form figured and referred by Hall in his ‘Palæontology of New York,’ vol. i, pl. lxxii, figs. 2 *a—c*, to *Fucoides secalinus*, Eaton. It seems, however, advisable to drop Eaton’s name altogether in view of the impossibility of determining the original form of the distorted examples to which Eaton applied it.

*Affinities.*—Var. *priscus* is characterised by its size and by its adpressed thecæ, which are small and closely set in the proximal region of the polypary. These features, together with the broad proximal end, serve to distinguish it from all other varieties of *Orthog. calcaratus*.

*Horizons and Localities.*—Llandeilo (zone of *Didymog. Murchisoni*); Glenkiln Shales (zone of *Dicellog. patulosus*).

*S. Wales*: Abereidly Bay, Pembrokeshire; Drefach, Mydrim, St. Clears. *N. Wales*: Tiddyndiewm. *S. Scotland* (?): Glenkiln Burn (?); Craigmiehan Seours (?).

*Associates, etc.*—Var. *priscus* is a common fossil at Abereidly Bay in the zone of *Didymog. Murchisoni*, where it occurs associated with *Didymog. Murchisoni*, *Mesog. calatus*, and *Cryptog. tricornis*. The occurrence of var. *priscus* in S.

Scotland is somewhat uncertain, but specimens occur in the Upper Glenkiln beds associated with *Dicellog. patulosus* and *Climacog. antiquus*, var. *lineatus*, which may be referable to it. In the Scottish examples the thecæ are not quite so closely set.

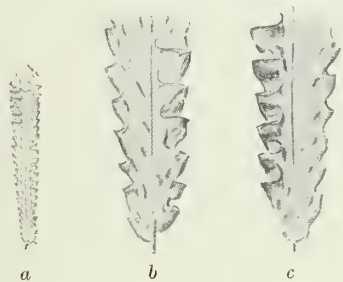
*Collections.*—Sedgwick Museum, British Museum

(Natural History), Lapworth, and the Authors.

*NOTE.*—*Orthog. calcaratus* and its varieties include

the majority of forms which have been hitherto referred by graptolithologists to *Diplog. pristis* (His.), and *Diplog. foliaceus*, Murch. Now that these two species are better known, *O. calcaratus* appears to us to be sufficiently distinct to be entitled to specific rank. The typical *Diplog. pristis* of Hisinger has not hitherto been recognised in Britain, but we figure here for comparison examples from the Trinucleus Shales of Wikarbyn, Dalecarlia, Sweden, kindly loaned to us by Dr. Törnquist of Lund, for that purpose. The typical *Diplog. foliaceus* of Murchison will be found described in the sequel.

FIGS. 165 a—c.—*Diplograptus* (*Orthograptus*) *pristis* (Hisinger).



a. Complete specimen, natural size, showing form of polypary. Wikarbyn, Dalecarlia. Coll. Dr. Törnquist.

b. Proximal end, obverse aspect as seen in sub-scalariform view ( $\times 5$ ). Ibid.

c. Reverse aspect (?) as seen in sub-scalariform view. Ibid.

***Diplograptus* (*Orthograptus*) *rugosus*, Emm., var. *apiculatus*, nov.** Plate XXX, figs. 7 a—d.

1880. *Diplograptus rugosus*, Lapworth, Ann. Mag. Nat. Hist. [5], vol. v, p. 168.

Polypary biconvex, from 2—4 cm. in length, widening gradually from 1 mm. till maximum breadth of 3.5 mm. is attained. Sricula conspicuous with stout virgella. Thecæ twelve to eight in 10 mm., walls approximately straight or with slight flowing sigmoid curvature; overlap one half, widening rapidly in direction of apertural margin, which is wide, horizontal, approximately straight and mucronate in bi-profile view; excavation very conspicuous.

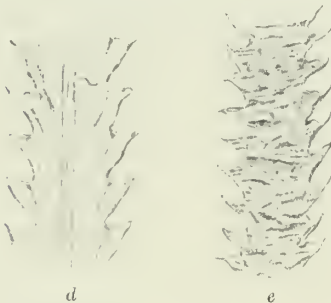
*Description.*—The polypary widens quickly at first but then more gradually, so that the maximum breadth is not attained till about 2 cm. from the proximal end. The sricula, when seen to its full extent, is 1.5 mm. in length; the virgella is conspicuous, and there is a spine on the opposite side of the aperture. Th. 1<sup>1</sup> originates from it at a point about half way along its length, and then grows downward until it reaches the level of the aperture, when it curves round, growing upward and outward for a short distance, giving off a spine where the change in direction of growth takes place; its aperture is everted and provided

FIGS. 166 a—c.—*Orthograptus rugosus*,  
var. *apiculatus*, nov.



- a. Proximal part of specimen in relief, obverse aspect, showing different appearances of the thecae. Laggan Gill, Girvan; Ardwell Group. Geol. Survey of Scotland.
- b. Proximal end, reverse aspect, with surface partly removed so as to show complete sicula, and the origin of septum. Enlargement of part of Pl. XXX, fig. 7 c.
- c. Reverse aspect showing origin of septum. Laggan Gill. Geol. Survey of Scotland.

FIGS. 166 d and e.—*Orthograptus rugosus*,  
var. *apiculatus*, nov.



- d. Distal thecae of a somewhat flattened specimen, bi-profile view. Laggan Gill; Ardwell Group. Geol. Survey of Scotland.
- e. Distal thecae of a slightly compressed specimen showing the appearance characteristic of Emmons' *D. rugosus*. ('American Geology,' pl. i, fig. 26.) Ibid.

with a short spine. Th. 1<sup>2</sup> grows from th. 1<sup>1</sup> nearly horizontally across the back of the sicula and then bends somewhat abruptly to grow upward; its aperture also is slightly everted and spinose. The aperture of th. 2<sup>1</sup> reaches the level of the apex of the sicula, but like all the thecae developed after th. 1<sup>1</sup> and th. 1<sup>2</sup> this aperture is sub-horizontal and mucronate, but not spinose.

In the reverse aspect of the polypary nothing is seen of the sicula except its aperture and the virgella (1 mm.), but the characters of the proximal thecae are usually clearly visible.

The thecae have an average length of 2.5 mm.; those nearest the proximal end show a slight tendency to flowing sigmoid curvature, but distally, the impressed edge of the polypary passes insensibly into the free edge, and the curvature is practically lost. The septal groove appears to originate between the fifth thecal pair in the obverse aspect and slightly lower down in the reverse.

*Affinities.*—*O. rugosus*, var. *apiculatus*, may be regarded as standing midway between *Orthog. calcaratus*, on the one hand, and *Glyptog. teretiusculus* on the other; the bi-profile view of the distal extremity shows a similar appearance to that presented by *O. calcaratus*, though the excavations are, perhaps, somewhat more pronounced; but in the proximal region of the polypary the small amount of overlap and the wide and deep excavations cause the form to resemble closely in some aspects *Glyptog. teretiusculus*. The more pronounced excavation and width of the aperture relatively to the length of the theca, should be sufficient to distinguish this form from all the other members of the group.

*Horizons and Localities.*—Upper Llandeilo and Lower Bala (Balclatchie and Ardwell Groups). Glenkiln-Hartfell.

*S. Scotland:* Laggan Gill; Ardmillan; Penwhapple; Piedmont Glen; Craigmiehan Seours, etc. *Shropshire:* Spy Burn. *Wales:* St. Clears (?).

*Associates, etc.*—*O. rugosus*, var. *apiculatus* occurs

somewhat abundantly in the Lower Girvan Rocks of the Girvan District, where it is often found in a beautiful state of low relief. It is commonly associated with *Cryptog. tricornis*, *Cl. bicornis*, *Cl. Scharenbergi*, *Dicranog. tardiusculus*, and other forms.

*Collections*.—Geological Survey of Scotland, Mrs. Gray, and Lapworth.

### Sub-genus **Glyptograptus**, Lapworth.

In the forms included in the sub-genus *Glyptograptus* there is not so much variation as in some of the other sub-genera; the polypary seems to have been typically more or less circular in section, while the thecae only show a marked departure from the shape of those of the typical species, *Glyptog. tamariscus*, when they exhibit a certain degree of torsion in their apertural region (*G. sinuatus*). The small amount of overlap is highly characteristic of all the members of this sub-genus.

#### GROUP I.

*Glyptograpti*, in which the axis of the theca was straight, the thecae semi-circular in section, and the apertural margins undulate; excavations wide and deep.

**Diplograptus (Glyptograptus) tamariscus**, Nicholson. Plate XXX, figs. 8 *a—d*.

1868. *Diplograptus tamariscus*, Nicholson, Quart. Journ. Geol. Soc., vol. xxiv, p. 526, pl. ix, figs. 10—13.

1876. *Diplograptus tamariscus*, Lapworth, Cat. West. Scott. Foss., pl. ii, fig. 34.

1877. *Diplograptus tamariscus*, Lapworth, Grapt. Co. Down, pl. vi, fig. 12.

1897. *Diplograptus tamariscus*, Törnquist, Diplograptidæ and Heteroprionidæ of Scania Rastrites Beds, Kongl. Fysiog. Sällsk i Lund Förhändl., vol. viii, p. 15, pl. ii, figs. 15—19.

Polypary long and narrow, varying from 7 mm. to 4·5 cm. in length, and rarely exceeding 1 mm. in breadth; sicula small, septum incomplete. Thecae fourteen to twelve in 10 mm., with pronounced sigmoid curvature, alternate; overlap slight, free edge rounded, apertural margin even or very slightly undulate, horizontal or slightly introverted in profile view.

*Description*.—The polypary varies considerably in size from 7 mm. to 4·5 cm.; it widens gradually from an initial breadth of 1·4 mm. to its maximum breadth of about 1 mm., or rather less when preserved in relief. The sicula has a length of 1 mm., the virgella when preserved may measure 5 mm. Th. 1<sup>1</sup> originates close to the aperture and grows down below it for a short distance before turning upward

and outward; th.  $1^2$  grows from it obliquely across the back of the sicula, so as to leave it free on one side for a considerable fraction of its length; its

FIG. 167 a—d.—*Glyptograptus tamariscus*, Nich.



- a. Small specimen in relief, obverse aspect, showing the sicula and septal groove. Ambleside, Skelgill Shales. One of Nicholson's original specimens. Brit. Museum (Nat. Hist.).  
 b. Reverse aspect of proximal end of specimen in relief. Note absence of septal groove. Ibid.  
 c. Distal thecae of same specimen.  
 d. Distal thecae of wider compressed specimen, showing greater amount of overlap. Enlargement of part of Pl. XXX, fig. 8 b.

aperture is on a level with the apex of the sicula. The septum commences at once, and is continued throughout the whole obverse aspect of the polypary, but is obviously incomplete, since there is no trace of it whatever in the reverse aspect.

The thecae are distinctly alternate in their arrangement, and frequently show well-marked growth-lines. They are rather more than 1 mm. in length, and overlap about one quarter to one third of their length. In the bi-profile view the apertural margins appear horizontal or slightly introverted; they are situated within long and deep excavations, occupying one half to one third of the total breadth of the polypary. But while the ventral wall of the theca is distinctly sigmoid, it is more flowing than that of species belonging to the genus *Climacograptus*, and the rounding of the free edge is particularly clear.

*Affinities.*—*G. tamariscus* is distinguished from other species of *Glyptograptus* by: (1) the smaller amount of overlap of the theca; (2) the more flowing outline of the ventral wall; (3) the greater depth of the excavation.

*Horizons and Localities.*—Llandoverly, Birkhill Shales, Skelgill Beds (zones of *Monog. gregarius* and *M. spinigerus* and their equivalents).

*Lake District:* Skelgill; Browgill; Troutbeck Valley, etc. *S. Scotland:* Dobb's Linn; Belcraig; Garple Linn; Mount Benger Burn; Woodlands, Girvan, etc.; *Wales:* Rhayader; Llanbryn-mair. *Ireland:* Donaghadee, Co. Down; Little River, Pomeroy, Co. Tyrone.

*Associates, etc.*—*Glyptog. tamariscus* occurs plentifully in an excellent state of preservation in the Skelgill Beds of the Lake District; it is also abundant, but in a compressed condition, in the Birkhill Shales of S. Scotland; its common associates are *Monog. gregarius*, *M. triangulatus*, *Cl. Törnquisti*, and *Cl. rectangularis*, at the lower horizon, and *Monog. spinigerus*, *M. argenteus*, *M. Clingani*, *M. lobiferus*, and *Cl. scalaris*, in the higher beds.

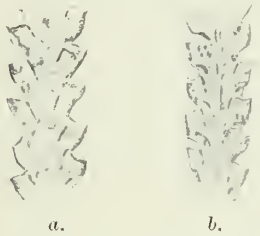
*Collections.*—British Museum (Natural History), Sedgwick Museum, Dr. Marr, Lapworth, and the Authors.

Var. *incertus*, var. nov. Plate XXX, figs. 9 *a—d*.

1876. *Diplograptus Hughesii*, Lapworth, Cat. West. Scott. Foss., pl. ii, fig. 37.

A variety of *Glyptog. tamariscus*, which differs from the typical form in being wider and shorter, and showing a greater amount of overlap of its thecæ in the bi-profile view, is of common occurrence in the Birkhill Shales, especially in the zone of *Monog. Sedgwickii*. It widens rapidly in the proximal region from 8 mm. to 2 mm., and thence the margins become subparallel. The thecæ are alternate in their arrangement, but not conspicuously so in the distal part of the polypary, and decidedly less so than in *Glyptog. tamariscus*; their average overlap is fully one half. In the obverse aspect the excavation appears to be more abrupt and the ventral wall consequently less flowing than in the typical form.

FIGS. 168 *a* and *b*.—*Glyptograptus tamariscus*, var. *incertus*, nov.



*a.* Distal theca, as seen from the reverse aspect. Enlargement of specimen on same slab as Pl. XXX, fig. 9 *c*.  
*b.* Distal theca from the obverse aspect. Enlargement of part of Pl. XXX, fig. 9 *c*.

*Horizons and Localities.*—Llandoverly, Birkhill Shales, Skelgill Beds (zone of *Monog. Sedgwickii*). *S. Scotland*: Dobb's Linn. *Lake District*: Mosedale, Long Sleddale; Skelgill.

*Associates, etc.*—Var. *incertus* appears to be a fairly common fossil throughout the Upper Birkhill Shales and their equivalents, especially in the zone of *Monog. Sedgwickii*, where it occurs associated with the forms usually met with in that zone.

*Collections.*—The Geological Survey of Scotland, the British Museum (Natural History), Sedgwick Museum, and the Authors.

**Diplograptus (Glyptograptus) serratus**, sp. nov. Plate XXX, figs. 10 *a—c*.

Polypary long and relatively broad, from 4 cm. to 5 cm. or more in length, widening quickly at first, but subsequently more gradually to a maximum breadth of 3.5 mm., which is then maintained. Thecæ stout, fourteen to eight in 10 mm., of the general *Glyptograptus* type, overlapping one third to one half their length; apertural margins slightly undulate, excavations conspicuous.

*Description.*—The polypary is always of considerable size; it widens rapidly in its initial portion from 1 mm. to 3 mm. and then very gradually to its maximum breadth of 3.5 mm., which is thereafter maintained; in some specimens, however, the width never exceeds 3 mm. The thecæ show a decided tendency to widen

in the direction of the aperture; and the apertural margins in bi-profile view are approximately horizontal, but with a tendency to eversion.

FIG. 169.—*Glyptograptus serratus*, sp. nov.



Proximal end, reverse aspect. Beleraig Burn, Birkhill Shales. Coll. Wood.

abundant fossil in S. Scotland in a definite bed at the base of the zone of *Monog. Sedgwickii*, where it occurs associated with *Climacog. Törnquisti* and *Cephalog. cometa*.

*Collection*.—The Authors.

*Affinities*.—*G. serratus* is a species of the same general type as *G. tamariscus*; it is, however, a much larger and coarser form, the distal thecae are more remote, and the apertural margins in bi-profile view show a tendency to eversion rather than introversion.

*Horizons and Localities*.—Llandovery, Birkhill Shales (zone of *Monog. Sedgwickii*).

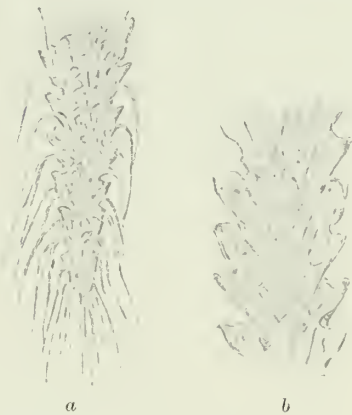
*S. Scotland*: Beleraig Burn; Dobb's Linn, etc.

*Associates, etc.*—*Glyptog. serratus* is a fairly

Var. **barbatus**, var. nov. Plate XXX, figs. 11 *a*, *b*.

A very remarkable variety of *Glyptog. serratus* has been found by Mr. Edward Greenly in Anglesea on approximately the same Llandovery horizon. In this

FIGS. 170 *a* and *b*.—*Glyptograptus serratus*, var. *barbatus*, nov.



*a*. Proximal end showing great development of thecal spines. Enlargement of part of Pl. XXX, fig. 11 *a*.  
*b*. Distal thecae of same specimen.

variety the proximal thecae are all adorned with mesial spines, which are robust and have a graceful downward curvature. In addition to these spines there are a number of thread-like hairs which proceed indiscriminately from the surface of these thecae, so that the proximal end of the polypary seems, as it were, to be enveloped in a tassel.

*Horizon and Locality*.—Llandovery (zone of *Monog. Sedgwickii*).

*Anglesea*: Pary's Mountain.

*Associates, etc.*—All the specimens of this variety at present known come from the same locality, where they occur in fair number and are associated with *Monog. Sedgwickii* and *M. discretus*.

*Collection*.—Mr. Edward Greenly.

**Diplograptus (Glyptograptus) teretiusculus** (Hisinger). Plate XXXI, figs. 1 *a*—*c*.

1840. *Prionotus teretiusculus*, Hisinger, Leth. Suecica, Suppl. II, p. 5, pl. xxxviii, fig. 4.

1881. *Diplograptus teretiusculus*, Tullberg, Bihang K. Svensk. Vet. Akad. Handl., vol. vi, no. 13, p. 18, pl. ii, figs. 1—7.

Polypary 4—6 cm. in length, widening very gradually till maximum breadth of 2 mm. is attained. Sicula of moderate size; virgella long, stout, and conspicuous; basal thecæ with unsymmetrically disposed spines. Thecæ fourteen to ten in 10 mm., of the general *Glyptograptus* type, sacculate above and impressed below, having a length of 2 mm. and overlapping for one half their extent; apertural margins slightly undulate.

*Description.*—The polypary may attain a length of 6 cm., but specimens measuring about 3 or 4 cm. are of commoner occurrence than the longer forms.

FIGS. 171 *a* and *b*.—*Glyptograptus tere-tiusculus* (His.).



*a.* Proximal end, reverse aspect; sicula pressed through and unusually prominent. Enlargement of part of Pl. XXXI, fig. 1 *a*.  
*b.* Proximal end, normal reverse aspect. Gwern-y-fed-fach, near Builth, Llandeilo Beds. Fraser's Collection.

FIGS. 171 *c* and *d*.—*Glyptograptus tere-tiusculus* (His.).



*c* and *d*.—Distal thecæ, showing the various appearances they present under compression. Enlargements of part of Pl. XXXI, fig. 1 *b*.

In general the specimens from the Welsh Borderland are somewhat narrower than the Swedish types described by Tullberg. Examples, however, are met with in association which agree exactly in their dimensions with those given by him, and there appears to be every gradation between them.

The proximal end of the polypary is relatively broad, but the proximal thecæ are small. The sicula has a length of about 1.5 mm., and the virgella is fully 3 mm. long. Th. 1<sup>1</sup> originates near the apex of the sicula and grows distinctly downward before bending round to grow outward and upward. It gives off a short spine close below its aperture. Th. 1<sup>2</sup> also grows in a downward direction before turning upward and outward, and carries a distinct sub-apertural spine below its slightly everted aperture.

The thecæ subsequently developed are all somewhat sacculate, with a constriction immediately below the apertural margin in compressed examples. In the reverse bi-profile view they all exhibit gently flowing sigmoid curvature in their ventral walls, and the free edge is but slightly rounded; they overlap from one third to one half their length. Their apertural margins are often markedly introverted, while in some cases there is also a suggestion of introversion of the whole apertural region. In what appears to be the reverse aspect the exca-

vations are also shallow and pouch-shaped, occupying about one fifth of the total breadth of the polypary, but in the obverse aspect the excavation appears more pronounced, the ventral wall more rounded, and the whole appearance nearer that of *G. tamariscus*. In some views a row of pustules close to the inner angle of the pouch is often shown, apparently due to the com-

pression of the inner corner of the apertural margin showing through from the under side.

*Affinities.*—*G. teretiusculus* shows many points of resemblance to *G. dentatus*, but it may be distinguished by its more distant and less introverted thecæ. From *G. teretiusculus*, var. *euglyphus*, it differs notably in the characters of the proximal end.

*Horizon and Localities.*—Upper Llandeilo; *Dicranograptus* Shales.

*Wales:* Pencerrig, near Builth; Gwern-y-fed-fach, near Builth; Newport; Spittal Road Cutting, Pembrokeshire.

*Associates, etc.*—*Glyptog. teretiusculus* occurs in some abundance in the Llandeilo rocks of Wales; it is commonly associated with *Nemag. pertenuis*, *Dicellog. sextans*, and other forms.

*Remarks.*—This species is very like Hall's *Diplog. angustifolius*, with which it may eventually be shown to be identical, in which case Hall's name will have to be relinquished.

*Collections.*—Sedgwick Museum, Lapworth, and the Authors.

Var. **euglyphus**, Lapworth. Plate XXXI, figs. 2 a—d.

1877. *Diplograptus dentatus*, Lapworth, Grapt. Co. Down, p. 132, pl. vi, fig. 13.

1880. *Diplograptus (Glyptograptus) euglyphus*, Lapworth, Ann. Mag. Nat. Hist. [5], vol. v, p. 166, pl. iv, figs. 14 a—c.

FIG. 172.—*Glyptograptus teretiusculus*,  
var. *euglyphus*, Lapw.



Proximal end, reverse aspect. Birnook  
Water, Abington; Glenkiln Shales.  
Coll. Lapworth.

In place of the typical form of *Glyptog. teretiusculus* there commonly occurs in S. Scotland a variety which differs from the type (1) in having a longer and more tapering polypary; (2) in the absence of lateral spines on the basal thecæ; and (3) in having the thecæ more remote in the proximal region. The polypary was parallel-sided for a great length, since fragments 10 cm. long and of uniform width are known; its proximal end, however, is pointed rather than square, as in the type form. The thecæ never exceed eleven to ten in 10 mm.

*Horizon and Localities.*—Glenkiln Shales (zone of *Nemag. gracilis*).

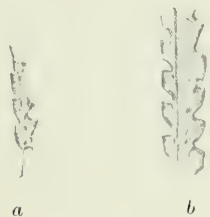
*S. Scotland:* Dobb's Linn; Cairn Ryan; Craigmiechan Seours; Reim Gill; Leadhills; Glenkiln Burn, etc.

*Associates, etc.*—Var. *euglyphus* is a fairly common fossil in the Glenkiln Shales of S. Scotland, where it occurs associated with *Dicellog. sextans*, *Didymog. superstes*, *Amplexog. perexcavatus*, *Nemag. gracilis*, and other forms.

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

Var. *siccatus*, var. nov. Plate XXXI, figs. 3 *a—d*.

FIGS. 173 *a* and *b*.—*Glyptograptus teretiusculus*, var. *siccatus*, nov.



*a*. Fragment showing proximal end and sicula. Enlargement of specimen on same slab as Pl. XXXI, figs. 3 *a, b*.  
*b*. Distal theca. Gwern-y-fed-fach, Llandeilo Beds. Coll. Elles.

Another variety of *Glyptog. teretiusculus* is distinguished by its very small size. It appears never to exceed 2 cm. in length and 1 mm. in breadth, and seems to have had a remarkably attenuate test, which is often, indeed, reduced to a mere film, while the virgula is always thread-like and wiry.

*Horizon and Localities*.—Llandeilo, Glenkiln Shales.

*S. Scotland*: Glenkiln Burn; Dobb's Linn; Beleraig Burn; Rein Gill, etc. *N. Wales*: Tiddyndicwm. *Central Wales*: Pencerrig, near Builth; Gwern-y-fed-fach, near Builth.

*Associates, etc.*—Var. *siccatus* is fairly common in the Glenkiln Shales and their equivalents; it occurs associated with *Nemag. gracilis*, *Climacog. Scharenbergi*, *Dicellog. sextans*, etc.

*Collections*.—Sedgwick Museum, and the Authors.

**Diplograptus (Glyptograptus) dentatus** (Brongniart.) Plate XXXI, figs. 4 *a—d*.

1828. *Fucoides dentatus*, Brongniart, Hist. Végét. Foss., vol. i, p. 70, pl. vi, figs. 9—12.

1865. *Diplograptus pristiniiformis*, Hall, Grapt. of Quebec Group, Geol. Surv. Canada, dec. 2, p. 110, pl. xiii, figs. 15—17.

1868. *Diplograptus pristiniiformis*, Nicholson, Quart. Journ. Geol. Soc., vol. xxiv, p. 140, pl. v, figs. 14, 15.

1875. *Diplograptus dentatus*, Lapworth, Quart. Journ. Geol. Soc., vol. xxxi, p. 656, pl. xxxiv, figs. 5 *a, b, d—h*.

1898. *Diplograptus dentatus*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 517.

Polypary somewhat concavo-convex, short, not exceeding 3 cm. in length, or 2 mm. in breadth. Sicula small, virgella conspicuous; lateral spines on proximal theca unsymmetrically disposed, rarely preserved. Theca eighteen to twelve in 10 mm., short, having an average length of 1.5 mm., overlap slight, whole of free part of theca introverted so that the sub-lobate apertural margin appears oblique in most views; excavations oblique, pouch-shaped, occupying one quarter of the width of the polypary and one third of its ventral margin.

*Description*.—*Glyptog. dentatus* presents very varied appearances after compression. In the obverse bi-profile view the sicula has a length of 1 mm., and th. 1<sup>st</sup> originates from near its aperture, growing at once outward and

upward; its aperture is concave, and appears to be prolonged into a spine. Th. 1<sup>2</sup> develops from th. 1<sup>1</sup>, growing at first horizontally across the sicula, and

FIGS. 174 a—c.—*Glyptograptus dentatus*  
(Brongniart).



- a. Proximal end, obverse aspect showing sicula. Cefn-farchen farm, near Llanfanteg Station. Upper Arenig. Geol. Surv. England.  
 b. Proximal end, reverse aspect showing virgella. Enlargement of part of Pl. XXXI, fig. 4 c.  
 c. Distal thecae in low relief. Llan, near Llanfanteg Station. Upper Arenig. Geol. Surv. England.

then upward and outward; in this case the spine seems to be given off near where the change in direction of growth takes place, but it is hard to determine where these spines actually originate. The septum makes its first appearance after two thecae have developed on each side of the sicula; the septal groove is somewhat flexed at first, but becomes straighter distally.

All the thecae subsequently developed show flowing sigmoid curvature of their ventral walls in bi-profile view, and the entire apertural region is somewhat introverted, so that the apertural margins appear approximately horizontal, but with a decided tendency to introversion. Judging from examples preserved in low relief it is probable that this is due to a certain twisting of the axis of the theca, this form pointing in the direction of the sub-group

of *Glyptograpti* next to be described.

*Affinities.*—*G. dentatus* unites in itself many characters found distinct in later forms. The polypary seems to have had a certain degree of concavo-convexity, bringing it near to that of the *Mesograpti*. Although in the general form of the thecae it agrees essentially with other *Glyptograpti*, yet the lobate character of the apertural margin is more pronounced than usual, and approaches more nearly to that of the *Orthograpti*. On the whole it apparently presents most analogies with *Glyptog. teretiusculus*, and we therefore group it with the *Glyptograpti*, but as an extreme form. It may be distinguished from *Glyptog. teretiusculus* by having smaller and more closely set thecae in the proximal region of the polypary, and by the introversion of the whole apertural region of its thecae.

*Horizons and Localities.*—Upper Arenig and Llanvirn; Upper Skiddaw Slates (Ellergill Beds).

*Shropshire*: Shelve Church. *N. Wales*: Pont Seiont; Pellig Mill; Arenig, etc. *S. Wales*: Porth Hayog; Llanvirn Quarry; Melin-y-castell, St. Clears; Llandeilo, Abercwin; Rhyd-y-behan Cottage, near Clynderwen railway station; near Llanfallteg railway station, etc. *Lake District*: Thornship Beck; Aik Beck, Pooley; Troutbeck; Ellergill, Milburn; N. W. Longside, Skiddaw; Mosedale Beck; Mungrisedale; Glenderamakin River; Bassenthwaite Sand-beds; Outerside; Master Sike, Crossfell.

*Associates, etc.*—*Glyptog. dentatus* is the oldest *Diplograptus* hitherto met with in Britain; it makes its appearance in the Arenig Rocks (zone of *Didymog.*

*extensus*), is common in the zone of *Didymog. bifidus*, and then disappears in the zone of *D. Murchisoni*. In the zone of *D. extensus*, it occurs in association with the zone fossil, *Tetrag. serra* and various *Callograpti*. In the zone of *D. hirundo*, *Glyptog. dentatus* is very rare, but it is found in abundance in the zone of *D. bifidus* associated with *Didymog. bifidus*, *D. artus*, *D. acutidens*, *Mesog. confertus*, and other forms.

The best preserved British specimens known to us come from South Wales, where the rocks have not been so much cleaved as they are in the Lake District. In some of these Welsh specimens the thecæ are not quite so closely set in the proximal region, numbering fifteen rather than eighteen in 10 mm. The examples occurring in the Arenig rocks of Shelve are small and poorly preserved.

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

Var. **appendiculatus**, Törnquist MS. Plate XXXI, fig. 5.

1898. *Diplograptus appendiculatus*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 518, fig. 30.

In addition to the more typical *Glyptog. dentatus* there occurs in the Skiddaw Slates a form which agrees with it in the essential details of the polypary and thecæ, but which is distinguished by the presence of a flattened vesicle proceeding from the distal extremity. This vesicle, which is about 2 cm. in length, resembles that of *Orthog. vesiculosus*.

*Horizon and Locality*.—Upper Skiddaw Slates.

*Lake District*: Outerside.

*Associates, etc.*—Var. *appendiculatus* has up to the present time been recorded only from the Skiddaw Slates. Its associates are unknown.

*Collection*.—Sedgwick Museum.

## GROUP II.

*Glyptograpti* in which the axis of the theca was twisted, the thecæ subcircular in section, and the apertural margins undulate; excavations very distinct.

**Diplograptus (Glyptograptus) sinuatus**, Nicholson. Plate XXXI, figs. 6 *a—c*.

1869. *Diplograptus sinuatus*, Nicholson, Ann. and Mag. Nat. Hist. [4], vol. iv, p. 235, pl. xi, fig. 11.

1897. *Diplograptus (Glyptograptus) sinuatus*, Perner, Grapt. de Bohême, pt. iii, p. 5, pl. ix, figs. 9—12, and fig. 3 (text).

Polypary thick, small, commonly less than 2 cm. in length, narrow for the first few mm. of length, then widening abruptly to a breadth of 1.5 mm., and,

subsequently, more gradually till a maximum of about 2 mm. is attained. Sicula small, virgella conspicuous, but rarely preserved. Thecae twelve to ten in 10 mm., with marked sigmoid curvature and slight torsion, free edge rounded, length 1.5 mm., overlapping one half their length; apertural margins slightly undulate and everted in bi-profile view.

*Description.*—The polypary presents a very characteristic appearance due to the peculiar mode of growth of the theca. Each of these grows at first in a normal manner parallel with the general direction of the polypary, but then takes a curve outward, and the axis twists so that the theca in its apertural region is turned at an angle to its previous direction of growth. The theca in its general form strongly recalls that of certain *Dicellograpti*.

FIGS. 175 a and b.—*Glyptograptus sinuatus*, Nich.



a. Proximal end in relief, showing long virgella. Skelgill, Ambleside; Skelgill Shales. Coll. Brit. Museum (Nat. Hist.).  
b. Distal thecae in relief. Enlargement of part of Pl. XXXI, fig. 6 a.

The polypary as a rule does not exceed 1 mm. in breadth (.7 mm. in relief) for the first 3 mm. of its extent; then, however, it abruptly widens to 1.5 mm. and subsequently very gradually till a maximum width of about 2 mm. is attained. In a few specimens the increase of breadth appears to be gradual throughout the proximal region of the polypary. The visible portion of the sicula is barely 1 mm. long, and the virgella when preserved may have a length of 5 mm., but this is exceptional (Fig. 175 a).

In the slender proximal region of the polypary the thecae are markedly alternate in their arrangement; there are four pairs of thecae in this narrow part, and in profile view the apertural margins tend to appear slightly everted. In the obverse aspect the aperture of th. 1<sup>1</sup> does not reach to the line of the apex of the sicula, while that of th. 1<sup>2</sup> is distinctly above it, and the sicula is free for a considerable fraction of its length on one side. The septum seems to originate at once.

The overlap of the thecae is least in the narrow proximal region, being barely one third of the thecal length, whereas in the wider part of the polypary an overlap of fully one half their length is attained. In the reverse aspect the peculiar mode of growth of the thecae causes their apertural margins to occupy fully one quarter the breadth of the polypary.

*Affinities.*—The only *Glyptograptus* to which *G. sinuatus* is closely allied is *G. persculptus*, from which, however, it differs in point of size and in having closer set thecae, which are also less twisted. From all other *Glyptograpti* at present known the peculiar mode of growth of the thecae should be sufficient to distinguish it.

*Horizon and Localities.*—Llandovery, Skelgill Beds (zones of *M. fimbriatus*, *M. argenteus*.)

*Lake District:* Skelgill; Troutbeck Valley; Mealy Gill; Swindale Beck, Knock, etc. *S. Scotland:* Dobb's Linn. *Wales:* Llanystwmdwy, near Criccieth; Rhayader.

*Associates, etc.*—*G. sinuatus* occurs in some profusion in the Skelgill Beds of the Lake District in the zone of *Monog. fimbriatus*; it is beautifully preserved in relief, and occurs with *Olimacog. Hughesi*, *Cl. rectangularis*, *Cl. Törnquisti*, *Monog. fimbriatus*, and other forms. It is also found in the zone of *Monog. argenteus* associated with the zone fossils. It is rarer in S. Scotland.

*Collections.*—Sedgwick Museum, British Museum (Nat. Hist.), Marr, Fearnside, Lapworth, and the Authors.

**Diplograptus (Glyptograptus) persculptus**, Salter. Plate XXXI, figs. 7 *a*—*c*.

1868. *Diplograptus persculptus*, Carruthers, Geol. Mag., p. 130.

1873. *Diplograptus persculptus*, Salter, *nom. nudum*, Cat. Fossils, Mus. Pract. Geol., p. 25.

Polypary 3 cm. or more in length, widening quickly to a maximum breadth of 2 to 2.5 mm., which is thereafter maintained. Sicula conspicuous, with small virgella. Thecæ ten to eight in 10 mm., long tubes with axes twisted, and with decided sigmoid ventral curvature, 2 mm. in length, overlapping one half, and with apertural margins slightly undulate; everted in profile view.

*Description.*—The only examples of this species known to us are preserved in a state of semi-relief. The polypary presents an appearance somewhat similar to

FIGS. 176 *a* and *b*.—*Glyptograptus persculptus*, Salter.



*a.* Obverse aspect, in relief showing sicula. Gogofau, Carmarthen, Llandovery Beds. Coll. Brit. Museum (Nat. Hist.).

*b.* Reverse aspect, in full relief showing the twisting of thecal axis. Ibid.

that noted in the case of *Glyptog. sinuatus*, but the torsion of the thecæ seems to have been much more pronounced. The polypary itself widens gradually from 1 mm. to a maximum of 2 to 2.5 mm., which is attained within 1.5 cm. of the proximal end. The sicula, when completely visible in young stages, measures 2.1 mm., but of this length not much more than 1 mm. is usually visible in the obverse aspect of the adult polypary. Th. 1<sup>1</sup> originates at a point about .5 mm. above the aperture of the sicula, and grows at first straight downward until it is some little distance below the level of the sicula, when it bends abruptly round and grows upward and, but very slightly, outward. Th. 1<sup>2</sup> grows upward and outward from it on the opposite side of the sicula in such a manner that it leaves the sicula free

for a considerable fraction of its length on one side. In the reverse aspect it is seen that the septum originates between th. 2<sup>2</sup> and th. 2<sup>1</sup>; it is slightly sinuous, the sinuosity being more marked in the reverse aspect.

As usual, the thecæ show the most pronounced sigmoid curvature near the proximal end of the polypary, and the torsion of the axis at the curve is also more noticeable in that region. To this is due the peculiar shape of the thecæ, which, like those of *Glyptog. sinuatus*, strongly recall the type of theca in certain *Dicellograpti*. Apart from their torsion, the thecæ appear to be tubes of approximately uniform breadth, having a length of 3 mm., and being overlapped for one half of it. The free edge is straight or slightly rounded in profile view, and has an average inclination of about 15° with respect to the general direction of the polypary. The apertural margin appears slightly concave and everted, and occupies one third to one quarter of the total breadth of the polypary.

*Affinities.*—In general form and appearance *G. persculptus* has many points of resemblance to *G. sinuatus*, but it is a much larger species, and the thecæ are more twisted, and more distant from each other.

*Horizon and Locality.*—Lower Llandovery (zone of *Cephalog. acuminatus*).

*Wales:* Gogofau, Carmarthenshire; Fuches-gan Farm, near Pont Erwyd, Cardiganshire.

*Associates, etc.*—The associates of *G. persculptus* at the type locality, Gogofau, are at present unknown, but in the Pont Erwyd district this species occurs with *Mesograptus modestus* and var. *parvulus*.

*Collections.*—British Museum (Natural History), Sedgwick Museum, and Mr. O. T. Jones.

#### Sub-genus **MESOGRAPTUS**, nov.

Within the sub-genus *Mesograptus* are here included those forms in which the appearances presented are in part those characteristic of a typical *Diplograptus* (*Orthograptus*), and in part those more characteristic of a typical *Climacograptus*.

In a first group the earlier thecæ have the appearance of those of a *Climacograptus*, with vertical or sub-vertical free edge and well-marked excavation, and the later thecæ the appearance of those of a *Diplograptus*, with inclined free edge and relatively insignificant excavation, and this in both the obverse and reverse aspects of the polypary. *Diplog. foliaceus* may be regarded as the type species of this group.

In a second group all the thecæ show on the reverse aspect of the polypary the appearances of those of a *Diplograptus*, and on the obverse aspect those of a *Climacograptus*. This group, which is typified by *Diplog. perexcavatus*, has been provisionally separated off by Lapworth as the sub-genus *Amplexograptus*.

The flattened forms belonging to the first of these groups are usually easily

identified as *Diplograpti*, but when fragmentary or in sub-relief have often been relegated to the *Climacograpti*. Forms belonging to the second group have been classed as *Climacograpti* or *Diplograpti*, according as the obverse or reverse aspect of the polypary has been presented.

## GROUP I.

*Mesograpti* in which the thecae were semicircular in section and the apertural margins somewhat undulating; excavations deep and conspicuous in proximal region of polypary only.

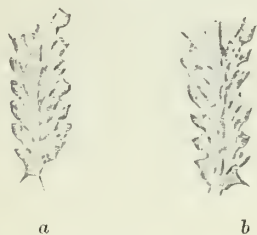
**Diplograptus (Mesograptus) foliaceus** (Murchison). Plate XXXI, figs. 8 a—f.

1839. *Graptolithus foliaceus*, Murchison, Silurian System, p. 694, pl. xxvi, fig. 3.

Polypary commonly short, about 3 cm. in length, with maximum breadth of about 3 mm.; margins parallel for greater part of length. Sicula small, virgella conspicuous, lateral spines rarely preserved, unsymmetrically disposed. Thecae fourteen to twelve in 10 mm., having an average length of 2 mm., and overlapping one half to two thirds their extent; apertural margins slightly undulate, concave in profile view.

*Description.*—Compared with that of the majority of forms which have been erroneously referred to it, the polypary of *M. foliaceus* is characteristically small, not exceeding 3 cm. in length. After widening rapidly in the proximal region it maintains a fairly constant breadth for the remainder of its length. The virgella is thread-like, and is occasionally prolonged for a short distance beyond the distal extremity.

FIGS. 177 a and b.—*Mesograptus foliaceus* (Murch.).



a. Proximal end, obverse aspect, showing portion of sicula. Meadowtown, Llandeilo Flags. Coll. Lapworth.  
b. Proximal end, reverse aspect, but showing sicula. Ibid.

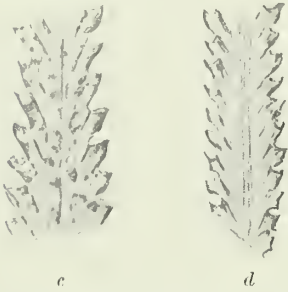
The sicula is rarely visible, but it appears to have had a length of at least 1 mm.; it is, however, usually concealed in the reverse aspect of the polypary. Details regarding the proximal end are obscure, but the presence of a virgella can usually be detected. On th. 1<sup>1</sup> a spine is given off close below the aperture; while on th. 1<sup>2</sup> the spine is

further removed from the aperture, and seems to be given off where change in the direction of growth occurs.

In the proximal region of the polypary the thecae are closely set, and as shown in bi-profile view nearly one half of the visible ventral wall of the theca is impressed. In the distal region the amount of impression dies out, so that the

excavation, as such, disappears, and the line of the apertural margin, at first horizontal, becomes decidedly oblique, and the form of the theca becomes

FIGS. 177 *c* and *d*.—*Mesograptus foliaceus* (Murch.).



*c*. Thecae near the distal end. Meadowtown, Llandeilo Flags. Coll. Lapworth.

*d*. Theca near the proximal end, showing the varying appearances presented. Enlargement of part of Pl. XXXI, fig. 8 *c*.

practically that of an *Orthograptus*.

*Affinities*.—With the exception of *Diplog. pristis*, His., no species has had so many allied forms referred to it by graptolithologists as *Mesog. foliaceus*, a practice which has had a strong justification in the more or less intermediate character of the species itself. *M. foliaceus* has been especially confounded with *Orthog. calcaratus* and its varieties; the smaller polypary and the more closely set thecae in the former and their progressive change in shape should, however, readily serve to distinguish it. It is probably more closely allied to *Glyptog. dentatus*, but its greater breadth and the shape of its thecae show that it is a distinct form.

*Remarks*.—The original type specimens of *M. foliaceus* (which are preserved in the Museum of the Geological Society of London, and which are figured by us on Pl. XXXI, figs. 8 *a*, *b*) are unfortunately mere fragments. Better examples have, however, been collected by Lapworth and others from the Llandeilo Flags at Meadowtown, Shropshire, whence Murchison's were obtained, but the nature of the rock and the mode of preservation render it extremely difficult to procure satisfactory specimens showing all the specific characters. There can be, however, no doubt that the examples represent a distinct species, and to this Murchison's name should be restricted.

*Horizon and Localities*.—Llandeilo Flags, Ardwell Group, Whittery Shales (?).

*Shropshire*: Meadowtown; Woolferton. *Wales*: Gwern-y-fed-fach, near Builth. *S. Scotland*: Piedmont Glen, Girvan District.

*Associates, etc.*—*Mesog. foliaceus* is not uncommon in the hard, sub-calcareous Llandeilo Flags of Meadowtown immediately overlying the Llandeilo Limestone, and, so far as known, it has no associates at this locality. Other forms which approach it closely, making allowances for the difference in mode of preservation, are found in the Girvan country (Ardwell Beds), in the Llandeilo Shales, near Builth, and in the Whittery Shales (?) at Woolferton, Shropshire.

*Collections*.—Lapworth, and Geological Survey of England and Wales. Murchison's types are preserved in the Collection of the Geological Society of London.

**Diplograptus (Mesograptus) multidentis**, sp. nov. Plate XXXI, figs. 9 a—d.

Polypary 5 cm. or more in length, increasing rapidly in breadth till the maximum of 3·5—4 mm. is attained; with flattened tube running through centre, and emerging at distal extremity. Sicula small; pair of proximal thecæ adorned with unsymmetrically disposed spines. Thecæ closely set, eighteen to fourteen in 10 mm., being in all profile views of a general *Climacograptus* type in the proximal region of the polypary, but acquiring the more typical *Orthograptus* characters towards its distal extremity with great overlap and undulating apertural margins.

*Description*.—The polypary is often of considerable length, but is quite narrow in the proximal region, where it never exceeds 1·2 mm. in breadth; it widens rapidly, however, in the first 1·5 cm. of its growth to attain its maximum breadth, which is then usually maintained for the greater part of its extent, though there is a tendency in some specimens to narrow distally.

The sicula has a length of only 1 mm. Th. 1<sup>1</sup> originates close to the aperture and grows almost at once outward and upward; it has an everted apertural edge prolonged into a spine, and in this respect differs from all the other thecæ of the proximal region; th. 1<sup>2</sup> grows at first obliquely across the sicula and then directly upward for a short distance, giving off a spine where upward growth commences.

In profile views the remaining thecæ in the proximal region all show the characteristics of those of a *Climacograptus*—viz., pronounced sigmoid curvature

of the ventral margin, straight but inclined free edge, and concave horizontal or slightly everted apertures. As the polypary grows, however, the sigmoid curvature decreases, the angle of inclination sinks to 30°, and the apertures become more and more everted, until a theca like that of *Orthograptus* is produced; so that while young polyparies and proximal fragments closely resemble those of a *Climacograptus* (except for th. 1<sup>1</sup>), distal fragments have all the characteristics of a typical *Orthograptus*.

In the proximal region the thecæ are small and very closely set, but distally they have a length of

2·5 mm. and overlap two thirds to three fourths of their extent. The flattened tube which runs throughout the polypary and emerges at the distal extremity, is very conspicuous in this species.

*Affinities*.—*M. multidentis* somewhat resembles *Climacog. tubuliferus*, on account of the presence of this broad central tube, and has very frequently been confounded with it. It should, however, be readily distinguished, not only by the progressive

FIG. 178.—*Mesograptus multidentis*, nov.



Proximal end, reverse aspect, in very low relief, showing the appearances presented by the earlier theca. Enlargement of part of specimen on same slab as Pl. XXXI, fig. 9 a.

change in the shape of the thecæ in the different parts of the stipe, but also by their greater number in a given unit of length.

*Horizon and Localities.*—Llandcilo-Bala, *Dicranograptus* Shales.

*Shropshire*: Oakwood, Pontesford. *N. Wales*: Conway Railway Cutting. *S. Wales*: Taff Bridge, St. Clears; Railway S. of Bletherstone, etc.

*Associates, etc.*—*Mesog. multidens* occurs in a fine state of preservation in the Habberley Brook at the Oakwood. It also occurs in *S. Wales*, but the forms are usually somewhat narrower than those from Shropshire, and, when cleaved, bear at first sight a certain resemblance to *Ulimacog. tubuliferus*. The species is commonly associated with *Dicellog. sextans*, *Dicranog. brevicaulis*, *Orthog. acutus*, and *Anplexog. perezcavatus* in the highest Glenkiln and Lowest Hartfell horizons.

*Collections.*—Mr. Benson, Mr. B. Smith, Sedgwick Museum, Geological Survey of England and Wales, Lapworth, and the Authors.

Var. **compactus**, Lapworth. Plate XXXI, figs. 10 *a—c*.

1873. *Diplograptus compactus*, Lapworth, *nom. nudum*, Geol. Mag., vol. x, p. 134.

What appears to be a distinct variety of *Mesog. multidens* occurs commonly at a slightly higher horizon than the typical form, and was distinguished by Lapworth in 1873 as *Diplog. compactus*, but not described or figured. It differs

FIG. 179.—*Mesograptus multidens*, var. *compactus*.



Proximal end, reverse aspect. Enlargement of part of Pl. XXXI, fig. 10 *c*.

from our typical form in the following particulars: (1) the polypary is narrower; (2) the thecæ are smaller; and (3) have less overlap.

The polypary has a length of 5—6 cm., and an average breadth of rather less than 3 mm., which is attained within 2 cm. of the proximal end where the width is about 1 mm. The apertural margins of the two basal thecæ are conspicuously spinose; those of the more distal thecæ are distinctly undulate, and closely resemble those of *Orthog. calcaratus*. The overlap never exceeds one half. As in the typical form, the polypary is furnished with a broad, flattened central tube, which probably contains the virgula.

*Affinities.*—In the characters of the distal thecæ, var. *compactus* approaches *Orthog. calcaratus*. It may, however, be distinguished from the forms belonging to that species by its smaller breadth and the characters of the proximal thecæ.

*Horizon and Localities.*—Lower Hartfell Shales (zone of *Dicranog. Clingani*), *Dicranograptus* Shales.

*S. Scotland*: Dobb's Linn, etc. *S. Wales*: ? Railway S. of Bletherstone.

*Associates, etc.*—Var. *compactus* is a somewhat rare fossil in the Lower Hartfell Shales, occurring in the zone of *Dicranog. Clingani*. It occurs, therefore, at a higher horizon than the typical form, which does not seem to range beyond the basal zone of the Hartfell Shales.

*Collections.*—Lapworth and the Authors.

**Diplograptus (Mesograptus) modestus**, Lapworth. Plate XXXI, figs. 11 *a—c*.

1876. *Diplograptus modestus*, Lapworth, Cat. West. Scott. Foss., pl. ii, fig. 33.

1877. *Diplograptus confertus*, Lapworth, Grapt. Co. Down, pl. vi, fig. 8.

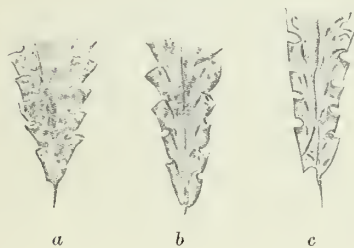
1897. *Diplograptus modestus*, Perner, Grapt. de Bohême, pt. iii, p. 5, pl. x, fig. 8.

1900. *Diplograptus modestus*, H. Lapworth, Quart. Journ. Geol. Soc., vol. lvi, p. 135.

Polypary robust, about 2 cm. in length, with maximum breadth of 3 mm., attained by rapid widening from proximal end. Sicula small, with conspicuous virgella. Thecæ fourteen to twelve in 10 mm.; sigmoid curvature pronounced in both profile views in proximal region, diminishing distally; overlapping one third to one half their length; apertural margins wide, undulate, occupying about one fourth of total breadth of polypary.

*Description.*—The polypary is robust and relatively wide; it may be said to be broadly rounded in the initial region, and the maximum breadth is attained so rapidly that the margins are subparallel almost from the beginning.

FIGS. 180 *a—c*.—*Mesograptus modestus*, Lapw.



*a.* Proximal end, obverse aspect. Enlargement of specimen on same slab as Pl. XXXI, figs. 11 *a, b*, and *d*.

*b.* Reverse aspect. Enlargement of specimen on same slab as Pl. XXXI, fig. 11 *c*.

*c.* Proximal end, impression of obverse side, and sicula. Enlargement of part of Pl. XXXI, fig. 11 *e*.

The sicula is small and relatively broad, and measures about 1 mm.; the virgella may be from 1 to 2 mm. or more in length, and is always fairly stout and therefore conspicuous. Th. 1<sup>1</sup> originates about half-way along the sicula, and grows first downward and then upward and outward, so that its aperture is nearly on a level with the apex of the sicula; while th. 1<sup>2</sup> crosses the sicula obliquely, so as to leave it free for a small fraction of its length on one side. The septum commences between th. 2<sup>2</sup> and th. 2<sup>1</sup>.

The polypary presents several views when compressed. In bi-profile view the *Climacograptus* character of the proximal end is most clearly seen in the obverse aspect, though it is fairly obvious in the reverse also. The excavation is pronounced, and the sigmoid curvature of the ventral walls sharp, though the free edge is often inclined; towards the distal end in this view the excavation, as such, disappears with the diminution of the curvature of the ventral walls.

The commonest and most characteristic view is that given in Fig. 180 *d*, showing apparently that the section of the polypary was somewhat concavo-convex, approximating to that in *Amplexograptus*.

*Affinities*.—Distal fragments of *M. modestus* bear a certain amount of resemblance to *Orthog. vesiculosus* and *O. bellulus*. It is, however, a smaller form than *O. vesiculosus*, and has more closely set thecae; and though resembling *O. bellulus* in these respects, has a proximal end different in its character.

FIG. 180 *d*.—*Mesograptus modestus*,  
Lapw.



*d*

*d*. Distal thecae, characteristic view.  
Enlargement of part of specimen  
on same slab as Pl. XXXI, fig. 11 *c*.

*Horizon and Localities*.—Llandovery, Birkhill Shales, Skelgill Beds, Dyffryn Flags, etc. (zones of *Orthog. vesiculosus* and *Cephalog. acuminatus*).

*S. Scotland*: Dobb's Linn; Frenchland Burn; Belcraig, etc. *Wales*: Rhayader; Pont Erwyd district, Cardiganshire; St. Martin's Cemetery, Pembrokeshire. *Lake District*: Skelgill; Keisley.

*Ireland*: Slate Quarry and Little River, Pomeroy, Co. Tyrone; Donaghadee, Co. Down.

*Associates, etc.*—*Mesog. modestus* is an extremely widespread species, occurring almost everywhere where the Lower Birkhill Shales or their equivalents are known, and being even of commoner occurrence than the zone fossil *Orthog. vesiculosus*; in some localities it occurs in such quantities as to constitute a distinct sub-zone. While occurring most abundantly within the limits of the *Orthog. vesiculosus* zone as originally defined by Lapworth, it occasionally survives into the overlying zone of *Monog. gregarius*; and somewhat smaller forms, which cannot at present be distinguished from the typical species, occur at the base of and throughout the zone of *Cephalog. acuminatus*. Its most usual associates at the typical horizon are *Orthog. vesiculosus*, *Climacog. medius*, *Cl. rectangularis*, *Monog. tenuis*, and various *Dimorphograpti*. At the underlying horizon it occurs with var. *parvulus* and *Glyptog. persculptus*.

*Collections*.—Geological Survey of Scotland, British Museum, Sedgwick Museum, Marr, O. T. Jones, H. Lapworth, Lapworth, and the Authors.

Var. **parvulus** (H. Lapworth). Plate XXXI, figs. 12 *a—d*.

1900. *Climacograptus parvulus*, H. Lapworth, Quart. Journ. Geol. Soc., vol. lvi, p. 131, fig. 20 *a, b*.

The form described by H. Lapworth as *Climacog. parvulus* is an extremely diminutive one, not exceeding 4–5 mm. in length, and possessing only four to six thecae on either side. The thecae in both aspects of the polypary recall those of

a *Climacograptus*, and it was this character which naturally led to its being referred to the genus *Climacograptus*. The free ventral margin of the theca, however,

FIGS. 181 a—c.—*Mesograptus modestus*, var. *parvulus* (H. Lapw.).



a. Reverse aspect, but showing sicula. Enlargement of Pl. XXXI, fig. 12 a.  
 b. Obverse aspect, showing sicula and origin of th. 1<sup>1</sup>. Enlargement of Pl. XXXI, fig. 12 c.  
 c. Ibid. Enlargement of Pl. XXXI, fig. 12 b.

is always slightly inclined, and both in this respect and in others the thecae of var. *parvulus* agree with those typical of the sub-group *Mesograptus*.

All the characters of this diminutive form agree precisely with those of the proximal part of the examples of *Mesog. modestus*, with which it is associated (comp. Figs. 180 c and 181 c). In our opinion, therefore, it can at the most be regarded only as a dwarf variety of that species, one in which the growth of the polypary has been arrested at a very early stage.

The distinction of var. *parvulus* as a separate variety finds support on stratigraphical grounds; for it occurs in abundance in the lowest beds only of the Llandovery in Wales and elsewhere, and is not known to survive into the zone of *Orthog. vesiculosus*, where *Mesog. modestus* itself is most abundant.

*Horizon and Localities*.—Lower Llandovery, Birkhill Shales, Lower Gwastaden Series (zone of *Cephalog. acuminatus*).

*Wales*: Rhayader; Fuches-gau Farm, near Pont Erwyd, Cardiganshire. *S. Scotland*: Dobb's Linn.

*Associates*.—Var. *parvulus* occurs at the base of the *Cephalog. acuminatus* zone in the Pont Erwyd district associated with *Mesog. modestus* and *Glyptog. persculptus*.

*Collections*.—H. Lapworth, O. T. Jones, and the Authors.

Var. *diminutus*, var. nov. Plate XXXI, figs. 13 a—c.

Associated with the typical *Mesog. modestus* there is occasionally found a form resembling it very closely but differing in its smaller size and in having the thecae more closely set. We consider it worthy of varietal distinction.

FIG. 182.—*Mesograptus modestus*, var. *diminutus*, nov.



Proximal end, reverse aspect. Enlargement of part of Pl. XXXI, fig. 13 a.

The length never exceeds 1.5 cm., and the breadth increases quickly from .6 mm. to about 1.5 mm. The thecae present the same peculiarities as those of the typical form, but number sixteen to fourteen in 10 mm.

*Horizon and Localities*.—Llandovery, Birkhill Shales, Skelgill Beds (zone of *Diplog. vesiculosus*).

*S. Scotland*: Dobb's Linn. *Lake District*: Skelgill.

**Diplograptus (Mesograptus) magnus**, H. Lapworth. Plate XXXI, figs. 14 *a*—*c*.

1900. *Diplograptus magnus*, H. Lapworth, Quart. Journ. Geol. Soc., vol. lvi, p. 132, fig. 21.

Polypary thick and robust, 4 cm. or more in length, narrow proximally, but widening for half its length until a maximum breadth of 4 mm. is attained, thence diminishing somewhat distally. Sicula conspicuous; septum nearly complete. Thecae closely set, fourteen to twelve in 10 mm., showing a progressive change of shape in different parts of the polypary, overlapping one half to two thirds their extent; apertural margins undulate, narrow, concave, and everted in bi-profile view.

*Description*.—The polypary is very thick, this being especially noticeable in specimens preserved in relief; it may attain a length of 4 cm. or more, but shorter specimens are of frequent occurrence; it widens fairly quickly till the maximum breadth is attained.

FIGS. 183 *a* and *b*.—*Mesograptus magnus*,  
H. Lapw.



*a*. Proximal end, obverse aspect, showing sicula and origin of th. 1<sup>1</sup>. Ddól Farm, Rhayader; Gwastaden Series (Ddól Shales). Coll. H. Lapworth.  
*b*. Distal thecae, right half in relief, left half an impression. Ibid.

The sicula has a length of 2 mm., and in the obverse aspect th. 1<sup>1</sup> is seen to originate from a point a little distance above the aperture, it grows at first downward, then bends round abruptly to grow outward and upward, while th. 1<sup>2</sup> develops from it, and, growing obliquely across the back of the sicula, leaves it free for a considerable fraction of its length on the right side. The septum is complete on the obverse side, but only makes its appearance at the reverse side between the seventh thecal pair.

All the thecae in the initial region have very pronounced sigmoid curvature of their walls in bi-profile view, but the free outer part is inclined; the general inclination of the theca is about 35° with respect to the axis of the polypary, the overlap is one half, and the apertural margin appears slightly everted. In the distal region the curvature becomes more uniform, the length of the thecae increases up to 3 mm., the overlap to two thirds their length, and the apertural margins appear still more decidedly everted.

When compressed, the thecae of the proximal region show some points of resemblance to those of a *Climacograptus*, while the distal thecae suggest those of a *Petalograptus*.

*Affinities*.—Distal fragments of *M. magnus* thus resemble similar portions of many *Petalograpti*, but the polypary is not tabular, the thecae are more closely set, and in the case of more or less perfect specimens the character of the proximal thecae serves as a further distinguishing feature.

*Horizon and Localities.*—Llandoverly, Birkhill Shales, Gwastaden Flags (zones of *Monog. gregarius* and *M. convolutus*).

*Wales:* Rhayader; River Twymyn, Llanbryn-mair; Rheidol Gorge, below Pont Erwyd; Llanystumdwy. *S. Scotland:* Dobb's Linn, etc. *Ireland:* Little River, Pomeroy, Co. Tyrone. *Lake District:* Skelgill.

*Associates, etc.*—*Mesog. magnus* occurs not uncommonly in the Birkhill Shales and their equivalents (zones of *Monog. gregarius* and *Monog. convolutus*); it is usually associated with *Monog. gregarius*, *M. convolutus*, *M. fimbriatus*, *M. jaculum*, *Climacog. Hughesi*, and *Cl. Törnquisti*.

*Collections.*—H. Lapworth, O. T. Jones, Fearn-sides, and the Authors.

## GROUP II.

*Mesograpti* in which the thecæ were semicircular in section and the apertural margins undulate; excavations deep and conspicuous in the obverse aspect throughout.

= *Amplexograptus*.

**Diplograptus (Amplexograptus) perexcavatus**, Lapworth. Plate XXXI, figs. 15 a—d.

1876. *Diplograptus perexcavatus*, Lapworth, Cat. West. Scott. Foss., pl. ii, fig. 38.

1877. *Climacograptus perexcavatus*, Lapworth, Grapt. Co. Down, p. 140, pl. vi, fig. 35.

1880. *Diplograptus perexcavatus*, Lapworth, Ann. Mag. Nat. Hist. [5], vol. v, p. 167, pl. v, fig. 25.

Polypary short and fairly broad, 1 to 4 cm. in length, with average breadth of 2 to 2.5 mm. for greater part of length. Sicular 2 mm. in extent, virgella conspicuous. Thecæ sixteen to twelve in 10 mm., basal ones with short spines unsymmetrically disposed; in the *obverse* aspect, of the general *Climacograptus* type, with sigmoid curvature of ventral margin, and wide, deep and conspicuous excavations occupying one half the breadth of the polypary and fully one half its ventral margin; in the *reverse* aspect, of the general *Glyptograptus* or *Orthograptus* type, with less pronounced sigmoid curvature of the ventral margin, inconspicuous excavations, and having the apertural margins somewhat oblique.

*Description.*—The polypary varies greatly in size, but is always fairly robust; the breadth commonly measures 2 to 2.5 mm.; there is some diminution in width towards the proximal end, which has the appearance of being rounded off.

The sicular appears to have had a length of 2 mm., but its full extent is rarely visible in the adult polypary; th. 1<sup>1</sup> originates some distance up the sicular,

grows downward to its aperture, and thence slightly upward and outward, giving off a spine at the mesial angle. Th. 1<sup>2</sup> grows across the sicula almost horizontally

FIGS. 184 *a* and *b*. — *Amplexograptus perexcavatus*, Lapw.



*a*. Proximal end, obverse aspect, showing part of sicula and origin of th. 1<sup>1</sup>. Figured Lapworth, Ann. Mag. Nat. Hist. [5], vol. v, pl. v, fig. 25 e. Dobb's Linn, Glenkiln Shales. Coll. Lapworth.  
*b*. Proximal end, reverse aspect. Ibid.

appearance intermediate in character between those of *Orthograptus* and *Glyptograptus*, the free edge of the theca being

FIGS. 184 *c* and *d*. — *Amplexograptus perexcavatus*, Lapw.



*c*. Distal thecae, obverse aspect, showing deep and conspicuous excavations like those in *Climacograptus*. Enlargement of part of Pl. XXXI, fig. 15 a.  
*d*. Distal thecae, reverse aspect (part in relief, part as an impression), showing *Diplograptus* appearance, Dobb's Linn, Glenkiln Shales. Coll. Lapworth.

rounded and inclined and only a short portion of the impressed edge being left visible; the apertural margin is slightly concave and oblique. In this aspect the overlap is conspicuous, the ventral wall extending almost to the central line of the polypary, so that the thecae overlap for fully one half their length, and their distinctly alternate arrangement is clearly brought out.

Occasionally an intermediate view is presented, having the appearance shown in Pl. XXXI, fig. 15 *c*, where the apertural margin is shown as distinctly convex.

In neither obverse nor reverse aspect is there any trace of a septal suture.

*Affinities*.—*A. perexcavatus* is clearly allied to the American species, *Diplog. amplexicaulis*, Hall, and probably also to *Glyptog. teretiusculus*. From *G. teretiusculus* it may, however, be readily separated by the pronounced concavo-convex section of the polypary, and the fact that in the obverse aspect the thecae approximate more closely to the *Climacograptus* type. *A. perexcavatus* may be separated from *D. amplexicaulis* by its smaller size and greater relative width, and the characters of the distal portions of the thecae.

*Horizon and Localities*.—Glenkiln Shales and Lower Hartfell Shales (zones of (1) *Nemag. gracilis*, (2) *Dicellog. patulosus*, (3) *Climacog. Wilsoni*).

*S. Scotland*: Glenkiln Burn; Black Linn; Craigmichan Seours; Dobb's Linn; Berrybush Burn; Leadhills. *Wales*: Llandrindod Wells; Tiddyndicwm; St.

Catherine's Bridge, Haverfordwest; Llandewi Velfrey; Trelydan Dingle, Welshpool. *Ireland*: Ballygrot; Coalpit Bay.

*Associates, etc.*—*A. perexcavatus* is a very abundant fossil in the Glenkiln Shales of S. Scotland and Wales, where it occurs associated with *Nemag. gracilis*, *Dicellog. sextans*, *Glyptog. teretiusculus* var. *euglyphus*, *Climacog. Scharenbergi*, *Cl. bicornis*, *Cl. peltifer*, etc.; it also occurs, but not so abundantly, in the zone of *Climacog. Wilsoni*, at the base of the Hartfell Shales, where it is found with *Cl. Scharenbergi*, *Cl. bicornis*, and *Cl. Wilsoni*.

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

**Diplograptus (Amplexograptus) confertus** (Lapworth). Plate XXXI, figs. 18 *a—e*.

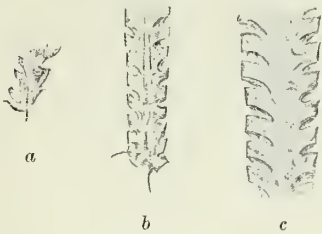
1875. *Climacograptus confertus*, Lapworth, Quart. Journ. Geol. Soc., vol. xxxi, p. 655, pl. xxxiv, figs. 4 *a—f*.

1880. *Climacograptus confertus*, Lapworth, Ann. Mag. Nat. Hist. [5], vol. v, p. 169, pl. iv, figs. 15 *a—c*.

Polypary characteristically small, rarely exceeding 2.5 cm. in length, and having an average uniform breadth of from 1—2 mm. Sicula 1 mm. (?) in length. Thecae sixteen to twelve in 10 mm.; in obverse aspect, with wide pouch-shaped excavations, declined towards the axis and occupying one third the breadth of the polypary; in reverse aspect, ventral margin rounded; apertural margin concave and oblique, denticle sharp.

*Description.*—The polypary varies very much in size. An average specimen is about 2 cm. in length and has a width of 1.5 mm., but small specimens having a

FIGS. 185 *a—c.*—*Amplexograptus confertus* (Lapw.).



*a.* Fragment of proximal end, obverse aspect. Old Quarry, Dan-yr-allt, Carmarthenshire; Upper Arenig Beds (zone of *Didymog. bifidus*). Geol. Survey of England and Wales.

*b.* Proximal end, reverse aspect. Enlargement of part of one of specimens figured on Pl. XXXI, fig. 18 *d*.

*c.* Distal thecae, obverse aspect, showing deep and oblique excavations. Enlargement of part of Pl. XXXI, fig. 18 *e*.

length of 1 cm. and a breadth of 1 mm. are not uncommon, and occasionally examples are found which measure as much as 4 cm. in length and are 2 mm. wide. There is a slight diminution in the width of the polypary towards the proximal end, but its margins are parallel for the greater part of its length.

The sicula is rarely seen, but it appears to have had a length of about 1 mm., and the virgella is slender but conspicuous. Th. 1<sup>1</sup> originates near the apex of the sicula and grows down to the aperture before bending outward and slightly upward. Both th. 1<sup>1</sup> and th. 1<sup>2</sup> possess sub-apertural spines.

The thecae number sixteen to twelve in 10 mm.; they have an average length of 1 mm., and, in the obverse aspect of the polypary, exhibit the sharp

sigmoid curvature so characteristic of those of the sub-genus *Amplexograptus*. The free part of the ventral wall is straight and slightly inclined, and the excavation is deep and oblique, but narrower than in *A. perezcaratus*.

Lapworth notes the occasional presence of a "rudimentary proximal spine" on each theca, but we have not been able to prove its existence with certainty.

*Affinities.*—*A. confertus* is closely allied to *Amplexog. perezcaratus*, but it may be distinguished by the smaller size and general form of the polypary, and by the introverted and narrower apertural excavations.

*Horizon and Localities.*—Lower Llanvirn (zone of *Didymog. bifidus*).

*Wales:* Porth-Hayog, Ramsey Island; Lampeter Velfrey; Llan Mill, near Whitland; Ffairfach Station, Llandeilo, etc.; Pont Sciont, Carnarvonshire.

*Associates, etc.*—*Amplexog. confertus* is a fairly common fossil in the zone of *Didymog. bifidus* in North and South Wales. It occurs associated with *D. bifidus*, *D. artus*, *D. acutidens*, and *D. patulus*.

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

**Diplograptus (Amplexograptus) cœlatus** (Lapworth). Plate XXXI, figs. 17 a—c.

1875. *Climacograptus cœlatus*, Lapworth, Quart. Journ. Geol. Soc., vol. xxxi, p. 655, pl. xxxv, fig. 8.

Polypary 5—6 cm. or more in length, widening fairly rapidly to a maximum breadth of 3·2 mm., and having parallel margins for the remainder of its extent. Sicula unknown, virgella and virgula of considerable length. Thecæ long and slender, ten to eight in 10 mm.; in the obverse aspect, ventral wall sigmoid, apertural margins slightly undulate, situated in short

FIG. 186. — *Amplexograptus cœlatus* (Lapw.).



Distal thecæ, showing a typical *Diplograptus* appearance on the left side and a *Climacograptus* appearance on the other. Enlargement of part of Pl. XXXI, fig. 8 b.

and shallow excavations occupying but a small fraction of the width of the polypary, and less than one fourth of the ventral margin; in the reverse aspect, denticle sharp and angle of inclination high with respect to the axis of the polypary.

*Description.*—The polypary is usually of considerable extent; the proximal end is about 1—1·5 mm. broad, but the maximum width is generally attained within the first cm. of its length and is continued up to the distal extremity. The virgula is greatly prolonged distally, and there is also a very long proximal prolongation (? virgella), sometimes as long as the polypary itself, which is thickened by a membrane for a distance of 2—3 mm. below the proximal end.

The two basal thecæ appear to have apertural spines, and in the obverse aspect, as usual, the distal thecæ show a characteristic *Climacograptus* form, but the upper edge of the excavation is abrupt even for this group, and its angle sometimes appears to carry a small spine, while the apertural margins are somewhat introverted. In the reverse aspect, which is less commonly met with, the thecæ have rather the appearance of those of an *Orthograptus*, but with slight introversion of the apertural margin.

*Affinities.*—Of all the species grouped by us in *Amplexograptus*, *A. cœlatus* most nearly resembles a *Climacograptus*. In the form of the polypary and in the characters of its thecæ it approximates to *Climacog. typicalis* of Hall, as figured in his "Graptolites of Quebec Group," 1865, p. 57, pl. A, figs. 1—9; but in the absence of figures or descriptions of the complete polypary it is impossible to decide if our form is identical with his. It is allied to *Amplexog. arctus*, but is a much more robust form and has remoter thecæ.

*Horizon and Localities.*—Llandeilo (zone of *Didymog. Murchisoni*).

*S. Wales*: Aberreiddy Bay; Blaen-y-delyn Quarry, Fishguard.

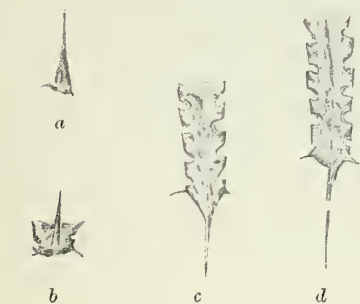
*Associates, etc.*—Lapworth's type specimens all come from Aberreiddy Bay, where *Amplexog. cœlatus* occurs associated with *Didymog. Murchisoni*, *Orthog. calcaratus*, var. *priscus*, and other forms.

*Collections.*—Sedgwick Museum and Mr. F. R. C. Reed.

### **Diplograptus (Amplexograptus) arctus**, sp. nov. Plate XXXI, figs. 16 *a—d*.

Polypary typically small, about 2 cm. in length, widening almost imperceptibly to a breadth of about 1 mm. Sicula 1·5 mm. in length, with very long

FIGS. 187 *a—d*.—*Amplexograptus arctus*,  
sp. nov.



*a*. Sicula and th. 11, on same slab as Pl. XXXI, fig. 16 *d*.

*b*. Sicula and four earliest thecæ. Ibid.

*c*. Proximal end of adult specimen, obverse aspect. Enlargement of part of Pl. XXXI, fig. 16 *b*.

*d*. Ibid. Enlargement of part of specimen on same slab as Pl. XXXI, figs. 16 *b* and *c*.

virgella; basal thecæ with conspicuous lateral spines unsymmetrically disposed. Thecæ of the general *Amplexograptus* type, long and slender, fourteen to ten in 10 mm.; overlap slight, not exceeding one half their extent.

*Description.*—The polypary is characteristically small, but some individuals are known which have a length of 3 cm. or more, and widen very gradually to a maximum breadth of 1·5 mm. from an initial width of ·8 mm. The smaller forms in which the breadth barely exceeds 1 mm. distinctly predominate.

The sicula is slender, and its apex passes so insensibly into the nema that it is difficult to deter-

FIGS. 187 *e* and *f*.—*Amplexograptus arctus*, sp. nov.



- e*. Distal thecæ, obverse aspect, showing deep excavations. Enlargement of part of specimen on same slab as Pl. XXXI, fig. 16 *d*.  
*f*. Distal thecæ, reverse aspect, showing their commonest appearance. Enlargement of part of another specimen on same slab as Pl. XXXI, fig. 16 *d*.

mine its exact length. The virgella is very long, being fully 8 mm. in extent, with a membrane in its initial portion; the spines on the basal thecæ are 1 mm. in length in the obverse aspect of the polypary, but are somewhat foreshortened in the reverse aspect. The thecæ are of the general *Amplexograptus* type, but the difference in the obverse and reverse aspects of the polypary is not so great as in *Amplexog. pereexcavatus*, and presumably, therefore, the polypary was not so decidedly concavo-convex in section.

The commonest view is that showing the reverse aspect (Fig. 187 *f*), when the free edge is seen to be somewhat rounded, and the apertural margins somewhat introverted, the excavation occupying one third

of the width of the polypary, and one half to one third of its ventral margin. In the obverse aspect the excavations are more conspicuous, the free edge of the thecal wall is straight, and makes a sharp angle with the impressed edge (Fig. 187 *e*).

*Affinities*.—*A. arctus* is undoubtedly closely related to *Amplexog. cœlatus*, but differs in its smaller size, and in having more closely-set thecæ. From *Amplexog. pereexcavatus*, to which it presents some resemblances, it differs in having (*a*) a narrower and less concavo-convex polypary, (*b*) rather more remote thecæ, and (*c*) a long virgella.

*Horizon and Locality*.—Llandeilo-Bala, *Dicranograptus* Shales.

*S. Wales*: Spittal Road Railway Cutting, near Clarbeston Road; Pan-têg.

*Associates, etc.*—*Amplexog. arctus* has a gregarious habit, and occurs in great profusion in a single bed in the Lower *Dicranograptus* Shales, where it is associated with *Dicellog. seatans*, *Glyptog. teretiusculus*, var. *euglyphus*, and other forms.

*Collections*.—Geological Survey of England and Wales, and the Authors.

PLATE XXVIII.

Sub-genus **Orthograptus**.

FIGS.

- 1 *a—d.*—*Orthograptus quadrinucronatus* (Hall). (Page 223.)
- 1 *a.* Typical specimen, characteristic sub-scalariform view. Mt. Benger Burn, S. Scotland. Hartfell Shales. Lapworth's Collection.
  - 1 *b.* Specimen showing distal prolongation of virgula, dominant bi-profile view. Hartfell Spa. Hartfell Shales. Wood's Collection.
  - 1 *c.* Bi-profile view, spines fore-shortened. Mt. Benger Burn. Hartfell Shales. Lapworth's Collection.
  - 1 *d.* Large specimen, dominant bi-profile view. Hartfell Spa. Hartfell Shales. Lapworth's Collection.
- 2 *a—d.*—*Orthograptus quadrinucronatus*, var. *spinigerus*, Lapworth. (Page 225.)
- 2 *a.* Long typical specimen. Hartfell Spa. Hartfell Shales. Lapworth's Collection.
  - 2 *b.* Smaller specimen, showing six large spines. Ibid.
  - 2 *c.* Typical specimen, bi-profile view. Ibid.
  - 2 *d.* Small specimen, characteristic sub-scalariform view. Mt. Benger Burn. Hartfell Shales. Lapworth's Collection.
- 3 *a—c.*—*Orthograptus Pageanus*, Lapworth. (Page 225.)
- 3 *a.* Complete and typical specimen. Hartfell Spa. Hartfell Shales. Lapworth's Collection.
  - 3 *b.* Smaller specimen. Ibid.
  - 3 *c.* Ditto. On same slab as fig. 3 *b.*
- 4 *a—c.*—*Orthograptus Pageanus*, var. *micracanthus*, Elles and Wood, nov. (Page 226.)
- 4 *a.* Typical specimen with virgular tube split. Hartfell Spa. Hartfell Shales (zone of *Dicranog. Clingani*). Lapworth's Collection.
  - 4 *b.* Specimen slightly narrowed by compression. Ibid.
  - 4 *c.* Two specimens in natural position on rock. Ibid.
- 5 *a.*—*Orthograptus Pageanus*, var. *abnormispinosus*, Elles and Wood, nov. (Page 226.)
- 5 *a.* Group of specimens in natural position showing typical form. Hartfell Spa. Hartfell Shales. Lapworth's Collection.

PLATE XXVIII (*continued*).

FIGS.

6 *a—d.*—*Orthograptus Whitfieldi* (Hall). (Page 227.)

- 6 *a.* Incomplete, but typical, specimen. Rein Gill, Abington. Glenkiln Shales. Geological Survey of Scotland, Edinburgh.
- 6 *b.* Characteristic specimen, with long virgella. Berrybush Burn, St. Mary's Loch. Glenkiln Shales. Geological Survey of Scotland.
- 6 *c.* Broad distal fragment. Beleraig Burn. Glenkiln Shales. Geological Survey of Scotland.
- 6 *d.* Small proximal fragment. Tiddyndicwm, N. Wales. Llandeilo Beds. Sedgwick Museum.

7 *a—c.*—*Orthograptus insectiformis*, Nicholson. (Page 228.)

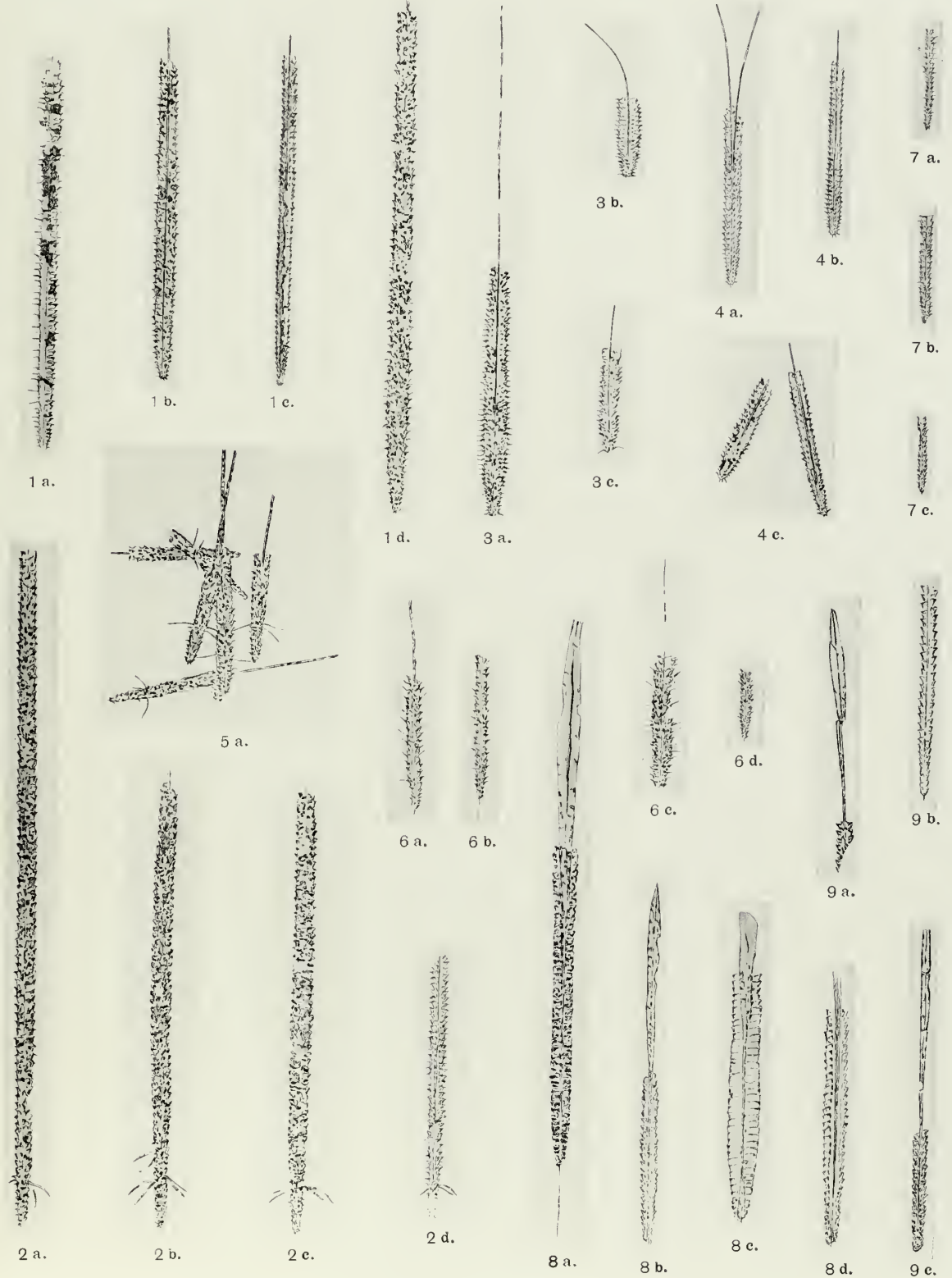
- 7 *a.* Typical, but incomplete, specimen. Dobb's Linn. Birkhill Shales (zone of *Mouog. gregarius*). Lapworth's Collection.
- 7 *b.* Somewhat broader distal fragment. *Ibid.*
- 7 *c.* Small, incomplete specimen. *Ibid.*

8 *a—d.*—*Orthograptus vesiculosus*, Nicholson. (Page 229.)

- 8 *a.* Typical and complete specimen, "bi-scalariform" view. Coalpit Bay, Co. Down. Lower Birkhill Beds. Museum of Natural History Society, Belfast.
- 8 *b.* Small, complete specimen, showing sicula. Dobb's Linn. Birkhill Shales (zone of *Orthog. vesiculosus*). Lapworth's Collection.
- 8 *c.* Broad specimen, "bi-scalariform" view, obverse aspect. *Ibid.*
- 8 *d.* Well-preserved specimen, sub-scalariform view. North end of Clanyard Bay, Drummore, Wigtown. Lower Birkhill Shales. Geological Survey of Scotland.

9 *a—c.*—*Orthograptus vesiculosus*, var. *pennae*, Hopkinson. (Page 231.)

- 9 *a.* Type specimen, incomplete, figured Hopkinson, 'Geol. Mag.,' 1872, vol. ix, pl. xii, fig. 6. Frenchland Burn, Moffat. Lower Birkhill Shales. Sedgwick Museum.
- 9 *b.* Incomplete specimen. Keisley, Westmoreland. Llandovery. Fearnside's Collection.
- 9 *c.* Complete typical specimen. Frenchland Burn? Lower Birkhill Shales. Geological Survey of Scotland.



ORTHOGRAPTUS.



PLATE XXIX.

Sub-genus **Orthograptus**.

FIGS.

- 1 *a—d.*—*Orthograptus mutabilis*, Elles and Wood, nov. (Page 232.)
- 1 *a.* Large typical specimen, reverse aspect. Dobb's Linn. Birkhill Shales. Lapworth's Collection.
  - 1 *b.* Smaller specimen, obverse aspect. On same slab as fig. 1 *a.*
  - 1 *c.* Short, broad specimen, reverse aspect. Ibid.
  - 1 *d.* Distal portion, compressed, doubtfully referable to this species. Ibid.
- 2 *a—e.*—*Orthograptus bellulus*, Törnquist. (Page 231.)
- 2 *a.* Typical specimen, showing long virgella. Dobb's Linn. Upper Birkhill Shales (*Monog. Clingani* band). Geological Survey of Scotland.
  - 2 *b.* Narrower specimen. Ibid. Lapworth's Collection.
  - 2 *c.* Ibid.
  - 2 *d.* Well-preserved specimen. Plewlands Burn, Raehills, Moffat. Birkhill Shales. Geological Survey of Scotland.
  - 2 *e.* Small specimen in relief, reverse aspect. Skelgill, Ambleside. Stockdale Shales. British Museum (Natural History), S. Kensington.
- 3 *a—e.*—*Orthograptus truncatus*, Lapworth. (Page 233.)
- 3 *a.* Typical specimen. Mount Benger Burn. Hartfell Shales (zone of *Dicranog. Clingani*). Lapworth's Collection.
  - 3 *b.* Ditto. On same slab as fig. 3 *a.*
  - 3 *c.* Smaller form, showing more gradual increase in width. Dobb's Linn. Hartfell Shales (zone of *Dicranog. Clingani*). Geological Survey of Scotland.
  - 3 *d.* Characteristic form. Hartfell Spa. Hartfell Shales (zone of *Dicranog. Clingani*). Wood's Collection.
  - 3 *e.* Ditto. Elles' Collection.
- 4 *a—e.*—*Orthograptus truncatus*, var. *intermedius*, Elles and Wood, nov. (Page 236.)
- 4 *a.* Short, but typical specimen. Hartfell. Lower Hartfell Shales (zone of *Climacog. Wilsoni*). Lapworth's Collection.
  - 4 *b.* Long distal portion. Ibid. Elles' Collection.
  - 4 *c.* Proximal portion, reverse aspect. On same slab as fig. 4 *b.*
  - 4 *d.* Very long, complete specimen. Hartfell Shales (zone of *Dicranog. Clingani*). Lapworth's Collection.
  - 4 *e.* Long distal portion. Hartfell Shales (zone of *Climacog. Wilsoni*). Wood's Collection.

PLATE XXIX (*continued*).

FIGS.

5 *a—d.*—*Orthograptus truncatus*, var. *pauperatus*, Lapworth MS. (Page 237.)

- 5 *a.* Small characteristic specimen, reverse aspect. Hartfell Spa. Hartfell Shales (zone of *Dicranog. Clingani*). Lapworth's Collection.
- 5 *b.* Ditto. Dobb's Linn. Hartfell Shales. Dr. Fraser's Collection.
- 5 *c.* Smaller specimen. Hartfell Spa. Hartfell Shales. Lapworth's Collection.
- 5 *d.* Ditto. On same slab as fig. 5 *c.*

6 *a—e.*—*Orthograptus truncatus*, var. *abbreviatus*, Elles and Wood, nov. (Page 235.)

- 6 *a.* Typical specimen, obverse aspect, well preserved. Dobb's Linn. Upper Hartfell Shales (zone of *Dicellog. anceps*). Elles' Collection.
- 6 *b.* Compressed specimen. Belcraig Burn. Hartfell Shales (zone of *Dicellog. anceps*). Elles' Collection.
- 6 *c.* Distal portion. Dobb's Linn. Hartfell Shales (zone of *Dicellog. anceps*). Wood's Collection.
- 6 *d.* Fairly complete specimen. On same slab as fig. 6 *c.*
- 6 *e.* Long narrow specimen, probably referable to this variety. Dobb's Linn. Lower Birkhill Shales. Wood's Collection.

7 *a—e.*—*Orthograptus truncatus*, var. *socialis*, Lapworth. (Page 237.)

- 7 *a.* Typical specimen, obverse aspect. Dobb's Linn. Upper Hartfell Shales (zone of *Dicellog. complanatus*). Lapworth's Collection.
- 7 *b.* Long specimen. Ibid.
- 7 *c.* Small specimen. Ibid.
- 7 *d.* Broad specimen. Ibid.
- 7 *e.* Characteristic form. Ibid.

8 *a—c.*—*Orthograptus cyperoides*, Törnquist. (Page 238.)

- 8 *a.* Relatively large specimen, obverse aspect. Dobb's Linn (Long Cliff). Birkhill Shales (zone of *Monog. gregarius*). Elles' Collection.
- 8 *b.* Characteristic form, reverse aspect. Ibid.
- 8 *c.* Small specimen, obverse aspect. Ibid.



ORTHOGRAPTUS.



PLATE XXX.

Sub-genera **Orthograptus** and **Glyptograptus**.

FIGS.

- 1 *a—c.*—*Orthograptus calcaratus*, Lapworth. (Page 239.)
- 1 *a.* Typical specimen. Dobb's Linn. Lower Hartfell Shales. Lapworth's Collection.
  - 1 *b.* Narrow specimen, compressed. Ibid.
  - 1 *c.* Shorter and broader specimen. Ibid.
- 2 *a—d.*—*Orthograptus calcaratus*, var. *basilicus*, Lapworth. (Page 243.)
- 2 *a.* Typical specimen, obverse aspect. Hartfell Spa. Hartfell Shales. Lapworth's Collection.
  - 2 *b.* Smaller complete specimen. Dobb's Linn. Hartfell Shales. Lapworth's Collection.
  - 2 *c.* Complete specimen showing characteristic view. Hartfell Spa. Hartfell Shales (zone of *Dicranog. Clingani*). Lapworth's Collection.
  - 2 *d.* Smaller specimen. On same slab as 2 *c.*
- 3 *a—c.*—*Orthograptus calcaratus*, var. *acutus*, Lapworth MS. (Page 242.)
- 3 *a.* Typical specimen, obverse aspect. Birnock, Leadhills. Glenkiln Shales. Lapworth's Collection.
  - 3 *b.* Characteristic specimen, somewhat distorted. Ibid.
  - 3 *c.* Smaller specimen. Deugh Water, Knockingarroch, Carsphairn. Glenkiln Shales. Geological Survey of Scotland, Edinburgh.
- 4 *a—c.*—*Orthograptus calcaratus*, var. *tennicornis*, Elles and Wood, nov. (Page 243.)
- 4 *a.* Small specimen. Morroch Bay, two miles south of Portpatrick. Lower Hartfell Shales. Geological Survey of Scotland.
  - 4 *b.* Specimen showing long virgula. On same slab as 4 *a.*
  - 4 *c.* Typical specimen, complete. Ibid.
- 5 *a—d.*—*Orthograptus calcaratus*, var. *vulgatus*, Lapworth MS. (Page 241.)
- 5 *a.* Distal part of characteristic specimen. Hartfell Spa. Lower Hartfell Shales (zone of *Climacog. Wilsoni*). Lapworth's Collection.
  - 5 *b.* Proximal portion, reverse aspect. On same slab as fig. 5 *a.*
  - 5 *c.* Complete specimen, obverse aspect. Hartfell Spa. Lower Hartfell Shales (zone of *Climacog. Wilsoni*). Wood's Collection.
  - 5 *d.* Typical specimen, obverse aspect. On same slab as Pl. XXIX, figs. 4 *b* and *c.* Elles' Collection.

PLATE XXX—*continued*.

FIGS.

- 6 *a—c*.—*Orthograptus calcaratus*, var. *priscus*, Elles and Wood, nov. (Page 244.)  
 6 *a*. Small narrow specimen, compressed, reverse aspect. Figured, Hopkinson and Lapworth, 'Quart. Journ. Geol. Soc.,' 1875, vol. xxxi, pl. xxxv, fig. 7 *b*. Aberciddy Bay. Llandeilo (zone of *Didymog. Murchisoui*). Sedgwick Museum.  
 6 *b*. Long, incomplete specimen, showing characteristic view of thecae. *Ibid.*, fig 7 *c*.  
 6 *c*. Small broad specimen, compressed. *Ibid.*, fig. 7 *a*.
- 7 *a—d*.—*Orthograptus rugosus*, var. *apiculatus*, Elles and Wood, nov. (Page 245.)  
 7 *a*. Typical specimen, preserved in low relief, obverse aspect. Laggan Gill, Girvan. Ardwell Beds. Geological Survey of Scotland.  
 7 *b*. Smaller perfect specimen, reverse aspect. *Ibid.*  
 7 *c*. Larger specimen, reverse aspect. On same slab as 7 *b*.  
 7 *d*. Small specimen. *Ibid.* Lapworth's Collection.
- 8 *a—d*.—*Glyptograptus tamariscus*, Nicholson. (Page 247.)  
 8 *a*. Small characteristic specimen. Duffkinnel. Birkhill Shales. Geological Survey of Scotland.  
 8 *b*. Broader and longer specimen. Dobb's Linn. Birkhill Shales. Wood's Collection.  
 8 *c*. Characteristic specimen. Dobb's Linn. Birkhill Shales. Lapworth's Collection.  
 8 *d*. Specimen on cleaved rock, reverse aspect. Belcraig Burn. Birkhill Shales. Elles' Collection.
- 9 *a—d*.—*Glyptograptus tamariscus*, var. *incertus*, Elles and Wood, nov. (Page 249.)  
 9 *a*. Characteristic specimen, incomplete. Dobb's Linn. Upper Birkhill Shales. Sedgwick Museum.  
 9 *b*. Ditto. Dobb's Linn. Upper Birkhill Shales. Lapworth's Collection.  
 9 *c*. Somewhat distorted specimen. Garple Linn, Moffat. Birkhill Shales. Lapworth's Collection.  
 9 *d*. "Bi-scalariform" view. On same slab as Fig. 9 *c*.
- 10 *a—c*.—*Glyptograptus serratus*, Elles and Wood, sp. nov. (Page 249.)  
 10 *a*. Typical specimen. Belcraig Burn. Birkhill Shales. Wood's Collection.  
 10 *b*. Broader specimen showing virgula, obverse aspect. *Ibid.*  
 10 *c*. Ditto, reverse aspect. On same slab as fig. 10 *b*.
- 11 *a, b*.—*Glyptograptus serratus*, var. *barbatus*, Elles and Wood, nov. (Page 250.)  
 11 *a*. Typical specimen. Pary's Mount, Anglesea. Birkhill Shales (zone of *Monog. Sedgwickii*). Greenly's Collection.  
 11 *b*. Somewhat narrower specimen. *Ibid.*



ORTHOGRAPTUS AND GLYPTOGRAPTUS.



PLATE XXXI.

Sub-genera **Glyptograptus**, **Mesograptus**, and **Amplexograptus**.

FIGS.

- 1 *a—e.*—*Glyptograptus teretiusculus* (Hisinger). (Page 250.)  
 1 *a.* Characteristic specimen, well preserved. Wellfield, Builth. Llandeilo Beds. Lapworth's Collection.  
 1 *b.* Broader specimen, showing characteristic view of theca. Pencerrig, near Builth. Llandeilo Beds. Sedgwick Museum.  
 1 *c.* Exceptionally long specimen, sub-scalariform view. Builth Road, Gwern-y-fed-fach. Llandeilo Beds. Fraser's Collection.  
 1 *d.* Specimen showing characteristic form. Ibid.  
 1 *e.* Small specimen. Ibid.
- 2 *a—d.*—*Glyptograptus teretiusculus*, var. *euglyphus* (Lapworth). (Page 252.)  
 2 *a.* Characteristic broad form. Cairn Ryan, Wigtown. Glenkiln Shales. Sedgwick Museum.  
 2 *b.* Long, narrow specimen, showing virgula, bi-profile view. Cross Burn at Ward, Barrhill. Glenkiln Shales. Geological Survey of Scotland.  
 2 *c.* Broad specimen, sub-scalariform view. Deugh Water, Knockingarroch, Carsphairn. Glenkiln Shales. Geological Survey of Scotland.  
 2 *d.* Long distal fragment, showing typical form. Birnock Water, Abington. Glenkiln Shales. Lapworth's Collection.
- 3 *a—d.*—*Glyptograptus teretiusculus*, var. *siccatus*, Elles and Wood, nov. (Page 253.)  
 3 *a.* Long distal fragment. Gwern-y-fed-fach, near Builth. Llandeilo Beds. Elles' Collection.  
 3 *b.* Complete small specimen, sub-scalariform view. On same slab as fig. 3 *a.*  
 3 *c.* Small distal fragment, sub-scalariform view. Gwern-y-fed-fach. Llandeilo Beds. Elles' Collection.  
 3 *d.* Small specimen, bi-profile view. Ibid.
- 4 *a—d.*—*Glyptograptus dentatus* (Brongniart). (Page 253.)  
 4 *a.* Specimen figured, Lapworth, 'Quart. Journ. Geol. Soc.,' 1875, vol. xxxi, pl. xxxiv, fig. 5 *c.* Llanvirn Quarry. Lower Llanvirn Beds (zone of *Didymog. bifidus*). Sedgwick Museum.  
 4 *b.* Long specimen, preserved as an impression, showing characteristic appearance. Gilfach-wen, near Clynderwen Station. Upper Arenig Beds (zone of *Didymog. bifidus*). Geological Survey of England and Wales.  
 4 *c.* Small specimen, bi-profile view. Rhyd-y-behan Cottage, near Clynderwen Station. Ibid.  
 4 *d.* Ditto. Cefin-farchen Farmyard, near Llanfallteg Station. Ibid.
- 5.—*Glyptograptus dentatus*, var. *appendiculatus*, Elles. (Page 255.)  
 5. Type specimen. Figured, Elles, 'Quart. Journ. Geol. Soc.,' 1898, vol. liv, p. 518, fig. 30. Sedgwick Museum.
- 6 *a—c.*—*Glyptograptus sinuatus*, Nicholson. (Page 255.)  
 6 *a.* Complete and typical specimen, in relief. Cliff above Lower Bridge, Skelgill. Skelgill Beds. Sedgwick Museum.  
 6 *b.* Specimen in relief. Skelgill, Ambleside. Skelgill Beds. Sedgwick Museum.  
 6 *c.* Typical specimen in Nicholson's original Collection. Skelgill, Ambleside. Skelgill Beds. British Museum (Natural History), S. Kensington.
- 7 *a—c.*—*Glyptograptus persculptus*, Salter. (Page 257.)  
 7 *a.* Typical specimen in relief, obverse aspect. Gogofau, Carmarthen. Lower Llandoverly. Sedgwick Museum.  
 7 *b.* Large specimen in partial relief. Ibid. British Museum (Natural History), S. Kensington.  
 7 *c.* Compressed specimen. Ibid. Sedgwick Museum.
- 8 *a—f.*—*Mesograptus foliaceus* (Murchison). (Page 259.)  
 8 *a.* One of the type specimens. Figured, Murchison, 'Silurian System,' 1839, pl. xxvi, fig. 3. Meadowtown, Shropshire. Llandeilo Flags. Geological Society of London.  
 8 *b.* Another figured specimen on same slab as fig. 8 *a.*  
 8 *c.* Fairly complete specimen. Meadowtown. Llandeilo Flags. Lapworth's Collection.  
 8 *d.* Ditto. Geological Survey of England and Wales.  
 8 *e.* Complete specimen in very low relief. Wooferton Mines, Shropshire. Whittery Shales (?). Lapworth's Collection.  
 8 *f.* Specimen showing proximal end well preserved. Gwern-y-fed-fach, near Builth. Llandeilo Beds. Fraser's Collection.
- 9 *a—d.*—*Mesograptus multidentis*, Elles and Wood, sp. nov. (Page 261.)  
 9 *a.* Typical specimen, well preserved. Oak Wood, Pontesford, Shropshire. Lower Bala Beds. Lapworth's Collection.  
 9 *b.* Long specimen, somewhat narrower. Ibid. Benson's Collection.  
 9 *c.* Long, flattened specimen. St. Clears Bridge, S. Wales. *Dicranograptus* Shales. Elles' Collection.  
 9 *d.* Specimen with virgular tube prolonged distally. Ibid.

PLATE XXXI—continued.

FIGS.

- 10 a—c.—*Mesograptus multidentis*, var. *compactus*, Lapworth. (Page 262.)  
 10 a. Complete specimen, somewhat narrower than usual, reverse aspect. Dobb's Linn. Hartfell Shales (zone of *Dicranog. Clingani*). Lapworth's Collection.  
 10 b. Shorter but broader specimen, showing virgular tube. Ibid.  
 10 c. Specimen showing average width, reverse aspect. Ibid.
- 11 a—e.—*Mesograptus modestus*, Lapworth. (Page 263.)  
 11 a. Typical specimen, showing characteristic appearance. Dobb's Linn. Lower Birkhill Shales (zone of *Orthog. vesiculosus*). Lapworth's Collection.  
 11 b. Large, but incomplete, specimen. On same slab as fig. 11 a.  
 11 c. Specimen with long virgula, somewhat distorted. Ibid. Sedgwick Museum.  
 11 d. Narrower specimen. Ibid. On same slab as figs. 11 a, 11 b.  
 11 e. Part of narrow specimen in partial relief. Fuches-gau Farm, near Pont Erwyd. Lowest Llandovery (base of zone of *Cephalog. acuminatus*). O. T. Jones' Collection.
- 12 a—d.—*Mesograptus modestus*, var. *parvulus* (H. Lapworth). (Page 264.)  
 12 a. Type specimen, reverse aspect, but with surface removed, so as to show sicula. Figured, H. Lapworth, 'Quart. Journ. Geol. Soc.,' 1900, vol. lvi, p. 132, fig. 20 b. Gwastaden, Rhayader. Lower Gwastaden Series (zone of *Cephalog. acuminatus*). H. Lapworth's Collection.  
 12 b. Larger specimen, well preserved, obverse aspect. Fuches-gau Farm, near Pont Erwyd. Lowest Llandovery Beds. O. T. Jones' Collection.  
 12 c. Small, broad specimen, reverse aspect. Ibid.  
 12 d. Incomplete specimen, obverse aspect. Ibid.
- 13 a—c.—*Mesograptus modestus*, var. *diminutus*, Elles and Wood, nov. (Page 265.)  
 13 a. Typical specimen, reverse aspect. Skelgill, Ambleside. Skelgill Beds (*Dimorphograptus* band). Sedgwick Museum.  
 13 b. Complete specimen, bi-profile view. Dobb's Linn. Lower Birkhill Shales. Elles' Collection.  
 13 c. Complete specimen, bi-scalariform view. Dobb's Linn. Lower Birkhill Shales (*Dimorphograptus* band). Lapworth's Collection.
- 14 a—c.—*Mesograptus magnus*, H. Lapworth. (Page 266.)  
 14 a. Type specimen, part in relief, part as an impression. Figured, H. Lapworth, 'Quart. Journ. Geol. Soc.,' 1900, vol. lvi, p. 133, fig. 21 b. Ddôl Farm, Rhayader. Gwastaden Series (zone of *Monog. fimbriatus*). H. Lapworth's Collection.  
 14 b. Smaller specimen in low relief. Rheidol Gorge, below Pont Erwyd, Cardiganshire. Llandovery Beds. O. T. Jones' Collection.  
 14 c. Narrow specimen, probably referable to this species. Ibid.
- 15 a—d.—*Amplexograptus perexcavatus*, Lapworth. (Page 267.)  
 15 a. Typical, complete specimen, obverse aspect. Kirkmichael Burn, S. Scotland. Upper Glenkiln Shales. Lapworth's Collection.  
 15 b. Long specimen, obverse aspect. On same slab as fig. 15 a.  
 15 c. Complete specimen, intermediate view. Dobb's Linn. Upper Glenkiln Shales. Geological Survey of Scotland.  
 15 d. Complete specimen in partial relief, bi-profile view. Ibid. Lapworth's Collection.
- 16 a—d.—*Amplexograptus arctus*, Elles and Wood, sp. nov. (Page 271.)  
 16 a. Large, fairly complete specimen, long virgella. Spittal Railway Cutting, S. Wales. Lower *Dicranograptus* Shales. Geological Survey of England and Wales.  
 16 b. Complete specimen, showing characteristic form. Ibid.  
 16 c. Distal fragment, showing virgula. On same slab as fig. 16 b.  
 16 d. Specimen showing general form. Ibid.
- 17 a—c.—*Amplexograptus cœlatus* (Lapworth). (Page 270.)  
 17 a. Type specimen, sub-scalariform view. Figured, Lapworth, 'Quart. Journ. Geol. Soc.,' 1875, vol. xxxi, pl. xxxv, fig. 8 c. Aberiddy Bay, S. Wales. Llandeilo Beds (zone of *Didymog. Murchisoui*). Sedgwick Museum.  
 17 b. Incomplete specimen, sub-scalariform view. Ibid., fig. 8 b.  
 17 c. Distorted specimen, bi-profile view, showing *Diplograptus* appearance. Ibid., fig. 8 a.
- 18 a—e.—*Amplexograptus confertus* (Lapworth). (Page 269.)  
 18 a. Specimen much distorted and compressed. Figured, Lapworth, 'Quart. Journ. Geol. Soc.,' 1875, vol. xxxi, pl. xxxiv, fig. 2 a. Porth Hayog, Ramsey Island. Upper Arenig (zone of *Didymog. bifidus*). Sedgwick Museum.  
 18 b. Specimen elongated by compression. Ibid., fig. 2 c.  
 18 c. Typical specimen, preserved as an impression, obverse aspect. Upper Arenig (zone of *Didymog. bifidus*). Geological Survey of England and Wales.  
 18 d. Two small specimens in association. Near Ffairfach Railway Station, Llandeilo. Upper Arenig (zone of *Didymog. bifidus*). Geological Survey of England and Wales.  
 18 e. Specimen of unusual length, preserved as an impression. Roadside E. of Church, Lampeter Velfrey. Upper Arenig. Turnbull's Collection, Sedgwick Museum.



GLYPTOGRAPTUS, MESOGRAPTUS AND AMPLEXOGRAPTUS.



THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

LONDON:

MDCCCXCII—MDCCCVII.

MONOGRAPH OF THE DEVONIAN FAUNA OF THE SOUTH OF  
ENGLAND.

ORDER OF BINDING AND DATES OF PUBLICATION OF VOL. II.

PAGES.	PLATES.	ISSUED IN VOL. FOR YEAR.	PUBLISHED.
General Title-page and Index	—	1907	December, 1907
1—56	I—V	1891	February, 1892
57—88	VI—X	1892	November, 1892
89—160	XI—XVII	1893	December, 1893
161—212	XVIII—XXIV	1895	October, 1895
213, 214	—	1907	December, 1907

A MONOGRAPH

OF THE

DEVONIAN FAUNA

OF THE

SOUTH OF ENGLAND.

BY

G. F. WHIDBORNE, M.A., F.G.S.

VOL. II.

THE FAUNA OF THE LIMESTONES

OF

LUMMATON, WOLBOROUGH, CHIRCOMBE BRIDGE, AND CHUDLEIGH

LONDON :

PRINTED FOR THE PALEONTOGRAPHICAL SOCIETY.

1892—1907.

PRINTED BY ADLARD AND SON, LONDON AND DORKING.

Phillips<sup>1</sup> under the name of *Actinocrinus triacontadactylus*, Miller?<sup>2</sup> is not clear, but neither of them corresponds with Miller's own figure of that species. Phillips' fossil probably does not belong to a crinoid at all, but to *Sphærospongia*, and our specimen is so indistinct that its true nature is very doubtful. It is more like a fossil figured by Sandberger,<sup>3</sup> but even that may not belong to a crinoid.

2. CLASS.—BLASTOIDEA, *Say*, 1825.<sup>4</sup>

1. GRADE.—EUBLASTOIDEA, *Bather*, 1899.<sup>5</sup>

1. *Series*.—TROOSTOBLASTIDA, *Bather*, 1899.<sup>5</sup>

1. *Family*.—TROOSTOCRINIDE, *Bather*, 1899.<sup>5</sup>

1. *Genus*.—TRICÆLOCRIINUS, *Meek and Worthen*, 1868.<sup>6</sup>

This genus is defined as having "the body broadest below, and the three spaces corresponding to the flattened sides of the typical species of *Troostocrinus* so profoundly and broadly excavated as to impart a very remarkable appearance to the lower part of the fossil." Dr. Bather<sup>7</sup> observes:—"A feature of more importance is the enclosure of the distal portion of the hydrospires within the thickness of the radial plate; this is probably due to the upward growth of the floor of the sinus, as has taken place, independently and to a less extent, in *Pentremites*." He points out that the excavations correspond with the three interbasal sutures. *Troostocrinus* is separated from *Metablastus* on account of its anal deltoid plate being irregular and external, and its possession of an anal spiracle.

1. TRICÆLOCRIINUS? LEEI, *Whidborne*.

1881. PENTREMITES, *Whidborne*. Geol. Mag., dec. 2, vol. viii, p. 288.

1886. TROOSTOCRINUS OR METABLASTUS, *Etheridge and Carpenter*. Brit. Mus. Catal. Blastoid., p. 130.

1886. METABLASTUS? *Etheridge and Carpenter*. Ibid., p. 198.

1889. TRICÆLOCRIINUS? LEEI, *Whidborne*. Geol. Mag., dec. 3, vol. vi, p. 80.

<sup>1</sup> 1841, Phillips, 'Pal. Foss.', p. 31, pl. xvi, fig. 43.

<sup>2</sup> 1821, Miller, 'Nat. Hist. Crinoid.', p. 95, pl. xxxviii, fig. 6.

<sup>3</sup> 1855, Sandberger, 'Verst. Rhein. Nassau,' p. 384, figure.

<sup>4</sup> 1825, Say, 'Journ. Acad. Nat. Sci. Philadelphia,' iv, p. 292.

<sup>5</sup> 1899, Bather, "Phylogenetic Classif. Pelmatozoa," 'Rep. Brit. Assoc.' for 1898, pp. 920, 921.

<sup>6</sup> 1868, Meek and Worthen, 'Proc. Acad. Nat. Sci. Philadelphia' for 1868, p. 358.

<sup>7</sup> 1900, Bather, 'Blastoidea' (in E. Ray Lankester, 'Treatise on Zoology'), III, p. 87.

*Description.*—Calyx small, bean-shaped, longitudinally flattened on four sides, so arranged as to form alternate triangles. At about one fourth the length from each end occur deep fissures, so that on one side at least it terminates in three or more sharp triangular limbs. Structure of test very massive.

*Size.*—Length (incomplete at basal end), 5·6 mm. Greatest width (which is about half-way down the preserved portion), 3·9 mm. Length of radial sinus, circa 1·75 mm.

*Locality.*—Barton. The unique, and, unfortunately, very indistinct specimen is in the Lee Collection in the British Museum [E 1044].

*Remarks.*—Of this specimen Messrs. Etheridge and Carpenter write, “It is too ill preserved for description, but has much the aspect of a *Troostocrinus* or *Metablastus*.” Considering the extremely worn state of the specimen, together with the general shape of what is left of it, it appeared to me that it might possibly be the remains of a species of the kindred *Tricelocrinus*, whose general shape and lower extensions might better accord with our fragment. This can, however, be regarded merely as a surmise.

*Affinities.*—It differs from the type species, *T. Woodmani*, Meek and Worthen,<sup>1</sup> by being less petaloid, by having shorter limbs, and by having the lower excavations extending further on as flattened spaces.

<sup>1</sup> 1873, Meek and Worthen, ‘Geol. Surv. Illinois,’ vol. v, p. 506, pl. xvi, fig. 4; and 1886, Etheridge and Carpenter, ‘Brit. Mus. Catal. Blastoid.,’ pl. xix, figs. 13—16.

#### ERRATA.

P. 192, line 1, delete “and Pl. XXV, fig. 1, 1a.”

P. 199, line 15, delete “and Pl. XXV, fig. 2, 2c.”

## INDEX TO VOLUME II.

NOTE.—Synonyms and the page-numbers of casual references to genera and species are printed in *italics*. The large Roman numerals are plate-numbers, and the small Roman numerals refer to the numbers of the figures on the respective plates.

	PAGE		PAGE
Acanthocladiidæ . . . . .	182-187	Athyris ? Bartoniensis . . . . .	101
<i>Acanthocrinus</i> . . . . .	204	— <i>concentrica</i> . . . . .	100, 101
Actinocrinus triacontadactylus . . . . .	213	— <i>Glassii</i> . . . . .	100
Actinopteria <i>Boydii</i> . . . . .	67	— <i>Newtoniensis</i> . . . . .	101
— <i>crenatissima</i> . . . . .	77, 78; IX, viii, ix	— <i>rugata</i> . . . . .	101
— <i>dilatata</i> . . . . .	64-67; VI, viii-x; VII, i-iii; VIII, viii	Atrypa <i>aspera</i> . . . . .	115, 116, 118, 119
— <i>hirundella</i> . . . . .	61-63; VI, v, vi; VII, iv	— <i>bifidæformis</i> . . . . .	119
— <i>Justi</i> . . . . .	70; VII, xii; VIII, i	— <i>compressa</i> . . . . .	115, 116, 117, 119
— <i>manca</i> . . . . .	61, 63	— <i>crenulata</i> . . . . .	134
— <i>musicata</i> . . . . .	63, 64; VI, vii	— <i>cuboides</i> . . . . .	134
— <i>placida</i> . . . . .	67-69; VII, v-xi; VIII, vii	— <i>desquamata</i> . . . . .	115, 116, 117, 118, 119, 120; XIII, xiii-xv
— ? <i>Robertsii</i> . . . . .	60, 61; VI, ii-iv	— <i>Eurydice</i> . . . . .	94
— <i>rudis</i> . . . . .	73, 74; VIII, iv, vi	— <i>flabellata</i> . . . . .	120
— <i>texturata</i> . . . . .	74-76; IX, ii-vii	— <i>impleta</i> . . . . .	134
— <i>Wurmii</i> . . . . .	71-73; VIII, ii, iii, v	— <i>implexa</i> . . . . .	130
Allorisma <i>cancellatum</i> . . . . .	120	— <i>inornata</i> . . . . .	95
— <i>dubium</i> . . . . .	4; I, ii, iii	— <i>insolita</i> . . . . .	118
Ambonychinæ . . . . .	50-53	— <i>juvenis</i> . . . . .	93
<i>Amorphotrypa</i> . . . . .	181	— ? <i>Leei</i> . . . . .	119, 120
Anatinidæ . . . . .	2-4	— <i>plebeia</i> . . . . .	98
<i>Anomia reticularis</i> . . . . .	114	— <i>protracta</i> . . . . .	139
<i>Anomites acuminatus</i> . . . . .	126	— <i>reticularis</i> . . . . .	114-116, 117, 118, 119, 120; XIII, x
— <i>lineatus</i> . . . . .	108	— <i>sphærica</i> . . . . .	135
— <i>pugnus</i> . . . . .	127	— <i>squamifera</i> . . . . .	118
Arcidæ . . . . .	39, 40	— ? <i>trigonella</i> . . . . .	115, 116, 118, 119; XIII, xi, xii
Arcinæ . . . . .	39, 40	— <i>triloba</i> . . . . .	128
Articulata . . . . .	91-159	Atrypidæ . . . . .	114-120
Asiphonida . . . . .	36-90		
Astartidæ . . . . .	32-36		

	PAGE		PAGE
<i>Avicula wniliana</i> . . . . .	73	British Museum, bryozoa in	166, 173-175, 177, 179
— <i>clathrata</i> . . . . .	64, 71	— — echinodermata in	190, 192, 193, 200, 210, 212, 214
— <i>Justi</i> . . . . .	70	— — lamellibranchiata in	7, 14, 15, 19, 25, 26, 28, 32, 34, 62, 79
— <i>migrans</i> . . . . .	75	Bryozoa . . . . .	161-188
— <i>normata</i> . . . . .	71	<i>Bucardites abbreviatus</i> . . . . .	31
— <i>oblonga</i> . . . . .	53	— <i>hystericus</i> . . . . .	20, 26, 27
— <i>perdita</i> . . . . .	71	<i>Culceola heteroclitia</i> . . . . .	111
— <i>plicatella</i> . . . . .	89	<i>Camarophoria ascendens</i> . . . . .	136-138; XV, vii-ix
— <i>reticulata</i> . . . . .	11, 12, 13	— <i>crumena</i> . . . . .	138
— <i>rudis</i> . . . . .	73, 74	— <i>Lummatonensis</i> . . . . .	139, 140
— <i>semiglobosa</i> . . . . .	73, 74	— cf. <i>megistana</i> . . . . .	142
— <i>texturata</i> . . . . .	74, 75	— <i>Phillipsii</i> . . . . .	127, 141, 142; XVI, i, ii
— <i>trapeziformis</i> . . . . .	71	— <i>protracta</i> . . . . .	138, 139
— <i>Wurmii</i> . . . . .	71	— ? <i>rhomboidea</i> . . . . .	139, 140
Aviculidæ . . . . .	50-80	<i>Camerata</i> . . . . .	189-204
Aviculinae . . . . .	53-80	Cardiidæ . . . . .	18-30
<i>Aviculopecten aviformis</i> . . . . .	85, 86; X, vii-xi	<i>Cardiomorpha ? polita</i> . . . . .	42
— <i>comma</i> . . . . .	88	<i>Cardium aliforme</i> . . . . .	18, 20
— <i>consolans</i> . . . . .	83	— <i>aliforme</i> . . . . .	18, 20, 24, 25, 27
— <i>Cybele</i> . . . . .	83	— <i>brevialatum</i> . . . . .	28
— <i>gracilinus</i> . . . . .	80	— <i>clathratum</i> . . . . .	19, 20
— <i>Oceani</i> . . . . .	89	— <i>elongatum</i> . . . . .	20
— <i>plicatus</i> . . . . .	89	— <i>inversum</i> . . . . .	26
Barton, brachiopoda from	99, 102, 105, 113, 122, 127, 132-134, 140, 152	— <i>paucicostatum</i> . . . . .	26, 27
— bryozoa from	163, 167, 175, 180	— <i>semialatum</i> . . . . .	22
— lamellibranchiata from	2, 9, 13, 14, 23, 42, 68, 76, 86	— <i>Villmareense</i> . . . . .	28
— <i>Tricælocrinus</i> from	214	<i>Centronella Guerangeri</i> . . . . .	120
Batostomella oomorpha	187, 188; XX, xii, xiii	— ? <i>imitatrix</i> . . . . .	94
Battersby Collection . . . . .	14	— <i>virgo</i> . . . . .	94, 95; XI, iv
Berry Pomeroy, lamellibranchiata from	6, 7	Champernowne Collection	87, 127, 151, 185, 190, 210
Bifida Huntii . . . . .	102	Chireombe Bridge, brachiopoda from	97, 103, 107
— ? <i>plana</i> . . . . .	102, 103; XII, viii	<i>Chonetes convolutus</i> . . . . .	158, 159
Blastoidea . . . . .	213	— <i>Hardrensis</i> . . . . .	157, 158, 159; XVII, xiii
Brachiopoda . . . . .	91-160	— <i>Manitobensis</i> . . . . .	157, 158
Bradley, lamellibranchiata from	2, 28, 31	— ? <i>Phillipsii</i> . . . . .	158, 159
Bristol Museum, brachiopoda in	91, 93, 94, 99, 101, 106, 114, 117, 119, 120, 126, 127, 131, 134, 139, 140, 155	<i>Chuttleigh, lamellibranchiata from</i>	1, 2, 26, 33, 35
— — lamellibranchiata in	71	<i>Conchidium britannicum</i> . . . . .	124, 125; XIV, ix
British Museum, brachiopoda in	92-94, 97, 99, 101, 103-108, 111-114, 116, 117, 120-122, 126-128, 131-134, 139, 140, 144, 147, 149, 152, 153, 155	<i>Conchita rhomboidalis</i> . . . . .	149
		<i>Conocardium aliforme</i> . . . . .	19, 20, 23, 28
		— <i>clathratum</i> . . . . .	I, 18-23, 25, 27, 28; I, xvii-xx; II, i-iii
		— <i>frater</i> . . . . .	30; II, x

	PAGE		PAGE
Conocardium hystericum . . . . .	26, 27; II, vi, vii	Cypricardinia striatissima . . . . .	9-11; I, ix, x
— <i>inversum</i> . . . . .	20	— <i>subelongata</i> . . . . .	11
— <i>Marsi</i> . . . . .	21, 23; IX, xii	Cyprinidæ . . . . .	5-17
— <i>minax</i> . . . . .	20, 27	Cyrtia <i>affinis</i> . . . . .	111
— <i>Ohioense</i> . . . . .	19, 21	— <i>Dalmani</i> . . . . .	112
— <i>Phillipsii</i> . . . . .	27, 28	— <i>Hamiltonensis</i> . . . . .	111, 112
— <i>pugnans</i> . . . . .	21, 24-26; II, iv, v	— <i>heteroclyta</i> . . . . .	111
— <i>rarum</i> . . . . .	28, 29	— ? <i>Whidbornei</i> . . . . .	110, 111
— <i>reflexum</i> . . . . .	25	Cyrtina amblygona . . . . .	113
— <i>vezatum</i> . . . . .	19, 21	— <i>Dalmani</i> . . . . .	112
— <i>Villmarensense</i> . . . . .	19, 28-30; II, viii, ix	— <i>Demarlii</i> . . . . .	112, 113
Crania proavia . . . . .	160; XVIII, i	— <i>heteroclyta</i> . . . . .	111-113; XII, x-xiii
Crenipecten ? <i>comma</i> . . . . .	88, 89; X, iv, v	— <i>rostrata</i> . . . . .	112
— <i>Oceani</i> . . . . .	89, 90; X, vi	Davidsonia <i>Verneuilii</i> . . . . .	142
Crinoidea . . . . .	189-213	<i>Derbyia</i> . . . . .	148
Cryptostomata . . . . .	164-187	Diplopora <i>pristina</i> . . . . .	182, 183; XX, iv
<i>Ctenocrinus stellaris</i> . . . . .	200	<i>Discina anomala</i> . . . . .	160
<i>Ctenodonta lepida</i> . . . . .	41	— <i>nitida</i> . . . . .	159
Cupressoerinus <i>abbreviatus</i> . . . . .	209	— <i>peltastes</i> . . . . .	159, 160; XVII, xiv
— <i>crassus</i> . . . . .	207, 208; XXIV, iv	East Oghwell, <i>Productella</i> from . . . . .	156
— <i>nodosus</i> . . . . .	209	Echinodermata . . . . .	189-214
— <i>Schlotheimii</i> . . . . .	209, 210; XXIV, iii, v	Edmondia <i>cœlata</i> . . . . .	2, 3; I, iv
— <i>tetragonus</i> . . . . .	208	— ? <i>dubia</i> . . . . .	4
— <i>Urogalli</i> . . . . .	209	— <i>sp.</i> . . . . .	3
Cyathocrinidæ . . . . .	210-212	Enantiosphen ( <i>Ehlertii</i> ) . . . . .	98; XI, viii
<i>Cyathocrinus geometricus</i> . . . . .	211	— <i>Vicaryi</i> . . . . .	97, 98; XI, v-vii
<i>Cypressoerinus crassus</i> . . . . .	208	Eublastoidea . . . . .	213
<i>Cypricardia crenicostata</i> . . . . .	10, 13	<i>Enmegalodon cucullatus</i> . . . . .	31
— <i>elegans</i> . . . . .	7	Fenestella <i>antiqua</i> . . . . .	163-165, 167, 168, 169
— <i>elongata</i> . . . . .	5, 7, 10, 11, 13, 14	— <i>arthritica</i> . . . . .	163, 170-172; XIX, v-x
— <i>guttata</i> . . . . .	12	— <i>delta</i> . . . . .	169, 170; XIX, ii
— <i>lamellosa</i> . . . . .	5, 7, 10	— <i>fanata</i> . . . . .	165-168, 169, 172; XVIII, vi-x; XIX, iii, iv
— <i>neglecta</i> . . . . .	6	— <i>laxa</i> . . . . .	169
— <i>squamifera</i> . . . . .	5, 7	— <i>plebeia</i> . . . . .	164, 167, 168
Cypricardinia <i>crenicostata</i> . . . . .	9	— <i>subrectangularis</i> . . . . .	173; XIX, xi, xii
— <i>distincta</i> . . . . .	5, 7	— <i>sp.</i> . . . . .	172; XX, iii
— <i>elongata</i> . . . . .	11, 12	Fenestellidæ . . . . .	164-182
— <i>ensiformis</i> . . . . .	13, 14; I, xiv-xvi	<i>Fenestrapora</i> . . . . .	181
— <i>gratiosa</i> . . . . .	5-7	Fistulata . . . . .	210-212
— <i>indenta</i> . . . . .	5, 8	Geological Society's Museum, brachiopoda	
— <i>inflata</i> . . . . .	5, 8	in the . . . . .	99, 109, 110, 117, 120, 121, 127, 134-136
— <i>lamellosa</i> . . . . .	5, 7	<i>Glossia Beyrichi</i> . . . . .	114
— <i>nitidula</i> . . . . .	9, 13		
— <i>reticulata</i> . . . . .	11-13; I, xi-xiii		
— <i>scalaris</i> . . . . .	I, 5-8; I, vi-viii		
— <i>squamifera</i> . . . . .	5, 8, 11		

	PAGE		PAGE
<i>Glassia obovata</i> . . . . .	114	Lee Collection, echinodermata in . . . . .	200, 212, 214
— <i>Whidbornei</i> . . . . .	114; XII, vii, ix	— lamellibranchiata in . . . . .	9, 14, 62, 68, 79, 81
<i>Goniophora cymbæformis</i> . . . . .	16	<i>Leiopteria lingulata</i> . . . . .	78-80; X, i
— <i>obliqua</i> . . . . .	16, 17; III, i	<i>Leptæna affinis</i> . . . . .	152
<i>Gorgonia antiqua</i> . . . . .	167, 171	— <i>convoluta</i> . . . . .	158
— <i>ripisteria</i> . . . . .	174, 175	— <i>fragaria</i> . . . . .	154-156
<i>Gosseletia</i> ? sp. . . . .	50; IV, vi	— <i>interstitialis</i> . . . . .	151, 152
<i>Gymnolæmata</i> . . . . .	164-188	— <i>irregularis</i> . . . . .	151
<i>Gypidia unguiformis</i> . . . . .	125	— <i>nobilis</i> . . . . .	153
Halberton, Conocardium from . . . . .	28	— <i>nodulosa</i> . . . . .	150
Hall Collection, lamellibranchiata in the . . . . .	74, 87	— <i>plana</i> . . . . .	152
<i>Halocrinites pyramidalis</i> . . . . .	209	— <i>rhomboidalis</i> . . . . .	149
— <i>Schlotheimii</i> . . . . .	209	<i>Lichas antiquus</i> . . . . .	20
<i>Haplocrinus decipiens</i> . . . . .	205, 206; XXIII, ix	<i>Lithocardiidae</i> . . . . .	18
<i>Hemitrypa oculata</i> . . . . .	163, 177-180; XIX, xiii-xx	Launmaton, brachiopoda from . . . . .	91-97, 99-114, 116, 117, 119-134, 136-145, 147, 149- 153, 155-160
<i>Heteromyaria</i> . . . . .	40-80	— bryozoa from . . . . .	164, 166, 169-178, 180, 181, 183-188
<i>Hexacrinus</i> ? <i>aberrans</i> . . . . .	199, 200; XXIII, iii	— crinoids from . . . . .	190, 194, 195, 198, 200, 202, 203, 205, 210-212
— <i>depressus</i> . . . . .	190, 191	— lamellibranchiata from . . . . .	1, 4, 6, 7, 9, 12, 14, 19-21, 23, 24, 29, 30, 36, 42, 49, 50, 53, 55, 56, 60, 62, 63, 65, 68, 70, 71, 74-77, 81, 83, 84, 86, 87
— <i>echinatus</i> . . . . .	195	<i>Lyriopecten fibratus</i> . . . . .	86-88; VI, i
— <i>interscapularis</i> . . . . .	190, 191; XXI, i-iv; XXII, i, ii	<i>Magellania juvenis</i> . . . . .	93; XI, iii
— <i>macrotatus</i> . . . . .	192-194, 207; XXII, iii-viii	— <i>Whidbornei</i> . . . . .	91, 92; XI, i
— <i>melo</i> . . . . .	190, 191	— sp. . . . .	92, 93; XI, ii
— <i>microglyphicus</i> . . . . .	196, 197; XXIII, i, ii	Meadfoot, <i>Productella</i> from . . . . .	156
— <i>ornatus</i> . . . . .	195, 196; XXII, xi	<i>Mækella</i> . . . . .	145
— <i>perarmatus</i> . . . . .	194, 195; XXII, ix, x	<i>Mecynodon carinatus</i> . . . . .	34-36; II, xv
— <i>quintangularis</i> . . . . .	198, 199; XXIII, vi, vii	— <i>columbinus</i> 1, 2, 33, 34, 36; II, xii-xiv	
— <i>Vicarii</i> . . . . .	197, 198; XXIII, iv, v	<i>Megalodon abbreviatus</i> . . . . .	31, 32
<i>Hippopodium abbreviatum</i> . . . . .	31	— <i>carinatus</i> . . . . .	16, 17, 34, 35
<i>Homomyaria</i> . . . . .	36-40	— ? <i>columbinus</i> . . . . .	33
Hope's Nose, brachiopoda from . . . . .	101, 102	— <i>cucullatus</i> . . . . .	15, 31, 56
— — bryozoa from . . . . .	171, 180	— <i>elongatus</i> . . . . .	31
<i>Hoplomytilus erassus</i> . . . . .	44, 45; IV, ii, iii	— <i>obliquus</i> . . . . .	16
<i>Inadunata</i> . . . . .	204-212	— ? <i>promineus</i> . . . . .	35
<i>Inarticulata</i> . . . . .	159, 160	<i>Megalodus carinatus</i> . . . . .	33, 34
<i>Integripalliata</i> . . . . .	18-36	— <i>cucullatus</i> . . . . .	31
<i>Isocardia Crokeri</i> . . . . .	15, 16; II, xi	<i>Meganteris Archiaci</i> . . . . .	95, 96
<i>Isotrypa</i> ? <i>Gregorii</i> . . . . .	180-182; XX, i, ii	— <i>inornata</i> . . . . .	95, 96; XII, i
<i>Koninckinidae</i> . . . . .	142	— ? <i>Vicaryi</i> . . . . .	97
Lamellibranchiata . . . . .	1-90		
Larviformes . . . . .	204-210		
Lee Collection, brachiopoda in . . . . .	99, 101, 102		
— bryozoa in . . . . .	175		

	PAGE		PAGE
Melocrinus hieroglyphicus . . . . .	201, 202; XXIV, i	<i>Orbiculoidea nitida</i> . . . . .	159
— stellaris . . . . .	200, 201; XXIII, xii	<i>Orthis areola</i> . . . . .	143
Merista plebeia . . . . .	98-100; XII, iii-vi	— <i>distorta</i> . . . . .	147
— <i>prunulum</i> . . . . .	99	— <i>Eifeliensis</i> . . . . .	145
<i>Metablastus</i> . . . . .	213	— <i>Hardreusis</i> . . . . .	157
<i>Modiola scalaris</i> . . . . .	5	— <i>interstitialis</i> . . . . .	151
Modiolopsis lepida . . . . .	41, 42; I, v	— <i>lepidus</i> . . . . .	143
— <i>polita</i> . . . . .	42, 43; IV, v	— <i>plicatella</i> . . . . .	143
— <i>tenera</i> . . . . .	41	— <i>pulcherrima</i> . . . . .	145, 146; XVII, vi
— <i>sp.</i> . . . . .	43; IV, vii	— <i>sacculus</i> . . . . .	145
<i>Modiomorpha submissa</i> . . . . .	43	— <i>striatula</i> . . . . .	143, 144, 145
Molluscoidea . . . . .	91-188	— <i>tennistriata</i> . . . . .	117
Monomyaria . . . . .	80-90	— <i>umbraculum</i> . . . . .	146
Mudstone Bay, Polypora from . . . . .	175	— <i>venustula</i> . . . . .	145
Museum of Practical Geology, brachiopoda in . . . . .	93, 94, 97, 99, 101, 103-107, 109, 112, 114, 116, 117, 119-122, 126-134, 137, 141, 142, 149, 150, 152, 155, 156	— ? <i>sp.</i> . . . . .	144; XVII, v
— of Practical Geology, bryozoa in . . . . .	166, 171, 175, 180	<i>Orthotetes distortus</i> . . . . .	147, 148; XVII, ii
— of Practical Geology, crinoids in . . . . .	190- 192, 194, 197, 198, 204, 206, 208, 211	— <i>umbraculum</i> . . . . .	146, 147
— of Practical Geology, lamellibranchiata in . . . . .	3, 6, 9, 12, 17, 19, 20, 35, 41, 44, 46-48, 51, 55, 58, 62, 67, 71, 75, 81, 86, 87, 90	— <i>Woolworthiana</i> . . . . .	146
Myalina <i>Beushauseni</i> . . . . .	47	<i>Parallelodon atavus</i> . . . . .	39, 40; I, i
— <i>crassa</i> . . . . .	51	<i>Parisocrinus? geometricus</i> . . . . .	211
— <i>Dammoniensis</i> . . . . .	47; III, vi	<i>Pecten illegalis?</i> . . . . .	89
— <i>egregia</i> . . . . .	45, 46, 47, 48; III, iv, v	— <i>Oceani</i> . . . . .	89
— <i>elliptica</i> . . . . .	55	— <i>plicatus</i> . . . . .	89, 90
— <i>luna</i> . . . . .	45, 48, 49; IV, i	<i>Pectinidæ</i> . . . . .	80-90
— <i>ornata</i> . . . . .	48	<i>Penniretipora? sp.</i> . . . . .	185, 186; XX, vii, viii, x
— <i>peratata</i> . . . . .	47	<i>Pentamerus acutolobatus</i> . . . . .	122, 123
— <i>pinnoides</i> . . . . .	49; IV, iv	— <i>biplicatus</i> . . . . .	122; XV, iv, v
— <i>stulta</i> . . . . .	48; III, viii	— <i>brevirostris</i> . . . . .	120, 121; XIII, ix; XIV, i-iii
Mytilarea? <i>Robertsii</i> . . . . .	51, 52; III, vii	— <i>formosus</i> . . . . .	122
Mytilidæ . . . . .	44-50	— <i>galeatus</i> . . . . .	122
<i>Mytilus Dammoniensis</i> . . . . .	46, 47, 52	— <i>sublinguifer</i> . . . . .	123, 124; XIV, vi-viii
— <i>pinnoides</i> . . . . .	49	<i>Pentremites</i> . . . . .	213
— <i>Robertsii</i> . . . . .	51	<i>Phyllopora</i> . . . . .	175
— <i>scalaris</i> . . . . .	5	Pilton, <i>Spirifera</i> from . . . . .	108
— <i>stultus</i> . . . . .	48	— bryozoa from . . . . .	163, 168, 169
Newton: see Wolborough.		<i>Platyerinus aberrans</i> . . . . .	199
Nucula <i>Protei</i> . . . . .	37, 38; III, iii	— <i>fritillus</i> . . . . .	206
<i>Omalia scalaris</i> . . . . .	5	— <i>interscapularis</i> . . . . .	190
		— <i>minutus</i> . . . . .	206
		— <i>ornatus</i> . . . . .	195
		— <i>pentangularis?</i> . . . . .	197
		— <i>Phillipsii</i> . . . . .	192
		— <i>quintangularis</i> . . . . .	198
		— <i>tuberculatus</i> . . . . .	192
		<i>Plectambonites rhomboidalis</i> . . . . .	149

	PAGE		PAGE
Plethomytilus retortus . . . . .	52, 53; V, i	Ramsleigh, Merista from . . . . .	99
<i>Pleurohynchus aleformis</i> . . . . .	18, 19	<i>Retepora antiqua</i> . . . . .	167, 170, 171
— <i>minax</i> . . . . .	25, 27	— <i>hexagona</i> . . . . .	174, 176
— <i>pugnans</i> . . . . .	24	— <i>prisca</i> . . . . .	163, 174, 175
— <i>trapezoidalis</i> . . . . .	26, 27	Retzia <i>ferita</i> . . . . .	103
— <i>Villmarensis</i> . . . . .	28	— <i>longirostris</i> . . . . .	103
Plymouth, Productella from . . . . .	156	Rhipidoerinus <i>crenatus</i> . . . . .	203; XXIII, viii
Polypora <i>pagana</i> . . . . .	176, 177; XVIII, v	Rhodoerinus <i>crenatus</i> . . . . .	203
— <i>populata</i> 174–176; XVIII, ii–iv; XIX, i		— <i>tessellatus</i> . . . . .	203
Posidonomya <i>lateralis</i> . . . . .	53	— (Acauthoerinus) sp. . . . .	204; XXIV, vi
— <i>oblonga</i> . . . . .	53, 54; IV, viii	Rhynchonella <i>acuminata</i> . . . . .	126
<i>Poteroerinus geometricus</i> . . . . .	211	— ? <i>anisodonta</i> . . . . .	132, 133; XV, i, ii
— <i>hemisphaericus</i> . . . . .	211	— <i>angularis</i> . . . . .	132
Prasinidæ . . . . .	40–43	— <i>Beyrichi</i> . . . . .	114
<i>Producta analoga</i> . . . . .	149	— <i>cuboides</i> . . . . .	134, 136, 137
Productella <i>fragarina</i> 155, 156; XVII, x, xi		— <i>Emmonsii</i> . . . . .	135
— <i>Shumardiana</i> . . . . .	154	— <i>flexistria</i> . . . . .	129
— <i>spinulicosta</i> . . . . .	154	— <i>hexatoma</i> . . . . .	132
— <i>subaculeata</i> . . . . .	154, 155, 156	— <i>Ibergensis</i> . . . . .	131
— <i>truncata</i> . . . . .	154	— <i>implexa</i> . . . . .	130, 131
— sp. . . . .	156, 157; XVII, xii	— <i>intermedia</i> . . . . .	135
Productidæ . . . . .	154–159	— <i>Leci</i> . . . . .	119
<i>Productus subaculeatus</i> . . . . .	154, 155	— ? <i>Lummatonensis</i> . . . . .	139
Protoschizodus ? <i>trigonellus</i> . . . . .	36, 37; III, ii	— <i>matereula</i> . . . . .	137
Pterinea <i>bellula</i> . . . . .	57–59; IV, xi	— <i>Missouriensis</i> . . . . .	127
— <i>crenatissima</i> . . . . .	77	— <i>Neapolitana</i> . . . . .	129; XV, iv
— <i>dilatata</i> . . . . .	64	— ? <i>Ogwelliensis</i> . . . . .	133, 134, 139, 140; XVI, v
— <i>hirundella</i> . . . . .	61	— <i>palumbina</i> . . . . .	137
— <i>migrans</i> . . . . .	75	— <i>parallelipipeda</i> 129–131; XV, x	
— <i>Morleti</i> . . . . .	73, 74	— <i>pentagona</i> . . . . .	131
— <i>normata</i> . . . . .	71	— <i>Phillipsii</i> . . . . .	141
— <i>obovata</i> . . . . .	67	— <i>primipilaris</i> . . . . .	129
— <i>placida</i> . . . . .	67	— <i>procuboides</i> . . . . .	135
— <i>rudis</i> . . . . .	73	— <i>protracta</i> . . . . .	137, 139
— <i>striatocostata</i> . . . . .	77	— <i>pugnooides</i> . . . . .	134, 135
— <i>texturata</i> . . . . .	75	— <i>pungus</i> . . . . .	127
— <i>Wurmii</i> . . . . .	71	— <i>reniformis</i> . . . . .	127
Pterinopecten <i>consolans</i> . . . . .	83, 84; IX, ii	— <i>subcordiformis</i> . . . . .	129
— <i>crenicostatus</i> . . . . .	82	— <i>subcuboides</i> . . . . .	129, 136, 137
— <i>Cybele</i> 82, 83; VIII, ix, x; IX, i		— <i>tetratoma</i> . . . . .	131
— <i>gracilinus</i> 80–82; IX, x; X, ii, iii		— <i>triloba</i> . . . . .	128
— <i>suborbicularis</i> . . . . .	82	— <i>triloboides</i> . . . . .	128; XV, iii
— <i>Vertumnus</i> . . . . .	83	— <i>renustula</i> . . . . .	135, 136
Ptilopora (?) sp. . . . .	184, 185; XX, vi	Rhynchonellidæ . . . . .	120–142
<i>Rafinesquina</i> . . . . .	148	<i>Ripidoerinus crenatus</i> . . . . .	203
Ramipora sp. . . . .	186, 187; XX, ix, xi	Rutotia <i>elliptica</i> 1, 55, 56; IV, ix, x; V, ii–ix	

	PAGE		PAGE
<i>Sanguinolaria lamellosa</i> . . . . .	9, 10	<i>Stropheodonta irregularis</i> . . . . .	151; XVII, i
<i>Sanguinolites</i> . . . . .	39	— ? <i>nobilis</i> . . . . .	152, 153, 154
<i>Schizodus</i> . . . . .	37	— <i>nodulosa</i> . . . . .	149, 150, 151, 153; XVI, vi-x
<i>Schizophoria</i> . . . . .	144, 146	— <i>perplana</i> . . . . .	151
Septopora (?) sp. . . . .	183, 184; XX, v	— <i>planolata</i> . . . . .	150, 151
Sinupalliata . . . . .	2-17	<i>Strophomena af. corrugatella</i> . . . . .	152, 153
Siphonidæ . . . . .	2-36	— <i>interstitialis</i> . . . . .	152, 153
Skenidium areola . . . . .	125, 143; XVII, vii, viii	— <i>irregularis</i> . . . . .	151
Sloly, Actinopteria from . . . . .	74	— <i>nobilis</i> (?) . . . . .	153
Sphaerocrinus geometricus . . . . .	211, 212; XXIV, viii-x	— <i>piligera</i> . . . . .	150, 151
— <i>stellatus</i> . . . . .	211	— <i>radiata</i> . . . . .	152
Sphaerospongia . . . . .	213	— <i>rhomboidalis</i> . . . . .	149, 150, 151
<i>Spirifera affinis</i> . . . . .	117	— <i>rugosa</i> . . . . .	149
— <i>conciuna</i> . . . . .	105, 106; XIII, viii	— <i>teniolata</i> . . . . .	153
— <i>curvata</i> . . . . .	107; XIII, iv, v	— <i>umbraculum</i> (?) . . . . .	117
— <i>cycloptera</i> . . . . .	105	— <i>varistriata</i> . . . . .	151-153
— <i>disjuncta</i> . . . . .	104	— <i>zigzag</i> . . . . .	152
— <i>gibbosa</i> . . . . .	110	<i>Strophomenidæ</i> . . . . .	143-154
— <i>glabra</i> . . . . .	107, 120	<i>Strygocephalus Burtini</i> . . . . .	96
— <i>infima</i> . . . . .	108; XIII, i-iii	<i>Symbathocrinidæ</i> . . . . .	206, 207
— <i>inflata</i> . . . . .	107	<i>Terebratula amblygona</i> . . . . .	113
— <i>insculpta</i> . . . . .	109	— <i>angularis</i> . . . . .	132
— <i>lineata</i> . . . . .	108	— <i>angulosa</i> . . . . .	129
— <i>modesta</i> . . . . .	107	— <i>anisodonta</i> . . . . .	132, 133
— <i>Newtoniensis</i> . . . . .	109	— <i>ascendens</i> . . . . .	136
— <i>nuda</i> . . . . .	106, 110	— <i>bijugata</i> . . . . .	133, 140, 141
— <i>pulchella</i> . . . . .	109, 110	— <i>concentrica</i> . . . . .	100
— <i>simplex</i> . . . . .	109	— <i>corvina</i> . . . . .	133
— <i>speciosa</i> . . . . .	104, 105	— <i>fornicata</i> . . . . .	128
— <i>subcuspidata</i> . . . . .	104, 105	— <i>hexatoma</i> . . . . .	133
— <i>sulcata</i> . . . . .	109	— ? <i>inequalis</i> . . . . .	93
— <i>undifera</i> . . . . .	105; XIII, vi, vii	— <i>juvenis</i> . . . . .	93
— <i>Urvii</i> . . . . .	108	— <i>megistana</i> . . . . .	142
— <i>Verneuilii</i> . . . . .	104	— ? <i>Newtoniensis</i> . . . . .	94
<i>Spiriferidæ</i> . . . . .	98-113	— <i>parallelepipedæ</i> . . . . .	129
<i>Spiriferina insculpta</i> . . . . .	109, 110	— <i>primipilaris</i> . . . . .	132
<i>Spirigera concentrica</i> . . . . .	100	— <i>pugnus</i> . . . . .	133
Stonhouse Hill, Conocardium from . . . . .	20	— <i>reniformis</i> . . . . .	127
Storthingocrinus fritillus . . . . .	206, 207; XXIII, x	— <i>rhomboidea</i> . . . . .	140
<i>Streptorhynchus crenistria</i> . . . . .	146-148	— <i>sacculus</i> . . . . .	91
— <i>umbraculum</i> . . . . .	146, 147	— <i>seminula</i> . . . . .	140
Stricklandinia (?) sp. . . . .	125; XVII, ix	— <i>subcordiformis</i> . . . . .	129, 130
Stringocephalus <i>brevirostris</i> . . . . .	120	— <i>tetratoma</i> . . . . .	130
— <i>Burtini</i> . . . . .	96, 97; XII, ii	— <i>virgo</i> . . . . .	94
<i>Strophalosia productoides</i> . . . . .	155	— <i>Wurmii</i> . . . . .	122, 123
<i>Stropheodonta interstitialis</i> . . . . .	151-153; XVII, iii, iv		



THE  
PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

LONDON:

MDCCCXCVI—MDCCCXCVII.

MONOGRAPH OF THE DEVONIAN FAUNA OF THE SOUTH OF  
ENGLAND.

ORDER OF BINDING AND DATES OF PUBLICATION OF VOL. III.

PAGES	PLATES.	ISSUED IN VOL. FOR YEAR	PUBLISHED.
General Title-page and Index	—	1907	December, 1907
1—112	I—XVI	1896	October, 1896
113—178	XVII—XXI	1897	December, 1897
179—236	XXII—XXXVIII	1898	December, 1898

A MONOGRAPH  
OF THE  
**DEVONIAN FAUNA**  
OF THE  
SOUTH OF ENGLAND.

BY  
G. F. WHIDBORNE, M.A., F.G.S.

VOL. III.

THE FAUNA OF THE MARWOOD AND PILTON BEDS  
OF  
NORTH DEVON AND SOMERSET.

LONDON:  
PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.  
1896—1907.

PRINTED BY ADLARD AND SON, LONDON AND DORKING.

## INDEX TO VOLUME III.

NOTE.—Synonyms and the page-numbers of casual references to genera and species are printed in *italics*. The large Roman numerals are plate-numbers, and the small Roman numerals refer to the numbers of the figures on the respective plates.

	PAGE		PAGE
Acanthocladiidæ . . . . .	189-192	Ashford Strand, echinodermata from . . . . .	212, 213
Aelisina longissima . . . . .	52; V, x	— — fish from . . . . .	3
<i>Acroculia acuta</i> . . . . .	48	Ashhill Quarry, brachiopoda from . . . . .	149, 156, 157, 161, 163, 165, 175, 181
— <i>Bischoffi</i> . . . . .	48	— — crinoid from . . . . .	216
Actinoceras? (Huronian) Crickii . . . . .	33-35; IV, ix, x-xii	Astroidea . . . . .	204-206
— <i>striatum?</i> . . . . .	28	<i>Athyris concentrica</i> . . . . .	148-151
Actinocrinus? Batheri . . . . .	222; XXXII, ii, iii	— <i>decussata</i> . . . . .	148
— Porteri . . . . .	220, 221; V, xxi; XXX, viii; XXXI, i, ii, v; XXXII, i	— <i>depressa</i> . . . . .	148-151
Aetinopteria rudis . . . . .	131, 132; XV, xiv	— <i>hispidæ</i> . . . . .	148
Adelocrinus hystrix . . . . .	224, 225; XXX, i-vii	— (Seminula) oblonga . . . . .	147, 148; XVII, xi, xii
Agoniatites sp. . . . .	24; IV, ii	— (Cleiothyris) Royssii . . . . .	148-151; XVII, xiii-xv; XVIII, i-v; XX, i, ii
Ambonychinæ . . . . .	117, 118	— <i>rugulosa</i> . . . . .	149
Ammonoidea . . . . .	24, 25	— ? sp. . . . .	146, 147; XVII, x
Anatifopus? anglica . . . . .	9; I, iv	<i>Atrypa decussata</i> . . . . .	148, 149
Anatinacea . . . . .	72	— <i>hispidæ</i> . . . . .	148, 149
Anisomyaria . . . . .	114-144	— <i>indentata</i> . . . . .	147
Annulosa . . . . .	198, 199	— <i>oblonga</i> . . . . .	147, 148
<i>Anodontopsis deltoideus</i> . . . . .	93	— <i>unguiculus</i> . . . . .	157
<i>Anomites scabriculus</i> . . . . .	170	<i>Avicula Austeni</i> . . . . .	136
Aparchites Lindstroemi . . . . .	16; III, iii	— <i>cancellata</i> . . . . .	126
<i>Arca prisca</i> . . . . .	113	— <i>Dammoniensis</i> . . . . .	126, 127
Arceidæ . . . . .	109-113	— <i>Ibergensis</i> . . . . .	132, 133
Archæocidaridæ . . . . .	202-204	— <i>pectinoides</i> . . . . .	73
Arthropoda . . . . .	3-24	— <i>rudis</i> . . . . .	131
Articulata . . . . .	145-180	— (Pterinea?) <i>serviens</i> . . . . .	124
Ashford Strand, brachiopoda from . . . . .	145, 147, 153, 154, 159, 161, 167, 169, 172, 175	— <i>sp.</i> . . . . .	122
— — bryozoa from . . . . .	185	Aviculidæ . . . . .	117-138

	PAGE		PAGE
Aviculinae . . . . .	118-138	Barnstaple,echinodermata from	203, 218, 221, 224, 226-232, 234-236
Aviculopecten <i>aquisgranensis</i> . . . . .	129	— gasteropoda from . . . . .	49, 57, 58
— <i>cf. exactus</i> . . . . .	131	— lamellibranchiata from	73, 83, 88, 96, 101, 105, 108, 124-126, 128, 129, 131, 137, 138
— <i>granulosus</i> . . . . .	130, 131; XIII, xv	— trilobites from . . . . .	10
— <i>nexilis</i> . . . . .	129, 130; XVI, v, vi; XVII, ii, iii	Batoerinidæ . . . . .	218
— ( <i>Melagrina</i> ) <i>rigida</i> . . . . .	73	Batostomellidæ . . . . .	196, 197
— <i>transversus</i> . . . . .	127, 128; XVI, i-iv	Bellerophon <i>bisulcatus</i> . . . . .	68-70
<i>Axinus deltoideus</i> . . . . .	93	— <i>clathratus</i> . . . . .	62
— <i>nuculoides</i> . . . . .	92, 93	— <i>decussatus</i> . . . . .	62
— <i>orbicularis</i> . . . . .	93, 95	— ( <i>Bucania</i> ) <i>elegans</i> . . . . .	62, 63; VII, i
Baggy, brachiopoda from	147, 164, 175, 177, 183, 184	— <i>globatus</i> . . . . .	64, 65
— cephalopoda from . . . . .	32-34	— <i>Gostariensis</i> . . . . .	67
— Conulites from . . . . .	199	— labyrinthodes . . . . .	63, 65; VIII, i, ii
— crustacea from . . . . .	10, 19, 23	— <i>macromphalus</i> . . . . .	66
— echinodermata from . . . . .	204	— <i>macrostoma</i> . . . . .	66
— gasteropoda from	38, 45, 46, 56, 60, 63, 64, 69, 70	— <i>Sandbergeri</i> . . . . .	67
— lamellibranchiata from	87, 89, 94, 96, 98, 101, 105, 106, 110, 114, 126, 129	— subglobatus . . . . .	64, 65; VIII, iii
Barnstaple Athenæum, brachiopoda in	150, 151, 156, 159, 163, 170, 174, 179, 181	— <i>trilobatus</i> . . . . .	68
— — bryozoa in	186, 198, 199	— <i>Urii</i> . . . . .	70, 71
— — cephalopoda in	24, 28-33	— ? sp. . . . .	65, 66; VIII, vii
— — echinodermata in	208, 212, 216, 219, 220, 223, 224, 229, 232, 234	Bellerophonitidæ . . . . .	62-71
— — fish in . . . . .	3	<i>Berenicea irregularis?</i> . . . . .	197
— — gasteropoda in	37, 39, 41- 43, 45, 47, 49, 51, 53, 55, 57, 58, 61, 63-65, 67	Beyrichia æquilatera . . . . .	20, 21; III, xv
— — lamellibranchiata in	73, 77, 79, 80, 81, 83, 86, 88, 98-100, 102, 104, 105, 108, 110, 112, 121, 126, 128, 129, 132, 134, 139, 141-144	— <i>Damesii</i> . . . . .	21; III, xvi
— — myriopoda in . . . . .	4	Beyrichiopsis <i>Ruperti</i> . . . . .	22; III, xvii
— — ostracoda in . . . . .	16	Blastoidea . . . . .	211-214
— — trilobites in . . . . .	10, 12	Brachiopoda . . . . .	145-184
— brachiopoda from	151, 163, 172, 176, 183	Brachymetopus <i>Woodwardii</i>	13, 14; II, ix-xi
— bryozoa from . . . . .	186, 198	Bradiford, brachiopoda from	153, 157, 161, 165, 167, 177, 179
— cephalopoda from . . . . .	24, 30, 33	— bryozoa from . . . . .	190
		— echinodermata from . . . . .	212, 213
		— lamellibranchiata from	81, 100, 104, 112, 132, 139, 141, 143
		— trilobite from . . . . .	10
		Braunton, brachiopoda from	149, 153, 157, 163, 165, 168-170, 175, 179
		— cephalopoda from . . . . .	26
		— echinodermata from	204, 208, 210, 219- 222, 224, 228, 229, 231, 234
		— gasteropoda from . . . . .	43, 57
		— lamellibranchiata from	80, 106, 110, 118, 122, 128, 129
		— trilobites from . . . . .	10, 12

	PAGE		PAGE
British Museum, brachiopoda in . . . . .	154	<i>Cimitaria</i> . . . . .	85
— cephalopoda in . . . . .	29, 33	Cirripedia . . . . .	9
— lamellibranchiata in . . . . .	85, 110	Cleiothyris . . . . .	148-151
— trilobites in . . . . .	10	Cobracephalus angulosus . . . . .	119; XIII, ix
Brushford, brachiopoda from . . . . .	156	Codonaster conicus . . . . .	214, 215; XXIX, iv
— bryozoa from . . . . .	185, 190	Celioerinus, sp. . . . .	236; XXXVIII, vii
— cephalopoda from . . . . .	31	Coleolus . . . . .	38
— erinoid from . . . . .	224	Collar Bridge, brachiopoda from . . . . .	161
— gasteropoda from . . . . .	53, 56, 60, 65	Conularia <i>continens</i> . . . . .	35
— lamellibranchiata from . . . . .	98, 128	— <i>deflexicosta</i> . . . . .	35, 36; IV, xiii
— trilobites from . . . . .	10, 11	Coomara Swamy Collection, erinoids in . . . . .	223, 229
Bryan Collection, Productus in . . . . .	172	Cornulites devonianus . . . . .	198, 199; XXXVII, i-iii
Bryozoa . . . . .	184-198	Crania ? <i>rieta</i> . . . . .	182; XXII, x
<i>Bucania Archiaci</i> . . . . .	62	— <i>ringens</i> . . . . .	182
— <i>elegans</i> . . . . .	62	Craniella <i>insecura</i> . . . . .	180, 181; XXII, ix
Budleigh Salterton, brachiopoda from . . . . .	154	— <i>Meduanensis</i> . . . . .	181
Camarotoecchia Partridgei 161, 162; XIX, xii-xiv		Crenipecten ? <i>auritus</i> . . . . .	139; XV, vii; XVI, xv, xvi
— <i>togata</i> 163, 164; XIX, xv-xviii		Crinoidea . . . . .	215-236
Camerata . . . . .	217-225	<i>Cromyocerinus</i> . . . . .	232
Camelford, brachiopoda from . . . . .	153	Croyde, brachiopoda from . . . . .	149, 153, 156, 157
Capulus <i>acutissimus</i> . . . . .	49, 50	— 159, 161, 165, 167, 169-171, 175, 177, 179	
— <i>acutus</i> . . . . .	49, 50	— bryozoa from . . . . .	185, 186, 188, 190, 192,
— <i>Bischoffi</i> . . . . .	49, 50	— 196, 201,	
— <i>compressus</i> . . . . .	47, 48; V, xviii	— cephalopoda from . . . . .	33
— <i>conicus</i> . . . . .	49, 50	— crustacea from . . . . .	8
— <i>dormitans</i> . . . . .	46	— echinodermata from . . . . .	208, 209, 219, 220
— <i>Hainensis</i> . . . . .	46	— gasteropoda from . . . . .	45, 47, 53
— <i>hercynicus</i> . . . . .	49, 50	— lamellibranchiata from . . . . .	78, 88, 96, 100,
— <i>rostratus</i> . . . . .	46; V, xv, xvi	— 101, 117, 121, 124, 129, 133, 138	
— <i>selcanus</i> . . . . .	49, 50	— trilobites from . . . . .	10
— <i>terminalis</i> . . . . .	46, 47; V, xvii	Crustacea . . . . .	6-24
<i>Cardinia Bodana</i> . . . . .	80	Cryptostomata . . . . .	184-195
— <i>inflata</i> . . . . .	92, 93	Ctenodonta <i>antiqua</i> . . . . .	101, 102, 103, 104; XIII, v
— <i>trapezoidalis</i> . . . . .	92, 93	— <i>daleidensis</i> . . . . .	102
<i>Cardioconcha</i> . . . . .	72	— ? <i>elliptica</i> . . . . .	103, 104; XIII, vi
Cariderpestes <i>gyius</i> . . . . .	3-5; I, ii	— <i>gibbosa</i> . . . . .	102
<i>Cassianella</i> . . . . .	119	— (Palæoneilo) <i>lirata</i> . . . . .	100-102; XII, xii,
Cephalopoda . . . . .	24-35	— xiii; XIII, i-iv	
Ceraticaris ? <i>sub-quadrata</i> . . . . .	7; I, v	— <i>Newtonii</i> . . . . .	99, 100; X, xv
— sp. . . . .	8; I, vi; II, xii	— (Kœneuia) <i>cf. obsoleta</i> . . . . .	106, 107;
Chonetes <i>Hardrensis</i> . . . . .	177, 178; XXII, iv	— XII, x	
— <i>Illinoisensis</i> . . . . .	179, 180; XXII, vii, viii	— <i>tensa</i> . . . . .	104-106; XII, viii, ix
— <i>Laquessiana</i> . . . . .	177	— <i>unioniformis</i> . . . . .	102
— <i>Logani</i> . . . . .	179	Cuevulka <i>amygdalina</i> . . . . .	109-111
— <i>Margaritacea</i> . . . . .	179; XXII, v, vi	— <i>angusta</i> . . . . .	109-111
— <i>sarcinulata</i> . . . . .	178	— <i>complanata</i> . . . . .	111
		— <i>depressa</i> . . . . .	111, 112; XI, xiv; XII, ii, iii

	PAGE		PAGE
<i>Cucullæa Hardingii</i> . . . . .	109-111	<i>Euphemus Barumensis</i> . . . . .	70, 71; VII, ii
— <i>trapezium</i> . . . . .	109, 110	<i>Fenestella antiqua</i> . . . . .	185
— <i>unilateralis</i> 72, 109-111; XI, iv-xiii; XIII, x, xi		— <i>crassa</i> . . . . .	188
<i>Curtonotus elegans</i> . . . . .	93, 95	— <i>laxa</i> . . . . .	188, 189
— <i>unio</i> . . . . .	97	— <i>fanata</i> . . . . .	185
<i>Cyathocerinus Barumensis</i> . . . . .	227	— <i>Lylli</i> . . . . .	187
— ? <i>macrodactylus</i> . . . . .	215	— <i>multioporata</i> . . . . .	188
<i>Cypricardia deltoidea</i> . . . . .	93, 94	— <i>plebeia</i> . 185, 186; XXII, xiv, xv; XXIII, i	
— <i>impressa</i> ? . . . . .	75	— <i>polyoporata</i> . 188; XXIII, iv, v	
— ? <i>rhombica</i> . . . . .	93	— ? <i>umbrosa</i> 186, 187; XXII, xvi; XXIII, ii, iii	
— <i>semisulcata</i> . . . . .	76	— <i>vera</i> . . . . .	187
<i>Cyrtia</i> . . . . .	153, 156	Fish remains . . . . .	3; I, i
<i>Cytherodon adpressus</i> . . . . .	93	<i>Fistulipora</i> ? sp. . . . .	197; XXIII, xvii
— <i>Chemungensis</i> . . . . .	93, 95	— . . . . .	198; XXIII, xviii, xix
— <i>quadrangularis</i> . . . . .	93, 95	<i>Flexibilia</i> . . . . .	215-217
— <i>rhombicus</i> . . . . .	93	<i>Frankmarsh, brachiopoda from</i> 157, 161, 165, 175	
<i>Desmodonta</i> . . . . .	72-89	— bryozoa from . . . . .	190, 198
<i>Digoniomya elegans</i> . . . . .	117; XIII, xiii	— cephalopoda from . . . . .	31
<i>Discina nitida</i> . . . . .	183; XXII, xi, xii	— gasteropoda from . . . . .	40, 43, 53
<i>Dolabra angusta</i> . . . . .	109	— lamellibranchiata from 99, 106, 108, 116	
— <i>depressa</i> . . . . .	111	<i>Fremington, brachiopoda from</i> 161, 168, 172-174, 80	
— <i>Hardingi</i> . . . . .	109	— cephalopoda from . . . . .	33
— <i>unilateralis</i> . . . . .	109	— echinodermata from 209, 216, 227	
<i>Drepanaster</i> . . . . .	208, 209	— gasteropoda from . . . . .	49
<i>Dulverton, fossils from</i> . . . . .	31, 113	— lamellibranchiata from 99, 108, 114, 116	
<i>East Anstey, fossils from</i> . 7, 10, 159, 188, 195		— trilobite from . . . . .	12
<i>Echinocaris Whidbornei</i> . . . . .	6, 7; I, iii	<i>Freshwater West, Capulus from</i> . . . . .	46
<i>Echinodermata</i> . . . . .	199-236	<i>Gasteropoda</i> . . . . .	35-71
<i>Echinoidea</i> . . . . .	199-204	<i>Geological Society's Museum, fossils in</i> 129, 165	
<i>Edmondia</i> ? <i>Athenæ</i> . . . . .	81; IX, iii	<i>Glaucaneme bipinnata</i> . . . . .	190
— <i>Bodana</i> . . . . .	80, 81; IX, v, viii	<i>Gomphoceratidæ</i> . . . . .	27, 28
— <i>Burlingtonensis</i> . . . . .	80	<i>Goniatites</i> sp. . . . .	25; IV, i
— ? <i>Hamlingii</i> . . . . .	82; XI, iii	<i>Goodleigh, brachiopoda from</i> 153, 161, 167, 168	
— <i>subovata</i> . . . . .	80	— lamellibranchiata from . . . . .	128
<i>Encrinasteriæ</i> . . . . .	204, 205	<i>Grammysiidae</i> . . . . .	74-86
<i>Entomostraca</i> . . . . .	10-14	<i>Gymnokemata</i> . . . . .	184-198
<i>Eocidaris</i> ? <i>æuaria</i> . . . . .	203	<i>Hagley Bridge, brachiopoda from</i> . . . . .	153
<i>Euasteriæ</i> . . . . .	205, 206	<i>Hamling Collection, brachiopoda in</i> 156, 158, 159	
<i>Eugaster granifer</i> . . . . .	207	— — bryozoa in . 188, 193, 196	
— ? <i>perarmatus</i> 209, 910; XXVII, iv-vi		— — crustacea in . . . . .	8
<i>Euomphalus radians</i> . . . . .	54		
— <i>serpens</i> . . . . .	52, 53		
— <i>vermis</i> . . . . .	52, 53; VI, iv		
— sp. . . . .	53		

	PAGE		PAGE
Hamling Collection, echinodermata in	206, 209	Leiopteria Conradi . . . . .	124, 125; XIV, vii
— — gasteropoda in . . . . .	43, 45, 53	— ? murata . . . . .	125; XIV, viii
— — lamellibranchiata	82, 110, 121, 124	<i>Lepeditia dorsicornis</i> . . . . .	18
Harford Landkey, Asteroidæ from . . . . .	206	— <i>mundula</i> . . . . .	19
Heanton, fossils from . . . . .	14, 136	Lepeditiidae . . . . .	15-24
Hexacrinidæ . . . . .	223-225	Lepidesthes? devonians	200-202; XXIV, i, ii; XXV, iii
Holopella <i>antiqua</i> . . . . .	43	<i>Leptæna caperata</i> . . . . .	175, 176
— <i>Hennahiana</i> . . . . .	43	— <i>Hardrensis</i> . . . . .	177
— <i>temisulcata</i> . . . . .	51; V, vii; VI, iii	— <i>interrupta</i> . . . . .	172
<i>Holoptychius</i> . . . . .	3	— <i>membranacea</i> . . . . .	176
Homomyaria . . . . .	72, 89-113	— <i>prælonga</i> . . . . .	168
Hope's Nose, Chonetes from . . . . .	178	— <i>scabricula</i> . . . . .	170, 176
		— <i>sordida</i> . . . . .	178
Ichthyocrinidæ . . . . .	215-217	Leptodesma anatinum	122-124; XIV, iv-vi
Ilfracombe Beds, brachiopoda in . . . . .	168	— <i>citimum</i> . . . . .	120; XIII, vii
Inadunata . . . . .	225-236	— <i>cultellatum</i>	121, 122; XIV, ii, iii
Inarticulata . . . . .	180-184	— sp. . . . .	121; XVI, i; XVII, i
Incheldon, brachiopoda from . . . . .	149	Leptodomus constricta	75, 76; VIII, viii, ix
Ironpost, bryozoa from . . . . .	195	— <i>semisulcata</i>	76, 77; IX, xxiii, xxiv
— gasteropoda from . . . . .	55	<i>Lingula circularis</i> . . . . .	184
— lamellibranchiata from . . . . .	99, 113	— <i>squamiformis</i>	183, 184; XXII, xiii
— <i>Orthoceras</i> from . . . . .	31	Looe, brachiopoda from . . . . .	159
Isochilina canaliculata	15; II, xiii-xv; III, i, ii	Lower Orchard Quarry, cephalopoda from . . . . .	31
<i>Isocrius macroductylus</i> . . . . .	215	Loxonema anglicum . . . . .	43, 44; V, vi
		— <i>Hallii</i> . . . . .	41; V, viii
Kingdon's, brachiopoda from	153, 161, 165, 167, 173, 177	— <i>Hennahianum</i> . . . . .	43
— cephalopoda from	24, 28, 30, 32	— <i>priscum</i> . . . . .	42, 43
— <i>Conulites</i> from . . . . .	199	— <i>rugiferum</i> . . . . .	43, 44
— crustacea from . . . . .	10, 16	— <i>subulata</i> . . . . .	41
— gasteropoda from	39, 42, 43, 51, 53, 55, 57, 63, 64, 67	— <i>trochleatum</i> . . . . .	41, 42; V, iv, v
— lamellibranchiata from	80, 83, 88, 94, 101, 126, 141	Luscott, cephalopoda from . . . . .	26
Kingscote, bryozoa from . . . . .	188	— Barton, brachiopoda from . . . . .	153
Kingsgate, bryozoa from . . . . .	185	<i>Macrocheilus imbricatum</i> . . . . .	45
Kledenia bursæformis	22, 23; III, xviii-xxiii	Macrochilina pusilla . . . . .	40; V, iii
Knowle Quarry, lamellibranchiata from . . . . .	110	— <i>turbinea</i> . . . . .	39, 40; V, i, ii
<i>Kænenia</i> . . . . .	106	<i>Macrodon pygmaeus</i> . . . . .	112
		Mainstone, brachiopoda from . . . . .	177
Lamellibranchiata . . . . .	72-144	Malacostraca . . . . .	6-8
Landlake, brachiopoda from . . . . .	165	<i>Manon cribosum</i> . . . . .	197
— lamellibranchiata from . . . . .	77, 131	Mantell Collection, Sphenotus in . . . . .	85
Laticosta Cave: see Baggy.		Marioerinus? mundus	219, 220; XXXIV, v; XXXVII, vi, vii
<i>Leda perdentata</i> . . . . .	104, 105	<i>Martinia</i> . . . . .	157
Leioclema? distans . . . . .	196; XXIII, xvi	Marwood, brachiopoda from . . . . .	163
		— cephalopoda from . . . . .	28, 30, 32

	PAGE		PAGE
Marwood, gasteropoda from	30, 45, 49, 65, 67	Naticopsis Hallii	44, 45; V, xi-xiii
— lamellibranchiata from	75, 79, 85, 94, 102, 110, 112, 126, 127	Nautilidæ	25-27
— trilobites from	10	Nautiloidea	25-35
Meadfoot, Tentaculites from	38	Newport, brachiopoda from	172
Medusaster parvus	205, 206; XXXVII, iv	New Road Quarry, trilobites from	10
Meer Top, lamellibranchiata from	134	North Moulton, lamellibranchiata from	110
Megistocrinus? sp.	218; XXXVII, v	Nucula latissima	105, 107, 108
Melocrinidæ	219, 220	— lineata	97, 98; X, xiii, xiv
Melonitidæ	199-202	— ovata	107
Millepora gracilis	193-195	— plicata	98
Modiola? amygdalina	114, 115; XIII, xii	— pullastriformis	102
Modiolopsis sp.	114; XII, vii	Nuculidæ	97-108
Mollusca	24-144	Nuculites adpressa	93
Molluscoidea	145-198	— Chemungensis	93
Murchisonia anglica	59, 60; VI, xiv	— ? latissimus	107; XII, xi
— angulata	59, 60	— sulcatina	104
— bistriata	62	Ophio-enerinasteriæ	206-210
— quadricincta	61	Ophinrea	206-211
— similis	61, 62; V, xxii, xxiii	Ophiurella? gregaria	210, 211; XXVIII, iii
— turbinata	59, 60	Ophiuridæ	210, 211
— sp.	60; VI, xv	Ophiuroidea	206-211
Museum of Practical Geology, brachiopoda in	149, 155, 156, 163, 170, 179, 183	Orbicula nitida	183
— of Practical Geology, bryozoa in	186, 187	Orchard House, brachiopoda from	153
— of Practical Geology, cephalopoda in	26, 28-30, 33	Orthis Hardrensis	177
— of Practical Geology, echinodermata		— interlineata	165; XX, vi, vii
in	201, 203-205, 207-210, 215, 217, 221, 222, 224, 228, 229, 231	— parallela	165
— of Practical Geology, gasteropoda in	43, 45, 53, 57, 58, 60, 63, 64, 67, 69, 70	— plicata	165
— of Practical Geology, lamellibranchiata in	75, 77, 78, 80, 83, 86-89, 92, 94, 96, 98, 100, 102, 105, 106, 110, 111, 114, 117, 118, 122, 126, 128, 131, 133, 138	— productoides	175
— of Practical Geology, trilobite in	10, 11	— semicircularis	166
Myophoria deltoidea	93, 94; X, v-viii	— sp.	165; XX, viii, ix
— inflata	92, 93; X, iii, iv	Orthoceras Barumense	30, 31; IV, vii, viii
— trigona	96, 97; X, ix-xi	— cylindraceum	31
Myriopoda	3-5	— Ludense	28, 29
Mytilarca? modioloides	117, 118; XIII, viii	— speciosum	29, 30; IV, iv
Mytilidæ	114-117	— striatum	28
		— tentaculare	38
		— rennense	31, 32
		— sp.	28, 29
		— sp.	32; IV, vi
Natica? meridionalis	45, 46; V, xiv	Orthoceratidæ	28-35
Naticidæ	44-46	Orthonychia acuta	48-51; V, xx, xxi; VI, i, ii
		— conica	49
		— quincyensis	49
		— rotunda	48; V, xix
		— subplicata	49
		Orthotetes crenistria	166-168; XX, x, xi

	PAGE		PAGE
Ostracoda . . . . .	12-24	Pilton, brachiopoda from . . . . .	145, 146, 151-153, 157, 159, 163, 165, 167, 168, 170, 171, 174-176, 179-182
Palæaster longimanus . . . . .	204, 205; XXVI, i-iv; XXIX, iii	— bryozoa from . . . . .	185, 186, 188, 193, 199
<i>Palæoconcha</i> . . . . .	72	— crustacea from . . . . .	7, 10-12, 17, 19-22
<i>Palæoneilo brevis</i> . . . . .	100	— echinodermata from . . . . .	201, 204, 207, 210, 215, 216, 221, 223, 224, 226, 228-230, 232, 234
— <i>sulcatina</i> . . . . .	104	— gasteropoda from . . . . .	36, 38, 40, 46-49, 52-54, 57, 59, 60, 62, 65
Palechinoidea . . . . .	199-204	— lamellibranchiata from . . . . .	78, 79, 83, 88, 96, 101, 108, 121-123, 127, 128, 131, 132, 134, 136, 137, 139, 141, 143
Panenka anglica . . . . .	72-74; VIII, x, xi	— Vicarage Well, brachiopoda from . . . . .	161
Parallelodon prisens . . . . .	113; XII, vi	— — cephalopoda from . . . . .	33
— <i>pygmæus</i> . . . . .	112, 113; XII, iv, v	— — gasteropoda from . . . . .	39, 41, 42, 53, 58, 61, 65
Partridge Collection, brachiopoda in . . . . .	166, 173, 183, 184	<i>Pinnatopora</i> . . . . .	189, 190
— — cephalopoda in . . . . .	31	Plaiestow Mill Quarry, Prothyris from . . . . .	88
— — crinoids in . . . . .	226, 227	<i>Platyceras acutissimum</i> . . . . .	49
— — crustacea in . . . . .	16-18	— <i>acutum</i> . . . . .	49
— — gasteropoda in . . . . .	40	— <i>compressum</i> . . . . .	47
— — lamellibranchiata in . . . . .	129	— <i>conicum</i> . . . . .	49
<i>Pecten alternatus</i> . . . . .	138	— <i>cultellus</i> . . . . .	49, 50
— <i>nevilis</i> . . . . .	129	— <i>dubium</i> . . . . .	49
— <i>polytrichus</i> . . . . .	132, 133	— <i>hercynicum</i> . . . . .	49
— <i>transversus</i> . . . . .	127	— <i>quincyensis</i> . . . . .	49, 50
Pectinidæ . . . . .	139-144	— <i>selcanum</i> . . . . .	49
Pembrokeshire, brachiopoda from . . . . .	183	— <i>subplicatum</i> . . . . .	49
— cephalopoda from . . . . .	30	Platyerinus ? anguliferus . . . . .	223; XXXVII, viii-xii
— gasteropoda from . . . . .	46, 69	Pleuronectites Hicksii . . . . .	142, 143; XVI, xiv
— lamellibranchiata from . . . . .	80, 94, 97, 126, 127	— <i>lepis</i> . . . . .	142; XVI, xii, xiii
Penniretipora bipinnata . . . . .	190, 191; XXIII, vi-viii	— Piltonensis . . . . .	140, 141; XVI, vii-xi
— <i>virgata</i> . . . . .	191, 192; XXIII, ix	Pleurotomaria aspera . . . . .	56, 57-59; VI, x-xiii
<i>Pentremites ovalis</i> . . . . .	212, 213	— <i>distinguenda</i> . . . . .	56
Pentremitidea Phillipsii . . . . .	212, 213; XXIX, v, vi	— <i>expansa</i> . . . . .	54, 55
Perischoëchinidæ . . . . .	199-204	— <i>gracilis</i> . . . . .	55, 56
Pernopecten insperatus . . . . .	143, 144; XVII, v	— Hamlingii . . . . .	56, 57, 58; VI, ix
Petherwyn, brachiopoda from . . . . .	157, 165, 167	— <i>interstitialis</i> . . . . .	57, 59
— bryozoa from . . . . .	185, 188	— <i>minima</i> . . . . .	57, 58
— lamellibranchiata from . . . . .	94	— <i>minuta</i> . . . . .	57, 58
Phacops <i>granulatus</i> . . . . .	11	— <i>victrix</i> . . . . .	58
— <i>latifrons</i> . . . . .	10, 11; I, vii-x; II, i-iv	— sp. . . . .	59; V, ix; VI, viii
Phillipsia Hicksii . . . . .	11-13; II, v-viii	Pleurotomariidæ . . . . .	56-62
Phthonia <i>cf. cylindrica</i> . . . . .	85	Poleshill, brachiopoda from . . . . .	145, 147, 149, 153, 159, 161, 167, 168, 170, 171, 175, 179
— sp. . . . .	85; IX, xix	— bryozoa from . . . . .	185, 186, 190, 197, 199
— sp. . . . .	86		
Phyllocarida . . . . .	6-8		
Pilland, Aviculopecten from . . . . .	128		
Pilton, Actinoceras from . . . . .	33		

	PAGE		PAGE
Poleshill, echinodermata from . . . . .	216, 231	Productus interruptus . . . . .	172, 173; XXII, i-iii
— lamellibranchiata from . . . . .	112, 122	— <i>lavispinus</i> . . . . .	177
— ostracoda from . . . . .	15	— <i>longispinus</i> ? . . . . .	169
— trilobites from . . . . .	10	— <i>praelongus</i> . . . . .	168, 169; XX, xii, xiii
<i>Porcellia Symondsii</i> . . . . .	27	— — var. <i>simplicior</i> . . . . .	169, 170; XX, xiv, xv
Porter Collection, brachiopoda in . . . . .	145, 146, 151, 159, 163, 166, 170, 174, 179, 182	— <i>scabrieulus</i> . . . . .	170, 171; XX, xvi-xviii; XXI, xii
— — bryozoa in . . . . .	186, 188, 197, 199	— cf. <i>subaculeatus</i> . . . . .	174, 175; XXI, i-iii
— — cephalopoda in . . . . .	31, 33	— <i>tenuistriatus</i> . . . . .	173
— — crustacea in . . . . .	7, 9, 10, 12, 14, 15, 19-22	Proctidae . . . . .	11-14
— — echinodermata in . . . . .	204, 209, 210, 216, 221, 223, 224, 226-228, 230-232, 234	Prosobranchia . . . . .	39-71
— — gasteropoda in . . . . .	36, 38, 40, 46- 48, 52-54, 57-60, 62	Protaster granifer . . . . .	207; XXVI, v, vi
— — lamellibranchiata in . . . . .	75, 78-80, 83, 86, 88, 94, 96, 97, 112, 114, 116, 122, 123, 128, 131, 134, 136, 137, 139, 141-143	— <i>gregarius</i> . . . . .	210
Poterioceras sp. . . . .	27, 28; IV, iii	— <i>perarmatus</i> . . . . .	209
— sp. . . . .	28; IV, v	— ? ( <i>Drepanaster</i> ) <i>scabrosus</i> . . . . .	208; XXIX, i, ii
Poteriocerinidae . . . . .	225-236	— — — var. . . . .	209; XXVII, i-iii; XXVIII, i, ii
Poteriocerinus <i>Batheri</i> . . . . .	233, 234	Prothyris contorta . . . . .	87, 88; IX, xv, xvi
— <i>Barunensis</i> . . . . .	227, 232; XXXIV, vi; XXXV, iii	— <i>recta</i> . . . . .	86, 87; IX, xii-xiv
— <i>stadiodactylus</i> . . . . .	233	— <i>scalprata</i> . . . . .	72, 88, 89; IX, xvii, xviii; X, xvi, xvii
— <i>tensus</i> . . . . .	226, 227; XXXV, i, ii; XXXVIII, i	— sp. . . . .	144; XVII, vi
— sp. . . . .	228; XXXV, iv, v; XXXVI, ix	Protocidaris acuaria . . . . .	203; XXV, i, ii
Pottington, brachiopoda from . . . . .	168	Pseudomelaniidae . . . . .	39-44
— trilobite from . . . . .	12, 14	<i>Pterinea</i> cf. <i>Damnoniensis</i> . . . . .	126
Pouch Bridge, brachiopoda from . . . . .	149, 153, 159, 161, 167, 169, 175	— <i>Ibergensis</i> . . . . .	132
— — bryozoa from . . . . .	188, 189	— <i>radiata</i> . . . . .	128
— — gasteropoda from . . . . .	60	Pterinopecten <i>Austeni</i> . . . . .	136, 137; XV, x, xi
— — lamellibranchiata from . . . . .	101, 126	— ? <i>Hallii</i> . . . . .	134, 135; XV, ii-vi
Præcardiidae . . . . .	72-74	— <i>mundus</i> . . . . .	137, 138; XV, xii, xiii
Primitia <i>bovifrons</i> . . . . .	19; III, xxv-xxx	— <i>polytrichus</i> . . . . .	132-134; XV, i
— <i>dorsicornis</i> . . . . .	18; III, xiii	— <i>scabriradians</i> . . . . .	135, 136; XV, viii; ix; XVII, iv
— <i>sparsinodosa</i> . . . . .	16, 17; III, iv-vi	Pteropoda . . . . .	35-39
— <i>vestita</i> . . . . .	19; III, xiv	Ptychopteria <i>Damnoniensis</i> . . . . .	72, 126, 127; XIII, xiv; XIV, ix-xiii
— sp. . . . .	17; III, vii, xi	— <i>Salamanca</i> . . . . .	126, 127
— sp. . . . .	18; III, xii	— <i>Sao</i> . . . . .	126, 127
Productus <i>Cora</i> . . . . .	173	<i>Pullastra antiqua</i> . . . . .	100-102
— <i>corrugatus</i> . . . . .	173, 174; XXI, iv, v	— ? <i>complanata</i> . . . . .	83
— <i>fimbriatus</i> . . . . .	172	— <i>elliptica</i> . . . . .	103
		Raleigh, fossils from . . . . .	141, 161
		Regulares . . . . .	211-215
		Reussellæria ? <i>formosa</i> . . . . .	145, 146; XVII, vii-ix

	PAGE		PAGE
<i>Retzia</i> . . . . .	146	Scaphiocrinus? <i>salebrosus</i>	232; XXXVII, xiii
Rhabdomeson? <i>distans</i> . . . . .	196	— <i>transcisus</i>	230; XXXVIII, iii
— <i>gracile</i> . . . . .	194; XXIII, xi-xv	— <i>sp.</i>	231, 232; XXXIV, viii
Rhaphistoma <i>junius</i> . . . . .	54-56; VI, v-vii	<i>Schizodus adpressus</i> . . . . .	93-95
Rhodocrinus? <i>sp.</i> . . . . .	217, 218; XXXI, iii	— <i>equalis</i> . . . . .	94, 95
<i>Rhombopora</i> . . . . .	193	— <i>Chemungensis</i> . . . . .	94, 95
Rhynchonella <i>laticosta</i> . . . . .	164; XX, iii, iv	— <i>deltoideus</i> . . . . .	94
— <i>Partridgiae</i> 161, 162; XIX, xii-xiv		— <i>fallax</i> . . . . .	96
— <i>pleurodon</i> . . . . .	161	— <i>inflatus</i> . . . . .	92, 93
— <i>reniformis</i> . . . . .	164	— <i>Kefersteini</i> . . . . .	92, 93
— <i>subdentata</i> . . . . .	163	— <i>quadrangularis</i> . . . . .	95
— <i>togata</i> . . . . .	163, 164; XIX, xv-xviii	— <i>rhombus</i> . . . . .	93-95
Roborough, brachiopoda from	147, 149, 151, 153, 161, 163, 171, 175, 179	— <i>trapezoidalis</i> . . . . .	92, 93
— bryozoa from . . . . .	186, 199	— <i>trigonus</i> . . . . .	96, 97
— echinodermata from	216, 223, 234	Scytatocrinus <i>arachnoideus</i>	235; XXXVIII, v, vi
— gasteropoda from . . . . .	58	— <i>stadiodactylus</i>	233, 234; XXXVI, ii-vi, viii; XXXVII, xiv
— lamellibranchiata from	75, 80, 122, 134, 141	Seminula <i>oblonga</i> . . . . .	147, 148; XVII, xi, xii
— trilobites from . . . . .	10	Shirwell, brachiopoda from	153, 161, 165, 167, 169, 173, 177
Rock Hill Quarry, brachiopoda from	177	— cephalopoda from . . . . .	24, 28, 30, 32
— Inn Quarry, brachiopoda from	167, 169	— crustacea from . . . . .	10, 16
<i>Saccocaris</i> . . . . .	7	— gasteropoda from	39, 42, 43, 51, 53, 55, 57, 63, 64, 67
Salpingostoma? <i>macromphalus</i>	64, 65, 66-68; VIII, iv, v	— lamellibranchiata from	80, 83, 88, 94, 101, 110, 126, 141
— <i>macrostoma</i> . . . . .	66	Sloly, Actinoceras from . . . . .	33
<i>Sanguinolaria lirata</i> . . . . .	100	— brachiopoda from . . . . .	153, 158, 184
— <i>soleniformis</i> . . . . .	84, 85	— crustacea from . . . . .	6, 8, 10
Sanguinolites <i>mimus</i>	78, 79; IX, iv, vi, vii	— echinodermata from . . . . .	217, 222
— <i>Porteri</i> . . . . .	77, 78; IX, ii	— gasteropoda from . . . . .	45, 64
— <i>solenoides</i> . . . . .	83	— lamellibranchiata from	77, 79, 80, 84, 88, 102, 105, 110, 126, 132
Saunton, brachiopoda from	147, 153, 158, 161, 165, 167, 169, 174, 175, 183, 184	— myriopoda from . . . . .	4
— bryozoa from . . . . .	190, 197, 198	Smoking House Lane, fossils from	139, 171
— crustacea from . . . . .	8, 10, 15-17	Snapper Quarry, fossils from	155, 158, 185
— echinodermata from . . . . .	223, 226	Solariidae . . . . .	52-56
— gasteropoda from . . . . .	42, 55, 69	South Petherwyn, brachiopoda from	149, 153, 155, 175, 176
— lamellibranchiata from	82, 92, 96, 98, 100	— — gasteropoda from . . . . .	58, 60
Scalariidae . . . . .	51, 52	— — lamellibranchiata from	72, 86, 104, 128
Scaldia? <i>longa</i> . . . . .	89, 90; X, i, ii	Sowden, gasteropoda from . . . . .	49
<i>Scalites</i> . . . . .	54	Spathella <i>munda</i> . . . . .	115, 116; IX, i; XI, i, ii
Scaphiocrinus? <i>inordinatus</i>	230; XXXIV, vii; XXXV, vi; XXXVIII, iv	Sphenotus <i>Hicksii</i> . . . . .	83; IX, ix
— <i>plumifer</i>	228, 229; XXXI, iv; XXXIII, i; XXXVI, i; XXXVIII, ii	— ? <i>soleniformis</i> . . . . .	84, 85; XII, i
		— <i>solenoides</i> . . . . .	83, 84; IX, x, xi

	PAGE		PAGE
<i>Spirifera arachnoidea</i> . . . . .	166	Tiverton, Cucullæa from . . . . .	110
— <i>Archiaci</i> . . . . .	152	Top Orchard Quarry, brachiopoda from . . . . .	151, 153, 156, 157, 169, 170, 175, 177, 181
— <i>Barumensis</i> . . . . .	153-155, 158	— — — bryozoa from . . . . .	190, 192, 195, 196, 199
— <i>Boucharli</i> . . . . .	156, 157	— — — cephalopoda from . . . . .	29, 30, 33
— <i>decussata</i> . . . . .	148	— — — echinodermata from . . . . .	204, 209, 214, 223, 224, 227
— <i>de-Royssi</i> . . . . .	148	— — — gasteropoda from . . . . .	37, 47, 49, 58, 63
— <i>disjuncta</i> . . . . .	152, 153	— — — lamellibranchiata from . . . . .	73, 75, 86, 100, 119, 126, 129, 134, 139, 141, 142, 144
— <i>lineata</i> ? . . . . .	151	— — — trilobites from . . . . .	10
— <i>Lonsdali</i> . . . . .	152, 153	Trepostomata . . . . .	196-198
— <i>mesomala</i> . . . . .	158, 159; XIX, viii, ix	<i>Trigeria</i> . . . . .	146
— <i>microgenma</i> . . . . .	151, 152; XVIII, vii, viii	Trigoniidæ . . . . .	92-97
— <i>Murchisoniana</i> . . . . .	153, 155	Trilobita . . . . .	10-14
— <i>obliterata</i> . . . . .	156, 157; XIX, i-iv	<i>Trimerocephalus lewis</i> . . . . .	11
— <i>rudis</i> . . . . .	163	Tropidodiscus trilobatus . . . . .	68, 69; VIII, vi
— <i>unguiculus</i> . . . . .	157	<i>Tropidoleptus carinatus</i> . . . . .	145
— (Martinia ?) <i>Urü</i> . . . . .	157, 158; XIX, v-vii	Tubicola . . . . .	198, 199
— <i>Verneuhii</i> . . . . .	152, 156, 158; XVIII, ix-xiii	<i>Turritella trochleata</i> . . . . .	41, 42
Spiriferidæ . . . . .	146-161	Tutshill, brachiopoda from . . . . .	153
<i>Spiriferina cristata</i> . . . . .	159-161; XIX, x, xi	Ulrichia interserta . . . . .	23, 24; III, xxiv
<i>Spirigera Roissyi</i> . . . . .	149	Unicardiidæ . . . . .	89, 90
Streblopteria . . . . .	140	Upcott Arch, brachiopoda from . . . . .	149, 151, 153, 157, 161, 165, 167-169, 177
<i>Streblotrypa Gregorii</i> . . . . .	192, 193; XXIII, x	— — bryozoa from . . . . .	190
<i>Streptorhynchus crenistria</i> . . . . .	166	— — crinoids from . . . . .	230, 232
<i>Strophalosia calvus</i> . . . . .	177	— — gasteropoda from . . . . .	40
— <i>productoides</i> . . . . .	171, 175-177; XXI, vi-xi	— — lamellibranchiata from . . . . .	98, 125, 129 143
<i>Strophomena rhomboidalis</i> . . . . .	168; XX, v	— — Orthoceras from . . . . .	31
Strophomenidæ . . . . .	165-168	— — ostracoda from . . . . .	15
<i>Subelymenia Symondsii</i> . . . . .	26, 27; VII, iii-iv	Vertebrata . . . . .	3
<i>Taxocrinus macrodaetylus</i> . . . . .	215, 216; XXXIII, ii-iv	West Angle Bay, brachiopoda from . . . . .	183
— <i>stultus</i> . . . . .	216, 217; XXXIV, i-iii	— — — gasteropoda from . . . . .	69
<i>Tellina inflata</i> . . . . .	92	— — — lamellibranchiata from . . . . .	80, 94, 97, 126
<i>Tentaculites conicus</i> . . . . .	36, 37; IV, xiv	— — — Orthoceras from . . . . .	30
— (Coleolus ?) <i>tentacularis</i> . . . . .	38, 39; IV, xv	Wiviliscombe, brachiopoda from . . . . .	153, 167
— <i>tenuicinctus</i> . . . . .	38		
— <i>tenuis</i> . . . . .	38		
<i>Terebratulata elongata</i> ? . . . . .	148-150		
— <i>laticosta</i> . . . . .	164		
— <i>pleurodon</i> ? . . . . .	161		
Terebratulidæ . . . . .	145, 146		
Tetrabranchiata . . . . .	24-35		
<i>Thetis</i> ? <i>trigona</i> . . . . .	97		
Tintagel, brachiopoda from . . . . .	153		

INDEX TO VOLUME III.

247

	PAGE		PAGE
Woodwardian Museum, brachiopoda in	149, 151, 153, 155, 169-171	Woodwardian Museum, lamellibranchiata in	73, 75, 77, 84, 88, 92, 96, 100, 102, 108, 110, 111, 119, 124-126, 128, 137, 138
— — bryozoa in	186, 187, 192, 195, 196, 198	Wrafton Lane, brachiopoda from	157, 168, 169 177, 185
— — cephalopoda in	24, 30, 33	— — echinodermata from	212, 213
— — crustacea in	7, 8, 10, 11	— — lamellibranchiata from	136, 141 143, 165
— — echinodermata in	204, 214, 217, 218, 221, 222, 226-232, 234- 236	— — trilobites from	. . . 14
— — gasteropoda in	42, 49, 55, 57, 58, 64, 69	Yeotomes, Actinoceras from	. . . 33



THE  
PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

VOLUME FOR 1907.

LONDON :

MDCCCXVII.

## NOTE.

THE Council of the Palæontographical Society regret that, owing to the lamented death of the Rev. J. F. Blake in July, 1906, the present Monograph of the Fauna of the Cornbrash remains incomplete. Mr. Blake had been occupied with the work for many years, and at his death left a large accumulation of notes for use in the concluding section. Most of the unfinished manuscript, however, proved to be of so desultory a nature that it could not be satisfactorily edited. The Council were therefore reluctantly compelled to terminate the volume with the part prepared for press by the author himself.

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### ORDER OF BINDING AND DATES OF PUBLICATION.

PAGES	PLATES	ISSUED IN VOL. FOR YEAR	PUBLISHED
Title-page and Index	—	1907	December, 1907
1—100	I—IX	1905	November, 1905
101, 102	—	1907	December, 1907

A MONOGRAPH

OF THE

FAUNA OF THE CORNBRAsh.

BY

REV. J. F. BLAKE, M.A., F.G.S.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1905—1907.

PRINTED BY ADLARD AND SON, LONDON AND DORKING.

colour bands. The specific name has, moreover, been used by Cossmann for a fossil figured ('Essai Pal. Comp.' v, 4-6) from the Bathonian of Boulogne, showing also several colour-bands.

## SCAPHOPODA.

Genus **DENTALIUM**, Linnæus.

The records of *Dentalium* are as follows :

*D. annulatum* (6, 25).                      *D. glabellum* (6).  
\**D. entaloides* (34, 40, 43).

Only one species is intended by these names. This was discovered by Phillips and figured amongst Cornbrash fossils without specific name. Bean, recording all the Cornbrash fossils known to him, mentioned the name *D. glabellum*, which could only therefore refer to Phillips' specimen. Leckenby having collected some *Dentalia* from the Kelloway Rock, Bean, convinced of their distinctness from the Cornbrash form, named them *annulatum*, but Leckenby, not recognising it, said the *same* species occurred in the Cornbrash, though all the specimens in his collection are of the other kind. Finally, Lycett introduced a new name from Deslongchamps, though both his figure and description refer to a specimen from the Lower Calcareous Grit, as may be seen by the matrix; but he refers to the other specimen, which *vice versâ* he calls a "Calcareous Grit example" as distinct, giving the true distinctions. The only *Dentalium*, then, in the Cornbrash has never been described, but only figured and named.

**Dentalium glabellum**, sp. nov. Plate IX, fig. 12.

1835. *Dentalium*, Phillips, Geol. Yorks., pl. iv, fig. 37.

1839. *Dentalium glabellum*, Bean, Ann. Mag. Nat. Hist. [2], vol. ii, p. 61 (n. n.).

*Type*.—Length 44 mm.; diameter 5.5 mm.; rate of increase unmeasurable—practically *nil*, say 1 in 60; radius of curvature 96 mm. Surface as smooth as possible, only the finest lines of growth observable, most easily seen at the larger end. From Scarborough. In the British Museum.

*Distribution*.—Ten examples have been seen from Scarborough—all of them from the Cornbrash, agreeing with the above.

*Relations*.—The *Dentalia* from the Lower Calcareous Grit which have been mistaken for Cornbrash specimens and referred to *D. entaloides*, have a more rapid rate of increase, a greater curvature, and the smaller end beautifully covered

with machine lines in a practically transverse direction. The *D. entaloides* itself is farther still removed in the first two of these distinctions, and also has noticeable transverse lines, apparently, by Deslongchamps' figure, more undulating.

# INDEX.

	PAGE		PAGE
Abbotsbury Wall Down ...	6	Ammonites humphriesianus ...	37
Acteon ...	95	— legayi ...	57
— sedgwicki ...	95	— macrocephalus ...	42, 43
Acteonina ...	95	— — compressus ...	45
— cinerea ...	97	— modiolaris ...	37
— elongata ...	96	— moorei ...	51
— gigantea ...	96	— subbakeriæ ...	49
— luidii ...	95	— sublævis ...	48
— scarburgensis ...	95, 96	— subradiatus ...	37
Actinopterygii ...	32	— terebratus ...	43
Alaria ...	60	— triplicatus ...	49
— bicornis ...	63	— tumidus ...	43
— bispinosa, var. elegans ...	63	Ammonoidea ..	36
— composita ...	64	Appleby ...	16
— denticulata ...	65	Aporrhaidæ ...	60
— erinacea ...	61	Aptyxiella ...	73
— glaucus ...	62	— blainvillei ...	74
— hamus, var. phillipsii ...	65	— lineata ...	74
— herinacea ...	61	Asteracanthus ...	28
— myurus, var. teres ...	61	— acutus ...	28
— palmata ...	65	— ornatissimus... ..	27
— pupæformis ...	62	— wastensis ...	29
— sp. ind. ...	66	— verrucosus ...	27, 29
— tridigitata ...	62	Ataphrus ...	92
Amberleya ...	83	— halesus ...	92
— armigera ...	84	Barnwell ..	14
Ammonites arbustigerus ..	51	Bedford ...	13
— bakeriæ ...	49	Belemnites redivivus ...	59
— broecchii... ..	37	— tornatilis ...	58
— bullatus ...	37	Belemnoidea ...	58
— discus ...	54, 56	Bicester ...	13
— funatus ...	49	Bittium ...	67
— herveyi ...	46	— lorieri ...	68
— hochstetteri ...	55		

	PAGE		PAGE
Bittium pingue ... ..	67	Curtodus rigauxi ... ..	31
Bletsoe ... ..	14	Cylindrites ... ..	97
Bourne End ... ..	14	— excavatus ... ..	97
Buckland Ripers ... ..	6	— thorenti ... ..	98
Bulla thorentea ... ..	98	Dentalium ... ..	101
— undulata ... ..	99, 100	— annulatum ... ..	101
Bullidæ ... ..	98	— entaloides... ..	101
Cadoceras ... ..	48	— glabellum... ..	101
— breve ... ..	48	East Fleet ... ..	5
Cayton Bay ... ..	17	Eucyclus ... ..	83
Cephalopoda ... ..	33	— armiger ... ..	84
Cerithiidæ ... ..	66	Eulima ... ..	75
Cerithinella ... ..	69	— communis ... ..	76
— biserialis... ..	70	— extricata ... ..	76
Cerithium ... ..	66	— lachryma ... ..	75
— blainvillei ... ..	74	— lævigata ... ..	75, 76
— defrancii ... ..	74	Eulimidæ ... ..	75
— gemmatum ... ..	67	Fairford ... ..	12
— granulatum ... ..	72	Fineshade ... ..	14
— lorieri ... ..	68	Folly Farm ... ..	9
— millepunctatum ... ..	67	Frome... ..	8
— multivolutum ... ..	70	Garsdon ... ..	11
— muricatum... ..	68	Gasteropoda ... ..	60
— tortile ... ..	69	Harpoceras ptychophorum ... ..	56
— variable ... ..	66	Harpoceratidæ ... ..	53
Cestraciontidæ ... ..	28	Heliocryptus ... ..	87
Charlton ... ..	11	— orsus ... ..	87
Chemnitzia heddingtonensis ... ..	77	Holwell ... ..	7
— simplex ... ..	77	Hydatina ... ..	98
— vittata ... ..	77	— limitata ... ..	100
Chippenham ... ..	9, 10	— magnifica ... ..	100
Cimoliosaurus brevior ... ..	22	— undulata ... ..	99
Cirencester ... ..	11	Islip ... ..	12
Cloughtonia ... ..	82	Kidlington ... ..	12
— depressa... ..	82	Kirklington ... ..	12
Clydoniceras ... ..	53	Langton ... ..	6
— discus ... ..	54	Liopleurodon ferox ... ..	23
— hochstetteri ... ..	55	Literature ... ..	18
— ptychophorum... ..	56		
— legayi ... ..	57		
Crocodilia ... ..	26		
Crocodilus oxoniensis ... ..	22		
Cryptaulax ... ..	68		
— tortilis ... ..	69		
Curtodus ... ..	29		

	PAGE		PAGE
Littorina ... ..	85	Nerinæa cingenda ... ..	71
— cassius ... ..	85	— dimidiata ... ..	73
— phillipsi ... ..	84	— fasciata ... ..	71
— punctura ... ..	79	— goodhalli ... ..	73
		— granulata ... ..	72
Machimosaurus ... ..	26	— sharmani ... ..	74
— rigauxi ... ..	26	Nerinæidæ ... ..	71
Macrocephalites ... ..	38	Neritopsis archiaci ... ..	80
— compressus... ..	45	— canaliculata ... ..	80
— herveyi ... ..	46		
— hudlestoni ... ..	47	Opisthobranchiata ... ..	95
— macrocephalus ... ..	42, 43	Oundle ... ..	14
— typicus ... ..	42		
Macromesodon ... ..	32	Palæohydatina undulata ... ..	99
— bathonicus ... ..	32	Patella ... ..	95
Malmesbury ... ..	10	— cingulata ... ..	95
Megalosaurus bucklandi ... ..	22	Perisphinctes... ..	49
Melania vittata ... ..	77	— flagellans ... ..	51
Mesodon ... ..	32	— mutatus ... ..	53
— bathonicus ... ..	32	— sp. ... ..	1, 52
Mollusca ... ..	33	— sp. ... ..	2, 53
Murænosaurus ... ..	25	— subbakeriæ ... ..	49
Murcott ... ..	11	Peterborough... ..	15
		Pisces ... ..	27
Natica... ..	78	Plesiosaurian humerus ... ..	25
— chauviniana ... ..	81	Plesiosauridæ ... ..	23
— cincta ... ..	81	Pleurotomaria ... ..	93
— insignis ... ..	78	— buchiana ... ..	93
— montreuilensis ... ..	80	— debilis ... ..	94
— punctura ... ..	79	— filigrana ... ..	94
— texata ... ..	80	— granulata ... ..	93
Naticidæ ... ..	78	— muensteri ... ..	94
Nautilidæ ... ..	33	Pliosaurus ferox ... ..	24
Nautiloidea ... ..	33	Polyptychodon ferox... ..	23
Nautilus ... ..	33	Pseudomelania ... ..	77
— baberi ... ..	33, 35	— scarburgensis ... ..	77
— calloviensis ... ..	36	— simplex ... ..	77
— giganteus ... ..	35	— vittata ... ..	77
— hexagonus ... ..	33, 36	Pseudomelaniadæ ... ..	76
— inflatus ... ..	34	Pterocera tridigitata ... ..	62
— lineatus ... ..	34	Purpurina ... ..	86
— subinflatus ... ..	34	— condensata ... ..	86
— truncatus ... ..	34	Pycnodontidæ ... ..	32
— tumidus ... ..	43	Pycnodus affinis ... ..	32
Nerinæa ... ..	71	— bucklandi... ..	27
— bathonica ... ..	72		

	PAGE		PAGE
Radipole ... ..	4	Terebra granulata ... ..	72
Reineckia rehmanni ... ..	53	Thrapston ... ..	14
Reptilia ... ..	22	Trochidæ ... ..	88
Rostellaria bispinosa ... ..	63	Trochonematidæ ... ..	83
— composita ... ..	64	Trochus ... ..	88
— lævigata ... ..	61	— angulatus ... ..	92
Rotella expansa ... ..	87	— bunburyi ... ..	88
Rushden ... ..	14	— domatus ... ..	91
		— duplicans ... ..	88
Sauropterygia ... ..	23	— halesus ... ..	92
Scaphopoda ... ..	101	— helius ... ..	92
Scarborough ... ..	17	— lacuna ... ..	90
Selachii ... ..	28	— monilitectus ... ..	88
Shipton-on-Cherwell ... ..	12	— scarburgensis ... ..	89
Steneosaurus boutilieri ... ..	22	— shiptonensis ... ..	91
— stephani ... ..	23	— strigosus ... ..	89, 90
Stephanoceras ... ..	38	— subglaber ... ..	89
— compressum ... ..	45	Turbinoid shells ... ..	82
— macrocephalum ... ..	42	Turbo cassius ... ..	85
Stephanoceratidæ ... ..	38	— elaboratus ... ..	86
Steventon ... ..	14	— funiculatus ... ..	85
Stilton ... ..	15		
Stonecliff Wood ... ..	16	Vanikoro ... ..	98
Stourton Caundle ... ..	8	— canaliculata ... ..	98
Strophodus ... ..	29	Vertebrata ... ..	22
— magnus ... ..	29		
— rigauxi ... ..	31	Weymouth ... ..	4
— subreticulatus ... ..	27	Wincanton ... ..	8
— tenuis ... ..	30	Woodstock ... ..	12
Sutton Benger ... ..	10		
		Yaxley ... ..	15
Teleosauridæ ... ..	26	Yorkshire ... ..	16
Teleosaurus subulidens ... ..	23		







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