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Geological Survey of the State of New York.

PALÆONTOLOGY:

VOLUME VIII.

AN INTRODUCTION TO THE STUDY

OF THE

GENERA

OF

PALÆOZOIC BRACHIOPODA.

PART II.

BY

JAMES HALL,

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ASSISTED BY

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ALBANY, N. Y.:

CHARLES VAN BENTHUYSEN & SONS.

1894.

DEDICATION.

To His Excellency,

ROSWELL P. FLOWER,

Governor of the State of New York:

Sir: I have the honor to present to your Excellency a volume of the Natural History of the State, entitled Volume VIII, Part II, Palæontology of New York.

This volume, published by authority of the Legislature, is the final one of thirteen in this department of Natural Science, and relates especially to the Class Brachiopoda. Any further investigations which may be made in this science will be published as separate papers or memoirs.

The volume is a continuation of Volume VIII, Part I, entitled an Introduction to the Study of the Palæozoic Brachiopoda; Part I having been communicated to your Excellency in 1892. The long delay in the publication of the second part is a matter of extreme regret to the author.

The objects of this work, as stated in the first part of the volume, were to bring together under one title a summary and revision of the genera of Palæozoic Brachiopoda, including in this revision all the genera which had been published in the preceding volumes of the Palæontology of the State, as well as in collateral works. This work has now been accomplished, so far as collections and means of publication have been afforded.

In concluding this work I wish to express my most sincere thanks to your Excellency for the liberal and kindly disposition manifested towards this undertaking; also my grateful acknowledgments to the Legislatures of the State of New York which, in the past, have so liberally responded to the needs of scientific investigation.

I have the honor to remain,
With great respect,
Your obedient servant,

JAMES HALL,

Albany, N. Y., *November* 29, 1894. *State Geologist and Palæontologist.*

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BRACHIOPODA ARTICULATA (*continued*).

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Page 202, under PUGNAX, add Plate lxii.
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PREFACE.

THE present volume brings to a close the publication of the

"*PALÆONTOLOGY OF NEW YORK*,"

AS A PART OF THE

"Natural History of the State of New York,"

according to the plan proposed and inaugurated by Governor WILLIAM H. SEWARD during his administration, 1839–1842.

At the time of the organization of the survey the question of publication had not been seriously considered; the annual reports made to the Governor and communicated to the Legislature were necessarily published in the ordinary octavo document form.

Hon. JOHN A. DIX, in his report preceding the organization of the Geological Survey, had stated that "it is supposed that the entire account of the survey may be contained in three octavo volumes of 700 pages each," together with an atlas, which should contain the maps, "with the necessary drawings of fossil remains." This was the only suggestion regarding the final publication of the results of the survey. In November, 1839, the Board of Geologists made a special communication to the Governor, calling his attention to several matters of interest to the Geological Survey, and concluding as follows:

"The board would also suggest to the Governor, as matters which will soon require attention, the mode and manner in which the final reports are to be published, and the number and style of maps, geological sections and diagrams."*

At a later period it was decided that the entire work should be published in quarto form.

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* Assembly Document 50, January, 1840.

The order of the several departments, as set forth in the first published volume of the Natural History, was as follows:

General Introduction:
[By William H. Seward.]

PART I.
Zoology:
By James E. De Kay.

PART II.
Botany:
By John Torrey.

PART III.
Mineralogy:
By Lewis C. Beck.

PARTS IV and V.*
Geology and Palæontology:
By William W. Mather, Ebenezer Emmons, Lardner Vanuxem and James Hall.

Agriculture was not prominent in the original plan of the survey, and representations coming from the State Agricultural Society, in 1842, led Governor Seward to recognize its importance in this relation. He decided that Agriculture and Palæontology should be considered as departments to be continued and completed as a part of the Natural History of the State of New York.

The Department of Agriculture was placed in charge of Dr. Ebenezer Emmons, who retained his position as State Geologist, and was also the custo-

* After 1842 the Department of Geology was designated as Part IV, Agriculture as Part V, and Palæontology as Part VI.

dian of the entire collections of the Geological Survey, which constituted the State Cabinet of Natural History; to the latter position he had been appointed by Governor SEWARD.

Mr. TIMOTHY A. CONRAD, who occupied the position of Palæontologist to the Geological Survey from 1837 to 1842, had published only such preliminary annual reports as were required of each department. At the latter date (1842) so little progress had been made in the work that only a small proportion of the characteristic fossils had been named or described. The Geologists therefore found it necessary to give names to most of the fossils used in illustrating their reports, these species being the more common and characteristic forms of each group of the New York geological series.

In the spring of 1843 the writer was placed in charge of the Palæontology of the State, while still retaining his position as State Geologist.* At that time there were practically no collections of fossils available for use in the work, nor appropriations of money for making such collections. There were no artists, either for original drawings or for lithography, and there was very little in the way of books on Geology and Palæontology.

Mr. CONRAD had estimated that a volume of one hundred quarto plates would be required to properly illustrate the fossils of all the formations in the State of New York. After the first year of exploration by myself and personal assistants, covering the entire series, from the Potsdam sandstones to the Chemung group inclusive, it was found that no satisfactory account of the fossils of the whole series could be given in a single volume, and that it would be necessary to confine attention to those coming from the lower rocks.† From that time forward efforts were directed to the preparation of descriptions and illustrations of fossils characterizing the lower division of the "New York system," which appeared in the first volume, published in 1847, containing 362 pages and ninety-nine plates of illustration.

In that volume due recognition was made of the sources from which material had been obtained for illustrating the work. Since that time

* See Preface to volume 1, Palæontology of New York.

† At the end of the first year (in 1844) the question of continuing the Departments of Agriculture and Palæontology was brought before the Legislature, and an extension of time allowed for the completion of the work, but no appropriation beyond the salaries of the officials was granted.

acknowledgments have been duly expressed, not only to amateur collectors of fossils, but also to professors in colleges and scientific gentlemen generally, both within the State and beyond its borders, for their willing aid in the progress of the work. Without such aid some portions could not have been properly illustrated (as I was compelled to depend solely on my own purse for collections made in the field during the preparation of the earlier volumes). These volumes (I, II, III), therefore, present a less complete illustration of the faunas of the geological formations to which they refer, than do the later volumes, which were published after the State had furnished means for making field collections.

Volumes I and II should be revised and republished with all the added knowledge of these faunas obtained during the past third of a century.

This work, from its commencement in 1843, has been prosecuted amid many difficulties, and often under conditions which would have justified its final abandonment. These hindrances have been overcome, and a series of volumes has been published, and accepted as a contribution to the scientific literature of the world.

The work in the agricultural and palæontological departments was carried on in the old State Hall (State Cabinet of Natural History) on State street, until 1845, when the authors were compelled to remove themselves and their work from the building. This requirement proved seriously burdensome to the Palæontologist, necessitating at once the erection of a building of moderate size with ordinary working rooms; and afterwards (when the Legislature began to make appropriations for collections of fossils), two extensive buildings were found necessary; these were erected at my own cost and fitted up with about four thousand drawers, for the proper disposition of the immense collections brought in from the field, together with rooms and conveniences for the preparation, study and arrangement of fossils, and offices for draughtsman and lithographer; and they were occupied as a museum and laboratory till the end of 1886. Prior to 1871 the Legislature made no provision for the expenses of these or any other working rooms, nor for clerk hire and incidental outlay.

From 1850 onward for several years no appropriations were made for carrying on the work, and even the author's small salary was discontinued. From

1850 to 1855 the work, except the printing and lithography, was carried on entirely at the author's personal expense, and it was abandoned early in the latter year.* Afterwards, in the same year, Hon. E. W. LEAVENWORTH, Secretary of State, undertook to reëstablish the work upon a proper basis, and the author was induced, by an appeal to his patriotism, to take it again in charge. To do this, he declined a position which would have insured him security of place and a life of quiet investigation in geological science. Under the new arrangement, for the first time in the history of the work, means were provided for the collection of fossils to illustrate the volumes still to be published. Because of these collections the work was necessarily much extended, and Volume V, originally planned as a single volume, including text and plates, has been expanded to four volumes. Volumes VI and VII, and all subsequent work,

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* The following extract from the Preface of Volume III will give a more clear idea of the then existing conditions:

"This department of the Geological Survey of the State was committed to my charge in 1843; Volume I was completed and published in 1847; and Volume II, so far as regarded my own labors, was completed in 1850, and the work of the third volume was at that time in progress. In the spring of that year, legislative enactment removed the direction of this work from the Governor of the State, and placed it in the hands of the Secretary of State, who was 'authorized and directed to take charge of all matters appertaining to the prosecution and publication of the Geological Survey of the State;' and in the third section of the the same law, it was made 'the duty of the Secretary of State and the Secretary of the Regents of the University, to report to the next Legislature a plan for the final completion of the said survey, and to submit the estimate of the cost of such completion.'

"In the Report from this Commission to the Legislature a proposition was made to pay the Palæontologist 'two thousand five hundred dollars' on the 'presentation of each successive volume, commencing with the third, to the Secretary of State;' which volume was to 'contain the manuscript letter-press ready for printing, and be accompanied with the very fossils described.'

"This 'proposition' was 'deemed *a just and liberal one*,' and it seems to have been anticipated that the work would go on under such conditions. The sum of money here proposed to be paid to defray the entire expense of collecting the fossils and the study and description of the same, together with the labor of superintending the drawings and engraving, was in fact entirely inadequate to pay for the collection of the fossils necessary for a single volume, and left, besides this, more than four years of labor to be performed by the Palæontologist without any remuneration whatever. Under these circumstances the work could not go on, and it became by this act virtually suspended in the early part of 1850.

"From the commencement of the work, the expenses of making the collections had been borne by myself. These collections, made up to that time, not only embraced most of those of the first and second volumes, but the greater part of the third volume, as well as extensive collections in the higher rocks of the New York series for the succeeding volumes. Besides these, I had made large collections of fossils in the same series of strata in the west, for the purpose of comparison with the New York species. In this way, as well as in examinations of the rock formations *in situ* over a large part of the Western States, for the purpose of determining the parallelism of the formations, I had already made great pecuniary sacrifices in carrying on the work. Under these circumstances, therefore, and with the new aspect presented by the law of 1850, and the action of the Commission relative thereto, I could no longer devote myself to its prosecution, and consequently made other arrangements for the occupation of my time, which, however, left me still some opportunity to continue my investigations in this work. As the contracts between the State and the engravers continued in force, the engraving, after 1851, was carried on somewhat slowly; my frequent and protracted absence rendering it impossible for me to give that personal attention to it which a work of this kind so fully demands. In order to prevent its entire cessation, I employed a person as an assistant (who afterwards became my draughtsman); the lithographer volunteering to contribute to pay a portion of the expense of such assistant, that his own work might not cease entirely. In this way the work was continued till 1855, no compensation whatever being paid to the author during this period."

have profited by the collections of fossils made from 1856 to 1865 inclusive, when appropriations for such collections ceased.

This final volume (VIII, Part II), after being held back for one year through want of an appropriation, was printed to page 317 in the autumn of 1893. At that point the printing was again suspended. In order to have a record of the date of the completed work, there was issued, in July, 1893, a fascicle containing the text, from page 1–176; embracing descriptions of the spire-bearing genera; and a second fascicle in December, 1893, carrying the text to page 317, including descriptions of the rhynchonelloids, pentameroids and terebratuloids. At that time the concluding chapter or summary was in type, but the appropriation having been exhausted the printer was compelled to suspend all work upon the volume; so that this chapter, bringing the text up to 350 pages, together with accompanying and concluding matter, was laid over to the present year.

In the original scheme of the work on the Brachiopoda the generic descriptions were to be accompanied with illustrations of the microscopic structure of the shell, but it was found inconvenient to accomplish this plan during its progress; though a large number of sections were prepared for microscopic study. This part of the work is postponed for the present, and probably will not be taken up again by the writer.

The great length of time since these studies were resumed in 1888, has enabled those assistants who were with me in the earlier preparation of the work to advance their investigations in the same line of concept, and to anticipate some of the results which have been reached in these volumes. While the final result in this direction is still distant, it is encouraging to see the work advancing in what the writer believes to be the only true method of studying every class of organisms.

In the Preface to Part I of Volume VIII, the author made acknowledgments to many personal friends, to collectors of fossils, to museums and geological surveys; he wishes to repeat these acknowledgments in the Preface to Part II, since this will probably be his last opportunity of connecting their names with the progress of the "Palæontology of New York."

During the fifty-one years which have elapsed since the commencement of this work, I have had many assistants who directly or indirectly have aided in, or have contributed to its progress. Among the earliest of these was Mr. Fielding B. Meek (afterwards Palæontologist to the United States Geological Survey of the Territories), whose services were largely given to the drawings for the plates of Volume III, which were lithographed by Mr. Frederick J. Swinton, the latter continuing his connection with the work till 1872, enriching the volumes by his excellent artistic work. During the early part of the same period, Mr. Ferdinand V. Hayden, who subsequently became Director of the U. S. Geological Survey, was my assistant, and, together with Mr. Meek, made a survey of the Mauvaises Terres of Nebraska, at my personal expense. Dr. Charles A. White, now of the National Museum at Washington, who had been my assistant in the Iowa Survey, was, for one year, engaged in the service of the Palæontology of New York, in making field collections and obtaining geological data. Mr. Robert P. Whitfield, now Curator of Geology in the American Museum of Natural History, was associated with me as preparateur, draughtsman and general assistant in the work for twenty years (1856 to 1876). After this date Mr. Charles D. Walcott, now Director of the U. S. Geological Survey, became my assistant for two years. In the final revision and publication of the four volumes, which constitute Volume V, I had the assistance of Mr. Charles E. Beecher, now Professor in Yale University, from the commencement of the Cephalopoda to the completion of the Lamellibranchiata, from 1878 to 1885. Mr. George B. Simpson, who has served the work for many years as draughtsman, has made himself very familiar with the Bryozoa and Corals of our geological formations, and has given very essential aid in the preparation and publication of Volume VI, as well as in other work connected with the Palæontology. He has also contributed to the State Museum reports a study on the Anatomy and Physiology of the *Anodonta fluviatilis*. In the capacity of my private assistant, the services of Mr. Charles Schuchert, now of the U. S. National Museum, were given to the forwarding of Volume VIII, as already stated in the Preface to Part I. Professor J. M. Clarke, who came into the work in 1886, has given essential aid in the preparation of

Volumes VII and VIII, as already related in the former volume, and also in Part I of the present volume, and has remained with me to its conclusion.

From the beginning of the work it has been the ambition of the author to secure accurate and artistic illustrations of the subjects under discussion. In the earlier part of the work these conditions could not be obtained, but in later years the style and accuracy of the representations has left little to be desired. In the Preface to Part 1 of this volume, I made acknowledgments to the draughtsmen and lithographers who have been engaged upon this work. The original drawings have been continued by Mr. EBENEZER EMMONS and Mr. GEORGE B. SIMPSON, and the lithography by Mr. PHILIP AST, who have attained a degree of perfection in their work of which it is my duty as well as my pleasure to speak in praise. My thanks are due to the printers, Messrs. CHARLES VAN BENTHUYSEN & SONS, now the veteran printing house of the country, with an uninterrupted intercourse to the fourth generation; covering a period of more than fifty years.

To the many successive Legislatures of the State of New York, as well as to the Chief Executives, the scientific public is indebted for the volumes which have been published under the title of PALÆONTOLOGY OF NEW YORK. In every Legislature the author has found gentlemen who were interested in science, and who were in sympathy with this work. Not only among members of the Legislature but among those who had previously held legislative and executive offices, as well as other prominent citizens of the State, the work has found encouragement and support. The people of the State may have the satisfaction of knowing that no other State legislature has sustained, through so many years, a scientific investigation carried on for the sake of science itself, and without anticipating direct economic results. For all this good-will and liberality to science, the writer desires to express, for himself and his scientific co-laborers, the most profound acknowledgments.

JAMES HALL,
State Geologist and Palæontologist.

ALBANY, N. Y., *December* 5, 1894.

INTRODUCTION

TO THE

STUDY OF THE GENERA OF THE PALÆOZOIC BRACHIOPODA.

II.

BRACHIOPODA ARTICULATA

(*CONTINUED*).

Genus SPIRIFER, Sowerby. 1815.

PLATES XXI–XXV, XXIX–XXXIX.

1815. *Spirifer*, Sowerby. Mineral Conchology, vol. ii, p. 42.
1818. *Spirifer*, Sowerby. Trans. Linnean Society, vol. xii, p. 514.
1820. *Terebratula*, Atwater. American Journal of Science, vol. ii, p. 244. pl. i, figs. 2, 3.
1836. *Spirifer*, Morton. American Journal of Science, vol. xxix, pp. 150, 152, pl. ii, figs. 1, 3; pl. xiv, figs. 34, 35.
1839. *Delthyris*, Conrad. Geol. Survey N. Y.; Third Ann. Rept. Palæont. Dept., p. 65.
1840. *Delthyris*, Conrad. Geol. Survey N. Y.; Fourth Ann. Rept. Palæont. Dept., p. 207.
1841. *Delthyris*, Conrad. Geol. Survey N. Y.; Fifth Ann. Rept. Palæont. Dept., p. 54.
1842. *Delthyris*, Conrad. Jour. Acad. Nat. Sci. Philadelphia, vol. viii, pp. 261–265, pl. xiv, figs. 16–18.
1842. *Spirifer*, d'Archiac and de Verneuil. Fossils of the older deposits of the Rhenish Provinces, p. 394.
1842. *Delthyris*, *Orthis*, Vanuxem. Geology of N. Y.; Report Third Dist., pp. 91, 94, 105, figs. 1, 2; p. 112, fig. 1; p. 123, fig. 1; p. 124, fig. 5; p. 132, fig. 3; p. 150, fig. 3; p. 179, fig. 3; p. 269, fig. 1.
1842. *Spirifer*, d'Orbigny. Voyage dans l'Amérique Méridionale. Pal., pp. 41, 48, pl. v, fig. 15; pl. xii, figs. 1, 2.
1843. *Delthyris*, Mather. Geology of N. Y.; Rept. First Dist., p. 342, fig. 1.
1843. *Delthyris*, Hall. Geology of N. Y.; Rept. Fourth Dist., p. 105, figs. 3, 4; p. 142, fig. 1; p. 148, fig. 1; p. 171, fig. 5; p. 198, figs. 2, 3; p. 200, fig. 5; pp. 202, 205, fig. 3; pp. 206, 207, figs. 1, 2, 5; p. 208, figs. 8, 10; p. 245, fig. 1; p. 269, figs. 3, 9; p. 270, figs. 1–5.
1843. *Spirifer*, Castelnau. Essai sur le Système Silurien de l'Amérique Septentrionale, pp. 40–43, pl. xii, figs. 3–6; pl. xiii, figs. 1, 4, 5; pl. xiv, figs. (?) 7, 16.
1844. *Delthyris*, Owen. Rept. Geol. Expl. of Iowa, Wisconsin and Illinois, p. 69, pl. xii, fig. 9.
1846. *Spirifer*, Morris and Sharpe. Quart. Jour. Geol. Soc. London, vol. ii, p. 276, pl. ii, figs. 1–3.
1847. *Spirifer*, Yandell and Shumard. Contribution to the Geol. of Kentucky, pp. 10, 14, 20, 33.
1849. *Spirifer*, Hall. American Journal of Science, vol. xx, p. 228.

1852. *Spirifer*, HALL. Palæontology of N. Y., vol. ii, pp. 66, 261–265, 327, 328, pl. xxii, figs. 2 *d*, 2 *r*, 3; pl. liv, figs. 2–6; pl. lxxiv, figs. 7–9.
1852. *Spirifer*, F. ROEMER. Kreidebildung von Texas, p. 88, pl. xi, fig. 7.
1852. *Spirifer*, HALL. Stansbury's Expl. and Survey of the Valley of the Great Salt Lake of Utah, p. 410, pl. iv, fig. 5.
1852. *Spirifer*, OWEN. Geol. Survey Wisconsin, Iowa and Minnesota, pp. 585, 586, pl. iii, figs. 1–6, 8; pl. v, figs. 4, 6.
1854. *Spirifer*, NORWOOD and PRATTEN. Jour. Acad. Nat. Sci. Philadelphia, vol. iii, pp. 72, 73, pl. ix, figs. 2, 3.
1855. *Spirifer*, SHUMARD. Geol. Survey of Missouri, pp. 202, 203, 216, pl. c, figs. 7, 8.
1856. *Spirifer*, HALL. Pacific Railroad Reports, vol. iii, pp. 101, 102, pl. ii, figs. 6–9, 12.
1856. *Spirifer*, BILLINGS. Canadian Naturalist and Geologist, vol. ii, pp. 134, 135, 137, 474, pl. ii, figs. 2, 3, 7, 8, pl. vii, figs. 9, 10.
1857. *Spirifer*, HAUGHTON. Journal of the Royal Society of Dublin, vol. i, p. 183.
1857. *Spirifer*, *Orthis*, HALL. Tenth Rept. N. Y. State Cab. Nat. Hist., pp. 57, 58, 60–63, 127–135, 154–164.
1857. *Spirifer*, HALL. Transactions of the Albany Institute, vol. iv, p. 8.
1858. *Spirifer*, HALL. Geology of Iowa, vol. 1, part ii, pp. 501–511, 519–521, 600–604, 641–645, 647, 660–663, 676, 705, 706–708, 709–711; pl. iv, figs. 1–8; pl. v, fig. i; pl. vi, fig. 1; pl. vii, figs. 5, 7, 8; pl. xiii, figs. 1–3; pl. xiv, figs. 1–5; pl. xx, figs. 1–5, 7; pl. xxi, fig. 1; pl. xxiii, figs. 6–9; pl. xxiv, fig. 4; pl. xxvii, figs. 4, 6; pl. xxviii, figs. 1, 2,
1858. *Spirifer*, MARCOU. Geology of North America, pp. 49, 50, pl. vii, figs. 2, 4, 5.
1858. *Spirifer*, *Delthyris*, ROGERS. Geology of Pennsylvania, vol. ii, part ii, p. 825, fig. 643; p. 826, fig. 650; p. 828, figs. 668–670, 673; p 829, fig. 683; p. 833, fig. 694.
1858. *Spirifer*, SHUMARD. Trans. St. Louis Acad. Sci., vol. i, pp. 292, 293, 390; pl. xi, figs. 3, 4.
1859. *Spirifer*, HALL. Palæontology of N. Y., vol. iii, pp. 198–205, 419–428, plates xxv, xxvi, xxvii, xxviii, xcvi, figs. 7–9; pl. xcvii, xcviii, figs. 1–8; pls. xcix, c.
1859. *Spirifer*, MEEK and HAYDEN. Proc. Acad. Nat. Sci. Philadelphia, vol. iii, second ser., p. 27.
1859. *Spirifer*, SHUMARD. Trans. St. Louis Acad. Sci., vol. i, p. 391.
1860. *Spirifer*, HALL. Canadian Naturalist and Geologist, vol. v, p. 145.
1860. *Spirifer*, MEEK. Proc. Acad. Nat. Sci. Philadelphia, vol. iv, second ser., pp. 308–310.
1860. *Spirifer*, HALL. Thirteenth Rept. N. Y. State Cab. Nat. Hist., pp. 71, 82, 94, 111.
1860. *Spirifer*, *Ambocœlia*, McCHESNEY. New Palæozoic Fossils, pp. 41–43.
1860. *Spirifer*, SWALLOW. Trans. St. Louis Acad. Sci., vol. i, pp. 641–646.
1860. *Spirifer*, F. ROEMER. Die silurische Fauna des westlichen Tennessee, p. 68, pl. v, fig. 8.
1860. *Spirifer*, EMMONS. Manual of Geology, p. 151.
1860. *Athyris*, BILLINGS. Canadian Jour., vol. v, new ser., p. 276, figs. 33, 34.
1861. *Spirifer*, NEWBERRY. Ives' Rept. Colorado river of the West, p. 127.
1861. *Spirifer*, McCHESNEY. New Palæozoic Fossils, p. 84.
1861. *Spirifer*, HALL. Ann. Rept. Geol. Survey of Wisconsin, pp. 25, 26.
1861. *Spirifer*, BILLINGS. Canadian Jour., vol. vi, new ser., pp. 253, 254, figs. 59–62; p. 255, figs. 63, 64; p. 256, figs. 65–67; p. 257, figs. 68–70; p. 258, figs. 71–73; p. 260, figs. 74–76; p. 261, figs. 77, 78.
1861. *Spirifer*, MEEK and WORTHEN. Proc. Acad. Nat. Sci. Philadelphia, vol. v, second ser., p. 143.
1862. *Spirifer*, WHITE. Proc. Boston Soc. Nat. Hist., vol. ix, p. 24.
1862. *Spirifer*, WHITE and WHITFIELD. Proc. Boston Soc. Nat. Hist., vol. viii, p. 293.
1862. *Spirifer*, WINCHELL. Proc. Acad. Nat. Sci. Philadelphia, vol. vi, second ser., pp. 405, 406.
1862. *Spirifer*, HALL. Geology of Wisconsin, vol. i, p. 69, figs. 5, 6, p. 436.
1862. *Delthyris* (CONRAD) HALL. Fifteenth Rept. N. Y. State Cab. Nat. Hist., pl. xi, fig. 18.
1863. *Spirifera*, DAVIDSON. Quart. Jour. Geol. Soc. London, vol. xix, pp. 170, 171, pl. ix, figs. 7–10.
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1863. *Spirifer*, BILLINGS. Proc. Portland Soc. Nat. Hist., vol. i, pp. 116, 117, pl. iii, figs. 15–17.
1864. *Spirifera (Martinia)*, MEEK and HAYDEN. Pal. Upper Missouri, pp. 17, 19, 20.
1864. *Spirifera*, MEEK. Palæontology of California, vol. i, p. 13, pl. ii, fig. 6.
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1866. *Spirifera*, GEINITZ. Carbon und Dyas in Nebraska, pp. 42, 44, 45, pl. iii, figs. 10, 18.
1866. *Spirifera, Martinia*, WINCHELL. Geological Report of the Lower Peninsula of Michigan, pp. 93, 94.
1866. *Spirifera*, SWALLOW. Trans. St. Louis Acad. Sci., vol. ii, pp. 408–410.
1866. *Spirifera*, BILLINGS. Catalogue Silurian Fossils of Anticosti, p. 48.
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1867. *Spirifera*, HALL. Twentieth Report N. Y. State Cab. Nat. History, pp. 251, 370, 371, pl. xiii, figs. 5–11, 14, 15.
1868. *Spirifera (Martinia)*, MEEK. Trans. Chicago Acad. Sci., vol. i, pp. 101–107, pl. xiv, figs. 1–3, 9, 12.
1868. *Spirifera (Martinia)*, MCCHESNEY. Trans. Chicago Acad. Sci., vol. i, pp. 34–36, pl. i, figs. 3, 4; pl. vi, fig. 5; pl. viii, fig. 3.
1868. *Spirifera*, MEEK and WORTHEN. Geol. Survey of Illinois, vol. iii, pp. 298, 384, 399, 414, 415, 434, 443, pl. vii, fig. 9; pl. viii, figs. 5–7; pl. x, figs. 1, 2, 5; pl. xiii, fig. 8.
1869. *Spirifera*, TOULA. Sitzungsb. d. k. k. Akad. Wissen. zu Wien, vol. lix, p. 3, pl. i, figs. 2–4.
1870. *Spirifera*, WINCHELL. Proc. American Philosophical Soc., vol. xii, pp. 245, 251, 252.
1870. *Spirifera*, MEEK and WORTHEN. Proc. Acad. Nat. Sci. Philadelphia, vol. xiv, sec. ser., p. 36.
1870. *Spirifera (Trigonotreta)*, MEEK. Proc. Acad. Nat. Sci. Philadelphia, vol. xiv, sec. ser., p. 60.
1871. *Spirifera (Trigonotreta)*. MEEK. Proc. Acad. Nat. Sci. Philadelphia, vol. xv, sec. ser., p. 179.
1872. *Spirifera (Martinia)*, MEEK. Hayden's Rept. U. S. Geological Survey of Nebraska, pp. 183, 184, pl. ii, fig. 3; pl. iv, fig. 4; pl. vi, fig. 12; pl. viii, figs. 2, 15.
1872. *Spirifera*, HALL and WHITFIELD. Twenty-fourth Rept. N. Y. State Cab. Nat. Hist., p. 182.
1873. *Spirifera*, HALL and WHITFIELD. Twenty-third Rept. N. Y. State Cab. Nat. Hist., pp. 237, 238, pl. xi, figs. 12–24.
1873. *Spirifera*, MEEK. Sixth Ann. Rept. U. S. Geol. Survey of the Terr., pp. 466, 470.
1873. *Spirifera*, MEEK and WORTHEN. Geological Survey of Illinois, vol. v, pp. 572, 573, pl. xxv, figs. 5, 7.
1874. *Spirifera*, RATHBUN. Bull. Buffalo Soc. Nat. Sci., vol. i, pp. 237, 239, 241, pl. viii, figs. 1–9, 11. 13–21; pl. ix., fig. 22.
1874. *Spirifera (Martinia)*, DERBY. Bull. Cornell University, vol. i, pp. 13, 15, 16, 19, plates i–v, viii, ix.
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1874. *Spirifera*, BILLINGS. Palæozoic Fossils, vol. ii, pp. 44, 45, 47, pl. iii, fig. 8; pl. iii A, figs. 3, 5.
1875. *Spirifera*, MEEK. Palæontology of Ohio, vol. ii, pp. 280, 290, 329, pl. xiv, figs. 5, 8; pl. xix, fig. 14.
1875. *Spirifera*, WHITE. Wheeler's Expl. and Survey West of the 100th Meridian, vol. iv, pp. 86, 88, 90, 132–136, pl. v, figs. 7, 8, 10; pl. x, figs. 1–3; pl. xi, fig. 9.
1875. *Spirifera*, MEEK and WORTHEN. Geol. Survey of Illinois, vol. vi, pp. 521, 523, pl. xxx, figs. 1–3.
1875. *Spirifera*, HALL and WHITFIELD. Twenty-seventh Rept. N. Y. State Cab. Nat. History, pl. ix, figs. 11–13, 17, 18.

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1876. *Spirifera*, MEEK. Bull. U. S. Geol. Survey of the Terr., vol. ii, p. 355, pl. i, fig. 3.

1877. *Spirifera*, HALL and WHITFIELD. King's U. S. Geol. Expl. Fortieth Parallel, vol. iv, pp. 254, 255, 269, 270, pl. iv, figs. 5–8 ; pl. v, figs. 13–15, 17, 18.

1877. *Spirifera* (*Trigonotreta*), MEEK. King's U. S. Geol. Expl. Fortieth Parallel, vol. iv, pp. 39–45, 88, 90, 91, pl. i, fig. 9 ; pl. iii, figs. 1, 3, 5 ; pl. iv, fig. 4 ; pl. ix, figs. 1, 2, 6.

1878. *Spirifera*, DAWSON. Acadian Geology, third ed., p. 292, fig. 91 ; p. 291, fig. 89 ; pp. 301, 499, fig. 176 ; pp. 596, 597.

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1878. *Spirifera*, MILLER. Proc. Davenport Acad. Sci., p. 222.

1879. *Spirifera*, HALL. Twenty-eighth Rept. N. Y. State Mus. Nat. History, pp. 156, 157, pl. xxiv, figs. 1–30.

1879. *Spirifera*, RATHBUN. Proc. Boston Soc. Nat. Hist., vol. xx, pp. 25–30.

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1880. *Spirifera*, WHITE. Second Ann. Rept. Indiana Bureau of Statistics and Geol., pp. 497, 503, 504, 517, plate iii, figs. 5, 6 ; pl. iv, figs. 1–5, 10, 11 ; pl. viii, fig. 3.

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1881. *Spirifera* (*Martinia*), WILLIAMS. Annals N. Y. Acad. Sci., vol. ii.

1881. *Spirifera*, MILLER. Jour. Cincinnati Soc. Nat. Hist., vol. iv. pp. 2, 314, pl. vii, figs. 9, 10.

1881. *Spirifera*, WHITE. Tenth Rept. State Geol. of Indiana, pp. 129, 135, 136, 149, pl. iii, figs. 5, 6 ; pl. iv, figs. 1–5 ; pl. viii, fig. 3.

1881. *Spirifera* (*Martinia*), WHITE. Wheeler's Expl. Survey west of the 100 Meridian, vol. iii, Appendix, p. xii.

1882. *Spirifera*, WHITFIELD. Bull. American Mus. Nat. Hist., vol. i, p. 47, pl. vi, figs. 13–15.

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1882. *Spirifera*, HALL. Eleventh Rept. State Geologist Indiana, pp. 294–297, pl, xxiv, figs. 1–20, 30 ; pl. xxvii, figs. 8, 9.

1882. *Spirifera* (*Martinia*), WHITE. Eleventh Rept. State Geol. Indiana, p. 372, pl. xlii, figs. 4–6.

1883. *Spirifera*, HALL. Twelfth Rept. State Geol. Indiana, p. 326, pl. xxix, figs. 13–15.

1883. *Spirifera*, WHITE. Twelfth Rept. U. S. Geological Survey Terr., pp. 135, 165, pl. xxxiv, fig. 10 ; pl. xli, fig. 2.

1883. *Spirifera*, HALL. Second Ann. Rept. N. Y. State Geol., plates li–lx, figs. 1–18 ; pl. lxi.

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1883. *Spirifera*, CALVIN. American Journal of Science, vol. xxv, p. 433.

1884. *Spirifera* (*Martinia*), WHITE. Thirteenth Rept. State Geologist of Indiana, pp. 132–134, pl. xvii, figs. 4–6 ; pl. xxxii, figs. 23, 24 ; pl. xxxv, figs. 3–5.

1884. *Spirifera* (*Martinia*), WALCOTT. Monogr. U. S. Geol. Survey, vol. viii, pp. 134–139, 143–145, 215–217, pl. iii, figs. 1, 3, 5, 6 ; pl. iv, figs. 1, 2 ; pl. vii, fig. 8 ; pl. xiv, figs. 3, 10–12, 14 ; pl. xviii, figs. 4, 7, 10, 11.

1885. *Spirifera*, CLARKE. Bull. U. S. Geol. Survey, No. 16, pp. 30, 31, pl. iii, figs. 12, 13.

1886. *Spirifera*, RINGUEBERG. Bull. Buffalo Soc. Nat. Sci., vol. v, p. 16, pl. ii, fig. 5.

1887. *Spirifera* (*Martinia*), HERRICK. Bull. Denison University, vol. ii, pp. 45, 46, pl. i, figs, 12, 13 ; pl. ii, figs. 22, 23.

1888. *Spirifera*, HERRICK. Bull. Denison University, vol. iii, pp. 43–46, pl. ii, fig. 16 ; pl. iii, fig. 26 ; pl. v, figs. 2, 3 ; pl. vi, figs. 2–4, 6, 7 ; pl. vii, fig. 11 ; vol. iv, pp. 14, 25–27, pl. ii, figs. 2, 4, 7, 8.

1888. *Spirifera*, KEYES. Proc. Acad. Nat. Sci. Philadelphia, p. 9.

1888. *Spirifera*, CALVIN. The American Geologist, vol. i, p. 82.

1888. *Spirifera*, CALVIN. Bull. Laboratory State University of Iowa, pp. 19, 28.
1889. *Spirifera*, NETTELROTH. Kentucky Fossil Shells, pp. 105–131, pl. vi, vii, viii, ix, x, xi, xii, xiii, figs. 36–38; pl. xvii, figs. 36–42; pl. xxvi, figs. 2–5; pl. xxix, figs. 13–16, 25; pl. xxxi, figs. 10, 11, 13; pl. xxxii, figs. 28–31; pl. xxxiii, figs. 23, 24.
1889. *Spirifer*, BEECHER and CLARKE. Memoirs N. Y. State Museum, pp. 75, 77, pl. vi, figs. 1–7, 9–11.
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1890. *Spirifera*, WORTHEN. Geol. Survey of Illinois, vol. viii, p. 105, pl. xi, fig. 5.
1890. *Spirifera*, FOERSTE. Proc. Boston Soc. Nat. Hist., vol. xxiv, p. 313, pl. v, figs. 5, 6.
1890. *Spirifera*, WILLIAMS. Bull. Geol. Soc. America, vol. i, p. 491, pl. xii, figs. 12, 13.
1890. *Spirifera*, HALL. Bull. Geol. Soc. America, vol. i, p. 567.
1890. *Spirifera*, HALL. Ninth Ann. Rept. N. Y. State Geologist, p. 9.
1891. *Spirifera*, HERRICK. Bull. Geol. Soc. America, vol. ii, p. 45, pl. 1, fig. 18.

SHELLS transversely elongate, rarely produced axially; with or without median fold and sinus. Hinge-line straight, usually forming the greatest diameter of the shell, but in some of the subdivisions of the genus, short and inconspicuous. Cardinal extremities alate, acuminate or rounded.

Surface covered with granulations, striæ, plications or costæ, variously grouped and which may be present or absent on the median fold and sinus; these are crossed by concentric growth-lines which may take the form of varices or expanded lamellæ, or be modified into fimbriæ of simple or compound spines. In the subgenera MARTINIA and MARTINIOPSIS the surface is smooth except for the concentric striæ. Shell substance fibrous, impunctate except as below described; in the smooth species the epidermal layer is minutely pitted.

The pedicle-valve has the umbo more or less elevated over the hinge-line, the apex acute, erect or incurved. The cardinal slopes show a slight tendency to concavity or excavation, and the median portion of the valve is more or less strongly depressed by a sinus. The cardinal area is broad, flat or incurved and its surface is transversely striated; the inner shell-layers bear a series of longitudinal or vertical canals at whose marginal extremities the fibrous tissue is produced into a row of denticles, corresponding to a row of pits on the opposite valve; thus forming an accessory articulation of the valves. The essential articulation is effected by means of stout, simple teeth lying at the marginal extremities of the triangular deltidium and supported by dental plates which are usually short, but, in rare types, may be produced even to the anterior margin of the valve The pedicle-passage or delthyrium is usually open. Normally it is closed by a pair of deltidial plates having the form of scalene triangles, which develop from the sides of the delthyrium and meeting, enclose wholly or partially a circular or oval pedicle foramen. At normal maturity these plates become anchylosed along the median suture and form a single convex plate (the so-called *pseudodeltidium*).

The usual absence of the deltidium may be due either to accidental removal or to resorption with advancing growth. In the adult and senile stages of development many species, especially in the line of development to SYRINGOTHYRIS, form a testaceous callosity in the pedicle-cavity, thickening the umbo and extending across the delthyrium, reaching in extreme cases, nearly to the cardinal margin.

The muscular area consists of a subtriangular pedicle-impression occupying the pedicle-cavity, and continuous with a deeply impressed oval or obcordate area, which is posteriorly situated and divisible into a narrow median adductor and broad lateral diductors, the surface of the latter being marked by radiating or racemose furrows. The posterior and anterior members of the diductors may frequently be distinguished, the former being of less extent and their surface markings somewhat different from those of the latter.

A median septum in this valve is usually absent; occasionally it is in a condition of incipient development, and in certain species having the aspect of SPIRIFERINA and belonging to the line of descent of which this genus may be regarded as the final or accessory product, it forms a most conspicuous feature of the interior.

In the brachial valve the umbo is inconspicuous, the apex only being incurved over the cardinal area; a median fold corresponds to the sinus of the opposite valve. The cardinal area is narrow and divided by a broadly triangular delthyrium. The dental sockets are narrow, moderately deep and bounded interiorly by highly developed socket walls, the extremities of which support the crural bases.

The cardinal process is a low, transverse, sessile apophysis, having its surface vertically striated; occasionally it is bipartite or it may be wholly resorbed.

The crura are long, straight and slightly divergent; their union with the primary lamellæ of the spiral ribbon is at a broadly obtuse angle. The brachial coils are directed outward and upward toward the cardinal angles of the valves and their variation in size and direction is in keeping with the differences in the marginal outline of the shell. The number of revolutions of the ribbon exceeds that in any other genus of brachiopods. There is no loop; its position, however, is indicated by a pair of short spinous processes originating on the primary lamellæ soon after their junction with the crura, and which are directed inward with a slight convergence.

The muscular area has about the same extent as that of the pedicle-valve, though less distinctly impressed and generally more elongated. It is constituted of two pairs of adductor impressions with their surfaces radiately or palmately striated. The anterior pair are central, narrow at their posterior extremities which are embraced by the broader posterior scars.

A faint median septum is sometimes present. In some instances of importance the socket walls are supported by septa which may be considerably produced over the bottom of the valve.

In both valves the genital region is distinctly punctated, but vascular markings are rarely observed.

Type, *Anomites striatus*, Martin (1809). Carboniferous limestone.

Observations.—*Historical.* This most prolific genus received its designation first in 1814, when its distinguished author, Mr. James Sowerby, read a communication before the Linnean Society entitled: "Some account of the spiral tubes or ligaments in the genus *Terebratula*, Lam., as observed in several species of fossil shells." The name was based upon the discovery of the spiral brachial supports in the species *Anomites striatus*, Martin. This contribution was not published until 1818 (Transactions of the Linnean Society, vol. xii, p. 514). Meanwhile, in the second volume of the Mineral Conchology (p. 42, 1815), Sowerby published and described the genus, citing as the only example the *Anomites cuspidatus*, Martin. Davidson has shown* that the author's intention was still to regard *A. striatus* as the type, for appended to his paper in the Linnean Society's Transactions is the remark: "I suspect *A. cuspidatus* figured since the

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* Introduction to British Fossil Brachiopoda, p. 81, foot note.

reading of this paper as *Sp. cuspidatus*, 'Min. Con.' tab. 120, * * * may have a similar construction within."

A few writers have, with excellent reason, argued the application of the term to species congeneric with *A. cuspidatus*. Among these were Professor KING (Monograph of the Permian Fossils of England, pp. 81, 126), and Mr. MEEK (Palæontology of the Upper Missouri, p. 19), both of whom would have applied KOENIG's term TRIGNOTRETA (1825) to spiriferoids of the type of *A. striatus*. It is, however, too late now to enforce the prior rights of *A. cuspidatus* to recognition as the type of SPIRIFER. WINCHELL, in 1863, founded his genus SYRINGOTHYRIS on a species (*S. typa*, Winchell) very similar to, if not identical with *A. cuspidatus* (according to KING and DAVIDSON),* and an inversion of the terms could only induce lamentable disorder in nomenclature.†

It is a most surprising fact that a group of brachiopods with so remarkable a representation in species as this, should afford so unsatisfactory a basis for generic subdivision. Of the various names which have been proposed by different authors but few can be advantageously applied.

TRIGONOTRETA was introduced by KOENIG, in 1825,‡ for a heterogenous assemblage of species, consisting mainly of SPIRIFER and ORTHIS. KING, in emending and adopting the term, selected the species *Terebratula Stokesi*, Koenig, as the type; this appears to have been a form with plicated fold and sinus, and is, hence, a member of the typical division of the genus, the *Aperturati*. Whatever significance the term may have is derived from KING's determinations, and TRIGONOTRETA, King, is a precise equivalent for *Spirifer striatus*, Martin.

CHORISTITES, Fischer de Waldheim, 1825.§ This name was proposed by the Russian author to replace SOWERBY's designation on the ground that the internal organization described by the latter was common to all "the Terebratulas." The first species of the genus cited both in this place and in his later work,

* Mr. CHARLES SCHUCHERT regards WINCHELL's species as not equivalent to the English form, but a synonym for *Spirifer* (*Syringothyris*) *Carteri*, Hall. See Forty-third Rept. N. Y. State Museum, p. 232, 1890.

† Professor KING subsequently abandoned his position in this matter (DAVIDSON, *op. cit.*, p. 81), and it would appear from Mr. MEEK's use of the term SPIRIFER in writings subsequent to 1864, that he also conceded the necessity for its adoption.

‡ Icones Fossilium sectiles, p. 3.

§ Sur la Choristite, p. 7.

"Oryctographie du Gouvernement de Moscou" (1830), is *Choristites Mosquensis*, Fischer (= *Spirifer Mosquensis*, de Verneuil). The generic term was based upon the existence in the pedicle-valve of highly developed dental plates extending almost or quite to the anterior margin; a character which has a less prominent development in a few other species, some of which, as for example, *Spirifer plicatellus*, cannot be satisfactorily grouped with *S. Mosquensis* on the basis of external characters. The greater or less prolongation of these septa or dental lamellæ will be found a feature of comparatively little taxonomic value among these fossils.

Delthyris, Dalman, 1828.* Dalman divided the genus Spirifer into Delthyris and Cyrtia, citing as his first example of the former, *Delthyris elevata*, Dalman, a species now well known in the European Silurian, and one of the plicate-fimbriate members of the genus. The name Delthyris may, with a restricted interpretation, have a value equivalent to that of Reticularia, McCoy, under which the nonplicate-fimbriate species may be included.

McCoy, in his "Synopsis of the Characters of the Carboniferous Fossils of Ireland" (1844), proposed a number of new names to subdivisions of the family *Delthyridæ*:

Fusella (*op. cit.*, p. 132); type, *Spirifer fusiformis*, Phillips; a small, transverse shell with smooth, rounded ribs, some of which are stated to occur on the median fold. The species is but little known, Davidson stating† that he had seen only the imperfect original in the collections of the British Museum.

Martinia (*op. cit.*, pp. 128, 139). "*Gen. Ch.*—Hinge-line shorter than the width of the shell; dorsal edges of the cardinal area obtusely rounded; surface smooth; spiral appendages small."

This group is excellently characterized, though McCoy was in error, as shown by Mr. Davidson and the Rev. Mr. Glass, in considering the spirals as having a less development in proportion to the dimensions of the shell than in other Spirifers. De Koninck, Davidson, Waagen and others have observed that the epidermal layer of the shell is minutely punctured. The first species which

* Kongl. Vetenskaps Akad. Handlingar, pp. 93, 99.

† British Carboniferous Brachiopoda, p. 57.

was cited by McCoy among examples of MARTINIA, is *Spirifer decorus*, Phillips, a form closely allied to, and in the opinion of Mr. DAVIDSON, identical with MARTIN'S *Anomites* (= *Spirifer*) *glaber*.

RETICULARIA (*op. cit.*, pp. 128, 142). First species cited, *Terebratula imbricata*, Sowerby = *Anomites lineatus*, Martin = *Spirifer lineatus* of authors. Shells of this type have the short hinge and the smooth or gently plicated surface characterizing MARTINIA, and like the latter have neither dental plates nor septa on the interior. The name is based upon a species whose surface is covered with concentric fimbriæ of doubled-barreled spines bearing single rows of lateral spinules,* and must probably be restricted to this type of exterior as in the more strongly plicated of the fimbriated Spirifers the surface spines are simple.

BRACHYTHYRIS (*op. cit.*, pp. 128, 144). Proposed for short-hinged plicated species, the first cited being *Spirifer duplicicosta*, Phillips, a very close ally externally and internally of *Spirifer striatus*.

Considering the great possibilities of variation among the Spirifers in the length of the hinge, it seems that this term must be considered a synonym for SPIRIFER in its strictest meaning.

MARTINIOPSIS, Waagen, 1883.† Type, *Martiniopsis inflata*, Waagen. Productus limestone. These are non-plicated shells with smooth exterior and punctured epidermal layer, as in MARTINIA. The distinction from MARTINIA is based upon the existence of well developed dental plates in the pedicle-valve and septa supporting the crura in the brachial valve.

Taxonomic. Whatever value any of the foregoing terms may possess, lies in the fact that it designates an extreme of accessory or lateral development from a typical normal SPIRIFER stock. With a large amount of material affording the successive steps in these variations this value is, to the student, so palpably diminished that he hesitates to make use of any designation which excludes the term SPIRIFER.

At the same time there are certain lines of development leading to definite resultants which it is necessary to regard as generically distinct from SPIRIFER

* See figures *Spirifer lineatus* given by Mr. DAVIDSON and Mr. JOHN YOUNG, Supplement to British Carboniferous Brachiopoda, pl. xxxiv, fig. 9, and expl. of plate, foot note. 1880.

† Salt-Range Fossils; Brachiopoda, p. 524.

though losing none of its external characters. We may cite the apparent outcome of SPIRIFERINA from the septate lamellose Spirifers; and SYRINGOTHYRIS as the final product of changes along the line of those plicate Spirifers with smooth fold and sinus. Such changes, then, which we recognize as having induced actual generic differences are confined to the interior and the intimate structure of the valves; external variations, as far as now known, when unaccompanied by internal changes, must be regarded as of altogether subordinate value.

These external differences, however, make an excellent basis for a grouping of the members of this protean genus, and one not merely conventional and arbitrary, since it serves to indicate, within the integrity of the genus, lines of progress leading to resultants which are no longer congeneric.

Several authors have proposed a classification of the Spirifers on the basis of their external ornamentation, and earlier writers were especially fond of attempts in this direction. Frequently the proposed arrangements have been vitiated by the inclusion within this genus of distinctly heterogeneous species. Thus with VON BUCH'S classification in 1836 and 1837,* and to some extent with that given by PHILLIPS in 1836.† The latter writer proposed six subdivisions of his Spirifers: a, *Cuspidatæ*; b, *Angustatæ*; c, *Radiatæ*; d, *Glabratæ*; e, *Terebratuliformes*; f, *Filosæ*. The list of species referred to the last two divisions contained no Spirifers, but ATHYRIS (e) and SCHIZOPHORIA, ORTHOTHETES and CHONETES (f). The *Cuspidatæ* were typified by *S. cuspidatus*, and this group is equivalent, in a restricted sense, to the genus SYRINGOTHYRIS, though it was also made to include species of CYRTIA, DERBYA and ORTHOTHETES. The *Angustatæ* and *Radiatæ* were separated on the basis of the length of the hinge, which, in the former, equaled or exceeded the width of the shell. Both included species with smooth and plaited fold and sinus. The *Glabratæ* included both *Spirifer glaber* and *S lineatus*, that is, both MARTINIA and RETICULARIA.

DE VERNEUIL‡ divided the Spirifers as follows: I. *Anormaux*, including the *équirostres* (= PORAMBONITES) and *biforés* (= PLATYSTROPHIA); II. *Lisses*, equivalent to RETICULARIA and MARTINIA, but embracing a species of TRIPLECIA; III.

* Ueber das Genus Delthyris; and Ueber Delthyris, oder Spirifer und Orthis.

† Illustrations of the Geology of Yorkshire.

‡ Géologie de la Russie de l'Europe, p. 127. 1845,

Costés, subdivided into the *costés* (= SPIRIFER ?, PENTAMERUS ?) and *costato-striés*, the latter including a radiate species and *Enteletes Lamarcki;* IV. *Plissés*, subdivided into the *aperturati*, with sinus plicate, and *ostiolati*, with sinus smooth; terms which had already been proposed by VON BUCH, and were derived from SCHLOTHEIM'S species, *S. aperturatus* and *S. ostiolatus.*

QUENSTEDT, in 1871, adopted these last-named divisions and added the division *Rostrati*, for species in which the hinge-line is short; this chaotic assemblage was made to include the smooth species of the Palæozoic (MARTINIA and RETICULARIA) as well as the Spiriferinas of the Carboniferous and Mesozoic.

In the American Palæozoic there are probably not less than two hundred species of the genus SPIRIFER. Representatives of the greater number of these have passed under our examination, and they, with the aid of not a few species unknown in American faunas, have furnished the evidence upon which the following proposed arrangement is based:

I. RADIATI. Typical example, *Spirifer radiatus*, Sowerby (including *S. plicatellus*, Sowerby).

(1)* 1840. *Delthyris*, CONRAD. Geol. Surv. N. Y., Pal. Dept.; Fourth Ann. Rept., p. 207.
(1) 1842. *Delthyris*, CONRAD. Journ. Acad. Nat. Sci. Phila., vol. viii, p. 261, pl. xiv, fig. 17.
(2) 1842. *Delthyris*, CONRAD. Journal Acad. Nat. Sci. Philadelphia, vol. viii, p. 261.
(1) 1842. *Delthyris*, VANUXEM. Geology of N. Y.; Rept. Third Dist, p. 120, fig. 1.
(1) 1843. *Spirifer*, CASTELNAU. Essai sur le Système Silur. de l'Amer. Septen., p. 41, pl. xiii, fig. 5; p. 42, pl. xiii, fig. 4.
(1) 1843. *Delthyris*, MATHER. Geology of N. Y.; Rept. First Dist., p. 343, fig. 1.
(1) 1843. *Delthyris*, HALL. Geology of N. Y.; Rept. Fourth Dist., p. 105, fig. 2 *a*, *b*.
(2) 1843. *Delthyris*, HALL. Geology of N. Y.; Rept. Fourth Dist., p. 105, fig. 1; p. 269, fig. 1.
(3) 1847. *Spirifer*, BARRANDE. Ueber die Brachiopoden der Silur. Schicht. Böhmens.
(1) 1852. *Spirifer*, HALL. Palæontology of N. Y., vol. ii, p. 66, pl. xxii, 2 *d–s* (not figs. 2 *a–c*, 2 *f*); p. 265, pl. liv, figs. 6 *a–f*.
(2) 1852. *Spirifer*, HALL. Palæontology of N. Y., vol. ii, p. 264, pl. liv, figs. 5 *a–f*.
(1) 1856. *Spirifer*, BILLINGS. Canadian Naturalist and Geologist, vol. i, p. 135, pl. ii, figs. 2, 3.
(2) 1856. *Spirifer*, BILLINGS. Canadian Naturalist and Geologist, vol. i, p. 137, pl. ii, fig. 8.
(1) 1859. *Spirifer*, HALL. Palæontology of N. Y., vol. iii, p. 202, pl. xxvii, figs. 1 *a–f*; pl. xxviii, figs. 8 *a–d*.
(2) 1860. *Spirifera*, EMMONS. Manual of Geology, p. 151.
(1) 1861. *Spirifera*, HALL. Ann. Rept. Geol. Survey of Wisconsin, p. 25.
(3) 1861. *Spirifera*, HALL. Ann. Rept. Geol. Survey of Wisconsin, p. 26.
(3) 1861. *Spirifera*, MCCHESNEY. Palæozoic Fossils, p. 84.
(1) 1862. *Spirifera*, HALL. Geol. Rept. Wisconsin, vol. i, p. 69, fig. 5; p. 436.
(3) 1862. *Spirifera*, HALL. Geol. Rept. Wisconsin, vol. i, p. 69, fig. 6; p. 436.

* The parenthetical numbers before the citations refer to the subdivisions of the group.

(1) 1863. *Spirifera*, HALL. Transactions of the Albany Institute, vol. iv, p. 211.
(1) 1863. *Spirifer*, BILLINGS. Geology of Canada, p. 317, figs. 328 *a*, *b*; p. 957, fig. 456; and Proc. Portland Soc. Nat. Hist., p. 117, pl. iii, fig. 16.
(2) 1863. *Spirifer*, BILLINGS. Geology of Canada, p. 317, fig. 329.
(1) 1866. *Spirifer*, BILLINGS. Catalogue Silurian Fossils Anticosti, p. 48.
(1) 1867. *Spirifera*, HALL. Twentieth Annual Report N. Y. State Cab. Nat. History, p. 370, pl. xiii, figs. 5, 7; p. 371, pl. xiii, figs. 9–11.
(3) 1867. *Spirifera*, HALL. Twentieth Annual Report N. Y. State Cab. Nat. History, p. 372, pl. xiii, figs. 14–16.
(2) 1867. *Spirifera*, HALL. Palæontology of N. Y., vol. iv, p. 218, pl. xxxv, figs. 1–9; p. 242, pl. xl, figs. 14–22.
(3) 1868. *Spirifera*, MCCHESNEY. Trans. Chicago Acad. Sci., vol. i, p. 35, pl. viii, fig. 3.
(1) 1872. *Spirifera*, HALL. Twenty-fourth Ann. Rept. N. Y. State Mus. Nat. Hist., p. 182.
(1) 1875. *Spirifera*, HALL and WHITFIELD. Twenty-seventh Ann. Rept. N. Y. State Mus. Nat. Hist., pl. ix, figs. 11, 13, 17, 18.
(1) 1879. *Spirifera*, HALL. Twenty-eighth Ann. Rept. N. Y. State Mus. Nat. Hist., p. 156, pl. xxiv, figs. 13–18; p. 157, pl. xxiv, figs. 20–30.
(1) 1880. *Spirifera*, WHITE. Second Ann. Rept. Indiana Bureau of Statistics and Geol., p. 497, pl. iii, figs. 5, 6.
(1) 1881. *Spirifera*, WHITE. Tenth Ann. Rep., State Geologist Indiana, p. 129, pl. iii, figs. 5, 6.
(1) 1882. *Spirifera*, HALL. Eleventh Ann. Rept. State Geologist Indiana, p. 294, pl. xxiv, figs. 13–18; p. 296, pl. xxiv, figs. 20–30.
(1) 1882. *Spirifera*, WHITFIELD. Geology of Wisconsin, vol. iv, p. 287, pl. xvii, figs. 1, 2.
(2) 1885. *Spirifera*, CLARKE. Bull. U. S. Geol. Survey, No. 16, p. 30, pl. iii, fig. 13.
(2) 1886. *Spirifera*, RINGUEBERG. Bull Buffalo Soc. Nat. Hist., vol. v, p. 16, pl. ii, fig. 5.
(1) 1889. *Spirifer*, BEECHER and CLARKE. Mem. N. Y. State Museum, p. 78, pl. vi, figs. 9–11.
(1) 1889. *Spirifera*, NETTELROTH. Kentucky Fossil Shells, p. 117, pl. xxxii, figs. 28–31; p. 129, pl. xxiv, fig. 25; pl. xxvii, figs. 17–19; p. 130, pl. xxix, figs. 13–16.
(1) 1890. *Spirifera*, FOERSTE. Proc. Boston Soc. Nat. Hist., vol. xxiv, p. 313, pl. v, figs, 5, 6.
(2) 1891. *Spirifer*, WHITEAVES. Contributions to Canadian Palæontology, vol. i, p. 224, pl. xxxii, fig. 1.

Smooth, radially undulated or plicated; fold and sinus smooth; entire surface covered with fine, filiform, radiating striæ, which may be minutely crenulated or granulose.

This group includes shells which may vary considerably in the length of the hinge and the degree of plication. *Spirifer radiatus* is frequently, and in American faunas usually devoid of plications, but the assumption of these characters is so gradual a process that there is no satisfactory distinction, in a large number of examples, between the smooth form and the typical plicated form of *S. plicatellus*. The plications are, however, never numerous or sharply defined.

These radiate shells may be conveniently subdivided as follows:

1. *Pauciplicati*, or those with few low plications; as *Spirifer radiatus*, Sowerby, *S. Eudora*, Hall, from the Clinton and Niagara faunas, and *S. macropleura*, Con-

rad, from the Lower Helderberg group. Though this type is not abundantly developed in American faunas it embraces a very considerable number of the many forms described by BARRANDE* from the Bohemian étages E and F. Among these species the cardinal area has but an incipient development or may be altogether absent, while the dental plates are frequently quite pronounced.

2. *Multiplicati*, or those with numerous plications; as *Spirifer Niagarensis*, Conrad, *S. asperatus*, Ringueberg, of the Niagara group; *S. Tullia*, Hall, of the Hamilton fauna; *S. Belphegor*, Clarke, of the Genesee shales; *S. mesastrialis*, Hall, of the Chemung group. In this group, with the more extended hinge and more abundant plications characterizing the Devonian and Carboniferous Spirifers generally, the radiate type of superficial structure has been maintained the longest. It is evident from material before us, that the type was continued into the faunas of the Lower Carboniferous.

3. *Dupliciplicati.* A few upper Silurian species have strong dichotomous plications and the filamentous surface striæ covered with asperities. Such are *Spirifer nobilis*, Barrande, from the étage E_2, and the Niagara limestone of Illinois and Wisconsin, and *S. Schmidti*, Lindström, from the Gotland limestone.

The RADIATI generally may be said to have prevailed at an early period in the history of the genus. The combination was one that was but little modified during its existence and was involved in no progressive development of generic characters.

II. LAMELLOSI. Typical examples, *Spirifer perlamellosus*, Hall, *S. mucronatus*, Conrad.

(2a) 1820. *Terebratula*, ATWATER. Amer. Jour. Sci. and Arts, vol. ii, p. 224, pl. i, figs. 2, 3.
(2a) 1841. *Delthyris*, CONRAD. Geol. Survey N. Y., Pal. Dept.; Fifth Ann. Rept., p. 54.
(1) 1842. *Delthyris*, CONRAD. Jour. Acad. Nat. Sci. Philadelphia, vol. viii, pp. 261, 262, pl. xiv, fig. 18.
(1) 1842. *Delthyris*, VANUXEM. Geology of N. Y.; Rept. Third Dist., p. 132, fig. 3.
(2a) 1842. *Delthyris*, VANUXEM. Geology of N. Y.; Rept. Third Dist., p. 150, fig. 3.
(1) 1843. *Delthyris*, HALL. Geology of N. Y.; Rept. Fourth Dist., p. 105, fig. 4; p. 200, fig. 5; pp. 202, 269, fig. 9; p. 270, fig. 5.
(2a) 1843. *Delthyris*, HALL. Geology of N. Y.; Rept. Fourth Dist., p. 198, figs. 2, 3; p. 205, fig. 32; p. 270, fig. 3.
(2a) 1843. *Spirifer*, CASTELNAU. Essai sur le Système Silur. de l'Amer. Septentr., pl. xiii, fig. 1.

* Système Silurien du Centre de la Bohême, vol. v, pls. i–viii.

(1) 1849. *Spirifer*, HALL. American Journal of Science, vol. xx, p. 228.
(1) 1852. *Spirifer*, HALL. Palæontology of N. Y., vol. ii, p. 261, pl. liv, fig. 2.
(1) 1856. *Spirifer*, BILLINGS. Canadian Naturalist and Geologist, vol. i, p. 137, pl. ii, fig. 7.
(2*a*) 1856. *Spirifera*, BILLINGS. Canadian Naturalist and Geologist, vol. i, p. 474, pl. vii, figs. 9, 10.
(1) 1857. *Spirifer*, HALL. Tenth Rept. N. Y. State Cab. Nat. Hist., p. 57, figs. 1–5.
(2*a*) 1857. *Spirifer*, HALL. Tenth Ann. Rept. N. Y. State Cab. Nat. Hist., pp. 130, 131.
(2*b*) 1857. *Spirifer*, HALL. Tenth Ann. Rept. N. Y. State Cab. Nat. Hist., pp. 62, 63, 134.
(1) 1858. *Delthyris*, ROGERS. Geology of Pennsylvania, vol. ii, p. 825, fig. 643.
(2*a*) 1858. *Spirifer*, HALL. Geol. Survey of Iowa, p. 507, pl. iv, figs. 6 *b*, *c*, *d*; p. 504, pl. iv, figs. 3 *a–c*.
(1) 1859. *Spirifer*, HALL. Palæontology of N. Y., vol. iii, p. 201, pl. xxvi, figs. 1, 2.
(2*b*) 1859. *Spirifer*, HALL. Palæontology of N. Y., vol. iii, p. 419, pl. xcvi, figs. 7 *a–f*; p. 421, pl. xcvi, figs. 9 *a–g*.
(1) 1860. *Spirifer*, HALL. Thirteenth Rept. N. Y. State Cab. Nat. Hist., p. 94.
(2*b*) 1860. *Spirifer*, MEEK. Proc. Acad. Nat. Sci. Philadelphia, vol. iv, p. 308.
(1) 1860. *Spirifer*, HALL. Canadian Naturalist and Geologist, vol. v, p. 145.
(1) 1861. *Spirifera*, BILLINGS. Canadian Journal, vol. vi, p. 258, figs. 71–73.
(2*a*) 1861. *Spirifera*, BILLINGS. Canadian Journal, vol. vi, pp. 254, 255, figs. 59–64.
(2*a*) 1862. *Spirifer*, A. WINCHELL. Proc. Acad. Nat. Sci. Philadelphia, vol. xiv, p. 405.
(1) 1863. *Spirifera*, BILLINGS. Proc. Portland Soc. Nat. Hist., vol. i, p. 117, pl. iii, fig. 17.
(1) 1863. *Spirifera*, BILLINGS. Geology of Canada, p. 372, fig. 392; p. 386, fig. 423; p. 957, fig. 455.
(2*a*) 1863. *Spirifera*, BILLINGS. Geology of Canada, p. 960, fig. 467; p. 386, fig. 424 *a–d*.
(2*a*) 1866. *Spirifera*, A. WINCHELL. Rept. Lower Peninsula of Michigan, p. 93.
(1) 1867. *Spirifera*, HALL. Palæontology of N. Y., vol. iv, pp. 192, 221, 222, 240, pl. xxvii, figs. 30–34; pl. xxx, figs. 1–9; pl. xxxv. figs. 10–23; pl. xl, figs. 1–13.
(2*a*) 1867. *Spirifera*, HALL. Palæontology of N. Y., vol. iv, p. 205, pl. xxxi, figs. 1–4; p. 207, pl. xxxi, figs. 14–19; p. 208, pl. xxxi, figs. 9, 10; p. 216, pl. xxxiv, figs. 1–32.
(2*b*) 1867. *Spirifera*, HALL. Palæontology of N. Y., vol. iv, p. 190, pl. xxvii, figs. 18–28.
(1) 1868. *Spirifera*, MEEK and WORTHEN. Geological Survey of Illinois, vol. iii, p. 384, pl. vii, fig. 9.
(1) 1871. *Spirifera*, NICHOLSON. Palæontology of Province of Ontario, p. 82.
(1*b*) 1874. *Spirifera*, NICHOLSON. Palæontology of Province of Ontario, p. 80.
(1) 1874. *Spirifera*, BILLINGS. Palæozoic Fossils, vol. ii, p. 47, pl. iii A, fig. 5.
(2*b*) 1876. *Spirifer*, MEEK. Simpson's Rept. Expl. Great Basin Utah, p. 346, pl. i, fig. 1.
(2*b*) 1877. *Spirifer*, MEEK. King's Rept. Expl. Fortieth Parallel, vol. iv, p. 41, pl. iii, fig. 3.
(1) 1878. *Spirifera*, DAWSON. Acadian Geology, third ed., p. 576.
(1) 1882. *Spirifera?*, WHITFIELD. Geology of Wisconsin, vol. iv, p. 332, pl. xxv, figs. 23, 24.
(2*a*) 1882. *Spirifera*, WHITFIELD. Geology of Wisconsin, vol. iv, p. 328, pl. xxv, figs. 27, 28.
(1) 1883. *Spirifera*, HALL. Second Report N. Y. State Geologist, pl. lix, figs. 9, 27–34; pl. lx, figs. 1–18.
(1) 1884. *Spirifera*, WALCOTT. Monogr. U. S. Geol. Survey, vol. viii, p. 135, pl. iv, fig. 2; pl. xiv, fig. 12.
(2*a*) 1884. *Spirifera*, WALCOTT. Palæontology Eureka Dist., pp. 136, 217, pl. vii, fig. 8.
(1) 1889. *Spirifera*, NETTELROTH. Kentucky Fossil Shells, pp. 128, 132, pl. xvii, figs. 38–42; pl. xxxi, fig. 13.
(2*b*) 1889. *Spirifera*, NETTELROTH. Kentucky Fossil Shells, p. 112, pl. xii, figs. 1–4.
(2*a*) 1889. *Spirifera*, NETTELROTH. Kentucky Fossil Shells, p. 134, pl. x, figs. 11–20, 23–25; p. 109, pl. x, figs. 1–5, 31–34, 36–39; p. 121, pl. x, figs. 21, 22, 26–30, 35, 40; p. 108, pl. xii, figs. 14, 15; p. 132, pl. xiii, figs. 36, 38; p. 126, pl. xxxi, figs. 10, 11.
(2*a*) 1891. *Spirifera*, WHITEAVES. Contributions to Canadian Palæontology, vol. i, p. 223.

Radially plicated; surface covered with numerous concentric lamellæ. In Silurian species the fold and sinus are non-plicate; the later forms usually bear a low median depression on the fold accompanied by a corresponding median ridge in the sinus.

In this division we meet with considerable diversity in exterior form, the hinge being at times short, and again extremely extended; always, however, making the greatest diameter of the shell. The cardinal area is usually low, but may be considerably elevated. The species all have a fine, very faintly developed median ridge in the interior of the brachial valve and the cardinal process developed as a low, single, multistriate apophysis, with sometimes a tendency to bilobation.

The lamellose species are conveniently subdivided into two groups:

1. *Septati;* those having a median septum in the pedicle-valve. The septum lies between the bases of the teeth but does not come into contact with them as in the genus CYRTINA, where the latter are supported by dental lamellæ resting on the bottom of the valve.

This character is found in an incipient condition of development in the Niagara species *Spirifer sulcatus*, Hisinger, and is a more conspicuous feature in subsequent forms, *S. perlamellosus*, of the Lower Helderberg, *S. raricosta*, of the Upper Helderberg, *S. consobrinus*,* of the Hamilton group and *S. mesacostalis*, of the Chemung group. Up to the period of the upper Devonian, at least in American faunas, the existence of this septum in the pedicle-valve is not accompanied by a punctation of the shell-tissue, nor by the union of the processes on the primary lamellæ of the spiral arms; features which characterize the genus SPIRIFERINA, and, indeed, form the only basis of distinction between some of the palæozoic members of this genus and these septate Spirifers. At present we are without evidence of the gradual assumption of punctation by shells in this line of development, but there can be no reason to doubt that its appearance here was of the same nature as along the line leading from SPIRIFER to SYRINGOTHYRIS,† gradual or sporadic.

* This is the species described as *Spirifer zic-zac*, Hall, in 1843. The same specific name was, curiously enough, used by F. ROEMER, in the same year, for a quite distinct Devonian SPIRIFER, and D'ORBIGNY, in 1850, proposed for the American species the name above used.

† See observations on the genera SYRINGOTHYRIS, CYRTINA and SPIRIFERINA.

Mr. Davidson has referred two Devonian species to Spiriferina, *S. cristata* Schlotheim, var. *octoplicata*, and *S. insculpta*, Phillips (?), both of which are described as having a punctate structure. It is not known, however, whether in these early forms the loop has attained its ultimate development; we might expect to find it with its lateral branches discrete as in the true Spirifers.

The species of this septate section have, so far as known, the surface of the concentric lamellæ covered with fine radiating striæ which were evidently not continued into spines or fimbriæ. Among the forms which are referred to the genus Spiriferina nearly every variation of surface ornament is to be found except this. The Carboniferous species, like *S. Kentuckiensis* and *S. solidirostris*, which resemble very closely in other respects these septate lamellose Spirifers, are fimbriated.

2. *Aseptati*. Those without a median septum in the pedicle-valve. These species are more abundantly plicated, often much more extended on the hinge than in the septate group. The lamellæ are without radial striations. The *Aseptati* group themselves naturally about two type-forms, the first, (a), *Spirifer mucronatus*, Conrad, an alate, multiplicate shell with a single low plication in the sinus and a corresponding depression on the median fold; the other, (b), *Spirifer submucronatus*, Hall, in which the fold and sinus are not plicate.

Of these subdivisions the latter was the first to appear in the American Palæozoic, and is represented by *S. submucronatus*, and *S. Cumberlandiæ*, Hall, of the Oriskany sandstone of Maryland, *S. macrus*, Hall, *S. gregarius*, Clapp, and an undescribed species from the Upper Helderberg group. *Spirifer gregarius* is of interest in having a high area, a rather short hinge, and in assuming some of the characters of the group of the *Ostiolati* in its internal umbonal callosities.

The Mucronatus-type does not appear earlier than the Hamilton fauna, where it is represented by *S. mucronatus*, *S. segmentus*, Hall, *S. bimesialis*, Hall, *S. subattenuatus*, Hall, *S. varicosus*, Conrad.

III. Fimbriati. Typical examples, *Spirifer fimbriatus*, Conrad, *S. lineatus*, Martin, *S. arrectus*, Hall.

(1*a*) 1842. *Orthis*, Vanuxem. Geology of N. Y.; Rept. Third Dist., p. 112, fig. 1.
(1*b*) 1842. *Orthis*, Vanuxem. Geology of N. Y.; Rept. Third Dist., pp. 91, 94.

(2) 1842. *Delthyris*, CONRAD. Jour. Acad. Nat. Sci. Philadelphia, vol. viii, p. 263.
(1*a*) 1843. *Orthis? (Delthyris)*, HALL. Geology of N. Y.; Rept. Fourth Dist., p. 142, fig. 1.
(1*a*) 1843. *Delthyris*, HALL. Geology of N. Y.; Rept. Fourth Dist., p. 105, fig. 3; p. 171, fig. 5.
(1*b*) 1843. *Delthyris*, HALL. Geology of N. Y.; Rept. Fourth Dist., p. 208, fig. 10; p. 345, fig. 1.
(1*a*) 1843. *Spirifer*, CASTELNAU. Essai sur le Système Silur. de l'Amer Septentr., p. 41, pl. xii, figs. 1, 2.
(1*a*) 1849. *Spirifer*, HALL. American Journal of Science, vol. xx, p. 228.
(1*a*) 1852. *Spirifer*, HALL. Palæontology of N. Y., vol. ii, p. 262, pl. liv, figs. 3 *a–k*; p. 328, pl. lxxiv, figs. 9 *a–h*.
(1*b*) 1852. *Spirifer*, HALL. Palæontology of N. Y., vol. ii. p. 263, pl. liv. fig. 4.
(2) 1853. *Spirifer*, SWALLOW. Trans. St. Louis Acad. Science, vol. ii, p. 86.
(1*a*) 1857. *Spirifer*, HALL. Tenth Rept. N. Y. State Cab. Nat. Hist., pp. 58, 62.
(2) 1858. *Spirifer*, HALL. Geol. Survey Iowa, vol. i, pt. ii, p. 505, pl. iv, figs. 5 *a–e*; p. 645, pl. xx, fig. 4; p. 705, pl. xxvii, fig. 4.
(1*a*) 1859. *Spirifer*, HALL. Palæontology of N. Y., vol. iii, p. 420, pl. xcvi, figs. 8 *a–e*; p. 422, pl. xcvii, figs. 1 *a–h*, 2 *a–i*; p. 205, pl. xxviii, figs. 4 *a–e*; p. 199, pl. xxv, figs. 1 *a–z*; p. 203, pl. xxviii, figs. 2 *a–f*; p. 198. pl. viii, figs. 17–23.
(1*b*) 1859. *Spirifer*, HALL. Palæontology of N. Y., vol. iii, p. 203, pl. xxviii, fig. 1.
(2) 1860. *Spirifer*, MCCHESNEY. New Palæozoic Fossils, p. 43.
(1*a*) 1861. *Spirifera*, BILLINGS. Canadian Journal, vol. v, p. 256, figs. 65–67.
(2) 1861. *Spirifera*, BILLINGS. Canadian Journal, vol. v., p. 257, figs. 68–70.
(2) 1862. *Spirifera*, WHITE and WHITFIELD. Proc. Boston Soc. Nat. Hist., vol. viii, p. 116, pl. iii, fig. 15.
(1*b*) 1863. *Spirifera*, BILLINGS. Proc. Portland Soc. Nat. Hist., vol i, p. 116, pl. iii, fig. 15.
(1*a*) 1863. *Spirifera*, HALL. Transactions of the Albany Institute, vol. iv, p. 212.
(1*a*) 1863. *Spirifera*, BILLINGS. Geology of Canada, p. 372, figs. 394 *a, b, c*; p. 960, fig. 466; p. 957, fig. 457.
(1*a*) 1867. *Spirifera*, HALL. Palæontology of N. Y., vol. iv, p. 189, pl xxvii, figs. 13–16; pl. xxviii, figs. 24–33.
(1*b*) 1867. *Spirifera*, HALL. Palæontology of N. Y., vol. iv, p. 239, pl. xxxix, figs. 1–12.
(2) 1867. *Spirifera*, HALL. Palæontology of N. Y., vol. iv, p. 214, pl. xxxiii, figs. 1–21; p. 250, pl. xxxiii, figs. 31–35.
(2) 1868. *Spirifer*, MEEK and WORTHEN. Geol. Survey Illinois, vol. iii, p. 434, pl. x, figs. 5 *a–e*.
(1*a*) 1868. *Spirifera*, MEEK and WORTHEN. Geol. Survey Illinois, vol. iii, p. 399, pl. viii, figs. 6 *a–d*, figs. 7 *a, b*.
(1*a*) 1874. *Spirifera*, BILLINGS. Palæozoic Fossils, vol. ii, p. 48, pl. iii A, figs. 4. 4 *c*.
(1*a*) 1879. *Spirifera*, HALL. Twenty-eighth Ann. Rept. N. Y. State Mus., p. 157, pl. xxiv, figs. 6–12, 19.
(1*a*) 1879. *Spirifera*, RATHBUN. Proc. Boston Soc. Nat. Hist., vol. xx, p. 25.
(1*a*) 1881. *Spirifera*, HALL. Eleventh Ann. Rept. State Geologist Indiana, p. 295, pl. xxiv, figs. 6–12, 19.
(1*b*) 1882. *Spirifera*, HALL. Eleventh Ann. Rept. State Geologist Indiana, p. 297, pl. xxvii, figs. 8, 9.
(2) 1884. *Spirifera (Martinia)*, WHITE, Thirteenth Annual Report State Geologist of Indiana, p. 133, pl. xxvii, figs. 4–6.
(2) 1884. *Spirifera (Martinia)*, WALCOTT. Palæontology Eureka Dist., pp 143–145, pl. iii, figs. 3, 6; pl. xiv, fig. 11.
(1*b*) 1888. *Spirifera*, CALVIN. Bull. Laboratories University of Iowa, p. 28.
(1*a*) 1889. *Spirifera*, NETTELROTH. Kentucky Fossil Shells, p. 114, pl. xii, figs. 12, 13, 16; p. 111, pl. xvii. figs. 36, 37.
(1*a*) 1889. *Spirifer*, BEECHER and CLARKE. Mem. N. Y. State Mus., vol. i, No. 1, p. 75, pl. vi, figs. 4–7.
(1*a*) 1891. *Spirifera*, WHITFIELD. Annals N. Y. Acad. Science, vol. v, p. 509, pl. v, figs. 4, 5.

Shells with few low plications or none; hinge line not greatly extended, often shorter than the greatest diameter of the shell; dental lamellæ moderately, sometimes notably developed; a low median septum may exist in the pedicle-valve. Surface covered with concentric rows or fringes of fine spines.

This group is susceptible of the following subdivision:

1. *Unicispinei* = Delthyris, Dalman, 1828, *sensu stricto*; those species in which the concentric fimbriæ are made up of short, simple, hollow spines. These are the early fimbriate species, the type of structure not extending, so far as now known, beyond the Devonian. The shells are distinguished from the other fimbriate Spirifers by their more extended and more distinctly plicated surface and the prominent, often sharply developed fold and sinus. Their more characteristic representatives in the American Palæozoic are *Spirifer crispus*, Hisinger, and var. *simplex*, Hall, of the Niagara faunas; *S. Vanuxemi*, Hall, of the Tentaculite limestone, *S. Saffordi*, *S. octocostatus*, Hall, of the Lower Helderberg group, *S. arrectus*, *S. tribulis*, Hall, of the Oriskany sandstone and *S. duodenarius*, Hall, of the Corniferous limestone.

This may be termed the (a) *S. crispus*-type.

An interesting series of forms which has had a parallel development with the *S. crispus*-type begins with the *S. bicostatus*, Vanuxem, and var. *petilus*, Hall, in the Niagara group, is represented by *S. modestus*, Hall, in the Lower Helderberg group, by a new species, *S. Canandaiguæ*,* from the Hamilton group of New York, and possibly, *S. urbanus*, Calvin, from a corresponding horizon in Iowa, the line terminating in (b) *S. laevis*, Hall, from the lower Portage shales at Ithaca, N. Y. These are all unicispinate, but have the short hinge, subcircular outline and obsolescent plications characterizing the duplicispinate group of the Fimbriati. It is important to observe that this little series has, with reference to the main line of development of these forms, an expression of immaturity, the low plications and short hinge being features indicative of such a condition among those species.† With the exception of *S. laevis*, all the members of this subordinate group (the *S. laevis*-type) are quite small; the Portage species, however, is one of the largest of fimbriate Spirifers, while its development, though abundant in individuals, is sharply localized. It stands out prominently as a

* For description of this species see Supplement to this volume.

† See observations on, and illustrations of *Spirifer bicostatus* and var. *petilus*, and young of *S. crispus* and var. *simplex*, in Memoirs New York State Museum, vol. i, No. 1, pp. 75–77, pl. vi, figs. 1–7, 1889.

strong senile development of a disappearing type. It has already been remarked that the term Delthyris, Dalman, may properly be restricted to the unicispinate Fimbriati. The name was applied to species of which *S. elevatus*, Dalman, was the first and typical member, a form not unlike *S. crispus*, Hisinger, and from faunas of the same age.

2. *Duplicispinei* = Reticularia, McCoy, 1844; those species in which the fimbriæ are composed of large, compound, hollow spines, often or always with lateral branches. Each spine is divided medially by a vertical septum, and along this line the spine is depressed exteriorly, giving it a double-barreled appearance; from each lateral margin are given off at regular intervals short spinules at right angles to the main spine.

This peculiar structure was first described by Mr. Davidson, in 1880, from its discovery by Mr. John Young in the Carboniferous species, *S. lineatus*, Martin. It had been observed by us some years earlier than this in the species *S. fimbriatus*, Conrad, of the Hamilton group, and upon the accompanying plates are illustrations of this species showing it. The scar left by the removal of the spines is elongate-oval or lachrymiform, divided medially by the base of the vertical lamella. In addition to this surface ornament the members of this subdivision are well characterized by their shortness of hinge, which does not equal the greatest transverse diameter of the shell, the low cardinal area, the usual obsolescence or absence of radial plications and even of median fold and sinus, and the presence of concentric striations or ridges serving as bases for the fimbriæ.

Of this group *Spirifer fimbriatus*, Conrad, is the earliest representative, a form quite remarkable in its vertical range, appearing in the Oriskany sandstone and in the succeeding faunas of the Schoharie grit, Corniferous limestone, Hamilton shales and Chemung sandstones. This species and *S. subundiferus*, Meek and Worthen, of Hamilton age, have more of the typical spiriferoid aspect in their well developed fold and sinus and low plications; in these respects they afford a variation from the later members of the group, which is naturally to be expected in the earliest representatives of a type of structure. The group is, on the whole, possessed of very persistent and stable characters, and its Carboniferous members have an expression so distinct from that of the normal SPIRIFER that many authors, among them DAVIDSON and WAAGEN, have admitted MCCOY'S term RETICULARIA with the value of a genus. With the evidence before us we are unable to accord this group a higher value than that assigned to the divisions of the RADIATI, the OSTIOLATI and the GLABRATI; a line of development which to all appearances terminated with palæozoic time.

To this second division of the FIMBRIATI belong the following American species: *S. fimbriatus*, Conrad, *S. subundiferus*, Meek and Worthen, of the Hamilton group, *S. hirtus*, White and Whitfield, of the Choteau limestone, *S. pseudolineatus*, Hall, of the Kinderhook and Keokuk groups, *S. setigerus*, Hall, of the St. Louis and Chester groups, *S. clarus*, Swallow, of the Chester group, *S. lineatus*, Martin, and *S. perplexus*, McChesney, of the Coal Measures.

IV. APERTURATI. Typical examples, *S. aperturatus*, Schlotheim, *S. disjunctus*, Sowerby, *S. striatus*, Martin.

(*b*) 1836. *Spirifer*, MORTON. American Journal of Science and Arts, vol. xxix, p. 150, pl. ii, fig. 3.
(*a*) 1839. *Delthyris*, CONRAD. Geol. Survey N. Y.; Pal. Dept.; Third Ann. Rept., p. 65.
(*a*) 1841. *Delthyris*, CONRAD. Geol. Survey N. Y., Pal. Dept.; Fifth Ann. Rept., p. 54.
(*a*) 1842. *Delthyris*, CONRAD. Jour. Acad. Nat. Sci. Philadelphia, vol. viii, p. 263.
(*a*) 1842. *Delthyris*, VANUXEM. Geology of N. Y.; Rept. Third Dist., p. 179, fig. 3; p. 123, fig. 1; p. 124, fig. 5.
(*a*) 1843. *Delthyris*, HALL. Geology of N. Y.; Rept. Fourth Dist., pp. 269, 270, figs. 1–4; p. 148, fig. 1.
(*a*) 1843. *Delthyris*, MATHER. Geology of N. Y.; Rept. First Dist., p. 342, fig. 1.
(*b*) 1852. *Spirifer*, OWEN. Geol. Survey Wisconsin, Iowa and Minnesota, p. 586, pl. v, fig. 6.
(*b*) 1852. *Spirifer*, F. ROEMER. Kreidebildung von Texas, p. 88, pl. xi, fig. 7.
(*b*) 1852. *Spirifer*, HALL. Stansbury's Expl. Great Salt Lake, p. 410, pl. iv, fig. 5.
(*c*) 1854. *Spirifer*, NORWOOD and PRATTEN. Jour. Acad. Nat. Sci. Philadelphia, second ser., vol. iii, p. 73, pl. ix, figs. 3 *a–e*.
(*e*) 1854. *Spirifer*, NORWOOD and PRATTEN. Jour. Acad. Nat. Sci. Philadelphia, second ser., vol. iii, p. 72, pl. ix, figs. 2 *a–c*.
(*b*) 1855. *Spirifer*, SHUMARD. Rept. Geol. Survey Missouri, p. 203, pl. c, fig. 8.
(*b*) 1856. *Spirifer*, HALL. Expl. and Survey for R. R. Route from Missouri to the Pacific, vol. iii, p. 102, pl. ii, figs. 9, 12.
(*e*) 1857. *Spirifer*, HALL. Transactions of the Albany Institute, vol. iv, p. 8.
(*e*) 1857. *Spirifer*, HALL. Tenth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 127.
(*f*) 1857. *Spirifer*, HALL. Tenth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 133.
(*a*) 1858. *Spirifer*, HALL. Geol. Survey Iowa, p. 502, pl. iv, fig. 2.
(*1a*) 1858. *Spirifer*, HALL. Geol. Survey Iowa, p. 501, pl. iv, figs. 1 *a–k*.
(*b*) 1858. *Spirifer*, HALL. Geol. Survey Iowa, vol. 1, pt. ii, p. 647, pl. xx, fig. 7; pl. xxi, figs. 1, 2; p. 604, pl. xiv, figs. 1–5; p. 641, pl. xx, fig. 1; p. 501, pl. vi, fig. 1; p. 709, pl. xxviii, fig. 2.
(*b*) 1858. *Spirifer*, MARCOU. Geology of North America, p. 49, pl. vii, fig. 2.

(c) 1858. *Spirifer*, HALL. Geol. Survey Iowa, vol. i, pt. ii, p. 519, pl. vii, fig. 5; p. 600, pl. xiii, fig. 1; p. 601, pl. xiii, fig. 2; p. 602, pl. xiii, fig. 3; p. 661, pl. xxiii, fig. 7; p. 662, pl. xxiii, fig. 8; p. 663, pl. xxiii, fig. 9.
(d) 1858. *Spirifer*, HALL. Geol. Survey Iowa, vol. i, pt. ii, p. 521, pl. vii, fig. 8; p. 644, pl. xx, fig. 3; p. 660, pl. xxiii, fig. 6; p. 676, pl. xxiv, fig. 4; pp. 706-708, pl. xxvii, fig. 6.
(e) 1858. *Spirifer*, HALL. Geol. Survey Iowa, vol. i, pt. ii, p. 711.
(e) 1858. *Spirifer*, MARCOU. Geology of North America, p. 50, pl. vii, fig. 4.
(a) 1859. *Spirifer*, HALL. Palæontology of N. Y., vol. iii, p. 425, pl. xcviii, figs. 1-8; pl. xcix, figs. 1-10; pl. c, figs. 1-8.
(a) 1859. *Delthyris*, ROGERS. Geology of Pennsylvania, vol. ii, pt. ii, p. 829, fig. 683; p. 826, fig. 650.
(b) 1860. *Spirifer*, SWALLOW. Trans. St. Louis Acad. Science, vol. i, p. 643.
(e) 1860. *Spirifera*, MCCHESNEY. New Palæozoic Fossils, p. 44.
(f) 1860. *Spirifer*, HALL. Thirteenth Ann Rept. N. Y. State Cab. Nat. Hist., p. 82.
(b) 1861. *Spirifer*, NEWBERRY. Ives' Rept. Colorado River of the West, p. 127.
(a) 1863. *Spirifera*, BILLINGS. Geology of Canada, p. 960, fig. 465.
(e) 1863. *Spirifera*, DAVIDSON. Quarterly Journal Geol. Soc. London, vol. xix, p. 171, pl. ix, figs. 7, 8.
(e) 1865. *Spirifera*, A. WINCHELL. Proc. Acad. Nat. Sci. Philadelphia, p. 118.
(b) 1866. *Spirifer*, GEINITZ. Carbon und Dyas in Nebraska, p. 44.
(e) 1866. *Spirifer*, SWALLOW. Trans. St. Louis Acad. Science, vol. ii, pp. 409, 410.
(a) 1867. *Spirifera*, HALL. Palæontology of N. Y., vol. iv, p. 243, pl. xli, figs. 1-19; pl. xlii, figs. 1-20; p. 203, pl. xxx, fig. 21.
(e) 1867. *Spirifera*, HALL. Palæontology of N. Y., vol. iv, p. 194, pl. xxvii, fig. 29; pl. xxviii, figs. 7-23.
(f) 1867. *Spirifera*, HALL. Palæontology of N. Y., vol. iv, p. 213, pl. xxxii, figs. 1-6.
(e) 1868. *Spirifera*, MCCHESNEY. Trans. Chicago Acad. Science, vol. i, p. 35, pl. i, fig. 4.
(b) 1870. *Spirifera*, MEEK and WORTHEN. Proc. Acad. Nat. Sci. Philadelphia, vol. xvii, p. 36.
(b) 1870. *Spirifer*, A. WINCHELL. Proc. Amer. Philos. Soc., vol. xii, p. 252.
(b) 1871. *Spirifer (Trigonotreta?)*, MEEK. Proc. Acad. Nat. Sci. Philadelphia, vol, xviii, p. 179.
(b) 1872. *Spirifer*, MEEK. Palæontology Eastern Nebraska, p. 183, pl. vi, fig. 12; pl. viii, fig. 15.
(b) 1873. *Spirifer*, MEEK and WORTHEN. Geol. Survey Illinois, vol. iii, p. 573, pl. xxv, fig. 7.
(e) 1873. *Spirifera*, HALL and WHITFIELD. Twenty-third Ann. Rept. N. Y. State Cab. Nat. History, p. 237, pl. xi, figs. 16-20.
(a) 1874. *Spirifera*, BILLINGS. Palæozoic Fossils, vol. ii, p. 45, pl. iii *a*, fig. 3.
(f) 1874. *Spirifera*, DERBY. Bull. Cornell University, vol. i, No. 2, p. 12, pls. i, ii, iv, v.
(e) 1874. *Spirifera*, DERBY. Bull. Cornell University, vol. i, No. 2, p. 15, pls. i, ii, iv.
(b) 1875. *Spirifera*, WHITE. Rept. Geogr. Surveys West 100th Meridian, p. 88, pl. v, fig. 10; p. 132, pl. x, fig. 1.
(b) 1875. *Spirifera (Trigonotreta)*, MEEK. Palæontology of Ohio, vol. ii, p. 280, pl. xiv, fig. 8.
(b) 1875. *Spirifera*. MEEK and WORTHEN. Geol. Survey Illinois, vol. vi, p. 521, pl. xxx, fig. 3.
(c) 1875. *Spirifera (Trigonotreta)*, MEEK. Palæontology of Ohio, vol. ii, p. 290, pl. xiv, fig. 5.
(c) 1875. *Spirifera*, WHITE. Rept. Geogr. Surveys West 100th Meridian, p. 86, pl. v, fig. 8.
(d) 1875. *Spirifera*, MEEK and WORTHEN. Geol. Survey Illinois, vol. vi, p. 523, pl. xxx, fig. 1.
(e) 1875. *Spirifera (Trigonotreta)*, MEEK. Palæontology of Ohio, vol. ii, p. 329, pl. xix, fig. 14.
(e) 1875. *Spirifera*, WHITE. Rept. Geogr. Surveys West 100th Meridian, p. 134, pl. xi, fig. 9.
(b) 1876. *Spirifer*, MEEK. Simpson's Rept. Expl. Great Basin of Utah, p. 353, pl. ii, fig. 3.
(b) 1876. *Spirifer (Trigonotreta)*, MEEK. Macomb's Rept. Expl. from Sante Fé to the Colorado, p. 139, pl. iii, fig. 5.
(e) 1876. *Spirifera*, MEEK. Bull. U. S. Geol. Survey, vol. ii, No. 4, p. 355, pl. i, fig. 3.
(b) 1877. *Spirifera*, HALL and WHITFIELD. Geol. Expl. Fortieth Parallel, vol. iv, p. 269, pl. v, figs. 13-15.
(b) 1877. *Spirifer (Trigonotreta)*, MEEK. Geol. Expl. Fortieth Parallel, vol. iv, p. 91, pl. ix, fig. 2.
(c) 1877. *Spirifera*, HALL and WHITFIELD. Geol. Expl. Fortieth Parallel, vol. iv, p. 254, pl. iv, figs. 5, 6; p. 255, pl. iv, figs. 7, 8.

(*e*) 1877. *Spirifer* (*Trigonotreta*), MEEK. Geol. Expl. Fortieth Parallel, vol. iv, p. 88, pl. ix, fig. 6.
(*b*) 1878. *Spirifera*, HARTT. Dawson's Acadian Geology, 3d ed., p. 300.
(*e*) 1878. *Spirifer*, DAWSON. Acadian Geology, 3d ed., p. 292, fig. 91.
(*b*) 1881. *Spirifera*, MILLER. Journal Cincinnati Soc. Nat. Hist., vol. iv, p 2.
(*e*) 1882. *Spirifera*, WHITFIELD. Bull. Amer. Mus. Nat. Hist., vol. i, No. 3, p. 47, pl. vi, figs. 13 15.
(*d*) 1883. *Spirifera*, WHITE. Twelfth Ann. Rep. U. S. Geol. Survey, p. 165, pl. xl, fig. 2.
(*e*) 1883. *Spirifera*, HALL. Twelfth Rept. State Geologist Indiana, p. 326, pl. xxix, figs. 13-15.
(*a*) 1884. *Spirifera*, WALCOTT. Palæontology of the Eureka District, p. 134.
(*b*) 1884. *Spirifera*, WHITE. Thirteenth Rept. State Geologist Indiana, p. 132, pl. xxxv, figs. 3-5.
(*e*) 1884. *Spirifera*, WALCOTT. Palæontology of the Eureka District, p. 216, pl. xviii, figs. 4, 7.
(*b*) 1887. *Spirifera*, HERRICK. Bull. Denison University, vol. ii, p. 45, pl. ii, fig. 22.
(*e*) 1887. *Spirifera*, HERRICK. Bull. Denison University, vol. i, p. 44, pl. ii, fig. 23.
(*b*) 1888. *Spirifer*, HERRICK. Bull. Denison University, vol. iii, p. 44, pl. iii, fig. 26; pl. vi, figs. 6-7; vol. iv, pl. vii, fig. 2.
(*e*) 1888. *Spirifer*, HERRICK. Bull. Denison University, vol. iv, p. 25, pl. ii, fig. 8.
(*b*) 1889. *Spirifera*, NETTELROTH. Kentucky Fossil Shells, p. 124.
(*f*) 1889. *Spirifera*, NETTELROTH. Kentucky Fossil Shells, p. 113, pl. xi, figs. 6-11; pl. xii, figs. 5-11.
(*e*) 1889. *Spirifera*, NETTELROTH. Kentucky Fossil Shells, p. 120, pl. ix, figs. 8-14.
(*b*) 1890. *Spirifera*, WORTHEN. Geol. Survey Illinois, vol. viii, p. 105, pl. xi, fig. 5.
(*a*) 1891. *Spirifera*, WHITEAVES. Contributions to Canadian Palæontology, vol. i, p. 221, pl. xxix, figs. 4, 5.

Forms with plications on the fold and sinus.

This may be regarded as the typical group of Spirifers as it includes the type-species *S. striatus*, Martin. Furthermore it is the most richly represented in species and at the same time is a most compact association, not presenting any substantial variations. Its members are strongly impressed with the typical spiriferoid characters which are maintained throughout its existence, the group terminating abruptly at the close of palæozoic time. In internal structure variations are slight and unimportant. The dental lamellæ are, as a rule, inconsiderably developed, and there is no median septum in either valve. *Spirifer* (= *Choristites*) *Mosquensis*, Fischer, is an example of a very few medioplicate species which have the dental plates highly developed; but in its closest ally in exterior characters, *S. Grimesi*, Hall, these are comparatively inconspicuous.

The external ornamentation, the arrangement of the plications and the nature of their superficial sculpture, afford a key to the subordinate grouping of these numerous species and indicates several important subsidiary lines of development. These species seem to have appeared as early as the Niagara fauna, in which occurs a suborbicular form (*S. præmonens*, sp. nov.) with low fold and sinus, similar to *S. Hungerfordi*, Hall, of the upper Devonian. In the

Lower Helderberg fauna we have but the single species, *S. concinnus*, Hall; in the Oriskany sandstone, *S. arenosus*, Conrad; in the Corniferous limestone, *S. unicus*, Hall (= *S. arenosus*), *S. Grieri*, Hall, and *S. divaricatus*, Hall. The last named species is the only representative of this type of structure in the Hamilton faunas, but from the upper Devonian onward the species multiply rapidly, becoming most abundant and varied in the different faunas of the lower Carboniferous and continuing until the close of palæozoic time. The key-note to the time value of the APERTURATI was suggested by DE VERNEUIL, who divided them into two subsections, "the first including species with fine, not dichotomous plications, all of which belong to the Devonian system; the second including those with broad [simple] plications or those which have the plications fine and always dichotomous. Spirifers of the last division are all Carboniferous or Permian."* With some reservation this statement is eminently true of the American APERTURATI, with which alone in the following classification we have to deal.

(a) Disjunctus-type. Forms with well developed fold and sinus, elongate hinge and elevated cardinal area; lateral plications simple, median plications dichotomous or intercalary.

Spirifer arenosus, Conrad,	Oriskany sandstone.
Spirifer unicus, Hall,	Corniferous limestone.
Spirifer Whitneyi, Hall,	Lower upper Devonian.
Spirifer disjunctus, Sowerby,†	Chemung group.

In the higher Chemung sandstone of Alleghany and Cattaraugus counties, N. Y., there is a well defined variety of this species which is of not uncommon occurrence. It is distinguished by a conspicuous median sulcus on the fold and has been well figured in Palæontology of New York, Volume IV, pl. xli, figs. 10–16. We propose to distinguish it by the varietal term *sulcifer*.

* Géologie de la Russie de l'Europe, p. 126, 1845.

† A preference is frequently expressed by the Continental writers for the term *S. Verneuili*, applied to this species by MURCHISON in 1840. In regard to the priority of these names, both introduced in the same year, MURCHISON has said in the 3d edition of his "Siluria" (p. 422, 1859): "VON DECHEN and his associates have used the name given by myself in honor of my friend DE VERNEUIL to the SPIRIFER which abounds in the same stratum [Verneuili-shales] in the Boulonnais. It is, however, the *Spirifer disjunctus*, having been previously named by SOWERBY."

A subordinate division of this section is the

(1) Hungerfordi-type, in which the fold and sinus are low, often obsolescent, the outline suborbicular and the cardinal area compressed laterally and incurved; dental lamellæ prominently developed. This type is represented by

S. præmonens, sp. nov., Niagara group.
S. Hungerfordi, Hall, Lower upper Devonian.

To the same division belongs the Russian species, *S. Anossofi*, de Verneuil, which TSCHERNYSCHEW considers as probably identical with *S. Hungerfordi* and an important index fossil of his uppermost middle Devonian fauna on the west slope of the Urals.*

Here must also be placed the *Spirifer Mosquensis*, Fischer, from the Carboniferous limestone of Miaschkowa, Russia, and the type of the genus CHORISTITES, Fischer. *Spirifer Grimesi*, Hall, of the Burlington limestone resembles this Russian species in external form, but lacks the prominent development of the dental lamellæ and the simple lateral plications possessed by *S. Hungerfordi* and *S. Mosquensis*. In our opinion, if the term CHORISTITES is to be admitted with subgeneric significance, it should be restricted to this small group of species beginning in the upper Silurian and ending in the Carboniferous.

(b) Striatus-type. Forms having a great number of duplicate lateral plications, well developed, rarely acuminate fold and sinus, and narrow, usually extended cardinal area. Species following closely the type of *S. striatus* are not common in American faunas though they abound elsewhere. We have:

S. striatiformis, Meek, Waverly sandstone.
S. Logani, Hall, Keokuk group.
S. striatus, Martin, Coal measures.
S. Marcoui, Waagen, Coal measures.

An important subsection of this group is composed of a series of forms representing successive stages in a line of development, which diverged early from the Striatus-stock and eventuated in some extravagant expressions of this type.

* Die Fauna des mittleren und oberen Devon am West-Abhange des Urals, pp. 174, 175.

In *Spirifer fastigatus*, Meek and Worthen,* of the Keokuk group, the fasciculation of the plications is very pronounced, the duplication of these plications beginning at an early stage in the development of the animal. In *S. Missouriensis*, Swallow, of the Choteau limestone, a similar fasciculation is apparent In *S. cameratus*, Morton, of the Coal measures, this character becomes very conspicuous, while the extreme of development is attained in *S. Texanus*, Meek, where the plications are sharply fasciculate, while the hinge is short, the fold and sinus prominent and acute and the surface granulose. *Spirifer fastigatus*, *S. cameratus* and *S. Texanus* might each well be taken as a type of structure of subordinate value to that of *S. striatus*, but in American faunas there are but these single representatives of each variation.†

(c) Imbrex-type. Alate, mucronate shells, with narrow cardinal area, fine, simple (very rarely duplicate) lateral plications, the plications on fold and sinus being of about the same size as the rest. The surface is frequently lamellose.

This group is restricted to the earlier faunas of the Carboniferous and is represented by

S. Newberryi, Hall,	Waverly group.
S. Marionensis, Shumard,	Waverly and Choteau groups.
S. biplicatus, Hall,	Kinderhook group.
S. imbrex, Hall,	Burlington limestone.
S. incertus, Hall,	Burlington limestone.
S. Forbesi, Hall,	Burlington limestone.
S rostellatus, Hall,	Keokuk group.
S. tenuicostatus, Hall,	Keokuk group.
S. subæqualis, Hall,	Keokuk and St. Louis groups.
S. lateralis, Hall,	Keokuk and St. Louis groups.

(d) Suborbicularis-type. Forms with suborbicular outline, broad, low and usually simple lateral plications; the median plications are few and indistinct.

S. suborbicularis, Hall, Kinderhook–Keokuk groups.
S. subcardiiformis, Hall, St. Louis group.

* As this name was preoccupied by MORTON, Mr. S. A. MILLER has introduced in its place *S. Mortonanus*.

† WAAGEN has included in his "Group of *Spirifer tegulatus*, Trautschold," *S. Musakheylensis*, Davidson, and *S. Ambiensis*, Waagen, all Carboniferous species of the Cameratus-type.

These species suggest the short-winged, rounded forms of *S. arenosus* occurring in the Oriskany sandstone of Cumberland, Maryland, and the type of structure is not dissimilar to that of *S. disjunctus* and its allies except in the general suppression of the external characters, the persistently shorter hinge and the occasional manifestation of dichotomous ribs.

(e) Orestes-type. Shells of small size, moderately extended on the hinge; lateral plications simple and usually few in number: fold and sinus angular and with few plications, of which the median members are much the strongest. Surface usually ornamented by fine, hair-like, often granulous radiating lines.

This group makes its appearance as early as the fauna of the Lower Helderberg group, in the species *S. concinnus*, Hall, which bears a few faint median plications, usually observable only near the anterior margins of the valves. In the Corniferous limetone, *S. Grieri*, Hall, is a similar form. With the appearance of the early Carboniferous faunas the type became abundantly exemplified, but disappeared in the Coal measures. It is represented by the following species:

S. concinnus, Hall,	Lower Helderberg group.
S. Grieri, Hall,	Corniferous limestone.
S. Orestes, Hall,	Lower Upper Devonian.
S. Williamsi, sp. nov.,	Chemung group.
S. Keokuk, Hall,	Keokuk group.
S. Littoni, Swallow,	St. Louis group.
S. bifurcatus, Hall,	St. Louis group.
S. Leidyi, Norwood and Pratten,	St. Louis and Chester groups.
S. increbescens, Hall,	Chester group.
S. opimus, Hall,	Coal measures.

(f) Divaricatus-type. Species with hinge not extended, low fold and sinus; numerous fine dichotomous lateral plications not differing in size from the median plications, all of which are crossed by fine, closely set concentric lines each bearing a fimbria of short, simple spines.

This peculiar type of structure is represented, as far a known, only by the species, *S. divaricatus*, Hall, of the Upper Helderberg and Hamilton faunas. It is remarkable in all its characters and perhaps should be regarded as an isolated example of aberrancy rather as the representative of a distinct section of the Aperturati. Its short hinge and fimbriate surface indicate its relations to the Fimbriati, while the pronounced dichotomization of its plications is without precedent among other Devonian Spirifers. The fasciculate effect produced by the duplication of the plications is suggestive of the Striatus-cameratus group. The species is, in fact, an early representative of that type of structure, upon it being superinduced the characters of the fimbriate type (DELTHYRIS).

V. OSTIOLATI. Typical examples: *Spirifer ostiolatus*, Schlotheim, *S. Oweni*, Hall.

1839. *Delthyris*, CONRAD. Geol. Survey N. Y.; Pal. Dept., Third Ann. Rept., p. 65.
1842. *Delthyris*, CONRAD. Journal Acad. Nat. Sci. Philadelphia, vol. viii, pp. 262, 263.
1843. *Delthyris*, HALL. Geology of N. Y.; Rept. Fourth Dist., pp. 206, 207, figs. 1, 2; p. 208, fig. 8.
1843. *Spirifer*, CASTELNAU. Essai sur le Système Silurien de l'Amérique Septentr., p. 40, pl. xiv, fig. 16; p. 41, pl. xii, fig. 6.
1844. *Delthyris*, OWEN. Rept. Geol. Expl. Iowa, Wisconsin and Illinois, p. 69, pl. xii, fig. 9.
1847. *Spirifer*, YANDELL and SHUMARD. Contributions to Geology of Kentucky, pp. 10, 14.
1852. *Spirifer*, OWEN. Geol. Survey Wisconsin, Iowa and Minnesota, p. 586, pl. iii, figs. 2, 6; p. 585, pl. iii, figs. 3, 4, 8.
1857. *Spirifer*, HALL. Tenth Ann. Rept. N. Y. State Cab. Nat. Hist., pp. 128, 129, 132, 135, 154, 155, 156, 158, 161, 163, 164.
1858. *Delthyris*, ROGERS. Geol. Survey Pennsylvania, vol. ii, p. 828; figs. 669, 670.
1858. *Spirifer*, HALL. Geol. Survey Iowa, vol. i, pt. ii, p. 508, pl. iv, fig. 7; p. 509, pl. iv, fig. 8; p. 510, pl. v, fig. 1; p. 520, pl. vii, fig. 7.
1863. *Spirifera*, BILLINGS. Geology of Canada, p. 386, figs. 422*a*, *b*.
1867. *Spirifera*, HALL. Palæontology of N. Y., vol. iv, p. 197, pl. xxix, figs. 1–8; p. 198, pl. xxiv, figs. 9–18; p. 209, pl. xxxi, figs 14–19; p. 211, pl. xxxi, figs. 11–13, 20–30; p. 220, pl. xxviii, figs. 12–16; p. 223, pl. xxxvi, figs. 1–13; p. 226, pl. xxxvii, figs. 10–20; p. 227, pl xxxviii, figs. 1–25; pl. xxxviii*, figs. 12–18; p. 230, pl. xxxviii *a*, figs. 23–32; p. 234, pl. xxxv, fig. 24; p. 292, pl. xxx, figs. 16–20.
1868. *Spirifera*, MEEK and WORTHEN. Geol. Survey Illinois, vol. iii, p 433, pl. xiii, fig. 8.
1868. *Spirifer*, MEEK and WORTHEN. Geol. Survey Illinois, vol. iii, p. 414, plate x, fig. 1.
1878. *Spirifera*, MILLER. Proc. Davenport Acad. Nat. Sci., p. 222.
1880. *Spirifera*, WHITE. Second Ann. Rept. Bureau Stat. and Geol. Indiana, p. 503, pl. iv, figs. 1–3; p. 504, pl. iv, figs. 4, 5
1881. *Spirifera*, WHITE. Tenth Ann. Rept. State Geologist Indiana, p. 135, pl. iv, figs. 1–3; p. 136, pl. iv, figs. 4. 5.
1882. *Spirifera* (*Cyrtina*), WHITFIELD. Geol. Wisconsin, vol. iv, p. 329, pl. xxv, figs. 25, 26; p. 329, pl. xxvi, fig. 3; p. 330, pl. xxvi, fig. 4; p. 331, pl. xxvi, figs. 1, 2.
1883. *Spirifera*, CALVIN. American Journal of Science, vol. xxv, p. 433.
1884. *Spirifera*, WALCOTT. Palæontology of the Eureka District, p. 137, pl. xiv, fig. 10.
1885. *Spirifera*, CLARKE. Bull. No. 16, U. S. Geol. Survey, p. 31, pl. iii, fig. 12.
1888. *Spirifera*, CALVIN. Bull. Laboratories State University Iowa, p. 19.
1889. *Spirifera*, NETTELROTH. Kentucky Fossil Shells, p. 105, pl. viii, figs. 1–8; p. 107, pl. ix, figs. 1–7; p. 115, pl. vi, figs. 1–7, 9, 11–17; p. 117, pl. vi, figs. 8, 10, 18–20; p. 123, pl. xi, figs. 1–5; p. 125, pl. xxvi, figs. 2–5; p. 126, pl. vii, figs. 1–10.

Forms with the median fold and sinus without plications.

These species, in the degree of plication of the sides and the development of the muscular scars, closely resemble the members of the foregoing group. As a rule, the Ostiolati are stouter shells, shorter on the hinge and more ventricose than the Aperturati; their surface is frequently ornamented with fine granules or interrupted radiating striæ, and in some instances this linear sculpture is so pronounced (e. g. *S. Parryanus*, Hall, *S. Macbridii*, Calvin) as to suggest a derivation from the multiplicate members of Radiati. The cardinal process is developed as a broad, thin, spreading plate, crossed longitudinally by numerous linear depressions; a feature which is progressively developed from the earlier members of the group toward the syringothyroids. There appears to be no substantial basis for a subordinate grouping of these species: they were evidently but slightly susceptible to variations in exterior characters. While the cardinal area is sometimes erect and broad, and at others more or less arched, these differences occur within specific limits. Many of the middle Devonian representatives bear a low median sulcus on the fold, which may be accompanied by a broad, very faint, indistinct plication apparent only near the anterior margin of the sinus. Such are *S. Oweni*, Hall, *S. granulosus*, Conrad (= *S. granuliferus*, Hall), *S. audaculus*, Conrad (= *S. medialis*, Hall), *S. Marcyi*, Hall, *S. asper*, Hall, *S. Macbridii*, Calvin, *S. eurytines*, Owen.

The differences of exterior are quite subordinate; the majority of the species, exemplified by *S. audaculus*, have smooth or lamellose plications, which are often marked by a linear depression on the summit of each; while others have the plications covered with elongate pustules (*S. granulosus*, *S. Marcyi*) or erect granules (*S. asper*). In *S. Parryanus* the minute elongate pustules are arranged upon the summits of distinct fine radial striæ.

A character which appears at times in other groups, but which here possesses the highest significance, is the gradual development of the callosity or transverse plate in the apex of the delthyrium. Originally, and always in the earlier species (*S. perextensus*, Meek and Worthen, *S. macrothyris*, Hall, etc.) an accompaniment of adult or senile growth, it eventually becomes a permanent character existing throughout all the later immature growth-phases of the shell. In its simpler manifestations it is a testaceous deposit extending across the delthyrium from its inner margins; as its size increases it unites the dental lamellæ, fills the rostral cavity of the valve and extends forward along the bottom of the shell between the posterior extremities of the diductor muscular bands. This is its condition as usually seen in the middle Devonian species, *S. granulosus* and *S. audaculus.*

Not infrequently this plate is less thickened and extends downward with a convex outer surface for two-thirds the length of the delthyrium, but this particular form of development occurs less often in the early species.

In all its phases it may be coëxistent with the true deltidium, though the latter is rarely retained in growth-stages where the apical callosity is well developed. From the last mentioned condition to the fully developed, adherent split tube of SYRINGOTHYRIS,* it is but a few short steps, but these are still wanting among the American Spirifers, as far as our observations have gone. An important intermediate stage is furnished by the peculiar species which we have provisionally placed in the so-called CYRTIA, namely, *Spirifer altus*, Hall, an extravagant representative of the European *S. simplex.* Here the transverse plate is thickened on its inner surface by the development of a vertical median ridge. In SYRINGOTHYRIS it is evident that the tube has been formed by the lateral expansion of this ridge, its margins becoming free and developing a tendency to incurve or curl toward each other over the median line, actually uniting at times while adherent to the plate, but remaining disconnected after the tube becomes free.

It is very probable that the thin epidermal layer of the shell in the granulous species of the OSTIOLATI was punctated; indeed the tuberculated surface itself, may be construed as evidence of such slight punctation.† In SYRINGOTHYRIS the shell is decidedly but variably punctated, the tubules sometimes penetrating the entire thickness of the shell, sometimes traversing only a

* For a more detailed account of the structure of this organ see the discussion of the genus SYRINGOTHYRIS.

† Mr. JOHN YOUNG, of Glasgow, has shown that the epidermal shell layer is minutely punctate in *Spirifer lineatus* (see DAVIDSON, Supplement to Carboniferous Brachiopoda, p. 275, pl. xxxiv, fig. 9), and it is not unlikely that the existence of a very tenuous external punctated layer will be found more generally prevalent among Spirifers than is now generally supposed.

portion of the inner layers; and on different portions of the valves the feature is differently developed. In *Spirifer plenus*, Hall, of the Burlington limestone, we have an example of a true SPIRIFER with the apical callosity in about the condition of development exhibited by the Devonian species, *S granulosus;* that is, with the syringothyroid tube incipient, but in which the shell is punctated for its entire thickness.

Of the Ostiolati, or syringothyroid Spirifers, the American faunas possess a considerable representation. The type was not specialized until the opening of the Devonian, and with the exception of the species just cited, *S. plenus*, and *S. neglectus*, Hall, of the Keokuk group, it passed into SYRINGOTHYRIS at the close of the Devonian period. It is, therefore, a Devonian spiriferoid type of preëminent importance.

A member of this group which represents a form of exterior somewhat unlike that of all the other species here associated with it, is *Spirifer acuminatus*, Conrad; characterized by its broad duplicate lateral plications, a feature of the rarest occurrence among the OSTIOLATI. This specific type, however, is widespread, being represented in the Devonian faunas of the continent of Europe by the shell known as *S. cultrijugatus*, F. Roemer.*

In the Upper Helderberg limestone are the following species of OSTIOLATI:

S. perextensus, Meek and Worthen.
S. macrothyris, Hall.
S. angustus, Hall.
S. Manni, Hall.
S. acuminatus, Conrad.

In the Hamilton group:

S. angustus, Hall.
S. Marcyi, Hall.
S. acuminatus, Conrad.
S. audaculus, Conrad.
S. ligus = *pennatus*, Owen.
S. Wortheni, Hall.
S. granulosus, Conrad.
S. fornax, Hall.
S. eurytines, Owen.
S. Parryanus, Hall.
S. asper, Hall.
S. Macbridii, Calvin.

* See ROEMER, Das rhein. Uebergangsgebirge, pl. iv, fig. 4; SCHUR., Beschr. Eifel. Brach., pl. xxxiii, fig. 1. Most instructive figures are given by QUENSTEDT, Brachiopoden, pl. lii, figs. 19–21. There is little doubt of the specific identity of the shells passing under these two names, and ROEMER's designation must eventually give way to the earlier one of CONRAD.

With the increase of the Aperturati, the Ostiolati diminish rapidly and in the upper Devonian faunas we know but a single species, *S. asper*, from the Chemung group of New York.*

VI. Glabrati. Typical examples, *Spirifer glaber*, Martin, *Martiniopsis inflata*, Waagen.

Forms with the surface smooth and glabrous; fold and sinus faintly developed except at the anterior margins of the valves.

The species embraced in this division have stronger differential characters than are found among the preceding groups. The shells have a very short hinge and low cardinal area, and the subcircular marginal outline causes a noticeable alteration in the form of the spiral arms. These have their bases well forward and are extended obliquely to the rounded cardinal extremities, in their position thus approximating the form assumed by these organs in Cyrtia and Cyrtina; the crura, also, and the primary lamellæ become very long. This difference is not, however, one of great significance and is to be expected in any Spirifer having such an outline.

The character of the muscular impressions is of greater importance; the broad scars of the didnctors in the pedicle-valve are here reduced to very narrow dimensions, are scarcely depressed and frequently not defined, but represented only by a radiate marking of the shell. In the brachial valve the adductor scars are two narrow impressions which widen anteriorly but are not divided transversely. The surface of the shell was covered with very fine concentric lines and the epidermal layer which is usually effaced, was minutely punctate. Faint lateral plications are sometimes visible.

These differences from the normal type of Spirifer have led many writers to adopt McCoy's term Martinia for *S. glaber* and its allies. It is evident, however, that this division of the smooth-shelled species embraces more than one subordinate type of structure; they may divided into

1. *Aseptati* (=Martinia, McCoy, 1844). Shells in which dental lamellæ and septa are wanting.

* There is a large and hitherto undescribed representative of this group in the limestone at Littleton, Iowa, which is regarded by Professor Calvin as of upper Devonian age.

McCOY's first species of his genus was *S. decorus*, Phillips, which DAVIDSON has regarded equivalent to MARTIN's earlier name *Anomites glaber*, a well known and widely distributed Carboniferous species.

American representatives of this type of structure are of exceedingly rare occurrence. Dr. DAVIDSON has identified *S. glaber* in the Carboniferous limestone of Nova Scotia,* and MEEK and WORTHEN have described *S. glaber*, var. *contractus*, from the Chester limestone of Illinois.

It has also been stated that the species *S. glaber* occurs in the Devonian, but it would seem that such identifications should be carefully reviewed. DAVIDSON, in his description of the Carboniferous brachiopods (p. 62), mentioned the fact that he had certain forms from the English Devonian which he considered indistinguishable from this Carboniferous species but he did not describe them at greater length, nor illustrate them. The shell called *S. glaber* by KAYSER (Zeitschrift der deutsch. geolog. Gesellsch., Bnd. xxiii, p. 581, pl. xii, fig. 1, 1871), from the middle Devonian of the Rhine, is evidently quite distinct from this species. Mr. WALCOTT has described under the name *S.* (*Martinia*) *glaber*, var. *Nevadensis*, a shell from the Eureka District of Nevada, which is stated to possess a surface bearing "obscure radiating plications, concentric striæ about 1 mm. distant [from each other], also fine radiating interrupted striæ" (Monographs U. S. Geological Survey, viii, p. 139, 1884). Both the description and the illustrations given of this fossil suggest the Devonian species *S. euryglossus*, Schnur, which, like *S. curvatus*, Schlotheim, is a fimbriate species belonging to the pauciplicate or *S. lævis*-group of the unicispinous section. Prof. H. S. WILLIAMS (The Life-History of *Spirifer lævis;* Ann. N. Y. Acad. Sci., vol. ii, No. 6, pp. 16 *et seq.*, 1881) has endeavored to demonstrate a lineal relationship between *S. glaber* and *S. lævis* of the lower Portage group, the latter a fimbriate species, the former non-fimbriate. In Mr. WALCOTT's work, referred to, this idea is carried to its logical extreme, the author referring the fimbriate species, *S. undiferus*, F. Roemer, *S. fimbriatus*, Conrad, *S. subundiferus*, Meek and Worthen, etc., to the genus MARTINIA together with *S. glaber* (pp. 144–146), and taking no note of the highly important difference between the fimbriate Spirifers with simple and with compound spines.

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*Quarterly Journal Geological Society, 1863, p. 170.

The Devonian form, *S. Maia*, Hall (= *Athyris Maia*, Billings), from the Corniferous limestone, is an excellent representative of this type of structure both externally and internally; and the list is completed, so far as our knowledge goes, by the addition of *S. subumbona*, Hall, of the Hamilton group.

2. *Septati.* Shells in which dental plates or septa are well developed.

We are compelled to recognize two groups of the septate Glabrati:

(a) MARTINIOPSIS, Waagen, 1883. Species with the lamellæ developed in both valves.

WAAGEN has described two species of this genus, *M. inflata* and *M. subpentagonalis*, from the Productus limestone of India,* and suggests that this type of structure appeared in the Devonian. Beyond the account given by Dr. WAAGEN we know nothing of these fossils.

(b) ("Gen. nov.," Tschernyschew), Type of *Martinia semiplana*, Waagen. Shells with dental lamellæ scarcely developed, but with a prominent median septum in the pedicle-valve.

Dr. TSCHERNYSCHEW has called attention to the peculiar structure of this shell,† suggesting the desirability of separating it from its usual association by a distinct designation. The species was embraced in the genus MARTINIA by WAAGEN, who did not observe the presence of the internal septum. WAAGEN and TSCHERNYSCHEW call attention to the generic similarity of KUTORGA'S *Spirifer corculum* with this species, both of which are from the Artinsk-beds, or Permo-carboniferous of Russia.

It seems very doubtful if these forms should be separated from QUENSTEDT'S genus MENTZELIA ‡ established upon the *Spirifer medianus* from the Muschelkalk of Silesia (Tarnowitz); though Dr. TSCHERNYSCHEW finds the essential difference in the presence of dental lamellæ in the latter and their absence in the Carboniferous species. QUENSTEDT compares these characters in *S. medianus* to those of *S. glaber*, saying that they "blos an der Wand ankleben, und sich nur an der Spitze des Loches auf die zierliche dreieckige Querlamelle stützen."

* Memoirs Geological Survey of India; Productus-limestone Fossils, p. 524.

† Allgemeine geologische Karte von Russland, Blatt 139; Beschreibung des Central-Urals und Westabhanges, p. 369, pl. v, figs. 1, 3, 1889.

‡ Petrefactenkunde Deutschlands; Brachiopoden, p. 522, 1871.

The presence of the median septum establishes another line of connection with the post-palæozoic members of the genus SPIRIFERINA, while the punctation of the epidermal layer only, retains these fossils in close association with the glabrate Spirifers.

The following table will afford a summary of the foregoing classification as far as it relates to the North American Spirifers. The names of species of which specimens have been examined stand in Roman text; those which have been placed in the grouping from a study of descriptions and illustrations only, are in italics; others, in regard to whose relations it has seemed unwise to express an opinion on account of the insufficiency of our knowledge, are omitted. Any names of extra-limital species stand in brackets.

I. RADIATI:

1. Pauciplicati:

S. radiatus, Sowerby,	Clinton and Niagara groups.
S. Eudora, Hall,	Niagara group.
S. Meta, Hall,	Niagara group.
S. Foggi, Nettelroth,	Niagara group.
S. rostellum, Hall and Whitfield,	Niagara group.
S. macropleura, Conrad,	Lower Helderberg group.

2. Multiplicati:

S. Niagarensis, Conrad,	Niagara group.
S. asperatus, Ringueberg,	Niagara group.
S. Tullius, Hall,	Hamilton group.
S. Belphegor, Clarke,	Genesee shale.
S. mesastrialis, Hall,	Chemung group.
S. sp. indes.,	Lower Carboniferous.

3. Dupliciplicati:

S. nobilis, Barrande,	Niagara group.
[S. Schmidti, Lindström,	Wenlock limestone.]

II. LAMELLOSI:

1. Septati:

S. sulcatus, Hisinger,	Niagara group.
S. perlamellosus, Hall,	Lower Helderberg group.

S. raricostus, Conrad,	Upper Helderberg group.
(?) *S. Knappianus*, Nettelroth,	Upper Helderberg group.
(?) S. disparilis, Hall,	Upper Helderberg group.
S. zic-zac, Hall = S. consobrinus, D'Orbigny,	Hamilton group.
S. mesacostalis, Hall,	Chemung group.

2. Aseptati:

a. Mucronatus-type:

S. segmentus, Hall,	Upper Helderberg group.
S. arctisegmentus, Hall,	Upper Helderberg group.
S. mucronatus, Conrad,	Hamilton group.
S. bidorsalis, Winchell,	Hamilton group.
S. sculptilis, Hall,	Hamilton group.
S. Hobbsi, Nettelroth,	Hamilton group.
S. Byrnesi, Nettelroth,	Hamilton group.
S. varicosus, Hall,	Hamilton group.
S. subattenuatus, Hall,	Hamilton and Chemung groups.
S. bimesialis, Hall,	Hamilton and Chemung groups.
S. desideratus, Walcott,	Lower Carboniferous.

b. Submucronatus-type:

S. Engelmanni, Meek and Worthen = *S. Worthenanus*, Schuchert,	Oriskany sandstone.
S. submucronatus, Hall,	Oriskany sandstone.
S. Cumberlandiæ, Hall,	Oriskany sandstone.
S. macrus, Hall,	Corniferous limestone.
S. Davisi, Nettelroth,	Corniferous limestone.
(?) S. gregarius, Clapp,	Corniferous limestone.

III. Fimbriati:

1. Unicispinei = Delthyris, Dalman, 1828:

a. Crispus-type:

S. crispus, Hisinger,	Niagara group.
S. crispus, var. simplex, Hall,	Niagara group.
S. Vanuxemi, Hall,	Lower Helderberg group.
S. Saffordi, Hall,	Lower Helderberg group.
S. cyclopterus, Hall,	Lower Helderberg group.

S. octocostatus, Hall,	Lower Helderberg group.
S. arrectus, Hall,	Oriskany sandstone.
S. tribulis, Hall,	Oriskany sandstone.
S. hemicyclus, Meek and Worthen,	Oriskany sandstone.
S. duodenarius, Hall,	Corniferous limestone.
b. Lævis-type.	
S. bicostatus, Vanuxem,	Niagara group.
S. bicostatus, var. petilus, Hall,	Niagara group.
S. modestus, Hall,	Lower Helderberg group.
(?) *S. nympha*, Billings,	Lower Helderberg group.
S. Canandaiguæ, sp. nov.,	Hamilton group.
(?) S. urbanus, Calvin,	Hamilton group.
S. lævis, Hall,	Portage group.
2. Duplicispinei = Reticularia, McCoy, 1844 :	
S. fimbriatus, Conrad,	Oriskany, Corniferous and Hamilton groups.
S. subundiferus, Meek and Worthen,	Hamilton Group.
(?) S. præmaturus, Hall,	Chemung group.
S. hirtus, White and Whitfield,	Choteau limestone.
S. pseudolineatus, Hall,	Kinderhook-Keokuk groups.
S. setigerus, Hall,	St. Louis-Chester groups.
S. clarus, Swallow,	Chester limestone.
S. lineatus, Martin,	Coal Measures.
S. perplexus, McChesney,	Coal Measures.
IV. Aperturati :	
a. Disjunctus-type :	
S. arenosus, Hall,	Oriskany sandstone.
S. unicus, Hall,	Corniferous limestone.
S. Whitneyi, Hall,	Upper Devonian.
S. disjunctus, Sowerby,	Chemung group.
S. disjunctus, var sulcifer, var. nov.	Chemung group.
S. Billingsanus, Miller,	Devonian.
1. Hungerfordi-type. = Choristites, Fisher, 1825 :	
S. præmonens, sp. nov.,	Niagara group.
S. Hungerfordi, Hall,	Upper Devonian.

b. Striatus-type:	
S. striatiformis, Meek,	Waverly group.
S. Grimesi, Hall,	Burlington limestone.
S. Logani, Hall,	Burlington limestone.
S. striatus, Martin,	Coal Measures.
S. Marcoui, Waagen,	Coal Measures.
1. Texanus-line:	
S. Missouriensis, Swallow,	Choteau group.
S. tenuimarginatus, Hall,	Keokuk group.
S. Mortonanus, Miller,	Keokuk group.
S. cameratus, Morton,	Coal Measures.
S. Texanus, Meek,	Coal Measures.
c. Imbrex-type:	
S. Newberryi, Hall,	Waverly group.
S. centronatus, Winchell,	Waverly group.
S. Marionensis, Shumard,	Choteau and Waverly groups.
S. albapinensis, Hall and Whitfield,	Kinderhook group.
S. biplicatus, Hall and Whitfield,	Kinderhook group.
S. imbrex, Hall,	Burlington limestone.
S. Forbesi, Hall,	Burlington limestone.
S. incertus, Hall,	Burlington limestone.
S. tenuicostatus, Hall,	Keokuk group.
S. lateralis, Hall,	Warsaw limestone.
S. subæqualis, Hall,	Warsaw limestone.
d. Suborbicularis-type:	
S. subrotundatus, Hall,	Kinderhook group.
S. suborbicularis, Hall,	Keokuk group.
S. subcardiiformis, Hall,	Warsaw limestone.
e. Orestes-type:	
S. concinnus, Hall,	Lower Helderberg group.
S. Grieri, Hall,	Upper Helderberg group.
S. Orestes, Hall and Whitfield,	Upper Devonian.
S. Williamsi, sp. nov.,	Chemung group.
S. Keokuk, Hall,	Keokuk group.
S. Littoni, Hall,	St. Louis group.
S. bifurcatus, Hall,	St. Louis group.

S. Leidyi, Norwood and Pratten,	St. Louis group.
S. Leidyi, var. *Meramecensis*, Swallow,	Warsaw limestone.
S. Leidyi, var. *Chesterensis*, Swallow,	Chester limestone.
S. increbescens, Hall,	Chester limestone.
S. increbescens, var. *Americanus*, Swallow,	Chester limestone.
S. increbescens, var. transversalis, Hall,	Chester limestone.
S. opimus, Hall,	Coal Measures.
S. acuticostatus, De Koninck,	Coal Measures.
S. annectans, Walcott.	Carboniferous.
f. Divaricatus-type :	
S. divaricatus, Hall,	Corniferous and Hamilton groups.

V. Ostiolati :

S. perextensus, Meek and Worthen,	Corniferous limestone.
S. macrothyris, Hall,	Corniferous limestone.
S. Manni, Hall,	Corniferous limestone.
S. angustus, Hall,	Corniferous and Hamilton groups.
S. Marcyi, Hall,	Hamilton group.
S. audaculus, Conrad.	Hamilton group.
S. Macconathi, Nettelroth,	Hamilton group.
S. formosus, Hall,	Hamilton group.
S. ligus, Owen,	Hamilton group.
S. Wortheni, Hall,	Hamilton group.
S. granulosus, Conrad,	Hamilton group.
S. fornax, Hall,	Hamilton group.
S. eurytines, Owen,	Hamilton group.
S. eurytines, var. fornaculus, Hall,	Hamilton group.
S. Parryanus, Hall,	Hamilton group.
S. asper, Hall.	Hamilton group.
S. Macbridii, Calvin,	Hamilton group.
S. Pluto, Clarke,	Genesee shales.
S. neglectus, Hall,	Keokuk group.
S. plenus, Hall,	Burlington limestone.
a. S. acuminatus, Hall,	Corniferous and Hamilton groups.

VI. GLABRATI:

1. Aseptati = MARTINIA, McCoy, 1844:

S. Maia, Billings,	Corniferous limestone.
S. subumbona, Hall,	Hamilton group.
S. contractus, Meek and Worthen,	Chester limestone.
S. glaber, Martin,	Coal Measures.

2. Septati:

a. MARTINIOPSIS, Waagen, 1883:

[*M. inflata*, Waagen,	Carboniferous.]
[*M. subpentagonalis*, Waagen,	Carboniferous.]

b. (MENTZELIA, Quenstedt, 1871):

[*S. corculum*, Kutorga,	Permo-carboniferous.]
[*M. semiplana*, Waagen,	Permo-carboniferous.]

GENUS (?) CYRTIA, DALMAN. 1828.

PLATES XXV, XXVI, XXVIII, XXXIX.

1821. *Anomites*, WAHLENBERG. Nova Acta Regiæ Soc. Scientifica, vol. viii, No. 3.
1828. *Cyrtia*, DALMAN. Kongl. Vetenskaps Acad. Handlingar, p. 118, pl. 3, fig. 1.
1828. *Cyrtia*, HISINGER. Bidrag Sven. Geogn. Anteckn., vol. iv, p. 220, pl. iv, fig. 1.
1837. *Spirifer*, VON BUCH. Ueber Delthyris, oder Spirifer und Orthis, p. 41.
1837. *Cyrtia*, HISINGER. Lethæa Suecica, p. 73, pl. xxi, figs. 1, 2.
1841. *Spirifera*, PHILLIPS. Palæozoic Fossils Cornwall, Devon and West Somerset, p. 71, pl. xxix, fig. 124.
1843. *Spirifer*, A. ROEMER. Versteinerungen des Harzgebirges, p. 12, pl. iv, fig. 11.
1852. *Spirifer*, HALL. Palæontology of New York, vol. ii, p. 66, pl. xxii, figs. 2 *a–e*, *f*.
1853. *Spirifer*, SCHNUR. Beschreib. Eifel. Brachiopoden, p. 207, pl. 36, figs. 1, 2.
1855. *Spirifer*, THE SANDBERGERS. Verstein. des rhein. Schicht.-Syst. in Nassau, p. 324, pl. xxxii, fig. 10.
1861. *Cyrtia*, BILLINGS. Canadian Journal, vol. vi, new ser., p. 262.
1862. *Cyrtia*, BILLINGS. Palæozoic Fossils, vol. i, p. 165, fig. 149.
1864. *Spirifera*, DAVIDSON. Monogr. Devon. Brach., p. 46, pl. vi, figs. 18-22.
1867. *Spirifera*, HALL. Twentieth Rept. N. Y. State Cab. Nat. Hist., p. 372, pl. xiii, figs. 12, 13.
1867. *Spirifera*, HALL. Palæontology of New York, vol. iv, pp. 248, 263, pl. xliii, figs. 1–7.
1871. *Spirifer*, KAYSER. Zeitschr. der deutsch. geolog. Gesellsch., vol. xxiii, p. 579.
1871. *Spirifer*, QUENSTEDT. Brachiopoden, p. 492, pl. liii, fig. 8.
1872. *Spirifera* (*Cyrtia*), HALL and WHITFIELD. Twenty-fourth Rept. N.Y. State Mus. Nat. Hist., p. 183.
1875. *Cyrtia*, HALL and WHITFIELD. Twenty-seventh Rept. N. Y. State Mus. Nat. History, pl. ix, figs. 22, 23.
1879. *Cyrtia*, NETTELROTH. Kentucky Fossil Shells, pp. 93, 94, pl. xxvii, fig. 21; pl. xxxiv, fig. 35; pl. xxxvi, figs. 60, 61.

When this name was introduced it was designed to embrace such spiriferoids as have a high, vertical cardinal area and a semi-pyramidal contour. In the original diagnosis no consideration was given to internal characters, and DAVIDSON subsequently demonstrated that these semipyramidal Spirifers represent at least two different types of interior. He therefore restricted CYRTIA to DALMAN'S first two examples, *C. exporrecta*, Wahlenberg, and *C. trapezoidalis*, Dalman; considering the latter as but a variety of the former, and separated from this association shells of the type of the *Calceola heteroclita*, Defrance, which have a punctate shell structure and the dental plates conjoined with a median septum. To the latter he applied the term CYRTINA, and in so doing by far the larger number of the semipyramidal spiriferoids were removed from DALMAN'S genus. CYRTIA now stands as the designation of a group with a very meager representation and of very slight morphological value.

The general habit of these shells is the coexistence of the vertical cardinal area with a convex deltidium perforated by a circular, oblique foramen; at the same time the cardinal area may be incurved to a considerable degree, as is apparent in the species *C. exporrecta* itself,* and is a more constant character in the larger Devonian species *C. Murchisoniana*, de Koninck.

At the time DAVIDSON established the genus CYRTINA, he expressed the opinion that CYRTIA "presents no other feature by which it can be separated from SPIRIFER proper, than that of its deltidium and foramen, which are characters of hardly sufficient importance to warrant the creation of a separate genus."† Though more than thirty years have elapsed since this judgment was expressed, it is fully supported by the evidence of to-day. Neither in the development of the dental lamellæ, the form of the brachial attachments, nor in the muscular impressions can be found any other basis for distinction from SPIRIFER than that indicated, namely, the structure of the deltidium; and it is quite clear that in both SPIRIFER, CYRTIA and CYRTINA, this character has had the same mode of development.

Notwithstanding these considerations which demonstrate the inferior generic value of this term, there is a certain external expression in these fossils, both in contour and ornamentation, which will not permit their association with

* See DAVIDSON'S figures given upon plate ix of his Silurian Brachiopoda.

† British Carboniferous Brachiopoda, p. 68.

SPIRIFER without the introduction into that genus of an inconvenient and refractory element. The fact of their variation in ornamentation while retaining the same contour, prevents the assimilation of the group into any of the subdivisions of SPIRIFER proposed above, and for such a reason it will be well to recognize the term, since it has been so long in use.

CYRTIA is, in effect, a group of cyrtiniform Spirifers, and its specific representation is quite small. The type species *C. exporrecta*, Wahlenberg, occurs in the Wenlock limestone, and in the fauna of the Niagara group the same form is associated with the variety *arrecta*, Hall and Whitfield. Mr. BILLINGS's species *C. Myrtea*, from Division 4 of the Anticosti series, appears to be identical with *C. exporrecta*. These, and a larger form from the Niagara dolomites of Wisconsin, which we shall term *C. radians*, sp. nov., all have the filamentous surface markings which characterize the Silurian Spirifers of the *S. radiatus*-type, though they show no tendency to become plicated. In the Devonian faunas the external ornament changes; thus in *C. Murchisoniana*, the shell is finely plicated on the sides and over fold and sinus, as in the *Spirifer disjunctus*-group of the *Ostiolati ;* in *C. cyrtiniformis*, Hall and Whitfield, of the upper Devonian of Iowa, the plications are coarser and more nearly equal over the lateral and median regions; in *C. simplex* (*Spirifer simplex*, Phillips), of the middle Devonian of Great Britain and Europe, the surface, as usually preserved, is apparently smooth, with sometimes traces of a few coarse lateral plications near the margins. Finely preserved examples of this species from the vicinity of Bredelar, Westphalia, show that the surface is covered with closely crowded concentric rows of very fine and short, simple spinules, as in the unicispinate group of the fimbriate Spirifers. The *Spirifer altus*, Hall, of the Chemung group, is another form which may be referred to CYRTIA. It has the lateral slopes more strongly plicated than *C. simplex*, and traces of plications are also visible upon the fold and sinus. It is remarkable for its great size and also for its agreement with *C. simplex* in the peculiar retrorse slope of the cardinal area which throws the apex of the pedicle-valve over, or in front of the center of the shell. In the Devonian Cyrtias the foramen in the deltidium is frequently obscured or absent at maturity. It may have existed at earlier stages of development and have become obliterated by subsequent overgrowth, but this assumption has yet to be verified. That maturity induces a modification of the deltidium is evinced by the internal median thickening of this plate in *C. alta.*

Genus CYRTINA, Davidson. 1858.

PLATES XXVII, XXXIX.

1852. *Spirifer*, Hall. Palæontology of N. Y., vol. ii, p. 266, pl. liv, fig. 7.
1855. *Cyrtia*, Shumard. Geology of Missouri, p. 204, pl. c, fig. 3.
1857. *Cyrtina*, Hall. Tenth Rept. N. Y. State Cab. Nat. Hist., pp. 64, 165, 166.
1858. *Cyrtia*, Hall. Geology of Iowa, vol. i, pt. ii, p. 512, pl. v. fig. 2.
1858. *Cyrtina*, Davidson. Monogr. British Carboniferous Brachiopoda, p. 66.
1859. *Cyrtia*, Hall. Palæontology of N. Y., vol. iii, pp. 206, 429, pl. xxiv, fig. 1; pl. xcvi, figs. 1–6; pl. xcviii, fig. 8.
1860. *Cyrtia*, Swallow. Trans. St. Louis Acad. Sci., vol. i, pp. 647, 648.
1861. *Cyrtia*, Billings. Canadian Journal, vol. vi, new ser., p. 262, figs. 80–82; p. 263.
1862. *Cyrtia*, White. Proc. Boston Soc. Nat. Hist., vol. ix, p. 25.
1863. *Cyrtia*, Billings. Canadian Naturalist and Geologist, vol. viii, p. 37.
1863. *Cyrtia*, Billings. Geology of Canada, p. 384, fig. 415.
1867. *Cyrtina*, Hall. Twentieth Rept. N. Y. State Cab. Nat. Hist., p. 251.
1867. *Cyrtina*, Hall. Palæontology of N. Y., vol. iv, pp. 263–270, pl. xliv, figs. 26–55.
1868. *Cyrtina*, Meek and Worthen. Geol. Survey of Illinois, vol. iii, pp. 383, 436, pl. vii, fig. 3; pl. xiii, fig. 4.
1868. *Cyrtina*, Meek. Trans. Chicago Acad. Sci., vol. i, pp. 97, 99, 100, pl. xiv, figs. 5–7, 8, 10.
1873. *Cyrtina*, Nicholson. Palæontology Province of Ontario, p. 83.
1874. *Cyrtina*, Billings. Palæozoic Fossils, vol. ii, p. 49, pl. 3*a*, fig. 6.
1874. *Cyrtina* (?), Rathbun. Bull. Buffalo Soc. Nat. Science, vol. i, p. 242.
1875. *Cyrtina*, Hall and Whitfield. Twenty-seventh Rept. N. Y. State Mus. Nat. History, pl. ix, figs. 14–16.
1884. *Cyrtina*, Walcott. Monogr. U. S. Geol. Survey, vol. viii, pp. 146, 147, pl. iii, fig. 2.
1888. *Cyrtina*, Herrick. Bulletin Denison University, vol. iv, p. 14.
1889. *Cyrtina*, Nettelroth. Kentucky Fossil Shells, pp. 95, 96, pl. xiii, figs. 4–16, 21–24.
1889. *Cyrtina*, Simpson. Trans. American Philosophical Society, p. 439, fig. 4.

Diagnosis. Shells usually of small size and semipyramidal contour. Pedicle-valve with a high, vertical or arched cardinal area, which may be unsymmetrical from distortion or unequal lateral growth; this area is divided medially by an elongate-convex deltidium, which may be perforated at any point below the apex, by a circular, direct or oblique foramen, or be without any evidence of such foramen. When present the foramen is accompanied by a sinus on the deltidium, extending from it to the apex of the valve; even when this foramen has been closed from senile deposition of testaceous matter this foraminal groove may remain.

The exterior surface bears a median sinus and more or less distinct lateral plications. On the interior the dental lamellæ are strongly developed and converge rapidly, meeting a median septum from the bottom of the valve. The union consists of a lateral junction of the dental lamellæ with the septum, the latter continuing for a short distance beyond the point of confluence as a vertical ridge, always apparent in the bottom of the spondylium thus formed. At the point of union these three plates constitute a tubular chamber which has no external opening in older shells, and may be filled by organic deposit.* The dental plates are shorter than the septum, the latter, at its base, extending beyond the center of the valve, its anterior margin being concave and its inner extremity acute and produced.

Brachial valve very shallow, with narrow, inconspicuous cardinal area Surface plicated as in the opposite valve. Cardinal process consisting of a double apophysis on the sides of which are strong, divergent crural plates The spiral cones are elongate-fusiform, each coil attaining its greatest diameter just below the center. They are directed obliquely upward and backward towards the middle of each lateral slope of the pedicle-valve. The loop is continuous, its branches being directed upward and forward, uniting at their extremities. The muscular impressions comprise two oval anterior, and fainter posterior scars. The surface ornamentation consists of radial plications which may cover both fold and sinus; in rare instances the lateral plications are absent. The concentric growth-lines are sometimes fine and crowded, at others distant and lamellose; occasionally the surface is coarsely papillose. Shell substance strongly punctate.

Type, *Calceola heteroclita*, Defrance. Middle Devonian.

Observations. With the appearance of this genus in the faunas of the Niagara group, comes the earliest indication of shell punctation in the spiriferoid brachiopods. It has been observed that when punctation appears among the Spirifers themselves, as in Martinia, Martiniopsis, etc., it is late in the history

* In the species *C. rostrata*, Hall, the median septum appears to traverse the tubular chamber, sometimes in an irregular way, dividing it into two lateral compartments. This structure may prove to be the homologue of the unsupported tube in Syringothyris.

of the group, and is a feature whose manifestation is confined to the epidermal layer of the shell. In CYRTINA, on the other hand, even in the earliest species, punctation appears to have permeated all the shell layers except the outer. The impunctate outer layer seems to become thinner in the later species, and there are indications that it is at times quite wanting. As far as investigations show, all the palæozoic forms now placed with CYRTINA agree in full with the type of structure described in the foregoing diagnosis. No important variations have been found in the arrangement of the internal lamellæ, the structure of the cardinal process, or brachidium.

After the close of the palæozoic period the representatives of this line of development appear to have undergone some modification. ZUGMAYER has shown that certain so-called Spiriferinas of the Rhætic beds, of which he has constituted his group *Dimidiatæ*,* have the same septal structure as CYRTINA, the dental lamellæ uniting to form a spondylium which is supported by the median septum; e. g., *Spiriferina uncinata*, Schlotheim, *S. austriaca*, Suess, *S. Suessi*, Winkler. Such forms, with all the outward expression of CYRTINA, and its principal internal peculiarity, are assuredly not Spiriferinas. They naturally evince some variations from the palæozoic type of CYRTINA, as seen in the figures of *S. Koessenensis* (pl. iii, fig. 5) and *S. Suessi* (fig. 18) given by this author, where the cardinal process is not bilobed but finely multilobed as in most of the later Spirifers, the brachial valve with a row of crenulations just within the hinge-line, and the spirals united by a transverse jugal band rather than by an erect anteriorly directed loop. As yet we have no satisfactory evidence that the palæozoic Cyrtinas were attached in early stages of growth by the calcareous cementation of the pedicle-valve. The frequent distortion of the umbo may be regarded as presumptive evidence of this fact, as in the genus DERBYA where early fixation did occur, though evidently not a necessary condition in all species or individuals. An attached CYRTINA has been described by BITTNER† from the St. Cassian beds under a new generic designation, CYRTOTHECA (*C. Ampezzana*), a minute shell whose size alone is indicative of an immature condition.

* Beiträge zur Paläontologie Oesterreich-Ungarns, Bnd. 1, 1882: Untersuchungen ueber rhätische Brachiopoden, p. 25.

† Brachiopoden der Alpinen Trias, p. 116, pl. xxxviii, fig. 19, 1890.

In its superficial ornamentation, species of CYRTINA, like those of CYRTIA, conform to a marked degree with that of the associated Spirifers. In the genus SPIRIFER it has been shown that the various modes of surface ornament have a more or less definite time-value, and the same fact is, to a certain degree, true of CYRTINA. In the fauna of the Niagara group the species *C. pyramidalis*, Hall, has an exterior probably fimbriate like that of *Spirifer sulcatus*. The greatest individual and specific development of these forms is in the Devonian where the representatives are mostly coarsely plicate shells with smooth fold and sinus, like the prevailing type of SPIRIFER of the same fauna. Among these are *C. Dalmani*, Hall, of the Lower Helderberg, *C. crassa*, Hall, of the Corniferous limestone, *C. Hamiltonensis*, Hall, of the Corniferous, Hamilton and Chemung groups, *C. triquetra*, Hall, and *C. umbonata*, Hall, of the middle Devonian, and *C. acutirostris*, Shumard, of the Choteau limestone. In the Oriskany sandstone occurs *C. rostrata*, Hall, a large species with the exterior coarsely lamellose and finely striated radially as in the associated *Spirifer raricosta*. *C. biplicata*, Hall, of the Schoharie grit and Corniferous limestone is a somewhat variable form with smooth exterior, low fold and sinus and obsolete lateral plications. Species with plicated fold and sinus are, like the Spirifers, rare in the Devonian, but become more frequent in the Carboniferous where the *Aperturati* predominate. In the American Devonian, *C. curvilineata*, White, is the only form of this character, and while this type is wanting in our Carboniferous faunas so far as known, it is represented in the European Carboniferous by *C. carbonaria*, McCoy, *C. dorsata*, McCoy, and *C. septosa*, Phillips, the last a large, broad-winged species with the external expression of SYRINGOTHYRIS. In the Waverly group of Ohio occurs the *C. lachrymosa*, sp. nov., a form with faint plications and strongly pustulose surface covered, near the beak, by fine concentric lines. The cherty beds of the Burlington series in Iowa contain an undescribed species which in external aspect is extremely like the Spiriferinas of the Keokuk and Chester groups, (e. g., *S. subelliptica* and *S. transversa*, McChesney), having the surface covered with closely crowded, concentric and fimbriated lamellæ.

GENUS SYRINGOTHYRIS, WINCHELL. 1863.

PLATES XXVI, XXVII.

1796. *Anomites*, MARTIN. Trans. Linnean Society, vol. iv, p. 44, pl. iii, figs. 1–6.
1809. *Conchyliolithus anomites*, MARTIN. Petrefacta Derbiensia, pl. xlvi, fig. 34; pl. xlvii, fig. 5.
1816. *Spirifer*, SOWERBY. Mineral Conchology, pl. cxx, figs. 1–3.
1840. *Spirifer*, TROOST. Fifth Geol. Rept. of Tennessee, pp. 17, 48.
1841. *Cyrtia*, TROOST. Sixth Geol. Rept. of Tennessee, pp. 11, 12.
1847. *Spirifer*, YANDELL and SHUMARD. Contribution to the Geology of Kentucky, pp. 19, 21.
1855. *Cyrtia*, McCOY. British Palæozoic Fossils, p. 426.
1857. *Spirifer*, HALL. Tenth Rept. N. Y. State Cab. Nat. Hist., pp. 169, 170.
1858. *Spirifer*, HALL. Geology of Iowa, vol. i, part ii, pp. 520, 603, 646, 647, pl. vii, fig. 6; pl. xiii, fig. 4; pl. xx, fig. 5.
1860. *Spirifer (Cyrtia ?)*, SWALLOW. Trans. St. Louis Acad. Sci., vol. i, p. 647.
1863. *Syringothyris*, A. WINCHELL. Proc. Acad. Nat. Sci. Philadelphia, vol. vii, sec. ser., pp. 6–8.
1865. *Syringothyris*, MEEK. Proc. Acad. Nat. Sci. Philadelphia, vol. ix, sec. ser., p. 275.
1866. *Spirifera*, HALL. Proc. American Philosophical Society, vol. x, p. 241.
1867. *Spirifer*, MEEK. American Journal Science, vol. xliii, p. 407.
1868. *Spirifer*, MEEK and WORTHEN. Geol. Survey of Illinois, vol. iii, p. 530, pl. xix, fig. 8.
1870. *Syringothyris*, A. WINCHELL. Proc. American Philosophical Society, vol. xii, p. 252.
1875. *Syringothyris*, MEEK. Palæontology of Ohio, vol. ii, pp. 285, 288, pl. xiv, fig. 7.
1875. *Syringothyris*, WHITE. Wheeler's Geogr. Surveys West of the 100th Meridian, vol. iv, pp. 88, 90, pl. v, fig. 9.
1877. *Spirifer*, MEEK. King's U. S. Geol. Expl. of the 40th Parallel, vol. iv, p. 87, pl. iii, fig. 11.
1880. *Spirifer*, WHITE. Second Annual Rept. Indiana Bureau of Statistics and Geology, p. 512, pl. vii, figs. 1, 2.
1881. *Spirifer*, WHITE. Tenth Rept. State Geol. of Indiana, p. 144, pl. vii, figs. 1, 2.
1884. *Syringothyris*, WALCOTT. Monogr. U. S. Geol. Survey, vol. viii, p. 219.
1888. *Syringothyris*, HERRICK. Bulletin Denison University, vol. iii, p. 41, pl. i, fig. 7; pl. ii, fig. 17; pl. v, figs. 4–7; vol. iv, p. 14.
1889. *Syringothyris*, SIMPSON. Trans. American Philosophical Society, p. 440, fig. 5; p. 441, fig. 6.
1890. *Syringothyris*, SCHUCHERT. Ninth Rep. N. Y. State Geologist, pp. 28–37.

Shells spiriferoid, usually large, with erect cardinal area and broad, multiplicate lateral slopes. Fold and sinus generally non-plicate. In the pedicle-valve the delthyrium is covered by a convex, imperforate plate, which is frequently absent. The dental lamellæ, more or less strongly developed, rest on the bottom of the valve, and at their anterior extremities are produced about the broad diductor impressions. They are united beneath the deltidium by a transverse plate arising from a testaceous callosity in the apex of the delthyrium. This plate is formed by the deposition of accretions to the margins of the delthyrium, which unite in the median line, the union being marked by a raised line less distinct on the upper than on the under side of the plate. From just within the lateral margins and on the inner side of the plate two lamellar processes are given off, which are curled toward each other with some irregularity, not meeting except where coalesced with the apical callosity, forming a tube which is split along its inner surface. This tube is adherent to the transverse plate as far as the latter extends, and is frequently produced beyond its termination.

Muscular scars as in SPIRIFER, their anterior portion being divided by a short median septum which is an extension from the apical calcareous deposit.

The brachial valve is spiriferoid in all internal details. The cardinal process is broad, multistriate and supported by a short median thickening. The spirals are large, the primary lamellæ bearing a pair of short, discrete spinous processes which represent the loop. The shell structure is more or less distinctly and abundantly punctate. It is probable that these punctæ perforate the epidermal layer and extend to the inner laminæ of the shell. The exterior is usually covered with a finely textile ornament which has been compared, in appearance, to "twilled cloth."

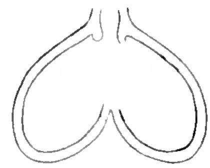

FIG. 40. The primary lamellæ of *Syringothyris typa.*

Type, *Syringothyris typa*, Winchell. Burlington limestone.

The relations of this genus to the Spirifers with smooth fold and sinus (*Ostiolati*) have already been adverted to at some length. In view of the existence of at least one punctated species of SPIRIFER (*S. plenus*, Hall) in which the transverse plate and split tube of SYRINGOTHYRIS are not present, and of gradational conditions in respect to other points of structure, which have been noticed, it is quite safe to assume that this peculiar group of forms is an outcome from normal development with variation along that spiriferoid line. The extravagant structure within the delthyrium, termed the split tube, may be regarded as the extreme manifestation of a tendency in all the later spiriferoids with plicated exterior to excessive secretion of testaceous matter in this region. Dr. KING, in 1868,* claimed to have found traces of this tube or canaliferous plate in a rudimentary condition in several species of SPIRIFER, *e. g.*, *S. striatus*,

* Annals and Magazine of Natural History, Fourth series, vol. ii, p. 18.

S. disjunctus. These observations have not yet been verified, but it would be reasonable to expect such phenomena even among Spirifers not belonging to the group of *Ostiolati.* Yet here, as in so many other generic groups of the brachiopods, it is the extreme development of a given peculiarity which serves as a basis of generic distinction from forms possessing the same character in a state of incipiency.

What may have been the function of this organ in the physiology of the animal is still a subject for speculation. KING suggested that it might have been a base of attachment for the pedicle-muscles. The pedicle, however, was probably atrophied in the mature condition of these shells; at least all means of egress were obstructed, except beneath the deltidium. There is no reason from analogy for assuming that the pedicle ever passed through this aperture, but in case it was thus extruded, Dr. KING'S supposition seems a plausible one. If, however, the pedicle was atrophied from the closure of its normal channel nearer the beak, this calcareous tube may have been an exudation encysting this functionless organ. In one interesting species from the earliest of the Carboniferous faunas, *S. Herricki*, Schuchert, there is a solid process in place of a tube beneath the transverse plate, which is extended to the bottom of the valve, thus forming a septum supporting the transverse plate, and exhibiting in a striking manner an inclination toward the internal structure of SPIRIFERINA.

The divergent views of KING and CARPENTER in regard to the punctation of the shell in *S. cuspidatus* are well known, and the discussions may be found principally in the Annals and Magazine of Natural History, and the Geological Magazine for the years 1867 and 1868.*

The late F B. MEEK was the first to demonstrate† that the shell substance in *S. cuspidatus* is punctate, and probably all the species possessed of a transverse plate and split tube have this shell structure. This punctation has been described as "patchy;" it is better developed or better retained in some parts of

* The student may also be referred to Dr. CARPENTER'S earlier observations in his report to the British Association, 1844, "On the Microscopic Structure of Shells," and to his treatise in DAVIDSON'S Introduction, "On the Intimate Structure of the Shells of the Brachiopoda," 1852.

† Proc. Academy of Natural Sciences, Phila., vol. ix, second ser., p. 275. 1865.

the shell than in others, a variation which may be due to the easy destruction of the delicate pores which are exceedingly small and much finer than in SPIRIFERINA, CYRTINA, and the terebratuloids.

Attention, however, may be directed to an interesting species from the Choteau limestone of Cooper county, Missouri, small in size, cyrtiniform in figure, with a highly and coarsely punctate shell.*

While regarding SYRINGOTHYRIS as an outcome from SPIRIFER along the line of the *Ostiolati*, the genus contains an occasional species which is isomorphic with the *Aperturati*. Such, for example, are the *S. Randalli*, Simpson, from the Waverly faunas of eastern Pennsylvania, and the *S. distans*, McCoy, of the Coal Measures of Great Britain and Belgium.

The type species of SYRINGOTHYRIS was named by Professor WINCHELL, *Syringothyris typa*, and was derived from the Burlington limestone. Drs. KING and DAVIDSON both regarded this fossil identical with *Spirifer cuspidatus*, Martin, and they have been followed by MEEK, WALCOTT and HERRICK, but SCHUCHERT † has pointed out differences which may serve to keep the European and American forms distinct.

The fact that the species *Spirifer Carteri*, Hall, from the Waverly sandstones of Ohio, is a SYRINGOTHYRIS has been long known. SWALLOW'S *Spirifer* (*Cyrtia ?*) *Hannibalensis*, from the Chotean limestone, is a smaller form of the same specific type as *S. typa*.

In the Waverly fauna of Pennsylvania occur the species described by Mr. G. B. SIMPSON as *S. Randalli* and *S. angulata*.‡ In the development of the same fauna in Ohio, and in the Keokuk group of Indiana, Illinois and Iowa, *S. texta*, Hall, and its allies are not uncommon species (*Spirifer textus*, Hall, *S. subcuspidatus*, Hall, *S. propinquus*, Hall).

*This is evidently an undescribed shell, and as it is an important one for our purposes the name *Syringothyris Missouri* is proposed. Its highly punctate shell, its size and form, all indicate a deviation toward CYRTINA, while the canaliform transverse plate is developed as a very delicate structure. For a fuller description of the species see the supplement to this volume.

† On Syringothyris, Winchell, and its American species; Report of the N. Y. State Geologist for 1889, p. 230. 1890.

‡ Proc. American Philosophical Society, vol. xvi, 1889, p. 435. These were described as *S. Randalli* and var *angulata*, but as the former possesses a plicate fold and sinus and in the latter the fold and sinus are smooth, it will be better to regard them as distinct species.

Mr. Schuchert has also referred to Syringothyris the species *Spirifer extenuatus*, Hall, of the Kinderhook group, for which he regards the *Syringothyris Halli*, Winchell, a synonym; and to the same genus, the *Cyrtia gigas*, Troost, from the lower Carboniferous of Tennessee, though we are without conclusive evidence of the nature of the interior in this fossil.

Genus SPIRIFERINA, d'Orbigny. 1847.

PLATES XXXV, XXXVI, XXXIX.

1847. *Spiriferina*, d'Orbigny. Comptes rendus, vol. xxv, p. 268.
1850. *Spiriferina*, d'Orbigny. Annales des Sciences Naturelles, vol. xiii, p. 334.
1852. *Spirifer*, Hall. Stansbury's Expl. and Survey of the Valley of the Great Salt Lake of Utah, p. 409, pl. iv, fig. 4.
1854. *Spiriferina*, Davidson. British Fossil Brachiopoda, p. 82, pl. vi, fig. 60.
1855. *Spirifer*, Shumard. Geology of Missouri, vol. i, p. 203.
1856. *Spirifer*, Norwood and Pratten. Journal Acad. Nat. Sci., Philadelphia, vol. iii, p. 71, pl. ix, fig. 1.
1856. *Spirifer*, Hall. Pacific Railroad Reports, vol. iii, p. 102, pl. ii, figs. 10, 11.
1858. *Spiriferina*, Shumard. Trans. St. Louis Acad. Sci., vol. i, pp. 294, 391.
1858. *Spirifer*, Hall. Transactions of the Albany Institute, vol. iv, p. 7.
1858. *Spirifer*, Hall. Geology of Iowa, vol. i, part ii, p. 706, pl. xxvii, fig. 5.
1859. *Spirifer*, Meek and Hayden. Proc. Acad. Nat. Sci., Philadelphia, vol. iii, sec. ser., p. 27.
1860. *Spirifera*, Meek. Proc. Acad. Nat. Sci., Philadelphia, vol. iv, sec. ser., p. 310.
1860. *Spirifera*, White. Journal Boston Society Nat. Hist., vol. vii, p. 232.
1860. *Spirifera*, McChesney. New Palæozoic Fossils, pp. 42, 43.
1862. *Spiriferina*, White. Proc. Boston Society Nat. Hist., vol. ix, pp. 24, 25.
1863. *Spiriferina*, Davidson. Quart. Journal Geol. Society London, vol. xix, p. 170, pl. ix, fig. 6.
1864. *Spiriferina*, Meek. Palæontology Upper Missouri, p. 19.
1865. *Spiriferina*, A. Winchell. Proc. Acad. Nat. Sci, Philadelphia, vol. ix, sec. ser., pp. 119, 120.
1866. *Spirifer*, Swallow. Trans. St. Louis Acad. Sci., vol. ii, p. 489.
1866. *Spirifer*, Geinitz. Carbon und Dyas in Nebraska, p. 45, pl. iii, fig. 19.
1868. *Spirifera*, McChesney. Trans. Chicago Acad. Sci., vol. i, p. 34, pl. vi, fig. 3.
1872. *Spiriferina*, Meek. Hayden's U. S. Geol. Survey of Nebraska, p. 185, pl. vi, fig. 3; pl. viii, fig. 11.
1874. *Spiriferina*, Derby. Bull. Cornell University, vol. i, p. 23, pl. ii, figs. 4–6, 13; pl. iii, figs. 12–14, 17; pl. v, fig. 4; pl. vi, figs. 8, 13, 14.
1875. *Spiriferina*, White. Wheeler's Geogr. Surveys West of the 100th Meridian, vol. iv, pp. 138, 139, pl. x, figs. 4, 8.
1876. *Spirifera*, Meek. Simpson's Rept. Expl. Great Basin of the Terr. of Utah, p. 352, pl. ii, fig. 1.
1877. *Spiriferina*, Meek. King's U. S. Geol. Expl. 40th Parallel, vol. iv, pp. 84, 85, pl. viii, fig. 1, 5; pl. xii, fig. 12.
1877. *Spirifera* (*Spiriferina ?*), Hall and Whitfield. King's U. S. Geol. Expl. 40th Parallel, vol. iv, p. 281, pl. vi, fig. 17.
1878. *Spiriferina*, Dawson. Acadian Geology, third ed., p. 291, fig. 90.
1878. *Spiriferina*, Etheridge. Quart. Journal Geol. Society London, vol. xxxiv, p. 269.
1882. *Spiriferina*, Whitfield. Bull. American Mus. Nat. Hist., vol. i, p. 48, pl. vi, figs. 16, 17.
1883. *Spiriferina*. Hall. Twelfth Rept. State Geol. Indiana, p. 327, pl. xxix, figs. 16, 17.

1883. *Spirifera (Spiriferina)*, HALL. Second Ann. Rept. State Geologist of N. Y., pl. lx, figs. 19–22, 26–29; pl. lxi, figs. 14–16.
1884. *Spiriferina*, WHITE. Thirteenth Rept. State Geologist Indiana, p. 135, pl. xxxv, figs. 13, 14.
1884. *Spiriferina*, WALCOTT. Monograph U. S. Geological Survey, vol. viii, pp. 218, 219, pl. xviii, figs. 12, 13.
1888. *Spiriferina*, HERRICK. Bull. Denison University, vol. iii, p. 47, pl. ii, figs. 9–11; pl. v, fig. 13; pl. x, fig. 3.
1891. *Spiriferina*, HERRICK. Bull. Geol. Soc. America, vol. ii, p. 46, pl. i, fig. 19.

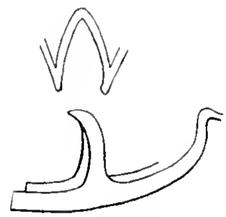
FIG. 41.
The loop of *Spiriferina Kentuckiensis*, Shumard. (C.)

Shells resembling SPIRIFER in external aspect; interiorly the pedicle-valve bears a median septum resting upon the bottom of the valve, its posterior portion lying between, but not united with the strong dental lamellæ. The processes on the primary lamellæ are continuous, forming a simple transverse or subacute loop.

Shell substance strongly punctate throughout.

Type, *Terebratulites rostratus*, Schlotheim. Lias.

This name is currently allowed to cover a large number of species presenting the most extreme variations in exterior characters and some important internal differences. The type of the genus is a form upon whose surface the plications are obsolescent and whose epidermis is covered with closely matted spinules; the median septum is discrete from the dental lamellæ, and the loop is a transverse band with a slight upward curve. Recent writers on the Triassic brachiopods, however, still strain the genus to include species in which the septum unites with and supports the convergent dental lamellæ, forming the structure characterizing the interior of CYRTINA.*

Among the palæozoic species referred to SPIRIFERINA, the prevailing expression is a strongly plicated exterior with well marked fold and sinus. The shells are usually of small size, and though occasionally with a spiniferous exterior, as in *S. spinosa*, the usual ornamentation consists of concentric lamellæ of growth, the surface of which is radially striated and probably minutely fimbriate. The development of the median septum in these species is never so extreme as in *S. rostrata* and the Liassic forms.

* See page 45 of this volume.

The accompanying figure of *S. Walcotti*, Sowerby, shows the great elevation of this wall, and the broad scars of the adductor muscles upon its lateral faces. This specimen indicates how important are the changes in the anatomy of the animal, resulting from, or productive of this median septum. The older species have furnished no direct evidence of similar muscular attachment, but there is no reason for doubting its existence wherever such a septum is found.

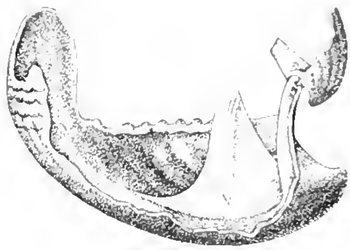

FIG. 42.
Spiriferina Walcotti, Sowerby; showing muscular scars on walls of median septum of pedicle-valve. (C.)

As far as observed, the loop of the palæozoic species is slightly different from that of the later members of the genus, and resembles that of CYRTINA, the lateral portions converging upward, between the spiral coils, and uniting in a slight anterior extension. The spiral ribbon is spiniferous in *S. rostrata*, but usually smooth in the Carboniferous species. In *S. spinosa*, and probably in other species, there is a solid calcareous deposition in the umbonal cavity of the pedicle-valve, filling the interspaces between the dental lamellæ and the median septum, not constituting a union of the three plates as in CYRTINA, but forming a secretion analogous to that found in the syringothyroid Spirifers, and to the transverse plate in SYRINGOTHYRIS itself. Both the palæozoic and Liassic species have broad crura, a faint elevated median ridge in the brachial valve, and a pair of divergent ridges lying on the surface of the first internal plications, extending fully, or more than one-half the length of the valve, and ending abruptly; probably the external fulcra of the adductor muscles.

It has already been observed that the derivation of the generic characters of this genus has been from the lamellose-septate Spirifers whose inception dates from the faunas of the Upper Silurian. Though none of these Silurian and Devonian species, in the American faunas, developed a punctate shell structure, they usually bear the lamellose, often radially striated exterior, prevailing among the Spiriferinas of the Carboniferous. Mr. DAVIDSON has described two of these lamellose species from the Devonian, which have a strongly punctated shell, *Spiriferina cristata*, Schlotheim, var. *octoplicata* and *S. insculpta*,* in which it has not been conclusively shown that the median septum exists, though this is a legitimate inference. The gradual assumption of the punctated structure is not so clearly defined among these forms as in the syringothyroid line of development, although one species, the *Spirifer transversus*, McChesney, from the Chester limestone, is a septate shell in which punctation is but feebly and sparsely developed.

The American species which may be referred to SPIRIFERINA are few. The *Spirifer solidirostris*, White, of the Kinderhook group, is a septate-lamellose shell, but the specimens we have examined do not evince punctation. *Spiriferina spinosa*, Norwood and Pratten, and *S. transversa*, McChesney, of the Chester (Kaskaskia) limestone, *S. subelliptica*, McChesney, of the Keokuk group; *S. Kentuckiensis*, Shumard, and var. *propatula*, Swallow, and *S. spinosa*, var. *campestris*, White, of the Coal Measures, are characteristic representatives. The forms which have been described as *S. Billingsi*, Shumard, *S. binacuta* and *S. Clarksvillensis*, Winchell, and *S. subtexta*, White, have not come under our observation. It should be remarked that WALCOTT has regarded† *S Kentuckensis* and var. *propatula*, and *S. spinosa* as synonyms of *Spiriferina cristata* (Schlotheim), Davidson.

GENUS AMBOCŒLIA, HALL. 1860.

PLATE XXXIX.

1842. *Orthis*, CONRAD. Journal Acad. Nat. Sci. Philadelphia, vol. viii, p. 264.
1843. *Orthis*, HALL. Geology of N. Y.; Rept. Fourth Dist., p. 180, fig. 8; p. 267, fig. 5.
1846. *Orthis*, ROUAULT. Bull. Soc. Géol. de France, sec. ser., vol. iv, p. 322, pl. iii, fig. 8.
1857. *Orthis*, HALL. Tenth Rept. N. Y. State Cab. Nat. Hist., p. 167, figs. 1-3.
1860. *Ambocœlia*, HALL. Thirteenth Rept. N.Y. State Cab. Nat. Hist., p. 71, figs. 1-3; p. 72, figs. 4-6; p. 81.
1862. *Ambocœlia (Spirifer?)*, WHITE. Proc. Boston Soc. Nat. Hist., vol. ix, p. 26.
1864. *Ambocœlia*, MEEK and HAYDEN. Palæontology of the Upper Missouri, p. 20.
1867. *Ambocœlia*, HALL. Palæontology of N. Y., vol. iv, pp. 258-262, pl. xliv, figs. 1-25.
1883. *Ambocœlia*, CLAYPOLE. Proc American Philosophical Society, vol. xxi, p. 232.
1887. *Ambocœlia*, ŒHLERT. Bull. de la Soc. d'Etudes Scientif. d'Angers, p. 6, pl. v. figs. 11-16.
1889. *Ambocœlia*, NETTELROTH. Kentucky Fossil Shells, pp. 85, 86, pl. xvii, figs. 25, 26.

DIAGNOSIS. Shells small, concavo-, or plano-convex. Marginal outline nearly semicircular. Hinge-line long and straight, its length nearly or quite equaling the greatest transverse diameter of the shell.

* Devonian Brachiopoda, pp. 46, 48, pl. iv, figs. 11-17.

† Palæontology of the Eureka District, p. 218. 1884.

Pedicle-valve greatly elevated; umbo arched and incurved; with a narrow median groove which becomes fainter or disappears towards the anterior margin. Cardinal area well defined and arched; divided medially by an open delthyrium whose lateral margins bear incomplete deltidial plates. Teeth prominent, erect, strongly recurved at the tips; not supported by dental plates. Muscular area quite restricted, consisting of narrow, elongate diductors, enclosing an almost linear adductor. The entire area is sometimes divided by a faint median ridge. The interior surface about the muscular area is strongly pitted.

Brachial valve convex at the beak, becoming depressed over the pallial region and reflexed near the margin. Cardinal area comparatively broad and standing at nearly right angles to the area of the opposite valve. Delthyrium open, the deltidial covering* attaining the same degree of development as in the pedicle-valve. Cardinal process narrow and much elongated, resting on the bottom of the valve except at its posterior extremity which is simply bifurcated. Crural plates erect, parallel; taking their origin in the deltidial plates and extending about one-fourth the distance across the valve. The spirals are attached by long crura, the ribbon making a few volutions only, thus forming loose coils, directed laterally. The loop has apparently the same incipient condition of development as in SPIRIFER. According to ŒHLERT,† the spiral ribbon bears spinules on its outer margins. Muscular impressions anterior and composed of four well defined adductor scars.

Surface smooth or with fine concentric striæ crossed by indistinct radiating lines; rarely spinous. Shell substance fibrous, impunctate.

Type, *Orthis umbonata*, Conrad. Hamilton group.

OBSERVATIONS.—The external characters of the Devonian forms of AMBOCŒLIA ally it to MARTINIA, and there is little doubt that the finely punctured epidermal layer is common to both. The structure of the interior, however, is so unlike that of SPIRIFER, in its elongate and simple cardinal process, long, parallel, erect crural plates and anterior muscular scars in the brachial valve, that the generic value of the group is beyond question. The type of structure is essentially

* *Chilidium*, Beecher.

† Bulletin de la Société d'Etudes Scientifiques d'Angers, 1887; Brachiopodes du Devonien de l'Ouest de la France, p. 6, pl. v, fig. 12.

Devonian. In America, *Ambocœlia umbonata* appears in the Corniferous limestone, and its existence is continued under more favorable conditions for development in the various faunas of the Hamilton group. In the latter faunas is also a larger form which has been described as *A. præumbona*, Hall, and in the Chemung group *A. umbonata* var. *gregaria*, Hall, is a very abundant shell. The *Orthis umbonata* was identified in the Devonian of western France (Gahard) by Marie Rouault as early as 1851,* and has been redescribed and figured by Œhlert in the work already cited.

There also occurs in the Hamilton shales of western New York a species with spinous exterior (*A. spinosa*, sp. nov.); and in the final appearance of Ambocœlia in the Coal Measures, where it is represented by the *Spirifer planoconvexus*, Shumard, the same condition of exterior occurs. In the latter, however, the surface spines are usually lost, the exterior appearing as in the Devonian species though showing the fine punctation or reticulation of the epidermal shell layer.

Genus METAPLASIA, nov. gen.

PLATE XXXIX.

This name is proposed for the little shell described in 1859 as *Spirifer pyxidatus*, Hall.† While it possesses a general spiriferoid aspect in outline, the structure of the hinge and deltidium, the pedicle-valve is the more convex and bears a broad fold, while the brachial valve is flat or slightly convex over the lateral extremities and depressed medially by a broad sinus. This reversal of the relative position of the fold and sinus is accompanied by some other peculiarities.

The teeth are stout and unsupported by lamellæ; the posterior extremities of the diductor impressions in the pedicle-valve are deeply impressed and separated by a short, thick septum. Anteriorly the muscular area is less clearly defined; from its distal margin diverge two ridges which were probably of vascular origin, and a few radiating furrows of similar character are seen on the lateral portions of the valve.

* Bull. Soc. Géol. de France, 2nd ser., t. viii, p. 322.

† Palæontology of New York, vol. iii, p. 428, pl. c, figs. 9-12.

In the brachial valve the cardinal process is quite prominently developed and is distinctly bilobed. The socket walls are elevated and recurved; anteriorly they are produced into short crural bases which are not free, but rest upon the bottom of the valve. The muscular area is narrow and elongate, and consists of a pair of central adductor scars embraced posteriorly by a broader pair. From the anterior margin of this area arise two vascular trunks which diverge outwardly and recurve, following the margins of the valve. These give off a series of branches externally and probably a shorter series toward the center of the valve. The ovarian markings are very distinct about the bases of the dental sockets.

The external surface of the shell is smooth or covered with very fine concentric lines. The shell substance is fibrous and apparently impunctate.

Whether this species was spiriferous has not been determined, none of the specimens examined having shown evidence of brachial supports. In some respects the characters of the species are suggestive of ORTHIS; for example, the well developed, bilobed, recurved cardinal process, filling the delthyrium of the brachial valve and extending beyond the plane of the cardinal area; the vascular sinuses, and to some extent, the arrangement of the muscular impressions. These features, taken in connection with the delthyrium of the pedicle-valve, which does not appear to have been covered, though sometimes partially filled with an apical accretion, may perhaps be interpreted as confirmatory evidence of the non-spiriferous character of the species.

Metaplasia pyxidata was described from the Oriskany fauna of Cumberland, Maryland. It is known to occur also in the Oriskany of New York and Canada, as well as in the decomposed chert of the Corniferous limestone in the Province of Ontario.

It may be here observed that the very peculiar species *Spirifer cheiroptyx*, described by D'ARCHIAC and DE VERNEUIL,* from the middle Devonian at Paffrath, and its ally in the Carboniferous limestones of Visé, *S. Oceani*, d'Orbigny,† have

* On the Fossils of the Older Deposits of the Rhenish Provinces: Trans. Geol. Soc. London, vol. vi, p. 370, pl. xxxv, figs. 6, a, b, 1842.

† Prodrome de Paléontologie stratigraphique, pl. i, p. 149, 1850. See, also, DE KONINCK, Faune du Calcaire carbonifère de la Belgique, 6e partie; Brachiopodes, p. 132, pl. xxviii, figs. 11-16, 1887.

a deep sinus on the brachial valve, and also a corresponding sinus on the opposite valve. Each valve is divided externally by two strong divergent ridges, into three depressed areas, one central and two lateral. QUENSTEDT, considering both species identical, erected for their reception* a special subdivision of his *Aperturati*, viz., *Cinctæ*. The hinge is long and the cardinal areas on both valves well developed; the surface is smooth or covered with fine concentric lines. Little is known of the interior, but it appears from QUENSTEDT'S description that a cardinal process is well developed and that the shell contains spirals similar to those of SPIRIFER.

It is very evident that, in association with this most peculiar exterior which of itself necessitates a separation of these species from SPIRIFER, will be found other peculiarities not pertaining to any of the subdivisions of that genus here adopted. To render the classification of the spiriferoids more homogeneous we propose for this aberrant group the designation VERNEUILIA (see plate xxxix).

GENUS WHITFIELDELLA, NOM. NOV.

PLATE XLVIII.

1828. *Terebratula*, DALMAN. Kong. Vetenskaps-Akad. Handlingar. pl. vi, fig. 7.
1842. *Atrypa*, VANUXEM. Geology of N. Y.; Rept. Third Dist., p. 112, fig. 5.
1843. *Atrypa*, HALL. Geology of N. Y.; Rept. Fourth Dist., p. 71, fig. 3; p. 142, fig. 5; Tables of Organic Remains, No. 13, fig. 5.
1852. *Atrypa*, HALL. Palæontology of N. Y., vol. ii, pp. 9, 76, 77, 260, 268, 269, 328, pl. iv, figs. 4, 5; pl. xxiv, figs. 1–4, 6; pl. lv, figs. 1, 2, 4; pl. lxxiv, fig. 10.
1856. *Atrypa*, BILLINGS. Canadian Naturalist and Geologist, vol. i, p. 137, pl. ii, fig. 9.
1858. *Atrypa*, ROGERS. Geology of Pennsylvania, vol. ii, part ii, p. 823, fig. 634.
1859. *Merista*, HALL. Palæontology of N. Y., vol. iii, p. 253.
1859. *Merista*, HALL. Twelfth Rept. N. Y. State Cab. Nat. Hist., pp. 77, 78.
1862. *Athyris, Charionella?*, BILLINGS. Palæozoic Fossils, vol. i, p. 146, fig. 124; p. 166, fig. 150.
1863. *Athyris*, BILLINGS. Geology of Canada, p. 317, figs. 320, 332–334.
1863. *Meristella*, HALL. Transactions of the Albany Institute, vol. iv, p. 226.
1867. *Meristina*, HALL. Palæontology of N. Y., vol. iv, p. 299.
1867. *Meristella*, DAVIDSON. British Silurian Brachiopoda, p. 112, pl. xxi, figs. 1–10.
1868. *Athyris?*, MCCHESNEY. Trans. Chicago Acad. Science, vol. i, p. 33, pl. viii, fig. 2.
1873. *Meristella (? Meristina)*, MEEK. Palæontology of Ohio, vol. i, p. 180, pl. xv, fig. 2.
1873. *Athyris*, NICHOLSON and HINDE. Canadian Journal, vol. xiv, new ser., pp. 144, 157.
1875. *Athyris*, NICHOLSON. Palæontology of the Province of Ontario, p. 61, fig. 32*a*; p. 62, fig. 32*e*.
1879. *Meristina*, HALL. Twenty-eighth Rept. N. Y. State Mus. Nat. Hist., p. 160, pl. xxv, figs. 1–7.
1882. *Meristina*, DAVIDSON. British Silurian Brachiopoda, Supplement, p. 94, pl. iv, figs. 20–23.
1882. *Meristina*, HALL. Eleventh Rept. State Geologist of Indiana, pp. 300, 301; pl. xxv, figs. 1–7.

* Petrefactenkunde Deutschlands; Brachiopoden, p. 510, pl. liii, figs. 70–72. 1871.

1882. *Meristella*, WHITFIELD. Geology of Wisconsin, vol. iv, p. 321, pl. xxv, fig. 5.
1883. *Meristella*, HALL. Transactions of the Albany Institute, vol. x, p. 71.
1889. *Meristina*, NETTELROTH. Kentucky Fossil Shells, p. 102, pl. xxxiii, figs. 10, 11.
1889. *Meristina*, BEECHER and CLARKE. Memoirs N. Y. State Mus., pp. 67-70, pl. vii, figs. 4-13.

DIAGNOSIS. Shells usually of small size; valves subequally convex, ovate or elongate in outline. Umbo of the pedicle-valve not high or greatly incurved, usually exposing the circular apical foramen, beneath which the deltidial plates are frequently retained. Cardinal slopes of both valves broad and not distinctly defined; anterior margin subtruncate and gently sinuate. In the typical forms there is a faint sinus on both valves near the anterior margin, otherwise the surface is smooth. On the interior the muscular impressions of the pedicle-valve are similar to those of MERISTELLA. In the brachial valve the hinge-plate is concave, divided by a deep central concavity which is supported by a median septum. On either side are the lobes bearing the bases of the crura. The brachidium* consists of two spiral cones arranged as in MERISTA, but as a rule the ribbon makes fewer (from six to twelve) volutions at maturity.


FIG. 43.

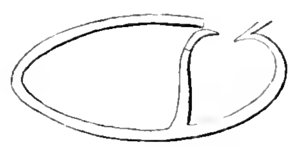
FIG. 44.

The loop of *Whitfieldella nitida*, Hall. (C.)

The loop is simple, the branches being more nearly erect than in MERISTA, MERISTELLA, etc., and beyond their junction continued into a short, acute, generally slightly curved process, which makes a large angle with the direction of the lateral branches. The muscular impressions, which are very faint, are divided, longitudinally, by the median septum, and, transversely, into anterior and posterior scars. From the ante-lateral margins of the muscular area in both valves, radiates a series of vascular sinuses, the principal trunks of which are very conspicuous; this feature, however, is rarely retained. External surface of the valves smooth or concentrically striate. Shell-substance fibrous, impunctate.

Type, *Atrypa nitida*, Hall. Niagara group.

* The term *brachidium* may be applied to the calcified brachial supports of all Brachiopoda.

Observations. This name is proposed as a substitute for the term Meristina in its current application to species not congeneric with *M. Maria*. The number of these species is, probably, comparatively large, and their features subject to considerable variation, though, with few exceptions, there are none having the structure of the brachidium as described above, which present differences in other respects sufficient to justify a separation from the type form. Heretofore the structure of the loop in this group has not been correctly demonstrated. Mr. Davidson figured and described preparations of *Atrypa nitida* and *Terebratula didyma*, Dalman* (which he regarded as equivalent terms), showing a loop erect and slightly inclined backward at its tip, but without the simple posterior prolongation; he applies to these species the generic term Meristina. The reasons are given elsewhere for restricting the genus Meristina to species similar to *M. Maria*, Hall; and though the second species mentioned in the original description of that genus, *Atrypa nitida*, agrees rather more closely in the form of the loop with the figure given at that time, both species vary from the structure as there represented, which is a condition not yet known to occur among the brachiopods. It is not unlikely, however, that this phase of development may be found among some early athyroid species.

We may with reasonable security refer to this genus the following American species: *Atrypa cylindrica*, Hall, *A. intermedia*, Hall, *A. naviformis*, Hall, of the Clinton group; *A. nitida*, Hall,† *A. crassirostra*, Hall (= *A. cylindrica*, Hall), of the Niagara group, and *Charionella? Hyale*, Billings, of the Guelph limestone. With these are probably to be associated *Atrypa oblata*, Hall, of the Medina sandstone, and *Athyris Harpalyce*, Billings, of the Lower-upper Helderberg

* Silurian Brachiopoda, Supplement, pl. iv, figs. 20–23*a*.

† In the original description of this species the appellation *nitida* was applied to a small form, elongate-subtriangular in outline and subtruncate on the anterior margin. At the same time a larger form with a more gradual anterior slope was designated as var. *oblata*. It is the latter which agrees more closely with the very abundant shell in the Niagara fauna of Waldron, Indiana, subsequently identified as *Meristella nitida* (Twenty-eighth Annual Report of the New York State Museum, p. 160. 1879), while the typical form of the species is found in the extension of the Niagara fauna to the southward, in the vicinity of Louisville, Kentucky. The similarity of the Waldron variation to the *Meristina didyma*, as identified by Davidson from the English Silurian, is very close, while the typical *Atrypa nitida* seems to maintain permanent differences. The Gotland forms of *Atrypa didyma* have a higher umbo than any of the American shells, constantly exposing the deltidial plates and the entire length of the pedicle-opening.

fauna of Square Lake, Maine. Of the foregoing species we know the character of the loop in *Whitfieldella cylindrica*, *W. nitida* and *W. intermedia*.

The forms of *Whitfieldella cylindrica* occurring in the Niagara limestone at Hillsboro, Ohio, have a remarkably elongate shape, broad and abrupt cardinal slopes on the pedicle-valve, subnasute anterior extremity. In these respects the species differs from other members of the group, but the character of its loop as developed from a solid internal cast in silica, requires, for the present, its retention in this association.

A very similar species in all external characters is DALMAN'S *Atrypa prunum*, from an equivalent horizon in Gotland

GENUS HYATTELLA, GEN. NOV.

PLATE XLVIII.

This term is introduced for a group represented by the peculiar species, *Atrypa congesta*, Conrad, of the fauna of the Clinton group.

This species has been found to possess a loop like that of WHITFIELDELLA, but presents some significant points of variation from that genus in other respects, viz.:

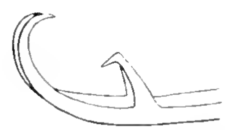

FIG. 45. The loop of *Hyattella congesta*, Hall. (C.)

The form is compactly subpentahedral; the umbo of the pedicle-valve acute, concealing most of the deltidium. The pedicle-valve bears a strong median sinus and two faint lateral sinuses, the opposite valve having corresponding folds. The surface of the shell and the ante-lateral margins are strikingly sinuate. Fine, sharp, closely crowded concentric striæ cover the exterior. The interior of the pedicle-valve has a deep and strongly striate pedicle-cavity, bounded by strong dental lamellæ; the diductor scars are distinctly defined, enclosing a linear adductor. In the brachial valve the hinge-plate is triangular and divided medially by a deep cleft. The lateral portions are broad and elevated, supporting short, straight crura. The spiral ribbon makes not more than six volutions, forming very loose coils. There is no median septum.

The differences from other meristelloids are sufficient to justify the separation of this species, with which we are at present able to associate only the form described by Mr. BILLINGS as *Athyris Junia*, from the Anticosti group, Divisions 2–4.*

GENUS DAYIA, DAVIDSON. 1881.

PLATE LV.

1839. *Terebratula*, J. DE C. SOWERBY. Murchison's Silurian System, pl. v, fig. 7.
1846. *Atrypa*, McCOY. Synopsis Silurian Fossils of Ireland, p. 40.
1847. *Terebratula*, BARRANDE. Silur. Brachiopoden aus Böhmen, pl. xv, fig. 4.
1848. *Terebratula*, DAVIDSON. Bull. Soc. Géol. de France, sec. ser., vol. v, pl. 328.
1848. *Hypothyris*, PHILLIPS. Mem. Geol. Survey Great Britain, p. 281.
1852. *Hemithyris*, McCOY. British Palæozoic Fossils, p. 204.
1859. *Rhynchonella*, SALTER. Murchison's Siluria, second ed., p. 545, pl. xxii, fig. 12.
1860. *Rhynchonella*, LINDSTRÖM. Gotlands Brachiopoder, p. 381.
1869. *Rhynchonella ?*, DAVIDSON. British Silurian Brachiopoda, p. 190, pl. xxii, figs. 20–23.
1881. *Dayia*, DAVIDSON. Geological Magazine, new ser., vol. viii, p. 291.
1882. *Dayia*, DAVIDSON. British Silurian Brachiopoda, Supplement, p. 96, pl. v, figs. 1–4.

Mr. DAVIDSON has established this genus upon the little species, *Terebratula navicula*, J. de C. Sowerby, from the Wenlock and Ludlow formations of Great Britain and the Island of Gotland. In his earliest description he referred the species with doubt to RHYNCHONELLA,† and at that time gave an elaborately illustrated account of the peculiar interior surface characters of the valves. Subsequently,‡ ascertaining from the preparations of the brachidium made by the Rev. Mr. GLASS, the distinctive structure of the loop, he proposed it as the type of a new generic division.

The shells of this species are small, subtrihedral in contour, with a very convex pedicle-valve which may be obscurely keeled along the middle and depressed laterally; and a brachial valve which is convex posteriorly, but becomes concave over the anterior region, and bears a well developed median sinus. The hinge-line is short; the cardinal area absent. The umbo of the pedicle-valve is gibbous and its apex closely incurved, concealing the foramen. Deltidial plates were probably developed but they appear to be invariably lost in separated valves. The delthyrium is wide, the teeth divergent, moderately conspicuous and unsupported by lamellæ. In the bottom of the valve are two

* Catalogues Silurian Fossils of Anticosti, p. 46. 1866.

† British Silurian Brachiopoda, p. 190, pl. xxii, figs. 20–23.

‡ 1881 and 1882, as cited.

narrow, divergent muscular grooves, bordered on their anterior edges by thickened ridges, both having the shape of a broad inverted V.

In the brachial valve the character of the hinge-plate has not been ascertained, but was probably simple, and it was supported by a median septum traversing about one-half the length of the valve; on either side of this septum are the lateral members of the adductor impression. The crura are short and straight; the primary lamellæ are attached to them by a subrectangular curve and pass outward just within the margin of the valve. The spirals are but slightly elevated and have their apices directed outward toward the lateral slopes of the opposite valve. The ribbon makes but three or four turns, and its outer anterior edges are quite coarsely fimbriated. The loop is situated anteriorly, taking its origin near the upward turn of the primary lamellæ; it is directed upward and backward, the lateral processes meeting at or just behind the center of the interior cavity. From the point of union proceeds a short, simple process, which does not make an angle with the rest of the loop.

We have had the opportunity of verifying most of these characters by cuttings of specimens obtained from the Gotland limestone. No congeneric species was known to Mr. Davidson, and, as far as our knowledge goes, there is no representative of this structure in the American palæozoic faunas.

The external resemblance of *Dayia navicula* to the *Atrypa bisulcata* of the Trenton limestone, is worthy of remark, and the differences between the two in the structure of the brachidium are actually slight, though in one the spirals are everted and in the other they are inverted. Further notice is taken of these differences in the discussion of the genus Cyclospira.

Genus HINDELLA, Davidson. 1882.

PLATE XLI.

1862. ***Athyris***, Billings. Palæozoic Fossils, vol. i, p. 144, fig. 121; p. 145, fig. 122.
1863. ***Athyris***, Billings. Geology of Canada, p. 317, fig. 331.
1882. ***Hindella***, Davidson. British Silurian Brachiopoda, Supplement, p. 130.
1885. ***Meristella***, Foerste. Bull. Denison University, vol. i, p. 88, pl. xiii, fig. 2.

Mr. Davidson has found that the meristelloid species described by Billings, from Junction Cliff, Anticosti (Division 1 of the Anticosti group), as *Athyris* *umbonata*, possesses a peculiar loop connecting the spirals, and has, therefore, upon this character based a distinct genus. The situation of this organ, the

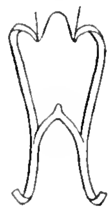

FIG. 46.

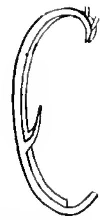

FIG. 47.

The primary lamellæ and loop of *Hindella umbonata*, Billings. (C.)

loop, is very far forward, and its inclination to the primary lamellæ is extremely oblique, the lateral processes or branches being directed backward in a low upward curve, uniting to form a short, straight, undivided stem. The posterior extremity of the entire process rarely extends back of the middle of the first lamellæ and does not rise to the center of the bases of the spirals.

The form of this loop is somewhat similar to that occurring in the genera, WHITFIELDELLA, HYATTELLA, NUCLEOSPIRA, etc., but its anterior position on the primary lamellæ and its very depressed form are without parallel among these brachiopods with everted spirals.

Congeneric with *Hindella umbonata* is BILLINGS' *Athyris Prinstana*, from the same locality; a shorter and more rotund form than *H. umbonata*, but probably no more than a variation of that species.

FIG. 48.

FIG. 49.

FIG. 50.

FIG. 51.

Consecutive transverse sections of the umbonal region of *Hindella umbonata*, Billings.

Fig. 48. Section just below apex of pedicle-valve, showing the grooved pedicle-passage.
Fig. 49. Section at apex of brachial valve, showing the dental lamellæ.
Fig. 50. A deeper section, exhibiting the teeth, and the remnants of the dental lamellæ bounding the muscular area.
Fig. 51. Section showing the lateral elements of the hinge-plate. (C.)

Some additional characters of these shells may be added:

The outline is subcircular or elongate-ovate; the valves convex; the pedicle-valve being gibbous in the umbonal region. The hinge-line is very short but the cardinal slopes are frequently long and transverse, which, with the fulness of the beaks of both valves, produces a "shouldered" appearance. There is a low sinus on the pedicle-valve which is apparent only over the pallial region; this is accompanied by a slight fold on the opposite valve. The apex of the pedicle-valve is closely incurved, concealing both deltidium and foramen. On the interior the teeth are moderately prominent and are supported by strong dental plates, which not only extend to the bottom of the valve, but are continued forward for about one-third the length of the shell, and inclose a narrow, elongate muscular area.* In the brachial valve the hinge-plate appears to be short and constructed on the same plan as that of MERISTINA and WHITFIELDELLA, with two diverging crural bases divided by a median groove, or a sub-triangular pit, and is supported by a median septum extending for about one-half the length of the valve. The spirals have their apices directed laterally and consist of nine or ten volutions of the ribbon. External surface smooth. Shell-structure fibrous, impunctate.

The external expression of the shells of HINDELLA is rendered peculiar by the fulness and close incurvation of the beaks, and these are distinguishing features. While the character of the loop is unique, the deep muscular scar of the pedicle-valve, the structure of the hinge-plate, and the smooth external surface, are features which demonstrate the close relationship of the genus to MERISTINA and WHITFIELDELLA.

GENUS MERISTINA, HALL. 1867.

PLATE XLVII.

1828. *Atrypa*, DALMAN. Kongl. Vetenskaps Akad. Handling., p. 134, pl. v, fig. 3.
1860. *Athyris*, ROEMER. Die Silurische Fauna der westlichen Tennessee, p. 70, pl. v, fig. 12.
1863. *Meristella*, HALL. Transactions of the Albany Institute, vol. iv, p. 212.
1866. *Meristella*, DAVIDSON. British Silurian Brachiopoda, p. 109, pl. xi, figs. 1-13.
1867. *Meristina*, HALL. Twentieth Rept. N. Y. State Cab. Nat. Hist., p. 157.
1867. *Meristina*, HALL. Palæontology of N. Y., vol. iv, p. 299.
1872. *Meristella*, HALL and WHITFIELD. Twenty-fourth Rept. N. Y. State Cab. Nat. Hist., p. 196.
1875. *Meristina*, HALL and WHITFIELD. Palæontology of Ohio, vol. ii, p. 132, pl. vii, figs. 5, 6.
1878. *Meristella*, ETHERIDGE. Quarterly Journal Geological Society London, p. 597.

* All the internal characters of the valves here described have been derived from transverse sections of the shell. The material examined, most of which has been placed at our service by the kindness of its collector, Professor ALPHEUS HYATT, has afforded no interiors or single valves. The figures given above, of sections across the umbonal region, show some of the features mentioned.

1879. *Meristina*, HALL. Twenty-eighth Rept. N. Y. State Mus. Nat. Hist., p. 159, pl. xxv, figs. 8-12.
1881. *Whitfieldia*, DAVIDSON. Geological Magazine, new ser., vol. viii, p. 156.
1882. *Meristina*, HALL. Eleventh Ann. Rept. State Geologist Indiana, p. 299, pl. xxv, figs. 8-12.
1882. *Whitfieldia*, DAVIDSON. British Silurian Brachiopoda, Supplement, p. 107.
1889. *Meristina*, NETTELROTH. Kentucky Fossil Shells, p. 101, pl. xxix, figs. 7-10.
1889. *Whitfieldia*, BEECHER and CLARKE. Memoirs N. Y. State Museum, p. 73, pl. vii, figs. 1-3.

DIAGNOSIS. Shell biconvex, the greatest depths of the valves being subequal. General expression meristoid. The beak of the pedicle-valve is erect in youth, but so greatly incurved at maturity as to totally conceal the foramen and deltidium. Cardinal slopes narrow but distinct, forming prominent shoulders which may be traced nearly to the middle of the lateral margins. A low, often indistinct median ridge extends from the apex forward; at about the middle of the shell it is divided by a faint groove, becoming broader toward the margin and continued into a subnasute extension. Lateral slopes scarcely depressed.

The brachial valve also bears a low median ridge, which manifests itself most conspicuously over the anterior portion of the shell.

On the interior of the pedicle-valve the teeth are conspicuous and are supported by thin plates, which extend to the bottom of the valve and are produced forward to form the lateral boundaries of the muscular area. Between the posterior portion of these plates lies the deep scar of the pedicle muscle, which is separated from the elongate and radially striate diductor impression by a prominent callosity.

In the brachial valve the hinge-plate is deeply divided in the middle by a narrow sulcus, the two lateral lobes being elevated, and supporting the crural bases. The plate is thickened on the under side and supported by a median septum, which extends for one-half the length of the valve. The crura are short and straight, and the primary lamellæ of the spiral ribbon originate from them at a sharp angle, diverge laterally as they turn downward, passing over a portion of the secondary volutions, approach each other toward the middle of their length, nearly meeting at the anterior edge of the median septum, thence again diverging to their anterior recurvature. The secondary volutions do not follow precisely the curvature of the primary lamellæ and the resultant cones at maturity have a gracefully undulated surface. The loop consists of two lateral branches, broad at their origin, inclined backward, and uniting to form a stem which bears a short bifurcation at its extremity.

The muscular area is elongate-ovate and more or less distinctly separated into anterior and posterior scars. Surface of the valves smooth or with fine concentric growth-striæ. Shell-substance fibrous, impunctate.

Type, *Meristella Maria*, Hall. Niagara group.

OBSERVATIONS. The name MERISTINA, proposed in Volume IV of the Palæontology of New York (p. 299), was introduced for the purpose of distinguishing from MERISTELLA a species, *M. Maria*, Hall, which possesses strong meristelloid characters but lacks the peculiar loop of that genus. Though the loop was imperfectly represented in the figure accompanying the first use of the name, it nevertheless constituted then, as it still does, the single important difference of the species from MERISTELLA. The precise character of this loop was fully determined subsequently (as described and illustrated in the present work), by the Rev. NORMAN GLASS, from specimens obtained at the celebrated locality, Waldron, Indiana,* and described by Dr. DAVIDSON in 1882.† Mr. GLASS found a loop of like structure in the English (Wenlock) examples of the *Atrypa tumida*, Dalman. In the place cited Dr. DAVIDSON expresses his conviction of the identity of the American species *M. Maria* with *Atrypa tumida*, and as the form of the loop then determined was new, he proposed to distinguish these fossils by the generic name WHITFIELDIA.

It is to be regretted that the laws of nomenclature do not permit the admission of this name. Whether or not DALMAN's species and the American *M. Maria* be conspecific,‡ they are at all events congeneric, and belong to the much earlier genus, MERISTINA. That this genus was imperfectly described

* Though this species is a rare fossil in the Niagara fauna of New York, it is very abundant at Waldron and far from infrequent in the Niagara dolomites of northern Illinois and southern Wisconsin.

† Silurian Supplement, p. 108, pl. v, fig. 6.

‡ We do not follow Mr. DAVIDSON in regarding these forms identical. They present differences which though slight, are positive and permanent variations of the same type of structure. A series of Gotland specimens of *Atrypa tumida*, obtained from, and identified by Dr. LINDSTRÖM, and submitted for our examination by Mr. CHARLES SCHUCHERT, shows that there are two readily apparent variations in the forms referred to the Swedish species, and it is an interesting fact that these are from different localities. One of these forms (from Westergarn) is of small size, strikingly subpentagonal outline, with high, strongly arched and narrow umbo on the pedicle-valve, the greatest diameter of the shell being in front of the middle; while

will not justify its overthrow, as long as the type-species is a well known form whose structure is now thoroughly understood; and as MERISTINA is a term which has come into quite general use, it may not be cast aside for a later term.

Accepting the foregoing interpretation of the characters of MERISTINA, we find but very few species which may be classed with those already discussed. The form described by BILLINGS as *Athyris Blancha*, from the peculiar fauna of Square Lake, Maine (which contains, as far as known, a commingling of fossils elsewhere characterizing the Lower and Upper Helderberg horizons), seems to be a species closely allied to *Meristina tumida*, more so than to *M. Maria.* Its expression is unlike that of MERISTELLA, though the character of the loop is undetermined. To the representatives of MERISTINA must be added the little

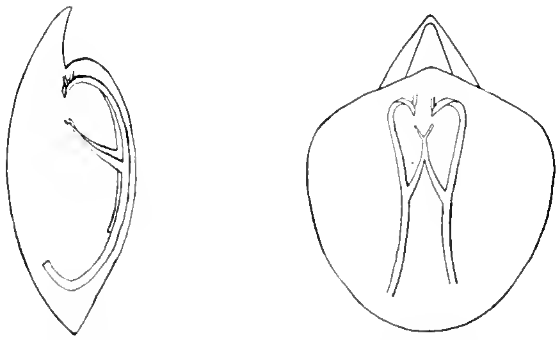

FIG. 52. FIG. 53.
The primary lamellæ and loop of *Meristina rectirostra*, Hall. (C.)

species *Meristella rectirostra*, Hall, from the Niagara fauna, a form which has the bifurcated loop, but is peculiar in the immature expression of its adult characters, namely, very small size, high, erect beak and unclosed delthyrium.

the other (from Fröjel) is of larger size, transversely subelliptical in outline, with low, broad, and slightly incurved beak.

It appears from Mr. DAVIDSON'S figures (Silurian Brachiopoda, pl. xi), that both forms occur in the English faunas. The characters of the American species differ from those which the Swedish and English specimens possess in common, in the following respects: (a) the abruptness of the cardinal slopes; (b) the obsolescence or absence of a median groove over the anterior portion of the brachial valve and its lesser development in the sinus of the pedicle-valve; (c) the general habit of the American species is uniform and its expression that of neither of the variations of the Swedish species just described, but of an intermediate character. The American form thus varies to such a degree that, while recognizing it as the representative of *Atrypa tumida*, it will serve a useful purpose to retain the original specific name.

Some interesting observations have been made upon the development of the brachidium in *Meristina Maria*, which may be introduced in this place; it is probable that the facts observed are equally true of all the athyroids.*

In the youngest condition of growth at which the spirals have been demonstrated (a shell with a length of 7 mm.) the ribbon makes six volutions (see Plate XLI, figure 9). The primary lamellæ are far stronger than the remainder of the ribbon, indeed it is often only these that can be detected, the rest of the coil being exceedingly delicate and leaving but a linear trace in the calcareous preparations. The cones are very depressed, in fact are coiled almost in the plane of the first volution, and their apices are far back of the transverse axis of the shell, which is not the case in the adult, where they lie in, or slightly in front of this axis. The second volution of the ribbon is scarcely more than one-half as long as the first, and the third stands in the same relation to the second. In these early stages of growth it has been impossible to determine fully the condition of the loop; it appears to be without the terminal bifurcation, and it is possible that this character was still undeveloped, though its absence may be accidental. In a later growth-stage (see Plate XLI, figure 10) the ribbon has greatly increased the number of its volutions, and the apices of the cones are more nearly central, but the cones themselves are still greatly depressed. The process of change from the primary condition of the spirals to their adult character was undoubtedly a complicated one, involving the constant resorption of the calcareous depositions made during the earlier stages. Attention may be directed to the effects of an accidental lesion or obstruction to the normal growth of this shell and its effect upon one of the spirals; the ribbon has adjusted itself with nicety, and probably without the disturbance of function to the contracted and irregular cavity of the valves.

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* Observations of similar import have been made upon the development of the spirals in *Rhynchospira evax*, Hall; see BEECHER and CLARKE, Memoirs of the New York State Museum, vol. i, No. 1, p. 60. 1889.

MERISTA, Suess. 1851.

PLATE XLVI.

1851. *Merista*, Suess. Brachiopoden der Koessener Schichten, p. 17, pl. i.
1851. *Merista*, Suess. Jahrb. der k. k. geolog. Reichsanst, vol, iv, p. 150.
1856. *Merista*, Suess. Classification der Brachiopoden von Th. Davidson, p. 85, pl. iii, figs. 18–20.
1859. *Camarium*, Hall. Palæontology of N. Y., vol. iii, pp. 486–488, pl. xcv, figs. 2–6.
1859. *Camarium*, Hall. Twelfth Rept. N Y. State Cab. Nat. Hist., p. 42.
1860. *Merista*, Hall. Thirteenth Rept. N. Y. State Cab. Nat. Hist., pp. 73, 93, figs. 10–13.
1862. *Camarium*, Hall. Fifteenth Rept. N. Y. State Cab. Nat. Hist., pp. 176, 181, figs. 10–13.
1867. *Merista*, Hall. Twentieth Rept. N. Y. State Cab. Nat. Hist., p. 258.
1881. *Merista*, Davidson. Geological Magazine, new series, vol. viii, p. 289.
1882. *Merista*, Davidson. British Silurian Brachiopoda, Supplement, p. 103, pl. v, figs. 10–13.

Diagnosis. Shells transverse or elongate, both valves generally inflated; anterior margin sinuate, producing a fold and sinus on the marginal portion of the brachial and pedicle-valves respectively.

In the pedicle-valve the apex is perforated by a circular foramen, which, however, is usually concealed at maturity, by the incurvature of the beak; deltidial plates rarely retained. On the interior the teeth are prominent and are supported by dental plates which extend either for a short distance into the interior cavity or are considerably produced at their bases as thickened ridges. Between the dental plates is an arched free plate (the "shoe-lifter" process) attached by its posterior and lateral margins, but at its anterior margin extending beyond the dental lamellæ and rising in a low, broad curve. In rare instances this process, from its origin, bears a sharp median carina which makes the anterior margin highly angulate. The muscular area appears to be limited to the space between the dental lamellæ and to the surface of the "shoe-lifter."

In the brachial valve a median septum is more or less strongly developed,* and divides a simple ovate adductor impression. The hinge-plate is short and deeply divided by a median groove. The brachial supports consist of spiral cones with their bases in apposition and parallel to the axial plane of the shell, and

* In the figures of *Merista herculea*, Barrande, the type-species, given by Mr. Davidson (Supplement British Silurian Brachiopoda, pl. v, figs. 10, 13), no evidence is seen of this dorsal septum; it appears, however, in Barrande's figures, both of this species and of *M. passer*, Barrande (Système Silurien, vol. v, pls. x, xiii, xiv), and in American species of this genus.

their apices directed toward the lateral margins. The loop has been shown by the Rev. NORMAN GLASS to have the following structure: the lateral branches approach and unite near the middle of the interior cavity, forming a very short stem, from the posterior extremity of which is given off a pair of arms. These curve downward to the primary lamellæ of the coil and returning, meet the lateral branches below their point of union; the whole forming a scissors-shaped arrangement essentially like that of MERISTELLA, differing only in minor respects indicated under the discussion of that genus.

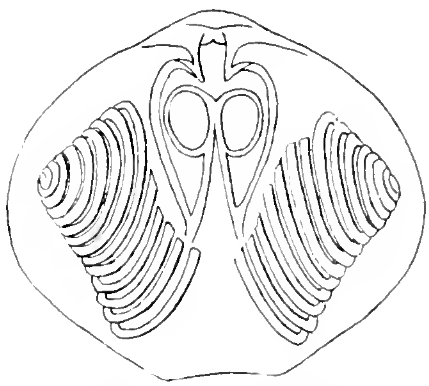

FIG. 54. The spirals and loop of *Merista herculea*, Barrande. (After DAVIDSON, from a preparation by GLASS.)

External surface of the valves smooth or with concentric growth-lines. Shell-substance fibrous.

Type, *Terebratula herculea*, Barrande. Etage E.

OBSERVATIONS. MERISTA is a genus rather sparingly represented in species, though some of the species, like *M. scalprum*, Roemer (= *M. plebeia*, Sowerby), of the European middle Devonian, are very abundant in individuals. In American faunas there are but three forms which may at present be referred to the genus, *M. typa*, Hall, *M. elongata*, Hall, a probable variety of the former, from the Lower Helderberg fauna at Cumberland, Maryland, and a new species, *M. Tennesseensis*, from a similar horizon in Perry county, Tennessee.

It appears from the description of the genus above given, that the essential difference between MERISTA and MERISTELLA lies in the existence, in the former, of the plate termed by KING the "shoe-lifter process"; the variations in the structure of the loop and hinge-plate being of minor importance. This internal plate, free at its inner edge, must have induced some important modification in the functions and internal arrangements of the animal. It is evident that its upper surface was one of muscular insertion, and whatever may have been the causes producing it, the cavity beneath it unquestionably enclosed and protected delicate portions of the viscera.*

The term CAMARIUM, Hall, was proposed for *Merista typa* (= *Camarium typum*), Hall, before the structure of *M. herculea*, Barrande, was well understood; subsequently the name was withdrawn. *Camarium typum* is, however, a shell with some interesting peculiarities and susceptible of great variation in the form and size of its "shoe-lifter." This is sometimes very narrow, as in the other species of the genus, but is oftener very wide on the margin and may extend for fully two-thirds the diameter of the valve. Usually it is evenly and highly arched, but often is sharply angled and abruptly elevated. The dental lamellæ may extend for a short distance over the surface of the plate, ending abruptly, or they may be produced along its margins as two greatly thickened, callous ridges. In these features, however, there does not appear to be any good basis for a separation of this species from its allies.

The genus MERISTA has usually been regarded as ranging from the faunas of the upper Silurian (Wenlock, Etage E, etc.) into the middle Devonian. In European faunas it appeared before the age of the genus MERISTELLA, but in America the appearance of the two genera was contemporaneous. It would be altogether natural to presume that species occurring so late as the middle Devonian and after so great an interval from the disappearance of the typical forms of the genus, must have undergone some more or less substantial modification. This is the case with the Devonian *Merista scalprum*, F. Roemer (= *M. plebeia*, Sowerby), from the Eifel and Devonshire. A careful examination of a considerable number of individuals from Pelm shows that a "shoe-lifter" is quite as conspicuously developed in the brachial as in the pedicle-valve, while the cavity beneath it is divided into two compartments by the median septum which extends beyond the anterior edge of the platform thus

* There can be no doubt that this plate in MERISTA is quite analogous to the supported spondylium of PENTAMERUS, CAMAROPHORIA, etc., as well as to the platform of the Trimerellids, to which attention has been directed in the preceding volume of this work. Of all these forms MERISTA is the only one in which this plate or platform is not supported by a median septum, though, as noticed below, such a supporting septum exists in certain Devonian meristoids. For the unsupported triangular plate, occurring in the pedicle-valve of the genera AULACORHYNCHUS and EICHWALDIA, it may be necessary to find a different interpretation, as suggested in a subsequent chapter.

formed. The figures of *Merista prunulum*, Schnur, from the Eifel, given by QUENSTEDT,* indicate that the same feature is also present in this species. It will be conceded that the taxonomic value of this feature is as important as the present basis of distinction between MERISTA and MERISTELLA, and it is very probable that these Devonian species will afford differences in the structure of the loop.† It will doubtless serve a useful purpose to separate such Devonian species from typical MERISTA, and the name DICAMARA is therefore proposed.

GENUS MERISTELLA, HALL. 1859.

PLATES XLIV, XLV.

1842. *Atrypa*, CONRAD. Journal Acad. Nat. Sci. Philadelphia, vol. viii, p. 265.
1842. *Atrypa*, VANUXEM. Geology of N. Y.; Rept. Third Dist., p. 120, fig. 2.
1843. *Terebratula*, CASTELNAU. Essai sur le Système Silurien de l'Amér. Septen., p. 39, pl. xiii, fig. 6.
1843. *Atrypa*, HALL. Geology of N. Y.; Rept. Fourth Dist., p. 202, fig. 2.
1857. *Merista*, HALL. Tenth Rept. N. Y. State Cab. Nat. Hist., p. 92, figs. 1–7; p. 94, figs. 1–6; p. 95, figs. 1–4; p. 97.
1858. *Atrypa*, ROGERS. Geology of Pennsylvania, vol. ii, part ii, p. 825, fig. 642.
1859. *Merista*, HALL. Palæontology of N. Y., vol. iii, pp. 247–252, 431, pls. xxxix, xl, xli, xliv, ci, fig. 3.
1860. *Meristella*, HALL. Thirteenth Rept. N. Y. State Cab. Nat. Hist., pp. 74, 84, 93, figs. 5–9; p. 95, figs. 1–5.
1860. *Athyris?*, BILLINGS. Canadian Journal, vol. v, new ser., p. 279, p. 274, figs. 29–32; p. 281, figs. 43, 44.
1861. *Meristella*, HALL. Fourteenth Rept. N. Y. State Cab. Nat. Hist., p. 100.
1862. *Meristella*, HALL. Fifteenth Rept N.Y. State Cab. Nat. Hist., p. 160, figs. 17–22, pl. iii, figs. 21, 22.
1863. *Meristella*, HALL. Sixteenth Rept. N. Y. State Cab. Nat. Hist., p. 50, figs. 27–34.
1863. *Meristella*, HALL. American Journal of Science, vol. xxxv, p. 396; vol. xxxvi, p. 11.
1863. *Meristella*, HALL. Transactions of the Albany Institute, vol. iv, pp. 139, 140.
1863. *Athyris*, BILLINGS. Proc. Portland Soc. Nat. Hist., vol. i, pp. 115, 116, pl. iii, figs. 13, 14.
1863. *Charionella*, BILLINGS. Geology of Canada, p. 373, fig. 397; p. 374, figs. 400*e*, 401; p. 385, fig. 420.
1866. *Merista*, A. WINCHELL. Geol. Rept. of the Lower Peninsula of Michigan, p. 94.
1867. *Meristella*, HALL. Palæontology of N. Y., vol. iv, pp. 295–299, 303–308, 420, plates xlviii, xlix, l, figs. 1–17; lxiii, figs. 15–22.
1868. *Merista*, MEEK and WORTHEN. Geological Survey of Illinois, vol. iii, p. 376, pl. vii, fig. 8.
1874. *Athyris*, NICHOLSON. Palæontology of the Province of Ontario, p. 86.
1874. *Athyris*, BILLINGS. Canadian Naturalist and Geologist, vol. vii, new ser., p. 240.
1884. *Meristella (Whitfieldia)*, WALCOTT. Monogr. U. S. Geol. Survey, vol. viii, p. 148, pl. iii, fig. 8.
1889. *Meristella*, NETTELROTH. Kentucky Fossil Shells, pp. 97, 98, pl. xv, figs. 2–8.
1889. *Meristella*, SIMPSON. Transactions of the American Philosophical Society, vol. xvi, p. 442, fig. 7.

* Petrefactenkunde Deutschlands; Brachiopoden, pl. li, figs. 69–75. 1871.

† Dr. DAVIDSON refers to preparations of *Merista prunulum* by ZUGMAYER, and implies that there are some minor differences in the loop, etc., from these structures in *M. herculea*. Dr. ZUGMAYER's observations have not been published, and therefore we can venture no opinion as to how far such differences as he may have discovered will fortify the distinction above indicated between the Silurian and Devonian species currently referred to MERISTA.

Diagnosis. Shells having the same general external characters as **Merista.** Valves convex, often inflated, cardinal areas obscure. The umbo of the pedicle-valve is incurved at maturity, concealing most, if not all of the foramen; in early stages of growth, however, the beak is more erect and exposes the deltidial plates in an elementary condition of development. The anterior margin of the shell is sinuate, and usually there is a sinus on the pedicle-valve, with a less conspicuous fold on the brachial valve; sometimes both valves bear a low sinus, or the sinus on the pedicle-valve may be absent, while the fold on the brachial valve is present, thus giving the shell a nasute anterior extension; again, fold and sinus may be absent on both valves.

In the interior of the pedicle-valve the delthyrium is wide, its margins being thickened into dental ridges. The teeth are conspicuous, often much thickened and curved backward at their tips, interlocking with the opposite valve in such a manner as to make a very firm articulation. The teeth are supported by lamellæ which rest upon the bottom of the valve, and are continued for a short distance about the posterior margin of the muscular impression. In old shells this portion of the valve becomes greatly thickened, the muscular impression correspondingly deepened, and the identity of the dental lamellæ is obscured by their becoming merged with the substance of the valve. The pedicle-cavity is deep and frequently shows a strong muscular scar. The impression of the diductor muscles is subquadrate-ovate or subtriangular in outline, very strongly impressed and usually clearly divisible into its two lateral components. The central adductor scar is faint, but linear when retained. The lateral scars are deeply striated longitudinally. The anterior margin of the muscular area is frequently obscure but is not infrequently a ridge from which radiate fine, anastomosing pallial sinuses. In the post-lateral regions the ovarian sinuses are sometimes retained.

In the brachial valve the beak is depressed and sometimes obscured by the incurvature of the umbo of the opposite valve. The dental sockets are narrow and divergent. The hinge-plate is subject to some unessential variation in form. Usually it is triangular, concave on the upper surface, and divided into two lobes by a median groove. The crura take their origin from just within the anterior margins of the lobes thus formed. In some species the hinge-plate is more subquadrate in outline, the variation being produced by the development of post-lateral expansions. This plate is supported by a median septum, which extends for somewhat more than one-third the length of the valve. The crura are short and straight, and the primary lamellæ of the brachidium originate from them at an acute angle, and come into closest apposition at the anterior extremity of the median septum. In the mature individual, the spiral ribbon makes about fifteen volutions, the bases of the cones being subparallel to the longitudinal axis of the shell and their apices directed toward its lateral margins. In their general shape the cones conform to the character of the interior cavity, and in the less convex species (*M. Walcotti*, *M. lenta*), they are appressed on the side of the flatter or brachial valve. The structure of the loop is the same as described for the genus MERISTA, with this difference, however: the circular arms of the loop curve first outward in the horizontal plane, then backward and abruptly downward to the inner edges of the primary lamellæ; in their return the same curvature is reversed and they therefore meet the stem of the loop in the horizontal plane, their point of union being invariably above the point of coalescence of the lateral branches of the loop.

The muscular area is elongate-ovate, and extends for the entire length of the median septum; the four adductor scars are sometimes distinctly seen, the posterior pair being broader and embracing the posterior extremities of the anterior scars.

External surface of the valves smooth or with concentric striæ. Shell-structure fibrous, impunctate.

Type, *Merista lævis*, Hall. Lower Helderberg group.

OBSERVATIONS. The term MERISTELLA was introduced in 1859,* in connection with a revised list of the fossils which had been described in Volumes I and II of the Palæontology of New York. The species which had been designated as *Atrypa naviformis*, from the Clinton group, is there referred to as *Merista? naviformis*, and in a footnote therefrom it is said: "This species and some others of the Clinton and Niagara groups differ somewhat from the true *MERISTÆ*; and

* Twelfth Annual Report of the New York State Cabinet of Natural History, p. 78.

should these differences prove of generic importance, I propose for them the name MERISTELLA." In the report for the following year (pp. 74, 75, published in 1860), the name was formally defined, and the distinction of the group from MERISTA was based upon the absence of the shoe-lifter process. Much of the discussion in this place involved comparisons with the *Atrypa tumida* of DALMAN, and as no type-species was definitely cited, some authors have regarded the Swedish species as the type of MERISTELLA. Such, however, was not the intention of the argument, and it was definitely so stated in a subsequent paper.* *Athrypa tumida* had been placed by Mr. DAVIDSON, first in a list of the typical representatives of the genus MERISTA,† and opportunity was taken in this place of demonstrating its similarity to SUESS's type, *M. herculea*, Barrande, but without the expression of an opinion as to its homogeneity with the species there cited in the list of examples of MERISTELLA, viz.: "*Meristella lævis, M. bella* and *M. arcuata*, of the Lower Helderberg group; *M. cylindrica* and *M. oblata*, of the Niagara and Clinton groups."

In the printing of the Thirteenth Report some changes were made in the matter relating to this genus after a very few of the pages had been struck off. As some of these first impressions fell into the hands of certain authors and elicited some degree of criticism, it seemed desirable to reproduce these pages in their original condition. This was done in the Fifteenth Annual Report of the New York State Cabinet of Natural History (pp. 178–181). In this place MERISTELLA was erroneously made synonymous with LIORHYNCHUS, the types quoted being *Atrypa quadricosta*, and *A. multicosta*, of the Hamilton group. This publication is void, and is referred to here only because of its having unfortunately introduced an element of confusion into the literature of this genus.

In the fourth volume of the Palæontology of New York (1867, pp. 295–299), MERISTELLA was more elaborately described and the complicated structure of the loop demonstrated and illustrated from silicified specimens of *M. arcuata*. The statement is there made, and has been subsequently confirmed, that the structure of this organ in *Meristella lævis*, which was the type-species in the description of 1860, is the same as that in *M. arcuata*.

* Twentieth Rept. State Cabinet (1867): On the Genera Athyris, Merista and Meristella, p. 264.
† Introduction to British Fossil Brachiopoda, p. 87.

It may be argued, and, indeed, has been assumed by some writers, that the proper type of this genus is that specified in the first use of the term MERISTELLA, *Atrypa naviformis*, of the Clinton group. No definition, however, of the genus was given in that connection, and though we are still in ignorance of the precise character of the loop in *A. naviformis*, it almost certainly differs from that of *M. lævis*, and all species belonging to MERISTELLA as this term is currently applied. To adopt this species as the type would be to ignore the elaborate diagnosis of the genus afterwards given as founded on *M. lævis*, and to cause an altogether indefensible confusion of nomenclature by giving MERISTELLA an uncertain value and requiring a new name for the extensive group of species now most properly referred to the genus.

To the genus MERISTELLA, then, may be referred such species as differ from MERISTA in having no shoe-lifter process, but, in its place, a very deep muscular impression. In both genera, the brachial supports, which were first demonstrated for MERISTELLA, by Mr. R. P. WHITFIELD (Palæontology of New York, vol. iv), and subsequently for MERISTA, by the Rev. NORMAN GLASS, afford no satisfactory basis of distinction, although there is a slight difference in them,

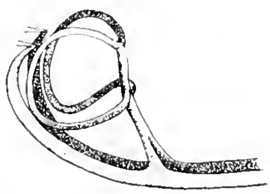

FIG. 55.

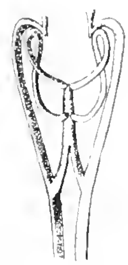

FIG. 56.

The loop of *Meristella Walcotti*. (C.)

as indicated above. The drawings of the loop here given are the first to represent with precision the character of the curvature of the circular branches. There is also, probably, a considerable and, perhaps, a significant difference in the structure of the hinge-plate of the two genera. This plate in MERISTA has been described from the small American species, *Merista Tennesseensis*, sp. nov., in default of any evidence of its character in *M. herculea*, and from this form that of MERISTELLA varies in its greater size, shallower median groove and more expanded surface.

The loop has been demonstrated in the following members of the genus: *M. lævis*, *M. arcuata*, *M. princeps*, *M. bella*, Hall, of the Lower Helderberg group; *M. lenta*, Hall, *M. Doris*, Hall, *M. Walcotti*, sp. nov., of the Oriskany sandstone; *M. nasuta*, Conrad, of the Upper Helderberg; *M. Barrisi*, Hall, and *M. Haskinsi*, Hall, of the Hamilton group. Besides these species the following may with security be regarded as congeneric: *M. Meeki*, *M. subquadrata*, Hall, of the Lower Helderberg; *M. lata*, Hall, of the Oriskany sandstone; *M. meta*, *M. rostrata*, Hall, *M. lens*, Winchell, of the Hamilton group, and perhaps *M. Houghtoni*, Winchell, of the upper Devonian.

From this list it appears that the genus was introduced, and attained its greatest development in species and numbers in the Lower Helderberg group, rapidly declining to its disappearance in the middle or upper Devonian. The genus has not been positively demonstrated in European faunas. In his earlier work on the Silurian Brachiopoda, DAVIDSON referred several forms to this genus, and BARRANDE has used the name in connection with certain species from the Etages E and F; some of these English and Bohemian species may prove true Meristellas, while others evidently belong to MERISTINA and WHITFIELDELLA. TSCHERNYCHEW, also, has figured a form from the Goniatite-beds of the western slope of the Urals, as *Meristella Barrisi*, Hall;* the fossil, however, is in many respects unlike the typical form of this species from the Marcellus limestone, and the accuracy of the generic reference of the Russian species is not apparent from an inspection of the figures.

SUBGENUS CHARIONELLA, BILLINGS. 1861.

PLATE XLII.

1843. *Atrypa*, HALL. Geology of N. Y.; Rept. Fourth District, p. 171, fig. 1.
1860. *Athyris?*, BILLINGS. Canadian Journal, vol. v, new ser., p. 278, figs. 35–38.
1861. *Charionella*, BILLINGS. Canadian Journal, vol. vi, new ser., pp. 148, 273, 274, figs. 100–102.
1863. *Charionella*, HALL. American Journal Science, vol. xxxv, second ser., p. 396.
1863. *Charionella*, HALL. Sixteenth Rept. N. Y. State Cab. Nat. Hist., p. 40.
1863. *Charionella*, BILLINGS. Geology of Canada, p. 374, fig. 400.
1867. *Meristella*, HALL. Palæontology of New York, vol. iv, p. 302, pl. xlvii, figs. 34–38.

* Fauna des mittleren und oberen Devon am West-Abhange des Urals, 1887, pl. xiii, figs. 1, 2.

Mr. Billings proposed this term for species of meristelloids in which the hinge-plate is so greatly modified as to be apparently absent. Upon examination of specimens of his typical species, *Atrypa scitula*, Hall (which is also probably identical with his second species, *Charionella Circe*), this structure is found to be of the following character: The general appearance is that of a pedicle-valve; two ridges, strongly recurved at their edges, pass along the margins of the delthyrium, enclosing the dental sockets; they are supported by thin lamellæ which converge toward the bottom of the valve; the crura arising from the extremities of the lateral ridges, are short and curved outward; the central portion of the plate must be considered as absent, or as very concave and merged in the substance of the valve.

This is a wide departure from the structure of the hinge-plate in the other spire-bearing brachiopoda. In other respects, however, except the almost total obsolescence of the median septum of the brachial valve, *Charionella scitula* is a near ally of Meristella. The muscular scars in the pedicle-valve are essentially similar, though in the brachial valve they are considerably more pronounced than in Meristella, occupying an elongate-oval space and being divisible into an anterior and posterior pair. Our preparations indicate that the loop has the same structure as in Meristella.

Assuming the identity of *Atrypa scitula*, Hall, with *Charionella Circe*, Billings, there is no other species known to us which can safely be referred to this genus. Mr. Billings subseqnently* applied this generic term to his *Charionella ? Hyale*, from the Guelph limestone, and to the *Meristella rostrata*, Hall, of the Hamilton group (Tully limestone); specimens of the former from Elora, Ontario, indicate that the species is a Whitfieldella. Of the latter we have seen no specimens showing the structure of the hinge.

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* See Palæozoic Fossils, vol. i, p. 166, fig. 150. 1862.

GENUS (OR SUBGENUS) PENTAGONIA, COZZENS. 1846.

PLATE XLII.

1841. *Atrypa*, CONRAD. Fifth Ann. Rept. Geol. Survey of N. Y., p. 56.
1846. *Pentagonia*, COZZENS. Annals of the Lyceum of Nat. Hist. of N. Y., vol. iv, p. 158, pl. x, fig. 3.
1857. *Rhynchonella*, HALL. Tenth Rept. N. Y. State Cab. Nat. Hist., p. 125.
1860. *Athyris ?*, BILLINGS. Canadian Journal, vol. v, p. 279, figs. 39–42.
1861. *Goniocœlia*, HALL. Fourteenth Rept. N. Y. State Cab. Nat. Hist., p. 101.
1862. *Meristella*, HALL. Fifteenth Rept. N. Y. State Cab. Nat. Hist., pl. ii, figs. 17–25; pl. xi, fig. 10.
1863. *Athyris*, BILLINGS. Geology of Canada, p. 373, fig. 396.
1864. *Pentagonia*, MEEK and HAYDEN. Palæontology of the Upper Missouri, p. 16.
1867. *Meristella* (*Pentagonia*), HALL. Palæontology of N. Y., vol. iv, pp. 309–311, pl. l, figs. 18–35.
1889. *Meristella*, NETTELROTH. Kentucky Fossil Shells, p. 99, pl. xv, figs. 9–16.

Among the species of meristelloid structure, an interesting variation in the form of the shell is presented by the little *M. lenta*, Hall, of the Oriskany sandstone. Here the pedicle-valve is very shallow and so deeply sinuate as often to appear concave; the brachial valve is quite convex, especially along the median line. A more extreme development of this form is seen in the *Atrypa unisulcata*, Conrad, of the Corniferous limestone and the Hamilton group, and it was to this species that the name PENTAGONIA was early applied by ISAACHAR COZZENS.* The description of the genus was brief, but the accompanying figures clear and unmistakable. This species is characterized by a very broad sinus on the pedicle-valve, which is limited by divergent carinæ, outside of which the cardinal or lateral slopes are very abrupt. On the brachial valve is a rounded median fold, which may be divided on its summit by a narrow sinus and in the umbo-lateral region are two short folds or flanges, beginning at the hinge-line, having a slightly sinuous curve and terminating before traversing much more than one-third the length of the valve; occasionally there is a second of these ridges on each side.

The muscular impressions of the valves are essentially as in MERISTELLA. The hinge-plate has a peculiar structure; it arises vertically from the bottom of the valve, presenting an erect, concave anterior face, which is traversed by a faint median ridge continuous with the septum of the valve. The posterior

* Description of Three New Fossils from the Falls of the Ohio; Annals of the New York Lyceum of Natural History, vol. iv (1846), p. 158, pl. x, figs. 3 *a*, *b* (*Pentagonia Peersi* = *Atrypa unisulcata*, Conrad).

portion of the upper surface of this plate bears a deep circular or crescentic concavity, most sharply defined on its anterior edge where it is bounded by the somewhat recurved vertical wall. On the lateral portions of the upper face of the anterior wall lie the elongate crural bases which are continued into short, straight crura, standing at an angle of about 45° to the plane of the horizontal face of the plate. The spiral cones are as in MERISTELLA, their curvature conforming to the peculiarly contracted interior cavity of the shell. Of the precise nature of the loop we are still in doubt. The shells are not common and are rarely in a condition suitable for the successful development of their structure. Figure 29, on Plate XLII, shows the extent of our knowledge in this direction, the specimen having a simple loop terminating in an undivided stem, not unlike that of HINDELLA. We are not, however, satisfied that the entire process is here retained, but enough is preserved to indicate that it may have been unlike that of MERISTA and MERISTELLA.

In the form of the shell itself there is an excellent ground for upholding the name PENTAGONIA, and as this is enforced by the character of the hinge-plate and probably, also, by that of the loop, the term may safely be adopted, though the genus has but a single known representative. For this two varietal names have been used ; (a) *uniplicata*, for the form with one pair of flanges on the brachial valve, (b) *biplicata*, for that in which these flanges are duplicate.* The specimens from the Corniferous limestone of New York and the Falls of the Ohio, appear to be always of the uniplicate form, while in the Hamilton group, though the species is of much less frequent occurrence, both varieties are present. The characters of PENTAGONIA, so far as known, ally it most nearly with MERISTELLA.†

* It is obvious that the first of these names, as it applies only to the typical form of the species, may be rejected ; the latter it will prove useful to retain.

† The name GONIOCŒLIA, Hall, which was suggested in 1861 for the *Atrypa unisulcata* (Fourteenth Report New York State Cabinet of Natural History, p. 101), is an exact synonym for PENTAGONIA, and may, therefore, be stricken from the list of genera.

GENUS CAMAROSPIRA, GEN. NOV.

PLATE XLII.

1867. *Camarophoria*, HALL. Palæontology of New York, vol. iv, p. 368, pl. lvii, figs. 40-45.

SHELLS essentially meristelloid in external and internal characters. The important difference from allied genera lies in the fact that the dental plates of the pedicle-valve, instead of resting upon the bottom of the valve, are more strongly convergent than in MERISTA, MERISTELLA, etc., uniting before they reach the internal surface of the valve, thus restricting the impression of the pedicle-muscle to a distinct chamber or spondylium, which is supported by a low median septum. In the typical species (*C. eucharis*, Hall) this chamber has the same extent as the deep pedicle-cavity in MERISTELLA, that is, about one-fourth the length of the valve, while the septum extends for a short distance beyond its anterior margin, dividing the scars of the adductor and diductor impressions. In this respect the internal structure of this valve is similar to that of the corresponding valve of PENTAMERUS.

In the brachial valve the hinge-plate is supported by a median septum slightly longer than that of the opposite valve, and the narrow, cordate muscular impression, which it divides medially, is considerably thickened. The valve bears everted spirals similar to those of other members of this group, but the specimens studied were not in a condition of preservation adapted to the determination of the structure of the loop.

The only species known to possess the peculiarities described is the *Camarophoria eucharis*, Hall, from the Corniferous limestone of Indiana and the Province of Ontario.

GENUS ATHYRIS, McCoy. 1844.

PLATES XLV, XLVI, XLVII.

1831. *Terebratula*, EATON. American Journal of Science, vol. xxi, p. 137.
1832. *Terebratula*, EATON. Geological Text Book, p. 46.
1838. *Atrypa*, CONRAD. Second Ann. Rept. Geol. Survey of N. Y., p. 111.
1842. *Terebratula*, D'ORBIGNY. Voyage dans l'Amérique Méridionale, Pal. p. 46, pl. iii, figs. 17–19.
1843. *Atrypa*, HALL. Geology of N. Y.; Rept. Fourth Dist., p. 198, fig. 5; Tables of Organic Remains, No. 65, fig. 5.
1844. *Athyris*, *Actinoconchus*, *Seminula*, McCoy. Synopsis Carbon. Foss. Ireland, pp. 128, 146, 149, 158.
1847. *Spirigera*, D'ORBIGNY. Comptes rendus, vol. xxv, p. 268.
1850 *Athyris*, *Cleiothyris*, KING. Permian Fossils of England, pp. 136–140, pl. x, figs. 1–10.
1850. *Spirigera*, D'ORBIGNY. Annales des Sciences Nat., vol. xiii, p. 337.
1852. *Terebratula*, HALL. Stansbury's Expl. and Survey of the Valley of the Great Salt Lake, Utah, p. 409, pl. iv, figs. 1, 2.
1853. *Terebratula*, SHUMARD. Marcy's U. S. Expl. of the Red River of Louisiana, p. 202, pl. iv, fig. 8.
1855. *Terebratuta*, SCHIEL. Pacific Railroad Reports, vol. ii, p. 108, pl. i, fig. 2.
1856. *Terebratula*, HALL. Pacific Railroad Reports, vol. iii, p. 101, pl. ii, figs. 3–5.
1857. *Spirigera*, HALL. Tenth Rept. N. Y. State Cab. Nat. Hist., p. 153, figs. 1, 2.
1857. *Athyris*, DAVIDSON. Monogr. Brit. Permian Brach., pp. 20–23, pls. i, ii.
1858. *Athyris*, DAVIDSON. Monogr. Brit. Carbon. Brach., pp. 77–87, pls. xv, xvi, xvii, xviii.
1858. *Terebratula*, *Spirigera* (*Athyris*), HALL. Transactions of the Albany Institute, vol. iv, pp. 7, 8.
1858. *Terebratula*, MARCOU. Geology of North America, pp. 51, 52, pl. vi, figs. 9, 10.
1858. *Spirifera*, ROGERS. Geology of Pennsylvania, vol. ii, part ii, p. 828, fig. 667.
1858. *Athyris*, HALL. Geol. Survey of Iowa, vol. i, part ii, pp. 600, 659, 702, 703, 714; pl. xii, fig. 6; pl. xxiii, figs. 4, 5; pl. xxvii, figs. 1, 2.
1859. *Spirigera*, MEEK and HAYDEN. Proc. Acad. Nat. Sci. Philadelphia, vol. iii, sec. ser., p. 20.
1860. *Athyris*, MEEK and WORTHEN. Proc. Acad. Nat. Sci. Philadelphia, vol. iv, sec. ser., p. 451.
1860. *Athyris*, WHITE. Journal Boston Soc. Nat. Hist., vol. vii, p. 229.
1860. *Athyris*, HALL. Thirteenth Rept. N. Y. State Cab. Nat. Hist., pp. 73, 89, 93, figs. 1–47, p. 94.
1860. *Athyris*, McCHESNEY. New Palæozoic Fossils, pp. 46, 47, 80, 81.
1860. *Athyris*, BILLINGS. Canadian Journal, vol. v, p. 273.
1860. *Spirigera*, SWALLOW. Trans. St. Louis Acad. Sci., vol. i, pp. 649–652.
1861. *Athyris*, NEWBERRY. Ive's Rept. on the Colorado River of the West, p. 126.
1861. *Athyris*, SALTER. Quart. Journal Geol. Soc. London, vol. xvii, p. 64, pl. iv, fig. 4.
1861. *Athyris*, BILLINGS. Canadian Journal, vol. vi, pp. 138, 145, figs. 54–57.
1861. *Athyris*, McCHESNEY. New Palæozoic Fossils, pp, 78, 79, 81.
1861. *Athyris*, HALL. Fourteenth Rept. N. Y. State Cab. Nat. Hist., p. 99.
1862. *Athyris*, HALL. Fifteenth Rept. N. Y. State Cab. Nat. Hist., p. 180, figs. 1–4; pl. iii, figs. 10–13, 15, 16, 24.
1862. *Athyris*, BILLINGS. Palæozoic Fossils, vol. i, p. 144.
1863. *Athyris*, BILLINGS. Geology of Canada, p. 373, fig. 399; p. 385, fig. 421.
1863. *Spirigera*, SWALLOW. Trans. St. Louis Acad. Sci., vol. ii, pp. 83–91.
1863. *Spirigera*, A. WINCHELL. Proc. Acad. Nat. Sci. Philadelphia, vol. vii, sec. ser., p. 6.
1863. *Athyris*, DAVIDSON. Quart. Journal Geol. Soc. London, vol. xix, p. 170, pl. ix, figs. 4, 5.
1864. *Athyris*, DAVIDSON. Monogr. Brit. Devon. Brach., p. 13–19, pls. iii, iv.
? 1865. *Athyris*, SHALER. Bull. Mus. Comparative Zoology, No. 4. p. 69.
1865. *Spirigera*, A. WINCHELL. Proc. Acad. Nat. Sci. Philadelphia, vol. ix, pp. 117, 118.
1866. *Spirigera*, A. WINCHELL. Geol. Rept. of the Lower Peninsula of Michigan, p. 94.

1866. *Athyris*, MEEK and WORTHEN. Geol. Survey of Illinois, vol. ii, p. 254, pl. xviii, fig. 8.
1866. *Athyris*, GEINITZ. Carbon und Dyas in Nebraska, pp. 40, 42, pl. iii, figs. 7–9.
? 1866. *Athyris*, BILLINGS. Catalogue Silurian Fossils of Anticosti, pp. 47, 48.
1867. *Athyris*, HALL. Twentieth Rept. N. Y. State Cab. Nat. Hist., pp. 152, 258.
1867. *Athyris*, HALL. Palæontology of N. Y., vol. iv, pp. 282–293, pls. xlvi, xlvii, figs. 1–33.
1867. *Athyris*, HALL. American Journal Science, vol. xliv, p. 48.
1868. *Athyris ?* MCCHESNEY. Trans. Chicago Acad. Science, vol. i, p. 33, pl. vi, fig. 4.
1869. *Spirigera (Athyris)*, TOULA. Sitzungsb. der kais. Akad. der Wissensch., vol. lix, p. 6, pl. i, fig. 5.
1871. *Athyris*, MEEK. Hayden's U. S. Geol. Survey of Nebraska, p. 180, pl. i, fig. 12; pl. v, fig. 8; pl. viii, fig. 4.
1873. *Athyris*, MEEK and WORTHEN. Geol. Survey of Illinois, vol. v, p. 570, pl. xxv, fig. 14.
1874. *Athyris*, DERBY. Bulletin Cornell University, vol. i, pp. 7, 10, pl. i, fig. 5, 8; pl. ii, figs. 9–12; pl. iii, figs. 8, 15–21, 29; pl. vi, figs. 2, 16; pl. ix, figs. 4–6.
1875. *Athyris*, MEEK. Palæontology of Ohio, vol. ii, p. 283, pl. xiv, fig. 6.
1875. *Spirigera*, WHITE. Wheeler's Expl. and Survey West of the 100th Meridian, vol. iv, pp. 91, 92, 141; pl. v, figs. 11, 12; pl. x, figs. 5, 6.
1876. *Athyris*, MEEK. Bull. U. S. Geol. Survey of the Terr., vol. ii, pl. i, fig. 2.
1876. *Athyris*, DERBY. Bull. Mus. Comparative Geology, vol. iii, p. 279.
1876. *Athyris*, MEEK. Simpson's Rept. Expl. Great Basin of the Terr. of Utah, p. 350, pl. ii, fig. 4.
1877. *Athyris*, HALL and WHITFIELD. King's U. S. Geol. Expl. 40th Parallel, vol. iv, pp. 256, 257, 271, pl. iv, figs. 10, 11, 15–17; pl. v, figs. 19, 20.
1877. *Athyris*, MEEK. King's U. S. Geol. Expl. 40th Parallel, vol. iv, pp. 81–83, pl. viii, fig. 6; pl. ix, figs. 3, 4.
1878. *Athyris*, DAWSON. Acadian Geology, third ed., p. 290, fig. 88.
1880. *Athyris*, WHITE. Second Ann. Rept. Indiana Bureau of Statistics and Geology, p. 502, pl. iv, figs. 8, 9.
1881. *Athyris*, WHITE. Tenth Rept. State Geologist Indiana, p. 134, pl. iv, figs. 8, 9.
1882. *Athyris*, WHITFIELD. Bulletin American Museum of Natural History, vol. i, pp. 49, 50, pl. vi, figs. 18–27.
1883. *Athyris*, HALL. Twelfth Report of the State Geologist of Indiana, pp. 328, 329, pl. xxix, figs. 18–27.
1884. *Athyris*, WHITE. Thirteenth Rept. State Geologist Indiana, p. 136, pl. xxxv, figs. 6–9.
1884. *Athyris*, WALCOTT. Monogr. U. S. Geol. Survey, vol. viii, pp. 148, 222, pl. xviii, fig. 5.
1884. *Athyris*, WORTHEN. Bull. Illinois State Mus. Nat. Hist., p. 24.
1887. *Athyris*, HERRICK. Bull. Denison University, vol. ii, p. 44, pl. ii, fig. 23.
1888. *Athyris*, KEYES. Proc. Acad. Nat. Sci. Philadelphia, p. 10.
1888. *Athyris*, HERRICK. Bull. Denison University, vol. iii, p. 49, pl. ii, figs. 1, 7; vol. iv, pp. 14, 24, pl. iii, fig. 6.
1889. *Athyris* NETTELROTH. Kentucky Fossil Shells, p. 87, pl. xvi, figs. 25–32.
1890. *Athyris*, WORTHEN. Geol. Survey of Illinois, vol. viii, p. 103, pl. xi, fig. 2.

" *General Characteristics.*—Nearly orbicular, small; no cardinal area or hinge-line; spiral appendages very large, filling the greater part of the shell."—MCCOY, *op. cit.*, p. 146.

DIAGNOSIS. Shells subequally biconvex; outline transversely elliptical, subcircular or elongate-subovate; surface medially sinuate.

In the pedicle-valve the beak is inconspicuous and incurved, usually concealing the foramen and deltidial plates; frequently, however, the former is exposed. Cardinal slopes not well defined in the typical group. The convexity of the valve is greatest in the umbonal region, the surface sloping evenly to the sides, and becoming depressed on the median line into a sinus, which is most conspicuous on the anterior margin. Beak of the brachial valve not prominent; a median fold corresponds in strength to the sinus of the opposite valve.

In the interior of the pedicle-valve the deltidial plates are usually absent; the teeth are prominent, recurved at the tips, and supported by stout dental lamellæ, which are not produced anteriorly about the muscular area. Between them lies a deep, transversely striated pedicle-cavity, and in front of this an ovate muscular scar extending about one-half the length of the valve and divided into flabellate diductors (which are frequently very indistinct) and narrow, cordate adductors. The pallial region is covered with ovarian pittings and branching sinuses.

In the brachial valve the dental sockets are broad and deep. The hinge-plate varies considerably in form; in the typical division of the genus it is subtriangular in outline, and supported by stout crural plates. The median portion is flat or concave, the lateral margins thickened and elevated. At the apex of the plate and just within the beak of the valve is a circular perforation (visceral foramen), which is continued beneath the plate into the cavity of the valve. The anterior margin of the plate is straight or slightly concave, occasionally trilobate, and the crura are attached at the extremities of the lateral ridges. Sometimes the outline of the hinge-plate is rendered subquadrate by the development of two post-lateral expansions.

The brachidium consists of spiral cones lying base to base, with their apices directed laterally. The form of these cones varies with that of the internal cavity, but as a rule they are much compressed vertically, the posterior curvature being short and convex, while the anterior curve is long and sometimes depressed. The crura originate from the hinge-plate at a large angle, are long and convergent; the primary lamellæ arising from their extremities, make an angular curve at their origin, thence, in the typical species, curving deeply upward and backward, to form the first volution. The spirals are connected by a loop, which takes its origin on the first half of the primary lamellæ, the

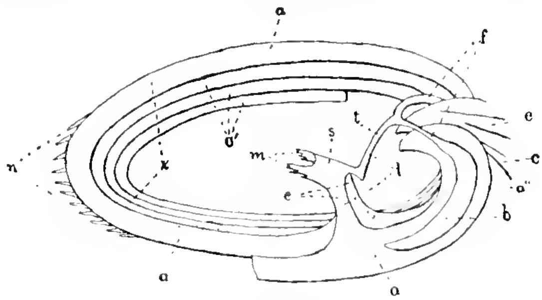

FIG. 57.
Diagram of the structure of the brachidium in ATHYRIS.

x. Spiral coil.
a. Primary lamellæ of spiral coil.
a'. Secondary lamellæ.
a''. Umbonal blades.
c. Crura.
l. Loop.
e. Lateral branches of loop.
s. Saddle.
m. Fimbriated extensions of saddle.
t. Stem of loop.
f. Arms of loop.
b. Accessory lamellæ.
n. Fimbria on outer margins of lamellæ.

two lateral lamellæ converging, and uniting at about half the distance across the base of the cones, to form a broad saddle with a convex upper surface; the anterior extremity of this saddle may be simple or divided; its posterior portion is narrowed, inclined downward or toward the beak of the brachial valve for a short distance, thence it rises abruptly toward the umbo of the pedicle-valve, and bifurcates near the extremities of the crura, each branch following the curvature of the primary lamellæ and continuing for only a part of the distance between the ends of the crura and the origin of the loop. These accessory lamellæ vary somewhat in form, are narrower than the ribbon of the coil, and lie between the primary, and the first band of the secondary lamellæ.

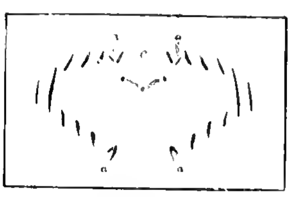

FIG. 58.

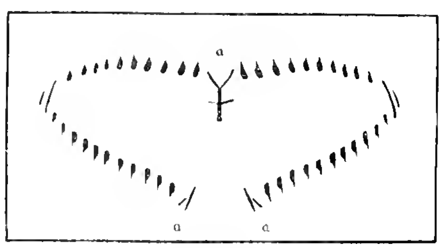

FIG. 59.

Fig. 58. Vertical section of *Athyris subtilita*, Hall, just back of the loop; showing the crura (c) and the accessory lamellæ (*a*).

Fig. 59. Vertical section of *Athyris subtilita*, Hall, through the stem of the loop. This view shows the great width of the primary lamellæ, the inclination of the accessory lamellæ (*a*, *a*) to them, and the thickened inner edges of the secondary lamellæ. (C.)

The muscular area consists of a long, ovate scar, which is divided into a subquadrate posterior pair, and a subcordate anterior pair of adductor impressions. These are separated longitudinally by a very faint median ridge. On casts of the interior the filling of the visceral foramen in the hinge-plate frequently shows a cross-striation like that of the pedicle-cavity of the opposite valve, and also indicates that the median ridge is continued throughout the extent of this passage.

The surface of the valves is variously ornamented; in the typical group, at each concentric growth-line, there is a broad lamellar expansion; in some cases this expansion is striated longitudinally, or it may be divided into flat spines, which merge into the lamella at their bases; again the spines may be long and tubular, but connected by the laminar expansions. The surface frequently appears to be smooth, or covered only with concentric striæ, and in one of the largest subdivisions of the genus (SEMINULA) this is a normal condition, while in other divisions it is often altogether casual.

Shell-substance fibrous, impunctate.

Type, *Terebratula concentrica*, von Buch. Middle Devonian.

OBSERVATIONS. The number of species which, in common usage, are referred to ATHYRIS, is very great. This name, like those of some other genera, ORTHIS, STROPHOMENA, ATRYPA, etc., has been a convenient receptacle for forms whose intimate relations were not thoroughly known; but the investigations of KING, DAVIDSON, GLASS, ZUGMAYER, BITTNER, and other careful students of the spiriferous brachiopods, have done much to eliminate from this association some of the more positively heterogeneous material. The diagnosis above given is restricted pretty closely to the essential characters of the well known species, *Terebratula concentrica*, von Buch. which, in the absence of any specified type, is usually, and quite properly regarded as the typical species, being it is the first in the list of descriptions accompanying the original account of the genus. McCOY applied the term ATHYRIS to shells, which in his belief, possessed no apical foramen or deltidium, but more careful observation soon showed that the concealment of the cardinal area was but a condition of growth, developed earlier in some species than in others, and hence the term was essentially a misnomer. On this account some authors, particularly the French and German writers, have preferred to use the term SPIRIGERA, proposed by D'ORBIGNY in 1847* to replace ATHYRIS, and founded on the same species. The term EUTHYRIS, also, was proposed by the late Professor QUENSTEDT,† but it has not come into general use. Among generic appellations there are too many misnomers which have an established and positive value, to permit the rejection of the term ATHYRIS without great inconvenience, attended by no equivalent advantage. The term is therefore used in a restricted application and substantial reasons will be given for a subdivision of the genus.‡

The essential feature which forms the basis of union of all the variations of the genus here discussed, is the nature of the loop. This complicated structure was first demonstrated by DAVIDSON in 1857§ for the species *Athyris pectinifera*, Sowerby. Since that date our knowledge of this organ has become more extended and more exact, and we now know its peculiarities in several species from the Devonian, Carboniferous and Permian faunas.

Athyris concentrica, representing a combination of characters which expresses the typical phase of athyroid structure, is distinguished from the subordinate divisions of the genus by the following differences:

(*a*) The usually transverse form; this is a feature subject to variation, but throughout the group this outline is striking, simply from the frequency of its occurrence.

(*b*) The lamellar expansions or varices at the concentric growth-lines are simple, that is, are not split up into spinules, nor do they embrace such spinules, but are usually transversely striated. They are often highly developed toward the margins of the valves, but are generally

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* Comptes rendus, vol. xxv, p. 268.

† Petrefactenkunde Deutschlands, p. 442. 1871.

‡ Students who may wish to follow the variation of opinion in regard to the value of the genus ATHYRIS, are referred to a paper by the late Mr. BILLINGS, Palæontologist of the Geological Survey of Canada, "On the Classification of the Subdivisions of McCoy's Genus Athyris, as determined by the Laws of Zoological Nomenclature;" American Journal of Science, vol. xliv (1867), p. 48. See, also, vol. xxxiii of the same Journal, pp. 127, *et seq.*

§ British Permian Brachiopoda, p. 21.

absent, probably from abrasion, on the earlier portions of the shell, and, as already observed, are frequently entirely lost.

(*c*) The hinge-plate is triangular, flat rather than concave in the middle, and without post-lateral expansions; it is, moreover, not elevated above the plane of the margins of the valve.

(*d*) The union of the primary lamellæ with the crura is more or less obtuse, the former making a curve upward, away from the crura, passing them again near the hinge-plate; thus appearing to make a noose on each side at their origin.*

(*e*) The loop is very long, its origin from the primary lamellæ being at or in front of the middle of their length.

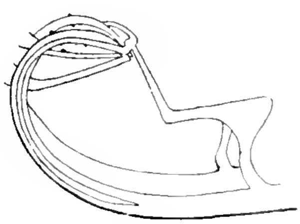


FIG. 60.

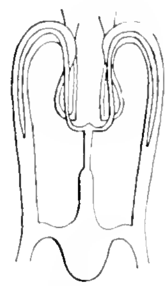


FIG. 61.

The crura and loop of *Athyris spiriferoides*, Eaton. (C.)

(*f*) The saddle of the loop is broad and undivided at its anterior extremity.

(g) The arms, or accessory lamellæ of the loop, are narrow.

(*h*) The saddle, accessory lamellæ and spiral bands are without spinules or fimbria.

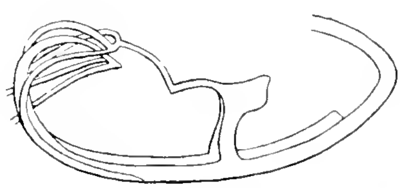


FIG. 62.

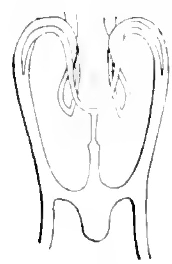


FIG. 63.

The crura and loop of *Athyris vittata*, Hall. (C.)

Of American species which are referable to this typical division of ATHYRIS, may be cited: *A. spiriferoides*, Eaton, of the Corniferous limestone and Hamilton

* This peculiar structure was first shown by Mr. R. P. WHITFIELD, for the species of *A. vittata*, Hall, and *A. spiriferoides*, Eaton, in Volume IV of the Palæontology of New York.

group; *A. Cora*, Hall, of the Hamilton group; *A. vittata*,* Hall, of the Corniferous limestone and Hamilton group; *A. Angelica*, Hall, of the Chemung group; *A. lamellosa*, Léveillé, of the Waverly and Keokuk groups; *A. incrassata*, Hall, of the Burlington limestone, and *A. Hannibalensis*, Swallow, of the Choteau limestone.

SUBGENUS CLIOTHYRIS, KING. 1850.

This name was introduced by Professor PHILLIPS, in 1841,† as a substitute for DALMAN's term ATRYPA, which this author did not regard as appropriate. The term was not subsequently used by him, nor was any typical species mentioned, so that in its original application the term has no meaning. Subsequently, and perhaps unfortunately, Professor WILLIAM KING revived the name,‡ giving a careful diagnosis and specifying as his type of the genus, *Atrypa pectinifera*, J. de C. Sowerby.

His description was: "Generally lenticular in form; minutely punctured; with variously characterised projecting laminæ of growth; *Spirals* pectinated; *Dental plates* large and separated; *Crural base* perforated; *Foramen* situated at the point of the umbone, and open inferiorly by the fissure."

At this date the genus ATHYRIS was not closely restricted or well understood. KING followed MCCOY in regarding *Terebratula concentrica*, von Buch, as its type, and demonstrated, though imperfectly, the existence of a process connecting the spiral coils of the shell.

Atrypa pectinifera is a Permian species which varies from the structure in the typical division of ATHYRIS in the following respects: The surface ornamentation consists of broad, thin, lamellar expansions which are divided almost, and sometimes quite to their bases, into long, flat spinules; hinge-plate narrow and rather acutely triangular; the primary lamellæ are attached to the

* These three species are pretty constant in their differences, the first being transverse, squamous forms, the others more orbicular and retaining but traces of the laminæ. The species present variations which are included by European palæontologists within the limits of *Athyris concentrica*, von Buch.

† Palæozoic Fossils of Cornwall, Devon and West Somerset, p. 55.

‡ The Permian Fossils of England, p. 137.

crura not only at their apices but for a short distance along their inner faces, not making the nooses peculiar to ATHYRIS proper; they are broad and blade-like, narrowing beyond the insertion of the loop; the loop is situated posteriorly; the accessory lamellæ are narrow near their origin, broaden and then taper again, having the shape of a sickle. The spiral ribbon, from the figures given by DAVIDSON and KING, appears to be pectinated on all its outer edges, but it has not been shown that the anterior extremity of the loop is similarly ornamented.

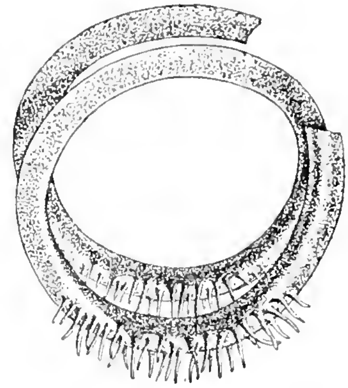


FIG. 64.
The fimbriated spirals of *Athyris pectinifera*, Sowerby. (DAVIDSON.)

These features are of sufficient significance to distinguish this group of species from the typical division of the genus. It must be granted, that as the really essential differences are in the structure of the spirals and loop, it will be impossible to make a final arrangement of these species until their internal structure has been fully elucidated. Temporarily, however, the character of the external ornament may be relied upon, inasmuch as we know the internal arrangements with which it is associated in the type-species, *Cliothyris pectinifera*.

This subgenus is equivalent to WAAGEN's section ORNATÆ, typified by the *Athyris Roysii*, Léveillé,* under which he includes, besides *A. Roysii* and *A. pectinifera*, five new species (*A. subexpansa*, *A. capillata*, *A. semiconcava*, *A. acutomarginalis*, *A. globulina*), all from the upper and lower divisions of the Productus limestone of the Salt-Range of India. In American faunas CLIOTHYRIS is represented by the species usually identified as *A. Roysii*, in the Waverly and Keokuk divisions of the lower Carboniferous, *A. hirsuta*, Hall (= *A. americana*, Swallow), from the St. Louis and Chester limestones, and *A. sublamellosa*, Hall, from the Burlington limestone.

* Productus limestone Fossils, p. 473. 1883.

Subgenus ACTINOCONCHUS, McCoy. 1844.

In the same work that contained the original description of Athyris, McCoy proposed the above term for a shell which he described as *Actinoconchus paradoxus*.

" *General Characteristics.*—Shell globose; the margin of both valves greatly extended, forming a flat, circular, striated disc; spiral appendages as in *Athyris.*"—(*Op. cit.*, p. 149.)

Its affinities with Athyris were evident to the author, and later writers have regarded it simply as a synonym for that term. The *Actinoconchus paradoxus* was subsequently shown by Davidson to be the same shell as Phillips' *Spirifera* (= *Athyris*) *planosulcata* (1836), which McCoy had himself identified among the Carboniferous fossils of Ireland from desquamated specimens (p. 148).*

There seem to be excellent reasons for reinstating this term in its original application, as *Athyris planosulcata* is a strongly individualized species which may well serve as the type of a group.

It is characterized by the extravagant development of the concentric lamellar expansions† which are striated radially by distant sulci "about half a line apart" (Davidson). These expansions appear to be actually fine, tubular spines connected by, or imbedded in a tenuous calcareous plate. The interior of the pedicle-valve bears a median septum which traverses the pedicle-cavity and half the length of the shell; also two strong dental plates which are continued forward, slightly diverging, for more than one-half the length of the septum. Mr. Davidson has given elaborate illustrations of the spirals and loop of this species, from preparations by the Rev. Norman Glass,‡ and from them it appears that the latter organ, the loop, has essentially the same conformation as in *Cliothyris pectinifera*, though it is placed further forward (see Silurian Supplement, p. 98, fig. 1.). The saddle of the loop is neither divided nor pectinated, while the spiral ribbon bears short spinules "on the edge and face of the lamellæ fronting the sides of the shell" (Davidson). *Athyris planosulcata* is a species

* McCoy afterwards referred the species to the genus Athyris: British Palæozoic Fossils, p. 436. 1855.

† See Davidson's superb figures in Carboniferous Brachiopoda, pl. xvi., figs. 7, 8.

‡ Supplement to British Silurian Brachiopoda, p. 98, figs. 1, 2, pl. iv, figs. 14–19.

which has a wide distribution through the lower and upper Carboniferous of England, Ireland and Belgium.

SUBGENUS SEMINULA, McCoy. 1844.

This is another term proposed in the "Synopsis of the Carboniferous Fossils of Ireland," which has been absorbed into the genus ATHYRIS by later writers. On page 150 of his work, McCOY mentions SEMINULA as "a genus formed for the reception of those little species which have a minute perforation but want the deltidium," and further, on page 158, describes the genus as follows:

"*General Characteristics.*—Shell small, subpentagonal; smooth or slightly plaited at the margin; beak of the dorsal valve small, with a minute perforation; no deltidium.

"The species of this genus are all small; the margin frequently indented, but no distinct plaits on the surface; the outline is usually more or less pentagonal; the beak has a very minute foramen for the passage of the muscle of attachment, but there is no *deltidium* separating the foramen from the hinge.

"The genus is peculiar to the Palæozoic rocks."

In this place the author described three species, the first of which, *Seminula pentahedra*, Phillips (sp.), may be taken as the type in absence of any specified typical species. PHILLIPS' species has been shown to be synonymous with *Spirifer ambiguus*, Sowerby, and is antedated by it. The other forms referred, in the work cited and subsequently, to SEMINULA by McCOY, have been shown by DAVIDSON to be not congeneric with *S.* (*Athyris*) *ambigua*. No generic importance can now be given to the apparent absence of the deltidium in this shell; it is simply concealed as in many other *Athyres* by the incurvature of the beak. Mr. DAVIDSON has described and elaborately figured the *Athyris ambigua*,* and from his work, with the aid of a series of specimens from the Carboniferous limestone of Great Britain,† it appears that the shell has certain characters which do not permit its easy association with the other subdivisions of ATHYRIS. The smooth exterior of the species, its subpentahedral form and

* Carboniferous Brachiopoda, p. 77, pl. xv, figs. 16–22; pl. xvii, figs. 11–14. 1858.

† For some of which we have been indebted to Prof. JOHN YOUNG, of the Hunterian Museum, Glasgow.

sinuate valves are distinctive features and to these must be added the peculiar character of the muscular scars. This subtype is largely represented in the American Carboniferous faunas and from an examination of its various species we deduce the following characterization:

Shells transverse, often elongate or ficiform; valves biconvex, the pedicle-valve with a median sinus over the pallial region, and the brachial valve with a corresponding ridge; both sinus and fold may be divided by a sharp median sulcus extending from the umbones to the margins. There is frequently evidence of a single obscure lateral fold on each side of both valves. The umbo of the pedicle-valve is incurved and the deltidial area is usually concealed; the foramen, however, is exposed as a circular or ovate aperture which encroaches on the substance of the valve. In the pedicle-valve the diductor muscular impressions are very faintly defined; the adductor and pedicle impressions are as in the typical forms of ATHYRIS. In the brachial valve the hinge-plate is highly developed, its upper face being subquadrate in outline, concave on the surface, the concavity deepening toward the visceral foramen which lies just beneath the beak; not infrequently the foramen is closed by secretions of testaceous matter. The posterior flanges of the plate pass beyond the hinge-line and into the umbonal cavity of the opposite valve. The anterior face of the plate is erect and the anterior edge somewhat trilobed, the lateral lobes bearing the crural bases. The crura are straight and their attachment to the primary lamellæ is of the same character as in CLIOTHYRIS, etc. The primary lamellæ, on the umbonal curve, are broad, the loop usually situated posteriorly. The saddle of the loop is often bilobed on its anterior margin, and frequently both it and the outer margins of the ribbon of the secondary volutions are fimbriated.

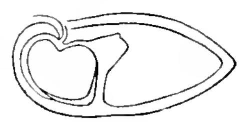


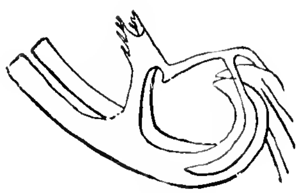
FIG. 65.
Loop of *Athyris trinuclea*, Hall. St. Louis limestone. (C.)

The muscular impressions of this valve are very narrow, and subdivided into two pairs of elongate scars. The members of the posterior pair are divided by a median septum or ridge, which begins beneath, though it does not support the hinge-plate. Branching vascular sinuses are sometimes retained over the pallial region of both valves.

Surface of the valves smooth, that is, with sharp, concentric striæ which were never produced into lamellæ.

The shells which constitute this group were apparently confined to the faunas of the Carboniferous age. The number of species in American faunas is not great, but we have now a pretty thorough understanding of four, *Athyris subquadrata*, Hall; *A. trinuclea*, Hall, of the St. Louis limestone; *A. Dawsoni*, sp. nov.,* of the lower Carboniferous beds of Windsor, Nova Scotia; and *A. subtilita*, Hall,† of the upper Carboniferous.

In all these species we now know the structure of the loop, and though in each it has a characteristic form, its variations are not of great significance.



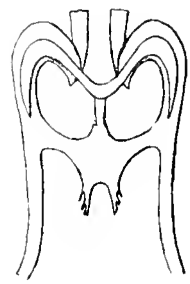


FIG. 66. FIG. 67.
The loop of *Seminula subtilita*, Hall. (C.)

In *A. subtilita* its position is more posterior than in the other species, the umbonal blades of the primary and accessory lamellæ are broader, the saddle

* Identified by DAVIDSON as *A. subtilita*. See Quarterly Journal Geological Society, vol. xix.

† *Athyris subtilita* is a protean species, some of whose variations in general form are illustrated on the accompanying plates. One feels at first disinclined to include under the same specific designation the broadly ficiform, the narrow elongate, the sinuate, non-sinuate, and trilobed shells which are customarily thus referred; but very abundant material shows the difficulty of separating them. The typical form of the species is the elongate shell, broad over the pallial region, and the extreme variations from this type of exterior may have a more or less important faunal or geological value. For example, the most abundant representative of the species occurring in the upper Coal Measures about Kansas City, is a narrow, elongate, slightly sinuate shell, one extreme of variation; again, we have been supplied by Professor S. CALVIN with a series of specimens from Winterset, Iowa, some of which are as deeply trilobate on the anterior margins as extreme forms of *A. subquadrata*; in both instances these variations are found to pass into the typical form of the species by insensible gradations, and as far as known there is little variability in the structure of the interior. In the St. Louis limestone at Pella, Iowa, there occurs a form which it is impossible to separate from *A. subtilita*; the occurrence of the species at so low an horizon is exceptional, while throughout the Coal Measures it is wide and characteristic.

deeply bilobed, its anterior margin and the edges of the secondary volutions fimbriate. The precise value of this pectination of the saddle and coils it is difficult to determine; it appears to be developed differently in different individuals. We are not satisfied as to the existence of this character in *A. trinuclea* and *A. subquadrata*, but in *A. Dawsoni* it is absent. Some individuals give indication of the pectination of the stem and the accessory lamellæ of the loop, and it has been shown by ZUGMAYER that in *Athyris* (*Spirigera*) *oxycolpus*, Emmrich, of the Rhaetic beds, the accessory lamellæ are deeply serrated, a feature coexisting with a bilobed saddle.*

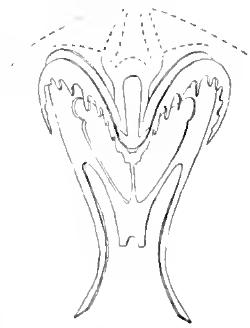


FIG. 68.
Pectinated loop of *Athyris oxycolpus*, Emmrich.
(ZUGMAYER.)

In *A. subquadrata* the lateral branches of the loop are long and projected forward at a sharp angle. In *A. trinuclea*, the origin of the loop is more anterior, the lateral branches erect and high, the surface of the bilobed saddle being close under the opposite side of the coils. *Athyris Dawsoni* is a very interesting

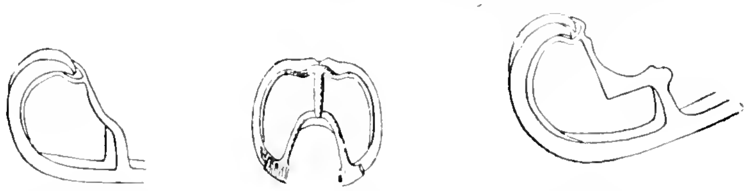


FIG. 69. FIG. 70. FIG. 71.
The loop of *Athyris* (*Seminula*) *Dawsoni*, sp. nov.; showing the variation in development of the saddle in different individuals. Fig 70 is a view from the umbonal region of the specimen represented in Fig. 69, indicating the marginal position of the accessory lamellæ upon the umbonal blades. (C.)

form occurring with most beautiful and exceptional preservation, the brachidium being retained with the slightest incrustation of calcareous matter upon it; all the rest of the shell and the filling of its interior cavity being removed. In this species the loop is normally almost without a saddle; at the union of the lateral branches there is a slight forward protuberance on each side, the stem arising therefrom almost without angulation; the accessory lamellæ, as shown in the accompanying figures, lie upon the inner edges of the primary

* ZUGMAYER, Untersuchungen ueber rhaetische Brachiopoden; Beitraege zur Palæontologie Œsterreich-Ungarns und des Orients, pl. iii, figs. 21–23, and p. 353, figs. 1–3. 1882.

lamellæ, and not between the primary and secondary lamellæ as usual; furthermore, these accessory lamellæ are very narrow.*

While from our present knowledge the group of SEMINULA must be regarded as confined to the Carboniferous (and Permian?) formations, there is a little species in the white sandstone of Pendleton, Indiana, in a fauna having much similarity to that of the Schoharie grit of New York, which has many of the internal shell-characters of *A. subtilita.* This species, *Athyris Rogersi*,† sp. nov., occurs in the condition of internal casts which show the form of the shell and the muscular impressions as described for SEMINULA, the subquadrate and perforate hinge-plate and the faint median septum in the brachial valve. The brachidium has not been developed. No other Devonian species showing similar affinities is known.

From our present knowledge, the athyroids, of the American palæozoic faunas appeared with this form, at the opening of the Devonian age. Mr. DAVIDSON has illustrated the spirals of a Wenlock species, *Terebratula læviuscula*, Sowerby,‡ which seemed to show the existence of accessory lamellæ. This little shell has recently been closely investigated by the Rev. NORMAN GLASS,§ who finds that the loop forms no saddle, and that the intercalary lamellæ are

* In the progress of this work some shells were received from a collection formerly belonging to the Rev. H. HERZER, of Berea, Ohio, bearing the label "*Athyris ambigua*, Cork, Ireland." The specimens possess a rather more transverse form than usual in *A. ambigua*, and the faint cancellation of the exfoliated surface would indicate that it was originally spinous or lamellose. It is evident that the species is not *A. ambigua*, but its specific identity is still uncertain. There is, however, no species of ATHYRIS of which the loop is known, where this organ (as shown in the accompanying figure) is so short and so closely confined to the umbonal region. The lateral branches originate from the primary lamellæ with a very slight anterior curve, being almost horizontal for a short distance; the umbonal blades of the primary lamellæ are very broad, beginning in an abrupt angle with the crura and having a slight curvature. The saddle is entire on the anterior margin and not fimbriate.

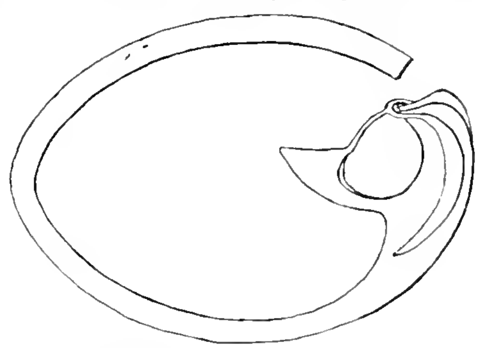


FIG. 72.
Loop of *Athyris*, sp. ?, Carboniferous limestone, Cork (?). (C.)

† Named for Dr. BENJAMIN ROGERS, of Pendleton, in recognition of his interest in the development of the fauna of this locality.

‡ British Silurian Brachiopoda, Supplement, p. 101, pl. iv, figs. 24–26.

§ Geological Magazine, Dec. III, vol. viii, p. 495. 1891.

short compared with those of a typical ATHYRIS and make but a short curve within the primary lamellæ. A very peculiar feature of this structure is the absence of an upright athyroid stem, the bifurcation of the intercalary lamellæ taking place at the point of union of the lateral supports of the loop, the whole apparatus having thus, the form of an inclined X, with its upper tips curved outward. The demonstration of this structure justifies the conclusion of Mr. GLASS that the species is not an ATHYRIS, but another of such incipient stages of athyroid structure as are represented by MERISTINA, WHITFIELDELLA, etc., though lacking the upright jugal stem which all those possess. Mr. GLASS has proposed to place the species under DAVIDSON'S genus BIFIDA, where it might perhaps rest, were we confident of the accuracy of the determination of the loop in *B. lepida* as given by Mr. DAVIDSON (see discussion of the genus BIFIDA), but as the shell certainly represents a distinct variation of structure from any heretofore observed, it will be far more satisfactory to recognize this fact by giving the species some distinctive term, as GLASSINA.

SUBGENUS SPIRIGERELLA, WAAGEN. 1883.

1862. *Athyris*, DAVIDSON. Quarterly Journal Geol. Soc. London, vol. xviii, p. 28, pl. i, fig. 8.
1863. *Athyris*, DE KONINCK. Foss. Paléoz. de l'Inde., p. 33, pl. ix, fig. 8.
1867. *Athyris*, VERCHÈRE. Jour. Asiat. Soc. Bengal, vol. xxxvi, pt. ii, p. 210, pl. ii, figs. 1, 1 *a*.
1874. *Athyris*, DERBY. Bull. Cornell University, vol. i, No. 2, p. 7, pl. i, fig. 7.
1883. *Spirigerella*, WAAGEN. Palæontologia Indica, p. 450.

Dr. WAAGEN has proposed to separate from ATHYRIS a considerable group of species, under the term SPIRIGERELLA. Adhering pretty strictly to the broader characters of the type-species, *S. Derbyi*, Waagen, it would seem that his association of species* under this term is to a certain degree heterogeneous; at all events, the group conforming in exterior characters to *Spirigerella Derbyi*, has a peculiar expression not shared by such forms as *S. grandis*, *S. media*, *S. ovoidalis*, and *S. fusiformis*, Waagen.

The distinctive features of SPIRIGERELLA are as follows: Exteriorly the shells are elongate, but may be transverse; their contour shows a decided tend-

* Ten in number, from the Carboniferous rocks of the Salt-Range.

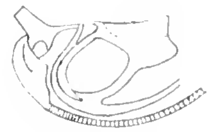


FIG. 73.
Loop of *Spirigerella Derbyi*, Waagen.
(WAAGEN.)

ency to plano-convexity, the pedicle-valve being depressed by a broad, flat sinus, and the brachial valve considerably elevated; the cardinal slopes are more or less pronounced; the surface is smooth or with sharp, concentric growth-lines, which were not produced into lamellæ or spines. On the interior the hinge-plate is high, the anterior face being erect, the upper face subquadrate in outline and concave, the posterior face extending considerably beyond the hinge; perforated by a visceral foramen. The loop is situated pretty well back and its structure is essentially like that in *Athyris planosulcata;* in *S. Derbyi*, however, the saddle of the loop, which is entire on its anterior margin, bears a median septum on its summit, extending from its anterior edge to the bifurcation of the stem; a feature not elsewhere observed among the athyroids, except in KAYSERIA.

In several respects these characters do not permit the assimilation of forms following the type of *Spirigerella Derbyi*, with any of the foregoing subdivisions. This subgenus and SEMINULA include only species with smooth shells; in SPIRIGERELLA the hinge-plate attained a larger size than in any other group, though its structure does not differ from that of *Athyris subtilita.*

It will accomplish an excellent purpose to restrict the term SPIRIGERELLA to forms having the subplano-convex contour, strongly developed cardinal slopes, and the septiferous loop. As far as the first two of these features are concerned, such a restriction would include all the forms embraced by WAAGEN in the typical division of the genus (*S. Derbyi*, *S. prælonga*, *S. hybrida*, *S. minuta*, Waagen), and also those referred to the group of *S. numismalis* (*S. numismalis* and *S. alata*, Waagen); while it eliminates the group of *S. grandis* (*S. grandis*, *S. media*, *S. ovoidalis*, *S. fusiformis*, Waagen). How far the structure of the loop in the restricted group agrees with that of *S Derbyi*, has yet to be demonstrated; but *S. grandis*, the only species besides *S. Derbyi* of which the loop is described, has not this vertical septum on the saddle, nor has it, or the group it represents, the contour of the closer allies of *S. Derbyi*, but is a more regular, elongate and biconvex shell. It seems probable that this group of Indian species will more naturally rest in association with *Seminula subtilita* than with the group of *Spirigerella Derbyi*.

We have no satisfactory evidence of the occurrence of SPIRIGERELLA in North American faunas.

The type of structure characterizing ATHYRIS is continued beyond the Palæozoic, being abundantly represented in the Alpine Trias faunas. These later fossils have been studied by various authors, and most recently described by BITTNER,* who has subdivided them into a number of groups all of which he holds subordinate in generic value to SPIRIGERA (= ATHYRIS). Of these, two principal divisions are made:

(I) Forms with simple spirals;

(II) Forms with double spiral bands.

Of the former are:

1. The "genuine Spirigeras": under which are included:
   a. Smooth forms.
   b. Species with sloping shoulders, retzioid rather than athyroid in outline, and bearing on the surface a few sharp plications, which, at the margin, are opposite, not alternate; PLICIGERA.

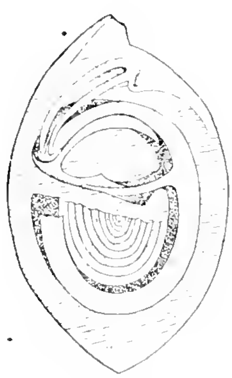


FIG. 74.

FIG. 75.

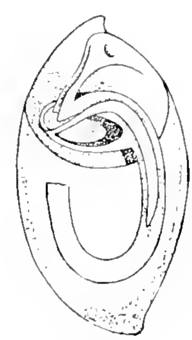


FIG. 76.

Fig. 74. *Tetractinella trigonella*, Schlotheim.
Fig. 75. Loop of *Dioristella indistincta*, Beyrich.
Fig 76. *Amphitomella hemisphæroidica*, Klipstein.
(BITTNER.)

* Brachiopoden der Alpinen Trias: Abhandl. der k. k. geolog. Reichsanst., Bnd. xiv. 1890.

b_1. TETRACTINELLA includes forms with four ribs on each valve.

b_2. PENTACTINELLA includes those with five ribs on each valve.

b_3. ANOMACTINELLA includes those with a number of ribs sharply developed toward the margin.

2. AMPHITOMELLA; smooth shells with a very strong cardinal plate, and a median septum in each valve extending the entire length of the shell and dividing the cavity into two chambers.
3. DIORISTELLA; smooth shells having a loop whose lateral branches return upon themselves, somewhat as in MERISTELLA.

GENUS KAYSERIA, DAVIDSON. 1882.

PLATE XLI.

1841. *Orthis*, PHILLIPS. Palæozoic Fossils Cornwall, Devon and West Somerset, p. 65, pl. xxvi, fig. 110.
1842. *Orthis*, D'ARCHIAC and DE VERNEUIL. Descr. Older Deposits Rhenish Provinces; Trans. Geol. Society, London, sec. ser., vol. vi, p. 396.
1853. *Orthis*, STEININGER. Geogn. Beschreibung der Eifel, p. 80, pl. v, fig. 5.
1864. *Atrypa*, DAVIDSON. British Devonian Brachiopoda, p. 51, pl. x, fig. 1.
1871. *Retzia*, QUENSTEDT. Petrefactenkunde Deutschlands; Brachiopoden, pl. li, figs. 21–25.
1871. *Retzia*, KAYSER. Zeitsch. der deutsch. geolog. Gesellsch., vol. xxiii, p. 161.
1882. *Kayseria*, DAVIDSON. Devonian Brachiopoda, Supplement, p. 21, pl. ii, figs. 11, 12.

Orthis lens, Phillips, the type-species of this genus, is a small middle Devonian shell, with depressed-convex or lenticular valves, radially plicated exterior, and a median plicated sinus on both valves. Its external expression is not unlike that of some of the retziiform species which belong to the genus RHYNCHOSPIRA, though it possesses an impunctate shell. The complicated internal organization has been elaborated by the Rev. NORMAN GLASS and described at length by Mr. DAVIDSON. The pedicle-valve bears a low, thickened median ridge, but is otherwise devoid of pronounced peculiarities. In the brachial valve there is a high median septum which arises from beneath the divided hinge-plate and reaches its greatest elevation at a point behind the center of the valve, whence it descends rather abruptly, traversing altogether about two-thirds the length of the valve.

The spiral cones form sharp angles with the crura, and are directed laterally; the loop is very stout, taking its origin at about one-third the length of the primary ribbon; it is directed somewhat posteriorly, its lateral elements uniting to form a short saddle which rests upon, and is supported by the most elevated part of the median septum. According to DAVIDSON's preparations the loop is continued into an upright simple stem, from the summit of which diverge the accessory lamellæ. At this point our own preparations do not fully corroborate this account, but indicate rather that this upright stem is continued completely across the umbonal cavity and comes into contact with the opposite valve, resting upon the median ridge of that valve, or with its extremity inserted into a groove upon that ridge.

We further find that the accessory lamellæ originate from a posterior elevation or process arising from the saddle of the loop and are given off at points just in front of the crural angles. The ribbon of the principal spiral cones is comparatively broad, thickened on the inner margins, making six or seven volutions in a full-grown shell. The accessory lamellæ are also produced into spirals which though more delicate are composed of as many volutions as the principal spirals. At their outset the branches of the accessory lamellæ pass between the first and second volutions of the principal ribbon, and the two are intercoiled in this manner for their entire extent. KAYSERIA is thus an athyroid with double spirals and the only species known

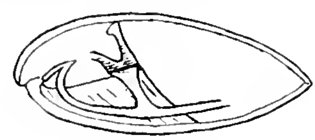


FIG. 77.
Approximate determination of the loop in *Kayseria lens*, Phillips.
(C.)

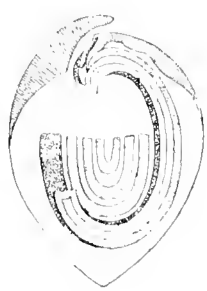


FIG. 78.

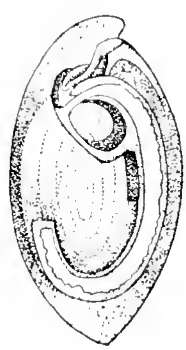


FIG. 79.

Fig. 78. *Pexidella Strohmayeri*, Suess.
Fig. 79. *Diplospirella Wissmanni*, Münster.
(BITTNER.)

in palæozoic faunas in which the accessory lamellæ attain so high a development. As already observed, BITTNER has detected a number of such double-spired forms in the Alpine Trias, over all of which he extends the generic term ATHYRIS (or SPIRIGERA), though he has introduced for them a number of subordinate names based upon slight differences of structure, as follows:

PEXIDELLA; smooth forms with thickened shells, and loop of inconspicuous size.

DIPLOSPIRELLA; smooth forms without shell-thickening and with prominent loop.

EURACTINELLA; cinctured forms with slightly developed area and broad ribs separated by deep, narrow furrows.

ANISACTINELLA; forms with alternating ribs, area and elevated deltidium.

The duplication of the spirals has also been observed in other Triassic genera, notably KONINCKINA, Suess, and AMPHICLINA, Laube;* shells differing from KAYSERIA and its Triassic allies in so many other points of structure that a close phyletic connection between them seems highly improbable.

GENUS RETZIA, KING. 1850.

PLATE L.

1845. *Terebratula*, DE VERNEUIL. Bull. de la Soc. géol. de France, second ser., vol. xi, p. 171, pl. xiv, figs. 10 *a*–*d*.
1850. *Retzia*, KING. Monogr. Permian Foss. England, p. 137.
1854. *Retzia*, DAVIDSON. Introd. British Fossil Brachiopoda, p. 88, pl. vi, fig. 77.
1886. *Retzia*, ŒHLERT. Annales Sci. Géol., vol xix, No. 1, p. 24, pl. xi, figs. 11–19.

"A Spiriferidia; in general oval longitudinally: ribbed or striated; with long punctures. *Large valve* foraminated at or near the apex of the umbone: with a triangular area, and a closed fissure. Type *Terebratula Adrieni*, De Verneuil." (KING, Monogr. of the Permian Fossils of England, p. 137.)

The term RETZIA has come into general use as a designation for palæozoic brachiopods which have an elongate-ovate form and radially plicated exterior.

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*See LAUBE, Die Fauna der Schichten von St. Cassian, Zweit. Abtheil., p. 28. 1865.
BEECHER, American Journal of Science, vol. xl, p. 211, pl. ii. 1890.

Many of the species originally included under this designation have been removed by the establishment of such generic divisions as RHYNCHOSPIRA, TREMATOSPIRA, EUMETRIA; but, as the determination of generic values in all these fossils is usually attended with difficulties, it is highly probable, and indeed certain that there are several distinct types of generic structure represented among the commoner species referred to RETZIA. It will be necessary to determine the value of this genus from the characters of the species *Terebratula Adrieni*, designated by Professor KING as its type; and our observations upon it lead to the belief that, strictly regarded, it presents a type of structure of rare occurrence, and with present knowledge no other species can be placed in the same association.

Terebratula Adrieni was described by de VERNEUIL in 1845* from the lower Devonian of Spain, but our fuller knowledge of the species is due to the descriptions and figures given by Dr. ŒHLERT, who has identified it from the lower Devonian of the Departement de la Sarthe, Sablé, Brulon, etc., France.†

With the help of Dr. ŒHLERT's published work and with his most considerate personal assistance,‡ we have made an earnest endeavor to develop the structure of the brachidium in this species. Unfortunately the specimens accessible were filled with a hard, opaque calcareous material, and such details as have been made out were obtained by the process of serial transverse sectioning. The nature of the interior of the brachial valve and the structure of the hinge-plate had already been demonstrated by ŒHLERT, and the results obtained in regard to the structure of the loop are so peculiar as to require corroboration, which the material at hand does not permit. The following account of the characters of the species represents the sum of our present knowledge of the genus.

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* Bulletin de la Société géol. de France. 2d Sér., tom. 11, p. 471, pl. xiv, figs. 10, *a–d*.

† See ŒHLERT; Etudes sur quelques Fossiles dévoniens de l'Ouest de France; Annales Sci. Géol., t. xix, No. 1, p. 24, pl. xi, figs. 11–19. 1886.

‡ Appreciating the necessity of making a thorough study of this rare species, we twice applied to Dr. ŒHLERT for specimens, and he has most generously met these requests, not only with a number of examples from the Departement de la Sarthe, but with copies of unpublished sketches of sections. This generosity and spirit of helpfulness is most cordially acknowledged.

Shell elongate-oval, rather broad over the pallial region. Surface covered with rather coarse, angular, usually simple plications. There is a trace of an indistinct median sinus on the pedicle-valve in which the plications are slightly smaller than those adjoining. The umbo of the pedicle-valve is incurved and its apex truncated by a circular foramen. The deltidium is triangular, flat, or arched by the incurvature of the beak; the deltidial plates are firmly anchylosed into a single piece and the original line of symphysis is represented by a thickened ridge. The edges of the cardinal area are well defined, but not alate on either valve, the beak and area of the brachial valve being entirely concealed by incurvature. The cardinal slopes are broad and smooth. On the interior of the pedicle-valve the teeth are rather small, and are supported by thin lamellæ which traverse the umbonal cavity and rest on the bottom of the shell. These lamellæ are produced forward for a short distance, limiting, posteriorly, the muscular area. The apical portion of the umbonal cavity contains a longitudinal tube attached by one side to the inner surface of the deltidium. Just within the outer opening of the foramen this tube appears to have been closed on all sides, but further toward the cardinal margin it becomes split along the back or outer surface, diminishing in size downward and disappearing entirely before reaching the hinge-line. (In the accompanying figures of transverse sections, 80–83 are from a single specimen, 84, 85 from another, and 86–98 from a third.) In sections made across the vertical foramen it is seen that the tube extends within the deltidium and forms a subcircular enfolding of testaceous matter from the margins of the foramen. This organ is similar to that elsewhere described in the genera Hustedia and Acambona, but it appears to be more highly developed and longer in Retzia than in either of these.


FIG. 80.


FIG. 81.


FIG. 82.


FIG. 83.


FIG. 84.


FIG. 85.

Figs. 80–85. *Retzia Adrieni*, de Verneuil. Consecutive sections to show internal structure of the umbonal regions.

Fig. 80. Outline of the shell, showing location of next three sections.
Fig. 81. Section across opening of foramen, with umbonal tube open on the back.
Fig. 82. Section further down, showing attachment of the remnants of the tube to the deltidial plates.
Fig. 83. Section near the hinge, showing last traces of tube adherent to the thickened deltidial plates.
Figs. 84, 85. Sections from another individual, one across the foramen, the other beneath it; showing the continuity of the tube. (C.)


FIG. 86.


FIG. 87.


FIG. 88.


FIG. 89.


FIG. 90.


FIG. 91.


FIG. 92.


FIG. 93.


FIG. 94.


FIG. 95.


FIG. 96.


FIG. 97.


FIG. 98.

Figs. 86–98. *Retzia Adrieni*, de Verneuil.

Fig. 86. Section just below the foramen; showing the entire umbonal tube.
Fig. 87. Showing the adherence of the tube to the still divided and discrete deltidial plates.
Figs. 88, 89. Sections at the umbo of the brachial valve; showing the interoal coalescence of the deltidial plates, and the open tube.
Fig. 90. Showing the dental lamellæ, and the median septum in the brachial valve.
Fig. 91. Section just above the apex of the brachial valve; showing the last traces of the deltidial plates, which are here free.
Fig. 92. Section at the apex of the brachial valve.
Fig. 93. Section cutting the posterior extension of the median and lateral lobes of the hinge-plate.
Fig. 94. The same features further down; showing also the appearance of the teeth, and the remnants of the dental lamellæ bordering the muscular area of the pedicle-valve.
Fig. 95. Section through the center of the hinge-plate; showing also the development of the dental sockets.
Fig. 96. Section showing the ante-median crest of the hinge-plate.
Fig. 97. The anterior edge of the hinge-plate and its supporting septum.
Fig. 98. Section in front of the hinge-plate; showing the crura and median septum. (C.)

In the brachial valve the hinge-plate is subquadrate on its upper surface, its posterior margin somewhat crescentic, the horns of the crescent extending into the umbonal cavity of the opposite valve; this character, however, is not so highly developed as in EUMETRIA. The structure of this plate appears to be essentially similar to that of HUSTEDIA; at all events, the tent-shaped crural supports of EUMETRIA are absent; there is, however, no trace here of the ligulate, curved process which occurs in HUSTEDIA, but the median portion of the upper face is convex and the lateral portions deeply grooved and bounded on the outside by the elevated crural bases. The hinge-plate is supported by a strong median septum which extends for nearly two-thirds the length of the valve. It is most highly elevated near the middle of its length, where it extends vertically about one-fifth of the distance across the internal cavity; thence it tapers rapidly to its anterior extremity.

The brachidium has been reconstructed from serial transverse sections of the shell in several directions, and the following description may be relied upon as approximately accurate. The umbonal blades of the primary lamellæ are comparatively narrow and considerably incurved at their apices, where attached to the long crura, as in EUMETRIA. The loop is situated well forward, just behind the center of the lamellæ;* its lateral branches are erect and long; they narrow with a slight twist just above their origin, as in the genera RHYNCHOSPIRA and TREMATOSPIRA, then broaden, curving outward and

FIG. 99.

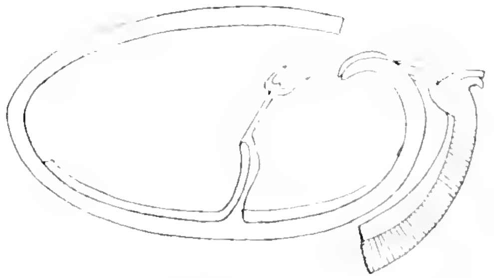

FIG. 100.

The loop of *Retzia Adrieni*, de Verneuil, as reconstructed from consecutive sections (C.)

* It will be observed that in the athyroid and retzioid genera, with the exception of NUCLEOSPIRA, broad umbonal blades and a posterior position of the loop characterize the Carboniferous forms, while in the earlier faunas the species have narrow primary lamellæ and a medially situated loop.

thence inward to their point of union. The stem is short, making an angle with the lateral branches, and is directed backward. It reaches the level of the crura at a considerable distance in front of them and is there bifurcated, each arm making a slight double or sigmoid curve. These arms are, however, too short to reach the umbonal blades. The stem itself is continued for a short distance above the point of bifurcation. The spiral ribbons make ten or eleven volutions in full-grown individuals. Fimbriæ are absent from both the spirals and loop.

Accepting this reconstruction of the loop as correct, this organ proves to be precisely what might be anticipated in this Devonian genus; it resembles that of the preëxisting genera RHYNCHOSPIRA and TREMATOSPIRA in its position on the primary lamellæ, its erect attitude, as well as in the slight twist in the ribbon near its origin, while the length of the lateral branches and the terminal bifurcation are like EUMETRIA. From RHYNCHOSPIRA the genus further differs in the presence of the split tube in the umbonal cavity, which feature seems to attain its highest development among these retzioid genera. There are also some additional differences of secondary importance in the structure of the hinge-plate in these two genera.

Retzia Adrieni is, therefore, a type of distinct generic structure, of which, as already remarked, no other representative is at present known It is quite certain that the genus is not a member of the palæozoic faunas of America, so far as known, the so-called Retzias of our Devonian being mostly referable to RHYNCHOSPIRA.

GENUS RHYNCHOSPIRA, HALL. 1859.

PLATE L.

1852. *Atrypa*, HALL. Palæontology of N. Y., vol. ii, p. 280, pl. lvii, fig. 7.
1857. *Waldheimia*, HALL. Tenth Ann. Rept. N. Y. State Cab. Nat. Hist., pp. 87–89.
1859. *Rhynchospira*, HALL. Twelfth Ann. Rept. N. Y. State Cab. Nat. Hist., pp. 29, 30, figs. 1–6.
1859. *Rhynchospira*, HALL. Palæontology of N. Y., vol. iii, pp. 213–217, 484, 485, pl. xxxvi, figs. 1, 2; pl. xxxvi A, fig. 1; pl. xcv A, figs. 1, 7–11.
1861. *Retzia*, BILLINGS. Canadian Journal, vol. vi, new ser., p. 147, fig. 58.
(?) 1862. *Retzia*, A. WINCHELL. Proc. Acad. Nat. Sci. Philadelphia, vol. vi, second ser., p. 406.
1863. *Rhynchospira*, HALL. Sixteenth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 58, figs. 12–17.
1863. *Rhynchospira*, HALL. Transactions of the Albany Institute, vol. iv, p. 213.
1863. *Retzia*, BILLINGS. Geology of Canada, p. 373, fig. 395.

1863. *Retzia*, BILLINGS. Proc. Portland Soc. Nat. Hist., vol. i, p. 114, pl. iii, fig. 11.
1867. *Rhynchospira*, HALL. Palæontology of N. Y., vol. iv, p. 278, figs. 1–6.
1879. *Retzia*, HALL. Twenty-eighth Ann. Rept. N. Y. State Mus. Nat. Hist., p. 160, pl. xxv, figs. 13–21.
1882. *Retzia*, HALL. Eleventh Ann. Rept. State Geologist Indiana, p. 302, pl. xxv, figs. 13–21.
1888. *Rhynchospira ?*, HERRICK. Bull. Denison University, vol. iv, p. 25, pl. iii, fig. 16.
1889. *Trematospira*, NETTELROTH. Kentucky Fossil Shells, pp. 135, 137, pl. xxxii, figs. 40–43.
1889. *Retzia*, BEECHER and CLARKE. Mem. N. Y. State Mus., vol. i, No. 1, pp. 55, 61, pl. v, figs. 1–16.

DIAGNOSIS. Shells elongate, retziiform; hinge-line short and curved. Umbo of the pedicle-valve incurved, usually concealing the deltidium; apex truncated by a circular foramen. Cardinal slopes gradual, scarcely excavated, not forming a false area. Deltidium triangular and flat or incurved; its lateral margins are sharply defined, and its surface traversed by a longitudinal median ridge, which is the line of solid coalescence of the constituent plates. The umbonal cavity does not contain the split deltidial tube which is present in the genera RETZIA, HUSTEDIA, etc. The teeth are small and well defined, and are not supported by dental plates. Muscular impressions very obscure.

In the brachial valve the hinge-plate has the general form of that in TREMATOSPIRA, but is much less elevated. Its posterior extension is slight, extending but a short distance beyond the hinge; it consists of two parts, a lower, which is closely appressed against the umbo, and deeply divided by a median cleft; and an upper, which is larger, conspicuously elevated and divided medially only at its margin, though the groove extends forward to the middle of the plate. The anterior portion is deeply concave and produced into two flat lobes which form the crural bases. The entire plate rests on stout supports which diverge at the bottom, leaving a triangular cavity beneath, in which there is a short, sometimes obscure median septum. The spirals make from six to nine volutions, the primary lamellæ being narrow and not greatly incurved. The loop is situated behind the middle of these lamellæ and is simple in its structure; its lateral branches narrow just above their origin, with a gentle posterior inclination, then broaden and meet at a little more than one-half the distance across the base of the coils, forming a broad, short, roof-shaped process, which is directed posteriorly and terminates in an oblique edge.

FIG. 101. The loop of *Rhynchospira formosa*, Hall. (C.)

The external surface is radially plicate, the plications being simple. In young shells there is a median sinus on both valves, but as growth advances, that of the brachial valve develops into a low fold. Both fold and sinus bear a number of small, intercalary plications, much finer than those adjoining on each side. Shell-substance rather sparsely punctate.

Type, *Waldheimia formosa*, Hall. Lower Helderberg group.

OBSERVATIONS. This generic division was separated from RETZIA at a time when certain Carboniferous species with subalate cardinal extremities were regarded as typical of that genus. Subsequently these later species were found to differ from the strict Devonian type of RETZIA, and a distinctive name, EUMETRIA, was proposed for them in 1864. In consequence of this, and while the typical RETZIA, *R. Adrieni*, was less accurately understood than now, the term RHYNCHOSPIRA fell into quite general disuse, its species being commonly referred to the old genus, RETZIA. Evidence has already been given demonstrating the peculiar distinctive value of RETZIA as based on its typical species, and though there is close external resemblance between the Devonian species, *R. Adrieni*, and the earlier typical forms of the genus RHYNCHOSPIRA, there is no longer any justification for associating the two in one division.

There are some important features which these two groups possess in common, and which, indeed, may be shared to a greater or less degree by all retzioid genera. In exterior structure, the finer division of the median plications, the smooth, gradually sloping umbo-lateral areas, occur in both RETZIA and RHYNCHOSPIRA. The coalescence of the deltidial plates is a feature occurring throughout the retzioid genera, though the union is perhaps more completely effected and subject to less variation in the Carboniferous forms. RETZIA and RHYNCHOSPIRA have a similar structure in the hinge-plates; and a character which occurs persistently in these genera and also in TREMATOSPIRA and PARAZYGA, is the narrowing of the lateral branches of the loop just above their points of origin on the primary lamellæ. RETZIA, however, possesses a split deltidial tube in the umbonal cavity, which is wanting in RHYNCHOSPIRA, and also a bifurcate termination of the stem of the loop.

To RHYNCHOSPIRA are to be referred, primarily the Lower Helderberg species, *Waldheimia formosa*, *W. globosa*, and *W. rectirostra*, Hall. It is also probable that the *Retzia Electra*, Billings, of the Square Lake, Maine, fauna, and the *Retzia Eugenia*, Billings, of the Hamilton group, belong to the same genus. Whether the species of the Waverly fauna here described as *Rhynchospira scansa*, sp. nov., is a true RHYNCHOSPIRA, cannot be determined from the material at hand.

A very considerable number of species from the American palaeozoic faunas have been referred to RETZIA, and of several of these it has been impossible to obtain representatives for examination Some of the specific names current are unquestionably synonyms for earlier terms, but after the elimination from the list, of species which may confidently be referred to some of the various genera of retzioids here discussed, there will still remain some whose internal structure is too imperfectly known to permit a discriminating reference. With regard to the so-called Retzias of the British and European Devonian and Silurian, it is hardly proper in this place to express more than the opinion that farther careful investigation of these shells is necessary to their correct generic classification.

In the development of the fauna of the Niagara group, at Waldron, Indiana, and southward, there is a very abundant species, *Rhynchospira evax*, Hall, 1863, which, in specific features, is closely related to the *Atrypa aprinis*, (de Verneuil) Hall (=*Retzia apriniformis*, Hall, 1859), of the Niagara fauna of New York, and generically to the later typical forms of RHYNCHOSPIRA, though presenting some differences worthy of note. The hinge-plate has no posterior extension, but its anterior lobes are greatly developed into long, divergent crural bases. They are separated to the apex of the beak as in *Parazyga hirsuta*, and between them lies a small linear cardinal process. There is also a stout median septum in this valve, whose height is equal to nearly one-half the depth of the valve. The loop has a more acute stem and its lateral branches are of the same width from their origin to the point of union. It is also frequently the case in this species that the deltidial plates remain distinct and uncoalesced at maturity. These differences from the typical RHYNCHOSPIRA are perhaps such as belong to an inceptive stage in the development of the genus, but it will serve a good purpose to distinguish the earlier forms possessing such characters by a separate name.

The term HOMŒOSPIRA is suggested, and the division will at present include *Retzia evax*, Hall, *Retzia apriniformis*, Hall, and *Retzia sobrina*, Beecher and Clarke; all of the Niagara fauna.

GENUS PTYCHOSPIRA, GEN. NOV.

PLATE L.

1834. *Terebratula*, VON BUCH. Ueber Terebrateln, p. 76, pl. ii, fig. 37.
1841. *Terebratula*, PHILLIPS. Pal. Foss. Cornwall, Devon and West Somerset, p. 89, pl. xxxv, fig. 163.
1841. *Terebratula*, D'ARCHIAC and DE VERNEUIL. Trans. Geol. Soc. London, second ser., vol. vi, p. 368, pl. xxxv, fig. 3.
1849. *Spirigerina*, D'ORBIGNY. Prodrome de Paléontologie, vol. i, p. 100.
1853. *Terebratula*, SCHNUR. Palæontographica, vol. iii, p. 184, pl. xxv, fig. 4.
1855. *Retzia*, THE SANDBERGERS. Verstein. der rhein. Schicht. Syst. in Nassau, p. 330, pl. xxxii, fig. 13.
1862. *Retzia*, WHITE and WHITFIELD. Proc. Boston Soc. Nat. Hist., vol. viii, p. 294.
1863. *Retzia*, HALL. Sixteenth Ann Rept. N. Y. State Cab. Nat. Hist., pp. 56, 57, figs. 4–6.
1864. *Retzia*, DAVIDSON. British Devonian Brachiopoda, p. 21, pl. iv, figs. 8–10.
1871. *Retzia*, QUENSTEDT. Petrefacktenkunde Deutschl.; Brachiopoden, pp. 433, 434, pl. li, figs. 10–14.
1871. *Retzia*, KAYSER. Zeitschr. der deutsch. geolog. Gesellsch., vol. xxiii, pp. 557, 558, pl. x, fig. 5.
1882. *Retzia*, DAVIDSON. British Devonian Brachiopoda, Supplement, p. 29, pl. i, figs. 30, 31.

Among the species currently referred to the genus RETZIA are a few which possess a very different exterior from the typical forms of all the retzioid genera here discussed. Certain of these fall into a natural group on the basis of a very coarsely and sparsely plicated surface, and to this group it is proposed to apply the above designation; it will include the *Terebratula ferita*, von Buch, *Retzia longirostris*, Kayser, both of the Eifel middle Devonian, and the *R. sexplicata*, White and Whitfield, of the Kinderhook group.

In *Terebratula ferita*, which is taken as the typical representative of this division, the surface of each valve bears seven radial plications, which are sharply angular and greatly elevated at the margins of the shell. The median plication on the brachial valve is usually divided by a fine sulcus, there being a corresponding ridge in the sinus of the opposite valve. The beak of the pedicle-valve is erect, and truncated obliquely by a circular foramen, beneath which lies a flat deltidium, the plates of which are, as in allied genera, more or less completely coalesced. The epidermal layer of the shell is finely pitted, the punctations apparently not continuing into the layers beneath, but producing a superficial ornamentation not unlike that occurring in EICHWALDIA. This ornamented layer extends even over the surface of the deltidium. The inner laminæ of the shell are fibrous and more sparsely punctated. There is no deltidial tube in the umbonal cavity of the pedicle-valve. The hinge-plate has not been completely demonstrated, but it appears to be similar to that of RHYNCHOSPIRA, with no prominent posterior extension, but with conspicuous crural bases which are curved upward. The whole process is supported by a well defined median septum. The spiral ribbon makes but few (four or five) volutions; the loop takes its origin behind the middle of the primary lamellæ, its lateral branches being slightly constricted near their bases; it is inclined backward in a broad curve, the union of the lateral branches taking place at a point just within the opposite side of the base of the cones. From this point the stem of the loop is continued as a simple process, outward between the coils and almost to the inner surface of the pedicle-valve.

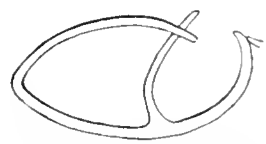

FIG. 103 The loop of *Ptychospira ferita*, von Buch. (C.)

GENUS UNCITES, DEFRANCE. 1827.

PLATE LII.

1776. *Terebratula*, BEUTH. Juliæ et Montium Subterranea, etc., p. 134.
1822. *Terebratulites*, SCHLOTHEIM. Petrefacktenkunde, pl. xix, fig. 1.
1827. *Uncites*, DEFRANCE. Bull. des Sciences, vol. xii, p. 152.
1834. *Terebratula*, VON BUCH. Ueber Terebrateln, p. 69.
1851. *Uncites*, QUENSTEDT. Handbuch der Petrefacktenkunde, p. 459, pl. xxxvi, fig. 40.
1853. *Uncites*, DAVIDSON. Introd. British Fossil Brachiopoda, p. 89, pl. vii, figs. 79–86.
1855. *Uncites*, THE SANDBERGERS. Verstein. der rhein. Schicht. Syst. Nassau, p. 333, pl. xxxi, fig. 5.
1864. *Uncites*, DAVIDSON. British Devonian Brachiopoda, p. 22, pl. iv, figs. 11, 12.
1871. *Uncites*, QUENSTEDT. Petrefacktenkunde Deutschl.; Brachiopoden, p. 231, pl. xliii, figs. 46–55.
1881. *Uncites*, DAVIDSON. Geological Magazine, new ser., vol. viii, p. 145.
1882. *Uncites*, DAVIDSON. British Devonian Brachiopoda, Supple., p. 30, figs. 1, 2.

DIAGNOSIS. Shells usually of large size, elongate-oval or subtriangular in marginal outline; valves convex. The pedicle-valve has a long and acuminate beak which is always arched or incurved and frequently distorted. There is no cardinal area and the hinge-line is greatly curved. There is no foramen in mature individuals though it may be retained in young forms. The deltidium is concave and consists of a single piece, all trace of the original components being lost. The teeth are supported by dental plates and between them lies a broad median ridge which narrows as it approaches the hinge. The brachial valve has a broad, full beak, which is closely incurved and concealed beneath the deltidium of the opposite valve. The cardinal process is large, erect and slightly bilobed on its posterior margin; it rests upon a short plate bearing two ridges which are continued into the bases of the crura. On either side of these ridges and just within the margins of the valve, is a strong, oval, concave, pouch-like plate. The crura are very long, passing into the primary lamellæ without interruption. The spirals are relatively small, situated anteriorly, and consist of seven or eight volutions. These are connected by a simple erect loop, which is situated medially, and terminates at the junction of the lateral branches in a short, horizontal process.

External surface of the valves covered with numerous radiating plications; occasionally smooth. Shell-substance fibrous, impunctate.

Type, *Terebratulites gryphus*, Schlotheim. Stringocephalus limestone (Middle Devonian).

Observations. Our knowledge of this old genus is still imperfect in many important respects, especially in regard to the muscular and other markings on the internal surfaces of the shells. Mr. Davidson has elucidated the character of the spirals, loop, hinge-plate and cardinal process,* and his restoration of the brachial apparatus and its attachments is here introduced.

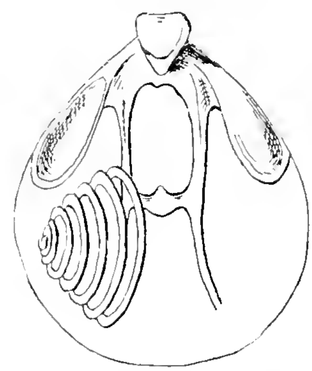

Fig. 103.
Interior of brachial valve of *Uncites gryphus*, Schlotheim; showing cardinal process, marginal pouches, spiral and loop. (Davidson.)

Quensted, in 1871, described† a shell from the Carboniferous limestone of Ratingen, as *Uncites carbonarius*, a striated species, having the biconvex exterior of Uncites; the form is, however, little known and its internal structure has not been demonstrated.

* Geological Magazine, New Series, vol. viii, p. 145, 1881; and Devonian Brachiopoda, Supplement, p. 30, pl. iii, figs. 5-10, 1882.

† *Op. cit.*, p. 520, pl. liv, figs. 47, 48.

The *Uncites lævis*, McCoy,* has been generally regarded by the best authorities as an imperfect or exceptional form of STRINGOCEPHALUS. In 1879, Dr. ŒHLERT described† a species, *U. Galloisi*, with a smooth exterior, from the Middle Devonian of Maine-et-Loire, France.

UNCITES is allied in its form, external ornament, coalesced deltidial plates, position of the spirals and the form of the loop, to the retzioid genera, but it differs widely in some important particulars. McCOY placed the genus in a family by itself; ZITTEL and ŒHLERT have included it with many other distantly related genera under the family *SPIRIFERIDÆ*. DAVIDSON, in his "General Summary" (p. 354), placed it by itself in a doubtful subdivision of this family, while WAAGEN has included it in his *Uncitinæ*, a subfamily of the heterogeneous group, *NUCLEOSPIRIDÆ*, of DAVIDSON.

The genus UNCITES has not been recognized in North America.

GENUS EUMETRIA, HALL. 1863.

PLATE LI.

1858. *Retzia*, HALL. Transactions of the Albany Institute, vol. iv, p. 9.
1858. *Retzia*, HALL. Geology of Iowa, vol. i, pt. 2, pp. 657, 704, pl. xxiii, fig. 1; pl. xxvii, fig. 3.
1863. *Eumetria*, HALL. Sixteenth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 55, figs. 1-3; p. 59.
1882. *Eumetria*, WHITFIELD. Bull. American Museum Nat. Hist., vol i, p. 50, pl. vi, figs. 28-30.
1883. *Eumetria*, HALL. Twelfth Ann. Rept. State Geologist Indiana, p. 335, pl. xxix, figs 28-30.

DIAGNOSIS. Shells elongate-terebratuliform; outline ovate. Valves subequally convex. Hinge-line short; cardinal area of the pedicle-valve somewhat elevated, primarily composed of symmetrical deltidial plates. In the adult condition the line of symphysis between these plates is lost, or represented by a faint line, giving the deltidium the appearance of a single vertical, or slightly incurved plate, sharply defined on its lateral margins. The foramen is apical, only its lower side encroaching on the deltidium. The cardinal extremities are slightly alate, a feature more noticeable on the brachial valve and which gives this valve a somewhat pectenoid appearance. On the interior of the pedicle-valve the teeth are of moderate size, but otherwise the shell is

* British Palæozoic Fossils, p. 380, pl. iia, fig. 6, 1852.

† Comptes rendus Soc. géol.; more fully discussed and illustrated in Annales de Sciences géologiques, 1880; author's copy, p. 5, pl. iv, figs. 1-4.

nearly devoid of markings of any kind. There is no apical foraminal tube as in RETZIA, no dental lamellæ, or muscular ridges, and only in extremely rare instances is there any trace of the muscular impressions.

In the brachial valve the structure of the hinge-plate is very complicated. It may be described as composed of two parts, a posterior and an anterior. The posterior portion is rather broadly crescentic in form, having the curvature of the umbonal margin of the valve; its lateral extensions form the socket-walls, which are moderately broad, deep and well defined. On the central portion of this part of the plate rests a second crescent, having its horns, which make nearly a semicircle, directed backward and into the umbonal cavity of the opposite valve. The curvature of the plate at this point is such that the base of the crescent lies upon the inner surface of the deltidium of the pedicle-valve, its horns crossing the deltidium, extending for fully half the length of the umbonal cavity, and being elevated at their tips, above the inner surface of the shell. The posterior part of the hinge-plate is connected with the anterior part only by a narrow, thickened median band, which is constricted transversely at the point of union, the transverse groove being crossed only by a very fine axial ridge. The anterior portion of this plate consists of a long, narrow, triangular, concave or spoon-shaped central process, the edges of which are sharply elevated, and the extremities of these marginal ridges are produced into two long, slender and nearly vertical crura The hinge-plate is not connected with the lateral portions of the shell, but is supported by two slightly divergent, upright laminæ which extend to the bottom of the valve; and since the valve is deep in this region, these laminæ are very conspicuous. The crura widen as they approach the apices of the primary lamellæ, and form their union with these by a short, abrupt lateral curve. The spiral cones are approximate, their apices lateral, the ribbon making eight or nine volutions in the adult individual. The umbonal blades are broad for one-third their length, narrowing abruptly in front of the loop. The loop is situated posteriorly, and is constructed as follows: two slender lateral processes are given off from the primary lamellæ, which are directed forward in low, downward curves, and near their extremities turn inward and upward, meeting at a point just behind the center of the shell-cavity.

From their point of union a single process is extended backward at an abrupt angle and with a very gentle downward curve, terminating just in front

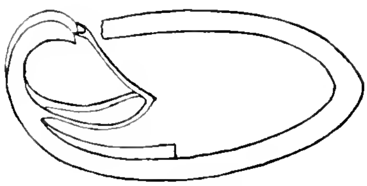

Fig. 104.

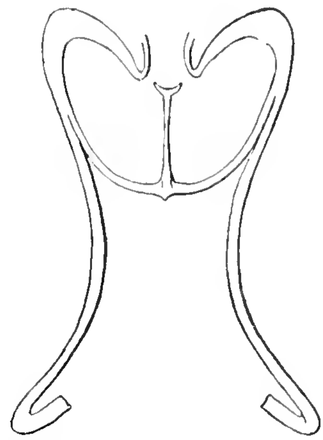

Fig. 105.

Two views of the loop of *Eumetria Verneuiliana*, Hall. (C.)

of the apices of the primary lamellæ and above the bases of the spiral cones; its extremity is broadened and bifurcated, these secondary processes, however, extending but a very short distance. The posterior edges of the lateral branches of the loop and of the primary lamellæ may be finely fimbriated.

There is usually no trace of a median septum in this valve, but occasionally an obscure ridge is preserved. No muscular markings have been observed.

The external surface is covered with numerous fine radiating striæ, which are rarely crossed by concentric lines. Shell-substance abundantly punctate.

Type, *Retzia vera*, Hall. Kaskaskia limestone.

Observations. The term Eumetria was proposed as a designation for shells which were believed to differ in the structure of the deltidium from forms at that time regarded as typical of the genera Retzia and Rhynchospira. In treating of the genus Rhynchospira it has been shown that the coalescence of the deltidial plates may occur in the early forms of that genus, as it does also in Retzia and Nucleospira, but nowhere does it become so well marked and notable a character as in the group of fossils under discussion. It was also shown in the original description of the genus Eumetria, that the umbonal cavity of the brachial valve contained a pair of diverging lamellæ which supported a concave plate, and that the continuation of the plate probably supported the spiral cones. The differentiation of the parts of the hinge-plate in EUMETRIA is not reproduced in any other genus, and the description here given is derived from excellent preparations of the interior of the valve, the element of possible error, which may exist in determinations where the nature of the material has rendered necessary reconstructions from serial sections, being here eliminated.*

The species *Retzia vera*, Hall, from the Kaskasia limestone of the lower Carboniferous series, was figured in illustration of the various distinctive features of the shells for which the term EUMETRIA was proposed, and it may be regarded as the typical form of the genus; the *Retzia serpentina*, de Koninck, from the Carboniferous limestone of Belgium, was also, at that time, regarded as a typical representative of the same group, but we have not a sufficiently critical knowledge of its interior characters to feel assured that the species is congeneric with *R. vera*.

The loop in EUMETRIA shows an interesting variation in form; in its posterior position, anterior direction, long, reflected stem and slight terminal bifurcation, it suggests the structure found in the Carboniferous species, *Athyris Dawsoni;* at the same time the absence of a saddle and the mere inception of the accessory lamellæ, occurring in association with the elongate-ovate shell, indicate the structural relationship to MERISTINA, MERISTA and MERISTELLA. Its nearest allies, however, in this and other respects, are the genera HUSTEDIA of the Coal Measures, ACAMBONA of the Burlington limestone, RETZIA of the Devonian and RHYNCHOSPIRA of the Silurian; forms which represent different stadia in the line of development of these plicated shells.

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* The determination of the critical features in RETZIA, EUMETRIA, HUSTEDIA, etc., has been attended with peculiar embarrassments, which patient and careful work alone have been able to successfully surmount. Representatives of all these genera are of infrequent occurrence and rarely well preserved for the study of their complicated interiors. To the student, who chooses to follow the methods here adopted for investigating these fossils, it may be advantageous to know that in our first determination we fell into the very natural error of identifying the testaceous crescent, or split tube, which appears in sections of the umbonal cavity of RETZIA, HUSTEDIA and ACAMBONA, with the crescentic arms of the hinge-plate in EUMETRIA. It is certainly a curious fact that two parts so distinct and capable of producing similar effects in transverse sections, should occur in the umbonal cavity of these fossils, but we are now satisfied that they do not coexist in any of the genera, or at least that where the crescent of the hinge-plate is at its maximum, the foraminal tube has a minimum development.

At present we can safely refer to EUMETRIA only the American forms, *E. vera* and var. *costata*, Hall, and *E. Verneuiliana*, Hall, from the Kaskaskia and Warsaw limestones of the lower Carboniferous series, which are, perhaps, all representatives of the same species. Of other finely striated species which may prove congeneric, is the *Retzia serpentina*, de Koninck,* but all the Carboniferous species with RETZIA-like exterior will need most careful scrutiny before their generic values can be determined.

GENUS ACAMBONA, WHITE. 1862.

PLATE LI.

1860. *Retzia*, SWALLOW. Trans. St. Louis Acad. Sci., vol. i, p. 653.
1862. *Acambona*, WHITE. Proc. Boston Society Nat. Hist., vol. ix, p. 27, figs. 1, 2.

This name was proposed for a large species described as *Acambona prima*, and its generic characters were given in the following language:

"Shell of the general appearance and surface characters of RETZIA; furnished with internal spires, pointing outward and downward (?). Beak of ventral valve prominent, incurved, pointed; area emarginate in front, or V-shaped, reaching to the point of the beak, and extending forward of the beak of the dorsal valve on each side of it. Beak of the dorsal valve closely incurved, filling, or nearly filling the forked space or emargination in the front part of the area, being itself without angular, hinged extensions, or area, to meet that of the opposite valve." (WHITE, *loc. cit.*)

Specimens of this species are quite rare, and we have seen none in which the beak is perfectly retained. The structure of the beak and the absence of a foramen, as given by WHITE, seem unnatural for a member of these retziiform shells, and in view of the author's statement (p. 28) that his figures are to some degree restorations, this point will require careful re-examination. Nevertheless the species *A. prima* bears an internal pedicle-tube, as in RETZIA and HUSTEDIA, a character absent in EUMETRIA, while the exterior characters of the shell are

* This species is referred to the genus ACAMBONA in DE KONINCK's last work on the Faune du Calcaire Carbonifère de Belgique; Brachiopodes, Explic., pl. xxii, figs. 25–31, 1889. Most of the figures given in this work, however, show a very clearly developed foramen, on the absence of which the genus ACAMBONA was based. WAAGEN, on the other hand, has more recently suggested that this rare species may prove congeneric with his *Uncinella indica*.

more like those of *Eumetria Verneuiliana*, Hall. The hinge-plate bears two short processes on its posterior edge, which extend only for a short distance into the umbonal cavity; this organ is very imperfectly known, but as far as understood it seems to be nearer in structure to that of HUSTEDIA than of EUMETRIA. *Acambona prima* was described from the lower beds of the Burlington limestone, and it is quite probably identical with the species described by Professor SWALLOW, at an earlier date, as *Retzia Osagensis*, from the Choteau limestone.

GENUS HUSTEDIA,* GEN. NOV.

PLATE LI.

1858. *Terebratula*, MARCOU. Geology of North America, p. 51, pl. vi, fig. 11.
1859. *Retzia*, MEEK and HAYDEN. Proc. Acad. Nat. Sci. Philadelphia, vol. iii, second ser., p. 27.
1860. *Retzia*, MCCHESNEY. New Palæozoic Fossils, p. 45.
1866. *Retzia*, GEINITZ. Carbon und Dyas in Nebraska, p. 39, pl. iii, fig. 6.
1868. *Retzia*, MCCHESNEY. Trans. Chicago Acad. Sciences, vol. i, p. 32, pl. i, fig. 1.
1872. *Retzia*, MEEK. Hayden's U. S. Geol. Survey Nebraska, p. 181, pl. i, fig. 13; pl. v, fig. 7.
1874. *Eumetria*, DERBY. Bull. Cornell University, vol. i, p. 4, pl. viii, figs. 4, 5, 7, 8, 10; pl. ix, fig 3.
1875. *Terebratula*, MARCOU. Trans. St. Louis Acad. Sci., vol. iii, p. 252.
1875. *Retzia*, WHITE. Wheeler's Geogr. Surveys West of 100th Meridian, vol. iv, pp. 141, pl. x, fig. 7.
1883. *Eumetria*, WAAGEN. Palæontologia Indica, ser. xiii, vol. iv, p. 487.
1884. *Retzia*, WALCOTT. Monogr U. S. Geol. Survey, vol. viii, p. 220, pl. vii, fig. 5.
1884. *Retzia*, WHITE. Thirteenth Ann. Rept. State Geologist Indiana, p. 136, pl. xxxv, figs. 10–12.

In external characters the shells constituting this genus are indistinguishable from those of EUMETRIA, except in their much coarser plication. For this reason they have been classed under the latter genus by several writers, though the internal structure in the two groups is curiously distinct. While the complicated structure of the interior in EUMETRIA was not understood such an association of the species was altogether natural. The type of this new genus the *Terebratula Mormoni*, Marcou (= *Retzia punctulifera*, Shumard),— a characteristic species of the upper Coal Measures in both North and South America. The essential difference of this species from *Eumetria vera* lies in the

* To the memory of the Honorable JAMES WILLIAM HUSTED, this interesting and widely distributed genus of Brachiopods is dedicated. A patron and promoter of science, who, during a period of more than twenty years, as Representative in the Assembly of the Legislature of New York, zealously espoused the interests of the Palæontology, and of every other department of the Natural History of the State of New York. A wise legislator and educator, a faithful and unswerving friend and counsellor of many years, his name deserves to be spoken with respect and reverence wherever geologic science shall be taught or studied, throughout the civilized world.

structure of the hinge-plate and of the umbonal cavity of the pedicle-valve. The latter contains an internal tube attached by one side to the deltidium, and split along the opposite side, a precisely similar structure to that observed in *Retzia Adrieni* and *Acambona Osagensis*, though not so highly developed as in the first of these. This structure is of so frail a nature that it is difficult to preserve it in prepared interiors of the valve, but it always reveals itself in transverse sections of the beak near its apex. The structure of the hinge-plate has been quite accurately described by DERBY* from the interiors of *Eumetria punctulifera* (= *Hustedia Mormoni*) obtained from the limestone of the Coal Measures at Bomjardim, on the Amazonas. Dr. WAAGEN has also given a very accurate account both of the hinge-plate and the brachidium in species which he has referred to EUMETRIA.† The hinge-plate, as it appears in the preparations of *Terebratula Mormoni*, is constituted as follows: It is erect and recurved into the umbonal cavity of the pedicle-valve, projecting considerably beyond the hinge-line; the upper face is convex and elevated medially, the posterior margin sinuate and crescentic, though the horns of the crescent are very short; two deep converging grooves pass over the upper face, and outside of these, on the lateral margin of the plate are strong lobes which bear the erect, slightly recurved crura; from the crural bases the lateral margins curve downward to the bottom of the valve and form the socket walls. At the base of the cardinal process and in the median line arises a free, slender, ligulate process which curves upward and backward with a somewhat less curvature than the plate, and rises to the highest point attained by the latter; the inner surface of this process is deeply grooved, and at its base it is supported by a median septum which extends for one-third the length of the valve. There is no tent-shaped structure for the support of the crura as in EUMETRIA.

FIG. 106.
Outline profile of *Hustedia Mormoni*, Marcou, with enlarged transverse sections of the umbo beneath the foramen; showing the internal tube adherent to the coalesced deltidial plates. (C.)

Dr. WAAGEN has suggested the similarity of this peculiar ligulate process to the visceral tube occurring in many forms of ATHYRIS, but it is evident from its

* Bulletin Cornell University, vol. i, No. 2, pp. 5, 6. 1874.
† Salt-Range Fossils; Brachiopoda, p. 486. 1883.

form and acute apex that it could not have been tubular, and, besides, there is no evidence of a perforation in the plate.

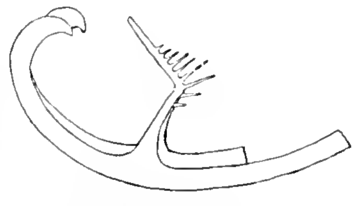

Fig. 107.
Loop of *Hustedia Mormoni*, Marcou. (c.)

The spirals have the same structure as in Eumetria, and Derby has shown that the posterior margins of the coils are fimbriated. The loop, also, is quite similar to that of *Eumetria Verneuiliana*. Waagen has represented it in *Eumetria* (*Hustedia*) *grandicosta*, Davidson, as terminating in a short, sharp, retrally directed stem, but in the American specimens this stem appears to be much longer and the posterior edges of the lamellæ both of the stem and the lateral branches are furnished with divergent spinules. In all our preparations the extremity of the stem appears to be simple.

The exterior of the shell is coarsely plicated and the structure strongly punctate.

The representation of this genus of shells in American faunas is restricted, so far as known, to the species *H. Mormoni**, which occurs in the upper Carboniferous of Missouri and Kansas, and has been identified by Derby in the Coal Measures both of Brazil and Peru. The two species described by Waagen from the Salt-Range of India as *Eumetria grandicosta*, Davidson, and *E. indica*, Waagen, belong to Hustedia, and probably also *Retzia* (*Terebratula*) *radialis*, Phillips, *Retzia carbonaria*, Davidson, and *R.* (*Terebratula*) *ulothrix*, de Koninck, from the British Coal Measures. *Retzia ulothrix*, *R. radialis*, *R. Davidsoni*, *R. intermedia*, de Koninck, occur in equivalent faunasin Belgium.†

It is probably true that the various species from the St. Cassian beds, which have been referred by Bittner‡ to the genus Retzia, have their closest relations with Hustedia. These are, for the most part, coarsely ribbed forms, some of them with extravagantly high areas. Their internal structure has not been satisfactorily demonstrated.

* Whether the other American Carboniferous species, *Retzia compressa*, Meek; *R. Woosteri*, White; *R. Meekana*, Shumard, and *R. papillata*, Shumard, are congeneric with *H. Mormoni*, is not yet determined.

† See Davidson, Carboniferous Brachiopoda, pp. 87, 88, 219, pl. xvii, figs. 19–21; pl. xviii, figs. 14, 15; pl. l, figs. 3, 4–9; and de Koninck, Faune du Calcaire Carbonifère de la Belgique; Brachiopodes, Explic., pl. xxii, figs. 1–4, 10–19.

‡ Brachiopoden der alpinen Trias, 1890.

Genus UNCINELLA, Waagen. 1883.

PLATE LI.

1883. *Uncinella*, Waagen. Memoirs Geological Survey of India; Palæontologia Indica, Ser. xiii; Salt-Range Fossils, vol. i, p. 494.

This name has been proposed for a single rare species, *Uncinella indica*, occurring in the middle division of the Productus limestone beds of India.

Dr. Waagen has described the genus as follows:

"In external shape the genus bears resemblance in a general way to *Retzia*. The valves are more or less finely plicated; no sinus or median fold is developed; the hinge-line is curved; the beak thick and strongly bent over, mostly appressed to the cardinal part of the dorsal valve; not provided with an area on its dorsal side, but bearing a distinct deltidium. It is pierced behind the apex by a large oval foramen. The apex of the dorsal valve is very strongly bent over, and partly concealed under the apical part of the ventral valve."

"* * * The shell bears spirals of the same general disposition as in *Retzia* or *Uncites*, but neither the loop nor the mode of junction of the primary lamellæ with the crura could be made out definitely. In the ventral valve below the apex of the beak, there is an excavated, small but very distinct deltidium; its composition of two pieces cannot, however, be made out. It does not reach down to the hinge-line, but is cut out below for the reception of the apex of the small valve. On both sides of the deltidium extend along the curved hinge-margin two long ridge-like hinge-teeth. They are not supported by dental plates, and there is also not a trace of other partitions.

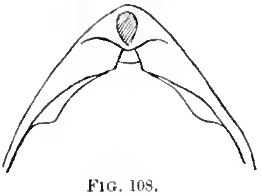

Fig. 108.

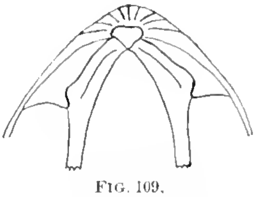

Fig. 109.

Interior cardinal region of pedicle and brachial valves of *Uncinella indica*, Waagen. (Waagen.)

"In the dorsal valve the apex is flattened, as if ground down, and bears a flat triangular space, as if for the insertion of muscles; a cardinal process is not present. At the apex two sharp ridges take their origin, limiting the dental sockets on the other side. These latter are elongated, deep triangular grooves. There is no hinge-plate spread out between the sockets. The crura take their origin immediately at the apex, as thin, shelly plates sloping strongly toward the middle line, and thus very nearly reach the bottom of the valve. As far as the dental sockets extend, these crural plates are fastened to them. Lower down they become free, and then form rather broad, shelly blades, which always retain their sloping position towards the middle line of the valve. They are sunk deeply into the interior of the valve, extending not very far from the bottom of it."

Shells of this structure are not as yet known in American faunas.

Genus TREMATOSPIRA, Hall. 1859.

PLATE XLIX.

1852. *Atrypa*, Hall. Palæontology of N. Y., vol. ii, p. 273, pl. lvi, fig. 3.
1857. *Spirifer*, Hall. Tenth Rept. N. Y. State Cab. Nat. Hist., p. 59, figs. 1–6; pp. 60, 168.
1859. *Trematospira*, Hall. Twelfth Rept. N. Y. State Cab. Nat. Hist., pp. 27, 77.
1859. *Trematospira*, Hall. Palæontology of N. Y., vol. iii, pp. 207–212.
1860. *Trematospira*, Hall. Thirteenth Rept. N. Y. State Cab. Nat. Hist., p. 82, pl. xxiv, fig. 3; pl. xxviii A, figs. 1, 5.
1860. *Athyris?*, Billings. Canadian Journal, vol. v, p. 282, figs. 45–47.
1863. *Trematospira*, Hall. Sixteenth Rept. N. Y. State Cab. Nat. Hist., p. 54.
1863. *Rhynchonella*, Billings. Geology of Canada, p. 315, fig. 322; p. 958, fig. 458.
1863. *Retzia*, Billings. Proc. Portland Society Nat. Hist., pp. 112, 113, figs. 8–10.
(?) 1866. *Trematospira*, A. Winchell. Geol. Rept. of the Lower Peninsula of Michigan, p. 94.
1867. *Trematospira*, Hall. Palæontology of N. Y, vol. iv, pp. 271, 272, 276, figs. 1–6; pl. xlv, figs. 7–15.
1884. *Trematospira*, Walcott. Monogr. U. S. Geol. Survey, vol. viii, p. 151, pl. iv, fig. 3.
1889. *Trematospira*, Nettelroth. Kentucky Fossil Shells, pp. 135, 136, pl. xvi, figs. 15–19.

Diagnosis. Shells transverse, subequally convex, with median fold and sinus on brachial and pedicle-valves respectively. Surface covered with radial, coarse or fine, simple or duplicate plications. Hinge-line straight, often long; cardinal extremities abruptly rounded; anterior margin sinuate. Umbo of the pedicle-valve incurved, its apex truncated by a circular foramen. Beneath it lies the delthyrium, which is covered by two short incurved plates, more or less closely anchylosed along the median suture, and so greatly thickened on their interior surface as to appear continuous with the substance of the valve.

This deltidial plate does not extend downward much more than one-half the distance from the apex to the cardinal margin, leaving beneath it a crescentic opening which is occupied by the beak of the opposite valve. On either side of the deltidial plate is a narrow and rather abrupt flattening of the shell, suggestive of a cardinal area. The umbonal cavity is short and usually much contracted, leaving only a simple passage for the pedicle. The teeth are approximate and prominent, arising from the bottom of the valve, and above the hinge-line curved backward and toward each other, making a very close and firm articulation with the other valve. The dental lamellæ are not continued along the interior of the valve. The muscular area is well defined and consists of a deep posterior area, in front of which lies a flabelliform scar, extending for fully one-half the length of the shell.

In the brachial valve the beak is not prominent and the false area is absent. A small chilidium is present and lies against the vertical posterior wall of the hinge-plate. The hinge-plate is greatly elevated, resting upon two stout supports which are placed very closely together, leaving no opening between them at the bottom of the valve. The upper face of the plate is quadrate, but very deeply divided by a median longitudinal groove, and less conspicuously, by a transverse groove; the surface is thus divided into four parts, two posterior portions which extend backward into the umbonal cavity of the opposite valve, as short, stout horns, and two anterior processes which are broader but equally elevated, the crura arising from the ante-lateral margins of the latter. In the deep longitudinal cleft or groove of the plate is a short, convex lobe, terminating posteriorly in a simple or double extremity; sometimes this part is absent. The whole process is rendered more prominent by being slightly constricted about its base. It is supported interiorly by a short median septum, which is frequently obsolete. The dental sockets are small and deep. The crura are broad, thin and comparatively short, uniting with the primary lamellæ in a sharp lateral curve without diminution or increase in size. The umbonal blades are not greatly incurved and are quite as narrow as any portion of the primary ribbon. The loop takes its origin well forward near the middle of the spiral cones; the lateral branches are somewhat broadened at their origin, but become slightly constricted and twisted just above their bases, and then widen again, attaining

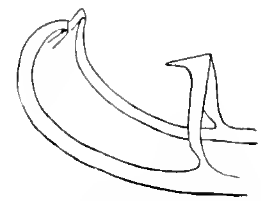

FIG. 110. Loop of *Trematospira multistriata*, Hall. (C)

their greatest width where they unite. From their line of union there is a short, acute and simple process extended horizontally backward. The attitude of the loop is erect, extending slightly backward at its base and then curving broadly forward and upward; in height, it reaches rather more than half-way across the bases of the spiral cones. The cones are situated as in allied genera, and the ribbon in mature shells, makes nine or ten volutions. Muscular impressions indistinct. Shell substance punctate.

Type, *Spirifer multistriatus*, Hall. Lower Helderberg group.

OBSERVATIONS. TREMATOSPIRA is well characterized in external features by its peculiar transverse form and general spiriferoid aspect; none of the allied genera can be confounded with it in these respects. Internally the structure of the hinge-plate and loop, the character of the muscular area and the nature of the articulation are all peculiar. The name TREMATOSPIRA was proposed for a series of species occurring in the Lower Helderberg fauna, some of which had been previously referred to the genus SPIRIFER. At the time of the description of the genus no particular form was specified as the type, but among the typical species the first mentioned was *T. multistriata*, Hall, although the first in the descriptive list is *T. perforata*, Hall.* The former is taken as the typical species, as it is better known and of more frequent occurrence; *T. perforata* appears to be congeneric in all respects.

The development of the Trematospiras in the Lower Helderberg fauna is remarkable; we have in the New York fauna, *T. multistriata*, *T. perforata*, *T. costata*, *T. simplex*, Hall, and from the Lower-upper Helderberg fauna at Square Lake, Maine, *T. dubia*, *T. Hippolyte* and *T. Maria*, Billings. In other faunas the genus is of rare occurrence. The *Atrypa camura*, Hall, of the Niagara group (*Trematospira camura*, Hall, 1859), is a small species which is probably the earliest representative of the genus, as it is doubtful if the still earlier form, described as *Retzia* (*Trematospira*) *granulifera*, Meek,† of the

* Palæontology of New York, vol. iii, p. 208.

† Palæontology of Ohio, vol. i, p. 128, pl. xi, fig. 6.

Hudson River group of Cincinnati, should be thus referred. Mr. C. D. Walcott has described a species, *T. infrequens*, from a lower Devonian horizon at Lone Mountain, Nevada;* and the latest representative of the group appears to be the *T. gibbosa*, Hall, of the Hamilton group, a form which is very strongly plicated, but presents no substantial generic differences from *T. multistriata* so far as its interior is known. Several other American species have been referred to this genus, some of which are now known not to be congeneric (*T. hirsuta* and *T. nobilis*, Hall, of the Hamilton group); and others which can not now be placed with precision (*T. Acadiæ*, Hall, Upper Silurian; *T. Matthewsoni*, McChesney, Niagara group; *T. liniuscula*, Winchell, Hamilton group). European investigators have not satisfactorily identified the genus among their faunas.

Genus PARAZYGA, gen. nov.

PLATE XLIX.

1857. *Waldheimia, Atrypa*, Hall. Tenth Ann. Rept. N. Y. State Cab. Nat. Hist., pp. 89, 168.
1859. *Trematospira*, Hall. Palæontology of New York, vol. iii, p. 216, pl. xxxvi, fig. 3.
1861. *Trematospira*, Hall. Fourteenth Ann. Rept. N. Y. State Cab. Nat. Hist , p. 101.
1862. *Trematospira*, Hall. Fifteenth Ann. Rept. N. Y. State Cab. Nat. Hist., pl. ii, figs. 11–16.
1863. *Retzia*, Billings. Geology of Canada, p. 385, fig. 419.
1867. *Trematospira*, Hall. Palæontology of New York, vol. iv, p. 274, pl. xlv, figs. 16–32.

The well known species of the Hamilton fauna of New York, *Atrypa*,† or *Trematospira*‡ *hirsuta*, Hall, agrees with typical forms of Trematospira in the general transverse and medially sinuate character of the exterior, but differs in certain details of structure sufficiently to necessitate its removal from that genus. The surface markings of the exterior consist of numerous fine, rounded, simple ribs, extending alike over median fold and sinus, and these are covered with exceedingly fine, short, hair-like spines, not so closely set nor so long as in Nucleospira. Usually these delicate spines are broken off, leaving only their bases, which indicate that the spines are hollow.

The umbo of the pedicle-valve is closely incurved and the deltidium (or coalesced deltidial plates) which is entirely concealed by the umbo of the opposite valve, is usually lost. The apical portion of the umbonal cavity bears an

* Palæontology of the Eureka District, p. 151, pl. iv, fig. 3.

† Tenth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 168. 1857.

‡ Palæontology of New York, vol. iv, p. 274.

introverted lamella which forms an incomplete tube like that in RETZIA, HUSTEDIA, etc., but of no great extent. The teeth are as in TREMATOSPIRA and are supported by stout plates. The muscular area is short, rather well defined, and is divided into a broad central adductor impression, along the lateral margins of which lie two flabellate diductor scars.

The hinge-plate is very narrow, and is composed of two vertical supports which have their origin on the downward umbonal slope of the interior. These supports are widely separated at their bases and inclose the marginal dental sockets; their anterior faces are vertical and their upper surfaces small and sub-triangular. They do not unite with each other at any point, but each is curved slightly back of the cardinal line, and on its ante-lateral angle supports a crus. The loop is situated at about the center of the primary lamellæ, bending backward for a short distance and then forward at an abrupt angle. Above this angulation its length is about twice that below it. It terminates as in TREMATOSPIRA, in a short, sharp and simple horizontal process, directed posteriorly.

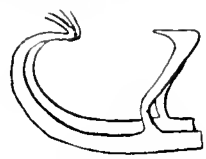

FIG. 111. Loop of *Parazyga hirsuta*, Hall. (c.)

The interesting combination of characters is best represented in the species cited, *Trematospira hirsuta*, Hall, of the Hamilton group,* and with the exception of the structure of the loop, the distinctive features were well illustrated on Plate XLIII of Volume IV of the Palæontology of New York. There is but one other species which can properly be placed in the same association, namely, the *Waldheimia* or *Trematospira Deweyi*,† Hall, of the Lower Helderberg fauna. This form is very similar to *Parazyga hirsuta* in external characters, its surface being finely plicated and with a median fold and sinus. Whether it was originally hirsute can not be decisively determined on account of the usual silicified condition of the shells. The beak of the pedicle-valve is so closely incurved that the foramen is almost or wholly obscured, and the deltidium has the appearance of a concave excavation in the solid substance of the shell, having thus almost precisely the structure occurring in NUCLEOSPIRA. The hinge-plate

* The species has also been identified in the Corniferous limestone of Louisville, Ky., and elsewhere.

† Named for the late Prof. CHESTER DEWEY, of Rochester, N. Y.

differs from that of *Parazyga hirsuta* in having the lateral portions united by a central lobe, and the entire process supported by a short, septiform median buttress. These differences in the hinge-plate are of inconsiderable importance and the loop is essentially like that of *P. hirsuta*; its posterior geniculation being more nearly at the middle of its length, the anterior bend shorter, the entire upper portion of the loop above the geniculation of the lateral branches being expanded laterally and the lamellæ much broadened.

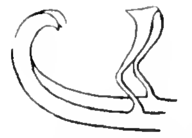

FIG. 112. Loop of *Parazyga Deweyi*, Hall. (C.)

GENUS ANOPLOTHECA, SANDBERGER. 1855.

PLATE LII

1853. *Terebratula*, SCHNUR. Beschr. der Eifel. Brachiopoden, p. 180, pl. xxiv, fig. 3.
1855. *Anoplotheca*, F. SANDBERGER. Sitzungsber. der k. k. Akad. der Wissensch. math. naturw. Class. pt. xvi, p. 5; pt. xviii, p. 102, pl. i, figs- 1–6.
1856. *Productus, Anoplotheca*, THE SANDBERGERS. Verstein. des rhein. Schicht. syst. Nassau, p. 351, pl. xxxiv, fig. 18.
1856. *Anoplotheca*, SUESS. Classification der Brachiopoden von Th. Davidson, p. 94, pl. iii, fig. 26.

This name was introduced by Dr. FRIDOLIN SANDBERGER, who described, first in April, 1855, the general external and internal characters of the genus, and in November of the same year, gave a partial account of the brachial apparatus. The following description is a translation of that given by SUESS in his German edition of DAVIDSON'S "Classification of the Brachiopoda," and is derived from the two accounts published by SANDBERGER.

"Shell oval in outline, concavo-convex, without pedicle-opening, cardinal area or deltidium. The hinge-line is arched, the inner margins somewhat elevated and radially grooved by the impressions of the cilia of the mantle. The convex ventral valve is the larger. On its interior, near the hinge, lie two stout teeth; along the median line from the beak, for one-half the length of the valve, extends a narrow ridge, which is divided at its lower extremity; on either side of this may be seen the impressions of the cardinal muscle, and at its lower end the little ovate scar of the adductor. Near the upper end of the cardinal scar originates, on each side, the main trunk of the vascular sinuses, which passes rather obliquely toward the margins, but before reaching them sends off a trifurcate lateral branch toward the center, and is itself divided.

"The dorsal valve is not very concave; its little cardinal process is divided, and is bordered on each side by a stout lamella, outside of these lying the deeply excavated dental sockets; to these lamellæ the two depressed spiral cones, with their many volutions, appear to be united; both cones having the same position as in KONINCKINA [?]. Beneath the cardinal process, and on either side of a thick median septum, lies a broad, oval impression of the adductor muscle, which is divided by a more or less prominently developed oblique ridge; from the upper and lower margins of this impression originate the vascular sinuses which are directed toward the edges of the valve. A small, round, deep impression beneath the cardinal process is, at present, not understood; it lies at the spot where presumably the curvature of the alimentary canal occurred. Shell-structure fibrous, impunctate."

The type of this genus is the little *Productus lamellosus*, Sandberger,* which is conceded to be synonymous with SCHNUR's *Terebratula venusta*† from the middle Devonian of the Eifel. From SCHNUR's description of the species we derive a more detailed account of the external sculpture of the shell than that given by SANDBERGER and SUESS.

The shell is small, concavo-, or plano-convex, with incurved umbo, open, or but partially closed delthyrium and no cardinal area.

"On the pedicle-valve is a narrow median groove separating two broadly rounded plications which bifurcate near their origin at the beak, and disappear near the middle of the valve; on each lateral slope are three additional and smaller plications which also disappear before reaching the anterior half of the shell. There is a faint plication in the median sinus. Both plications and sinuses are crossed by closely set, imbricating concentric growth-lines, which make the surface quite rough, more so than in *T. lepida*, which the shell very closely resembles."

This species has not received the careful study it requires in order to elucidate some of its critical features. SANDBERGER's description and figures are, nevertheless, excellent, and the more important of these have been here introduced. The structure of the loop is still unknown. The spirals were coiled

* Die Versteinerungen des rheinischen Schichtensystems in Nassau, pl. xxxiv. fig. 18. 1850–1856.

† Zusammenstellung und Beschreibung sämmtlicher im Uebergangsgebirge der Eifel vorkommenden Brachiopoden, p. 180, pl. xxiv, fig. 3, a. b. 1853.

obliquely outward, toward the lateral slopes of the pedicle-valve, similar to those of ATRYPA, though more divergent.

In 1882, Mr. DAVIDSON introduced* the term BIFIDA as a generic designation for the species above referred to by SCHNUR as a very close ally of *Terebratula venusta*, viz.: *T. lepida*, Goldfuss, as quoted by D'ARCHIAC and DE VERNEUIL,† the *Atrypa lepida*, Davidson,‡ and the *Retzia lepida*, Kayser,§ a form occurring in association with *T. venusta* in the Devonian of the Eifel, and known also in the middle Devonian of Torquay.

Mr. DAVIDSON has shown, from preparations made by the Rev. Mr. GLASS, that the spiral coil is loosely arranged, the ribbon making but four or five volutions; the apices of the cones are directed obliquely outward toward the lateral slopes of the pedicle-valve. The loop is described as simple, "like that in *Meristina* [WHITFIELDELLA], with the exception that it is placed nearer to the attachments of the hinge-plate, and that, at the point where the two lamellæ composing the loop join, there is a short bifurcation directed upwards" (p. 28). It was this alleged bifurcation of the loop that suggested the name BIFIDA, and on the basis of this also that Mr. DAVIDSON compared and classified the shell with the genus WHITFIELDIA (=MERISTINA.) The accompanying figure shows the structure of this organ as described by him. A careful study of this shell‖ has led to a quite different result in regard to the structure of the loop. These observations have been made not only from translucent preparations, but also by consecutive sectioning of opaque specimens, and the conclusions verified by frequent repetition of the process.

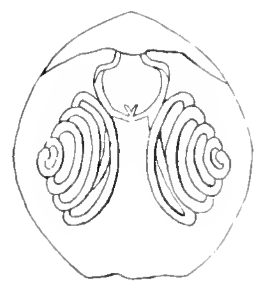

FIG. 113.
Bifida lepida, Goldfuss
The brachidium as represented by DAVIDSON from preparations by GLASS.

The accompanying figures are of sections made from opaque specimens cut in a plane vertical to the longitudinal axis of the shell, the series

* Supplement to British Devonian Brachiopoda, p. 27.
† Transactions of the Geological Society of London, second ser., vol. vi, p. 386. 1840.
‡ British Devonian Brachiopoda, p. 52. 1864.
§ Zeitschr. der deutschen geolog. Gesellschaft, vol. xxiii, p. 559. 1871.
‖ From specimens from Gerolstein in the Eifel, furnished by Dr. E. HOLZAPFEL, of Aachen.

beginning at the beak. Figures 114, 115 show the cross-section of the broad, stout hinge-plate, its convex central area and its elevated crural bases; in figure 115 is a faint indication of the median ridge in the upper or pedicle-valve. In figure 116 the crural bases are apparently merged with the socket walls, the hinge-plate has become depressed, and its median

FIG. 114.

FIG. 115.

FIG. 116.

FIG. 117.

FIG. 118.

FIG. 119.

FIGS. 114-119. Consecutive transverse sections of *Anoplotheca* (*Bifida*) *lepida*, Goldfuss. (C.)

Fig. 114. Section just below apex of pedicle-valve; showing the teeth and the form of the hinge-plate or cardinal process.

Fig. 115. Section a little further forward; showing the elevation of the socket walls and the beginning of the median septum in both valves.

Fig. 116. Section at anterior edge of hinge-plate.

Fig. 117. Section cutting the posterior volutions of the spirals; showing the height of the septum in the brachial valve and the thickened median ridge in the pedicle-valve.

Fig. 118. Section through the loop; showing its lateral branches and a portion of its erect, simple stem, and also the grooved surface of the median ridge in the pedicle-valve.

Fig. 119. Section along the stem of the loop and slightly back of the junction of the lateral branches; showing the articulation of the stem with the grooved ridge of the upper valve, and the height of the median septum supporting the loop. Figs. 114-118 are from the same specimen; fig. 119 from another example.

elevation has taken the form of a low septum; in fig. 117 the median septum of the brachial valve is very prominent, the median ridge of the opposite valve undivided, and the lamellæ of the first volution of the coils and the stem of the loop are shown. This figure shows the manner in which the loop is supported by the median septum; also a portion of the vertical stem of the loop, and the grooving of the median ridge in the pedicle-valve; and in fig. 119 the stem of the loop is seen to be produced to the inner surface of the pedicle-valve and its apex fitted into the groove of the median ridge. The mutual relations of the different parts of the internal apparatus

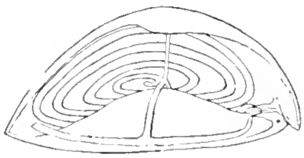

FIG. 120. FIG. 121.

Figs. 120, 121. The brachidium of *Anoplotheca* (*Bifida*) *lepida.* (×)

Fig. 120. A lateral view, showing the relations of the loop to the median septum and ridge.
Fig. 121. A posterior view from behind.

are better seen in the accompanying constructive figures (120, 121), one representing a view of the interior from the side, the other from the umbonal region.

This structure shows an admirable adaptation in the loop for resistance to strains; the slotted median ridge of the pedicle-valve is short and thick, extending for about one-half the length of the shell, and is most deeply excavated at the point where the stem of the loop is inserted. (See figure of the interior of this valve given on Plate LII, fig. 19.) The cardinal process in this species has not, so far as we are aware, been described or figured, but our sections show that it is quite similar to that of *Anoplotheca venusta,* as described by SANDBERGER and SUESS. The latter species also has the median septum in each valve, and though the character of its loop is not known, it will be shown that in similar forms from American faunas this organ possesses the same structure as in *Terebratula lepida.* It is highly improbable that two species, so closely similar in external and internal characters as *Anoplotheca venusta* and *Bifida lepida*, and coexisting in the same fauna, are not congeneric. Therefore, with our present knowledge, it seems necessary to conclude that the term BIFIDA is altogether synonymous with ANOPLOTHECA.

SUBGENUS CŒLOSPIRA, HALL. 1863.

PLATE LIII.

1839. *Atrypa*, SOWERBY. Murchison's Silurian System, p. 637, pl. xx, fig. 7.
1841. *Atrypa*, CONRAD. Geol. Surv. N. Y.; Ann. Rept. Palæont. Dept., p. 54.
1843. *Atrypa*, HALL. Geology of N. Y.; Rept. Fourth Dist., p. 71, fig. 4.
1852. *Atrypa*, HALL. Palæontology of N. Y., vol. ii, pp. 74, 75, pl. xxiii, figs. 9-11.
1855. *Hemithyris*, MCCOY. British Palæozoic Fossils, p. 201.
1857. *Leptocœlia*, HALL. Tenth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 107.
1859. *Leptocœlia*, HALL. Palæontology of N. Y., vol. iii, p. 245, pl. xxxviii, figs. 1-7.
1863. *Cœlospira*, HALL. Sixteenth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 60.
1866. *Leptocœlia*, BILLINGS. Catalogue of Silurian Fossils of Anticosti, p. 48.
1866. *Atrypa*, DAVIDSON. British Silurian Brachiopoda, p. 136, pl. xiii, figs. 23-30.
1867. *Cœlospira, Leptocœlia*, HALL. Palæontology of N. Y., vol. iv, pp. 328-330 (fig. 1), 365, pl. lii, figs. 13-19; pl. lvii, figs. 30-39.
1884. *Leptocœlia*, DAVIDSON. General Summary, p. 424.

The term CŒLOSPIRA was proposed in the Sixteenth Annual Report of the New York State Cabinet of Natural History (p. 60) for the Lower Helderberg species *C. concava*, Hall, which originally had been referred* to the genus LEPTOCŒLIA. The reason for the separation was expressed in a figure of the brachial apparatus accompanying the first use of this name. The spirals were represented as loosely coiled and almost in the same plane, the apices being very slightly elevated and directed outward; the loop posteriorly situated, broad and continuous, very similar to that of ZYGOSPIRA. The *Leptocœlia concava* is a small plano-, or subconcavo-convex shell, covered with rather numerous simple or bifurcating plications. The pedicle-valve has distant teeth arising from the lateral cardinal slopes, and in front of the umbonal cavity are a pair of rather deep oval diductor scars, which embrace the anterior extremities of two narrow, less excavated adductors. These are separated by a narrow, more or less conspicuously developed median ridge as in *Terebratula venusta* and *T. lepida*.

The cardinal process has the same structure as in ANOPLOTHECA, consisting of a central portion curved backward to, or slightly beyond the hinge, and faintly bilobed on its posterior extremity. The crural bases are consolidated with the central process and are continuous with the socket walls. There is a stout

* Palæontology of New York, vol. iii, p. 245, 1859; and Tenth Rept. N. Y. State Cabinet, p. 107, 1857.

median ridge dividing the muscular impressions and supporting the cardinal process.

The structure of the brachial apparatus has been carefully re-examined, and it is found that the crura are slender and rather long, slightly converging toward their apices, forming an acute angle where they meet the primary lamellæ; the latter turn outward and backward, remaining widely separated throughout their extent. The coil is lax, the ribbon making but about three volutions, and the cones, though very slightly elevated, have their apices directed outward, toward the lateral slopes of the pedicle-valve. These shells vary considerably in convexity both naturally and from accidental compression, and where the internal cavity is shallow the spirals may appear to be coiled almost in oblique planes.

The umbonal curves of the primary lamellæ are very broad and stout; the loop arises on their posterior limb, broad and strong, its lateral processes curving gently forward and thence upward, not as in ZYGOSPIRA, nor as represented in the original figure of these organs in *Cœlospira concava*, but elevated and acutely angulated at the apex.

Beyond the junction of the lateral processes the loop is continued as a simple stem which is inclined backward and may have been extended to the surface of the internal ridge on the pedicle-valve, as in *Terebratula lepida*.

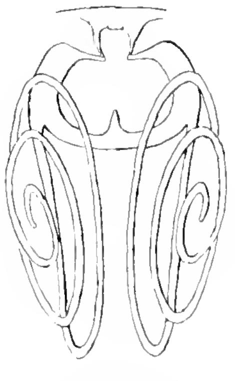

FIG. 122.

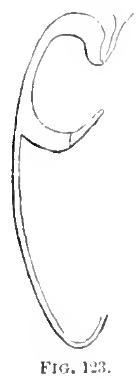

FIG. 123.

Fig. 122. The brachidium of *Cœlospira concava*, Hall.
Fig. 123. Profile, showing the elevation of the loop. The stem of the loop is probably broken and therefore shorter than is natural. (C.)

In front of the base of the loop the primary lamellæ become at once narrow and delicate, and it not infrequently happens, in preparations of the interior, that the more fragile portions of the ribbon are lost, leaving only the umbonal blades and the loop.

The same details both of exterior and interior structure have been observed in the species *Cœlospira Camilla*, Hall, of the Corniferous limestone of New York and Canada, and, with the exception of the brachial apparatus, in the *Atrypa acutiplicata*, Conrad, of the same fauna. It is clearly evident that the structure in the species of Cœlospira here mentioned, is essentially the same as in *Anoplotheca venusta* and *A.* (*Bifida*) *lepida*. The only material difference, that can now be indicated between these forms, is one of greater geological than biological significance; the later, or middle Devonian forms (Anoplotheca) being more convex, more coarsely and sparsely plicated and more strongly striated concentrically. Upon this basis of distinction the name Cœlospira may be retained with a subgeneric value.

There are a few species in the Clinton fauna which have the outward expression of Cœlospira, and agree with it in the structure of the articulating apparatus. These species are *Atrypa plicatula*, Hall, *A. planoconvexa*, Hall, and *A. hemisphærica* (Sowerby), Hall (= *Leptocœlia hemispherica*, Davidson). The brachidium in these forms is not yet known, and their reference to Cœlospira is therefore provisional.

Genus LEPTOCŒLIA, Hall. 1859.

PLATE LIII.

1841. *Atrypa*, Conrad. Geol. Survey N. Y.; Rept. Palæont. Dept., p. 55.
1846. *Atrypa*, Morris and Sharpe. Quart. Jour. Geol. Soc., vol. ii, p. 276, pl. x, fig. 3.
1856. *Orthis*, Sharpe and Salter. Trans. Geol. Society London, second ser., vol. vii, p. 203.
1857. *Leptocœlia*, Hall. Tenth Ann. Rept. N. Y. State Cab. Nat. History, p. 108.
1859. *Leptocœlia*, Hall. Palæont. of N. Y., vol. iii, pp. 449–452, pl. ciii b, figs. 1 *a–g*; pl. cvi, figs. 1 *a–f*.
1861. *Orthis*, Salter. Quart. Jour. Geol. Society, vol. xvii, p. 68, pl. iv, fig. 14.
1868. *Leptocœlia*, Meek and Worthen. Geol. Surv. Illinois, vol. iii, p. 397, pl. viii, figs. 3 *a–c*.
1892. *Leptocœlia*, Ulrich. Palæozoische Verstein. aus Bolivien: Neues Jahrb. für Mineral., etc., Beilagebnd. viii, p. 60, pl. iv, figs. 9 *a*, *b*, 10–13.

The typical species of this group is *L. flabellites*, Conrad, of the Oriskany sandstone; a shell which differs, as far as its structure is known, from *Cœlospira concava*, only in its greater size and coarser, simple plication of the surface. In general contour, structure of hinge, cardinal process, muscular scars and internal septa, it agrees throughout with Anoplotheca and Cœlospira. In the original diagnosis of Leptocœlia, *L. flabellites* was described and figured as possessing a terebratuloid loop. It was, however, distinctly stated that the evidence of this structure was confined to a single specimen containing cavities in its filling of quartz, which corresponded to the restoration given. Subsequent investigations have not corroborated this observation.

The specimens of this species are not favorably preserved for the retention of the brachial apparatus, those from Cumberland, Maryland, being replaced by silica and often filled with coarsely crystallized quartz, while those from New York, Gaspé and the South American localities are usually in the form of casts in an arenaceous sediment. Later observations have not shown any trace of the organ described, and it is highly improbable that a species agreeing in all known points of structure with the spirigerous groups just discussed, and having also a fibrous shell structure, should possess a terebratuloid loop. Reference has been made to the fact that in *Cœlospira concava* the stout umbonal blades of the primary lamellæ and the loop are frequently all that is retained of the brachial apparatus, the rest of the brachidium being very delicate; the parts thus retained are by themselves certainly suggestive of terebratuloid structure, and not unlike the loop ascribed to *L. flabellites.* With our present knowledge it would be unwise to separate Leptocœlia too widely from Anoplotheca and Cœlospira.

There are but two other species which can safely be referred to the group of *L. flabellites*, namely, *L. dichotoma* and *L. fimbriata*, Hall, also from the Oriskany fauna at Cumberland. The latter shell possesses a peculiarity in the extension, from between the cardinal extremities of the valves, of the inner lamina of the shell substance in the form of a row of spinules having the appearance of matted cilia. (See Plate LIII, figs. 47, 50.)

Leptocœlia flabellites, the type species, is remarkable for its wide distribution. Like *Tropidoleptus carinatus* and *Vitulina pustulosa*, it abounds in the lower Devonian strata of South America. Morris and Sharpe described the species under the name *Atrypa palmata*, from material collected by Darwin in the Falkland Islands; Salter described it as *Orthis Aymara*, from various localities in the cordilleras of Bolivia; and ULRICH has cited a large list of additional localities which indicate its general and abundant occurrence in that country. It has not been reported in the rich lower and middle Devonian faunas of the Amazonas, but occurs at Ponta Grossa, Brazil. SALTER identified it as *Orthis palmata* among some palæozoic fossils from South Africa, and ULRICH suggests that a similar shell from the Cape, referred to by MURCHISON* and subsequently by DE VERNEUIL† as *Orthis callactis*, is probably this species.

Of the three species so intimately associated in the Bolivian Devonian, *Leptocœlia flabellites*, *Vitulina pustulosa*, and *Tropidoleptus carinatus*, the last is the only one which occurs in European or Asian faunas; all occur in South Africa in faunas which are probably of lower Devonian age. In North America, this association is broken, and LEPTOCŒLIA disappears with the early Devonian; TROPIDOLEPTUS and VITULINA appearing only with the introduction of the Hamilton fauna.

GENUS VITULINA,‡ HALL. 1860.

SUPPLEMENTARY PLATE.

1860. *Vitulina*, HALL Thirteenth Rept. N. Y. State Cab. Nat. Hist., p. 72, figs. 1, 2; p. 82.
1862. *Vitulina*, HALL. Fifteenth Rept. N. Y. State Cab. Nat. Hist., p. 187.
1867. *Vitulina*, HALL. Palæontology of New York, vol. iv, pp. 409–411, pl. lxii, figs. 1, *a–i*.
1874. *Vitulina*, RATHBUN. Bull. Buffalo Society of Natural Sciences, vol. i, p. 255, pl. ix.
1876. *Vitulina*, DERBY. Bull. Museum Harvard College, vol. iii, No. 12, p. 282.
1881. *Vitulina*, RATHBUN. Proc. Boston Society of Natural History, vol. xx, p. 36.
1890. *Vitulina*, DERBY. Archivos do Museu Nacional do Rio de Janeiro, vol. ix, p. 76.
1891. *Vitulina*, ULRICH. Neues Jahrbuch für Mineralogie, etc., p. 273.
1892. *Vitulina*, ULRICH. Neues Jahrbuch für Mineralogie, etc., Beilageband iii, p. 71, pl. iv, figs. 26–29.

The nature of the widely distributed little species *Vitulina pustulosa*, Hall, has never been fully understood. When the generic characters were first described their similarities to both LEPTOCŒLIA and TROPIDOLEPTUS were suggested, but these were not reiterated with the more detailed description and

* Silurian System, p. 701.

† Bull. Société Géol. France, vol xi, p. 166. 1840.

‡ This name is said by DALL to have been employed by SWAINSON in 1840 for a genus of Gastropoda, but it does not appear in the later conchological manuals. See DALL, Bull. U. S. Nat. Mus. No. 8, p. 75. This is possibly in error for VITULARIA, Swainson. 1840.

illustration of *V. pustulosa* in 1867.* Its general external resemblance to TROPIDOLEPTUS and its almost universal association with that genus in Devonian faunas have led to a tacit concession, on the part of some authors, of structural relations in the two genera. All observations upon VITULINA have heretofore been based upon separated valves or casts of their interiors. Specimens in which the valves are retained in their normal position are of extreme rarity, and it is from such an example, obtained in the Hamilton shales of Alden, New York, that we have succeeded in demonstrating the species to be spiriferous, and that its structural characters ally it closely to the genera which have just been discussed. The distinctive features of the genus may be summarized as follows:

Shell of rather small size; plano-convex in contour, transverse, the hinge-line making the greatest diameter of the valves. The pedicle-valve is convex, its umbo scarcely elevated and its apex not prominent or incurved. A cardinal area is highly developed, and is divided medially by an open, triangular delthyrium, which bears no traces of deltidial plates in any condition that has been observed. The delthyrium is very wide, its base covering more than one-third the extent of the hinge-line. The teeth are blunt, thickened, and not supported by dental plates. The scar of the pedicle-muscle is distinctly defined, but those of the other muscles are obscure in their limitation. Under the most favorable preservation, there appears a posterior flabelliform pair, situated just in front of the pedicle-scar, and in advance of these a median scar enclosed by two anterior diductor impressions. There is, at times, a low median ridge, which is purely muscular in its origin.

The brachial valve is depressed-convex or flat; it bears a narrow cardinal area coëxtensive with that on the opposite valve. The delthyrium is wide and open, and when the conjoined valves are viewed from behind, the cardinal process and socket walls are clearly seen through the wide pedicle-passage. The former of these, the cardinal process, is a straight, simple apophysis, like that in ANOPLOTHECA and CŒLOSPIRA; and the socket walls, which are also the bases of the crura, are short, but prominent and elevated, bordering deep and narrow

* Palæontology of New York, vol. iv, pp. 409–411, pl. lxii.

dental sockets. The brachidium consists of loosely coiled spirals of about four volutions, the cones having their apices directed toward the lateral margins of the valves. On the dorsal side the primary lamellæ are close together, but on the ventral side they are wide apart, this fact indicating that the bases of the spirals do not lie in parallel planes but converge toward the brachial valve, so that the slope of the cones, which are somewhat appressed laterally, is essentially that of the lateral slopes of the pedicle-valve. The character of the loop has not been ascertained. The muscular impressions consist of four distinct adductor scars which are separated medially by a low, thin ridge.

Surface of both valves covered by a few coarse plications, continuous from the umbones to the margins. Of these there are four or five on the lateral slopes. On the pedicle-valve the median pair is the strongest, and forms a sort of double fold with a low sinus between them. On the brachial valve there is a corresponding low median sinus, which contains a simple or double plication. The exterior is covered with fine elevated radiating lines which are usually interrupted to form radiating rows of elongate, lachrymiform pustules.

Shell substance fibrous, impunctate.

Vitulina now takes its place quite naturally in close association with Cœlospira and Leptocœlia. Yet the remarkable development of the cardinal area on both valves and the great open delthyrium are features which suggest an alliance with the orthoids. In so late a representative of this group of spiriferous genera the occurrence of these characters may probably be interpreted as a single recurrence of an early phase of development.

Like the genus Tropidoleptus, with which Vitulina is closely associated wherever it occurs, the latter appeared suddenly, attained a very prolific development, and as abruptly disappeared. In South America it appears with *Tropidoleptus carinatus* wherever Devonian faunas have been recognized, and perhaps more abundantly in the lower Devonian, in association with *Leptocœlia palmata*, Salter, or *L. flabellites*, Conrad, than in those faunas considered equivalent to the Hamilton shales of New York. Dr. O. A. Derby, in reporting the species from the Province of Matto Grosso, Brazil, says: "This generic form would seem to be peculiarly a South American one, since, while it is rare and only very locally distributed in North America, and has apparently not yet been recognized in Europe, it appears in every South American collection of Devonian fossils that has come under my notice. On the Amazonas it is one of the most abundant and characteristic shells in both the lower (Maecurú) and upper (Ereré) divisions. It occurs also in the collections made by Prof. ALEX. AGASSIZ at Lake Titicaca, in Bolivia, and by myself at Ponta Grossa, in the Brazilian province of Paraná, although in both these cases, as in that of Matto Grosso, only a mere handful of fossils was obtained."* A. ULRICH reports that the species was also found in Bolivia by STEINMANN, near Tarabuco, and by STÜBEL in the valley of the Rio Sicasica.† The same author has identified this shell in close association with *Leptocœlia flabellites*, among fossils collected by SCHENCK in the Bokkeveld Mountains, in South Africa.

In North America, *Vitulina pustulosa* is restricted to the middle Devonian, occurring only, so far as known, in the soft shales of the Hamilton group in western New York. Even here it is not generally diffused, but its gregarious habit is evinced by its abundance in the few localities from which it has been reported.

GENUS ANABAIA, CLARKE.

This name has been introduced in an unpublished account of the "Upper Silurian Fauna of the Rio Trombetas, Province of Pará, Brazil,"‡ for a Silurian

FIG. 124. FIG. 125. FIG. 126. FIG. 127.

Figs. 124–127. *Anabaia Paraia*, Clarke.

Fig. 124. Exterior, showing the brachial valve.
Fig. 125. Profile of a somewhat compressed specimen.
Fig. 126. Interior of the brachial valve; showing the cardinal process, crura, dental sockets and septum.
Fig. 127. Internal cast of portion of the pedicle-valve; showing the muscular scars. (C.)

* Nota sobre a Geologia e Paleontologia de Matto Grosso, pp. 76, 77. 1890.
† Neues Jahrbuch für Mineralogie, etc., Beilageband viii, pp. 71–73, pl. iv, figs. 26–29. 1892.
‡ Archivos do Museu Nacional do Rio de Janeiro, vol. x

shell allied to *Leptocœlia flabellites* in the structure of its cardinal process and articulating apparatus, having, however, a highly convex brachial valve with a median septum extending one-half its length, two short, abruptly ending plications on the low median fold, upturned anterior margins, and explanate cardinal extremities. As far as the structure of its type species, *Anabaia Paraia*, Clarke, is known, it appears to be the precursor of the Devonian shells referred to Anoplotheca and Leptocœlia.

Genus NUCLEOSPIRA, Hall. 1859.

PLATE XLVIII.

1843. *Atrypa*, Hall. Geology of N. Y.; Rept. Fourth Dist., p. 200, fig. 3.
1852. *Orthis*, Hall. Palæontology of N. Y., vol. ii, p. 250, pl. lii, fig. 1.
1857. *Spirifer*, Hall. Tenth Rept. N. Y. State Cab. Nat. Hist., p. 57.
1859. *Nucleospira*, Hall. Twelfth Rept. N. Y. State Cab. Nat. Hist., pp. 24-26.
1859. *Nucleospira*, Hall. Palæontology of N. Y, vol. iii, pp. 219-223, pl. xiv, fig. 1; pl. xxviii, b, figs. 2-19.
1860. *Nucleospira*, White. Jour. Boston Soc. Nat. Hist., vol. viii, p. 227.
1863. *Nucleospira*, Hall. Transactions of the Albany Institute, vol. iv, p. 226.
1867. *Nucleospira*, Hall. Palæontology of N. Y., vol. iv, pp. 278, 279, pl. xlv, figs. 33-57.
1879. *Nucleospira*, Hall. Twenty-eighth Rept. N. Y. State Mus. Nat. Hist., p. 160, pl. xxv, figs. 22-28.
1882. *Nucleospira*, Hall. Eleventh Rept. State Geologist of Indiana, p. 301, pl. xxv, figs. 22-28.
1882. *Nucleospira*, Whitfield. Annals N. Y. Acad. Sciences, vol. ii, p. 194.
1884. *Nucleospira*, Walcott. Monogr. U. S. Geol. Survey, vol. viii, p. 147.
1889. *Nucleospira*, Nettelroth. Kentucky Fossil Shells, pp. 103, 104, pl. xxxii, figs. 1-4; pl. xxxiii, figs. 7-9.

Diagnosis. Shells usually small, subcircular in outline. Valves subequally convex, often gibbous or ventricose. Hinge-line very short, cardinal extremities rounded. On the pedicle-valve the cardinal area is low and obscured by the incurvature of the beak. Only in very young specimens is the deltidium exposed, and it then consists of two plates attached to the lateral margins of the delthyrium; in mature individuals these plates are coalesced and incurved, the median suture is lost and the foramen covered; the appearance of the deltidium is that of a triangular concave plate, limited by rather sharp dental ridges and covering the delthyrium for about half its length. The teeth are prominent, approximate, recurved at their tips, supported by thickened bases but not by lamellæ. Dental sockets very narrow. The muscular area is flabellate and extends for nearly one-half the length of the shell; it is composed of two elongate-ovate adductor scars enclosed by broad and radially striated diductors. A conspicuous median septum begins in the umbonal region and extends to within a very short distance of the anterior edge of the valve.

In the brachial valve the hinge-plate arises with a vertical anterior face from the bottom of the shell; but just above the plane of the margins of the valve it is reflected in a curve so abrupt that its upper face becomes horizontal. The anterior face is concave and quadrate in outline; the posterior face is subtriangular, flat or concave, and is frequently bilobed at its extremity. In profile the plate has a hook-shaped appearance; its posterior extremity being elevated considerably above the beak of the valve, and when the valves are in articulation, extending quite to the bottom of the umbonal cavity of the pedicle-valve. The crural bases are situated on the vertical face of the plate, just at the point of recurvature. The crura are slender, straight, long and rod-like, having a length equal to fully one-fourth that of the shell. They are attached at their tips to the inner surfaces of the primary lamellæ. The primary lamellæ of the spiral coils are greatly incurved and their apices close together; their umbonal blades are very broad. The loop originates at about one-fourth the length of the lamellæ, is inclined slightly backward, the lateral branches uniting directly in front of the apices of the lamellæ, and forming a simple straight stem, which is continued beyond the opposite edge of the coil and almost to the inner surface of the pedicle-valve. The spiral ribbon makes from six to ten volutions, and the cones have their altitude in the transverse diameter of the shell.

The muscular area is very narrow and elongate, the posterior adductor scars enveloping the extremities of the anterior adductors. They are divided into pairs by a median septum of the same extent as that of the pedicle-valve. Fine racemose vascular sinuses are sometimes retained over the pallial region of both valves.

The external surface usually bears a low median sinus and fold on the pedicle and brachial valves respectively. The epidermal layer of the shell is usually, probably always, covered with numerous fine, short spinules; these, when removed, leave the surface with only regularly concentric growth-lines marked by papillæ which are the bases of the spinules.

Type, *Spirifera ventricosa*, Hall. Lower Helderberg group.

OBSERVATIONS. NUCLEOSPIRA is a well defined and very compact genus. Though not largely represented in species, it has a considerable vertical range, appearing in the middle Silurian and disappearing probably in the middle or upper Devonian. The genus is allied in some general respects to the genera which Mr. DAVIDSON associated with it, under his sub-family *NUCLEOSPIRIDÆ*, viz.: RETZIA, MERISTINA, EUMETRIA and TREMATOSPIRA, but the distinctive features of the brachidium bring it into closer association with ANOPLOTHECA and CŒLOSPIRA, notwithstanding the great differences in exterior. The spinulous surface, which appears to be common to all the species, is suggestive of PARAZYGA and some forms of ATHYRIS. The peculiar structure of the delthyrial covering, resulting from a coalescence of the deltidial plates, is not unlike that of EUMETRIA and TREMATOSPIRA, and the same extreme of modification is reached in *Parazyga Deweyi*. The imperforate hinge-plate is extravagant in its elevation and peculiar in form. Hitherto the character of the loop has not been accurately determined, and yet this structure is very simple; a union of the lateral branches at a low angle and the continuation of an undivided straight stem across the interior cavity. The explanation of the various imperfect determinations of this part which have been given by different authors, is to be found in the fact that the long, slender crura, the broad umbonal blades of the primary lamellæ and the lateral branches of the loop almost, and sometimes actually meet. Any detachment of the interior part of the shell, either intentional or accidental, is very likely to pass through this point of convergence and remove from the seven processes there approximating the simple continuation of the loop. This stem of the loop is continued beyond the bases of the spiral cones, and may reach the surface of the pedicle-valve, but it does not articulate in a slotted ridge in the similarly constructed loop of the genus BIFIDA or ANOPLOTHECA, nor is its extremity bifurcated to embrace the low median septum of the valve. The stem usually makes a large angle with the lateral branches of the loop, and is deflected posteriorly; its surface is generally cylindrical, but in *Nucleospira concentrica* it is considerably flattened.

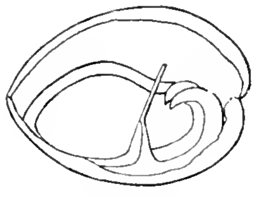

FIG. 128.

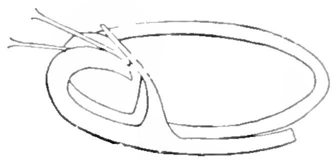

FIG. 129.

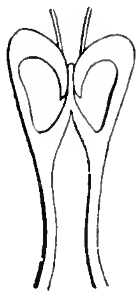

FIG. 130.

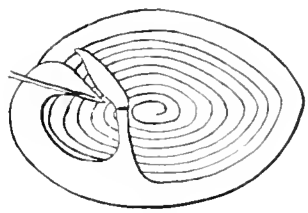

FIG. 131.

Fig. 128. A preparation of *Nucleospira ventricosa*, Hall; showing the umbonal blades, the loop and the form of the first volution of the spirals.

Figs. 129, 130. The primary lamellæ and loop of *Nucleospira ventricosa*, Hall.

Fig. 131. A preparation of *Nucleospira concinna*, Hall; showing one-half of the brachidium, the mode of attachment of the crura to the umbonal blades and the flattened stem of the loop. (C.)

The structure of the hinge-plate and brachial apparatus is now known in the following species of this genus: *N. pisum*, Sowerby, of the Wenlock limestone; *N. pisiformis*, Hall, of the Clinton and Niagara group; *N. ventricosa*, Hall; *N. elegans*, Hall, of the Lower Helderberg, and *N. concinna*, Hall, of the Corniferous and Hamilton groups. Besides these, the following American species have been described: *N. concentrica* and *N. rotundata*, Whitfield, of the Lower Helderberg group, and *N. Barrisi*, White, of the Kinderhook.

A single individual of what appeared, from external characters, to be the species *Nucleospira concinna*, Hall, from the Corniferous limestone of the Falls of the Ohio, affords a surprising variation in the structure of the loop. The internal parts have the same development and mutual relations as in specimens of the species from the Hamilton shales, except that the stem makes a slightly anterior instead of posterior bend at its junction with the lateral branches, and each of these branches bears a single row of irregular, somewhat ramose processes directed toward the inner edges of the umbonal blades. What the significance of these processes may be is not evident from a study of the specimen. They do not appear to be of mechanical origin or due to crystallization of silica upon the lamellæ, but may possibly indicate a pathological or excresential condition.

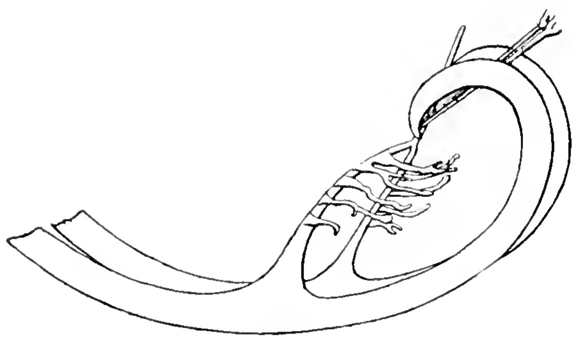

FIG. 132.
Loop of *Nucleospira*, sp.?, from the Corniferous limestone at the Falls of the Ohio. (C.)

GENUS CYCLOSPIRA, GEN. NOV.

PLATE LV.

1842. *Orthis*, EMMONS. Geology of New York; Rept. Second Dist., p. 395, fig. 4.
1847. *Atrypa*, HALL. Palæontology of New York, vol. i, p. 139, pl. xxxiii, figs. 3 *a–e*.

This proposed division is founded on the species, *Orthis bisulcata*, Emmons (*Atrypa bisulcata*, Hall), of the Trenton limestone, which in external characters is very similar to the *Dayia navicula*, Sowerby, of the Wenlock fauna. It is indeed surprising to find that two species so nearly alike externally, should differ so essentially in internal features as to require their separation into groups which appear but remotely related.

Atrypa bisulcata is a subtrihedral shell with a very convex pedicle-valve and a depressed brachial valve. The larger valve has a prominent umbo, the beak being closely incurved over the hinge, concealing both foramen and deltidium. The umbo is longitudinally keeled, but at about one-third the length of the valve a median furrow begins on this ridge, widening anteriorly, and thus making a double keel over the forward parts of the shell. The lateral slopes are broad and smooth, interrupted only in the umbo-lateral regions by a short fold on each side, originating at the beak and lying just within the margins.

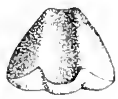

FIG. 133.

FIG. 134.

Front and profile views of *Cyclospira bisulcata*, Emmons. × 2.

The brachial valve is slightly convex posteriorly, becoming concave medially over the pallial region. The median sinus bears a low fold corresponding to the central groove of the opposite valve. On the interior of the pedicle-valve the shell in the umbonal region is very thick, and in this thickened portion the scar of the pedicle-muscle, and in front of it, the adductor scar is excavated. At the anterior edge of the muscular area the shell becomes suddenly and abruptly thinner, and thus that area lies on a well-developed, solid platform. In the brachial valve the hinge-plate is small and supported by a low median septum which extends about two-thirds the length of the valve.

The crura diverge slightly as they pass downward, making a very low curve or slight angulation at their union with the primary lamellæ. The spiral ribbon is very delicate and quite short, making but two and one-half or three volutions, which are almost circular. The interesting feature of these spirals is that they are coiled in planes nearly parallel to the vertical axial plane of the shell. The best of our preparations, which are transparencies, show quite clearly that the apices of the spirals are very slightly introverted, and the primary whorls are so close together that this slight introversion brings the apices into approximation. This deviation from the vertical is apparently quite normal, and is fully corroborated by the ZYGOSPIRA-like contour of the shell; and yet it would require but slight mechanical or casual disturbance of the spirals to produce an equal inclination outwardly. As to the loop, there is as yet no satisfactory proof of its existence; indeed, the evidence derived

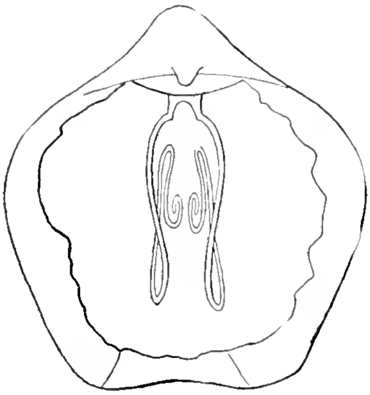

Fig. 135.

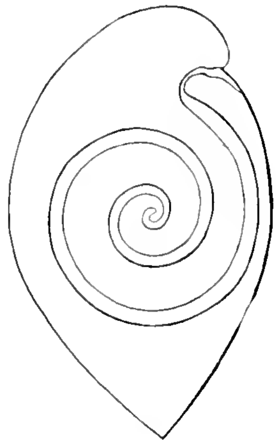

Fig. 136.

The brachidium of *Cyclospira bisulcata*, Emmons. (c.)

from a number of transparent preparations is decidedly negative upon this point. Where the crura are attached to the primary lamellæ, the ribbon is broadened, and just in front of these points there appear to have been two short convergent apophyses which may be construed as discrete elements of a loop. Though an unprecedented occurrence, it would not be surprising or unnatural to find this early spirigerous shell actually ajugate. Subsequent investigations of the brachidium must be relied upon to determine whether or not the loop was ever a continuous lamella, but hitherto, repeated preparations of the brachial apparatus have given no satisfactory evidence of such a structure.*

The peculiarities of the internal supports combined with the nature of the hinge-plate and the contour and smooth exterior of the shell, make an association which removes *Atrypa bisulcata* from any intimate connexion with Zygospira, Catazyga and Glassia, in which the spirals are also introverted, and

* Specimens of *Atrypa bisulcata* in a suitable condition for the determination of the internal characters are rare. When the matrix is opaque, it usually consists of a mass of organic debris which has broken down the delicate brachidium. Through the kindness of Mr. W. R Billings, of Ottawa, we have been permitted to examine an extended series of specimens from his collection and to select for cutting such as possessed a translucent filling, and upon these the determinations have been based.

from DAYIA, which, as already suggested, has only an external resemblance to this species.

It is not known with certainty whether other representatives of this type of structure exist among the species of the earlier faunas. Mr. E. BILLINGS described a species, *Athyris Lara*, from his Division 2 of the Anticosti group,* which has somewhat the form of *Cyclospira bisulcata*, and Mr. DAVIDSON states† that it contains introverted spirals.

In another species, or series of species, we find abundant and convincing evidence of the existence of a slight modification of this type contemporaneous with *Cyclospira bisulcata*. The *Atrypa exigua*, Hall,‡ a diminutive shell described from the Trenton limestone of New York, has a similar contour to *C. bisulcata*, though the pedicle-valve is less convex and the ante-lateral margins of the valves bear evidence of coarse plication. In this little shell the brachial valve has a simply divided hinge-plate, and upon these divisions rest the two short convergent crura; joining the latter at a low angle, the primary lamellæ diverge laterally, converge slightly toward their anterior margins, thence curve vertically upward, nearly touching the inner surface of the pedicle-valve and very

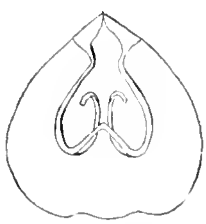

FIG. 137.

FIG. 138.

The brachidium of *Atrypa* (*Protozyga*) *exigua*, Hall. (c.)

gradually approaching each other. The ribbon is continued with a decided internal inclination, until it completes slightly more than one entire volution. Toward the anterior margins of the primary lamellæ a strong loop is given off, its lateral branches projected very obliquely backward, sometimes scarcely rising between the coils, the union forming a broad angle on the anterior margin with a subacute process on the outer margin. In the accompanying figures

* Catalogues of the Silurian Fossils of the Island of Anticosti, p. 47. 1866.

† British Silurian Brachiopoda, Suppl., p. 121. 1862.

‡ Palæontology of New York, vol. i, p. 141, pl. xxxiii, figs. 6 *a–d*. 1847.

the structure of the brachidium has been represented from silicified specimens. It may be remarked that in some of the preparations of this fossil the loop is situated somewhat nearer the middle of the primary coils.

Many preparations have been made of the brachidium in shells of this species not only from New York, but also from the Trenton horizon of Rochester, Minn., Beloit, Wis., and Auburn, Mo. They have been found in various conditions of incrustation and replacement, but with a constancy of the characters described.

Atrypa exigua has been playing a somewhat varied *rôle* in recent American literature. SARDESON has described it as a new species,* under the name *Zygospira? aquila* from the Trenton limestone at Minneapolis and other localities in Minnesota. WINCHELL and SCHUCHERT have included it in a supposed primitive impunctate terebratuloid genus, HALLINA, and have termed it *Hallina Nicolleti.*† Mr. SARDESON has been the first to give a figure of the internal structure of the shell (*op. cit.*, fig. 18), the specimen represented having been cut in such a manner as to expose only the loop and that portion of primary lamellæ lying behind its bases. The appearance of the brachidium is thus quite suggestive of some MAGELLANIA-like brachiopod. This writer, however, recognized the similarity of the brachidium to that of ZYGOSPIRA, suggesting that in "other sections there appear to be spiral coils anterior to the part shown in the figure, situated in the dorsal valve mainly, and with the apices together." Messrs. WINCHELL and SCHUCHERT have, from similar incomplete preparations, unfortunately misapprehended the shell.

The value of the proposed genus HALLINA can not, however, be established from the characters of this species only, as the type form specified by the authors is *Hallina Saffordi*, W. and S., from the Trenton or Glade limestone at Lebanon, Tenn. This is a small shell, oval in outline, and with biconvex valves which bear from fifteen to twenty subangular surface plications, beginning in the umbonal regions; it has, therefore, an altogether different exterior from *Atrypa exigua*, and is indeed not unlike an immature condition of the well known species, common in the Glade limestone and elsewhere at the Trenton

* Bull. Minnesota Academy of Natural Sciences, vol. iii, No. 3, p. 335, pl. iv, figs. 15–18. 1892.

† American Geologist, vol. ix, p. 292. 1892. Geological Survey of Minnesota, vol. iii, pp. 471, 474, pl. xxxiv, figs. 59–62. 1893.

horizon, the *Atrypa*, *Zygospira* or *Anazyga recurvirostra*, Hall. The value of the genus HALLINA must be derived from this species, and, after examination

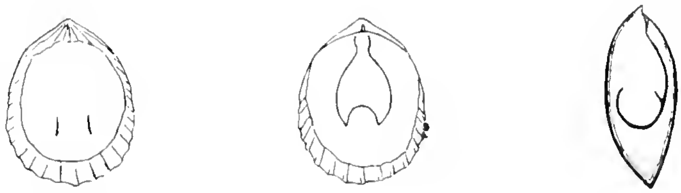

FIG. 139 FIG. 140. FIG. 141.

Preparations showing the structure of the brachidium in *Hallina Saffordi*, Winchell and Schuchert.

Fig. 139. The pedicle-valve cut so as to show the tips of the ascending lamellæ.

Fig. 140. The opposite side, showing the form of the primary lamellæ as far as the base of the loop, and the character of the latter.

Fig. 141. View showing the form of the brachidium in profile. (C.)

of specimens from the original locality, we have been unable to find evidence that it is any more terebratuloid in its characters than the *Hallina Nicolleti*; indeed, it possesses a brachidium of precisely the same structure as the latter.*

The *Atrypa exigua* and *Hallina Saffordi* present the minimum development of the spiral cones; the inward inclination of their apices, though but slight, and the highly developed loop, show that they are actually inceptive forms of ZYGOSPIRA, while the difference in external surface of the two, smooth in the former except for the low folds about the margins, finely and completely plicated in the latter, the nearly vertical plane of the spirals, as well as their brevity, afford again evidence of the great variability in early types of structure. For the *Atrypa exigua* the term PROTOZYGA is proposed; its relations to CYCLOSPIRA are evident, the differences between the two lying in the longer, more nearly vertical and parallel spirals of the latter, and (with the present evidence) in its incomplete loop, indications only of jugal processes being present near the posterior part of the primary lamellæ.†

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* *Hallina Saffordi* has a simple hinge-plate composed of two discrete processes, upon which the crura are based, a low median septum in the brachial valve, and well defined though small dental plates. For further illustration of this shell, see Supplementary plate.

† The internal structure of *Atrypa bisulcata* had been demonstrated and described in manuscript under the name CYCLOSPIRA, some time before the treatise on the Silurian Brachiopoda of Minnesota, by WINCHELL and SCHUCHERT (Geological Survey of Minnesota, vol. iii) was undertaken. As it proved desirable to refer to this type of structure in that work, and as the determinations above given, were known to one of the authors, the name CYCLOSPIRA was there used with our knowledge and consent.

GENUS GLASSIA, DAVIDSON. 1881.

1849. *Atrypa*, SOWERBY. Silurian System, pl. viii, fig. 9.
1859. *Athyris?* SALTER. Siluria, second ed., p. 542, pl. xxii, fig. 16.
1867. *Athyris*, DAVIDSON. British Silurian Brachiopoda, p. 121, pl. xii, fig. 19; pl. xiii, figs. 5, *a*.
1881. *Glassia*, DAVIDSON. Geological Magazine, new series, vol. viii.
1882. *Glassia*, DAVIDSON. British Devonian and Silurian Brachiopoda Supplement, p. 38, pl. i, figs. 10–14; pp. 116–120, pl. vii, figs. 9–20.

Shells small, biconvex; elongate-ovate in outline; surface smooth. Umbo of the pedicle-valve not conspicuous; beak depressed. Structure of the deltidium and hinge as in NUCLEOSPIRA. Muscular impression consisting of two widely divergent, oval diductor scars, between which lies a broad adductor scar.

FIG. 142. FIG. 143. FIG. 144.

Figs. 142–144. *Glassia obovata*, Sowerby.

Fig. 142. Interior of the pedicle-valve.
Figs. 143, 144. Views of the exterior. Natural size. (DAVIDSON.)

Brachial valve with an internal septum. The spiral cones have their bases toward the lateral margins of the shell and their apices at the center of the internal cavity; their position with reference to each other is therefore just the reverse of that in MERISTELLA, RETZIA, etc. The cones are laterally compressed, and the ribbon makes but few volutions. The loop originates as in ATRYPA, is continuous, bending downward into the space between the cones and making a sharp angle at the point of union, which may be directed upward.

Type, *Atrypa obovata*, Sowerby. Wenlock and Ludlow formations.

In this genus and CYCLOSPIRA the spirals are at the extreme of introversion, and the structure of the brachidium in its entirety is quite similar to that observed in ATRYPINA, though the introversion of the spirals is less complete in the latter. GLASSIA stands in the same relation to ATRYPINA as PROTOZYGA

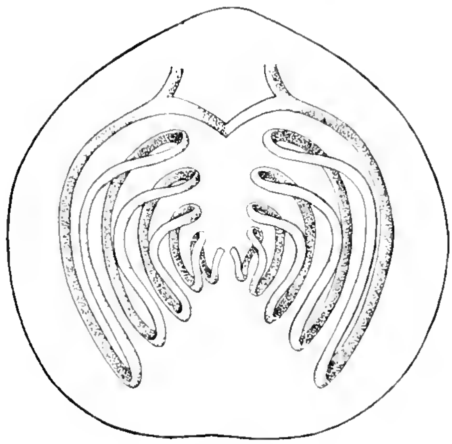

FIG. 145.
Brachidium of *Glassia obovata*, Sowerby. (DAVIDSON.)

to HALLINA; GLASSIA and PROTOZYGA having essentially smooth exteriors and the others a plicated surface. Other differences will probably be found in GLASSIA and ATRYPINA, and these are indicated by the peculiar structure of the deltidial plates in the former, as described above. DAVIDSON recognizes three species of GLASSIA, *G. obovata*, Sowerby, *G. elongata*, Davidson, from the Wenlock shales, and *G. Whidbornii*, Davidson, from the middle Devonian of Torquay. The continuation of this type of structure into the Devonian is of interest as being the only instance of the passage of the primitive zygospiroid structure beyond the limits of the Silurian. GLASSIA is represented in the lower Silurian of North America by an undescribed species found by Dr. C. ROMINGER in a drifted boulder of Trenton limestone, near Ann Arbor, Michigan, in association with *Cyclospira bisulcata*. This species, *Glassia Romingeri*, has the smooth, convex valves and the introverted spirals of *G. obovata*, but is a more elongate shell. (See Supplement for description.)

GENUS ZYGOSPIRA, HALL. 1862.

PLATE LV.

1847. *Atrypa, Orthis?, Stenocisma*, HALL. Palæontology of N.Y., vol. i, pp. 140-142, 288, pl. xv, fig. 15; pl. xxxiii, figs. 4, 5; pl. lxxix, fig. 5.
1859. *Rhynchonella?*, HALL. Twelfth Rept. N. Y. State Cab. Nat. Hist., p. 66.
1860. *Atrypa*, HALL. Thirteenth Rept. N. Y. State Cab. Nat. Hist., p. 69.
1862. *Zygospira*, HALL. Fifteenth Rept. N. Y. State Cab. Nat. Hist., p. 154, figs. 1, 2.
1862. *Zygospira*, BILLINGS. Canadian Naturalist and Geologist, vol. vii, p. 393.
1862. *Athyris*, BILLINGS. Palæozoic Fossils, vol. i, p. 147, figs. 125-127.
1863. *Athyris, Rhynchonella?*, BILLINGS. Geology of Canada, p. 168, fig. 152; p. 211, fig. 211; p. 212, figs. 214-216.
1864. *Stenocisma*, MEEK and HAYDEN. Palæontology of the Upper Missouri, p. 16.
1866. *Rhynchonella, Zygospira*, BILLINGS. Catalogue Silurian Fossils of Anticosti, pp. 44, 46.
1867. *Zygospira*, HALL. Twentieth Rept. N. Y. State Cab. Nat. Hist., p. 267.
1868. *Zygospira*, MEEK. Geological Survey of Illinois, vol. iii, p. 377.
1872. *Zygospira*, HALL. Twenty-third Rept. N. Y. State Cab. Nat. Hist., pl. xiii, figs. 23-25.
1873. *Zygospira*, MEEK. Palæontology of Ohio, vol. i, pp. 125, 126, pl. xi, figs. 4, 5.
1875. *Zygospira*, MILLER. Cincinnati Quarterly Journal of Science, vol. ii, pp. 58, 59.
1878. *Zygospira*, U. P. JAMES. The Palæontologist, No. i, p. 7.
1879. *Zygospira*, ULRICH. Journal Cincinnati Soc. Nat. Hist., vol. ii, p. 14, pl. vii, fig. 10.
1882. *Zygospira*, HALL. Eleventh Rept. State Geologist of Indiana, p. 305, pl. xxvii, fig. 7.
1882. *Zygospira, Anazyga*, DAVIDSON. British Silurian Brachiopoda, Supplement, pp. 122, 128.
1883. *Zygospira*, HALL. Transactions of the Albany Institute, vol. x, p. 70.
1889. *Zygospira*, NETTELROTH. Kentucky Fossil Shells, p. 138, pl. xxxiv, figs. 21-25.
1893. *Zygospira*, WINCHELL and SCHUCHERT. Geological Survey of Minnesota, vol. iii, pp. 465-469, pl. xxxiv, figs. 42-48.

DIAGNOSIS. Shells usually small. Outline subcircular or transversely oval. Contour subplano-convex. Surface sharply plicate. Pedicle-valve with a median plicated ridge. Umbo narrow and prominent; beak acute and incurved. Foramen elongate, rarely apical, enclosed by the deltidial plates. Hinge-line long and straight; cardinal extremities rounded. A distinct false area is formed by a pair of ridges diverging from the beak toward the cardinal extremities. On the interior the teeth are moderately well developed and unsupported by dental lamellæ.

The brachial valve is depressed convex in the umbonal region and bears a more or less conspicuous median sinus. The hinge-plate consists of two broad, stout processes, diverging outwardly, grooved on their summits, and separated from each other by a narrow, sharp cleft. They form both the socket walls and crural bases, and are supported by a low median ridge. Muscular impressions obscure in the typical species.

The crura are short and straight at their union with the primary lamellæ, making a rectangular curve. The first half-volution of the ribbon lies just within the margins of the valves, and the number of volutions is small. The spirals have their bases parallel to the lateral slopes of the pedicle-valve and their apices directed obliquely toward the center of the opposite valve. The loop is a continuous band, variable in position and shape. It may originate on the posterior or anterior limb of the primary lamellæ, or be placed medially; its apex is always angular and directed anteriorly and the lateral curves vary in length and degree according to their position with reference to the spirals.

Type, *Producta modesta*, (Say) Hall. Hudson River group.

OBSERVATIONS. The existence of atrypiform spirals in *Producta modesta* (*Atrypa modesta*, Palæontology of New York, Vol. I, p. 141), was recorded in the Thirteenth Annual Report on the State Cabinet of Natural History, p. 69, and subsequently in the Fifteenth Report of that institution; the structure of the spirals and their connection was described and figured, and the new genus ZYGOSPIRA, erected on the basis of these characters.

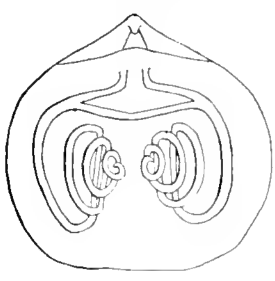

FIG. 146.

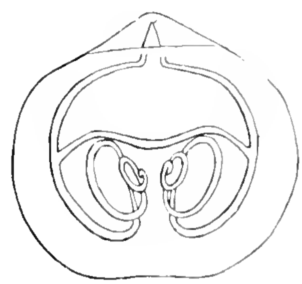

FIG. 147.

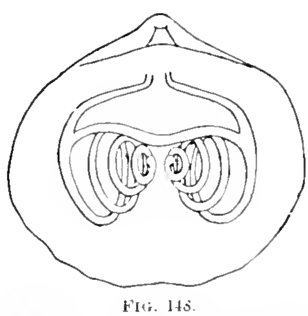

FIG. 148.

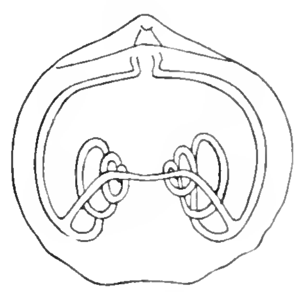

FIG. 149.

Preparations of *Zygospira modesta*, (Say) Hall; showing the variation in position of the loop. (C.)

A most remarkable feature of this genus is the variability in the position of the loop. This is not a specific character, but a matter of variation among individuals of a given species. For example, in the type-species, *Z. modesta*, the loop may be found in any of the four positions represented in the accompanying figures, which have been made from actual preparations. The same peculiarity is shown in *Z. Cincinnatiensis*, Meek, *Z Kentuckiensis*, James, and *Z. recurvirostra*, Hall.

It is, nevertheless, true that, of a given number of individuals, say of *Z. mŏdesta*, the larger fraction will have the loop near the posterior limb of the primary lamellæ; at the same time, examples thoroughly typical in all other respects, will have this organ placed as far forward as it ever occurs in the species *Z. recurvirostra*, while in the latter species the larger percentage of a given number of individuals will have the loop anterior, and a few have it situated medially. These two species, *Z. modesta* and *Z. recurvirostra*, represent the extreme possibilities of variation in this respect, and while it may be said that the normal position of the loop in the former is posterior, and in the latter anterior, yet the variations of the one anteriorly, pass the limit reached by the variation of the other posteriorly. This mobility in the loop of Zygospira is without parallel among other genera, and it has led to some erroneous observations and determinations, based upon insufficient data.*

The term Anazyga, therefore, which was proposed by Davidson in 1882† for the species *Atrypa recurvirostra*, Hall, on the basis of its anterior and recurved loop, must be rejected. In the illustration which this author has given, the position of the loop is, perhaps, more extremely anterior than in any of the numerous preparations we have studied, but there can be no question that characteristic examples of the species have a condition of the brachial apparatus which is indistinguishable from that of *Z. modesta*.

Zygospira has a very considerable representation in species. It seems to have made its appearance in the fauna of the Trenton limestone, in *Producta*

* Reference is made to the observations and criticisms by Dr. Davidson in the Supplement to the British Silurian Brachiopoda (p. 122), upon the original determination and illustrations of the position of the loop in *Z. modesta*. The latter are correct, though they may not represent the extreme posterior position assumed at times by the loop of this species.

† Op. cit., p. 128.

modesta, (Say) Hall, *Atrypa recurvirostra** and *A. deflecta*, Hall. In the Hudson River group are the species *Z. modesta*, (Say) Hall, *Z. Kentuckiensis*, James, *Z. Cincinnatiensis*, Meek, *Z. concentrica*, Ulrich, *Z. paupera*, Billings, and probably the *Rhynchonella mica*, Billings. There is still another species in this fauna as it is developed in Pike county, Missouri, *Zygospira putilla*, sp. nov. (see Plate LV, figs. 35–37), which possesses an unusually elongate form, but retains the coarsely plicate surface of *Z. modesta*; its loop appears to be persistently posterior in its position.

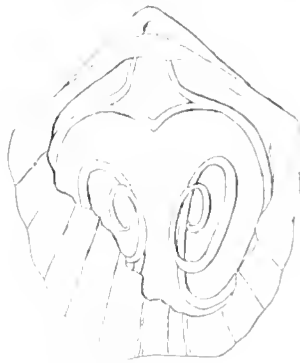

FIG. 156.
Preparation showing the brachidium of *Zygospira putilla*. (C.)

In faunas of later date occurs the species which has been described as *Z. minima*, Hall, in the Niagara group at Waldron, Indiana, but it is exceedingly rare, and its internal structure is not known. The genus has not been satisfactorily identified in European faunas.

SUBGENUS CATAZYGA, S.-GEN. NOV.

PLATE LVI.

MR. E. BILLINGS described,† in 1862, the species *Athyris Headi*, from the Hudson River formation on the "south shore of the St. Lawrence, opposite Three Rivers." It is a rather large, subcircular or ovoid shell, with valves more convex than in ZYGOSPIRA, the rotundity of the pedicle-valve obscuring the usual prominence of the umbo in that genus. Both valves bear a low median sinus, while the external surface, instead of being coarsely plicated as in ZYGOSPIRA, is covered with a great number of fine radiating striæ. The typical external expression of ZYGOSPIRA is thus to a large degree lost. On the interior of the pedicle-valve the muscular impressions are well defined and similar to those seen on the internal casts of the *Orthis?* or *Zygospira erratica*, from the sandy Hudson River

* Messrs. WINCHELL and SCHUCHERT have recently separated from the shells usually referred to this species certain larger and more finely striated shells from the Trenton and Galena horizons. These are termed *Zygospira Uphami*. See American Geologist, vol. ix, p. 291 (1892), and Geological Survey of Minnesota, vol. iii, p. 468, pl. xxxiv, figs. 45–48 (1893). By the favor of Prof. N. H. WINCHELL we have been permitted to refer to advanced pages of the latter work.

† Palæozoic Fossils, vol. 1, p. 147, fig. 125.

(Lorraine) shales of central New York, that is, the pedicle-cavity is deep, and in front of it lies a more deeply excavated, short, sharply defined and longitudinally striated impression. In the brachial valve is a broad anterior and a narrow, elongate posterior pair of scars. The spirals are of essentially the same character as in *Z. modesta*, though the form of the cones is such that their apices converge toward the median line in a plane just below the surface of the brachial valve. The loop, however, differs; in the first place, it is persistently posterior in its position, originating as in ATRYPA, the lateral lamellæ bending downward toward the bottom of the brachial valve and directed forward in lines which are parallel for a short distance. Thence they bend inward and upward, meeting in a sharp angle in the space just behind the apices of the spirals.

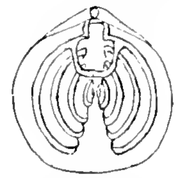

FIG. 151.
Preparation of *Catazyga Headi*, Billings; showing the form of the spiral cones and loop, as viewed from the brachial valve. (C.)

These external and internal peculiarities afford a sufficient basis for the separation of shells of this type from *Z. modesta* and its allies. Mr. BILLINGS described two varieties of *A. Headi*, viz., *A. borealis*, from Lake St. John and the Saguenay River; and *A. Anticostiensis*, from Anticosti, both from the Hudson River formation. The former "differs from the typical form in being more elongate-oval and in having a more tumid umbo" (*op. cit.*, p. 147). This elongate variety prevails in the Hudson River fauna of Ohio, though in association with shells agreeing with the typical *A. Headi.* The variety *Anticostiensis* retains more of the contour of a ZYGOSPIRA, the pedicle-valve being more prominently keeled, the convexity more unequal, and, furthermore, there is a broad sinus on the brachial valve, while there is no trace of one on the other valve. This fossil is like *Z. erratica*, both in contour and in the fine striation of the exterior. If there is a specific difference in the two forms it is extremely slight, too slight, indeed, with our present knowledge, to indicate either in words or illustration. These forms are interesting as being intermediary between the typical ZYGOSPIRA and the representatives of the proposed subgenus CATAZYGA.*

* Our specimens of *Athyris Headi* and its variety *A. Anticostiensis* are from the original localities, and from the investigation of these we are compelled to disagree with Mr. DAVIDSON's determinations given upon pages 126-128 of his Supplement to the British Brachiopoda. On page 127 he states that

It ought, perhaps, to be observed that in a postscript note circulated with some copies of the Twelfth Report on the New York State Museum of Natural History, the name ORTHONOMÆA was proposed as a generic designation for *Orthis ? erratica.* Should it become desirable to distinguish these finely striated species from the more typical coarsely plicated ZYGOSPIRA and the biconvex CATAZYGA, this term would be entitled to consideration.

GENUS CLINTONELLA. GEN. NOV.

PLATE LII.

DIAGNOSIS. Shells usually small, suboval in outline; valves subequally biconvex, the axis of greatest convexity being oblique, making an angle of about 55° with the vertical axis of the shell. Pedicle-valve with a small umbo, which is compressed laterally, the apex being slightly incurved. The cardinal area is replaced by a wide triangular delthyrium, which is unaccompanied by any trace of deltidial plates. The medially elevated umbo merges anteriorly into a sinus which makes a deep flexure at the margin; it bears two plications, both of which reach the beak; sometimes a trace of a third plication may be seen. The lateral slopes bear from four to eight radial plications of smaller size.

On the interior the teeth are prominent, strongly recurved at their tips and supported by lamellæ which terminate abruptly. The lower and inner margins of these lamellæ are thickened, contracting the pedicle cavity, which is, consequently, narrow and deep. The diductor scars are of moderate size, flabellate in outline and deeply impressed at their posterior extremity. They

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Anticostiensis and *borealis* "are only variations in shape of the same species, but specifically distinct from the *Zygospira* (*Athyris ?*) *Headi* of BILLINGS." Further, in indicating the differences between *A. Headi* and *A. Anticostiensis*, he says: "the most marked external characters consist in *Headi* having in the dorsal valve a somewhat deep longitudinal depression or sinus, while, on the contrary, *Anticostiensis* has the sinus on the ventral valve." On the preceding page, in treating of *Z. erratica*, the author says: "*Z. erratica* also bears some resemblance to *Z. Headi* in its external form, especially as in both species there is a somewhat deep sinus in the dorsal valve." It seems probable from these statements that Mr. DAVIDSON has confounded the typical *A. Headi* with the variety *A. Anticostiensis*, and this supposition is apparently borne out by the assertion that the Rev. Mr. GLASS succeeded in developing the brachial apparatus in *Z. erratica*. This species, as far as we know, is invariably preserved as sandstone casts or in a matrix of sandstone, and to develop its internal apparatus has proven an impossibility. The specimens of *Z. Anticostiensis* are, however, usually in limestone, and are very favorable subjects for such treatment.

are crossed by traces of the radial surface plications. Between them lie the narrow obovate adductor scars.

In the brachial valve the beak is inconspicuous; the umbonal region depressed for about one-third the length of the shell, thence anteriorly becoming developed into a median fold. The greatest convexity of the valve is attained in front of the center. The cardinal margin is scarcely thickened; the dental sockets quite narrow. The hinge-plate consists of two flattened processes, inclined toward each other and closely approximate along their inner bases, though not meeting. Each process is divided into an anterior and posterior lobe, the latter being the smaller and resting upon the former. These anterior lobes are narrow and slender, and constitute the crural bases. Spirals are present, but their direction and the nature of the loop are undetermined. A stout median ridge supports the hinge-plate and divides the scars of the adductor muscles. In both valves the lateral portions of the umbonal region is pitted. The plications of the surface are covered by fine, sharp and elevated concentric striæ. Shell substance, fibrous, impunctate.

Type, *Clintonella vagabunda*, sp. nov. Clinton group.

Observations. This interesting shell possesses a hinge-plate of similar structure to that prevailing among the spire-bearing genera of the Clinton fauna, Whitfieldella (*W. intermedia*, *W. naviformis*), Hyattella (*H. congesta*, *H. junia*), Coelospira (*C. planoconvexa*), and occurring also in the genus Zygospira. Though the structure of its brachial supports is unknown, the association of the hinge-plate and the peculiar muscular impressions, with the strongly plicated rhynchonelloid exterior, would effect an incongruity if introduced into any of the generic divisions now recognized. The evidence now attainable indicates an intimate relation to Zygospira, and from these indications it seems probable that this shell will be found to possess introverted spirals.

Clintonella vagabunda was obtained from a drifted and decomposed block of sandstone found without label among the collections presented to the New York State Museum by the Albany Institute. This specimen had been collected by the late Governor De Witt Clinton, in remembrance of whose intelligent, cordial and influential interest in the study of the fossils of the State of New York this generic name is proposed. This small block was virtually composed of the shells of this fossil with a few specimens of an undescribed ATRYPINA (*A. Clintoni*, sp. nov.) and fragments of the trilobite *Encrinurus ornatus*. It was probably derived from the outcrops of the sandstone of the Clinton group in Orleans county, or vicinity, New York.

GENUS ATRYPINA, GEN. NOV.

PLATE LIII.

1845. *Terebratula*, DE VERNEUIL. Géol. de la. Russ. d'Europe et des Mont. de l'Oural, p. 96, pl. x, figs. 14 *a–e*.
1848. *Terebratula*, DAVIDSON. Bull. Soc. Géol. de France, vol. v, second ser., p. 332. pl. iii, fig. 32.
1852. *Atrypa*, HALL. Palæontology of New York, vol. ii, p. 277, pl. lvii, figs. 6 *a–m*.
1857. *Leptocœlia*, HALL. Tenth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 108.
1859. *Leptocœlia*, HALL. Palæontology of New York, vol. iii, p. 246, pl. xxxviii, figs. 8–12.
1859. *Rhynchonella*, *Retzia*, SALTER. Murchison's Siluria, second ed., p. 250, fig. 6; p. 544.
1860. *Retzia*, LINDSTROM. Gotland's Brachiopoda, p. 337.
1867. *Retzia ?* DAVIDSON. Brit. Silurian Brachiopoda, p. 128, pl. xiii, figs. 10–13.
1868. *Trematospira ?* MEEK and WORTHEN. Geol. Surv. Illinois, vol. iii, p. 381, pl. vii, fig 2.
1879. *Cœlospira*, HALL. Twenty-eighth Ann. Rept. N. Y. State Mus. Nat. Hist., p. 162, pl. xxv, figs. 39–43.
1882. *Cœlospira*, HALL. Eleventh Ann. Rept. State Geologist Indiana, p. 303, pl. xxv, figs. 39–43.
1882. *Atrypa*, DAVIDSON. Brit. Silur. Brach., Suppl. p. 114, p. vii, figs. 7 *a*, *b*.
1889. *Cœlospira*, BEECHER and CLARKE. Mem. N. Y. State Mus., vol. 1, No. 1, p. 64, pl. v, figs. 17–23.

DIAGNOSIS. Shells small, subovate or subcircular in marginal outline, plano-, or subconcavo-convex in contour; surface coarsely and sparsely plicated.

Pedicle-valve with the umbo prominent, the beak abruptly acute and more or less incurved. Foramen apical, and deltidial plates normally developed. The cardinal margins of the valve are somewhat extended in the typical species, though the hinge itself is quite short. Teeth divergent and unsupported, taking their origin on the lateral cardinal slopes, and very slightly recurved. Muscular scars exceedingly faint; no internal septa observable.

Brachial valve with the cardinal process small, consisting of two short lobes, which meet at their apices, not extending back of the hinge-line, and diverging anteriorly. The surface of each lobe may be longitudinally grooved, but the inner and outer divisions thus formed, are confluent at their outer extremities. The anterior face of the process is abrupt and vertical, its lower portion being continuous with the socket walls. In front of the cardinal process, but not supporting it, is a low median ridge, on either side of which are obscure muscular imprints. The brachial apparatus consists of introverted spirals whose bases lie against the lateral slopes of the pedicle-valve and whose apices are directed toward the center of the brachial valve. The ribbon is loosely coiled and makes but three or four volutions. The loop is situated posteriorly and constructed as in ATRYPA, except that its lateral lamellæ appear to be always united in an acute angle, which is directed inward.

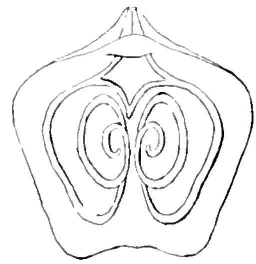

FIG. 152.
The brachidium of *Atrypina disparilis*, Hall. (C.)

Muscular impression composed of large flabellate diductors, enclosing distinct adductor scars.

Type, *Leptocœlia imbricata*, Hall. Lower Helderberg group.

OBSERVATIONS. It has become necessary to establish a division for a number of little species whose structural characters have not heretofore been well known and which have, on that account, been referred indifferently to various genera, as ATRYPA, LEPTOCŒLIA, CŒLOSPIRA, TREMATOSPIRA, etc. Among these which are evidently congeneric on the basis described, are *Atrypa* (*Cœlospira*) *disparilis*, Hall, of the Niagara group, *Atrypina Clintoni*, sp. nov., of the Clinton fauna, *Leptocœlia imbricata*, Hall, of the Lower Helderberg group, and *Atrypa Barrandii*, Davidson, of the Wenlock limestone. This type of external and internal structure is continued upward into the lower Devonian where it is represented by the *Terebratula sublepida*, de Verneuil.*

While atrypoid in external expression the shells differ from ATRYPA, even in its broadest significance, in their uniformly small size, preponderating convexity of the pedicle-valve, few and very coarse plications usually crossed by fine

* Preparations made from specimens of this species from the lower Devonian of the Northern Urals, kindly furnished by Prof. F. SCHMIDT, of St. Petersburg, show all the internal characters of *Atrypina imbricata*.

imbricating concentric lines. The structure of the cardinal process differs in some respects from that of *Atrypa reticularis*, being much more like that of *Zygospira modesta;* while, in regard to the brachial apparatus, the coiling of the spirals is lax, the cones themselves introverted more as in ZYGOSPIRA than in ATRYPA, and the loop, though posterior in position, is apparently continuous and acutely angled as in CATAZYGA.

To this group may be applied the foregoing term, ATRYPINA, a name suggesting the affinities of the fossils.

GENUS ATRYPA, DALMAN. 1828.

PLATE LIV.

1767. *Anomia*, LINNÉ. Systema Naturæ, ed. xii, p. 1152.
1820 *Terebratulites*, SCHLOTHEIM. Petrefactenkunde, p. 262. Nachtr., pl. xvii, fig. 2; pl. xviii, fig. 2; pl. xx, fig. 4.
1821. *Anomites*, WAHLENBERG. Nov. Act. Reg. Soc. Scientif. Upsal., vol. viii, p. 65.
1822. *Terebratula*, SOWERBY. Mineral Conchology, vol. iv, p. 324, fig. 2.
1828. *Atrypa, Terebratula*, DALMAN. Kongl. Vetenskaps. Akad. Handlingar, pp. 127, 128, 143, pl. iv, figs. 2, 3; pl. vi, fig. 6.
1837. *Atrypa, Terebratula*, HISINGER. Lethæa Suecica, pp. 75, 81, pl. xxi, figs. 11 *a–e;* pl. xxiii, figs. 8 *a–c*.
1842. *Atrypa*, CONRAD. Jour. Acad. Nat. Sci. Philadelphia, vol. viii, p. 265.
1842. *Atrypa, Hipparionyx*, VANUXEM. Geology of N. Y.; Rept. Third Dist., p. 88, fig. 12; p. 132, fig. 2; p. 139, fig. 5; p. 163, fig. 3; pp. 164, 182, fig. 4.
1843. *Terebratula*, CASTELNAU. Essai sur le Système Silurien, p. 40, pl. xiii, fig. 8.
1843. *Atrypa*, HALL. Geology of N. Y.; Rept. Fourth Dist., p. 73, fig. 8; p. 108, fig. 37; p. 175, fig. 5; p. 198, fig. 4; p. 200, figs. 1, 2; p. 215, fig. 3; p. 271, figs. 1–3; Tab. of Org. Rem., No. 13, fig. 1.
1844. *Atrypa*, OWEN Geol. Expl. of Iowa, Wisconsin and Illinois, pl. xii, figs. 2, 10.
1847. *Spirigerina*, D'ORBIGNY. Comptes rendus, vol. xxv, p. 268.
1847. *Terebratula*, YANDELL and SHUMARD. Contribution to the Geol. of Kentucky, p. 10.
1849. *Terebratula*, HALL. American Journal of Science, vol. xx, p. 227.
1852. *Atrypa*, HALL. Palæontology of N. Y., vol. ii, pp. 72, 79, 270–272, pl. xx, fig. 10; pl. xxiii, fig. 8; pl. lv, fig. 5; pl. lvi, figs. 1, 2.
1852. *Rhynchonella*, SALTER. Sutherland's Jour. of a Voyage in Baffin's Bay, etc., vol. ii, p. 221, pl. v, figs. 1–3, 5.
1854. *Atrypa*, DAVIDSON. Introd. British Fossil Brachiopoda, p. 90, pl. vii, figs. 87–94.
1856. *Atrypa*, BILLINGS. Canadian Nat. Geol., vol. i, pp. 134, 137. 474, pl. ii, fig. 10; pl. vii, fig. 11.
1857. *Atrypa*, HALL. Tenth Rept. N. Y. State Cab. Nat. Hist., p. 122, figs. 1–7; p. 168.
1858. *Atrypa*, ROGERS. Geology of Pennsylvania, vol. ii. part ii, p. 828, fig. 671; p. 829, fig. 681.
1858. *Atrypa*, HALL. Geol. of Iowa, vol. i, part ii, p. 515, pl. vi, fig. 3.
1859. *Atrypa*, HALL. Palæontology of N. Y., vol. iii, p. 253, pl. xlii. fig. 1.
1860. *Atrypa*, HALL. Thirteenth Rept. N. Y. State Cab. Nat. Hist., p. 84.
1860. *Atrypa*, ROEMER. Die Silurische Fauna der westlichen Tennessee, p. 69, pl. v, figs. 9, 10.
1860. *Trematospira*, MCCHESNEY. New Palæozoic Fossils, p. 71.
1861. *Atrypa*, BILLINGS. Canadian Journal, vol. vi, p. 264, figs. 84–87.

1863. *Atrypa*, Billings. Geology of Canada, p. 315, fig. 321; p. 318, fig. 335; p. 384, fig. 416.
1865. *Atrypa*, Davidson. British Devonian Brachiopoda, pp. 53–59, pl. x, figs. 3–13; pl. xi, figs. 1–12.
1865. *Atrypa*, Shaler. Bull. Mus. Comparative Zoology, No. 4, p. 68.
1867. *Atrypa*. Davidson, British Silurian Brachiopoda, pp. 130–136, pl. xiv, figs. 1–22; pl. xv, figs. 1–8.
1867. *Atrypa*, Whitfield. Twentieth Rept. N. Y. State Cab. Nat. Hist., p. 141.
1867. *Atrypa*, Hall. Palæontology of N. Y., vol. iv, pp. 312–327, plates li, lii, figs. 1–12; pls. liii, liiiA.
1868. *Atrypa*, Meek and Worthen. Geol. Survey of Illinois, vol. iii, p. 430, pl. xiii, fig. 7.
1868. *Trematospira*, McChesney. Trans. Chicago Acad. Sci., vol. i, p. 32, pl. vii, fig. 3.
1868. *Atrypa*, Meek. Trans. Chicago Acad. Sci., vol. i, pp. 96, 97, pl. xiii, figs. 12, 13.
1868. *Atrypa*, Meek and Worthen. Geol Survey of Illinois, vol. iii, p. 432, pl. xiii, fig. 11
1872. *Atrypa*, Hall and Whitfield. Twenty-fourth Rept. N. Y. State Mus. Nat. Hist., pp. 197–199.
1875. *Atrypa*, Hall and Whitfield. Palæontology of Ohio, vol. ii, p. 133, pl. vii, figs. 12–14.
1877. *Atrypa*, Meek. King's U. S. Geol. Expl. Fortieth Parallel, vol. iv, p. 38, pl. i, fig. 7; pl. iii, fig. 6.
1878. *Atrypa*, Etheridge. Quart. Jour. Geol. Society London, vol. xxxiv, p. 596.
1879. *Atrypa*, Hall. Twenty-eighth Rept. N. Y. State Mus. Nat. Hist., p. 162, pl. xxv, figs. 44–47.
1880. *Atrypa*, White. Second Ann. Rept. Indiana Bureau of Statistics and Geol., p 502, pl. v, figs. 7–9.
1881. *Atrypa*, White. Tenth Rept. State Geologist of Indiana, p. 134, pl. v, figs. 7–9.
1882. *Atrypa*, Hall. Eleventh Rept. State Geologist of Indiana, p. 304, pl. xxv, figs. 44–47.
1882. *Atrypa*, Whitfield. Geology of Wisconsin, vol iv, p. 333, pl. xxvi, figs. 5–8.
1884. *Atrypa*, Walcott. Monogr. U. S. Geol. Survey, vol. viii, p. 150, pl. xiv, figs. 4, 6.
1885. *Atrypa*, Foerste. Bull. Denison University, vol. i, p. 90, pl. xiii, fig. 9.
1889. *Atrypa*, Beecher and Clarke. Memoirs N. Y. State Museum, vol. i, p. 51, pl. iv, figs. 12–20.
1889. *Atrypa*, Nettelroth. Kentucky Fossil Shells, pp. 88–92, pl. xiv, figs. 1–23; pl. xv, fig. 1; pl. xxxii, figs. 5–8, 44–47, 64–66.
1890. *Atrypa*, Foerste. Proc. Boston Society Nat. Hist., vol. xxiv, pp. 314–316, pl. vi, figs. 8, 9.

Diagnosis. Shells subcircular or longitudinally suboval in outline. Gibbous, strongly inequivalve. Hinge-line short, straight; cardinal extremities rounded. Beaks not prominent.

Pedicle-valve the smaller; convex in the umbonal region, but depressed and often deeply sinuate anteriorly. Beak small, usually incurved in advanced growth-stages, concealing the foramen and deltidium. The foramen is triangular in young shells, extending to the hinge-line, but becoming gradually closed by the growth of deltidial plates, and at maturity is circular and apical, encroaching slightly on the substance of the valve. The plates of the deltidium are not coalesced along the median suture. On the interior the umbonal cavity is short but very broad. The teeth are large, widely separated and doubly grooved, first by an oblique furrow at the base, into which is fitted a crenulated ridge of the other valve, then by a short longitudinal depression on the summit; the tooth is doubly curved and reflected, making the articulation of the valves very firm. These teeth arise from the inner surface of the lateral slopes of the valve, and are hence unsupported by lamellæ. The muscular impressions are sharply defined; the triangular pedicle-scar is followed in front, by a median elongate double scar of the adductors, outside of which are strong, radiately striate, flabellate diductors, which frequently extend beyond the middle of the valve.

Brachial valve convex or rotund in the middle, with a median fold which is rarely developed except toward the anterior margin. Beak incurved and concealed. No cardinal area. The hinge-plate is composed of two diverging processes which may or may not meet at the apex. Each of these processes is obliquely grooved, forming an inner and outer lobe. The latter forms the upper portion of the socket wall which is curved downward and unites with the lateral surface of the valve, forming a broad dental socket which is traversed by an oblique crenulated ridge. The inner lobes of the hinge-plate are short, their extremities free, bearing the crura.*

These crura are long and narrow, diverge laterally and are attached to the primary lamellæ near their ante-lateral curvature. The mode of attachment

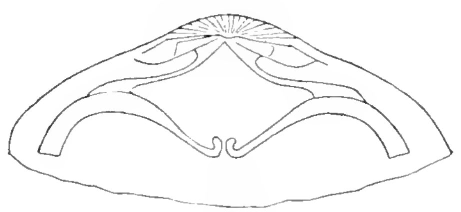

FIG. 153.

Diagram of *Atrypa reticularis*; showing the form and structure of the loop and the mode of attachment of the crura to the hinge-plate and the primary lamellæ. (C.)

is peculiar, the crural lamellæ bending upward and then abruptly downward, greatly widening at the line of contact and touching the spiral ribbon only at its outer margin. The demarkation between the crura and the ribbon of the coils is therefore very distinct. The spirals have, in a general sense, their bases parallel to the inner surface of the pedicle-valve and the apices directed toward the deepest point of the opposite valve. Their axes are more or less

* In the mode of attachment of the crura, as heretofore represented, they have been made to appear as if derived from the outer lobes of the hinge-plate. See Palæontology of New York, vol. iv, pl. liiiA, figs. 22, 25.

convergent, so that the approximate surfaces of the cones are flattened. The basal section of these cones is hemicordate, the anterior extremity being much the narrower, but the upper volutions are more nearly elliptical. The ribbon is broad, being conspicuously so on the anterior curves of the first few volutions, each one extending considerably beyond the next following. These anterior curves may be more or less distinctly fimbriated. The loop is composed of two processes which are continuations of the primary lamellæ without angulation. These processes are situated posteriorly, directed toward the center of the shell, and are, in effect, the starting points of the spirals. They have the following structure: the ribbon maintains its usual width for a considerable distance within the point of attachment to the crura, then narrows rather abruptly, the processes ascending as they approach each other. Their terminations in mature shells are broadened, thickened, erect and recurved at the tips, having a clavate appearance. In immature growth-stages or undeveloped adult conditions this thickening is absent, the extremities of the processes are in close apposition, or may form a continuous lamella. The muscular impressions consist of four large adductor scars divided by a low median ridge.

Ovarian pittings and vascular sinuses occur over the inner surfaces of both valves. The latter consist of two main trunks, sending two branches posteriorly, and two longer, converging branches anteriorly.

External surface covered with radial plications crossed by concentric growth-lines; at the crossing of the two series of lines the external layers of the shell may be produced into broad lamellar expansions or hollow spines.

Shell-substance fibrous, impunctate.

Type, *Anomia reticularis*, Linné. From the Clinton to the Waverly groups inclusive.

Observations. A great number of brachiopods, whose generic relations were of the most uncertain character, have, in the past, been referred to this genus since the date of its establishment.

Following closely the foregoing diagnosis will result in eliminating from this group the great majority of species passing under the name of Atrypa, and in retaining only those which conform to the well-known *A. reticularis*, primarily in the structure of the brachidium, and secondarily, in the expression of the exterior. Such forms are comparatively few in number, and most authors have been disposed to regard them as representing unessential variations from the specific type of *A. reticularis*. There is, however, a multitude of designations which have been applied to contemporaneous variations or consecutive mutations of this specific type, some of them unnecessary, but many very useful both to the geologist and the systematist.*

Atrypa reticularis is a shell characterized by its fine plications, which duplicate rapidly at or between the concentric growth-lines. This duplication or bifurcation of the plications occurs at irregular intervals in the growth of the shell. It is a secondary condition of growth and if it manifests itself at an early stage, a finer plication results than when its appearance is delayed until later growth. This variability in appearance and rapidity of recurrence produces individual differences of expression in the plication of the shell, which, however, lead to no varietal modifications.

The concentric growth-lines are bases of free squamæ or lamellæ, which under favorable conditions may be retained, but are usually abraded, so that the common expression of the exterior is that of an entire absence of such growths. This is the condition where the valves have been replaced by silica (a very common mode of retention), or in specimens which have been gathered from compact limestone. Under better preservation, as in soft shales or shaly lime-

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* The time-values of oscillations of, or from the specific type, manifest themselves so clearly in this genus, that it is here necessary to express such variations with caution and precision. Barrande introduced a distinction between primary and secondary modifications of a specific type, by proposing to restrict the term *variety* to the former, that is, "to forms which possess the principal characters of an admitted species, but which differ from it in one or more important modifications, manifesting themselves in a considerable number of individuals;" and to designate as *variants*, secondary modifications of form and surface ornamentation. It would be granted by most investigators that modifications of a specific type more essential than changes in form and surface characters, would be a sufficient basis for a complete separation from such species; hence this distinction between *variety* and *variant*, holding the latter subordinate to the former, becomes largely arbitrary; and it is only in rare instances that any practical use can be made of it. *Variant* becomes a useful term applied to the different phases of expression within the limit of the specific type, but in this meaning it is neither subordinate to the term variety, nor does it necessarily indicate an inceptive condition in the departure of a variety from the specific type. The time-value of variations from the species has been expressed by Waagen, who proposed to restrict the term *variety* to oscillations of the type contemporaneous with the type itself, and applied the term *mutation* to variations appearing after the extinction of the type.

stones, the shells show the fact that the squamæ of earlier growth, or those upon the umbonal and median surfaces of the valves, have been worn off during the life, or before the fossilization of the shell; the later squamæ, which are stronger, broader, and more closely crowded about the margins, are those usually retained, and these are sometimes of great width, not infrequently equaling and sometimes exceeding the diameter of the valves.*

This form first appears in the Clinton group of the State of New York, and in rocks of corresponding age elsewhere in the United States. It continues its existence through the Niagara group, the Lower and Upper Helderberg groups, the Hamilton and Chemung groups, and into the fauna of the Lower Carboniferous, carrying the same features through all these periods, and presenting no variety of form or surface-markings which can be considered as more than variations of expression depending upon the surrounding physical conditions or similar influences. Nevertheless, in most of these successive faunas this type-form has, for each one, an expression so distinct and peculiar that these variations, without accessory evidence, are often sufficient for the determination of geological horizons.

The shells occurring in the Clinton group of New York and Ontario are characterized by their suborbicular form and the generally small size of the adult.†

In the fauna of the Niagara group this form is continued, though its habit of growth is larger, and the concentric lamellæ of the surface more closely set, as it prevails in the Niagara shales of New York. In the soft shales and limestone at Waldron, Indiana, it presents itself with greater rotundity or convexity of valves; at Louisville, Kentucky, a common form is a small, elongate rather than orbicular, shell, with characteristically obsolescent plication. Shells of the same character as the last also occur sparingly at Waldron and in New York. In the Lower Helderberg fauna the elongate variant prevails in the Shaly limestone, attaining a greater size than in the preceding fauna; while in

* See DAVIDSON, Silurian Brachiopoda, pl. xiv, figs. 1, 2.
BARRANDE, Système Silurien, vol. v, pl. xix, fig. 7.
WHITEAVES, Contrib. to Canadian Palæontology, vol. i, pl. xxxvii, fig. 8.

† It is hardly necessary, were it possible, to determine with precision which of the many expressions of *Atrypa reticularis* was borne by the specimens which served the Swedish savant as the type of the species.

the upper and lower Pentamerus limestones the shell is rotund and the elongate form not represented.

The absence of the specific type from the Oriskany fauna has yet to be accounted for. The normal Oriskany fauna of eastern New York is local, and the immigration of this species was probably excluded by the coarse, sandy character of the sediments, and their accompanying physical conditions. Where the fauna of the Oriskany is commingled with that of the Upper Helderberg, as in the arenaceous limestones of the Province of Ontario, *Atrypa reticularis* reappears with its Devonian aspect.

In the Schoharie grit the expression of this shell is rendered peculiar by a flattening or sharp definition of the usually undefined fold upon the gibbous brachial valve. This peculiarity of the brachial valve is lost in the succeeding fauna (Corniferous limestone). Here we meet two distinct variants; (*a*) a small, elongate shell, like that common in the Lower Helderberg fauna, but invariably of less size (the *A. ellipsoidea*, Nettelroth); these are locally found in great numbers, indicating a gregarious habit; (*b*) a much larger, highly convex shell, having an outline intermediate between the others, and without the highly developed sinus of the pedicle-valve. This shell abounds throughout New York, though its occurrences are mostly in scattered or isolated areas.

Passing to the Hamilton fauna, the prevailing forms are of medium size, with straight, somewhat extended cardinal line, moderately gibbous brachial valve and highly lamellose surface about the margins. These are accompanied rather sparingly by shells of great size, which do not, however, materially modify their external expression. In the calcareous beds of the upper Devonian, as in Iowa, these large shells become predominant, retaining the outline of their predecessors in the Hamilton group, but farther characterized by the lateral compression of the brachial valve. The smaller form, which occurs sparingly in the Chemung sandstones of New York, is still similar to that prevailing in the Hamilton shales. The figures given by Professor HERRICK,* of the shell occurring in a Devonian facies of the Waverly, or earliest Carboniferous fauna of Ohio, indi-

* HERRICK, Bulletin Scientific Laboratories of Denison University, vol. iii, p. 98, pl. iii, fig. 11, 1887; vol. iv, pl. ix, fig. 7, 1888 The expression of this Waverly shell, judging from the figures cited, is more that of the medium sized individuals of the Hamilton group than of the large forms of the later Devonian.

cate that the species at its latest appearance had undergone no variation in form or surface-characters. The range through time, of *Atrypa reticularis*, is unequaled by any other organism except that of the brachiopod *Leptæna rhomboidalis*, Wilckens, and it far outranks that species in geographic distribution and prolific individual development.

Almost coincident in time with the appearance of *Atrypa reticularis*, in its typical aspect, we find in the shales of the Niagara group shells which are persistently small, with few and coarse plications, more or less distinct median fold and sinus, and strong concentric lamellæ. These shells have been designated as *Atrypa rugosa* and *A. nodostriata*, Hall. The former is the smaller and more extreme in the simplicity of its exterior.

During the periods of the Lower Helderberg and Oriskany in New York, and throughout the known extent of these faunas, such coarsely plicated shells entirely disappeared from view, but returned in a depauperated condition in the Corniferous limestone. In the Hamilton group they acquire a much larger size and very gibbous form, the concentric lamellæ being distant and strongly developed. This is the shell known as *Atrypa aspera*, Schlotheim. At this horizon the form mentioned is intimately associated with the typical, more finely plicated *A. reticularis*, but abundant material affords no evidence of the passage from one to the other. The coarsely plicated shell is continued into the Chemung group, where, in New York, it presents a peculiar expression in the much reduced number of its plications, and in the strong median elevation of the brachial valve, which is not infrequently concave in the middle and angular on the margins, these angulations becoming nodose from the elevation of the strong concentric lamellæ. In the calcareous sediments of the Chemung group in the State of Iowa and other northwestern localities, the coarse-ribbed shells also abound, though they possess a different expression than those of the eastern Chemung fauna, having a very gibbous brachial valve without median fold, and more conspicuous plications. They do not, however, approach even remotely, the appearance of the typical *A. reticularis*, with which they are associated. These shells have been designated by the term *A. aspera*, var. *occidentalis*, Hall.

There are certain coarse-ribbed variations of the typical *A. reticularis* occurring in the Upper Silurian faunas of Great Britain, Sweden and Bohemia, which appear to be unrepresented in North America. These have sometimes received the designations of var. *aspera* or *Murchisoniana*, but writers who have dealt with them agree that they are connected by insensible gradations with the typical form of the species. These seem to us to be simply instances of individual variation due to a deficiency in the usual bifurcation of the plications, and leading to no such distinct specific expression as that borne by *Atrypa rugosa*, of the Niagara group. Yet to fully apprehend the fundamental relations of the species *Atrypa reticularis* to the species *A. rugosa*, it is necessary to have recourse to extremely young conditions of the species. Figure 1, on Plate LIV, represents the earliest growth-stage of *A. reticularis* observed, the shell having a length of 2.25 mm. This is still a secondary condition of growth, as shown by the two concentric varices and the well-developed plications, but the simplicity of the latter and their relatively great size is a character continued to much later growth (see, for example figs. 21, 22, on plate xiv, of DAVIDSON's Silurian Brachiopoda). When duplication begins, it is carried on with great rapidity in the development of the typical form. It is thus evident that coarse and sparsely duplicated ribs accompanying normal adult size imply a continuance of immature conditions, or an early deficiency of development; and this genetic modification is the more forcibly expressed when the size of the adult is small, as in *A. rugosa.**

However strong the presumptive evidence may be, that the typical or finely plicated *Atrypa reticularis*, and the coarse-ribbed forms known as *A. rugosa*, *A. aspera*, etc., have originated from a common source, we can not yet indicate the form to which they are both united by an uninterrupted transition. At all events, from the opening of the Upper Silurian to the close of the Devonian period, the two types of external structure have led an independent existence. Though in American faunas, the line of descent of *A. reticularis* is interrupted

* The simple exterior of this fossil suggests its relation to the still smaller, coarsely plicated shells which have been placed under the genus ATRYPINA (*A. disparilis*, Niagara group; *A. imbricata*, Lower Helderberg group). In the structure of its brachidium and the direction of the spiral cones, *A. rugosa* is a true ATRYPA, although its loop is continuous.

during the epoch of the Oriskany sandstone, and that of the coarse-ribbed type broken by an hiatus extending from the close of the Niagara to the opening of Corniferous epoch, this is a purely local or American peculiarity. There is abundant evidence in the works of European writers, of the presence of both forms in faunas of Russia and Germany which are essentially homotaxic with the Lower Helderberg and Oriskany of this country.*

In the variant of *Atrypa reticularis*, occurring in the Niagara fauna at Waldron, Indiana, the free concentric lamellæ frequently show a tendency to fold inward at the summit of the principal plications. The infolded edges fail to unite, and this tendency to the formation of tubules is apparently carried no further at this period. More extreme results were attained by the *Atrypa aspera* of the Hamilton shales, or possibly by its migrated ancestor, during the period of time represented by the deposition of the Lower Helderberg, Oriskany and Upper Helderberg sediments. At all events, the *Atrypa spinosa* of the Hamilton shales is but an *A. aspera* with the lamellæ enfolded into tubular spines. Intermediate stages connecting these different phases are not present in this fauna; it is furthermore evident that these spines are an early genetic condition, being found on the youngest portions of the adult shell; both of these facts pointing to the attainment of this condition at an earlier period. This spinose form is continued into the Chemung faunas (*A. hystrix*), with some modification of expression, the spines being few and long, and the plication of the surface very coarse and quite simple; the shell in its decline thus representing a decided return to the primitive type of structure.

Contemporaneously with the form of *A. reticularis* in American faunas, appears another, the *Atrypa marginalis*, Dalman, which, according to SALTER and DAVIDSON, actually antedates *A. reticularis* in Great Britain, where it is stated to occur as low down as the Caradoc.

* See D'ARCHIAC and DE VERNEUIL. Géologie de la Russie, etc., p. 93, pl. xi, fig. 13. 1845.
SCHNUR. Palaeontographica, vol. iii, p. 181, pl. xxiv, fig. 4. 1854.
KAYSER. Abhandl. Geol. Specialkarte von Preuss. u. den Thür. Staat., pp. 184, 185, pl. xxviii, figs. 4-6. 1878.
TSCHERNYSCHEW. Fauna des unt. Devon am West-Abhange des Urals, p. 42. 1885.

This shell is characterized by its sharp median fold and sinus, numerous fine fasciculate plications and freedom from concentric lamellæ. The expression of the species is thus quite different from that of *A. reticularis*, but after the introduction of the Wenlock fauna the connection between the two is indicated by the *Atrypa imbricata*, Sowerby, which is a similar but highly imbricated shell, whose resemblance to *Atrypa rugosa* of the Niagara group at once suggests itself. The type of *A. marginalis* was not highly variable nor, in America, long-lived. A small variety is the *A. Calvini*, Nettelroth, of the Niagara formation at Louisville. After the disappearance of the Niagara fauna, however, this group does not return, unless the imperfectly known *A. pseudomarginalis*, Hall, of the Upper Helderberg group, be considered a remote descendant.

All the forms considered above are true Atrypas in the structure of the brachidium, so far as that feature is known. No successful attempt has been made to demonstrate this structure in the Lower Silurian representatives of *A. marginalis*, but should they prove to possess slightly convergent spiral cones, directed toward the middle point of the brachial valve, and a simple continuous loop, as in later examples of the species, and most of the early forms of *A. reticularis*, we may seek the source of Atrypa in early Silurian times. It seems not to have been a derivative of Zygospira or Catazyga, but to have developed in a line essentially parallel with those genera and to have had its origin in common with them.

The variations in exterior form are accompanied by some degree of difference in the structure of the brachial supports. How far this apparent difference is due to the stage of development of the individual has yet to be determined. The normal form of the spirals in the mature *A. reticularis*, is that of laterally compressed cones, the first two or three coils of the ribbon being extended beyond the rest along their anterior curvature. In *A nodostriata* the mature form of the spiral is a cone, which narrows quite rapidly above its base, is round and slender, tapering to an acute apex which is inclined inward to meet that of its companion; while in

*A. marginalis** the cone is broad, obtuse at the apex and the anterior curves of the ribbon are not materially extended.

In young individuals the cones appear to be broad, low and obtuse, and the ribbon makes but few volutions. The form and structure of the brachidium was represented in a series of beautiful figures, by Mr. R. P. WHITFIELD, in 1868,† and some of these were reproduced in the Fourth Volume of the Palæontology of New York. The peculiar structure of the loop as a pair of separate processes, was first accurately figured by QUENSTEDT,‡ and afterwards described and illustrated by Mr. WILLIAM GURLEY.§ The character of these lamellæ has been given in the diagnosis of the genus, but it is highly probable that these lateral processes of the loop were not discrete in all stages of growth. Mature specimens frequently have the extremities of the process in so close apposition that to all appearances they are united; young individuals rarely show any trace of disunion at the center of the loop and often no evidence of unusual thickening at this point. Mr. DAVIDSON, who has called attention to the interrupted loop in *A. reticularis*, also figured in the same work‖ a preparation of *A. marginalis* in which the loop is continuous. A specimen of *A. marginalis* in which the lateral processes of the loop are distinct is figured on Plate LIV, fig. 24.

After examination of a considerable number of preparations of the loop made from immature specimens, it seems highly probable that this process was disrupted as the age of the individual and the strain upon the loop from the rapid growth of the spiral coils increased. Should this proposition be supported by more detailed investigation, it will help to an explanation of the uninterrupted condition of the loop in all stages of growth in the atrypoid genera, ZYGOSPIRA, GLASSIA, ATRYPINA, etc. They are forms which virtually antedated the appearance of ATRYPA, and the more elementary condition of

* DAVIDSON has shown that the spiral ribbon in this form is fimbriated, and this character we also find well preserved in natural preparations of the spirals of *A. reticularis* from the Hamilton formation of Clarke county, Indiana.

† Twentieth Ann. Rept. N. Y. State Cab. Nat. Hist., pp. 141–144, pl. i, figs. 1–8. 1867.

‡ Petrefactenkunde Deutschlands, Brachiopoden, pl. xlii, figs. 87*a*, 90. 1871.

§ Proceedings American Philosophical Society, vol. xvii, p. 337, pl. xiv. 1878.

‖ British Silurian Brachiopoda, Suppl. p. 113. 1882.

their structure is indicated, among other things, by their possessing, throughout the existence of the individual, a condition of the loop which was but an immature phase in Atrypa.

The mode of attachment of the crura to the primary lamellæ has not before been fully described, though the figures given by Whitfield and Quenstedt approach the truth most nearly. Among the illustrations of the genus is one (Plate LIV, fig. 17) showing a malformation or hypertrophy of one of the crura, which had become detached from the hinge-plate during the life of the animal. The effort to renew the connection was not successful, but resulted in an extravasation of testaceous matter about the broken extremity; such, in fact, as has taken place about the disconnected extremities of the loop.

Subgenus GRUENEWALDTIA, Tschernyschew. 1885.

PLATE LII.

This name has been proposed* for the species *Terebratula latilinguis*, Schnur,† originally described from the middle Devonian at Gerolstein. This species was

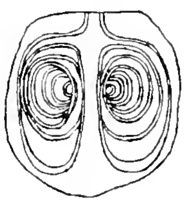

Fig. 154.

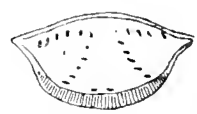

Fig. 155.

Spirals of *Gruenewaldtia latilinguis*, Schnur. In fig. 155, the pedicle valve is the lower and the two median dots represent sections of the primary lamellæ. (Tschernyschew.)

considered by Kayser as a variety of *Atrypa reticularis*.‡ The Russian specimens have the pedicle-valve very convex, the relative convexity of the valve in *A. reticularis* being reversed in this species. From the description and figures given by Tschernyschew, the spiral cones have their bases lying against

* Die Fauna des Unteren Devon am West-abhange des Urals, pp. 46, 89, pl. vi, figs. 75–77.

† Zusammenstellung and Beschreibung sämmtlicher im Uebergangsgebirge der Eifel vorkommenden Brachiopoden, p. 183, pl. xxv, fig 1, 1853.

‡ Zeitschr. der deutsch. geol. Gesellsch., vol. xxiii, p. 545. 1871.

the lateral slopes of the pedicle-valve, and thus the outer face of the cones is parallel to, and just within the surface of the brachial valve. It is such a modification of the brachial apparatus as must necessarily ensue from the variation in the contour of the shell. The character of the loop has not been determined.

Genus KARPINSKIA, Tschernyschew. 1885.

PLATE LII.

This designation has been applied* to a species, *Karpinskia conjugula*, Tschernyschew, from the lower Devonian of the Ural Mountains, which is characterized by an elongate form, radially plicated and subequally convex valves. The spirals have the same position as in Atrypa, though the character of the loop is still unknown. In the pedicle-valve are diverging dental plates, and in the brachial valve a median septum. The vascular trunks are simple and direct, extending to the anterior margin of the valves without branching.

* Die Fauna des Unteren Devon am West-abhange des Urals, pp. 48, 90, pl. vii, figs. 80, 86.

GENUS RHYNCHONELLA, FISCHER DE WALDHEIM. 1809.

The number of palæozoic species which are currently referred to this genus, and consequently regarded as congeneric with the Russian upper Jurassic *R. loxia*, Fischer, the type-species, is very great. To the most conservative student such an assemblage, presenting every variety of external configuration, must seem more like a hap-hazard and conventional association than a natural group. But we are, nevertheless, here confronted by the fact that features of internal structure, upon the variations of which we are wont to base taxonomy, are most persistent. The crura, hinge apparatus and deltidial structure of *R. loxia* are features which were attained and became fixed in the Silurian period; the extreme pyramidal contour of that species, its smooth surface with few and faint marginal plications, is not, however, except in rare instances, reproduced among the palæozoic forms. What is thus true of the predecessors of *R. loxia* is also, to a large degree at least, true of its living descendants.

From a careful study of the structure of the ancient Rhynchonellas it has become apparent that slight variations from the type of interior possessed by *R. loxia* are frequently of marked continuance, and we must, therefore, be prepared for closer discriminations in this great group of species than have elsewhere been necessary or advisable, and to emphasize such of these deviations from this stable line of development, as are justified by their persistence and the convenience of classification.

The earlier names introduced among this group of fossils, such as CYCLOTHYRIS, McCoy, HYPOTHYRIS and EPITHYRIS, Phillips, were based upon the relations of the foramen to the deltidium. It has now become evident that these varying relations are essentially developmental phases. A triangular pedicle-aperture is an immature condition; it may continue as such even to maturity, or throughout the existence of the individual; it may become closed by normal growth of the deltidial plates, which remain discrete or become united, at first enclosing, and perhaps finally obliterating, a subapical foramen; in mature and senile conditions, the aperture if extant, may, by resorption of the shell, encroach upon the apical substance of the valve. Persistence of any of these conditions at maturity may be of collateral value in determining the subdivisions of these fossils, but it is impossible to base important values upon them. It is indeed uncertain whether the authors of the names above mentioned had before them species of RHYNCHONELLA, and those terms must necessarily be rejected.

The first inquiries before us are: What is RHYNCHONELLA in its strict signification? and, How far is it represented in palæozoic faunas?

GENUS RHYNCHONELLA, SENSU STRICTO.

PLATE LVI.

*1809. *Rhynchonella*, FISCHER DE WALDHEIM. Notice des Fossiles du Gouv. de Moscou, p. 35, pl. ii, figs. 5, 6.
1827. *Rhynchonella*, DE BLAINVILLE. Dict. des Sciences Naturelles, vol. xlv, p. 426.
1837. *Rhynchonella*, FISCHER DE WALDHEIM. Oryctogr. du Gouv. de Moscou, pl. xxiv.
1853. *Rhynchonella*, DAVIDSON. Introd. British Fossil Brachiopoda, pl. vii, fig. 99.
1856. *Rhynchonella*, SUESS. Classif. der Brachiopoden von Th. Davidson, pl. iv, fig. 1.
1871. *Rhynchonella*, QUENSTEDT. Petrefactenkunde Deutschlands; Brachiopoden, pl. xxxviii, fig. 108.
1880. *Rhynchonella*, ZITTEL. Handb. der Paläontologie, p. 689, figs. 529 *a–d*.

Subpyramidal shells having the margins of the valves sinuous or angulated. Pedicle-valve with a median sinus beginning in front of the convex umbo, and in the type-species, becoming broad and deep, producing a prominent linguiform extension at the anterior margin. Brachial valve convex in the umbonal region and developing anteriorly a prominent median fold. Surface of both valves more or less plicated, often accompanied (as in the type) by fine concentric lines of ornament. The apex of the pedicle-valve is but slightly incurved and exposes a circular or elongate-oval foramen enclosed by deltidial plates beneath, and above by the substance of the valve. There is a narrow pseudo-area defined by oblique cardinal ridges diverging from the beak. On the interior the teeth are well developed and are supported by lamellæ which rest on the bottom of the valve near the beak, but are free anteriorly. The muscular area consists of a moderately deep oval scar extending one-third the length of the valve, and composed of two large diductors completely enclosing

* The citations here given refer only to *Rhynchonella loxia*. Accounts of congeneric Jurassic species will be found in the works of DAVIDSON, FISCHER DE WALDHEIM, SOWERBY, D'ARCHIAC and DE VERNEUIL.

small central adductors. The posterior surface about the muscular area is pitted with ovarian markings.

In the brachial valve there is no cardinal process; the crural plates are simple divergent, somewhat expanded on the upper surface but not conjoined except where they converge beneath the beak and meet the median septum, which extends for about one-half the length of the valve. The crura are long and curved upward toward the opposite valve. Muscular area elongate-subquadrate, with small posterior and large anterior adductor scars.

Shell-structure fibrous.

Type, *Rhynchonella loxia*, Fischer de Waldheim.* Upper Jurassic.

Observations. It may be doubted whether precisely this combination of internal characters exists among the palæozoic faunas. To the expression of so extreme a view we have been led by the fact that of all the preparations, natural and mechanical, of the interior structure of these shells that have been examined, none show a strict conformity therewith, each possessing some variation of considerable significance; a linear or a clavate cardinal process; absence of dental lamellæ or brachial septum; coalesced crural plates or an inter-crural pit. These differentials permit groupings of the palæozoic species among themselves, which do not include the typical Rhynchonellas. The interior of many of the American palæozoic species is still unknown; the foregoing statement is based upon the representatives of the various faunas that we do know, which, indeed, taken together make a major percentage of described species. As to exterior characters, the peculiar modification of form possessed by *R. loxia* is most rarely met with in palæozoic species, perhaps only in the *R. acuminata*, Martin, of the upper Devonian and the Carboniferous, and, naturally enough, this species fails to conform in internal structure with *R. loxia*. The modifications of external form, while manifestly of subordinate significance, accompany with some persistence the variations of the interior.

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* This diagnosis has been derived from excellent exteriors and internal casts of *R. loxia*, from Charaschowa, Russia.

The evidence leaves little room for doubt that the combination of characters forming the rhynchonelloid type of structure deviated at an early age from the same stock whence ORTHIS has been derived. The earliest "Rhynchonellas" of which we know the interior, are not Rhynchonellas in any true sense, but properly connecting morphological phases between ORTHIS and RHYNCHONELLA, inceptive stages of the fuller development attained in later faunas.

In this aspect of the subject it seems preferable to consider the palæozoic Rhynchonellas essentially in a chronological order, thereby leading up to the later types of structure, and thus following the natural course of development and variation so far as the material in hand permits.

At the outset it will be necessary to indicate the very primitive structure obtaining in some of the earliest species, and in order to distinguish these inceptive forms it will be necessary to introduce, as a new division, the

GENUS PROTORHYNCHA, GEN. NOV.

PLATE LVI

1847. *Atrypa*, HALL. Palæontology of New York, vol. i, p. 21, pl. iv (bis), fig. 5.
1862. *Porambonites*, BILLINGS. Palæozoic Fossils, vol. i, p. 140, figs. 117 *a–g*.

Shells biconvex, with a low, ill-defined fold and sinus on brachial and pedicle-valves respectively. Pedicle-valve with a false cardinal area defined by ridges diverging from the beak. Pedicle-passage triangular, rarely showing any trace of deltidial plates. Teeth very small, supported by thin lamellæ which rest upon the bottom of the valve and are not adnascent to the lateral walls of the shell. In the brachial valve the dental sockets are small; the hinge-plate consists of two minute discrete processes, the surfaces of which are slightly inclined toward each other. These were the bases of the brachial supports but show no points of attachment to the crura; they are separated by a triangular incision extending to the bottom of the valve. There is no cardinal process nor median septum in the brachial valve, and no trace of muscular scars in either valve.

Type, *Atrypa dubia*, Hall. Chazy limestone.*

* It should be observed that these details of structure have been derived from specimens obtained from the gorge of the Kentucky river, at High Bridge, Kentucky.

Observations. These characters, it will at once be remarked, are rhynchonelloid, but are essentially primitive in all respects. The type of structure, if strictly interpreted, does not appear to have been a prolific one. The associates of *Atrypa dubia* in the Chazy fauna, namely, *A. plena*, Hall, and *A. altilis*, Hall, are larger, more coarsely plicated shells, with a short median septum in the brachial valve, and a stronger development of the crural bases. They evince a higher development of rhynchonelloid characters and perhaps may be regarded with more propriety as early representatives of the large division here termed Camarotœchia, than as congeneric with *Protorhyncha dubia*. The *Porambonites Ottawaensis*, of Billings, from the Black River limestone of the Pauquette Rapids, appears to be a representative of this structure. The relations of Protorhyncha with the genus Orthis are evinced in the tendency to the formation of a cardinal area, the usually open delthyrium at maturity, and in the short, blunt hinge-processes.

Genus ORTHORHYNCHULA, gen. nov.

PLATE LVI.

1889. *Orthis*, Nettelroth. Kentucky Fossil Shells, p. 41, pl. xxxiv, figs. 7–13.

Shells rhynchonelloid in contour; hinge-line short, straight, extending for about one-third the transverse diameter of the valves. A true cardinal area is present on both valves, that of the pedicle-valve being considerably the broader, erect, often incurved. Each valve also possesses a distinct triangular delthyrium, that of the pedicle-valve, according to the evidence at hand, never being in any degree closed by deltidial plates. External surface strongly and simply plicated, the median fold and sinus being well developed. On the interior, the pedicle-valve possesses blunt teeth which rest upon the laterally thickened walls of the valve and are not supported by lamellæ. Between, and slightly in front of these lies a short, subquadrate muscular scar. The brachial valve possesses a linear cardinal process, on either side of which are two discrete crural plates, sharply concave on the upper surface and diverging anteriorly for a considerable distance.

Shell-substance fibrous, impunctate.

Type, *Orthis Linneyi*, Nettelroth. Hudson River group.

Observations. No more decisive evidence of the close generic relations of Orthis and Rhynchonella than is furnished by this species, can be desired or expected. The shell is, in effect, a Platystrophia with shortened hinge, narrowed and acuminate beak, and well-developed crural processes; or the proposition is convertible; it is a Rhynchonella, with cardinal areas and uncovered delthyria on both valves. There is a singular anachronism in the sole appearance of this type of structure at a period so long after the distinctive ingredient stocks were well established, a fact which may, to some degree at least, be ascribed to our incomplete knowledge; at the same time there is an eminent fitness in the concurrence of this Platystrophia-like Rhynchonella in a fauna with Platystrophia itself, at its highest and most varied development.

Orthorhynchula Linneyi is rather widely distributed in the Hudson River fauna of Kentucky, but is not known to the eastward.

Genus RHYNCHOTREMA, Hall. 1860.

PLATE LVI.

1842. *Atrypa*, Conrad. Journal Acad. Nat. Sci. Philadelphia, vol. viii, p. 264.
1847. *Atrypa*, Hall. Palæontology of N. Y., vol. i, pp. 146–148, 289, pl. xxxiii, figs. 13 *a–y*, 14 *a–c*; pl. lxxix, fig. 6.
1859. *Rhynchonella*, Hall. Twelfth Ann. Rept. N. Y. State Cab. Nat. Hist., pp. 65, 66.
1860. *Rhynchotrema*, Hall. Thirteenth Ann. Rept. N. Y. State Cab. Nat. Hist., pp. 66–68, figs. 8–13.
1873. *Rhynchonella*, Meek. Palæontology of Ohio, vol. i, p. 123, pl. xi, figs. 6 *a–f*.
1875. *Trematospira*, Miller. Cincinnati Quarterly Journal of Science, vol. ii, p. 60.
1889. *Rhynchonella*, Nettelroth. Kentucky Fossil Shells, p. 83, pl. xxxiv, figs. 26–29.

This name, introduced more than thirty years ago, was designed to indicate a peculiar variation in structure, which is not often retained even in the type-species itself, though its absence is unquestionably due to accidental causes. On this account, perhaps, the term Rhynchotrema has failed of general adoption, and it is only quite recently that some writers* have indicated a disposition to employ it.

* See Waagen, Salt-Range Fossils, p. 410. Dr. Waagen, taking as of prime importance the absence of dental lamellæ in the typical species, has suggested the occurrence of the group among the American Devonian Rhynchonellas. Probably, however, the type of structure, of which the lack of dental lamellæ is but a single element, was more narrowly restricted in its vertical range. Œhlert, in Fischer's Manuel de Conchyliologie (1887), has also used the term, and accompanies it with some original figures, used in a previous publication (Bull. Soc. Géol. de France, 3e Ser., t. xii, p. 426, pl. 10, *a*, *b*), but which fail to show the critical characters of the genus.

In the Thirteenth Annual Report of the New York State Cabinet of Natural History (1860) some specimens of *Rhynchonella increbescens*,* Hall (= *R. capax*, Conrad), from the Hudson River group of Iron Ridge, Wisconsin, which preserved the details of internal structure most admirably, were described and illustrated.

The essential part of this description (p. 67) was as follows:

"This species, like some others of the genus, becomes extremely gibbous or ventricose with age, and the apex of the ventral valve is closely incurved over the beak of the opposite valve. Nor is this all, for the beak is perforate, and in many specimens we are able to discover a distinct foramen in the substance of the shell; indeed, sometimes this foramen is above or exterior to the apex of the beak, but it is rarely possible to distinguish the continuity of the substance of the shell between this foramen and the beak of the opposite valve. Externally, therefore, this feature might not be considered incompatible with RHYNCHONELLA, where the base of the foramen is often formed by the beak of the dorsal valve; and it might be supposed that as the shell increased and the incurvation became too great to permit the protrusion of the pedicle at the ordinary foramen, the notch in the beak might be deepened until it would reach beyond the apex. Sometimes, however, this foramen is seen to be surrounded by the substance of the shell; thus becoming a simple perforation, without the appearance of deltidial plates.

"The real condition and relations of this foramen I have recently been able to determine satisfactorily, from an examination of some separated valves and imperfect specimens collected by Mr. WOOLSON, of Iron Ridge, Wisconsin, from the green shales beneath the iron ore. The interior of the dorsal valve has the usual aspect of this valve of other *Rhynchonellæ*, except that in the center of the apophysary process, at the base of the crura, there is a narrow central process which is more distinct than usual. In the ventral valve there are two strong teeth which fit into deep sockets in the opposite valve and above these, the triangular space *is partially or entirely occupied by a concave solid area*: beneath which, extending from the interior of the shell, there is a distinct foramen

* It seems necessary to consider as the *Rhynchonella capax* of CONRAD, the ventricose shells which, in the work cited, were referred to *R. increbescens*. The latter term was introduced in 1847 for shells from the Trenton limestone of New York, which never attain the great gibbosity common in *R. capax*, but are not unlike the immature individuals of that species. It seems therefore *R. increbescens* has no higher value than a designation for an earlier and somewhat modified type of *R. capax*.

which passes out at the apex or above the apex of the valve, a groove on the lower side always extending thence to the apex. This area [deltidium] sometimes shows a longitudinal suture line, but this feature is not always visible."

The original specimens from which this account was derived are now before us, and enlarged drawings have been made from them which will show more clearly than did the original wood cuts, the accuracy of the description. The solid process in the umbonal cavity of the pedicle-valve is the deltidial plates, which are of great size, and are cemented firmly to the bottom of the valve. The concavity of their surface must be due, in a large degree, to the obese growth of the valves which forced the apex of the brachial valve against the deltidial wall. In younger shells, therefore, we should expect to find this cavity less strongly developed. Frequently these deltidial plates are wholly detached, and where retained, as in specimens from Richmond, Indiana, and elsewhere, they are narrower, not meeting and enclosing the foramen beneath, as in the shells described above. The encroachment of the pedicle-passage upon the substance of the valve, is thus due somewhat to the individual conditions of the shell, and is analogous to the complete enclosure of this channel in old examples of *Leptæna rhomboidalis*, Wilckens, to which reference has been previously made. The teeth rest upon the thickened lateral walls of the valve, and there appears to have been no development of dental lamellæ unless it was at a very early period in the life of the individual.

In the brachial valve there is a thickened median septum which may extend for more than one-half the length of the shell, and it is upon the posterior extremity of this that the slender median cardinal process rests. This delicate apophysis is frequently distorted to one side or the other. The bases supporting the crura are divided by a very narrow median cleft, and are remarkably broad and stout, abruptly deflected to the deep dental sockets. The crura take their origin from the central portion of this comparatively broad hinge-plate, instead of from the margins of the dental sockets, as is usually the case in the palæozoic rhynchonelloids. The structure of the hinge apophyses in both valves is a persistent character, while the peculiarities of the deltidium, as has been observed, are variable with age and external conditions. The muscular impressions are usually strongly developed, there being beneath the deltidial plates a deep scar of the pedicle-muscle, while the adductor impression on the pedicle-valve is often very marked. The adductors of the brachial valve and the diductors of the pedicle-valve are more or less distinctly defined.

Shells possessing the features indicated became prevalent in the fauna of the Hudson River group (*R. capax*, Conrad, *R. increbescens*, Hall, *R. dentata*, Hall), but probably made their earliest appearance in that of the Trenton limestone (*R. increbescens*, Hall, *Trematospira quadriplicata*, Miller). There is thus far no satisfactory evidence of its existence in later faunas.

Genus RHYNCHOTRETA, Hall. 1879.

PLATE LVI

1828. *Terebratula*, Dalman. Kong. Vetenskaps-Akad. Handlingar. p. 141, pl. vi, fig. 3.
1828. *Terebratula*, Hisinger. Bidrag till Sveriges Geognosi, pt. iv, p. 239, pl. vi, fig. 3.
1839. *Terebratula*, J. de C. Sowerby. Silurian System, p. 625, pl. xii, fig. 13.
1846. *Atrypa*, McCoy. Synopsis Silurian Fossils Ireland, p. 39.
1848. *Hypothyris*, Phillips and Salter. Mem. Geol. Survey of Great Britain, vol. ii, pt. i, p. 280.
1852. *Atrypa*, Hall. Palæontology of New York, vol. ii, p. 276, pl. lvii, figs. 4 *a–r*.
1859. *Rhynchonella*, Hall. Twelfth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 77.
1859. *Retzia*, Salter. Murchison's Siluria, second edition, pl. xxii, fig. 8.
1860. *Rhynchonella*, Lindström. Öfvers. Kongl. Vetenskaps-Akad. Förhandl., p. 365.
1867. *Rhynchonella*, Davidson. British Silurian Brachiopoda, p. 164, pl. xxi, figs. 7–11.
1879. *Rhynchotreta*, Hall. Twenty-eighth Ann. Rept. N.Y. State Mus. Nat. Hist., pp. 166–168, figs. 1–4, pl. xxv, figs. 29–38.
1882. *Rhynchotreta*, Hall. Eleventh Ann. Rept. State Geologist of Indiana, pp. 309–311, figs. 1–4, pl. xxv, figs. 29–38.
1883. *Rhynchonella*, Davidson. British Silurian Brachiopoda, Suppl., p. 154, pl. x, figs. 9, 10.
1889. *Rhynchotreta*, Beecher and Clarke. Mem. N. Y. State Mus., vol. i, No. 1, pp. 47–51, pl. iv, figs. 12–22.
1889. *Rhynchotreta*, Nettelroth. Kentucky Fossil Shells, pp. 84, 85, pl. xxxii, figs. 58, 59, 62, 63.

Elongate-triangular, strongly plicated shells with fold and sinus normal, in adolescent and mature stages; long and broad cardinal slopes; beak erect, acuminate and produced on the pedicle-valve. Foramen at maturity apical, its upper margin encroaching on the substance of the valve. Deltidium very conspicuous, convex, the component plates, in their later development, being anchylosed along the median suture. Dental lamellæ vertical, resting on the bottom of the valve and enclosing a deeply impressed muscular scar; diductor scars elongate-flabelliform, divided by oblique ridges into anterior and posterior members;

adductor impression central, elongate and very small. The brachial valve bears a median septum which extends for one-half the length of the shell; being divided toward its posterior extremity, each branch supporting one process of the divided hinge-plate. The crura are long, slightly curved and somewhat expanded at their tips; between these there is a small, simple, cardinal process.

External surface covered with exceedingly fine, filiform, papillose, concentric lines. Shell-substance fibrous, impunctate.

Type, *Terebratula cuneata*, Dalman. Wenlock and Niagara groups.

OBSERVATIONS. The elongate-triangular outline and the surface-ornamentation of the only species that can now be referred to this group afford external peculiarities which at present appear to be of considerable importance. Many rhynchonelloids show slight evidence of a reversal of the relative convexity of the two valves in the process of growth; here, however, this reversal is a feature which is conspicuously apparent in the mature shell, on account of its accomplishment only at a late stage in its development; hence the umbonal region of the sinus-bearing valve is convex, and that of the fold-bearing valve concave, for nearly one-half the length of the shell.*

The great size and elevation of the deltidial plates and their unusual convexity are also peculiarities which characterize the mature condition of the shell. In the interior the brachial valve has somewhat the same construction as in RHYNCHOTREMA, that is, shows coexistence of a median septum, slender and simple cardinal process and discrete hinge-processes. Their relative degree of development, however, is different, and in the structure of the pedicle-valve, its dental lamellæ and muscular scars, the diversity is notable. We are inclined to regard these differential characters as forming a good basis for the generic (or subgeneric) distinction of the species.† The American representa-

* For a full discussion and illustration of the nature of this reversal in contour and also of the development of the deltidial plates, see Memoirs New York State Museum, vol. i, No. 1, pp. 47–51, pl. iv, figs. 12–22. 1889.

† It is necessary to correct here certain errors in the original description of the genus RHYNCHOTRETA. One is an error of assumption, that the crura united to form a terebratuloid loop; subsequent examinations prove them discrete, somewhat curved and explanate at their extremities. Another, that the substance of the shell is finely punctate.

tive of *R. cuneata* has been regarded as a variety of the specific type, var. *Americana*, Hall. It occurs sparingly in the Niagara fauna of New York, but abounds at Waldron, Indiana, and is not uncommon in the dolomites of Illinois and Wisconsin. In Great Britain, however, the species appeared earlier, being found, according to DAVIDSON, in the Lower Llandovery if not even in the Upper Caradoc.

GENUS STENOSCHISMA, CONRAD. 1839.

PLATE LVI.

1839. *Stenoscisma*. CONRAD. Second Ann. Rept. Palæont. Dept., p. 59.
1859. *Rhynchonella*, HALL. Palæontology of New York, vol. iii, p. 236, pl. xxxv, figs. 6 *a* *g*.
1867. *Stenocisma*, HALL. Palæontology of New York, vol. iv, pp. 334, 335.

Mr. CONRAD, in speaking of the rocks and fossils of the State of New York, in his Second Annual Report (p. 59), makes use of this term for shells, the only representative of which specified by him, is "the common Silurian bivalve *Terebratula Schlotheimii*, Von Buch." The *T. Schlotheimi* is a well-known Permian, not Silurian species, and some writers, notably Dr. ŒHLERT in FISCHER's Manuel de Conchyliologie, have considered it necessary to apply the term STENOSCHISMA (STENOSCISMA as written by CONRAD) in accordance with the characters of von BUCH's species, which renders it equivalent to KING's genus, CAMAROPHORIA (1845). It is important in such a matter to get as near as possible to Mr. CONRAD's intentions; that he was at a disadvantage in drawing comparisons or making identifications of American with European species is evident from his characterization of *T. Schlotheimi* as a "common Silurian bivalve."

Unquestionably he had before him at the time, and intended by this designation some New York species, and in Volume IV of the Palæontology of New York (p. 334) the author states that Mr. CONRAD had used this name on a lithographed but unpublished plate of the fossils of the Lower Helderberg group, to designate a species subsequently described* as *Rhynchonella formosa*, Hall. This is as close an approximation to Mr. CONRAD's conception as is now possible

* Palæontology of New York, vol. iii, p. 236.

and we should feel justified in assuming *Rhynchonella formosa* to be the type of the genus rather than to reject the well-established term CAMAROPHORIA and substitute STENOSCHISMA for it.

Upon reviewing the Devonian shells which were referred to STENOSCHISMA in Volume IV of the Palæontology of New York, it has become evident that some modification may be necessary in the application of that term. The internal structure of the type-species *R. formosa* was not at that time demonstrated, nor, so far as we are aware, has it since been determined with the accuracy now required. The Stenoschismas of Volume IV are characterized by a strong septum in the brachial valve, cleft posteriorly, each lateral branch supporting one of the crural bases; the latter are thus separated medially by the triangular cleft whose base is the divided median septum. An elongate umbonal cavity is thus formed beneath the hinge-plate, and this must be regarded of some morphological significance in the relation of these shells to CAMAROPHORIA and its allies. The species possess no cardinal process, and the teeth are supported by parallel vertical dental lamellæ.

These characters are not shared by *Rhynchonella formosa*. In this species all our preparations show that the septum of the brachial valve is represented only by an exceedingly obscure median thickening, being in fact virtually wanting; there is no such median subcardinal cavity as above described, but the hinge-plate is divided by a fissure which extends to the bottom of the shell, and contains a slender longitudinal cardinal process; the divisions of the hinge-plate are not large, have concave upper surfaces, and the crura, which are long, recurved and expanded at their extremities, are produced from the inner angles of these divisions without interruption. The dental lamellæ of the pedicle-valve are short and convergent. The surfaces of the dental sockets, which in the Devonian species are sometimes crenulated, are here smooth. It is necessary to recognize the importance of these palpable differences in *R. formosa* and the group of shells ascribed to STENOSCHISMA in the work referred to, and it seems necessary to render to this genus a stricter construction than it has heretofore received. In so doing *R. formosa* will stand as the only known representative of the type of structure described, and we are inclined to recognize in it a nearer relationship to Rhynchotrema, than to the Silurian and Devonian representatives of Camarotœchia; in other words, the existence or absence of the median brachial septum should be regarded as of less significance than the co-existence of a similar type of hinge-structure.

In exterior characters *Stenoschisma formosa* is a trihedral, strongly plicated shell with well-developed fold and sinus, of an expression not uncommon throughout the Devonian rhynchonellids.

Genus CAMAROTŒCHIA, nom. nov.

PLATE LVII.

1841. ***Atrypa***, Conrad. Ann. Rept. Palæont. Dept. N. Y., p. 55.
1843. ***Atrypa***, Hall. Geology of New York; Rept. Fourth Dist.; Tables of Organic Remains, No. 66, figs. 3, 4; No. 67, fig. 2.
1847. ***Atrypa***, Hall. Palæontology of New York, vol. i, pp. 21, 23, pl. iv (bis), figs. 7, 9.
1852. ***Atrypa***, Hall. Palæontology of New York, vol. ii, p. 70, pl. xxiii, figs. 4, 5; p. 274, pl. lvii, fig. 1; p. 279, pl. lviii, figs. 3, 4.
1857. ***Rhynchonella***, Hall. Tenth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 78, figs. 1–7; p. 82, figs. 1–3; pp. 81, 86.
1860. ***Rhynchonella***, Billings. Canadian Journal, vol. v, pp. 271, 272.
1860. ***Rhynchonella***, Hall. Thirteenth Ann. Rept. N. Y. State Cab. Nat Hist., pp. 87, 88.
1862. ***Rhynchonella***, A. Winchell. Proc. Acad. Nat. Sci. Philadelphia, pp. 407, 408.
1862. ***Rhynchonella***, Billings. Palæozoic Fossils, vol. i, pp. 141–143, figs 118–120.
1863. ***Rhynchonella***, Hall. Transactions of the Albany Institute, vol. iv, pp. 215, 216.
1867. ***Rhynchonella (Stenocisma)***, Hall. Palæontology of New York, vol. iv, pp. 335–345, 348–353, pl. liv, figs. 1–59; pl. liv *a*, figs. 1–23, 44–49; pl. lv, figs. 1–52.
1879. ***Rhynchonella***, Hall. Twenty-eighth Rept. N. Y. State Mus. Nat. Hist., pp. 163, 164, pl. xxvi, figs. 12–33.
1882. ***Rhynchonella***, Hall. Eleventh Ann. Rept. State Geologist of Indiana, pp. 305–307, pl. xxvi, figs. 12–33.
1884. ***Rhynchonella***, Walcott. Monogr. U. S. Geol. Survey, vol. viii, p. 152, pl. xiv, fig. 3; pl. xv, fig. 6; p. 155, pl. xiv, fig. 8.
1887. ***Rhynchonella***, Gosselet. Annales de la Société Géologique du Nord, vol. xiv, p. 188, pls. i–iii.
1888. ***Rhynchonella***, Herrick. Bulletin Labor. Denison University, vol. iii, pp. 39, 40, pl. v, fig. 1; pl. vii, fig. 25; pl. x, fig. 9.

By restricting the application of the term Stenoschisma to shells agreeing in hinge-structure with *Rhynchonella formosa*, the necessity is created for a new designation for the large group of shells to which that term was applied in 1867.* While these shells are susceptible to considerable variation in exterior,

* Palæontology of New York, vol. iv.

they usually maintain a full trihedral contour with shallow pedicle-, and convex brachial valves, evincing little, if any evidence at maturity, of a reversal of the relative convexity of early growth, a feature so apparent in some of the other groups of the rhynchonelloids. Their distinctive characters, however, are internal; the median septum of the brachial valve is divided posteriorly in such a manner as to form an elongate cavity, which does not extend to the bottom of the valve. Each branch of the septum supports one of the lateral divisions of the hinge-plate, to which are attached the curved crural processes. In normal conditions of development the median interspace of the hinge-plate is not closed. The dental sockets, bordering the hinge-plate, are crenulated in the species which are assumed as representing the typical characters of the group. There is no cardinal process.

In the pedicle-valve slender vertical lamellæ support the rather small teeth and extend well into the cavity of the valve, enclosing a deep and narrow pedicle-scar.

This is a group of shells highly developed in species, and eminently characteristic of the Devonian faunas, and hence the *Rhynchonella congregata*, Conrad, is designated as the type of the genus. This species is abundant in the condition of excellently preserved internal casts, in the sandy shales of the Hamilton group of central and eastern New York. The type of structure is, however, much older, probably as ancient as the early Trenton faunas of the Lower Silurian, where it seems to be represented by the species *Rhynchonella altilis* and *R. plena*, Hall, of the Chazy limestone.* In the succeeding faunas of the Silurian are *R. fringilla* and *R. glacialis*, Billings, from Division I, of the Anticosti series; *R. aequiradiata*, Hall, of the Clinton group; *R. obtusiplicata*, Hall, of the Niagara group, and it may prove that *R. Indianensis*, *R. neglecta*, *R. Whitii* and *R. acinus*, Hall, from the same faunas of New York and Indiana, also belong here, though their external habit, *i. e.*, small size, compressed or elongated valves, is not usual in this group. At the appearance of the Lower Helderberg faunas, with their multiplicity of rhynchonellids, this type of structure appears to have

* This opinion is based upon serial transverse sections of the shells; since no separated valves or satisfactory internal casts of these species have been obtainable.

yielded somewhat to the robust forms possessing a cardinal process, which are referred to the genus UNCINULUS. We have not been able to obtain exhibitions of the hinge-structure in all these numerous forms and consequently reserve an opinion with regard to the proper association of some of those of less common occurrence. It is, however, interesting to find the structure of CAMAROTŒCHIA possessed by the extravagantly gibbous species *R. ventricosa*, as precisely the same combination of external and internal characters reappears in the later faunas of the Waverly group.

In the Oriskany sandstone we meet with a number of large and ponderous rhynchonellids which furnish some important evidence as to the values of the characters upon which the classification here adopted is based. In *Rhynchonella Barrandii*, Hall, which probably attained the greatest size of any of these species, the median division of the hinge-plate and the septal cavity appear to have been always present, a cardinal process absent. In *R. speciosa*, Hall, and *R. pliopleura*, Conrad, the younger shells have the same cardinal structure, but with increased age, probably for the most part after maturity, the median pit becomes obscured by the deposition of testaceous matter about the bases of the crura until no evidence of it remains but a linear median depression. This extreme is attained only in old shells, and the groove indicating the line of union of the lateral parts of the hinge-plate is never obliterated. Thus the hinge-plate takes on the appearance of a single solid lobe. In the pedicle-valve of young shells of all these species there is, close to the apex, evidence of very thin dental lamellæ cemented to the lateral walls of the shell. The teeth, however, do not rest upon these, as their extremities are not free, but both in this stage of growth and always afterwards they are continuous with, and rest upon the lateral walls of the valve, as in the genus RHYNCHOTREMA. The gradational variation indicated by these shells, in characters which in other groups are of indicial value according to their degree of development, leads to the conviction that the homogenity of CAMAROTŒCHIA as a zoological association will be better assured by removing these and similar species therefrom and applying to them a distinctive term of subordinate value, *e. g.*, PLETHORHYNCHA. Among the species of the Upper Helderberg, Hamilton and Chemung faunas, few will be found which present any material variation from the type of CAMAROTŒCHIA. Therefore, with our present knowledge, all the species definitely referred to STENOSCHISMA in Volume IV of the Palæontology of New York, may tentatively be embraced under this new term, that is:

In the Corniferous limestone:

Rhynchonella Tethys, Billings.
Rhynchonella? Billingsi, Hall.
Rhynchonella Carolina, Hall.
Rhynchonella Sappho, Hall.

In the Hamilton group:

Rhynchonella Sappho, Hall.
Rhynchonella Horsfordi, Hall.
Rhynchonella congregata, Conrad.
Rhynchonella prolifica, Hall.
Rhynchonella Dotis, Hall.
Rhynchonella carica, Hall.

In the Chemung group:

Rhynchonella eximia, Hall.
Rhynchonella Stephani (or *Stevensi*), Hall.
Rhynchonella duplicata, Hall.
Rhynchonella contracta, Hall.
Rhynchonella orbicularis, Hall.

The type was continued further upward into the early faunas of the Lower Carboniferous, where it is represented in the Waverly group by some of the species already named, *R. Sappho*, *R. contracta*,* and *R. Sageriana* and *R. Marshallensis*, A. Winchell.

* According to the identifications by Prof. C. L. HERRICK, Bull. Laboratories Denison University, vol. iii, pp. 39, 40. 1888.

LIORHYNCHUS, Hall. 1860.

PLATE LIX.

1842. *Orthis, Atrypa,* Vanuxem. Geology of N. Y.; Rept. Third Dist., p. 146, fig. 3; p. 168, fig. 2; p. 182, fig. 2.
1843. *Atrypa,* Hall. Geology of N. Y.; Rept. Fourth Dist., p. 182, fig. 11; p. 223, fig. 2, Tables of Organic Remains, No. 67, fig. 1.
1855. *Rhynchonella,* Shumard. Rept. Geol. Surv. Missouri, p. 205.
1860. *Leiorhynchus,* Hall. Thirteenth Ann. Rept. N. Y. State Cab. Nat. Hist., pp. 75, 85, 86, figs. 1*a*, *b*.
1860. *Rhynchonella?* Billings. Canadian Journal, vol. v, p. 273, figs. 26–28.
1863. *Rhynchonella?* Billings. Geology of Canada, p. 384, figs. 418*a–c*.
1866. *Leiorhynchus,* A. Winchell. Rept. Lower Peninsula of Michigan, p. 95.
1867. *Leiorhynchus,* Hall. Palæontology of N. Y., vol. iv, pp. 355–364, pl. lvi, figs. 1–49; pl. lvii, figs. 1–29.
1868. *Rhynchonella,* Meek. Trans. Chicago Acad. Sci., vol. i, p. 93, pl. xiii, figs. 9*a–c*.
1873. *Leiorhynchus,* Hall and Whitfield. Twenty-third Ann. Rept. N. Y. State Cab. Nat. Hist., p. 240, pl. xi, figs. 25–27.
1874. *Leiorhynchus,* Nicholson. Geological Magazine, new ser., vol. i, p. 120.
1884. *Rhynchonella, Leiorhynchus,* Walcott. Monogr. U. S. Geolog. Survey, vol. viii, p. 153, pl. xv, figs. 1–4; pp. 157–159, pl. xix, figs. 5, 9.
1885. *Leiorhynchus,* Clarke. Bull. U. S. Geolog. Surv., No. 16, pp. 24, 31, 33, 68, pl. iii, fig. 14.
1886. *Rhynchonella,* Ulrich. Contributions to American Palæontology, p. 26.
1887. *Liorhynchus,* Œhlert. Fischer's Manuel de Conchyliologie, p. 1308.

During the period of the predominance of the foregoing species of Camarotœchia in the middle Devonian, certain shells, not essentially varying from them in internal structure, assumed a peculiar exterior expression, the fold and sinus becoming strongly plicated, while the lateral slopes are covered with low, faint or obsolescent duplicating ribs; umbones smooth; substance of the shell very thin. To this group the term Liorhynchus* was applied in 1860, and the typical species is the *Orthis quadricostata*, Vanuxem, of the Hamilton faunas.

These shells constitute an interesting lateral line of development which was continued from the later Devonian into the early faunas of the Carboniferous, where it probably outlived its parental type. The species of the middle Devonian seem to have flourished most abundantly in the bituminous sediments of the Hamilton series. Thus in the Marcellus shales and limestones, shells of

* Thirteenth Report New York State Cabinet of Natural History, p. 75. The original spelling of this term was Leiorhynchus; as above given its orthography is probably less open to objection. The term is retained for these fossils, although the word was earlier in use for a recent genus of *Vermes* (according to Agassiz), or *Coleoptera* (according to Dall). What its value may be in this latter use we are not informed, but at all events there is little danger of any confusion of intent in its application to groups so remotely connected.

the *Liorhynchus limitaris*, Vanuxem, frequently constitute entire strata of some inches in thickness; and also, in the more bituminous layers of the Hamilton group proper, *L. multicostus*, Hall, and at times, *L. quadricostatus*, Hall, become very abundant, and are correspondingly rare as the shales lose their organic matter and become more calcareous. In the black Genesee shales, *L. quadricostatus*, Hall, is often abundant. Where the succession of the sediments was more persistently calcareous or arenaceous the shells adapted themselves to their surroundings, though under such circumstances not attaining so great development in individuals. In the calcareous layers of the Hamilton group at Thedford, Ontario, *L. Laura*, Billings,* is not of infrequent occurrence. *L. Kelloggi*, Hall, occurs in the upper Devonian calcareous sandstones of northern Ohio; *L. mesacostalis*, *L. sinuatus*, Hall, and *L. globuliformis*, Vanuxem,† in the sandstones of the Chemung group; the *L. Newberryi*, Hall and Whitfield, from the Erie shales, of Devonian age; the *L. Greenianus*, Ulrich, from the Knobstone formation of Keokuk age, and the *L. Boonensis*, Shumard, in the Burlington limestone.

In the later representatives of this subgenus there is a tendency to obsolescence of the plications over the entire surface; and in all specimens where the interior is well preserved, the muscular impressions of the brachial valve form narrow, elongate-oval scars alongside the median septum. Frequently, also, the narrow pit beneath the hinge-plate supported by the median septum, is of conspicuous size, as in *L. globuliformis.* The significance of the group of fossils embraced by the foregoing divisions, CAMAROTŒCHIA, PLETHORHYNCHUS and LIORHYNCHUS cannot be gainsaid. The existence of an incipient spondylium between the divisions of the hinge-plate, supported by the median septum, at once indicates a relationship, not so much to the pentameroids, which have for the most part preceded these in time, but to the spondylium-bearing shells of the later palæozoic periods, CAMAROPHORIA and its allies.

* Some of the more oblate forms of this species seem indistinguishable from *L. multicostus*, Hall, but *L. Laura* normally has an elongate-oval outline which is not possessed by typical examples of the former.

† Before us is a specimen of the *Rhynchonella castanea*, Meek, from the Eureka District of Nevada, agreeing with Mr WALCOTT'S identification of this species as described in volume viii, Monographs of the U. S. Geological Survey, p. 153. This specimen demonstrates a very close specific similarity to *Liorhynchus globuliformis*, Vanuxem, and serves to fix its generic relations beyond doubt.

GENERA (1) WILSONIA (QUENSTEDT), KAYSER, 1871; (2) UNCINULUS, BAYLE, 1878; (3) UNCINULINA, BAYLE, 1878; (4) HYPOTHYRIS (McCOY), KING, 1850.

PLATES LVIII, LX.

(1)* 1816. *Terebratula*, J. SOWERBY. Mineral Conchology, vol. ii, p. 38, pl. cxviii, fig. 2.
(1) 1821. *Anomites*, WAHLENBERG. Nova Acta Reg. Soc. Upsal, p. 67.
(1) 1828. *Terebratula*, DALMAN. Kongl. Vetenskaps. Akad. Handling., p. 139, pl. iv, fig. 1.
(1) 1834. *Terebratula*, VON BUCH. Ueber Terebrateln, p. 47.
(4) 1834. *Terebratula*, VON BUCH. Ueber Terebrateln, p. 68, pl. xi, figs. 29, *a*, *b*.
(1) 1839. *Terebratula*, J. DE C. SOWERBY. Silurian System, p. 615, pl. v, fig. 21; pl. vi, fig. 7.
(4) 1840. *Atrypa*, J. DE C. SOWERBY. Trans. Geol. Soc. London, 2nd ser., vol. v, pl. lvi, fig. 24; pl. lvii, figs. 5, 6.
(4) 1841. *Atrypa*, PHILLIPS. Palæoz. Foss. Cornwall, Devon and West Somerset, p. 84, pl. xxxiv, fig. 150.
(4) 1842. *Atrypa*, VANUXEM. Geology of N. Y.; Rept. Third Dist., p. 163, fig. 1.
(4) 1843. *Atrypa*, HALL. Geology of N. Y.; Rept. Fourth Dist., p. 215, fig. 1.
(4) 1844. *Terebratula*, F. ROEMER. Verstein. rhein. Uebergangsgeb., p. 65.
(1) 1845. *Terebratula*, DE VERNEUIL. Géol. de la Russ. et des Mont. de l'Oural, p. 87, pl. x, fig. 8.
(4) 1846. *Hypothyris*, KING. Annals and Magazine of Natural History, vol. xviii, p. 28.
(1) 1846. *Atrypa*, McCOY. Synopsis Silurian Fossils of Ireland, p. 42.
(1) 1848. *Hypothyris*, PHILLIPS and SALTER. Mem. Geol. Surv. Great Britain, vol. ii, pt. 1, p. 282.
(2) 1850. *Hemithyris*, D'ORBIGNY. Prodrome de Paléontologie, p. 92.
(4) 1850. *Hypothyris*, KING. Permian Fossils of England, p. 111.
(1) 1852. *Rhynchonella*, DAVIDSON. Annals and Magazine of Natural History, 2nd ser., vol. ix, pl. xiii.
(4) 1852. *Rhynchonella*, THE SANDBERGERS. Verstein. des rhein. Schicht. Syst. Nassau, p. 43, pl. xxxiii, fig. 12.
(4) 1853. *Rhynchonella*, SCHNUR. Beschr. der Eifel. Brach., p. 185, pl. xxv, fig. 5; p. 187, pl. xxvi, fig. 3; p. 239, pl. xlv, fig. 4.
(2) 1857. *Rhynchonella*, HALL. Tenth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 66, figs. 1–7; p. 68, figs. 1–3.
(1) 1858. *Rhynchonella*, F. SCHMIDT. Archiv für Naturk. Liv., Esth., und Kurlands, vol. ii, p. 210.
(2) 1859. *Rhynchonella*, HALL. Palæontology of New York, vol. iii, pp. 25–28, 30, pl. xxix, fig. 4; pl. xxx, figs. 1, 2; pl. xxxi, figs. 1–3; pl. xxxiii, figs. 1*a*–*p*.
(2) 1860. *Rhynchonella*, F. ROEMER. Silur. Fauna des Westl. Tennessee, p. 72, pl. v, fig. 14.
(1) 1860. *Rhynchonella*, HALL. Canadian Naturalist and Geologist, vol. v, No. 2, p. 146.
(1) 1867. *Rhynchonella*, DAVIDSON. Brit. Silurian Brachiopoda, pp. 167–173, pl. xxiii, figs. 1–14.
(4) 1867. *Rhynchonella*, HALL. Palæontology of New York, vol. iv, p. 346, pl. liv*a*, figs. 24–43.
(2) 1867. *Rhynchonella*, DAVIDSON. Brit. Silurian Brachiopoda, p. 166, pl. xxi, figs. 1–6, 28.
(2) 1869. *Rhynchonella*, DE VERNEUIL. Tchihatcheff's Asie Mineure, Paléontologie, pp. 9, 468.
(1) 1871. *Terebratula*, QUENSTEDT. Petrefactenk. Deutsch.; Brachiopoden, p. 193, pl. xlii, figs. 19–48.
(4) 1871. *Terebratula*, QUENSTEDT. Petrefactenk. Deutsch.; Brachiopoden, pl. xlii, figs. 15–18.
(1) 1871. *Rhynchonella*, KAYSER. Zeitschr. der deutsch. geolog. Gesellsch., vol. xxiii, p. 502.
(4) 1871. *Rhynchonella*, KAYSER. Zeitschr. der deutsch. geolog. Gesellsch., vol. xxiii, pp. 507–515, pl. ix, figs. 3, 4.
(4) 1877. *Rhynchonella*, HALL and WHITFIELD. Geolog. Expl. Fortieth Parallel, vol. iv, p. 247, pl. iii, figs. 4–8.

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* The citations are numbered to correspond with the generic titles.

(2) 1878. *Uncinulus*, BAYLE. Explic. de la Carte géolog. France, vol. iv, Atlas, pl. xi, figs. 17–20.
(3) 1878. *Uncinulina*, BAYLE. Explic. de la Carte géolog. France, vol. iv, Atlas, pl. xiii, figs. 13–16.
(4) 1878. *Rhynchonella*, BARRIS. Proc. Davenport Acad. Nat. Sci., vol ii, p. 285, pl. xi, figs. 5, 6.
(2) 1879. *Rhynchonella*, HALL. Twenty-eighth Ann. Rept. N. Y. State Mus. Nat. Hist., p. 165, pl. xxvi, figs. 34–40.
(2) 1883. *Uncinulus*, WAAGEN. Salt-Range Fossils, Brachiopoda, p. 424.
(1) 1883. *Rhynchonella*, DAVIDSON. Brit. Silur. Brachiopoda; Suppl., p. 156.
(2) 1884. *Uncinulus*, ŒHLERT. Bull. de la Soc. géol. de France, 3d ser., vol. xii, pp. 426–432, pl. xxi, figs. 1*a–s*; pl. xxii, figs. 2 *a–n*.
(4) 1884. *Rhynchonella*, WALCOTT. Monogr. U. S. Geol. Surv., vol. viii, p. 157.
(3) 1884. *Rhynchonella*, ŒHLERT. Bull. de la Soc. géol. de France, 3d ser., vol. xii, p. 420, pl. xviii, fig. 5*a–o*.
(4) 1884. *Rhynchonella*, CLARKE. Neues Jahrb. für Mineral., Beilagebnd. iii, p. 385.
(4) 1890. *Rhynchonella*, WILLIAMS. Bull. Geol. Soc. America, vol. i, pp. 481–500, pls. xi, xiii.
(4) 1891. *Rhynchonella*, CLARKE. American Geologist, August, p. 100.

There are large numbers of palæozoic rhynchonellas which are characterized by a full subcuboidal or subpentahedral contour, a fold and sinus not sharply developed except at the anterior margin, an abrupt anterior slope, sharply serrated lateral margins of contact, and low surface plications, each of which, on the front of both valves, is marked by a fine median line.

Shells with such external features appeared in the middle or upper Silurian, multiplied in the early Devonian, and continued their existence into the faunas of the Carboniferous. They were early distinguished as the *group of Rhynchonella Wilsoni*, Sowerby, taking their name from the common species of the Wenlock fauna, which was quite fully described and illustrated by DAVIDSON in the Annals and Magazine of Natural History, 1852,* and still more elaborately in his Silurian Brachiopoda, 1869.† In 1871, QUENSTEDT‡ termed the shells "die Wilsonier" or "the Wilsoni's," introducing for them a trinomial nomenclature, as, for example, *R. Wilsoni Bohemica*, *R. Wilsoni pila*, etc., etc.

That this term was not intended as a generic or subgeneric designation is evident from its mode of use, but in the same year Professor E. KAYSER,§ in referring to QUENSTEDT's recently expressed opinion, says that "the characters [mentioned] seemed to him [QUENSTEDT] sufficient for the establishment of a separate subgenus "WILSONIA." Thus the name WILSONIA was introduced,

* P. 249, pl. xiii, figs. 12–14.

† P. 168, pl. xxiii, figs. 1–18.

‡ Petrefactenkunde Deutschlands; Brachiopoden, p. 193.

§ Zeitschrift der deutsch. geolog. Gesellsch., vol. xxiii, p. 502.

and by many European authors has been applied to shells of this character. Mr. DAVIDSON did not adopt it; Drs. WAAGEN and ŒHLERT* have objected to its admission on account of its morganatic introduction and have preferred to use the term UNCINULUS, proposed by BAYLE in 1878.

A critical study of this group of subcuboidal shells has compelled the adoption of somewhat different conclusions than those expressed by other investigators in regard to their generic values and appropriate designation. Thus far the broader application of the term WILSONIA (a name which should be accredited to KAYSER rather than to QUENSTEDT, the former being not only the first to use the term, but accompanying it with a careful account of the characters of the group), has rested mainly upon external features. DAVIDSON did, indeed, as early as 1852, describe the muscular scars and interior apophyses both of *R. Wilsoni*, Sowerby, and also of *R. sub-Wilsoni*, D'Orbigny, the latter a lower Devonian shell from Normandy (Néhou), and the type of BAYLE's genus UNCINULUS;† and to ŒHLERT‡ we owe a most careful delineation of the internal characters of the latter. Both of these species are characterized by the great size and depth of the diductor scars of the pedicle-valve, the thickened teeth unsupported by vertical lamellæ, and both have a well developed median septum in the brachial valve. But they differ most conspicuously, and most importantly, in the structure of the hinge-plate. In *R. Wilsoni* (WILSONIA) the plate is very small, is divided medially by a shallow incision into distinct crural bases, and has no cardinal process. In fact the structure is not unlike that of CAMAROTŒCHIA, though never so highly developed as in the Devonian species of that genus. So far as we are aware, among the many figures of *R. Wilsoni* to be found in literature, none have been given which show the construction of this part; those upon Plate LVIII have been made from a clean internal cast of the American shell identified by DE VERNEUIL with *R. Wilsoni*, but subsequently termed *R. Saffordi*, Hall, and which occurs in the Niagara fauna of Perry county, Tennessee, at Louisville, Kentucky, and in the upper members of the Arisaig series, in Nova Scotia.

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* Dr. ŒHLERT, in some of his later papers, has withdrawn his objections and adopts WILSONIA (Quenstedt), Kayser, in preference to UNCINULUS, Bayle.

† Explication de la carte géolog. France. 1878.

‡ Bull. Société géolog France, 3d ser., vol. xii, pl. xxi, figs. 1, a–s. 1884.

On the other hand, the Devonian species, *R. sub-Wilsoni*, d'Orbigny, possesses a solid, undivided hinge-plate and a highly developed cardinal process, as was shown by DAVIDSON, in 1852, and by ŒHLERT, in 1884; and though having external contour, median septum and unsupported teeth, as in *R. Wilsoni*, should not be placed in too intimate association with the latter. The generic characters of *R. subwilsoni* are positive, those of *R. Wilsoni* are unsubstantial. If WILSONIA has any value as a distinctive designation it is subordinate to CAMAROTŒCHIA, and as such may serve to characterize the subcuboidal shells of this group which, like *R. Barrandii*, Hall, and the species constituting the proposed subgenus PLETHORHYNCHUS, have the teeth unsupported by dental lamellæ. To adopt the name WILSONIA for all the shells possessing the internal characters of *R. Wilsoni*, without regard to external form, and thus make it the equivalent of the group CAMAROTŒCHIA, would be to deviate widely from the intent of the authors of the term; hence, *per contra*, it becomes necessary to restrict the application of the name to very narrow limits.

In American faunas the typical WILSONIA is but sparsely represented. With it may be placed the species *R. Saffordi*, Hall, to which reference has been made. Perhaps the *R. ventricosa*, Hall, of the Lower Helderberg fauna (Shaly limestone), a shell referred to in the discussion of CAMAROTŒCHIA, should be associated with it. *Rhynchonella Wilsoni* is a species of wide distribution in the European Upper Silurian, and has been described in Great Britain, Sweden, Russia and Spain; DAVIDSON gave its vertical range as from the Llandovery to the Ludlow periods. It is probably true that the very few other species of similar type of exterior, which have been described from the Wenlock and equivalent faunas, are congeneric, but this statement can be made only with reservation.

BAYLE, in 1878, proposed* to use the term UNCINULINA for a species described by him as *Uncinulina fallaciosa*, from the lower Devonian of Néhou and elsewhere. To Dr. ŒHLERT, again, we owe the elaboration of this shell.† The species is subcuboidal in form, less globose than *R. Wilsoni*, but with the abrupt

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* Explication Carte géolog. France, Atlas, pl. xiii, figs. 13-16.

† *Op. cit.*, p. 420, pl. xviii, figs. 5*a*–*o*. 1884.

anterior slope characterizing the entire group. The internal casts figured by ŒHLERT show less highly developed muscular scars and testaceous thickenings, a somewhat irregularly divided hinge-plate supported by a median septum and slightly developed dental plates. The structure is, in short, very similar to that of WILSONIA, and there appears to be no good reason for dissociating the shell from *R. Wilsoni*, inasmuch as the relative depth and size of muscular scars are features of but inferior importance. At all events, the type of structure seems to be the same as that which prevails among the earlier representatives of CAMAROTŒCHIA. BAYLE's species, however, bears no little resemblance to SOWERBY's *Terebratula Stricklandi*,* of the Wenlock fauna, a species finely developed in the Niagara faunas of Indiana, Illinois and Wisconsin. We have been supplied with beautiful internal casts of this species by T. A. GREENE, Esq., of Milwaukee, obtained from the dolomites in that vicinity, and these show a peculiar conformation of the hinge-plate, the lateral components of which are divided medially for a portion of their length only, toward the apex the plates being curved upward and uniting, thus forming an arched and hollow process which is, of course, the representative of the cardinal apophysis in UNCINULUS. This is a very simple condition of development of this process, and it is interesting to find it so early in the history of the group. The figure of the hinge-plate of *R. fallaciosa* given by ŒHLERT (5*l*), is similar to the impression usually obtained from internal casts of *R. Stricklandi*, and it may be found that the French species possesses the incipient cardinal process of that shell; in this event the term UNCINULINA may have a certain value as a distinctive designation for shells in this condition of development, but for the present it seems wiser to include *R. Stricklandi* within the limits of the genus UNCINULUS.

It is in the fauna of the Lower Helderberg group that the subcuboidal Rhynchonellas with a highly developed process, attain their characteristic and most extreme development. Dr. ŒHLERT's figures of this process in *Uncinulus subwilsoni* show it to be a simple crescentic apophysis striated longitudinally, but in *Rhynchonella mutabilis*, *R. abrupta*, *R. vellicata*, and *R. nucleolata*, Hall, of the Lower Helderberg group, there is usually some evidence of a median division;

* Not *Rhynchonella Stricklandi* (Sow.), Schnur, which is a Devonian shell.

frequently this is obscured to such a degree as to be observable only at the summit of the stout, erect process, as in *R. vellicata*, but in the other species its duplicate character is usually retained. Figures are given in this volume, showing the various forms of this process from a bidentate condition very suggestive of its appearance in the leptænoid shells, to a condition in which the parts are firmly coalesced into a simple process. These various conditions are, in a certain sense, developmental, but are also features of specific value, though it should be observed that in old shells, where there is a tendency to extravagant secretion, the process is thickened, as are also the median septum and internal walls of the valves. The term UNCINULUS, embracing these shells, forms a very compact association, which, in American faunas, seems to leave its last trace in the *R. speciosa*, Hall, of the Oriskany sandstone, of which mention has already been made in the discussion of PLETHORHYNCHA; a shell which, in a senile condition, shows a tendency to the formation of a cardinal process.

There is good reason to believe that this peculiar combination of characters was derived from the RHYNCHOTREMA of the Lower Silurian, the shells having somewhat the same external aspect, while on the interior the unsupported teeth and linear cardinal process of RHYNCHOTREMA point to this conclusion. At the same time it is worthy of remark that in the latter genus the cardinal process lying between the parts of the divided hinge-plate, seems to be a remnant of the median septum, while this apophysis in UNCINULUS has evidently been formed by the subapical coalescence of the lateral components of that plate.

The last of the strongly subcuboidal species to appear in the American Palæozoic faunas are variants of the well-known horizon-marker, *Rhynchonella* (*Atrypa*) *cuboides*, Sowerby; namely, *R. venustula*, Hall, of the Tully limestone, *R. Emmonsi*, Hall and Whitfield, from the upper Devonian of the White Pine District of Nevada, and *R. intermedia*, Barris, from the upper Devonian of Iowa.*

Rhynchonella cuboides, in European faunas, is indicial of upper Devonian age. Its representative in the Tully limestone, *R. venustula*, is associated with a fauna composed almost exclusively of the species of the Hamilton shales.

* Mr. C. D. WALCOTT regards the last named a synonym for *R. Emmonsi*. See Palæontology of the Eureka District, p. 157.

The internal structure of these species has never been carefully elucidated, and it is a matter of great difficulty to obtain material suitably preserved for the elaboration of the critical features of the hinge. Clean internal casts are seldom found, and no instance of the silicification of the valves has come to our notice. By careful serial sectioning, however, it has been possible to ascertain with reasonable accuracy the character of the hinge. The teeth are usually supported by short vertical lamellæ; the hinge-plate is quite small and is composed of two broad, short lateral processes, which are divided, for a portion of their length only, by a median incision extending to the bottom of the valve but not forming an inceptive spondylium as in CAMAROTŒCHIA. The dental plates are large. There is but the barest indication of a median septum in the brachial valve. The muscular impressions are small and not deep; those of the pedicle-valve making an oval scar continued from the narrow pedicle-cavity; those of the brachial valve being narrow, elongate and extremely obscure.* The interior of the pedicle-valve frequently preserves the ovarian pittings and vascular sinuses while the characters are but faintly retained on the brachial valve. The development of these features seems to be of specific or varietal value only, as they are more rarely shown in the European examples of *R. cuboides* and are absent in *R. Emmonsi*, which is a more finely plicated shell, possessing other internal structure here described.

The characters described are distinctive, but that they also occur in such allied species of the middle Devonian as *R. procuboides*, Kayser, *R. primipilaris*, von Buch, and *R. parallelepipeda*, Bronn, we can only surmise from a similarity of exterior. They are reproduced with a very slight development of the median septum, in *R. Grosvenori*, Hall, of the St. Louis limestone.

To shells of this nature may appropriately be applied the designation HYPOTHYRIS, King, 1846. There may seem to be some objection to the adoption of this term, which was introduced at an earlier date by PHILLIPS† for certain

* DAVIDSON has given, on plate ii, of his Supplement to the Devonian Brachiopoda, figures (19, 19*a*) of an internal cast which is referred to *R. cuboides*, but it would seem to be an erroneous reference. There is nothing in the figures which suggests this species, but it appears to represent a concavo-convex shell with an extended beak and strong flabellate muscular scars on both valves; in many respects suggestive of a species of EATONIA.

† Palæozoic Fossils of Cornwall, Devon, and West Somerset, p. 35. 1841.

shells perhaps rhynchonelloid in character, but it has not been, nor will it ever be possible to determine the author's conception of the term from his very brief diagnosis: "Beak acute, perforation below it." No species was cited and the name was never used in such a manner as to lead to any notion of its intended significance.

Recognizing the obstacles to the adoption of the term, Professor KING redefined it in volume xviii (p. 28) of the Annals and Magazine of Natural History (1846), deriving his diagnosis from the *Atrypa cuboides*, Sowerby, which he specified as the type of the group. It is evident from KING's observations, both in the work cited and in his Permian Fossils (pp. 110–112, 1850), that he intended the term HYPOTHYRIS to replace FISCHER DE WALDHEIM's name RHYNCHONELLA as an appellation for those shells, previously classed with the *TEREBRATULIDÆ*, which had a plicated exterior and an acute beak. Now that the state of our knowledge requires a narrower and more precise delimitation of these fossils, we are brought back to the original species, *A. cuboides*, as expressing the restricted value of the genus HYPOTHYRIS, King, and that term will be adopted for this group of Rhynchonellas in preference to introducing a new one.

SUBGENUS PUGNAX, S.-GEN. NOV.

PLATE LX.

1809. *Conchyliolithus anomites*, MARTIN. Petrefacta Derbiensia, pl. xxii, figs. 4, 5; pl. xxxii, figs. 7, 8; pl. xxxiii, figs. 5, 6.
1822. *Terebratula*, SOWERBY. Mineral Conchology, pl. cccxv, fig. 3; pl. cccxvi, figs. 5, 6; pl. cccxxiv; pl. cccxxv, figs. 1–6.
1834. *Terebratula*, VON BUCH. Ueber Terebrateln, p. 33.
1836. *Terebratula*, PHILLIPS. Geology of Yorkshire, vol. ii, p. 222, pl. xii, figs. 4–12, 16, 17, 25–30.
1840. *Atrypa*, SOWERBY. Trans. Geol. Soc. London, 2nd ser., vol. v, pl. lvi, figs. 15–18.
1841. *Terebratula*, PHILLIPS. Palæoz. Foss. Cornwall, Devon and West Somerset, p. 86, pl. xxxv, fig. 154; p. 87, pl. xxxv, fig. 156.
1843. *Terebratula*, DE KONINCK. Animaux fossiles de la Belgique, p. 278, pl. xvii, figs. 3*a–f*.
1845. *Terebratula*, DE VERNEUIL. Géol. de la Russ. et des Mont. de l'Oural., p. 78, pl. x, fig. 1.
1855. *Rhynchonella*, SHUMARD. Second Ann. Rept. Geol. Surv. Missouri, pl. c, fig. 5.
1858. *Rhynchonella*, HALL. Transactions of the Albany Institute, vol. iv, p. 10.
1858. *Rhynchonella*, HALL. Geology of Iowa, vol. 1, pt. 2, p. 658, pl. xxiii, fig. 2 *a*, *b*.
1858. *Terebratula*, MARCOU. Geology of North America, p. 58.
1859. *Camarophoria*, SHUMARD. Trans. St. Louis Acad. Sci., vol. i, p. 394.

1860. *Rhynchonella*, DAVIDSON. British Carbon. Brachiopoda, pp. 93-105, pl. xx, figs. 1-13; pl. xxi, figs. 1-20; pl. xxii, figs. 1-15; pl. xxiii, figs. 1-22.
1860. *Rhynchonella*, MCCHESNEY. Trans. Chicago Acad. Sci., vol. i, pp. 49, 50.
1862. *Rhynchonella*, WHITE. Proc. Boston Soc. Nat. Hist., vol. ix, p. 23.
1865. *Rhynchonella*, DAVIDSON. British Devon. Brachiopoda, pp. 62, 63, pl. xii, figs. 12-14; pl. xiii, figs. 6-13.
1866. *Rhynchonella*, MEEK. Geological Survey Illinois, vol. ii, p. 153, pl. xiv, figs. 4*a*, *b*.
1868. *Rhynchonella*, MEEK. Geological Survey Illinois, vol. iii, p. 450, pl. xiv, figs. 7*a*-*d*.
1871. *Terebratula*, QUENSTEDT. Petrefactenk. Deutschlands; Brachiopoden, p. 190, pl. xlii, figs. 5-7.
1883. *Rhynchonella*, WILLIAMS. American Journal of Science, vol. xxv, p. 91.
1884. *Rhynchonella*, WALCOTT. Monogr. U. S. Geol. Surv., vol. viii, p. 155, pl. xiv, figs. 7, 7*a*.
1885. *Rhynchonella*, CLARKE. Bull. U. S. Geol. Surv., No. 16, p. —.
1887. *Rhynchonella*, DE KONINCK. Faune du Calcaire Carbonifère de la Belgique, pt. 6, Brachiopodes, pls. ix, x, xi, xii.

DIAGNOSIS. Shells with deep fold and sinus; elevated, and often acuminate on the anterior margin; more or less sharply plicated, the plications usually being simple, those of the fold and sinus the strongest, and those of the lateral slopes often obscure or obsolete. Pedicle-valve shallow; brachial valve deep. Teeth supported by vertical lamellæ; hinge-plate similar in structure to that of HYPOTHYRIS: the median septum of the brachial valve is extremely faint when present, but is usually undeveloped. Muscular impressions not large but well-defined and clearly subdivided. Vascular sinuses sometimes retained on the pedicle-valve, always obscure on the brachial valve.

Type, *Conchyliolithus anomites acuminatus*, Martin. Carboniferous limestone.

It is apparent that these shells, in the character of their internal apophyses, are not widely removed from those of the type of *Rhynchonella cuboides.* The contour of the shells affords a difference of fundamental significance, and its trihedral expression in *R. acuminata* is the nearest approach, among palæozoic species, to the form of the typical RHYNCHONELLA, *R. loxia.*

The group requires a distinctive name, and the term PUGNAX has been selected as it serves to commemorate VON BUCH'S term *Pugnaceæ*, which was applied to a division of the *Rhynchonellas*, embracing the typical forms of this sub-genus.

This combination of characters appeared in the middle or later Devonian and during the various faunas of the Carboniferous became prolific in species. Among its representatives in American rocks are *R. pugnus*, Martin, and *R. reniformis*, Sowerby, of the Chemung faunas of New York; *R. alta*, Calvin, from the Upper Devonian of Iowa;* *R. Missouriensis*, Shumard, and *R. striato-costata*, Meek and Worthen, of the Choteau limestone; *R. explanata*, McChesney, of the Chester limestone; *R. mutata*, Hall, *R. Ottumwa*, White, of the St. Louis group; *R. Uta*, Marcou, *R. Eatoniiformis*, McChesney, and the *Camarophoria Swalloviana*, Shumard, of the Upper Carboniferous limestone.

Shells of this type of exterior abound in all later palæozoic faunas.

GENUS EATONIA, HALL. 1857.

PLATE LXI.

1841. *Atrypa*, CONRAD. Ann. Rept. Palæont. Dept. N. Y. Geol. Survey., p. 56.
1842. *Atrypa*, VANUXEM. Geology of N. Y.; Rept. Third Dist., pp. 120, 121, figs. 4, 5.
1843. *Atrypa*, MATHER. Geology of N. Y.; Rept. First Dist., p. 342, fig. 3; p. 343, figs. 3, 4.
1843. *Atrypa*, HALL. Geology of N. Y.; Rept. Fourth Dist., p. 148, fig. 3.
1857. *Eatonia*, HALL. Tenth Ann. Rept. N. Y. State Cab. Nat. Hist., pp. 90–92, figs. 1–7.
1859. *Eatonia*, HALL. Twelfth Ann. Rept. N. Y. State Cab. Nat. Hist., pp. 35–37, figs. 1–7.
1859. *Eatonia*, HALL. Palæontology of N. Y., vol. iii, pp. 241–243, 432–438, pl. xxxvii, figs. 1 *a–y*, 2 *a–c*; pl. xxxviii, figs. 14–26; pl. ci, figs. 1, 2; pl. ci *a*, figs. 2–6.
1868. *Eatonia*, MEEK and WORTHEN. Geol. Surv. Illinois, vol. iii, p. 395, pl. viii, figs. 2 *a–d*.

Concavo-convex shells with median fold and sinus, and plicated or radiate-lineate exterior. Anterior margin deeply sinuate. From the beak of the pedicle-valve diverge two lateral cardinal ridges which limit a more or less distinct false area. On the interior the teeth are adnascent to the lateral walls

* The *Rhynchonella alta*, Calvin, which some American writers have considered equivalent to *R. pugnus*, Martin, is a local form retaining quite persistently the features of *R. anisodonta*, Phillips (*R. pugnus*, var. *anisodonta*, Davidson). Though always smaller than the representatives of *R. pugnus*, occurring in the High Point (New York) fauna, at the base of the Chemung series, it less frequently shows a tendency toward the acute *acuminata*-like fold than the latter. The fact that the New York shell evinces gradations in form which include both the *pugnus* and the *acuminata* type of exterior is but a further substantiation of the argument upon which McCOY, in 1852, reduced the latter to a variety of the former. This position has been contested by DAVIDSON and other writers, who nevertheless note the great variability of the shells passing under these two names. That it may be convenient to retain both terms is undoubtedly true, but the passage of one series of forms into the other is quite as apparent among the Devonian as among the Carboniferous shells. It may be a fair question whether the Devonian shells passing as *R. pugnus* and *R. acuminata* are entitled to these names; whether, for instance, it would not be better to retain PHILLIP'S name, *R. anisodonta*, for the former, and, possibly, *R. triangularis*, Sowerby, for the latter. In both of the former cases the originals were from the Carboniferous limestone of Derbyshire and attained, as a usual habit, a much greater size than the Devonian shells. The American Carboniferous shells representing the specific type of *R. pugnus*, namely, *R. striato-costata*, Meek and Worthen, *R. Missouriensis*, Shumard, bear a fine radiate-lineate ornamentation, and what might be interpreted as a similar character is apparent in many of DAVIDSON'S figures of the Carboniferous species (Carboniferous Brachiopoda, pl. 22), though this feature is not mentioned in his descriptions. The same character is highly developed in the Devonian species, *R. Meyendorfi*, de Verneuil, a sharply acuminate shell without plications.

of the valve, all traces of supporting lamellæ being absent. Muscular area large, flabellate and deeply excavated in the substance of the shell. Pedicle impression broad, traversed medially by a longitudinal groove; diductors extending for about one-half the length of the shell, their outer margins being elevated; they enclose a pair of small central adductor scars whose posterior margins are raised into prominent myophores. The scars are divided by a slight median septum which is continued posteriorly: this septum being often rendered very conspicuous by the growth of the shell about the apophyses of the cardinal process of the opposite valve, and in extreme cases its development is such that it rises above, and encloses the adductor scars, the latter being excavated in its substance.

In the brachial valve the dental sockets are long and narrow, the cardinal process very large and composed of a stout, erect stem resting upon a rather short median septum, and divided at its summit into two long, divergent, tooth-like branches, whose upper faces extend to the interior surface of the opposite valve; hence their greatest elevation is at their anterior extremities, whence they slope toward the beak of the valve, usually uniting before that point is reached. The surface of attachment of each of these apophyses is medially grooved. Below them, and at the base of the central stem, arise the crura, which are long, straight and slender, with expanded extremities. The muscular scars are clearly defined and consist of a pair of small posterior adductors, and in front of them a larger pair whose surface is radially striated, the entire area being elongate-oval. Vascular impressions are occasionally retained in the pedicle-valve.

Type, *Atrypa medialis*, Vanuxem. Lower Helderberg group. (Delthyris shaly limestone.)

Observations. In the species of this genus the internal apophysary system attains its highest development among the rhynchonelloids. Though the form of the shells is invariably elongate-, or transversely subquadrate, their internal characters demonstrate their close alliance to the subcuboidal shells of Uncinulus, and the genus prevails where the latter is most prolific, namely, in the faunas of the Lower Helderberg and Oriskany groups. EATONIA bears very much the same relation to UNCINULUS as the subgenus PUGNAX to the cuboidal shells of HYPOTHYRIS. The species of EATONIA possess two quite distinct types of exterior, one strongly plicated over fold, sinus and lateral slopes, the other radially lineate, with broad margins of contact, which are usually crenulated as if by the extremities of the rounded plications. To the former belong *E. medialis*, Vanuxem, and *E. eminens*, Hall, of the Lower Helderberg group, *E. sinuata* and *E. Whitfieldi*, Hall, of the Oriskany sandstone; to the latter, *E. singularis*, Vanuxem, of the Lower Helderberg, *E. peculiaris*, Conrad, of that fauna and of the Oriskany sandstone, and *E. pumila*, Hall, also of the Oriskany sandstone.

GENUS CYCLORHINA, GEN. NOV.

PLATE LXI.

1860. *Rhynchospira*, HALL. Thirteenth Rept. N. Y. State Cab. Nat. Hist., p. 83.
1867. *Trematospira?*, HALL. Palæontology of New York, vol. iv, p. 412, pl. lxiii, figs. 33-36.
1889. *Retzia (Trematospira)*, WHITEAVES. Contrib. Canadian Palæont., vol. i, pt. 2, p. 116.

Shells of comparatively large size at maturity, subtriangular in outline; biconvex, the convexity of the brachial valve being the greater. Fold and sinus very broad, and developed in the usual manner, on brachial and pedicle-valves respectively.

On the pedicle-valve the apex is obtuse, not elevated, and is very broadly truncated by a large circular foramen, which, even in the earliest growth-stages observed, is enclosed for fully five-sixths of its periphery by the substance of the valve. The deltidial plates are incipient at maturity and scarcely evident in young shells; the delthyrial margins are extremely divergent. The cardinal line is short but straight, and its extremities are produced on each side to form a short alate process or wing, similar to those in the genus EUMETRIA. These extensions occur on both valves, and are very apparent in the younger shells, but become somewhat obscured with the increase of convexity accompanying maturity. On the interior, the teeth are large and blunt, and attached to the lateral walls of the shell, though they also rest upon the thick lamellæ similarly attached except at their anterior margins, and which converge downward to form a deep, broad, transversely striated pedicle-cavity. The thickened lateral margins of this impression are continued anteriorly to about the center of the shell, forming an elongate-quadrate diductor scar which encloses a small oval adductor.

The brachial valve has a convex umbo, showing no evidence of concavity in early stages of growth. Beneath the beak is a very fine, vertical, linear cardinal process which appears to be continuous with an obscure median longitudinal ridge, traversing about one-half the length of the valve. Both of these are frequently involved in the shell-substance and evident only in sections of the shell. The hinge-plate is deeply divided medially, each lateral portion being supported by a deep vertical septum resting on the bottom of the valve. The upper surfaces of the hinge processes are obliquely concave the outer and anterior angle being much elevated and the slope thence to the dental sockets abrupt. The crura are attached to the inner margins of these plates, are not curved, but their distal extremities are expanded into spoon-shaped processes which have their concave surfaces toward the brachial valve. Their are no thickened muscular scars as in the opposite valve.

The surface is covered with sharply angular, simple plications, most of which begin in the umbonal regions, and the broad fold and sinus may bear as many as from eight to twelve of these. All the plications are crossed by fine, sharp concentric lines of ornamentation, which crenulate the summits of the ridges.

Shell-substance fibrous, impunctate.

Type, *Rhynchospira nobilis*, Hall. Hamilton group.

OBSERVATIONS. The peculiar structure of this shell involved the earlier determination of its generic relations in much doubt. It was described in the Thirteenth Report of the State Cabinet of Natural History (p. 83, 1860), as *Rhynchospira nobilis*, and in Volume IV of the Palæontology of New York (p. 412, 1867), it was referred to TREMATOSPIRA? The acquisition of new material* from the Hamilton group at Thedford, Canada, has afforded the means of demonstrating that the shell is not spire-bearing. The external aspect of the

* Largely by the favor of Professor SAMUEL CALVIN, of Iowa City, Iowa.

shell in both its young and immature conditions is, in a certain measure suggestive of RHYNCHOTRETA, a resemblance increased by the peculiar concentric ornamentation of both, but lessened by the low, truncated beak of the pedicle-valve of CYCLORHINA. On the interior the structure is altogether different. The shell presents a rare combination of structural features which have been observed only in the single species mentioned. It seems to approach most nearly to the type exemplified by WAAGEN'S genus TEREBRATULOIDEA, especially in the structure of the deltidium and foramen.

It is elsewhere observed that variations in the foramen and deltidial plates among the rhynchonelloids were largely features of developmental value. In this case, however, the great encroachment of the foramen on the substance of the valve must have been fully effected at a very early stage of growth, for in the youngest shells observed it is as extremely developed as in mature individuals. The alate or auriculate character of the cardinal extremities is a distinctive feature, while the slight development of the median septum and cardinal process may not be regarded as of much significance in a comparison with TEREBRATULOIDEA. The straightness of the crura is a feature quite unusual among the rhynchonelloids, perhaps nowhere so marked as here, while the concave expansion of their extremities is of more frequent occurrence.

GENUS TEREBRATULOIDEA, WAAGEN. 1883.

1862. *Rhynchonella*, DAVIDSON. Quarterly Journal Geol. Soc. London, vol. xviii, p. 29.
1863. *Rhynchonella*, DE KONINCK. Fossiles paléozoiques de l'Inde., p. 36.
1883. *Terebratuloidea*, WAAGEN. Salt-Range Fossils; Brachiopoda, pp. 413–424, pl. xxxiii, figs. 1–12.

DIAGNOSIS. "Shell more or less transversely oval or rounded, in its general appearance *Rhynchonelloid*, with strongly plaited valves and a high median fold in the dorsal and a corresponding sinus in the ventral valve. Hinge-line curved, beak truncated with a terminal round foramen; deltidium formed of two distinct plates, which limit the foramen below only for a very short distance.

"Internally, the ventral valve with two strong hinge-teeth, which are, however, not supported by dental plates. The dorsal valve bears a tolerably large triangular hinge-plate, which is united on both sides by the deep dental sockets.

and is triangularly cut open in the middle up to the very apex of the valve, which also is a little cut out. There is no cardinal process. On both sides of

FIG. 156.

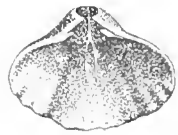

FIG. 157.

FIG. 158.

Terebratuloidea Davidsoni, Waagen.

Fig. 156. View of the exterior.
Fig. 157. Interior of the pedicle-valve
Fig. 158. Interior of the brachial valve. (WAAGEN.)

the median incision very short curved crura take their origin, and proceed for a short distance in a slightly diverging direction towards the interior of the shell. There is no median dorsal septum.

"The muscular and vascular impressions are not sufficiently distinct to be described accurately." (WAAGEN, *op. cit.*, p. 414.)

Type, *Terebratuloidea Davidsoni*, Waagen. Permo-Carboniferous.

OBSERVATIONS. The difference existing between these shells and those constituting the subgenus PUGNAX, appears to be mainly in the constant presence, in all later growth-stages, of a large apical truncating foramen. Dr. WAAGEN makes this a feature of first importance. Its character at maturity and its presence in immature phases of the shell are a repetition of the facts observed in *Cyclorhina nobilis*; like the latter, also, the exterior of the shell suggests a spire-bearing interior, and WAAGEN mentions his surprise at the discovery that his shells were rhynchonelloid. But for the presence of this highly developed foramen it would be difficult to distinguish the Indian shells from some of the small species of the American Upper Carboniferous faunas, belonging to the subgenus PUGNAX, which have the foramen normally concealed at maturity and but partially enclosed at any stage of growth. In the former it is fully developed at an early stage and maintained throughout the subsequent history of the individual. The relation of TEREBRATULOIDEA to PUGNAX thus appears to be that of a senile to an immature condition of development.

GENUS RHYNCHOPORA, KING. 1856.

PLATE LVIII.

1844. *Terebratula*, DE VERNEUIL. Bull. de la Soc. géol. de France, vol. i, p. 27.
1845. *Terebratula*, DE VERNEUIL. Géol. de la Russ. et des Mont. de l'Oural, p. 83, pl. x, figs. 5 *a*, *b*.
1848. *Terebratula*, GEINITZ. Verstein. des deutsch. Zechsteingeb., p. 12, pl. iv, figs. 41, 42.
1856. *Rhynchopora*, KING. Annals and Magazine of Natural History, second series, vol. xvii, p. 506, pl. xii, figs. 7-11.
1860. *Rhynchonella*, WHITE. Jour. Boston Soc. Nat. Hist., vol. vii, p. 236.
1861. *Rhynchonella*, GEINITZ. Dyas, p. 83, pl. xv, figs. 29-32.
1880. *Rhynchopora*, DAVIDSON. British Carb. Brachiopoda, Suppl., p. 286, pl. xxxiii, figs. 11 *a-c*.
1885. *Rhynchopora*, TSCHERNYSCHEW. Permsky Esvestnyace Kostromskoy Guberny, p. 21, pl. iii, fig. 20; pl v, figs. 34-36.
1887. *Rhynchoporina*, ŒHLERT. Fischer's Manuel de Conchyliologie, p. 1305.

There are very few rhynchonelloid species in the Carboniferous and Permian faunas which, without evincing any essential difference from CAMAROTŒCHIA in the character of the internal apophyses, possess a strong shell-punctation, not merely superficial but extending quite through the thickness of the valves. To one of these shells, *Terebratula Geinitziana*, de Verneuil, KING gave the name RHYNCHOPORA, in 1856; a Permian species described from Russia, though the examples upon which KING established its generic characters were obtained from the Zechstein of Germany (Röpsen). Dr. GEINITZ had identified DE VERNEUIL'S species in 1848,* and in 1861† in the German faunas, and TSCHERNYSCHEW‡ has more recently shown that the Russian specimens possess the shell punctation, so that there is no reason to doubt the specific identity of the type. None of the figures which have been given of this species nor of the *R. Nikitini*, Tschernyschew,§ also from the Permian, nor of the *R Youngi*, Davidson,‖ from the Upper Carboniferous limestone of Ayrshire, show the interior characters of the shells. From an examination of the only American species which can now be referred to RHYNCHOPORA, namely, *Rhynchonella pustulosa*, White, of the Burlington limestone, it appears that the teeth are supported by conspicuous vertical lamellæ, the septum of the brachial valve well developed and the

* Die Versteinerungen des deutschen Zechsteingebirge, p. 12, pl. iv, figs. 41, 42.

† Dyas, p. 83, pl. xv, figs. 29-32.

‡ *Op. cit.*, p. 21.

§ *Op. cit.*, p. 21, pl. v, figs. 34-36.

‖ Suppl. Carboniferous Brachiopoda, p. 286, pl. xxxiii, figs. 11 *a-c*.

hinge-plate medially divided and without cardinal process. Externally the shells are strongly plicate with broad, low fold and sinus, and abrupt anterior slope.

As far as the structure of the species of Rhynchopora is understood, the complete punctation of the shell must be regarded as the only reliable differential from earlier rhynchonellid groups. The appearance of this character late in the palæozoic history of the *Rhynchonellidæ* suggests its similar manifestation in some of the Spirifers of the Carboniferous, in Syringothyris and in Spiriferina. Future study may show that the inner shell laminæ of the early rhynchonellids is not uniformly impunctate, and should this be demonstrated, the appearance in this group of a highly punctated shell like Rhynchopora will be more readily intelligible.

It has been suggested by Œhlert that the term Rhynchoporina may be used in preference to King's term Rhynchopora, on the ground that the latter had been previously used by Latreille for a genus of Coleoptera. The latter author's term appears to be not Rhynchopora, but Rhynchophora, and as the words are etymologically distinct, it seems best not to disturb Dr. King's term.

CAMAROPHORIA, King. 1846.

PLATE LXII.

1809. *Conchyliolithus anomites*, Martin. Petrefacta Derbiensia, pl. xxxvi, fig. 4.
1834. *Terebratula*, von Buch. Ueber Terebrateln, p. 39, pl. ii, fig. 32.
1836. *Terebratula*, Phillips. Geology of Yorkshire, vol. ii, p. 222, pl. xii, figs. 18-20.
1841. *Terebratula*, Phillips. Palæozoic Fossils Cornwall, Devon and West Somerset, p. 88, pl. xxxv, fig. 158.
1844. *Atrypa*, McCoy. Synopsis Carb. Fossils Ireland, p. 154, pl. xviii, fig. 8.
1844. *Camarophoria*, King. Annals and Magazine of Natural History, vol. xiv, p. 313.
1845. *Terebratula*, de Verneuil. Géol. de la Russie, vol. ii, pp. 101-103, pl. viii, figs. 4 *a-e*.
1846. *Camarophoria*, King. Annals and Magazine of Natural History, vol. xviii, p. 28.
1850. *Camarophoria*, King. Monogr. Permian Fossils of England, pp. 113-122, pl. vii, figs. 10-32; pl. viii, figs. 1-8.
1854. *Camarophoria*, Davidson. Introd. British Fossil Brachiopoda, p. 96, pl. vii, figs. 108-113.
1855. *Rhychonella*, Shumard. Geology of Missouri, p. 204, pl. c, figs. 5 *b*, 5 *c*.
1857. *Camarophoria*, Davidson. British Permian Brachiopoda, pp. 23-28, pl. ii, figs. 16-31.
1857. *Camarophoria*, Howse. Annals and Magazine of Natural History, vol. xix, second series, p. 50, pl. iv, figs. 3, 4.
1858. *Camarophoria* (?), Shumard. Trans. St. Louis Acad. Sci., vol. i, p. 296, pl. xi, fig. 2.
1858. *Rhynchonella*, Hall. Transactions of the Albany Institute, vol. iv, p. 11.
1860. *Camarophoria*, Davidson. British Carboniferous Brachiopoda, pp. 113-118, pl. xxiv, figs. 9-22; pl. xxv, figs. 1-12.
1860. *Rhynchonella*, Swallow. Trans. St. Louis Acad. Sci., vol. i, p. 653.
1860. *Rhynchonella*, Meek and Worthen. Proc. Acad. Nat. Sci. Philadelphia, vol. iv, second series, p. 451.
1861. *Camarophoria*, Geinitz. Dyas, p. 84, pl xv, figs. 33-48.
1862. *Rhynchonella*, White. Proc. Boston Soc. Nat. Hist., vol. ix, p. 23.
1862. *Pentamerus*, White and Whitfield. Journal Boston Soc. Nat. Hist., vol. viii, p. 295.
1865. *Camarophoria*, Davidson. British Devonian Brachiopoda, p. 70, pl. xiv, figs. 19-22.
1866. *Camarophoria*, Meek and Worthen. Geol. Survey of Illinois, vol ii, p. 251, pl. xviii, fig 7.
1868. *Rhynchonella*, Meek and Worthen. Geol. Survey of Illinois, vol iii, p. 450, pl. xiv, fig. 7.
1881. *Camarophoria*, Miller. Journal Cincinnati Soc. Nat. Hist., vol. iv, p. 8, pl. vii, fig. 7.
1882. *Camerophoria*, Worthen. Bull. Illinois State Museum, No. 1, p. 39.
1882. *Camarophoria ?*, Whitfield. Bull. American Mus. Nat. Hist., p. 54, pl. vi, figs. 35-39.
1883. *Camarophoria*, Waagen. Palæontologia Indica, ser. xiii, vol. iv, p. 435.
1883. *Camerophoria*, Worthen. Geological Survey of Illinois, vol. vii, p. 318, figs. *a-c*.
1883. *Camarophoria*, Hall. Twelfth Rept. State Geologist Indiana, p. 334, pl. xxix, figs. 35-39.
1887. *Stenoschisma*, Oehlert. Fischer's Manuel de Conchyliologie, p. 1309, fig. 1095.

Diagnosis. Subtrigonal, concavo-convex rhynchonelliform shells, with median fold and sinus well developed, and surface more or less strongly plicated. Beak sharp, incurved; deltidial plates in an incipient condition, often wanting.

In the pedicle-valve the dental plates converge, forming a moderately large spondylium which, in the umbonal region, rests upon the bottom of the valve, but anteriorly is supported by a vertical median septum. The spondylium is short, while the supporting septum is carried beyond it, sometimes to nearly one-half the length of the shell. Near the teeth, which are small, there are two accessory supporting lamellæ abutting on one side against the outer surface of the converging dental plates, and on the other against the interior cardinal surface of the valve; thus enclosing small lateral umbonal cavities. Muscular scars of this valve always obscure.

In the brachial valve the cardinal plate is narrow, subtriangular, in the typical species bearing a very small cardinal process, which in other species is rarely present. The hinge-plate is traversed by two fine, divergent ridges running outward from the beak and continuous beyond the anterior edge of the plate into long, slender and upwardly curving crura. Beneath the crura arises a broad, shallow, trough-shaped plate, which, near the apex, is supported by a short median septum resting on the valve. This process is strongly curved toward the opposite valve and is continued for most of its length beyond the termination of the median septum. Usually it widens outwardly, and then narrows rather abruptly, or even acutely, to its extremity. The adductor muscular scars are well developed in this valve, forming a broadly oval or subcircular impression.

Vascular sinuses are sometimes retained on both valves.

Type, *Terebratulites Schlotheimi*, von Buch.* Permian.

OBSERVATIONS. According to our present knowledge, this genus represents the latest appearance of the camarellid interior. Its relations to the various groups of the rhynchonellids is largely, and we may say with a single reservation, wholly external. Species of CAMAROTŒCHIA do develop, in the brachial valve, an elongate cavity on the summit of the median septum; this is always in an incipient condition and is attained quite independently of any association with, or derivation from CONCHIDIUM and its allies. From this source may have come the brachial spondylium of CAMAROPHORIA, though the mode of attachment beneath, instead of in continuity with the hinge-plate, may perhaps render such assump-

* DAVIDSON, at various times, expressed the opinion that this specific term should be regarded as a synonym for MARTIN'S *Conchyliolithus anomites crumena*, from the Carboniferous limestone. There are some differences in the two shells as described and illustrated by Mr DAVIDSON, and as the typical forms of each are from distinct faunas it is wiser to keep them apart. The Permian shell is the type of CAMAROPHORIA.

tion open to question. No observed rhynchonellid has a septum or evinces any tendency to the formation of a spondylium in the pedicle-valve, as in CAMAROPHORIA. CAMAROPHORIA is a genus combining a modified pentameroid interior with a rhynchonelloid exterior. The genus appeared in the early Devonian, when the prevalence of the pentameroids was past, and species of CAMAROTŒCHIA were on the increase. Its earliest representative in American palæozoic faunas seems to be a shell which occurs in the Corniferous limestone of Cass county, Indiana, and which is hardly distinguishable from the middle Devonian forms referred to the *Terebratula rhomboidea*, Phillips.* This American shell, the occurrence of which has not before been noted, corresponds with the Devonian shells figured by DAVIDSON, though nearly all the specimens give some evidence of lateral plications about the margins. No opinion will be here expressed as to the specific identity of these Devonian, Carboniferous and Permian shells, except to distinguish by the name, *Camarophoria rhomboidalis*, the American Devonian species, from the Carboniferous shells described by PHILLIPS as *Terebratula rhomboidea*. Representatives of the genus are never abundant in American faunas, and the species mentioned appears to be its only known example in the Devonian.†

In the early Carboniferous faunas are a few well-defined species: *C. ringens*, Swallow, from the chert beds of the Burlington limestone; *C subtrigona*, Meek and Worthen, from the Keokuk group; *C. Wortheni*, Hall, and *Rhynchonella subcuneata*, Hall, from the St. Louis formation.

The species *C. Giffordi*, Worthen, has been described from the Coal Measures, and *C. bisulcata* and *C. Swallovana*, Shumard, from beds considered to be of Permian age.‡

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* PHILLIPS' species was based upon specimens from the Carboniferous limestone of Bolland (Geology of Yorkshire, p. 222, pl. xii, figs. 18–20. 1836). Later, in his Palæozoic Fossils of Cornwall (p. 88, pl. xxxv, fig. 158. 1841), he referred the Devonian shell to the same species, and is followed by DAVIDSON and other authors in ascribing to this species a range from the Devonian into the Permian, where it passes under the name of *C. globulina*, Phillips (see DAVIDSON, Carboniferous Brachiopoda, p. 115; Devonian Brachiopoda, p. 70; KAYSER, Zeitschr. der Deutsch. geolog. Gesellsch., vol. xxiii, p. 529).

† The shell described in Volume IV of the Palæontology of New York (p. 368) as *Camarophoria Eucharis*, Hall, from the Corniferous limestone, is spirigerous, and has been taken as the type of the proposed genus CAMAROSPIRA.

‡ The *Camarophoria globulina*, (Phillips) Davidson, and *C. Dawsoniana*, Davidson, from the upper Carboniferous of Windsor, Nova Scotia, are not Camarophorias but rhynchonellids, similar to *R. Uta*, Marcou.

There is considerable variation in exterior among the Camarophorias. *C. Schlotheimi* is a triangular or deltoidal shell with the plication clearly developed on fold and sinus, but obscure on the lateral slopes. The greater number of the European and Indian Carboniferous and Permian species have a similar exterior. In *C. Schlotheimi*, von Buch, and *C. Humbletonensis*, Howse, the margins of the shell are, normally, expanded as in some Devonian forms of *Atrypa reticularis*. *Camarophoria subtrigona*, Meek and Worthen, *C. isorhyncha*, McCoy, are large subcuboidal species, while *C. ringens*, Swallow, *C. caput-testudinis*, White, and *C. subcuneata*, Hall, are acutely triangular in outline, with broad, concave cardinal slopes. The species of both the latter groups are strongly plicated throughout, while in *C. ringens* the surface also bears a fine radiate lineation.

The *Camarophoria* (*Pentamerus*) *lenticularis*, White and Whitfield, from the Yellow sandstones beneath the Burlington limestone, at Burlington, Iowa, is a shell widely different from all the foregoing in external features. The valves are biconvex and their outline subcircular; it has no fold and sinus and no plications, the surface being smooth and regularly arched. To associate it generically with the plicate trihedral Camarophorias requires an effort of the imagination. At the same time its internal characters are normal for Camarophoria, except that the broad, spatuliform spondylium rests upon the valve for most of its length, the median septum penetrating it and projecting above it into the interior cavity of the shell. It is proposed to signalize these differences, and thus to render the association constituting Camarophoria the more homogeneous, by giving this species the subgeneric designation, Camarophorella.

GENUS SYNTROPHIA,* GEN. NOV.

PLATE LXII.

1861. *Camarella*, BILLINGS. Canadian Naturalist and Geologist, vol. vi, p. 318.
1862. *Stricklandinia?*, BILLINGS. Palæozoic Fossils, vol. i, p. 85, figs. 77, 78.
1864. *Orthis*, A. WINCHELL. American Journal of Science, second series, vol. xxxvii, p. 229.
1882. *Leptæna*, *Triplesia*, WHITFIELD. Geology of Wisconsin, vol iv, p. 171, pl. i, figs. 6, 7; pl. iii, fig. 6; p. 172, pl. x, figs. 1, 2.
1886. *Triplesia*, WHITFIELD. Bull. American Mus. Nat. Hist., vol. i, No. 8, p. 303, pl. xxiv, figs. 9–11.
1892. *Syntrophia*, HALL. Palæontology of N. Y., vol. viii, part i, p. 270.

In considering the spondylium-bearing shells of the earlier faunas, there are great difficulties in the determination of positive taxonomic characters. The features of the exterior and, to a great degree, those of the interior, are plastic and variable, failing to assume that fixity of form possessed by their successors in later faunas, and upon which we depend for a proper conception of generic values. Here circumspection must be used, lest generic distinctions be too arbitrary, or too narrowly drawn on the basis of differences which, among later fossils, would properly be considered of higher significance. The earlier divisions must be allowed more elasticity, as the types they include are formative and inconstant. The spondylium-bearing species of the Lower Silurian are mostly subtrihedral shells with the external aspect of RHYNCHONELLA, but there are a few described species which have an exterior similar to members of the genera PROTORTHIS and BILLINGSELLA, that is, they are small, transversely elongate in outline, with straight, well-defined cardinal area. Such are the *Stricklandinia? Arachne* and *S. Arethusa*, Billings, of the Quebec group (Limestone No. 2); *Orthis Barabuensis*, A. Winchell, from the Potsdam sandstone of Baraboo, Wisconsin, and the *Triplesia lateralis*, Whitfield, of the Calciferous fauna of New York and Vermont. For these shells the name SYNTROPHIA will be adopted, the last-named species being selected as the type of the group, since the material derived from various sources has afforded the means of obtaining a very clear conception of its external and internal features.

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"The *Triplesia lateralis*, Whitfield, of the Fort Cassin beds (Calciferous sandstone), contains a spoon-shaped process in each valve, that in the pedicle-valve being supported by a median septum. It therefore becomes necessary to remove this form to a distinct genus and to a different association, and it will be described and illustrated in its proper place under the name SYNTROPHIA."—Palæontology of New York, vol. viii, part i, page 270. (This note was printed in 1891.)

*Triplesia lateralis** is a transversely elongate, biconvex shell, with a straight hinge-line whose length nearly equals the greatest diameter of the valves, and each valve is medially divided by an open delthyrium. The external surface is smooth, with fine concentric lines visible only about the margins; the inner shell-layers show a strongly fibrous radiating structure without punctation. The pedicle-valve bears a more or less clearly developed median sinus and the brachial valve a broad, indistinct fold.

On the interior the teeth are very small, lying at the extremities of the delthyrial margins and supported by dental plates which converge and unite before reaching the bottom of the valve. Thus is formed a deep but short spondylium, which is supported, near its apical portion, by a median septum, but is free for fully one-half its length.

In the brachial valve there are also two convergent plates bounding the deltidial cavity, larger and stronger than those of the opposite valve. These plates may rest upon the bottom of the valve, and probably always do so toward the posterior extremity, but anteriorly they become free, forming a spondylium which is supported by a median septum extending beyond the anterior edge of the plate. Thus these two valves, which are very similar in exterior, the pedicle-valve being only slightly the more convex and with a low median sinus, are also closely alike on the interior, each being furnished with a spondylium.

Adhering to this species, as typical of a peculiar generic structure, there seems no reason to doubt that BILLINGS' species *Stricklandinia? Arachne* and *S. Arethusa* should be associated with it. They are externally of the same character except that the surface of the former bears obscure radiating plications. On the interior the septum supporting the spondylium is longer and projects anteriorly, and the description of *S.? Arachne* states that in the brachial valve there is no median septum. While we have not had the opportunity of examining the originals of these species, it may be observed that in *Syntrophia lateralis* this septum is so delicate as to be detected with difficulty in preparations of the interior, but transverse sections of the valves do not fail to reveal it.

* WHITFIELD, Bull. American Museum of Nat. History, vol. i, No. 8, p. 303, pl. xxiv, figs. 9-11. 1886.

The figures of *Leptæna Barabuensis*, given by WHITFIELD, represent internal casts of both valves indicating the existence of a supported spondylium in each.* It may be that BILLINGS' *Orthis? Armanda*,† from the Quebec group, is an allied species with a radially striated exterior.

The relations of these shells to STRICKLANDIA = STRICKLANDINIA are not remote in these points of structure, and it may be inferred that they represent the inception of the structure which is exhibited by the Stricklandinias of the later Silurian and the Devonian. In the contour of the exterior a slight variation is presented by the *Triplesia primordialis*, Whitfield,‡ from the Potsdam sandstone of Adams county, Wisconsin, and the *Camarella calcifera*, Billings, from the Quebec group.§ By the greater development of the median fold and sinus the form of the shell becomes subtrihedral and resembles, not a little, some of the Trenton limestone species of TRIPLECIA; but *Camarella calcifera* possesses a very small spondylium in the pedicle-valve and probably one in the brachial valve also. At present there seems no valid reason for excluding these shells from the genus SYNTROPHIA. They evidently bear no relation to TRIPLECIA.

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* Geology of Wisconsin, vol. iv, pl. i, figs. 6, 7; pl. iii, fig. 6.

† Palæozoic Fossils, vol. i, p. 303, figs. *a, b, c*.

‡ Geology of Wisconsin, vol. iv, p 172, pl. x, figs. 1, 2. 1882.

§ Canadian Naturalist and Geologist, vol. vi, p. 318. 1861.

GENERA (1) CAMARELLA, BILLINGS, 1859; (2) PARASTROPHIA, GEN. NOV.; (3) ANASTROPHIA, HALL, 1867.

PLATES LXII, LXIII.

(3) 1839. *Terebratula*, J. DE C. SOWERBY. Murchison's Silurian System, pls. xii, xiii.
(2) 1847. *Atrypa*, HALL. Palæontology of N. Y., vol. i, p. 144, pl. xxxiii, fig. 10.
(3) 1848. *Terebratula*, DAVIDSON. Bull. Soc. Géol. de France, second series, vol. v, p. 328.
(3) 1848. *Hypothyris*, SALTER. Mem Geol Survey Great Britain, vol. ii, p. 28?.
(3) 1852. *Atrypa*, HALL. Palæontology of New York, vol. ii, p. 275, pl. lvii, fig. 2.
(1) 1856. *Atrypa*, BILLINGS. Canadian Naturalist and Geologist, vol. i, p. 208, figs. 20–23.
(2) 1857. *Pentamerus*, BILLINGS. Geological Survey of Canada; Rept. of Progress for 1856; p. 295
(3) 1857. *Pentamerus*, HALL. Tenth Rept. N. Y. State Cab. Nat. Hist., p. 104, figs. 1, 2.
(3) 1859. *Pentamerus*, HALL. Twelfth Rept. N. Y. State Cab. Nat. Hist., p. 77.
(3) 1859. *Pentamerus*, HALL. Palæontology of New York, vol. iii, p. 260, pl. xlviii, fig. 1.
(3) 1859. *Rhynchonella*, SALTER. Murchison's Siluria, p. 544, pl. xxii, fig. 10.
(1) 1859. *Camarella*, BILLINGS. Canadian Naturalist and Geologist, vol. iv, pp. 301, 302, 445, figs. 23, 24.
(3) 1860. *Rhynchonella*, LINDSTRÖM. Gotland's Brachiopoden, p. 366.
(1) 1861. *Camarella*, BILLINGS. Geology of Vermont, vol. ii, p. 949, fig. 353.
(1) 1861. *Camarella*, BILLINGS. Palæozoic Fossils, vol. i, p. 10, fig. 13.
(2) 1862. *Camarella*, BILLINGS. Palæozoic Fossils, vol. i, p. 148, figs. 128, *a*, *b*.
(1) 1863. *Camarella*, BILLINGS. Geology of Canada, p. 127, figs. 52, 53; p. 143, figs. 77, 78; p. 168, fig. 154; p. 284, fig. 290.
(3) 1863. *Pentamerus*, BILLINGS. Geology of Canada, p. 957, fig. 453.
(3) 1865. *Brachymerus*, SHALER. Bull. Mus. Comparative Zoology, No. 4, p. 69.
(1) 1865. *Camarella*, BILLINGS. Palæozoic Fossils, vol. i, pp. 219, 304, fig. 295; p. 305, fig. 297.
(1) 1866. *Camarella*, BILLINGS. Catalogue Silurian Fossils of Anticosti, p. 45.
(3) 1867. *Anastrophia*, HALL. Twentieth Rept. N. Y. State Cab. Nat. Hist., p. 163.
(3) 1867. *Anastrophia*, HALL. Palæontology of N. Y., vol. iv, p. 374.
(3) 1869. *Rhynchonella*, DAVIDSON. British Silurian Brachiopoda, p. 178, pl. xxii, figs. 24–27.
(3) 1879. *Anastrophia*, HALL. Twenty-eighth Rept. N. Y. State Mus. Nat. Hist., p. 168, pl. xxvi, figs. 41–49.
(3) 1882. *Anastrophia*, HALL. Eleventh Rept. State Geologist of Indiana, p. 311, pl. xxvi, figs. 41–49.
(2) 1883. *Rhynchonella*, DAVIDSON. British Silurian Brachiopoda, Suppl., p. 201, pl. xi, figs. 26 *a–d*.
(1) 1883. *Stricklandinia?*, DAVIDSON. British Silurian Brachiopoda, Suppl., p. 166, pl. ix, figs. 27–29.
(1) 1886. *Camarella*, WALCOTT. Bull. U. S. Geol. Survey, No. 30, p. 122, pl. vii, fig. 8.
(1) 1889. *Camarella?*, WALCOTT. Proc. U. S. National Museum, vol. xii, p. 36.
(3) 1889. *Anastrophia*, BEECHER and CLARKE. Memoirs N. Y. State Museum, p. 32, pl. iii, figs. 14–16.
(3) 1889. *Anastrophia*, NETTELROTH. Kentucky Fossil Shells, p. 47, pl. xxxii, figs. 17–20.
(1) 1890. *Camarella?*, WALCOTT. Tenth Ann. Rept. Director U. S. Geological Survey, p. 614, pl. lxxii, figs. 4 *a–d*.

CAMARELLA, BILLINGS. 1859.

PLATE LXII.

The name CAMARELLA was originally applied to subtrihedral biconvex shells with low median fold and sinus; having, in effect, a rhynchonelloid exterior. The first species of the genus cited by its author, and that which will be taken as representing the typical structure of the group, is *Camarella Volborthi*, Billings, from the Black River limestone of the Ottawa river; a very similar shell is the *C. Panderi*, described at the same time from the same locality; indeed, there may be reason to doubt if there is a valid specific difference in these shells, as both the Canadian specimens and examples from the Trenton limestone of New York (Jacksonburg), afford a series passing from the typical plicated form of one to the non-plicated form of the other.

Camarella Volborthi has full, convex valves, which are smooth about the umbonal region, but anteriorly develop a few low plications which are rather the more conspicuous on the median fold and sinus, and the fold, sinus and plications are clearly developed on the often abrupt anterior slope of the valves.

The pedicle-valve is the more convex up to maturity, but thereafter the brachial valve becomes the deeper. The beak of the pedicle-valve is erect or slightly incurved and beneath it lies a triangular delthyrium which, so far as observed, shows, neither in this species nor in *C. Panderi*, any evidence of deltidial plates. The cardinal slopes are abrupt and oblique, and no cardinal area is developed on either valve. On the interior are dental lamellæ which converge, and uniting, are supported by a short median septum, forming thus a well-defined spondylium like that of SYNTROPHIA.

In the brachial valve the hinge-structure is similar to that of CAMAROTŒCHIA, the crural plates converging and forming a short, very small median cavity, which is supported by a long septum. The crura are short and the lateral divisions of the hinge-plate small. No cardinal process exists.

The internal structure of CAMARELLA is, thus, not unlike that of SYNTROPHIA, notwithstanding the wide difference of exterior.

Many American species have been referred to this genus, but, from present knowledge it would seem to be quite restricted in range and specific representation. Apparently it does not pass beyond the faunas of the Lower Silurian, and it is probable that most of the species referred to the genus by Mr. BILLINGS will prove to have been accurately placed, though in regard to some of them, their rarity and unfavorable preservation make it impossible to be positive. The species *Camarella? antiquata*, Billings, from the early primordial faunas, may or may not belong here; we know it only from the figures of the exterior given by BILLINGS and WALCOTT, and these afford no indication of its generic character except that it has a plicated rhynchonelloid exterior.

Mr. WALCOTT's species, *C. minor*,* from the Olenellus zone, at Stissing Mountain, Duchess county, N. Y., is a smooth, biconvex species, and the figures of internal casts given by this author indicate that the pedicle-valve possessed a small spondylium beneath the beak, resting upon the botton of the valve, the plates bounding it being produced about and just within the cardinal margins. The brachial valve appears to be without a median septum or spondylium, but may have had a narrow hinge-plate. Mr. WALCOTT states that the casts studied by him are imperfect and the generic reference only provisional.

With CAMARELLA should probably be placed DAVIDSON's *Stricklandinia? Balcletchiensis*,† a rather large rhynchonelliform shell with a short spondylium in the pedicle-valve, and without cardinal area.

PARASTROPHIA, GEN. NOV.

PLATE LXIII.

Among the species which have been currently referred to CAMARELLA are the well-known *Atrypa hemiplicata*, Hall, of the Trenton fauna, and the *Pentamerus reversus*,‡ Billings, of the Anticosti group. These are shells of considerable size. The inequality of the valves, which becomes apparent in old shells of *Camarella Volborthi*, is here carried to a greater extreme, becomes developed in immature growth-stages, and in the mature individual the brachial valve is much the more convex, its umbo and beak projecting conspicuously beyond that of the pedicle-valve. These shells have essentially lost their rhynchonelloid expression, being broad and transversely oval in outline, while the median fold and sinus are retained in their normal relations. The surface bears low, rounded plications which are stronger on the fold and sinus, but are also apparent on the lateral slopes near the margins of the valves. Over the median and umbonal portions of the valves they are obsolescent. The cardinal margin is moderately long and nearly straight, but there is no evidence of a cardinal area on either valve.

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* Tenth Ann. Rept. Director U. S. Geological Survey, p. 614, pl. lxxii, figs. 4 *a–d*. 1890.

† See DAVIDSON, Silurian Brachiopoda, Suppl., p. 166, pl. ix, figs. 27–29.

‡ The latter has also been referred by different writers to ANASTROPHIA and TRIPLECIA.

In the pedicle-valve the delthyrium is broadly triangular and is usually filled, partially or wholly, by the beak of the opposite valve. On the interior the dental lamellæ make a strong spondylium which reaches almost to the bottom of the valve, being supported by a very low median septum extending nearly one-half the length of the shell.

In the brachial valve there are two vertical crural plates not connected by a cardinal process. These are slightly convex on their inner surfaces and at their point of greatest convexity they unite with two longitudinal and gradually convergent lamellæ, which form a spondylium narrower than that of the opposite valve, and supported by a very low median septum somewhat longer than that of the pedicle-valve. In a species from the Hudson River group, of Wilmington, Illinois, which has currently passed under the name of *Camarella hemiplicata*,* this median septum is usually absent, the plates of the spondylium resting on the bottom of the valve, but in *Atrypa hemiplicata* and *Pentamerus reversus* the small septum is always present.

To such forms it is proposed to apply the term Parastrophia, assuming the *Atrypa hemiplicata*, Hall, as the typical species.

This type of structure is continued upward into the faunas of the Niagara group, and in the dolomites of southern Wisconsin occur a number of interesting species, our knowledge of which has been derived from the elaborate collections made in that region by Thomas A. Greene, Esq., of Milwaukee. Here are at least three species which are new to science, all of them being preserved as most instructive internal casts. These are described in the Supplement to this Volume as *Parastrophia Greenii*, *P. latiplicata* and *P. multiplicata*, figures of all being given upon the accompanying plates.

Among these shells there are no material variations except such as have already been noticed among the earlier species; for example, the spondylium of the more convex or brachial valve may be supported by a low median septum for its entire length (*P. Greenii*), or for a portion of its length may rest upon

* This form is much less extended than *Atrypa hemiplicata*, Hall; its plications are larger, sharper and fewer in number, and distinctly marginal. It is a shell quite different from the Trenton species, and may be termed *Parastrophia divergens*.

the inner surface of the valve (*P. latiplicata*, *P. multiplicata*). This feature seems to some extent subject to variation within specific limits; that is, being more or less of an individual peculiarity.

The brachial valve of *P. latiplicata* and *P. multiplicata* shows four distinct ovate muscular scars about the anterior prolongation of the median septum, and these are of quite the same character as those in the corresponding valve of ANASTROPHIA. Indeed, in all of these species the interior structure does not materially differ from that of ANASTROPHIA, though, being a thin-shelled group, the muscular impressions are not as clearly developed. In exterior characters, however, the differences are more significant.

To the six American species which are above referred to PARASTROPHIA, are probably to be added the *Rhynchonella Scotica*, Davidson, from the Llandeilo of Ayrshire,* and the *Pentamerus* (*Atrypa*) *rotundatus*, Sowerby, from the Wenlock of Wenlock Edge.†

It is probable that upon a shell of similar structure to PARASTROPHIA, GAGEL has recently based his proposed genus BRANCONIA, *B. borussica*, from the Lower Silurian diluvial boulders in Ostpreussen (Die Brachiopoden der cambrischen und silurischen Geschiebe im Diluvium der Provinzen Ost- and Westpreussen: Beiträge zur Naturkunde Preussens herausgegeben von der Physikalisch-Oekonomischen Gesellschaft zu Königsberg, p. 62, pl. iv, fig. 12. 1890). From the description and figures of the exterior of a single specimen it appears to be a trihedral shell of rhynchonelloid aspect, but with a median septum in each valve. What the inner relations of these septa were, or any other interior characters of the shell, is not made known. It seems very doubtful if the author is correct in regarding the more convex valve as the *ventral*, and the shallow valve as the *dorsal*, but it will be impossible to pass judgment on the value of the genus as now defined. So early a representative of this structure should receive further elucidation.

* DAVIDSON, Silurian Brachiopoda, Suppl. p. 201, pl. xi, figs. 26 *a–d*.

† Silurian Brachiopoda, p. 150, pl. xv, figs. 9–12

ANASTROPHIA, Hall. 1867.

PLATE LXIII.

Under the term Anastrophia has been grouped a number of species with reversed convexity, the disparity of the two valves in this respect surpassing that prevailing in Parastrophia. Their external surface is covered with numerous fine and sharp dichotomizing ribs, extending to the apices of the beaks and frequently crossed by delicate concentric lines. The type of this genus is the *Pentamerus Verneuili*, Hall, of the Lower Helderberg shaly limestone, and with it are to be associated the *Atrypa interplicata*, (Sowerby) Hall, and *Anastrophia internascens*, Hall, of the Niagara group; the *Terebratula deflexa*, Sowerby, of the Wenlock limestone, and the shell passing under the same name in a corresponding fauna of the Island of Gotland.

In this group again, the internal apophyses are subject to some variation. The spondylia of the valves are quite large, extending not less than one-third the length of the shell. As in Parastrophia, that of the pedicle-valve is the wider and is supported by a median septum near its anterior extremity. In the earlier species, *A. internascens*, *A. deflexa*, this spondylium may be thus supported for nearly or quite its entire length, but in *A. Verneuili*, the latest representative of the group, the structure is usually the same as in later members of Parastrophia. On Plate LXIII is given a figure of an interior of this species in which the lateral walls of the spondylium have folded, one over the other, and thus formed a tubular cavity open at both ends. What the significance of this modification may be, can not be judged from the single specimen. In the brachial valve the convergent plates generally rest upon the inner surface of the shell, though at times, in *A. Verneuili*, the spondylium is supported at its anterior extremity. The crural plates are extravagantly developed, forming two broad wing-shaped vertical expansions, concave on their outer surfaces; their upper edges are curved over the hinge-line, their anterior edges broadly notched, and below this point appears the base of attachment for the crura; the walls of the spondylium being connected with them at the most convex point of their inner surfaces. The dental sockets are always small, and old shells frequently show a false foramen in the beak, which is simply an extension of the spondylium that does not appear to be accidental. The muscular impressions of this valve are frequently defined as a fourfold scar about the anterior end of the spondylium; in the pedicle-valve these impressions are rarely discernible.

It has been shown that in early age the shells of ANASTROPHIA are normally biconvex, and the brachial valve scarcely deeper than the opposite.* In this condition the form of the shell resembles that of normal individuals of *Camarella Volborthi*, and in this series of forms, beginning in CAMARELLA where senile shells evince a gibbosity of the brachial valve and a tendency toward reversion of convexity, and ending with the Lower Helderberg *Anastrophia Verneuili*, we have a consecutive and gradational development in internal structure, which is accompanied by more abrupt variations in exterior. On the basis of the former it would be difficult to apprehend where division lines should be drawn, but the differences in the latter afford immediate and reliable means of distinction.

GENUS PORAMBONITES, PANDER. 1830.

PLATE LXIII.

1820. *Terebratulites*, SCHLOTHEIM. Petrefactenkunde auf ihr. jetz. Standpunkt, p. 282.
1830. *Porambonites*, PANDER. Beitr. zur Geogn. des russ. Reiches, pp. 95–100, pl. iii, fig. 9; pl. xi, figs. 1–8; pl. xii, figs. 1–8; pl. xiii, figs. 1–7; pl. xiv, figs. 1–4; pl. xv, figs. 1–4; pl. xvi A, fig. 12; pl. xvi B, fig. 7.
1834. *Terebratula*, VON BUCH. Ueber Terebrateln, p. 104.
1840. *Spirifer*, VON BUCH. Beitr. zur Kennt. Gebirgsform. Russl., pp. 13, 16, pl. ii, figs. 2–7.
1840. *Terebratula*, VON EICHWALD. Silurian System in Estland, pp. 132, 135.
1845. *Spirifer*, DE VERNEUIL. Géol. de la Russie et des Mont. de l'Oural, vol. ii, pp 127, 130–134, pl. ii, figs. 2, 3; pl. iii, fig. 1.
1847. *Porambonites*, D'ORBIGNY. Paléontologie Française; Terr. Cret., vol. iv, p. 345.
1850. *Isorhynchus*, KING. Monogr. Permian Fossils of England, p. 112.
1852. *Porambonites*, VON EICHWALD. Lethæa rossica, vol. i, p. 793.
1853. *Porambonites*, SHARPE. Quarterly Journal Geol. Soc. London, vol. ix, p. 155.
1854. *Porambonites*, DAVIDSON. Introd. British Fossil Brachiopoda, p. 99, pl. vii, figs. 120–126.
1869. *Porambonites*, DAVIDSON. British Silurian Brachiopoda, p. 195, pl. xxv, figs. 16 *a–d*.
1877. *Porambonites*, HALL and WHITFIELD. King's U. S. Geol. Expl. Fortieth Parallel, p. 234, pl. i, fig. 16.
1889. *Porambonites*, NOETLING. Zeitschr. der deutsch. geolog. Gesellsch., vol. xxxv, p. 355, pls. xv, xvi.
1890. *Porambonites*, GAGEL. Brachiop. der camb. und silur. Geschiebe im Diluv. der Provinz. Ost- und Westpreussen, pp. 50–52, pl. v, figs. 1–7.

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* See BEECHER and CLARKE, Memoirs N. Y. State Museum, vol. i, No. 1, p. 32, pl. iii, figs. 14–16 *a*. 1889. *Anastrophia internascens*, Niagara group.

"Shell robust, transverse or elongate, sometimes distinctly triangular and globose. Valves unequally convex, the dorsal always the deeper. Ventral valve with a sinus to which there is not always a corresponding fold on the dorsal valve. Hinge-line straight; hinge-teeth very strong, resting on a broad hinge-plate. In both valves a small obtusely triangular area, which is higher in the ventral than in the dorsal valve. Both valves with a broad pedicle-passage, never closed by a pseudodeltidium. Sometimes the beak of the dorsal valve is so strongly incurved that its perforation is not visible from outside. On the lateral slopes is a more or less strongly defined *pseudolunule*.*

"In the interior of the ventral valve are two long, robust dental lamellæ which rapidly converge and unite, sometimes before the bottom of the valve is reached, then forming a low median septum. Their anterior portion is always free while their posterior portions are sometimes coalesced into a single piece. In the dorsal valve there are two short crural plates not rising to more than one-third the height of the shell; these may remain independent or sometimes unite to form a single piece.

"The muscles are attached between and on the convergent plates, and, in the dorsal valve, also in front of them.

"Surface-sculpture more or less finely sieve-like.

"Shell-structure apparently fibrous.

"All species are confined to the lower Silurian."

Type, *Porambonites intermedia*, Pander.†

The above diagnosis is that given by NOETLING, in an admirable paper on the structure and systematic position of the genus.‡ Although so old a genus and so abundantly represented in the Silurian faunas of Russia, no satisfactory conclusion as to its generic affinities had been reached until the publication of this author's investigations, to whose figures of the interior structure of the valves, obtained from silicified specimens, the student is referred for illustration supplementary to that given in this Volume.

* This term is applied by NOETLING to an area on the cardinal slopes usually delimited by some sharply defined growth-line of an immature stage of development. It designates a feature of slight morphological value.

† Beiträge zur Geognosie des russischen Reiches, p. 95, pl. xvi A, fig. 12. 1830.

‡ Beitrag zur systematischen Stellung des Genus Porambonites, Pander; Zeitschrift der deutschen geologischen Gesellschaft, vol. xxxv, p. 355, pls. xv, xvi. 1883.

PANDER described thirty-one species of PORAMBONITES, all of which were directly absorbed by VON BUCH into the genus SPIRIFER of his conception.* DE VERNEUIL, in the Géologie de la Russie,† included these species in his division "Spirifer anormaux," section "Equirostrés," corresponding to the section "Biforés," which embraces species of the genus PLATYSTROPHIA, King. This author placed eleven of PANDER's species under VON BUCH's *Spirifer porambonites*, 1840, and eight others as synonyms of SCHLOTHEIM's *Terebratulites æquirostris*, 1820.

After D'ORBIGNY's resuscitation of PANDER's term,‡ and suggestion of the relation of the genus to the rhynchonelloids, the name again became current,§ SHARPE‖ and EICHWALD¶ indicating the affinities of the shells to the pentameroids, the latter considering its position intermediate between them and the strophomenoids.

DAVIDSON, in his Introduction to the Brachiopoda, placed PORAMBONITES in a family by itself, *PORAMBONITIDÆ*, regarding its place as between the *RHYNCHONELLIDÆ* and *STROPHOMENIDÆ*. NOETLING elaborates this conception, placing PORAMBONITES and PENTAMERUS in one family, *PORAMBONITIDÆ*, regarding the position of this family as "between the *STROPHOMENIDÆ*, with which it is connected through PORAMBONITES, and the *RHYNCHONELLIDÆ*, by way of PENTAMERUS and CAMAROPHORIA" (p. 378).

After a careful study of NOETLING's figures of the interiors of these shells, it becomes evident that the most direct relationship to these fossils is to be found in those pentameroids which have been designated as PARASTROPHIA and ANASTROPHIA. The frequent great size and thickness of the shells of PORAMBONITES accounts for a certain degree of obscuration of interior detail, but in all these genera we find the well-developed and supported spondylium in the

* Beitrag zur Kenntniss der Gebirgsformat. Russlands, p. 13. 1840.

† *Op cit.*, p. 127. 1845.

‡ Paléontologie Française ; Terr. Cret., vol. iv, p. 345. 1847.

§ Meanwhile KING, in ignorance of PANDER's term, had proposed the name ISORHYNCHUS, with SCHLOTHEIM's *Spirifer æquirostris* as the type. He found the genus bearing relation to PENTAMERUS, CAMAROPHORIA, etc.

‖ Quarterly Journal Geological Society, vol. ix, p. 155. 1853.

¶ Lethæa rossica, vol. i, p. 793.

pedicle-valve, and the convergent plates of the opposite valve which may or may not unite before the surface of the valve is reached.* Again, it has been already observed that ANASTROPHIA possesses an uncovered foramen in each valve, and this may also be true of PARASTROPHIA, but in PORAMBONITES a cardinal area is retained on both valves, and this character, more than any other, serves to show the derivation of these shells to be from the same ancestral stock as ORTHIS and its allies.

In external characters there is also an agreement in contour with the genera named. The shells of PORAMBONITES are frequently gibbous, the convexity of the brachial valve usually exceeding that of the pedicle-valve. The punctate ornament of the exterior lamina is purely superficial.

While PORAMBONITES is so abundant in the Silurian strata of Russia and Scandinavia, its representation in the American faunas is most meager, if indeed it exists here at all. The species *Porambonites Ottawaensis*, Billings, from the Black River limestone, does not belong to this genus, but is probably a member of the proposed group ORTHORHYNCHULA; the *Porambonites obscurus*, Hall and Whitfield, described from the lower Silurian of the White Pine District of Nevada,† is known only from a single pedicle-valve, which may prove a representative of the genus, and, if so, the only one recognized in our faunas.

The species which was the first of DE VERNEUIL's group of "Spirifer anormaux equirostrés," *S. Tscheffkini*, de Verneuil,‡ from the lower Silurian of the environs of St. Petersburg, has a general external resemblance to species of PORAMBONITES, but the cardinal area of the valves is much more highly developed and extends for nearly the width of the shell. So far as we know, the character of its interior has never been dem-

FIG 159.
A cardinal view of a specimen of *Spirifer* (*Noetlingia*) *Tscheffkini*.
(DE VERNEUIL.)

* Attention has already been directed to a slight variation in all these genera in regard to the actual degree of union in the lamellæ of this valve. In PARASTROPHIA they are normally confluent, though *P. divergens* furnishes an exception to the rule in having them free to the bottom of the valve. In PORAMBONITES they appear to be normally discrete.

† In KING's U. S. Geological Explorations Fortieth Parallel, p. 234, pl. i. fig. 16. 1877.

‡ Géol. de la Russie, etc., p. 129, pl. ii, figs. 1, *a*, *b*.

onstrated, though NOETLING mentions (*loc. cit.*, p. 368) having seen a specimen showing the internal characters, which convinced him that it could not be a true PORAMBONITES. The nature of these features, however, is not stated. Well preserved interiors of this shell must be of rare occurrence and opportunity is taken therefore of elucidating its structure by a series of transverse sections from the beaks forward. It will be seen from these accompanying figures that there is a spondylium in each valve, that of the pedicle-valve being at the outset the larger, and continuing further forward than the other. Both are supported by a stout median septal callosity, which, in the brachial

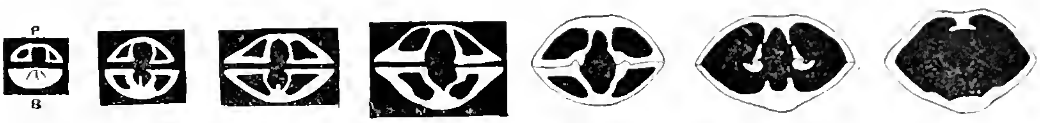

FIG. 160. FIG. 161. FIG. 162. FIG. 163. FIG. 164. FIG. 165. FIG. 166.

Figs. 160–166. Transverse serial sections of a single specimen of *Spirifer* (*Noetlingia*) *Tscheffkini*, showing the structure of the internal apophyses and septa. In all the sections the pedicle-valve (P) is above, the brachial valve (B) below. (C.)

valve widens and becomes lost in the thickened shell-substance of the muscular region; that of the pedicle-valve becomes narrowed anteriorly and eventually leaves the spondylium free, or nearly so. These characters are not materially different from those of PORAMBONITES, but a feature of high significance in *Spirifer Tscheffkini* is the presence of a simple linear cardinal process in the spondylium of the brachial valve. This, with the long, double-areaed hinge-line, the biforate umbones and suggestive external resemblance in contour to PLATYSTROPHIA, forms a more strongly orthoid combination than has been heretofore observed among shells with such pronounced pentameroid affinities, and thus makes a more direct connection between PORAMBONITES and the orthoid stock whence they have all been derived. The distinctive generic value of this shell as above expressed may be indicated by the term NOETLINGIA.

Genus LYCOPHORIA, Lahusen. 1885.

PLATE LXIII.

This name has been proposed for the *Atrypa nucella*, Dalman, a species not unlike Porambonites in general external features. The valves are rotund and have neither fold nor sinus, so that the anterior margin of contact is almost straight or very gently sinuous. The beaks are full and closely incurved and only the pedicle-valve appears to have retained a foramen, though the cardinal area is present in both. The brachial valve bears a hinge-plate which is recurved into the pedicle-cavity of the opposite valve and is produced into a long, curved cardinal process, bifurcate at its extremity. The crural plates are connected with the elevated margins of the four adductor impressions. In the opposite valve the teeth are supported by divergent plates which extend forward for about one-half the length of the shell and rest upon the bottom of the valve. Externally the shell is smooth in the umbonal regions, but anteriorly is covered with low, rounded plications crossed by fine concentric lines.

The systematic relations of this species are very interesting. It is associated with Porambonites in the lower Silurian faunas about St. Petersburg and in Scandinavia, and its similarity to that genus in contour and, to a certain extent, in details, is apparent.

While Porambonites is strongly orthoid in the structure of its cardinal features, and Noetlingia possesses the simple linear cardinal process of Platystrophia, *Atrypa nucella* adds to these orthoid features the cardinal process of a streptorhynchoid, like Triplecia and Mimulus, thus presenting another point of tangency between these shells and the pentameroids; or, more precisely, another phase in the development from the comprehensive primordial stock represented by Protorthis, Billingsella, etc., toward the full and typical expression of Orthis, Orthothetes, Strophomena and Conchidium.

Genus CONCHIDIUM, Linné. 1753.

PLATES LXIV, LXV, LXVI, LXVII.

1753. *Conchidium*, Linné. Museum Tessinianum, p. 90, pl. v, figs. 8, *a*, *b*.
1766. *Helmintholitus*, Linné. Systema Naturæ, ed xii, vol. iv, p. 163.
1798. *Anomites*, Hisinger. Minerograph. Anmerkning. öfver Gottland; Vet. Akad. Handling, p. 285.
1813. *Pentamerus*, Sowerby. Mineral Conchology, vol. i, p. 73, pls. xxviii, xxix.
1828. *Gypidia*, Dalman. Kongl. Vetenskaps Akad. Handlingar, pp. 93, 100.
1839. *Pentamerus*, Sowerby. Murchison's Silurian System, p. 615, pl. vi, figs. 8 *a*–*c*.
1841. *Pentamerus*, Hisinger. Lethæa Suecica, p. 74, pl. xxi, figs. 10 *a*–*c*.
1843. *Pentamerus*, A. Roemer. Die Versteinerungen des Harzgebirges, pl. iv, fig. 16.
1845. *Pentamerus*, de Verneuil. Géol. de la Russie et des Mont. de l'Oural, vol. ii, pp. 113 118, pl. vii, figs. 1–3.
1850. *Pentamerus*, A. Roemer. Beitr. zur geolog. Kenntn. der nordwest. Harzgeb., p. 59.
1852. *Pentamerus*, Hall. Palæontology of New York, vol. ii, p. 341, pl. lxxix, figs. 1, 2.
1854. *Pentamerus*, Davidson. Introd. British Foss. Brach., p. 97, pl. vii, fig. 116.
1854. *Pentamerus*, Gruenewaldt. Memoires Sav. Étrang. Acad. Imp. Sci. St. Pétersbourg, vol. vii, p. 26, pl iv, fig. 15.
1855. *Pentamerus*, Conrad. Proc. Acad. Nat. Sci. Philadelphia, vol. vii, p. 441.
1860. *Pentamerus*, Lindström. Gotland's Brachiopoden, p 365.
1860. *Pentamerus*, Emmons. Manual of Geology, p. 107, figure.
1861. *Pentamerus*, Billings. Canadian Journal, vol. vi, p. 269.
1863. *Pentamerus*, Billings. Geology of Canada, p. 337, fig. 341.
1867. *Pentamerus*, Hall. Twentieth Ann. Rept. N. Y. State Cab. Nat Hist., p. 373, pl. xiii, figs. 22–24.
1867. *Pentamerus*, Hall. Palæontology of New York, vol. iv, pp. 369–374.
1867. *Pentamerus*, Davidson, British Silurian Brachiopoda, p. 142, pl. xvi, figs. 1–3; pl. xvii, figs. 1–10; pl. xix, fig. 3.
1871. *Antirhynchonella, Pentamerus*, Quenstedt. Petrefactenkunde Deutschlands; Brachiopoden, p. 231, pl. xliii, figs. 36–39.
1872. *Pentamerus*, Hall and Whitfield. Twenty-fourth Ann. Rept. N. Y. State Mus. Nat. Hist., pp. 184–186.
1875. *Pentamerus*, Hall and Whitfield. Twenty-seventh Ann. Rept. N. Y. State Mus. Nat. Hist., pl. x, figs. 1–12.
1879. *Pentamerus*, Emerson. Geol. Frobisher Bay; Hall's Arctic Exped., App. III, p. 578.
1879. *Pentamerus*, Barrande. Système Silurien du Centre de la Bohême, vol. v, pl. xx, figs. 9 14; pl. xxi, figs. 10–13; pl. xxiv, fig. 8; pl. lxxix, figs. 1–3.
1880. *Pentamerus*, Angelin and Lindström. Fragmenta Silurica, p. 24, pl. xx, figs. 1–29.
1881. *Zdimir*, Barrande. Système Silurien, vol. vi, p. 171, pl. ccxcii, figs. 17 20.
1882. *Pentamerus*, Whitfield. Geology of Wisconsin, vol. iv, p. 314, pl. xxiii, figs. 1, 2.
1886. *Gypidia*, Ulrich. Contributions to American Palæontology, vol. i, p. 28, pl. iii, fig. 2.
1887. *Conchidium*, Œhlert. Fischer's Mannel de Conchyliologie, p. 1311, fig. 1097.
1888. *Pentamerus*, Novák. Zeitschr. der deutsch. geolog. Gesellsch., vol. xl, p 588.
1889. *Pentamerus*, Nettelroth. Kentucky Fossil Shells, pp. 53, 55, 57, 60, pl. xxvii, figs. 14–16; pl. xxviii, figs. 1–8; pl. xxix, figs. 1, 2, 17.
1890. *Pentamerus*, Gagel. Brach. der camb. und silur. Geschiebe im Diluv. der Provinz. Ost- und Westpreussen, pp. 53, 54, pl. iv, figs. 2–4.
1891. *Pentamerus*, Whiteaves. Canadian Record of Science, p. 295, pl. iii, figs. 3, 4.
1892. *Pentamerus*, R. Etheridge, Jr. Pentameridæ of New South Wales,; Records Geol. Survey N. S. W., vol. viii, pt. ii, p. 49, pl. x, figs. 1–8; pl. xi, figs. 1–4, 10–12.
1892. *Pentamerus*, Miller. Seventeenth Ann. Rept. State Geologist Indiana, p. 687, pl. xiii, figs. 5, 6.

Shells elongate-subtrigonal or subpentagonal in outline, strongly inequivalve, biconvex; median fold and sinus faint, if at all developed. Anterior margins of contact usually straight, with sometimes a faint fold, at others a low sinus on both valves. Surface with numerous sharp or rounded, simple or divided plications extending from beaks to margins; cardinal slopes broad and usually smooth.

In the pedicle-valve the umbo is elevated, attenuated, more or less incurved, not prone upon the opposite valve. No cardinal area is developed. The delthyrium is very broad and bears a concave deltidium, which, however, is frequently wanting. Teeth small, supported by convergent lamellæ which unite in the interior cavity and form a single median vertical septum of variable length; in the typical species usually extending almost, and sometimes quite to the anterior margin, and vertically, for fully one-half the depth of the combined valves. The spondylium is very narrow and deep; combined with the median septum the height of these plates equals fully two-thirds the depth of the valves. The anterior margins of these plates are doubly incurved, the most projecting points being at the base of the septum, and at its line of union with the dental lamellæ. The median septum consists of two vertical lamellæ, each continuous with one of the component plates of the spondylium. The spondylium was the seat of

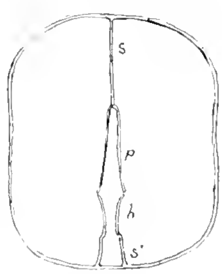

Fig. 167.

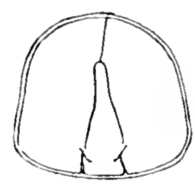

Fig. 168.

Fig. 167 *Pentamerus* (*Conchidium*) *Knighti*, Sowerby. A transverse section in the umbonal region.
s. Septum of the pedicle-valve. *p*. Dental plates forming ventral spondylium.
s'. Septa of the brachial valve. *b*. Crural plates resting on the septa. (C.)

Fig. 168. *Conchidium laqueatus*, Conrad Transverse section, showing the deflection of the median septum, the deep, narrow spondylium of the pedicle-valve, and the septa of the brachial valve bearing inclined crural processes. (C.)

muscular attachment, and it bears a series of fine radiating lines along its median portion, and transverse or concentric lines over its lateral slopes; the former probably representing the scar of the adductor, and the latter the impressions of the diductor muscles. In the brachial valve the beak is obtuse and closely incurved into the deltidial cavity or spondylium of the opposite valve. The dental sockets are long and narrow, their inner margins being bordered by two broad, convergent crural plates, which extend toward the bottom of the valve, but do not reach it. These sloping plates are supported by two vertical septa, with which they are united, not at their extremities, but obliquely, just within their free edges. At the anterior angles of these free edges, there are two long, straight or slightly curved, rod-like crural processes extending into the anterior cavity of the shell. Beneath the beak is a faintly developed, bilobate or multilobate cardinal process. The muscular scars lie on the surface of the valve between the two vertical septa, and extend for some distance in front of them. They are divided by a low axial ridge.

Shell-substance fibrous, impunctate.

Type, *Conchidium biloculare*, Linné (= *Gypidia* or *Pentamerus conchidium*, Dalman *et al.*). Upper Silurian limestone, Gotland.

Observations. The great diversity of form presented by the fossils commonly referred to the genus Pentamerus, necessitates a careful scrutiny of their structural relations. From this extensive group of species a number of forms deviating from the typical structure have been separated. In 1859, Mr. Billings brought together, under the name Stricklandia, one peculiar association of such forms. It has already been shown that certain small, equiconvex or reversed-convex pentameroid forms, as Parastrophia and Anastrophia should be held in close generic relations with Camarella The variations which occurred during the Devonian, at a period when the climacteric development of the pentameroids had passed, have been grouped under various designations, as Gypidula, Pentamerella, Amphigenia, etc., which will presently be considered in detail. Recognizing the distinctive value of these terms, there still remains for consideration a group of fossils which first appeared in the middle Silurian, rapidly attained an enormous development and probably disappeared in the middle Devonian; in other words, the genus, "Pentamerus." This group, compact as it may seem in both external and internal structural features, has apparently been developed along various lines from a central origin, and when such variations are considered in connection with certain established claims of nomenclature, a further subdivision of these shells will prove both useful and requisite.

The essential foundation for a subordinate grouping of these pentameroids was indicated by DE VERNEUIL so long ago as 1845,* when he proposed a division into two sections; (1) those without a sinus, (2) those with a sinus. The former of these was divided into (*a*) plicated shells, including *P. Knighti*, *P. biloculare*, etc.; and (*b*) smooth shells, such as *P. oblongus*, *P. borealis*, etc. The second section included shells of the type of *P. galeatus*. These three divisions indicate the main lines of variation in external characters.

To the plicated species without well defined fold and sinus must be applied LINNÉ's original term CONCHIDIUM, founded in 1753 upon the Swedish species, widely known as *Gypidia conchidium*, Dalman, which is identical with *Conchidium biloculare*, Linné. The diagnosis of this genus, above given, has been derived from an abundant representation of specimens of the species, and, in respect to some critical features, with the aid of the elaborate illustration given in ANGELIN'S (LINDSTRÖM'S) "Fragmenta Silurica." This shell is peculiar in its elevated and unciform beak; in this as well as other respects it is homologous with the much larger and more robust American shell, *P. laqueatus*, Conrad (= *P. nobilis*, Emmons), which occurs in enormous quantities in the Niagara dolomites, about Delphi, Indiana. Usually these plicated species have a lower, though narrower beak, and are constructed on the plan of *P. tenuistriatus*, Walmstedt, of the Upper Silurian of Gotland; those with the broader form and almost subquadrate sectional outline, like the well-known *P. Knighti*, Sowerby, being of rare occurrence.† With *P. tenuistriatus* may be associated the American species

* Géologie de la Russie et des Mont. de l'Oural, p. 111.

† NETTELROTH has described as *P. Knighti* a shell from the Corniferous limestone near Louisville, Ky. (Kentucky Fossil Shells, p. 57, pl. xxix, figs. 12, 17). While the species is similar in general contour to the English Silurian shell, it is much smaller and more coarsely plicated, and it must be regarded as a quite distinct form, which for convenience's sake may be known as *Conchidium Nettelrothi*. *Pentamerus Littoni*, Hall, of the Niagara group, is another representative of the *P. Knighti* type of exterior.

P. Nysius, *P. tenuicosta*,* *P. Knappi*, Hall and Whitfield, and the shell described in this work as *Conchidium Greenii*, sp. nov., from the Niagara dolomites of south-eastern Wisconsin. There are some other American species of this genus of more distinctly local and restricted groups, such as the so-called *Gypidula unguiformis*, Ulrich, *Pentamerus Colletti*, Miller, *P. decussatus*, Whiteaves, the last recently described from the yellow dolomites of the Grand Rapids of the Saskatchewan River; † all of which are concentrically striated and finely plicated species. Another form, small and very coarsely ribbed, is the *C. crassiplica*, sp. nov.

CONCHIDIUM makes its appearance in America in the fauna of the Niagara dolomites in the states of Wisconsin, Iowa, Illinois, Indiana and Kentucky, while it is not known in the equivalent fauna of New York. In like manner it appeared in the faunas of the Wenlock and Aymestry of England, and at an equivalent horizon in Gotland, Esthonia and Bohemia. It does not occur in the Lower Helderberg, nor in the earlier faunas of the Upper Helderberg; its latest representative in this country is NETTELROTH's *P. Knighti* (= *C. Nettelrothi*, nom. nov.), said to be from the Corniferous limestone.‡ In Europe it is continued to a later date in the large Russian middle Devonian species *P. Bashkiricus*, de Verneuil, and *P. pseudobashkiricus*, Tschernyschew. The shell described by BARRANDE from the etagé G_3, as a lamellibranch, under the name *Zdimir solus*, has been shown by NOVÁK to be a pentameroid of this plicate type §

* There remains some obscurity in regard to the significance of the terms *P. Nysius* and its varieties *crassicosta* and *tenuicosta*, from the Niagara rocks at Louisville. The species was described as having from twenty-five to forty plications; to the coarsely plicate shells the former term was applied, and to the more finely plicate the latter. Between these shells there is evidently something more than difference in degree of plication. The finely plicate shells (*tenuicosta*) are smaller and have shallower valves and low, inconspicuous beaks. NETTELROTH has shown that the character of the ornamentation of the smaller shells is persistent, not gradational. But the separation from *P. Nysius* of these two varieties leaves nothing to represent the specific type. Therefore, instead of leaving the identity of *P. Nysius* to be merged between the two varieties, it will be better, and in accordance with rule, to assume the shell known as var. *crassicosta*, the first of the varieties named, as the typical form of *P. Nysius*. For the other variety the name *Conchidium tenuicosta* will be used in preference to NETTELROTH's proposed term *P. complanatus* (lib. cit., p. 53).

† Canadian Record of Science, p. 295. 1891.

‡ It may be well to verify the geological horizon of this species before basing any conclusions upon its occurrence in the Corniferous limestone.

§ Zeitschr. der deutsch. geol. Gesellsch., vol. xi, p. 588. 1888.

Genus PENTAMERUS, Sowerby. 1813.

PLATES LXVII, LXVIII, LXIX, LXX.

1813. *Pentamerus*, J. Sowerby. Mineral Conchology, vol. i, p. 76, pl. xxviii.
1839. *Pentamerus*, J. de C. Sowerby. Silurian System, pl. xix, figs. 9, 10.
1843. *Pentamerus*, Hall. Geology of New York; Rept. Fourth Dist., p. 70, figs. 1–5.
1845. *Pentamerus*, de Verneuil. Géologie de la Russie, p. 119, pl. viii, figs. 1 *a–c*.
1852. *Pentamerus*, Hall. Palæontology of New York, vol. ii, p. 79, pl. xxv, figs. 1 *a–m;* pl. xxvi, figs. 1 *a–d;* p. 103, pl. xxxi, fig. 1.
1854. *Pentamerus*, Eichwald. Bull. Soc. Imp. Natural. Moscou, pt. 1, p. 91.
1854. *Pentamerus*, F. Schmidt. Neueste Untersuch. ueber Brachiopoden, p. 213.
1859. *Pentamerus*, Eichwald. Lethæa rossica, vol. i, p. 788, pl. xxxiv, fig. 23.
1861. *Pentamerus*, McChesney. New Palæozoic Fossils, p. 85.
1863. *Pentamerus*, Billings. Geology of Canada, p. 316, fig. 326.
1866. *Pentamerus*, Billings. Catalogue Silur. Fossils Anticosti, p. 45.
1867. *Pentamerus*, Davidson. British Silurian Brachiopoda, p. 151, pl. xviii, figs. 1–12; pl xix, figs. 1, 2.
1867. *Pentamerus*, Hall. Palæontology of New York, vol. iv, pp. 369–374.
1868. *Pentamerus*, McChesney. Trans. Chicago Acad. Sci., vol. i, pl. ix, fig. 1.
1872. *Pentamerus*, Hall and Whitfield. Twenty-fourth Ann. Rept. N. Y. State Mus. Nat. Hist., p. 183.
1875. *Pentamerus*, Hall and Whitfield. Twenty-seventh Ann. Rept. N. Y. State Mus. Nat. Hist., pl. x, figs. 13, 14.
1875. *Pentamerus*, Hall and Whitfield. Palæontology of Ohio, vol. ii, pp. 137, 139, pl. vii, figs. 9–11.
1882. *Pentamerus*, Whitfield. Annals N. Y. Acad. Science, vol. ii, p. 195.
1882. *Pentamerus*, Whitfield. Geology of Wisconsin, vol. iv, pp. 288, 291, pl. xvii, figs. 3–9.
1889. *Pentamerus*, Nettelroth. Kentucky Fossil Shells, pp. 60–62, pl. xxix, figs. 23, 24; pl. xxx, figs. 2–4.
1889. *Pentamerus*, Foerste. Proc. Boston Society Nat. Hist., vol. xxiv, p. 324, pl. v, figs. 17, 18.
1890. *Pentamerus*, Whitfield. Annals N. Y. Acad. Sci., vol. v, p. 513, pl. v, figs. 11–22.
1890. *Pentamerus*, Gagel. Die Brachiop. der camb. und silur. Geschiebe im Diluvium der Provinzen Ost- und Westpreussen, p. 53, pl. iv, fig. 1.

Since it seems necessary to restrict the term Conchidium to those pentameroids embraced by de Verneuil in his division "plissés, sans sinus," it becomes desirable to apply the designation Pentamerus to the second division of those shells, the "lisses, sans sinus." This use of Sowerby's term is in precise accordance with recognized rules of nomenclature. The first species cited by Sowerby, and that which has been generally regarded as typical of the genus by authors who have preferred this term to the earlier designation of Linné, is *P. Knighti*, a plicated shell, which belongs to Conchidium.* The second of Sowerby's typical examples, and that to which must be accorded his generic

* The *P. Aylesfordi*, Sowerby, cited in the "Mineral Conchology" as another of the typical species of Pentamerus, was subsequently regarded by that author as a synonym for *P. Knighti* (Silurian System, p. 615, 1839), and the name has consequently fallen into disuse.

term, is the *Pentamerus lævis*, a shell with a smooth exterior, and of which Mr. Davidson remarks: *

"It is admitted now by palæontologists that *P. lævis*, Sow., is the young of *P. oblongus*; and if it were necessary to strictly adhere to rules of priority, James Sowerby's name, published in August, 1813, would perhaps require [have] to be adopted in preference to that of *oblongus*, given to the adult shell by Mr. J. de C. Sowerby in 1839; but, when we read over Mr. James Sowerby's unsatisfactory description, and examine his small, very incomplete figure, it seems preferable to preserve for this shell the now generally adopted and well-known designation of *oblongus*."

Pentamerus oblongus is a species of very variable contour, with a smooth exterior, sometimes bearing a few broad and obscure radiating undulations, transverse or elongate-oval in outline; the valves are usually shallow, but in some of the many variations of the species attain a considerable depth. Though there is no median fold and sinus, a median anterior prolongation of the valves, defined by two convergent lateral furrows, is a normal character, as shown in the original figures given in the "Silurian System" (plate xix, fig. 10). This gives the shell a trilobed character which is carried to an extreme development in the series of shells connecting the typical form with those constituting the variety *cylindricus*, Hall. In American faunas, where this species attains a great development in individuals, its numerous variations in contour and general expression often possess a definite local value. The shell abounding in the Pentamerus limestone of the Clinton group of New York is, as a rule, of comparatively small size, broadly oval or obovate, rarely elongate in outline; though the trilobation of the exterior is always apparent, it is seldom conspicuously defined. Rarely the shell is narrowed across the umbones, and subtriangular in outline. (See Plate LXVII, fig. 2.) In New York this species is not known outside of the Clinton fauna, but passing westward, it abounds in the dolomites which bear a Niagara fauna in the states of Ohio, Indiana, Illinois, Wisconsin and Iowa.

At Yellow Springs, Ohio, the prevalent form is a large, elongate, usually strongly trilobed shell, with narrow beaks and long, oblique cardinal slopes.

* Silurian Brachiopoda, p. 153.

The same form of shell occurs rarely in Wisconsin (Door county), and has been described by McChesney as *P. bisinuatus*,* a name which may serve a useful purpose as a varietal designation. About Richmond, Indiana, a broader, more ovate shell predominates, which does not widely differ from the characteristic form of the Clinton fauna of New York. At Utica, in the same State, and in the vicinity of Louisville, the narrow elongate shell, *P. oblongus*, var. *cylindricus*, abounds; it is usually deep-valved and distinctly trilobed.

Among the shells occurring in the dolomites of Wisconsin there is a great variation in form, with a tendency to increasing depth of valves, but these variations are less extreme, and their geographic value has not been determined. Thus also with the representatives of the species in the dolomites of Iowa (Earlville and elsewhere). In the siliceous beds of the Niagara group in the latter State (Jones county), there is a small, ovate, often elongate variety, with the trilobation rather faintly marked, and a quite distinct form in the rusty chert of the same county, the latter a subquadrate shell, very broad across the cardinal region, with nearly straight, parallel lateral margins, very full and prominent umbo, distinctly trilobate surface, the median lobe being divided by a linear axial groove on both valves. This is so well defined a shell and so distinctively local in its value that it may receive the varietal designation *subrectus*.

With all these variations in exterior there are some slight differences in the interior structure. A concave deltidium is sometimes retained, and a faint

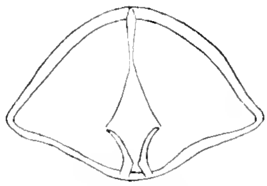

Fig. 169.

Fig. 170.

Fig. 171.

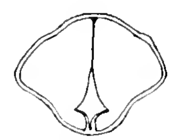

Fig. 172.

Fig. 169. *Pentamerus oblongus*, Sowerby. A transverse section, showing the septa. (C.)

Figs. 170, 171. Transverse sections of the septa of *Pentamerus oblongus*. Fig. 170 shows the septum of the pedicle-valve and the enclosure of its base by the shell-substance of the valve. Fig. 171 is an enlargement of the septa of the brachial valve, and shows a thin coating of testaceous matter upon the inner faces of the prismatic walls. (C.)

Fig. 172. *Pentamerus cylindricus*, Hall. A transverse section, showing the septa. (C.)

lobation of the apical end of the spondylium is the sole evidence of a cardinal process. The depth of the spondylium and septa varies with the convexity of

* Descriptions of New Species of Fossils, p. 85, pl. ix, fig. 1. 1859.

the valves; usually, however, the septa of the brachial valve are very short and rest upon the inner surface of the shell. It sometimes happens that these septa unite before reaching the inner surface, and the spondylium thus formed is supported by a very low axial septum. This is the case in the original specimen of *P. bisinuatus*, McChesney, and in the Wisconsin shell referred to that variety by WHITFIELD.* It is more conspicuously developed in the Iowa shell which has just been mentioned as *P. oblongus*, var. *subrectus*, and it serves to confirm the varietal character of that form. It has been already observed that the union or independence of these dorsal septa in the genera ANASTROPHIA and PARASTROPHIA can be regarded as a feature of only secondary importance. In the later pentameroids it will be found that the difference becomes fixed and of more positive significance, but in the Silurian shells it is still a variable feature, but not of usual occurrence. At times an exceedingly faint obsolescent radial plication of the exterior is observable in *P. oblongus*, and this feature is also occasionally apparent in *P. pergibbosus*, Hall and Whitfield, and more noticeable in *P. occidentalis*, Hall, of the Guelph fauna of the Province of Ontario, and of the Niagara fauna of Ohio and Wisconsin.†

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* Geology of Wisconsin, vol. iv, p. 290, pl. xvii, fig. 3. 1882.

† The shells which are currently referred to *Pentamerus pergibbosus* also vary not a little among themselves, and it would be no difficult matter to acquire a series of forms to demonstrate that this is but another extreme of development which has originated in *P. oblongus*. The originals of *P. pergibbosus* from the Niagara dolomites of Darke county, Ohio, are rather small shells with long, oblique cardinal slopes, narrow umbones and very deep valves. In the limestones about Milwaukee shells of this character attain great size, and in the chert of Jones county, Iowa, occurs a very small shell which cannot be separated from this species by any decisive characters.

Mr. WHITFIELD has figured ‡ as one of the variations of *P. oblongus*, a gibbous shell from the upper coral beds of the Niagara group at Ashford, Wisconsin; a similar, though persistently smaller shell abounds in the dolomites of the Maquoketa region near Dubuque, and at Hopkinton, Iowa. The latter has been generally identified as *P. pergibbosus*. It is, however, quite a different shell from that occuring in Darke county, Ohio, its full, rotund valves, broad across the cardinal region, producing an expression distinct from that of *P. pergibbosus*, while the suggestion of trilobation of the surface which is shown on all the specimens examined, indicates its nearer relations to *P. oblongus*; as a corrected identification of this shell, the name *P. oblongus*, var. *Maquoketa*, is suggested. It is observed above that the variety of *P. oblongus*, prevailing in Ohio (var. *bisinuatus*), is represented with extreme rarity among the Clinton shells of New York. Similarly, the variety *Maquoketa* is known to occur on this side of the Mississippi only, in the Wisconsin locality cited. On Plate LXVIII, figure 13, there is given a figure of a shell of great size, probably from Indiana, which is nearer to this than to any other form of *P. oblongus*.

The differences between *P. pergibbosus* and the *P. occidentalis*, Hall, from the Guelph fauna are also obscure. The latter has the cardinal slopes very broad, the axial slopes flattened or depressed and the

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‡ *Op. cit.*, pl. xvii, figs. 8, 9.

It is evident from the foregoing remarks that PENTAMERUS is an exceedingly plastic type, and its duration is essentially the same in all countries. DAVIDSON finds *P. oblongus* restricted to the lower and upper Llandovery rocks. In the Baltic Provinces of Russia the species *P. borealis*, von Eichwald, a shell very similar to that variety of *P. oblongus*, here termed *subrectus*, occurs in agglomerations (Borealis-bank) like those of *P. oblongus* in the Clinton limestone, at a low horizon in the upper Silurian. Above this is the zone of *P. Esthonus*, another form very close to *P. oblongus*. In Scandinavia, *P. oblongus* is found in a higher horizon, which corresponds more nearly with its occurrence in the Niagara dolomites of the interior States. *P. Samojedicus*, Keyserling, from the Petschora-land is still another smooth species from a corresponding horizon.

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shell subquadrate in transverse section. The surface, in the usual preservation of the shell, has strong concentric, often squamous growth-lines and distinct traces of radiating plications. It is doubtful if these plications were ever strongly developed, and in any considerable collection of specimens it is easy to demonstrate the gradation of this species from *P. pergibbosus*. In association with this shell at Guelph there occurs an undescribed species of a well-defined CONCHIDIUM, not unlike the plicated shell referred by WHITFIELD (*op. cit.*, p. 314, pl. xxiii, figs. 1, 2,) to *P. occidentalis*.

GENERA (1) BARRANDELLA, NOM. PROPOS.; (2) PENTAMERELLA, HALL, 1867; (3) SIEBERELLA, ŒHLERT, 1887; (4) GYPIDULA, HALL, 1867.

PLATES LXXI, LXXII.

(3) 1827. *Atrypa*, DALMAN. Kongl. Vetenskaps. Acad. Handlingar, p. 130.
(3) 1834 *Terebratula*, VON BUCH. Ueber Terebrateln.
(3) 1839. *Atrypa*, J. DE C. SOWERBY. Silurian System, pl. xii, fig. 4.
(1) 1839. *Atrypa*, J. DE C. SOWERBY. Silurian System, pl. xiii, fig. 8.
(2) 1841. *Atrypa*, CONRAD. Geol. Survey N. Y.; Ann. Rept. Palæont. Dept., p. 55.
(3) 1843. *Terebratula*, A. ROEMER. Verstein. des Harzgebirges, p. 19, pl. xii, fig. 25.
(3) 1845. *Pentamerus*, DE VERNEUIL. Géologie de la Russie, etc, vol. ii, p. 120, pl. viii, figs. 3 *a–g*.
(1) 1848. *Pentamerus*, DAVIDSON and DE VERNEUIL. Bull. Soc. Géol. de France, second ser., vol. v, pp. 333, 346
(4) 1852. *Atrypa*, OWEN. Geol. Survey Wisconsin, Iowa and Minnesota, p. 583, pl. iii A, fig. 4.
(1) 1852. *Pentamerus*, HALL. Palæontology of New York, vol. ii, p. 81, pl. xxiv, figs. 7 *a–d*.
(2) 1857. *Pentamerus*, HALL. Tenth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 120, figs. 1–10.
(1) 1857. *Pentamerus*, BILLINGS. Rept. Prog. Geol. Survey of Canada, p. 296.
(3) 1857. *Pentamerus*, HALL. Tenth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 105, figs. 1–3.
(1) 1858. *Pentamerus*, F. SCHMIDT. Silur. Format. Estlands; Archiv für Naturkunde, vol. ii, p. 212.
(4) 1858. *Pentamerus*, HALL. Geology of Iowa, vol. i, pt. 2, p. 514, pl. vi, figs. 2 *a–c*.
(3) 1859. *Pentamerus*, HALL. Palæontology of New York, vol. iii, p. 257, pl. xlvi, figs. 1 *a–z*; pl. xlvii, figs. 1 *a–m*.
(3) 1859. *Pentamerus*, VON EICHWALD. Lethaea rossica, vol. i, pl. xxxv, figs. 19, 20.
(1) 1860. *Pentamerus*, LINDSTRÖM. Öfversigt kongl. Veten. Acad. Förhandl., p. 365, pl. xii, fig. 6.
(2) 1860. *Pentamerus*, *Spirifer*, HALL. Thirteenth Ann. Rept N. Y. State Cab. Nat. Hist., pp 86, 90.
(3) 1860. *Pentamerus*, F. ROEMER. Silur. Fauna des westl. Tennessee, p. 73, pl. v, fig. 11.
(1) 1861. *Pentamerus*, HALL. Rept. Progress Geolog. Survey Wisconsin, p. 2.
(1) 1863. *Pentamerus*, BILLINGS. Geology of Canada, p. 316, fig. 327.
(3) 1865. *Pentamerus*, WINCHELL and MARCY. Mem. Boston Soc. Nat. Hist., vol. i, p. 94, pl. ii, fig. 11.
(1) 1866. *Pentamerus*, BILLINGS. Catalogue Silurian Fossils Anticosti, p. 45.
(4) 1866. *Pentamerus*, MEEK and WORTHEN. Geol. Survey Illinois, vol. ii, p. 325.
(1) 1867. *Pentamerus*, DAVIDSON. British Silurian Brachiopoda, p. 149, pl. xvii, figs. 11–14.
(1) 1867. *Pentamerus* (*Pentamerella*), HALL. Twentieth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 374, pl. xiii, figs. 18–21.
(2) 1867. *Pentamerella*, HALL. Palæontology of New York, vol. iv, pp. 373, 375–379, pl. lviii, figs. 1–21, 24–43.
(3) 1867. *Pentamerus*, DAVIDSON. British Silurian Brachiopoda, p. 145, pl. xv, figs. 13–23.
(4) 1867. *Gypidula*, HALL. Palæontology of New York, vol. iv, pp. 373, 380, 381, pl. lviii, figs. 22, 23; pl. lviii A, figs. 1–8.
(4) 1868. *Pentamerus*, MEEK and WORTHEN. Geological Survey of Illinois, vol. iii, pp. 428, 429, pl. xiii, figs. 5, 6.
(1) 1871. *Pentamerus*, QUENSTEDT. Petrefactenkunde Deutschlands; Brachiopoden, p. 222, pl. xliii, figs 44, 45.
(1) 1875. *Pentamerus*, HALL and WHITFIELD. Palæontology of Ohio, vol. ii, p. 138, pl. vii, figs. 7, 8.
(3) 1878. *Pentamerus*, KAYSER. Abhandl. zur geol. Specialkarte von Preussen, etc., Bnd. 2, Heft 4, pp. 156–159, pl. xxvii, figs. 1–9, 13.
(4) 1878. *Gypidula*, CALVIN. Bull. U. S. Geol. Survey of the Terr, vol. iv, p. 730.
(1) 1879. *Pentamerus*, *Clorinda*, BARRANDE. Système Silurien, vol. v, pls. xxii, xxiv, cxix, cxxxviii.

(3) 1879. *Pentamerus*, Barrande. Système Silurien, vol. v, pls. xx, xxi, xxiii, lxxvii, lxxviii, lxix, cxvi, cxvii, cxviii, cxix.
(1) 1882. *Pentamerus*, Hall. Eleventh Ann. Rept. State Geologist Indiana, p. 299, pl. xxvii, fig. 15.
(1) 1882. *Pentamerus*, Whitfield. Geology of Wisconsin, vol. iv, p. 291, pl. xvii, figs. 11-13.
(3) 1883. *Pentamerus*, Davidson. British Silurian Brachiopoda, Suppl., p. 164, pl. ix, figs. 25, *a*.
(4) 1884. *Gypidula*, Walcott. Monogr. U. S. Geol. Survey, vol. viii, p. 159-161, pl. iii, figs. 4, 7; pl. xiv, fig. 15; pl. xv, fig. 5.
(1) 1887. *Antirhynchonella*, Œhlert. Fischer's Manuel de Conchyliologie, p. 1311.
(3) 1887. *Sieberella*, Œhlert. Fischer's Manuel de Conchyliologie, p. 1311.
(1) 1889. *Pentamerus*, Nettelroth. Kentucky Fossil Shells, p. 64, pl. xxiii, figs. 12-14.
(3) 1889. *Pentamerus*, Nettelroth. Kentucky Fossil Shells, pp. 59, 63, pl. xxvii, figs. 25-27; pl. xxxiii, figs. 25-29, 31-33.
(1) 1892. *Pentamerus*, R. Etheridge, Jr. Pentameridæ of New South Wales; Records Geol. Survey N. S. W., vol. iii, pt. 3, p. 52, pl. xi, figs. 5-9.
(4) 1892. *Pentamerus*, Whiteaves. Contributions to Canadian Palæontology, vol. i, p. 290.

The elongate, subequally biconvex pentameroids being restricted to the divisions above discussed, there remains to be considered the large group of *galeatiform* shells which are characterized by their usually small size, inequal convexity, and deep, overarching pedicle-valve. A typical representative of this variable and undoubtedly heterogeneous group is the well-known *Atrypa* (*Pentamerus*) *galeata*, Dalman. These are the fossils embraced in de Verneuil's grouping as "Pentamerus avec sinus," all having a median sinus more or less strongly developed. Two divisions of the first order may be based upon the position of this sinus, namely, those having it (1) on the pedicle-valve, and (2) on the brachial valve. In the former division belong such species as *P. fornicatus*, Hall, and *P. Areyi*, sp. nov., of the Clinton group; *P. linguifer*, Sowerby, and *P. ventricosus*, Hall, of the later Silurian, as well as shells which have been referred to the Devonian subgenus, Pentamerella (*P. arata*, Conrad, *P. dubia*, Hall, etc.). With the latter division we may place *P. galeatus*, Dalman, *P. nucleus*, *P. pseudogaleatus*, Hall, *P.* (*Sieberella*) *Sieberi*, von Buch, etc , of the Silurian, and the various species of the subgenus Gypidula (*G. comis*, Owen, *G. læviuscula*, Hall, *G. Romingeri*, sp. nov.). This grouping might form a very convenient arrangement of these species, were the field clear of generic terms, but in each group designations of unequal value have been introduced, based upon variations in other respects than contour alone. The Devonian members of each group develop with more or less distinctness a striated cardinal area and small and convex deltidial plates, with some accompanying variation in the character of the internal septal plates. These divisions will be considered more at length.

(A). *Galeatiform pentameroids bearing the fold on the brachial valve and the sinus on the pedicle-valve.*

Among the Silurian shells of this group there are two types of exterior, one plicated (*P. fornicatus*, *P. Areyi*, of the Clinton group), and the other smooth (*P. linguifer*, *P. ventricosus*, of the Wenlock-Niagara). There is, however, little

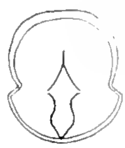

FIG. 173.

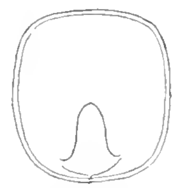

FIG. 174.

Fig. 173. *Pentamerus* (*Barrandella*) *linguifer.* Transverse section near the anterior extremity of the median septum in the pedicle-valve; showing the form of the spondylia. (C.)

Fig. 174. *Pentamerus* (*Barrandella*) *Barrandii*, Billings. A transverse section in front of the termination of the median septum of the pedicle-valve; showing the form of the spondylium in both valves, and the coalescence of the septa in the (lower) brachial valve. (C.)

if any difference in internal structure. DAVIDSON has shown* that *P. linguifer* bears a short spondylium in the pedicle-valve, supported only at its posterior surface, the free extension being produced forward and upward into the cavity of the opposite valve; and, also, that the crural plates of the brachial valve are convergent. The accompanying transverse section of this shell shows that these plates are concave on their outer surfaces and are supported by convergent septa uniting as they reach the valve and leaving but a single median line of union on its surface. With very slight variation in the degree of convergence of the last-named plates the same structure exists in the *P. ventricosus*, of the Niagara dolomites, a shell whose differences from *P. linguifer* it may be difficult to establish.† In the strongly plicated Clinton species, *P. Areyi*, the internal structure varies in having, so far as known, a well developed spon-

* Silurian Brachiopoda, pl. xvii, fig. 14 *b*.

† This remark refers to the normally smooth shell which served as the type of the species. There is, however, a variation closely associated with *P. ventricosus*, both structurally and in its occurrence, which has low plications on fold and sinus, though the lateral slopes are smooth. Figures of this form are given on Plate LXXI.

dylium in the brachial valve supported by a single axial septum. *Pentamerus fornicatus* is a small shell with a few broad, obscure plications, the most conspicuous lying in the sinus of the pedicle-valve. The whole expression of its exterior is very similar to *P. Barrandii*, Billings, from the Anticosti series, though the latter is an elongate and much larger shell, interesting in having the sinus and fold, in immature growth-stages, on pedicle- and brachial valves respectively, but reversing this arrangement at maturity. This reversion is, however, to some extent illusory and need not affect the association of the species with *P. fornicatus*; it is essentially due to the plication in the sinus of the immature pedicle-valve, which, after middle growth, fills up, and entirely obliterates the sinus itself; the effect in the mature shell being intensified by the corresponding development of the axial furrow on the immature fold of the opposite valve.

A peculiar internal character of all these shells is the series of strong vascular, or ovarian sinuses, which radiate from the umbonal region of the pedicle-valve. These are complicated with the undefined diductor scars and are therefore to a certain extent of muscular origin. In *Pentamerus fornicatus* these are highly developed and produce strong ridges on the casts of the valve; while in *P. ventricosus* they are more numerous and much finer. In *P. linguifer* the character of the inner surface of the valves has not been described, but in transverse sections we find evidence that these sinuses were highly developed. It was for similarly ridged internal casts that BARRANDE proposed the generic term CLORINDA (*C. armata*, Etage *G*, type; *C. ancillans*, Etage *E*), both his species being pentameroids which in external form were probably not unlike *P. linguifer*.

No name has been introduced which can be appropriately employed as a designation for this group of species typified by *Pentamerus linguifer*, Sowerby. ŒHLERT* has given to the term ANTIRHYNCHONELLA, Quenstedt, 1871, a value which would justify its use in this case were it not that the French author has evidently misinterpreted the original application of this name, which was incidentally suggested for such pentameroids as have the position of the median

* FISCHER's Manuel de Conchyliologie, p. 1311.

fold and sinus the reverse of that in RHYNCHONELLA.* It is therefore proposed to designate them by the term BARRANDELLA.

The term PENTAMERELLA, Hall (1867), embraces, in a broad sense, the Devonian representatives of the same type of exterior, though the latter present some structural differences. The shells are of larger size than those of BARRANDELLA and strongly plicate, possessing a very narrow cardinal area, an elongate pseudo-area, and incipient deltidial plates. The median septum on the interior of the pedicle-valve is very short, and at times is altogether absent. In the brachial valve the crural plates and supporting septa form a distinct spondylium which is broadly sessile on the surface of the valve. The typical form of this division is the *Atrypa arata*, Conrad, a shell which abounds in the Schoharie grit and Corniferous limestone, and with it have been associated these other Devonian species: *P. Pavilionensis*, Hall,† of the Hamilton group, *P. dubia*, Hall, *P. micula* and *P. obsolescens*, Hall, from the middle Devonian faunas of Iowa. All of these shells have the ovarian surface of the pedicle-valve strongly pitted.

(B). *Galeatiform pentameroids having the fold on the pedicle-valve and the sinus on the brachial valve.*

Here we meet with a nearly parallel development to that observed among the Barrandellas and Pentamerellas. In external character there is a greater uniformity as the shells are almost invariably plicated and the typical contour is subjected to but very slight variation. The Silurian shells which pass under the name of *Pentamerus galeatus*, Dalman, have a very considerable

* Petrefactenkunde Deutschlands; Brachiopoden, p. 231. The term as here employed is simply the "Antirhynchonella-," but in the index (p. 727) the Latin form of the name is used. If any species can be taken as typical of ANTIRHYNCHONELLA, it is the *Conchidium tenuistriatus*, Walmstedt, mentioned in immediate connection with the single use of this name, and not *Pentamerus linguifer*, which is cited by QUENSTEDT as an illustration of the fact that the position of fold and sinus in the pentameroids is sometimes the same as in the Rhynchonellas. ANTIRHYNCHONELLA if adopted would be simply synonymous with CONCHIDIUM.

† It is often difficult to make a satisfactory distinction between the Hamilton shell and *P. arata*. The latter is quite variable, the typical form from the grits and limestones having rather broad and shallow valves and comparatively few, strongly dichotomous ribs. Specimens from the grits are frequently much larger, sometimes very arcuate and finely ribbed. The form prevailing in the Hamilton shales has fewer and more simple ribs and is rarely so large as *P. arata*. By a typographical error in the original description of this shell the name has come into use as *P. papilionensis*. We take this opportunity of correcting it to *Pavilionensis*, the current form being meaningless.

development of the median septum of the pedicle-valve, while the spondylium is moderately long, and is free for fully two-thirds its length. In the brachial valve of typical examples from the Gotland and Wenlock limestones no spondylium is formed; the septa supporting the crural plates resting directly on the

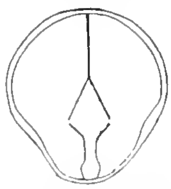

FIG. 175.

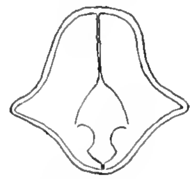

FIG. 176.

Fig. 175. Transverse section of *Pentamerus* (*Sieberella*) *galeatus*, near the beaks, the pedicle-valve being uppermost; showing the discrete septa of the brachial valve. (C.)

Fig. 176. *Pentamerus* (*Sieberella*) *Sieberi*, von Buch. Transverse section, showing the form of the spondylia. (C.)

surface of the valves. To what extent the latter feature varies among the European Silurian specimens of this species we do not know, but in the American representatives of this type of structure, the variability in development of these crural plates is very apparent, and confirms the opinion already expressed, that the union or independence of the septa of the brachial valve is not a feature of generic importance. There are two American shells which are currently referred to this species; the one from the Lower Helderberg fauna of New York has the closest similarity to the English shells in all points of structure, and in this one the septa in question invariably remain independent. A smaller shell also occurs in the Upper Silurian fauna of Perry county, Tennessee, which derives its name from an early identification by the late Professor FERDINAND ROEMER.* In this shell, however, these septa appear to be frequently, if not invariably, convergent, forming a spondylium resting upon a median septum. In view of this and similar evidence which has already been cited, it seems impossible to follow ŒHLERT, who has proposed to restrict, under the generic name SIEBERELLA,† shells of this type in which these plates are united and supported. This name has been based upon the species *P. Sieberi*, von Buch, a shell which abounds in the Bohemian Etage F_2‡ and in the Hercyn-

* Die Silurische Fauna des westlichen Tennessee, p. 73, pl. v, fig. 11.

† In FISCHER's Manuel de Conchyliologie, p. 1311. 1887.

‡ BARRANDE, Système Silurien, vol. v, pls. xxi, lxxvii–lxxix, cxviii, cxix.

ian of the Hartz Mountains,* resembling *P. galeatus* in contour though somewhat shorter and more sharply costated. If the significance of this variability be restricted to a specific or even more subordinate value, we shall have a group of Silurian shells essentially equivalent to BARRANDELLA, comprising such species as *P. galeatus*, *P. Roemeri*, nom. propos. (= *P. galeatus*, Roemer, *op. cit.*), *P. nucleus*, Hall, *P. uniplicatus*, Nettelroth, *P. Sieberi*, von Buch. All these shells are without evidence of cardinal area or deltidial plates, have the plication of the surface more strongly developed upon fold and sinus, and agree in the internal structure of the pedicle-valve. As the designation SIEBERELLA has been brought into use for one of these species, we may take the liberty of broadening its significance by basing it upon more stable characters than those selected by its author, and applying the term to all shells of this type of structure, taking no account of the specific variability in the internal structure of the brachial valve.

Typical Swedish and English Silurian specimens of *Pentamerus* (*Sieberella*) *galeatus* possess a peculiar surface sculpture consisting of very fine, irregularly anastomosing concentric lines, and, in rare instances, a similar character is preserved in the Lower Helderberg specimens of the same species. In regard to the various shells from the Devonian that are referred to *P. galeatus* by the European palæontologists, it may be suggested that they are less likely to represent this specific type than to indicate the presence, in those faunas, of shells referable to the Devonian genus GYPIDULA.

This group GYPIDULA, Hall, 1867, includes those galeatiform shells of the second division which have a well-defined, true, cross-striated cardinal area, and narrow, but erect or convex, incipient deltidial plates. On the interior the teeth are unusually strong, the septum of the pedicle-valve very short, the spondylium being free for most of its length. In the opposite valve the dental sockets are distinct, the crural plates expanded nearly horizontally, being divided at their beginning

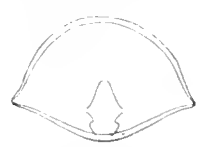

FIG. 177.
Pentamerus (*Gypidula*) *comis*, Owen.
A transverse section in front of the short median septum of the pedicle-valve; showing the form of the spondylia.
(C.)

* KAYSER, Abhandl. zur geol. Specialkarte von Preussen, etc., Band 2, heft 4, p. 156, pl. xxvii, figs. 1–9, 13. 1878.

by a narrow median cardinal process. The inner moiety of the crural plates is deflected to a vertical or slightly divergent position, and in this form they are produced anteriorly. These plates rest upon two broadly convergent septa which unite with the valve making a sessile spondylium, which is acute at its anterior extremity, and lies at, or in front of the center of the valve. The character of this structure in the brachial valve is not variable in GYPIDULA.

The typical species of this genus is the *Pentamerus occidentalis* (= *P. comis*, Owen), from the middle Devonian of Iowa, a shell which is usually more or less plicate, though these plications constantly show a tendency to obsolescence. With it are to be associated the *G. læviuscula*, Hall, a small, smooth species, *G. mundula*, Calvin, also from the Iowa Devonian, *G. subglobosa*, Meek and Worthen, from the Hamilton fauna at Rock Island, Illinois; *G. Romingeri*, sp. nov., a large, strongly plicate shell from the Hamilton fauna at Alpena, Michigan, and *G. Lotis*, Walcott, from the "Upper Devonian, on the west side of Applegate Cañon, White Pine Mining District, Nevada."* The type was not one of long duration, and appears to be altogether absent from the New York faunas.

GENUS CAPELLINIA,† GEN. NOV.

PLATE LXX.

Shells large, elongate subovate; the relative size and convexity of the valves, normal for PENTAMERUS, are here reversed, the brachial valve being the larger and deeper, with full, strongly arcuate and incurved umbo and beak, the apex of which is concealed within the delthyrium of the opposite valve. The pedicle-valve has an acute suberect beak which is not arched posteriorly, but rises directly from the cardinal margins. Below it is a broad delthyrium without evidence of deltidial plates; there is no hinge-line, but the margins of the delthyrium make subacute angles with the lateral margins of the valve. Cardinal slopes very broad and abrupt. The surface of the pedicle-valve is flattened above, while that of the brachial valve is evenly and deeply convex; it also shows a tendency to trilobation or obscure radial plication. The arrange-

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* Palæontology of the Eureka District, p. 161, pl. iii, fig. 9.

† Dedicated to Cav. GIOVANNI CAPELLINI, Professor in Bologna and Senator of the Kingdom of Italy; in recognition of his scientific achievements, and in grateful recollection of a personal friendship of many years.

ment of the internal septa and spondylium is the same as in *Pentamerus oblongus*, except that the supporting septa of the brachial valve are higher and more nearly vertical.

Type, *Capellinia mira*, sp. nov. Niagara dolomites of Wisconsin.

OBSERVATIONS. This remarkable shell is virtually a *Pentamerus oblongus* in which the relative convexity of the valves is reversed and this reversion carried to a great extreme. The single species observed, which has not before been described, has been studied from a number of examples obtained from the dolomites of Niagara age, in the vicinity of Milwaukee, Wisconsin, and loaned for study and use in the preparation of this volume by T. A. GREENE, Esq., of that city. It has not been observed elsewhere. These reversed shells have afforded no evidence that a normal relation of the valves existed in early growth-stages, and in this respect they differ from the reversed shells of the genus ANASTROPHIA.

GENUS STRICKLANDINIA, BILLINGS. (1863) 1859.

PLATE LXXIII.

1839. *Spirifer Atrypa*, J. DE C. SOWERBY. Silurian System, pl. xxi, figs 3, 21; pl. xxii, fig. 6.
1846. *Spirifer*, McCOY. Silurian Fossils of Ireland, p. 37, pl. iii, fig. 24.
1848. *Spirifer*, DE VERNEUIL. Bull. Soc. Géol. France, second ser., vol. v, p. 347.
1852. *Spirifer*, HALL. Palæontology of N. Y., vol. ii, p. 66, pl. xxii, fig. 3.
1859. *Pentamerus*, SALTER. Murchison's Siluria, second ed., pp. 100, 230, figs. 1, 3.
1859. *Stricklandia*, BILLINGS. Canadian Naturalist and Geologist, vol. iv, p. 132–135.
1861. *Stricklandia*, BILLINGS. Canadian Journal, vol. vi, p. 265.
1862. *Stricklandia*, BILLINGS. Palæozoic Fossils, vol. i, p. 84.
1863. *Stricklandia*, BILLINGS. Proc. Portland Soc. Nat. Hist., vol. i, p. 114.
1863. *Stricklandinia*, BILLINGS. Canadian Naturalist and Geologist, vol. viii, p. 370.
1866. *Stricklandinia*, BILLINGS. Catalogue Silurian Fossils of Anticosti, p. 45.
1867. *Stricklandinia*, HALL. Twentieth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 160.
1867. *Stricklandinia*, HALL. Palæontology of N. Y., vol. iv, p. 369.
1867. *Stricklandinia*, DAVIDSON. British Silurian Brachiopoda, pp. 157–163, pl. xix, figs. 13–23; pl. xx, figs. 1–13.
1868. *Stricklandinia*, BILLINGS. Geological Magazine, vol. v, p. 59, pl. iv.
1870. *Stricklandinia*, MEEK and WORTHEN. Proc. Acad. Nat. Sci. Philadelphia, vol. xiv, second ser., p. 37.
1874. *Stricklandinia*, BILLINGS. Palæozoic Fossils, vol. ii, pp. 78, 81, 83, fig. 49; pp. 84–89, pl. vi, figs. 1, 2; pl. vii, figs. 1, 4.
1875. *Stricklandinia*, MEEK and WORTHEN. Geol. Survey of Illinois, vol. vi, p. 502, pl. xxiv, fig. 5.
1876. *Stricklandinia*, WHITE Proc. Acad. Nat. Sci. Philadelphia, vol. vi, third ser., p. 30.
1877. *Stricklandinia*, WHITFIELD. Annual Rept. Geol. Survey of Wisconsin, p. 81.
1880. *Stricklandinia*, DAWSON. Canadian Naturalist and Geologist, vol. ix, second ser., p. 341.

1880. *Stricklandinia*, WHITE. Proc. U. S. National Museum, p. 48.
1882. *Stricklandinia*, WHITFIELD. Geology of Wisconsin, vol. iv, p. 315, pl. xxiii, figs. 3-5.
1883. *Stricklandinia*, DAVIDSON. British Silurian Brachiopoda, Suppl., pp. 164, 165, pl. ix, figs. 1-5.
1884. *Stricklandinia*, KIESOW. Ueber Silur. und Devon. Geschiebe Westpreussens, p. 51, pl. iii, fig. 7.
1889. *Stricklandinia*, NETTELROTH. Kentucky Fossil Shells, pp. 64, 65, pl. xxxiv, figs. 31-34.
1889. *Stricklandinia*, FOERSTE. Proc. Boston Soc. Nat Hist., vol. xxiv, p. 321, pl. v, figs. 1-4.
1890. *Stricklandinia*, GAGEL. Brachiop. der Camb und Silur. Geschiebe im Diluv. der Provinz. Ost- und Westpreussen, pp. 61, 62, pl iv, figs. 9, 10.

"GENERIC CHARACTERS. Shell usually large, elongate-oval, transversely-oval or circular; in some species with a straight hinge-line, more or less extended; valves nearly equal, varying from depressed convex to strongly convex; a short mesial septum in the interior of the ventral valve, supporting a small, triangular chamber beneath the beak, as in *Pentamerus;* in the dorsal valve two very short or rudimentary socket plates, which in some species bear prolonged calcified processes for the support of the serrated arms. Both valves with an area, that of the ventral valve the largest, the dorsal area sometimes incurved over the ventral, and concealing it wholly or in part.

"No muscular impressions have as yet been clearly observed in the ventral valve, but in the dorsal there are two oblong or subovate scars a little below the beak, one on each side of the median line. * * * The surface is usually coarsely and rather irregularly covered with radiating ridges, sometimes nearly smooth." (BILLINGS, Palæozoic Fossils, vol. ii, pt. i, p. 78, 1874.)

Type, *Stricklandinia Gaspensis*, Billings. Middle Silurian.

These pentameroids are principally remarkable for the unusual development of the cardinal areas of both valves in the larger and more typical species, and the straight orthoid hinge in the earlier and smaller members of the group. The combination of such features with an internal chambered structure is not of frequent occurrence among these genera. In PENTAMERELLA and GYPIDULA the definition of the cardinal area of the larger valve is generally obscure and its delimitation in these species may be regarded as occasional or spasmodic. In STRICKLANDINIA* this feature is sharply defined on both valves, and so persistent is it that we look for the origin of this combination, not among the various pentameroids which have just passed in review, but to the small, transverse shells of the early faunas to which the term SYNTROPHIA has been

* The name originally used by Mr. BILLINGS for these shells was STRICKLANDIA, but this he withdrew, as the term had been used for a genus of fossil plants, and proposed in its place the term STRICKLANDINIA.

applied (type, *Triplesia lateralis*, Whitfield, of the Calciferous fauna). Some of these early species were described as STRICKLANDINIA by BILLINGS (*S. Arachne* and *S. Arethusa*, from the Quebec group), but the author subsequently expressed his conviction that they represented a distinct type of generic structure. (Palæozoic Fossils, vol. ii, pt. i, p. 89.)

Some writers have assumed as the typical representative of BILLINGS' genus the species *Atrypa* or *Pentamerus lens*, Sowerby, an elongate shell of considerable size, from the Llandovery faunas, and allied in form and the general smoothness, or faint ribbing of its exterior, to the American species *S. Davidsoni*, Billings. Though the English species is mentioned frequently in the original discussion of the genus, we may feel more secure in the interpretation of the author's intentions by assuming as the type, the form first described by him, *S. Gaspensis*, a very large and strongly plicated shell with all the characteristic features positively developed.

On the brachial valve of this genus the short dental plates, at their inner angles, bear long crural processes. Though the expanded portions of these dental plates do not unite as in AMPHIGENIA to form a hinge-plate, yet the development of the crura and the abbreviation of the median septa suggest analogy with the latter genus rather than with PENTAMERUS, CONCHIDIUM, etc. STRICKLANDINIA is represented in the American Palæozoic by the following species: *S. Gaspensis*, *S. brevis*, *S. Anticostiensis*, *S. Davidsoni*, *S. Salteri* and *S. Melissa*, all described by BILLINGS, from the middle Silurian faunas of Canada; the last of these being a smooth shell, probably the same as that described from the Niagara dolomites of Illinois, under the name *S. deformis*, by MEEK and WORTHEN.* Besides these are *S. Canadensis*, Billings, from the Clinton group of the Province of Ontario, *S. castellana*, White, and *S. multilirata*, Whitfield, from the Niagara dolomites of Iowa and Wisconsin.

* Geological Survey of Illinois, vol. vi, p. 502.

GENUS AMPHIGENIA, HALL. 1867.

PLATES LXXIII, LXXIV.

1842. *Pentamerus*, VANUXEM. Geology of N. Y.; Rept. Third Dist., p. 131, fig. 1.
1843. *Pentamerus*, HALL. Geology of N. Y.; Rept. Fourth Dist.; Table of Organic Remains.
1857. *Meganteris*, HALL. Tenth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 123, figs. 1, 2.
1859. *Rensselæria*, HALL. Twelfth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 38.
1859. *Rensselæria*, HALL. Palæontology of N. Y., vol. iii, p. 453.
1861. *Stricklandinia*, BILLINGS. Canadian Naturalist and Geologist, vol. vi, p. 267, figs. 91, 92.
1863. *Stricklandinia*, BILLINGS. Geology of Canada, p. 371, fig. 390.
1867. *Amphigenia*, HALL. Twentieth Ann. Rept. N. Y State Cab. Nat Hist., p. 163.
1867. *Amphigenia*, HALL. Palæontology of N. Y, vol. iv, pp. 374, 382-381, pl lviii A, figs. 21-27; pl. lix, figs. 1-11.
1868. *Stricklandinia*, MEEK and WORTHEN. Geological Survey of Illinois, vol. iii, p. 402, pl. viii, fig. 1; pl. ix, fig. 5.
1874. *Amphigenia*, BILLINGS. Canadian Naturalist and Geologist, vol. vii, second ser., p. 240.
1879. *Amphigenia*, RATHBUN. Proc. Boston Society Nat. Hist., vol. xx, p. 34.
1885. *Amphigenia?*, ŒHLERT. Annales des Sciences Naturelles, vol. xii, p. 8 (author's ed.), pl. xii, figs. 5, 6; pl. xiii, figs. 7-9.

"Shells inequivalved, oval, ovoid or rectangular, more or less convex or gibbous, without mesial fold or sinus. Valves articulating by teeth and sockets, without area. The dental lamellæ in the ventral valve conjoined on their dorsal [ventral] sides, forming an angular trough or pit, which opens exteriorly by a triangular fissure beneath the beak, and in its anterior extension is supported on the central septum. Dorsal valve with a strong thickened cardinal process or hinge-plate, bordered by the teeth sockets, anchylosed to the bottom of the valve and supporting the crura, which extend into the cavity of the shell.

"In all the specimens examined there is a foramen extending beneath the hinge-plate, and ending in a perforation at the beak. The shell-substance is distinctly punctate, and, in exfoliated specimens, presents a prismatic structure. So far as known, the crura terminate in slender extensions, without appendage of any kind." (HALL, *loc. cit.*)

Type, *Pentamerus elongatus*, Vanuxem. Corniferous limestone.

AMPHIGENIA is a remarkable genus. Retaining the striking external contour of RENSSELÆRIA, a terebratuloid, its punctate shell-structure, and the same arrangement of muscular scars, it differs from that genus in the persistent development of a spondylium in the pedicle-valve, and of long, discrete crural processes in the brachial valve. These differences are apparently slight, but they involve important considerations, and are of themselves a demonstration of the close genetic relation between the pentameroids and terebratuloids; at the same time they seem, from the study of related genera, to represent a retrogression of the earlier Rensselæria type, a consideration which is somewhat fortified by the fact that Amphigenia, the earlier Rensselæria type, appeared abruptly in an enormous numerical development in the seas depositing the Upper Helderberg limestones, and as abruptly disappeared with the cessation of those deposits. During its existence the specific type of *A. elongata* scarcely varied.

To the generic diagnosis above given the following amplification in some structural details may be added:

The prevailing *form* of the mature shell is elongate-ovoid, high shouldered, broadest behind and sloping to a narrow and graceful curve anteriorly. This is quite the same character of outline as that occurring in *Rensselæria ovoides*. In young shells this prominence of the posterior portions is not attained, and they have the sloping shoulders and general expression of the mature shells of Newberria, a later and immediately succeeding genus. The obtuse median fold on both valves at maturity is also less clearly defined in youth. The surface is generally smooth with irregularly distant festoons or wrinkles of growth, and distinct radiating striæ may usually be seen, especially in young individuals.

The *substance* of the shell is impunctate on the surface. Beneath the epidermal layer is another that is highly punctated; within this, and apparently forming the innermost lamina, is a third layer whose surface is minutely wrinkled, and is very suggestive of the "Runzelschicht" of the ammonoid cephalopods.

In the *pedicle-valve* the spondylium is short and is distinctly formed by the union of the dental lamellæ with a medium septum. In Rensselæria these lamellæ are highly developed, but are usually appressed against the lateral walls of the valve, being free only at their anterior margins, while between them lies the well-defined and longitudinally-divided muscular area. It is a natural inference, therefore, that the muscles of Amphigenia were implanted on the spondylium, and there is no evidence of scars elsewhere in this valve. As in Rensselæria, however, the vascular sinuses are visible on the post-lateral surfaces.

In the *brachial valve* the hinge-plate is not always perforated by the visceral foramen, though it probably has been at some time in the history of the individual. With age it became filled up by adventitious deposits. The crura are long, straight, inclining upward or toward the opposite valve and are expanded at their extremities into palmate processes. The muscular scars in this valve are sharply developed, forming together an elongate adductor area, clearly divisible into an attenuate anterior pair and a broader posterior pair. The former have about twice the length of the latter and are marked by transverse, fine, closely-set wrinkles; the latter are radiately and coarsely striate. From the posterior termination of this area to beneath the hinge-plate extends a broad, smooth sinus, from which is given off a pair of strong lateral branches, which ramify over the genital area in the umbonal region. Thus, except in the character of its crural processes, the structure of the brachial valve and the indications in regard to the composition of the muscular system are identical with those of *Rensselæria ovoides*.

As already observed, the specific type of *Amphigenia elongata* varies little, if at all, during the existence of the genus. *A. elongata*, var. *curta*, was described by Meek and Worthen, from the beds at Jonesboro, Ill., which have been regarded as of the age of the Oriskany sandstone of New York, though containing a number of Upper Helderberg types. Similarly, *A. elongata* has been reported by Billings from the Oriskany fauna of Cayuga, Ontario, in which there is even a larger representation of Upper Helderberg species. In the New York faunas it appeared first in the Schoharie grit, where it is not common. In the Corniferous limestone it abounds in certain localities, especially in the western part of the state, and with the close of the Upper Helderberg it disappears.

The occurrence of fine, large and typical examples of the species in the lower Devonian sandstones of the rivers Mæcurú and Curuá, Province of Pará, Brazil, has been noted by Rathbun (*loc. cit.*).

Œhlert has described as *Amphigenia? Bureaui*, a large shell with smooth exterior and small spondylium in the pedicle-valve, resting on the bottom of the valve and not supported by a septum, as in *A. elongata*. This shell is from the lower or middle Devonian of Montjean and Challones (Maine-et-Loire), France.

Genus RENSSELÆRIA, Hall. 1859.

PLATES LXXV, LXXVI, LXXVII.

1832. *Terebratula*, Eaton. Geological Text-book, p. 45.
1839. *Atrypa*, Conrad. Geological Survey of N. Y.; Third Ann. Rept. Pal. Dept., p. 65.
1842. *Atrypa*, Conrad. Journal Acad. Nat. Sci. Philadelphia, vol. viii, p. 266, pl xvi, fig. 17.
1842. *Atrypa*, Vanuxem. Geology of N. Y.; Rept. Third Dist., p. 123, fig 2.
1843. *Atrypa*, Hall. Geology of N. Y.; Rept. Fourth Dist., p. 148, fig. 2.
1843. *Pentamerus*, Castelnau. Essai sur le Syst. Silurien de l'Amér. Septen., p. 38, pl. xv, figs. 1, 2.
1844. *Terebratula*, F. Roemer. Das rhein. Uebergangsgebirge, p. 68, pl. i, figs. 6 *a*, *b*.
1857. *Meganteris*, Hall Tenth Rept. N. Y. State Cab. Nat. Hist., pp. 97–99, 101–103.
1858. *Meganteris*, Rogers. Geology of Pennsylvania, vol. ii, pt. ii, p. 826, fig. 649.
1859. *Rensselæria*, Hall (partim). Twelfth Rept. N. Y. State Cab. Nat. Hist., pp. 39–41.
1859. *Rensselæria*, Hall. Palæontology of New York, vol. iii, pp. 254–256, 453–457, 461–464, pl. xlv, figs. 2–4; pls. civ, cv, cviii.
1862. *Atrypa*, (Conrad) Hall. Fifteenth Rept. N. Y. State Cab. Nat. Hist., pl. xi, fig. 14.
1864. ? *Rensselæria*, Davidson. Monogr. British Devonian Brachiopoda, p. 10, pl. iv, figs. 5–7.
1870. *Rensselæria*, Dall. American Journal of Conchology, vol. vi, p. 105.
1874. *Rensselæria*, Billings. Palæozoic Fossils, vol. ii, p. 41, pl. iii, figs. 7, 10.
1876. *Rensselæria*, F. Roemer. Lethæa Palæozoica, pl. xxiii, fig. 5.
1882. ? *Rensselæria*, Davidson. Suppl. Devonian Brachiopoda, p. 19, pl. i, figs. 20, 20 *a*.

Diagnosis. Shell oval or elongate-ovate in outline, subovoid in contour, broadest posteriorly; valves unequally convex, with a more or less distinct median elevation on both. Cardinal slopes broadly flattened in the typical species. Lateral margins compressed and often strongly inflectted.

Pedicle-valve with full, scarcely salient umbo; beak acute, incurved, with terminal foramen. Beneath and on each side of the beak is a concave, sharply defined space, but no proper cardinal area. Distinct deltidial plates divided by a median suture may be present, but they are usually concealed by incurvature, or atrophied by the encroachment of the umbo of the opposite valve.

On the interior the teeth are prominent but not thickened, widely divergent and close within the margins of the valve. They are supported by stout dental plates which rest for most of their length upon the bottom of the valve, but are free along their posterior margins. These plates are closely appressed against the lateral walls of the shell and become coalescent therewith in later growth-stages. The muscular impression is restricted to the posterior portion of the valve, covering a very narrow longitudinal area. Between the dental plates at the bottom of the pedicle-cavity lies a narrow median scar, and in front of this a very deep, elongate impression which is sometimes clearly divided into central adductor scars embraced by the diductor impressions. This distinction is usually lost and only a median division by a slight longitudinal septum is discernible. The entire area does not extend more than one-third the whole length of the valve. Over the post-lateral slopes are numerous fine, irregularly ramifying genital sinuses.

The brachial valve is considerably the less convex and is often flattened. The beak is minute and usually obscured by the overlapping pedicle-valve. The hinge-plate is large, flat, triangular, sometimes thin, often thickened on its posterior portion and resting on the bottom of the valve. It is separated from the lateral shell-walls by narrow dental grooves widening at their extremities. Normally this plate appears to have been perforated by a visceral foramen entering at the underside and opening at or beneath the apex of the beak. This perforation is however frequently filled by adventitious deposits though traces of it are discernible in the oldest shells, and in casts of the interior the filling of the tube is often preserved. The median portion of the plate, lying between two vertical supporting lamellæ resting on the bottom of the valve, is preserved in the earliest and simpler species, but in the larger and later forms of the genus, is frequently resorbed, giving the plate the appearance of being composed of subtriangular, discrete lateral halves.

The crura are the continuation of the upper portions of the supporting septa. Neither these nor the rest of the brachidium have been seen in the type species, *R. ovoides*, of the Oriskany sandstone,* but in *R. Marylandica*, the crura are broadened just beyond their base of attachment, and from their upper angles are given off the jugal processes which are long, pointing upward and inward, but not uniting. From the lower angles the descending arms take their origin, following the curves of the valve, diverging for a short distance, thence abruptly approaching, and uniting to form a broad elongate, acutely triangular plate, which is not supported by a median septum, or otherwise connected with the valve. From the middle of the posterior margin of the plate arises a small rod-like process, which extends for a short distance upward toward the crura. The entire length of the brachidium is nearly two-thirds that of the valve.

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* The figures of the brachial supports ascribed to *R. ovoides* in the Twelfth Report on the State Cabinet of Natural History, p. 41, represent the species *R. Marylandica*, which at that date had not been separated from *R. ovoides*.

The muscular area is less clearly delimited than that of the opposite valve, and its component scars are not often distinctly defined. It is, however, broader and longer than on the pedicle-valve, and is divided transversely into anterior and posterior adductor scars, the former being the larger, and their surface covered by branching lines radiating from a median longitudinal ridge. From the narrow and somewhat elevated posterior extremities of this area extends a broad median sinus, on either side of which arises a stout vascular trunk bending backward and over the post-lateral slopes. Secondary branches are given off from both its margins. These vascular markings of the genital region are rarely well defined.

Surface of the shell distinctly plicated, with sparse concentric wrinkles near the anterior margin. The radial lines may be fine or coarse, but no species is known in which the surface is entirely smooth.*

Shell-substance punctated beneath the epidermal layer.

Type, *Terebratula ovoides*, Eaton. Oriskany sandstone.

Observations. The discussion of the genus Amphigenia has given occasion to notice its close resemblance in form and various structural details to the typical Rensselæria, or properly, to the Rensselærias most closely associated with that genus in time. The existence of a spondylium in the one, and of a terebratuloid brachidium in the other, are the distinctive differences in the two groups.

A considerable number of species has been referred to the genus Rensselæria, but it seems necessary to remove some of them to other genera on account of significant structural differences; and among those which remain to Rensselæria in this somewhat restricted sense, there are still some variations of a chronological or developmental value. In the type species, *R. ovoides*, we are dealing with a shell in which size, form and structural features have been carried beyond the normal mature or acmic stage of phyletic development. This becomes evident from a comparison with the earlier species

* The species *R. lævis*, Hall, from the Shaly limestone of the Lower Helderberg group, was described as having a smooth exterior, and should this prove to be the fact the shell will probably prove not to belong to this genus. Its interior is still unknown.

occurring in the Shaly limestone of the Lower Helderberg group, *R. æquiradiata*, Conrad, *R. elliptica*, Hall, *R. mutabilis*, Hall, in all of which the form is terebratuloid, the umbonal slopes very gradual, not full and squared, the beak of the pedicle-valve prominent and suberect, exposing the undisturbed deltidial plates; while the muscular scars are but feebly developed. Similar characters are shown in *R. Cumberlandiæ*, of the Oriskany fauna at Cumberland, Maryland, where predominating species of this formation are associated with many Lower Helderberg types. In *R. Cayuga*, sp. nov., of the later Oriskany of Ontario, the elongate-oval form of the shell is maintained with close incurvature of the beaks and increased convexity of the brachial valve. The high-shouldered form and linguate outline of *R. ovoides*, which it shares with AMPHIGENIA, is also well exemplified in *R. Marylandica*.

In the structure of its brachidium, RENSSELÆRIA is very similar to CENTRONELLA. This similarity has been frequently noticed and has been brought out with especial emphasis by ŒHLERT in his demonstration of the brachial supports of *Terebratula Guerangeri*, de Verneuil,* though we can not follow this author in his reference of such plicated shells to the genus CENTRONELLA. This genus bears upon the surface of the broad anterior plate a median ridge which projects a little at each extremity; in *C. Julia*, A. Winchell, this ridge becomes a prominent vertical plate. There is, however, in these shells no posterior and upward projection of the ridge, as in RENSSELÆRIA. In the earlier and smaller forms of RENSSELÆRIA, the hinge-plate is thin and perforated by an oval foramen which lies below the apex of the umbo. It is also distinctly divided by diverging ridges at whose extremities originate the crura. This structure is precisely that of *T. Guerangeri*, and in respect to the brachidium throughout there is no material difference except in the lesser development of the anterior plate in the latter.

Rensselæria mutabilis, Hall, of the Lower Helderberg fauna, which is the smallest known representative of the genus, frequently exhibits a primitive condition of the brachidium in the imperfect coalescence of the lateral parts of the anterior plate and the development of a median ridge upon its lower side.

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* Note sur Terebratula (Centronella) Guerangeri; Bull. de la Soc. d'Etudes Scientif. d'Angers, 1883, pp. 1-11, pls. i, ii.

These features, which are shown in the figures herewith given, are accompanied by a correspondingly primitive expression of the exterior, the form of the shell being terebratuloid with the usual oblique cardinal slopes and regularly everted margins.

Fig. 178.

Fig. 179.

Loop of *Rensselaeria mutabilis*, Hall.

Fig. 178. View from above; showing the perforated hinge-plate and the simple irregular line of coalescence of the lateral processes.

Fig. 179. View from in front; showing the upward curvature of the anterior plate and the median ridge on its under surface. (C.)

Of the species which have been referred to RENSSELÆRIA, *R. Suessana*, Hall, from the Oriskany fauna of Maryland, and also known in the lower Oriskany of the Hudson River valley, presents differences in form and structure sufficient to render its association with *R. ovoides* unnatural and unsatisfactory. These shells are lentiform in general contour; moderately and subequally convex; both valves with an obscure and undefined median fold. The beak of the pedicle-valve is prominent, never incurved sufficiently to conceal its deltidial plates and foramen. The cardinal margin beneath the beak is flattened into a well-defined pseudarea, and the short inflection of the margin beginning here is continued along the lateral portion of the shell, where it meets a similar marginal inflexion from the opposite valve. These produce the sharp introversion of the lateral margins which is also one of the characteristics of the genus MEGALANTERIS.

The surface of the valves is covered with fine, hair-like radiating striæ, which often are visible only near the margins or at their thickened extremities on the inflexed portions of the shell.

On the interior the dental lamellæ are short and do not rest upon the valve. The hinge-plate is supported by two vertical septa, the median cleft and visceral foramen are more or less obscured and with sometimes a bilobed callus in its place. The brachidium has long, straight jugal processes, the triangular anterior plate in numerous specimens shows that the posterior rod-like process from the median ridge of that plate extends upward almost to the crura, but terminates abruptly and has no connexion whatever with the latter. To distinguish this peculiar modification of the RENSSELÆRIA-type, it is proposed to adopt the subgeneric term, BEACHIA.* *Rensselæria Suessana*, so far as now known, is its only representative.

With our present knowledge the genus RENSSELÆRIA must be recognized as the earliest and most primitive type of terebratuloid structure. That this genus, and CENTRONELLA, together with the plicated group of *Terebratula Guerangeri*, and perhaps also, the plicated shells incompletely described by WAAGEN as NOTOTHYRIS, from the Permo-Carboniferous limestones, have had a common origin must be regarded as beyond a reasonable doubt.

The simple loop in all of these forms is but the result of the coalescence of the two lateral arms or extended crural processes; and anything more simple than the triangular loop of RENSSELÆRIA would be only the discrete processes of AMPHIGENIA and the rhynchonelloids.

RENSSELÆRIA appeared with the Lower Helderberg fauna and, in America, disappeared with the Oriskany sandstone. The *Terebratula strigiceps*, F. Roemer, from the lower Devonian of Siegen† has been referred to this genus by KAYSER, and though the internal characters of this species have not been demonstrated, its exterior endorses this interpretation. Elsewhere in Europe the existence of RENSSELÆRIA has not been satisfactorily established.

* It is with great satisfaction that I dedicate this interesting generic form to the Hon. ALLEN C. BEACH, of Watertown, N. Y., an earnest advocate and patron of science, who, while Lieutenant-Governor of the State in 1870, recognized the importance of establishing the State Cabinet of Natural History as an organization for the promotion of scientific research, as intended by its founders, and, with the aid of a few friends, secured the enactment of a law organizing the institution as the "State Museum of Natural History." The purpose of this law was to carry into effect the recommendation of the Legislature of 1866:—to place that organization "in the condition required by the present state of science, and to maintain it in full efficiency as a Museum of Scientific and Practical Geology and Comparative Zoology."

In this connection I recall with pleasure the interest taken in this matter by Hon. WILLIAM F. ALLEN, at that time State Comptroller, and afterwards Judge of the Court of Appeals, who drew the form of this bill and aided in securing its passage by the Legislature.

† See also QUENSTEDT, Petrefactenk. Deutschlands; Brachiopoden, p. 343. 1871.

GENUS NEWBERRIA, HALL. 1891.*

PLATE LXXVIII.

1867. *Rensselæria*, MEEK. Trans. Chicago Acad. Sci., vol. i, pt. i, p. 108, pl. viii, fig. 8; pl. xiv, fig. 4.
1867. *Rensselæria?* HALL. Palæontology of New York, vol. iv, p. 385, pl. lviii A, figs. 9-20.
1883. *Rensselæria*, CLAYPOLE. Proc. American Philosophical Society, p. 235.
1891. *Newberria*, (HALL) WHITEAVES. Contributions to Canadian Palæontology, vol. i, pt. 3, p. 237, pl. xxx, figs. 3, 4, 4 a.
1891. *Newberria*, HALL. Tenth Ann. Rept. N. Y. State Geologist, pp. 91-99, pls. v, vi.

DIAGNOSIS. Shell elongate-ovoid, having the general contour and external aspect of RENSSELÆRIA and AMPHIGENIA, but without the strongly radiate-striate surface prevailing in the former genus, and less strongly developed in the latter. The greatest convexity of the valves is in the umbonal region, or above the middle of their length, and in some forms the surface is distinctly flattened over the lateral slopes, leaving the median portion of the valves very prominent and sometimes subangular. The cardinal and lateral margins are regular, even and not inflected.

The pedicle-valve has the rostrum produced and incurved, the apex slightly truncated by the subcircular foramen; deltidial plates small and obscure. The teeth are comparatively small, projecting forward and gently upward, free at their extremities, and supported by narrow dental plates which join the bottom of the valve above the middle of its length and are continued forward as slender, widely divergent ridges upon the inner surface, gradually merging into the shell.

In the bottom of the rostral and umbonal cavity is a broad, usually ill-defined muscular area, from which radiates a series of vascular ridges and depressions extending into the marginal region of the valve. The diductor scars are situated posteriorly and deeply impressed; between and in front of them is a narrow, elongate adductor scar which is rarely divided medially and often extends forward to, or beyond the center of the valve. On each side of the muscular impression is a thickened area, very narrow at its origin in the

*On account of similarity to RENSSELÆRIA in exterior form and external shell-markings, the discussion of NEWBERRIA is introduced here, though we are still in ignorance of the structure of its brachial apparatus. Further consideration of the RENSSELÆRIA brachidium and its variations is given with the observations on CENTRONELLA and its allies, immediately following.

rostral region or pedicle-cavity, and produced into divergent ridges, usually two on each side, and a fifth in the median axis. These may extend to the margins or disappear before reaching the middle of the valve and are variously subdivided by vascular grooves and sinuses emanating from them.

In the brachial valve the hinge-plate is small, similar to that of RENSSELÆRIA and AMPHIGENIA in general form, but is of relatively less size than in the former genus and is not perforated by a visceral foramen opening beneath the apex. Two very narrow, almost linear and closely submarginal dental sockets extend nearly to the apex; within them lie two broad, subtriangular crural plates, which are divided by a triangular median fissure extending to the bottom of the valve. The inner anterior angles of these plates bear the slender crural processes, the extent of which is unknown. In mature individuals the apical portion of the hinge-plate is peculiarly constructed; the lateral areas become more or less completely united, without altogether obliterating the median triangular fissure, and above this point the surface is excavated into a spoon-shaped cavity, when the development is extreme, or is transversely angular in the average individual. At a short distance from the hinge-plate and in the bottom of the valve there arises a low median ridge, which continues for a short distance, separating the obovate, narrowly flabelliform scars of the anterior and posterior adductor muscles. The anterior scars are considerably the larger, and their surface is longitudinally striated. The vascular grooves and ridges are more obscurely developed than in the pedicle-valve.

Surface smooth or covered with fine concentric striæ accompanied by stronger wrinkles of growth. The inner laminæ are sometimes marked by obscure radiating striæ near the margins of the valves.

Shell-substance finely punctate.

Type, *Rensselæria? Johannis*, Hall. Hamilton group.

OBSERVATIONS. Several of the earlier species of RENSSELÆRIA have an essentially similar form to the representatives of this genus. This, however, is not the broad-shouldered form of *R. ovoides* nor of AMPHIGENIA, and none have radiating surface striæ of the latter shells. In AMPHIGENIA the high dental lamellæ bounding the muscular impressions of the pedicle-valve are supported by a median septum; in RENSSELÆRIA and MEGALANTERIS this supporting septum is wanting, the convergent lamellæ resting on the bottom of the valve. In NEWBERRIA, however, these lamellæ are exceedingly divergent and quite short; the muscular impressions being sunk in the shell without other delimitation. In typical forms of RENSSELÆRIA, as well as of AMPHIGENIA, the hinge-plate is not deeply divided medially, and is perforated by a visceral foramen, though the latter is frequently closed. In NEWBERRIA there is no evidence of this perforation. The peculiar apical structure of the hinge-plate has been made out from internal casts of the best known species, *N. Claypolii*, Hall, and, upon comparing with these the description and figures of *Megalanteris inornata* (*Atrypa inornata*, d'Orbigny), given by ŒHLERT,* the latter clearly evince a similar structure. The strong development of the sinuses in NEWBERRIA is a feature of distinction. In the allied genera RENSSELÆRIA, AMPHIGENIA and MEGALANTERIS, the sinuses are more or less clearly defined in the umbonal region and about the area of muscular insertion, but in NEWBERRIA the great trunk vessels originate about the ante-lateral edges of the muscles and traverse the brachial region, while the posterior surfaces of the valves are free of them.

The distinctive differences in this type of structure from RENSSELÆRIA were indicated in the Fourth Volume of the Palæontology of New York, where the species there described as *Rensselæria? Johannis* was referred to that genus with doubt and a suggestion incidentally made that a new generic division might, with further knowledge, be erected for it.† This fossil was from the beds of the Hamilton group, at Waterloo, Iowa. There was also known at that time, in the collections of Professor G. C. SWALLOW, then State Geologist of Missouri, a larger form possessing similar characteristics, from the Hamilton rocks of Moniteau county, Missouri, which has since been described as *Newberria Missouriensis*, (Swallow) Hall.‡

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* Annales des Sciences Géologiques, vol. xix, art. No. 1, p. 20, pl. ii, figs. 1–10.

† The term RENSSELANDIA was there used in this incidental manner, but as it was not defined and etymologically is without meaning, it can not be adopted.

‡ Tenth Report of the New York State Geologist, p. 97, pl. v, figs. 10–12. 1891.

With our present knowledge there may also be included in the same group, the species described by MEEK, from the McKenzie river, as *Rensselæria lævis*,* and more recently identified by WHITEAVES, in the same region, associated with *Stringocephalus Burtini*, and other characteristic middle Devonian species; and also the interesting and abundant form discovered by Professor E. W. CLAYPOLE in the sandstones of the age of the Hamilton group, in Perry county, Pennsylvania,† subsequently described as *Newberria Claypolii*. This shell occurs in great quantities both at the locality cited, and in a coarser pebbly sandstone at Pine Grove, Schuylkill county, in the same State, a locality which has furnished most instructive specimens of both the interior and exterior of the shell.

There can be little reason to doubt that ŒHLERT'S *Megalanteris inornata* (d'Orbigny sp.), to which reference has already been made, represents this genus in the Devonian of western France. The agreement is found both in the detailed structure of the hinge-plate, the arrangement of the muscular areas and the character of the vascular sinuses. In default of other evidence, it may be considered probable that the *Atrypa Deshayesi*, Caillaud, *A. amygdala*, d'Orbigny, and *Terebratula amygdalina*, Goldfuss (Kayser), from the lower and middle Devonian of France and Germany, also represent the genus NEWBERRIA. This genus seems to be a later modification of the RENSSELÆRIA-type of brachiopod structure. The true RENSSELÆRIA, so far as known, closed its existence, in America at least, with the disappearance of the fauna of the Oriskany sandstone. AMPHIGENIA is not known in the faunas succeeding those of the Upper Helderberg, while NEWBERRIA occurs in the lower and middle Devonian, Hamilton group, and is probably not of earlier age.

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* Not *Rensselæria lævis*, Hall, Pal. N. Y., vol. iii, p. 256. 1859.

† See Proceedings of the American Philosophical Society, p. 235. 1883.

Genera (1) CENTRONELLA, Billings, 1859; (2) ORISKANIA, gen. nov.; (3) SELENELLA, gen. nov.; (4) ROMINGERINA, gen. nov.; (5) TRIGERIA, Bayle, 1875; (6) NOTOTHYRIS, Waagen, 1882.

PLATES L, LXXVI, LXXIX.

(5) 1841. *Terebratula*, Phillips. Palæoz. Foss. Cornwall, Devon and West Somerset, p. 91, pl. xxxv, fig. 167.
(1) 1857. *Rhynchonella*, Hall Tenth Ann. Rept. N. Y. State Cab. Nat Hist., p. 124, figs. 1–6.
(1) 1859. *Centronella*, Billings. Canadian Naturalist and Geologist, vol. iv, p. 131, figs. 1–5.
(5) 1860. *Rhynchospira*, Hall. Thirteenth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 83.
(1) 1861. *Centronella*, Billings. Canadian Journal, vol. vi, p. 271, fig. 97; p. 272, figs. 98, 99.
(1) 1861. *Centronella*, Hall. Fourteenth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 102.
(1) 1862. *Centronella*, Hall. Fifteenth Ann. Rept. N. Y. State Cab. Nat. Hist., pl. iii. figs. 1–5.
(1) 1862. *Centronella*, Billings. Canadian Naturalist and Geologist, vol. vii, p. 392.
(4) 1862. *Centronella*, A. Winchell. Proc. Acad. Nat. Sci. Philadelphia, vol. vii, p. 405.
(5) 1862. *Rensselæria*, Billings. Proc. Portland Soc. Nat. Hist., vol. i, p. 115, plate, fig. 12.
(6) 1862. *Terebratula*, Davidson. Quarterly Journal Geological Society, vol. xviii, p. 27, pl. ii, fig. 4.
(1) 1863. *Centronella*, Hall. Sixteenth Ann. Rept. N. Y. State Cab Nat. Hist., pp. 45–47, figs. 13–17.
(1) 1863. *Centronella*, Hall. American Journal of Science, vol. xxxv, p. 402.
(1) 1863. *Centronella*, Billings. American Journal of Science, vol. xxxvi, p. 236.
(1) 1863. *Centronella*, Billings. Geology of Canada, p. 374, figs. 403–405.
(4) 1863. *Cryptonella*, Hall. Sixteenth Ann. Rept. N. Y. State Cab. Nat. Hist., pp. 41–43.
(4) 1863. *Cryptonella*, Hall. American Journal of Science, vol. xxxv, pp. 399–402.
(6) 1863. *Terebratula*, de Koninck. Foss. Paléoz. de l'Inde, p. 32, pl. ix, fig. 4.
(1)? 1865. *Centronella*, A. Winchell. Proc. Acad. Nat. Sci. Philadelphia, vol. ix, pp. 122, 123.
(1) 1867. *Centronella*, Hall. Palæontology of New York, vol. iv, pp. 399–403, 420, pl. lxi A, figs. 1–40.
(3) 1867. *Centronella*, Hall. Palæontology of New York, vol. iv, p. 419, pl. lxi A, figs. 47–49.
(4) 1867. *Centronella*, Hall. Palæontology of New York, vol. iv, p. 419, pl. lxi A, figs. 41–45.
(5) 1867. *Centronella*, Hall. Palæontology of New York, vol. iv, p. 276, pl. xlv, figs. 1–6.
(1)? 1870. *Centronella*, A. Winchell. Proc. American Philosophical Society, vol. xii, p. 254.
(5) 1875. *Trigeria*, Bayle. Explic. de la Carte Géolog. de France, Atlas, pl. xiii, figs. 5–12.
(6) 1878. *Terebratula*, Abich. Geolog. Forsch. in der Kaukasisch. Ländern, I, p. 68, pl. vi, fig. 10.
(5) 1882. *Centronella*, Davidson. British Devonian Brachiopoda, Suppl., p. 14, pl. i, figs. 7–9.
(6) 1882. *Notothyris*, Waagen. Productus limestone Fossils; Brachiopoda, pp. 375–390, pl. xxviii, figs. 1–13; pl. xxx, figs. 13, 14.
(5) 1883. *Centronella*, Œhlert. Bull. de la Soc. d'Etudes Scientif. d'Angers, pp. 1–11, pl. i, figs. 1–11; pl. ii. figs. 1–6.
(5) 1885. *Centronella*, Œhlert. Bull. de la Société d'Etudes Scientif. d'Angers, pp. 1–5, plate, figs. 1–19.
(1) 1888. *Centronella*, Herrick. Bull. Denison University, vol. iii, p. 49, pl. ii, fig. 5.
(1) 1889. *Centronella*, Nettelroth. Kentucky Fossil Shells, p 153, pl. xxxi, figs. 14–17.
(5)? 1890. *Centronella* (?), Derby. Archivos do Museu Nacional do Rio de Janeiro, vol. ix, p. 84.
(6)? 1890. *Notothyris* (?), Derby. Archivos do Museu Nacional do Rio de Janeiro, vol. ix, p. 81.
(2) 1892. *Centronella*, Beecher and Clarke. American Journal of Science, vol. xliv, p. 414.

In discussing the genus Rensselæria and its subgenus Beachia, it has been observed that these shells combine a plicated or striated exterior with a brachidium constructed upon the same type as that of Centronella, Billings.

The latter genus was established in the same year (1859) as RENSSELÆRIA, and was founded upon a small plano-convex species with smooth exterior, the *Rhynchonella glans-fagea*, Hall, from the Upper Helderberg group.

The original description and figures illustrative of this genus did not give the structure of the brachidium with accuracy, but this was afterwards made out by Dr. CARL ROMINGER and shown in his excellent figure, given in the Sixteenth Report on the New York State Cabinet of Natural History (p. 47, 1863), and which is reproduced in this place. Subsequent examinations have endorsed the correctness of ROMINGER's determination and also show that the type upon which it is constructed is the same as in RENSSELÆRIA; the actual differences of expression appearing (1) in the shortness of the jugal processes, (2) in the less extended anterior plate, and (3) in the prominent median crest or ridge upon that plate, not produced posteriorly into a rod-like apophysis.

It has already been observed that in the early (Lower Helderberg) species of RENSSELÆRIA, such as *R. mutabilis*, some of these features, as the length of the crura, and the development of the median process are not so advanced as in the later and typical species of the genus, nor as in *R.* (*Beachia*) *Suessana*.

Upon farther examination of more extensive material it is found that this type of brachidium-structure has, without essential variation in itself, been associated in Devonian faunas with a considerable variety of external form and ornamentation of the shell. This fact has already been observed by some authors. Reference has been made to ŒHLERT's observation* of a similar brachidium, with a perforated hinge-plate, in certain small plano-convex or biconvex plicated or ribbed species, *Terebratula Guerangeri*, *Centronella Bergeroni* and *C. Gaudryi*, from the Devonian of western France, all of which he has referred to CENTRONELLA on the basis of this structure. DERBY has found a brachidium of similar structure, though somewhat more nearly approaching that of RENSSELÆRIA, in another small and strongly ribbed biconvex species from the Devonian of the State of Matto Grosso, Brazil, described by him under the name *Centronella ? Margarida*.†

* Bull. de la Soc. d'Etudes Scientif. d'Angers, 1883, pp. 1-11, pl. i, figs. 1-11; pl. ii, figs. 1-6; *ditto*, 1885, pp. 1-5, plate, figs. 1-19.

† Notá sobre a Geologia e Paleontologia de Matto Grosso: Archivos do Museu Nacional do Rio de Janeiro, vol. iv, p. 84, figures. 1890.

In the Devonian of North America we find species externally similar to *Terebratula Guerangeri*, and shall presently recur to them in considering the precise variation of structure which such forms exemplify.

Further, there is evidence of the existence, in the Upper Helderberg fauna, of a small, smooth biconvex terebratuliform shell, with sloping cardinal margins which bears the same form of brachidium as *Centronella glans-fagea.**

This type of brachial apparatus, however different may be the exterior of the shells bearing it, whether ribbed, striated or smooth, biconvex or plano-convex, has a definite time-value, and our present knowledge indicates that, beginning its existence in the Lower Helderberg, it is continued into the Oriskany sandstone, Upper Helderberg and Hamilton groups without material modification.

From this time onward the structure yielded to modifying influences. In the *Centronella Julia* of A. WINCHELL, a smooth, biconvex species from the Marshall group of Michigan, at the base of the Lower Carboniferous series, the anterior triangular plate of the brachidium bears a high vertical lamella extending in both directions beyond the limits of that plate into the cavity of the pedicle-valve.

Such forms must be kept apart from the earlier and typical Centronellas, as indicative of a progressed stage of development. The strongly plicated shells from the Productus limestone (Carboniferous) of the Salt-Range of India, which WAAGEN has described under the generic name NOTOTHYRIS (though the structure of their brachidia is not fully known), will undoubtedly prove to possess some modification of the CENTRONELLA type. Such a modification is evident in DERBY'S *Notothyris? Smithi* (*loc. cit.*) from the Devonian, a similarly plicated species which may prove to be an ancestral form of the Carboniferous NOTOTHYRIS.

Returning again to the genus CENTRONELLA and restricting our conception to forms similar to that regarded by its author as typical, the following diagnosis may be deduced :

* Farther reference will be made to this shell.

Shells plano-convex or concavo-convex. Pedicle-valve with acute incurved beak, perforated at its extremity, the foramen being continuous with a partially closed delthyrium; medially ridged, and with abruptly sloping sides. On the interior the teeth are large, thick at their extremities and adherent to the lateral walls of the shell. Between them is a deep pedicle-cavity, in the bottom of which lie the elongate scars of the adductor muscles, and about their anterior portion the small, flabellate diductors.

The brachial valve is very shallow, rendered concave exteriorly by a median sinus which does not make itself apparent on the interior. Beak small, apex not incurved. Dental sockets broad, bounded interiorly by the high walls of the hinge-plate. This plate is divided medially by a deep furrow extending to the apex, and therefore consists of two processes which are elevated, thickened and rest on the bottom of the valve. From the anterior face of these arise the crura which converge for a short distance, and expand to form two broad acute jugal processes. From here the lateral branches of the brachidium curve outward, gradually turning from a vertical to a horizontal position, broaden rapidly and unite to form an anterior triangular plate which bears a median ridge, where the two lateral branches are conjoined. The whole of the anterior portion of the brachidium is inclined gently upward toward the cavity of the opposite valve.

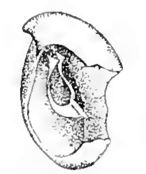

FIG. 180.
Centronella glans-fagea, Hall.
A preparation showing the brachidium.
(ROMINGER.)

The muscular impressions occupy an elongate area below the hinge-plate, and are divided by a median ridge, but are only obscurely divisible into their elementary scars. The lateral portions of this valve frequently bear a series of vascular sinuses in the pallial region.

Surface smooth or with concentric lines crowded near the margins of the valves. Shell-substance punctate.

Type, *Rhynchonella glans-fagea*, Hall. Upper Helderberg group.

OBSERVATIONS. The type of external form and internal structure exemplified by this species is probably also represented by the *C. alveata*, Hall (= *C. Hecate*, Billings), of the same fauna, and is carried forward from the Schoharie grit and Corniferous limestone into the succeeding fauna of the Hamilton group (*C. impressa* and *C. Glaucia*, Hall).

All these typical forms of CENTRONELLA were preceded in the fauna of the lower Oriskany of eastern New York by a large species, the earliest known possessor of the characteristic naviculoid form and smooth exterior of *Centronella glans-fagea.* The form of the brachidium of this shell (which has not hitherto been described*), has not been determined, but there is every reason to infer that it differs in no essential feature from that of CENTRONELLA, for the reason, as already observed, that variation in these shells during the Devonian was virtually restricted to exterior characters and did not affect the conformation of the brachial supports. The hinge-plate of this shell, however, is notably different from that of any of its allies; it is elongate-triangular, continuous between the crural bases, and bears a median vertical crest, or cardinal process, which begins at the apex, rises rapidly in height, and extends for fully one-half the length of the plate on its upper edge, but at its base is shortened and constricted, forming a projecting cardinal spur.

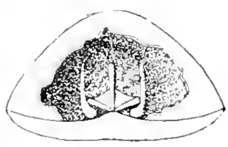

FIG. 181.

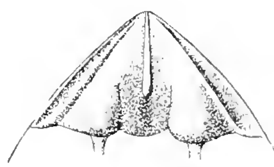

FIG. 182

FIG. 183.

Oriskania navicella, sp. nov.

Fig. 181. A cardinal view; showing the hinge-plate and the elevation of the narrow median crest or cardinal process. The specimen also retains the teeth of the pedicle-valve and a portion of the dental lamellæ, though the latter are broken near the surface of the valve.

Fig. 182. An enlargement of the hinge-plate; showing the crural lobes and the extent of the cardinal process.

Fig 183. A profile of the same specimen; showing the thickness of the plate and the uncinate form of the cardinal process. X 3 (C.)

Such an extravagant modification of the normal form of the hinge-plate in RENSSELÆRIA and CENTRONELLA is the more remarkable on account of its early age, as this shell antedates the appearance of the typical Devonian species with divided hinge-plate and without cardinal process, and it is proposed to distinguish

* "*Centronella*, of the type of *C. glans-fagea* but of great size." BEECHER and CLARKE. Notice of a new lower Oriskany fauna in Columbia county, New York; Amer. Journal of Science, vol. xliv, p. 414. 1892.

this type of structure by the name ORISKANIA. The typical form is described in the Supplement to this Volume as *Oriskania navicella*.

It is a fact of much interest that the centronellid type, with naviculoid shell, divided hinge-plate and simple brachidium, is reproduced in the Alpine Triassic faunas, in the genus (?) NUCLEATULA, Zugmayer,* a shell which evinces only an immaterial variation in the narrowness and fimbriation of the anterior plate of the brachidium.

Before considering the later modifications of the centronellid type, we may refer to another form of exterior expression assumed by the same type. A small, hitherto unnoticed species occurring in the Upper Helderberg of the Province of Ontario, possesses a smooth exterior, terebratuliform outline, narrow at the umbones and broad in the pallial region, with biconvex valves. While the detailed structure of the hinge-plate is yet unknown, the brachidium is similar to that of RENSSELÆRIA and CENTRONELLA; the anterior plate broader and less attenuate than in RENSSELÆRIA and without its central, rod-like posterior extension, and also lacks the median ridge or thickening along the symphysis of the lateral elements, which exists in CENTRONELLA. The form of the shell scarcely suggests the naviculoid contour of true CENTRONELLA, while it at once brings to mind some of the biconvex species that have heretofore been

FIG. 184.

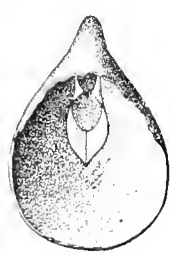

FIG. 185.

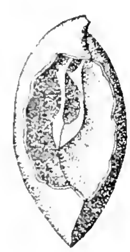

FIG. 186.

Selenella gracilis, sp. nov.

Fig. 184. Outline profile of conjoined valves.
Fig. 185. Preparation showing the form of the loop.
Fig. 186. An oblique view; showing the upward curvature of the anterior plate. X 3. (C.)

classed with that genus, *e. g.*, *Centronella Julia*. From such of these whose interiors are known it differs notably, and it so evidently indicates a distinct stadium

* See BITTNER, Brachiopoden der Alpinen Trias; Abhandl. der K.-k. Geol. Reichstanst., vol. xiv, p. 208. 1890.

or departure in the variations of this type of structure as to require a separate designation. The name SELENELLA is therefore introduced for the subgeneric type, its representative species being *Selenella gracilis*, sp. nov.

As already observed, this shell presents the first combination of the smooth, biconvex valves with an unmodified RENSSELÆRIA–CENTRONELLA brachidium. From our experience such a simple combination could not be of long continuance, and thus far we have no evidence of its subsequent appearance. Biconvex and smooth-valved centronellids do occur, however, at a much later period and after the close of the Devonian, but these have undergone a very material modification in the form of the brachidium. In *Centronella Julia*, A. Winchell, one such small, smooth species, from the Marshall group of Michigan,

FIG. 187. FIG. 188.

Romingerina Julia, Winchell.

Fig. 187. A restoration of the loop; showing the extent of the median plate.
Fig. 188. A profile view; showing the elevation of this plate, the double curvature of its upper margin and its fimbriated edge. X 4. (A. WINCHELL.)

the median ridge on the anterior plate of the brachidium is elevated into a conspicuous vertical lamella, extended both anteriorly and posteriorly, being in fact a double plate produced by the abrupt deflection of each lateral branch of the brachidium near the median line; union taking place along the upper edge, which almost reaches the inner surface of the pedicle-valve. Professor ALEXANDER WINCHELL, who was the first to demonstrate this structure, adds in regard to this feature: *

* The little species from the Chemung sandstones at Rushford, N. Y., which has been identified by WILLIAMS as *Centronella Julia* (Bull. U. S. Geol Survey, No. 41, p. 56. 1887), has the brachidium of similar structure though with a less ante-posterior extension of the vertical plate.

"The upper edge where viewed from the side, is flatly roof-shaped, while the lower edge describes two convexities, the greater anterior, leaving a notch between them. The surfaces of the loop and median plate are covered with minute, obliquely conical pustules, in some cases seeming to become spinulous."*

Forms with this characteristic modification of the loop may be designated by the term ROMINGERINA.†

After the disappearance of the Palæozoic faunas, we again find in the Alpine Trias (Hallstätter-kalk) smooth, biconvex centronellids, less complicated in the structure of the brachidium than ROMINGERINA, even having the brachial supports smaller and more delicate, if not more simple in plan, than in SELENELLA. These shells have been described by BITTNER (*loc. cit.*, p. 206. 1890) under the generic term JUVAVELLA. Their brachidia are very short, the lateral branches but slightly expanded anteriorly and abruptly turned into a vertical plane.

We may now turn to the consideration of the plicated centronellids which have already been closely investigated by ŒHLERT, and have received attention from WAAGEN, DERBY and DAVIDSON. This discussion would with propriety form a continuation of the observations already made upon the genus RENSSELÆRIA, for it is the plicated and lineate shells of that genus which represent the earliest appearance of the CENTRONELLA-type. The lower Devonian species, from the west of France, in which Dr. ŒHLERT has determined the existence of a centronellid brachidium, are all biconvex or subplano-convex species; *Terebratula Guerangeri*, de Verneuil, is covered with strong rounded plications, *Centronella Gaudryi*, Œhlert, with numerous fine plications, while on *C. Bergeroni*, Œhlert, there are a few coarse angular ribs. All have a decided external resemblance to certain spire-bearing forms of the genera RHYNCHOSPIRA, TREMATOSPIRA and ZYGOSPIRA. The brachidium has been isolated in none of these, but sections demonstrate that this structure in all these forms is similar to that

* Proc. Acad. Nat. Sci. Philadelphia, p. 405. 1862.

† Dr. CARL ROMINGER, to whom this genus is dedicated, was the first American investigator who succeeded in producing satisfactory translucent preparations of the fossil brachiopods with calcified brachidia. Many of the determinations published in the Reports on the New York State Cabinet from 1861–67, and in Volume IV of the Palæontology of New York, as there recognized, were based upon his preparations.

of *Centronella glans-fagea*, though having the anterior plate much smaller. *Centronella Guerangeri* is known to possess a perforated hinge-plate, though in the other species this plate appears to have been divided.

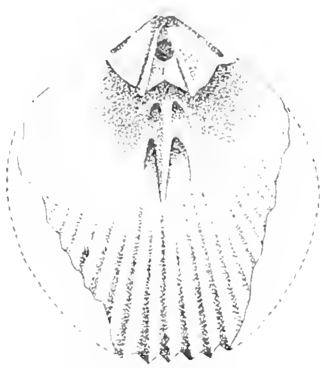

FIG. 189. *Trigeria Guerangeri,* de Verneuil.
The interior of the brachial valve; showing the perforated hinge-plate and the muscular scars.
(ŒHLERT.)

ŒHLERT draws attention to the fact that BAYLE, in 1875,* applied the name TRIGERIA to two lower Devonian species, the first, the *Terebratula Adrieni*, de Verneuil, which was already the type of the genus RETZIA, King; the second, *Terebratula Guerangeri*. This name, unfortunately, was not defined, but as a designation is required for these plicated centronellids, it is now proposed to make use of the term introduced by this French author, basing its value upon his second species. TRIGERIA is represented in the Oriskany sandstone at Cumberland, Maryland, by a species very similar to *T. Gaudryi;* indeed, upon careful comparison with Dr. ŒHLERT's description and figures there seems no good basis of distinction between the two forms, and the American fossil will be thus referred awaiting further evidence. It is quite probable that the species described by BILLINGS as *Rensselæria Portlandica*,† from the Lower Helderberg fauna of Square Lake, Maine, is another representative of the same type of structure.‡

* Explication de la Carte Géologique de France, Atlas, pl. xiii, figs. 5-12.

† Proceedings of the Portland Society of Natural History, vol. i, p. 115, plate, fig. 12. 1862.

‡ For the opportunity of examining the original specimens of the species we are indebted to Professor B. K. EMERSON, of Amherst College.

DERBY'S *Centronella? Margarida*, from the lower or middle Devonian of Matto Grosso, Brazil, is a shell somewhat different from the foregoing species in external expression, its size being smaller and its habit more retziiform. Its author has compared it to the *Retzia Wardiana*, Hartt and Rathbun, of the Ereré fauna on the Amazonas, a species which is suggestive of the *Rhynchospira lepida*, Hall, of the Hamilton fauna of New York. Dr. DERBY has given a very complete representation of the brachidium of the species, which arises from a divided hinge-plate, bears the long, anterior plate characteristic of RENSSELÆRIA, and lacks any evidence of the posterior median extension or of a vertical median plate. In the species which has been described as *Rhynchospira lepida*, of the Hamilton shales of New York, and in the *Centronella virgo* (*Terebratula virgo*, Phillips), from the middle Devonian of Torquay,* both very closely allied in the character of the plicated exterior, there exists the same form of brachidium.

This combination of external and internal characters is thus a variant from that of CENTRONELLA or TRIGERIA, but until our knowledge of these small shells is further advanced, the species may be provisionally associated with TRIGERIA.

FIG. 190.

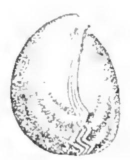

FIG. 191.

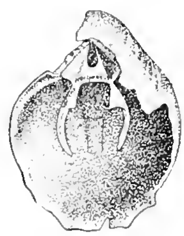

FIG. 192.

Notothyris subvescicularis, Davidson.

Fig. 190. A dorsal view of the exterior.
Fig. 191. A profile of the same shell.
Fig. 192. The interior of the brachial valve; showing the perforated hinge-plate and the lateral lamellæ of the loop.
(WAAGEN.)

Reference has already been made to the fact that WAAGEN introduced the name NOTOTHYRIS† for a group of small, coarsely plicated, biconvex species

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* See preparations of the brachidium of this plicated species made by the Rev. NORMAN GLASS, and given by DAVIDSON, Devonian Brachiopoda, Suppl., p. 14, pl. i, figs. 7–9. 1882.

† Productus-limestone Fossils; Brachiopoda, p. 375. 1882.

whose internal structure is but partially known, but which seem to indicate a certain relationship to the centronellids. This author states that all his preparations of the brachidium showed the lateral branches to be disconnected, but he believes this to be probably due to imperfect preservation. All of the eight described species of this genus (*Terebratula subvescicularis*, Davidson, type) are from the Upper Carboniferous of India, and similar forms have not been identified with certainty in other countries. The Devonian species *Notothyris? Smithi*, Derby, has a perforated hinge-plate and a brachidium very similar in form to that of CENTRONELLA, but instead of the curved anterior plate, it has a simple cross-bar connecting the lateral branches. In DIELASMA and other terebratuloids we know that the reflected or ascending branches are frequently lost, and it is more than likely that the typical *Notothyres* possessed an anterior cross-bar as in the Devonian species.

GENUS SCAPHIOCŒLIA, WHITFIELD. 1891.

1891. *Scaphiocœlia*, WHITFIELD. Trans. American Inst. Mining Engineers, vol. xix, p. 106, figs. 1–4.

"A terebratuloid, brachiopodous shell, having a strongly convex ventral valve, and a longitudinally and angularly sulcated dorsal valve; both of which are strongly plicated. Internally the ventral valve has a strong, deep, triangular byssal opening and muscular seat, and the dorsal has strong crural processes; but the loop or calcified appendages are unknown. Shell structure strongly fibrous, without any puncture under a hand-magnifier."

Type, *Scaphiocœlia Boliviensis*, Whitfield. Devonian.

OBSERVATIONS. As suggested by Mr. WHITFIELD, this great shell has, the appearance of a gigantic plicated CENTRONELLA, and in the absence of any definite knowledge of its internal structure, may provisionally be regarded as allied to that genus and those plicated centronelloids which have been herein designated by the term TRIGERIA. The only species known, *S. Boliviensis,* is stated to sometimes exceed three and one-half inches in length. It was found by Mr. A. F. WENDT in the vicinity of Sucré or Quechista, Bolivia, in a sandy, ferruginous limestone, associated, according to WHITFIELD, with *Spirifer Quichua* and *Terebratula Antisiensis*, d'Orbigny.

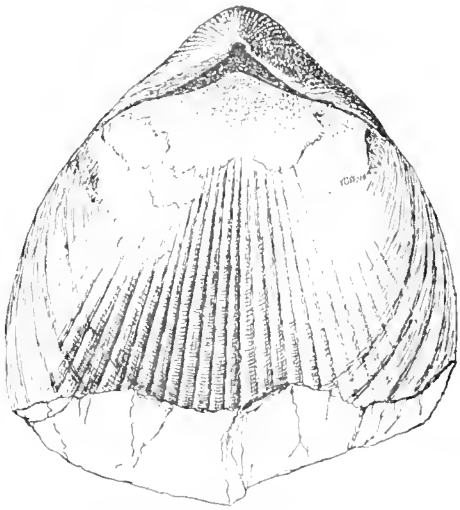


FIG. 193.

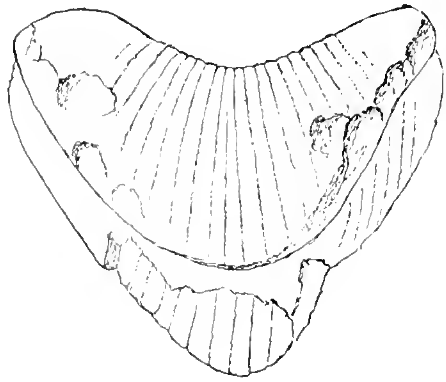


FIG. 194.

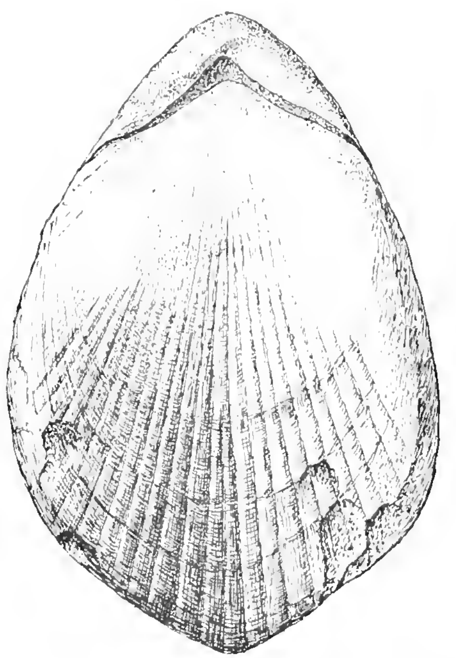


FIG. 195.

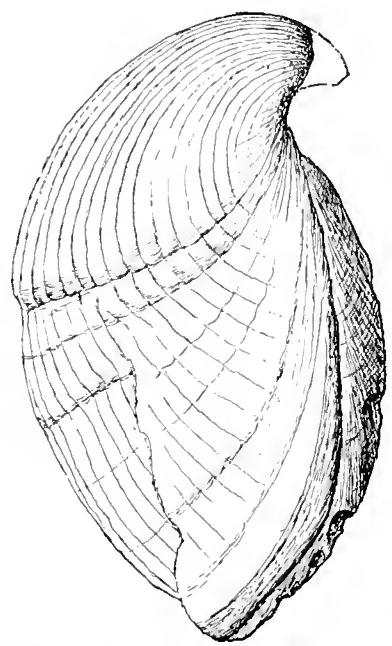


FIG. 196.

Scaphiocœlia Boliviensis, Whitfield

Figs. 193-196. Views of two individuals, showing the external characters of the species.

(WHITFIELD.)

GENUS MEGALANTERIS, SUESS. 1855.

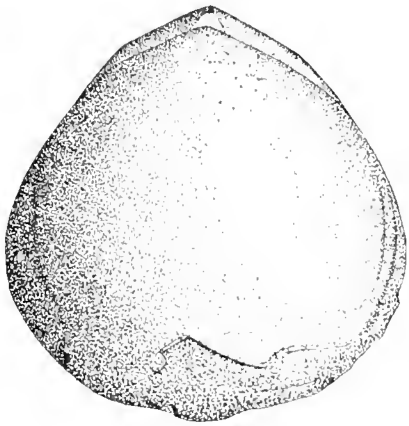
PLATE LXXVII.

1830. *Terebratula*, DE VERNEUIL. Bull. Soc. Géol. de France, 2 ser., vol. vii, p. 175, pl. iv, fig. 2.
1855. *Meganteris*, SUESS. Ueber Meganteris; Sitzungsber. der Kais. Acad. der Wissensch. zu Wien.
1856. *Meganteris*, SUESS. Classification der Brachiopoden, von Th. Davidson, p. 43, pl. ii, fig. 18.
1857. *Meganteris*, HALL. Tenth Ann. Rept N. Y. State Cab. Nat. Hist., p. 101.
1859. *Rensselæria*, HALL. Palæontology of New York, vol. iii, p. 458, pl. cvi, fig. 2 *a–l*.
1861. *Rensselæria*, MCCHESNEY. Descr. New Fossils from Palæozoic Rocks of West. States, p. 85.
1867. *Rensselæria*, MCCHESNEY. Trans. Chicago Acad. Sciences, vol. i, p. 36, pl. vii, figs. 2 *a–c*.
1868. *Rensselæria*, MEEK and WORTHEN. Geological Survey of Illinois, vol iii, p. 401, pl. viii, figs. 4 *a, b*.
1871. *Meganteris*, QUENSTEDT. Petrefactenkunde Deutschlands; Brachiopoden, p. 344, pl. xlvii, figs. 21, 22.
1876. *Meganteris*, F. ROEMER. Lethæa Palæozoica, pl. xxiii, fig. 6.
1887. *Megalanteris*, ŒHLERT. Fischer's Manuel de Conchyliologie, p. 1319.
1891. *Newberria ?*, HALL. Tenth Rept. N. Y. State Geologist, p. 95.

Though this generic division is of long standing, its value has been regarded as somewhat uncertain. Shells agreeing with the type of MEGALANTERIS in external form and in the conformation of the interior of the valves are not of uncommon occurrence; but these are so closely allied to RENSSELÆRIA in external form, that the possession by them of a brachidium widely dissimilar to the corresponding apparatus of that genus seems *a priori* improbable. The idealized restoration of this structure, given by SUESS, has not been confirmed by later investigations, but neither has it been disproved; and we are therefore justified in assuming its accuracy. The American species, *M. ovalis*, Hall, is not favorably preserved for the retention of those parts.

To apprehend the author's conception of this genus, a translation of the diagnosis inserted in his edition of DAVIDSON'S "Classification of the Brachiopoda" is here introduced:

"Shell, in the only species hitherto known, large, smooth, equally biconvex, of very variable, elongate-hexagonal to transversely oval outline, and with punctated shell structure. Beak depressed, with a small opening for the pedicle-muscle, reaching to the somewhat incurved umbo of the pedicle-valve and limited on both sides by a depressed deltidium. Hinge apparatus strong, similar to that of other terebratuloids. Below the beak of the dorsal valve, the central part of the hinge-plate is swollen into a callous uncinate process, which is subcubical, and on its surface bears two small V-shaped ridges for the attachment of the cardinal muscles; on both sides are two flattened areas, presumptively places of attachment for the inner, dorsal branches of the



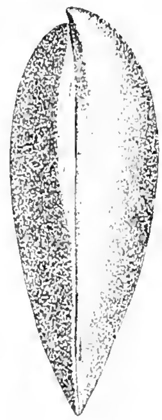
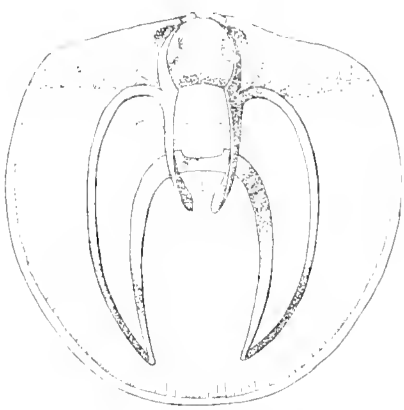


FIG. 197. FIG. 198.
Megalanteris Archiaci, de Verneuil.
Figs. 197, 198. Views of the exterior of the species.
(DE VERNEUIL.)

pedicle; at its base it is excavated and funnel-shaped. Between the sides of these swellings and the sockets, lie the points of attachment of the brachial apparatus. The crura are produced into two broad, straight rods, extending almost to the middle of the shell, curved somewhat inward, rounded at the ends, and which on the whole, have little similarity to the converging



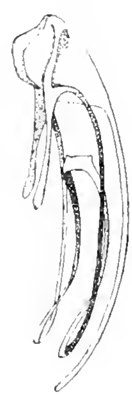


FIG. 199. FIG. 200.
Megalanteris Archiaci, de Verneuil.
Figs. 199, 200. A restoration of the brachial apparatus.
(SUESS.)

processes of other Terebratulas. From the upper part of these rods arises the brachial support, consisting of a very slender calc-ribbon, which, somewhat as in WALDHEIMIA, first extends to the vicinity of the anterior margin, then bends abruptly backward, inclining somewhat toward the center of the shell-cavity, and is closed by a short, straight cross-piece, above which the ascending branches project as short points; this cross-piece and the upper part of the ascending branches lie below the plane of the straight rods. While in the small valve the hinge-muscle and the inner pair of dorsal pedicle-muscles are attached to the callous process, the outer pair of pedicle-muscles appears to have been fastened to the upper portion of the crura. The impressions of the adductors, of which but two are discernible, lie somewhat above the middle of the valve, in two cavities, often very deep, semicircular on their posterior margins, but oblique and shallow in front.

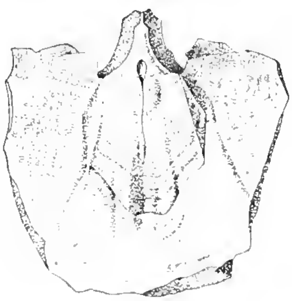


FIG. 201.

FIG. 202.

Megalanteris Archiaci, de Verneuil.

Fig. 201. An internal cast of the umbonal region of the pedicle-valve. (SUESS.)
Fig 202. The interior of the umbonal region of the brachial valve; showing the cardinal process. (DE VERNEUIL.)

"In the large valve the muscular area is close about the umbo, and is similar to that of the terebratuloids; a middle elongate space corresponds probably to the adductor muscles; on either side of this, one recognizes the impressions of the diductor muscles, and outside and somewhat behind these, though not always clearly defined, are the areas of insertion of the ventral branches of the pedicle-muscle, which also seems to lie on the inner surface of the dental plates.

"On the inner surface of both valves may be distinguished four impressions of trunk-sinuses, from which arise no dichotomous branches as in other terebratuloids. The posterior part of the outer pair of these sinuses is in each valve surrounded by the impressions of the genital organs, whose outer portion is divided by three or four parallel finer vessels, which are given off from the margin of the trunk-sinus at right angles. In the larger valve on the inner side of the outer pair of trunk-sinuses, may be seen fine branches, originating at sharp angles. Further, in this valve may sometimes be seen, between the outer and inner, and also between the two inner trunk-sinuses, two finer radiating veins. All these vascular sinuses appear to unite in this valve to form a large lacune surrounding the area of muscular insertion. A ridge-like, elongate callosity crossed by irregular furrows, follows the cardinal margin on the dorsal valve."

Type, *Terebratula Archiaci*, de Verneuil.

Observations. Leaving out of consideration for the present the peculiar structure of the brachidium, we find the other characters of the shell sufficiently distinct from those of Rensselæria and its allies; and these differential features are found in the general smoothness of the exterior,* the inflexion of the cardinal and lateral margins of the valves, the prominence and sharp delimitation of the diductor scars of the pedicle-valve, and the subcylindrical elevation of the hinge-plate into a veritable cardinal process, in which all traces of supporting lamellæ are lost, and whose posterior face is grooved and striated by the insertion of the muscles. This latter feature is unusual in the palæozoic terebratuloids, and is at once suggestive of the structure in the large and heavy rhynchonelloids (Plethorhynchus), so that it proves a distinctive character of importance.

An excellent representative of this type of structure is the American Oriskany species, originally described† as *Meganteris ovalis*, Hall, but which has been subsequently and currently referred to Rensselæria. In the original description the similarity of the internal casts to those of *Megalanteris Archiaci* was noted. *Megalanteris ovalis* is not an abundant species in the Oriskany sandstone of New York and Ontario, and is represented in the formations in the vicinity of Jonesboro, Illinois, by a smaller, more elongate form with erect beak, deep cardinal and marginal excavations, the *Rensselæria Condoni*, of

* Internal casts frequently show a minutely radiate surface about the margins, but this structure probably belongs to the inner laminæ of the shell.

† Tenth Annual Report on the Condition of the N. Y. State Cabinet of Natural History, p. 101. 1857.

McChesney. None of the specimens that have been sectioned retain the brachial apparatus.

The name Meganteris or Megalanteris* has been adopted by various writers, sometimes with questionable accuracy. *Megalanteris Archiaci*, de Verneuil (sp.), the type of the genus, was described from the Devonian beds of Sabéro and the mountains of Léon, Spain; the material upon which Suess founded his determination of the brachidium, seems to have been derived from the lower beds of the Eifel. Quenstedt has also given figures of internal casts of this form from Lahneck. The species *Atrypa inornata*, d'Orbigny, from the lower Devonian of western France, has been referred to this genus by Œhlert,† but the figures given by him show a want of conformity to the generic characters of Megalanteris, both in the form of the hinge-plate, the muscular impressions and the regularity of the lateral margins.

Kayser has suggested‡ the similarity of the *Terebratula amygdalina*, Goldfuss, to Megalanteris, and Œhlert, in the work cited, refers d'Orbigny's species, *A. amygdala*, and the *A. Deshayesi*, Caillaud, to the same genus, remarking their close similarity to *A. inornata*. Barrois has also described and figured § *A. inornata* and *A. Deshayesi* under the name Megalanteris. It has already been suggested that these European lower Devonian shells represent a type of structure different from that of *M. Archiaci*, which is hereinbefore designated as Newberria.

Mr. Davidson figured, without name, in his British Devonian Brachiopoda (pl. xx, fig. 15), and subsequently (Devonian Supplement, p. 20, pl. iii, fig. 1) as *Meganteris ? Vicaryi*, the exterior of a large shell from the middle Devonian of Woolborough, England, having a smooth surface and inflected margins, but of its internal characters nothing is known. A median line on the brachial valve indicates the presence of an internal septum.

* The latter word, substituting the feminine for the masculine form of the adjective, was introduced by Œhlert, in 1887.

† Annales des Sciences Géologiques. vol. xix, p. 20, pt. ii, figs. 1–10.

‡ Zeitschr. der deutsch. geolog. Gesellsch., vol. xxiii, p. 499. 1871.

§ Faune du Calcaire d'Erbray, p. 151, pl. x, figs. 5, 6. 1887.

GENUS STRINGOCEPHALUS, DEFRANCE. 1827.

(emend. SANDBERGER. 1842.)

1827. *Strygocephalus*, DEFRANCE. Diction. des Sciences Nat., vol. li, p. 102, Atlas pl. lxxv, figs. 1, 1*a*.
1827. *Terebratula*, SOWERBY. Mineral Conchology, pl. dlxxvi, fig. 1.
1834. *Terebratula*, VON BUCH. Ueber Terebrateln, p. 117.
1839. *Strigocephalus*, SOWERBY. Trans. Geol. Soc. London, vol. v, second ser., pl. lvi, figs. 10, 11.
1840. *Strygocephalus*, D'ARCHIAC and DE VERNEUIL. Trans. Geol. Soc. London, vol. vi, 2 ser., p. 393.
1841. *Strigocephalus*, PHILLIPS. Palæoz. Foss. Cornwall, Devon and West Somerset, p. 79, fig. 141.
1842. *Stringocephalus*, SANDBERGER. Leonhard und Bronn's Jahrbuch, p. 386.
1850. *Stringocephalus*, F. ROEMER. Beitr. zur Kenntn. des nordw. Harzgeb., p. 24, pl. x, fig. 2.
1852. *Uncites*, MCCOY. British Palæoz. Foss., p. 380, pl. ii A, fig. 6.
1853. *Stringocephalus*, SCHNUR. Beschreib. Eifel. Brachiopoden, p. 195, pl. xxviii, fig. 5; pl. xxix, fig. 1; pl. xxxi, fig. 1.
1850. *Strigocephalus*, KING. Permian Fossils, p. 70, pl. xix, fig. 1.
1853. *Stringocephalus*, SUESS. Verh. der zool. bot. Vereins zu Wien, vol. iii.
1855. *Stringocephalus*, THE SANDBERGERS. Verst. des rhein. Schicht. Syst. in Nassau, p. 307, pl. xxxi, fig. 4 *a*-*d*.
1856. *Stringocephalus*, DAVIDSON. Introduction Brit. Brachiopoda, p. 73, pl. vii, fig. 98.
1856. *Stringocephalus*, SUESS. Class. der Brach. von Th. Davidson, p. 62, pl. i, fig. 16.
1864. *Stringocephalus*, DAVIDSON. Brit. Devon. Brachiopoda, p. 11, pl. i, figs. 18-22; pl. ii, figs. 1-11.
1871. *Strigocephalus*, QUENSTEDT. Brachiopoden, p. 234, pl. xliii, figs. 56-75; pl. xliv, figs. 1-8.
1871. *Stringocephalus*, KAYSER. Zeitschr. der deutsch. geolog. Gesellsch., vol. xxiii, pl. di.
1891. *Stringocephalus*, WHITEAVES. Contrib. Canad. Palæont., vol. i, No. 5, p. 235, pl. xxix, figs. 10, 10 *a*, 11, 11 *a*.

Shell varying in outline from transverse to elongate-oval, biconvex; the brachial valve being somewhat the deeper; the greater convexity is in the umbonal region, giving to the brachial valve a high-shouldered appearance.

On the pedicle-valve the beak is somewhat narrow, its apex being abruptly attenuate, acute and often greatly incurved. From beneath the beak diverge two sharp ridges extending to the extremities of the hinge and delimiting the broad cardinal excavations which seem to constitute a true cardinal area. The delthyrium is broad and triangular; in young shells it may be wholly open or incompletely closed by the imperfectly developed deltidial plates, while at maturity it is closed with the exception of a circular foramen, and in old shells the deltidial plates are anchylosed, forming a single plate which becomes incurved, and the foraminal passage is thus obscured, and may take the form of a tube or sheath prolonged into the umbonal cavity.

On the interior the teeth are short, free and curved upward at their extremities. In the middle of the valve is a vertical longitudinal septum, which extends from the beak to near the anterior margin. This septum is short and thick posteriorly, but becomes thinner and higher towards the front, ending abruptly in the pallial region.

In the brachial valve the umbo is obtuse. The cardinal area is distinctly developed and divided by a very broad triangular fissure, the covering of which (chilidium) is frequently retained, much modified by the presence of the great

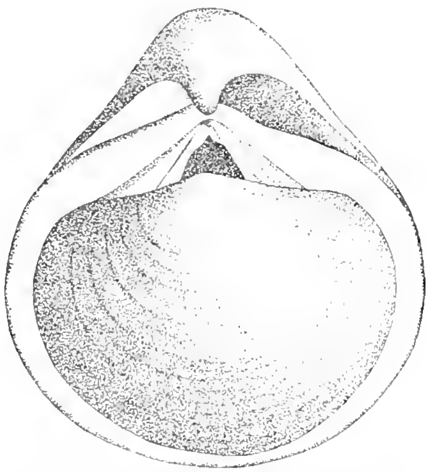
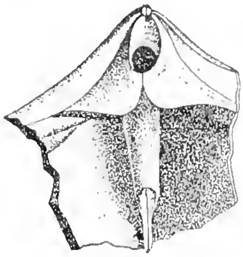


FIG 203 *Stringocephalus Burtini*, Defrance.
Dorsal views of two individuals; showing the differences assumed in growth by the umbo of the pedicle-valve.
(QUENSTEDT.)

cardinal process. The dental sockets are comparatively shallow. The general form of the hinge-plate is triangular, with its apex anterior; its central portion is separated from the narrow, blade-shaped lateral divisions and is produced into a great cardinal process, rounded posteriorly, narrow and sharp on its anterior surface, and produced upward and backward into the cavity of the opposite valve. At the edge of the median septum of that valve it bifurcates, sending out a short clavate apophysis on either side of it. The lateral portions of the hinge-plate begin at the socket-walls which are high and narrow, extend downward, inward and forward to the anterior extremity of the plate, whence they curve upward into the crura. The crura are long, broadened and curved upward towards their extremities where the primary arms of the brachidium arise at a sharp angle. The latter curve backward and outward, and skirt the inner margins of the valves as a very broad, continuous lamella, which is not reflexed though somewhat curved upward on the anterior margin.



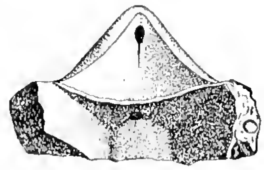


FIG. 204. FIG. 205. FIG. 206.

Stringocephalus Burtini, Defrance.

Fig. 204. Umbonal cavity of the pedicle-valve with discrete deltidial plates.
Fig. 205. The internal sheath or projection of the pedicle-passage.
Fig. 206. The umbonal cavity of a pedicle-valve in which coalescence of the deltidial plates is almost complete.
(QUENSTEDT.)

From the inner margins of this lamellæ, on its exterior and lateral extension, arises a series of linear processes converging toward, and some of them perhaps

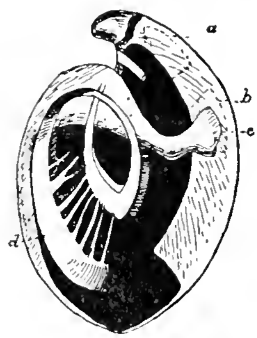


FIG. 207. *Stringocephalus Burtini*, Defrance.

A restoration of the interior, showing the internal pedicle-sheath and the strong median septum of the pedicle-valve; the great cardinal process, one of its terminal lobes (*c*) lying on either side of the septum; the form of the loop with the radial filaments extending from the anterior lamellæ (*d*) to the crura. At (*a*) is the insertion of the diductor muscle, at (*b*) that of the adductor. (HOERNES.)

reaching the crura. A low, thick median septum extends for about half the length of the valve.

The muscular impressions on both valves are exceedingly obscure, and have never been fully described or illustrated.

Surface smooth, with fine concentric growth-lines; sometimes a low median sinus exists on both valves near the margin.

Shell-substance impunctate externally, but the inner laminæ are sparsely perforated.

Type, *Stringocephalus Burtini*, Defrance. Middle Devonian.

Observations. This old and well known genus has been discussed by many writers, but to King, Suess and Quenstedt our knowledge of its internal structure is especially due. Its characters are extravagant and its composition is peculiar and unique, the genus standing quite apart from other terebratuloids. Whence its origin is still a mystery. The duration of the type was brief, though its development was abundant and characterized a distinct horizon of the middle Devonian, the "Stringocephalus beds." Its presence, however, has not been widely known outside of Germany and England, and hence its recent discovery by Whiteaves in the Mackenzie River Basin of British North America, is of much interest. Here it is associated with various middle Devonian species.

Authors are pretty generally agreed that the different specific designations which have been suggested for slight variations in form, etc., are based upon minor characters, insufficient to separate them from the type-species, *S. Burtini*. The *S. Bohemicus*, Barrande,* is a much earlier form (F_2,) whose generic characters are entirely uncertain.

* Système Silurien, vol. v, p. 218, pl. 83, iv.

Genus CRYPTONELLA, Hall. 1861.

PLATE LXXX.

1860. *Terebratula*, Hall. Thirteenth Ann. Rept. N. Y. State Cab. Nat. Hist., pp. 88, 89.
1861. *Cryptonella*, Hall. Fourteenth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 102.
1862. *Cryptonella*, Hall. Fifteenth Ann. Rept. N. Y State Cab. Nat. Hist., pl. iii, figs. 6, 7, 8, 9.
1862. *Cryptonella*, Billings. Canadian Naturalist and Geologist, vol. vii, p. 392.
1863. *Cryptonella (partim)*, Hall. Sixteenth Ann. Rept N. Y. State Cab. Nat. Hist., p. 42, figs. 8–11; p. 43, figs. 8–11; p. 48. figs. 22, 23; p. 49, figs. 24–26.
1863. *Cryptonella (partim)*, Hall. American Jour. Sci., vol. xxxv, p. 396.
1863. *Cryptonella (partim)*, Billings. American Jour. Sci , vol. xxxvi, p. 238.
1863. *Cryptonella (partim)*, Hall. Transactions of the Albany Institute, vol. iv, pp. 132, 148.
1865.(?)*Centronella*, A. Winchell. Proc. Acad. Nat Sci. Philadelphia, vol ix, second ser., p. 123.
1867. *Cryptonella*, Hall. Twentieth Ann. Rept. N. Y. State Cab. Nat Hist., p. 164.
1867. *Terebratula*, *Cryptonella*, Hall. Palæontology of New York, vol. iv, pp. 386–389, 391, 398, pl. lx, figs. 5–16, 32–44, 49–65, 68–71; pl. lxi, figs. 1–41.
1868. *Centronella*, Hartt. Dawson's Acadian Geology, second ed., p. 300, fig. 99.
1872. *Cryptonella*, Hall and Whitfield. Twenty-fourth Ann. Rep. N. Y. State Cab. Nat. Hist., p. 199.
1874. *Waldheimia*, Derby. Bull. Cornell Univ., vol. i, No. 2. p. 3, pl. iii, viii, ix.
1879. *Retzia*, Barrande. Système Silurien du Centre de la Bohême, vol. v, pls. xiii, cxli.
1882. *Waldheimia*, Davidson. British Devonian Brachiopoda, Suppl., pp. 12, 13, pl. i, figs. 1–4.
1884. *Cryptonella*, Walcott. Monogr. U. S Geol. Survey, vol. viii, p. 163, pl. iv, fig. 4; pl. xv., fig. 2
1888. *Cryptonella*, Herrick. Bull. Denison University, vol. iii, p. 48, pl. v, fig. 10.
1890. *Terebratula*, Nettelroth. Kentucky Fossil Shells, p 155, pl. xvi, figs. 20–22.

This name, though introduced in 1861, first acquired a positive value in 1867. In the original description of the genus no type-species was designated though several Devonian shells, *Terebratula Lincklæni*, *T. rectirostra T. lens*, *T. planirostra*, were suggested as differing from Terebratula in some external features, and in the character of the muscular impressions. Subsequently, in 1862, the name was applied to a rare and previously undescribed species from the Lower Helderberg, *C. eximia*, of which figures were given showing the exterior, together with illustrations of the interior in a species not named.* In the following year the interpretation of the name was based largely upon the evidence of the internal structure presented by the *Centronella Julia*, A. Winchell, a shell of similar exterior to those upon which Cryptonella has been founded.† The subject was rediscussed in 1867 (Palæontology of New York, Volume IV, pp. 392, 393); the brachidia of two species originally placed under the genus, *T. rectirostra* and *T. planirostra*, had been developed, and as this evidence is of

* Fifteenth Ann. Rept. N. Y. State Cab. Nat. Hist., pl. iii, figs. 6–9.

† Sixteenth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 43.

primary importance we must accept this rehabilitation of the genus. Thus constituted CRYPTONELLA includes a group of terebratuloid shells having the following characters:

Valves subequally convex; elongate-oval in outline, broadest in the pallial region. Pedicle-valve with prominent, erect or slightly incurved umbo; deltidial plates well developed; foramen circular, apical, rarely encroaching upon the umbo, or becoming oval as in many species of DIELASMA; the inverted pedicle-sheath or collar is slightly developed within the aperture. The teeth are strong and supported by dental lamellæ which divide the umbonal cavity into three chambers; near the apex they join the somewhat thickened scar of the pedicle-muscle, and extend beyond its anterior margin with a slight convergence, resting always on the bottom of the valve. The pedicle-muscle makes the strongest scar of all the muscular bands, the adductors being narrow and central, and the diductors scarcely delimited.

In the brachial valve the hinge-plate is large, elongate and concave; it is divided by two low ridges diverging from the apex, and from these the plate rises toward the sides into decidedly elevated socket-walls; between the diverging ridges the surface is rather deeply depressed, and, toward the apex, is perforated by a circular foramen. The crura are slender, very short, curving inward and upward, making two long and narrow crural apophyses. The descending lamellæ are carried forward, following the curves of the valves

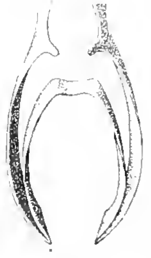


FIG. 208. *Cryptonella planirostra*, Hall.
The brachidium; showing the long descending and ascending lamellæ.

for nearly two-thirds the length of the shell, and abruptly reflected; the ascending lamellæ returning to within a short distance of the crural apophyses.

The whole structure is very similar to the brachidium of the adult living MAGELLANIA (WALDHEIMIA).*

The adductor scars are more or less distinct, the anterior members being the more clearly defined. These scars are usually represented only by three straight lines diverging from the umbonal region. Vascular sinuses originate about the muscular areas of both valves and are directed forward with frequent ramifications.

The shell-structure is highly punctate.

It thus appears that the Devonian shells which can be referred to CRYPTONELLA do not materially differ in the structure of the brachidium from the living MAGELLANIA. There are several species in the American faunas, currently referred to this genus, whose brachidia have not yet been developed, *e. g.*, *C. eximia*, Hall, of the Lower Helderberg, *C. Iphis*, Hall, of the Upper Helderberg, and *C. Eudora*, Hall, of the Chemung, but in all these the probability of their being congeneric with *C. rectirostra*, is enhanced by the demonstration of the absence of the transverse dorsal band on the brachidium of the latter. From DAVIDSON's determinations we know that the same type of brachidium existed in the Devonian faunas of Great Britain, *Waldheimia juvenis*, Sowerby (sp.), and *W. Whidbornii*, Davidson,† both shells with smooth exterior, the latter with biconvex valves, the former with a plano-convex or centronellid contour. From certain preparations made by Dr. CARL ROMINGER, in 1863,‡ it was determined that the *Terebratula* or *Retzia melonica*, Barrande, from the Bohemian Etage F_2 (Konieprusian), possesses a brachidium of the same type. This is a large biconvex shell quite different in expression from the diminutive navicu-

* In the description and illustrations of 1867 the brachidium was represented as possessing a transverse band on the dorsal side, uniting the descending branches at points just below, and slightly back of the position of the crural apophyses. Such a transverse band does not exist. In making preparations of these internal parts slight ineptitude will divide the long concave hinge-plate in such a manner that its anterior edge remains attached to the crura. Repeated attempts with the knife have almost invariably given this result, but certain specimens in which the entire brachidium has been changed to pyrites have determined the inaccuracy of such preparations and the absence of this abnormal structure.

† Devonian Supplement, 1882, pp. 12, 13, pl. i, figs. 1–4.

‡ Sixteenth Report on New York State Cabinet of Natural History, p. 49, figs. 24–26. See also BARRANDE, Système Silurien, vol. v, pl. cxli. 1879.

loid shell from the upper Wenlock shales which DAVIDSON has described* as *Waldheimia Mawi;* a species which strikingly resembles *Cyclospira bisulcata*, both in form and size. This shell has a low median septum in the brachial valve, and its brachidium is longer and much broader than in those of the Devonian. In all of DAVIDSON's representations of the interior of these species, the hinge-plate, which we may assume to be somewhat constructive, is given with a distinct cardinal process in the Devonian species, like that of the living MAGELLANIA, though in *W. Mawi* there appears to be a trace of a perforation in the plate. These structures, however, are not fully described. The actual difference in the composition of this plate in the recent Magellanias and the Devonian Cryptonellas, as above described, may be regarded as a highly important basis of distinction between these forms. Were it necessary, however, to rely upon this difference alone, we should fall far short of separating their remote predecessors of the palæozoic era as widely from MAGELLANIA as the evidence seems to require.

The form of the long, recurved adult loop in such living genera as MAGELLANIA, MACANDREWIA and TEREBRATELLA, has been shown by various investigators to be but the terminal condition of a series of metamorphoses. Evidence concerning the immature condition of the loop in any of the fossil terebratuloids is extremely difficult to obtain. In the very early growth-stages of *Cryptonella planirostra*, where the shell has a length of not more than 4 or 5 mm., the brachidium is simply a miniature of its adult condition. However, from what we now know of the changes in living and extinct Brachiopoda of similar character, it seems a natural and necessary inference that the brachidia of all such terebratuloids have undergone modifications or metamorphoses which, though slight in comparison with similar changes in the living species, yet do involve a progressive change from the simple loop of RENSSELÆRIA and CENTRONELLA to the resultant acquired in MAGELLANIA and TEREBRATELLA of modern seas.

It should not be overlooked, however, that in the recent genera of terebratuloids these modifications of the loop are complicated by the presence of a median septum, which is an integral part of the brachidium, and the absence of such a

* Silurian Supplement, 1882, pp. 76, 77, pl. iv, figs. 1-3.

septum in these Devonian and Carboniferous terebratuloids gives a greater simplicity to the variations of the loop in different stages of growth, though their final condition is the same.

Cryptonella ranges upward into the early faunas of the Carboniferous period; well defined internal casts of a large form like the full-grown examples of *C. planirostra*, occur in the Waverly group of Ohio, and it seems probable that the *Centronella Alii*, A. Winchell, described from the Marshall group of Michigan, will prove to be a Cryptonella.

Accompanying precisely the same structure of hinge-plate as that just described is a variation in the form of the brachidium presented by several of the Devonian species which have usually been referred to Terebratula, namely, *T. Sullivanti*, *T. Harmonia*, Hall, of the Corniferous limestone, *T. simulator* and *T. Lincklæni*, Hall, of the Hamilton group. The brachidium, compared with that of the normal Cryptonella, is quite short, extending less than one-half the length of the brachial valve, and the recurvature of the ascending branches exceedingly slight. This recurved lamella is so delicate that it is rarely completely preserved, but when retained the entire brachidium has the form represented in the adjoining figure. The crural apophyses are situated more

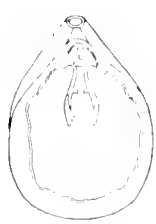


Fig. 209.

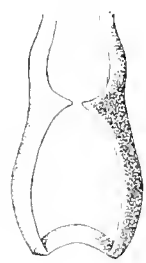


Fig. 210.

Fig. 209. *Terebratula* (*Eunella*) *simulator*, Hall; showing the character of the hinge-plate, the relative length and usual preservation of the brachidium, with the ascending band lost.

Fig. 210. *Terebratula* (*Eunella*) *Sullivanti*, Hall; a dorsal view of the complete brachidium.

anteriorly than in Cryptonella and are much broader at the base. It would be hardly justifiable to include these species in the same group with typical forms of Cryptonella, and hence, to forms having this type of brachidium, it is proposed to apply the term Eunella.

In the Carboniferous limestone of Windsor, Nova Scotia, we find a very interesting form, in the species described as *Centronella Anna*, Hartt,* where the long and greatly recurved CRYPTONELLA brachidium is retained with some accompanying modifications in other features. It seems, beyond doubt, that Professor HARTT misapprehended the structure of the brachidium in the shell. He has represented it as somewhat similar to that of *Centronella Julia*, A. Winchell, the descending branches uniting anteriorly to form a vertical median plate. By good fortune there has been obtained an example of this rare shell, filled with compact crystalline calcite, a most unusual condition of preservation in this limestone; and the demonstration of the brachidium from this specimen is very complete.

The external form of the shell is unusual, being plano-convex or naviculoid, as in the typical species of the genus CENTRONELLA; the brachial valve is depressed-convex or nearly flat and the pedicle-valve medially ridged with abrupt slopes at the sides. The dental lamellæ of the pedicle-valve are well developed as in CRYPTONELLA. In the brachial valve there is a short, tripartite hinge-plate, supported by a median septum of considerable height in the umbonal region and extends for fully one-half the length of the valve, becoming low anteriorly.

The crura are very short and are continued almost immediately into the long convergent crural apophyses The descending branches of the brachidium extend for nearly the entire length of the shell, following the curvature of the valve and approaching each other anteriorly, their extremities being again directed outward. The ascending branches extend backward to points not far in front of the crural apophyses, where they are united by a transverse band. The outer margins of the descending lamellæ are fringed with rather long, irregularly set spinules directed toward the commissure of the valves. There are no spinules elsewhere on the brachidium. Although we are not inclined to place a high value upon the presence of these spinules, they seem to be, in many cases, a natural accompaniment of the brachidium in late palæozoic species (see observations on ATHYRIS); but the entire combination of the centronellid

* HARTT in DAWSON'S Acadian Geology, second ed., p. 300, fig. 99. 1868.

contour of the shell, highly developed median septum, with the fimbriated descending branches of the brachidium, warrants the separation of this type

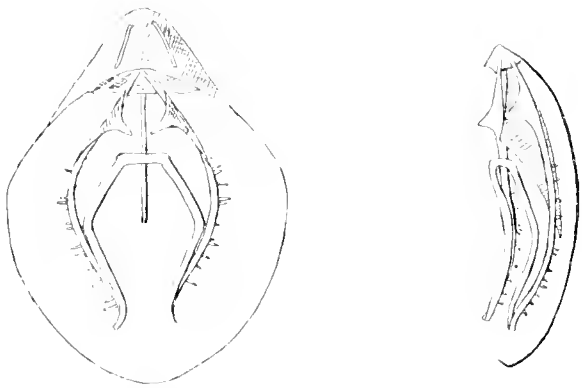


FIG. 211. FIG. 212.

Centronella (Harttina) Anna, Hall.

Dorsal and profile views of a preparation of the brachidium; showing the hinge-plate, broad jugal processes, fimbriated descending lamellæ, long recurved lamellæ, and prominent median septum in the brachial valve.

(C.)

of structure from other known genera, from which it may be distinguished by the term HARTTINA.

A Carboniferous species, *Waldheimia Coutinhoana*, with an essentially similar internal structure, has been described by DERBY * from the Amazonas. This shell is rather more biconvex than *Harttina Anna*, and has a lesser development of the dorsal septum; together, they represent the continuance of the CRYPTONELLA-type of brachidium into the later palæozoic faunas.

* Bulletin of the Cornell University, vol. i, No. 2, p. 3, pl. iii, fig. 22; pl. viii, fig. 6; pl. ix, figs. 1, 2. 1874.

Genus DIELASMA, King. 1859.

PLATE LXXXI.

1809. *Conchyliolithus anomites*, Martin. Petrefacta Derbiensia, p. 11.
1816. *Terebratulites*, Schlotheim. Denkschr. der K. Akad. der Wissensch. zu München, vol. vi, p. 27.
1824. *Terebratula*, Sowerby. Mineral Conchology, vol. v, p. 65.
1824. *Terebratula*, von Buch. Ueber Terebrateln, p. 90.
1836. *Terebratula*, Morton. American Journal of Science, vol. xxix, p. 150, pl. ii, fig. 4.
1844. *Atrypa*, McCoy. Synopsis Carb. Foss. Ireland, p. 153.
1845. *Terebratula*, de Verneuil. Géol. de la Russie et des Mont. de l'Oural, vol. ii. pp. 63, 65, pl. ix, figs. 7, 8.
1848. *Terebratula*, Geinitz. Verstein. der deutsch. Zechst. Gebirg., p. 11, pl. iv, figs. 27 36.
1850. *Epithyris*, King. Monogr. Permian Foss. England, p. 146, pl. vi, figs. 40–45.
1854. *Terebratula*, Semenow. Die Foss. des schles. Kohlenk., p. 11, pl. iii, fig. 5.
1855. *Seminula*, McCoy. British Palæozoic Fossils, p. 408.
1856. *Terebratula*, Hall. Pacific R. R Reports, vol. iii, p 101, pl. ii, figs. 1, 2.
1857. *Terebratula*, Davidson. British Permian Brachiopoda, pp. 3–11, pl. i, figs. 5–22; pl ii, fig. 2.
1857. *Terebratula*, Davidson. British Carboniferous Brachiopoda, pp. 11–16, pl. i, figs. 1–16, 23–32; pl. ii, figs 1–8.
1858. *Terebratula*, Hall. Transactions of the Albany Institute, vol. iv, pp 6, 7, 35.
1858. *Terebratula*, Hall. Geology of Iowa, vol. i, pt. ii, p. 711.
1859. *Dielasma*, King. Proc. Dublin Univ. Bot. Zool. Assoc, vol. i, p. 260.
1859. *Terebratula*, Meek and Hayden. Proc. Acad. Nat. Sci. Philadelphia, vol. iii, second ser., p. 26.
1859. *Terebratula*, Shumard. Trans. St. Louis Acad. Sci., vol. i, p. 392.
1860. *Terebratula*, White. Jour. Boston Soc. Nat. Hist., vol. vii, p. 228.
1861. *Terebratula*, McChesney. New Palæozoic Fossils, p. 82.
1861. *Terebratula*, Geinitz. Dyas, p. 82, pl. v, figs. 14–28.
1863. *Terebratula*, Hall. Sixteenth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 48.
1863. *Terebratula*, Davidson. Quart. Jour. Geolog. Soc. London, vol. xix, p. 169, pl. ix, figs. 1–3.
1863. *Terebratula*, Swallow. Trans. St. Louis Acad. Sci., vol. ii, p. 83.
1867. *Terebratula*, Hall. Palæontology of New York, vol. iv, p. 389, pl. lx, figs. 17–25, 66, 67.
1868. *Terebratula*, White and St. John. Trans. Chicago Acad. Sci., vol. i, p. 119.
1869. *Terebratula*, McChesney. Trans. Chicago Acad. Sci., vol. i. p. 37, pl. i, fig. 2.
1869. *Terebratula*, Toula. Sitz. der Kais. Akad. der Wissensch zu Wien, vol. lix, p. 1, pl. i, fig. 1.
1871. *Terebratula*, Quenstedt. Petrefactenkunde Deutschlands; Brachiopoden, pp. 427, 429, pl. li, figs. 1–9.
1873. *Cryptonella*, Hall and Whitfield. Twenty-third Ann. Rept. N. Y. State Cab. Nat. Hist., pp. 225, 229.
1872. *Terebratula*, Meek. Sixth Ann. Rept. N. Y. S. Geol. Survey Terr., p. 470.
1873. *Terebratula*, Meek and Worthen. Geol. Survey of Illinois, vol. v, p. 572, pl. xxv, fig. 15.
1874. *Terebratula*, Derby. Bull. Cornell University, vol. i, pp. 1, 63, pl. ii, figs. 1, 3, 8, 16; pl. iii, fig. 24; pl. vi, fig. 15.
1875. *Terebratula (Dielasma)*, White. Wheeler's Expl. and Survey West 100th Merid., vol. iv, pp. 93, 144, pl. xi, fig. 10.
1878. *Terebratula*, Dawson. Acadian Geology, third ed., p. 287, fig. 87.
1880. *Terebratula*, Davidson. British Carboniferous Brachiopoda, Suppl., p. 269, pl. xxx, fig. 7.
1882. *Terebratula*, Whitfield. Bull. American Mus. Nat. Hist., vol. i, pp. 54, 55, pl. vi, figs. 53–64.
1882. *Terebratula*, White. Eleventh Rept. State Geol. Indiana, p. 361, pl. xxxix, figs. 6–8.
1882. *Dielasma*, Waagen. Productus-limestone Fossils; Brachiopoda, pp. 336–359, pls. xxv, xxvii.
1883. *Terebratula*, Hall. Twelfth Rept. State Geol. Indiana, pp. 336, 337, pl. xxix, figs. 53–64.

1884. *Terebratula*, WHITE. Thirteenth Rept. State Geol. Indiana, p. 137, pl. xxxii, figs. 17-19.
1884. *Terebratula*, WALCOTT. Monogr. U. S. Geol. Survey, vol: viii, p. 224.
1884. *Dielasma*, DAVIDSON. British Fossil Brachiopoda; General Summary, p. 411.
1887. *Dielasma*, DE KONINCK. Faune du Calcaire Carbonifère de la Belgique, pp. 5-31, pls. i-viii.
1889. *Terebratula*, NETTELROTH. Kentucky Fossil Shells, p. 155, pl. xvi, figs. 20-22.
1890. *Terebratula (Cryptonella)*, CALVIN. Bull. Lab. Nat. Hist. State Univ. Iowa, p. 174, pl. 3, fig. 4.
1893. *Dielasma*, BEECHER and SCHUCHERT. Proc. Biol. Soc. Washington, vol. viii, pp. 71-78, pl. x.

Some years before the introduction of this term its distinguished author had applied PHILLIPS' name, EPITHYRIS, to certain Permian species (*Terebratulites elongatus*, Schlotheim, type) which he found to differ from TEREBRATULA, in the sense in which the term was then current, in their "prominent dental plates and transversely semi-elliptical moderately recurved loop." EPITHYRIS, as used by PHILLIPS, has no significance as a generic term; whatever value it might have was thus given it by KING, but the author subsequently decided to discard the term and introduce a new one, DIELASMA. The name has not been widely adopted, though this fact appears to have come, less from any objection to, or insufficiency in, the distinctive characters of the division, than to a general disposition to leave all the terebratuloid shells of the Palæozoic with the old genus, TEREBRATULA. WAAGEN has recognized the value of this genus and the usual facility with which its species may be recognized. It is not, however, upon the characters given by KING that we can rely for the distinction of DIELASMA from the other palæozoic terebratuloids. In external form, the convexity of both valves is generally well developed, and the outline is usually elongate-oval. But in both of these respects there is very considerable variation; the development of a median sinus on both valves with a plication and groove at the bottom of it, as in the *Terebratula turgida*, Hall, of the Chester limestone, and *T. vescicularis*, de Koninck, of the Coal Measures, produces a form at once suggestive of the typical biplicate TEREBRATULA of the Jurassic age. A general depression of the pedicle-valve anterior to the umbo, and a corresponding elevation of the opposite valve, appearing first in the *Cryptonella Calvini*, Hall and Whitfield, of the middle Devonian, is carried to an extreme in the *T. bovidens*, Morton, of the Coal Measures.

The apex of the pedicle-valve is closely incurved, so that in adult shells but little remains of the deltidial plates. The foramen is large, quite generally encroaching upon the umbo and often becoming very oblique to the longitudinal axis; with the increase of this obliquity the deltidial plates are thickened in their inner surface, which thus becomes more or less protruded. The inverted sheath or collar within the foramen is highly developed and clearly shown on internal casts. On the interior the dental plates are conspicuous, as in CRYPTONELLA, but they stand vertically upon the bottom of the valve, not showing the convergence and often actual union occurring in that genus.

In the brachial valve the dental sockets are quite deep and narrow, the socket-walls rising abruptly, though not attaining the height of the dental plates of the opposite valve. They are distinctly separated from the crural plates or margins of the hinge-plate, and converge toward the apex where they merge into a slightly elevated cardinal process; the latter usually appearing as a crescentic submarginal wall, though when best preserved is seen to be composed of two lateral, somewhat rounded lobes. The crural plates are two divergent vertical lamellæ, originating just below the cardinal process, and attaining a length equal to the distance between their extremities, which is about one-third the width of the valve at that point. Between these plates lies the long shallow hinge-plate, which is raised but little above the bottom of the valve, and is sometimes actually adherent to it. This plate attains its greatest width at the extremities of the vertical crural plates, its margins converging thence anteriorly, its full length often equaling one-third that of the valve. To this plate are attached all the muscles of the brachial valve, the scars of both anterior and posterior adductors being frequently clearly defined upon its surface. Upon comparison of this structure with that of CRYPTONELLA the homologies are at once apparent, but there is a

FIG. 213. *Dielasma bovidens*, Morton. An enlargement of the umbonal portion of the brachial valve; showing the slightly thickened processes on either side of the beak. (C.)

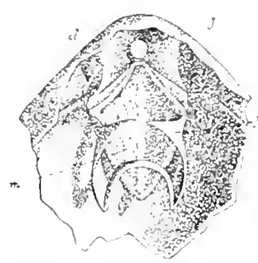


FIG. 214. *Dielasma elongatum*, Schlotheim. The interior of the umbonal region of the two valves; showing the highly developed dental plates (*d*), the elongate, sessile hinge-plate with its muscular scars, and the form and mode of attachment of the brachidium. (DAVIDSON.)

total difference in the expression of the two. The lateral divisions of the plate in CRYPTONELLA have become merged with the valve and lost in DIELASMA. The median division, which is also to a certain extent myiferous in CRYPTONELLA, is carried to an extreme of development in DIELASMA, where it forms a distinct platform. In DIELASMA the crura are greatly abbreviated. The descending lamellæ of the brachidium are attached to, and are continuous with the crural plates, as far as the latter extend. The crural apophyses on the upper margins of these lamellæ are developed behind the points where the lower margins of the lamellæ are free from the crural plates. The lateral parts of the brachidium are more or less divergent, the recurvature of the ascending lamellæ rather short and the entire structure does not extend beyond the middle of the shell. The ascending lamellæ are very fragile and usually destroyed in fossilization.

It is thus evident that the differentials of DIELASMA are highly developed and these having become fixed at the opening of the Carboniferous period, species of the genus abounded until the close of the Permian.

In American faunas the specific values of these forms have not been thoroughly determined, but we may quote as characteristic examples of DIELASMA, the following: *Terebratula formosa* and *T. turgida*, Hall, of the Warsaw limestone, *T. Rowleyi*, Worthen, and *T. Burlingtonensis*, White, of the Burlington limestone, and *T. bovidens*, Morton, of the Coal Measures. The type of structure was, however, well defined in the Devonian, and the *Cryptonella Calvini*, Hall and Whitfield, of the middle Devonian of Iowa, is an excellent representative of the earliest forms of the genus. The great specific representation of the genus in the later Carboniferous faunas has been demonstrated by the labors of DE KONINCK* and WAAGEN.†

It has been suggested by WAAGEN‡ that the *Terebratula Lincklæni*, Hall, of the Hamilton fauna of New York, might prove to be an early representative of DIELASMA. Reasons have already been advanced to show that this species, with

* Faune du Calcaire Carbonifère de la Belgique; Ann. du Mus N. Y. d'Hist. Nat. de Belg., vol. xiv, pt. vi, pp. 5-31, pls. i-viii. 1887.

† Palæontologia Indica; Productus-limestone Fossils, pp. 336-359, pls. xxv-xxvii. 1882.

‡ *Op. cit.*, p. 337.

T. simulator, Hall, and some others, possessing a narrow and slightly recurved but decidedly elongate brachidium, conveniently constitute a subdivision of CRYPTONELLA. But there are other Devonian species in which the loop is far more like that of DIELASMA, as for example the *Terebratula Romingeri*, Hall, a form widely distributed in the Hamilton fauna of North America; and the *T.* (*Cryptonella*) *Iowensis*, Calvin, a large, biconvex, and often beautifully preserved shell, from the middle Devonian of Fayette and elsewhere in Iowa.* In this shell the hinge-plate is constructed as in CRYPTONELLA and is not adherent to the bottom of the valve as in DIELASMA, though it may be close to it; the crura also arise normally from the lateral divisions of this plate. With these distinctive differences from DIELASMA, the resemblance to the latter genus in the form of the brachidium is striking, its descending branches being highly divergent, the ascending branches abruptly recurved, making a broad, gentle curvature above; at the same time this recurved band is so very fragile as to be almost invariably destroyed. The entire length of the loop, as in DIELASMA, and in contradistinction to CRYPTONELLA and EUNELLA, is about one-third that of the brachial valve. This peculiar structural variation may be designated by the term CRANÆNA.† Probably other American Devonian species, besides the two mentioned, will be found to belong to this group when satisfactory evidence of their internal structure has been obtained.

FIG. 215. *Terebratula* (*Cranæna*) *Romingeri*, Hall. An outline showing the DIELASMA form of the brachidium and the divided hinge-plate.

Recent observations by BEECHER and SCHUCHERT‡ upon the development of the brachidium in *Dielasma turgida*, Hall, of the St. Louis limestone, show that in its earliest observed condition, in a shell about 4 mm. in length, it is altogether like that of primitive forms of RENSSELÆRIA (*R. mutabilis*); the lateral branches uniting by simple coalescence to form a triangular median plate, which is not thickened along the line of suture, either below, as in *R. mutabilis*, or above, as

* CALVIN, Bull. Lab. State University of Iowa. p. 174, pl. iii, fig. 4.

† To Miss AGNES CRANE, of Brighton, England, an associate in the later labors of Dr. THOMAS DAVIDSON, and an astute student of the Brachiopoda.

‡ Development of the Brachial Supports in Dielasma and Zygospira, *op. cit.* 1893.

in CENTRONELLA. The adult condition of the loop is derived from this primitive condition by progressive resorption of the pointed anterior portion of the plate, and the complete obscuration of the median suture by anchylosis is not effected

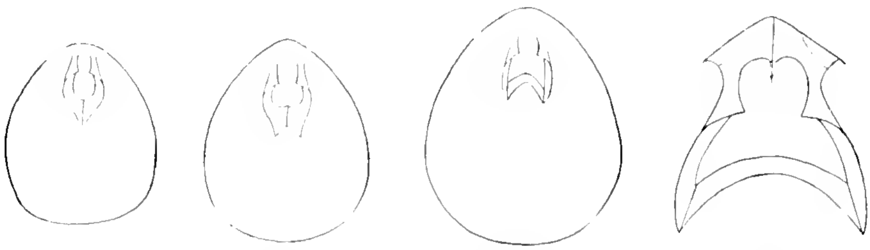


FIG. 216. FIG. 217. FIG. 218. FIG. 219.

Dielasma turgida, Hall.

Fig. 216. The centronelliform stage of the loop. × 6.
Fig. 217. A later stage; showing the resorption of the anterior portion of the loop. × 6.
Fig. 218. Early DIELASMA stage, produced by further resorption. × 6.
Fig. 219. Loop and hinge-plate of a mature specimen. × 6.

till near maturity. It is thus clearly demonstrated that the brachidium of DIELASMA and, inferentially, all similarly recurved loops are secondary modifications of the primitive structure finding its mature expression in RENSSELÆRIA and CENTRONELLA.

DIELASMINA, WAAGEN. 1882.

1882. *Dielasmina*, WAAGEN. Productus-limestone Fossils; Brachiopoda, p. 369, pl. xxvii, fig. 10.

This name has been applied to certain plicated species in the Productus-limestone of India, which possess more or less of the characters of DIELASMA.

FIG. 220. FIG 221.

Dielasmina plicata, Waagen.
Dorsal and frontal views. (WAAGEN.)

They have the dental plates of the pedicle-valve and the general form of the brachidium in that genus, as far as the interior is now known, but for the present the distinctive difference lies in the nature of the exterior. This distinction is certainly a convenient one, but the type of structure, so far as our knowledge extends, is unknown in American faunas. The type-species of this genus is *D. plicata*, Waagen, and this is said to be its only representative.

HEMIPTYCHINA, Waagen. 1882.

1862. *Terebratula*, Davidson. Quart. Journ. Geol. Soc. London, vol. xviii, p. 27, pl. ii, fig. 1.
1863. *Terebratula*, de Koninck. Foss. Paléoz. de l'Inde, p. 32, pl. ix, fig. 1.
1878. *Terebratula*, Waagen. Records Geol. Surv. India, vol. ix, p. 186.
1882. *Hemiptychina*, Waagen. Productus-limestone Fossils; Brachiopoda, pp. 361–375, pl. xxvi, figs. 6–10; pl. xxvii, figs. 1–9, 11.

Dr. Waagen has found that certain plicated terebratuloids of Permo-Carboniferous faunas do not possess dental plates. The significance of the generic name above used and the nature of the author's argument, both indicate that the conception of the proposed genus was based upon such plicated shells. The author, however, adds that the plication of the exterior "is not absolutely indispensable for the shells belonging to the genus" (*op. cit.*, p. 361) and, unfortunately, without citing any species as typical, gives, first in his list of descriptions a smooth shell, *H. sublævis*, Waagen. The propriety of including these plicated and smooth shells in the same genus appears, on certain grounds, open to objection; and the author's intention will undoubtedly be better interpreted by regarding the plicated shell, *Terebratula Himalayensis*, Davidson, as typical of the Hemiptychina; a shell of whose interior something is known and from which it is clearly evident that the author's diagnosis was largely drawn.

Fig. 222. *Hemiptychina Himalayensis*, Davidson
A portion of the interior; showing the absence of dental plates in the pedicle-valve, and the Dielasma-like brachidium. (Waagen.)

These plicated terebratuloids without dental plates are unknown in American faunas; but we do find a very limited representation (as yet restricted to a single form) of smooth species without dental plates. It is here proposed to separate these shells from HEMIPTYCHINA and to distinguish them by the term BEECHERIA,* giving a brief account of the interior structure as exemplified in *B. Davidsoni*, sp. nov.,† of the Carboniferous limestone of Windsor, Nova Scotia.

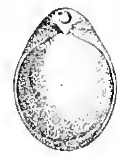


FIG. 223. *Beecheria* (*Hemiptychina*) *sublævis*, Waagen. Dorsal view; showing the smooth exterior. (WAAGEN.)

The general character of the interior is that of DIELASMA, except that the dental plates are wholly absent or represented only by faint ridges which never reach the bottom of the pedicle-valve. The peculiar myiferous hinge-plate of DIELASMA is wholly merged with the valve, but the crural ridges are still retained and the descending lamellæ originate from them at the bottom of the valve in very much the same way as in DIELASMA. The crural apophyses are broad and erect, there being no part of the descending branches behind them. Sometimes the brachial valve retains a low muscular impression which has the form of the platform of DIELASMA. This species and *Beecheria* (*Hemiptychina*) *sublævis*, Waagen, constitute the known representatives of this type of structural variation.

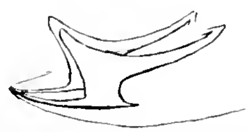


FIG. 224. *Beecheria Davidsoni*, sp. nov. An enlarged profile of the brachidium; showing the manner in which lamellæ arise from the bottom of the valve, the broad posterior jugal processes and the much narrower descending lamellæ. The anterior transverse or reflected band is not fully retained. (C.)

GENUS CRYPTACANTHIA, WHITE and ST. JOHN. 1867.

1867. *Waldheimia?* (*Cryptacanthia*), WHITE and ST. JOHN. Trans. Chicago Academy of Sciences, vol. i, pt. i, p. 119, fig. 3.

Our knowledge of this genus is still very imperfect. The authors described as *Waldheimia? compacta*, a rather small, plano-convex or naviculoid shell from

* In recognition of his important contributions to our knowledge of the Brachiopoda.

† This is the shell identified by DAVIDSON as *Terebratula sacculus*, Martin. (On the Lower Carboniferous Brachiopoda of Nova Scotia; Quart. Journ. Geol. Soc., vol. xix, p. 169, pl. ix, figs. 1–3, 1863.)

the Upper Coal Measures of Madison county, Iowa, where it is said to be associated with the *Terebratula millipunctata*, Hall (=*Dielasma bovidens*, Martin). The original figures showing the outline of the exterior are here reproduced. Of the internal structure the authors say that "the loop seems to be essentially like that of WALDHEIMIA in form, but the crura of the loop appear to be joined, forming with the hinge-plate a foramen of moderate size; and the loop-band is armed with numerous spines which point outward towards the shell in all directions."

FIG. 225.
Waldheimia? (Cryptacanthia) compacta, White and St. John. A copy of the original figure. (WHITE and ST JOHN.)

This shell appears to be very rare, and we have had no opportunity of examining specimens. Attention, however, may be directed to a somewhat similar form of brachidium from the chert beds of the Burlington limestone, at Burlington, Iowa, belonging to a species whose identity is not fully established. This structure is represented in the accompanying figure. From a well-developed, elevated and tripartite hinge-plate, bearing a slight bilobed cardinal process at its apex, arises a very short brachidium of the type of DIELASMA or CRANÆNA. The outer margins of both descending lamellæ and the short ascending lamellæ are bordered with numerous short spinules. Furthermore, there appears to be a solid longitudinal band passing from the hinge-plate to the posterior curve of the ascending lamellæ. This curious character is not a septum, as the entire apparatus is elevated from the bottom of the valve; but it may prove to be wholly casual, and a result of an interlocking of the minute quartz crystals with which the brachidium is

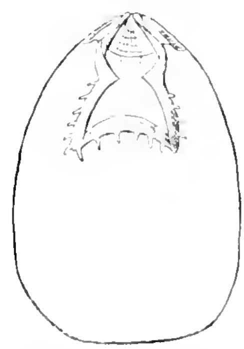


FIG. 226. A fimbriated DIELASMA-like brachidium from the chert of the Burlington limestone.
The median dotted lines indicate the position of the longitudinal band described as probably casual in origin. The outline of the valve is wholly constructive.

encrusted. Possibly a similar occurrence explains the apparent union of the crural apophyses described by WHITE and ST. JOHN as occuring in CRYPTACANTHIA. The external form of the Burlington limestone species is apparently more biconvex than in *Cryptacanthia compacta*, and the generic characters of both are extremely uncertain.

GENUS TROPIDOLEPTUS, HALL. 1857.

PLATE LXXXII.

1839. *Strophomena*, CONRAD. Ann. Rept. Geolog. Dept. N. Y., p. 64.
1847. *Leptæna*, DE VERNEUIL. Bull. Soc. Géol. de France, second ser., vol. iv, p. 705, pl. iii, figs. 7, 7 *a*.
1853. *Leptæna*, SCHNUR. Palæontographica, vol. iii, p. 220, pl. xl, fig. 2.
1856. *Strophomena*, THE SANDBERGERS. Verstein. der rhein. Schichten-systems, p. 66, pl. xxxiv, fig. 8.
1857. *Tropidoleptus*, HALL. Tenth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 151, figs. 1, 2.
1859. *Tropidoleptus*, HALL. Twelfth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 31.
1865. *Leptæna?* DAVIDSON. British Devonian Brachiopoda, p. 87, pl. xvii, figs. 1-3.
1867. *Tropidoleptus*, HALL. Palæontology of New York, vol. iv, p. 404, pl. lxi A, figs. 50-52; pl. lxii, figs. 2 *a-c*, 3 *a-y*.
1868. *Tropidoleptus*, MEEK and WORTHEN. Geology of Illinois, vol. iii, p. 427, pl. xiii, fig. 2.
1874. *Tropidoleptus*, RATHBUN. Bull. Buffalo Soc. Nat. Sci., vol. i, p. 254, pl. ix, fig. 10.
1876. *Tropidoleptus*, DERBY Bull. Mus. Harvard Coll., vol. iii, No. 12, p. 282.
1881. *Tropidoleptus*, RATHBUN. Proc. Boston Soc. Nat. Hist., vol. xx, p. 35.
1889. *Tropidoleptus*, NETTELROTH. Kentucky Fossil Shells, p. 46, pl. xvii, figs. 14, 15.
1890. *Tropidoleptus*, DERBY. Arch. Mus. Nac. de Rio de Janeiro, vol. ix, p. 76.
1892. *Tropidoleptus*, ULRICH. Paleoz. Verstein. aus Bolivien; Neues Jahrb. für Mineral., etc., Beilagebnd. viii, p. 73, pl. iv, figs. 32-34.

DIAGNOSIS. Shells with the general external aspect of RAFINESQUINA; concavo-, or plano-convex. Hinge-line straight; in young shells forming the greatest transverse diameter and frequently extended at the cardinal extremities, but in mature and old shells shorter than the transverse diameter in the pallial region. Marginal outline varying from longitudinally semi-elliptical in youth, to transversely subelliptical at maturity. Surface covered with simple, low plications, all extending from beak to margins. The median plication on the pedicle-valve and the corresponding sinus on the brachial valve are broader and more conspicuous than the others.

The pedicle-valve is regularly convex, becoming slightly concave on the cardinal slopes. It bears a moderately broad cardinal area, coextensive with the hinge-line, which is divided by a broad, open delthyrium, which, in no observed condition of growth, bears a covering of any sort, but is filled by the cardinal process of the other valve. The base of the delthyrial cavity is thickened and transversely striated, probably by the attachment of the pedicle-muscle. The teeth are not situated at the extremities of the delthyrial margins, but lie within and in front of them, arise from the bottom of the valve as two erect, divergent subquadrate crests, resting upon low ridges which bound the muscular area. These peculiar teeth are smooth and abrupt on their inner faces, while their outer faces are deeply crenulated. A low groove separates each from the cardinal area. The muscular area is broadly flabellate, extending more than half-way across the valve, and consists of two large diductor scars enclosing a narrow median pair of adductors.

The brachial valve is slightly concave, often nearly flat. Cardinal area narrow, but clearly developed; chilidium prominent. Cardinal process large, erect, smooth on its posterior surface, and bilobed at its summit. Each of these lobes is excavated above, so that the upper portion of the posterior wall is free from the rest of the process. In front of this is a broad, smooth floor, sloping toward the bottom of the valve. The margins of this area form the elevated socket-walls, and their anterior extremities are the bases of the crura. The dental sockets are deep and their outer walls corrugated for the reception of the teeth. The posterior portion of the sockets and the lower part of the cardinal process are covered by the erect, convex chilidium. At the anterior edge of the cardinal process lies a broad, thick, not elevated median ridge, which gradually narrows and becomes developed into a sharp, thin septum, attaining its highest point at about the center of the valve, whence it slopes rather more abruptly downward, terminating at the anterior third of the valve. From the crural bases extends a pair of long, slender lamellar processes, which curve outward, are directed upward, again converge and unite with the median septum on its lateral faces and just in front of its highest point. Slightly convergent, slender jugal processes are given off not far from the origin of the lateral lamellæ. The scars of the adductor muscles are situated just in front of the cardinal process on either side of the septum, and are not clearly delimited.

Shell-substance highly punctated in all its parts.

Type, *Strophomena carinata*, Conrad. Lower and middle Devonian.

Observations. The original determination of the characters of Tropidoleptus led to its assignment with the terebratuloids. Presumably on account of its external expression, systematists and other students have generally been unwilling to admit this determination, placing the genus preferably among the strophomenoid and leptænoid genera. After the examination of a large amount

Fig. 227.

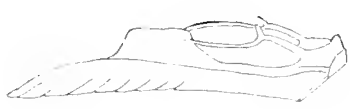


Fig. 228.

Tropidoleptus carinatus, Conrad.

Fig. 227. The interior of the brachial valve; showing the cardinal process, crenulated dental sockets, loop and median septum.

Fig. 228. The same in profile; showing the height of the median septum and the mode of attachment of the lamellæ of the loop.

of material, representing the various growth-stages of the shell from a size less than 2 mm. in diameter to maturity, and having reviewed all the points involved in the original account of the brachidium, these have been found to be correct in every particular. In no observed condition of growth does there exist a deltidium on the pedicle-valve, and hence it becomes necessary to recognize Tropidoleptus as a terebratuloid genus, unique among the palæozoic brachiopoda.

The actual union of the lateral lamellæ of the brachidium with the median septum in this shell is the earliest evidence and only known instance in palæozoic faunas of a condition which is prevalent among the terebratuloids of existing seas. The investigations of DAVIDSON, DALL, FRIÈLE, ŒHLERT and BEECHER have shown that in TEREBRATELLA, MAGASELLA, KRAUSSINA, PLATIDIA, BOUCHARDIA, and, indeed, all genera where the median septum is highly developed, the calcification of the lamellæ of the brachidium begins quite as soon from the lateral walls of the septum as from the crural bases on the hinge-plate. Calcification thus proceeds both posteriorly and anteriorly. In all modifications of the brachidium attendant upon the resorption of later growth, the median septum is most intimately concerned, and in the terminal stage of such modifications every trace of this septum may have been removed (compare *Magellania venosa*, *Macandrevia cranium*).

The mature condition of TROPIDOLEPTUS, when compared with the variations from resorption, through which the loop of the *TEREBRATELLIDÆ* has passed, is found to be very simple, showing only the primary completed calcification of the lateral branches or descending lamellæ, and affording no evidence whatever of any modification resulting from resorption of the calcified tissues. Its condition is directly comparable to the mature form of the loop in PLATIDIA, and to what is termed by BEECHER the *platidiform stage* in MUHLFELDTIA and MACANDREVIA.* The transverse and strongly plicated valves with well developed cardinal areas, are features in harmony with the condition of the brachidium, as similar characters are borne in the primitive conditions expressed by the mature KRAUSSINA, CISTELLA, MEGATHYRIS, etc. Immature specimens of TROPIDOLEPTUS frequently show an uncompleted condition of the calcification of the brachidium. All the evidence thus points to the conclusion that this interesting genus is an early representative of the family *TEREBRATELLIDÆ.*

The wide distribution of *T. carinatus* through the Devonian of North and South America has already been referred to in the discussion of the genus VITULINA. In the argillaceous shales of the Hamilton group in western New York

* See Revision of the Families of the Loop-bearing Brachiopoda, by CHARLES E. BEECHER; Transactions of the Connecticut Academy, vol. ix, p. 376, pl. i. 1893.

the species is exceedingly abundant and very generally distributed, but it is rarer toward the east where deposits become more arenaceous. Yet wherever the Devonian sandstones are known in Brazil and Bolivia the species abounds. A similar form passing current under the name *Strophomena* or *Leptæna laticosta*, Conrad, also occurs in the lower Devonian sandstones (Coblentzian) of Germany. An additional species, *T. occidens*, Hall, has been described from the limestones of Hamilton age at Iowa City, Iowa, but its internal characters are not known.

GENERA

WHOSE SYSTEMATIC POSITION IS UNDETERMINED.

GENUS EICHWALDIA, BILLINGS. 1858.

PLATE LXXXIII.

1848. *Terebratula*, DAVIDSON. Bull. Soc. Géol. de France, second ser., vol. v, pl. iii, fig. 34.
1849. *Atrypa*, D'ORBIGNY. Prodrome de Paléontologie, vol. i, p. 40.
1852. *Atrypa*, HALL. Palæontology of New York, vol. ii, p. 281, pl. lvii, figs. 5 *a–t*.
1858. *Eichwaldia*, BILLINGS. Rept. Geol. Survey Canada for 1857, p. 190, figs. 24 *a–e*.
1859. *Rhynchonella*, *Porambonites*, SALTER. Murchison's Siluria, second ed., pp. 250, 544.
1860. *Porambonites*, LINDSTRÖM. Gotland's Brachiopoden, p. 364.
1863. *Rhynchonella?* HALL. Transactions of the Albany Institute, vol. iv, p. 217.
1866. *Eichwaldia*, BILLINGS. Catalogue Silurian Foss. Anticosti, p. 10.
1867. *Eichwaldia*, *Dictyonella*, HALL. Twentieth Ann. Rept. N. Y. State Cab. Nat. Hist., pp. 274–278, figs. 1–7.
1869. *Eichwaldia?* DAVIDSON. British Silurian Brachiopoda, p. 193, pl. xxv, figs. 12–15.
1875. *Eichwaldia*, HALL. Twenty-eighth Ann. Rept. N. Y. State Mus. Nat. Hist., p. 159, pl. xxvi, figs. 50–54.
1879. *Eichwaldia*, BARRANDE. Système Silurien du Centre de la Bohême, vol. v, pl. lxxxi, figs. I–III.
1880. *Eichwaldia*, LINDSTRÖM. Angelin's Fragmenta Silurica, p. 25, pl. ii, figs. 16–20.
1883. *Eichwaldia*, DAVIDSON. British Silurian Brachiopoda, Suppl., p. 140, pl. viii, figs. 15, 16.
1884. *Eichwaldia*, DAVIDSON. British Fossil Brachiopoda, General Summary, p. 355.
1884. *Eichwaldia*, YOUNG. Geological Magazine, vol. i, No. 5, p. 214.
1889. *Eichwaldia*, BEECHER and CLARKE. Mem. N. Y. State Mus., vol. i, No. 1, p. 31, pl. iii, figs. 11–13.

These curious shells have been carefully studied by BILLINGS, HALL, DAVIDSON, LINDSTRÖM and YOUNG, and though we have a pretty complete understanding of their structure, their affinities and phylogeny are still obscure. Their characters are as follows:

SHELLS subtriangular in outline, with biconvex valves, the pedicle-valve having a broad median sinus, and the brachial valve a corresponding median fold.

The umbo of the pedicle-valve is acute and arched over the opposite valve, though not closely appressed against it. As far as has been ascertained, the umbonal space between the two valves is open, that is, there is no normal deltidium or pair of deltidial plates extending from the apex downward; but there is a short, triangular plate or diaphragm which begins at the apex of this valve, and extends forward beyond the posterior edge of the brachial valve, and thus serves the purpose of the deltidium, though deeply depressed within the cavity of the pedicle-valve. This diaphragm is usually quite short and confined to the apical region, but it may extend for fully one-fifth the length of the valve, its anterior margin being free and its lateral margins adherent to the inner cardinal slopes. The cardinal line may be regarded as extending nearly to the lateral extremities of the valves; the articulating apparatus consists of a pair of long marginal ridge-like teeth on the divergent cardinal slopes, fitting into narrow marginal grooves on the brachial valve. There is sometimes a trace of a median septum over the pallial region. In the brachial valve is a small callus, boss or cardinal process lying directly beneath the apex. Below this is a strong

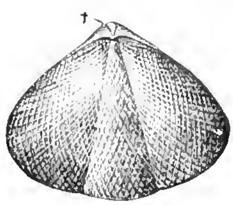


FIG. 229.

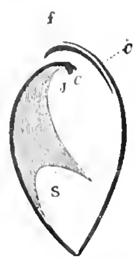


FIG. 231.

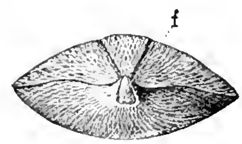


FIG. 230.

FIG. 234.

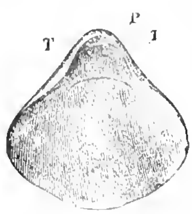


FIG. 232.

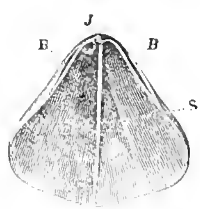


FIG. 233.

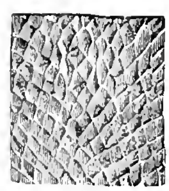


FIG. 235.

Eichwaldia reticulata, Hall.

Fig. 229. Dorsal view.
Fig. 230. Cardinal view.
Fig. 231. Longitudinal section of the two valves.
Fig. 232. Interior of pedicle-valve.
Fig. 233. Interior of brachial valve.
Fig. 234. Vertical section of shell.
Fig. 235. Enlargement of the surface.

Notation: f, "bare spot," foramen ? ; P(c), deltidium or internal plate; c′, umboual surface of pedicle-valve; T, teeth; B, dental sockets; J, cardinal process; S, median septum of brachial valve.

median septum, which increases in height anteriorly and rises to an acute, anteriorly directed apex at about two-thirds the length of the shell. In front of this point its anterior edge is concave, the septum disappearing not far within the margin of the valve.

No traces of muscular scars have been observed on either valve.

The external surface of the valves is covered by a coarse network of superficial cells, usually hexagonal, sometimes circular in outline. In all species and in early growth-stages there is a bare, smooth, triangular area at the beak of the pedicle-valve, where this superficial ornament does not extend.

It has been shown by YOUNG that the shell of *Eichwaldia Capewelli* is composed of three layers; first, the outer, coarsely meshed and wholly superficial layer; below this, a more compact layer perforated by numerous small polygonal cells,

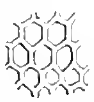


FIG. 236.

FIG. 237.

FIG. 238.

FIG. 239.

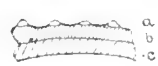


FIG. 240

Eichwaldia Capewelli, Davidson.

Fig. 236. Hexagonal cells of the outer surface of the shell in unworn specimens.
Fig. 237. Small polygonal cells in walls of hexagonal cells.
Fig. 238. Polygonal cell layer between outer hexagonal cells and inner dense layer.
Fig. 239. Perforated inner dense layer.
Fig. 240. Vertical section of the shell; *a*, outer hexagonal cell-walls; *b*, polygonal cell layer; *c*, inner dense layer with minute perforations. (YOUNG.)

the apertures of which are exposed in the greater cells of the outer layer; and, on the inner surface, a dense lamina with minute perforations.

The peculiar bare spot on the umbo of the pedicle-valve, from which the external shell-layers are absent, requires a brief notice. This area is the opening of an aperture entering the valve between the outer shell and the internal umbonal diaphragm. The smooth surface of the area is the inner surface of this diaphragm, which is considerably thickened about its apex. YOUNG has called attention to the fact that along the margins of this bare spot the superficial laminæ are unfinished and the edges of this outer layer rough and ragged. This is especially true of the anterior edge, while the lateral edges appear to be invariably straight and to diverge at a constant angle.* The latter evidently represent the lines of attachment of the internal diaphragm to the lateral walls of the valve. In the youngest shells that have been observed†

* See BEECHER and CLARKE, Memoirs N. Y. State Museum, vol. i, No. 1. p. 32.

† BARRANDE, Système Silurien, vol. v, pl. lxxxi, figs. 1, 2; BEECHER and CLARKE, *op. cit.*, pl. iii, fig. 11.

this smooth spot is present and it is always accompanied by a decided incurvature of the apex of the valve.

The condition of the edges of this aperture has convinced some observers of the probable atrophy of the pedicle, and the fixation of the shell by solid cementation at this point. It must, however, be borne in mind that among the

FIG. 241.

FIG. 242.

Eichwaldia subtrigonalis, Billings.

Dorsal and ventral views of a silicified young shell retaining the pedicle; showing its protrusion from the umbona aperture. From photographs of the original specimen described by BILLINGS.

original illustrations of the type-species, *E. subtrigonalis*, Mr. BILLINGS represented a young shell in a silicified condition, with an extended pedicle protruding from, or at least covering the aperture represented by the bare spot. Through favor of Mr. J. F. WHITEAVES, of the Geological Survey of Canada, we have been furnished with photographs and drawings of this specimen, and notwithstanding this remarkable instance of the replacement of a soft organ by silica, there seems, from this evidence, to be no reason to doubt that the umbonal aperture was solely for the passage of the pedicle. Such being the case, it will naturally follow that the internal plate or umbonal diaphragm is a modified condition of the deltidium or of the deltidial plates, probably the former.

The earliest species of this genus, of which we have information, is the type-form, *E. subtrigonalis*, Billings, which was described from the Black River limestone at Paquette's Rapids, on the Ottawa River. The other American species are all from the Niagara faunas, *E. coralifera*, Hall, occurring in the New York shales, *E. reticulata*, Hall, in the calcareous shales at Waldron, Indiana, *E. gibbosa* and *E. concinna*, Hall, in the limestones of western Tennessee, and *E. Anticostiensis*, Billings, from Anticosti. *Eichwaldia Capewelli*, Davidson, appears to be not uncommon in the Wenlock shales of England, and has been identified by Lindström, in the Island of Gotland. BARRANDE has illustrated three species from the étages E and G, namely, *E. Dormitzeri*, *E. Branikensis*, *E. Bohemica*, Barrande.

It may be well to observe that as the species *E. subtrigonalis*, upon which the genus was established, has a surface quite devoid of the cellular epithelial lamina which is so characteristic of all the other known species, the term DICTYONELLA, Hall (1867),* may be found of use in distinguishing the latter group of shells.

GENUS AULACORHYNCHUS, DITTMAR. 1871.

PLATE LXXXIII.

1854. *Chonetes?* SEMENOW. Zeitschr. der deutsch. geolog. Gesellschaft, vol. vi, p. 345, pl. v, figs. 1*a–d*.
1862. *Chonetes*, DAVIDSON. British Carboniferous Brachiopoda, p. 278, pl. lv, fig. 13.
1871. *Aulacorhynchus*, DITTMAR. Ueber ein neues Brachiopoden-Geschlecht aus dem Bergkalk; Verh. d. k. Akad. d. Wissensch. St. Petersburg, second ser., vol. vii, p. 1, pl. i.
1870. *Chonetes??* MEEK and WORTHEN. Proc. Acad. Nat. Sci. Philadelphia, p. 35.
1873. *Isogramma*, MEEK and WORTHEN. Geological Survey of Illinois, vol. v, p. 568, pl. xxv, figs. 3*a–d*.
1882. *Aulacorhynchus*, BARROIS. Recherches sur les Terrains anciens des Asturies et de la Gallice, p. 326, pl. xvi, figs. 6*a–d*.
1884. *Aulacorhynchus*, DAVIDSON. British Fossil Brachiopoda; Appendix to Supplements, p. 283, pl. xx, fig. 22.

SHELLS short, transversely elongate or alate; extremities often rounded; hinge-line straight, usually making the greatest width of the shell. Valves very thin and fragile. Pedicle-valve slightly convex, with traces of a broad, obscure median sinus; brachial valve flat. Surface covered with numerous regular and continuous, concentric rounded folds or ridges which are separated by furrows of equal width.

In the pedicle-valve the character of the articulating processes has not been fully ascertained. There appears, however, to have been no cardinal area, and but exceedingly small teeth, judging from the analogy of the brachial valve. Just within the apex of the valve, which is closely appressed against the opposite one, begins a pair of divergent, elevated ridges, which extend for one-third, or even one-half the length of the shell, and enclose a thickened area or platform, which terminates abruptly in a transverse anterior margin. This platform is the seat of the adductor and divaricator muscles, and probably rests upon the bottom of the valve and is not vaulted.

In the brachial valve there is a prominent cardinal process from the base of which diverge two lateral ridges or socket-walls, lying just within the hinge-line;

*Twentieth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 274.

behind them are linear depressions or dental sockets. There is also a low median ridge extending from the base of the cardinal process into the pallial region.

The substance of the shell shows a coarsely prismatic cellular structure, as in PORAMBONITES and EICHWALDIA. According to BARROIS, this cellular lamina is not superficial but is covered by a thin epidermal layer.

Type, *Aulacorhynchus Pachti*, Dittmar. Carboniferous limestone.

OBSERVATIONS. There is still much to be learned of the structure of these curious shells. Their similarity in external aspect to DE KONINCK'S *Chonetes concentrica*, led some of the early writers to refer them to that genus and species, but SEMENOW, the first author to notice these fossils, observed their differences from CHONETES, in the absence of cardinal spines and the existence of a thickened triangular plate in the pedicle-valve, and suggested that they were to be regarded as typical of a new brachiopod genus. MEEK and WORTHEN are the only authors who have described the brachial valve, and upon it was based the conception of their genus ISOGRAMMA, which must yield to DITTMAR'S term introduced two years earlier. More recently BARROIS has added some important observations upon the structure of the genus.

Species of this genus are not common, but appear to be widely distributed in Carboniferous countries, Russia, Silesia, Scotland, and the Asturias. In North America the only species known is the *Isogramma millepunctata*, Meek and Worthen, from the upper Coal Measures of Marion county, Illinois.

The origin and affiliations of AULACORHYNCHUS are involved in great uncertainty. The resemblance to CHONETES is fortified by the existence of a stout cardinal process, while the triangular muscular plate, the close incurvature of the beak and obscuration or obliteration of the pedicle-passage and deltidium, are features similar to those existing in EICHWALDIA. It may be suggested that the pedicle in AULACORHYNCHUS was extruded in a manner similar to that in EICHWALDIA, and that, hence, the platform may have been vaulted and slightly raised above the bottom of the valve, though this is not evident from the usual preservation of the fragile shells, where compression has closed any such cavity. These similarities to EICHWALDIA are still further seen in the coarse cellular structure of the shell.

GENUS LYTTONIA, WAAGEN. 1883.

1878. *Bactrynium*, WAAGEN. Records Geol. Surv. India, vol. xi, pp. 186, 187.
1880. *Thecidea*, ZUGMAYER. Unters. über rhät. Brachiopoden; Beitr. zur Paläon. von Oesterreich-Ungarn, I, p. 22.
1882. *Leptodus*, KAYSER. Richthofen's China, vol. iv, p. 161.
1883. *Lyttonia*, WAAGEN. Productus-limestone Fossils; Brachiopoda, pp. 396–403, pl. xxix, figs. 1–3; pl. xxx, figs. 1–11.

SHELLS of great size, highly inequivalve and very irregular; frequently with broad lateral expansions.

Pedicle-valve convex, thick; apex not distinct; hinge-line short and straight; teeth faintly developed. On the interior are numerous ridges extending in slight curves toward the lateral margins; in the median line is a smooth space bearing a central vertical ridge.

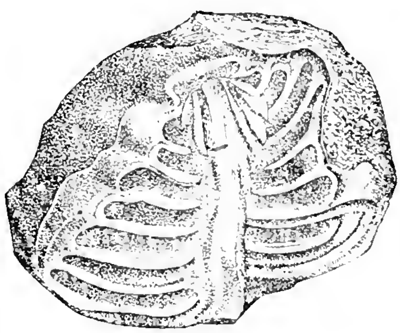


FIG. 243.

FIG. 244.

Lyttonia nobilis, Waagen

Fig. 243. Cardinal part of a pedicle-valve; showing the hinge-line, median and lateral septa
Fig. 244. A portion of the interior of a brachial valve. (WAAGEN.)

Brachial valve operculiform, not extending to the margins of the opposite valve. Cardinal process small and bilobed; median surface of the interior with divergent grooves corresponding with the ridges of the other valve.

External surface covered with flexuous lines of growth.

Shell-substance punctate in the inner layers.

Type, *Lyttonia nobilis*, Waagen. Carboniferous. India and China.

Genus OLDHAMINA, Waagen. 1883.

1863. *Bellerophon*, de Koninck. Quart. Jour. Geol. Soc. London, vol. xix, p. 8.
1880. *Thecidea*, Zugmayer. Unters. über rhät. Brachiopoden; Beitr. zur Paläont. Oesterreich-Ungarn, I, p. 22.
1883. *Oldhamina*, Waagen. Productus-limestone Fossils; Brachiopoda, pp. 403–409, pl. xxxi, figs. 1–9.

Shells highly concavo-convex.

Pedicle-valve subhemispherical; apex incurved, at maturity covered by a callosity, as in Bellerophon; attached by cementation in early growth. Hinge-line short and straight, not interrupted in the middle; below it lie well-developed teeth. Interior surface of the valve covered with diverging lateral ridges.

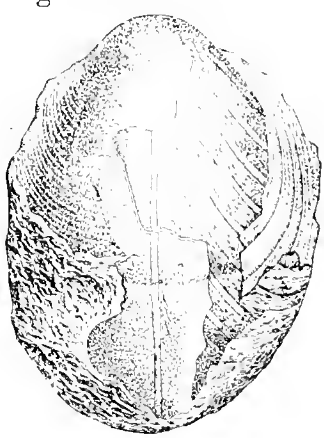


Fig. 245.

Fig. 246.

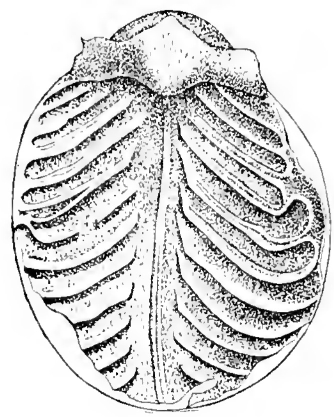


Fig. 247.

Oldhamina decipiens, de Koninck.

Fig 245. The exterior of a pedicle-valve with the shell partly exfoliated.
Fig. 246. Posterior view of the brachial valve; showing elevation and lobation of the cardinal process.
Fig. 247. The interior of a pedicle-valve; showing the median and lateral ridges. (Waagen.)

Brachial valve concave. Cardinal process inconspicuous, quadripartite at the summit; continuous with a median ridge extending the entire length of the valve. Internal surface covered with divergent grooves corresponding to the ridges of the opposite valve.

Exterior smooth or with numerous concentric lines of growth.

Type, *Oldhamina decipiens*, de Koninck. Carboniferous. India and China.

Dr. Waagen has described the structure of these genera at great length, and from his investigations infers that the shells are not distantly related to

THECIDEA and PTEROPHLOIOS. If this be true, they constitute the only satisfactorily known representatives of the family *THECIDEIDÆ* in palæozoic faunas.

KAYSER described, under the name *Leptodus Richthofeni*, a species of LYTTONIA from among the fossils collected by RICHTHOFEN in China; otherwise these genera are unknown outside of India.

GENUS RICHTHOFENIA, KAYSER. 1881.

1863. *Anomia*, DE KONINCK. Quarterly Journal Geol. Soc. London, vol. xix, p. 6, pl. iv, figs. 7-9.
1863. *Anomia*, DE KONINCK. Foss. Paléoz. de l'Inde, p. 18, pl. iii, figs. 7-9.
1881. *Richthofenia*, KAYSER. Zeitschr. der deutsch. geolog. Gesellsch., vol. xxxiii, p. 351.
1882. *Anomia* (*Richthofenia*), WAAGEN. Neues Jahrb. für Mineral., vol. i, p. 115.
1883. *Richthofenia*, WAAGEN. Records Geol. Survey of India, vol. xvi, pt. i, p. 12, pls. i, ii.
1883. *Richthofenia*, KAYSER. Richthofen's China, vol. iv, p. 195, pl. xxiv, figs. 6-8.
1885. *Richthofenia*, WAAGEN. Productus-limestone Fossils; Brachiopoda, pp. 733-743, pl. lxxxii, fig. 1; pl. lxxxii A, figs. 1-4; pl. lxxxiii, figs. 1-19.

These peculiar fossils, which bear a striking external resemblance to certain operculated corals, and present some suggestive similarities to the lamellibranchs

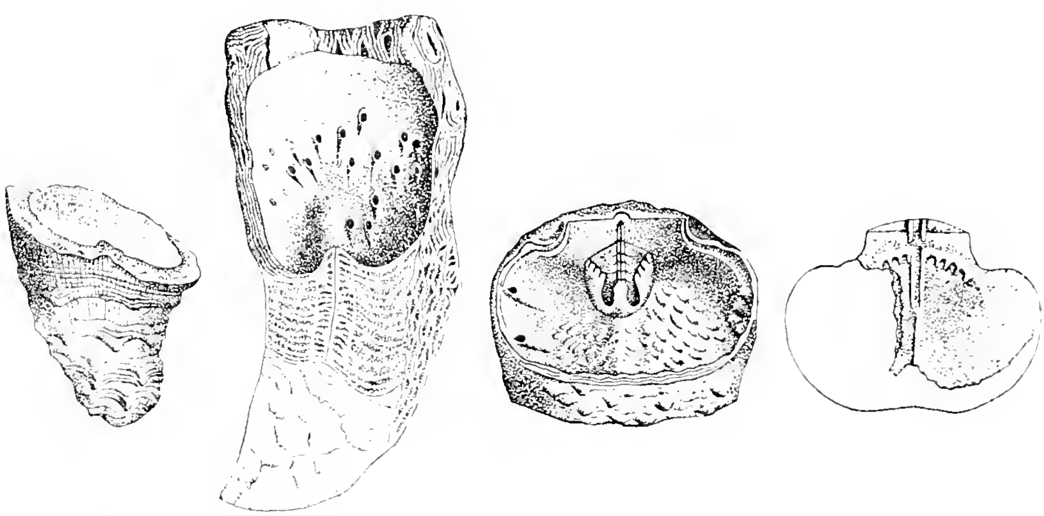


FIG. 248. FIG. 249. FIG. 250. FIG. 251.

Richthofenia Lawrenciana, de Koninck.

Fig. 248. The exterior of the two valves in articulation
Fig. 249. Longitudinal section of the pedicle-valve; showing the interior cavity and the cellular shell substance.
Fig. 250. The interior of the pedicle valve; showing the hinge-line and muscular scars.
Fig. 251. The interior of the brachial valve. (WAAGEN.)

Hippurites and Radiolites, have been carefully elaborated by Waagen, who arrives at the conclusion that they are of brachiopodous nature, the normal brachiopod characters being somewhat obscured by their mode of growth. From the accompanying figures, taken from Waagen's illustration of the genus, it appears that the valves when well preserved show a distinct hinge-line, faint articulating processes and muscular impressions, all more similar to the corresponding structures in the brachiopods, than to anything occurring among the corals or Rudista. If this evidence of the brachiopodous nature of these fossils prove convincing, the remarkable development of the cellular testaceous tissue of the pedicle-valve which produces the striking external resemblance to a coral, is certainly a no more extreme deviation from the brachiopod-type than are such bodies as Hippurites, Caprotina, Radiolites, etc., from the type of lamellibranchiate structure. The shells were evidently attached by solid fixation at the apex of the pedicle-valve, and this attachment strengthened by the epithecal rootlets extending downward from the walls of the valve, similar to those in Omphyma and other corals.

In regard to the taxonomic position of Richthofenia, Waagen says:

"To sum up all that has been said on the affinities of Richthofenia, we have found that these shells most probably belong to the *Brachiopoda*, but that they constitute so strong a group within this class, that though they may be assignable to the Arthropomata, yet they can not be placed immediately in the vicinity of any known group. They show on the one hand external affinities to the corals, and on the other structural affinities to the *Pelecypoda*. This conflicting evidence alone will justify my considering them at least as a proper sub-order, for which I introduce the name of '*Coralliopsida*.'"

Two species of this genus have been described, the *Anomia Lawrenciana*, de Koninck, and *R. Sinensis*, Waagen. Both of them probably occur in the Carboniferous beds of the Salt-Range of India, but the latter is the form upon which the genus was founded by Kayser, and was obtained from the upper Carboniferous rocks of Lo-Ping, China.

SUPPLEMENTARY NOTE ON VITULINA.

(See pp. 138–141.)

Since the printing of the pages of this Volume, embracing the spire-bearing brachiopods, attention has been directed by Professor H. S. WILLIAMS to the fact that the presence of calcified brachial supports in VITULINA was noted by him in his address before Section E of the American Association for the Advancement of Science, in 1892. (See American Geologist, volume x, No. 3, page 165. 1892.) The language used in this place is as follows:

"The most striking evidence of the affinity of these several faunas was derived from the study of three rather abundant genera of brachiopods; *Leptocœlia*, *Vitulina* and *Tropidoleptus*, genera which I would describe as old-type genera for this Devonian period, *i. e.*, preserving the form and general characteristics of the lower Silurian *Orthidæ* and *Strophomenidæ*, but assuming the later character of calcified brachial supports of the *Terebratulas* and *Spiriferidæ*. This is the case for at least the first two genera, and *Tropidoleptus* possesses the punctate structure characteristic of the Terebratulas."

If it was the author's intention to intimate, in these sentences, that VITULINA is possessed of calcified *spirals*, his meaning has been most successfully veiled, and the reader might quite as fairly infer that the genus was regarded as bearing a loop. Professor WILLIAMS has, however, kindly communicated some further details of this structure accompanied by a figure, *drawn from memory*, showing a multispiral cone directed toward the cardinal angle, and an elongate loop showing "what appeared evidence of a saddle and accessory lamella as in *Athyris*." The cones are actually paucispiral and directed toward the lateral slopes of the pedicle-valve, but as to the structure of the loop our specimen has furnished no satisfactory evidence. The presence of a highly developed saddle and accessory lamellæ would be surprising if true, and indeed quite incongruous with our present knowledge of related genera.

December, 1893.

SUMMARY.

THE EVOLUTION OF THE GENERA OF THE PALÆOZOIC BRACHIOPODA.

At the conclusion of the discussions upon the Inarticulate palæozoic genera, some inferences were drawn as to the phylogeny and derivation of the more conspicuous types of inarticulate structure (Part I, pp. 161–170). At that time it had become evident that the variation in the form, position and mode of enclosure of the pedicle-passage affords a more satisfactory index of lines of progress and development, and gives a more lucid and reliable conception of the rise and decline of brachiopod genera, than the modifications in any other single character or association of characters.

Previous writers have usually ascribed a high value to the disposition of the muscular scars upon the inner surface of the valves, the form of the genito-vascular sinuses, the configuration and degree of calcification of the brachia. The last of these must still be regarded as having a significance inferior in importance only to the mode of enclosure of the pedicle; but to the other features mentioned our present knowledge accords a less value in classification. By this is meant that the muscular system, the disposition and interrelations of the separate muscular bands, adheres closely to a standard type of expression throughout the Class.

This is especially true of the Articulate genera, where, from beginning to end, no radical modification of the type, in this respect, is effected. It is less true, perhaps, in the more highly specialized and more complicated muscular structures of the inarticulates, a group in which our knowledge of the fossil representatives is not altogether satisfactory on account of the tenuity and ready destructibility of the shells. It is quite natural to find in such a highly organized group the possibility of variation more frequently manifested.

The opinion expressed in the "Conclusion" to the Brachiopoda Inarticulata, that the "feature of paramount importance" in dealing with the evolution of the palæozoic brachiopodous genera "will be found in the character of the pedicle-passage" (p. 161),* its conformation and accessories, has been substantiated by all the later investigations of this work,† and is still maintained as the true basis of classification.

It is not the present purpose to recapitulate at any length the substance of the deductions already set forth in regard to the Inarticulate genera. The views expressed have not been materially modified; but during the interval since their publication an extraordinary interest has been manifested in the study of the Brachiopoda both recent and fossil, especially in France, Austria and America, and the additions thereby made to our knowledge invite special attention.

Lingula has been shown to be a comprehensive type, not existent in primordial faunas. As yet it is impossible to indicate any difference of generic importance between the Lingula of the Lower Silurian and that of existing seas. Its elongate form is not primitive, and its complicated muscular system is indicative of an advanced stage of progress. We may therefore look for the precursors of this type of structure among the less elongate (Lingulella) and more orbicular genera (Obolus, Obolella). In the diagrammatic scheme of the derivation of Lingula, given upon page 164 of Part I, Lingulella and Obolella are represented as divergent from some unknown earlier inceptive stock, whose existence, represented by a mark of interrogation, was deemed probable from the comparative study of these genera. Such an inceptive form would presumptively be wholly elementary in its contour, outline and structure of pedicle-opening, and, in fact, be little more than an amplification of the infantile condition in its descendants. It has since been observed by Beecher

* It is proper to explain in this place, that though the title-page to Volume VIII, Part I, bears the date of 1892, the pages relating to the Inarticulata, including the concluding chapter referred to, had been completed and printed in July, 1890. Certain of these (pp. 120–160), relating to the structure and development of the pedicle-passage in Orbiculoidea, Schizocrania, Trematis, etc., were reset and issued separately at that date, with lithographic plates (IV E and IV F), and this printed excerpt was distributed among students of the brachiopoda as well as to the general scientific public.

† The subordinal classification of the Brachiopoda introduced by Waagen (1883–1885) was based to some extent upon the conformation of the pedicle-passage. The phyletic value of variations in this structure was first clearly indicated by Eugène Deslongchamps, and has been subsequently elaborated by several writers.

that the embryonic shell or protoconch (*protegulum*) of the brachiopod is "semi-circular or semi-elliptical in outline, with a straight or arcuate hinge-line, and no hinge-area. A slight posterior gaping is produced by the pedicle-valve being usually more convex than the brachial."* It appears, furthermore, to be composed of corneous, impunctate shell-tissue. The same investigator finds that the species described by BILLINGS as *Obolus Labradoricus*, from a horizon at L'Anse au Loup, now regarded as Lower Cambrian, and subsequently identified by WALCOTT, at the same horizon at Swanton, Vermont,† is the nearest approach of the adult brachiopod to the simple type of the protoconch: a semicircular corneous shell, with gaping cardinal margins. This shell has been distinguished by the generic term PATERINA.

There are, undoubtedly, other brachiopodous shells of obolelloid type that are quite as ancient as PATERINA; still the latter exemplifies the line along which the development of more complicated forms has proceeded, and it is in all respects the simplest known brachiopod. PATERINA is an embodiment of the predicted ancestor of the linguloids and obolelloids, and, with our present knowledge, it appears to be the radicle of all the brachiopoda, both inarticulate and articulate.

The departure from LINGULA, through LINGULOPS and LINGULASMA to TRIMERELLA, by the progressive development of the vaulted muscular platform (see Part I, pp. 46, 165, plates i, ii, iv*a*) is confirmed by evidence which is unusually complete and conclusive. Various intermediate stages have also been indicated by which a similar resultant is attained from the primitive obolelloids through LAKHMINA,

* BEECHER: Development of the Brachiopoda, Part I. Introduction; American Journal of Science, vol. xli, p. 344. 1891.

† In a later work Mr. WALCOTT has concluded that the Swanton fossil is sufficiently distinct from the typical *Obolus* (or *Kutorgina*) *Labradoricus* to require a new designation, and has therefore termed it *Kutorgina Labradorica*, var. *Swantonensis* (See "Fauna of the Lower Cambrian;" Tenth Ann. Rept. Director U. S. Geological Survey, pl. lxiv, figs 2, 3, dated 1890, issued 1892). The figures given in the work cited show that the var. *Swantonensis* is in many respects the more primitive type, its valves being the more nearly equiconvex, its surface characters simple concentric striæ, while in the typical *O. Labradoricus*, there is a conspicuous elevation of the umbo of the pedicle-valve, a low median sinus on the brachial valve, as well as indications of radial plications about the beak; all these are secondary characters which indicate progress toward the true KUTORGINA (*K cingulata*). It seems evident that the generic term PATERINA was based upon the Swanton fossil, and hence, if the author's intentions are correctly interpreted, the type of the genus is *Paterina Swantonensis*, Walcott As to the value to be ascribed to differences of shell-composition within a given association of closely related genera, see remarks under the discussion of LINGULA and TRIMERELLA, and in the following pages.

ELKANIA and DINOBOLUS (p. 28, plates iii, iv *b*). The chronogeny of the various elements is in full accord with the structural progress along both lines of derivation; a single genus in this series, LINGULOPS, enduring in an unmodified condition from faunas (Hudson River) antedating the appearance of TRIMERELLA, to those in which TRIMERELLA abounds (Niagara and Guelph dolomites).

The entire group of linguloid and oboloid genera is bound together, as already shown, by the possession of an unenclosed marginal pedicle. They compose the MESOCAULIA or LINGULACEA of WAAGEN (1883) (ATREMATA of BEECHER, 1891).*

The leading element in this group, LINGULA, attained a static condition in early Silurian faunas; the oscillations of the type were mainly confined to the preceding faunas; those of later date are but slight departures in a few directions only. The combination termed LINGULA having once become fixed, maintained itself with unexampled adjustment to changing conditions, even into the existing seas. GLOSSINA, DIGNOMIA, BARROISELLA and TOMASINA, which represent early deviations along the line of its descent, embody no substantial variations, though the two last named (pp. 62, 65, plate ii) demonstrate the gradual assumption of articulating processes, a tendency which not infrequently makes itself apparent in this group where the pedicle-passage is wholly marginal. It is seen in SPONDYLOBOLUS, and is sometimes faintly manifested in OBOLUS and OBOLELLA; in TRIMERELLA there is occasionally a low cardinal process as shown by DAVIDSON and KING, and Gotland specimens of *T. Lindstræmi* bear long submarginal slotted ridges on the cardinal edges (LINDSTRÖM). This mode of articulation, though not frequently seen in American specimens of TRIMERELLA, is so much like that of EICHWALDIA, and the general form of the shells of the two genera is so similar, that there is

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* To ensure greater freedom of treatment and relief from the embarrassments of an inelastic classification, the discussions in these volumes have intentionally been left free of terms designating taxonomic values higher than genera. By provisionally declining allegiance to any prescribed formulas in classification, not only has the manner of treatment of the comprehensive material studied been more natural, but the student will find himself less encumbered with artificial restrictions and freer from collisions with rock-ribbed party-walls, which, to use an old Scotch phrase, "are nane o' God's makin'." It had, nevertheless, been the intention to summarize, in a tabulated form, at the close of this work, the broader relations of the genera discussed, not with any intention of introducing a series of new taxonomic terms, but to express succinctly these interrelations as they appear upon a review of the whole field of research. Such a table will be found at the close of this chapter.

a good excuse for associating them closely, as has been done by ŒHLERT, who places the latter genus among the Inarticulates EICHWALDIA presents a peculiar modification of the pedicle-passage, and all its essential characters, acquired at an early Silurian age, were maintained to the close of the Upper Silurian without substantial variation. The origin of EICHWALDIA is, at present, but a matter of conjecture; such resemblance as it bears to TRIMERELLA, in its incipient articulating apparatus, seems to be only an instance of isomorphy.

The second main division of the Inarticulate genera is composed of those in which the pedicle-aperture, in the immature stages or in primitive adult conditions, takes the form of a marginal incision of the pedicle-valve, but becomes enclosed in the shell-substance in later stages of growth. To this group WAAGEN applied the term DIACAULIA* (or DISCINACEA, 1883), which, like MESOCAULIA, is an admirable expression of the significance of the pedicle-passage. The name NEOTREMATA was subsequently introduced by BEECHER (1891) as an ordinal term for not only such forms as these, but also for those like CRANIA, of whose fixation by means of a pedicle there is yet no evidence.

The mode of development and enclosure of the marginal incision in the genus ORBICULOIDEA has already been demonstrated,† and it has been shown that ŒHLERTELLA, TREMATIS and SCHIZOCRANIA, which have an unenclosed aperture at maturity, are primitive conditions through which ORBICULOIDEA passes in the development of the individual. These primitive adult conditions occur in various faunas from the primordial (DISCINOLEPIS) to the Lower Carboniferous (ŒHLERTELLA), and while these genera might be conveniently associated on the basis of this feature, it is doubtful whether such grouping would be a natural one, or a proper expression of the relations of these forms to the various contemporary mature types.

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* This name was originally printed DAIKAULIA, probably a typographical error in the spelling of the first syllables.

WAAGEN, following usage in the employment of the terms LYOPOMATA and ARTHROPOMATA as ordinal designations, subordinate only to the name of the Class, Brachiopoda, introduced MESOCAULIA and DIACAULIA as names of *suborders*. It is a purely arbitrary matter whether the former terms be regarded as designations of orders or subclasses. They are, in either case, inferior in the first degree to the Class itself. Hence the fact that WAAGEN employed the latter terms as suborders is no ground for rejecting either of them for a later name having the same significance.

† Volume VIII, Part I, *loc. cit.*

In ACROTRETA, CONOTRETA, LINNARSSONIA, ACROTHELE and IPHIDEA the pedicle-aperture is persistently located at the apex of the pedicle-valve. This group of genera is one of very early date, for the most part contemporaneous with PATERINA, and the existing evidence would indicate that it was not directly ancestral to the line of TREMATIS–ORBICULOIDEA (*DISCINIDÆ*). The incipient formation of an internal foraminal tube is seen in several of these genera (ACROTRETA, ACROTHELE, LINNARSSONIA), and this feature attains its maximum in the true SIPHONOTRETA of the Lower Silurian, where the foramen is still apical and the tube wholly internal. Hence SIPHONOTRETA appears to be a normal termination of this line of descent. SCHIZAMBON, in the comprehensive meaning of the term ascribed to it in this work, has the pedicle-passage superficial, and in such shells as *Schizambon fissus*, Kutorga, and var. *Canadensis*, Ami, the condition of this passage is perfectly analogons to that of SIPHONOTRETA, the entire difference being in the enclosure of the latter. In SCHIZAMBON the fibers of the pedicle, extending through the foramen near the middle of the pedicle-valve, were directed toward the apex of that valve, and along the concave floor of the external pedicle-groove. The inner aperture of the pedicle-tube in SIPHONOTRETA, corresponds to the "foramen" of SCHIZAMBON, and the outer aperture, or true foramen of the former to the grooved umbo of the pedicle-valve in the latter. Hence in SCHIZAMBON, thus considered, there is no evidence of a progress of the external aperture, or true foramen, anteriorly beyond the apex of the pedicle-valve. These two genera are but slight departures from the same type of structure, but it would appear that this deviation took place during primordial times, as the typical SCHIZAMBON (*S. typicalis*, Walcott) is a primordial fossil. The newly described genus, TREMATOBOLUS, Matthew* (*T. insignis*, Matthew, type), appears to be another primordial representative of this structure, with the tubular enclosure of the pedicle more highly developed. Thus all these genera, from ACROTHELE to SCHIZAMBON and SIPHONOTRETA, possess an apical foramen, and the development both of the internal tube and the corresponding external groove has been a gradual one. They represent termini of slightly divergent series; consequently they may all be safely

* Canadian Record of Science, January, 1893, pp. 277–279, figs. 1 *a–d*.

included under the old family designation introduced by KUTORGA in 1848, SIPHONOTRETIDÆ

CRANIA and its allies (CRANIELLA, PSEUDOCRANIA, PHOLIDOPS) constitute a group in which there is, thus far, no satisfactory evidence of the existence of the pedicle, and we are left to the inference that this organ became atrophied at a very early growth-stage. The study of recent Cranias has not yet determined this point, but this will probably be ultimately accomplished. At whatever stage of growth the pedicle was lost, we may infer that its disappearance, in CRANIA, and generally in CRANIELLA, was directly followed by a solid fixation of the animal by the substance of one of the valves. In PHOLIDOPS there was no such cementation, but at a correspondingly early stage the shell became wholly independent. All these shells with central or subcentral beaks have an external resemblance to ORBICULOIDEA; the formation of the secondary growth of the valves behind the apices or position of the protoconch, is a further substantial agreement with the DIACAULIA as contrasted with the abbreviated posterior peripheral shell-growth in the MESOCAULIA (LINGULA, OBOLUS). It is nevertheless to be observed that no trace of a former pedicle-slit, incision or perforation, is found on mature or immature shells, and it would be difficult to comprehend in what manner such an essential modification of the shell could be wholly concealed by later growth.* Were the pedicle marginal in primitive growth-stages, and subsequently atrophied, the obliteration of the marginal opening by later resorption and growth would be a readily intelligible process. There is, hence, in this default of evidence, a good reason to doubt the close affinities of CRANIA and PHOLIDOPS to the DIACAULIA. Present knowledge would seem to indicate that they were primarily of the type of the MESOCAULIA, and that their resemblance to the DIACAULIA is wholly of secondary growth.†

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* Quite early conditions of *Crania siluriana* and *Craniella Hamiltoniæ*, from 1.5 to .5 mm in diameter, are fully cemented. Examples of *Pholidops Hamiltoniæ*, not above .5 mm in diameter, give no indication of a pedicle-passage or surface characters not present in the adult.

† Some species of PHOLIDOPS (*P. arenaria*, *P. linguloides*) have a terminal submarginal apex; and their resemblance exteriorly to the oboloids is very striking. This is, however, no more than a resemblance, as they show, on the under side, the same mode of peripheral growth beneath the beak as the other forms of the genus in which the umbones are more nearly central.

WAAGEN'S term for this group, GASTROPEGMATA (or CRANIACEA) may therefore prove to be equivalent to each of these other two divisions.

The great gulf which has seemed to exist between the Inarticulate or Lyopomatous, and the Articulate or Arthropomatous divisions of the Class Brachiopoda; those without teeth and those with teeth; those with a largely corneous shell, and those whose shell is essentially calcareous, is not yet fully spanned at many points.

These divisions were based upon the study of living brachiopods in which all the characteristic differences are pronounced and fixed. We naturally expect to find, however, among the early brachiopods, in which the adjustment of the organism to its conditions was highly sensitive, that the oscillation and specialization of characters has been very rapid. The development of articulating processes has already been noticed among the linguloids, in BARROISELLA, TOMASINA and TRIMERELLA, among the oboloids in SPONDYLOBOLUS, and among the siphonotretoids in TREMATOBOLUS. It is known that the shell of many inarticulates is almost wholly calcareous, as in the *TRIMERELLIDÆ* and all of the so-termed GASTROPEGMATA. The alteration in the nature of the shell-substance from protoconch, or its exemplar, PATERINA, which appears to be wholly or essentially corneous, to the typical articulate brachiopod, in which the corneous substance is reduced to a thin epidermal film, is a gradual process whose various stages are well understood. In OBOLELLA, ELKANIA, and the early forms of LINGULA, the deposition of calcareous salts in the shell was already advanced, these layers alternating with thinner layers of corneous substance. The gradual and eventual predominance of the calcareous shell-matter along both of these lines of development is seen in the ponderous Trimerellids of the later Silurian. The graduation of the corneous PATERINA (*Kutorgina Labradorica*, var. *Swantonensis*) through *Kutorgina Labradorica*, and into the true calcareous Kutorginas (*K. cingulata*, *K. Whitfieldi*), is similar evidence. In *Kutorgina Latourensis*, MATTHEW described a minute tooth on either side of the pedicle-opening,* and it has been stated that *K. cingulata* shows faint traces of articulating processes at

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* Illustrations of the Fauna of the St. John Group, No. 3, p. 42. 1885.

or near the extremities of the cardinal line.* Such cases indicate, in the texture and composition of the shell, a direct passage from the most primitive inarticulate to the articulate type. In this feature only, the connection between the two divisions of the class is no closer or more clearly manifested than in the instances mentioned, but it has been shown† that *Kutorgina cingulata* may retain a pedicle-covering or external sheath, in fact a true deltidium bearing an apical perforation, like that in CLITAMBONITES. A deltidium-like structure is highly developed or fully retained at maturity in IPHIDEA. This is evidence of the highest moment, and shows conclusively the line along which the clitambonitoids and strophomenoids have been derived. It is an immediate departure from the primitive type of the brachiopod into the articulate subtype.

Passage from the inarticulate to the articulate plan of structure was thus effected at a very early period; indeed, almost at the outset of the history of the group. The continuance of the two types has since been that of diverging series, constantly widening the structural gap between them. We have no evidence that this chasm has been bridged at any other point than near its source; the inclinations from the one type toward the other, shown in the articulating processes of BARROISELLA, TOMASINA, etc., represent uncompleted accessory lines of development, which were abruptly terminated without accomplishing the full transition. Such forms have left no descendants, so far as known.

Before entering upon a summary of the phyletic relations of the genera of the Articulata, it is important to apprehend the full significance of the modifications here appearing in the structure of the pedicle-passage and the surfaces upon which the muscular bands are implanted; in other words, the origin and development of the deltidium, the deltidial plates, and the spoon-shaped muscular platform, or spondylium, which may occur in either or both valves, and may be supported or not supported by a median septum.

The *deltidium* and *deltidial plates*, though similar in function, are profoundly distinct, both in origin and structure. The former is primitive and funda-

* BEECHER, American Journal of Science, vol. xliv, p. 138. 1892.

† BEECHER, *loc. cit.*

mental, the latter is wholly secondary; a replacement of, but never a derivative from the former. In the foregoing discussions of the genera these parts have been distinguished simply by the designations generally current; the term deltidium referring exclusively to the convex external portion of the pedicle-sheath, such as occurs in CLITAMBONITES, STROPHOMENA, RAFINESQUINA, and their allies, and which, under no condition, shows evidence of composition or consolidation of separate parts. The term *deltidial plates* has been applied to that condition of the external sheath in which a division into component parts is evident, as in ATHYRIS, ATRYPA, MERISTA, the terebratuloids, etc.; or inferential, as in CYRTIA and CYRTINA. The terminology is here so imperfect as easily to cause confusion, and though it had not seemed needful heretofore to suggest an improvement, it has become necessary, for the proper consideration of the subject, to employ a more distinctive expression for these fundamentally different structures. The secondary structures known as *the deltidial plates*, whether already discrete as in the terebratuloids, rhynchonelloids and meristoids, or solidly coalesced, as in NUCLEOSPIRA, PARAZYGA, CYRTIA and CYRTINA, will henceforward be termed the *deltarium*, in application to the parts as a whole, or the *deltaria* in referring to the component plates. It may also prove convenient to adopt the term introduced by BRONN, *pseudodeltidium*, for the coalesced condition of the deltaria in SPIRIFER, CYRTIA, etc., as this is its original meaning; but the significance of the term will be subordinate to that of *deltarium*.

The researches by KOWALEVSKI,* upon the development and detailed anatomy of THECIDEA (LACAZELLA) and CISTELLA (= ARGIOPE, KOW.), have recently been interpreted in the bearing upon these structures by BEECHER, who has also added new data derived from the study of *Magellania flavescens* and *Terebratulina septentrionalis*. *Thecidea*, or *Lacazella Mediterranea*, is the latest and only existing brachiopod which retains a true deltidium at maturity. During the cephalula-stage of the embryo, before the inversion of the mantle lobes to enclose the head, two shell-plates begin to form, one on the inner side of the dorsal mantle lobe, the other directly opposite to it on the outer surface of that portion of the

*Observations on the Development of the Brachiopoda; Proceedings of the Session of the Imperial Society of Amateur Naturalists, etc., held at the University of Moscow, Eleventh year, vol. xiv. 1874.

body which subsequently becomes the pedicle. In this condition of growth the ventral lobe of the mantle is but slightly developed and bears no shell-plates.

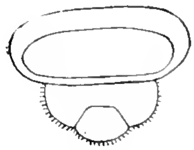

FIG. 252.

FIG. 254.

FIG. 257.

FIG. 253.

FIG. 255.

FIG. 256.

FIG. 258.

Thecidia (Lacazella) Mediterranea.

Fig. 252. Cephalula, dorsal side; showing below, the cephalic segment with eye spots, and on the upper segment the dorsal shell-plate.

Fig. 253. Dorso-ventral longitudinal section of cephalula; below is the cephalic segment, at the right the dorsal mantle lobe, the darker line on its inner margin representing the beginning of the dorsal valve, and the similar line on the adjoining side of the body the incipient deltidium.

Fig. 254. A later growth-stage, in which the mantle lobes have turned downward The body shell-plate is seen in the upper part of the figure.

Fig. 255 Dorso-ventral longitudinal section of the preceding; showing the inversion of both mantle lobes. The relations of the dorsal and body (deltidium) plates are indicated by the heavy lines at the right. The ventral plate is also seen on the lobe at the left.

Figs. 256. Profile of a very young *Leptæna rhomboidalis*, oriented to correspond with the foregoing figures.

Figs. 257, 258. Views of adult *Thecidea Mediterranea* similarly placed.

(BEECHER; figs 252–255, adapted from KOWALEVSKI.)

These features are seen in the accompanying figure of a longitudinal section of such an embryo. In the directly following growth-stage the reversion of the mantle lobes has taken place; the shell-plate before on the inner surface of the dorsal lobe is now on its outer surface, and assumes the normal position of the dorsal or brachial valve. A corresponding plate has developed on the outer surface of the ventral mantle lobe, and between the inner edges of these two plates lies the great pedicle which bears on its dorsal side a third plate, meeting the dorsal, but widely separated from the ventral plate. This third plate is the incipient deltidium. The deltidium is, thus, not a secretion from the mantle, but from the body of the embryo, and it has been shown that the shell-punctations, which are usually present in the valves of the deltidium-bearing species, such as *Leptæna rhomboidalis*, *Chonetes scitula*, etc., do not exist in the deltidium.*

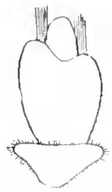

FIG. 259.

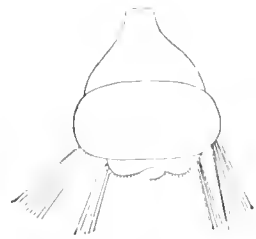

FIG. 261.

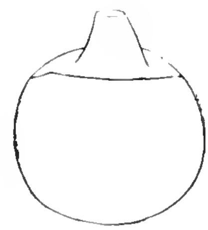

FIG. 263.

FIG. 260.

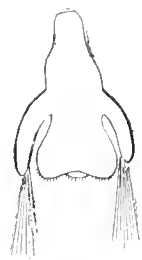

FIG. 262.

FIG. 264.

Cistella Neapolitana.

Fig. 259. The completed cephalula-stage.
Fig. 260. Longitudinal section of same; the shell-secreting surfaces are represented by heavy lines.
Fig. 261. The larva after inversion of the mantle lobes.
Fig. 262. Longitudinal section based on the preceding. The shell-bearing surfaces are now on the outside of the animal, the large pedicle extending upward.
Figs. 263, 264. Dorsal and profile views of a very young shell; showing the large posterior opening between the valves and the thick pedicle.

(BEECHER; adapted from KOWALEVSKI and SHIPLEY.)

In the corresponding stages of growth in CISTELLA and TEREBRATULINA, there is no evidence of this body-plate, no indication in any growth-stage of a deltidium, but the pedicle-passage formed by the ultimate union of the valves at their cardinal extremities remains uncovered until a comparatively late stage. By removing the shell from adult specimens of TEREBRATULINA and MAGELLANIA in which the deltaria have become more or less completely developed, it has been

* In AULOSTEGES the surface of the deltidium is covered with short spinules or tubercles. Such spinules in the productoids imply a punctation of the shell, wherever occurring on the valves, but an examination of the deltidium in this genus indicates that the secondary modification of the surface of the deltidium is not accompanied with a punctate structure.

found that these plates are derived from two secondary expansions of the mantle of the pedicle-valve enveloping the base of the pedicle.* These manifest themselves only in later or post-larval growth-stages, and as they are a product of the mantle lobes, may partake of the same punctate structure as the valves.

Fig. 265.

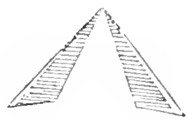

Fig. 266.

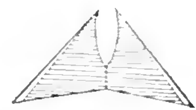

Fig. 267.

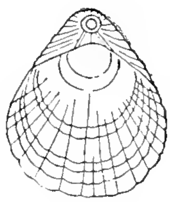

Fig. 268.

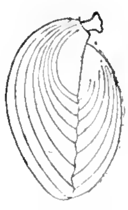

Fig. 269.

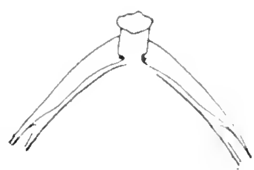

Fig. 270.

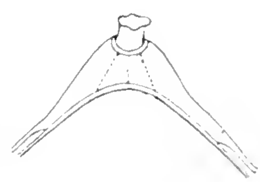

Fig. 271.

Fig. 265. Delthyrium of a young *Rhynchonella*.
Fig. 266. The same, at a later stage, with two triangular deltaria.
Fig. 267. The same, at completed growth of the deltaria.
Figs. 268, 269. Dorsal and profile views of *Magellania flavescens*; showing deltaria and pedicle.
Fig. 270. Dorsal view of the umbonal portion of an adult *Terebratulina septentrionalis*, with the shell removed by acid; showing slight secondary extensions of the ventral mantle at the base of the pedicle, small deltaria only being formed in this species.
Fig. 271. A similar preparation of *Magellania flavescens*; showing the complete envelopment of the base of the pedicle by secondary expansions of the ventral mantle, which have formed the deltaria, as shown in fig. 268. (Beecher.)

These plates may unite along the median line, obliterate the foramen, or even extinguish all trace of their original division, as frequently seen in Spirifer, Cyrtia and Cyrtina (*pseudodeltidium*), thus simulating in every respect the true deltidium; though it is now evident that these and the deltidium are of fundamentally different nature. These structures, then, become, at once, a most important basis of classification among the articulate Brachiopods.

In this work the term *spondylium* has been applied to the spoon-shaped plate which, when present, is usually found in the pedicle-valve only, but among the pentameroids frequently occurs in both valves. It has become evident since the introduction of the term that these processes in the two valves, though

* Beecher, *loc. cit.*

similar in aspect, are similar neither in origin nor function, and it becomes necessary to modify the application of this term. Hence it is proposed to restrict the term *spondylium* to the plate existing in the pedicle-valve, and to the plates of the brachial valve, whether united or discrete, the name *cruralium* will be applied. The distinction of the parts is necessary to a proper apprehension of their value.

The *spondylium* is an area of muscular implantation. In its early or incipient condition it is evident that it originates from the convergence and coalescence of the dental lamellæ, and forms a receptacle for the proximal portion of the pedicle, and for the capsular or pedicle muscles. In CLITAMBONITES and PENTAMERUS, where it attains its greatest development, it bears all the muscles of the valve, the central adductor, and the lateral diductor scars being often clearly defined, while the posterior portion of the plate is still reserved for the attachment of the pedicle, if functional. Considering this structure in its incipient condition, where, as in ORTHIS, it is represented only by the convergent dental plates which usually unite with, or rest upon the bottom of the valve, and enclose only the base of the pedicle and its muscles, it will be evident that the plate is actually but a modification of the original pedicle-sheath. It is, evidently, the inner moiety of this sheath surrounding the pedicle, which has become involved or enclosed by the growth of the pedicle-valve, and further modified by the development of articulating processes where it comes in contact with the brachial valve. It therefore follows, as a natural inference, that wherever the spondylium is present, whether in the incipient condition or in the more advanced stage of development in which it supports all the muscles of the valve, it is, or, at some period of growth, has been accompanied by the *external* portion of the sheath, which is termed the deltidium. Thus the spondylium appears to be but the complement of the deltidium, or the original plate formed upon the body of the embryo, and that portion of the adult shell to which the term deltidium has been applied, is the other part of the original or primitive deltidial plate or pedicle-sheath. Here again our terminology seems at fault and should be further adapted to the proper conception of these structures. Should the term *prodeltidium* be employed for the primitive body plate or the pedicle-sheath in its entirety, we shall then have the terms *spondylium* and *deltidium* applied to corresponding and equivalent modified parts of this plate, the former internal, the latter external.

The adult condition of the shell does not always furnish complete, and sometimes not even suggestive evidence of the relations of the spondylium and deltidium. For example, in the genus ORTHIS and its various subdivisions, the delthyrium is almost always open at maturity and indeed all through the later growth-stages of the shell. The deltidium unquestionably existed at an early stage and has usually become resorbed long before evidences of maturity in other respects are assumed; the spondylium, also, does not pass beyond a condition which makes the pedicle-cavity a clearly defined feature of the interior. In more elementary or less modified orthoid structures like BILLINGSELLA, PROTORTHIS, and the *Orthis deflecta* and *O. loricula* (see Plate V A, figs. 30, 31), the deltidium is fully retained at maturity, while the spondylium remains in its condition of a simple pedicle-cavity. The coexistence of both features with a high degree of development, as in CLITAMBONITES, POLYTŒCHIA, etc. indicates a more primitive condition than in ORTHIS, though in such cases the extension of the spondylium to such a degree as to carry all the muscular bands of the pedicle-valve must be regarded as a secondary modification of this organ. In PENTAMERUS and allied genera, where the spondylium attains its greatest development, the deltidium is usually lost, but when retained is very thin and has a concave exterior, a form doubtless largely due to the arching of the umbo of the pedicle-valve over the full, procumbent beak of the brachial valve. The spondylium occurs in various modified conditions; in cases where the teeth are wholly without dental lamellæ, or where such lamellæ do not extend to the bottom of the valve, it seems necessary to regard them as instances of degeneracy or resorption of the primitive spondylium. As the growth, modification and disappearance of the differential parts of the prodeltidium do not progress *pari passu*, there will frequently be examples of one being retained when the other has disappeared. A remarkable illustration of this fact is afforded by the genus CAMAROPHORIA, which possesses a highly developed spondylium, while the deltidium has been resorbed and secondary deltidial plates or deltaria formed about the pedicle-passage.

In the fundamental division of the Articulata two groups will be recognized, one embracing those forms in which the prodeltidium is represented by the deltidium and spondylium, one or both; the other a group in which the prodeltidium has been fully modified, resorbed or replaced. The former group is equivalent to WAAGEN'S suborder, APHANEROPEGMATA (1883), with the addition of THECIDEA and its allies, and to BEECHER'S PROTREMATA (1891), excepting the genus TROPIDOLEPTUS. So deep-seated does this difference in these groups of genera appear, that examples of such combinations of primary and secondary conditions as shown by CAMAROPHORIA, are of the rarest occurrence.

The spoon-shaped process of the brachial valve, which has been termed the *cruralium*, is a feature of more fugitive value. It is formed by the convergence or union of the crural plates, and it may rest upon the inner surface of the valve, or like the spondylium, be supported by a median septum. More often the crural plates, when highly developed, stand erect upon the valve and do not unite, but their position is highly variable, and it has been shown that in PENTAMERUS, CONCHIDIUM, and their allied forms, the union of these plates is not of first importance as a generic character. When the crural plates extend to the bottom of the valve as distinct septa, they simply enclose an extension of the median incision of the hinge-plate. It has become evident, from a study of the hinge-plate, that the so-called visceral foramen which perforates it, and which is often present in ATHYRIS, RENSSELÆRIA, CRYPTONELLA, etc., is a remnant of this aperture, the remainder of the median opening having become filled by a testaceous secretion. There is every reason to believe that the visceral foramen was actually traversed by the lower alimentary canal, and if this were true, then the deep and narrow median chamber bounded by the crural plates must also have enclosed the terminal portion of the intestine. Within it lie the elongate scars of the adductor muscles, and when the chamber is elevated by the completed formation of a *cruralium*, these scars are still within it, as in the case of the spondylium. It is therefore the morphic equivalent of the spondylium. Its supporting median septum, when present, is composed of two lamellæ, each representing one of the coalesced or adherent crural plates.*

The unsupported convex internal plate or "shoe-lifter" in the pedicle-valve of Merista and Dicamara must be interpreted as an entirely different structure from the spondylium. It is not produced by convergent dental plates, but these, on the contrary, are divergent, the arched plate uniting its inner edges. Its origin and the reason of its existence are still obscure. The readiness with which the filling of the cavity between this plate and the outer wall of the valve separates from the shell, carrying with it the enclosing walls, leads to the suggestion that the "shoe-lifter" may be the innermost lamina of the shell separated from the rest of the valve and leaving it thinner in this region. This plate, upon its convex surface, bears the muscular bands, in whole or in part. In Eichwaldia it has been observed that the small internal plate of the pedicle-valve is probably a modified condition of the deltidium, as the pedicle passes beneath it, while the platform in Aulocorhynchus may prove to be wholly of muscular origin.

The compound "shoe-lifter," divided by the median septum in the brachial valve of Dicamara, is like the corresponding plate n the pedicle-valve in having no connection with, or origin from the articulating apparatus. This plate is not a *cruralium*, and in precisely the same sense that the simple "shoe-lifter" is not a spondylium. Such cases as Merista and Dicamara are, therefore, not to be cited as examples of the concurrence of spondylium and *cruralium*, with the secondary condition of the pedicle-covering or deltarium, but are, rather, illustrations of the production of parts which may be similar in function in the mature condition, but are totally distinct in origin; in other words, interesting instances of morphic equivalents.

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* In the pentameroids the median septum of the pedicle-valve supporting the spondylium, is formed in a similar manner by a continuation and coalescence of the dental plates, and wherever the median supporting septum exists in this group, it will probably be found to have this composition. Median and lateral septa, however, in the valves of the Brachiopoda, have a highly diverse origin in different cases. In most instances, except where bearing spondylia, they are evidently of muscular origin and surfaces of muscular attachment, as shown in Spiriferina (see figure 42, page 53, and remarks in foot-note, Part I, p. 49); while in the *Trimerellidæ* they appear to be the residuum left by the resorption of a thick testaceous deposition about and beneath the area of muscular insertion.

The *cardinal area* is a feature more generally developed among the forms included by WAAGEN under his term APHANEROPEGMATA (=PROTREMATA, Beecher), that is, among forms possessing the deltidium, but it is very irregular in its occurrence among all the articulate Brachiopoda. The genus SPIRIFER furnishes a most striking instance of its persistence in the deltarium-bearing shells; its usual absence in PENTAMERUS and CONCHIDIUM serves to demonstrate that it is not an indispensable character of its group. It is probable that the existence of this area has little fundamental connexion with the condition of the pedicle-passage. It is a very palpable fact that there is a much mo.e intimate relation between it and the general form of the shell; thus in the elongate shells, like the terebratuloids, meristoids, retzioids and the pentameroids for the most part, there is no such area present. Where the form of the shell is more generally transverse, as among the *ORTHIDÆ*, in STROPHOMENA, CLITAMBONITES, DERBYA, SPIRIFER, etc., the area is highly developed. This area is a characteristic feature of all early deltidium-bearing species, and, where it manifests itself occasionally in one of these groups which has for the most part lost, or never developed this area, as in PORAMBONITES, GYPIDULA and PENTAMERELLA among the pentameroids, its appearance may be regarded as the resumption of a primitive or original character which was normal for that division of the Articulates in some period of its history.

Similarly we meet with a cardinal area in an early rhynchonellid type, ORTHORHYNCHULA, and this is an evidence of the first significance as indicating the source from which the extensive group of the Rhynchonellas originated. These are shells which, at a very early period, assumed the deltarium or secondary condition of the pedicle-covering. It would be presumptuous to assume that a single species of this great group developed a cardinal area solely from mechanical causes, such as obstructed growth on the posterior margins of the valves. Its presence seems, rather, to suggest the perpetuation of an ancestral character indicating that these modified shells have been derived from a more primitive condition in which the cardinal area was normal and, no doubt, accompanied by a deltidium. In the absence of further evidence such a character is of much interest and importance.

Under the guidance of the structural features above considered, the main lines of derivation of the Articulate genera are more readily apprehended.

The earliest known representatives of a given group of genera are not always the most primitive in structure. In the instance cited in the preceding paragraph, *Orthorhynchula Linneyi* is perhaps, by itself considered, the closest expression of the fundamental stock from which the rhynchonellids have been derived, but it is by no means the earliest of the group. It is known only in the latest fauna of the Lower Silurian, while in the earlier faunas, PROTORHYNCHA, RHYNCHOTREMA and CAMAROTŒCHIA have attained an abundant development. ORTHORHYNCHULA either represents a resumption of the primitive type, subsequent to such modifications as appear in the earlier rhynchonelloid genera, or a continuance of that type, without modification, through preexisting forms as yet unknown. Such instances could be multiplied, as facts of similar import are constantly recurring, and a careful consideration of the stage of development or decline of each separate and individual organ is requisite to determine how far the organism in question is a direct or modified outcome of the fundamental type; or a degenerate or senile relapse, after modification, to phyletic immaturity.

The most elementary structure, then, observable among the Articulate Brachiopods, is the combination of the deltidium with a distinct pedicle-cavity, whose anterior margins are not free, and whose lateral walls or dental lamellæ are not highly developed; these features being accompanied by gently and unequally biconvex valves, well defined cardinal areas and elongate hinge-line; producing, in effect, a generally orthoid expression both of interior and exterior. This is the condition of BILLINGSELLA of the Cambrian, *Orthis loricula* and *O. deflecta* of the Trenton group, and *O.? laurentina* of the Hudson River fauna, and it is continued without essential modification, except in the gradual contraction of the pedicle-cavity and deltidium, into STROPHOMENA of the Silurian, its allies and successors, ORTHOTHETES of the Devonian, and DERBYA of the Carboniferous, HIPPARIONYX, TRIPLECIA, STREPTORHYNCHUS, etc., into LEPTÆNA, RAFINESQUINA, STROPHEODONTA, PLECTAMBONITES, CHONETES and PRODUCTUS.

The tendency to contract the pedicle-cavity and deltidium presents its extreme manifestation in the Devonian forms of STROPHEODONTA, STROPHONELLA and LEPTOSTROPHIA, where it has become almost, and sometimes quite obliterated, and the entire pedicle and umbonal cavity filled with testaceous secretions. Such filling can occur only in a discarded and useless space, after the pedicle has ceased to be functional. A morphological consideration of much importance presents itself here, as well as in many other groups of genera where the shells attain great size. The evidence is very direct from the study of the structural features as given above, that the entire muscular system on the ventral side of the body, is, in primitive forms, inserted upon the base of the pedicle-cavity. This is apparent from a study of such a shell as *Orthis callactis*, where it is perfectly clear that no muscular bands were attached to the pedicle-valve outside the limits of this strong and condensed posterior area, which is but a sessile spondylium. The contraction of this pedicle-cavity is accompanied by (whether in relation of c use to effect can not be stated) a diffusion of the area of muscular attachment, and when the shells are large, as in STROPHOMENA, RAFINESQUINA, STROPHEODONTA, ORTHOTHETES, DERBYA, etc., the necessity for powerful muscles, or some similar cause, magnifies this expansion of the muscular area until the original contents of the pedicle-cavity may be represented by enormous muscles whose scars extend almost to the anterior margin of the valve, as in HIPPARIONYX and RHIPIDOMELLA.

In this great group of genera there are two types of contour, one, as in LEPTÆNA, being normally convexo-concave, that is, with the pedicle-valve convex and the brachial valve parallel to it and concave; the other, as in STROPHOMENA, having this contour reversed, the pedicle-valve at first convex, but subsequently and through all later growth-stages concave, while the brachial valve becomes correspondingly convex. In both cases, as in other brachiopods, the primitive and post-embryonic valves are both convex. The peculiar reversal of contour, which is never more extremely manifested than in this group, but nevertheless occurs in other genera, such as ATRYPA, many Rhynchonellas, etc., is a purely secondary condition. Its causes have not been fully investigated, but an unequal peripheral growth of the two valves, arising from inequality in the size of the ventral and dorsal mantle lobes, seems to be a partial if not sufficient explanation of its existence. As either the presence or absence of this reversal is a normal secondary condition, it is not possible to give it great weight in a broader grouping of the genera, for we find that STROPHONELLA is but a reversed STROPHEODONTA, passing through similar phases; AMPHISTROPHIA is a reversed BRACHYPRION, both existing in faunas of the same age, and STROPHOMENA is a reversed RAFINESQUINA, both similarly coexistent.

With this presentation of the subject it seems neither necessary nor desirable to propose any broad division of this group of genera. In 1846 KING proposed to embrace STROPHOMENA and its allies, in the family *STROPHOMENIDÆ*. The large number of generic values allied to STROPHOMENA, which have been determined since that date, make this comprehensive family divisible *ad libitum, sed non in majorem Dei gloriam.*

The calcareous fixation of the pedicle-valve to extraneous bodies after the closure of the pedicle-passage and atrophy of the pedicle itself, is repeatedly manifested by these shells. This, as already shown, is a pre-adult condition in ORTHOTHETES, DERBYA and STREPTORHYNCHUS, the shell becoming wholly free before full growth was attained; but in LEPTÆNISCA and DAVIDSONIA the attachment was maintained throughout the later existence of the shell.

The impressions left by the spiral arms upon the interior of the valves in DAVIDSONIA and LEPTÆNISCA, and also observed by DAVIDSON in specimens of *Rafinesquina Jukesi* and *Leptæna rhomboidalis*, show a complete correspondence in the direction and curvature of the coils, and we are left to infer that other members of the *STROPHOMENIDÆ* were in agreement with this structure, and, hence, that the arms in their uncalcified condition approached nearer the calcified spirals of *KONINCKINIDÆ* (CŒLOSPIRA, KONINCKINIA, etc.) than to any other group.

The condition of the pedicle-passage possessed by these shells is maintained by CHONETES and PRODUCTUS, without great modification in other respects. CHONETES possesses a marginal row of strong cardinal spines or tubes communicating with the internal cavity of the valves. Yet we are acquainted with forms (*e. g.*, *Anoplia nucleata*) in which these spine-tubes do not manifest themselves externally. PRODUCTUS is normally covered with spines on one or both valves, but there are some species which possess none. The cardinal area, deltidium and teeth, which are retained in CHONETES, PRODUCTELLA, STROPHALOSIA and AULOSTEGES, become wholly obliterated in the direct line of productoid development. In all these forms the "reniform impressions" retained on the inner surface of the brachial valve, are evidence of fleshy brachia possessing a similar curvature to those of the *STROPHOMENIDÆ*

This group of genera has long been designated by the family name *PRODUCTIDÆ* introduced by GRAY in 1840, though, in correlating the various divisions of WAAGEN's proposed group, APHANEROPEGMATA, there would be excellent reason for considering the chonetids and productids components of a subfamily inferior in value to the *STROPHOMENIDÆ* and equivalent to the divisions *Orthothetinæ*, Waagen, 1884, and *Rafinesquininæ*, Schuchert (*emendatus*), 1893.*

Returning to the point of departure, we shall find that in the genus ORTHIS, which in its broadest significance is tantamount to the family *ORTHIDÆ*, Woodward, 1852, since the elimination of several heterogenous branches, the deltidium was resorbed at an early stage of growth, leaving the delthyrium a wide, uncovered aperture during all the later stages of existence. The pedicle in this group of shells was undoubtedly large and vigorously functional throughout all mature conditions, as it is of very rare occurrence that any secretions of calcareous matter are found in the apex of the delthyrium, such as are frequently observed in mature and senile conditions of SPIRIFER. The sharp delimitation of the pedicle-cavity containing all the muscular scars of the pedicle-valve, which occurs in the earlier forms (those of ORTHIS in its restricted meaning, such as *O. callactis*, *O. costalis*, etc.) is maintained in all the numerous subdivisions of the genus, with the exception of RHIPIDOMELLA in which there is a great expansion of the muscular scars, similar to that in the *STROPHOMENIDÆ* and to which reference has just been made. Otherwise the sessile condition of the spondylium is not modified throughout the entire history of this group.

The elevation of the spondylioid plate, or the base of the pedicle-cavity, into a true spondylium, is a phenomenon of equally early age to the two conditions

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* American Geologist, vol. xi, p. 153.

already discussed. It appears in a highly developed state in conjunction with the unmodified deltidium, first in PROTORTHIS, of the Cambrian, then in POLYTŒCHIA, SYNTROPHIA, CLITAMBONITES and SCENIDIUM, of the early and later Silurian and of the Devonian.

A parallel line of development is exhibited by spondylium-bearing forms in which the deltidium disappeared at a very early period, and the shells possess a trihedral, generally coarsely plicated and decidedly rhynchonelloid exterior. It seems highly probable that this line was differentiated in the early Cambrian, as indications of this structure are observable in some primordial species, as *Camarella ? minor*, Walcott, and *Stricklandinia ? Balcletchensis*, Davidson; in the Silurian it is represented by CAMARELLA and PARASTROPHIA; also by the more rotund and more finely plicate shells, ANASTROPHIA, PORAMBONITES, LYCOPHORIA and NOETLINGIA. The last-named genera are not homogeneous with the others in the phases of development which they represent, all of them retaining the cardinal areas more or less distinctly, while LYCOPHORIA and NOETLINGIA also possess a cardinal process in the brachial valve. The presence of the cardinal area in such early structures must be regarded as a retention, rather than a resumption of a primitive character.

Whatever may be the oscillation in form and the variation in secondary characters presented by CAMARELLA, PARASTROPHIA and their allies, present evidence indicates that they must be regarded as the genetic precursors, as they are the secular precedents of the great group of true pentameroids (PENTAMERUS, CAPELLINIA, CONCHIDIUM, BARRANDELLA, SIEBERELLA, PENTAMERELLA, GYPIDULA, STRICKLANDINIA, AMPHIGENIA); and, indeed, the last of these pentameroids, CAMAROPHORIA, of the Carboniferous and Permian faunas, is an exemplification of, and in fact a return to the rhynchonelloid exterior and the camarellid aspect, with the addition of deltaria in the delthyrium.

While considering in detail the pentameroid genera mentioned above, it has been shown that in certain of them, as PENTAMERUS and CONCHIDIUM, a true deltidium is often retained, though it is a fragile structure rendered concave by the arched growth of the umbones of the valves, and is generally absent. In others, as GYPIDULA and PENTAMERELLA, there are occasionally evidences of lateral, erect or convex growths upon the margins of the delthyrium, which may be interpreted either as remnants of a resorbed convex deltidium, or as highly accelerated secondary deltaria. Every now and then specimens will show a clearly developed cardinal area; always in STRICKLANDINIA, frequently and normally in GYPIDULA, rarely and of exceptional occurrence in PENTAMERELLA. STRICKLANDINIA possesses so straight and long a hinge, so sharply defined an area and so short a spondylium, that it is more natural to regard this genus as the accompaniment, rather than the close organic kin of the other pentameroids, deriving its differentials directly from those long-hinged and straight-hinged shells of the early Silurian, which constitute the genus SYNTROPHIA.

It will not now appear a matter of inexplicable aberrancy that the spondylium presents itself in the great secondary groups comprising the rhynchonellids, and those shells with calcified brachidia. Hence we meet with it in CYRTINA and CAMAROSPIRA in a highly developed state, and in CAMAROTŒCHIA in a less advanced condition, while AMPHIGENIA presents the remarkable combination of a spondylium coexistent with a shell of completely Rensselaerioid aspect (that is in respect to form, contour, muscular markings and articulating apparatus), and with rhynchonelloid brachial supports.

Attention has already been directed to the fact that some of the *RHYNCHONELLIDÆ*, early in their history, occasionally retain a well-defined cardinal area, and that, in default of other evidence, the presence of this character may be regarded as indicative of the common origin of ORTHIS, the *STROPHOMENIDÆ* and the Rhynchonellas. The earliest phyletic stages of the rhynchonellids must have been highly accelerated, for there is no evidence of any form which has shown the slightest trace of a deltidium. Nevertheless the early forms of the Silurian, such as ORTHORHYNCHULA and PROTORHYNCHA, rarely show any indication of deltaria at maturity but the delthyrium, in its final stage, is unobstructed and simple, as in young conditions of later rhynchonellids in which the deltaria fully develop. We may look upon the *RHYNCHONELLIDÆ* as a family whose characters became established very early and have been perpetuated up to the present without departure, at any time, from the early derived type.

In the study of the multifold variations of the articulates bearing calcified spiral brachial supports, the HELICOPEGMATA of WAAGEN (1883), the conclusion has enforced itself that the degree of solidification of the brachia in this group is to be regarded as an index of differentiation. To illustrate: there is no evidence for assuming that the single volution made by the spiral in PROTOZYGA and HALLINA represents an incomplete spiculation of the brachia, or that the spiniform and discrete jugal processes in SPIRIFER, persisting throughout the genus, do not fully exemplify the adult condition of the jugum (=loop) in these shells. The mode of spiculation of the brachia in such of the living terebratuloids, in which the solidification is direct, or without complicated metamorphoses, is on the whole confirmatory of this inference; but as there is no living representative of the spire-bearing forms, evidence in regard to the mode and degree of spiculation in this group, derived from the existing loop-bearing shells in which the brachial supports pass through highly complicated metamorphoses, is not altogether germane. In such intricate structures as the brachidia of ATHYRIS, KAYSERIA, KONINCKINA, etc., there can be little doubt that the calcified apparatus represents the full extent of the fleshy brachia simply, if for no other reason, because the further expansion of the brachial laminæ would not be possible for want of space. Moreover, in the spiculation of the spirals in all these old shells there have been no changes of form in later growth except those proceeding from the normal process of resorption and deposition necessary for increase in size and length. The reason why the spiculation should be complete in the spire-bearing forms, while in the ANCYLOBRACHIA or the terebratuloids, it does not extend beyond the loop or the lateral extensions of the brachia, but in the *RHYNCHONELLIDÆ* affects only the crura, and in the *STROPHOMENIDÆ*, does not occur, even in the most elementary condition, is for future investigations to ascertain.

The form of the paired spirals varies but little except under the necessity of conforming to the interior cavity of the valves. Their inclination and direction is a feature of much significance when considered with reference to the development of the entire shell. It is the loop, or to employ a term more appropriate in view of the homologies of the spire-bearing and loop-bearing shells, the *jugum*, however, which is subject to the most frequent variations in form, and which serves as the generic index. When the spirals are directed outward toward the lateral margins of the valves, the jugum seems to be much more variable than in shells where the spirals are introverted or take some intermediate position. In the latter there is a much greater variation in the position of the loop upon the primary lamellæ than occurs in the former.

The earliest spire-bearing shells yet discovered are the simplest in the structure of the brachidium. HALLINA, PROTOZYGA, CYCLOSPIRA, of the Lower Silurian, possess brachidia which make a little less than one or two volutions of the calcified lamellæ, with a slight inclination toward each other, and to the median axis of the shell. ZYGOSPIRA and GLASSIA, the contemporaries and successors of these primitive structures, show progressed conditions of the same form of brachidium. In these genera, however, there is a slight deviation in the vertical axes of the spirals from the transverse axis of the shell, the apices being inclined somewhat toward the brachial valve, and this tendency to lateral evolution in the spiral cones is carried to its extreme in the genus ATRYPA, where the multispiral cones of the fully matured forms of the Devonian may sometimes have their axes nearly parallel. This is the termination of all revolution of the cones, a change through an arc of less than 90°, probably due in a large degree to alterations in the form of the internal cavity of the valves; and the fact that this revolution here ceases, strictly delimits the group of forms bearing spirals to this type (*ATRYPIDÆ*).

It is well to emphasize the fact, lest misconceptions already set on foot should become prevalent, that no wider revolution of the spiral cones exists. It is true that there is a difference of 180° in the position of the axes of the spiral cones in CYCLOSPIRA and SPIRIFER, but the spirals have never, by gradual changes, revolved from their inverted position in the former to their everted position in the latter Such a process might have been possible, but had it actually occurred the forms resulting would have been totally different in structure from any now known. Instead of having the primary lamellæ and jugum on the dorsal side as in all shells with everted spirals, these parts would lie on the ventral side of the shell. It must hence be inferred that the

Spiriferidæ, the *Athyridæ*, the *Meristidæ*, and all genera with everted brachidia are related to the *Atrypidæ* only through their early ancestral forms.

The Lower Silurian faunas have furnished no evidence of species with everted spirals, and this hiatus in our knowledge forbids any satisfactory deductions as to the source or derivation of these forms. It is true in a general sense that the eversion of the spirals is accompanied by a convexity of both valves, just as the inverted spirals of the *Atrypidæ* are associated with valves of notably unequal depth. Still, among the latter, Glassia possesses biconvex valves, while of the former the group composed of Cœlospira, Anoplotheca, Koninckina and Amphiclina, is characterized by convexo-plane or convexo-concave valves. In this group also the apices of the spirals are not directed toward the lateral commissures of the valves, but toward the lateral slopes of the pedicle-valve, such a form and direction being a necessary outcome of the contracted interior space. From present evidence it would seem probable that among the early Silurian species will be found some form whose spiral ribbon deviates outwardly from the vertical plane to the same degree as it inclines inwardly in Cyclospira and Protozyga. Indeed, in *Cyclospira bisulcata* itself, the spiral sometimes lies so nearly in the vertical plane that the inward inclination of the apices is not always positive. Only some such form of the earliest faunas could have been the progenitor of the everted spirals.

In the *Atrypidæ*, possibilities of a variation in the form of the jugum were much restricted; in the other groups of the spire-bearers these were very great, and resulted in the production of a wonderful series of modifications whose relations it is not necessary to rehearse here. The extreme range of these modifications is seen in the simple termination of the jugum in Whitfieldella, Rhynchospira, etc.; the bifurcate extremity in Meristina, Eumetria and Retzia, their terminal branches in Kayseria, Diplospirella, etc., finally becoming coextensive with the lamellæ of the primary spirals and thus forming a second pair of spiral cones. This complication of the brachidium is effected only late in the history of the various groups producing them. Koninckina and Amphiclina are double-spiraled convexo-concave shells, which are the post-palæozoic and final representatives of Anoplotheca and Cœlospira. Pexidella and Diplo-

SPIRELLA, of the St. Cassian beds, are double-spiraled athyroids; KAYSERIA, of the middle Devonian, which is the only double-spiraled form known in the Palæozoic, appears to be an aberrant and accelerated representative of the stock which by more gradual development produced RETZIA and EUMETRIA.

Only one large group of spire-bearing shells retains the cardinal area, namely, the *SPIRIFERIDÆ*, a family with everted spirals, one of the earliest to appear and the last to disappear. Its abundant representatives possess the longest of spirals, and for the most part these are greatly extended transversely, held at arm's length as it were, unsupported by a connecting jugum (except in the sparsely represented genera CYRTINA and SPIRIFERINA); but in spite of the delicacy of the structure and its apparent mechanical disadvantages in the absence of a continuous jugum, this type of structure has maintained its distinctive character and multiplied in a most remarkable manner.

The relations of the brachiopods with spiral brachidia to the ANCYLOBRACHIA, or those shells commonly spoken of as the terebratuloids, has been a fruitful subject of discussion, and given rise to investigations of great astuteness and merit. Reference has already been made to the facts established by BEECHER and SCHUCHERT, from the development of the brachidium in ZYGOSPIRA, which show that this atrypid passes through a growth-stage in which the brachidium has a simple terebratuloid form, similar to that in the mature condition of DIELASMA; that the spirals are formed by the continued growth of the descending lamellæ of the loop beyond the point of their recurvature into the ascending lamellæ. What is thus true of ZYGOSPIRA we must assume to have been equally true of all the spire-bearers, and the analogies thus established between them and the loop-bearing shells are these: The entire loop in DIELASMA, CRYPTONELLA, etc., corresponds to that portion of the brachidium, in the spire-bearing forms, which lies behind the anterior basal edges of the jugum; the descending lamellæ of the former represent only the posterior portion of the primary lamellæ of the latter, while the ascending lamellæ and transverse connecting band of the ANCYLOBRACHIA are the equivalent of the jugum in the spire-bearers. The spirals, however, are a later development in the individual, and are hence undoubtedly a subsequent phyletic condition. Hence it is inferred that the spire-bearing forms derived their brachidia from a primitive terebratuloid condition, and this derivation has been effected by growth with accompanying resorption. The progressive modification of the loop in the recent terebratellids by resorption of calcareous tissue in the growth of the individual, is a well-known fact which has invited the study of many investigators. In such forms this modification is extreme, and is unquestionably complicated by the intimate connection of the loop with the median septum of the brachial valve. With the single exception of Tropidoleptus, among the palæozoic genera, there is no clear evidence that the median septum has shared in, or contributed to, the growth-modification of the brachial supports; nevertheless, the outcome and final result of this growth with modification in the most progressed forms of Terebratella and such palæozoic genera as Dielasma, Cryptonella, Harttina, etc., is the same.

Progressive modification of the brachial supports in both the Helicopegmata and palæozoic Ancylobrachia being now fully established, it is interesting to observe that the primitive condition of the loop, as in *Dielasma turgida,* is one of simple apposition of the two short brachial processes, at their expanded anterior extremities; having the expression of the mature loop in the genera Centronella, Rensselaeria, Selenella, etc. A simple step further back would afford a condition in which the brachial processes with their expanded extremities are not as yet united, but discrete as in the rhynchonellids. A more primitive condition than that in Centronella or the centronellid stage in Dielasma, could not be different from this. On the ground of these differences in the conditions of the brachidium and the phyletic stages corresponding thereto, it would seem fair to infer that, of the rhynchonellids, the terebratuloids and the spire-bearers, the first is the primitive stock, and the spire-bearers legitimate derivations from that stock, through the terebratuloids, or both of the latter derived along divergent lines from the rhynchonellids. This conclusion, however coherent and consistent with the geological evidence, will be found to lack stability until the data are sufficient to establish the fact that the brachia themselves, and not alone their calcareous supports, have passed through corresponding phases of growth and derivation. This latter question must long be a matter of legitimate speculation, and in view of this fact a few arguments of such a nature in this place will be permissible. The living representatives of RHYNCHONELLA and TEREBRATULA are animals in which a very considerable part of the brachia does not become sufficiently spiculized to form a continuous calcareous support. In *R.* (*Hemithyris*) *psittacea*, for example, the brachia are as highly developed in the form of coiled spiral arms as they could have been in most of the ancient spire-bearers, but their calcareous supports are only the short lamellæ known as the crural processes. All of the living ANCYLOBRACHIA which possess a long curved loop like that of CRYPTONELLA and DIELASMA of the Palæozoic, have an unsupported median unpaired spiral arm, coiled in a direction which is the reverse of that prevailing among the spire-bearers If, now, we are to interpret the condition of the brachia in their nearest living representative, it becomes necessary to assume that on the one hand, the palæozoic rhynchonellids possessed long coiled spiral arms, and, on the other, that DIELASMA and its palæozoic allies and affines, when mature, were provided with the unpaired coiled arm of TEREBRATELLA. This assumption, in the first place, totally destroys the inference above made as to the primitive relation of the rhynchonellids to the terebratuloids and spire-bearers; and, secondly, would seem to necessitate a novel and unexpected interpretation of the brachial structure in all the spire-bearers. If DIELASMA possessed the median arm, supported at its base by the transverse band of the loop, which corresponds to the jugum of the spire-bearers, then in the DIELASMA-stage of ZYGOSPIRA and other spiriferous shells, where this stage was well defined, there must also have been a median coiled arm of some extent. This median arm, in living forms, is due, as shown by BEECHER, to the necessity of finding room for the cilia or tentacles multiplying at the extremities of the brachia. The mere presence of the transverse band in DIELASMA and the DIELASMA-stage of ZYGOSPIRA, implies a similar extension of the brachia, and from the analogy, a median arm. The subsequent growth of the brachia in ZYGOSPIRA, carrying the calcareous ribbon forward, beyond the bases of the loop and into lateral spiral cones, would not of itself afford sufficient reason for assuming that the growth of the brachia at their extremities, which produced the median arm, was necessarily discontinued, but rather that this median unpaired arm coexisted with the lateral paired spirals. This course of argument, though seemingly logical appears, to be based on insufficient premises.

The brachiopods with which we have to deal in the palæozoic are essentially primitive structures, whether rhynchonellids, terebratuloids or spire-bearers. If the living RHYNCHONELLA and TEREBRATELLA in their mature conditions possess extensive unsolidified arms, it does not necessarily follow that their early palæozoic representatives were provided with similar uncalcified extensions; on the contrary, it would be much more reasonable and in accordance with our knowledge of natural laws to infer that in these early forms the adult condition of the brachia was more nearly that of immature conditions of these organs in their living representatives. There is a primitive condition of development in the terebratuloids in which the loop is coextensive with the brachia; there is reason to believe that such has been the relation of these parts in the mature phases of the primitive terebratuloids, as CENTRONELLA, RENSSELAERIA, CRYPTONELLA, DIELASMA, etc.; in TROPIDOLEPTUS, which has been shown to represent a highly primitive phyletic condition of the *TEREBRATELLIDÆ*; and, also, in the earliet spire-bearers and rhynchonellids. Hence the conclusion above expressed as to the successive phyletic relations of the primitive rhynchonellids, terebratuloids and spire-bearers, and based upon the relations and modifications in the form of their brachial supports, is fairly substantiated by the evidence drawn from other data.

Finally, it is important to emphasize the intimate similarity between RENSSELAERIA and the pentameroid genus AMPHIGENIA; genera in which the essential distinction between the typical forms of each lies in the simple loop of the former and the long, expanded but still discrete crural processes of the latter. Attention has been directed to these similarities and differences, and it has also been pointed out that the spondylium in *Amphigenia elongata* is at times almost reproduced in specimens of *Rensselaeria ovoides* where the dental lamellæ are highly developed.

TABLE OF CLASSIFICATION.

CLASS BRACHIOPODA.

PATERINA,* Beecher, 1891.

SUB-CLASS INARTICULATA, HUXLEY; LYOPOMATA, OWEN.

Order MESOCAULIA, or LINGULACEA, Waagen.

FAMILY *OBOLIDÆ*, KING.

OBOLUS, von Eichwald, 1829.
Ungula, Pander, 1830.
Ungulites, Bronn, 1848.
AULONOTRETA, Kutorga, 1848.
Acritis, Volborth, 1869.
SCHIMIDTIA, Volborth, 1869.
MICKWITZIA, Schmidt, 1888.
SPONDYLOBOLUS, McCoy, 1852.
OBOLELLA, Billings, 1861.
Discellomus, Hall, 1871.
ELKANIA, Ford, 1886.
Billingsia, Ford, 1886.
BOTSFORDIA, Matthew, 1893.
NEOBOLUS, Waagen, 1885.
MONOBOLINA, Salter, 1865.

FAMILY *LINGULIDÆ*, GRAY.

LINGULA, Bruguière, 1792.
Pharetra, Bolten, 1798.
Lingularius, Duméril, 1806.
LEPTOBOLUS, Hall, 1871.
GLOSSINA, Phillips, 1848.
DIGNOMIA, Hall, 1871.

* The genus PATERINA, representing, according to our present knowledge, the fundamental stock or radicle of all the Brachiopods, might be embraced by some of the primitive families, both of the Inarticulata and the Articulata. By placing it in this arrangement, outside both the great sub-classes, it is the purpose to express the fact that the genus belongs as much to one as to the other, and that it is actually beyond the pale of both as it has not assumed the differential characters of either.

LINGULIDÆ—Continued.

LINGULELLA, Salter, 1866.
LINGULEPIS, Hall, 1863.
BARROISELLA, Hall, 1892.
TOMASINA, Hall, 1892.

FAMILY *TRIMERELLIDÆ*, DAVIDSON and KING.

LAKHMINA, Œhlert, 1887.
Davidsonella, Waagen, 1885.
LINGULOPS, Hall, 1871.
LINGULASMA, Ulrich, 1889.
DINOBOLUS, Hall, 1871.
Conradia, Hall, 1862.
Obolellina, Billings, 1871.
MONOMERELLA, Billings, 1871.
TRIMERELLA, Billings, 1862.
RHINOBOLUS, Hall, 1874.

Order DIACAULIA, or DISCINACEA, Waagen.

FAMILY *DISCINIDÆ*, GRAY.

DISCINOLEPIS, Waagen, 1885.
Lingulodiscina, Whitfield, 1890.
PATERULA, Barrande, 1879.
SCHIZOBOLUS, Ulrich, 1886.
TREMATIS, Sharpe, 1847.
SCHIZOCRANIA, Hall and Whitfield, 1875.
ŒHLERTELLA, Hall, 1892.
ORBICULOIDEA, d'Orbigny, 1847
SCHIZOTRETA, Kutorga, 1848.
LINDSTRŒMELLA, Hall, 1892.
ROEMERELLA, Hall, 1892.

FAMILY *SIPHONOTRETIDÆ*, KUTORGA.

ACROTHELE, Linnarsson, 1876.
LINNARSSONIA, Walcott, 1885.
DISCINOPSIS, Matthew, 1892.
ACROTRETA, Kutorga, 1848.
CONOTRETA, Walcott, 1889.
MESOTRETA, Kutorga, 1848.
SCHIZAMBON, Walcott, 1884.
SIPHONOTRETA, de Verneuil, 1845.
ORBICELLA, d'Orbigny, 1849.
Keyserlingia, Pander, 1861.
HELMERSENIA, Pander, 1861.

Order GASTROPEGMATA, or CRANIACEA, Waagen.

FAMILY *CRANIDÆ*, KING.

CRANIA, Retzius, 1781.
Numulus, Stoboeus, 1732.
Ostracites, Beuth, 1776.
Criopus, Poli, 1791.
Criopoderma, Poli, 1791.
Orbicula, Cuvier, 1798.

CRANIIDÆ—Continued.

Orbicularius, Duméril, 1806.
Craniolites, Schlotheim, 1820.
Choniopora, Schauroth, 1854.
CRANIELLA, Œhlert, 1887.
CARDINOCRANIA, Waagen, 1885.
PHOLIDOPS, Hall, 1860.
Craniops, Hall, 1859.
PSEUDOCRANIA, McCoy, 1851.
Palæocrania, Quenstedt, 1871.

SUB-CLASS ARTICULATA, HUXLEY; ARTHROPOMATA, OWEN.

Order PROTREMATA,* Beecher.

FAMILY *KUTORGINIDÆ*,† SCHUCHERT.

KUTORGINA, Billings, 1861.
SCHIZOPHOLIS, Waagen, 1885.
(?) VOLBORTHIA, von Möller, 1873.
IPHIDEA, Billings, 1872.

FAMILY *ORTHIDÆ*, WOODWARD.

ORTHIS, Dalman, 1828.
Orthambonites, Pander, 1830.
PLECTORTHIS, Hall, 1892.
DINORTHIS, Hall, 1892.
PLAESIOMYS, Hall, 1892.
HEBERTELLA, Hall, 1892.
ORTHOSTROPHIA, Hall, 1883.
PLATYSTROPHIA, King, 1850.
HETERORTHIS, Hall, 1892.
BILOBITES, Linné, 1775.
Dicoelosia, King, 1850.
DALMANELLA, Hall, 1892.
RHIPIDOMELLA, Œhlert, 1880.
Rhipidomys, Œhlert, 1887.
SCHIZOPHORIA, King, 1850.
ORTHOTICHIA, Hall, 1892.
ENTELETES, Fischer de Waldheim, 1830.
Syntrielasma, Meek, 1865.

FAMILY *STROPHOMENIDÆ*, KING.

ORTHIDIUM, Hall, 1892.
STROPHOMENA, Rafinesque (de Blainville), 1825.
DERBYA, Waagen, 1884.
MEEKELLA, White and St. John, 1868.
STREPTORHYNCHUS, King, 1850.

* In employing as the fundamental divisional distinction in the Articulata, the presence of the deltidium or deltidial plates, the term PROTREMATA, better than any other, covers those genera in which the primitive pedicle-covering is represented by either the deltidium, the spondylium, or both.

† Mr. SCHUCHERT includes under this family term two genera, KUTORGINA and SCHIZOPHOLIS, which have usually been regarded as belonging to the inarticulate sub-class. The reasons for installation of these as the elementary family of the Articulata are given elsewhere.

STROPHOMENIDÆ—Continued.

Orthothetes, Fischer de Waldheim, 1830.
Hipparionyx, Vanuxem, 1842.
Kayserella, Hall, 1892.
Triplecia, Hall, 1858.
Dicraniscus, Meek, 1872.
Mimulus, Barrande, 1879.
Streptis, Davidson, 1881.

Family *LEPTÆNIDÆ*.

Leptæna, Dalman, 1828.
Leptagonia, McCoy, 1844.
Rafinesquina, Hall, 1892.
Stropheodonta, Hall, 1852.
Brachyprion, Shaler, 1865.
Douvillina, Œhlert, 1887.
Leptostrophia, Hall, 1892.
Pholidostrophia, Hall, 1892.
Strophonella, Hall, 1879.
Amphistrophia, Hall, 1892.
Leptella, Hall, 1892.
Plectambonites, Pander, 1830.
Christiania, Hall, 1892.
Leptænisca, Beecher, 1890.
Davidsonia, Bouchard, 1847.

Family *CHONETIDÆ*.

Chonetes, Fischer de Waldheim, 1837.
Anoplia, Hall, 1892.
Chonetella, Waagen, 1884.
Chonetina, Krotow, 1888
Chonostrophia, Hall, 1892.
Chonopectus, Hall, 1892.

Family *PRODUCTIDÆ*, Gray.

Strophalosia, King, 1844.
Orthothrix, Geinitz, 1847.
Leptænalosia, King, 1845.
Daviesiella, Waagen, 1884.
Aulosteges, von Helmersen, 1847.
Productella, Hall, 1867.
Productus, Hall, 1867.
Marginifera, Waagen, 1884.
Proboscidella, Œhlert, 1887.
Etheridgina, Œhlert, 1887.

Family *THECIDIIDÆ*, Gray.

Lyttonia, Waagen, 1883.
Oldhamina, Waagen, 1883.

Family *RICHTHOFENIDÆ*, Waagen.

Richthofenia, Waagen, 1883.

Family *BILLINGSELLIDÆ.* Schuchert.

Billingsella,* Hall, 1892.

Family *CLITAMBONITIDÆ.* N. H. Winchell and Schuchert.

Protorthis, Hall, 1892.
Polytœchia, Hall, 1892.
Clitambonites, Pander, 1830.
Pronites, Pander, 1830.
Gonambonites, Pander, 1830.
Hemipronites, Pander, 1830.
Orthisina, d'Orbigny, 1847.
Scenidium, Hall, 1860.
Mystrophora, Kayser, 1871.

Family *STRICKLANDINIIDÆ.*

Syntrophia, Hall, 1892.
Stricklandinia, Billings, 1859.

Family *CAMARELLIDÆ.*

Camarella, Billings, 1859.
Parastrophia, Hall, 1893.
Anastrophia, Hall, 1879.
Brachymerus, Shaler, 1865.
(?) Branconia, Gagel, 1890.
Porambonites, Pander, 1830.
Isorhynchus, King, 1850.
Noetlingia, Hall, 1892.
Lycophoria, Lahusen, 1885.
Camarophoria, King, 1846.
Camarophorella, Hall, 1893.

Family *PENTAMERIDÆ.*

Conchidium, Linné, 1753.
Gypidia, Dalman, 1828.
Antirhynchonella, Quenstedt, 1871.
Zdimir, Barrande, 1879.
Pentamerus, Sowerby, 1813.
Barrandella, Hall, 1893.
Sieberella, Œhlert, 1887.
Capellinia, Hall, 1893.
Pentamerella, Hall, 1867.
Gypidula, Hall, 1867.
Amphigenia, Hall, 1867.

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* The genus Billingsella, in correspondence with its early geological age, presents an elementary structural aspect indicating that it may have served as a point of departure for the *Orthidæ* and *Strophomenidæ*.

Order TELOTREMATA, Beecher.

Sub-order ROSTRACEA, Schuchert.

FAMILY *RHYNCHONELLIDÆ*, GRAY.

PROTORHYNCHA, Hall, 1893.
ORTHORHYNCHULA, Hall, 1893.
RHYNCHOTREMA, Hall, 1860.
RHYNCHOTRETA, Hall, 1879.
STENOSCHISMA, Conrad, 1839
CAMAROTŒCHIA, Hall, 1893.
LIORHYNCHUS, Hall, 1860.
WILSONIA, (Quenstedt) Kayser, 1871.
UNCINULUS, Bayle, 1878.
UNCINULINA, Bayle, 1878.
HYPOTHYRIS, (McCoy) King, 1850.
PUGNAX, Hall, 1893.
EATONIA, Hall, 1857.
CYCLORHINA, Hall, 1893.
TEREBRATULOIDEA, Waagen, 1883.
RHYNCHOPORA, King, 1856.
RHYNCHONELLA, Fischer de Waldheim, 1809.

Sub-order ANCYLOBRACHIA, Gray.

FAMILY *CENTRONELLIDÆ*, WAAGEN.

RENSSELAERIA, Hall, 1859.
BEACHIA, Hall, 1893.
NEWBERRIA, Hall, 1891.
CENTRONELLA, Billings, 1859.
ORISKANIA, Hall, 1893.
SELENELLA, Hall, 1893.
ROMINGERINA, Hall, 1893.
TRIGERIA, Bayle, 1875.
(?) NOTOTHYRIS, Waagen, 1882.
SCAPHIOCŒLIA, Whitfield, 1891.
MEGALANTERIS, Suess, 1855.
(?) ENANTIOSPHEN, Whidborne, 1893.

FAMILY *STRINGOCEPHALIDÆ*, DALL.

STRINGOCEPHALUS, Defrance, 1827.

FAMILY *TEREBRATULIDÆ*, DALL.

CRYPTONELLA, Hall, 1861.
EUNELLA, Hall, 1893.
HARTTINA, Hall, 1893.
DIELASMA, King, 1859.
Epithyris, King. 1850.
CRANÆNA, Hall, 1893.
DIELASMINA, Waagen, 1882.
HEMIPTYCHINA, Waagen, 1882.
BEECHERIA, Hall, 1893.
(?) CRYPTACANTHIA, White and St. John, 1867.

Family *TEREBRATELLIDÆ*, King.

Tropidoleptus, Hall, 1857.

Sub-order Helicopegmata, or Spiriferacea, Waagen.

Family *ATRYPIDÆ*, Dall.

Hallina, N. H. Winchell and Schuchert, 1892.
Protozyga, Hall, 1893.
(?) Cyclospira, Hall, 1893.
Zygospira, Hall, 1862.
Anazyga, Davidson, 1882.
Orthonomæa, Hall, 1858.
Catazyga, Hall, 1893.
Glassia, Davidson, 1882.
Atrypina, Hall, 1893.
(?) Clintonella, Hall, 1893.
Atrypa, Dalman, 1828.
Karpinskia, Tschernyschew, 1885.
Gruenewaldtia, Tschernyschew, 1885

Family *SPIRIFERINIDÆ*, Davidson.

Cyrtina, Davidson, 1858.
Spiriferina, d'Orbigny, 1847.

Family *SPIRIFERIDÆ*, King.

Spirifer, Sowerby, 1815.
Trigonotreta, Koenig, 1825.
Brachythyris, McCoy, 1844.
Fusella, McCoy, 1844.
Choristites, Fischer de Waldheim, 1825.
Delthyris, Dalman, 1828.
Reticularia, McCoy, 1844.
Martinia, McCoy, 1844.
Martiniopsis, Waagen, 1883.
Cyrtia, Dalman, 1828.
Syringothyris, A. Winchell, 1863.
Ambocœlia, Hall, 1860.
Metaplasia, Hall, 1893.
Verneuilia, Hall, 1893.

Family *NUCLEOSPIRIDÆ*, Davidson.

Nucleospira, Hall, 1858.
Dayia, Davidson, 1882.
Hindella, Davidson, 1882.
Whitfieldella, Hall, 1893.
Hyattella, Hall, 1893.
(?) Camarospira, Hall, 1893.

Family *CŒLOSPIRIDÆ*.

Anoplotheca, Sandberger, 1856.
Bifida, Davidson, 1882.
Cœlospira, Hall, 1863.
Leptocœlia, Hall, 1859.
(?) Anabaia, Clarke, 1893.

Family *RETZIIDÆ.*

RHYNCHOSPIRA, Hall, 1859.
HOMŒOSPIRA, Hall, 1893.
PTYCHOSPIRA, Hall, 1893.
TREMATOSPIRA, Hall, 1857.
PARAZYGA, Hall, 1893.
RETZIA, King, 1850.
UNCINELLA, Waagen, 1883.
EUMETRIA, Hall, 1864.
ACAMBONA, White, 1862.
HUSTEDIA, Hall, 1893.

Family *UNCITIDÆ*, Waagen.

UNCITES, Defrance, 1825.

Family *MERISTELLIDÆ*, Waagen.

MERISTA, Suess, 1851.
Camarium, Hall, 1859.
DICAMARA, Hall, 1893.
MERISTELLA, Hall, 1860.
CHARIONELLA, Billings, 1861.
(?) PENTAGONIA, Cozzens, 1846.
Goniocœlia, Hall, 1861.

Family *ATHYRIDÆ*, Waagen.

MERISTINA, Hall, 1867.
Whitfieldia, Davidson, 1882.
GLASSINA, Hall, 1893.
ATHYRIS, McCoy, 1844.
Spirigera, d'Orbigny, 1847.
CLIOTHYRIS, King, 1850.
ACTINOCONCHUS, McCoy, 1844
SEMINULA, McCoy, 1844.
SPIRIGERELLA, Waagen, 1883.
KAYSERIA, Davidson, 1882.

INCERTÆ SEDIS.

EICHWALDIA, Billings, 1858.
Dictyonella, Hall, 1867.
AULACORHYNCHUS, Dittmar, 1871.
Isogramma, Meek and Worthen, 1873.

DESCRIPTIONS OF NEW SPECIES

FIGURED IN VOLUME VIII, PART II.

Orthis ? glypta, sp. nov.

PLATE LXXXIV, FIGS. 8, 9.

Shell small, transverse, with long, straight hinge, making the greatest diameter of the shell; short along the median axis; marginal outline transversely subelliptical Pedicle-valve with a broad and low median sinus and generally depressed surface The exterior bears from twelve to sixteen low, flat plications, separated by narrow sulci, and sometimes with a fine groove on the surface of each. These extend from apex to margins, and are crossed by fine, undulating, subconcentric lines apparently in two oblique sets, producing a peculiarly reticulated or wavy surface similar to that occurring in the Swedish Silurian species, *O. Loveni*, Lindstrom The muscular area of the pedicle valve is small. Length of an average pedicle-valve, 12 mm.; width, 18 mm.

Niagara dolomites. *Near Milwaukee, Wisconsin.*

Strophonella costatula, sp nov.

PLATE LXXXIV, FIGS. 15, 16

Shell subsemicircular in outline; hinge-line straight or slightly arched; surface depressed concavo-convex.

Pedicle-valve elevated at the beak, becoming rapidly depressed anteriorly, the median depression continued upon the short linguiform extension at the anterior margin. Corresponding to this depression is a broad anterior fold on the opposite valve. The surface of both valves is covered with a few coarse, round, sharply elevated ribs, which rapidly bifurcate or multiply by implantation. These are more or less irregular or sinuous, elevated at the concentric varices and crossed by faint concentric lines.

The typical example has a length of 21 mm. and a width on the hinge of 24 mm.

Niagara group. *Louisville, Kentucky.*

PLECTAMBONITES PRODUCTA, sp. nov.

PLATE LXXXIV, FIGS. 23, 24, 25.

The original of this species is an internal cast of the pedicle-valve, with short, straight hinge; rather narrow, depressed umbo, the shell becoming highly convex and greatly produced anteriorly. The sides of the valve are somewhat appressed medially and the anterior margin slightly expanded and suboval in outline. The cast shows the impression of short, divergent dental plates and a moderately broad muscular impression. The width of the shell on the hinge is 10 mm.; its length, 23 mm.; its convexity from the posterior margin, 8 mm.; from the anterior margin, 28 mm.

Niagara dolomites. *Yellow Springs, Ohio.*

SPIRIFER CRISPATUS, sp. nov.

PLATE XXXVI, FIGS. 9, 10.

Shell small, with moderately high, incurved area, scarcely extended on the hinge; well-developed median fold and sinus, and three coarse plications on each lateral slope. The surface is covered by conspicuous concentric lamellæ.

Niagara group. *Maryland.*

SPIRIFER CANANDAIGUÆ, sp. nov.

PLATE XXXVII, FIGS. 23, 24, 25.

Shells of rather small size, having somewhat the aspect of an elongate and umbonate *S. fimbriatus*. Umbo of pedicle-valve prominent, narrow and closely incurved at the apex. Hinge-line quite short, cardinal area small, incurved. Median sinus deep, produced on the anterior margin, its anterior width being nearly equal to the length of the hinge. On each lateral slope are from two to four low radial undulations or plications, all of which are sharply defined at the umbones. Surface covered with very fine, closely crowded concentric lines which are granulous and were originally fimbriate. Length of typical specimen, 21 mm.; greatest width, 22 mm.; length of hinge, 10 mm.

Hamilton group. *Centerfield and Canandaigua Lake, N. Y.*

SPIRIFER MUCRONATUS, CONRAD, var. POSTERUS, var. nov.

PLATE XXXIV, FIGS. 27-31

A late variety of the typical Hamilton form, characterized by its small size, usually narrow bodies and acuminate cardinal extremities.

Chemung group. *Tompkins county, N. Y.*

SPIRIFER DISJUNCTUS, SOWERBY, var. SULCIFER, var. nov.

PLATE XXX, FIG. 16.

This variety is distinguished by the sharply defined median sulcus on the folds of the brachial valve. It has heretofore been embraced within the limits of *S. disjunctus*, but the character referred to appears to be persistent.

Chemung group. *Near Olean, N. Y.*

SPIRIFER WILLIAMSI, sp. nov.

PLATE XXXVII, FIGS. 20, 21, 22.

Shells of the form of *Spirifer increbescens*, Hall, and varying but little in size. Median fold and sinus well developed. The latter bearing usually three, sometimes four plications, finer than those on the lateral slopes. Of these the median plication is generally the strongest. This, however, is not always the case, the arrangement of these plications being frequently quite irregular. The median fold generally bears a median groove and one lateral plication on each side. On each lateral slope of the shell are seven or eight plications.

A normal example measures: Length, 15 mm.; width on hinge, 24 mm.

Chemung group. *Allegany county, N. Y.*

SPIRIFER NEWBERRYI, Hall. 1883.

(See Report State Geologist for 1882, Plate (xxxi) 56, Figs. 9, 10).

PLATE XXXI, FIGS. 9, 10.

Shell moderately large, with sharp cardinal angles. Surface plication consisting of numerous fine simple or duplicate ribs which cover the median fold. On each lateral slope there are twenty-five to thirty of these plications. The plications and the grooves between them are covered with fine radiating lines.

Waverly group. *Ohio.*

CYRTIA RADIANS, sp. nov.

PLATES XXVIII, FIGS. 4, 5, 50, 52; XXXIX, FIG. 33.

The typical form is of medium size, with high area, incurved umbo and general cyrtiniform aspect. Its outer surface is characterized by an absence of plications and fine radial striæ. Median fold and sinus well developed.

Clinton group. *Rochester, N. Y.*

An allied but larger form, here referred to this species, occurs in the Niagara dolomites, near Milwaukee, Wisconsin.

CYRTINA UMBONATA, Hall, var. ALPENENSIS, var. nov.

PLATE XXVIII, FIGS. 16-20.

Cyrtina umbonata, Hall, from the original locality in Iowa, is a small shell, often obscurely plicated; this variety possesses the contour of *C. umbonata*, but is a larger and more robust shell with broad and well-defined plications, smooth median fold and sinus.

Hamilton group. *Alpena, Michigan.*

CYRTINA LACHRYMOSA, sp. nov.

PLATE XXVIII, FIGS. 36, 37, 47.

Shells small; cardinal area high, more or less incurved. Surface with low and rather narrow median fold and sinus, on each side of which are two or three low, faint plications. Lateral margins of the cardinal area broadly rounded.

Surface covered with elongate pustules, some of them coarse, but the greater number quite fine.

Height of an average specimen, 5 mm.; width and length, 6 mm.

Waverly group. *Richfield, Ohio.*

Syringothyris Missouri, sp. nov.

PLATE XXXIX, FIGS. 29-31.

Shell small, cyrtiniform; cardinal area high, slightly incurved toward the apex; lateral cardinal margin broadly rounded, rendering the definition of the area quite obscure. Median fold and sinus neither wide nor highly developed. Surface of both smooth. Each lateral slope with five or six low plications.

Interiorly the pedicle-valve bears strong divergent dental lamellæ which are attached to the surface of the valve for fully one-third of its length. There is no median septum. The transverse delthyrial plate is thin and is developed into a delicate but distinct tube. Shell substance highly punctate on the inner laminæ. Height of original specimen, 13 mm.; cardinal width, 18 mm.; length, 15 mm.

Choteau limestone. *Choteau Springs, Missouri.*

Ambocœlia spinosa, sp. nov.

PLATE XXXIX, FIGS. 16-18.

Shell of rather large size, hinge-line straight, equaling the full diameter of the valve. Brachial valve depressed convex in the umbonal region, concave anteriorly, with upturned margins. Medially there is a low and indistinct elevation which disappears toward the front. Pedicle-valve not known. Surface bearing faint traces of concentric lines and covered with numerous elongate depressions which were probably bases of insertion of epidermal spinules.

Length of original specimen, 7 mm.: width in the hinge, 9 mm.

Hamilton shales. *Livonia Salt Shaft, Livingston county, N. Y.*

SEMINULA ROGERSI, sp. nov.

PLATE XLVII, FIGS. 1-4.

Shell rather small, suboval in outline. Valves subequally convex. Pedicle-valve with a low, broad median sinus and brachial valve with a corresponding fold, both becoming more distinct toward the anterior margin. Lateral slopes depressed-convex. Umbones not conspicuous; deltidium concealed.

External surface smooth.

A normal individual measures 15 mm. in length, and 13 mm. in greatest width.

Pendleton sandstone (Schoharie grit). *Pendleton, Indiana.*

ATHYRIS DENSA, sp. nov.

PLATE XLVI, FIGS. 6-12

Shell transversely elongate, valves compressed: median fold and sinus not conspicuously developed. Pedicle-valve shallow, with broad, sharply angled cardinal slopes, greatly thickened interiorly. The anterior margin is frequently extended into a linguate process at the termination of the median sinus. Brachial valve the more convex, with an indistinct, flattened, and sometimes broadly grooved median fold with regular and even lateral slopes. In the interior of the valves the form of the muscular scars is normal, though there is a notable variation in the size of the diductor scars.

St. Louis group. *Washington county, Indiana; Colesburgh, Kentucky.*

SEMINULA DAWSONI, sp. nov.

PLATE XLVII, FIGS. 32-34.

(See pages 95, 96.)

This species was originally identified as *Athyris subtilita*, Hall, by DAVIDSON (Quarterly Journal of the Geological Society of London, vol. xix, 1863). Its differences from this species are indicated on the pages referred to.

Carboniferous limestone. *Windsor, Nova Scotia.*

Meristella Walcotti, sp. nov.

PLATES XLIII, FIGS 16, 17; XLIV, FIGS 6-11, 23, 32.

Shell elongate-ovate, valves convex, regular. Pedicle-valve with umbo moderately full and beak incurved; foramen generally concealed at maturity. Cardinal slopes concave and well delimited by divergent cardinal ridges. Dorsum more or less distinctly ridged in the umbonal region, broadly convex anteriorly and slightly extended on the anterior margin, but with no median sinus. Brachial valve with the median elevation somewhat more strongly defined, especially in the umbonal region. Umbo-lateral slopes rather more abrupt than in the other valve.

Internal structure normal for the genus.

Oriskany sandstone. *Cayuga, Ontario.*

Merista Tennesseensis, sp. nov.

PLATE XLII, FIGS. 1-6.

Shell subpentahedral in outline, transverse, rarely elongate. Valves subequally convex, with broad, low fold and sinus developed on the anterior portion of the brachial and pedicle-valves respectively. Umbo of pedicle-valve not conspicuous, apex truncated at maturity by a circular foramen. Deltidial plates concealed by incurvature. Umbo of brachial valve full, apex acute. External surface smooth. Dimensions of an average example: length, 17 mm.; greatest width, 19 mm.

Upper Silurian. *Perry county, Tennessee.*

Zygospira putilla, sp. nov.

PLATE LIV, FIGS. 35-37.

Shell small, elongate-suboval in outline. Pedicle-valve the more convex; umbo narrowed, apex acute, delthyrium unclosed. Medially this valve is elevated by a strong double plication, the parts of which diverge anteriorly, leaving a flat, low depression between them, and in this lies a single faint plication. The lateral slopes are considerably depressed, and each bears from four to seven coarse, often irregular plications, only a part of them reaching the beak.

The brachial valve is depressed-convex, with a conspicuous median fold, grooved longitudinally and bounded by deep marginal depressions. The lateral slopes are more convex than on the other valve, but are similarly plicated. Surface of the valves usually without concentric growth lines.

An average example has a length of 8 mm. and a greatest width of 7 mm.

Hudson River group. *Near Edgewood, Pike county, Missouri.*

CAMAROPHORIA RHOMBOIDALIS, sp. nov.

PLATE LXII, FIGS. 25–29.

Shells of rather small size, subtriangular in outline with cardinal margins extending for half the length of the valves. Pedicle-valve with apex scarcely elevated, incurved, with deltidial plates usually concealed; slightly convex about the umbo, broadly depressed medially, forming a sinus which makes a linguiform extension on the anterior margin. This sinus may bear one and sometimes traces of two other low plications. The lateral slopes are smooth, except at the margins, where there is faint evidence of one or two plications on each. The brachial valve is convex and broadly rounded with abrupt umbo-lateral slopes; broad, low median fold, apparent only in the pallial region, and bearing a median plication. Traces of two lateral plications are visible at the margin of the valve, and these are somewhat more distinct on the surface than on the opposite valve. Surface smooth or with fine concentric lines. The interior structure of the shell is normal for this genus.

Corniferous limestone. *Cass county, Indiana.*

PARASTROPHIA DIVERGENS, sp. nov.

PLATE LXIII, FIGS. 4-7.

Shell of medium size with strongly convex brachial valve and depressed convex, anteriorly concave pedicle-valve. The beak of the pedicle-valve is erect, but not conspicuous; from the gently convex umbo the surface slopes gradually to the lateral margins, and abruptly to the front, forming a broad and deep sinus, which is sharply defined at the sides, and bears from two to four angular plications. Two or more smaller plications occur on each lateral slope.

The brachial valve is well rounded in the umbonal region, but the median fold is defined only near the anterior margin. It bears from three to five plications, with three on each lateral slope. All the plications, as well as fold and sinus, become obsolete in the umbonal region, and in old and thickened shells the latter can be distinguished only at the anterior margins of the valves. In the interior there is a supported spondylium in the pedicle-valve, but in the brachial valve the septal plates do not unite.

Hudson River group. *Wilmington, Illinois.*

Parastrophia Greenii, sp. nov.

PLATE LXIII, FIGS. 17-20, 22.

Shell robust, with convex brachial valve and shallow pedicle-valve, convex in the umbonal region, but concave anteriorly. Beaks not prominent; that of the pedicle-valve low but erect; that of the brachial valve full and incurved. Cardinal slopes sharply defined on pedicle-valve. Median fold and sinus on brachial and pedicle-valves not strongly defined except at the anterior margin. The brachial valve bears six broadly rounded plications which are obsolete in the umbonal region; four of these belong to the median fold, the other two to the lateral slopes. The pedicle-valve has five plications, with three in the median sinus. Interior with a median supporting septum in each valve.

Niagara dolomites. *Near Milwaukee, Wisconsin.*

Parastrophia multiplicata, sp. nov.

PLATE LXIII, FIGS. 15, 16, 21.

This species differs from *P. Greenii* in its more conspicuously developed median fold and sinus, flatter and larger plications, and the greater number of the latter on the lateral slopes. The usually sessile spondylium of the brachial valve may also prove a distinguishing feature.

Niagara dolomites. *Near Milwaukee, Wisconsin.*

PARASTROPHIA LATIPLICATA, sp. nov.

PLATE LXIII FIGS. 23-27.

This species is distinguished from the two preceding by its smaller size, less robust form, two broad plications on the fold and one in the sinus, with but a single pair on the lateral slopes.

Niagara dolomites. *Near Milwaukee, Wisconsin.*

LIORHYNCHUS LESLEYI, sp. nov.

PLATE LIX, FIGS. 34-36.

Shell of medium size with shallow pedicle-, and deep brachial valve. Median sinus on the former well defined; median fold on the latter broad and not sharply delimited. Surface of both valves sharply and abundantly plicated.

Upper Devonian. *Pennsylvania.*

BARRANDELLA AREYI, sp. nov.

PLATE LXXI, FIGS. 14-16.

Shell small, ventricose, with sinus on the pedicle-valve and fold on the brachial valve. Surface on both valves rather sharply and coarsely plicated, the largest plication being in the median sinus, with traces of finer ones on the slopes of the sinus. The median fold bears two well-defined plications with faint traces of others, while on each lateral slope of the valves there are four or five less sharply angular ribs.

Clinton group. *Rochester, N. Y.*

CONCHIDIUM GREENII, sp. nov.

PLATE LXVI, FIGS. 20-22.

Shell subequally biconvex, ventricose, subcircular in marginal outline. Umbones full and rounded, both incurved, that of the pedicle-valve somewhat elevated. There is no evidence of median fold and sinus. Surface of each valve bearing, over the pallial region, from forty-five to fifty rounded plications, which very gradually increase by implantation and become more numerous anteriorly. These plications are of slightly unequal size, which appears to be due to variation in the rate of their multiplication. In the umbonal regions the plications are obsolete.

Niagara dolomites. *Near Milwaukee, Wisconsin.*

CONCHIDIUM CRASSIPLICA, sp. nov.

PLATE LXVI, FIGS. 21, 25.

Shell elongate, subelliptical in outline. Valves subequally convex, depressed above; cardinal slopes broad and abrupt on both. Umbo of the pedicle-valve erect, not prominent; surface slightly elevated medially. Umbo of brachial valve depressed, apex concealed; median region depressed anteriorly; surface of both valves bearing broad rounded plications, separated by deep grooves. Of these plications there are from eight to ten on each valve over the pallial region; by dichotomizing these become more numerous anteriorly.

Niagara group. *Near Louisville, Kentucky.*

CONCHIDIUM GEORGIÆ, sp. nov.

PLATE LXVI, FIGS. 18, 19

Pedicle-valve unknown; brachial valve trilobed by the development of a strong median fold which extends from apex to margin, and is sharply delimited by abrupt lateral slopes. The sides of the valve are convex, rather narrow, and slope abruptly to the lateral margins. Umbo full and incurved. Surface covered with numerous duplicating plications, of which from fifteen to twenty may be counted on each side at the margins, and twelve to fourteen in the fold.

Clinton group. *Trenton, Georgia.*

CAPELLINIA MIRA, sp. nov.

PLATE LXX, FIGS. 6-14.

(See pages 248, 249.)

Selenella gracilis, sp. nov.

(See page 270, figs. 184–186.)

Oriskania navicella, sp. nov.

PLATE LXXIX, FIGS. 25-27.

(See pages 269, 270, figs. 181–183.)

Rensselæria Cayuga, sp. nov.

PLATE LXXV, FIGS. 1, 2.

Shell lenticular, often of large size; suboval in marginal outline. Valves subequally biçonvex, sloping regularly in all directions. Apex of the pedicle-valve scarcely prominent; umbo not conspicuous, somewhat elevated medially. Divergent cardinal ridges and cardinal slopes well defined. Brachial valve with apex depressed and concealed; somewhat less convex in the umbonal region than the opposite valve. Surface of both valves covered with a great number of fine, simple, thread-like, rarely duplicating plications, of which from seventy to one hundred may be counted on each valve near the anterior margin.

Oriskany sandstone. *Cayuga, Ontario.*

Bœcheria Davidsoni, nom. nov.

PLATE LXXIX, FIGS. 33-36.

(See page 300, fig. 224.)

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TO

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I. Register of Authors' Names.

(These references do not include names used in association with specific designations.)

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II. Register of Genera.

(Names in *italics* are synonyms; figures in FULL-FACE type denote place of description.)

III. Register of Species.

(Names in *italics* are synonyms; figures in FULL-FACE type after new species denote the place of description.)

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PLATES AND EXPLANATIONS.

PLATE XXI.

(Figures 1-29 by R. P. WHITFIELD.)

Legend : Δ. Delthyrium.
D. Deltidium.
t. Teeth.
d. Dental plates.
j. Cardinal process
b. Dental sockets.
c. Crura.
s. Median septum.
s′. Callosity in the delthyrium.
x. Crural ridges.
r. Diductor scars.

GENUS SPIRIFER, SOWERBY.

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SPIRIFER NIAGARENSIS, Conrad.

Fig. 1. A medium sized specimen; showing the radiate-lineate exterior.
Fig. 2. The interior of the cardinal portion of a brachial valve; showing the crural plates.
Fig. 3. A portion of the interior of the pedicle-valve; showing the elongate muscular area.
Fig. 4. The median portion of the cardinal areas of conjoined valves; showing the deltidium, cardinal process and crural plates. × 3.
Fig. 25. The surface characters. × 5.
Niagara group. *Lockport, N. Y.*

SPIRIFER PLICATELLUS, Linné.

Figs. 6-8. Figures of typical specimens of this form; the first from Sweden, the other from the Island of Gotland. Figure 28 is an enlargement of the surface of the latter.

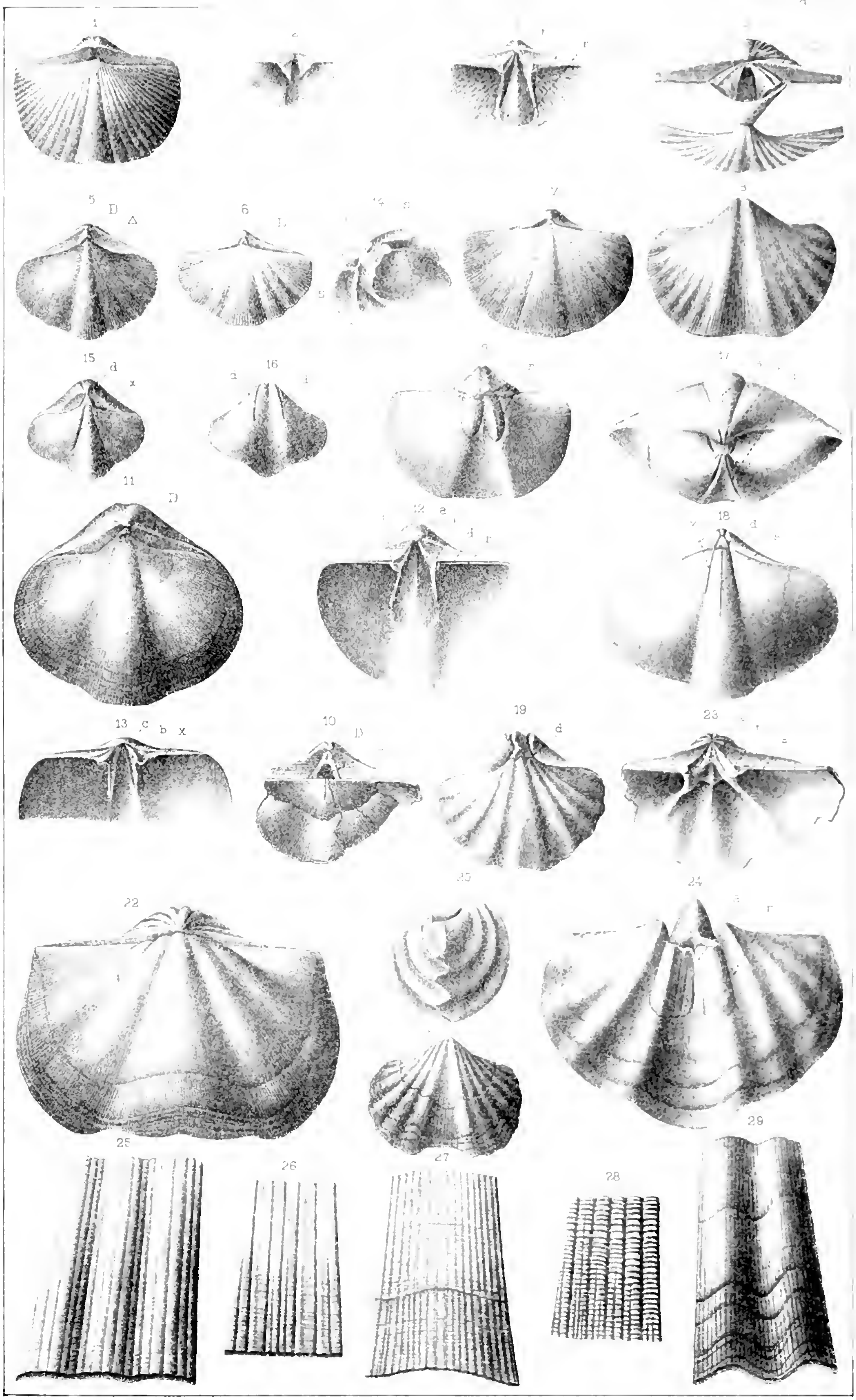
SPIRIFER RADIATUS, Sowerby.

Fig. 5. A small individual with a few low lateral plications. This is, apparently, one of the passage forms between the typical *S. plicatellus* and the non-plicate *S. radiatus*. Distinction between the two forms is not possible among American shells.
Niagara group. *Locality?*
Fig. 9. A partial cast of the interior; showing the diductor scars.
Fig. 10. A cardinal view of a specimen partially retaining the deltidium.
Niagara group. *Western New York.*
Fig. 11. A typical non-plicate adult retaining the deltidium.
Fig. 12. The interior of the pedicle-valve; showing teeth and muscular scars.
Fig. 13. The interior of the cardinal portion of the brachial valve; showing the dental sockets and crural plates.
Fig. 26. An enlargement of the surface characters.
Niagara group. *Waldron, Indiana.*

SPIRIFER RADIATUS, Sowerby (?).

Figs. 15, 16. Opposite sides of an internal cast of both valves; showing the elevated cardinal area, and impressions of the long dental plates in figure 16.
Figs. 17, 18. Two views of a larger internal cast; showing the elevated area, and faint median ridge on the brachial valve.
Fig. 14. The interior of a portion of the conjoined valves; showing a low median septum in the brachial valve.
Niagara dolomites. *Wisconsin.*

This shell is narrower on the lateral slopes than the more typical forms of *S. radiatus*, and differs from them internally in the presence of the slight median septum in the brachial valve.


1
5 D Δ
6
7
15 d x
16
11 D
12
18 d
13 c b x
10 D
19 d
23
22
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24
25
26
27
28
29

GENUS SPIRIFER, SOWERBY.

Page 1.

SPIRIFER EUDORA, Hall.

Fig. 19. An internal cast; showing the impressions of the dental plates.
Fig. 20. A profile of the same.

Niagara group. *Racine, Wisconsin.*

Fig. 21. The exterior of the pedicle-valve; showing the lineate surface.
Fig. 29. An enlargement of the surface of the same specimen.

Niagara group. *Waldron, Indiana.*

SPIRIFER MACROPLEURA, Conrad.

Fig. 22. A dorsal view of a normal, mature individual; showing the surface characters.

Lower Helderberg group. *Schoharie, N. Y.*

Fig. 27. An enlargement of the surface of the same specimen.
Fig. 23. The interior of a portion of the pedicle-valve; showing the callosity of the delthyrium.
Fig. 24. An internal cast of the pedicle-valve; showing the impressions of the pedicle, adductor and diductor muscles.

Lower Helderberg group. *The Helderbergs, N. Y.*

PLATE XXII.

(Figures 1-7, 9-14, 17, 18, 22-24 by R. P. WHITFIELD, 8, 15, 16, 19-21 by F. B. MEEK.)

Legend: A. Cardinal area, pedicle-valve.
t. Teeth.
s. Median ridge.
s′, s″. Callosity in delthyrium.
r. Diductor scars.
c′. Socket-walls.
j. Cardinal process.
b. Dental sockets.

GENUS SPIRIFER, SOWERBY.

Page 1.

SPIRIFER OWENI, Hall.

Fig. 1. Dorsal view of a normal adult.

Fig. 2. A profile of the same.

Fig. 3. The interior of the cardinal portion of a brachial valve; showing the dental sockets and socket-walls.

Fig. 4. A portion of the interior of the pedicle-valve; showing the apical callosity, and the scar of the diductor muscles.

Fig. 5. A corresponding portion of a smaller shell of this species.

Fig. 6. The interior of the cardinal portion of two valves in articulation, the pedicle-valve lying beneath.

Fig. 7. An enlargement of the surface from a worn specimen.

Hamilton group. *Clarke county, Indiana.*

SPIRIFER PARRYANUS, Hall.

Fig. 8. The usual form of the shell; the cardinal area being foreshortened.

Fig. 9. An enlargement of the surface characters.

Limestones of the Hamilton group. *Davenport, Iowa.*

Figs. 15, 16. Two views of an internal cast. This is the condition of the shell which has been known as *S. capax*, Hall.

Fig. 17. An enlargement of surface striæ, in a worn specimen.

Sandstones of the Hamilton group. *Mouth of Pine Creek, Iowa.*

SPIRIFER MARCYI, Hall.

Fig. 10. A normal individual, from which the cardinal extremities have been broken.

Fig. 11. A cardinal view of the same example.

Fig. 12. The interior of a brachial valve; showing the articulating apparatus.

Fig. 13. The interior of a fractured and incomplete portion of the pedicle-valve.

Fig. 14. An enlargement of the surface; showing the elongate, lachrymiform pustules.

Hamilton group. *Genesee county, N. Y.*

SPIRIFER TULLIUS, Hall.

Fig. 18. The exterior of a pedicle-valve.

Hamilton shales. *Onondaga county, N. Y.*

SPIRIFER LIGUS (= SPIRIFER PENNATUS), Owen.

Fig. 19. An adult individual; showing normal characters.

Fig. 20. A smaller individual.

Fig. 21. Cardinal views of articulated valves.

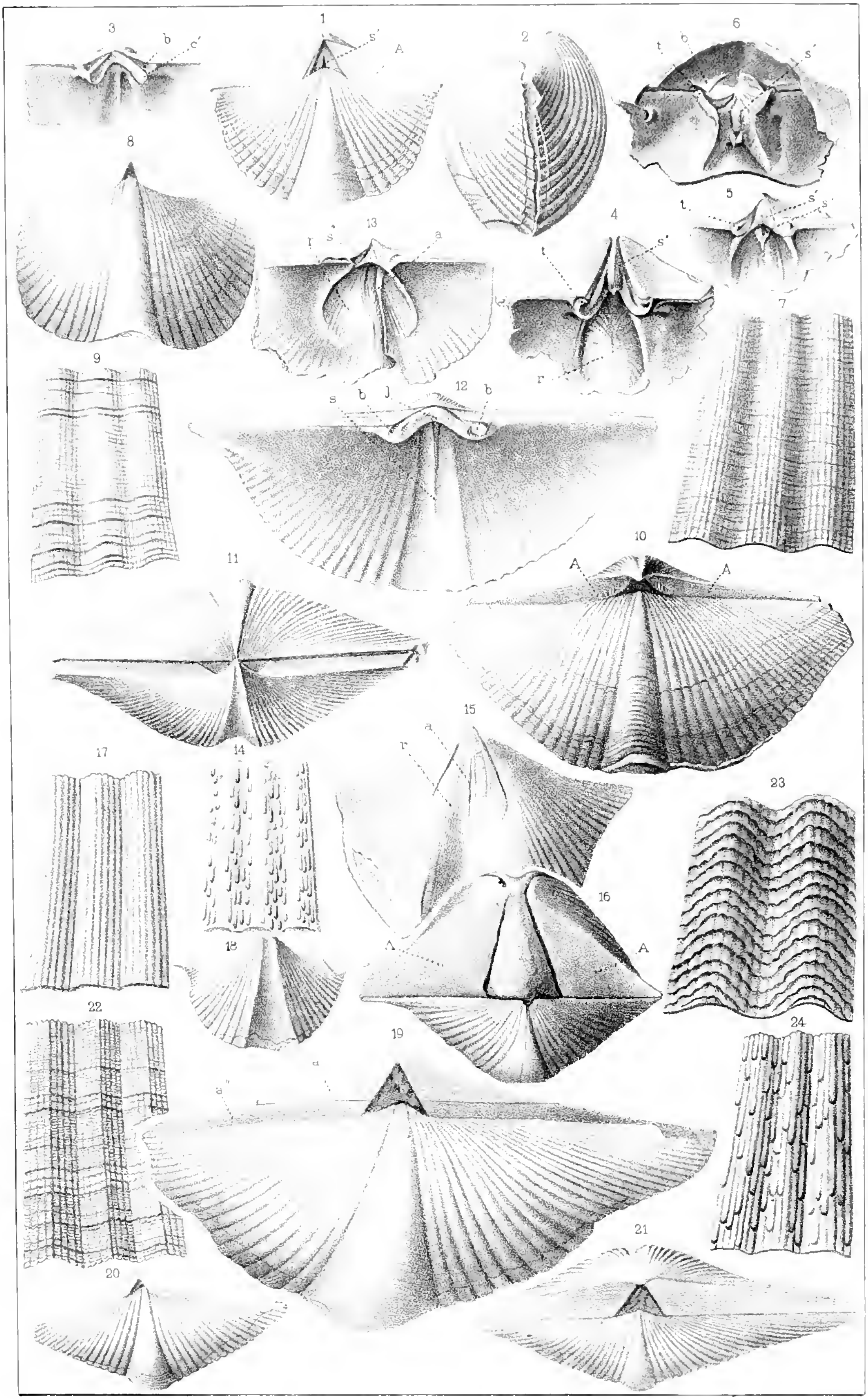
Figs. 22-24. Enlargements of the surface, in different conditions of preservation. Figs. 22 and 24, × 5; fig. 23 a higher enlargement from a portion of fig. 22, in which the fine radiating surface lines are lost.

Hamilton group. *New Buffalo and Independence, Iowa.*

BRACHIOPODA.

Spiriferidæ

Generic Illustrations



R. P. Whitfield.   H. Bergman lith.

PLATE XXIII.

(Figures 1-18 by R. P. WHITFIELD.)

Legend:
A. Cardinal area, pedicle-valve.
a′. Inner division, pedicle-valve.
a″. Outer division, pedicle-valve.
F. Delthyrium.
s′. Apical callosity.
d. Dental lamellæ.
x. Pedicle-cavity.
x′. Muscular cavity.
r. Diductor scars.
j. Cardinal process.
b. Dental sockets.
a. Anterior adductors.
a′. Posterior adductors.

GENUS SPIRIFER, SOWERBY.

Page 1.

SPIRIFER GRANULOSUS, Conrad.

Fig. 1. Dorsal view of a normal adult, retaining the shell.

Fig. 2. The interior of a pedicle-valve; showing the apical callosity in the delthyrium and the character of the muscular area.

Fig. 3. The interior of a brachial valve; showing the articulating apparatus and muscular area.

Fig. 4. An enlargement of the surface; showing the papillose character of the shell.

Fig. 5. The central portion of a cast of the brachial valve; showing the striated cardinal process and the two pairs of adductor scars. × 2.

Fig. 6. A similar view of another specimen.

Fig. 7. A cast of the muscular area of the pedicle-valve with the muscular impression unusually elongate.

Fig. 8. A similar view of a larger specimen.

Fig. 9. Another view of the same parts, the muscular area being proportionally shorter and smaller than in the preceding figure.

Fig. 10. A view of the same characters in another example. All these specimens show variations in the form of the muscular area, the size of the adductor scars as well as different degrees of development of the callosity of the delthyrium.

Fig. 11. A portion of the muscular area of the pedicle-valve; showing its surface markings and the distinction between the diductor and adductor scars. × 2.

Fig. 12. A profile of an internal cast of the pedicle-valve; showing the filling of the rostral and muscular cavities.

Fig. 13. Similar cast of another pedicle-valve with a more elevated muscular impression.

Fig. 14. An enlargement of a partly exfoliated surface.

Hamilton shales. *Western New York.*

Fig. 15. An enlargement of a worn surface. The coarse punctations are not structural but probably due to some boring sponge.

Hamilton group. *Cumberland, Maryland.*

SPIRIFER MACROTHYRIS, Hall.

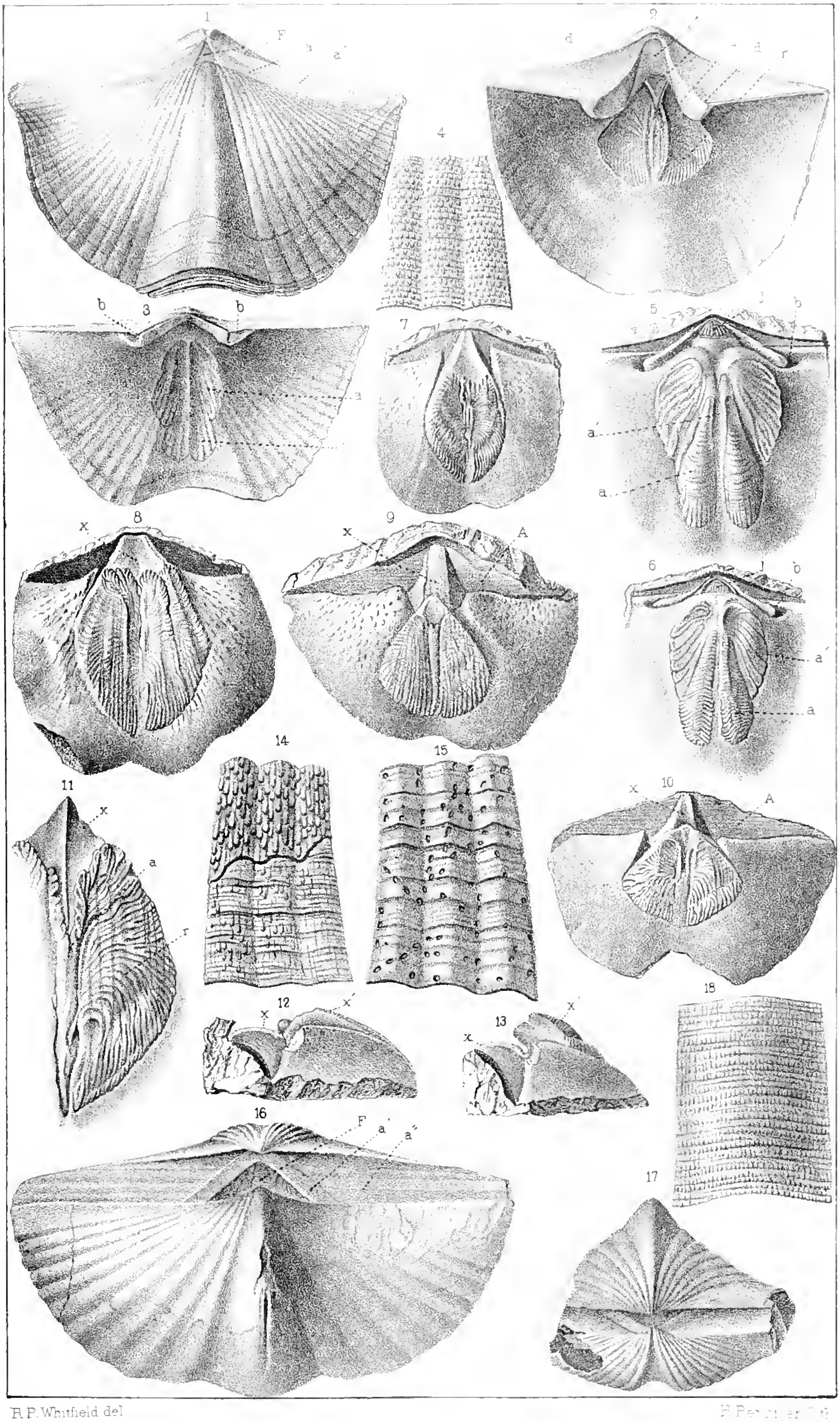
Fig. 16. The exterior of a full-grown individual.

Fig. 17. A cardinal view of an imperfect specimen; showing the elevation of the valves.

Fig. 18. An enlargement of the surface; showing the crenulate margins of the concentric lamellæ.

Corniferous limestone. *Near Columbus, Ohio.*

Generic Illustrations



R.P. Whitfield del

PLATE XXIV.

(Figures 1–27 by R. P. WHITFIELD.)

Legend: Δ. Delthyrium.
D. Deltidium.
Dg. Deltidial grooves.
t. Teeth.
s′. Apical callosity.
j. Cardinal process.
b. Dental sockets.
c′. Socket-walls.
a. Anterior adductors.
a′. Posterior adductors.
r. Diductors.

GENUS SPIRIFER, SOWERBY.

Page 1.

SPIRIFER AUDACULUS, Conrad.

Fig. 1. A small individual of normal proportions.
Fig. 2. A brachial valve of an average example.
Fig. 3. The pedicle-valve of a rotund specimen.
Figs. 4, 5. Dorsal and profile views of an individual with short hinge and fewer plications.
Fig. 6. Front view of an average adult.
Fig. 7. The interior of the brachial valve; showing the articulating apparatus and muscular scars.
Fig. 8. A cardinal portion of a larger brachial valve; showing the same structures more distinctly.
Fig. 9. The interior of a pedicle-valve; showing the formation of the apical callosity, and the character of the muscular area.
Fig. 10. The central portion of the cardinal area of the pedicle-valve, retaining the remnants of the deltidial covering. × 2.
Fig. 11. A similar view of another example; showing the high development of the delthyrial callosity.
Fig. 12. A part of the brachial valve; showing the cardinal process, articulating apparatus and the character of the adductor scars. × 2.
Fig. 13. An enlargement of the external surface; showing the grooves on the summits of the plications.

Hamilton shales. *Western New York.*

SPIRIFER ANGUSTUS, Hall.

Figs. 14, 15. Dorsal and ventral views of the exterior of a rather large individual.
Fig. 16. A cardinal view of the same specimen.
Fig. 17. An enlargement of the external surface; showing the flattened plications and incipient grooves.

SPIRIFER AUDACULUS, var. MACRONOTUS, Hall.

Fig. 18. A cardinal view of a large individual which retains the deltidial covering in a broken condition.
Fig. 19. A cardinal view of a shallower, more extended individual.
Fig. 20. A profile view of the same.
Fig. 21. A view of the interior of the pedicle-valve, looking into the umbonal cavity; showing the callosity and dental plates.
Fig. 22. Central portion of the cardinal area; showing the highly developed delthyrial callosity. × 2.
Fig. 23. A similar view of another specimen in which the deltidial covering is retained in a broken condition.
Fig. 24. The interior of a part of the pedicle-valve; showing the divisions of the muscular area, and the thickened dental ridges.
Fig. 25. The interior of a similar specimen, the apex being removed to show more clearly the details of the muscular impression.
Figs. 26, 27. Enlargements of the external surface; showing characters which are often seen on the same shell.

Hamilton shales. *Western New York.*

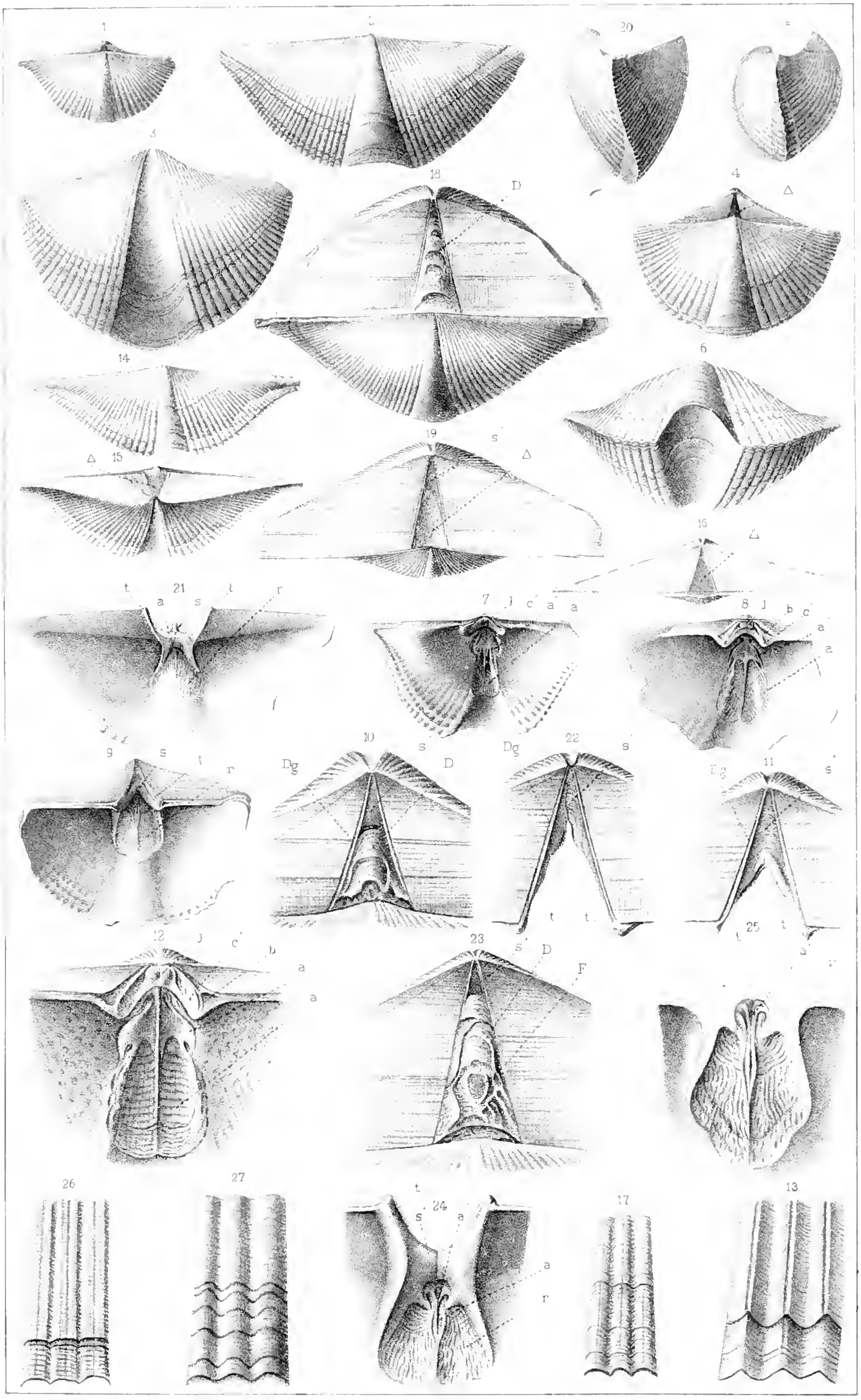


PLATE XXV.

(Figures 1-8 by F. B. MEEK; 9-16, 22-24, 26-31 by R. P. WHITFIELD; 17-21, 25, 32-35 by E. EMMONS.)

Legend : Δ. Delthyrium.
Dg. Deltidial groove.
s′. Apical callosity or tube.
s. Median septum.
d. Dental lamellæ.
j. Cardinal process.
b. Dental sockets.
c. Socket-walls.
a. Anterior adductors.
a′. Posterior adductors.

GENUS CYRTINA, DAVIDSON.

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CYRTINA ROSTRATA, Hall.

Fig. 1. A front view of a specimen somewhat below average size.
Fig. 2. A cardinal view of the same; showing the tubular edge of the median septum within the delthyrium.
Fig. 3. A brachial valve of a larger example.
Figs. 4, 5, 8. Views of an old shell, much thickened about the margins of the valves. Fig. 8 shows the edge of the median septum within the delthyrium.
Fig. 6. The interior of a brachial valve.
Fig. 7. The interior of the pedicle-valve, looking into the umbonal cavity; showing the convergent dental lamellæ, their union with the median septum, and the tubular edge of the latter.

Oriskany sandstone. *Albany county, N. Y., and Cumberland, Md.*

GENUS SPIRIFER, SOWERBY.

Page 1.

SPIRIFER MACBRIDII, Calvin.

Fig. 9. The exterior of a brachial valve.
Fig. 10. The exterior of a pedicle-valve, somewhat foreshortened; showing the faint plication in the sinus.
Fig. 11. A cardinal view; showing the elevation of the area, and the degree of development of the apical callosity.
Fig. 12. The central cardinal portion of the interior of a brachial valve; showing the articulating apparatus and the composition of the muscular area. × 2.
Fig. 13. The interior of a pedicle-valve; showing the development of the dental plates.
Fig. 14. The interior of a brachial valve retaining the spiral cones; showing their position, number of volutions and the anterior portion of the long crura.
Figs. 15, 16. Enlargements of the surface; the former from the lateral plications, the latter from the median sinus.

Hamilton group. *Rockford, Iowa.*

SPIRIFER sp., compare S. MACBRIDII, Calvin.

Figs. 17, 18. Views of the exterior of a specimen, with two low, broad plications on the median sinus, and having a somewhat different aspect than normal examples of *S. Macbridii.*
Fig. 19. An enlargement of the surface, which is covered with radiating rows of elongate pustules, distinctly coarser than in *S. Macbridii.*

Hamilton group. *Probably from the blue shales at Rock Island, Illinois.*

SPIRIFER ASPER, Hall.

Fig. 20. The front view of a normal individual.
Fig. 21. The exterior of a brachial valve.

Hamilton group. *New Buffalo, Iowa.*

Fig. 22. A pedicle-valve viewed from above.
Fig. 23. The cardinal view of a pedicle-valve with highly developed delthyrial callosity; the central extension concave on the inner side; showing the incipient stage of the canaliferous tube of SYRINGOTHYRIS.
Fig. 24. An enlargement of the surface.

Hamilton group. *Rockford, Iowa.*

Fig. 25. The exterior of a pedicle-valve, probably representing this species.

Hamilton group. *Canandaigua, N. Y.*

PLATE XXV—Continued.

GENUS CYRTIA, DALMAN.

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CYRTIA CYRTINIFORMIS, Hall and Whitfield.

Figs. 26–28. Three views of a normal example; showing the external characters.

Fig. 29. A cardinal view; showing the great height of the area. × 2.

Fig. 30. The central cardinal portion of the conjoined valves; showing the dental plates of the pedicle-valve, the cardinal process and socket-walls of the brachial valve. × 2.

Fig. 31. The interior of a portion of the brachial valve; showing the cardinal process, dental sockets and socket-walls, and the subdivision of the muscular area. × 3.

Fig. 32. A specimen, showing the crura, jugal processes and spiral cones.

Hamilton group. *Rockford, Iowa.*

GENUS SYRINGOTHYRIS, A. WINCHELL.

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SYRINGOTHYRIS HANNIBALENSIS, Swallow.

Fig. 33. The exterior of a portion of the brachial valve.

Fig. 34. A cardinal view of the pedicle-valve; showing the delthyrial callosity or canaliferous plate.

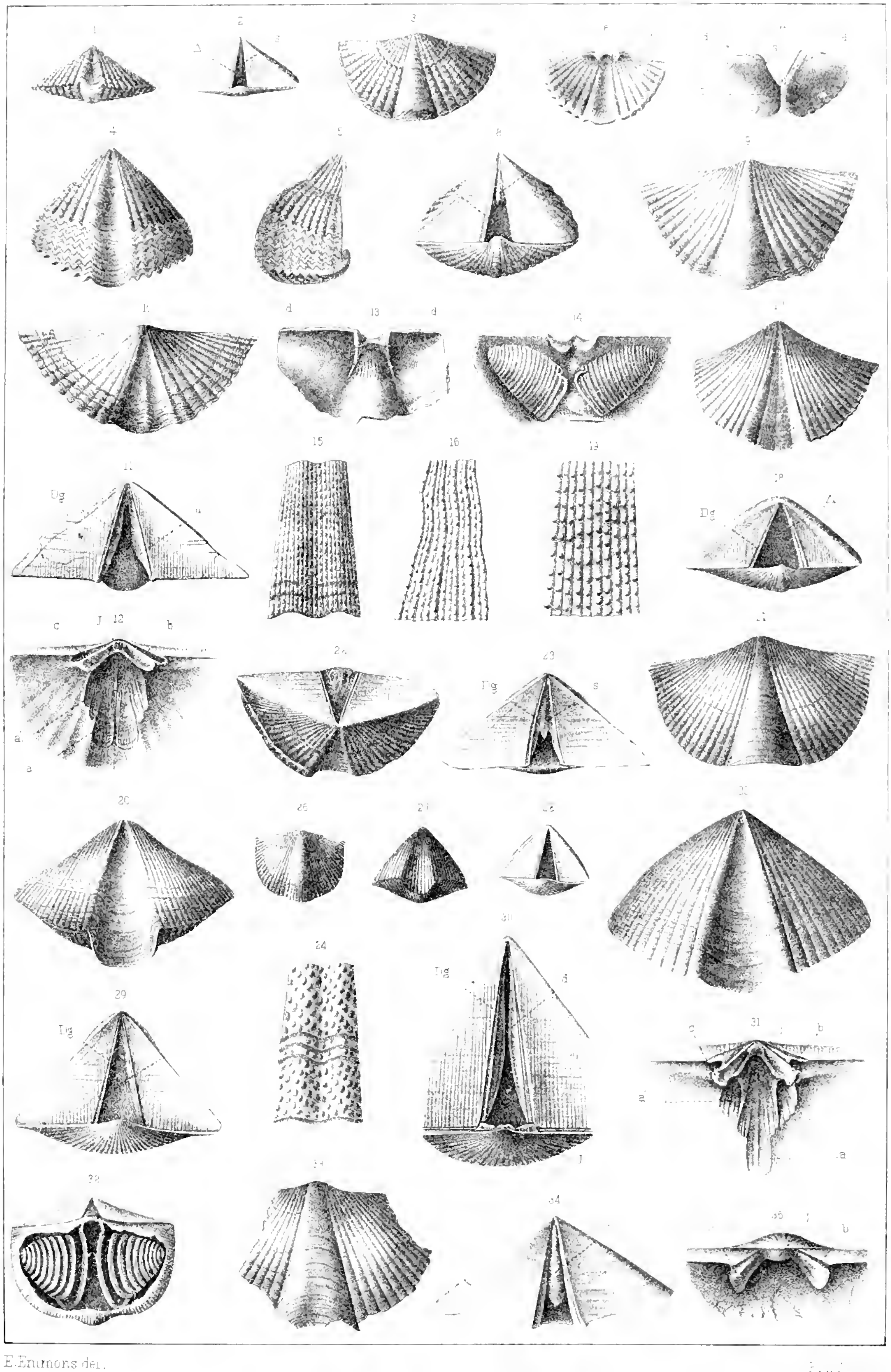
Fig. 35. The articulating apparatus of the brachial valve. × 2.

Choteau limestone. *Pike county, Missouri.*

BRACHIOPODA

Spiriferidae

Generic Illustration



E. Emmons del.

PLATE XXVI.

(Figures 1-7, 9-11 by R. P. Whitfield; 8 by F. B. Meek; 12 by E. Emmons.)

Legend: A. Cardinal area.
Δ. Delthyrium.
Dg. Deltidial grooves.
s′. Transverse delthyrial plate.
T. Tubular portion of plate.
T′. Internal cast of tube.
j. Cardinal process.
b. Dental sockets.
r. Diductor scars.
a. Adductor scars.

Genus CYRTIA, Dalman.

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Cyrtia alta, Hall.

Fig. 1. The internal cast of the brachial valve; showing the striated cardinal area, structure of the articulating apparatus and the faint plications on the median fold.

Fig. 2. The front view of an internal cast of the pedicle-valve; showing the muscular area and the faintly plicated sinus.

Fig. 3. An exterior view of the cardinal area of the pedicle valve; showing the concave plate filling the upper part of the delthyrium.

Fig. 4. A cardinal view of an internal cast of the pedicle-valve; showing the impression left by the thickened inner wall of the delthyrial plate.

Fig. 5. A portion of an internal cast of a small brachial valve retaining traces of the muscular scars.

Chemung group. *Meadville, Penn.*

Genus SYRINGOTHYRIS, A. Winchell.

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Syringothyris typa, A. Winchell.

Fig. 6. The apical portion of a pedicle-valve; showing the dental plates, the delthyrial plate, with the central tubular portion projecting beyond its broken margin.

Fig. 7. The opposite side of the same specimen; showing the extension of the canaliferous tube which is slit along its inner surface.

Fig. 10. The interior of the umbonal portion of the pedicle-valve; showing the greatly thickened tubular or canaliferous plate, not closed along its inner surface.

Burlington limestone. *Burlington, Iowa.*

Syringothyris subcuspidatus, Hall.

Fig. 8. A cardinal view of the original specimen.

Keokuk limestone. *Keokuk, Iowa.*

Fig. 11. The interior of a large pedicle-valve; showing the transverse plate and the extension of the tube.

Keokuk group. *Nauvoo, Illinois.*

Syringothyris texta, Hall.

Fig. 9. Central cardinal portion of an internal cast of the conjoined valves; showing the impressions of the cardinal process, dental plates and the filling of the tubular portion of the transverse plate.

Fig. 12. A preparation, showing the elongate spiral brachial supports, the jugal processes and a portion of the crura. (c.)

Keokuk group. *New Providence, Indiana.*

BRACHIOPODA.

Spiriferidae

Generic Illustrations

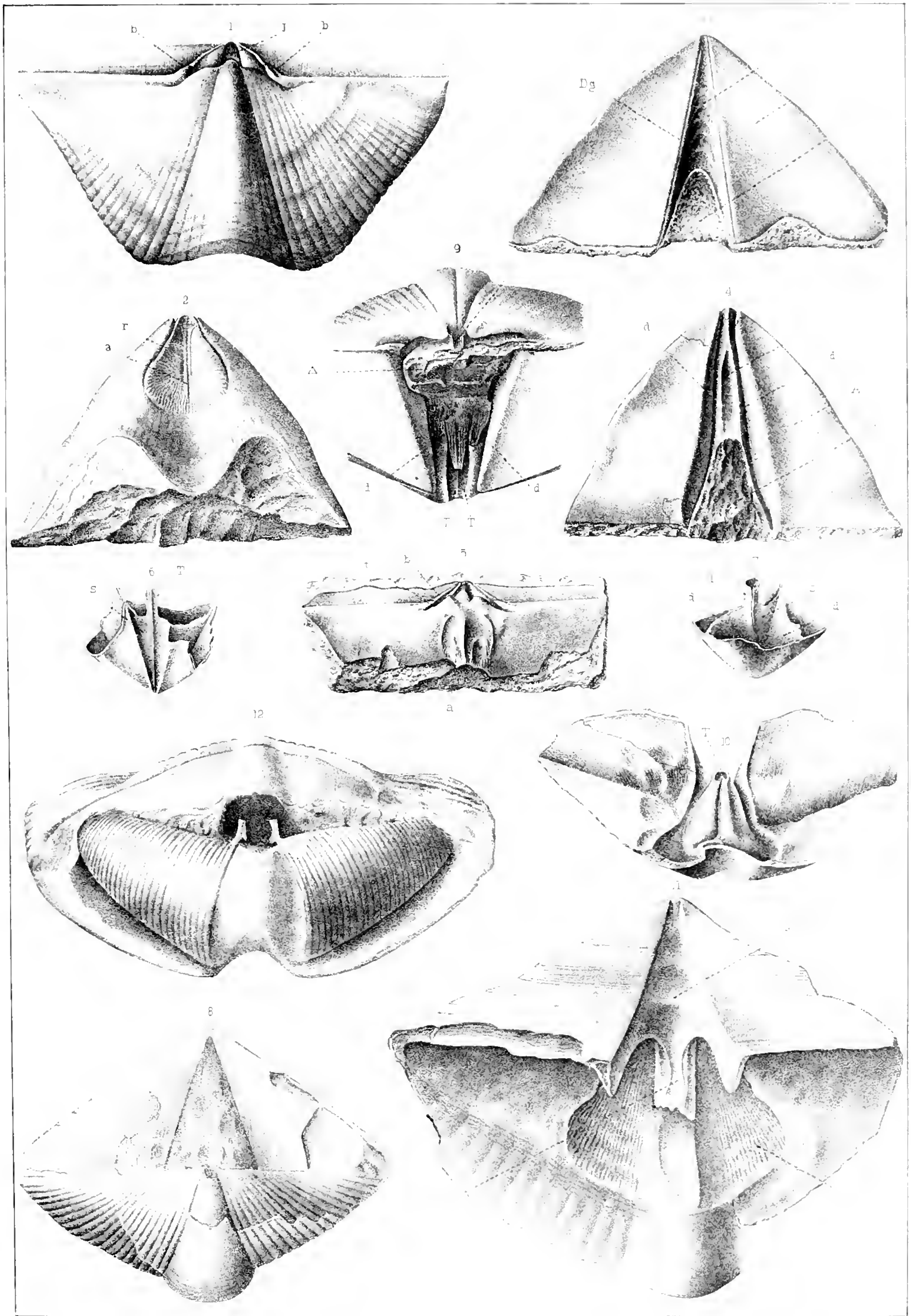

PLATE XXVII.

(Figures 1-17 by E. EMMONS; 18 by F. B. MEEK; 19, 20 by R. P. WHITFIELD.)

Legend: D. Deltidium. | d. Dental plates.
s'. Transverse delthyrial plate. | a. Adductor scars.
T. Tubular portion of plate. | r. Diductor scars.

GENUS SYRINGOTHYRIS, A. WINCHELL.

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SYRINGOTHYRIS TYPA, A. Winchell.

See Plate 26.

Figs. 1, 2. Cardinal and ventral views of one of the original specimens; showing the normal form of the species.

Fig. 3. A portion of the umbonal region of the pedicle-valve; showing the dental plates and tubular transverse plate.

Burlington limestone.

SYRINGOTHYRIS TEXTA, Hall.

See Plate 26.

Fig. 4. The exterior of a large brachial valve; showing the prevailing extended form of the shell.

Fig. 5. An internal cast of the pedicle-valve; showing the impressions of the adductor and diductor scars.

Fig. 6. The cardinal view of a specimen retaining both valves, and showing the usual elevation of the area.

Fig. 7. The central cardinal portion of the pedicle-valve; showing the transverse delthyrial plate and the free, completed extremity of the tube which is elsewhere adherent to the inner surface of the plate. × 2.

Fig. 8. A transverse section of the pedicle-valve a short distance below the apex; showing the dental lamellæ resting on the bottom of the valve, the transverse plate and the adherent tube on the inner side.

Fig. 9. A section of the same valve nearer the hinge and below the edge of the transverse plate. The free portion of the tube is seen to be open on the inner side.

Fig. 10. A longitudinal axial section of conjoined valves; showing the extent of the internal tubular plate. The portion marked *s'* is the deltidial covering and is represented incorrectly, as it extends for only about two-thirds of the distance from the apex to the cardinal process of the brachial valve.

Fig. 11. A transverse section; showing the form and extent of the spiral cones.

Fig. 12. An enlargement of the shell-structure; showing the minute, distant pores scattered among the fibers.

Keokuk group. *New Providence, Indiana.*

SYRINGOTHYRIS RANDALLI, Simpson.

Fig. 13. A cardinal view of an internal cast; showing the position of the deltidial covering, and the tubular extension of the apical plate.

Fig. 14. An internal cast of the pedicle-valve; showing the adductor and diductor scars.

Fig. 15. A cardinal view of a specimen retaining the convex deltidial covering.

Fig. 17. A cardinal view of the specimen represented in fig. 14; showing the position of the deltidial covering and of the internal split tube.

Fig. 16. A similar view of another specimen, in which the cast of the tubular plate is concealed by the upward projection of the filling of the delthyrial cavity. The position of the deltidial covering is not defined with sufficient distinctness in the figure.

Waverly group. *Warren, Penn.*

PLATE XXVII—Continued.

SYRINGOTHYRIS SUBCUSPIDATUS, Hall.

See Plate 26.

Fig. 18. A front view of the pedicle-valve; showing its exterior and elevation, with the baso-lateral margins of the brachial valve.

Keokuk group. *Keokuk, Iowa.*

GENUS SPIRIFER, SOWERBY.

Page 1.

SPIRIFER WORTHENI, Hall.

Fig. 19. A view of the original specimen.

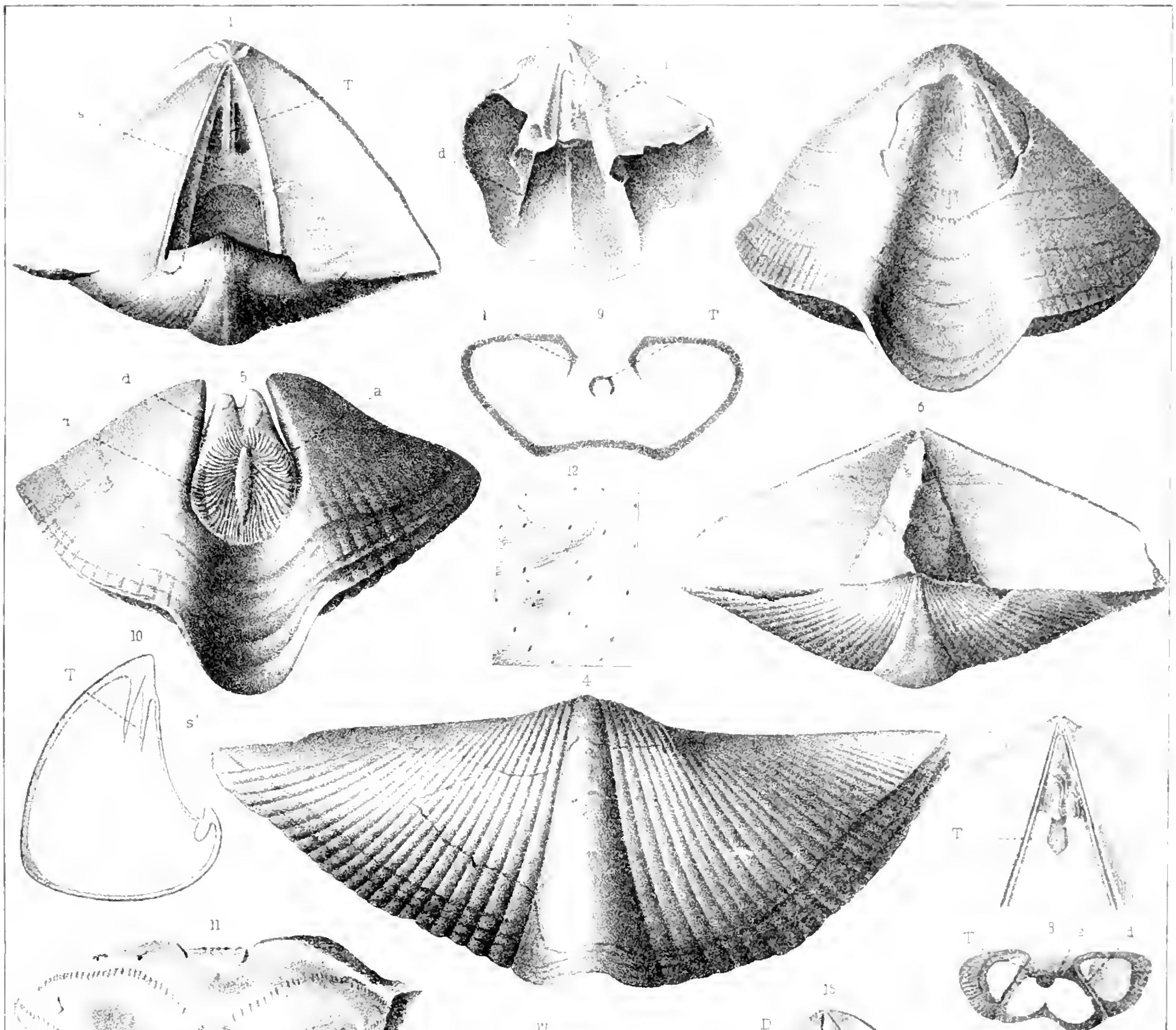
Fig. 20. An enlargement of the external surface of the shell.

Upper Helderberg group. *Near Hamburg, Illinois.*

BRACHIOPODA

Spiriferidae

Generic Illustrations



E. Emmons

PLATE XXVIII.

(Figures 1, 48, 49 copies; 2-5, 8-13, 15, 21-29, 31-33, 43, 50, 52 by R. P. Whitfield; 6, 7, 14, 16-20, 30, 34-42, 44-47, 51, 53, 54 by E. Emmons.

Legend: D. Deltidium.
F. Foramen.
d. Dental lamellæ.
s. Median septum.
s′. Callosity in delthyrium.
T. Tubular edge of the median septum.
j. Cardinal process.
b. Dental sockets.
c. Socket-walls.

Genus CYRTIA, Dalman.

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Cyrtia exporrecta, Wahlenberg.

Fig. 1. The exterior of a normal example. (After Davidson.)'

Figs. 48, 49. (On bottom line of plate.) Enlarged views; showing the deltidial covering, foramen and elongate foraminal groove. In fig. 49 the foramen has been normally or casually closed. (After Davidson.)

Fig. 51. Transverse section of the umbonal region; showing the dental lamellæ resting on the bottom of the valve and the thickening at their union with the deltidial covering.
Wenlock limestone. *England.*

Cyrtia exporrecta, Wahlenberg, var. arrecta, Hall and Whitfield.

Figs. 2, 3. Cardinal and profile views of the original specimen.
Niagara group. *Louisville, Kentucky.*

Cyrtia radians, sp. nov.

See Plate 21.

Figs. 4, 5. Cardinal and front views of a small example; showing the finely radiate-lineate exterior.

Figs. 50, 52. (On bottom line of plate.) The central cardinal area of two examples; showing the direct, circular foramen and the elongate foraminal groove. × 3.
Clinton group. *Rochester, N. Y.*

Genus CYRTINA, Davidson.

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Cyrtina rostrata, Hall.

See Plate 25.

Fig. 6. The interior of a pedicle-valve; showing the junction of the dental lamellæ with the median septum.
Oriskany sandstone. *Cumberland, Maryland.*

Cyrtina biplicata, Hall.

Fig. 7. A view of the pedicle-valve of a silicified internal cast; showing a portion of one of the spirals.
Corniferous limestone. *Drift at Ann Harbor, Michigan.*

Fig. 8. A cardinal view of conjoined valves; showing the imperforate deltidium.

Figs. 9, 10. Front and dorsal views of the same specimen.
Schoharie grit. *Schoharie, N. Y.*

Cyrtina curvilineata, White.

Fig. 11. A view of a large specimen; showing the plicated median fold of the brachial valve, and the distorted umbo of the opposite valve.

Fig. 12. A profile of the same specimen.

Cyrtina crassa, Hall.

Figs. 13, 15. Two views of the exterior of a large individual.
Corniferous limestone. *Phelps, N. Y.*

Fig. 14. A cardinal view of a smaller individual, somewhat restored at the apex; showing the imperforate deltidial covering and the irregular growth of the shell at the cardinal extremities.
Corniferous limestone. *Canandaigua, N. Y.*

Cyrtina umbonata, Hall, var. Alpenensis, var. nov.

Figs. 16, 17. Views of an individual of normal size at this locality, but much larger and more freely plicated than the Iowa forms of *C. umbonata.*

Fig. 18. The conjoined valves split along the median septum; showing the extreme anterior extension of the latter, its acute anterior extremity, and the penetration of its median edge beyond the base of the dental lamellæ.

Fig. 19. Lateral view; showing the form of the spiral cone, its extension into the cavity divided by the median septum, and the projection of the loop downward and toward the brachial valve. × 2¼. (c.)

Fig. 20. Front view of a preparation; showing the normal shape of the spiral cones, which are somewhat constricted at their bases, expand for about one-half their length and thence taper very gradually, terminating in blunt extremities. The form of the crura and loop is also shown. × 1½. (c.)
Hamilton group. *Alpena, Michigan.*

Cyrtina Hamiltonensis, Hall, var. recta, Hall.

Figs. 21, 22. Views of a normal example; showing the high, erect cardinal area.
Hamilton group. *Western New York.*

Cyrtina Hamiltonensis, Hall.

Fig. 23. Axial section of the combined valves; showing the form of the median septum and the supported dental plate.

Fig. 24. An individual sectioned transversely at about the middle of the cardinal area; showing the relations of the deltidial covering, dental plates, median septum and spiral cones.

Fig. 25. A cardinal view of an internal cast of conjoined valves.

Fig. 26. The interior of a brachial valve; showing cardinal process, socket-walls and muscular impression.

Fig. 27. The exterior of a pedicle-valve with slightly distorted umbo.

Fig. 28. Opposite side of the same specimen; showing the elongate foramen on the deltidial plate.

Fig. 29. An internal cast of the pedicle-valve; showing the position of the median septum.

Fig. 30. A preparation, showing the position of the spiral cones in the pedicle-valve. × 2. (c.)
Hamilton group. *Localities in Western New York and Ontario.*

Fig. 31. Cardinal view of a specimen in which the spirals have been partially silicified. × 2.
Corniferous limestone. *Falls of the Ohio.*

Fig. 32. An internal cast of the brachial valve; showing the adductor scars.

Fig. 33. Enlargement of the articulating apparatus of the brachial valve; showing cardinal process, dental sockets and socket-walls.
Hamilton group. *Western New York.*

Fig. 43. An enlargement of the external surface; showing the fine pustules.

Fig. 45. An enlargement of the shell structure; showing the punctæ of various sizes, penetrating the fibrous layers.

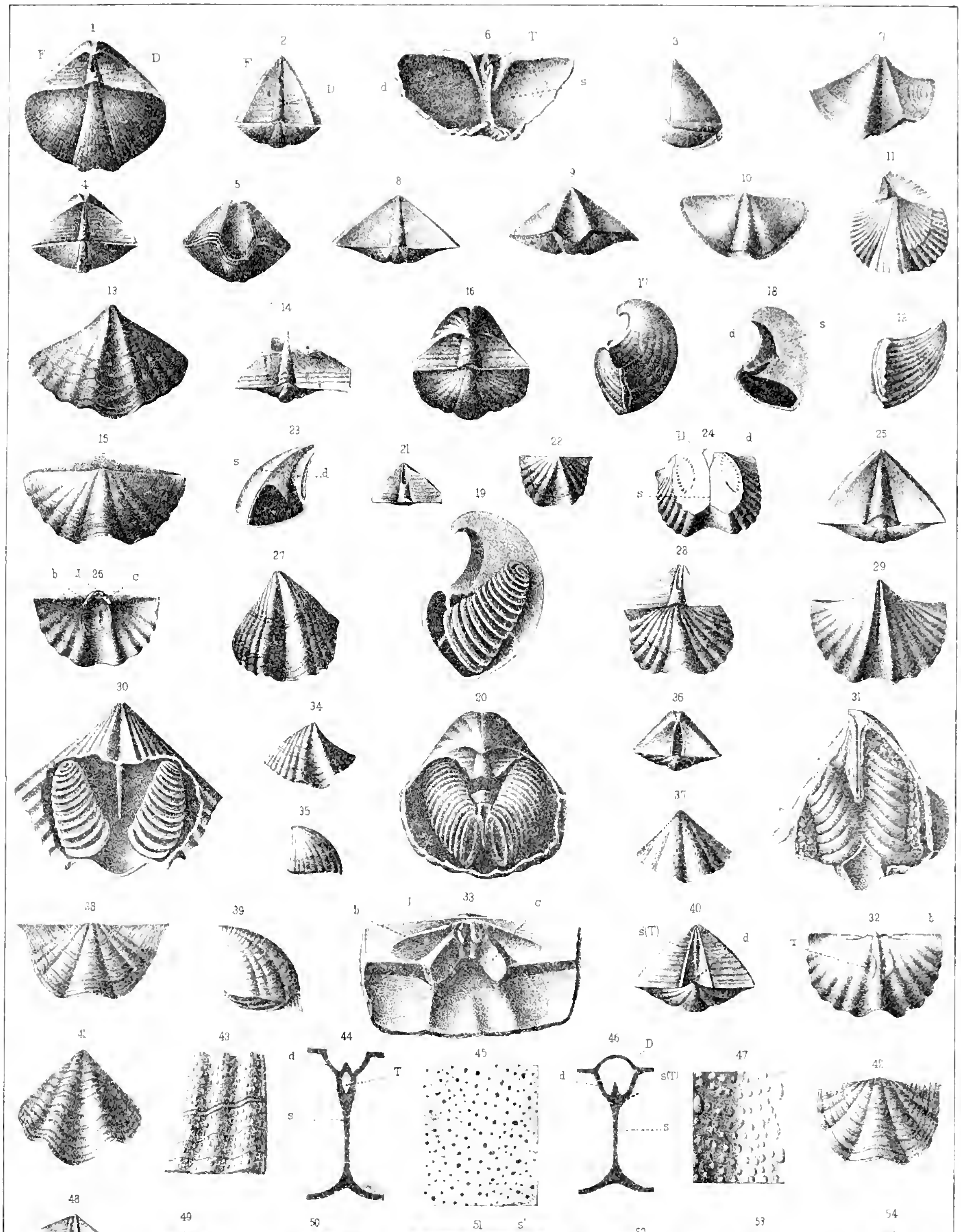
Fig. 46. A portion of a transverse section of the umbonal region; showing the deltidial covering, and the thickened dental lamellæ at their union with the median septum, the edge of the latter extending into the deltidial cavity. × 3.

Fig. 53. The deltidial portion of the pedicle-valve enlarged; showing the elongate foraminal aperture and the fine cross striation of the deltidial covering. × 3.
Hamilton group. *Widder, Ontario.*

BRACHIOPODA.

Spiriferinæ

Generic Illustrations



E. Emmons del.

PLATE XXVIII—Continued.

Cyrtina triquetra, Hall.

Figs. 34, 35. Views of an average specimen; showing curvature of the umbo and height of the cardinal area. × 2.

Hamilton group. *Rock Island, Illinois.*

Cyrtina lachrymosa, sp. nov.

Figs. 36, 37. Views of an average example; showing the regular, slightly incurved cardinal area, and the sparsely pustulose exterior. × 2.

Fig. 47. An enlargement of the exterior; showing the large pustules of various sizes. × 5.

Waverly group. *Richfield, Ohio.*

Cyrtina acutirostris, Shumard.

Fig. 38. An exterior of a brachial valve, unusually extended on the hinge. × 2.

Figs. 39-42. Views of a normal example; showing the high, incurved cardinal area in figures 39 and 40, and the strongly lamellose or squamous exterior of the valves in figures 41 and 42. × 2.

Fig. 44. A portion of a transverse section of the umbonal region of a specimen in which the deltidial covering is lacking; showing the cavity or tube formed at the union of the dental lamellæ with the median septum. × 3.

Fig. 54. The deltidial portion of the pedicle-valve, in which but a part of the deltidial covering is retained; showing the edge of the median septum penetrating the deltidial cavity. × 3.

Choteau limestone. *Pike county, Missouri.*

PLATE XXIX.

(Figures 1-5, 7-17 by E. EMMONS; 6 by R. P WHITFIELD.)

GENUS SPIRIFER, SOWERBY.

Page 1.

SPIRIFER ARENOSUS, Conrad.

Fig. 1. An individual with most of the brachial valve removed; showing the brachial cones encrusted with silica.

Fig. 2. An internal silicious cast from which the calcareous spiral ribbon has been naturally removed, exhibiting the casts of the conical cavities.

Fig. 3. A silicified specimen; showing a portion of the spiral cones.

Fig. 4. A larger example, slightly reconstructed from a silicified interior; showing the long crura, the disconnected jugal processes, the form of the primary lamellæ and the shape and direction of the cones.

Oriskany sandstone. *Cumberland, Maryland.*

SPIRIFER AUDACULUS, Conrad.

See Plate 24.

Fig. 5. A preparation, showing the character of the brachidium. (c.)

Hamilton group. *Canandaigua Lake, N. Y.*

SPIRIFER HUNGERFORDI, Hall.

Fig. 6. A specimen with the brachial valve removed; showing the form of the brachidium.

Upper Devonian. *Rockford, Iowa.*

SPIRIFER GREGARIUS, Clapp.

Fig. 7. A preparation, showing one of the spiral cones, with its jugal process and crus. × 2. (c.)

Corniferous limestone. *Falls of the Ohio.*

SPIRIFER MUCRONATUS, Conrad.

Fig. 8. A preparation, showing the form and size of the primary lamellæ and the long, tapering spiral cones. (c.)

Hamilton group. *Canandaigua Lake, N. Y.*

SPIRIFER GRANULOSUS, Conrad.

See Plate 23.

Figs. 9, 10. Two views of a preparation, showing the form and direction of one of the spirals. (c.)

Hamilton group. *Petosky, Michigan.*

Figs. 11, 12. A preparation, showing the length of the crura, jugal processes and the narrow, small primary lamellæ. (c.)

Hamilton group. *Canandaigua Lake, N. Y.*

SPIRIFER LIGUS, Owen.

See Plate 22.

Fig. 13. A preparation, showing the crural bases, their attachment to the crura, and the form of the spiral cones which appear to have been somewhat disturbed toward the apices. (c.)

Hamilton group. *Independence, Iowa.*

SPIRIFER SUBUMBONA, Hall.

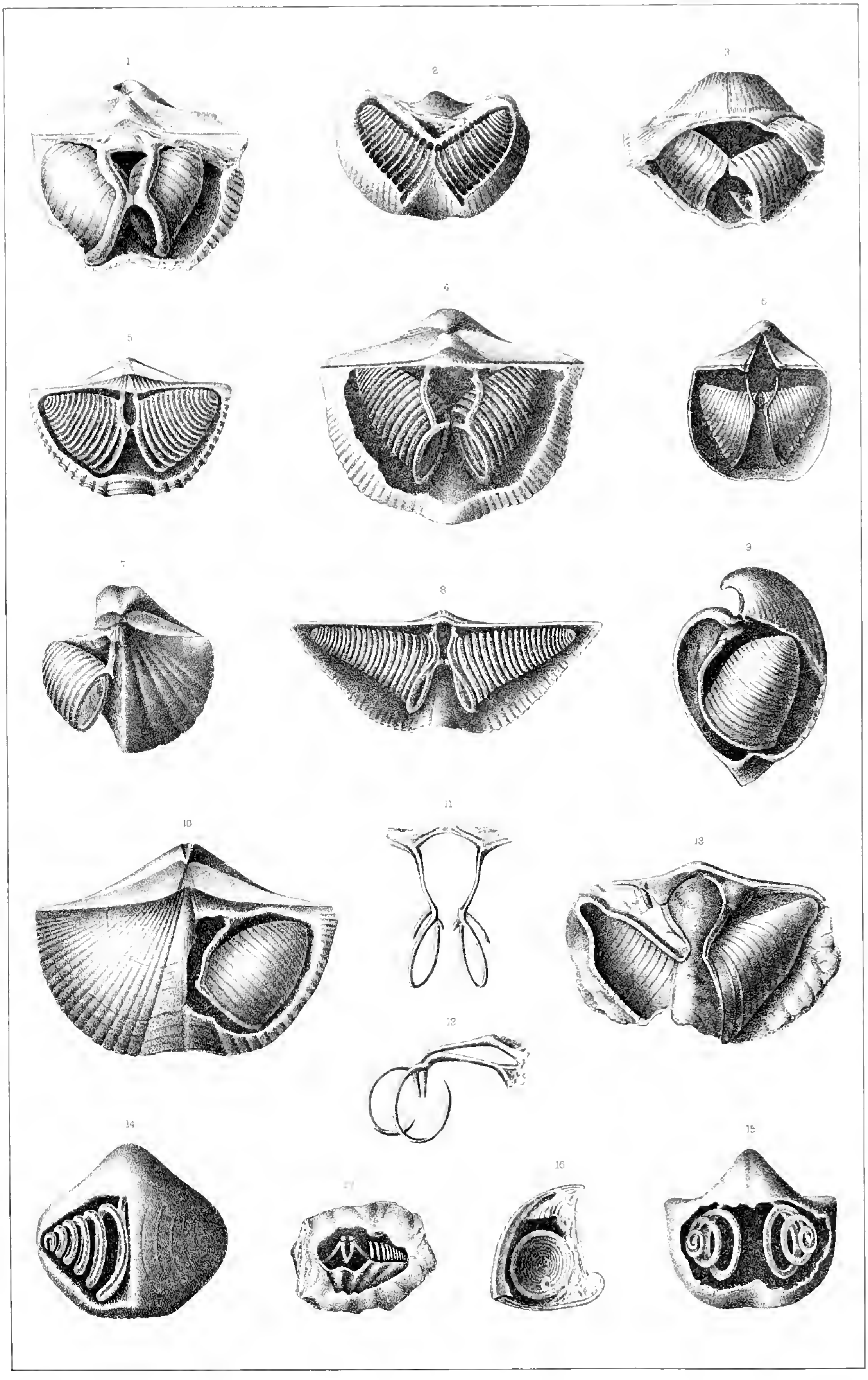
Fig. 14. A preparation, showing the lax coil of the spiral. × 4. (c.)

Hamilton group. *Western New York.*

BRACHIOPODA.

SPIRIFERIDÆ.

Generic Illustrations



E. Emmons del.

Phil. Ast lith.

PLATE XXIX—Continued.

SPIRIFER NOBILIS, Barrande.

Fig. 16. A section along the longitudinal axis looking into one of the coils. The apparent process on the second volution is casual.

Niagara group. *Near Chicago, Illinois.*

GENUS AMBOCŒLIA, HALL

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AMBOCŒLIA UMBONATA, Conrad.

Fig. 15. A preparation, showing the loosely coiled spirals with but few volutions. × 6. (c.)

Hamilton group. *Western New York.*

GENUS SPIRIFERINA, D'ORBIGNY.

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SPIRIFERINA KENTUCKIENSIS, Shumard.

Fig. 17. A specimen whose brachidium is preserved in pyrite; showing the united jugal processes which form a continuous loop. The pedicle-valve is on the lower side of the figure.

Coal Measures. *Vinton county, Ohio.*

PLATE XXX.

(Figures 1-17, 19, 20, 23-27, 30 by R. P. WHITFIELD; 18, 21, 22, 28, 29 by F. B. MEEK.)

Legend : A. Cardinal area.
a′. Inner division.
a″. Outer division.
Δ. Delthyrium.
D. Deltidium.
t. Teeth.
j. Cardinal process.
b. Dental sockets
a. Adductor scars.
r. Diductor scars.

GENUS SPIRIFER, SOWERBY.

Page 1.

SPIRIFER CONCINNUS, Hall.

Fig. 1. A large individual; showing the incipient plications on the fold.
Fig. 2. Cardinal area of the pedicle-valve retaining the deltidial covering.
Lower Helderberg group. *The Helderbergs, N. Y.*

SPIRIFER ARENOSUS, Conrad.

See Plate 29.

Fig. 3. An entire individual, of small size, compared with the New York examples, but near normal proportions for this locality.
Oriskany sandstone. *Cumberland, Maryland.*
Fig. 4. The internal cast of a pedicle-valve; showing the great diductor scars, enclosing the adductors.
Fig. 5. The central cardinal portion of an internal cast of the brachial valve; showing the form of the cardinal process and the size of the adductor scars. $\times 1\frac{1}{2}$.
Fig. 6. The articulating apparatus of the brachial valve.
Fig. 7. The cardinal area of a pedicle-valve; showing the deltidial covering and teeth
Oriskany sandstone. *Eastern New York.*

SPIRIFER UNICUS, Hall (=S. ARENOSUS, Conrad).

Fig. 8. The original specimen; showing the plicated sinus.
Upper Helderberg group. *Clarence Hollow, N. Y.*

SPIRIFER GRIERI, Hall.

Figs. 9-11. Views of a normal individual.
Fig. 12. The brachial valve of a larger shell with stronger plications on the fold.
Fig. 13. Front view of the same specimen.
Upper Helderberg group. *Ohio.*

SPIRIFER DISJUNCTUS, Sowerby.

Fig. 14. The internal cast of a pedicle-valve with alate cardinal extremities; showing the size and composition of the muscular area.
Chemung group. *Meadville, Penn.*
Fig. 15. A small, nearly entire individual, retaining the shell.
Fig. 17. The internal cast of a small, short-winged pedicle-valve.
Sandstones of the Chemung group. *Western New York.*

SPIRIFER DISJUNCTUS, Sowerby, var. SULCIFER, var. nov.

Fig. 16. The internal cast of a brachial valve; showing the sulcus on the plicated median fold.
Chemung group. *Near Olean, N. Y.*

SPIRIFER WHITNEYI, Hall.

Fig. 18. An individual of normal size, but rather short hinge.
Fig. 19. The interior of a brachial valve.
Chemung group. *Rockford, Iowa.*

BRACHIOPODA.

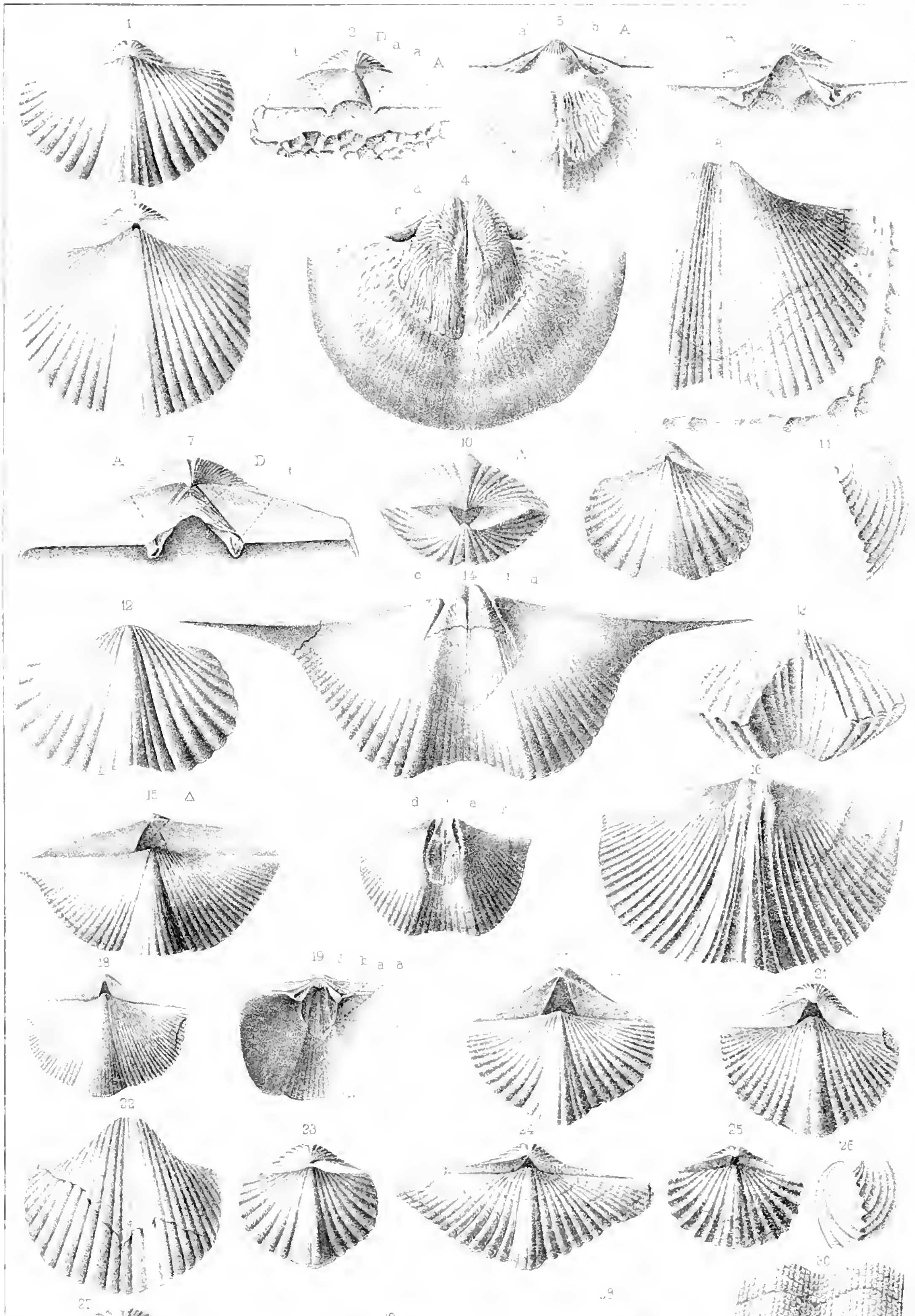

PLATE XXX—Continued

Spirifer Orestes, Hall and Whitfield.

Fig. 20. A normal adult individual.

Chemung group. *Rockford, Iowa,*

Spirifer Keokuk, Hall.

Figs. 21, 22. Views of a normal individual.

Keokuk group. *Keokuk, Iowa.*

Fig. 23. A small example, with short, rounded cardinal extremities.

Keokuk group. *Lizard Creek, Iowa.*

Fig. 24. A specimen with extended hinge ; showing the extreme of variation in form.

Keokuk group. *Marion county, Iowa.*

Spirifer Leidyi, Norwood and Pratten.

Figs. 25, 26 Dorsal and profile views of a normal example.

Chester limestone. *Chester, Illinois.*

Spirifer increbescens, Hall.

Figs. 27, 28. Dorsal and profile views of a rather large shell, with relatively short hinge.

Fig. 29. A smaller individual, with more extended hinge-line.

Fig. 30. Enlargement of the surface characters in this species.

Chester limestone. *Chester, Illinois.*

PLATE XXXI.

(Figures 1-3, 6-10, 12, 15, 18, 19 by R. P. WHITFIELD; 4, 5, 11, 13, 14, 16, 17 by F. B. MEEK.)

Legend:
- A. Cardinal area.
- Adt. Denticulated cardinal margin.
- Dg. Deltidial grooves.
- s'. Callosity in delthyrium.
- t. Teeth.
- j. Cardinal process.
- h. Dental sockets.
- a. Adductor scars.
- r. Diductor scars.

GENUS SPIRIFER, SOWERBY.

Page 1.

SPIRIFER INCREBESCENS, Hall.

See Plate 30.

Fig. 1. A portion of the interior of the pedicle-valve; showing the denticulations along the cardinal margin, the delthyrial callosity and the form of the muscular scar.

Fig. 2. Corresponding portion of a brachial valve; showing cardinal process and dental sockets.

Fig. 3. An enlargement of the cardinal area to show the denticulated cardinal edge of the pedicle-valve. The surface of the shell on the area is somewhat exfoliated, exposing the series of vertical canals, each of which terminates in a denticle. The margin of the brachial valve shows a series of small sockets corresponding to the denticles.

Chester limestone. *Chester, Illinois.*

SPIRIFER OPIMUS, Hall.

Figs. 4, 5. Brachial and profile views of a normal individual.

Coal Measures. *Iowa.*

Fig. 6. The interior of the pedicle-valve; showing the character of the muscular impression.

Fig. 7. The interior of a brachial valve.

Coal Measures. *Bomjardim, Brazil.*

SPIRIFER GRIMESI, Hall.

Fig. 8. A cardinal view; showing the high, relatively short area, and the convexity of the valves.

Fig. 16. Dorsal view of a nearly entire individual of normal mature size.

Fig. 17. The interior of a portion of the pedicle-valve; showing the structure of the muscular area.

Fig. 18. A portion of an internal cast of the pedicle-valve; showing the impressions of the adductor and diductor muscular scars.

Fig. 19. Enlargement of the radiating surface striæ.

Burlington limestone. *Burlington, Iowa.*

SPIRIFER NEWBERRYI, sp. nov.

Fig. 9. The exterior of the brachial valve; showing the fine plications.

Fig. 10. An enlargement of the surface; showing the fine striæ.

Waverly group. *Ohio.*

SPIRIFER IMBREX, Hall.

Fig. 11. The exterior of a brachial valve.

Fig. 12. An enlargement of the surface; showing the bifurcating plications and the lamellose concentric striæ.

Burlington limestone. *Burlington, Iowa.*

SPIRIFER SUBÆQUALIS, Hall.

Figs. 13, 14. Cardinal and dorsal views of the original specimen; showing the imbricated exterior.

Warsaw limestone. *Warsaw, Illinois.*

SPIRIFER MARIONENSIS, Shumard.

Fig. 15. A view of a rather small example; showing the fasciculate plications.

Choteau limestone. *Pike county, Missouri.*

BRACHIOP[illegible]

Generic Illustrations

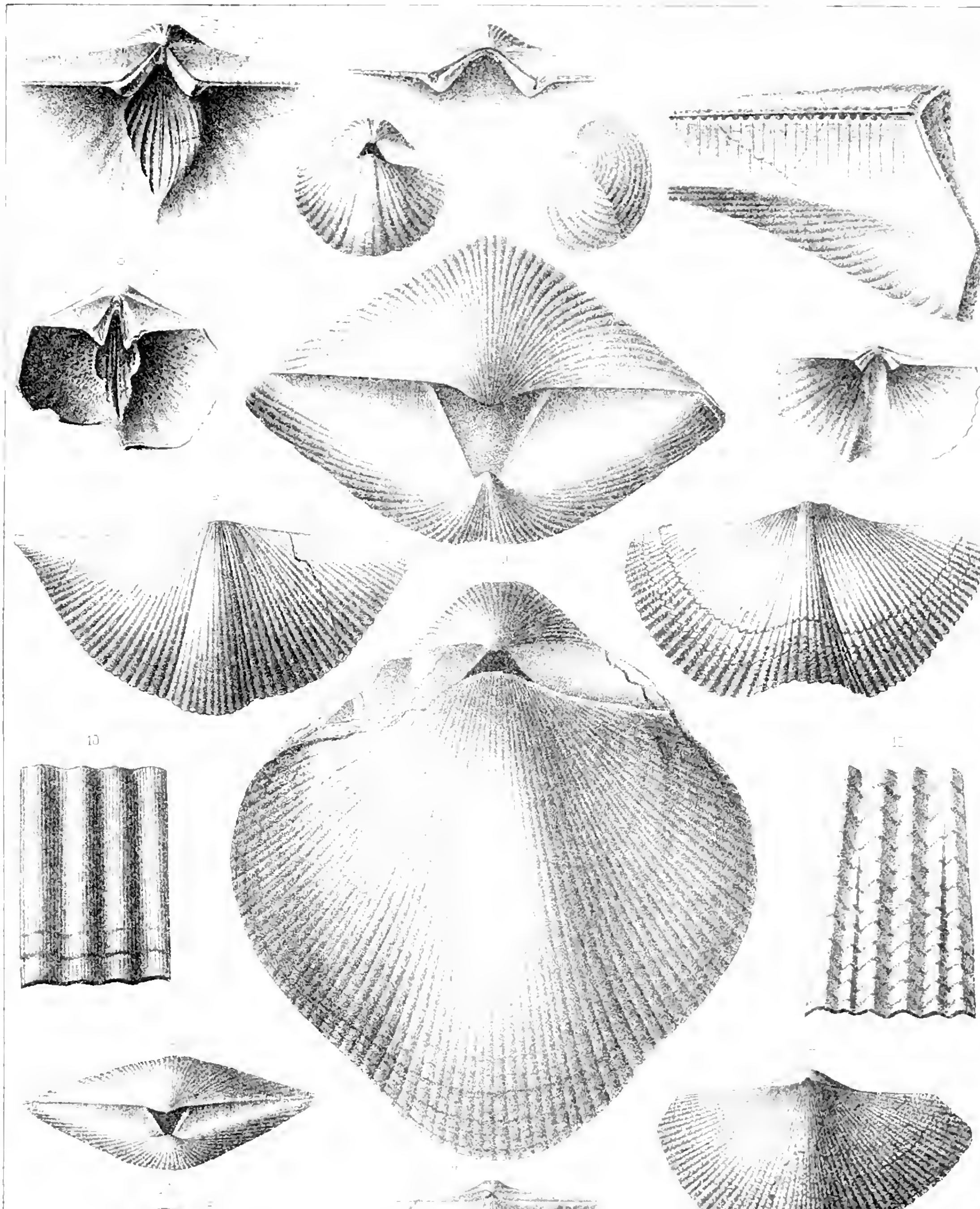

PLATE XXXII.

(Figures 1-3, 7-10, 12-15 by R. P. WHITFIELD; 4-6, 11 by F. B. MEEK.)

Legend: Δ. Delthyrium. a. Anterior adductors.
t. Teeth. a′. Posterior adductors.
s. Delthyrial callosity. r. Diductors.

GENUS SPIRIFER, SOWERBY.

Page 1.

SPIRIFER LATERALIS, Hall.

Fig. 1. Dorsal view of a large and rather convex individual.
Fig. 2. Front or marginal view of the same specimen.
Fig. 3. An enlargement of the surface; showing the pustulose striæ on the plications.
Warsaw limestone. *Warsaw, Illinois.*

SPIRIFER TENUIMARGINATUS, Hall.

Figs. 4, 6. Views of an individual of normal size.
Keokuk group. *Keokuk, Iowa.*

SPIRIFER ROSTELLATUS, Hall.

Fig. 5. A dorsal view of the original specimen.
Keokuk group. *Skunk River, Iowa.*

SPIRIFER LOGANI, Hall.

Fig. 7. A dorsal view of the original specimen; showing the great size and general external characters of the species.
Fig. 8. The interior of a portion of the pedicle-valve; showing the articulating apparatus and the adductor and diductor musculars scars.
Keokuk limestone. *Near Nauvoo, Illinois.*

SPIRIFER CAMERATUS, Morton.

Fig. 9. A large individual; showing the usual angular fasciculation of the plications.
Fig. 10. Front view of the same specimen; showing the relative size of fold and sinus.
Coal Measures. *Missouri.*
Fig. 11. An individual with broad, low fascicles composed of rounded plications. The breadth of the fascicles is somewhat unusual.
Coal Measures. *Iowa.*
Fig. 12. An example with the fascicles reduced to sharp, coarse, angular, bifurcating plications. This form and that represented in fig. 11, indicate the extremes of variation in exterior in this species.
Fig. 13. An enlargement of a portion of the internal cast of the brachial valve; showing the narrow muscular impression and the anterior and posterior adductor scars.
Fig. 14. An enlargement of a similar portion of a cast of the pedicle-valve; showing the composition of the muscular area.
Fig. 15. An enlargement of the surface ornamentation. The surface is marked by extremely fine concentric striæ, which are minutely papillose. Distinct imbricating lines of growth supervene towards the anterior margin.
Coal Measures. *Ohio and Illinois.*

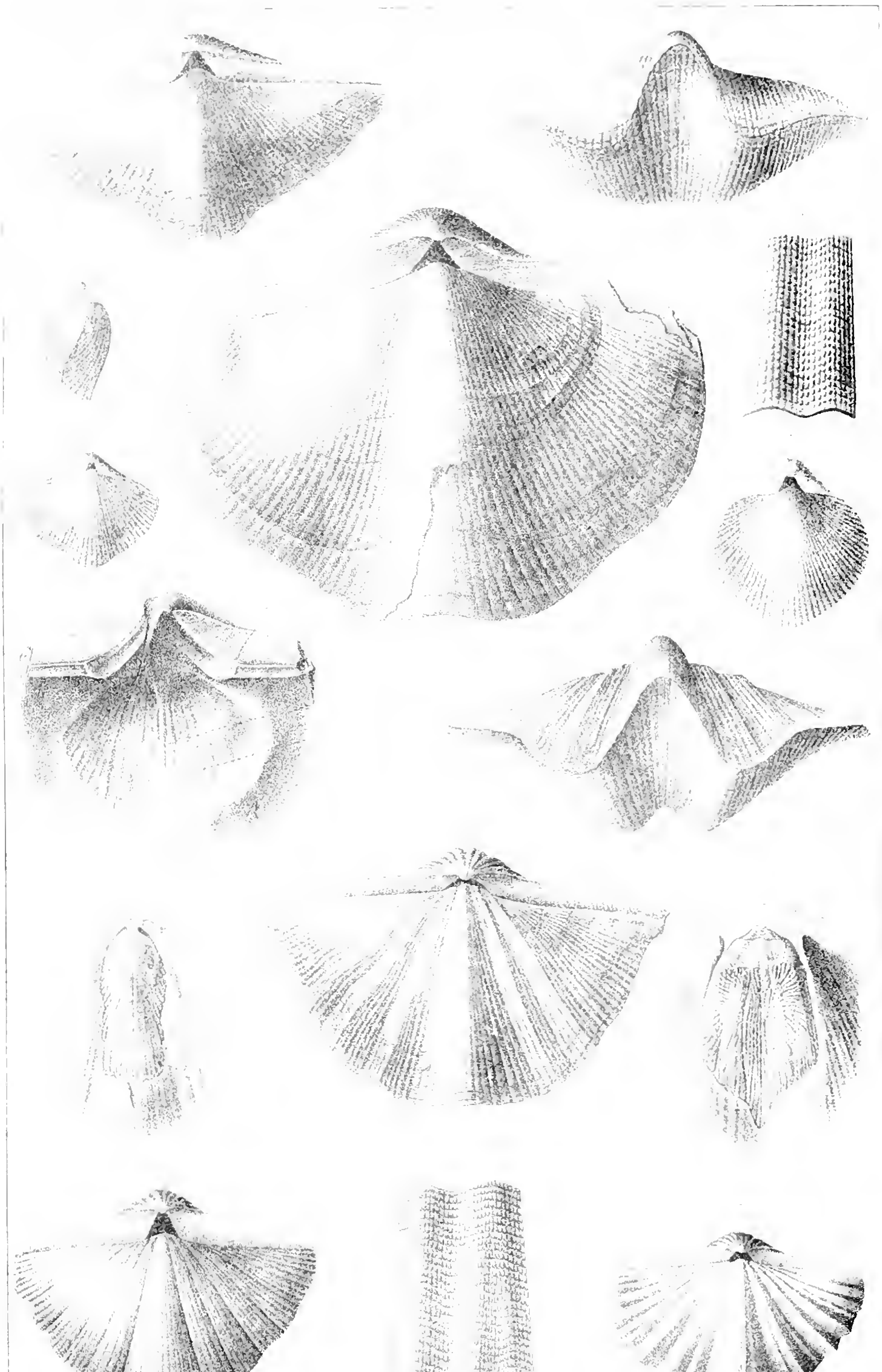

PLATE XXXIII.

(Figures 1-23, 27 by R. P. WHITFIELD; 24-26 by F. B. MEEK.)

Legend:
- A. Cardinal area.
- D. Deltidium.
- f. Foramen.
- t. Teeth.
- s. Median septum.
- s'. Delthyrial callosity.
- Dg. Margins of delthyrium (brachial valve).
- f'. Fissure at base of dental sockets (brachial valve).
- g. Rostral callosity.
- b. Dental sockets.
- c. Crura.
- sp. Spirals.
- a. Adductor scars.
- r. Diductor scars.

GENUS SPIRIFER, SOWERBY.

Page 1.

SPIRIFER TRIBULIS, Hall.

Fig. 1. The exterior of a brachial valve of an average example; showing the lamellose surface.

Fig. 2. The exterior of a brachial valve.

Fig. 3. The interior of a pedicle-valve; showing the character of the muscular area

Fig. 4. A cardinal view of conjoined valves; showing the elevation of the area.

Oriskany sandstone. *Cumberland, Maryland.*

SPIRIFER SUBMUCRONATUS, Hall.

Fig. 5. The exterior of a normal example, retaining the deltidial covering and showing the foramen

Fig. 6. An enlargement of the cardinal portion of the same specimen; showing the foramen at its summit.

Fig. 7. An enlargement of the surface; showing fine radial striations on the summit of each lamella. The shading upon this figure is such as to give an incorrect expression to the projection of the concentric lamellæ.

Oriskany sandstone. *Cumberland, Maryland.*

SPIRIFER DUODENARIUS, Hall.

Figs. 8, 9. Dorsal and cardinal views of a normal adult; showing general form and external characters.

Fig. 10 The interior of a portion of the pedicle-valve; showing the dental lamellæ, the apical callosity and the low median septum.

Fig. 13. An enlargement of the external surface; showing the fimbriated lamellæ. As in fig. 7 the shading is applied in such a manner as to give an incorrect appearance to the lamellæ.

Corniferous limestone. *Western New York.*

Fig. 11. The internal cast of a pedicle-valve; showing the outline of the muscular area.

Fig. 12. The internal cast of a brachial valve.

Schoharie grit. *Schoharie county, N. Y.*

Figs. 14, 15. Two views of a specimen doubtfully referred to this species.

Locality ?

SPIRIFER CUMBERLANDIÆ, Hall.

Fig. 16. An individual of normal proportions, retaining the deltidial covering and showing the concentric lamellæ.

Fig. 17. A partial cast of the interior of a pedicle-valve, retaining the spirals and showing the impression of the deep, muscular scars.

Fig. 18. Profile of the specimen represented in fig. 16.

Fig. 19. The interior of a brachial valve; showing the articulating apparatus and low median ridge.

Fig. 20. The interior of an imperfect pedicle-valve, retaining the perforated deltidial covering; showing the articulating apparatus and the composition of the muscular area, with a minute foramen at the summit of the deltidial plate.

Fig. 21. An enlargement of the umbonal portion of the same specimen.

PLATE XXXIII—Continued.

Fig. 22. An enlargement of the umbonal portion of the brachial valve represented in fig. 19; showing the structure of the articulating apparatus with more detail, the partially closed foramen at the apex of the valve, and the low median septum.

Fig. 23. An enlargement of the surface; a portion of the concentric lamellæ showing faint radial striations.

Oriskany sandstone. *Cumberland, Maryland.*

SPIRIFER ARRECTUS, Hall.

Fig 24. The exterior of an exfoliated pedicle-valve.

Fig. 25. The exterior of a large brachial valve, retaining a few of the concentric lamellæ.

Fig. 26. The internal cast of a pedicle-valve; showing the cast of the deep muscular impression.

Fig 27. An enlargement of the external surface. This representation is very imperfect. The exterior of the shell is strongly lamellose, each lamella bearing a series of simple spinules.

Oriskany sandstone. *Albany county, N. Y.*

BRACHIOPODA.

Spiriferidæ

Generic Illustrations

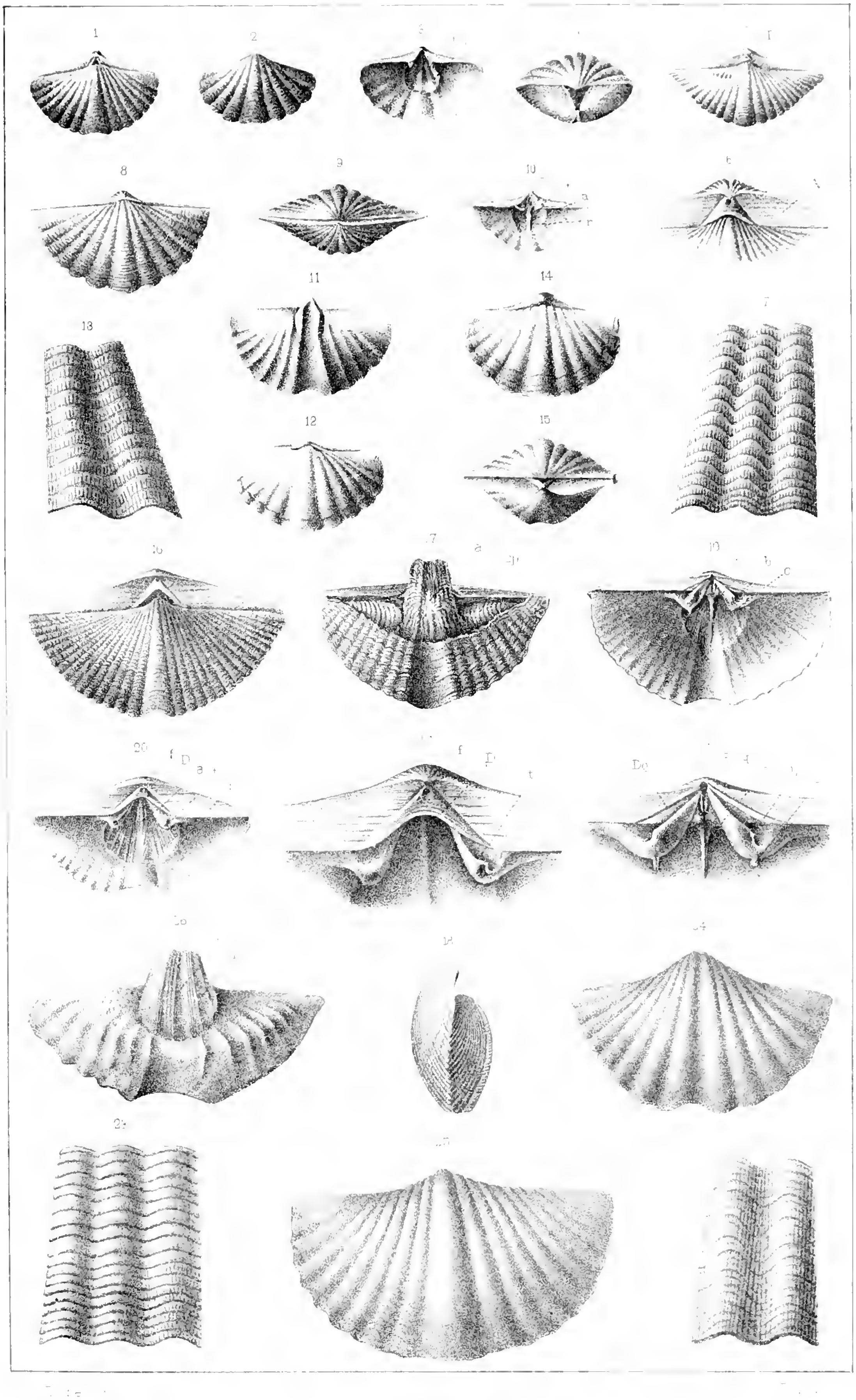

PLATE XXXIV.

(Figures 1-33 by R. P. WHITFIELD.)

Legend: A. Cardinal area (outer division).
A′. Cardinal area (inner division).
Δ. Delthyrium.
s′. Delthyrial callosity.
t. Teeth
d. Dental lamellæ.
j. Cardinal process.
b. Dental sockets.
c. Socket-walls.
s. Median septum.
a. Adductor scars.
r. Diductor scars.

GENUS SPIRIFER, SOWERBY.

Page 1

SPIRIFER MACRUS, Hall.

Fig. 1. The exterior of a pedicle-valve; showing the lamellose character of the surface.
Corniferous limestone. *Western New York.*

Fig. 2. A cardinal view of an internal cast of the pedicle-valve.

Fig. 3. An internal cast of the pedicle-valve; showing the size of the muscular impression.
Schoharie grit. *Schoharie, N. Y.*

SPIRIFER VARICOSUS, Hall.

Fig. 4. A brachial valve; showing the character of the external surface.

Fig. 5. A cardinal view; showing the height of the cardinal area and the width of the delthyrium.

Fig. 6. The interior of a brachial valve; showing the articulating apparatus. × 2.

Fig. 7. The interior of a portion of the pedicle-valve with a highly developed delthyrial callosity.

Fig. 8. An enlarged view of another specimen showing the same structure.
Upper Helderberg group. *Williamsville and western New York.*

SPIRIFER CONSOBRINUS, d'Orbigny (= SPIRIFER ZIC-ZAC, Hall).

See Plate 35.

Fig. 9. A normal adult; showing the lamellose exterior, and the sulcus on the median fold.
Hamilton group. *Western New York.*

SPIRIFER ARCTISEGMENTUS, Hall.

Fig. 10. A pedicle-valve, viewed from the apex.

Fig. 11. A cardinal view of the same specimen; showing the height of the area, its outer and inner divisions, and the form of the delthyrium.

Fig. 12. An enlargement of the lamellose external surface.
Hamilton group. *Clarke county, Indiana.*

SPIRIFER MUCRONATUS, Conrad.

Fig. 13. A specimen of the usual form and proportions in the soft shales; showing the lamellose exterior.

Fig. 14. A shorter and more rotund specimen.
Hamilton group. *Canandaigua Lake, N. Y.*

Fig. 15. A small pedicle-valve with highly extended cardinal extremities.
Marcellus shales. *Near Alden, N. Y.*

Fig. 16. A specimen with long, narrow, acuminate cardinal extremities. This is a somewhat unusual form.
Hamilton group. *Darien Center, N. Y.*

Fig. 17. The interior of a brachial valve; showing the articulating apparatus and muscular area.

Fig. 18. The interior of a pedicle-valve; showing the teeth and muscular area.

Fig. 19. An enlargement of a portion of the brachial valve; showing the detailed structure of the dental sockets, cardinal process and adductor muscular scars.

Fig. 20. A similar enlargement of the corresponding parts of the pedicle-valve, the muscular impressions being much broader than in the preceding specimen.

PLATE XXXIV—Continued.

Fig. 21. An enlargement of the external lamellose surface.

Hamilton group. *Western New York.*

Fig. 22. An internal cast of a pedicle-valve with greatly extended and attenuate cardinal extremities. This and approximate forms are very abundant in the coarser shales of Albany, Schoharie and Otsego counties.

Hamilton group (sandy shales). *Schoharie county, N. Y.*

Spirifer bimesialis, Hall.

Fig. 23. A cardinal view of conjoined valves; showing the height and slight incurvature of the area.

Fig. 24. The exterior of a brachial valve.

Fig. 25. The exterior of a specimen more extended on the hinge.

Fig. 26. An enlargement of the external surface; showing the imbricating lamellæ.

Upper Devonian. *Independence, Iowa.*

Spirifer mucronatus, Conrad, var. posterus, var. nov.

(This shell in one of its forms was identified as *Delthyris mucronata*, in Geology of New York; Report on the Fourth District, 1843 (p. 270, fig. 3), and the shell termed in that work *D. acuminata*, Hall, is probably the same form. It is a variation from the typical form of *S. mucronatus*, similar to those represented in figs. 15 and 16 of this plate, with broad or narrow bodies and acuminate cardinal extremities. The original term, *acuminata*, can not be applied to this shell on account of preoccupancy.)

Fig. 27. The exterior of a brachial valve; showing the lamellose surface and extended cardinal extremities.

Fig. 28. An internal cast of the pedicle-valve; showing the impression of the muscular area but no evidence of the median septum which exists in *S. mesacostalis*.

Figs. 29, 30. Internal casts of brachial valves.

Fig. 31. The central portion of an interior of the brachial valve, enlarged; showing the muscular scars and articulating apparatus.

Chemung group. *Tompkins county, N. Y.*

Spirifer mesacostalis, Hall.

Fig. 32. View of the exterior of an extended specimen; showing the lamellose surface and biplicate median fold.

Fig. 33. A pedicle-valve; showing the plication in the median sinus.

Chemung group. *Allegany county, N. Y.*

Fig. 34. A cardinal view of conjoined valves; showing the width of the cardinal areas.

The smaller and shorter forms of this species differ little in general aspect from *Sp. mucronatus* in some of its varieties, and in its squamose surface, but the cardinal area is distinctly wider, the median fold deeply duplicate and an angular plication in the median sinus. The casts of the interior are readily distinguished by the presence of a distinct septum in the ventral valve.

BRACHIOPODA.

Generic Illustrations

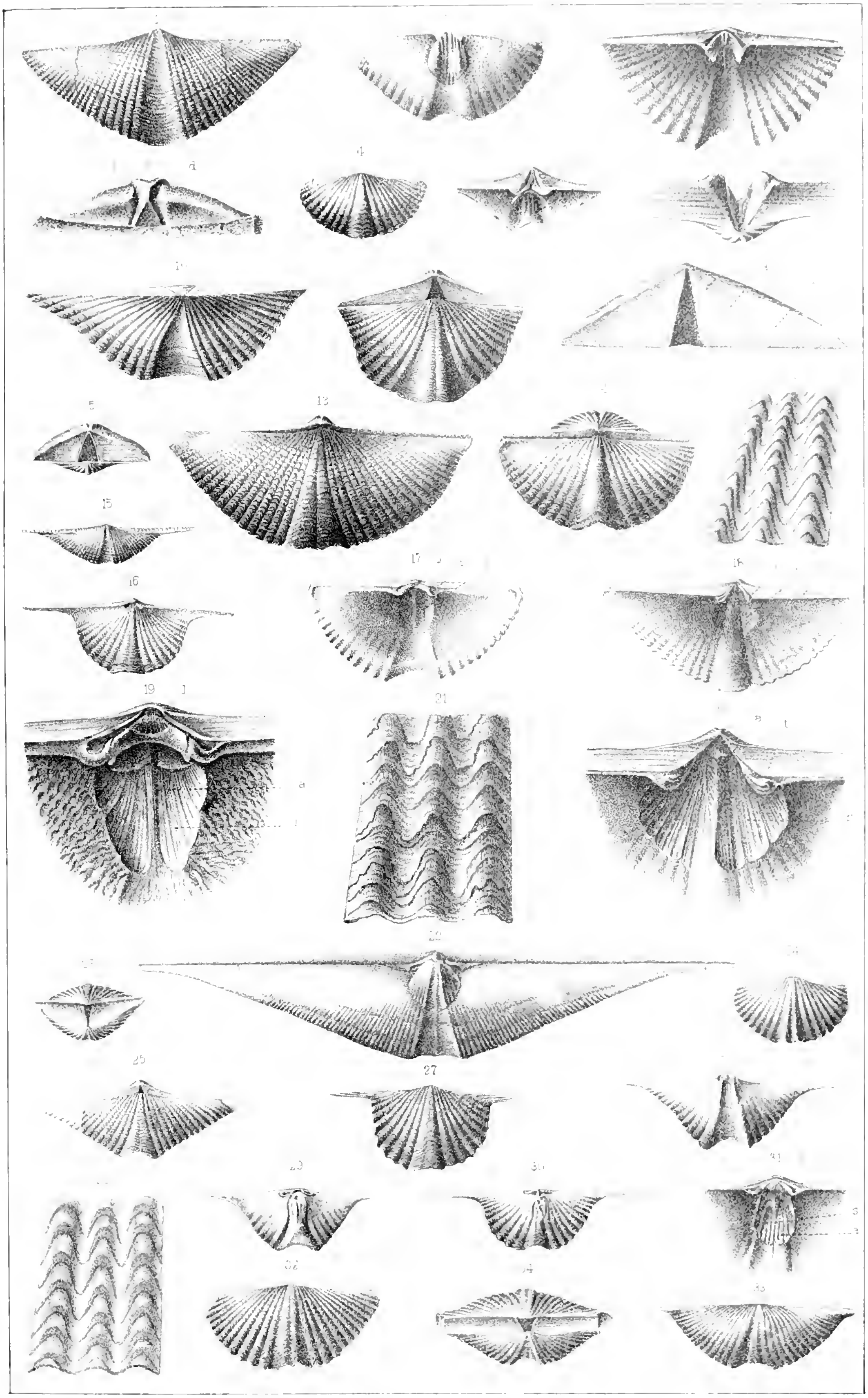

PLATE XXXV.

(Figures 1-29 by R. P. Whitfield.)

Legend:

D. Deltidial plates.
Δ. Delthyrium.
F. Foramen.
t. Teeth.
d. Dental lamellæ.
x. Pedicle-cavity.
s. Median septum.
j. Cardinal process.
b. Dental sockets.
c. Crura.
a. Anterior adductors.
a′. Posterior adductors.
r. Diductors.

Genus SPIRIFER, Sowerby.

Page 1

Spirifer sulcatus, Hisinger.

Fig. 1. An individual of normal proportions; showing the lamellose exterior.

Figs. 2, 3. Enlargements of the central portion of the cardinal area of two examples. The deltidial plates have not united in either specimen, but have attained a more advanced development in fig. 2 than in fig. 3.

Fig. 4. Enlargement of the external lamellose surface; showing the minute pustules on the radial striations.

Niagara group. *Lockport, N. Y.*

Spirifer raricostus, Conrad.

Fig. 5. A brachial view of a specimen of ordinary size.

Fig. 6. An enlargement of the surface of the same specimen; showing the inequidistant lamellæ.

Corniferous limestone. *Central New York.*

Spirifer perlamellosus, Hall.

Fig. 7. A normal adult shell, retaining the deltidial covering and foramen.

Fig. 8. A median longitudinal section of conjoined valves; showing the dental plates and median septum of the pedicle-valve and the crura of the brachial valve.

Fig. 9. An enlargement of the external surface; showing the crowded and radially striated lamellæ.

Fig. 10. An enlargement of the central portion of the cardinal area, bearing a perforated deltidial covering in which the plates are completely coalesced and extend to the beak of the brachial valve.

Fig. 11. A similar enlargement from another specimen, having a shorter deltidial covering.

Fig. 12. The interior of a pedicle-valve; showing the imperforate deltidial covering and the median septum.

Fig. 13. An enlargement of the central portion of a brachial valve; showing the crura and the peculiar bilobed form of the cardinal process lying at the base of the socket-walls.

Lower Helderberg group. *The Helderbergs. N. Y.*

Spirifer raricostus, Conrad.

Fig. 14. An enlargement of the central portion of the cardinal area; showing its transverse striation and the incipient deltidial plates.

Corniferous limestone. *Albany county, N. Y.*

Fig. 15. An oblique view of the pedicle-valve; showing the median septum.

Corniferous limestone. *Western New York.*

Fig. 16. The interior of a pedicle-valve of a small individual; showing the teeth and low septum.

Fig. 17. An internal cast of a pedicle-valve; showing the filling of the rostral cavity, the position of the median septum and the impression of the muscular scars.

Schoharie grit. *Albany county, N. Y.*

PLATE XXXV—Continued.

Spirifer consobrinus, d'Orbigny.

See Plate 34.

Fig. 18. The interior of an imperfect pedicle-valve; showing the median septum, which appears as a low ridge in the bottom of the valve.

Hamilton group. *Western New York.*

Genus SPIRIFERINA, d'Orbigny.

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Spiriferina transversa, McChesney.

Fig. 19. An entire specimen; showing the general form and proportions, and the lamellose exterior.

Fig. 20. The interior of a portion of the pedicle valve; showing the median septum.

Chester limestone. *Buzzards' Roost, Alabama.*

Fig. 23. A cardinal view of an individual with a high area.

Fig. 24. Oblique view of the interior of a pedicle-valve; showing the median septum

Fig. 25. The interior of a brachial valve; showing cardinal process, dental sockets and low median ridge. × 2.

Carboniferous limestone. *Itaitúba, Brazil.*

(Figs. 23–25 are from specimens figured by Derby, Bulletin of the Cornell University, vol. i, pl. ii, fig. 6; pl. iii, fig. 12; pl. v, fig. 4. 1874.)

Spiriferina subelliptica, McChesney.

Fig. 21. The interior of a portion of the pedicle-valve; showing median septum and muscular scars.

Fig. 22. The interior of a portion of the brachial valve; showing the articulating apparatus, elevated muscular ridges and low median ridge. × 2.

Keokuk group. *New Providence, Indiana.*

Spiriferina spinosa, Norwood and Pratten.

Figs. 26, 27. Views of an entire example; showing the exterior characters.

Fig. 28. A longitudinal median section through conjoined valves; showing the height of the median septum.

Fig. 29. An enlargement of the external surface; showing the bases of the spinules and the punctæ of the shell.

Chester limestone. *Chester, Illinois.*

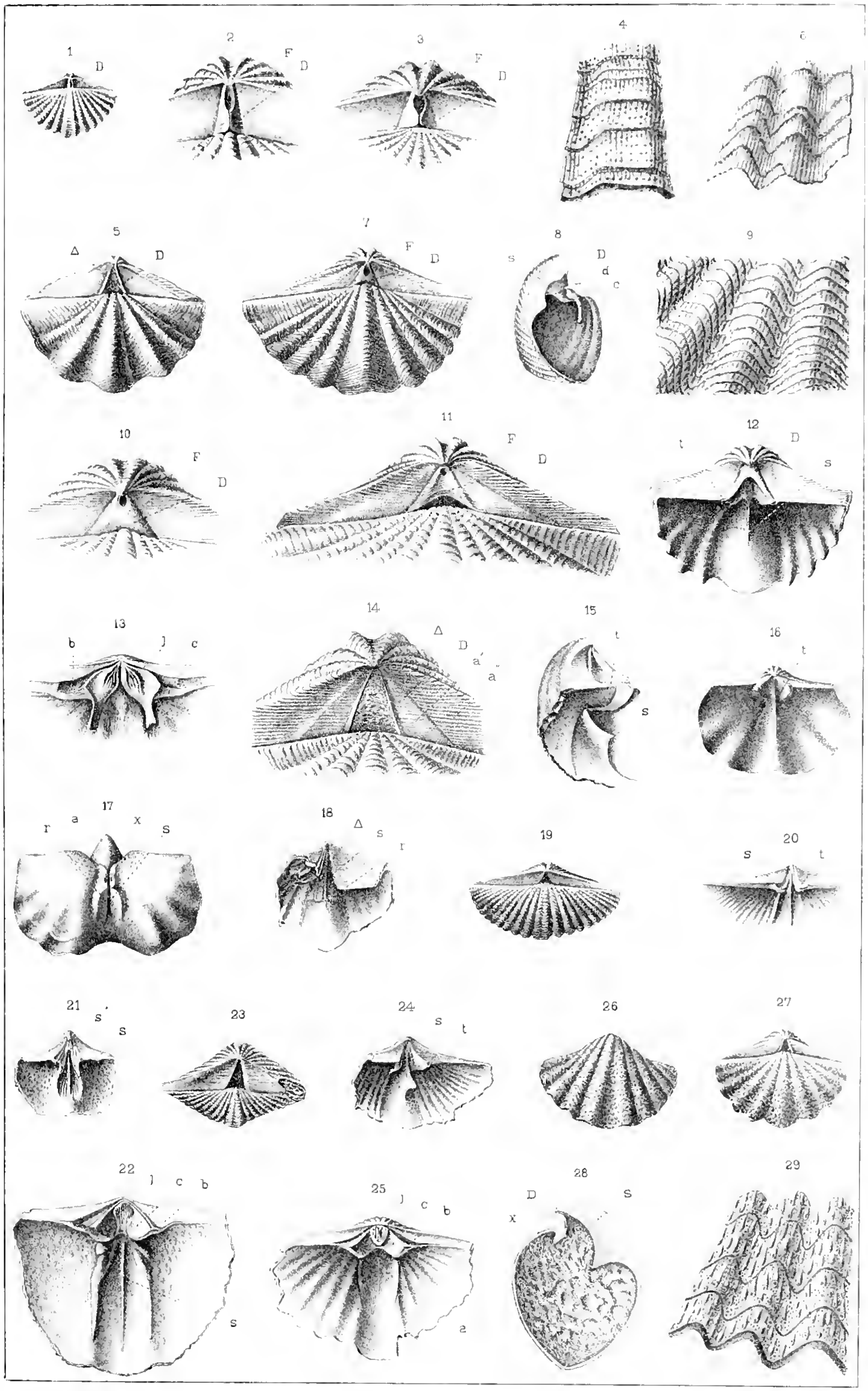
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PLATE XXXVI.

(Figures 1-30 by R. P. WHITFIELD.)

Legend (except figure 30):

D. Deltidial plates.
Δ. Delthyrium.
t. Teeth.
d. Dental lamellæ.
y. Rostral cavity.
s. Median septum.
j. Cardinal process.
b. Dental sockets.
c. Socket-walls.
a. Adductor scars.
d. Diductor scars.
v. Vascular sinuses.

GENUS SPIRIFER, SOWERBY.

Page 1.

SPIRIFER CRISPUS, Hisinger.

Fig. 1. The exterior of a normal adult. × 2.

Fig. 2. An enlargement of the umbonal region; showing the undefined cardinal area and incipient deltidial plates.

Niagara group. *Rochester, N. Y.*

Fig. 3. The interior of a pedicle-valve; showing a more sharply defined area, and strong dental lamellæ. × 3.

Fig. 4. The interior of a brachial valve; showing area and articulating apparatus. × 3.

Niagara group. *Waldron, Indiana.*

Fig. 5. An enlargement of a portion of the interior of the brachial valve; showing the articulating apparatus and cardinal process.

Fig. 6. An enlargement of the external surface; showing the closely crowded lamellæ bearing bases of minute spinules.

Niagara group. *Rochester, N. Y.*

SPIRIFER BICOSTATUS, Hall.

Fig. 7. The exterior of a normal specimen; showing the lamellose surface.

Niagara group. *Vernon Center, N. Y.*

SPIRIFER TENUISTRIATUS, Hall.

Fig. 8. View of the original specimen; showing the radially striated plications.

Lower Helderberg group. *Decatur county, Tennessee.*

SPIRIFER CRISPATUS, sp. nov.

Figs. 9, 10. Views of a coarsely plicate, highly lamellose shell, probably representing an undescribed species.

Niagara group. *Maryland.*

SPIRIFER VANUXEMI, Hall.

Fig. 11. The exterior of a normal individual; showing the elevation of the umbo of the pedicle-valve, the undefined cardinal area and the lamellose surface. × 2.

Lower Helderberg group. *Litchfield, N. Y.*

SPIRIFER CYCLOPTERUS, Hall.

Fig. 12. The exterior of an average specimen.

Fig. 13. The interior of a portion of a pedicle-valve; showing teeth and muscular impression. × 2.

Lower Helderberg group. *Schoharie, N. Y.*

PLATE XXXVI—Continued.

Genus SPIRIFERINA, d'Orbigny.

Page 51.

Spiriferina Kentuckiensis, Shumard.

Fig. 14. The exterior of a pedicle-valve.

Fig. 15. An oblique view of the interior of the pedicle-valve; showing the median septum and muscular impressions.

Fig. 16. The cardinal view of an exfoliated shell; showing the character of the area and deltidial plates.
Coal Measures. *Illinois.*

Genus SPIRIFER, Sowerby.

Page 1.

Spirifer fimbriatus, Conrad.

See Plate 38.

Fig. 17. The internal cast of a pedicle-valve; showing the composition of the muscular area.
Schoharie grit. *Schoharie, N. Y.*

Figs. 18, 19. Dorsal and profile views of a normal example; showing the lateral plications and the concentrically striated surface covered with the bases of spinules.
Upper Helderberg group. *Western New York.*

Fig. 20. An enlargement of the surface; showing the bases of the spinules.

Fig. 21. A pedicle-valve which retains a portion of the spinules.
Hamilton group. *Western New York.*

Fig. 22. A cardinal view of an internal cast of conjoined valves; showing the vascular sinuses.
Hamilton group. *Hardy county, Virginia.*

Spirifer præmaturus, Hall.

Fig. 23. The internal cast of a pedicle-valve, retaining a trace of a median septum.
Chemung group. *Allegany county, N. Y.*

Fig. 24. The internal cast of a pedicle-valve; showing the impressions of the dental lamellæ and a low median septum.

Fig. [25. Another cast of the pedicle-valve, which retains the muscular impression.
Chemung group. *Meadville, Pennsylvania.*

Spirifer setigerus, Hall.

Figs. 26, 27. Dorsal and profile views of a rotund, normal example; showing the incipient deltidial plates and fimbriated lamellæ.
Chester limestone. *Chester, Illinois.*

Spirifer pseudolineatus, Hall.

Fig. 28. The cardinal view of a large example.

Fig. 29. A dorsal view of the same specimen; the shell has been exfoliated on different parts of the surface, presenting the features shown in figure 30.

Fig. 30. An enlargement of the surface; showing the tubular character of the surface spinules, and, at *c*, the penetration of these tubes beneath the epidermal layer of the shell. The spinules are represented as simple, short and blunt, but they are, on the contrary, furnished with rows of lateral branches, and are long, slender and acute.
Keokuk limestone. *Keokuk, Iowa.*

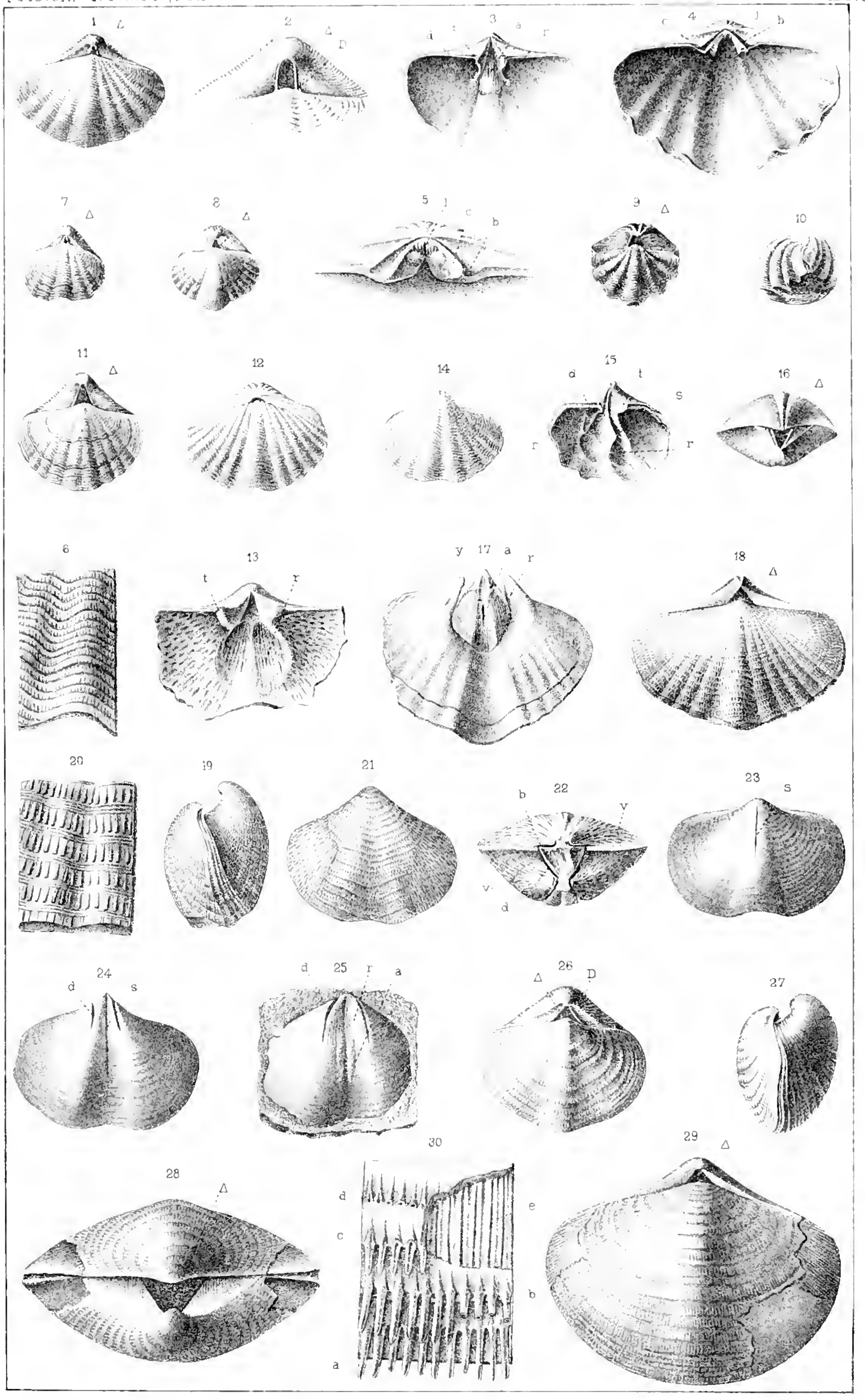
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PLATE XXXVII.

(Figs. 1-12, 26-31 by R. P. WHITFIELD; 13-15, 18, 19, 23, 24 by E. EMMONS; 16, 17, 20-22, 25, 32, 33 by G. B. SIMPSON.)

GENUS SPIRIFER, SOWERBY.

Page 1.

SPIRIFER NIAGARENSIS, Conrad.

See Plate 21.

Fig. 1. An enlarged view of the deltidial region of the pedicle-valve; showing the uncompleted growth of the deltidial plates.
Niagara shales. *Western New York.*

SPIRIFER NOBILIS, Barrande.

Figs. 2, 3. Opposite sides of an internal cast; showing the coarse, duplicating plications, the impressions of strong dental lamellæ and a low median ridge in the pedicle-valve.
Niagara dolomites. *Racine, Wisconsin.*

SPIRIFER MESASTRIALIS, Hall.

Fig. 4. The exterior of a brachial valve, with highly extended cardinal extremities.
Fig. 5. The brachial valve of a specimen much shorter on the hinge. Both specimens show the fine striation of the median fold.
Chemung group. *Southwestern New York.*

SPIRIFER TULLIUS, Hall.

Figs. 6, 7. Views of an average specimen. The fine radial lineation of the surface is not shown in the figures.
Hamilton shales. *Skaneateles, N. Y.*

SPIRIFER SCULPTILIS, Hall.

Fig. 8. Exterior of a pedicle-valve; showing the strong, distant lamellæ.
Hamilton group. *Western New York.*

SPIRIFER CONSOBRINUS d'Orbigny (= S. ZIC-ZAC, Hall).

See Plate 34.

Figs. 9, 10. Views of both valves of a normal example; showing the sharp plications and the closely crowded concentric lamellæ.
Hamilton group. *Canandaigua Lake, N. Y.*

SPIRIFER GREGARIUS, Clapp.

Figs. 11, 12. Two views of an average specimen; showing the short hinge, prominent umbo, and the broad, deep sinus of the pedicle-valve.
Corniferous limestone. *Falls of the Ohio.*

SPIRIFER KEOKUK, Hall, var.?

Figs. 13-15. Views of a silicified shell, with sharp lateral plications, and low duplicate median plications on the fold and sinus.
St. Louis group. *Southern Indiana?*

SPIRIFER TEXANUS, Meek.

Figs. 16, 17. Views of a rather small specimen; showing the short hinge, elongate form and highly arched umbo of the pedicle-valve.
Carboniferous limestone. *Graham county, Texas.*

PLATE XXXVII—Continued.

SPIRIFER FORBESI, Norwood and Pratten.

Fig. 18. An enlarged view of the cardinal area of the pedicle valve, from which the surface layer has been partially exfoliated, exposing the vertical canals traversing the shell-substance.
Burlington limestone. *Burlington, Iowa.*

SPIRIFER LATERALIS, Hall.

See Plate 32.

Fig. 19. An enlargement of the cardinal area, showing features similar to the preceding.
Warsaw group. *Clifton, Illinois.*

SPIRIFER WILLIAMSI, sp. nov.

Figs. 20-22. Views of an enlarged example; showing the low, coarse and sparse plication of the median fold and sinus.
Chemung group. *Allegany county, N. Y.*

SPIRIFER CANANDAIGUÆ, sp. nov.

Figs. 23, 24. Two views of a somewhat distorted individual; showing the low, rounded lateral plications and narrow umbo.

Fig. 25. An enlargement of the surface; showing the closely crowded concentric rows of fine granules or spine-bases. × 5.
Hamilton shales. *Canandaigua Lake, N. Y.*

SPIRIFER HUNGERFORDI, Hall.

Figs. 26, 27. Dorsal and profile views of a specimen with elongate outline and short hinge.

Fig. 28. Anterior view of the same individual; showing the development of the median fold and sinus.

Fig. 29. A shell with an extended hinge-line and short longitudinal axis; presenting the extreme of variation in this respect.

Fig. 30. The central portion of the interior of a pedicle-valve; showing the teeth, dental lamellæ and muscular impressions. × 2.
Upper Devonian. *Rockford, Iowa.*

SPIRIFER PLENUS, Hall.

See Geol. Rept. of Iowa, p. 603, pl. xiii. 1858.

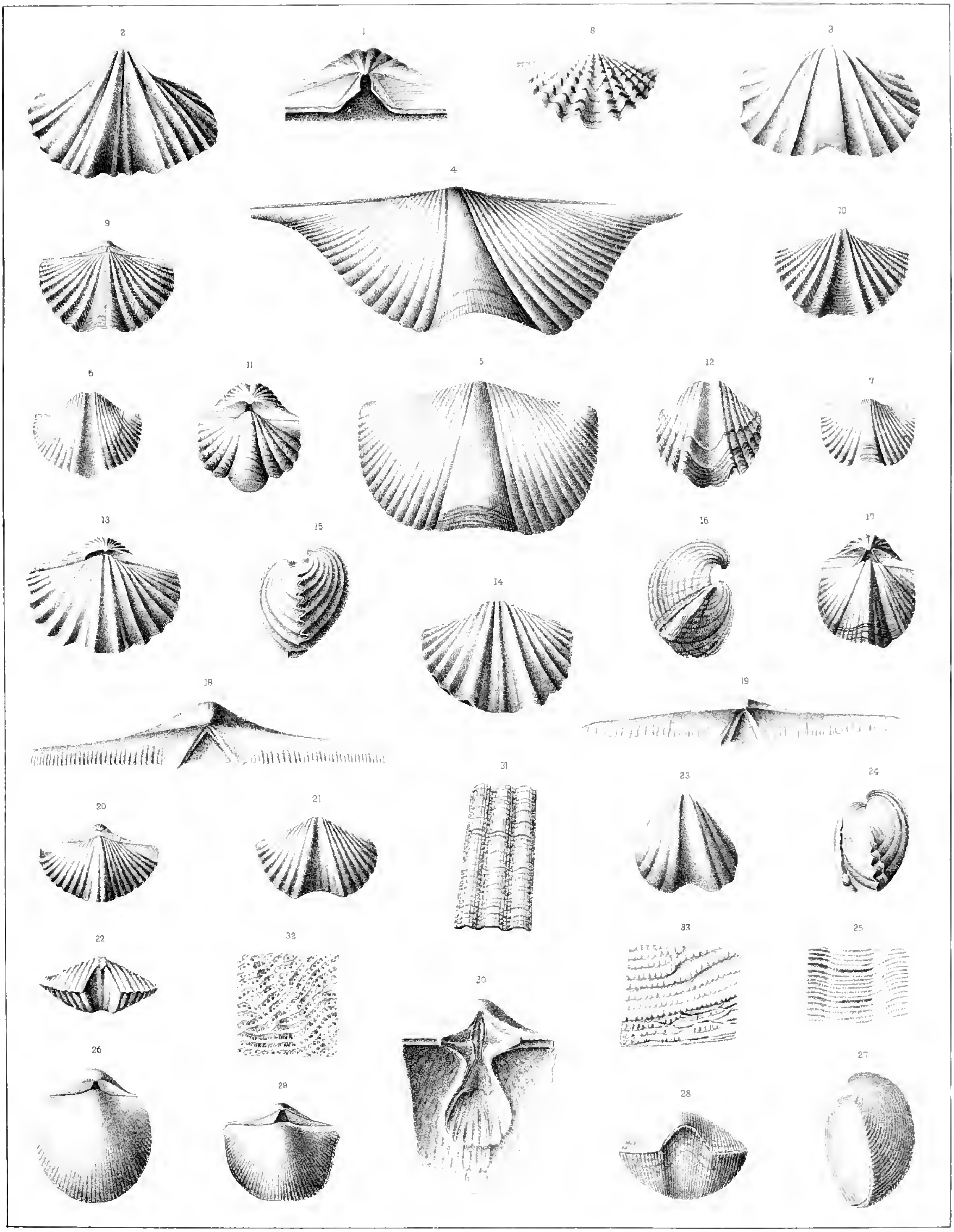
Fig. 32. An enlargement of a portion of the inner surface of the shell; showing the punctæ. × 4.

Fig. 33. A portion of the external surface near the anterior margin. × 6.
Burlington limestone. *Burlington, Iowa.*

BRACHIOPODA.

SPIRIFERIDÆ.

Generic Illustrations



R P Whitfield del

Phil. Ast lith.

PLATE XXXVIII.

(Figs 1-8, 11-13, 15-19 by R. P. WHITFIELD; 9, 10, 14 by G. B. SIMPSON.)

GENUS SPIRIFER, SOWERBY.

Page 1.

SPIRIFER MODESTUS, Hall.

Fig. 1. A silicified example; showing the usual condition of the exterior, and the absence of any defined cardinal area. × 2.

Fig. 3. The interior of a portion of the pedicle-valve; showing the form of the muscular area.

Lower Helderberg group. *Cumberland, Maryland.*

SPIRIFER LINEATUS, Martin.

Figs. 2, 4. Two views of a small specimen; showing the form and usual condition of the surface.

Fig. 7. An enlargement of the surface; showing the spine-bases along the growth-lines.

Fig. 8. An enlargement of the cardinal area of the specimen represented in fig. 4; showing the incipient development of the deltidial plates and limitation of the cardinal area.

Coal Measures. *Iowa.*

SPIRIFER MAIA, Billings.

Figs. 5, 6. Two individuals, showing slight variations in length of hinge and marginal outline.

Corniferous limestone. *Near Columbus, Ohio.*

SPIRIFER FIMBRIATUS, Conrad.

See plate 36.

Fig. 9. An enlargement of a portion of the exterior; showing the long, medially grooved and divided surface-spines, with their lateral spinules. × 3.

Fig. 10. A thin section of these compound spines; showing their interior filling and the lateral spinules. × 3.

Hamilton shales. *Canandaigua Lake, N. Y.*

SPIRIFER LÆVIS, Hall.

Fig. 11. A cardinal view of the pedicle-valve; showing the completed deltidial covering.

Fig. 12. Exterior of a pedicle-valve; showing faint lateral undulations.

Fig. 13. An internal cast of the pedicle-valve; showing the impression of the muscular area and ovarian markings.

Portage group. *Ithaca, N. Y.*

SPIRIFER HIRTUS, White and Whitfield.

Fig. 14. An enlargement of the surface; showing the concentric rows of spine-bases, each of which retains the remnant of the median partition dividing it into two chambers. × 5.

Kinderhook group. *Illinois.*

SPIRIFER DIVARICATUS, Hall.

Figs. 15-17. Front, dorsal and profile views of an entire individual of normal adult size; showing the relatively short hinge, high area, low fold and sinus, and the even plication of the entire surface.

Hamilton group. *York, N. Y.*

SPIRIFER MORTONANUS, Miller (= S. FASTIGATUS, Meek and Worthen).

Fig. 18. The pedicle-valve of a large individual.

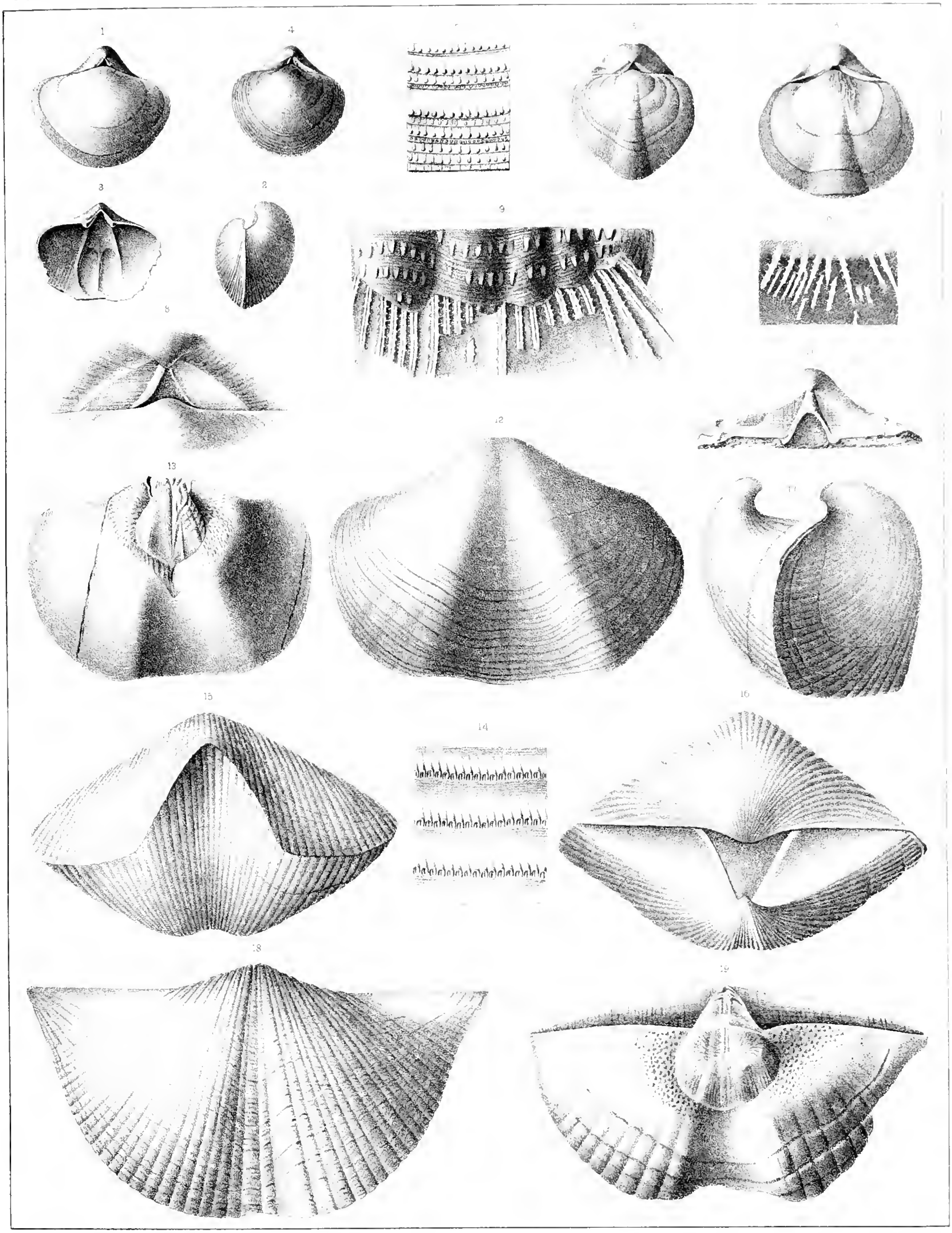
Fig. 19. Internal cast of a pedicle-valve; showing the vertical striation of the cardinal area, the impression of the muscular area and the ovarian markings.

Keokuk group. *Crawfordsville, Indiana.*

BRACHIOPODA.

SPIRIFERIDÆ.

Generic Illustrations



R P Whitfield del

Phil Ast lith.

PLATE XXXIX.

(Figs. 1-3 copies; 4-9, 39-41 by R. P. WHITFIELD, 10-14, 19-27, 29-31, 34-36, 42 by G. B. SIMPSON; 15-18, 28, 32, 33, 37, 38 by E. EMMONS.)

GENUS VERNEUILIA, GEN. NOV.

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VERNEUILIA CHEIROPTERYX, de Verneuil.

Figs. 1-3. Three views; showing the slight asymmetry of the shell, and the trisulcate surface of each valve. (After DE VERNEUIL.)

Middle Devonian. *Paffrath, Germany.*

GENUS AMBOCŒLIA, HALL.

Page 54.

See Plate 29.

AMBOCŒLIA UMBONATA, Conrad.

Figs. 4-6. Three views of an average example; showing the great convexity of the pedicle-valve, its median groove, and the depressed-convex, marginally concave brachial valve.

Fig. 7. The interior of the pedicle-valve; showing the elevated umbo, the thickened, unsupported teeth and the partial filling of the delthyrium. × 3.

Fig. 8. The interior of the brachial valve; showing the low cardinal process, elevated crural plates, and the four adductor scars. × 3.

Fig. 9. A preparation, showing the volutions of the spiral coils. × 3.

Hamilton shales. *Western New York.*

AMBOCŒLIA PLANOCONVEXA, Shumard.

Figs. 10-12. Views of a rather large example; showing the general form and contour of the valves.

Fig. 14. Posterior view of the same specimen; showing the cardinal areas, the imperfectly developed deltidial plates and chilidium × 3.

Coal Measures. *Springfield, Illinois.*

Fig. 13. A small individual.

Fig. 15. Enlargement of the surface of the same specimen; showing the short spinules. × 5.

Coal Measures. *Manhattan, Kansas.*

AMBOCŒLIA SPINOSA, sp. nov.

Fig. 16. The exterior of a brachial valve.

Fig. 17. An enlargement of the surface; showing the narrow, elongate depressions which were probably the bases of superficial spines. × 5.

Fig. 18. Internal cast of the same specimen; showing the impression of the dental sockets and crural plates, and the faint adductor scars.

Hamilton group. *Livonia Salt Shaft, N. Y.*

GENUS METAPLASIA, GEN. NOV.

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METAPLASIA PYXIDATA, Hall.

Fig. 19. Interior of a brachial valve; showing the articulating apparatus, adductor scars and vascular sinuses about the muscular area and over the marginal regions. × 2.

Fig. 20. Posterior view of the same valve; showing the width of the cardinal area, elevation of the cardinal process and socket-walls, and the linguate extension of the median sinus on the anterior margin. × 2.

Fig. 21. Internal cast of the pedicle-valve; showing the median fold, and the impressions of divergent, probably vascular sinuses extending forward from the pedicle-cavity. × 2.

Fig. 22. Interior of a portion of the pedicle-valve; showing the narrow cardinal area, thickened teeth and deep muscular scar. × 2.

Oriskany sandstone. *Cayuga, Ontario.*

GENUS SPIRIFERINA, D'ORBIGNY.

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See Plates 29, 36.

SPIRIFERINA, sp. ?

Fig. 23. Interior of a portion of the brachial valve; showing the articulating apparatus and the divergent muscular ridges in the bottom of the valve. × 3.

Fig. 24. A portion of the interior of the pedicle-valve; showing a highly developed delthyrial callosity uniting the dental lamellæ and supported by a median septum. × 2.

Chester limestone. *Caldwell county, Kentucky.*

PLATE XXXIX—Continued.

GENUS CYRTINA, DAVIDSON.

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See Plates 25, 28.

CYRTINA, sp. ?

Fig. 25. An enlargement of the surface; showing the bases of concentric rows of spinules. × 4.

Fig. 26. Cardinal view of an internal cast of the pedicle-valve, broken so as to show the convergent dental plates uniting with the median septum, and the slight projection of the edge of the latter within the spondylium thus formed.

Fig. 27. The same specimen viewed from above; showing the length of the median septum.

Fig. 28. An enlargement of a portion of the interior of the pedicle-valve; showing the convergence of the dental plates, and the projection of the median septum beyond their union. × 3.

Chert-beds of the Burlington limestone. *Burlington, Iowa.*

GENUS SYRINGOTHYRIS, WINCHELL.

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See Plates 25, 26, 27.

SYRINGOTHYRIS MISSOURI, sp. nov.

Figs. 29–31. Three views of the typical specimen; showing its small size, elevated pedicle-valve, broadly rounded cardinal margins, and coarse lateral plications. Internally this shell has the syringothyroid tubiferous plate, and the shell-substance is highly punctate.

Chotean limestone. *Pike county, Missouri.*

GENUS CYRTIA, DALMAN.

Page 10.

See Plates 21, 25, 26, 28.

CYRTIA EXPORRECTA, Wahlenberg, var. ARRECTA, Hall and Whitfield.

See Plate 28.

Fig. 32. View of the umbonal cavity of the conjoined valves; showing the foramen, the strong dental plates, and the articulating apparatus. × 2.

Niagara group. *Louisville, Kentucky.*

CYRTIA RADIANS, sp. nov.

Fig. 33. Internal cast of a large specimen; showing the general contour of the pedicle-valve, the impression of its dental plates and low median septum.

Niagara group. *Milwaukee, Wisconsin.*

CYRTIA SIMPLEX, Phillips.

Figs. 34, 35. Cardinal and profile views of an entire individual of average size; showing the recumbent cardinal area and the unplicated surface.

Fig. 36. An enlargement of the surface of the same specimen; showing the fine radial lines, which are interrupted concentrically and produced into short spinules. × 10.

Middle Devonian, *Bredelar, Westphalia.*

CYRTIA ALTA, Hall.

See Plate 26.

Fig. 37. The cardinal area of the pedicle-valve; showing the vertical striation by the shell canals, and retaining the deltidial covering.

Fig. 38. Profile of a pedicle-valve in its normal position; showing the inclination of the cardinal area. Incipient plications are also seen about the anterior margins of the valve.

Chemung group. *Meadville, Pennsylvania.*

GENUS SPIRIFER, SOWERBY.

Page 1.

SPIRIFER ACUMINATUS, Conrad.

Figs. 39, 40. Profile and cardinal views of a normal example; showing the sharply elevated median fold and the duplicate plications.

Corniferous limestone. *Sandusky, Ohio.*

Fig. 41. Internal cast of a large pedicle-valve; showing the size and composition of the muscular area.

Hamilton shales. *Eastern New York.*

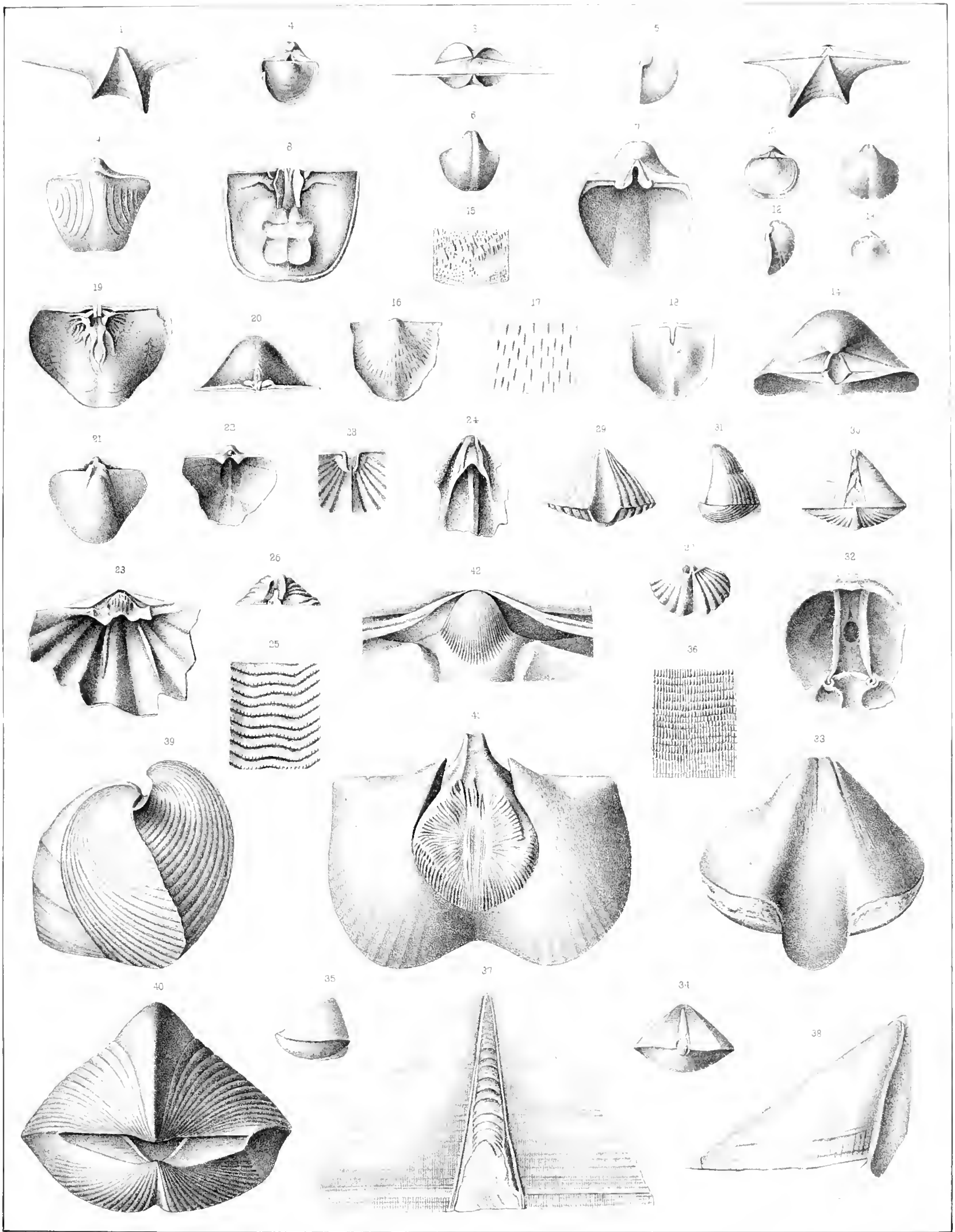
Fig. 42. Internal cast of the central cardinal portion of the brachial valve; showing the impression of the deeply striated cavity representing the cardinal process, the position of the cardinal area, dental sockets and socket-walls. × 4.

Corniferous limestone. *Hanover, Indiana.*

BRACHIOPODA.

SPIRIFERIDÆ.

Generic Illustrations.



G.B. Simpson del.

Phil. Ast lith.

PLATE XL.

(Figures 1-3, 6, 7, 10, 12-21, 23-31 by E. Emmons; 4, 5, 22 by R. P. Whitfield; 8, 9, 11 by G. B. Simpson.)

Legend:
- dl. Dental lamellæ.
- hp. Hinge-plate.
- vs. Median cleft of hinge-plate.
- cs. Crural plates.
- s. Median septum.
- l. Loop.
- x. Stem of loop.
- r. Diductor scars.
- a. Anterior adductors.
- a′. Posterior adductors.
- v. Vascular sinuses.

Genus WHITFIELDELLA, gen. nov.

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Whitfieldella intermedia, Hall.

Fig. 1. The interior of a pedicle-valve; showing the unclosed delthyrium, teeth and convergent dental lamellæ. × 2.

Fig. 2. Cardinal portion of the brachial valve; showing the median division of the hinge-plate into two triangular processes. × 4.

Clinton group. *Hamilton, Ontario.*

Whitfieldella naviformis, Hall.

Fig. 3. The cardinal portion of a brachial valve; showing the structure of the hinge-plate, which is primarily divided medially, the median cleft being partially filled by an erect lobe. × 3.

Clinton group. *Western New York.*

Whitfieldella nitida, Hall.

Fig. 4. The cardinal portion of a pedicle-valve; showing the teeth, and the foramen almost enclosed by the substance of the shell. × 3.

Fig. 5. The cardinal portion of a brachial valve; showing the medially divided hinge-plate, the faint median septum and the elongate dental sockets. × 3.

Fig. 6. A preparation of the spirals and loop in a specimen in which the entire brachidium has been detached from the crura and revolved through an arc of 180°, entirely reversing its normal position.

Fig. 7. A profile of the same specimen. In both of these figures the horizontal stem of the loop as represented is much too long, and in figure 7, the dotted line from the letter *x* should terminate at this stem and not on the supporting matrix. (c.)

Figs. 8, 9. Two views of a large and transverse example; the usual form occurring in this locality.

Niagara group. *Waldron, Indiana.*

Fig. 10. An internal cast of conjoined valves; showing the position of the dental plates in the pedicle-valve, the impression of the divided hinge-plate, muscular scars and vascular sinuses in the brachial valve. × 2.

Niagara dolomites. *Milwaukee, Wisconsin.*

Fig. 11. Dorsal view of an elongate shell, having the greatest width anteriorly.

Niagara group. *Waldron, Indiana.*

Figs. 12, 13. Dorsal and anterior marginal views of a shell; showing the prevailing form of the species at this locality. × 2.

Niagara group. *Louisville, Kentucky.*

Whitfieldella didyma, Dalman.

Figs. 14, 15. Two views of an average specimen; showing the usual form of the shell, and the narrow, elevated umbo of the pedicle-valve.

Wenlock limestone. *Island of Gotland.*

WHITFIELDELLA CYLINDRICA, Hall.

Figs. 16, 17. Ventral and profile views of a large individual.

Fig. 18. A preparation of the brachidium; showing the mode of attachment of the spirals and the form of the loop. (c.)

Fig. 19. A similar preparation; showing the form of the spirals when exposed by the removal of the brachial valve. (c.)

Fig. 20. The internal cast of a pedicle-valve; showing the deep impression of the diductor scars.

Fig. 21. The internal cast of a brachial valve; showing the impressions of the crural plates and short median septum. The anterior portions of this shell are concealed by the matrix.

Fig. 22. The exterior of a normal example; showing the high shouldered umbones and inconspicuous beak.

Niagara group. *Hillsboro, Ohio.*

GENUS HYATTELLA, GEN. NOV.

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HYATTELLA CONGESTA, Conrad.

Fig. 23. The internal cast of a pedicle-valve; showing the impressions of the pedicle-cavity and the muscular area. × 2.

Fig. 24. A cardinal view of the same specimen; showing the impression of the dental lamellæ and of the divided hinge-plate. × 2.

Clinton group. *Reynale's Basin, N. Y.*

Fig. 25. Exterior of a rather large specimen; showing the trilobation of the exterior which is frequently more developed than in this instance; also the fine concentric lineation of the surface. × 2.

Clinton group. *Lockport, N. Y.*

Fig. 26. A restoration of a brachidium, made from transverse sections of silicified specimens. (c.)

Clinton group. *Reynale's Basin, N. Y.*

Fig. 27. The cardinal portion of a brachial valve; showing the structure of the hinge-plate, its narrow median division, and the bases of the crura. × 5.

Fig. 28. The same specimen viewed in profile from the front; showing the conspicuous elevation of the lateral divisions. × 5.

Clinton group. *Lockport, N. Y.*

HYATTELLA JUNIA, Billings.

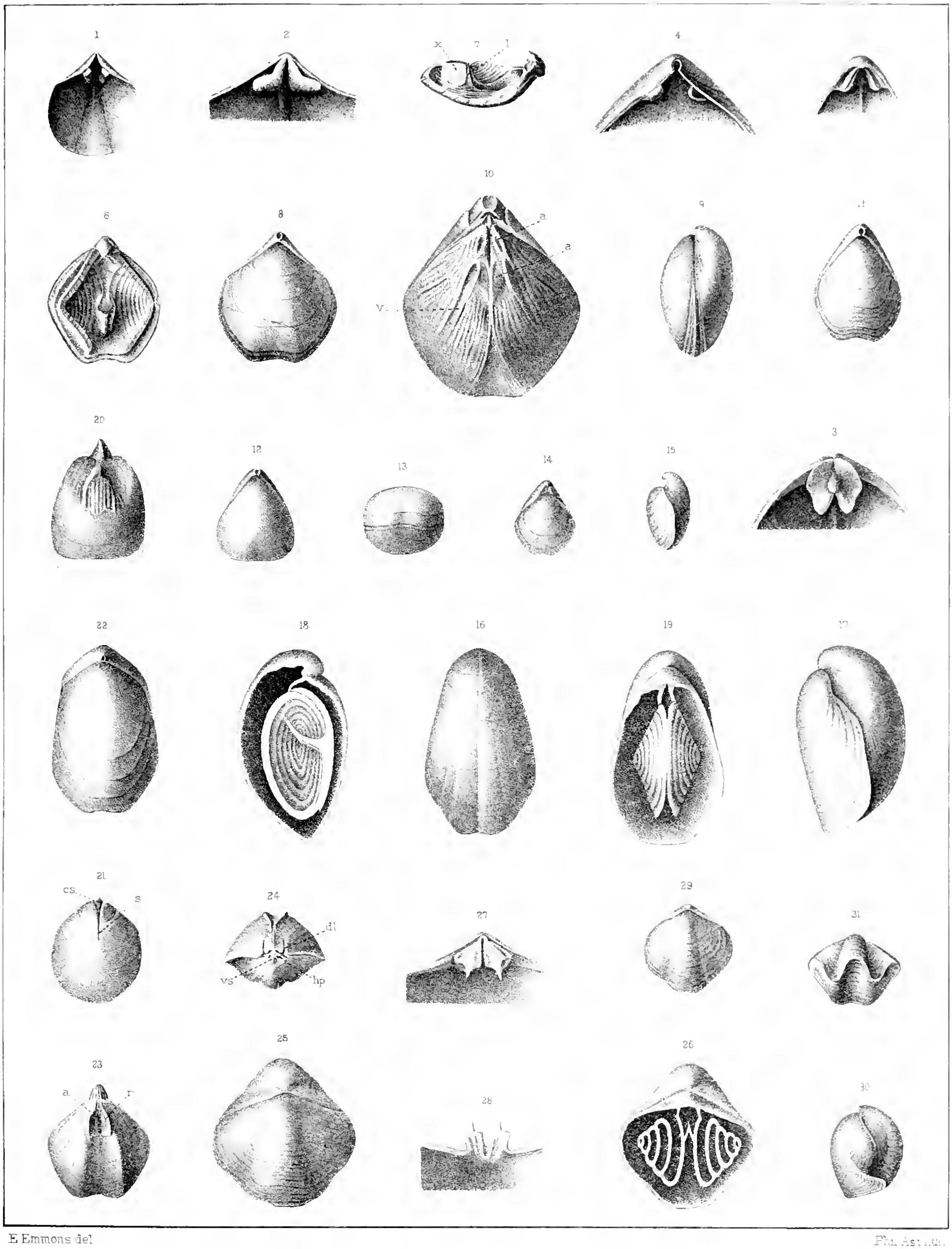
Figs. 29-31. Three views of a normal individual; showing the strong lobation of the surface and the fine concentric lineation. × 2.

Middle Silurian. *Cape East, Anticosti*

BRACHIOPODA.

MERISTIDÆ.

Generic Illustrations



E Emmons del

Phil. Ast. lith.

PLATE XLI.

(Figures 1 by C. E. BEECHER; 2, 3, 29, 30 by G. B. SIMPSON, 4, 7, 8, 11-20, 22-28, 31, 32 by E. EMMONS; 5, 6 by R. P. WHITFIELD; 9, 10, 21 by J. M. CLARKE.)

Legend: r. Diductor scars.
a. Adductor scars.
p. Cast of the pedicle-cavity.

GENUS MERISTINA, HALL.

Page 65.

MERISTINA MARIA, Hall.

Fig. 1. The youngest shell observed; showing the foramen which is concealed in the adult condition, and the lenticular valves without fold or sinus. × 5.

Figs. 2, 3. Two views of an average adult individual; showing the gibbosity of the valves, the close incurvature of the beaks and the development of the fold and sinus.

Fig. 5. The cardinal portion of the brachial valve; showing the median cleft in the hinge-plate, forming an elongate cavity supported by a low median septum. × 2.

Fig. 6. The cardinal portion of a mature pedicle-valve; showing the open delthyrium from which the deltidial plates have been resorbed, and the thick teeth supported by dental plates.

Niagara group. *Waldron, Indiana.*

Fig. 7. The brachidium, viewed from the brachial valve and naturally retained by incrustation; showing the form of the cones and the bifurcated loop.

Niagara dolomites. *Bridgeport, Illinois.*

Fig. 8. A preparation of the brachidium, showing its relations to the valves, and the great size of the primary lamellæ. (c.)

Fig. 9. A preparation, showing the condition of the brachidium at a very early stage of growth. The primary lamellæ are very long and much stronger than the others; the spiral cones much depressed and its volutions few and lax. The stem of the loop appears to be simple at its extremity, but this may be due to imperfect retention. × 5. (c.)

Fig. 10. A larger but still immature shell which has suffered an injury to the peripheral growth of the valves on one side. This obstruction has produced a deformation of the spiral cone on that side, which has conformed itself to the irregularly contracted cavity, probably without disturbance of function. The spiral cones are still very depressed in comparison with the adult condition seen in figs. 7, 8 and 11, but the loop seems to have attained its normal condition. × 2. (c.)

Fig. 11. A restoration of the brachidium, viewed from the pedicle-valve, a portion of the cones being removed to show the loop, the great divergence of the umbonal curves of the primary lamellæ, and the mode of attachment of these lamellæ to the crura.

Fig. 12. A preparation of the interior, in which the brachidium has become detached from the crura and been revolved through nearly 180°, almost reversing its relations to the shell but without the disturbance of any of its parts. The median septum of the brachial valve remains in its normal position. (c.)

Fig. 13. Lateral view of one of the spiral cones in its normal relation to the valves; showing the slight compression in two directions upon the ventral slopes. (c.)

Niagara group. *Waldron, Indiana.*

Fig. 14. A partial internal cast of the pedicle-valve; showing the impressions of the conspicuous dental lamellæ and of the deep diductor scars.

Fig. 15. An internal cast of a large pedicle-valve; showing features similar to those in the preceding figure, and radiate vascular markings over the pallial region.

Fig. 16. The internal cast of a smaller shell which had been greatly thickened in the umbonal region of the pedicle-valve; showing the impression of the strong muscular scar and the vascular sinuses diverging from about its margins.

Fig. 17. A cardinal view of the same specimen; showing the filling of the pedicle-cavity, and the position of the median septum of the brachial valve.

Niagara dolomites. *Bridgeport, Illinois.*

MERISTINA RECTIROSTRA, Hall.

Fig. 18. A young shell with elongate valves.

Figs. 19, 20. The mature shell; showing its usual outline and the erect beak of the pedicle-valve.

Fig. 21. The beaks of an adult specimen, enlarged to show the unclosed triangular delthyrium. × 3.
Niagara group. *Waldron, Indiana.*

MERISTINA BLANCHA, Billings.

Figs. 22, 23. Two views of the original specimen.
Lower Helderberg. *Square Lake, Maine.*

MERISTINA TUMIDA, Dalman.

Fig. 4. An internal cast; showing the median septum, muscular scars and vascular sinuses of the brachial valve.
Wenlock limestone. *Wenlock Edge, England.*

Figs 24, 25. Two views of a specimen rather below the average size; showing the low, concave median fold on the brachial valve.
Upper Silurian. *Westergarn, Island of Gotland.*

GENUS HINDELLA, DAVIDSON.

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HINDELLA UMBONATA, Billings.

Figs. 26, 27. Two views of a specimen which is extreme in the degree of contraction of the umbo of the pedicle-valve. × 2.

Figs. 29, 30. The more usual form of the shell, having full, shouldered umbones on both valves.
Middle Silurian. *Junction Cliff, Anticosti.*

HINDELLA PRINSTANA, Billings.

Fig. 28. The usual form of this shell, which is more orbicular in outline and less distinctly angulated at the cardinal angles than in the typical *H. umbonata*, represented in figs. 29 and 30. In a large number of these shells it is very difficult to fix upon determinative characters distinguishing these two forms.
Middle Silurian. *Junction Cliff, Anticosti.*

GENUS KAYSERIA, DAVIDSON.

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KAYSERIA LENS, Phillips.

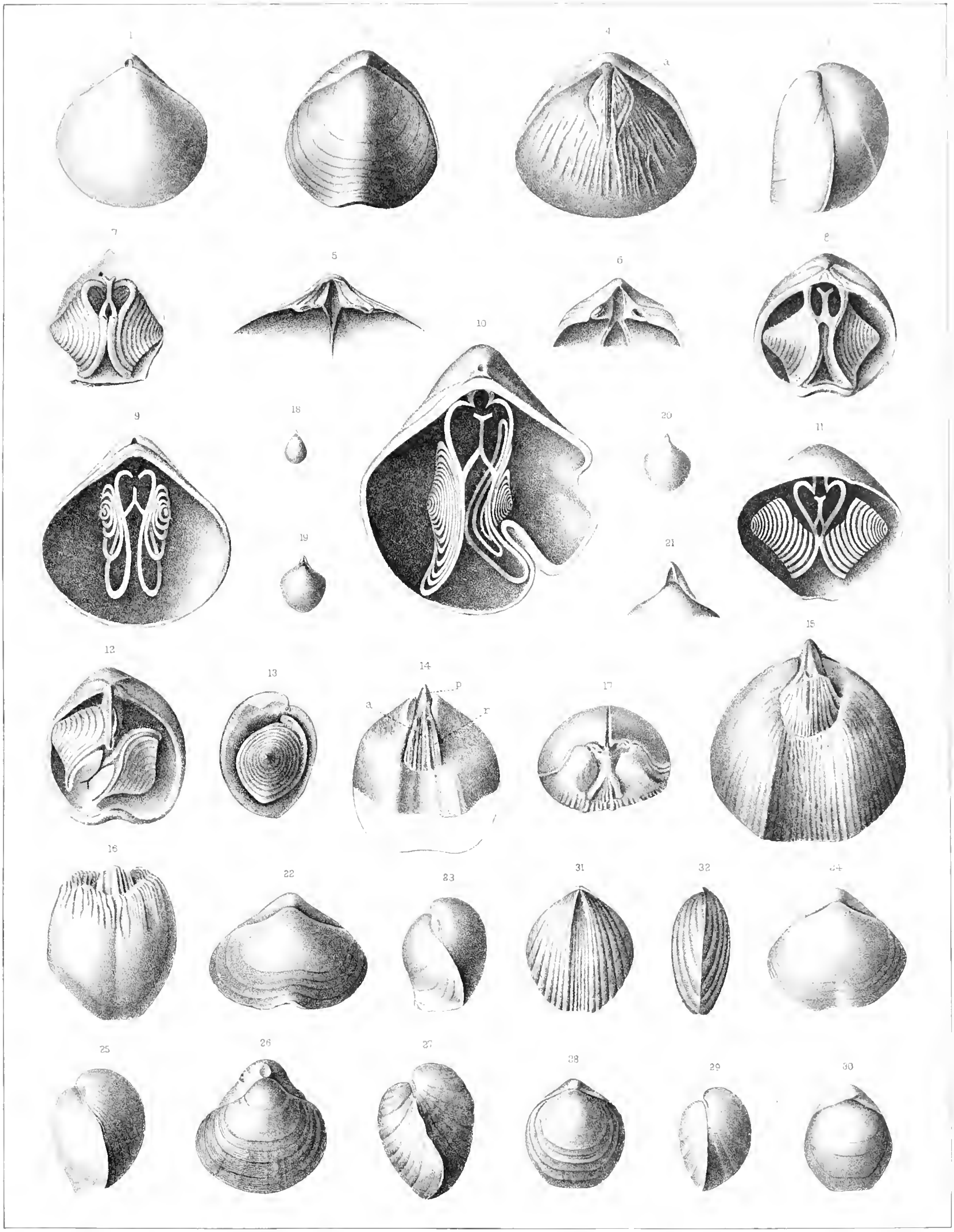
Fig. 31. Dorsal view of an average example; showing the slight projection of the beak of the pedicle-valve, and the fine plication of the median sinus. × 2.

Fig. 32. Profile of the same specimen; showing the relatively slight convexity of the valves. × 2.
Middle Devonian. *Eifel, Germany.*

BRACHIOPODA.

MERISTIDÆ.

Generic Illustrations.



E. Emmons del.   Phil. Ast lith.

PLATE XLII.

(Figures 1-6, 11-21, 25, 27-29 by E. EMMONS; 7-10, 22-24, 26, 30-32 by R. P. WHITFIELD.)

Legend : pl. "Shoe-lifter."
t. Teeth.
dl. Dental lamellæ.
hp. Hinge-plate.
s. Septum of brachial valve.
b. Dental sockets.
c. Crura.
a. Adductor scars.
r. Didnctor scars.

GENUS MERISTA, SUESS.

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MERISTA TENNESSEENSIS, sp. nov.

Figs. 1, 2. Two views of the exterior of a somewhat elongate example.
Fig. 3. The interior of a pedicle-valve of a broader form; showing the "shoe-lifter" process.
Fig. 4. The interior of a brachial valve of the same specimen; showing the divided hinge-plate and the median septum.
Fig. 5. The exterior of the pedicle-valve; showing the cavity left by the removal of the "shoe-lifter."
Fig. 6. A broad individual viewed from the brachial valve.

Lower Helderberg group. *Perry county, Tennessee.*

MERISTA TYPA, Hall.

Fig. 7. The interior of a pedicle-valve somewhat incomplete about the margins; showing the great width of the "shoe-lifter," and the extension of the dental plates upon its surface.
Figs. 8, 10. Two views of the exterior of a normal adult specimen.
Fig. 9. Interior of a pedicle-valve in which the "shoe-lifter" is highly arched and the dental lamellæ conspicuously thickened.
Fig. 11. A pedicle-valve having a very broad and low "shoe-lifter," and short, scarcely divergent dental plates.
Fig. 12. An imperfect pedicle-valve with sharply angled and highly elevated "shoe-lifter," and prominent dental plates.

Lower Helderberg group. *Cumberland, Maryland.*

SUBGENUS DICAMARA, S.-GEN. NOV.

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DICAMARA SCALPRUM, F. Roemer.

Fig. 13. A profile of a specimen cut to show the form of one of the spiral cones.
Fig. 14. View of the same preparation from the pedicle-valve; showing the spirals and the cavity left by the removal of the "shoe-lifter."

Middle Devonian. *Hartz Mountains (?), Germany.*

Fig. 15. The interior of a brachial valve; showing the "shoe-lifter," and the dividing median septum. Drawn from a gutta-percha impression which retains on the posterior margin a portion of the pedicle-valve.
Fig. 16. A view of a specimen which shows the cavity left by the removal of the "shoe-lifter" of the brachial valve, the median septum remaining in place. The apical portion of the cavity of the "shoe-lifter" of the pedicle-valve is also shown.

Middle Devonian. *Pelm, Germany.*

GENUS CHARIONELLA, BILLINGS.

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CHARIONELLA SCITULA, Billings.

Fig. 17. Dorsal view of a specimen from which a portion of the shell has been removed exposing the muscular impressions of the brachial valve and the median thickening of the hinge.

Fig. 18. An internal cast of the pedicle-valve; showing the impression of the muscular area and traces of the radiating lines on the inner laminæ of the shell.

Fig. 19. The cardinal portion of the brachial valve. The hinge-plate in this genus takes the form of a concave thickening adherent to the bottom of the valve. That portion of it which forms the socket-walls lies close against the margins of the valves making very narrow dental sockets. The crura arise from the inner extremities of these walls.

Corniferous limestone. *Cayuga, Ontario.*

CHARIONELLA HYALE, Billings.

Figs. 20, 21. Two views of an internal cast, having a hinge-structure similar to that in the preceding species.

Guelph limestone. *Guelph, Ontario.*

GENUS PENTAGONIA, COZZENS.

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PENTAGONIA UNISULCATA, Conrad.

Fig. 22. The exterior of a pedicle-valve; showing the broad, angular median sinus.

Fig. 23. A cardinal view of the same specimen; showing the median sinus on each valve and the single pair of cardinal folds on the brachial valve.

Fig. 24. Anterior marginal view of the same specimen; showing the elevation of the median fold of the brachial valve.

Corniferous limestone. *Western New York.*

Figs. 25, 26. Profile and cardinal views of a specimen which has no sinus on the fold of the brachial valve.

Hamilton group. *Centerfield, N. Y.*

Fig. 27. The hinge-plate as viewed from the front; showing the erect position of the crura.

Fig. 28. The same specimen viewed from above; showing the deep central excavation of the hinge-plate, the form of the socket-walls and the position of the crura. × 3.

Fig. 29. A preparation, showing the form of one of the spiral cones and of a portion of the loop. It is probable that the latter feature is incomplete. (c.)

Hamilton group. *Western New York.*

Fig. 30. The interior of a brachial valve; showing articulating processes, muscular impression and short, low median septum.

Corniferous limestone. *Falls of the Ohio.*

Fig. 31. Cardinal view of a shell with two pairs of folds on the posterior margin of the brachial valve. This is the form which has been termed var. *biplicata.*

Hamilton group. *Darien, N. Y.*

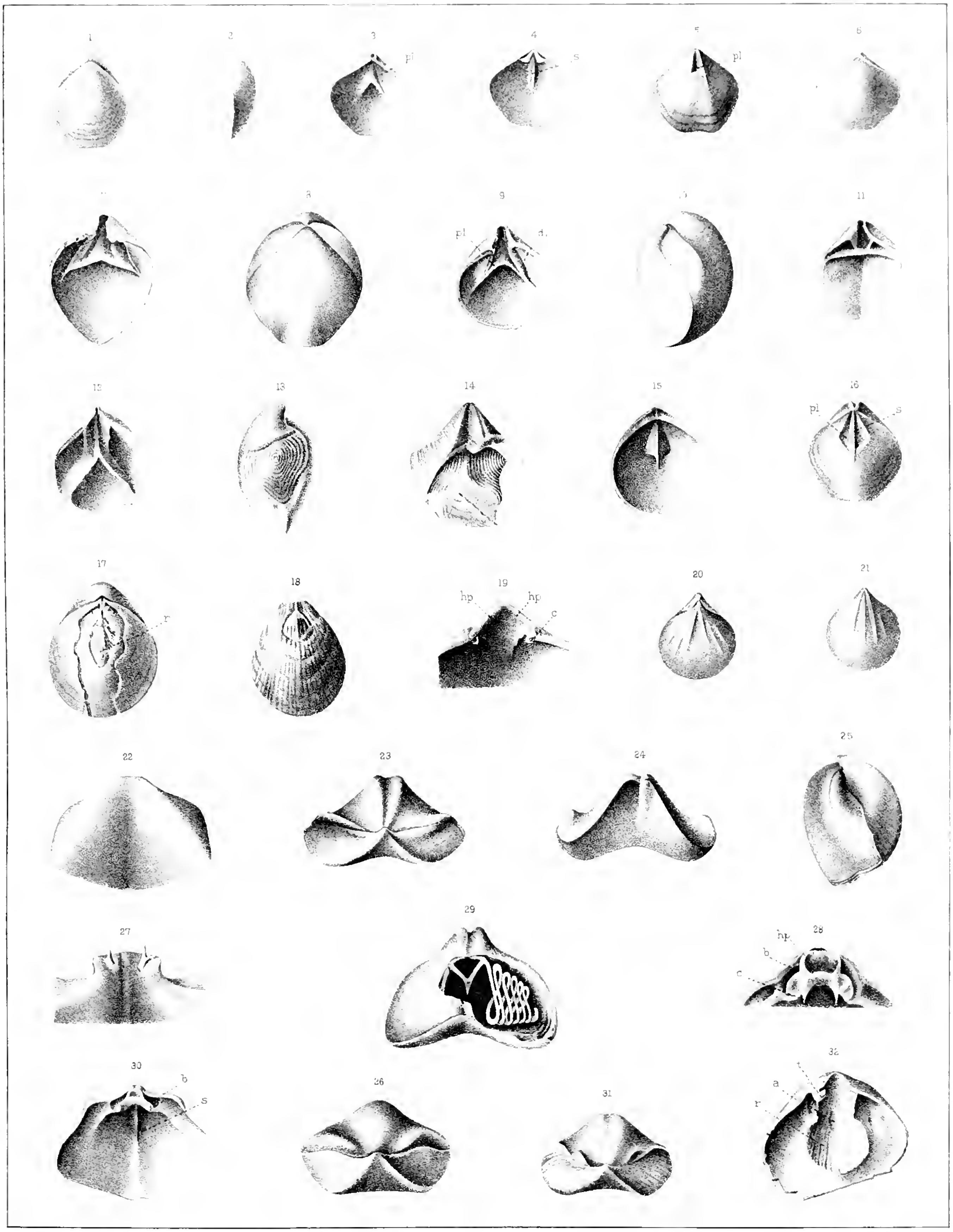
Fig. 32. The interior of an imperfect pedicle-valve; showing the articulating apparatus and muscular impressions.

Corniferous limestone. *Falls of the Ohio.*

BRACHIOPODA.

MERISTIDÆ.

Generic Illustrations.



E Emmons del.

PLATE XLIII.

(Figures 1-13 by F. B. MEEK; 14, 15, 18-30 by R. P. WHITFIELD; 16, 17 by E. EMMONS.)

GENUS MERISTELLA, HALL.

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MERISTELLA ARCUATA, Hall.

See Plate 44.

Figs. 1, 2. Two views of a normal shell; showing form and contour.
Lower Helderberg group (shaly limestone). *The Helderbergs, N. Y.*

MERISTELLA LÆVIS, Hall.

See Plate 44.

Figs. 3-6. Dorsal, profile, cardinal and front views of an adult shell.
Lower Helderberg group (shaly limestone). *Albany county, N. Y.*

MERISTELLA BELLA, Hall.

See Plate 44.

Figs. 7-9. Ventral, front and dorsal views of a normal individual; showing the median sinus on both valves.
Lower Helderberg group. *Schoharie, N. Y.*

MERISTELLA PRINCEPS, Hall.

Figs. 10, 11. Profile and front views of an example of extremely large size, with an unusual development of the shallow median sinus and linguiform extension in front.
Figs. 12, 13. Dorsal and ventral views, presenting the usual characters of an adult specimen.
Lower Helderberg group. *Schoharie, N. Y.*

MERISTELLA SUBQUADRATA, Hall.

Figs. 14, 15. Dorsal and profile views of a typical specimen.
Lower Helderberg group. *Schoharie, N. Y.*

MERISTELLA WALCOTTI, sp. nov.

See Plate 44.

Figs. 16, 17. Dorsal and profile views of a rotund and rather elongate example.
Oriskany sandstone. *Cayuga, Ontario.*

MERISTELLA NASUTA, Conrad.

See Plate 44.

Fig. 18. Ventral view of a shell of median size.
Corniferous limestone. *Erie county, N. Y.*
Figs. 19, 20. Dorsal and profile views of an unusually large, strongly nasute example; showing in profile the plano-convex contour of the shell. This is the form originally described as *Meristella Elissa*, Hall.
Schoharie grit. *Albany county, N. Y.*

MERISTELLA DORIS, Hall.

Figs. 21, 22. Dorsal and profile views of a normal shell; showing the deltidial plates and fine radial surface striæ.
Corniferous limestone. *Williamsville, N. Y.*

Meristella Haskinsi, Hall.

See Plate 44.

Figs. 23, 24. Dorsal and profile views of the usual form of the species.
Hamilton shales. *Moscow, N. Y.*

Meristella Barrisi, Hall.

See Plate 44.

Figs. 25, 26. Ventral and dorsal views of different shells, giving the external characters.
Limestone of the Marcellus shales. *Stafford, N. Y.*

Meristella rostrata, Hall.

Figs. 27, 28. Dorsal and profile views, showing the usual form and size of the species.
Tully limestone. *Ovid, N. Y.*

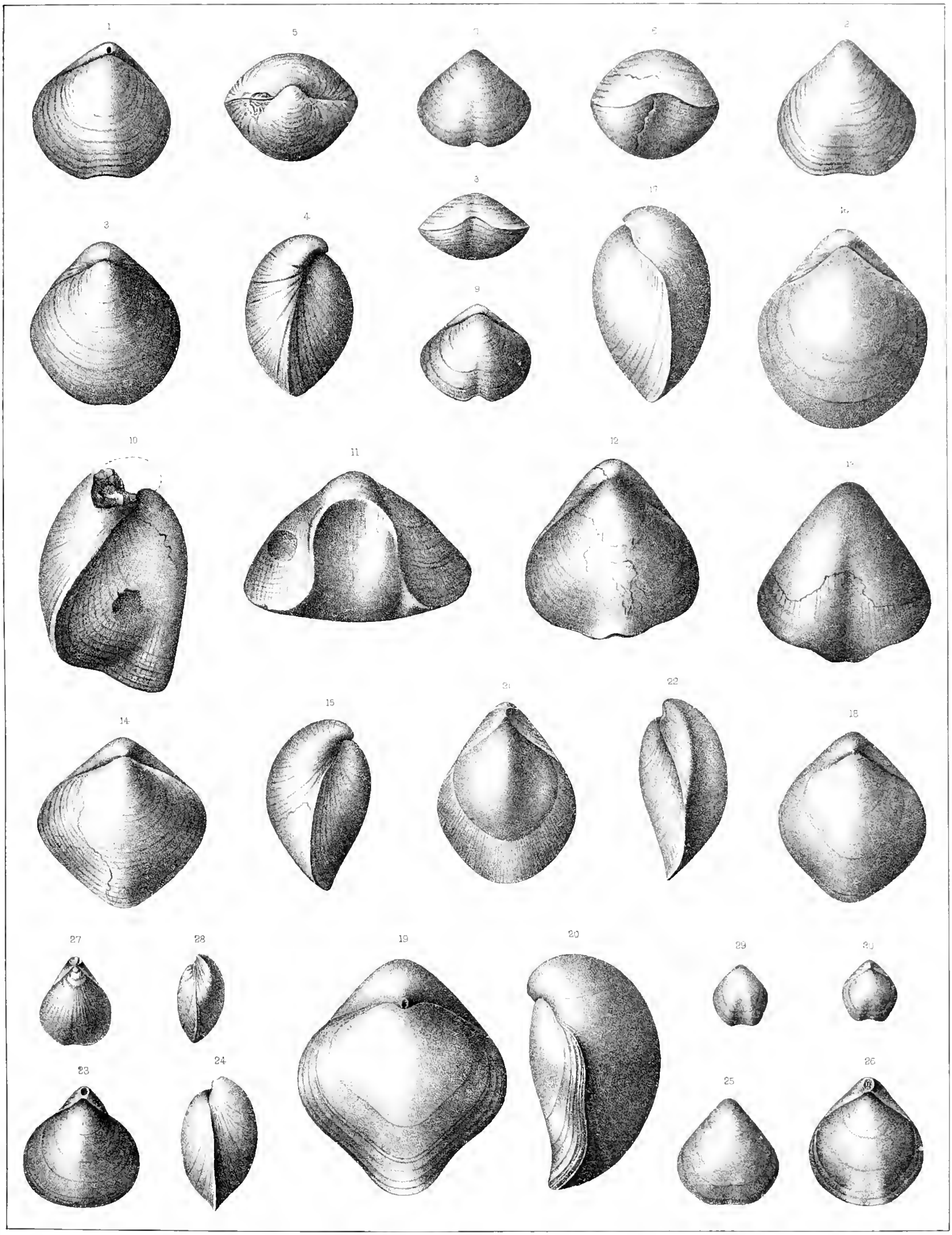
Meristella Meta, Hall.

Figs. 29, 30. Dorsal and ventral views of an adult specimen.
Hamilton group. *Delphi, N. Y.*

BRACHIOPODA.

MERISTIDÆ.

Generic Illustrations



R. P. Whitfield del.

Phil. Ast lith.

PLATE XLIV.

(Figures 1-12, 15-19, 23, 24, 27, 28, 31, 32 by E. EMMONS; 13, 14, 20-22, 25, 26, 29, 30 by R. P. WHITFIELD.)

Legend: dp. Deltidial plates.
p. Pedicle-cavity.
d. Teeth.
r. Diductor scars.
a. Anterior adductors.
a′. Posterior adductors.

GENUS MERISTELLA, HALL.

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MERISTELLA BELLA, Hall.

See Plate 43.

Fig. 1. The interior of a pedicle-valve; showing the teeth, the deeply excavated muscular area and the testaceous thickening which fills the pedicle-cavity except along the median line.

Fig. 2. The interior of the brachial valve; showing the subquadrate outline of the hinge-plate, its post-lateral expansions and the ante-lateral position of the crural bases. × 3.

Fig. 3. The hinge-plate viewed in profile from the anterior margin of the brachial valve; showing its concave surface, the elevation of the crural bases and the median supporting septum.

Lower Helderberg group. *The Helderbergs, N. Y.*

MERISTELLA LÆVIS, Hall.

See Plate 43.

Fig. 4. The hinge-plate; showing its subtriangular form, median concavity and supporting septum. × 3.

Lower Helderberg group. *Albany county, N. Y.*

MERISTELLA ARCUATA, Hall.

See Plate 43.

Fig. 5. The hinge-plate viewed from in front; showing the dental sockets and socket-walls, elevation of the crural bases and the median septum.

Lower Helderberg group. *Schoharie, N. Y.*

MERISTELLA WALCOTTI, sp. nov.

See Plate 43.

Fig. 6. The spirals and loop, naturally preserved by incrustation of silica, and exposed by the removal of the pedicle-valve. The specimen is viewed from the anterior margin, and in the cavity between the cones is seen the loop with its scissors-shaped branches.

Fig. 7. The same specimen viewed from the posterior margin, and showing the position of the branches of the loop with reference to the ribbon of the spiral cones.

Fig. 8. A similar preparation, to which a portion of the internal cast of the valves adheres. The specimen is viewed from the dorsal side and shows the form of the spiral cones and the length of the median septum.

Fig. 9. An internal longitudinal view; showing the position and form of the loop and one of the spiral cones. Partially restored.

Fig. 10. A naturally incrusted brachidium viewed from the dorsal side, and showing the prominence of the primary lamellæ of the cones.

Fig. 11. A similar specimen; showing the spiral cones on the ventral side.

Fig. 23. A view of the brachidium from the ventral side, a portion of the cones being omitted to show the primary lamellæ and loop. Restored.

Fig. 32. The hinge-plate. Drawn from a gutta-percha cast.

Oriskany sandstone. *Cayuga, Ontario.*

MERISTELLA LATA, Hall.

Fig. 12. An internal cast of the pedicle-valve; showing the filling of the pedicle-cavity and of the deep muscular impression.

Oriskany sandstone. *Albany county, N. Y.*

Meristella nasuta, Conrad.

See Plate 43.

Fig. 13. An internal cast of a pedicle-valve; showing the position of the teeth and the deep muscular impressions.

Fig. 14. An internal cast of a small and very elongate pedicle-valve; an unusual variation in form.

Schoharie grit. *Albany county, N. Y.*

Fig. 19. A pedicle-valve retaining the brachidium in a silicified and incrusted condition; showing the form of the cones and retaining in position the median septum of the brachial valve.

Corniferous limestone. *Williamsville, N. Y.*

Fig. 20. A similar specimen, the spirals being unincrusted and exposed by weathering.

Fig. 21. The interior of an incomplete pedicle-valve; showing dental plates and muscular impressions.

Fig. 22. The interior of a brachial valve; showing the subtriangular, medially concave hinge-plate, dental sockets, median septum and elongate adductor muscular area.

Fig. 24. The hinge-plate enlarged; showing the median depression, crural bases and supporting septum. × 3.

Fig. 25. Cardinal view of an internal cast of conjoined valves; showing the impressions of the muscular scars, teeth and dental lamellæ, sockets and median septum.

Corniferous limestone. *Western New York.*

Fig. 26. An internal cast of the brachial valve.

Schoharie grit. *Schoharie, N. Y.*

Meristella lenta, Hall.

Fig. 15. An internal cast of the pedicle-valve; showing the strong muscular scars and the generally depressed surface. × 2.

Fig. 16. A preparation, showing the form of the spiral cones resting in the pedicle-valve, with the median dorsal septum in position.

Fig. 17. An internal cast of the brachial valve, showing its convexity and the position of the median septum. A portion of the filling of the pedicle-cavity of the opposite valve is also exposed. × 2.

Fig. 18. A longitudinal internal view, showing the position and form of the loop and one of the spiral cones. Restored.

Oriskany sandstone. *De Cewville, Ontario.*

Meristella Barrisi, Hall.

See Plate 43.

Figs. 27, 28. Two views of a preparation, showing the form of one of the spiral cones.

Fig. 29. An internal cast of conjoined valves; showing the position of the median septum and dental lamellæ.

Fig. 30. An internal cast of the pedicle-valve.

Limestone of the Marcellus shale. *Stafford, N. Y.*

Meristella Haskinsi, Hall.

See Plate 43.

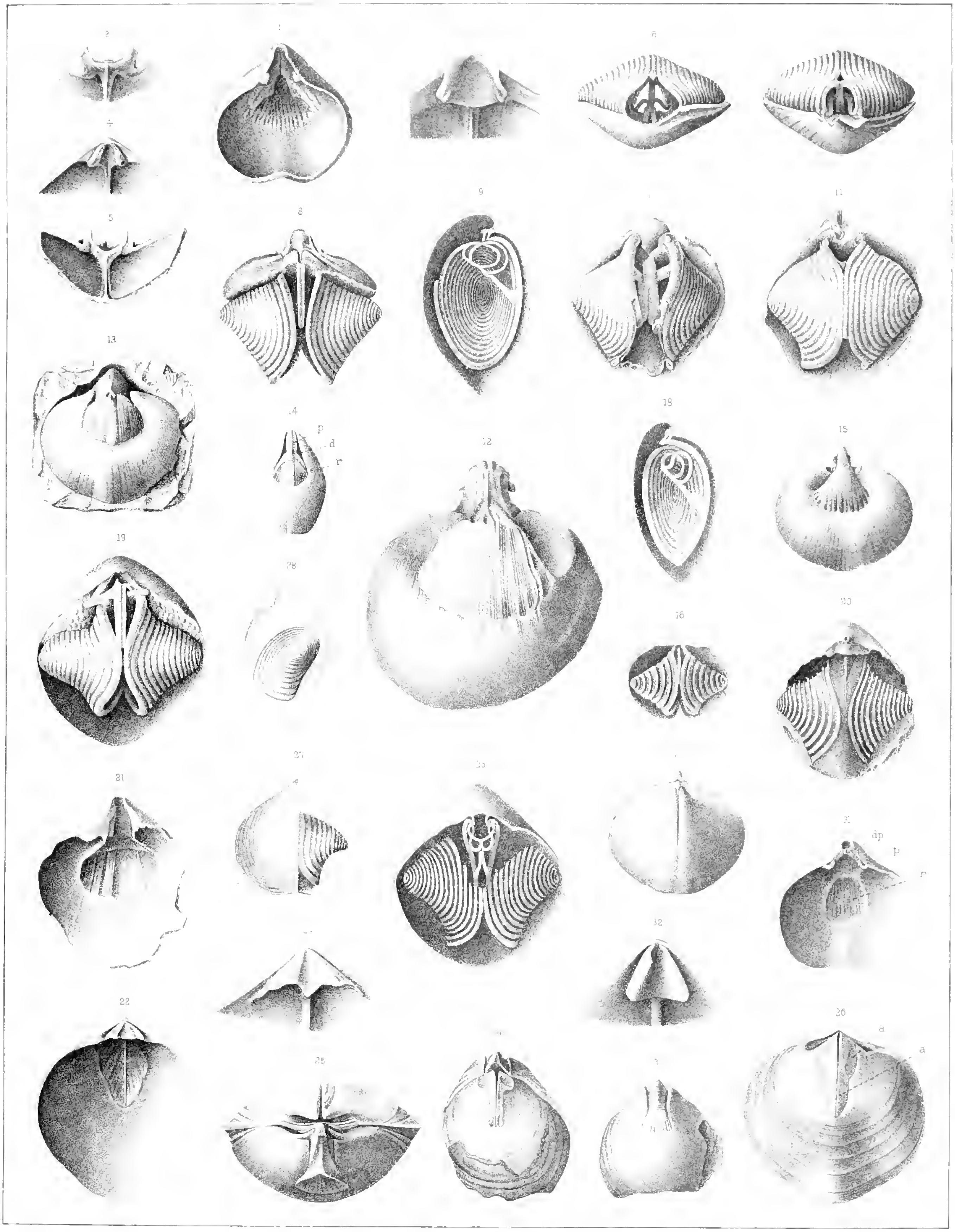
Fig. 31. The interior of a pedicle-valve retaining the deltidial plates, and showing the teeth and muscular scars.

Hamilton group. *Canandaigua Lake, N. Y.*

BRACHIOPODA.

MERISTIDÆ

Generic Illustrations



E Emmons del.

Phil Ast lith.

PLATE XLV.

(Figures 1-3, 6-12, 16, 18-21, 26-28, by R. P. WHITFIELD; 4, 5, 13-15, 25, 29, 30 by E. EMMONS; 17 by G. B. SIMPSON.)

GENUS ATHYRIS, McCOY.

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ATHYRIS VITTATA, Hall.

Figs. 1-3. Dorsal, profile and anterior marginal views of a normal individual; showing its comparatively short transverse diameter and the development of the median fold and sinus.

Fig. 4. The hinge-plate as viewed from above; showing the trilobation of the anterior margin, the deep depression of the median portion, the coalescence of the lateral portions with the socket-walls, and the large, unobstructed visceral foramen. The lateral lobes are the bases of the crura and are incorrectly represented as entire at their outer extremities. × 3. (c.)

Fig. 5. The interior of the cardinal portion of conjoined valves, the brachial valve being above. This view shows the elevation of the anterior face of the hinge-plate, the internal opening of the visceral foramen, the extension of the median lobe of the plate, the thickened crural plates, the crura attached to the crural lobes and their mode of union with the primary lamellæ of which a portion is shown. × 3. (c.)

Hamilton group. *Falls of the Ohio.*

ATHYRIS CORA, Hall.

Figs. 6-10. Dorsal, profile, cardinal, ventral and frontal views of the original specimen, which is somewhat exfoliated about the umbones; showing the sublenticular contour and the low median sinus on each valve.

Hamilton group. *Delphi, N. Y.*

ATHYRIS SPIRIFEROIDES, Eaton.

Fig. 11. Dorsal view of a large and senile individual, having the surface lamellæ highly developed and the median fold conspicuously elevated at the anterior margin.

Fig. 12. The interior of a pedicle-valve; showing the mature condition of the foramen without deltidial plates, the pedicle-, adductor and diductor scars.

Hamilton group. *Soft shales of Western New York.*

Fig. 13. A preparation of the brachidium, one of the spiral cones being removed to expose the structure of the loop. This figure shows the depressed ventral surface of the cones, the mode of attachment of the crura to the primary lamellæ, the anterior position of the loop, its broad lateral branches and saddle, the long stem, and the width and extent of the accessory lamellæ. × 2. (c.)

Hamilton group. *Alpena, Michigan.*

Fig. 14. An enlargement of the hinge-plate; showing its subquadrate-triangular outline, the oblique aperture of the visceral foramen, the thickening of the crural bases and the elevation of their posterior extension in the form of socket-walls; also the dental sockets and the slight submarginal thickening outside of them. × 3.

Fig. 15. An anterior view of the same specimen; showing the stout crural plates resting upon the bottom of the valve, and forming the inner wall and base of the dental sockets. In the background are seen the posterior elevation of the socket-walls, the visceral foramen and the beak. × 3.

Hamilton group. *Clarke county, Indiana.*

Fig. 16. A dorsal view of conjoined valves of a small individual on which the surface lamellæ are few and distant.

Hamilton group. *Western New York.*

Fig. 17. The interior of a brachial valve; showing the structure of the articulating apparatus and the elongate scar of the adductor muscles.

Hamilton group. *Falls of the Ohio.*

Figs. 18, 19. Dorsal and cardinal views of a narrow and rather rotund individual. Fig. 19 shows the marginal inflexion on the cardinal slopes of the pedicle-valve.

Fig. 20. Frontal view of a shell, showing about the minimum development of the median fold and sinus.

Fig. 21. Frontal view of a large example in which the development of median fold and sinus has virtually attained its maximum.

Hamilton group. *Various localities in the soft shales of Western New York.*

Fig. 22. A dorsal view of an internal cast of conjoined valves, showing the impression of the hinge-plate, the filling of the visceral foramen, the muscular scars and vascular markings, and also the cast of the rostral cavity of the pedicle-valve.

Hamilton group. *Hardy county, Virginia.*

Fig. 23. A ventral view of a preparation of the brachidium; showing the form of the spirals, the crura and their attachment to the primary lamellæ, and the accessory lamellæ.

Fig. 24. An internal cast of the pedicle-valve, slightly broken at the umbo; showing the adductor and diductor impressions, and the vascular sinuses.

Fig. 25. The exterior of a transverse, coarsely lamellose individual.

Hamilton group. *Various localities in the shales of Western New York.*

ATHYRIS ANGELICA, Hall.

Fig. 26. The exterior of a brachial valve.

Fig. 27. The exterior of a pedicle-valve. These figures show the fine, crowded concentric striæ extending from umbones to margins.

Fig. 28. An internal cast of a pedicle-valve; showing the filling of the deep pedicle-cavity, and the indistinct scar of the diductors.

Chemung group. *Belmont, N. Y.*

Fig. 29. Anterior view of the hinge-plate; showing the straight anterior edge, the crural plates, visceral foramen, and the elevation of the posterior portion of the surface. × 3.

Fig. 30. A profile view of an old and gibbous shell, with a few strong growth-lines.

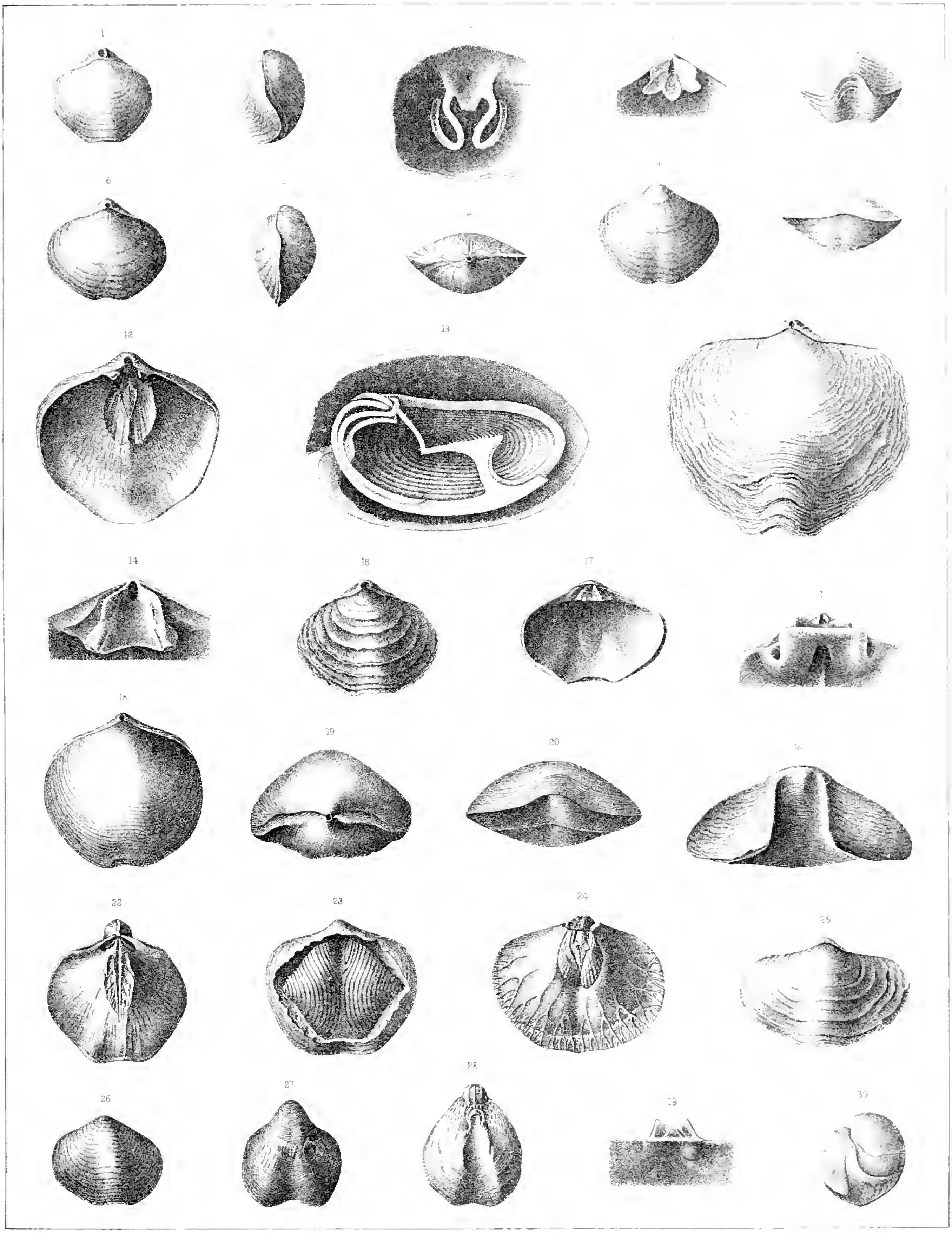
Chemung group. *Belfast, N. Y.*

BRACHIOPODA.

Palæont N Y Vol IV Pt Vol VIII

Generic Illustrations

Plate XLV



R P Whitfield del

F. Ast lith.

PLATE XLVI.

(Figures 1-5 by R. P. Whitfield; 6, 10, 15, 22-24 by G. B. Simpson; 7-9, 11-21, 25-28 by L. Emmons.)

Legend: p. Filling of pedicle-cavity.
t. Teeth.
d. Dental lamellæ.
cs. Cardinal margin.
r. Diductor scars.
a. Anterior adductors.
a′. Posterior adductors.
vc. Cast of visceral foramen.
hp. Cast of hinge-plate.

Genus ATHYRIS, McCoy.

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See Plate 45.

Athyris polita, Hall.

Fig. 1. A ventral view of an internal cast; showing the filling of the rostral cavity and the muscular impressions.

Fig. 2. Dorsal view of the same specimen.

Figs. 3-5. Profile, dorsal and ventral views of a specimen retaining the external surface.

Chemung group. *Steuben county, N. Y.*

This species has more the contour of shells which have been placed under the subgenus Seminula, than of the true Athyris. Should its surface prove to be devoid of free lamellæ, it would naturally fall into that group.

Athyris densa, sp. nov.

Fig. 6. The interior of a small but thickened and entire pedicle-valve; showing the broad cardinal surfaces, the deep pedicle-cavity and the relatively large muscular impressions which extend almost to the anterior margin of the valve.

St. Louis group. *Colesburgh, Kentucky.*

Fig. 7. The interior of a larger pedicle-valve; showing the thickening in the umbonal region and the division of the muscular area by a prominent ridge.

Fig. 8. The interior of a pedicle-valve with broader cardinal margins than the preceding specimens, and retaining the median ridge, but with the muscular area obscure.

St. Louis group. *Washington county, Indiana.*

Figs. 9, 10. Profile and dorsal views of conjoined valves; showing the contour of the shell, the foramen and broad cardinal slopes of the pedicle-valve, the median elevation and low marginal sulcus of the brachial valve.

St. Louis group. *Colesburgh, Kentucky.*

Fig. 11. The interior of a pedicle-valve, with a relatively small muscular area, and a linguate extension of the anterior margin which is much foreshortened in the figure.

St. Louis group. *Lanesville, Indiana.*

Fig. 12. The interior of a pedicle-valve; showing in fuller detail the structural features.

St. Louis group. *Colesburgh, Kentucky.*

Athyris Hannibalensis, Swallow.

Fig. 13. A dorsal view of the exterior of conjoined valves; showing the highly lamellose surface.

Fig. 14. The exterior of a pedicle-valve; showing the bases of the free lamellæ, and the low median sinus.

Fig. 15. The interior of a pedicle-valve; showing the character of the muscular area.

Choteau limestone. *Louisiana, Missouri.*

Athyris lamellosa, Léveillé.

Fig. 16. The ventral side of an internal cast of conjoined valves; showing the striated scar of the pedicle-muscle, the cordate and sharply defined adductor scars, and the faintly outlined diductors. Near the anterior margin is a portion of one of the broad concentric lamellæ.

Fig. 17. The opposite side of the same specimen; showing the peculiar form and division of the adductor scars, and a portion of one of the concentrically striated free lamellæ.

Waverly group. *Sciotoville, Ohio.*

Fig. 18. The exterior of a pedicle-valve; showing the normal marginal outline of the species.

Fig. 19. The exterior of a large brachial valve with few and distant lamellæ and unusually extended hinge-line. The first of these lamellæ bears a serrated margin, while the rest are regular. The anterior and lateral margins of the valve are concealed by the great expansion of the submarginal lamella.

Keokuk group. *Crawfordsville, Indiana.*

Fig. 20. The central cardinal portion of an internal cast of conjoined valves, enlarged; showing the position of the teeth, dental plates and hinge-plate, the filling of the pedicle-cavity and visceral foramen, the latter being traversed for its entire length by a median groove, representing a faint median ridge upon the brachial valve, extending from the apex across the muscular area. × 3.

Waverly group. *Sciotoville, Ohio.*

Athyris incrassata, Hall.

Fig. 21. The exterior of a somewhat weathered pedicle-valve.

Burlington limestone. *Burlington, Iowa.*

Genus SPIRIFER, Sowerby.

Page 1.

Fig. 22. This figure is an enlarged representation of an internal cast of a small pedicle-valve belonging to a species of Spirifer similar to *S. pseudolineatus*, Hall. This fossil occurs in the soft shales of the Waverly group, and its generic characters are usually obscured. Its relation to Spirifer is indicated by the long, thin dental lamellæ, low median septum, and fine surface spines which are plainly double-barrelled at the base. Additional specimens obtained since this plate was engraved show that these spines bear series of short lateral branches.

Waverly group. *Richfield, Ohio.*

Genus ATHYRIS, McCoy.

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Subgenus CLIOTHYRIS, King.

Cliothyris Roysii, Léveillé.

Fig. 23. Dorsal view of conjoined valves; showing the concentric rows of flat spines. × 2.

Keokuk group. *Keokuk, Iowa.*

Fig. 24. An enlargement of a portion of the surface.

Chester limestone. *Jackson county, Kentucky.*

Cliothyris hirsuta, Hall.

Fig. 25. Dorsal view of an average specimen denuded of its spines. × 2.

Fig. 26. A larger specimen with portions of the rows of flat spines adhering. × 2.

Fig. 27. View of the hinge-plate; showing the crescentiform wall made by the crural lobes, and the thick central lobe of the plate. × 5.

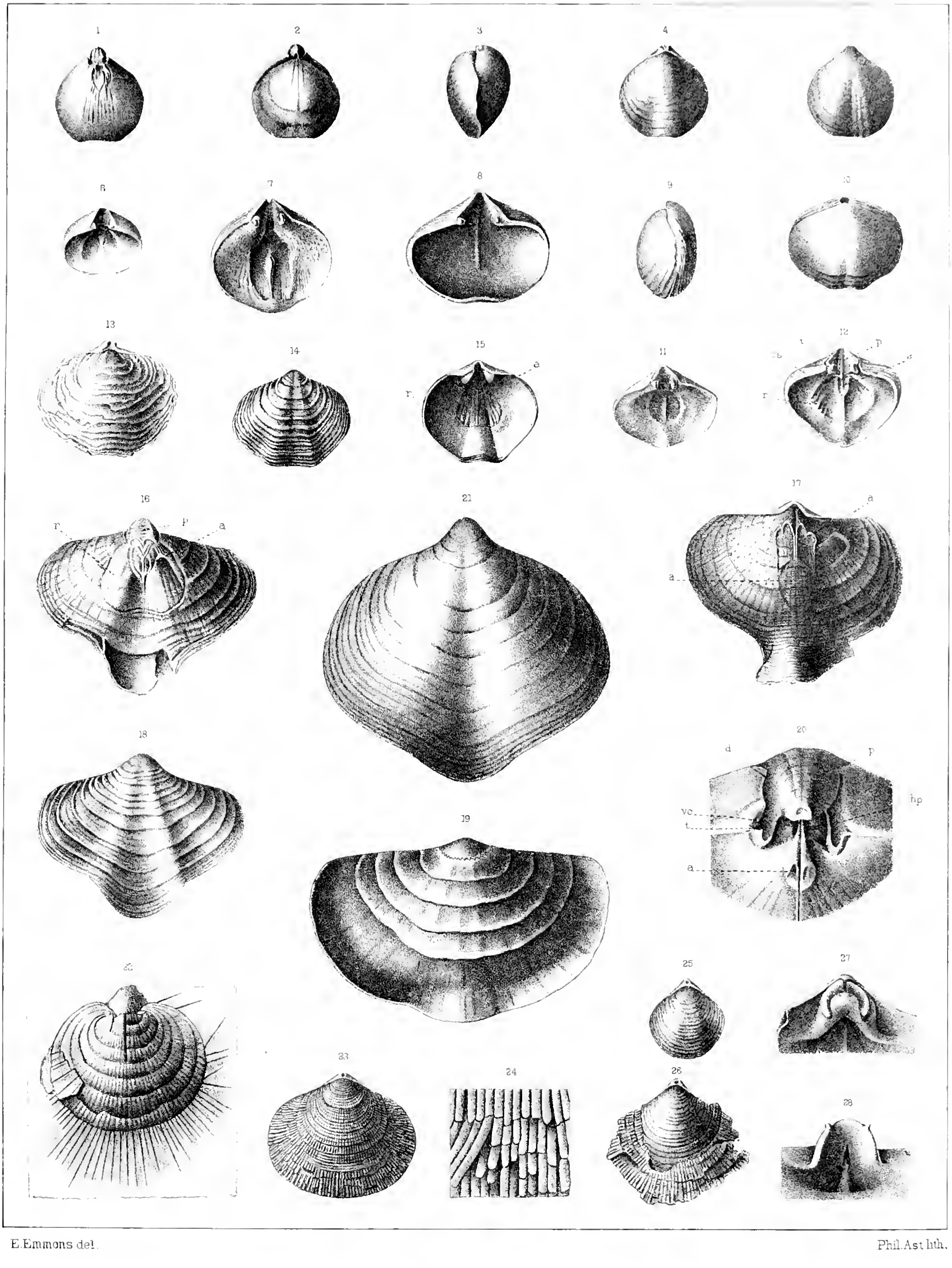
Fig. 28. The same specimen viewed from in front; showing the elevation of the hinge-plate, the crural bases and the minute visceral foramen which is usually closed in its upward extension. × 5.

St. Louis limestone. *Bloomington, Indiana.*

BRACHIOPODA.

ATHYRIDÆ.

Genera Illustrations



E. Emmons del.

Phil. Ast lith.

PLATE XLVII.

(Figs. 1-6, 12, 16-20, 22-34 by E. EMMONS; 7-11, 13-15, 21 by G. B. SIMPSON.)

Legend:
- p. Pedicle-cavity.
- vc. Visceral canal.
- a. Adductors.
- a'. Anterior adductors.
- r. Diductors.
- v. Vascular sinuses.
- ub. Umbonal blades of primary lamellæ.
- al. Accessory lamellæ.

GENUS ATHYRIS, McCOY.

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SUBGENUS SEMINULA, McCOY.

SEMINULA ROGERSI, sp. nov.

Fig. 1. A dorsal view of an internal cast of conjoined valves.

Fig. 2. A ventral view of a similar specimen; showing the cast of the pedicle-cavity and muscular scars.

Fig. 3. A cardinal view of the specimen represented in figure 2; showing, in addition to the features mentioned, the casts of the visceral foramen and hinge-plate.

Fig. 4. A profile of the specimen represented in figure 1.

Pendleton sandstone. *Pendleton, Indiana.*

SEMINULA TRINUCLEA, Hall.

Fig. 5. A dorsal view of conjoined valves; showing the contour of the species. × 2.

Fig. 6. A frontal view of the same specimen. × 2.

St. Louis limestone. *Bloomington, Indiana.*

Fig. 10. A ventral view of an internal cast of conjoined valves; showing the filling of the pedicle-cavity and the small muscular scar. × 1½.

Fig. 11. A dorsal view of the same specimen; showing the filling of the pedicle-cavity and the visceral foramen, the cavity of the dental and hinge-plates, and the faint muscular area. × 1½.

St. Louis group. *Spergen Hill, Indiana.*

Fig. 12. A dorsal view of a more strongly trilobed internal cast; showing with greater distinctness the character of the muscular area.

St. Louis group. *Harrison county, Indiana.*

Fig. 13. A view of the hinge-plate; showing its subquadrate outline and the prolongation of the crural lobes. × 5.

Fig. 14. The same specimen viewed from the beak, the latter being removed to show the elevation of the posterior extension of the plate, and exposing the visceral foramen. × 5.

St. Louis group. *Spergen Hill, Indiana.*

SEMINULA SUBQUADRATA, Hall.

Fig. 7. A dorsal view of conjoined valves, showing the sharp and distant concentric lines.

Chester limestone. *Crittenden county, Kentucky.*

Fig. 8. A dorsal view of a somewhat more orbicular form.

Fig. 9. A profile of the same specimen.

This shell is associated with typical forms of *S. trinuclea* and at this locality passage forms between these two extremes of expression are readily found. At other localities this form may prevail to the exclusion of the others.

St. Louis limestone. *Spergen Hill, Indiana.*

Fig. 15. The interior of a brachial valve of a more distinctly trilobed individual; showing the adductor scars and the hinge-plate which is slightly broken on the anterior margin.

Fig. 16. An anterior view of the hinge plate; showing the visceral foramen and the elevation of the crural plates and lobes. × 3.

St. Louis limestone. *Pella, Iowa.*

SEMINULA SUBTILITA, Hall.

Fig. 17. A view of the hinge-plate; showing its excavate upper face, subquadrate outline, striated posterior extensions and minute visceral foramen. × 5.
(?) Chester limestone. *Caldwell county, Kentucky.*

Fig. 18. The hinge-plate of another specimen; showing some differences in outline and surface. The position of the visceral foramen is occupied by a minute lobe. × 5.
Coal Measures. *Manhattan, Kansas.*

Fig. 19. A dorsal view of an orbicular and faintly lobed form.
Coal Measures. *Coppers Creek, Iowa.*

Fig. 20. A large specimen, very broad in the pallial region and strongly lobed on the anterior margin.
(?) Chester limestone. *Chester, Illinois.*

Fig. 21. A large individual with greatest width more posterior, strong anterior lobe, and sharp concentric lines.
Coal Measures. *Chariton county, Missouri.*

Fig. 22. An extremely trilobed shell with the greatest width near the anterior margin. The fine radiating lines upon the shell are seen only where the epidermal layer has been abraded.
Coal Measures. *Winterset, Iowa.*

Fig. 23. An extremely elongate form, broadly lobed on the anterior margin.
Coal Measures. *Miami county, Kansas.*

Fig. 24. The interior of the pedicle-valve of an old and much thickened shell; showing the deep pedicle-cavity and the broad, obscurely-defined muscular area.
Coal Measures. *Kansas City, Missouri.*

Fig. 25. An internal cast of the spiral cones, viewed from the dorsal side.
Coal Measures. *Locality?*

Fig. 26. A preparation of the brachidium, a portion of the spirals being cut away to expose the loop. The figure shows the furcated anterior extremity of the saddle, the position and extent of the accessory lamellæ and the fimbriation of the anterior portion of the first few lamellæ of the coils. × 3. (c.)
Coal Measures. *Winterset, Iowa.*

Fig. 27. A dorsal view of an internal cast slightly restored at the beak; showing the adductor scars and vascular impressions.

Fig. 28. The opposite side of the same specimen; showing the adductor scars while the diductors are not clearly defined. This is a cast in iron-stone and its source is undetermined, but it is probably from the
Coal Measures. *Ohio.*

Fig. 29. The interior of a very elongate and much thickened pedicle-valve; showing the adductor and diductor scars deeply excavated in the shell substance. × 2.
Coal Measures. *Near Kansas City, Missouri.*

Fig. 30. Anterior marginal view of a large and old shell with greatly thickened valves. This shell is of the form represented in figure 22, but is much older and is somewhat unsymmetrical, having suffered injury at the right of the median fold.

Fig. 31. A preparation of the brachidium, the upper half of the spiral cones having been removed. This figure has been drawn from a transparency, and the saddle of the loop appears very long. Through an error in lithography the lateral branches of the loop have been disconnected from the primary lamellæ. × 2. (c.)
Coal Measures. *Winterset, Iowa.*

SEMINULA DAWSONI, sp. nov. (= ATHYRIS SUBTILITA, Davidson).

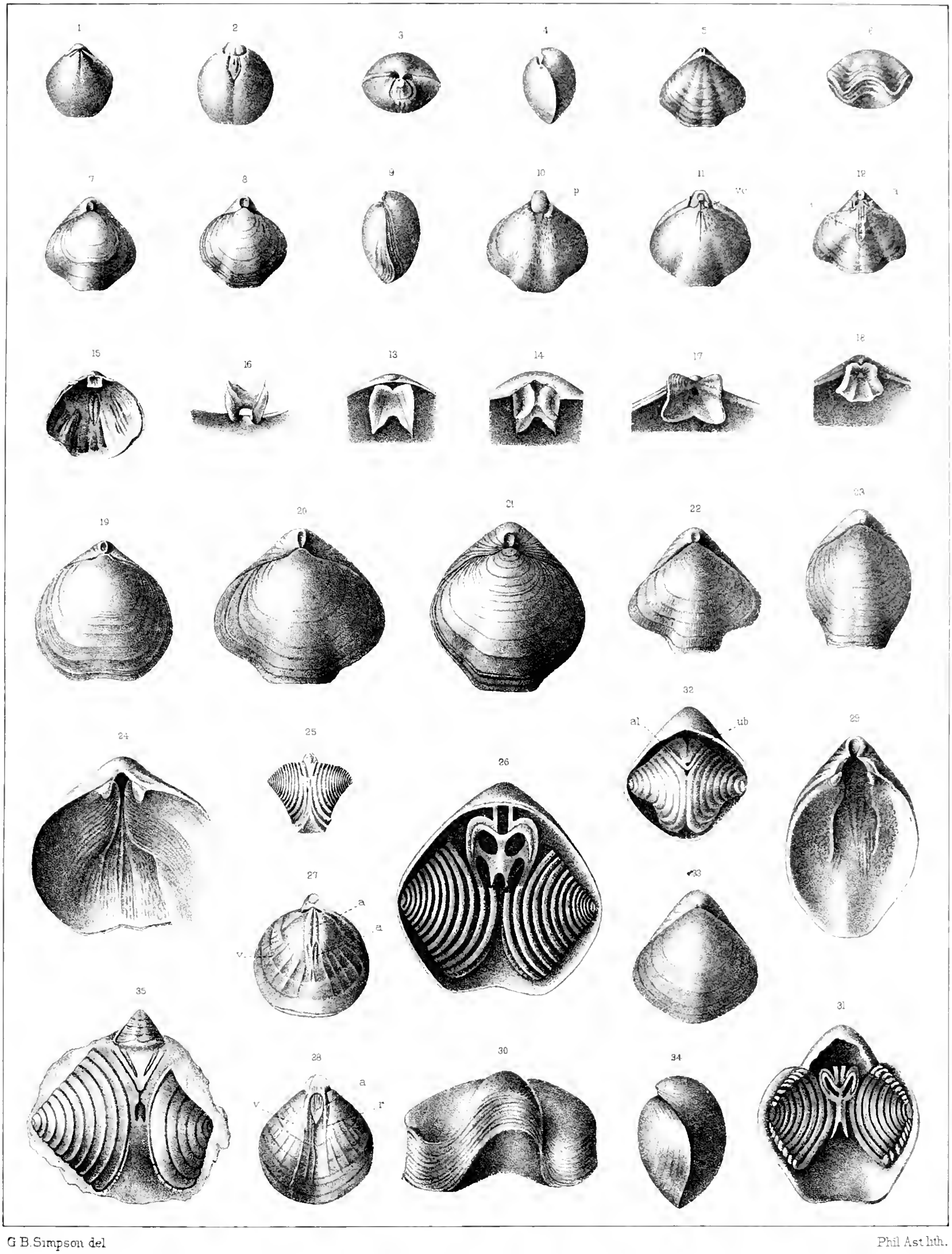
Fig. 32. A view of the brachidium naturally preserved by incrustation and exposed by the removal of a portion of the pedicle-valve; showing the form of the cones and the position of the accessory lamellæ. × 2.

Fig. 33. A dorsal view of the exterior of conjoined valves. × 2.

Fig. 34. A profile view of the same specimen. × 2.
Coal Measures. *Windsor, Nova Scotia.*

ATHYRIS (SEMINULA ?) sp. ?

Fig. 35. A transparency viewed from the ventral side; showing the attachment of the crura to the primary lamellæ, a portion of the loop and the accessory lamellæ and the fimbriated coils of the spirals. The specimen is interesting in showing the asymmetry of the coils, the cone on the left side possessing eleven volutions, that on the right but eight. The filling of the shell is transparent calcite and the brachidium has been replaced by red hematite. × 3. (c.)
Coal Measures? *Ohio.*



G B. Simpson del · Phil Ast lith.

PLATE XLVIII.

(Figs. 1-3, 6, 10, 11, 21-24, 26-29, 33, 34 by E. Emmons; 4, 5, 7-9 by F. B. Meek; 12-20, 25, 30-32 by R. P. Whitfield.)

Legend: D. Coalesced deltidial plates.
t. Teeth.
s. Median septum.
a. Adductors.
a′. Anterior adductors.
r. Deductors.
c. Crura.
hp. Hinge-plate.
ub. Umbonal blades.
l. Stem of loop.

Genus NUCLEOSPIRA, Hall.

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Nucleospira pisum, Sowerby.

Fig. 1. A dorsal view; showing the fine surface spines. × 2.
Wenlock shale. *England.*

Nucleospira ventricosa, Hall.

Fig. 2. A dorsal view of conjoined valves which retain the epidermal spines over a portion of the surface. × 2.

Fig. 3. A profile view of a comparatively large individual, denuded of its spines; showing the usual convexity of the valves.

Fig. 4. A profile view of a brachial valve; showing the crural bases and the recurved hinge-plate extending backward beyond the apex of the valve.

Fig. 5. The interior of a brachial valve with the umbonal portion of the pedicle-valve adhering, viewed from in front; showing the elevation and lobation of the hinge-plate, and the median septum.

Fig. 6. A preparation, showing the broad umbonal blades of the primary lamellæ, their attachment to the crura, and also the lateral branches of the loop, the upright stem being broken off. × 3.

Fig. 18. The interior of a pedicle-valve; showing the concave coalesced deltidial plates and the median septum.
Lower Helderberg group (Shaly limestone). *The Helderbergs, N. Y.*

Nucleospira concentrica, Hall.

Fig. 7. The exterior of a pedicle-valve; showing the sharp concentric growth-lines.
Lower Helderberg group. *Decatur county, Tennessee.*

Nucleospira elegans, Hall.

Fig. 8. A dorsal view of conjoined valves; showing the transverse form of the shell and the low median sinus on the brachial valve.

Fig. 9. A profile view of the same specimen.
Lower Helderberg group. *Cherry Valley, N. Y.*

Fig. 10. A preparation exposing, by the partial removal of the pedicle-valve, the structure of the brachidium. In the umbonal region the crura and umbonal blades are exposed, and at (*l*) is the projecting upright stem of the loop. All of the lamellæ are slightly encrusted with a silicious deposit. × 2.

Fig. 11. A profile of the same specimen; showing one of the cones and the projecting extremity of the loop. × 2. (c.)
Lower Helderberg group (Shaly limestone). *Schoharie, N. Y.*

Nucleospira concinna, Hall.

Fig. 12. A dorsal view of conjoined valves retaining a portion of the spinulose surface.

Figs. 13-16. Ventral, dorsal, cardinal and profile views of a normal example from which the surface spinules have been lost; showing the normal subplano-convex contour of the valves and the linear median depression on each.

Fig. 17. The interior of a pedicle-valve; showing the concave, coalesced deltidial plates, articulating processes, adductor and diductor scars.

PLATE XLVIII—Continued.

Fig. 19. An internal cast of the pedicle-valve; showing sharply defined impressions of the adductor and diductor scars.

Fig. 20. An internal cast of the brachial valve; showing the character of the adductor impression.

Hamilton group. *Shales of western New York.*

Fig. 21. The interior of a pedicle-valve. × 2.

Corniferous limestone. *Columbus, Ohio.*

Fig. 22. Umbonal portion of the interior of a pedicle-valve; showing the testaceous thickening over the posterior portion of the muscular area. × 3.

Hamilton group. *Canandaigua Lake, N. Y.*

Fig. 23. The hinge-plate viewed from in front, the upper surface of the plate being held in a horizontal position; showing the concave surface of the plate and size of the crural lobes. × 3.

Fig. 28. The same specimen viewed from above. × 3.

Corniferous limestone. *Columbus, Ohio.*

Fig. 24. A portion of the brachidium, viewed from the dorsal side; showing the curvature of the spiral volutions, the long straight crura, their attachment to the primary lamellæ, and the foreshortened loop. × 3.

Fig. 25. A portion of the external surface of the shell, enlarged to show the character of the spinules.

Hamilton group. *Western New York.*

Fig. 26. The interior of a brachial valve; showing some difference in the form of the hinge-plate from that seen in figs. 23 and 28; also the adductor scars and vascular markings.

Hamilton group. *Falls of the Ohio.*

Fig. 27. The hinge-plate viewed from in front in the line of the bottom of the valve; showing the elevation of its anterior face and the sharp upward inclination of the crural bases. × 3.

Fig. 29. The articulating apparatus of conjoined valves; showing the elevation of the hinge-plate and crural bases, and their relation to the teeth of the other valve. × 3.

Fig. 30. A profile of the brachial valve; showing the recurvature of the hinge-plate and the projection of the crural bases.

Fig. 31. The interior of the same valve; showing the upper face of the cardinal process and the muscular impressions.

Fig. 32. An enlargement of the cardinal portion of the pedicle-valve; showing the concave, completely coalesced and solid deltidial plates, and the teeth. × 5.

Hamilton group. *Western New York.*

Fig. 33. A preparation of the brachidium retaining one-half of the spiral cones, and the crura, primary lamellæ and the loop complete. The lamellæ of the brachidium are silicified and the lateral branches of the loop bear along their inner or posterior margins a series of fine, somewhat irregular, branching processes, directed outward, toward or outside of the primary lamellæ.

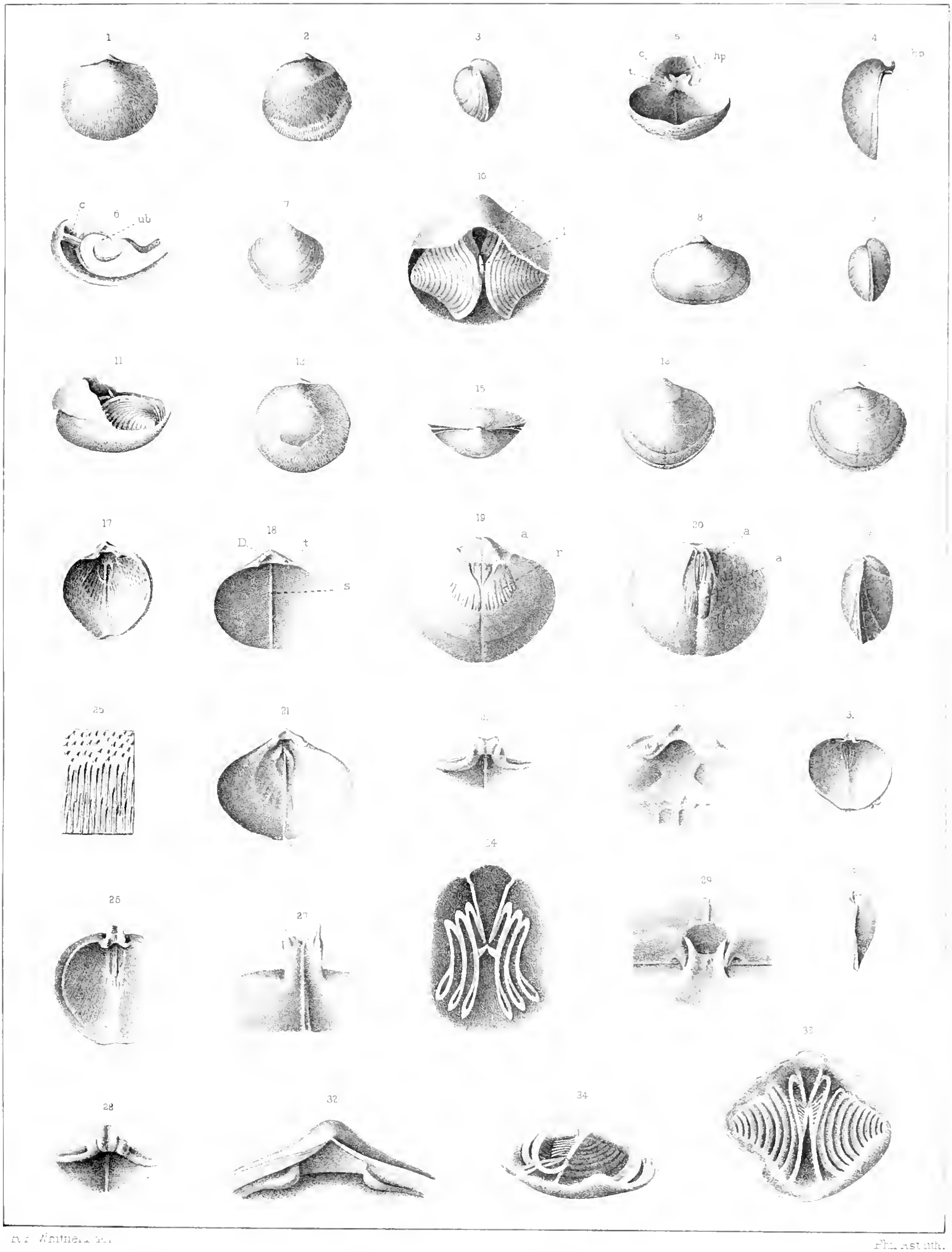
Fig. 34. An oblique view of the same specimen. × 3. (c.)

This peculiar structure has been observed in this single instance only. The shell in all external and other features is indistinguishable from *N. concinna*, and the nature and value of this peculiar variation in the structure of the loop is yet to be determined. (See page 146, fig. 132.)

BRACHIOPODA.

NUCLEOSPIRIDÆ.

Generic Illustrations



R. P. Whitfield del.

Phil. Ast lith.

PLATE XLIX.

(Figures 1, 4, 7, 8, 11, 15, 21, 36-38, 46 by E. Emmons; 2, 3, 5, 6, 9, 10, 22-35, 39-42 by R. P. Whitfield; 13, 14, 43-45, 47 by G. B. Simpson.)

Legend : c. Crural lobes.
c′. Posterior portion.
dp. Coalesced deltidial plates.
t. Teeth.
dt. Delthyrial tube.

Genus HINDELLA, Davidson.

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See Plate 41.

Hindella Prinstana, Billings.

Fig. 1. A preparation exposing the structure of the brachidium by removal of a portion of the pedicle-valve ; showing the anterior position of the loop, its oblique direction, long lateral branches and short terminal process. The spiral cones are represented as having their upper halves removed. × 3. (c.)

Middle Silurian. *Junction Cliff, Anticosti.*

Genus TREMATOSPIRA, Hall.

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Trematospira camura, Hall.

Fig. 2. A dorsal view of the exterior of conjoined valves.
Fig. 3. A ventral view of a similar, somewhat larger specimen.
Fig. 4. A view of a preparation showing by translucence the structure of the brachidium. × 3. (c.)

Niagara group. *Lockport, N. Y.*

Trematospira perforata, Hall.

Figs. 5, 6. Dorsal and ventral views of a typical individual, showing the character of the exterior.

Lower Helderberg group (Shaly limestone). *The Helderbergs, N. Y.*

Trematospira Hippolyte, Billings.

Figs. 7, 8. Dorsal and profile views of the original specimen.

Lower Helderberg group. *Square Lake, Maine.*

Trematospira multistriata, Hall.

Figs. 9, 10. Dorsal and ventral views of the exterior of a normal example.
Fig. 11. A preparation showing one of the spiral cones, the form and position of the loop and the mode of attachment of the primary lamellæ and crura. (c.)
Fig. 12. The central cardinal portion of the pedicle-valve, viewed from the apex ; showing the foramen, teeth and coalesced concave deltidial plates. The median line of union of the latter is retained on the specimen, but is obscured in the lithograph
Fig. 13. The hinge-plate viewed from its upper surface, showing its deep median excavation, the prominence of the lateral lobes and their division into anterior and posterior processes. × 3.
Fig. 14. Another specimen of the hinge-plate viewed from the apex of the valve ; showing the elevation of the post-lateral lobes, the formation of a small median callosity, the constriction at the base of the process and the striated basal callosity, the lateral portions of which form the socket-walls. The apex of the valve, lying without and below this area, should have been more distinctly represented, the plications diverging from this point. × 3.

Lower Helderberg group (Shaly limestone). *The Helderbergs, N. Y.*

Trematospira dubia, Billings.

Figs. 15, 16. Dorsal and cardinal views of the original specimen.

Lower Helderberg group. *Square Lake, Maine.*

Trematospira simplex, Hall.

Fig. 17. A dorsal view of a normal example ; showing the external characters. × 2.
Fig. 18. An enlargement of the surface of the same specimen ; showing the pustules of the outer laminæ. × 5.

Lower Helderberg group. *Decatur county, Tennessee.*

Trematospira costata, Hall.

Figs. 19, 20. Dorsal and ventral views of a very large and finely developed individual ; showing the transverse form, the character of the plication and concentric lineation.

Lower Helderberg group (Shaly limestone). *The Helderbergs, N. Y.*

TREMATOSPIRA MARIA, Billings.

Fig. 21. A dorsal view of the original specimen.
Lower Helderberg group. *Square Lake, Maine.*

GENUS RHYNCHOSPIRA, HALL.

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RHYNCHOSPIRA (?) SUBGLOBOSA, Hall.

Fig. 22. A dorsal view of an internal cast of the conjoined valves; showing the form of the shell and the impression of the hinge-plate. This is the original specimen and its generic relations are not fully determined.
Schoharie grit. *Schoharie, N. Y.*

GENUS TREMATROSPIRA. HALL

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TREMATROSPIRA GIBBOSA, Hall.

Figs. 22–26. Dorsal, ventral, cardinal and frontal views of a large, old and thickened shell; showing the coarse and sharp plication and presenting the usual form of the species.

Fig. 27. A smaller example with the median fold and sinus less distinctly developed.
Hamilton group. *Yates county, N. Y.*

GENUS PARAZYGA, GEN. NOV.

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PARAZYGA HIRSUTA, Hall.

Figs. 28–32. Dorsal, ventral, cardinal, frontal and profile views of a normal individual; showing the form, contour and fine plication of the valves. The surface of the shell was covered with short and exceedingly fine hair-like spinules which are retained only under the most favorable preservation This is one of the original specimens of the species.

Fig. 33. A preparation, showing, by removal of the brachial valve, the form of the spiral cones and their attachment to the crura.

Fig. 34. The interior of a pedicle-valve; showing the character of the muscular area and the concave deltidial plates.

Fig. 35. The interior of a brachial valve; showing hinge-plate and muscular impressions.

Fig. 36. A preparation of the brachidium, the pedicle-valve and the upper portion of the spiral cones being removed; showing the mode of attachment of the crura and primary lamellæ and the form of the loop. The hinge-plate is not correctly represented. × 2. (c.)

Fig. 37. The hinge-plate enlarged; showing its bipartite form and the broad dental sockets. × 3.

Fig. 38. The interior of the rostral region of the pedicle-valve from which the marginal portion has been removed, exposing the short delthyrial or pedicle tube, and remnants of the teeth and dental plates. × 3.

Fig. 39. The cardinal portion of the pedicle-valve; showing the delthyrial tube and the greatly abbreviated, concave and solid remnants of the deltidial plates. × 3.
Hamilton group. *Various localities in the soft shales of Western New York.*

PARAZYGA DEWEYI, Hall.

Figs. 40–42. Dorsal, profile and ventral views of the original specimen; showing the form of the shell. In figure 40 the brachial valve is represented as too flat medially, there being a low fold to correspond with the sinus on the opposite valve which is shown in fig. 42.

Fig. 43. The interior of a portion of the brachial valve; showing the form of the hinge-plate and a short median septum. × 3.

Fig. 44. The same specimen viewed from the cardinal margin; showing the elevation of the hinge-plate, its recurvature and the lobation of its surface. × 3.

Fig. 45. The interior of a portion of the pedicle-valve; showing the concave and solid deltidial plates, coalesced only at their anterior margin, and the recurved teeth. The deltidial plates are continuous with the substance of the shell which fills the entire rostral cavity. × 3.

Fig. 46. A preparation showing the form of the spiral cones, the position of the loop, the geniculation of its lateral branches and the shape of the saddle. (c.)
Lower Helderberg group (Shaly limestone). *The Helderbergs, N. Y.*

GENUS TREMATOSPIRA, HALL.

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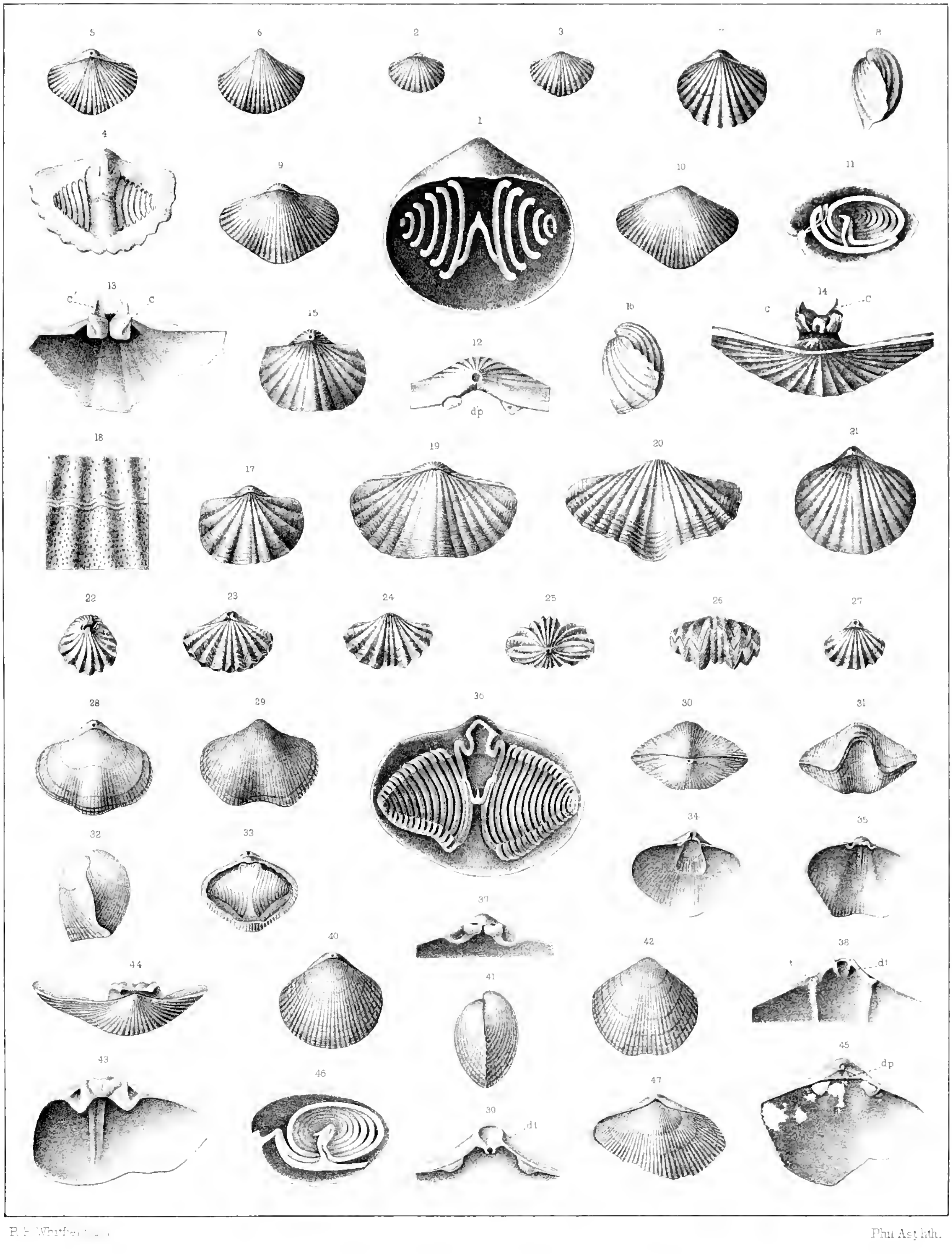
TREMATOSPIRA EQUISTRIATA, sp. nov.

Fig. 47. A dorsal view of an incomplete shell, similar in form to *T. multistriata*, but differing from that species in the regular, equal, rounded and unbifurcated surface plications. Those in *T. multistriata* are not satisfactorily represented in figures 9 and 10, but are sharper and often strongly fasciculate.
Lower Helderberg group. *Cumberland, Maryland.*

BRACHIOPODA.

TREMATOSPIRIDÆ.

Generic Illustrations



R.P. Whitfield

Phil Ast lith.

PLATE L.

(Figures 1-5 copies; 6, 8, 12-14, 26-31, 41-48, 51, 52 by E. EMMONS; 7, 9-11, 16, 17, 20, 22, 24, 32-35 by G. B. SIMPSON; 15, 18, 19 by J. M. CLARKE; 21 by F. B. MEEK; 23, 25, 36-40, 49, 50 by R. P. WHITFIELD.)

Legend: t. Teeth. b. Dental sockets. s. Median septum (pedicle-valve).
d. Dental plates. c. Crura. s'. Median septum (brachial valve).
hp. Hinge-plate.

GENUS RETZIA, KING.

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RETZIA ADRIENI, de Verneuil.

Figs. 1, 2. Dorsal and ventral views of a typical specimen; showing the characters of the exterior.
Fig. 3. A dorsal view of a smaller example, from which a portion of the brachial valve has been removed, exposing the median septum and a portion of one of the spiral cones.
Fig. 4. An enlarged view of a shell which has been transversely sectioned just in front of the umbones; showing the hinge-plate, dental sockets and median septum.
Fig. 5. The interior of a portion of the brachial valve; showing the hinge-plate and median septum.
The above figures are copied from ŒHLERT, Annales Sci. Géol., t. xix, No. 1. 1886.
Fig. 6. A dorsal view of a somewhat flattened example.
Fig. 7. A more rotund individual, imperfect about the ante-lateral margin.
Fig. 8. A view of a similar specimen of larger size.
Fig. 9. A dorsal view of the umbonal region of conjoined valves; showing the excavate cardinal slopes of the pedicle-valve and the concave coalesced deltidial plates. × 2.
Lower Devonian. *Department de la Sarthe, France.*

GENUS PTYCHOSPIRA, GEN. NOV.

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PTYCHOSPIRA FERITA, von Buch.

Fig. 10. A profile view of an average individual; showing the coarse plication, and the extension of the anterior margin. × 2.
Fig. 11. A dorsal view of the same specimen; showing the coalesced deltidial plates. × 2.
Middle Devonian. *Eifel, Germany.*

PTYCHOSPIRA LONGIROSTRIS, Kayser.

Fig. 12. A dorsal view of a specimen; showing the narrow and elevated beak of the pedicle-valve.
Middle Devonian. *Eifel, Germany.*

PTYCHOSPIRA (cf.) SEXPLICATA, White and Whitfield.

Figs. 13, 14. Dorsal and ventral views of a specimen, probably referable to this species.
Burlington limestone. *Burlington, Iowa.*

SUBGENUS HOMŒOSPIRA, S.-GEN. NOV.

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HOMŒOSPIRA EVAX, Hall.

Fig. 15. A dorsal view of the youngest shell observed. In this stage of growth the beak of the pedicle-valve is erect and the deltidial plates not developed; the surface of the valves is smooth and evidence of plications is visible only outside of the second concentric growth-line. × 25.
Figs. 16, 17. Profile and dorsal views of a full-grown specimen; showing the adult characters of the exterior.
Fig. 18. The umbonal region of a young shell in which the deltidial plates have united at the base, enclosing an oval foramen. × 7.
Fig. 19. A similar view of a more fully grown individual with unusually erect beak and nearly ovate foramen. × 3.
Fig. 20. The interior umbonal portion of a fully-matured example; showing the complete obsolescence of the deltidial plates and the enclosure of the foramen by the substance of the valve; also the projecting, recurved teeth. × 2.
Niagara group. *Waldron, Indiana.*

GENUS RHYNCHOSPIRA, HALL.

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RHYNCHOSPIRA FORMOSA, Hall.

Fig. 21. A dorsal view of a typical specimen; showing the character of the exterior.
Fig. 22. The interior of the cardinal portion of the pedicle-valve of a normal adult; showing the circular foramen, the completely coalesced deltidial plates, and the teeth. × 2.
Fig. 23. The interior of a pedicle-valve; showing similar characters with less detail.
Fig. 24. The interior of a brachial valve; showing the form of the hinge-plate, the dental sockets and the median septum.
Fig. 25. An interior view of the cardinal portion of articulated valves; showing the elevation of the hinge-plate, and the median septum of the brachial valve, and the muscular depression of the pedicle-valve. × 2.
Lower Helderberg group (Shaly limestone). *The Helderbergs, N. Y.*

Subgenus HOMŒOSPIRA, s.-gen. nov.

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Homœospira sobrina, Beecher and Clarke.

Fig. 26. A ventral view of an individual of about average size.

Figs. 27, 28. Profile and dorsal views; showing the convexity of the valves and the character of the plication and concentric ornamentation. × 2.

Niagara group. *Waldron, Indiana.*

Genus RHYNCHOSPIRA, Hall.

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Rhynchospira Electra, Billings.

Figs. 29-31. Dorsal, ventral and profile views of the original specimen.

Lower Helderberg group. *Square Lake, Maine.*

Subgenus HOMŒOSPIRA, s. gen. nov.

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Homœospira (cf) evax, Hall.

Fig. 32. A dorsal view of an average specimen; showing the character of the deltidial plates and the surface plications. × 2.

Fig. 33. The interior of a pedicle-valve.

Fig. 34. The interior of a brachial valve; showing the hinge-plate and median septum. × 2.

Fig. 35. The cardinal portion of the last specimen, enlarged to show in more detail the structure of the hinge-plate. × 5.

Upper Silurian. *Perry county, Tennessee.*

Genus TRIGERIA, Bayle.

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Trigeria lepida, Hall.

Figs. 36-38. Dorsal, ventral and profile views of a typical specimen; showing the character of the exterior and the form of the deltidial plates. × 2.

Fig. 39. A dorsal view of a more elongate shell, with a pronounced median sinus on the brachial valve. × 2.

Fig. 40. An enlargement of the umbonal region of the specimen represented in fig. 36; showing the deltidial plates, the form of the foramen and its encroachment upon the apex of the valve. × 6.

Hamilton group. *Canandaigua Lake, N. Y.*

(The lithographing of this plate was completed before the discovery of the fact that this species is a terebratuloid allied to Rensselæria, and referable to the genus Trigeria, Bayle, as interpreted in this work.)

Genus RHYNCHOSPIRA, Hall.

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Rhynchospira (?) Eugenia, Billings.

Figs. 41-43. Dorsal, ventral and profile views of a specimen; showing the usual form of exterior at this locality. × 2. Hamilton group. *York, N. Y.*

Rhynchospira (?), sp.

Fig. 44. A view of the exterior of a pedicle-valve, the only specimen of the species observed, and referred to this genus with doubt.

Waverly group. *Northwestern Pennsylvania.*

Rhynchospira scansa, sp. nov.

Fig. 45. A view of the exterior of a pedicle-valve; showing a median sulcus similar to that occurring in the typical representatives of the genus.

Waverly group. *McKean county, Pennsylvania.*

Genus CAMAROSPIRA, gen. nov.

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Camarospira Eucharis, Hall.

Figs. 46, 47. Dorsal and ventral views of the exterior. The position of the median septum is seen through the shell-substance on each valve.

Fig. 48. A profile view; showing the convexity of the valves.

Corniferous limestone. *Cass county, Indiana.*

Fig. 49. A dorsal view of the original example of *Camarophoria Eucharis;* showing a rather more pronounced median fold on the brachial valve.

Fig. 50. A ventral view of a specimen broken so as to expose the spondylium of the pedicle-valve.

Corniferous limestone. *Cayuga, Ontario.*

Fig. 51. A median longitudinal section; showing the spondylium and supporting septum of the pedicle-valve and the septum of the brachial valve. × 1½

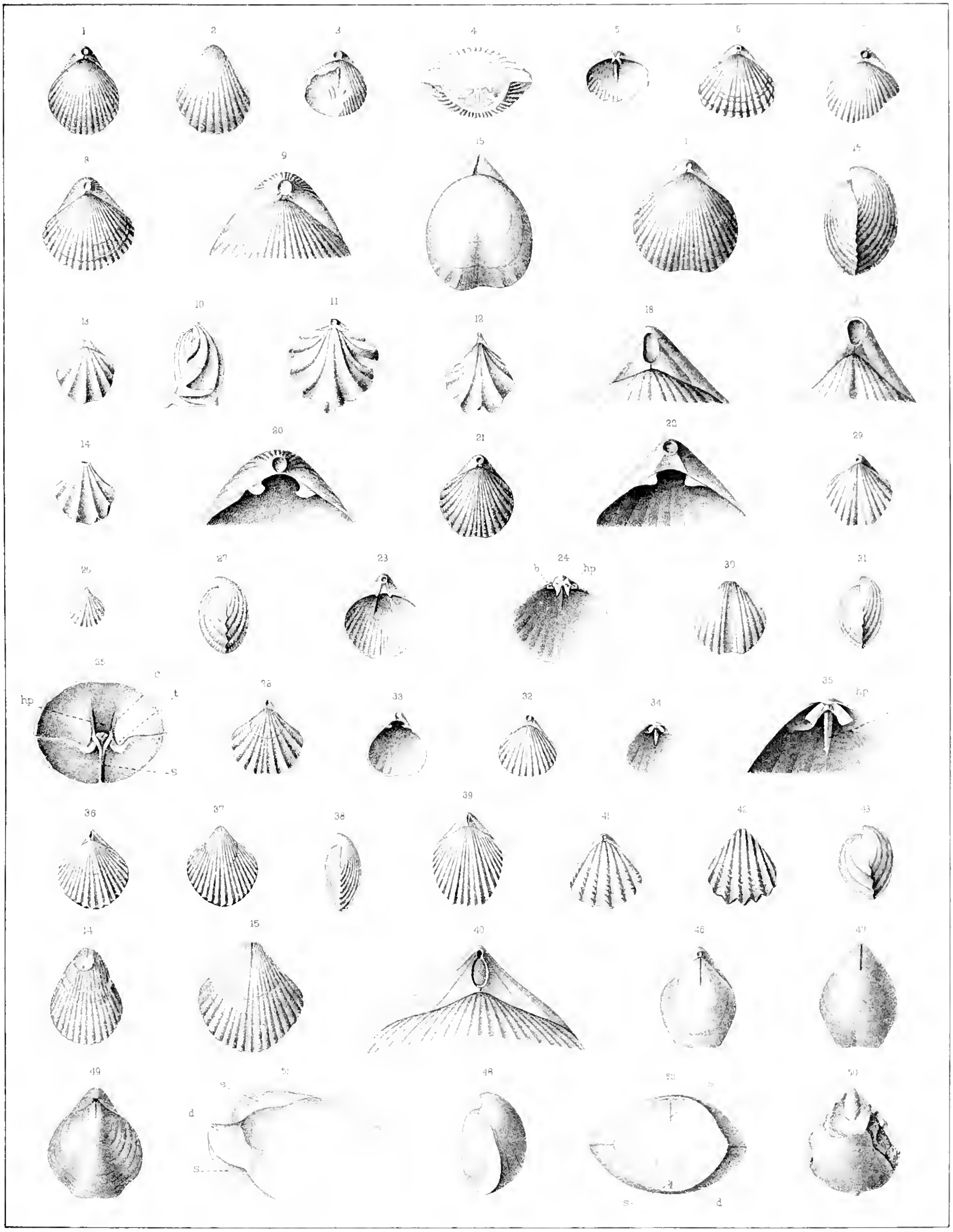
Fig. 52. A transverse section in the umbonal region; showing the spondylium and septa. × 1½.

Corniferous limestone. *Cass county, Indiana.*

BRACHIOPODA.

RETZIIDÆ.

Generic Illustrations



G B Simpson del

Phil Ast lith

PLATE LI.

(Figures 1-7, 13-16, 18, 23-26, 28, 29, 31-41 by G. B. SIMPSON; 8, 9, 20-22 by J. M. CLARKE; 17 by F. B. MEEK; 19, 27, 30 by E. EMMONS; 10-12 copies.)

GENUS HUSTEDIA, GEN. NOV.

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HUSTEDIA MORMONI, Marcou.

Figs. 1-4. Ventral, dorsal, frontal and profile views of an average individual; showing the coarse plication of the surface.

Fig. 5. An enlarged view of the exterior of the pedicle-valve. × 2.

Fig. 6. The opposite side of the same specimen; showing the coalesced deltidial plates. × 2.

Fig. 7. An enlargement of the umbonal region; showing the coalesced deltidial plates, and the flattened cardinal slopes of the brachial valve. × 5.

Fig. 8. A preparation of the hinge-plate, viewed from in front; showing the elevation of the large recurved median part, the crural lobes, and the projection of the anterior ligulate process.

Fig. 9. A profile view of the same specimen; showing the great recurvature of the body of the plate, the direction of the crural processes, and the extent of the anterior ligulate process. × 5. (C.)

Coal Measures. *Near Kansas City, Missouri.*

GENUS UNCINELLA, WAAGEN.

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UNCINELLA TYPICA, Waagen.

Figs. 10-12. Dorsal, profile and ventral views of a typical specimen; showing the exterior characters. (WAAGEN.)

Permo-carboniferous. *Salt-Range, India.*

GENUS EUMETRIA, HALL.

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EUMETRIA VERNEUILIANA, Hall.

Figs. 13, 14. Dorsal and profile views of an unusually elongate shell.

Figs. 15, 16 Similar views of an example which has the usual form of the species.

Fig. 17. A dorsal view of the original specimen of the species, enlarged.

In all the above specimens the deltidial plates are seen to be wholly coalesced, which is the normal condition at maturity.

Fig. 18. A dorsal view of a small individual in which the median division-line between the deltidial plates is still retained. × 3. This and the preceding figure represent the species as it occurs in the limestone at this locality.

Fig. 19. The detached brachidium, enlarged, and viewed from the ventral side: showing the attachment of the crura to the primary lamellæ, the form of the loop, its long, straight bifurcate stem, and the shape of the spiral cones. × 2. (C.)

Fig. 20. The interior of the cardinal region of articulated valves, viewed with the plane of the hinge horizontal. This preparation shows, in the background, the large foramen and below it the flattened inner surface of the coalesced deltidial plates, which afford no evidence of a median suture. On either side are the elongate teeth filling the equally elongate dental sockets. The hinge-plate consists of two parts, (*a*) the posterior portion which takes the form of a crescent, its horns lying back upon the inner surface of the deltidial plates and the umbonal slopes; this is connected laterally with the socket-walls and anteriorly with (*b*), the anterior portion, which is tent-shaped and consists of two deep and broad lateral lamellæ resting on the bottom of the valve, united above by a deeply concave horizontal plate; from the anterior angles formed by the union of these plates arise the divergent and greatly elevated crural processes. In this figure the anterior portion of this apparatus is considerably foreshortened. It will be observed that the specimen shows no evidence of the delthyrial tube occurring in RETZIA, HUSTEDIA, etc. × 10. (C.)

Fig. 21. The same preparation viewed with the pedicle-valve inclined upward; showing the length of the anterior transverse plate. × 5.

Fig. 22. A view of the same specimen with the pedicle-valve inclined downward; showing the elevation of the crural plates and processes. × 5.

St. Louis group. *Spergen Hill, Indiana.*

Fig. 23. An internal cast of a brachial valve which retains a portion of the hinge-plate and shows the backward projection of the posterior crescent.

Fig. 24. A dorsal view of a specimen, drawn from the impression of a natural mould represented in fig. 25.

Fig. 25. A mould of the exterior of a portion of both valves.

Fig. 26. The umbonal portion of the same specimen, enlarged; showing the maximum development of the foraminal tube, which is but a slightly introverted lamina. The figure was also designed to represent the separation along the hinge-line of the deltidial plates from the flattened cardinal surfaces of the brachial valve, but by an error in the lithography this line has been made to appear as a break continuous with a slight fracture on each side of the pedicle-valve. × 3.

St. Louis group. *Greene county, Missouri.*

EUMETRIA VERA, var. COSTATA, Hall.

Fig. 27. The cardinal portion of a pedicle-valve; showing the completely coalesced deltidial plates. × 3.

Fig. 28. A view of a pedicle-valve from which the shell has been partially exfoliated; showing the faintly defined muscular area.

Figs. 31, 32. Dorsal and profile views of the same specimen.

Chester limestone. *Crittenden county, Kentucky.*

Fig. 29. A dorsal view of a specimen from which the shell has been exfoliated, exposing the elongate, narrow muscular impression of the brachial valve.

Fig. 30. The upper half of a preparation of the brachidium; showing in the solid opaque matrix the attachment of the crura to the primary lamellæ, and the bifurcate extremity of the loop. × 2.

Chester limestone. *Chester, Illinois.*

Fig. 33. The interior of the umbonal portion of a brachial valve; showing the posterior horns of the hinge-plate, the concave median plate and the elongate, narrow dental sockets. The crural plates and their processes have been lost. × 3.

Chester group. *Crittenden county, Kentucky.*

EUMETRIA VERNEUILIANA, Hall.

Figs. 34, 35. Dorsal and profile views of a specimen with coarse surface plications.

St. Louis group. *Spergen Hill, Indiana.*

EUMETRIA VERA, Hall.

Fig. 36. The umbonal portion of an old shell enlarged to show the thickening of the coalesced deltidial plates which have become conspicuously protuberant. This thickening has been accompanied by a similar growth on the brachial valve which has rendered the flattened cardinal expansion very prominent, as seen on the right of the beak. The growth of the brachial valve has been somewhat unsymmetrical. × 2

Fig. 37. The umbonal portion of a specimen which has been broken longitudinally nearly in the median axis. On the upper portion is exposed the surface of the more distant of the two crural plates, flattened below by the transverse concave plate and the upward extension of the nearer of the crural plates. The outer shell is retained about the beak of the pedicle-valve. × $1\frac{1}{4}$.

Chester group. *Crittenden county, Kentucky.*

The distinction between the three forms of EUMETRIA here represented is one not easy to carry out with an abundance of material. *Eumetria Verneuiliana* was founded upon the small, very finely plicated shells from the white limestones at Spergen Hill, Ind., but it was suggested in the original description that the larger shells occurring in a silicified condition at the same locality and elsewhere, are of the same species. *E. vera* was based upon specimens of about the same size as the latter, with a somewhat coarser plication, derived from the Kaskaskia (Chester) limestone at Chester, Illinois, and *E. vera*, var. *costata* on larger and more coarsely plicated shells from the same locality. It is very frequently difficult, notwithstanding the slight differences in geological horizon, to distinguish the larger form of *E. Verneuiliana* from the typical form of *E. vera*, while a distinction between the two forms of *E. Verneuiliana* occuring at Spergen Hill is often more readily made.

GENUS ACAMBONA, WHITE.

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ACAMBONA? OSAGENSIS, Swallow.

Fig. 38. A dorsal view of an imperfect specimen of the *Retzia Osagensis*, Swallow, which will probably prove to belong to this genus.

Fig. 39. A portion of the surface of the shell enlarged. The lower part of the figure represents the punctations of the outer surface, where it has been exposed and somewhat weathered; above is the surface of one of the inner layers covered with fine pustules. The plications are much more distinctly defined on the inner layers, but they are not obsolete on the outer layer as here represented. × 5.

Choteau limestone. *Pike county, Missouri.*

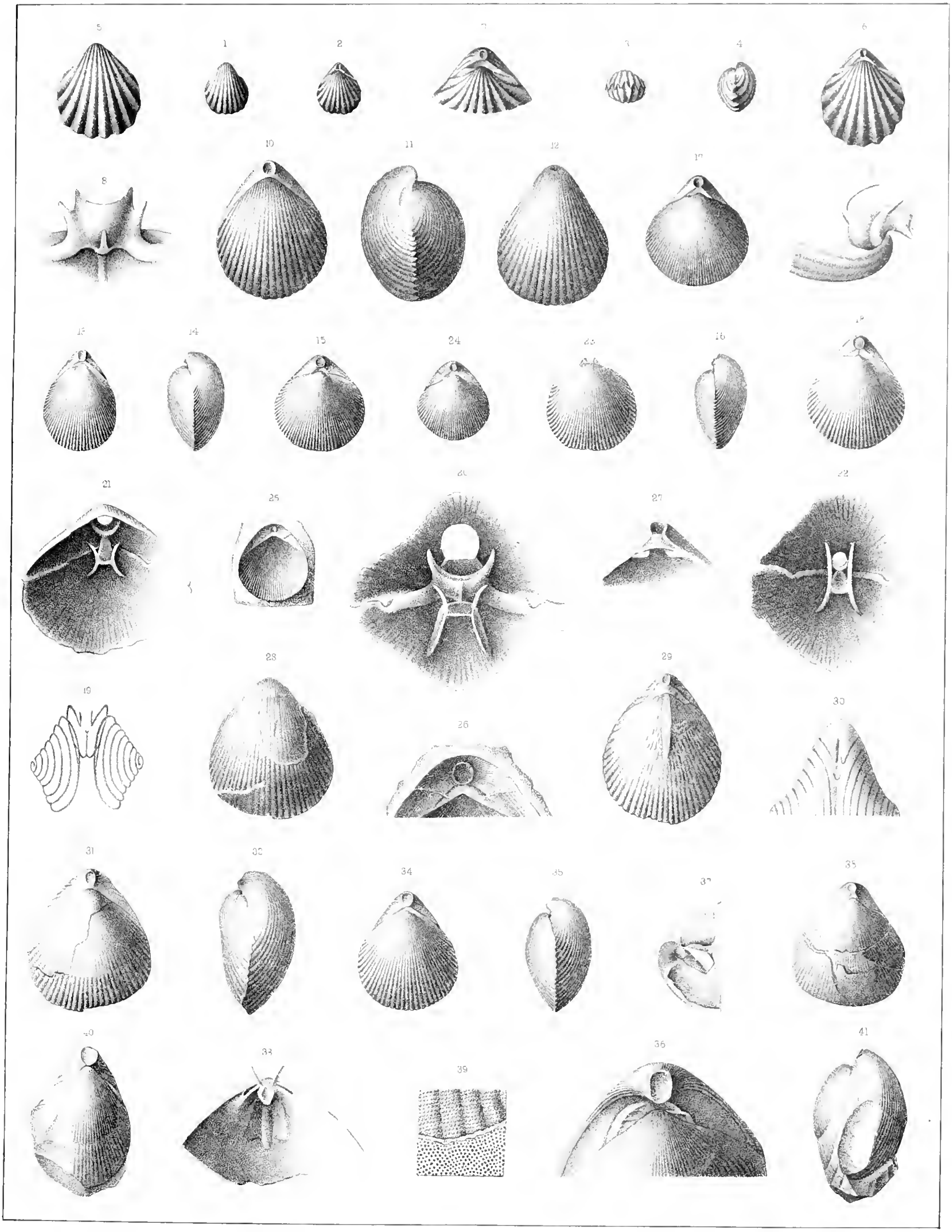
ACAMBONA PRIMA, White.

Figs. 40, 41. Dorsal and profile views of an incomplete specimen which is regarded as belonging to this species.

Burlington limestone. *Burlington, Iowa.*

BRACHIOPODA.

RETZIIDÆ.



G B Simpson del. Phil. Ast lith.

PLATE LII.

(Figures 1-15 by G. B. SIMPSON; 16-19 by E. EMMONS; 20-36 copies.)

GENUS CLINTONELLA, GEN. NOV.

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CLINTONELLA VAGABUNDA, sp. nov.

Fig. 1. A dorsal view of an internal cast retaining the shell on the umbo of the pedicle-valve. Below the foramen is seen a portion of the lower surface of the hinge-plate.

Fig. 2. A view of another specimen similarly preserved, though the hinge-plate is wholly removed.

Fig. 3. A profile of the same specimen; showing the normal convexity of the valves and the elevation of the median fold on the brachial valve.

Fig. 4. A ventral view of the same specimen; showing the depth of the median sinus.

Fig. 5. The interior of an imperfect pedicle-valve; showing the teeth and open delthyrium. × 2.

Fig. 6. The interior of a pedicle-valve; showing the elevation and curvature of the teeth. × 2.

Fig. 7. The interior of the umbonal portion of the brachial valve; showing the divided hinge-plate and the low median ridge. × 3.

Fig. 8. An internal cast of a pedicle-valve; showing the muscular area crossed by the plications of the shell. × 2.

Fig. 9. The interior of the umbonal region of conjoined valves, viewed from in front; showing the mode of articulation and the bilobed cardinal process. × 3.

Fig. 10. A cast of the interior of the pedicle-valve; showing the division of the muscular area into adductor and diductor scars. × 2.

Fig. 11. An incomplete interior of the brachial valve; showing the hinge-plate and muscular scars. × 2.
Clinton group. *Drift of Western New York.*

GENUS CŒLOSPIRA, HALL.

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CŒLOSPIRA PLICATULA, Hall.

See Plate 53.

Figs. 12-14. Ventral, profile and dorsal views of the exterior; showing contour and character of plication.
Clinton group. *Lockport, N. Y.*

CŒLOSPIRA PLANOCONVEXA, Hall.

See Plate 53.

Fig. 15. The interior of a pedicle-valve. × $1\frac{1}{2}$.
Clinton group. *Hamilton, Ontario.*

CŒLOSPIRA (cf.) HEMISPHERICA, Sowerby.

Fig. 16. The interior of a pedicle-valve. × 3.
Clinton group. *Near Wolcott, N. Y.*

GENUS ANOPLOTHECA, SANDBERGER.

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ANOPLOTHECA LEPIDA, Goldfuss.

Figs. 17, 18. Dorsal and profile views of an average specimen; showing the slightly concavo-convex contour, the low, sparse plications and fine concentric lineation. × 5.

Fig. 19. A portion of the interior of a pedicle-valve; showing the teeth resting upon the thickened shell-wall, and the median septum grooved for the reception of the extremity of the loop.
Middle Devonian. *Gerolstein, Eifel.*

Anoplotheca venusta, Schnur.

Fig. 20. The interior of a brachial valve, enlarged; showing the cardinal process and muscular impression.

Fig. 21. An internal cast of the pedicle-valve, enlarged; showing the diductor scars and vascular impressions.

Figs. 22, 23. Ventral and dorsal views of the exterior.

Fig. 24. An enlarged view of a specimen showing, by the removal of a portion of the pedicle-valve, the spiral cones, their form and direction.

(Figs. 20, 21, 24 are after Sandberger; figs. 22, 23 after Schnur.)

Middle Devonian. *Eifel, Germany.*

Genus UNCITES, Defrance.

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Uncites gryphus, Schlotheim.

Fig. 25. A specimen from which a portion of the pedicle-valve has been broken, exposing the interior and showing the lateral pouch-shaped expansions of both valves and the incurved beak and crura of the brachial valve. (Davidson.)

Middle Devonian. *Chimay, Belgium.*

Fig. 26. A profile of a specimen retaining both valves; showing their convexity, and the prolongation of the beak of the pedicle-valve. (Davidson.)

Middle Devonian. *Paffrath, Germany.*

Fig. 27. A dorsal view of a medium-sized specimen; showing the character of the exterior and the deep delthyrium. (Davidson.)

Middle Devonian. *Chimay, Belgium.*

Fig. 28. A dorsal view of a large individual with distorted unciform beak. (F. Roemer.)

Middle Devonian. *Eifel, Germany.*

Fig. 29. The interior of the umbonal region of the brachial valve, enlarged; showing the hinge-plate, lateral pouches, and grooved ridges extending forward from the base of the hinge-plate. (Davidson.)

Middle Devonian. *Torquay, England.*

Genus KARPINSKIA, Tschernyschew.

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Karpinskia conjugula, Tschernyschew.

Figs. 30–32. Profile, dorsal and ventral views of the exterior of conjoined valves.

Fig. 33. A transverse section; showing the form of the spiral cones and their convergence into the cavity of the brachial valve.

(Tschernyschew.)

Lower Devonian. *Ural Mountains, Russia.*

Subgenus GRUENEWALDTIA, Tschernyschew.

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Gruenewaldtia latilinguis, Schnur.

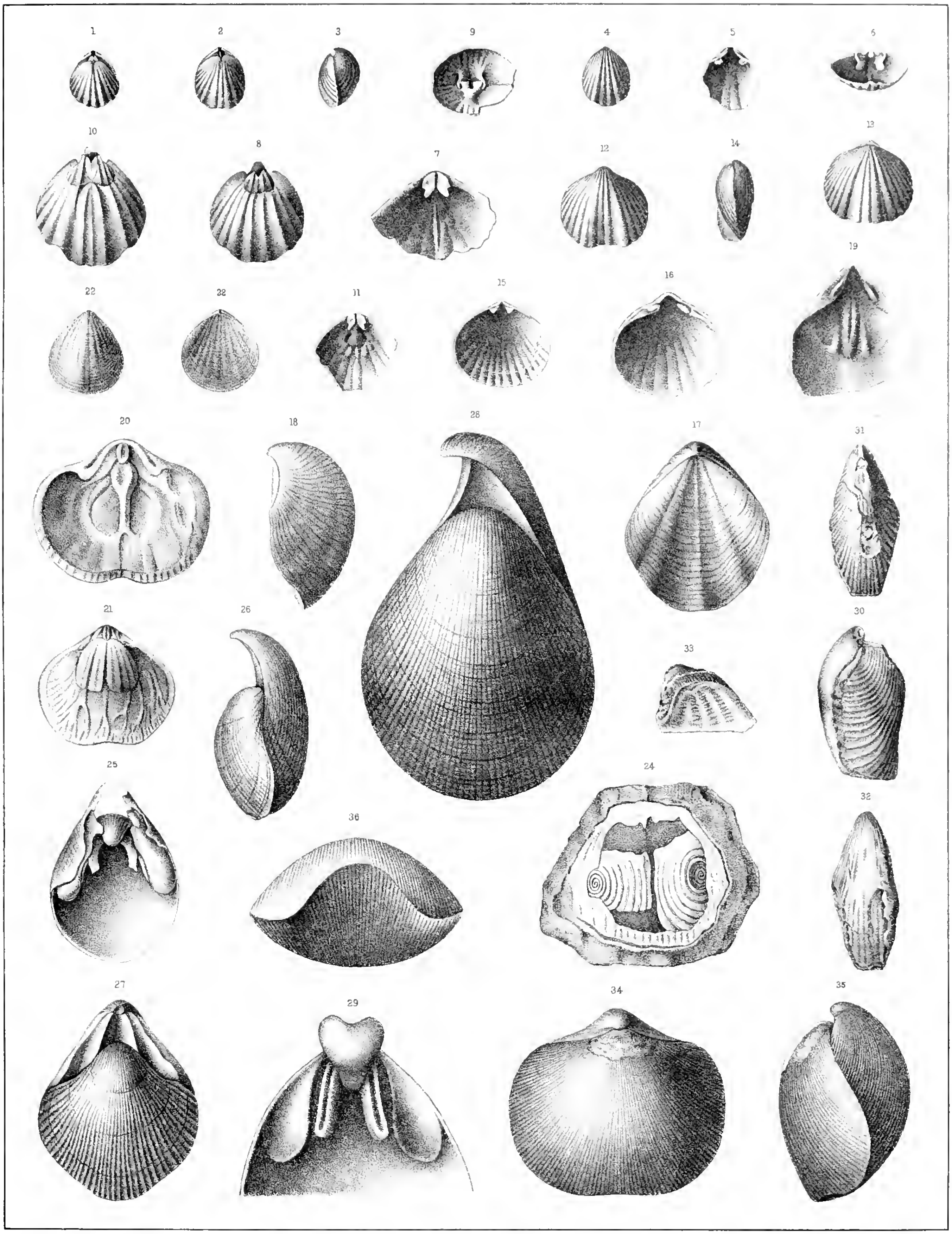
Figs. 34–36. Dorsal, profile and frontal views; showing the contour and exterior markings of the species. (Schnur.)

Middle Devonian. *Gerolstein, Germany.*

BRACHIOPODA.

MISCELLANEOUS

Generic Illustrations



G B Simpson del

Phil. Ast lith.

PLATE LIII.

(Figures 1-3, 5-7, 11-13, 17-23, 29, 30, 36-38, 46, 48, 54, 55 by G. B. SIMPSON, 4 by J. M. CLARKE; 8, 9, 14, 15, 31, 40-42, 45, 47, 49, 51, 53 by E. EMMONS; 10, 16, 24-28, 32-35, 39 by R. P. WHITFIELD, 43, 44, 50, 52 by F. B. MEEK.)

GENUS ATRYPINA, GEN. NOV.

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ATRYPINA DISPARILIS, Hall.

Figs. 1-3. Ventral, profile and dorsal views of an average mature example; showing the plano-convex contour, sparse plication and concentric surface markings. × 2.

Fig. 4. A dorsal view of a very young individual; showing the deltidial plates beneath the erect beak, the deep median sinus of the brachial valve and its low plications. × 5.

Niagara group. *Waldron, Indiana.*

ATRYPINA IMBRICATA, Hall.

Fig. 5. The interior of a pedicle-valve; showing the concave deltidial plates and the teeth. × 2.

Fig. 6. The interior of an incomplete pedicle-valve; showing the deep pedicle-cavity. × 2.

Fig. 8. The interior of a brachial valve; showing the bilobed cardinal process and a portion of one of the spirals. × 2.

Fig. 9. A cardinal view of the same specimen; showing a narrow area and the size of the cardinal process. × 2½.

Fig 10. The cardinal region enlarged; showing the slightly concave deltidial plates, the circular foramen nearly enclosed by the substance of the valve, and the lamellæ of the surface. × 5.

Lower Helderberg group. *Near Clarksville, N. Y.*

GENUS CŒLOSPIRA, HALL.

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CŒLOSPIRA PLANOCONVEXA, Hall.

See Plate 52.

Figs. 11-13. Ventral, dorsal and profile views of a specimen, natural size; showing the contour and surface characters of the shell.

Fig. 14. The interior of a brachial valve; showing the form of the cardinal process and the thickened median ridge. × 2.

Fig. 15. A still further enlargement of a portion of the same valve, to show the grooved lobes of the cardinal process. × 5.

Fig. 16. The interior of an incomplete brachial valve; showing cardinal process, dental sockets, and the muscular depressions on either side of the thickened median ridge; enlarged.

Clinton group. *Hamilton, Ontario.*

GENUS ATRYPINA, GEN. NOV.

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ATRYPINA CLINTONI, sp. nov.

Fig. 7. The interior of an incomplete brachial valve; showing the bilobed hinge-plate and the median muscular ridge. × 3.

Fig. 17. A dorsal view of a specimen; showing the internal cast of the brachial valve and the teeth and rostral cavity of the pedicle-valve. × 2

Fig. 18. An internal cast of the pedicle-valve; showing the adductor and diductor muscular scars. × 2.

Fig. 19. The exterior of a pedicle-valve. × 2.

Clinton group. *Drift of western New York.*

GENUS CŒLOSPIRA, HALL.

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CŒLOSPIRA CONCAVA, Hall.

Fig. 20. The exterior of a pedicle-valve. × 2.

Fig. 21. The exterior of a brachial valve; showing its concavity and the posterior portion of the cardinal process. × 2.

Fig. 22. The interior of the brachial valve; showing the character of the cardinal process and socket-walls, and the median thickening between the muscular impressions. × 3.

Fig. 23. The interior of an incomplete pedicle-valve; showing the open delthyrium, the teeth and muscular impressions. × 3.

Lower Helderberg group (Shaly limestone). *Near Clarksville, N. Y.*

Cœlospira camilla, Hall.

Figs. 24–26. Dorsal, profile and ventral views of a typical specimen; showing the contour and surface characters. × 2.

Fig. 27. The interior of the brachial valve; showing the elevated and somewhat recurved hinge-plate. × 4.

Fig. 28. The interior of a pedicle valve; showing the open delthyrium, the teeth and muscular impressions. × 4.

Corniferous limestone. *Caledonia, N. Y.*

Fig. 29. The interior of a pedicle-valve; showing characters similar to those of the preceding figure. × 2.

Fig. 30. The exterior of a pedicle-valve. × 2.

Fig. 31. The interior of a brachial valve; showing the hinge-plate and median ridge. × 3.

Corniferous limestone. *Le Roy, N. Y.*

Cœlospira acutiplicata, Conrad.

Figs. 32–35. Dorsal, profile, ventral and frontal views of the exterior of a typical specimen; showing the contour, coarse, sharp plication and concentric lineation of the valves

Corniferous limestone. *Jamesville, N. Y.*

Fig. 36. The interior of a portion of the brachial valve; showing the recurved hinge-plate, deep dental sockets and median ridge. × 3.

Fig. 37. The exterior of a pedicle-valve slightly imperfect about the margins. × 2.

Fig. 38. The interior of the same specimen; showing the open delthyrium and teeth. × 2.

Corniferous limestone. *Waterloo, N. Y.*

Fig. 39. The interior of a brachial valve with faint lateral plications; showing the hinge-plate, dental sockets and median ridge.

Corniferous limestone. *Sangerfield, N. Y.*

Genus LEPTOCŒLIA, Hall.

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Leptocœlia flabellites, Hall.

Figs. 40–42. Dorsal, ventral and profile views of an average example; showing the contour and surface characters.

Fig. 43. The interior of a brachial valve; showing the structure of the hinge-plate, dental sockets and muscular area.

Fig. 44. A profile of a large shell; showing the plano-convex contour.

Fig. 45. The interior of a brachial valve, somewhat imperfect about the margins; showing a slight variation of the characters as represented in fig. 43.

Fig. 46. The cardinal region of another brachial valve, enlarged; showing the excavation of the cardinal process on either side of a median ridge, and the projection of the crural lobes. × 2.

Fig. 53. The interior of a pedicle-valve; showing the open delthyrium, teeth, adductor and diductor scars.

Oriskany sandstone. *Cumberland, Maryland.*

Leptocœlia fimbriata, Hall.

Fig. 47. Dorsal view of the posterior portion of the shell; showing the fimbria of spinules or testaceous processes extending from between the cardinal margins. × 3.

Fig. 48. A profile of a brachial valve; showing the elevation of the cardinal process and crura. × 3.

Fig. 49. Cardinal view of a brachial valve; showing the elevation of the cardinal process, socket-walls and crura, and the foreshortened cardinal spinules.

Fig. 50. Dorsal view of conjoined valves; showing the exterior characters and the cardinal spinules. × 3.

Fig. 51. The interior of a brachial valve; showing the structure of the articulating apparatus, the character of the muscular area, and the marginal spinules which are inserted upon this valve. × 2.

Fig. 52. The interior of a pedicle-valve; showing the foramen, teeth and muscular area. × 2.

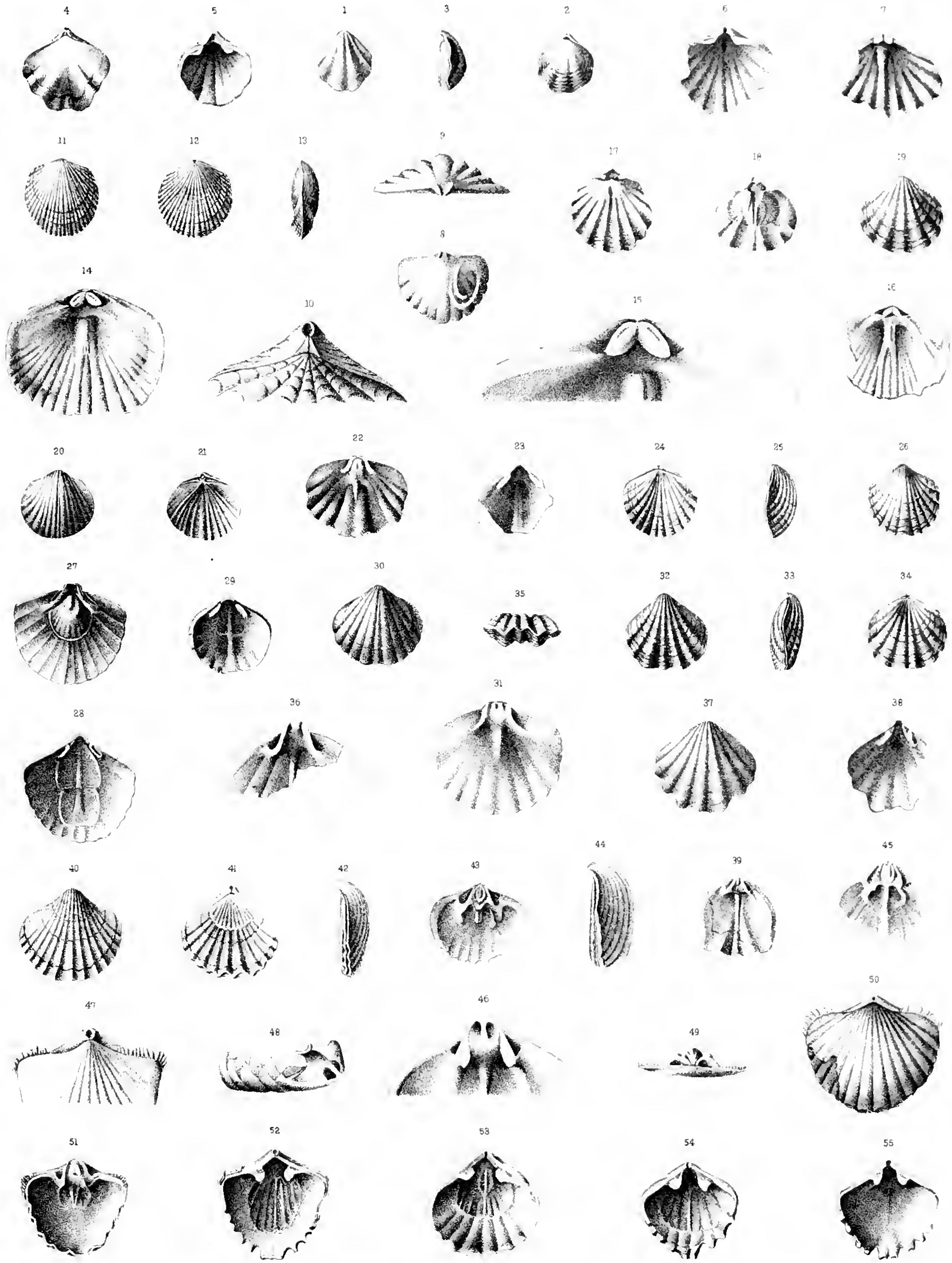
Figs. 54, 55. Interiors of pedicle-valves; showing some variation in the retention of the structural features. × 2.

Oriskany sandstone. *Cumberland, Maryland.*

BRACHIOPODA.

CŒLOSPIRIDÆ.

Generic Illustrations



E. Emmons del.
Phil. Ast lith.

PLATE LIV.

(Figures 1-3, 23-26, 30, 35-37 by E. EMMONS; 6, 9-11, 13-16, 21, 22-27, 31-34 by G. B. SIMPSON; 4, 5, 7, 8, 12, 17-20, 28, 29, 38-40, 47, 48 by R. P. WHITFIELD; 41-46 copies.)

GENUS ZYGOSPIRA, HALL.

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ZYGOSPIRA RECURVIROSTRA, Hall.

Figs. 1-3. Dorsal, ventral and cardinal views of the exterior of an average example. × 3.
Trenton limestone. *Middleville, N. Y.*

Figs. 4, 5. Dorsal and profile views of a more finely plicated specimen. × 3.
Trenton limestone. *Savannah, Illinois.*

Fig. 6. Dorsal view of a shell much more finely plicated than the foregoing, and with a broader median sinus on the brachial valve. This is the prevailing form at this locality.
Trenton horizon. *Frankfort, Kentucky.*

ZYGOSPIRA MODESTA (Say), Hall.

Fig. 7. Dorsal view of the exterior; showing the character of the plication. × 3.

Fig. 8. A profile of a somewhat larger individual. × 3.
Hudson River group. *Near Cincinnati, Ohio.*

Fig. 9. The interior of a brachial valve; showing the bilobed cardinal process. × 2.

Fig. 10. A portion of the same specimen enlarged to show more distinctly the structure of this process. × 6.
Hudson River group. *Versailles, Indiana.*

Fig. 12. An enlargement of the cardinal region; showing the deltidial plates and the encroachment of the foramen upon the umbonal portion of the shell. In this specimen the false cardinal area is unusually developed, but it does not take on the appearance and sharp definition of a true area as here represented; the upper margin never showing such angularity.
Hudson River group. *Near Cincinnati, Ohio.*

ZYGOSPIRA KENTUCKIENSIS, James.

Figs. 11, 15, 16. Ventral, dorsal and profile views of an average specimen, natural size; showing the exterior characters and large size of this form.
Hudson River group. *Oldham county, Kentucky.*

ZYGOSPIRA CINCINNATIENSIS, Meek.

Figs. 13, 14. Ventral and dorsal views of the exterior: showing the character of the plication and the unequal size and distribution of the ribs on fold and sinus. × 2.
Hudson River group. *Cincinnati, Ohio.*

ZYGOSPIRA (ORTHONOMÆA) ERRATICA, Hall.

Fig. 17. The interior of a brachial valve; showing the bilobed cardinal process, muscular and vascular impressions.

Fig. 18. The interior of a pedicle-valve; showing the open delthyrium, deep, posteriorly situated muscular scar, and the lateral impressions at the sides of this scar. The impressions in the pallial region which are represented as branching sinuses are believed to be traces of the primary lamellæ of the spiral coils. Figs. 17 and 18 are drawn from gutta-percha impressions taken from natural casts of the interior.

Fig. 19. Ventral view of a natural cast of the interior; showing the muscular scars of the pedicle-valve. × 2.

Fig. 20. A natural cast of the brachial valve; showing the arrangement of the muscular scars. × 2.
Hudson River group. *Drift blocks in central and western New York.*

Fig. 21. The exterior of a pedicle-valve; showing its contour and the fine surface plication.
Hudson River group. *Hamilton, Ontario.*

Fig. 22. The interior of a pedicle-valve; showing the cardinal process and muscular scars. From a gutta-percha mould.

Fig. 23. An enlargement of the cardinal process of the same specimen; showing its bilobate character. × 3.
Hudson River group. *Drift blocks of central New York.*

Subgenus CATAZYGA, s.-gen. nov.

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Catazyga Headi, Billings.

Figs. 24-26. Dorsal, profile and cardinal views of the exterior; showing the biconvex valves, the fine plication of the exterior and the median depression on the brachial valve. Natural size.

Hudson River group. *Near Ottawa, Canada.*

Figs. 28, 29. Dorsal and profile views of another specimen.

Hudson River group. *Near Cincinnati, Ohio.*

Fig. 30. The interior of a portion of the pedicle-valve; showing the deep muscular scar.

Hudson River group. *Waynesville, Indiana.*

Catazyga Headi, var. borealis, Billings.

Fig. 27. A dorsal view of a rather large specimen of this variety.

Hudson River group. *Waynesville, Indiana.*

Figs. 31, 32. Dorsal and profile views of a smaller shell.

Anticosti group. *Island of Anticosti.*

Catazyga Headi, var. Anticostiensis, Billings.

Fig. 33, 34. Ventral and dorsal views of the exterior; showing the outline, contour and fine surface plication.

Hudson River group. *Collingwood, Ontario.*

Genus ZYGOSPIRA, Hall.

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Zygospira putilla, sp. nov.

Figs. 35-37. Dorsal, profile and ventral views of the exterior of an average example. × 2.

Hudson River group. *Near Edgewood, Pike county, Missouri.*

Genus CYCLOSPIRA, gen. nov.

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Cyclospira bisulcata, Emmons.

Figs. 38-40. Dorsal, profile and ventral views of the exterior of a specimen bearing a marginal plication in the sinus of the brachial valve. × 2.

Trenton limestone. *Watertown, N. Y.*

Genus DAYIA, Davidson.

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Dayia navicula, Sowerby.

Figs. 41-43. Dorsal, frontal and profile views of an average example, enlarged.

Fig. 44. A restoration showing the character of the spirals and loop.

Figs. 45, 46. Enlarged translucent preparations of the spirals; showing the lateral direction of the apices and the fimbriation of the spiral coils. (Davidson.)

Ludlow shales. *Shropshire, England.*

Genus PROTOZYGA, gen. nov.

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Protozyga exigua, Hall.

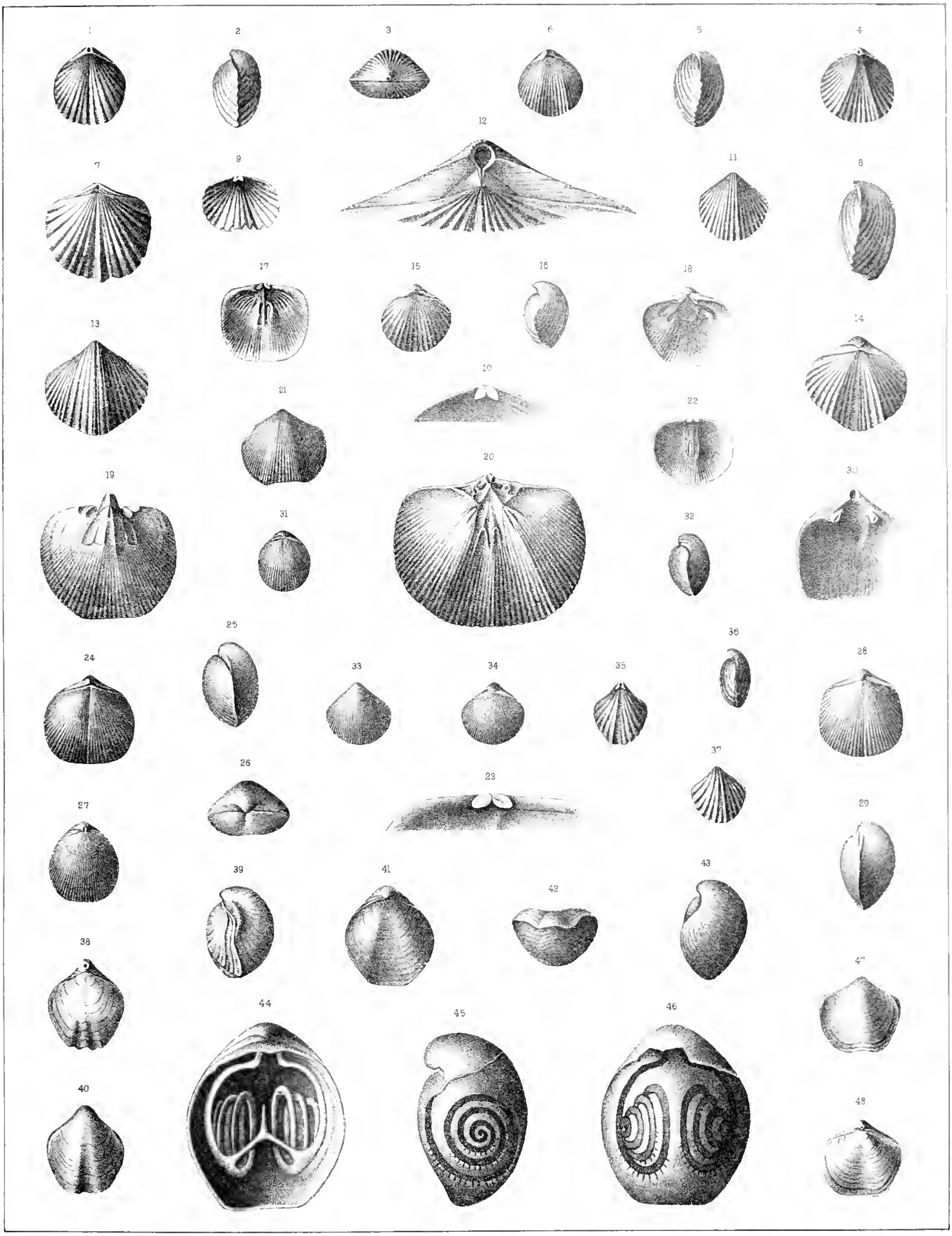
Figs. 47, 48. Ventral and dorsal views of a specimen; showing the naviculate contour and smooth exterior. Shells of this species usually bear one or two low, broad marginal folds on each side of the median axis. × 2.

Trenton limestone. *Watertown, N. Y.*

BRACHIOPODA.

ZYGOSPIRIDÆ.

Generic Illustrations



G B.Simpson del

Phil Ast lith.

PLATE LV.

(Figures 1 by J. M. CLARKE; 2, 11, 12, 15-17 by G. B. SIMPSON; 3-9, 18-21, 23, 26, 27 by R. P. WHITFIELD; 10, 13, 14, 22, 24, 25 by E. EMMONS.)

Legend:
- P. Pedicle passage.
- p. Pedicle cavity.
- dp. Deltidial plates.
- hp. Hinge-plate.
- c. Crural lobes.
- b. Dental sockets.
- sr. Ridge in dental sockets.
- a. Adductor scars.
- n. Diductor scars.
- o. Ovarian markings.
- v. Vascular trunks.
- v'. Secondary vascular sinuses.

GENUS ATRYPA, DALMAN.

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ATRYPA RETICULARIS, Linné.

Fig. 1. Dorsal view of the youngest individual observed; showing the slight convexity of the brachial valve in the umbonal region, its general depression anteriorly, low median sinus, few plications, erect beak of pedicle-valve, triangular delthyrium and incipient deltidial plates. × 10.

Fig. 2. Exterior of the pedicle-valve of a mature individual from the same locality; showing the extensions of the concentric lamellæ.

Niagara group. *Waldron, Indiana.*

Figs. 3, 4. Dorsal and profile views of an elongate, finely plicate and gibbous shell, without strong concentric growth lines.

Lower Helderberg group (Shaly limestone). *Near Clarksville, N. Y.*

Figs. 5, 6. Dorsal and profile views of an orbicular, subequally biconvex, finely plicate shell.

Fig. 7. The interior of a pedicle-valve; showing the broad pedicle cavity, widely separated teeth, pedicle, adductor and diductor muscular scars, ovarian markings and crenulated ante-lateral margins.

Fig. 8. The interior of a brachial valve; showing the structure of the hinge-plate, dental sockets and the muscular scars.

Hamilton group. *In the soft shales of western New York.*

Fig. 9. An internal cast of a large pedicle-valve; showing the impression of the rostral cavity and large muscular scars, ovarian markings, vascular trunks and secondary sinuses.

Corniferous limestone. *Le Roy, N. Y.*

Fig. 10. A preparation exposing the brachidium of a large individual, by the removal of the brachial valve. The spiral cones have their bases parallel to the surface of the pedicle-valve and their apices directed upward and inward, into the cavity of the convex brachial valve. The figure shows the laterally appressed form of the cones, the great width and anterior extension of the primary lamellæ, the attachment of the latter to the crura, and the discrete, recurved branches of the loop. (c.)

Chemung group. *Haskinsville, N. Y.*

Fig. 11. The cardinal portion of the brachial valve, enlarged; showing the reduced and completely divided hinge-plate, and the broad dental sockets which are traversed by a crenulated median ridge. ×3.

Fig. 12. A posterior view of the cardinal portion of the pedicle-valve; showing the elevation of the distant teeth, the double grooving and recurvature of their extremities. × 3.

Figs. 13, 14. Fragments of the spiral lamellæ; showing their fimbriate outer margin. × 10.

Fig. 15. A portion of the primary lamellæ with its attachment to one of the crura. This specimen is viewed from the dorsal side and shows the incurvature of the crus and its union with the outer edge of the lamella. × 10.

Fig. 16. A view of the loop drawn from the ventral side of the brachidium; showing the thickened and recurved extremities of the lateral branches. × 10.

Fig. 17. A portion of the primary lamellæ and one of the crura, the latter being in a pathologic condition which has resulted in hypertrophy of this part. × 10.

Hamilton group. *Clarke county, Indiana.*

ATRYPA ASPERA, Schlotheim, var. OCCIDENTALIS, Hall.

Figs. 18, 19. Dorsal and profile views of a Devonian shell; showing the gibbosity of the brachial valve, the coarse plications and strong concentric lamellæ.

Fig. 20. A preparation of the brachidium exposed by the removal of the pedicle-valve; showing the form of the cones and loop. (WHITFIELD.)

Upper Devonian. *Independence, Iowa.*

ATRYPA SPINOSA, Hall.

Fig. 21. The exterior of the pedicle-valve; showing the extension of the concentric lamellæ into well-defined spinules. When these spinules are removed such shells present coarse, strong plications like those of *A. aspera.*

Hamilton group. *Moscow, N. Y.*

Fig. 22. Dorsal view of a specimen with longer spines. A portion of the brachial valve has been removed, showing one of the spiral cones, which is considerably depressed.

Hamilton group. *Canandaigua Lake, N. Y.*

ATRYPA HYSTRIX, Hall.

Fig. 23. The exterior of a pedicle-valve, with coarse ribs, strong concentric lamellæ and stout, long marginal spines.

Chemung group. *Near Bath, Steuben county, N. Y.*

ATRYPA MARGINALIS, Dalman.

Figs. 24, 25. Dorsal and profile views of a preparation showing the brachidium which has been exposed by the removal of the brachial valve. The spiral cones are more regularly conical and more obtuse at their apices than is usual in *A. reticularis.* In this specimen, also, the lateral branches of the loop are discrete. The figures also show the great elevation of the linguiform extension of the median sinus on the pedicle-valve. × $2\frac{1}{2}$.

Middle Silurian. *Anticosti.*

ATRYPA PSEUDOMARGINALIS, Hall.

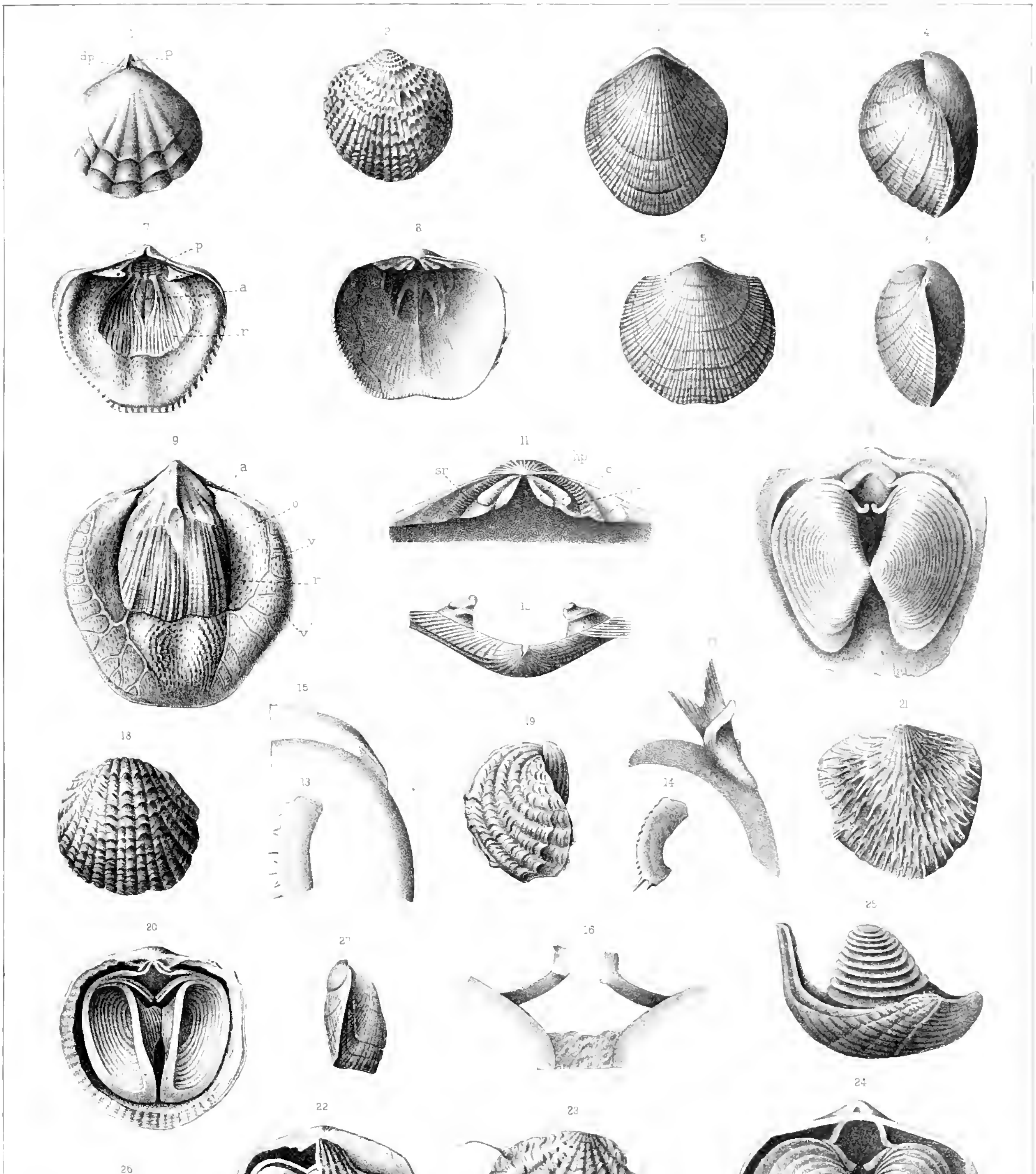
Figs. 26, 27. Dorsal and profile views of the original specimen; showing the convexity of the valves and the strong median fold on the brachial valve.

Corniferous limestone. *Schoharie, N. Y.*

BRACHIOPODA.

ATRYPIDÆ.

Generic Illustrations.



R.P. Whitfield del.

Phil Ast lith.

PLATE LVI.

(Figures 1-13, 16-23, 28-34, 36, 37, 45 by G. B. SIMPSON; 14, 15, 24-27 by R. P. WHITFIELD; 35, 38 by C. E. BEECHER; 39-44 copies.)

GENUS RHYNCHONELLA, FISCHER DE WALDHEIM.

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RHYNCHONELLA LOXIA, Fischer de Waldheim.

Figs. 1-5. Dorsal, ventral, profile, frontal and cardinal views of a normal mature individual, retaining the smooth external surface, and showing the contour, acuminate median fold and sparse lateral plication.

Fig. 6. Cardinal view of an internal cast; showing the cavity of the dental plates and median septum.

This is the type of the genus RHYNCHONELLA.

Upper Jurassic. *Charaschowa, Russia.*

GENUS PROTORHYNCHA, GEN. NOV.

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PROTORHYNCHA ÆQUIRADIATA, Hall.

Fig. 7. An internal cast of the brachial valve; showing the length of the median septum. × 2.

Fig. 8. The cardinal portion of the brachial valve, enlarged; showing a clearly defined cardinal area, oblique dental sockets, the broad, rather ill-defined hinge-plate, with a median cavity whose lateral walls are continuous with the median septum. × 3.

Fig. 9. An internal cast of a larger pedicle-valve; showing a well defined median sinus and a very restricted muscular scar in the umbonal region. × 2.

Clinton group. *New Hartford, N. Y.*

GENUS ORTHORHYNCHULA, GEN. NOV.

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ORTHORHYNCHULA LINNEYI, Nettelroth.

Figs. 10-12. Dorsal, profile and ventral views of the exterior of an average example; showing contour and character of plication.

Fig. 13. The central portion of the cardinal region, enlarged; showing the sharply defined cardinal area and the open delthyrium. × 3.

Fig. 19. The interior of a pedicle-valve; showing the obscurely defined muscular impression, the cardinal area, open delthyrium and teeth. The area has been encroached upon by the delthyrium and consequently diminished in size.

Hudson River group. *Nashville, Tennessee.*

The original specimens of this species are from Danville and neighboring localities, Kentucky.

GENUS RHYNCHOTREMA, HALL.

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RHYNCHOTREMA CAPAX, Conrad.

Figs. 14, 15. Dorsal and frontal views of a somewhat gibbous adult; showing the character of the plication and the fine concentric lineation.

Hudson River group. *Frankfort, Kentucky.*

Fig. 16. The interior of a pedicle-valve; showing the thickened deltidial plates consolidated with the valve, the deep pedicle and muscular cavity, and recurved teeth.

Hudson River group. *Richmond, Indiana.*

Fig. 17. The interior of a pedicle-valve; showing the broad, concave deltidial plates, in contact for their entire length along the median line, greatly thickened and consolidated with the bottom of the valve beneath; also the recurved teeth resting upon the thickened lateral walls, the pair of shallow depressions in the umbonal region and the deep diductor scar in the middle of the valve, which has been greatly encroached upon by the umbonal thickening of the shell.

Fig. 18. An enlargement of the umbonal portion of the same specimen. The small cavity at the base of the deltidial plates is the inner opening of the pedicle-passage which was functional at this advanced growth-stage of the shell, its outer opening being on the back of the umbo, considerably removed from the beak, and connected with the apex by a groove whose margins are shown in the figure. (For more complete illustration of this structure, see supplementary plate.)

Fig. 20. The interior of an incomplete brachial valve; showing the hinge-plate, cardinal process and median septum.

Fig. 21. An enlargement of the umbonal portion of the same specimen; showing the deflection of the vertical septiform cardinal process, the character of the hinge-plate, socket-walls, sockets and crural apophyses.

Figs. 17, 18, 20, 21 are from the specimens upon which the characters of the genus were originally established.

Hudson River group. *Iron Ridge, Wisconsin.*

Fig. 22. The interior of an old brachial valve; showing the deflection of the cardinal process and the thickened hinge-plate.

Fig. 23. The interior of a pedicle-valve in which the deltidial plates have been partially resorbed, leaving the pedicle cavity open and exposing a well defined pedicle scar. The impression of the diductor muscles is large and expanded, indicating that the contraction of the scar with age, as seen in figure 17, is due to the encroachment of testaceous deposits upon the area of muscular insertion.

Hudson River group. *Richmond, Indiana.*

Figs. 24-27. Dorsal, ventral, profile and frontal views of a young shell which, at an early growth-stage, suffered an interruption to the regular development of its plications on both valves, the subsequent shell-growth being irregular and showing but an imperfect development of the plications. The cessation of normal growth at the same stage on both valves would indicate that the production of the abnormal shell was due to a pathologic condition of the mantle, which has thus reproduced in the later development of the valves, an elementary condition of growth.

Hudson River group. *Near Cincinnati, Ohio.*

GENUS CAMAROTŒCHIA, GEN. NOV.

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CAMAROTŒCHIA FRINGILLA, Billings.

Figs. 28-30. Dorsal, profile and ventral views of a large and finely developed individual; showing the external characters of the species.

Anticosti group. *Gull Cape, Anticosti.*

GENUS RHYNCHOTRETA, HALL.

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RHYNCHOTRETA CUNEATA, Dalman, var. AMERICANA, Hall.

Figs. 31-34. Dorsal, profile, ventral and frontal views of an average example; showing the contour of the shell, the character of the plication and fine concentric surface markings.

Fig. 35. Dorsal view of the youngest individual observed; showing the open delthyrium, broad umbones and the median sinus on the brachial valve. × 6. (After BEECHER and CLARKE.)

Niagara group. *Waldron, Indiana.*

Figs. 36, 37. Ventral and dorsal views of an internal cast of conjoined valves; showing, in figure 36, the impression of the pedicle muscle, the diductor and adductor scars bounded by divergent ridges, and, in figure 37, the cast of the deltidial cavity and the extent of the median septum.

Niagara dolomites. *Near Milwaukee, Wisconsin.*

Fig. 38. The cardinal region of an adult specimen, enlarged; showing the unusual size of the deltidial plates, their outward flexion along the median suture, the apical and encroaching position of the foramen. × 5. (After BEECHER and CLARKE.)

Niagara group. *Waldron, Indiana.*

RHYNCHOTRETA CUNEATA, Dalman.

Figs. 39, 40. Profile and dorsal views of a normal adult. (After DAVIDSON.)

Wenlock limestone. *Dudley, England.*

GENUS STENOSCHISMA, CONRAD.

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STENOSCHISMA FORMOSA, Hall.

Figs. 41-43. Dorsal, profile and ventral views of the exterior.

Fig. 44. Frontal view of another example.

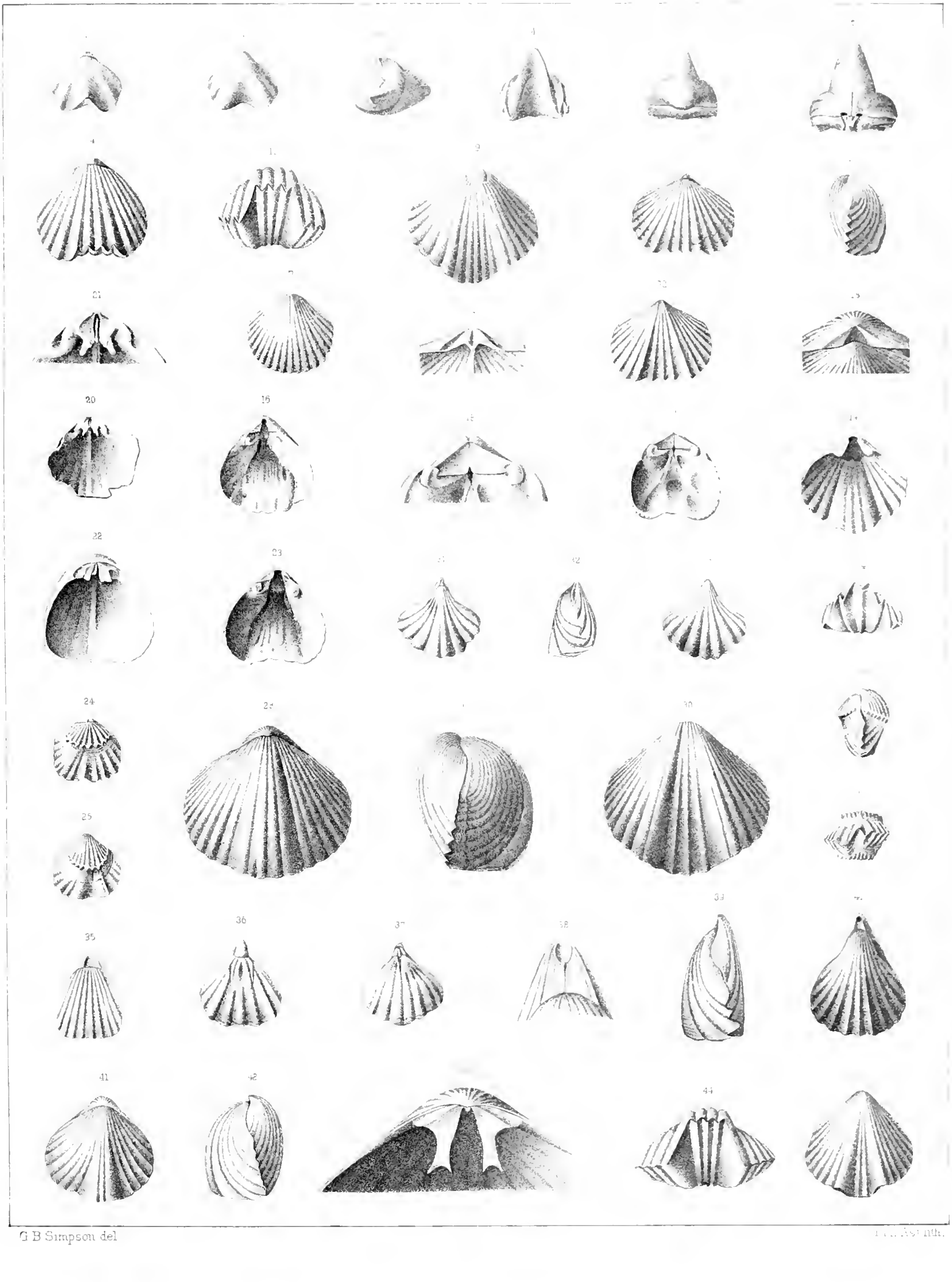
Fig. 45. Enlargement of the hinge-plate; showing its deep median division, minute cardinal process, flat crural lobes and concave crura. × 4.

Lower Helderberg group (See Vol. III, p. 236, pl. xxxv). *Albany county, N. Y.*

BRACHIOPODA.

RHYNCHONELLIDÆ.

Generic Illustrations



G B Simpson del

PLATE LVII.

(Figures 1–50 by R. P. Whitfield; 51–54 by E. Emmons.)

Genus CAMAROTŒCHIA, gen. nov.

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Camarotœchia Tethys, Billings.

Figs. 1, 2. Cardinal and profile views of a rather large shell.
Corniferous limestone. *Province of Ontario.*

Camarotœchia Billingsi, Hall.

Fig. 3. Dorsal view of an internal cast; showing the position of the median septum.
Corniferous limestone. *Western New York.*

Camarotœchia Carolina, Hall.

Figs. 4, 5. Dorsal and cardinal views of a partially exfoliated specimen.
Fig. 6. Front view of a more gibbous shell.
Corniferous limestone. *Sandusky, Ohio.*

Camarotœchia Horsfordi, Hall.

Figs. 7–9. Cardinal, frontal and profile views of a typical mature individual.
Hamilton shales. *Moscow, N. Y.*

Camarotœchia Sappho, Hall.

Figs. 10–14. Dorsal, ventral, cardinal, profile and frontal views of a large and typical example.
Hamilton group. *Western New York.*

Camarotœchia congregata, Hall.

Figs. 15–19. Dorsal, ventral, cardinal, frontal and profile views of a large individual.
Fig. 20. Cardinal view of an internal cast; showing the cavities of the dental plates and median septum.
Fig. 21. An internal cast of the pedicle-valve; showing a large diductor impression.
Fig. 22. A similar cast of the interior with the muscular area more restricted.
Fig. 23. An internal cast of a brachial valve; showing the length of the median septum, the filling of the cardinal cavity and the scars of the adductor muscles.
Figs. 24, 25. Enlargements of the internal casts of the umbonal portion of the brachial valve; showing the filling of the incipient spondylium and the crenulation of the outer socket-walls.
Figs. 26, 27. The same parts drawn from gutta percha impressions taken from natural casts of other individuals; showing the broad hinge-plate with its median division terminating in a spondylium, which is supported by branches of the median septum.
Hamilton group. *Various localities in the sandy shales of Schoharie, Otsego and Madison counties, N. Y.*

Camarotœchia contracta, Hall.

Figs. 28, 29, 31. Dorsal, profile and frontal views of an internal cast.
Figs. 30, 32. Dorsal and cardinal views of a cast with coarser plications on the median fold.
Chemung group. *Central and western New York.*

Camarotœchia Stevensi (= Rhynchonella Stephani), Hall.

Fig. 33. An internal cast of the pedicle-valve.
Figs. 34, 35. Dorsal and cardinal views of a cast of the brachial valve: showing the filling of the spondylium and the length of the median septum.
Chemung group. *Bradford county, Pennsylvania.*

CAMAROTŒCHIA (?) DUPLICATA, Hall.

Figs. 36–38. Ventral, frontal and dorsal views of the original example; showing the single plication and sulcus on sinus and fold respectively, and the obscure and sparse lateral plication.

Fig. 39. The interior of a brachial valve, drawn from a gutta-percha cast; showing the hinge-plate, crura, median septum and muscular impressions, and also the thickening of the shell in the umbonal region. × 2.

Chemung group. *Cattaraugus county, N. Y.*

CAMAROTŒCHIA DOTIS, Hall.

Figs. 40, 41. Ventral and profile views of a specimen of rather broad form, with rounded plications.

Hamilton group. *Eighteen-Mile Creek, N. Y.*

CAMAROTŒCHIA PROLIFICA, Hall.

Figs. 42, 43. Dorsal views of two internal casts; showing slight differences in the degree of its plication.

Hamilton group. *Schoharie and Otsego counties, N. Y.*

CAMAROTŒCHIA EXIMIA, Hall.

Figs. 44, 45. Cardinal and dorsal views of an internal cast.

Chemung group. *Ithaca, N. Y.*

CAMAROTŒCHIA ORBICULARIS, Hall.

Fig. 46. An internal cast of a brachial valve; showing the cast of the spondylium.

Fig. 47. Cardinal view of an internal cast; showing the filling of the rostral cavity and the extent of the thickened median septum.

Fig. 48. An internal cast of the pedicle-valve; showing the adductor and diductor muscles and the ovarian markings.

Fig. 50. An enlargement of a portion of the interior of the pedicle-valve; showing the detailed structure of the muscular impression.

Chemung group. *Meadville, Pennsylvania.*

CAMAROTŒCHIA CONTRACTA, Hall.

Fig. 49. An internal cast of the pedicle-valve; showing the form of the muscular area. (See figs. 28–32.)

Hamilton group. *Near Cardiff, N. Y.*

CAMAROTŒCHIA, sp. ?

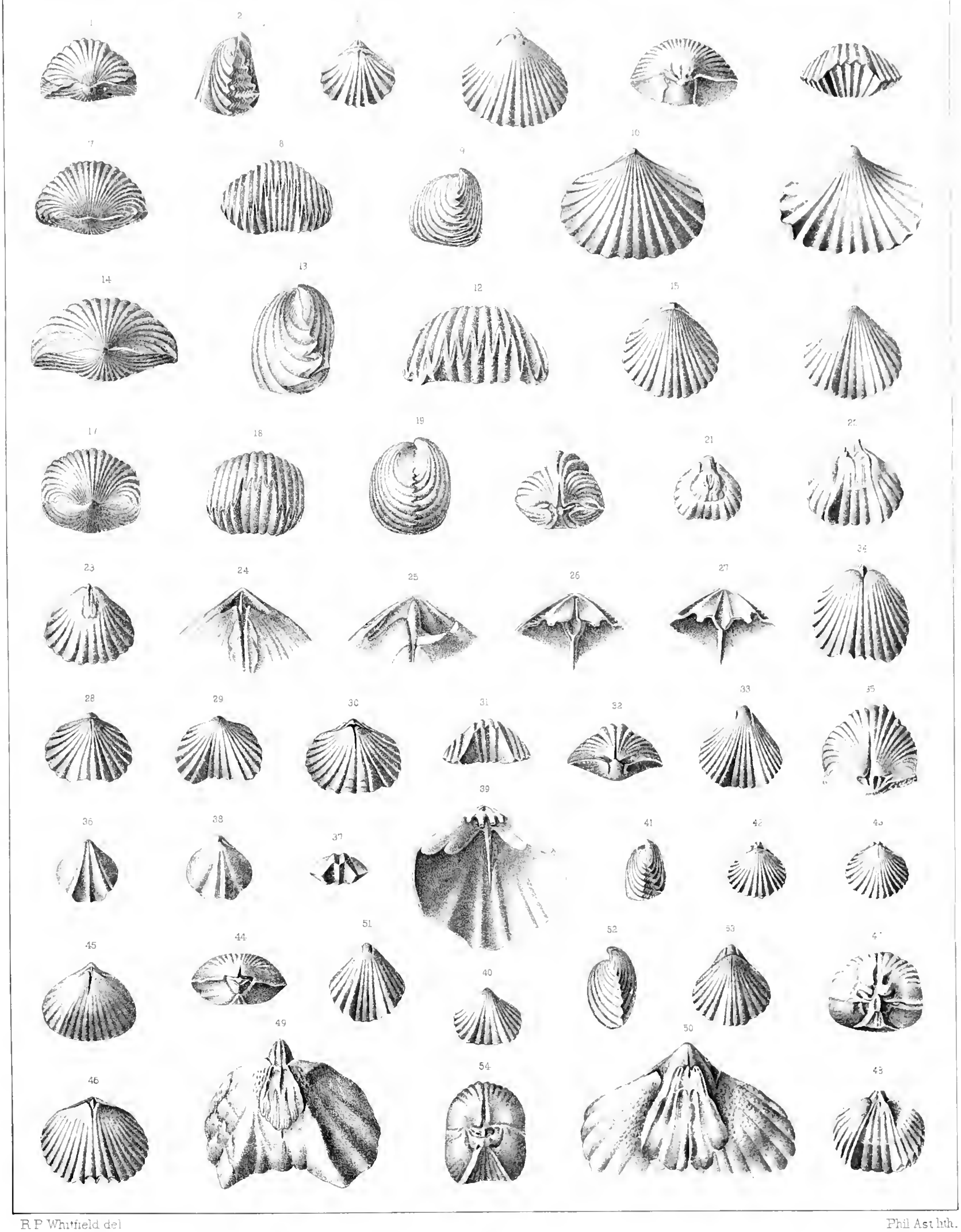
Figs. 51–53. Ventral, profile and dorsal views of an internal cast in chert.

Burlington limestone. *Burlington, Iowa.*

CAMAROTŒCHIA, sp. indet.

Fig. 54. Cardinal view of an extremely gibbous internal cast; showing the filling of the muscular cavity in the pedicle-valve and the spondylium in the brachial valve, the cavities left by the dental plates, hinge-plate, crura and median septum.

Waverly group. *Ohio.*



R P Whitfield del

Phil Ast lith.

PLATE LVIII.

(Figures 1-10, 15-19, 24, 25, 36, 40 by G. B. SIMPSON; 11, 12, 14, 35 by E. EMMONS; 13, 20-23, 26-33 by F. B. MEEK.)

GENUS RHYNCHOPORA, KING

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RHYNCHOPORA PUSTULOSA, White.

Figs. 1-4. Dorsal, ventral, front and profile views of an average example.

Burlington limestone. *Burlington, Iowa.*

GENUS WILSONIA, (QUENSTEDT) KAYSER.

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WILSONIA SAFFORDI, Hall.

Figs. 5-7, 10. Dorsal, ventral, frontal and profile views of a normal adult individual.

Figs. 8, 9. Front and profile views of another specimen, with broader median fold and greater anterior gibbosity.

Fig. 11. The interior of a pedicle-valve; showing the teeth and muscular impressions. × 2.

Fig. 12. Cardinal view of an internal cast of conjoined valves; showing the muscular impressions and the cavities left by the dental plates and median septum. × 2.

Niagara group. *Perry county, Tennessee.*

WILSONIA VENTRICOSA, Hall.

Fig. 13. Profile view of an average specimen; showing the extreme gibbosity of the valves.

Fig. 14. The interior of a thickened pedicle-valve; showing the scars of the pedicle and diductor muscles.

Lower Helderberg group (Upper Pentamerus limestone). *Schoharie county, N. Y.*

GENUS UNCINULUS, BAYLE.

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UNCINULUS ABRUPTUS, Hall.

Fig. 15. The interior of the umbonal portion of the pedicle-valve; showing the marginal teeth with dental plates lying close against the shell-walls. × 2.

Fig. 16. Cardinal view of the articulating apparatus of the brachial valve of a young shell; showing the triangular, divided cardinal process and the elevation of the crura. × 3.

Figs. 17, 18. Two views of the corresponding parts in an adult shell in which the lobes of the cardinal process and the lateral portions of the hinge-plate are considerably thickened. × 2.

Fig. 19. The interior of a pedicle-valve; showing the faintly defined muscular scar.

Figs. 20, 21. Dorsal and front views of conjoined valves of a typical specimen.

Lower Helderberg group (Shaly limestone). *Albany and Schoharie counties, N. Y.*

UNCINULUS MUTABILIS, Hall.

Figs. 22, 23. Profile and front views of a mature shell; showing its subspherical shape.

Figs. 24, 25. Two views of the interior umbonal region of the brachial valve; showing the thickened median septum, curved and elevated crura and bilobed cardinal process. × $1\frac{1}{2}$.

Lower Helderberg group (Shaly limestone). *Albany and Schoharie counties, N. Y.*

UNCINULUS NOBILIS, Hall.

Fig. 26. Front marginal view of an adult shell.

Lower Helderberg group (Upper Pentamerus limestone.) *Albany and Schoharie counties, N. Y.*

UNCINULUS PYRAMIDATUS, Hall.

Figs. 27, 28. Profile and front views of an average specimen.

Lower Helderberg group (Shaly limestone). *Albany county, N. Y.*

SUBGENUS PLETHORHYNCHA, S.-GEN. NOV.

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PLETHORHYNCHA SPECIOSA, Hall.

Figs. 29-31. Cardinal, front and profile views of a large entire individual; showing the robust form of the shell, its subquadrate transverse section, serrate margins and broad, somewhat concave lateral slopes. The abrupt marginal extensions of the cardinal slopes of the pedicle-valve, fitting into corresponding excavations of the brachial valve, as shown in figures 29 and 30, are the thickened teeth which are cemented to the walls of the shell throughout their entire extent and, at their summits only, fitted into shallow sockets in the opposite valve.

Fig. 32. The interior of a brachial valve, slightly broken about the margins; showing a thickened, undivided hinge-plate, bilobed cardinal process, narrow dental sockets and the median septum.

Fig. 33. A cardinal view of the same specimen; showing the elevation of the cardinal process and crura and the marginal excavations for the reception of the teeth.

Fig. 34. Cardinal view of the umbonal portion of an old shell in which the entire hinge-plate has become greatly thickened and elevated, and the apical portion or cardinal process resorbed and excavated. The projecting points above are the bases of the crura.

Fig. 35. The interior of a small pedicle-valve; showing the form of the teeth, and faint median muscular ridge on the bottom of the valve.

Fig. 36. The interior of a young brachial valve in which the hinge-plate is divided, its lateral portions resting on the median septum, and the cardinal margins but slightly excavated for the reception of the teeth.

Fig. 37. The umbonal portion of the same specimen, enlarged; showing the small cardinal process and the median division of the hinge-plate resting on the septum and forming an incipient spondylium. × 2.

Oriskany sandstone. *Cumberland, Maryland.*

GENUS UNCINULUS, BAYLE.

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UNCINULUS (UNCINULINA) STRICKLANDI, Sowerby.

Fig. 38. Cardinal view of an internal cast of both valves, the brachial valve being represented above; showing the cavities representing the median septum, the cardinal process and hinge-plate, and the ridge filling the median division of the latter.

Niagara dolomites. *Near Milwaukee, Wisconsin.*

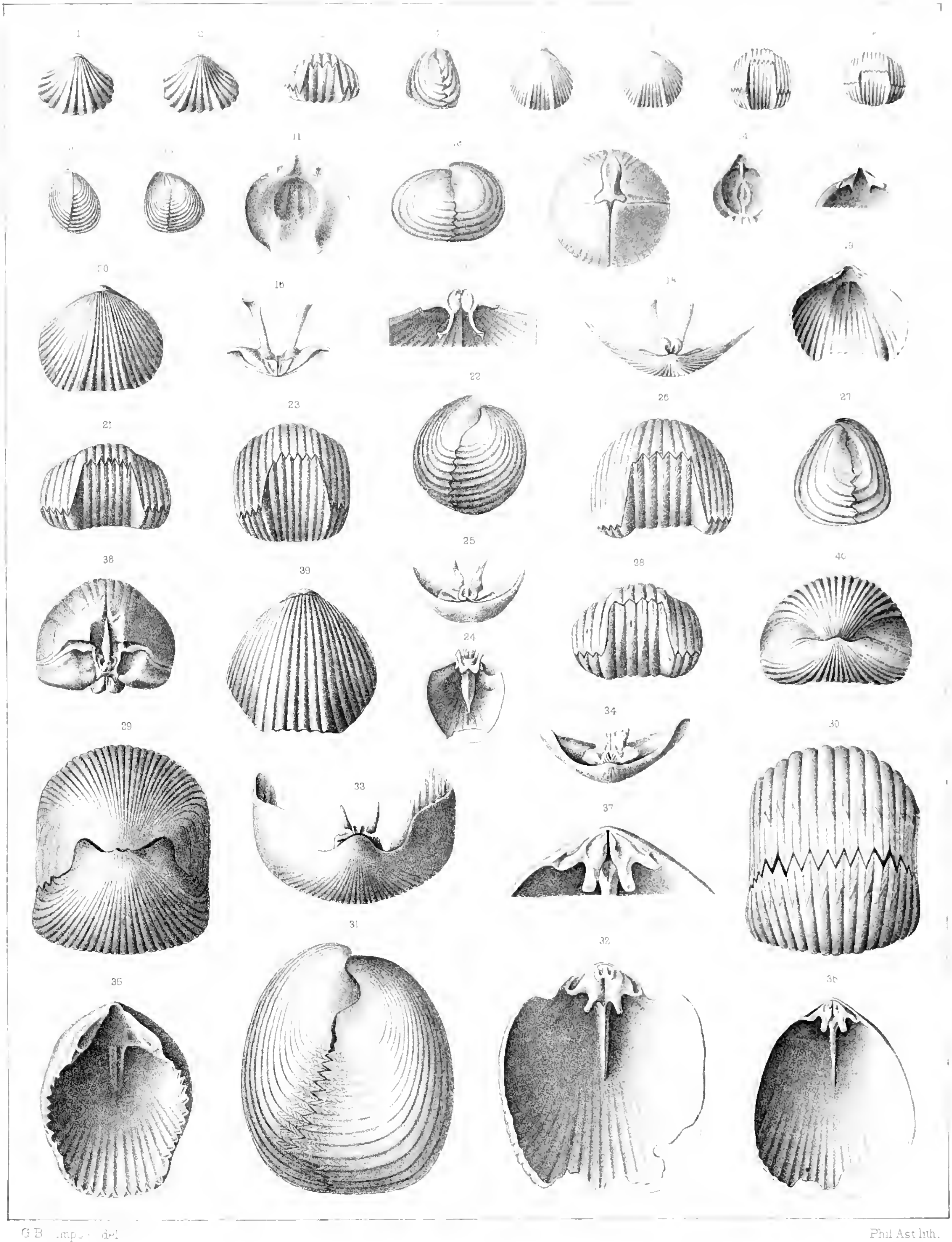
Figs. 39, 40. Dorsal and cardinal views of the exterior of a normal adult; showing the low median fold and the smooth cardinal slopes.

Niagara group. *Waldron, Indiana.*

BRACHIOPODA.

RHYNCHONELLIDÆ.

Generic Illustrations.



G.B. Simpson del. — Phil Ast lith.

PLATE LIX.

(Figs. 1-12, 18-22, 26, 30, 31, 37, 38 by R. P. WHITFIELD; 13, 14, 24, 25, 28, 29, 32, 33 by E. EMMONS; 15-17, 23, 27, 34-36 by G. B. SIMPSON.)

GENUS LIORHYNCHUS, HALL.

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LIORHYNCHUS LIMITARIS, Vanuxem.

Figs. 1, 2. Dorsal and frontal views of a small individual.
Marcellus shales (Goniatite limestone). *Schoharie county, N. Y.*

Figs. 3-5. Frontal, cardinal and ventral views of a larger specimen.
Limestone of the Marcellus shales. *Avon, N. Y.*

LIORHYNCHUS DUBIUS, Hall.

Figs. 6, 7. Ventral and dorsal views of a typical specimen.
Marcellus shales. *Locality?*

LIORHYNCHUS MULTICOSTA, Hall.

Fig. 8. The exterior of a pedicle-valve of an elongate specimen, the regular growth of which has been interrupted in the umbonal region.

Fig. 9. The brachial valve of a more orbicular and typical shell.

Fig. 10. A cardinal view; showing the convexity of the valves.
Hamilton group. *Western New York.*

LIORHYNCHUS MESACOSTALIS, Hall.

Fig. 11. The exterior of the pedicle-valve; showing the inequal plication of the sinus.

Fig. 12. An internal cast of a large brachial valve; showing the position of the median septum, the elongate muscular scars and the absence of plications on the lateral slopes.
Chemung group. *Tompkins county, N. Y.*

LIORHYNCHUS LAURA, Billings.

Figs. 13, 14. Ventral and dorsal views of a rather elongate individual.

Fig. 15. Posterior view of the hinge-plate and crura; showing the great elevation of the latter and their basal expansions. × 4.

Fig. 16. The same specimen, viewed from above; showing the narrow, submarginal dental sockets, the broad triangular divisions of the hinge-plate, the median septum and the recurvature of the long crura. × 4.

Fig. 17. The interior of the umbonal portion of the pedicle-valve; showing the open delthyrium, small teeth and faint muscular impression.
Hamilton group. *Widder, Ontario.*

LIORHYNCHUS KELLOGGI, Hall.

Fig. 18. Cardinal view of an internal cast; showing the cavities left by the dental plates, median septum and crura.

Figs. 19, 20. Dorsal and ventral views of a normal adult; showing the obsolescence of plications except upon fold and sinus.
Hamilton group. *Northern Ohio.*

LIORHYNCHUS QUADRICOSTATUS, Vanuxem.

Fig. 21. View of a crushed and somewhat distorted pedicle-valve of large size; showing the character of the plication.

Fig. 22. A small internal cast of the brachial valve in which the lateral plications are obsolete.

PLATE LIX—Continued.

LIORHYNCHUS GLOBULIFORMIS, Vanuxem.

Fig. 23. The exterior of the brachial valve; showing its rotundity, the low, faintly plicated fold and smooth convex lateral slopes.

Hamilton group. *Otsego county, N. Y.*

Fig. 24. The exterior of a pedicle-valve with traces of marginal plications on the sinus.

Fig. 25. An internal cast of a more orbicular shell with stronger median plication.

Black shale (Genesee shales). *Lexington, Indiana.*

Fig. 26. An internal cast of the brachial valve; showing the extent of the median septum and the form of the adductor scars.

Fig. 27. Enlargement of the umbonal portion of an internal cast of the brachial valve; showing the filling of the dental sockets and spondylium, the cavities left by the removal of the hinge-plate and thickened median septum.

Chemung (?) group. *Broome county, N. Y.*

LIORHYNCHUS CASTANEUS, Meek.

Figs. 28, 29. Profile and dorsal views of a well preserved individual; showing the great convexity of the brachial valve, and the exceedingly obscure plication visible only on the median fold.

Lower Devonian. *Eureka District, Nevada.*

LIORHYNCHUS ROBUSTUS, sp. nov.

Figs. 30, 31. Cardinal and ventral views of a very sharply marked internal cast of large size, representing an hitherto undescribed species; showing the muscular impressions of both valves and the vascular sinuses in the pedicle-valve radiating from the impression left by an umbonal testaceous callosity.

Chemung group. *Steuben county, N. Y.*

LIORHYNCHUS KELLOGGI, Hall.

Figs. 32, 33. Dorsal and ventral views of an adult shell with more distinct plication than that represented in figures 19, 20.

Hamilton group *Northern Ohio.*

LIORHYNCHUS LESLEYI, sp. nov.

Figs. 34-36. Dorsal, ventral and profile views of a mature shell; showing the rather obscurely defined fold on the convex brachial valves, the deep sinus of the pedicle-valve, and the unusually complete plication of the lateral slopes.

Upper Devonian. *Pennsylvania.*

LIORHYNCHUS NEWBERRYI, Hall and Whitfield.

Fig. 37. An internal cast of the brachial valve; showing the large size of the shell, low median fold, and fine plication.

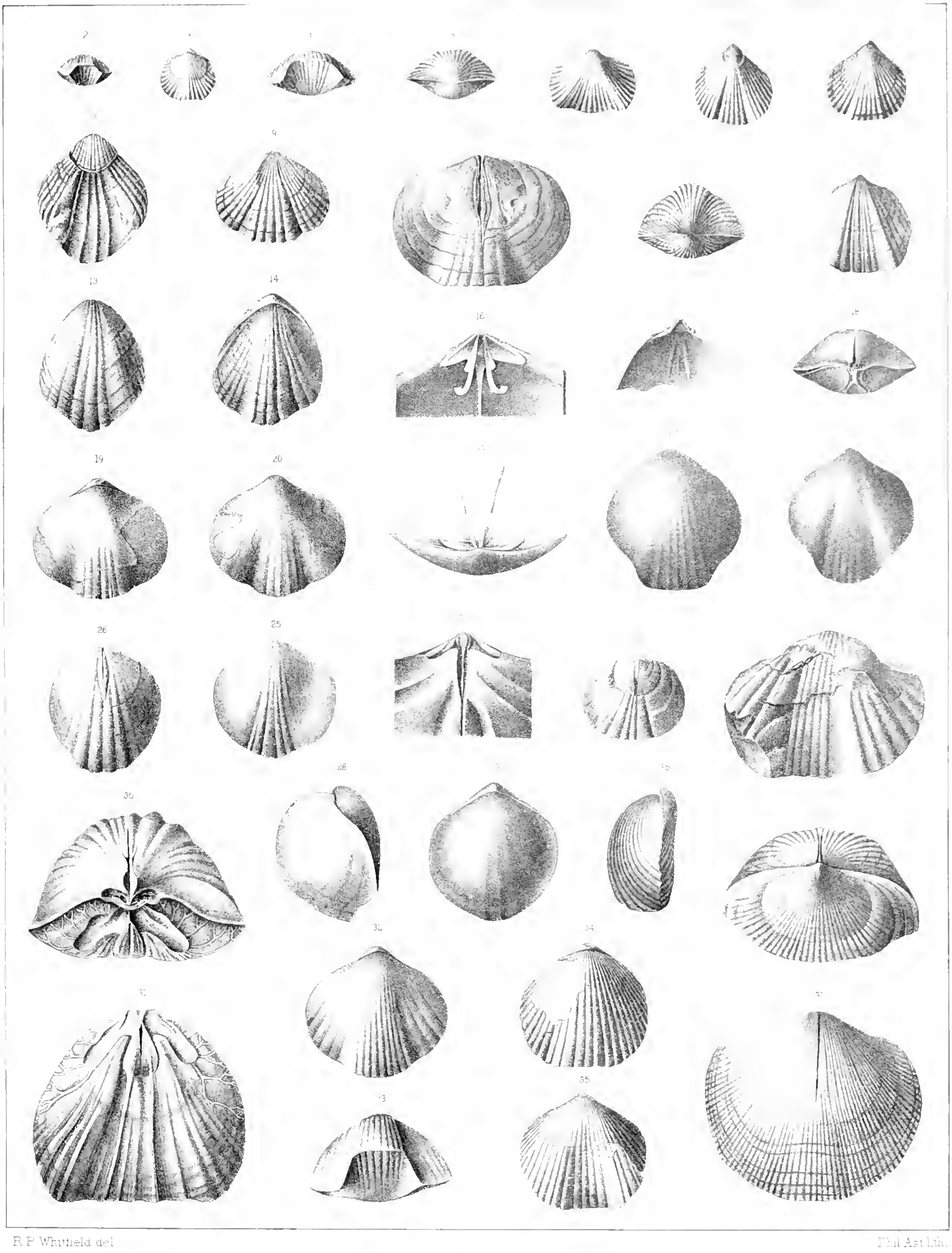
Fig. 38. Cardinal view of an incomplete internal cast of both valves.

Upper Devonian. *Kelloggsville, Ohio.*

BRACHIOPODA.

RHYNCHONELLIDÆ.

Generic Illustrations



R. P. Whitfield del.

Phil. Ast. Lith.

PLATE LX.

(Figures 1–3, 6–10, 13–48, 51, 53, 54 by G. B. Simpson; 4, 5, 11, 12 by E. Emmons; 49, 50, 52, 55 by R. P. Whitfield.)

Subgenus PUGNAX, s.-gen. nov.

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Pugnax altus, Calvin.

Figs. 1–3. Dorsal, profile and frontal views of an average specimen; showing the trihedral form and the character of the plication.

Middle Devonian. *Solon, Iowa.*

Figs. 4, 5. Frontal and profile views of an individual with highly elevated median fold.

Middle Devonian. *Hackberry Grove, Iowa.*

Pugnax pugnus, Martin.

Figs. 6, 7. Dorsal and ventral views of an internal cast; showing the form of the muscular impressions on the two valves.

Figs. 8, 9. Front views of two specimens; showing some difference in the elevation of the median fold and, in figure 9, vascular markings on the sinus of the pedicle-valve.

Fig. 10. A profile view of the specimen represented in figures 6, 7.

Lower Chemung group. *High Point, Naples, N. Y.*

Pugnax eatoniiformis, McChesney.

Figs. 11, 12. Front and profile views of the original specimen; showing the strong but sparsely plicated median fold and sinus and the smooth lateral slopes.

Coal Measures. *Graysville, Illinois.*

Pugnax Grosvenori, Hall.

Fig. 13. Ventral view of an average specimen. × 2.

Fig. 14. Profile of another specimen; showing the subtrihedral form. × 2.

Figs. 15–17. Front views of three individuals; showing differences in the size of median fold and sinus and in the number of plications. × 2.

St. Louis group. *Spergen Hill, Indiana.*

Pugnax mutatus, Hall.

Figs. 18, 19. Dorsal and profile views of an average example.

Fig. 20. The interior of an incomplete pedicle-valve; showing an open delthyrium, small teeth and dental plates.

Fig. 21. A portion of the interior of a brachial valve; showing the divided hinge-plate.

Fig. 22. Front view of the specimen represented in figure 18; showing the width and elevation of the fold.

St. Louis group. *Spergen Hill, Indiana.*

Pugnax Ottumwa, White.

Figs. 23, 24. Dorsal and front views of a normal example; showing the plication about the margins and the elevation of the median fold.

Fig. 25. The interior of a portion of the brachial valve; showing the broadly divided hinge-plate. × 2.

Fig. 26. The interior of an incomplete pedicle-valve; showing teeth and dental plates. × 2.

St. Louis group. *Pella, Iowa.*

Pugnax Swalloviana, Shumard.

Figs. 27–29. Dorsal, profile and front views; showing the contour and character of plication. × 2.

Fig. 30. Profile view of an internal cast; showing vascular sinuses on the brachial valve. × 2.

Figs. 31, 32. Ventral and dorsal views of a smaller shell. × 2.

In all of these the absence of plications over the umbonal regions is a notable feature.

Upper Coal Measures. *Manhattan, Kansas.*

PUGNAX MISSOURIENSIS, Shumard.

Figs. 33, 34. Dorsal and profile views of an average example; showing the lineate striation of the surface.
Choteau limestone. *Pike county, Missouri.*

LIORHYNCHUS (?) BOONENSIS, Shumard.

Fig. 35. Cardinal view of the hinge-plate; showing its median division and the elevation of the crura. × 3.
Choteau limestone. *Cooper county, Missouri.*

PUGNAX GREENIANUS, Ulrich.

Figs. 36–38. Front, profile and dorsal views of an internal cast of an average individual; showing the smooth lateral slopes and faint plication of fold and sinus.
Keokuk group. *New Albany, Indiana.*

PUGNAX UTA, Marcou.

Figs. 39–41. Dorsal, profile and front views of an average adult shell.

Fig. 42. The interior umbonal portion of the brachial valve; showing the broad hinge-plate and narrow median incision. × 3.
Coal Measures. *Manhattan, Kansas.*

PUGNAX EXPLANATUS, McChesney.

Figs. 43–45. Front, dorsal and profile views, drawn from a sulphur cast of the original specimen.
Kaskaskia limestone. *Illinois.*

PUGNAX, sp. ?

Figs. 46–48. Profile, front and dorsal views of an undetermined internal cast. The shell has some points of similarity to the *Rhynchonella Illinoisensis*, Meek and Worthen.
Coal Measures. *Graham county, Texas.*

GENUS HYPOTHYRIS, KING.

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HYPOTHYRIS VENUSTULA, Hall (= RHYNCHONELLA CUBOIDES, Sowerby).

Figs. 49, 50, 52. Cardinal, frontal and profile views of a typical specimen; showing the subcuboidal form, low median fold and broad, deep median sinus.

Fig. 51. Front view of an internal cast with fewer plications, and showing the branches of the vascular trunks on the sinus.

Figs. 53, 54. Internal casts of pedicle-valves; showing the muscular impression, and some variation in the form of the vascular sinuses.

Fig. 55. An internal cast of the pedicle-valve, enlarged to show the system of vascular sinuses. × 2.
Tully limestone. *Ovid, N. Y.*

BRACHIOPODA.

RHYNCHONELLIDÆ.

Generic Illustrations

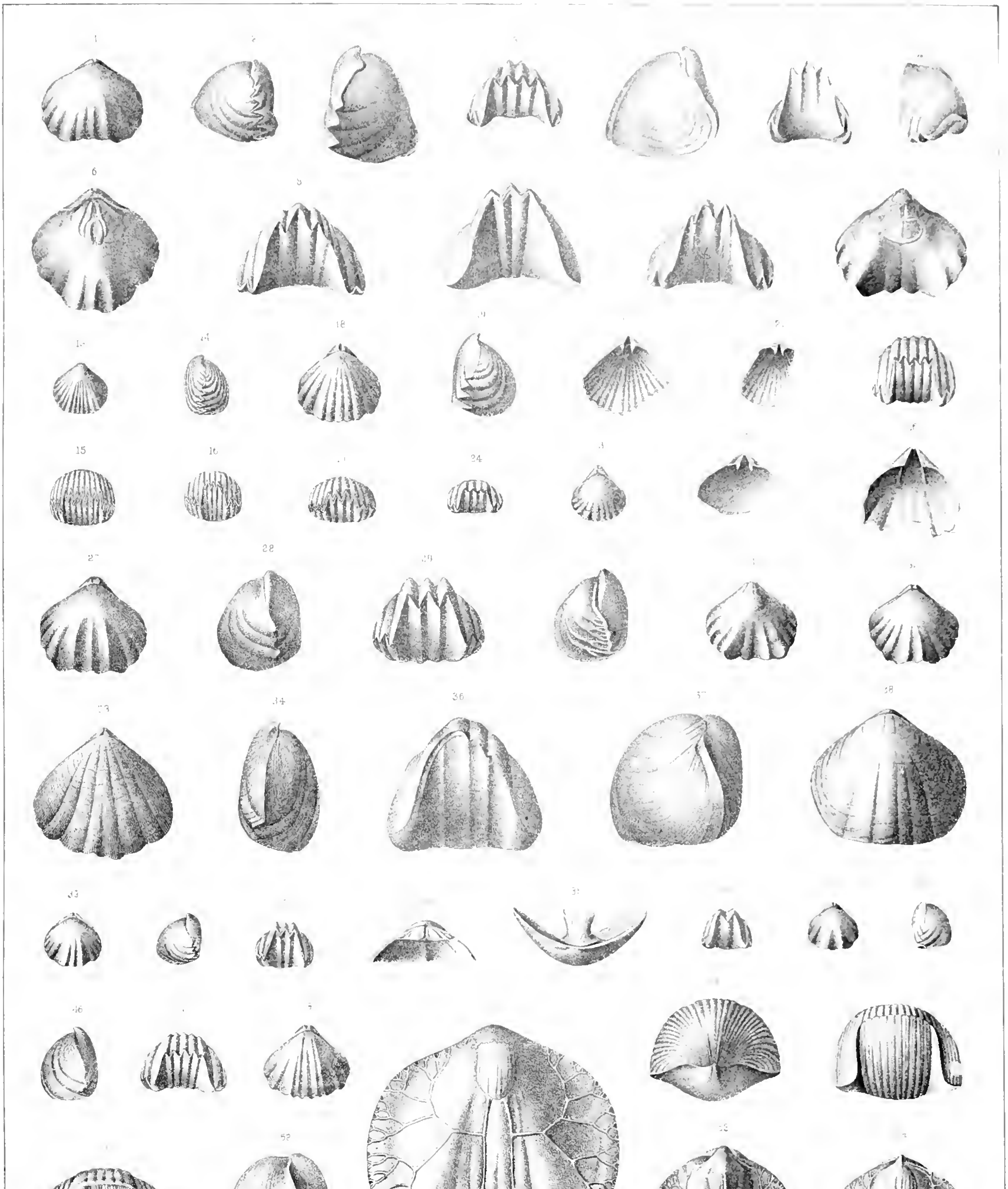

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PLATE LXI.

(Figures 1–10, 20, 23, 27, 28, 32, 37, 38 by G. B. SIMPSON; 11, 12 by R. P. WHITFIELD; 13–19, 21, 22, 25, 26, 29–31, 33–35 by F. B. MEEK; 24, 36 by E. EMMONS.)

GENUS CYCLORHINA, GEN. NOV.

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CYCLORHINA NOBILIS. Hall.

Figs. 1, 2, 4, 5. Ventral, profile, dorsal and cardinal views of a young shell; showing the obtuse umbones, deeply truncated beak of the pedicle-valve, straight cardinal line, and low median fold and sinus.

Fig. 3. The interior of the umbonal portion of the brachial valve; showing the divided hinge-plate and its thickened lateral divisions. × 3.

Figs. 6–9. Profile, cardinal, frontal and ventral views of a mature individual.

Fig. 10. An enlargement of the external surface; showing the fine concentric lines which crenulate upon the crest of each plication. × 3.

Hamilton group. *Thedford, Ontario.*

Fig. 11. The interior of an incomplete pedicle-valve; showing the teeth, and the scars of the pedicle, adductor and diductor muscles.

Fig. 12. A weathered specimen; showing the cavities occupied by the crura.

Hamilton group. *Darien, N. Y.*

GENUS EATONIA, HALL.

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EATONIA SINGULARIS. Vanuxem.

Fig. 13. Ventral view of an unusually large specimen.

Figs. 14–16. Cardinal, frontal and profile views of a normal example.

Lower Helderberg group (Shaly limestone). *Albany county, N. Y.*

EATONIA PECULIARIS. Conrad.

Fig. 17. Dorsal view of an average specimen.

Lower Helderberg group (Shaly limestone). *Albany county, N. Y.*

Fig. 18. The interior of a brachial valve, viewed in profile from the front; showing the elevation of the cardinal process, its lobation and the crura.

Fig. 19. An internal cast of the pedicle valve; showing the impressions of the adductor and diductor muscular scars and pallial sinuses. × 2.

Oriskany sandstone. *Albany county, N. Y.*

Fig. 20. The interior umbonal portion of the brachial valve, enlarged; showing the elongated lobes of the cardinal process, each of which bears a median groove; the divergent crural apophyses are attached to the body of the process beneath these lobes. × 3.

Oriskany sandstone. *Cumberland, Maryland.*

Fig. 21. An internal cast of a brachial valve; showing the impression of the hinge-plate and muscular scars.

Oriskany sandstone. *Albany county, N. Y.*

Fig. 22. Front marginal view of a specimen; showing the development of median fold and sinus and the dentate margins.

Lower Helderberg group (Shaly limestone). *The Helderbergs, N. Y.*

Figs. 23, 24. The interior of brachial valves; showing the variation in form of the cardinal process. Figure 24 represents an old shell in which the process and socket-walls have become thickened and the parts consolidated.

Fig. 25. The interior of a pedicle-valve; showing the open delthyrium, marginal teeth, large diductor scars, small adductors with strongly elevated posterior walls; the dentate shell margins and lingulate extension of the median sinus.

Oriskany sandstone. *Cumberland, Maryland.*

Fig. 26. An internal cast of the pedicle-valve.

Oriskany sandstone. *Albany county, N. Y.*

PLATE LXI—Continued.

Eatonia Whitfieldi, Hall.

Figs. 27, 28. Ventral and dorsal views of a rather small shell; showing the plicated exterior.
Oriskany sandstone. *Cumberland, Maryland.*

Eatonia medialis, Vanuxem.

Figs. 29, 30. Dorsal and profile views of an average example; showing the exterior characters.

Fig. 31. Front view of a large shell; showing the development of the median fold and sinus.

Fig. 32. An oblique view into the umbonal cavity of a specimen in which a small portion of the brachial valve is in articulation with the pedicle-valve; showing the stout cardinal process with the crura arising from its base, and the adductor muscular scars with their elevated posterior wall.

Fig. 33. An internal cast of an old pedicle-valve with unusually large muscular scars.

Fig. 34. Ventral view of the specimen represented in figures 29, 30.

Fig. 35. An internal cast of an average pedicle-valve.
Lower Helderberg group. *Albany and Schoharie counties, N. Y.*

Eatonia sinuata, Hall.

Fig. 36. A brachial valve of average size from which the shell is partially exfoliated, exposing the cast of the cardinal process and showing the adductor scars.

Fig. 37. An enlargement of the cardinal process viewed from in front; showing the short crural bases below, and the stout lobes above. × 3.

Fig. 38. An internal cast of the brachial valve; showing the four scars of the adductor muscles.
Lower Helderberg group (originally cited as Oriskany sandstone). *Cumberland, Md.*

BRACHIOPODA.

RHYNCHONELLIDÆ.

Generic Illustrations

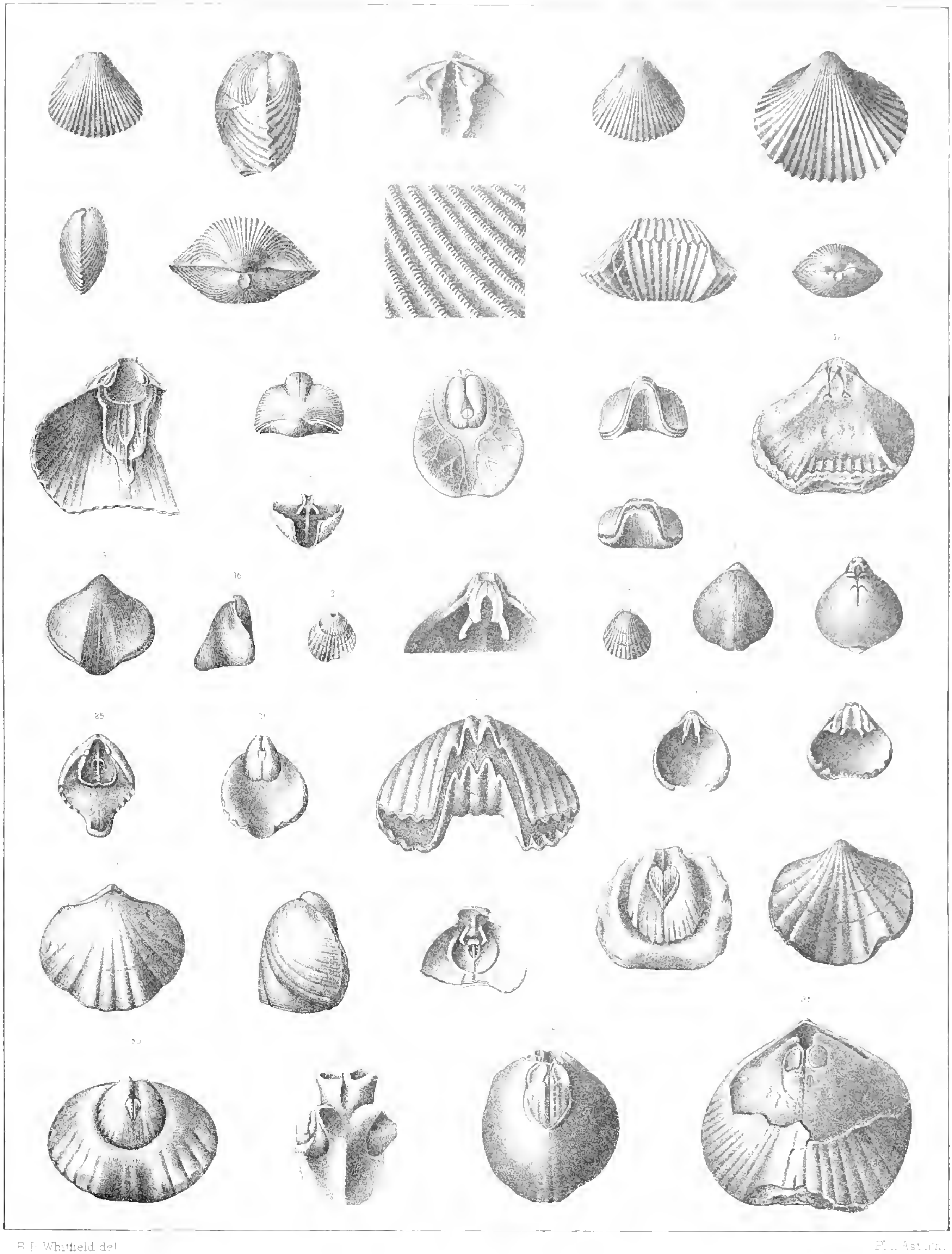

PLATE LXII.

(Figures 1-5, 8-10, 14-16, 21-23, 37-45, 52, 53 by E. EMMONS; 7, 8, 11-13, 17-20, 24-36, 46-51 by G. B. SIMPSON.)

GENUS SYNTROPHIA, GEN. NOV.

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SYNTROPHIA LATERALIS, Whitfield.

Fig. 1. The exterior of a pedicle-valve; showing the long, straight hinge and broad median sinus.

Fig. 2. The exterior of a brachial valve; showing the broad, obscure median fold.

Fig. 3. The exterior of a small pedicle-valve.

Fig. 4. A portion of the interior of the pedicle-valve; showing the cardinal area and spondylium. × 3.

Fig. 5. Cardinal view of conjoined valves which have been transversely sectioned in the umbonal region; showing the spondylium in both valves. The shell has been cut just in front of the supporting septa, the brachial valve being above. × 2.

Fig. 6. Cardinal view of the specimen represented in fig. 1; showing the cardinal area.

Figs. 7, 8. Internal casts of two brachial valves with impressions of vascular sinuses.

Fig. 9. A portion of the interior of the pedicle-valve; showing the complete spondylium and the division of its surface into median (adductor) and lateral (diductor) muscular areas. × 3.

Fig. 10. Oblique view of the specimen represented in fig. 1; showing the elevation of the spondylium and the length of its supporting median septum.

Calciferous formation (Fort Cassin beds). *Fort Cassin, Vermont.*

GENUS CAMARELLA, BILLINGS.

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CAMARELLA VOLBORTHI, Billings.

Figs. 11, 12. Dorsal views of two shells; showing a slight difference in outline and very faint median marginal plication.

Trenton limestone. *Jacksonburgh, N. Y.*

Figs. 13, 14, 15, 16. Profile, dorsal, ventral and front views of a more strongly plicated shell. × 2.

Fig. 17. Cardinal view of conjoined valves which have been transversely sectioned in the umbonal region; showing the spondylium of the pedicle-valve and its median supporting septum. × 4.

Fig. 18. The interior of the umbonal portion of the brachial valve; showing the small apical spondylium and the median septum. × 4.

Black River limestone. *Paquette's Rapids, Ottawa River.*

CAMARELLA PANDERI, Billings.

Figs. 19, 20. Dosral and front views of an average example.

Figs. 21, 22, 23. Dorsal, front and profile views of an individual with no trace of lateral or marginal plications. × 2.

Black River limestone. *Paquette's Rapids, Ottawa River.*

GENUS SYNTROPHIA, GEN. NOV.

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SYNTROPHIA (?) CALCIFERA, Billings.

Fig. 24 The exterior of the pedicle-valve; showing the elevated umbo, deep median sinus and extended hinge-line. × 2.

Quebec group. *Pointe Levis, Canada.*

GENUS CAMAROPHORIA, KING.

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CAMAROPHORIA RHOMBOIDALIS, sp. nov.

Fig. 25. Dorsal view of a specimen of somewhat below the average size.

Fig. 26. Frontal view of a similar specimen enlarged; showing the character of the marginal plication and the development of fold and sinus. × 2.

Figs 27, 28, 29. Dorsal, ventral and front views of an average adult shell, possessing a sharper median fold and sinus, stronger plication, and showing the median septum in each valve through the substance of the shell.

Corniferous limestone. *Peru, Indiana.*

SUBGENUS PUGNAX, S.-GEN. NOV.

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PUGNAX (?) DAWSONIANUS, Davidson.

Fig. 30. Dorsal view of a young shell without plication. × 2.

Figs. 31, 32, 33. Dorsal, profile and front views of a shell with mature characters; showing the marginal plication and the elevation of the beak. × 2.

Carboniferous limestone. *Windsor, Nova Scotia.*

GENUS CAMAROPHORIA, KING.

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CAMAROPHORIA SUBCUNEATA, Hall.

Fig. 34. Dorsal view of a young, but freely plicated shell; showing the shallow valves, subtriangular outline, and long cardinal slopes.

Figs 35, 36. Profile and front views of a mature and gibbous shell, showing the character of the plication and the broad, concave cardinal slopes.

Fig. 37. A portion of the interior of the pedicle-valve, showing the spondylium supported by a median septum. The summits of the teeth have been broken, showing their lateral union with the walls of the shell. × 2.

St. Louis group. *Washington county, Indiana.*

CAMAROPHORIA SUBTRIGONA, Meek and Worthen.

Figs. 38, 39, 40. Cardinal, frontal and ventral views of an internal cast; showing the contour of the shell, the denticulate margin of the valves on the broad cardinal slopes, the sharply serrate anterior and lateral margins and the cavity left by the spondylium and median septum of the pedicle-valve.

Chert of the Burlington limestone. *Burlington, Iowa.*

Figs. 41, 43. Internal casts of pedicle-valves, showing the form of the muscular impression.

Keokuk group. *Nauvoo, Illinois.*

Fig. 42. The umbonal portion of an internal cast of both valves, enlarged, the pedicle-valve being above. This figure shows the cavity of the spondylium, median septum and oblique dental plates of the pedicle-valve; median septum and small umbonal spondylium of the brachial valve. × 3.

Chert of the Burlington limestone. *Pike county, Missouri.*

SUBGENUS PUGNAX, S.-GEN. NOV.

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PUGNAX MISSOURIENSIS, Swallow.

Figs. 44, 45. Cardinal and profile views of an internal cast of a large specimen; showing the contour of the shell, the cavities of the median septum of the brachial valve, the dental plates and the foreshortened outline of the muscular area in the pedicle-valve.

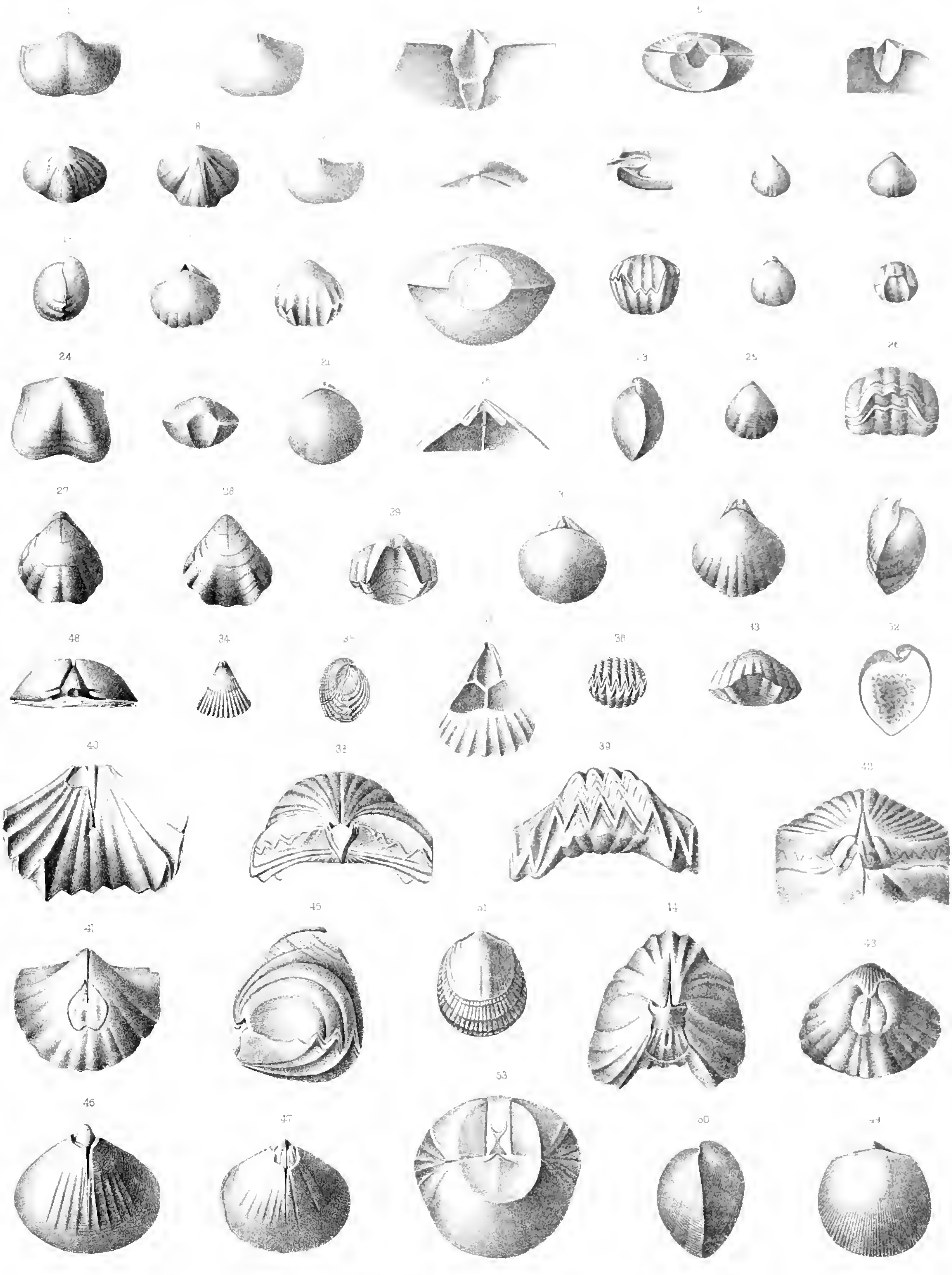
Yellow standstones of the Burlington group. *Burlington, Iowa.*

BRACHIOPODA.

CAMAROPHORIIDÆ.

Generic Illustrations

Palæont. N.Y. Vol. IV ... Vol. VIII   Plate



G. B. Simpson del.

PLATE LXII—Continued

Subgenus CAMAROPHORELLA, s. gen. nov.

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Camarophorella lenticularis, White and Whitfield.

Fig. 46 An internal cast of the pedicle-valve; showing the cavity left by the spondylium and median septum. The external surface of the shell is smooth, the low, radiating ridges shown in this figure and in fig. 47, being impressions of internal sinuses, probably vascular in their nature. × 2.

Fig. 47. An internal cast of the brachial valve; showing the impressions of spondylium and median septum. In this valve the spondylium is flat and the supporting septum penetrates it, extending for a short distance into the interior cavity of the shell. × 2.

Fig. 48. A cardinal view of an internal cast of the pedicle-valve; showing the filling of the spondylium and the cavities left by the median septum and the oblique dental plates. × 2.

Yellow sandstones of the Burlington group. *Burlington, Iowa.*

Genus LYCOPHORIA, Lahusen. 1885.

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Lycophoria nucella, Dalman.

Figs. 49, 50. Dorsal and profile views of a finely plicated, orbicular specimen. In fig. 49, the muscular area is faintly outlined through the substance of the brachial valve.

Fig. 51. The exterior of the brachial valve of a more strongly plicated shell which has been somewhat worn in the umbonal region, disclosing the outline of the elongate muscular area.

Fig. 52 A longitudinal median section of the two valves; showing the thickening of the umbonal region of the brachial valve and the projection of the cardinal process into the umbonal cavity of the pedicle-valve.

Fig. 53. Cardinal view of specimen transversely sectioned in the umbonal region, the pedicle-valve being above; showing the dental plates and erect, bifurcate cardinal process. × 2.

Lower Silurian. *Near St. Petersburg, Russia.*

PLATE LXIII.

(Figures 1-3, 8-16, 21-28, 30, 33-36 by G. B. Simpson; 4-7, 17-20, 29, 37, 44 by E. Emmons, 31, 32 by F. B. Meek; 38-43 by R. P. Whitfield.)

Genus PARASTROPHIA, gen. nov.

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Parastrophia hemiplicata, Hall.

Figs. 1, 3. Dorsal and front views of an average specimen; showing the elevation of the plicated fold.
Fig. 2. Cardinal view of an internal cast; showing the median septa and spondylia of both valves.
Trenton limestone. *Jacksonburgh, N. Y.*

Parastrophia divergens, sp. nov.

Fig. 4. Ventral view of an average specimen, somewhat worn in the umbonal region, exposing the spondylium and supporting septum.
Fig. 5. Front view; showing the elevation of the median fold and the low, sparse plication.
Fig. 6. Dorsal view of the same specimen, which has been so worn at the beak as to expose the convergent walls of the spondylium.
Fig. 7. Cardinal view of a specimen transversely sectioned in the umbonal region; showing the spondylia. In the shallower or pedicle-valve the median septum is very low and scarcely apparent, while in the brachial valve the lateral walls of the spondylium, in this section, rest upon the bottom of the valve. The crural plates arising from this spondylium are also shown. × $1\frac{1}{2}$.
Hudson River group. *Wilmington, Illinois.*

Parastrophia reversa, Billings.

Figs. 8, 9, 10, 14. Ventral, profile, dorsal and cardinal views of the exterior of an average example; showing the relative convexity of the valves and the character of their plication.
Fig. 11. Cardinal view of a specimen which has been transversely sectioned in the umbonal region, the brachial valve being represented below; showing the spondylium of the pedicle valve supported by its median septum, and the septal plates of the brachial valve resting on the bottom of the shell and supporting the crural apophyses.
Figs. 12, 13. Dorsal and ventral views of a smaller specimen; showing the fine concentric lineation of the surface.
Clinton horizon. *Island of Anticosti.*

Parastrophia multiplicata, sp. nov.

Figs. 15, 16. Anterior and profile views of an internal cast; showing the broad, strong plications of which there are four on the median fold and three in the sinus.
Fig. 21. Cardinal view of another individual; showing the casts of the spondylia of the two valves, in the brachial valve the lateral walls having rested upon the inner surface of the shell. The muscular scars of the brachial valve are also retained.
Niagara dolomites. *Near Milwaukee, Wisconsin.*

Parastrophia Greenii, sp. nov.

Figs. 17, 18, 19, 20. Ventral, profile, dorsal and cardinal view of an internal cast; showing the character of the plication of the surface, and the median septum of each valve.
Fig. 22. Cardinal view of another and rather more convex internal cast; showing the cavities left by the median septa.
Niagara dolomites. *Near Milwaukee, Wisconsin.*

Parastrophia latiplicata, sp. nov.

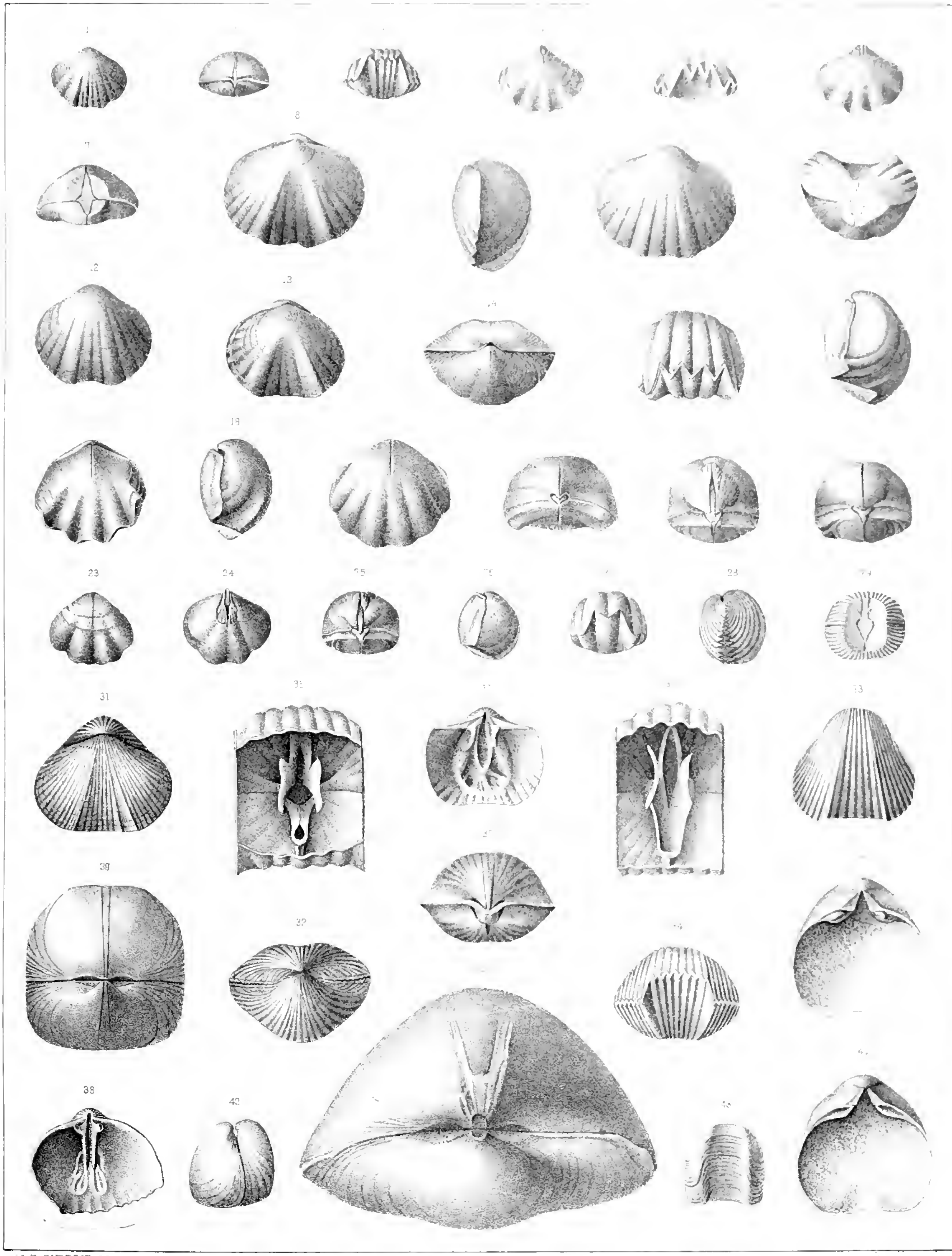
Fig. 23. An internal cast of the brachial valve; showing the few broad plications and the cavity of the median septum.
Fig. 24. An internal cast of the brachial valve in which the filling of the spondylium is exposed and the four scars of the adductor impression distinctly retained.
Figs. 25, 26. Cardinal and profile views of the same specimen.
Fig. 27. Anterior view of a specimen; showing the elevation of the median fold, and the character of the plication.
Niagara dolomites. *Near Milwaukee, Wisconsin.*

The original specimens of this and the two preceding species are from the collection of Thomas A. Greene of Milwaukee.

BRACHIOPODA

ANASTROPHIIDÆ

Generic Illustrations



G B Simpson del.

GENUS ANASTROPHIA, HALL.

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ANASTROPHIA DEFLEXA, Sowerby.

Fig. 28. Profile of a normal adult example; showing the surface plication and the predominant convexity of the brachial valve.

Wenlock limestone. *Wenlock Edge, England.*

Fig. 29. Cardinal view of a specimen which has been transversely sectioned in the umbonal region; showing the supported spondylium of the pedicle (lower) valve, and the septal plates of the brachial valve, bearing the crural apophyses.

Wenlock limestone. *Island of Gotland.*

ANASTROPHIA INTERNASCENS, Hall.

Fig. 30. Cardinal view of an internal cast, represented with the brachial valve above; showing the cavities of the septal and socket plates in the brachial valve, and of the spondylium and its median septum in the pedicle-valve. × 2

Niagara dolomites. *Near Milwaukee, Wisconsin.*

ANASTROPHIA VERNEUILI, Hall.

Figs. 31, 32. Ventral and cardinal views of a large individual; showing the contour and character of the surface plication.

Figs. 33, 34. Dorsal and front views of a somewhat smaller specimen with more regularly and sharply plicated surface.

Fig. 35. An enlargement of the interior of the umbonal region of conjoined valves, the pedicle-valve being represented below. In the brachial valve the convergent septal plates bear lateral bilobed expansions or flanges, which are the crural apophyses as shown in section, in figure 29. In the pedicle-valve the walls of the supported spondylium are folded over each other in such a manner as to form a tubular chamber. This appears to be an abnormal character, as it has been observed in this instance only, but it is nevertheless a natural growth without evidence of break or lesion in the walls of the spondylium. × 2.

Fig. 36. Similar parts in another specimen in which the spondylium is normally open, but the crural apophyses less perfectly retained than in the shell represented in fig. 35. × 2.

Lower Helderberg group. *The Helderbergs, New York.*

Fig. 37. The interior of a portion of the brachial valve; showing the cavity of the sessile spondylium or septal plates and the four scars of the adductor muscles.

Lower Helderberg group. *Perry county, Tennessee.*

Fig. 38. A similar interior with the septal plates and muscular scars more sharply defined; showing also the false foramen produced by the encroachment of the septal cavity or spondylium upon the beak.

Lower Helderberg group. *The Helderbergs, New York.*

GENUS PORAMBONITES, PANDER.

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PORAMBONITES ÆQUIROSTRIS, Schlotheim.

Fig. 39. Cardinal view of a specimen showing the cardinal area on each valve and, by translucence, the double septa of both valves. × 2.

Fig. 40. A portion of the interior of the pedicle-valve; showing cardinal area, delthyrium and teeth.

Fig. 41. A similar view of the brachial valve; showing cardinal area, delthyrial opening and dental sockets.

Figs. 42, 43. Profile and front views of a ventricose shell; showing the relative convexity of the valves and the development of median fold and sinus.

Lower Silurian. *Russia*

PORAMBONITES GIGAS, Schmidt.

Fig. 44. Cardinal view of an average specimen; showing the cardinal area and apical foramen on each valve. By the exfoliation of the shell of the brachial (upper) valve, the bases of the divergent septal plates are exposed.

Lower Silurian (Lykholmer-Schichten). *Estland, Russia.*

PLATE LXIV.

(Figures 1-13 by R. P. Whitfield; 14-16 copies.)

Genus CONCHIDIUM, Linné.

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Conchidium Nysius, Hall and Whitfield.*

See foot-note on page 235.

Figs. 1, 2. Dorsal and profile views of a small, coarsely plicated shell.
Figs. 7, 8. Dorsal and profile views of a large individual.
Niagara group. *Near Louisville, Kentucky.*

Conchidium tenuicosta, Hall and Whitfield.

Figs. 3, 4. Dorsal and cardinal views of an adult specimen, showing the outline, contour and fine plication of the surface.
Fig. 5. Dorsal view of a young individual.
Niagara group. *Near Louisville, Kentucky.*

Conchidium multicostatum, Hall.

Fig. 6. Dorsal view of an internal cast; showing the fine plication about the margins.
Niagara group. *Waukesha, Wisconsin.*

Conchidium Littoni, Hall.

Figs. 9, 10. Dorsal and profile views of an average specimen; showing the abundant plication of the surface and the characteristic breadth of the valves in the umbonal region.
Niagara group. *Hardin county, Tennessee.*

Conchidium Knappi, Hall and Whitfield.

Figs. 11, 12, 13. Profile, dorsal and cardinal views of the original specimen; showing the contour and duplicate plication of the valves.
Niagara group. *Near Louisville, Kentucky.*

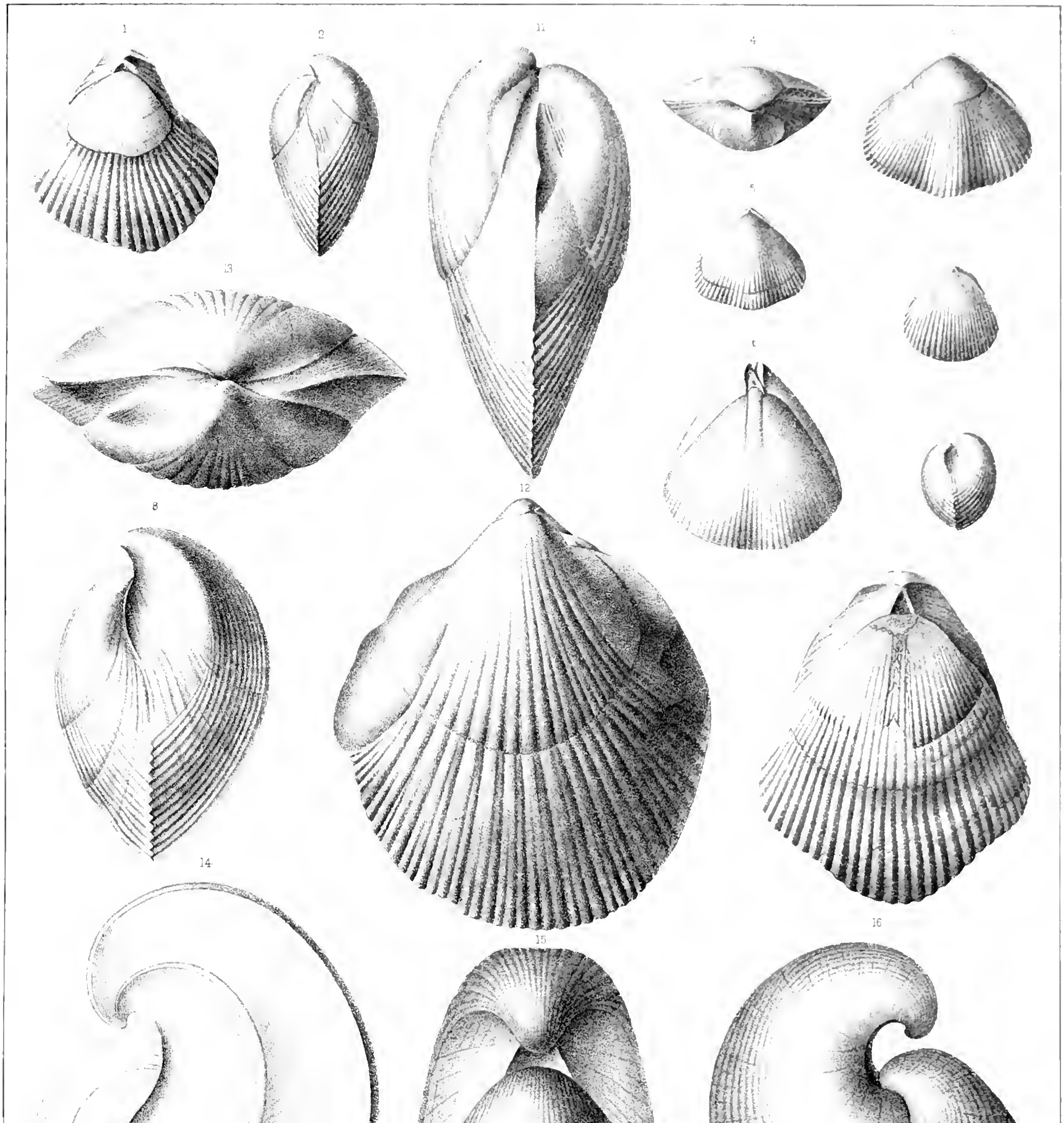
Conchidium Knighti, Sowerby.

Fig. 14. Longitudinal section of the valves; showing the development of the spondylia and median septa. The specimen is so broken as to exhibit the proximal wall of the spondylium of the pedicle-valve and the distal wall of that in the opposite valve.
Amestry limestone. *Near Leintwardine, Shropshire.*

Figs 15, 16. Dorsal and profile views of an average typical example; showing the contour of the species, conspicuous and incurved umbo of the pedicle valve, and the complete plication of the surface.
Amestry limestone. *Aymestry, England.*
(Figures 14-16 after Davidson.)

BRACHIOPODA.

PENTAMERIDÆ.



R.P. Whitfield del. Phil. Ast lith.

PLATE LXV.

(Figures 1-3, 5 by G. B. SIMPSON; 4, 6-9 by E. EMMONS.)

GENUS CONCHIDIUM, LINNÉ.

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CONCHIDIUM DECUSSATUM, Whiteaves.

Fig. 1. Ventral view of a specimen partially exfoliated in the umbonal region; showing the fine, duplicate plication and the delicate concentric lineation of the surface.

Fig. 2. Dorsal view of the umbonal portion of an internal cast; showing the cavity of the spondylium and median septum of the pedicle-valve, and the genital markings about the beak.

Niagara group. *Grand Rapids of the Saskatchewan River, British America.*

CONCHIDIUM LAQUEATUM, Conrad (=PENTAMERUS NOBILIS, Emmons).

Fig. 3. An anterior view of a portion of the interior, looking into the chamber produced by the union of the spondylium and septal plates; showing the curvature of the latter, their explanate upper surfaces, and the foreshortened crural apophyses.

Fig. 5. Another view of the same specimen; showing the spondylium with a portion of the median septum adhering, and the extent of the septal plates and crural processes.

Figs. 4, 6, 9. Dorsal, ventral and profile views of an internal cast of a rather narrow shell; showing the contour, character of the plication and smooth umbonal slopes.

Fig. 7. Longitudinal section of conjoined valves; showing the extent of the median septum of the pedicle-valve quite to the anterior margin of the valve, its concave anterior edge, the projecting extremity of the spondylium, and in the brachial valve, the relatively short spondylium and septa, and the projection of the crural apophyses.

Fig. 8. An internal cast of a brachial valve which retaines the prevailing broader form of the species.

Niagara dolomites. *Delphi, Indiana.*

BRACHIOPODA.

PENTAMERIDA

Generic Illustrations

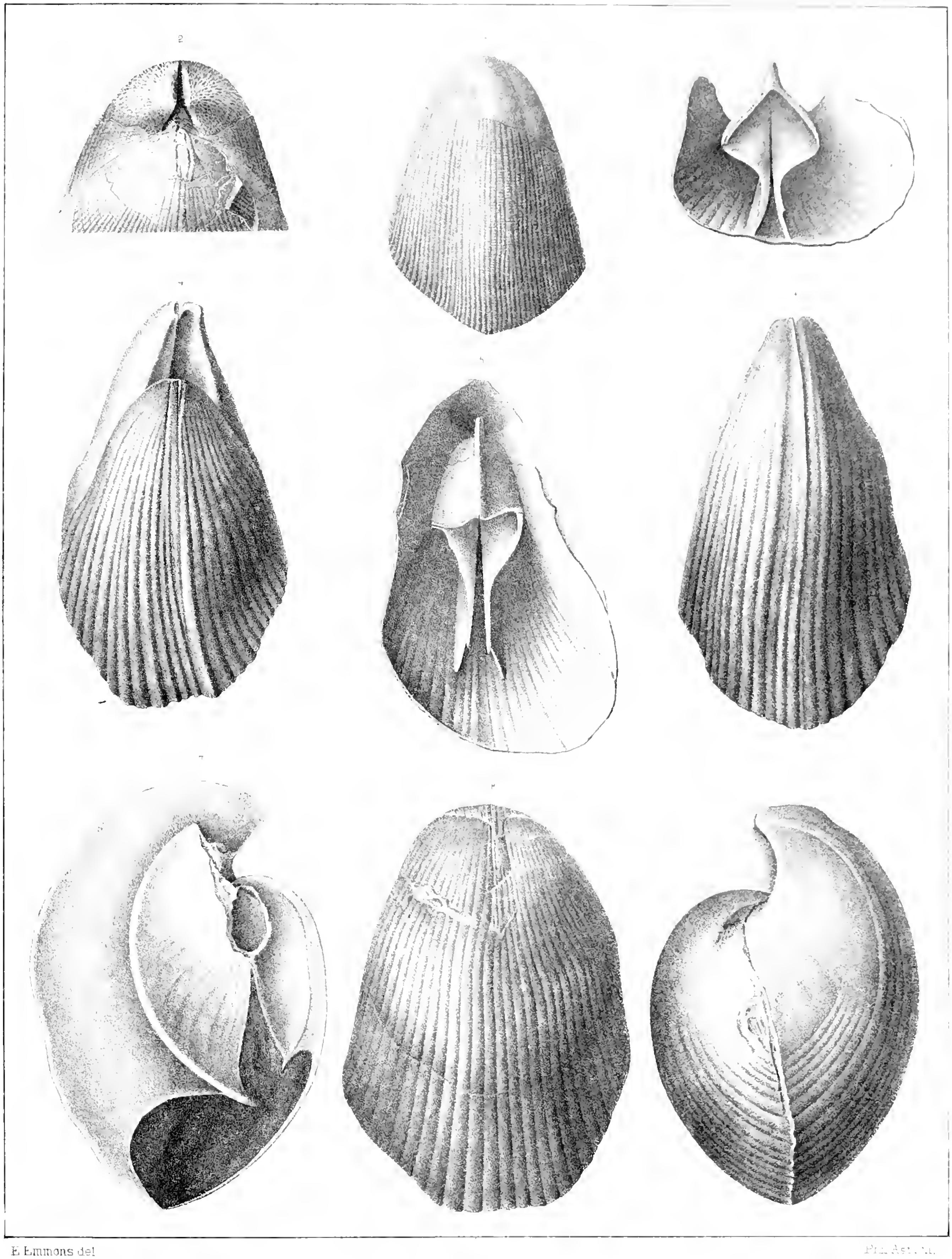

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PLATE LXVI.

(Figures 1–5, 11, 13, 14, 16–19, 23–25 by L. EMMONS; 6, 8, 10 by R. P. WHITFIELD; 7, 9 by F. S. SWINTON; 12, 20–22 by G. B. SIMPSON.)

GENUS CONCHIDIUM, LINNÉ.

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CONCHIDIUM UNGUIFORMIS, Ulrich.

Figs. 1–3. Dorsal, cardinal and ventral views of the original specimen; showing the form of the shell, the character of its plication, its concentric varices and fine growth-lines. The drawings are slightly restored in the umbonal region of the pedicle-valve.

Fig. 4. A lateral view of the same specimen, in which the median septum and spondylium of the pedicle-valve are exposed.

Niagara group. *Near Louisville, Kentucky.*

CONCHIDIUM, sp. indet.

Fig. 5. An internal cast of a small pedicle-valve, with a coarsely plicated surface; showing the apical portion of the filling of the spondylium and a somewhat distorted median septum.

Niagara dolomites. *Near Milwaukee, Wisconsin.*

CONCHIDIUM EXPONENS, sp. nov.

Figs. 6–9. Interiors of pedicle (figs. 6, 7) and brachial (figs. 8, 9) valves of a strongly costate shell; showing the structure of the interior.

Niagara group (Halysites bed). *Louisville, Kentucky.*

CONCHIDIUM MULTICOSTATUM, Hall.

See Plate 64.

Fig. 10. A profile of the original specimen, an internal cast

Niagara dolomites. *Wauwautosa, Wisconsin.*

CONCHIDIUM BILOCULARE, Linné.

Fig. 11. Dorsal view of an average example; showing the form of the shell, character of the surface, and retaining a portion of the deltidium.

Fig. 12. A profile of the same specimen; showing the long, concave and smooth cardinal slopes.

Fig. 13. A natural longitudinal section of conjoined valves; showing the relation of the spondylium and septal plates.

Fig. 14. Ventral view of the same individual; showing the length of the median septum.

Upper Silurian limestone. *Island of Gotland.*

CONCHIDIUM DECUSSATUM, Whiteaves.

See Plate 65, figs. 1, 2.

Fig 15. Dorsal view of a small example; showing the form and exterior characters of the species.

Niagara dolomites. *Rapids of the Saskatchewan River, British America.*

CONCHIDIUM COLLETTI, Miller.

Figs 16, 17. Ventral and profile views of a pedicle-valve; showing the fine plication, frequent imbricating growth-varices, and the expanded anterior margin.

Niagara limestone. *Indiana.*

CONCHIDIUM GEORGIÆ, sp. nov.

Figs. 18, 19. Dorsal and cardinal views of the brachial valve; showing the conspicuous median fold and the plication of the surface.

Clinton group. *Trenton, Georgia.*

CONCHIDIUM GREENII, sp. nov.

Figs. 20-22. Profile, cardinal and ventral views of a specimen somewhat restored about the margins; showing the short, ventricose valves and fine, duplicate plication.

Niagara dolomites *Near Milwaukee, Wisconsin.*

CONCHIDIUM, sp.

Fig. 23. An internal cast of the pedicle-valve of a probably undescribed species; showing the character of the plication and the length of the median septum.

Niagara dolomities. *Hawthorne, Illinois.*

CONCHIDIUM CRASSIPLICA, sp. nov.

Figs. 24, 25. Dorsal and profile views; showing the ovate form of the shell, the subequally convex valves, short and depressed beak of the pedicle valve and the coarse, duplicate plication of the surface.

Niagara group. *Probably from the vicinity of Louisville, Kentucky.*

BRACHIOPODA.

PENTAMERIDÆ

Generic illustrations

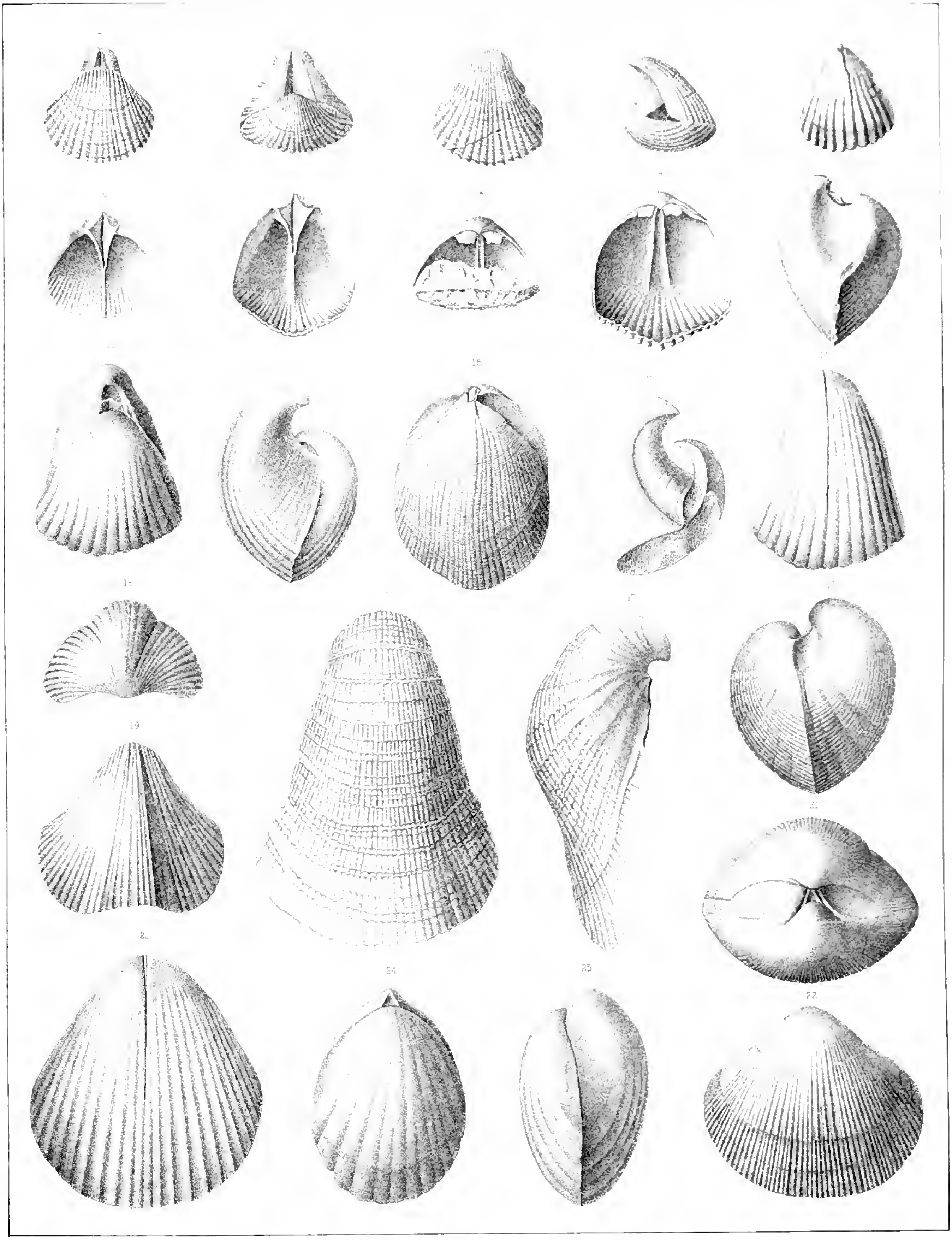

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PLATE LXVII.

(Figures 1, 2, 11-19 by E. Emmons; 3-10, 20 by G. B. Simpson.)

Genus CONCHIDIUM, Linné.

Page 231.

Conchidium (?) occidentalis, Hall.

Figs. 1, 2. Ventral and profile views of a specimen retaining a portion of the shell in a somewhat macerated condition; showing the form of the species and faint traces of plications over the anterior surface.

Fig. 3. A portion of the exterior surface enlarged; showing the irregular lamellose concentric growth lines and the faint radial plications. × 2.

Fig. 4. Profile of the umbonal portion of both valves, that of the pedicle-valve retaining its normal contour and showing its great elevation, conspicuous incurvature and uniform contour.

Fig. 5. Dorsal view of an internal cast of a somewhat distorted example; showing the impressions of the septal plates in the brachial valve.

Guelph dolomites. *Galt, Ontario.*

Conchidium scoparium, sp. nov.

Figs. 6, 7. Dorsal and ventral views of a specimen retaining much of the shell; showing the outline of the species and preserving a very distinct and rather fine radial plication.

Guelph dolomites. *Durham, Ontario.*

Conchidium obsoletum, sp. nov.

Figs. 8, 9. Ventral and dorsal views of an internal cast of a species possessing a few low and broad plications. The figures show the length of the median septum in the pedicle-valve, and the position of the septal plates of the brachial valve, and also the adductor muscular scars of the latter, a feature which is rarely retained with distinctness in this genus.

Niagara dolomites. *Genoa, Ottawa county, Ohio.*

Genus PENTAMERUS, Sowerby.

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Pentamerus pergibbosus, Hall and Whitfield.

Fig. 10. A view looking into the umbonal cavity of conjoined valves; showing the spondylium and its supporting septum below, and the crural processes of the brachial valve above. The spondylium is extremely narrow and deep, having scarcely greater width than the supporting septum.

Niagara dolomites. *Near Chicago, Illinois.*

Fig. 14. Cardinal view of an internal cast of a large individual; showing the relative depth of the valves and the cavities left by the spondylium and septa.

Fig 15. Profile view of a similar internal cast; showing the normal contour of the species.

Niagara dolomites. *Near Milwaukee, Wisconsin.*

Fig. 16. Cardinal view of an internal cast of a small shell, which shows with much distinctness the position and form of the deltidium.

Chert of the Niagara group. *Wisconsin.*

Fig. 17. Profile of a small and gibbous internal cast, having somewhat the form of the *P. oblongus*, var. *Maquoketa* (see figs. 11-13), but less regularly convex.

Figs. 18, 19. Cardinal views of internal casts; showing the variation in the convexity of the valves and the position of the internal apophyses

Niagara dolomites. *Near Milwaukee, Wisconsin.*

PLATE LXVII—Continued.

Pentamerus oblongus, var. Maquoketa, var. nov.

Figs. 11, 12. Dorsal and profile views of an internal cast of a characteristic example; showing the ovoid and regularly convex valves.

Fig. 13. A cardinal view of another individual; showing the position and extent of the internal plates.

Niagara dolomites. *Near Dubuque, Iowa.*

Pentamerus oblongus, Sowerby.

Fig. 20. The interior of the umbonal portion of a silicified shell; showing the spondylium and median septum.

Niagara dolomites. *Hillsboro, Ohio.*

BRACHIOPODA.

PENTAMERIDÆ.

Generic Illustrations

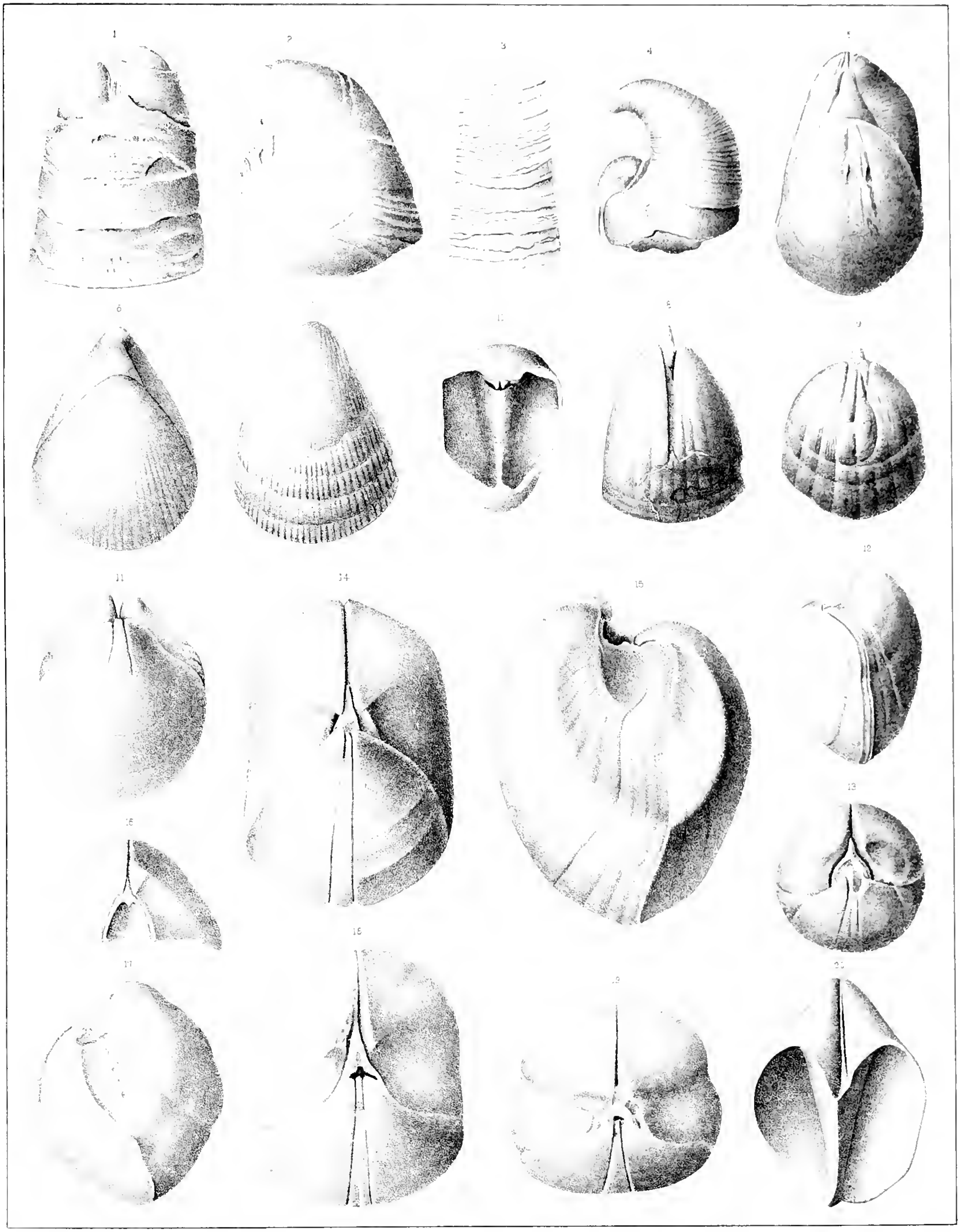

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PLATE LXVIII.

(Figures 1-8 by E. EMMONS.)

GENUS PENTAMERUS, SOWERBY.

Page 236.

PENTAMERUS OBLONGUS, Sowerby.

Figs. 1, 2. Dorsal views of two shells; showing the variation in outline assumed by the species at this locality. Fig. 1 (see also plate lxix, fig. 7) approaches the subquadrate outline of *P. oblongus*, var. *subrectus* (see fig. 6 and plate lxix, figs. 8-10), but has less conspicuous umbones and less convex valves; fig. 2 has a peculiarly triangular outline, which is reproduced with a strongly trilobate anterior margin in the larger specimens from Yellow Springs, Ohio (see figs. 3-5).

Clinton group. *Rochester, New York.*

Fig. 3. Dorsal view of a large, elongate shell, with a broad median lobe.

Fig. 4 Ventral view of another specimen of similar character, the two lateral grooves defining the median and lateral lobes being very strong. The specimen shows the cavity of a very short median septum.

Fig. 5. Dorsal view of a smaller specimen, less distinctly trilobed, but with the umbo of the pedicle-valve very broad, though slightly imperfect at the apex. (Compare in this respect plate lxix, fig. 8.) The lateral undulations on the brachial valve are actually very faint and have been made much too conspicuous in the figure.

Niagara dolomites. *Yellow Springs, Ohio.*

PENTAMERUS OBLONGUS, var. SUBRECTUS, var. nov.

See Plate lxix.

Fig. 6. Dorsal view of a large individual of this variety slightly imperfect at the anterior margin; showing the subquadrate outline, medially convex and broadly lobed valves.

Niagara beds. *Jones county, Iowa.*

PENTAMERUS OBLONGUS, var. CYLINDRICUS, Hall and Whitfield.

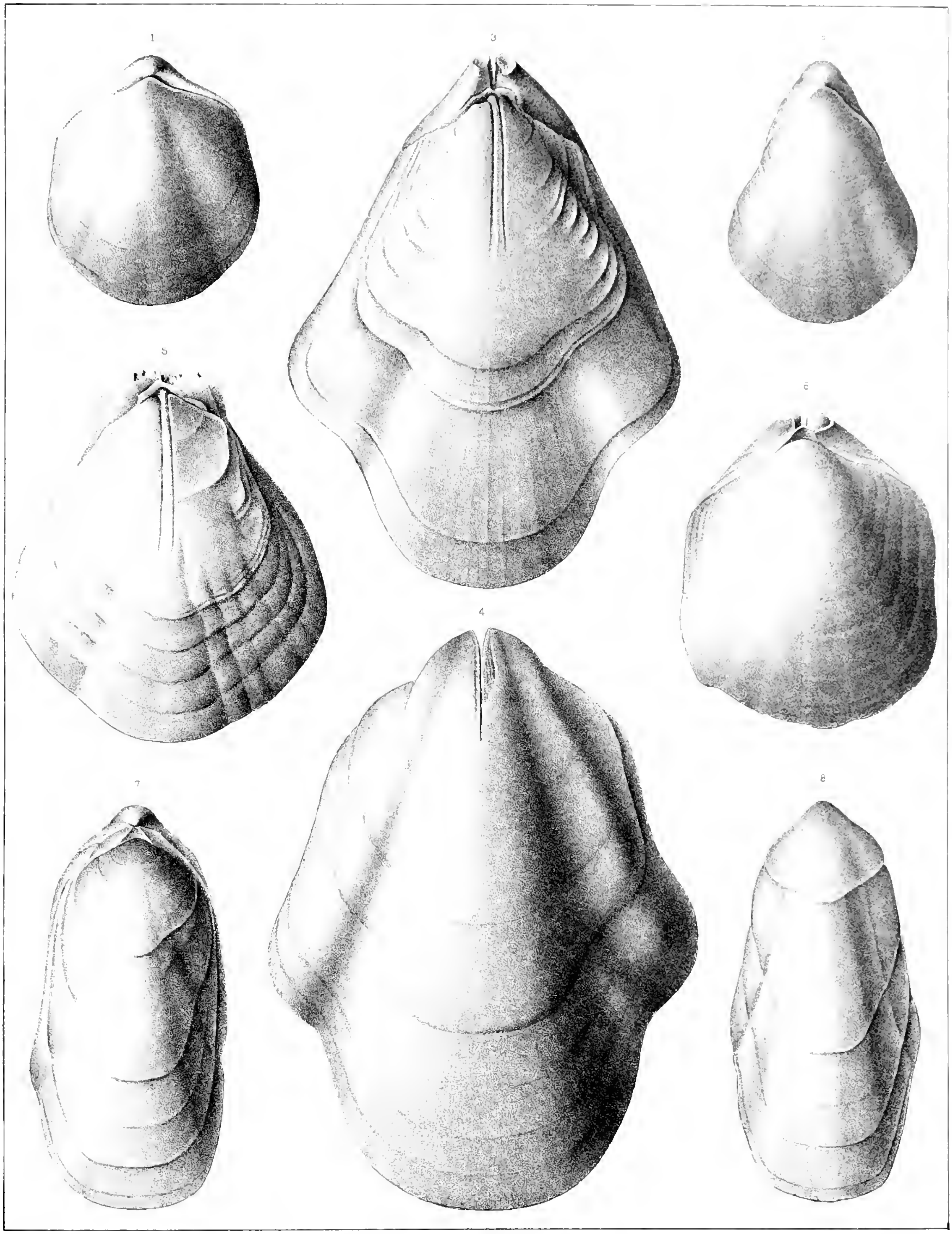
Figs. 7, 8. Dorsal and ventral views of a characteristic example of this variety; showing the extremely elongate-elliptical outline and broadly trilobed exterior.

Niagara dolomites. *Utica, Indiana.*

BRACHIOPODA.

PANTAMERIDA

Generic Illustrations



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Phil Ast lith.

PLATE LXIX.

(Figures 1–10, 13 by G. B. Simpson; 11, 12 by R. P. Whitfield.)

Genus PENTAMERUS, Sowerby.

Page 236.

Pentamerus oblongus, Sowerby.

Fig. 1. Dorsal view of an internal cast of a small shell, broadly trilobed and having a similar outline to young forms of the variety *subrectus* (see figs. 2, 3) though with much shallower valves.
Niagara dolomites. *Richmond, Indiana.*

Pentamerus oblongus, var. subrectus, var. nov.

See Plate 68.

Figs. 2, 3. Dorsal and ventral views of a small specimen of subquadrate outline, trilobed exterior, and showing the single median septum in both valves.

Figs. 8–10. Dorsal, profile and ventral views of a normal mature individual; showing the characteristic subquadrate outline, prominent umbo of the pedicle-valve, trilobate exterior, and linear median depression on both valves.
Niagara beds. *Castle Grove township, Jones county, Iowa.*

Pentamerus oblongus, Sowerby.

Figs. 4, 5. Dorsal and ventral views of a small elongate internal cast in chert, similar in contour and size to a form occurring at Utica, Indiana, in association with the variety *cylindricus*. This shell occurs in the chert of the Maquoketa region near Dubuque, Iowa, but not in immediate association with the var. *subrectus*.
Niagara beds. *Jones county, Iowa.*

Fig. 6. Dorsal view of the umbonal region of an internal cast in chert; showing the cavities left by the septum and septal plates, the deltidium and the lateral divisions of the hinge-plate. × 2.
Niagara beds. *Monmouth, Iowa*

Fig. 7. Ventral view of a subquadrate shell with the lobation of the surface distinctly defined. The dorsal view of this specimen is given upon plate lxviii, fig. 1.
Clinton group. *Rochester, New York.*

Pentamerus oblongus, var. cylindricus, Hall and Whitfield.

Figs. 11, 12. Profile and dorsal views of the original specimen of this variety; showing the elongate form and a faint trilobation of the exterior.
Niagara group. *Near Louisville, Kentucky.*

Pentamerus oblongus, Sowerby.

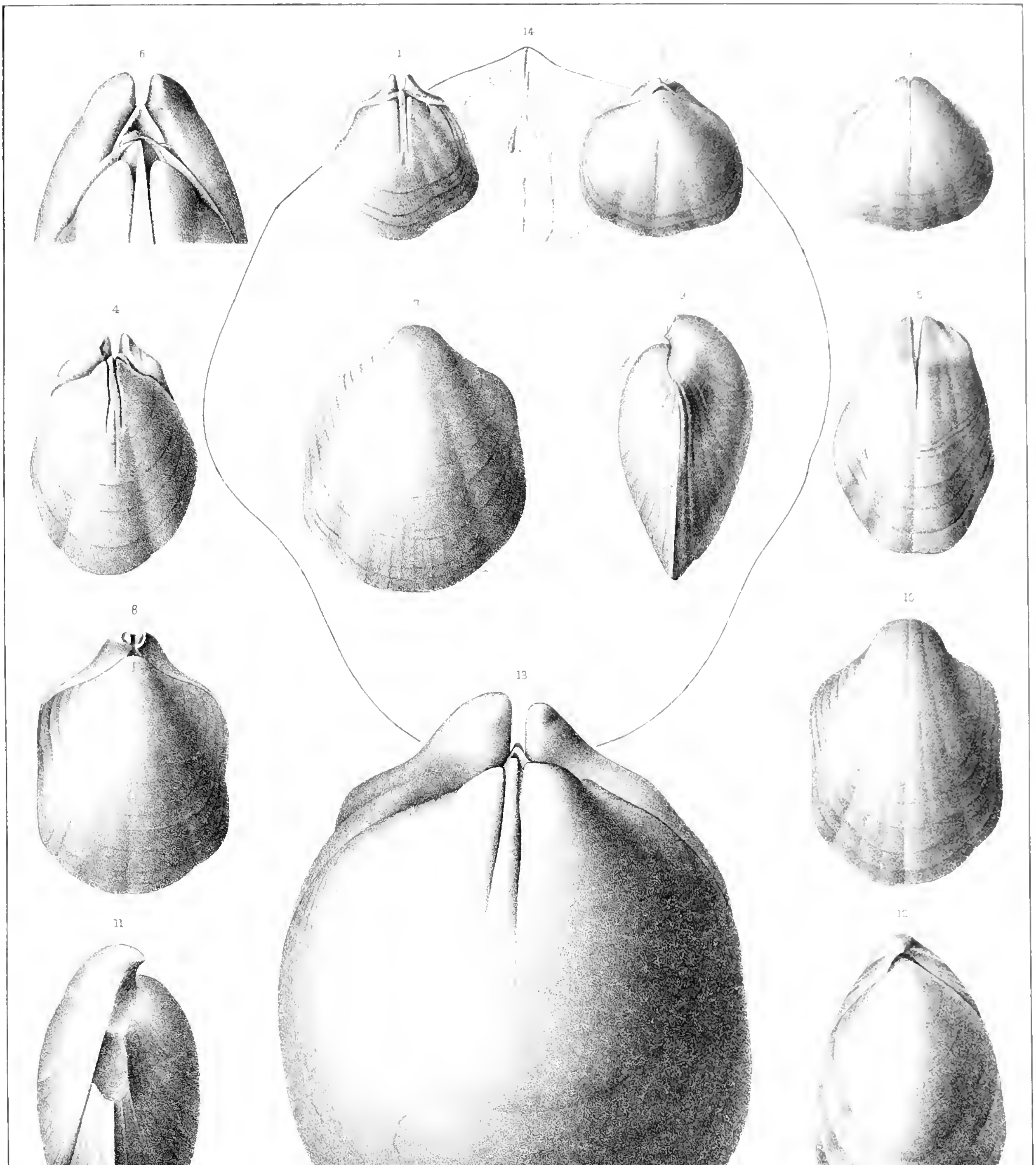
Fig. 13. Dorsal view of an internal cast of a large and evenly convex shell having the ovoid form and regular contour of the var. *Maquoketa* (see plate lxvii, figs. 11–13), which, however, is a persistently smaller form.
Niagara dolomites. *Locality uncertain; probably Northern Indiana.*

Fig. 14. An outline sketch of a large brachial valve having the broadly ovate form and trilobed exterior of the specimens from Yellow Springs, Ohio, represented on plate lxviii, figs. 3–5.
Niagara dolomites. *Probably from the vicinity of Richmond, Indiana.*

BRACHIOPODA.

PENTAMERIDÆ.

Generic Illustrations



E. Emmons del.

Phil. Ast lith.

PLATE LXX.

(Figures 1, 2, 4-14 by E. EMMONS; 3, copy.)

GENUS PENTAMERUS, SOWERBY.

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PENTAMERUS OBLONGUS, Sowerby.

See plates lxviii, lxix.

Fig. 1. Dorsal view of an internal cast of a broadly ovate shell, with evenly convex valves.
Niagara dolomites. *Near Milwaukee, Wisconsin.*

Fig. 2. A natural longitudinal section through both valves; showing the comparatively short median septum and septal plates, the projecting spondylium and crural processes.
Clinton group. *Rochester, New York*

Fig. 3. A copy of the original figure of this species given by MURCHISON in "Silurian System," plate xix, figure 10.

Fig. 4. Dorsal view of a large, elongate-subovate shell, with trilobed surface, broadly shouldered umbones and closely incurved and depressed ventral beak.
Clinton group. *Rochester, New York.*

PENTAMERUS OBLONGUS, var. SUBRECTUS, var. nov.

See plates lxviii, lxix.

Fig. 5. A somewhat weathered specimen in which the valves have been displaced from their normal position, exposing the spondylium of the pedicle-valve, and, by the removal of the rock, also showing a part of the united septal plates of the brachial valve. This spondylioid condition of these plates is a normal feature of this variety.
Niagara beds. *Jones county, Iowa.*

GENUS CAPELLINIA, GEN. NOV.

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CAPELLINIA MIRA, sp. nov.

Figs. 6, 7. Ventral and cardinal views of an average specimen: showing the predominant convexity of the brachial valve, the smooth surface and the position and extent of the internal plates.

Fig. 8. Cardinal view of another example in which the convexity and umbonal incurvature of the brachial valve are still more conspicuously developed.

Fig. 9. Cardinal view of a pedicle-valve; showing the inconspicuous, suberect beak and wide delthyrium.

Fig. 10. Ventral view of the same specimen; showing the length of the median septum.

Fig 11. Profile view of a normal individual; showing the relations of the valves.

Figs. 12, 13. Ventral and profile views of anotner example in which the umbo of the pedicle-valve is abruptly depressed.

Fig. 14. A brachial valve, showing the length of the septal plates and a low radial plication over the umbonal region.
Niagara dolomites. *Near Milwaukee, Wisconsin.*

BRACHIOPODA.

PENTAMERIDA.

Generic Illustrations

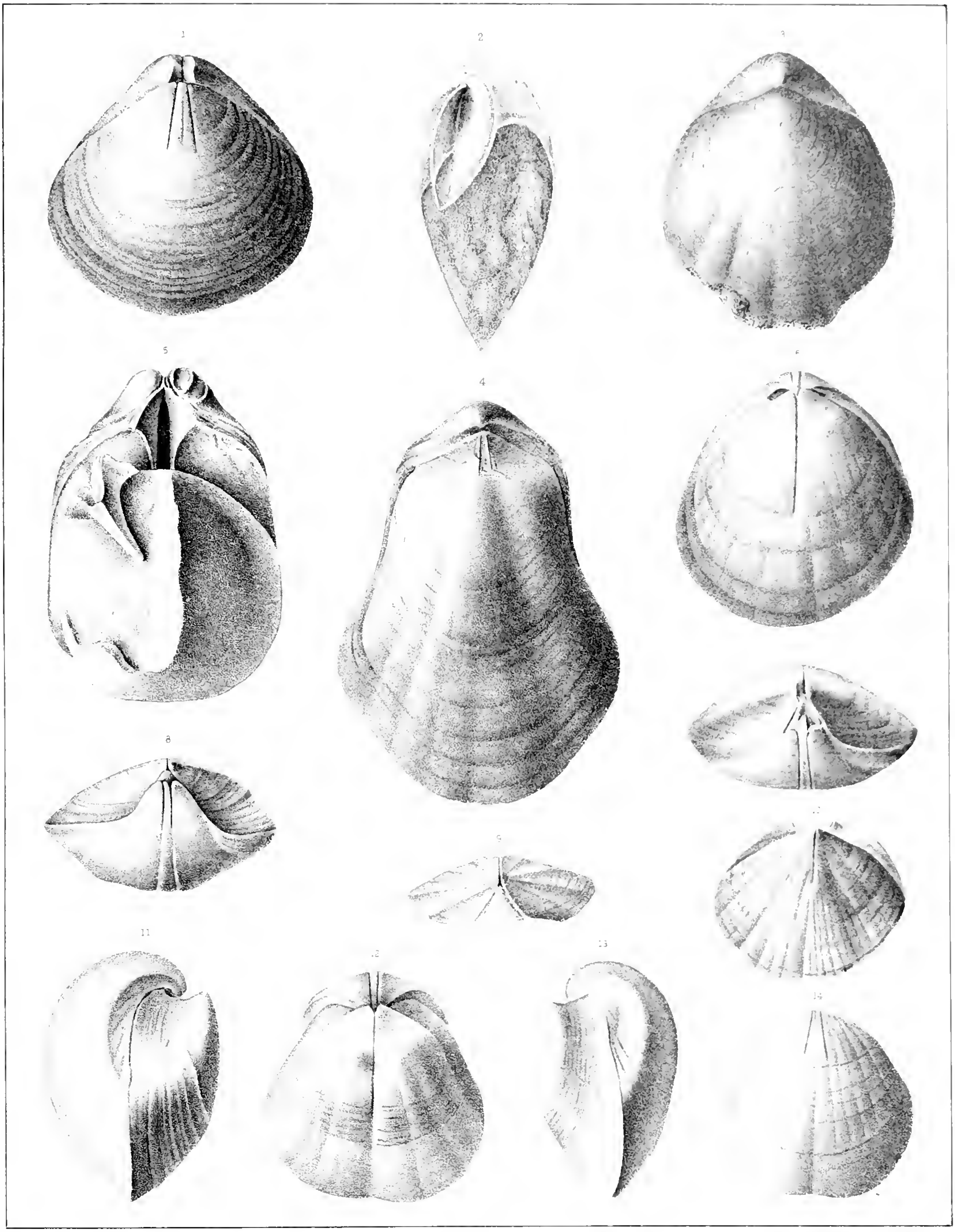

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PLATE LXXI.

(Figures 1-3 copies; 4, 5, 21-33 by R. P. WHITFIELD; 6-10, 11-16, 34-38 by G. B. SIMPSON; 11-13, 17-23 by E. EMMONS).

GENUS BARRANDELLA, GEN. NOV.

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BARRANDELLA LINGUIFERA, Sowerby.

Figs. 1, 2. Dorsal and profile views of a normal individual; showing the character of the exterior and the well defined median fold on the brachial valve.

Fig. 3. A longitudinal median section of the valves; showing the small spondylium and extremely short median septum of the pedicle-valve, and one of the septal plates of the brachial valve.

Wenlock limestone. *Dudley, England.*

(Figures 1-3 after DAVIDSON.)

BARRANDELLA VENTRICOSA, Hall.

Figs. 4, 5. Front and dorsal views of a typical example; showing the fold upon the brachial valve, its faint plication, and the cavities of the median septa.

Niagara dolomites. *Waukesha, Wisconsin.*

Figs. 6, 7. Ventral and profile views of a ventricose specimen with a low sinus on the pedicle-valve.

Figs. 8-10. Dorsal, profile and front views of a smaller individual having the fold and sinus distinctly plicate.

Niagara dolomites. *Near Milwaukee, Wisconsin.*

BARRANDELLA FORNICATA, Hall.

Figs. 11-13. Profile, dorsal and ventral views of the exterior of a specimen of average size; showing the median fold on the brachial valve, the single broad plication in the sinus of the pedicle-valve, and the fainter plication of the lateral slopes.

Clinton group. *Lockport, New York.*

BARRANDELLA AREYI, sp. nov.

Figs. 14-16. Dorsal, profile and ventral views of a normal example; showing the strongly plicated fold and sinus on the brachial and pedicle valves respectively, and the sharp plication of the lateral slopes. × 2.

Clinton group. *Rochester, New York.*

BARRANDELLA BARRANDII, Billings.

Figs. 17, 18. Dorsal and ventral views of a large and typically developed individual; showing the broad plication in the median sinus of the pedicle-valve and the corresponding median groove on the opposite valve; also the finer plication of the medio-lateral region.

Figs. 19, 20. Dorsal and profile views of a smaller and more gibbous specimen.

This species, in its earlier growth stages, is very similar in form and contour to *B. fornicata* (figs. 11-13), but the rapid increase in size of the median plication in the sinus of the pedicle-valve, during the later growth stages of the shell, has the effect of reversing the relative position of fold and sinus in the final condition of growth.

Anticosti group. *Bescie River, Anticosti.*

PLATE LXXI—Continued.

GENUS PENTAMERELLA, HALL.

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PENTAMERELLA ARATA, Conrad.

Figs. 21, 22. Longitudinal profiles of pedicle-valves: showing the spondylium and the variation in the development of the supporting septum.

Fig. 23. The interior of the pedicle-valve viewed from in front; showing the spondylium and its supporting septum and the ovarian markings over the surface of the valve beneath the spondylium.

Corniferous limestone. *Near Junction City, Kentucky.*

Figs. 24-27. Ventral, dorsal, profile and anterior views of a characteristic individual; showing the irregular dichotomous plication of the surface and the development of fold and sinus on brachial and pedicle-valves respectively.

Schoharie grit. *Albany county, New York.*

Fig. 28. An interior of the brachial valve; showing the completed spondylium resting upon the bottom of the valve.

Fig. 29. The interior of an incomplete pedicle-valve; showing the form of the spondylium.

Corniferous limestone. *Waterloo, New York.*

PENTAMERELLA PAVILIONENSIS, Hall.

Fig. 30. Dorsal view of a large individual from which a portion of the brachial valve has been removed exposing the inner surface of the sessile spondylium.

Fig. 31. The exterior of a pedicle-valve; showing the well developed median sinus and the irregular plication.

Hamilton shales. *Canandaigua Lake, New York.*

PENTAMERELLA DUBIA, Hall.

Figs. 32, 33. Cardinal and profile views of the original specimen; showing the form and proportions, and the clearly defined cardinal area of the pedicle-valve.

Hamilton beds. *Near Iowa City, Iowa*

Figs. 34, 35. Dorsal and ventral views of a characteristic specimen from which the shell is partially exfoliated on the pedicle-valve.

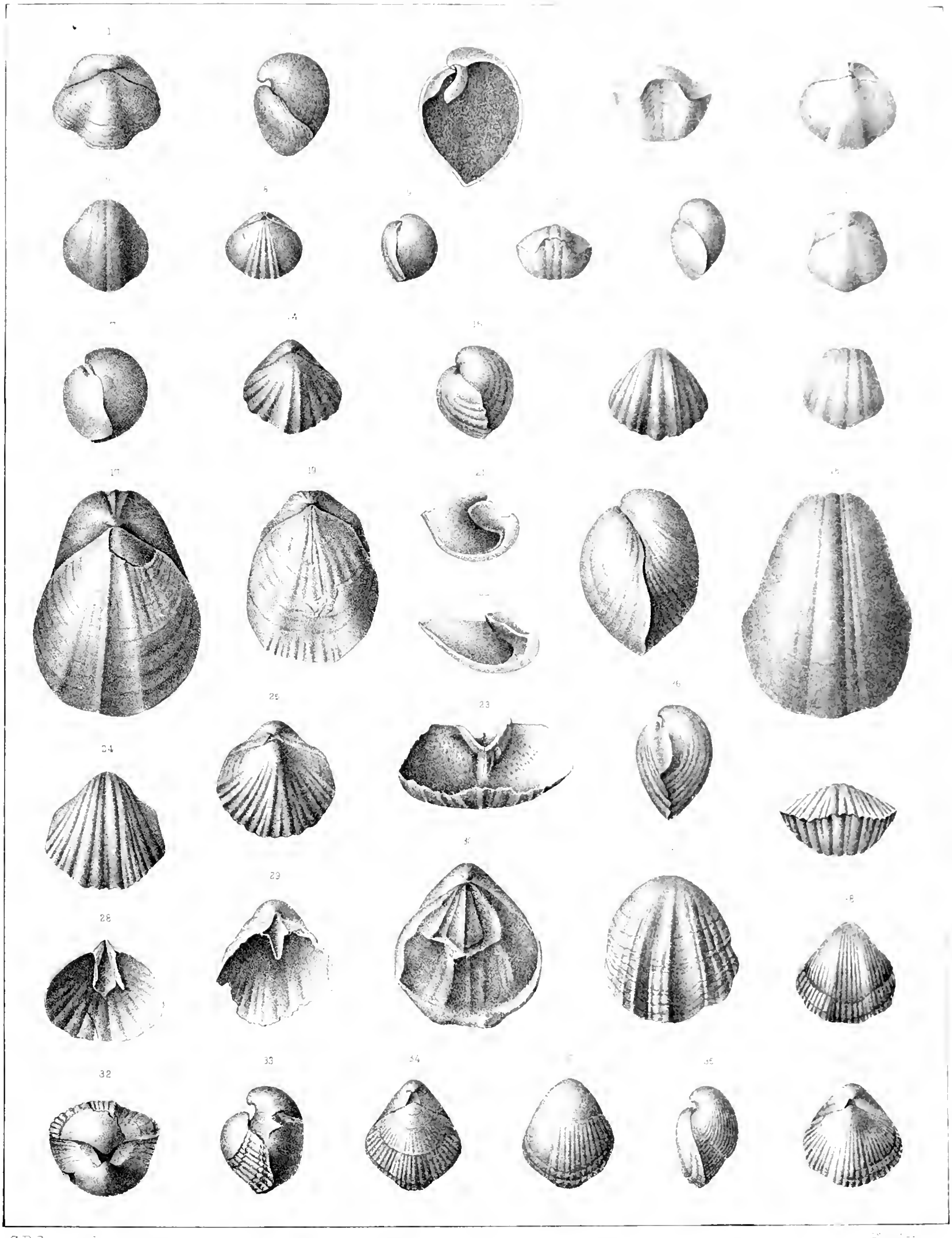
Figs. 36, 37, 38. Profile, dorsal and ventral views of another example having the cardinal area obscurely defined and the surface covered with fine, regular plications.

Hamilton beds. *Littleton, Iowa.*

BRACHIOPODA.

PENTAMERIDA

Generic Illustrations



G. B. Simpson del.

PLATE LXXII.

(Figures 1-3, 18-20, 22, 23 by R. P. Whitfield; 4, 5 copies; 6-9, 21, 27-33 by E. Emmons, 10-14 by F. B. Meek, 15-17, 21, 25, 26 by G. B. Simpson.)

Genus SIEBERELLA, Œhlert.

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Sieberella nucleus, Hall and Whitfield.

Figs. 1-3. Dorsal, profile and front views of the original specimen; showing the form of the shell and the strong plication in the median sinus.

In limestone of the age of the Clinton group. *Near Louisville, Kentucky.*

Sieberella Sieberi, von Buch.

Figs. 4, 5. Dorsal and front views of a typical mature example; showing the strong plication of the surface and the sinus in the brachial valve.

Lower Devonian (Etage F_2). *Koniepras, Bohemia.* (After Barrande.)

Sieberella Roemeri, nom. nov. (*Pentamerus galeatus*, F. Roemer).

Fig. 6. Dorsal view of an individual of rather large size; showing the characteristic plication of the sinus and lateral slopes about the margin, and their obsolescence in the umbonal region.

Upper Silurian. *Perry county, Tennessee.*

Sieberella galeata, Dalman.

Figs. 7, 8. Dorsal and profile views of a well-developed example, with transverse form, highly convex valves, typically developed plicated sinus and obscurely plicated lateral slopes.

Fig. 9. An enlargement of the external surface of the same specimen; showing the fine, irregularly anastomosing concentric raised lines.

Wenlock limestone. *Dudley, England.*

Figs. 10, 11. Profile and dorsal views of an elongate shell with plicated sinus and smooth lateral slopes.

Fig. 12. A view of the interior of conjoined valves; showing the spondylium and its supporting septum, one of the septal plates and its crural process.

Fig. 13. Cardinal view of a large internal cast of both valves; showing the cavities left by the spondylium and septum in the pedicle-valve, and by the septal plates in the brachial valve; also the genital markings in the umbonal region of the pedicle-valve.

Lower Helderberg group. *The Helderbergs, New York.*

Sieberella pseudogaleata, Hall.

Fig. 14. Profile view of a typical specimen; showing the absence of surface plications. The representation of radial lines in the drawing is erroneous.

Lower Helderberg group (Upper Pentamerus limestone). *The Helderbergs, New York.*

Genus GYPIDULA, Hall.

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Gypidula comis, Owen.

Figs. 15-17. Dorsal, ventral and profile views of a normal example; showing the marginal plication of the valves, their convexity and the development of median fold and sinus on pedicle and brachial valves respectively.

Upper Devonian. *Lime Creek, Iowa.*

Figs. 18, 19. Dorsal and cardinal views of a plicated specimen which retains a well defined cardinal area.

Fig. 20. Dorsal view of the umbonal region enlarged; showing the longitudinally striated and sharply delimited cardinal area.

Upper Devonian. *Independence, Iowa.*

Fig. 21. Dorsal view of a somewhat elongate shell, with full, prominent umbo, and destitute of surface plications.

Upper Devonian. *Lime Creek, Iowa.*

Figs. 22, 23. Front and profile views of a more orbicular shell, also without plications. Should the smooth shells, now included under this name, be found to present permanent differences from the plicated forms, they may be termed *Gypidula lævis.*

Upper Devonian. *Independence, Iowa.*

Fig. 24. The interior of the umbonal portion of conjoined valves; showing, above, the free spondylium of the pedicle-valve, and, beneath, the sessile spondylium of the brachial valve.

Silicious beds, probably of the age of the Hamilton group. *Central Indiana.*

Gypidula læviuscula, Hall.

Figs. 25, 26. Dorsal and profile views of an average specimen; showing the smooth, evenly convex valves and the almost complete obsolescence of fold and sinus.

Upper Devonian. *Lime Creek, Iowa.*

Gypidula Romingeri, sp. nov.

Fig. 27. Cardinal view of a pedicle-valve; showing a well defined cardinal area, the teeth and the form of the spondylium.

Fig. 28. Dorsal view of the umbonal region of the specimen represented in fig. 30, enlarged to show the sharply defined cardinal area and the deltidial plates or remnants of the deltidium. × 2.

Fig. 29. The interior of a brachial valve; showing the curved walls of the sessile spondylium.

Fig. 30. Dorsal view of an individual of average size, with an unusually flat brachial valve; showing the cardinal area, plates of the deltidium and coarse, irregularly duplicate plication of the surface.

Figs. 31, 32. Dorsal and profile views of a large specimen with a finer and more regular surface plication, more conspicuous and deeply incurved ventral umbo and clearly defined sinus on the brachial valve. The shell is largely exfoliated over the brachial valve, exposing the broken base of the spondylium and the genital markings about it on the surface of the cast.

Fig. 33. The interior of a large brachial valve; showing the form and extent of the spondylium.

Hamilton group. *Near Alpena, Michigan.*

BRACHIOPODA.

PENTAMERIDA.

Generic Illustrations

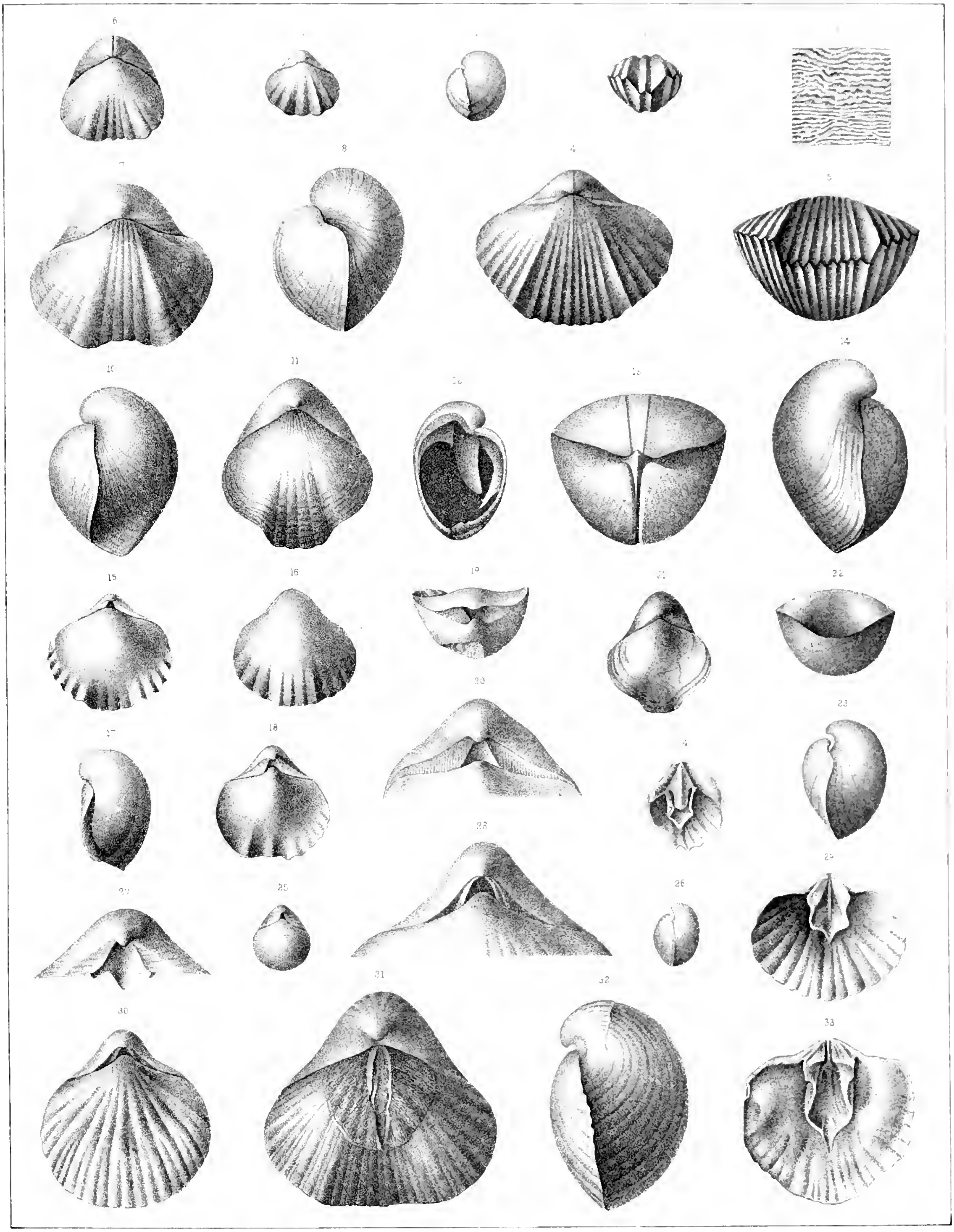

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PLATE LXXIII.

(Figures 1-10, 14-19 by E. Emmons; 11 by G. B. Simpson; 12, 13, 20 by R. P. Whitfield.)

Genus STRICKLANDINIA, Billings.

Page 219.

Stricklandinia multilirata, Whitfield.

Figs. 1, 2. Ventral and dorsal views of an internal silicious cast. The figures show the short, straight hinge, the sharp delimitation of the cardinal region and the orbicular outline of the valves. In figure 1 is seen the low median groove and the apex of the filling of the spondylium; figure 2 shows the median fold of the brachial valve and the cast of the small but prominent muscular scar.

Niagara dolomites. *Near Milwaukee, Michigan.*

Stricklandinia castellana, White.

Figs. 3-6. Dorsal, profile, cardinal and ventral views of a characteristic specimen; showing the nearly equiconvex valves, the strong, irregularly fasciculate or duplicate plication, and, in fig. 5, the cavities left by the spondylium and low median septum of the pedicle-valve.

Fig. 7. Cardinal view of a partial internal cast, the pedicle-valve being represented beneath; showing the position of the spondylium and its supporting septum and the casts of the muscular impressions on the brachial valve.

Niagara group. *Jones county, Iowa.*

Stricklandinia deformis, Meek and Worthen.

Figs. 8, 9. Profile and cardinal views of an internal cast; showing the delimitation of the cardinal area of the pedicle-valve and the filling of the spondylium.

Fig. 10. Dorsal view of the umbonal portion of a specimen, to show the short, straight hinge-line and the subauriculate cardinal extremities.

Niagara group. *St. Charles, Illinois.*

Stricklandinia Gaspensis, Billings.

Fig. 11. Dorsal view of a large individual, drawn from a plaster cast of the original specimen; showing the form of the shell, a portion of the cardinal area and the abundant plication of the surface.

Upper Silurian. *Gaspé, Nova Scotia.*

Stricklandinia Anticostiensis, Billings.

Fig. 12. The interior of the umbonal portion of a brachial valve; showing the short, convergent crural plates and the low median muscular ridge in the bottom of the valve.

Fig. 13. A view looking into the umbonal cavity of the pedicle-valve; showing the spondylium and its supporting septum.

Fig. 14. The interior of a pedicle-valve, distorted by natural growth, and showing a sharply defined cardinal area, delthyrium and spondylium.

Stricklandinia Davidsoni, Billings.

Fig. 15. Dorsal view of an average example; showing its trilobed, medially elongate form.

Anticosti group. *Anticosti.*

PLATE LXXIII—Continued

GENUS AMPHIGENIA, HALL.

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See Plate 74

AMPHIGENIA ELONGATA, Vanuxem.

Fig. 16. Ventral view of a cast of the interior of the pedicle-valve; showing the filling of the spondylium and the cavity of the short median septum.

Schoharie grit. *Schoharie, New York.*

Fig. 17. The interior of the umbonal portion of a brachial valve; showing the structure of the hinge-plate, its apical perforation, and the crura with their jugal processes.

Fig. 18. Profile view of the same specimen somewhat enlarged to show the direction and extent of the crura, jugal apophyses and crural plates.

Fig. 19. The interior of the umbonal portion of the pedicle-valve; showing the teeth and the entire spondylium.

Corniferous limestone. *Le Roy, New York.*

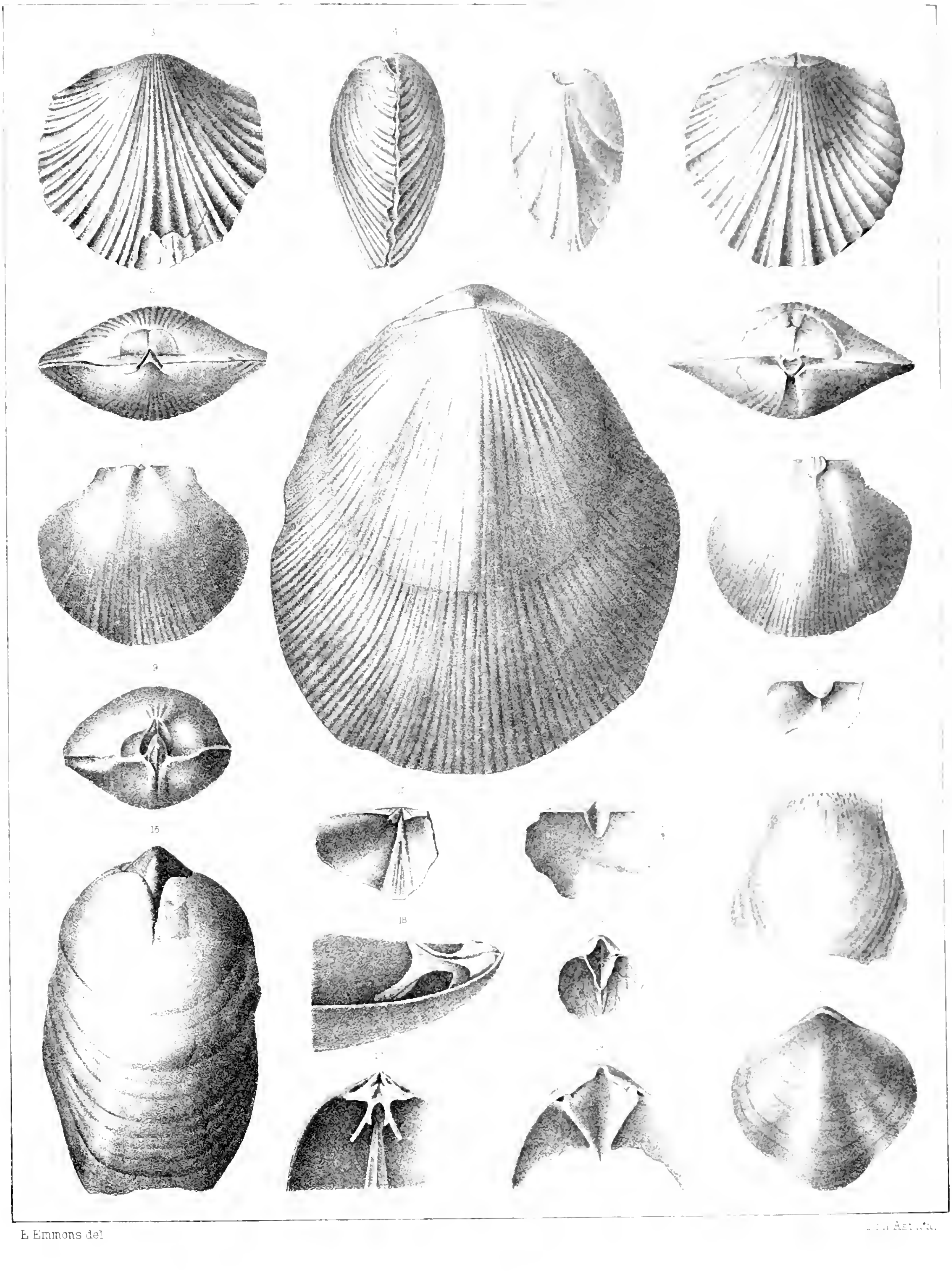
Fig. 20. The interior of the umbonal portion of a pedicle-valve; showing vascular sinuses on the surface of the valve beneath the spondylium.

Corniferous limestone. *From the drift of Southern Michigan.*

B R A C H I O P O D A

PENTAMERIDA

Generic Illustrations



E Emmons del

PLATE LXXIV.

(Figures 1-9 by R. P. WHITFIELD.)

GENUS AMPHIGENIA, HALL.

Page 252.

See Plate 73

AMPHIGENIA ELONGATA, Vanuxem.

Fig. 1. Dorsal view of a partial cast; showing the muscular impressions and vascular sinuses of the brachial valve, and the cavity left by the medially divided hinge-plate.

Corniferous limestone. *Clarence, New York.*

Fig. 2. Cardinal view of an internal cast: showing the filling of the spondylium and of the visceral foramen, and the cavities left by the median septum and hinge-plate.

Fig. 3. Median longitudinal section of both valves; showing the degree of development of the spondylium, median septum, and septal plates; also the great thickness of the shell in the umbonal region of the brachial valve and the length of the crura, with their convex terminal expansion.

Corniferous limestone. *Le Roy, New York.*

Fig. 4. Dorsal view of an individual of medium size with regularly elliptical form and finely striated surface.

Fig. 5. An internal cast of the umbonal portion of the brachial valve; showing the septal plates, the four sharply defined scars of the adductor muscles, the vascular sinuses and genital markings.

Corniferous limestone. *Western New York.*

Fig. 6. The exterior of a brachial valve having the characteristic subovate outline.

Figs. 7, 9. Dorsal and profile views of a shell of full medium size with gibbous valves and finely striated surface.

Corniferous limestone. *Cayuga, Ontario.*

Fig. 8. Internal cast of a large brachial valve; showing the muscular impression and the cavity left by the removal of the hinge-plate.

Corniferous limestone. *Le Roy, New York.*

BRACHIOPODA.

AMPHIGENIIDÆ.

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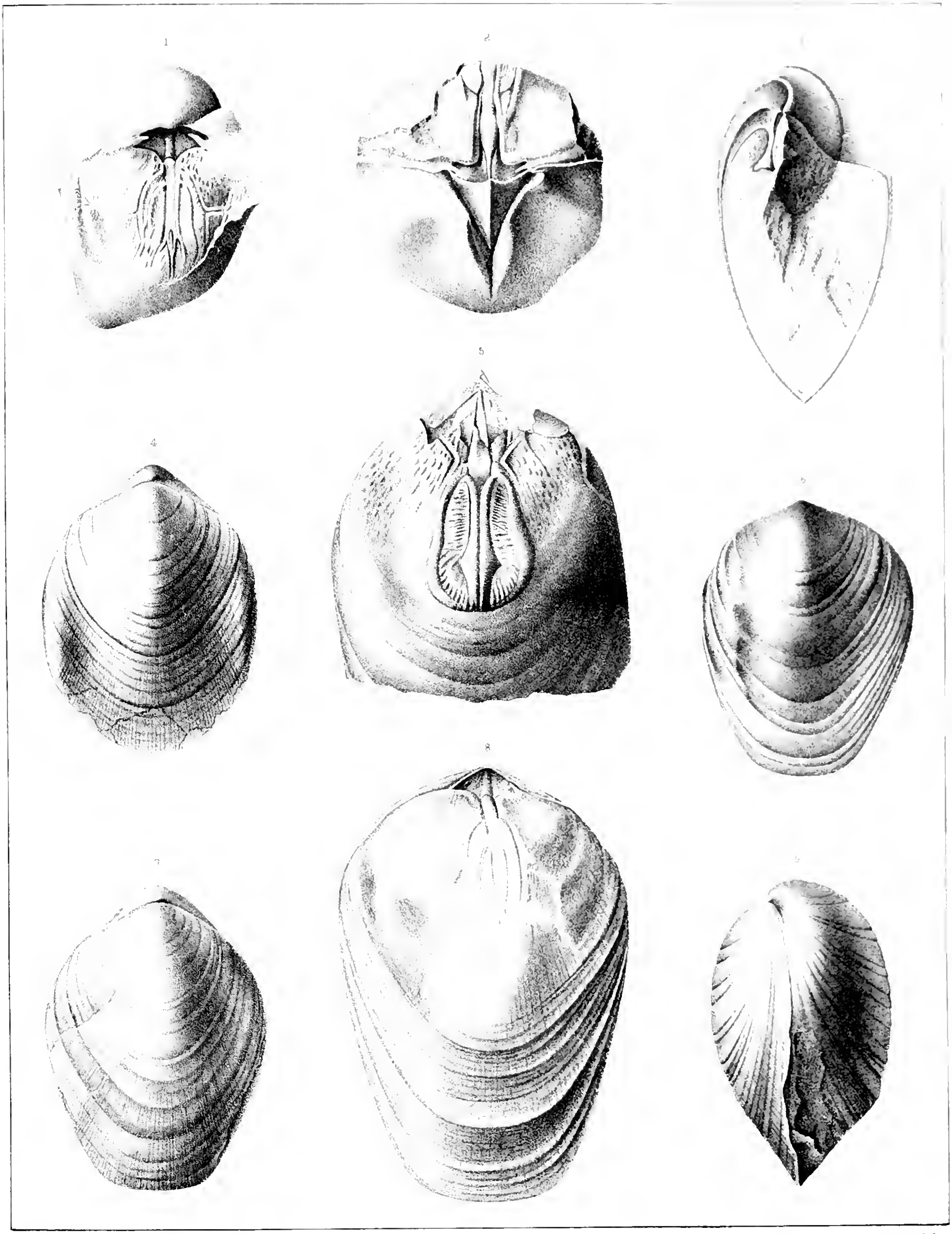

R. P. Whitfield del. | Phil. Ast lith.

PLATE LXXV.

(Figures 1-6 by G. B. SIMPSON; 7, 9 by F. B MEEK; 9 by E. EMMONS.)

GENUS RENSSELÆRIA, HALL.

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RENSSELÆRIA CAYUGA, sp. nov.

Figs. 1, 2. Dorsal and ventral views of a specimen which retains most of the shell; showing the fine surface plication and the lenticular form of the valves.
Oriskany sandstone. *Cayuga, Ontario.*

RENSSELÆRIA OVULUM, sp. nov.

Fig. 3. An internal cast of the brachial valve; showing the muscular scars, the large cavity left by the hinge-plate, and the genital markings in the umbonal region

Fig. 4. An internal cast of the pedicle-valve; showing the filling of the deep muscular cavity and its division by the diductor and adductor scars, and the cavities left by the teeth. This species differs from the foregoing in i s persistently greater size, much more convex valves, and coarser plication of the surface. It is a more orbicular and more regularly convex shell than *R. ovoides.*
Oriskany sandstone. *Cayuga, Ontario.*

RENLSELÆRIA OVOIDES, Eaton.

Fig. 5. An internal cast of the brachial valve; showing the cavity of the hinge-plate, the branching vascular sinuses in the umbonal region and the anterior and posterior divisions of the adductor muscular impression, the surface of the posterior scars being strongly marked with ramifying lines. The structure and arrangement of all of these parts is strikingly similar to that occurring in *Amphigenia* (see plate lxxiv, fig 5).
Oriskany sandstone. *Schoharie, New York.*

Fig. 6. An internal cast of a pedicle-valve having a regularly oval outline, and showing the filling of the muscular impression and the cavities left by the teeth.
Oriskany sandstone. *Springport, Cayuga county, New York.*

Fig. 7. The exterior of a pedicle-valve, having the characteristic inflexion of the lateral margins anteriorly, and showing the fine surface plication.

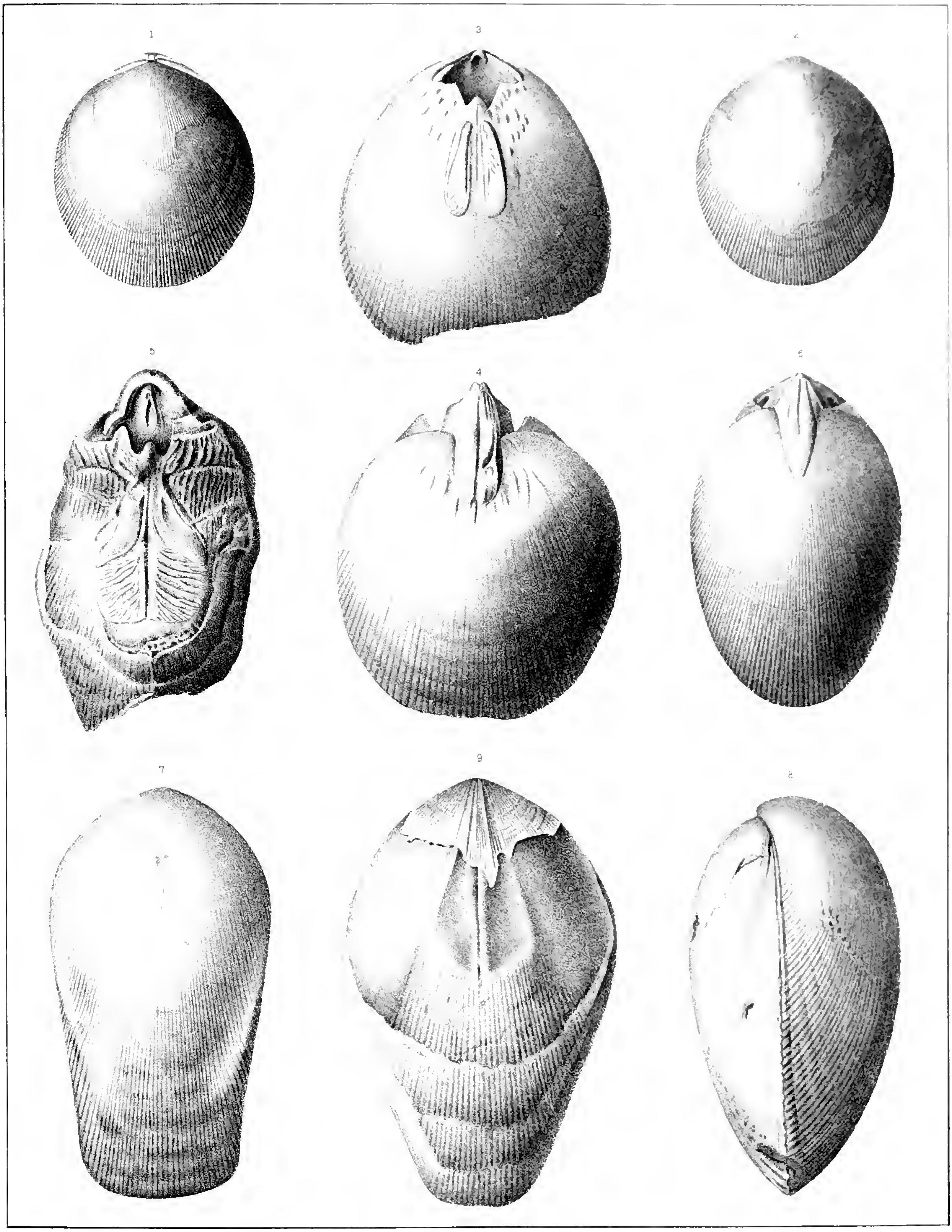
Fig. 8. Profile of conjoined valves; showing the usual convexity of the species. The shell of the brachial valve has been exfoliated, losing its surface plication.
Oriskany sandstone. *The Helderbergs, New York.*

Fig. 9. A brachial valve which is broadly flattened in the umbonal region and greatly narrowed anteriorly. The shell has been lost except about the umbo, exposing a portion of the muscular sears.
Oriskany sandstone. *Knox, New York.*

BRACHIOPODA.

RENSSELAERIDÆ.

Generic Illustrations



G. B. Simpson del.

Phil. Ast lith.

PLATE LXXVI.

(Figures 1-3a, 9, 21-24 by R. P. Whitfield, 4-7, 20 by E. Emmons, 8, 11-15, 17, 25-28 by F. B. Meek, 10, 16, 18, 19 by G. B. Simpson.)

Genus RENSSELÆRIA, Hall.

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Rensselæria mutabilis, Hall.

Figs. 1, 2. Dorsal and profile views of a rather large and somewhat elongate shell.

Fig. 3. An outline sketch showing the loop and its relative length.

Fig. 3a. The loop enlarged to show its form in more detail, the elongate triangular expansion formed by the union of the descending lamellæ, and the median ridge along the line of coalescence of these parts, produced upwardly and posteriorly into a free extremity.

Lower Helderberg group. *Becraft's Mountain, Columbia county, New York.*

Genus TRIGERIA, Bayle.

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Trigeria Portlandica, Billings.

Figs. 4, 5. Dorsal and ventral views of the original specimen of *Rensselaeria Portlandica*, Billings, which is tentatively referred to the Genus Trigeria.

Lower Helderberg group. *Square Lake, Maine.*

Trigeria Gaudryi, Œhlert.

Figs. 6, 7. Dorsal and profile views of an internal cast, provisionally referred to this species; showing the form of the shell, the fine and simple plication of the exterior and the cavities left by the removal of the dental plates in the pedicle valve and the median septum in the brachial valve. In fig. 7 the convexity of the valves is not satisfactorily represented, the brachial valve being too convex and the opposite valve not convex enough.

Oriskany sandstone. *Cumberland, Maryland.*

Genus RENSSELÆRIA, Hall.

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Rensselæria Marylandica, Hall.

Fig. 8. Enlarged view of the cardinal portion of the pedicle-valve; showing the foramen and deltidial plates.

Fig. 10. Dorsal view of a typical exterior; showing the fine surface plication and the oval outline of the valves.

Fig. 11. Dorsal view of another individual, less sharply plicated and having a less convex brachial valve.

Fig. 12. The interior of a nearly complete pedicle-valve; showing the deep and strong dental lamellæ resting upon, though not consolidated with the bottom of the valve, and the elongate muscular impressions.

Fig. 13. Longitudinal section of the valves; showing the loop in profile, its anterior extension and the elevation of the crural apophyses; also the depth of the dental plates in the pedicle-valve and the umbonal thickening of the shell.

Fig. 14. The interior of the brachial valve; showing the medially divided hinge-plate and the loop with its long, acutely triangular anterior plate and median ridge with its short and free posterior extension.

Fig. 15. Profile of the specimen represented in fig. 11; showing the convexity of the valves.

Fig. 17. The cardinal portion of the brachial valve; showing the form of the hinge-plate, the obsolete visceral foramen, and the anterior median division.

Fig. 19. The interior of the umbonal portion of a brachial valve of an old shell in which the hinge-plate is much thickened. The specimen is projected backward to show the inner extremity of the

visceral canal, the outer opening being visible at the apex of the plate. This canal is, however, closed by testaceous deposit, and the median division of the plate on its upper surface largely obscured from the same cause.

Fig. 20. The interior of the umbonal portion of the pedicle-valve; showing the dental plates and muscular impressions.

Oriskany sandstone. *Cumberland, Maryland.*

Genus AMPHIGENIA, Hall.

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Amphigenia elongata, Hall.

See Plates 73, 74.

Fig. 9. The cardinal portion of the brachial valve; showing the form of the hinge-plate, its median depression, the opening of the visceral foramen, a portion of the septal plates and the branching vascular sinuses.

Corniferous limestone. *Le Roy, New York.*

Genus RENSSELÆRIA, Hall.

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Rensselæria ovoides, Eaton.

See Plate 75.

Fig. 16. The hinge-plate enlarged; showing its form, the opening of the visceral canal, the highly developed crural plates; also the elongate dental sockets and outer socket walls. × 2.

Fig. 18. A cast of the hinge-plate; showing the unbroken filling of the visceral canal.

Oriskany sandstone. *The Helderbergs, New York.*

Rensselæria mutabilis, Hall.

See figures 1–3a.

Figs. 21, 22. Dorsal and profile views of a broad, ovate form with elevated umbo, open delthyrium, well-defined cardinal slopes and rather coarse surface plication.

Lower Helderberg group. *Becraft's Mountain, Columbia county, New York*

Rensselæria æquiradiata, Conrad.

Figs. 23, 24, 25. Dorsal, profile and front views of one of the original specimens: showing the form of the shell and the character of its plication.

Lower Helderberg group (Upper Pentamerus limestone). *Schoharie, New York.*

Rensselæria elliptica, Hall.

Figs. 26, 27, 28. Dorsal, profile and front views of the original specimen; showing the form and convexity of the shell.

Lower Helderberg group (Shaly limestone). *Schoharie, New York.*

BRACHIOPODA.

RENSSELAERIDÆ.

Generic Illustrations.

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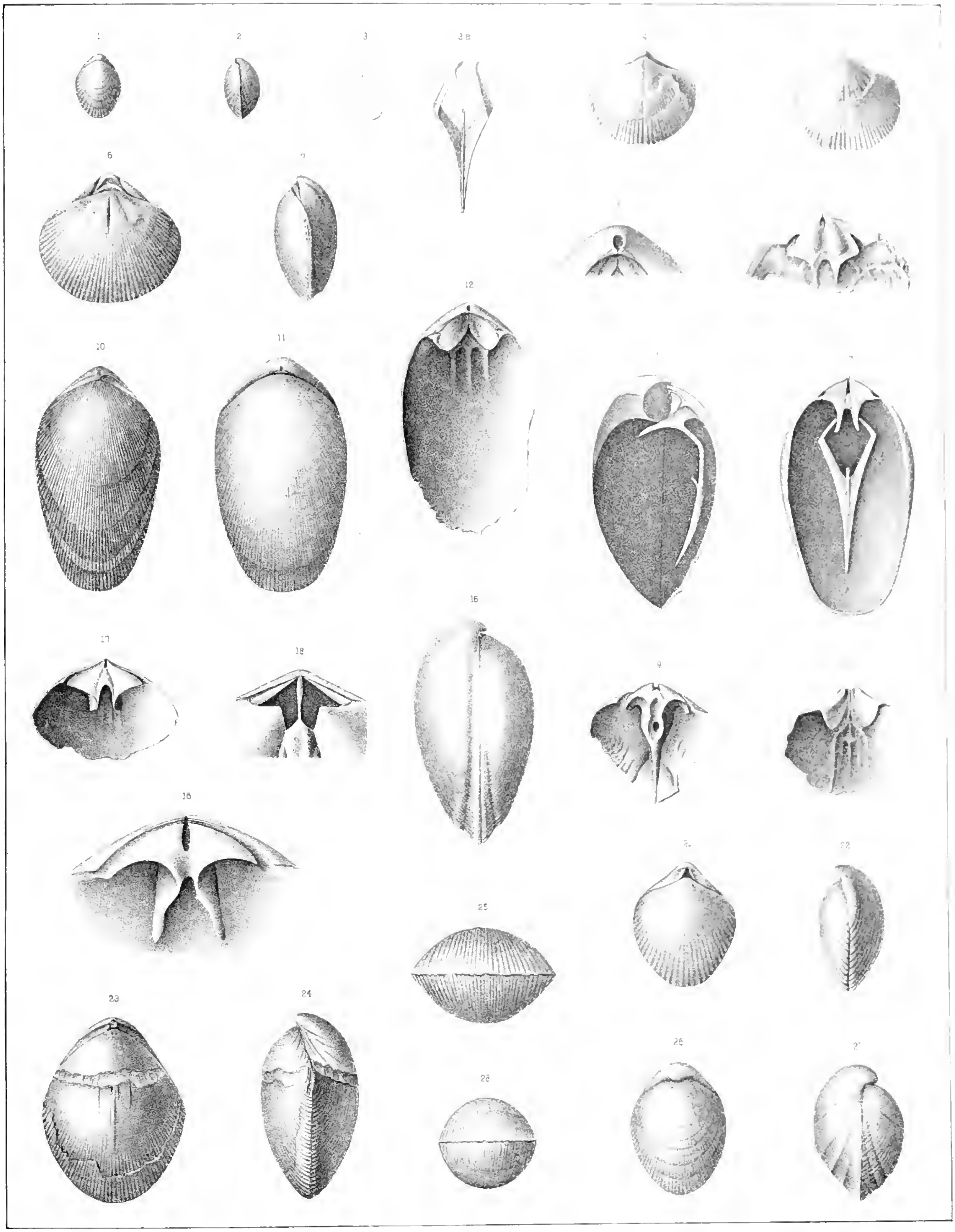
Plate LXX.



R P Whitfield del

Ph. n Ast lith.

PLATE LXXVII.

(Figures 1-9, 23-25 by F. B. Meek; 10, 11, 17-22 by G. B. Simpson; 12-14 by R. P. Whitfield; 26-28 by E. J. Swinton.)

Subgenus BEACHIA, s.-gen. nov.

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Beachia Suessana, Hall.

Fig. 1. The interiors of two pedicle-valves, the upper retaining the deltidial plates, the lower having lost these plates, but showing the dental lamellæ. Both figures show an obscure muscular area divided by a low median ridge.

Fig. 2. The interior of a brachial valve; showing the hinge-plate, medially depressed and perforated at its apex by the visceral foramen, the dental sockets, and the form of the loop with the median rod-like process extending backward and upward from the anterior plate.

Fig. 3. Front view of conjoined valves; showing the fine plication of the surface and the inflexion of the lateral margins.

Fig. 4. Median longitudinal section of conjoined valves; showing in profile the loop with its long, erect crural apophyses, the elevation and direction of the median process extending backward from the anterior plate.

Fig. 5. Views of the interior of two brachial valves; showing the inflected lateral margins and some variation in the condition of the hinge-plate.

Figs. 6, 7, 9. Ventral, profile and dorsal views of a typical example; showing the outline, contour and plication of the valves and their lateral marginal inflexion.

Fig. 8. Profile of a smaller shell, with the marginal inflexion of the valves extending to the anterior extremity.

Figs. 10, 11. Views of the hinge-plate in two individuals; showing differences due to age and consequent thickening of the parts. × 2.

Oriskany sandstone. *Cumberland, Maryland.*

Genus MEGALANTERIS, Suess.

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Megalanteris ovalis, Hall.

Fig. 12. An internal cast of the pedicle-valve; showing the filling of the deep scar of the diductor muscles, enclosing the small subcordate adductor scar, with traces of vascular sinuses and genital markings.

Fig. 13. The dorsal side of an internal cast; showing the deep impression of the prominent hinge-plate and cardinal process, and the adductor muscular scars.

Fig. 14. A similar view of another specimen to which a portion of the pedicle-valve adheres; showing the cavity of the hinge-plate and the division of the muscular area into anterior and posterior scars.

Oriskany sandstone. *Schoharie, New York.*

Fig. 15. The ventral side of another internal cast; showing the impressions of the muscular scars and vascular sinuses.

Fig. 16. Dorsal view of the same specimen; showing the deep cavities left by the grooved cardinal process, crural bases, and adductor scars.

Figs. 17, 18. Posterior and interior views of the cardinal portion of the brachial valve, enlarged; showing the hinge-plate and the stout, erect, bilobed and deeply grooved cardinal process, the broad crural bases, and a portion of the muscular impression. × 2.

Figs. 19, 20, 21. Interior, profile and front views of a gutta-percha impression taken from a natural cast of the interior, having a very highly developed cardinal process divided on its posterior face by a single median groove; showing also the crural bases and muscular area divided by a low median septum.

Fig. 22. The umbonal portion of the brachial valve, drawn from a gutta-percha impression taken from the specimen represented in fig. 16. The two grooves on the posterior face of the cardinal process are characterized by series of fine, diverging lines.

Oriskany sandstone. *Albany county, New York.*

PLATE LXXVII—Continued

GENUS RENSSELÆRIA, HALL.

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RENSSELÆRIA CUMBERLANDIÆ, Hall.

Figs. 23–25. Dorsal, profile and ventral views of one of the original specimens; showing the form and proportions of the shell, the marginal plication of the surface, the deltidial plates and sharply defined cardinal slopes.

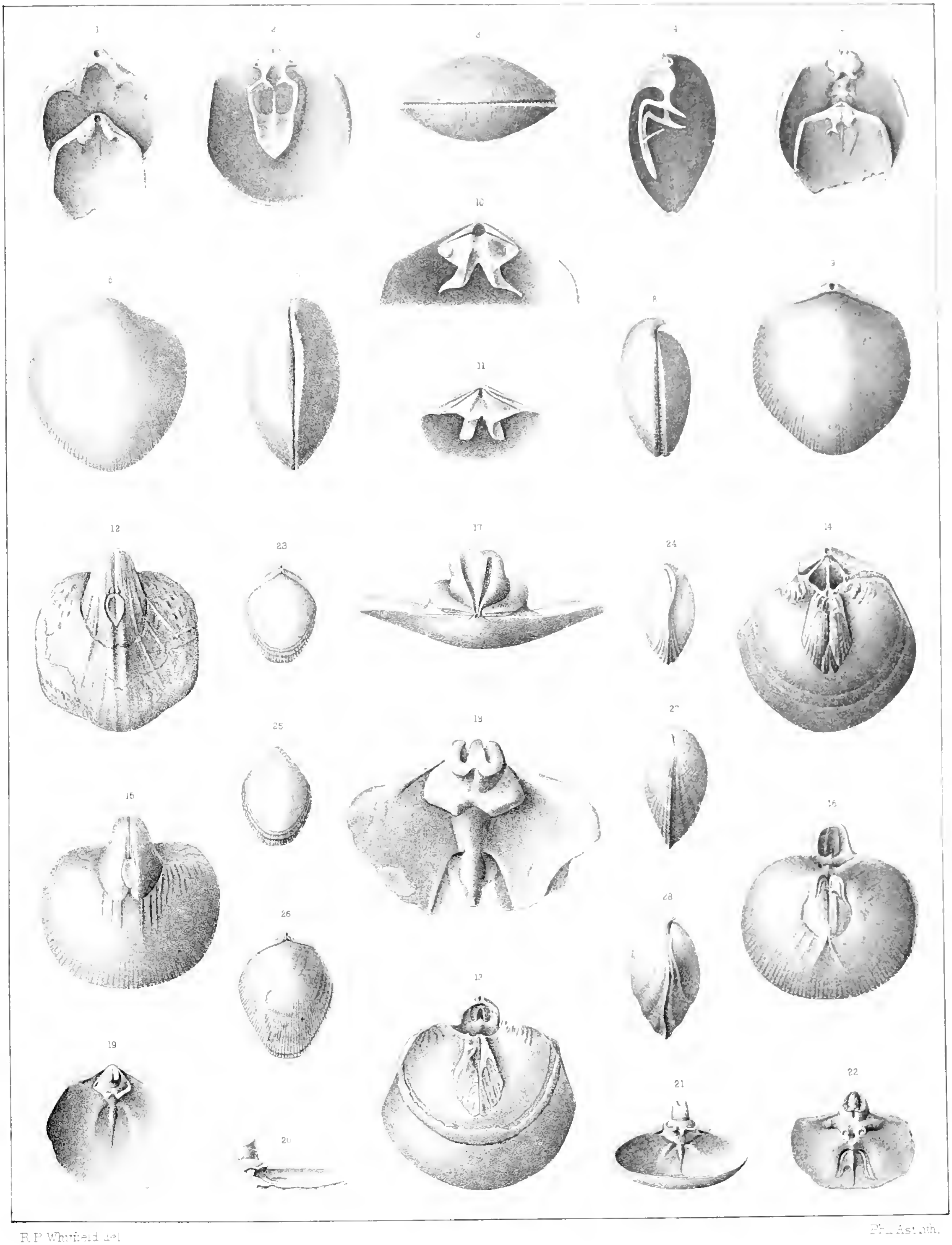
Oriskany sandstone. *Cumberland, Maryland.*

RENSSELÆRIA INTERMEDIA, Hall.

Fig. 26. Dorsal view of the exterior; showing the form and character of plication.

Figs. 27, 28. Profile views of different individuals; showing the convexity of the valves.

Oriskany sandstone. *Cumberland, Maryland.*



R P Whitfield del

Ph. Ast. lith.

PLATE LXXVIII.

(Figures 1-9, 17-23 by G. B. Simpson; 10-16 by R. P. Whitfield.)

Genus NEWBERRIA, Hall.

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Newberria Claypolii, Hall.

Fig. 1. An internal cast of a portion of the pedicle-valve; showing the divergent impressions of the dental lamellæ; the irregularly divided scar of the adductor muscles; the narrow anterior adductor and strong vascular impressions.

Fig. 2. A portion of the interior of the brachial valve, drawn from a gutta-percha impression of a natural internal cast; showing the division of the hinge-plate, and the striated adductor impressions.

Fig. 3. An internal cast of a small pedicle-valve in which the impressions of the vascular sinuses are very strongly developed.

Fig. 4. An internal cast of a brachial valve preserving the usually elongate form of mature individuals, and showing the muscular and vascular impressions.

Fig. 5. The interior of a pedicle-valve, from a gutta-percha impression; showing an open delthyrium, the divergent dental plates, the muscular and vascular impressions.

Fig. 6. An internal cast of the pedicle-valve; showing the impression of the apical cup-shaped depression of that valve. By the removal of the filling of the dental sockets, the cardinal slope is made to appear unusually large and flat.

Fig. 7. An internal cast of a large and symmetrical pedicle-valve.

Fig. 8. An internal cast of a large and somewhat deformed brachial valve, which shows the usual size and division of the hinge-plate and the character of the adductor scars.

Fig. 9. An internal cast of a pedicle-valve in which the muscular scars and vascular sinuses, both primary and secondary, are highly developed.

Sandstones of the Hamilton group. *Perry county, Pennsylvania.*

Newberria Johannis, Hall.

Fig. 10. An internal cast of the umbonal portion of a pedicle-valve, with the muscular and vascular markings distinctly retained.

Fig. 11. An internal cast of the upper portion of a brachial valve; showing the cavity left by the divided hinge-plate and the adductor muscular scars.

Figs. 12, 13. Dorsal and ventral views of a large and characteristic specimen; showing the elongate-oval form, the decided median angulation of the valves and the rugose concentric growth of the surface.

Fig. 14. The exterior of a pedicle-valve of a small individual.

Figs. 15, 16. Dorsal and profile views of a similar specimen; showing the convexity of the valves.

Hamilton group. *Waterloo, Iowa.*

Newberria lævis (Meek sp.), Whiteaves.

Figs. 17, 18 Dorsal and ventral views of an internal cast of a very large and symmetrical individual; showing the striated anterior adductor scars on the brachial valve, and the elongate muscular area, with the casts of the vascular sinuses in the umbonal region of the pedicle-valve. The fine radiating striæ near the anterior margin of the specimen belong to the inner laminæ of the shell.

Figs. 19, 20. Profile and dorsal views of an individual retaining the shell, and showing the normal convexity of the valves.

Hamilton group. *Ramparts of the Mackenzie River, British America.*

Newberria Missouriensis, Swallow.

Figs. 21, 22. Ventral and dorsal views of an individual from which the shell is partially exfoliated, exposing the muscular and vascular impressions on the pedicle-valve.

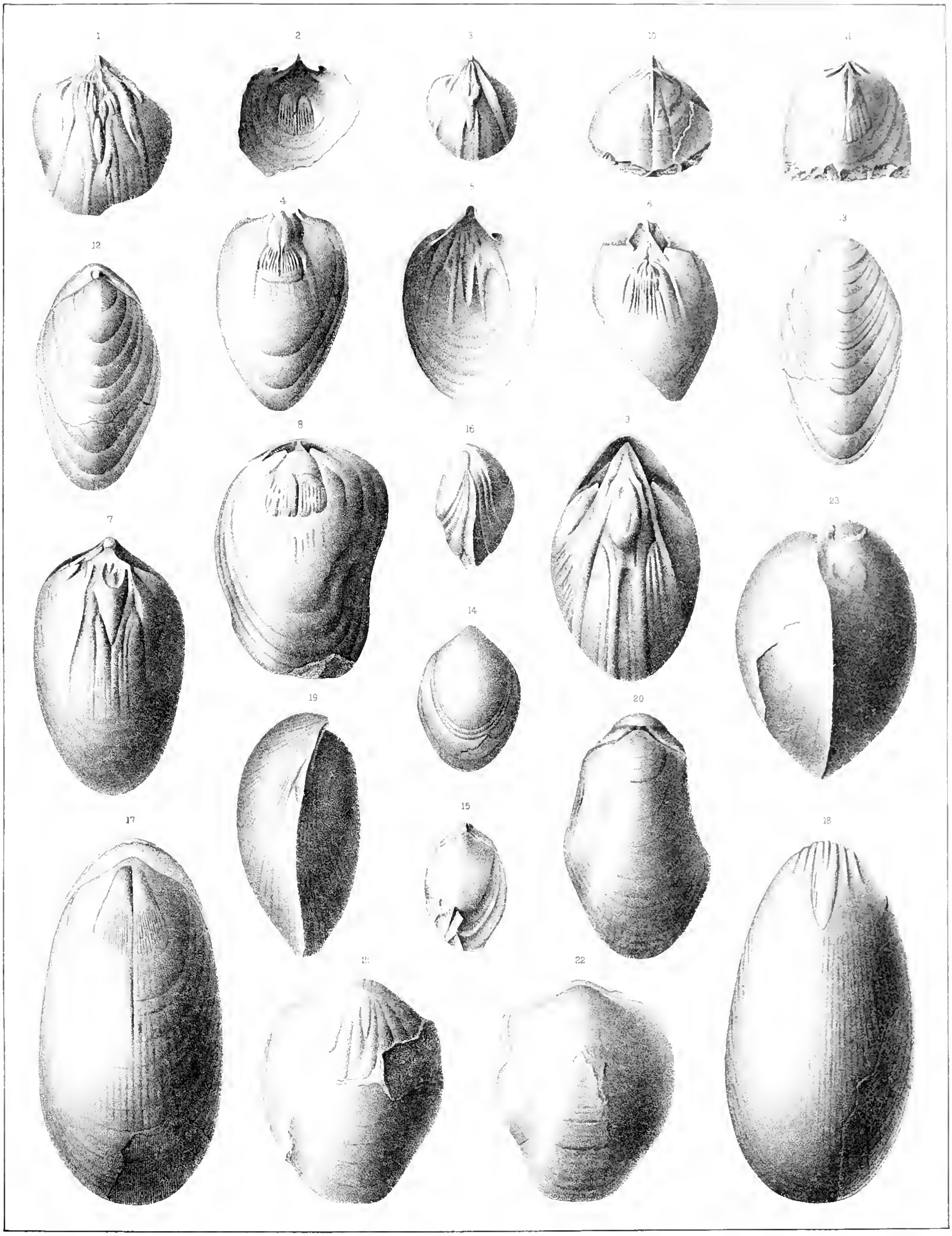
Fig. 23. Profile of a large, gibbous individual.

Hamilton group. *Moniteau county, Missouri.*

BRACHIOPODA.

RENSSELAERIDÆ.

Generic Illustrations



G. B. Simpson del.

Phil. Ast lith.

PLATE LXXIX.

(Figures 1-20, 22-24, 29, 30, 40-42 by R. P. WHITFIELD; 21, 28, 36-38 by G. B. SIMPSON; 25-27, 31-35, 39 by E. EMMONS.)

GENUS CENTRONELLA, BILLINGS.

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CENTRONELLA GLANS-FAGEA, Hall.

Fig. 1. Dorsal view of a large individual.

Figs. 2-4. Dorsal, ventral and profile views of a small specimen, having a more elongate outline than the preceding; showing the convexo-concave contour. × 3.
Schoharie grit. *Albany county, New York.*

Figs. 5, 6. Dorsal and profile views of a very ventricose individual having the elevated character of *C. tumida*, Billings, but of smaller size.
Corniferous limestone. *Cayuga, Ontario.*

Fig. 7. An internal cast; showing impressions of the hinge-plate, dental sockets and muscular scars of the brachial valve. × 2.
Schoharie grit. *Albany county, New York.*

Fig. 8. Dorsal view of a specimen having the brachial valve quite flat. × 2.
Corniferous limestone. *Drift, near Ann Arbor, Michigan.*

Figs. 9, 10. Profile and inner views of the loop and its attachment; showing the divided hinge-plate and the narrow anterior expansion of the loop with its median ridge. × 5.
Corniferous limestone. *Western New York.*

Figs. 11, 12. Dorsal and profile views of a very gibbous shell, which shows the foramen and deltidial plates.
Corniferous limestone. *Drift, near Ann Arbor, Michigan.*

Fig. 13. An internal cast of the pedicle-valve; showing the impressions of the teeth and the deep scar of the pedicle-muscle, the anterior extremity of which is enclosed by the diductor scars. × 2.
Schoharie grit. *Albany county, New York.*

Fig. 14. Dorsal view of an internal cast; showing the muscular scars and the impression of the hinge-plate. × 2.
Corniferous limestone. *Drift, near Ann Arbor, Michigan.*

Fig. 17. The interior of the umbonal portion of the brachial valve; showing the thickened divisions of the hinge-plate and the adductor scars. × 3.

Fig. 21. The interior of a brachial valve; showing the hinge-plate and the variation in the form of the muscular scars. × 3.
Corniferous limestone. *Cayuga, Ontario.*

CENTRONELLA HECATE, Billings.

Fig. 15. Dorsal view of a specimen; showing the elongate form and general similarity to *C. impressa*, Hall, with which it may be identical.
Corniferous limestone. *Cayuga, Ontario*

CENTRONELLA IMPRESSA, Hall.

Fig. 16. Dorsal view of an average individual; showing the form and concave brachial valve.

Fig. 18. The interior of the pedicle-valve, retaining the deltidial plates and teeth.

Fig. 19. The interior of a brachial valve; showing the greatly thickened divisions of the hinge-plate, and the minute cardinal process.

Fig. 20. The interior of a brachial valve; showing the divided hinge-plate, the elongate muscular scars and the vascular sinuses. × 2.
Hamilton shales. *Bellona, New York.*

CENTRONELLA ALVEATA, Hall.

Figs. 22-24. Dorsal, profile and ventral views of the original specimen; showing the large size, elongate form and deep median fold and sinus.
Onondaga limestone. *Locality ? (New York).*

Genus ORISKANIA, gen. nov.

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Oriskania navicella, sp. nov.

Figs. 25–27. Dorsal, profile and ventral views of the exterior; showing the elongate form and plano-convex contour of the species.

Oriskany sandstone. *Rondout, New York.*

Genus ROMINGERINA, gen. nov.

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Romingerina Julia, A. Winchell.

Fig. 28. Dorsal view of a large internal cast; showing the form of the shell and the impression of the divided hinge-plate. × 2.

Figs. 29, 30. Dorsal and profile views of a smaller internal cast; showing the convexity of both valves. × 2.

Marshall group. *Pointe aux Barques, Michigan.*

Genus CRYPTONELLA, Hall.

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Cryptonella (?) inconstans, Herrick.

Figs. 31, 32. Dorsal and ventral views of a small internal cast; showing the form of the shell and muscular markings.

Waverly group. *Medina county, Ohio.*

Genus BEECHERIA, gen. nov.

Page 300.

Beecheria Davidsoni, nom. nov.

Figs. 33, 34. Dorsal and profile views of an average specimen.

Fig. 35. Dorsal view of a more elongate shell.

Fig. 36. The internal cardinal structure exposed by the removal of a portion of the pedicle-valve; showing the absence of dental plates in the valve, and the structure of the loop. × 3.

Carboniferous limestone. *Windsor, Nova Scotia.*

Genus HARTTINA, gen. nov.

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Harttina Anna, Hartt.

Figs. 37–39. Dorsal, profile and ventral views of a well-preserved example; showing the subplano-convex contour of the valves.

Carboniferous limestone. *Windsor, Nova Scotia.*

Genus CENTRONELLA Billings.

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Centronella (?) navicella, Hall.

Figs. 40–42. Dorsal, profile and ventral views of the original example, which is referred with doubt to this genus.

Upper Devonian *Rockford, Iowa.*

BRACHIOPODA.

CENTRONELLIDÆ.

Generic Illustrations

R P Whitfield del. [illegible] Ast. lith.

PLATE LXXX.

(Figures 1-17, 23-35 by R. P. Whitfield, 18-22, 36-39 by E. Emmons.)

Genus CRYPTONELLA, Hall.

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Cryptonella rectirostra, Hall.

Figs. 1-3. Dorsal, ventral and profile views of a small shell with characteristic outline.

Fig. 4. Dorsal view of a large, somewhat distorted specimen, retaining the deltidial plates.

Hamilton shales. *Canandaigua Lake, New York.*

Cryptonella planirostra, Hall.

Fig. 5. Dorsal view of an average specimen retaining the deltidial plates.

Figs. 6, 7. Dorsal and profile views of a large and much thickened shell.

Hamilton shales. *Western New York.*

Figs. 8, 9. Ventral and dorsal views of an internal cast; showing the muscular impressions and vascular sinuses.

Hamilton group. *Hardy county, Virginia.*

Fig. 10. An enlargement of the cardinal portion of the pedicle-valve; showing the foramen, deltidial plates and teeth.

Hamilton group. *Moscow, New York.*

Cryptonella eximia, Hall.

Fig. 11. Profile view of a somewhat gibbous shell; showing the contour of the valves.

Fig. 12. An enlargement of the umbonal portion of the valves; showing the foramen, deltidial plates and cardinal slopes. × 3.

Lower Helderberg group. *The Helderbergs, New York.*

Subgenus CRANÆNA, s.-gen. nov.

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Cranæna Romingeri, Hall.

Figs. 13-15. Dorsal, ventral and profile views of a typical example; showing the median sinus on the pedicle valve and the anterior emargination. × 2.

Figs. 16, 17. The loop of this species, greatly enlarged; showing the divergence of the descending branches, their short recurvature, and the conspicuous crural apophyses.

Hamilton group. *Thunder Bay, Michigan.*

Figs. 18, 19. Dorsal and ventral views of a somewhat broader form.

Hamilton group. *Iowa City, Iowa.*

Genus DIELASMA, King.

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Dielasma Calvini, Hall and Whitfield.

Figs. 20-22. Dorsal, profile and ventral views of a mature individual; showing the form and contour of the valves and retaining the foramen and deltidial plates.

Hamilton group. *New Buffalo, Iowa.*

Subgenus EUNELLA, s.-gen. nov.

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Eunella Sullivanti, Hall.

Fig. 23. An enlarged view, showing the loop. × 3.

Corniferous limestone. *Cayuga, Ontario.*

Figs. 24-26. Dorsal, ventral and profile views of one of the original specimens.

Corniferous limestone. *Columbus, Ohio.*

EUNELLA SIMULATOR, Hall.

Fig. 27. Dorsal view of a specimen which has been cut to show the loop, the recurved branch of which is not retained. × 2.
Hamilton group. *Widder, Ontario.*

EUNELLA LINCKLÆNI, Hall.

Figs. 28, 29. Dorsal and profile views of a normal mature example.
Hamilton group. *Canandaigua Lake, New York.*

Fig. 30. The loop of a varietal form of the species.
Hamilton group. *Thunder Bay, Michigan.*

Figs. 31, 32. Ventral and dorsal views of an internal cast; showing the cavities left by the dental and hinge-plates and the diverging muscular or vascular lines on both valves.
Hamilton shales. *Hamilton, New York.*

EUNELLA HARMONIA, Hall.

Figs. 33, 34. Dorsal and profile views of one of the original specimens.
Corniferous limestone. *Falls of the Ohio.*

Fig. 35. Dorsal view of a broader shell, ground down to expose the loop.
Corniferous limestone. *Cayuga, Ontario.*

SUBGENUS CRANÆNA, S.-GEN. NOV.

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CRANÆNA IOWENSIS, Calvin.

Fig. 36. Dorsal view of a large example from which the shell has been partially exfoliated, exposing the muscular markings of the brachial valve.

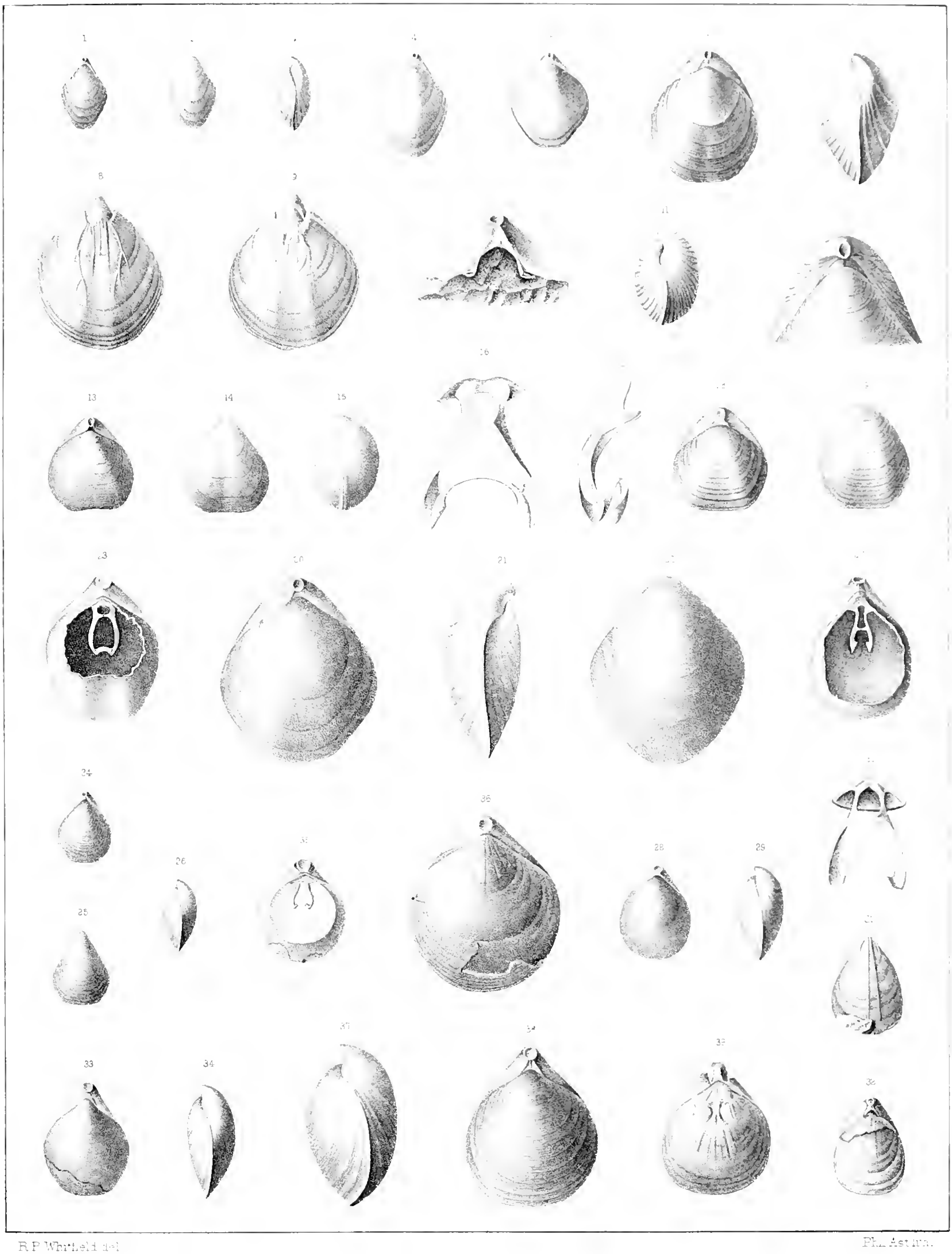
Figs. 37, 38. Profile and dorsal views of a normal individual retaining the shell intact and showing the deltidial plates.

Fig. 39. Dorsal view of an internal cast; showing the muscular scars of the brachial valve and the cavities left by the dental lamellæ of the pedicle-valve.
Hamilton group. *Rockford, Iowa.*

BRACHIOPODA.

CRYPTONELLIDÆ.

Generic Illustrations



R P Whitfield del.

Ph. Ast lith.

PLATE LXXXI.

(Figures 1-3, 5-21, 26, 29, 30 by E. Emmons; 4 by G. B. Simpson; 22-25, 27, 28 by R. P. Whitfield.)

Genus DIELASMA, King.

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Dielasma turgida, Hall.

Figs. 1-3. Dorsal, ventral and profile views of an average specimen with median sinus on both valves.

Fig. 4. Profile of an old shell with highly ventricose valves.

St. Louis group. *Washington county, Indiana.*

Figs. 5, 6. Front and dorsal views of a small shell having the median sinus very broad. × 2.

Figs. 7, 8. Front and dorsal views of a specimen having a single plication in the sinus of the pedicle-valve and a corresponding groove on the opposite valve. × 1½.

Chester group. *Spencer county, Indiana.*

Dielasma Burlingtonensis, White.

Figs. 9-11. Dorsal, profile and ventral views of a small shell.

Chert of the Burlington limestone. *Louisiana, Missouri.*

Dielasma formosa, Hall.

Figs. 12, 13. Profile and dorsal views of a small internal cast.

Fig. 14. Profile of a shell of about the same size, but with more gibbous valves.

Fig. 15. Dorsal view of an internal cast; showing that in these small shells the muscular platform of the brachial valve is not clearly defined.

St. Louis group.

Fig. 16. A cast of the cardinal portion of the pedicle-valve, enlarged to show the cavity left by the enfolded margin of the pedicle-passage, the dental lamellæ and deltidial plates. × 2.

Fig. 17. An internal cast of the brachial valve; showing the impression left by the base of the muscular platform, and the genital markings about the muscular area.

Figs. 18, 19. Profile and dorsal views of a specimen of medium size.

St. Louis group.

Fig. 20. Dorsal view of a large individual retaining the shell.

Fig. 21. Dorsal view of a specimen cut to expose the loop.

Figs. 22, 23. Ventral and dorsal views of the loop of the same specimen enlarged. As is usual in these shells the recurved lamella is not perfectly retained.

Fig. 24. Dorsal view of a large internal cast; showing a portion of the base of the muscular platform, and divergent, probably vascular impressions over the adjoining surface.

Figs. 25, 26. Profile and dorsal views of a characteristic and somewhat gibbous example.

St. Louis group.

Dielasma Rowleyi, Worthen.

Figs. 27, 28. Profile and dorsal views of an internal cast, referred with hesitation to this species; showing the muscular platform of the brachial valve, and the cavities of the dental lamellæ.

Chouteau limestone. *Graydon Springs, Missouri.*

Dielasma bovidens, Morton.

Figs. 29, 30. Dorsal and profile views of a rather gibbous specimen; showing the contour of the valves and the oblique foramen. The concentric surface lines appear to be to some extent color-markings, and not infrequently faint traces of a radial coloration are discernible in the shells. This specimen is of about the average size of the species as it occurs at this locality.

Upper Carboniferous. *Kansas City, Missouri.*

Fig. 31. Dorsal view of an internal cast of a narrow and elongate shell, in which the impression of the muscular platform of the brachial valve is sharply defined.

Fig. 32. A gutta-percha impression made from the same specimen; showing the collar or inverted lamella about the foramen, a portion of the dental plates and the form of the muscular platform.

Upper Carboniferous limestone. *Southern Indiana.*

Figs. 33–35. Profile, dorsal and ventral views of a large and characteristic example; showing the curvature of the valves, the broad concavity of the pedicle-valve and the reflexion of the anterior margins; also the oblique foraminal aperture.

Upper Carboniferous limestone. *Harrison county, Missouri.*

Dielasma. sp.?

Fig. 36. Cardinal view of a specimen enlarged to show the oblique opening of the pedicle-passage and its cross-striated surface. × 3.

Fig. 37. An internal cast of the brachial valve; showing the form and striation of the muscular platform. × 3.

Chester group. *Caldwell county, Kentucky.*

Dielasma obovata, sp. nov.

Figs. 38–40. Dorsal, profile and ventral views of a specimen having the aspect of *D. formosa*, but said to be from the Coal Measures.

Coal Measures. *Kentucky.*

Genus CRYPTONELLA, Hall.

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Cryptonella subelliptica, sp. nov.

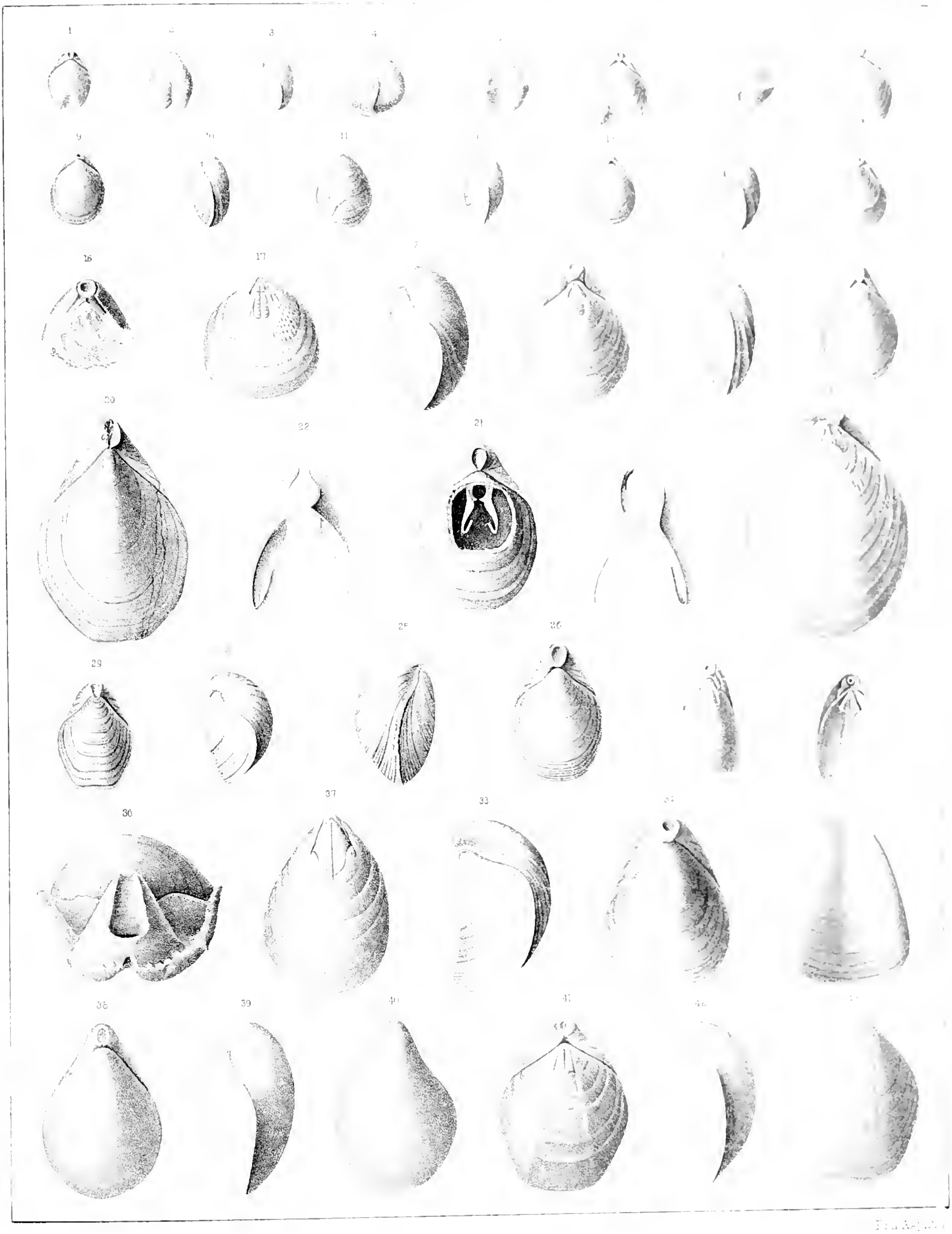
Figs. 41–43. Dorsal, profile and ventral views of a large internal cast in iron-stone; showing the form, contour and muscular scars of the brachial valve.

Waverly group. *Sciotoville, Ohio.*

BRACHIOPODA.

CRYPTONELLIDÆ.

Generic Illustrations.



E Emmons del

PLATE LXXXII.

(Figures 1–6, 10–13, 18, 22, 23, 25, 26 by G. B. Simpson; 7, 24 by E. Emmons; [illegible] G. P. Wh[illegible])

Genus CŒLOSPIRA, Hall.

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Cœlospira hemispherica, Sowerby.

Figs. 1, 2. Exteriors of two pedicle-valves; showing the contour, character of pliation and concentric striæ.

Figs. 3, 4. Exteriors of brachial valves.

Clinton group. *Western New York.*

Cœlospira plicatula, Hall.

See Plate 52.

Fig. 5. The interior of a portion of the brachial valve; showing the divided hinge-plate and median ridge. × 2.

Clinton group. *Wayne county, New York.*

Genus ATRYPINA, gen. nov.

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Atrypina Clintoni, sp. nov.

See Plate 53.

Fig. 6. The exterior of a pedicle-valve. × 2

Clinton group. *From a boulder; Western New York.*

Genus ANABAIA, Clarke.

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Anabaia Paraia, Clarke.

Fig. 7. An internal cast of the brachial valve; showing the impression of the cardinal process and the marginal elevation of the median fold.

Middle Silurian. *Rio Trombétas, Brazil.*

Genus VITULINA, Hall.

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Vitulina pustulosa, Hall.

Fig. 8. The exterior of a pedicle-valve of an average specimen.

Fig. 9. The exterior of a brachial valve.

Fig. 10. Ventral side of an internal cast; showing the impressions of the teeth, adductor and diductor muscles. × 2.

Hamilton shales. *Western New York.*

Fig. 11. Ventral view of a preparation; showing three volutions of the spiral cone which is directed toward the lateral margin of the shell.

Hamilton shales. *Alden, New York*

Figs. 12, 13. Interiors of brachial valves; showing the cardinal process and low crural plates

Middle Devonian. *Ereré, Brazil.*

Figs. 14-16. Dorsal, profile and ventral views; showing the plication, contour and pustulose exterior. × 3.

Fig. 17. The interior of a brachial valve; showing the cardinal area, wide delthyrium and well developed teeth. × 2.

Fig. 18. A view looking into the umbonal cavity of the pedicle-valve to show the elevation of the teeth × 3.

Fig. 19. Cardinal view of the specimen represented in figs 14-16; showing the cardinal area on each valve, the open delthyrium and cardinal process. × 3.

Fig. 20. The interior of a brachial valve. × 2

Fig. 21. An internal cast of the pedicle-valve; showing the muscular impressions. × 2.

Figs. 22, 23. Interiors of brachial valves; showing cardinal process and muscular impressions. × 2.

Fig. 24. Interior of a brachial valve; showing the cardinal area and process, crural plates and muscular scars. × 3.

Fig. 25. An enlargement of the external surface; showing the radiating rows of elongate pustules.

Hamilton shales. *From various localities in Western New York.*

GENUS TROPIDOLEPTUS, HALL.

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TROPIDOLEPTUS CARINATUS, Conrad.

Fig. 26. The pedicle-valve of a very young shell; showing the acuminate cardinal extremities and the coarse, simple and sharp plication. × 3.

Hamilton group. *Canandaigua Lake, New York.*

Fig. 27. An enlargement of an interior layer of the shell; showing punctæ.

Fig. 28. A horizontal section of the shell substance; showing the radial rows of oblique tubules penetrating the fibrous shell substance

Fig 29. Cardinal view of the umbonal portion of the valves; showing the open delthyrium, the great development of the chilidium, and the cardinal area × 3.

Figs. 30-32. Ventral, profile and dorsal views of an average example; showing the characters of the exterior.

Fig. 33 An internal cast of a large pedicle-valve; showing the impression of the area, pedicle-cavity, teeth and dental ridges.

Fig. 34. An internal cast of a brachial valve; showing the impression of the cardinal process and crenulated dental sockets.

Fig. 35. The interior of a pedicle-valve; showing the cardinal area, open delthyrium and the prominent crenulated teeth.

Fig. 36. The interior of a brachial valve; showing the cardinal process, crenulated dental sockets and median septum.

Hamilton group. *From various localities in the argillaceous and arenaceous shales of Central and Western New York.*

TROPIDOLEPTUS OCCIDENS, Hall.

Figs. 37, 38. Dorsal and ventral views of the original specimen of the species.

Hamilton group. *Iowa City, Iowa.*

Generic Illustration

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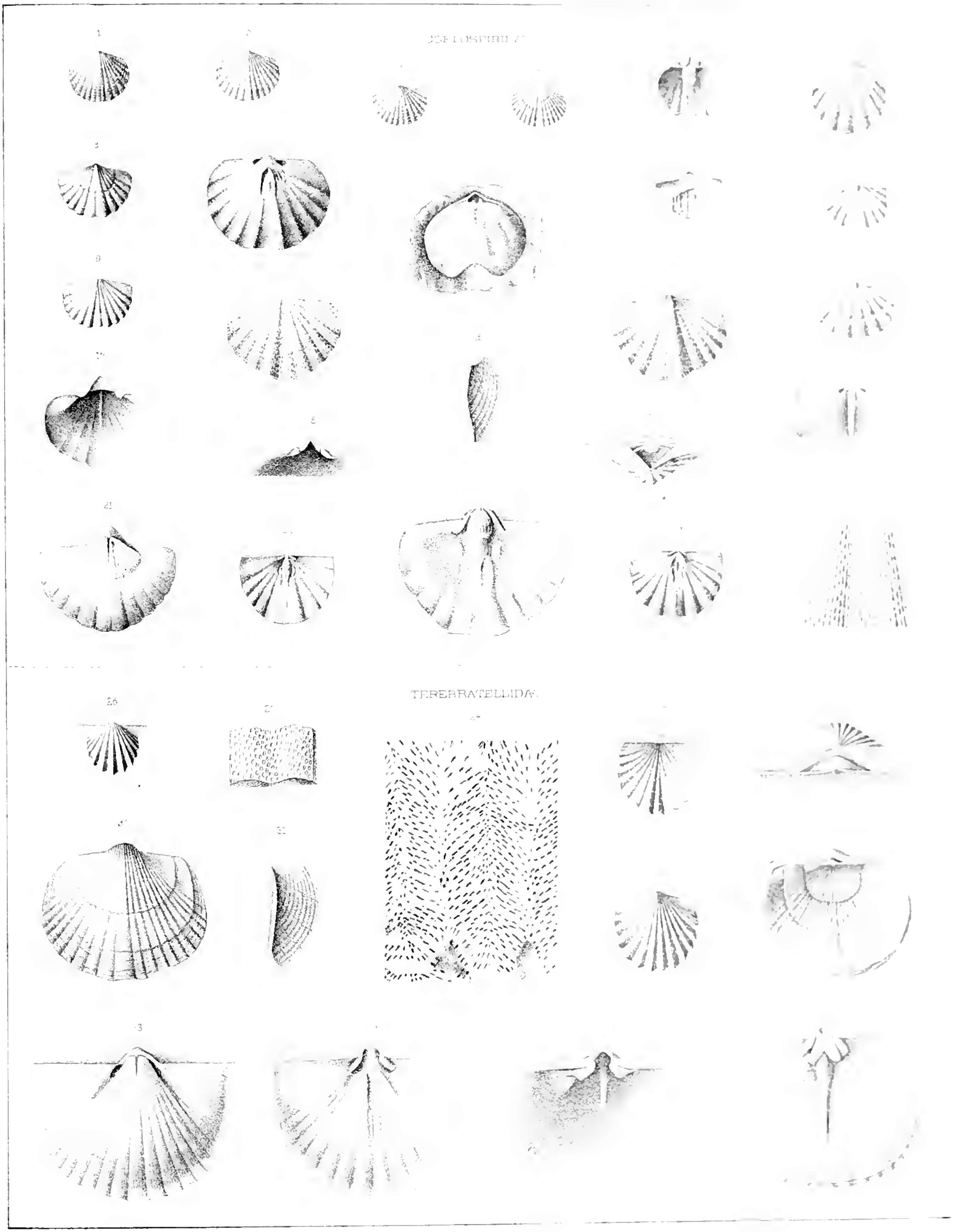

R.P. Whitfield del.

PLATE LXXXIII.

(**Figures 1-8, 12, 13, 26-41** by G. B. Simpson, 9 by C. E. Beecher, 10, 11 by R. P. Whitfield, 14-25 by E. Emmons.)

Genus EICHWALDIA, Billings.

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Eichwaldia subtrigonalis, Billings.

Fig. 1. Dorsal view of conjoined valves, the brachial valve being so broken as to expose the median septum.

Figs. 2–4. Dorsal, cardinal and front views; showing the smooth surface, and the "bare spot," or pedicle aperture. These figures are from the original specimens of the species.

Black River limestone. *Paquette's Rapids, Canada.*

Eichwaldia concinna, Hall.

Fig. 5. Dorsal view of the original specimen.

Niagara group. *Perry county, Tennessee.*

Eichwaldia gibbosa, Hall.

Fig. 6. Dorsal view of the original specimen.

Fig. 7. An enlargement of the external surface, showing the punctae. × 5.

Niagara group. *Perry county, Tennessee.*

Eichwaldia reticulata, Hall.

Fig. 8. The interior of the umbonal portion of the pedicle-valve; showing the triangular internal apical plate. × 2.

Fig. 9. Dorsal view of the youngest specimen observed. × 10. (After Beecher and Clarke, Memoirs N. Y. State Museum, Vol. 1, No. 1.)

Figs. 10, 11. Cardinal and dorsal views of an average specimen; showing the pedicle-aperture and the character of the external surface. × 2.

Fig. 12. The interior of the pedicle-valve; showing the open delthyrium and the linear ridges on the lateral margins. × 2.

Fig. 13. The interior of a brachial valve; showing the cardinal process and the marginal grooves for the reception of the ridges on the opposite valve. × 2.

Niagara group. *Waldron, Indiana.*

Genus AULACORHYNCHUS, Dittmar.

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Aulacorhynchus millepunctatus, Meek and Worthen.

Fig. 14. The exterior of a pedicle-valve, from which a portion of the shell has been exfoliated, showing the inner surface of the triangular muscular platform.

Fig. 15. A very large brachial valve; showing the outline and surface characters.

Coal Measures. *Crooked Creek, Illinois.*

Genus TRIPLECIA, Hall.

Part 1, page 269.

Triplecia Niagarensis, sp. nov.

Figs. 16-19. Cardinal, profile, oblique cardinal and front views of an internal cast; showing the sharply defined median fold and sinus on brachial and pedicle-valves respectively, the marginal plication, and the cavity left by the cardinal process.

Fig. 20. View of the articulating processes, taken from a gutta percha impression of the same specimen; showing the bifurcated cardinal process and the teeth. × 5.

Niagara dolomites. *Near Milwaukee, Wisconsin.*

GENUS TREMATOSPIRA, HALL.

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TREMATOSPIRA TENNESSEENSIS, sp. nov.

Figs 21-23. Dorsal, profile and ventral views of the shell; showing the convexity of the valves and the coarse plication.

Lower Helderberg group. *Perry county, Tennessee.*

SUBGENUS HOMŒOSPIRA, s.-gen. nov.

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See Plate 50.

HOMŒOSPIRA APRINIFORMIS, Hall.

Figs. 24, 25. Dorsal and profile views; showing the contour and character of plication.

Niagara group. *Cumberland, Maryland.*

GENUS EUMETRIA, HALL.

Page 115.

See Plate 51.

EUMETRIA VERNEUILIANA, Hall.

Figs. 26, 27. Dorsal and profile views of a large, sharply costate individual.

St. Louis limestone. *Spergen Hill, Indiana.*

GENUS PTYCHOSPIRA, gen. nov.

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See Plate 50.

PTYCHOSPIRA SEX-PLICATA, White and Whitfield.

Fig. 28. The exterior of a pedicle-valve of the type specimen.

Kinderhook group. *Burlington, Iowa.*

GENUS ZYGOSPIRA, HALL.

Page 154.

See Plate 54.

ZYGOSPIRA PUTILLA, sp. nov.

Figs. 29, 30. Dorsal and ventral views of a typical example.

Hudson River group. *Pike county, Missouri.*

GENUS RHYNCHOTREMA, HALL.

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See Plate 56.

RHYNCHOTREMA CAPAX, Conrad.

Fig. 31. Cardinal view of the pedicle-valve shown on plate 56, fig. 17; showing the excavation of the pedicle-passage and its opening through the substance of the shell. × 3.

Hudson River group. *Iron Ridge, Wisconsin.*

GENUS GLASSIA, DAVIDSON.

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GLASSIA ROMINGERI, sp. nov.

Fig. 32. A preparation showing the introverted coils and the direction of the loop. × 3.

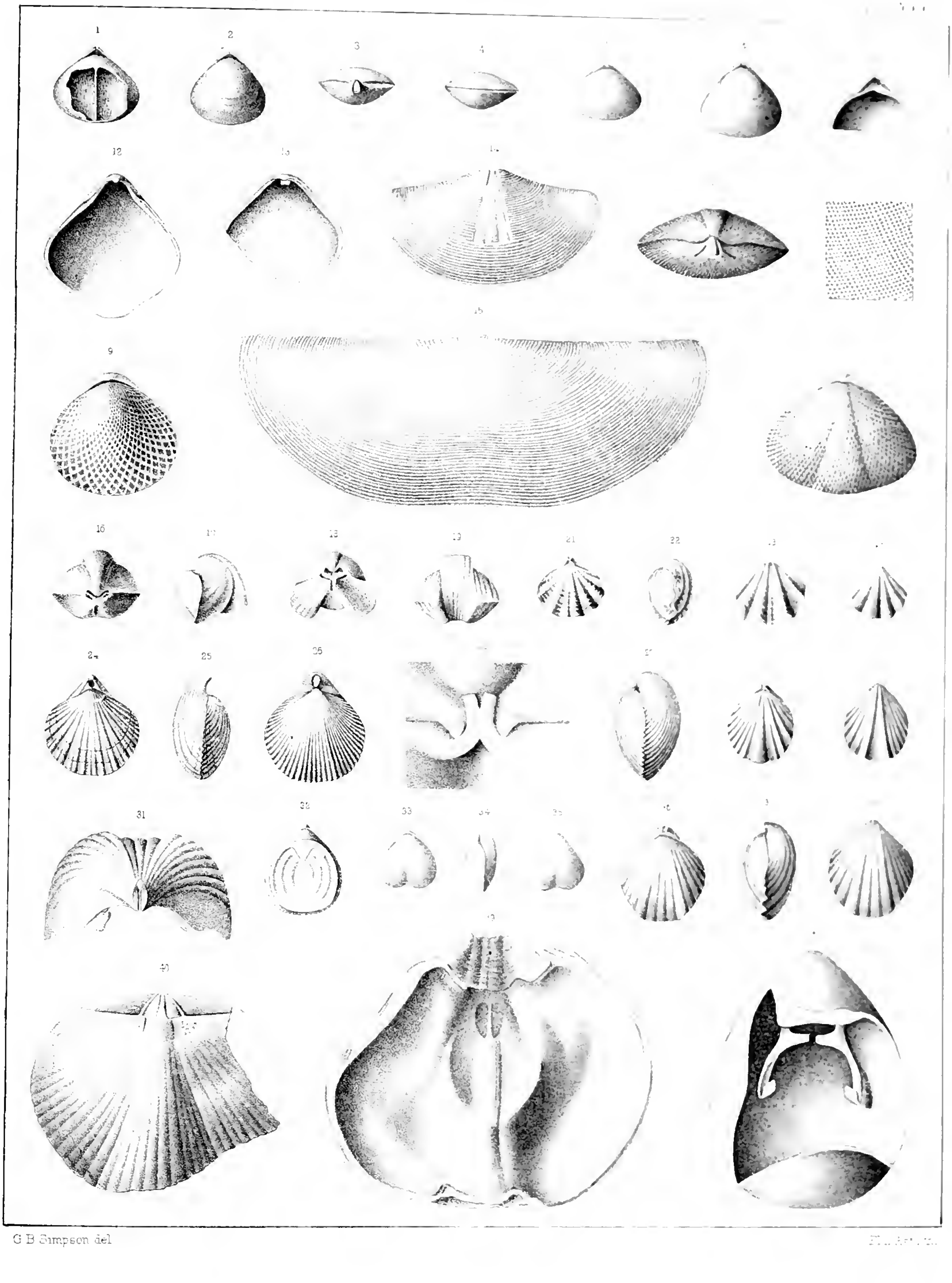
Figs. 33-35. Dorsal, profile and ventral views of a specimen, showing the smooth exterior and bilobed anterior margins of the valves. × 2.

Trenton limestone. *In a drift boulder, near Ann Arbor, Michigan.*

BRACHIOPODA

MISCELLANEOUS

Generic Illustrations



G B Simpson del

PLATE LXXXIII—Continued.

GENUS HALLINA, N. H. WINCHELL and SCHUCHERT.

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HALLINA SAFFORDI, N. H. Winchell and Schuchert.

Figs. 36–38. Dorsal, profile and ventral views of a typical example. × 5.
Trenton limestone. *Lebanon, Tennessee.*

GENUS ATHYRIS, McCOY.

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See Plates 45–47.

ATHYRIS INCRASSATA, Hall.

Fig. 39. The interior of a pedicle-valve of average size; showing the pedicle, adductor and diductor impressions, and the thickened shell-margins.
Warsaw limestone. *Desmoines River, Iowa.*

GENUS STRICKLANDINIA, BILLINGS.

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See Plate 73.

STRICKLANDINIA CHAPMANI. sp. nov. (Compare BILLINGS, Palaeozoic Fossils, vol. ii. pt. i. pl. vii, fig. 3).

Fig. 40. An incomplete internal cast of the pedicle-valve; showing the impression left by the highly developed cardinal area.
Niagara group. *Hamilton, Ontario.*

SUBGENUS CRANÆNA, S.-GEN. NOV.

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CRANÆNA IOWENSIS, Calvin.

Fig. 41. A preparation showing the structure of the loop, the ascending branches being but partially retained × 2.
Middle Devonian. *Fayette, Iowa.*

PLATE LXXXIV.

(Figure: 1-4, 14-19, 23-25, 29, 36, 37, 41-46 by G. B. Simpson; 5-13, 20-22, 30-35, 38-40 by E. Emmons; 25-28 copies.)

Protorthis, sp. ?

Fig. 1. The interior of a pedicle-valve; showing the small spondylium made by the union of the short dental plates, the low median ridge and the muscular impressions × 2.

Fig. 2. A portion of the same specimen drawn so as to show more clearly the convergence of the dental lamellæ.

Calciferous horizon. *Fort Cassin, Vermont.*

ORTHOTROPIA, gen. nov.

Orthotropia dolomitica, sp. nov.

Fig. 3. Ventral view of an internal cast, natural size; showing the form of the shell, the short, straight hinge, and the conspicuous muscular scars.

Fig. 4. The interior of a pedicle-valve; showing the cardinal area, open delthyrium, muscular scar and short median septum.

Figs. 5-7. Ventral, dorsal and cardinal views (the last with the pedicle-valve above) of an internal cast; showing the form of the muscular impressions, the median septum in each valve, and the elevation of the cardinal area, × 2. The external surface of the shell is unknown.

Niagara dolomites. *Near Milwaukee, Wisconsin.*

The generic characters of this shell are so distinctly unlike those of any existing genus that it is here proposed to distinguish it by the new term Orthotropia.

Orthis ? glypta (Compare *O. Loveni*, Lindström), sp. nov.

Fig. 8. A partial internal cast of the pedicle-valve; showing the outline of the shell, its surface ornamentation and the form of the muscular impression.

Fig. 9. A similarly preserved shell with but a single series of radial plications and showing the peculiar reticulating surface sculpture. × 2.

Niagara dolomites. *Near Milwaukee, Wisconsin.*

Orthis flabellites, Hall. var. *Spania*, var. nov.

See plates 5 and 20.

Fig. 10. An internal cast of a pedicle-valve, having the expression of *O. flabellites*, but with scarcely more than one-half of the number of plications usual in this species.

Niagara dolomites. *Near Milwaukee, Wisconsin.*

Stropheodonta (Pholidostrophia) nacrea, Hall.

See Plate 15.

Fig. 11. The interior of a brachial valve; showing the muscular scars and vascular sinuses. × 2.

Hamilton shales. *Livonia Salt Shaft, New York.*

Stropheodonta (Brachyprion) profunda, Hall.

See Plates 12 and 20.

Fig. 12. A portion of an internal cast of a large pedicle-valve; showing the cardinal area, the partial filling of the delthyrium, the small adductor and large diductor impressions.

Niagara dolomites. *Near Milwaukee, Wisconsin.*

Stropheodonta (Douvillina) Cayuta, Hall.

See Plate 15.

Fig. 13. The interior of a pedicle-valve; showing the elevation of the muscular scar into a well defined platform; also the abrasion of the cardinal area by the teeth of the opposite valve.

Chemung group. *Steuben county, New York.*

Stropheodonta (Brachyprion) corrugata, Hall.

See Plate 15.

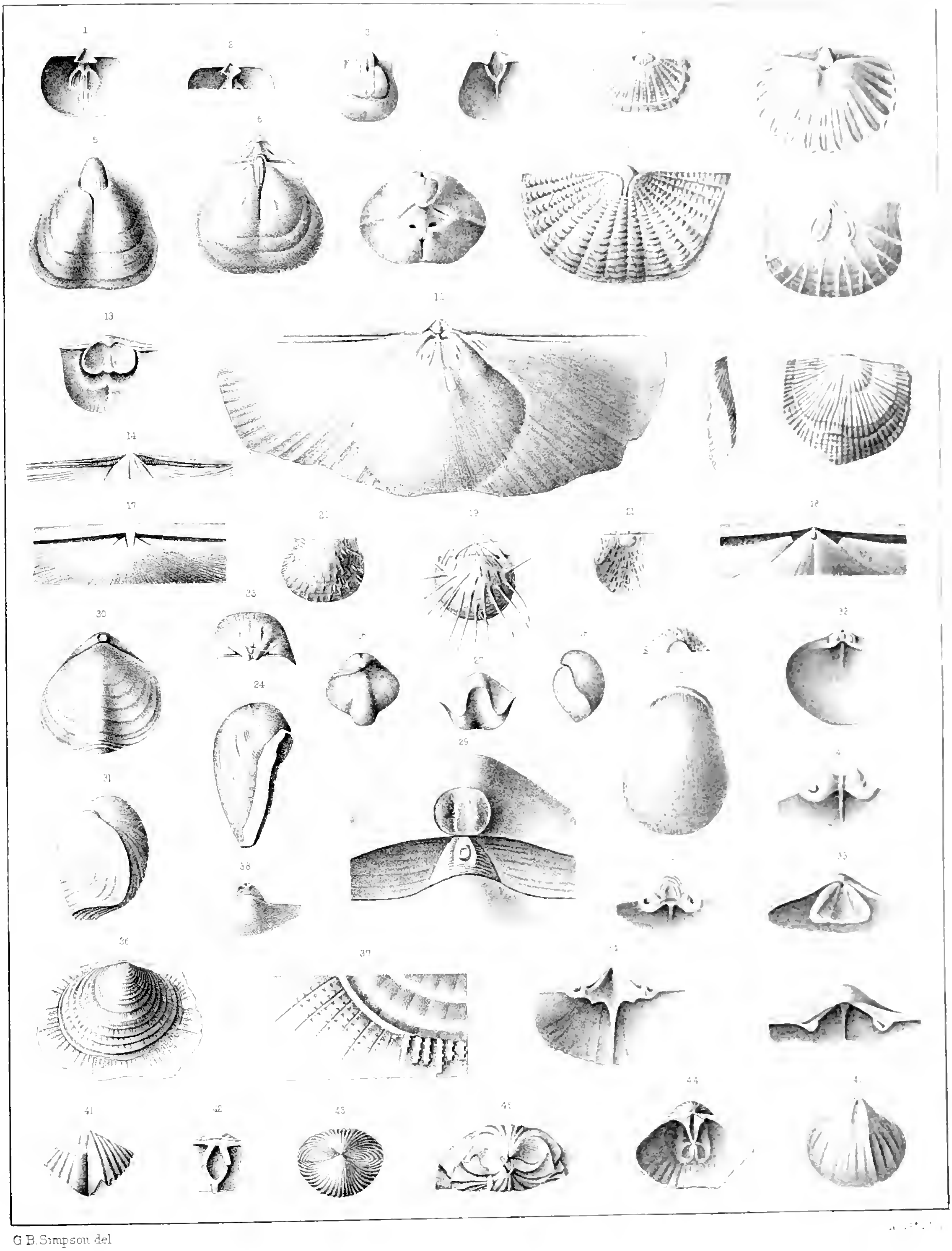
Fig. 14. A portion of an internal cast of the pedicle-valve enlarged to show the crenulations of the hinge-plate, near the beak. × 2.

Clinton group. *Rochester, New York.*

BRACHIOPODA.

MISCELLANEOUS

Generic Illustrations



G. B. Simpson del.

Strophonella costatula, sp. nov.

Figs. 15, 16. Dorsal and profile views of the shell; showing the reversed convexity of the valves and the sharply rounded, irregularly dichotomizing plications.

Niagara group. *Louisville, Kentucky.*

Rafinesquina alternata, Conrad.

Figs. 17, 18. Enlargements of umbonal portions of internal casts of the pedicle-valve, to show the filling of the pedicle-passage. In fig. 18, which represents the older shell, this filling is seen to be the smaller and is constricted at its base, evincing thus the tendency of the shell to close this passage at its inner extremity. × 3.

Hudson River group. *Erratic blocks in western New York.*

Productella navicella, Hall.

See Plate 17.

Fig. 19. A small pedicle-valve preserving the spines in a perfect condition and showing the convergence of the cardinal spines. × 5.

Hamilton group. *Canandaigua Lake, New York.*

Strophalosia Rockfordensis, sp. nov.

See Plate 17a.

Figs. 20, 21, 22. Ventral, dorsal and cardinal views of a specimen; showing the general external characters and the umbonal cicatrix

Upper Devonian. *Rockford, Iowa.*

Plectambonites producta, sp. nov.

Figs. 23, 24, 25. Cardinal, profile and front views of an internal cast of a pedicle-valve; showing the form of the teeth and muscular impressions, the short hinge and the greatly produced anterior margin.

Niagara dolomites. *Yellow Springs, Ohio.*

Hyattella congesta, Hall.

See Plate 40.

Figs 26–28. Dorsal, front and profile views of one of the original specimens (Palæontology of New York, vol. II. pl. xxiii, figs. 1, f, g, i).

Clinton group. *Monroe county, New York.*

Spirifer lævis, Hall.

See Plate 38.

Fig. 29. A portion of the cardinal region enlarged to show the peculiar structure of the deltarium, which bears a circular perforation with elevated margins, and is surrounded by an elongate, smooth area, at the edges of which the growth lines are sharply interrupted. × 3.

Chemung group. *Near Ithaca, New York.*

Seminula subquadrata, Hall.

See Plate 47.

Figs. 30, 31. Dorsal and profile views of the original specimen.

Kaskasia limestone. *Chester, Illinois.*

Cliothyris Royssii, Léveillé.

Fig. 32. The interior of a brachial valve; showing the form of the hinge-plate

Coal Measures. *Tournai, Belgium.*

Athyris concentrica, von Buch.

Fig. 33. An enlargement of the hinge-plate; showing its form, tripartite division, and apical perforation.

Middle Devonian. *Ferques, Brittany.*

TORYNIFER, GEN. NOV.

TORYNIFER CRITICUS, sp. nov.

Figs. 34, 35. A fragment of a pedicle-valve, with well defined cardinal area, prominent teeth, convergent dental lamellæ forming a distinct spondylium supported by a median septum. Nothing further is known of this peculiar shell. Its general relations are probably less athyroid than orthoid. × 2

Though but this fragment is known, it bears the critical structure which separates it from other genera, and may hence as well receive a distinctive designation now as hereafter, when its other characters shall have been determined.

St. Louis group. *La Rue, Kentucky.*

SPIRIFER (cf.) HIRTUS, White and Whitfield.

See Plate 46.

Fig. 36. A pedicle-valve, showing the compound spines at the concentric growth-lines.

Fig. 37 A portion of the same specimen enlarged, to show more distinctly the character of these spines.

Waverly group. *Richfield, Ohio.*

NUCLEOSPIRA CONCINNA, Hall.

See Plate 48.

Fig. 38. Posterior cardinal view of the brachial valve; showing the elevation and curvature of the cardinal process. × 3

Hamilton group. *Clarke county, Indiana*

NUCLEOSPIRA VENTRICOSA, Hall.

See Plate 48.

Fig. 39. View of the cardinal process. × 13

Fig. 40. The same specimen projected backward to show the elevation of the crural bases.

Lower Helderberg group. *Schoharie, New York.*

CYRTINA NEOGENES, sp. nov.

Fig. 41. The pedicle-valve of a very transverse SPIRIFERINA-like species, broken so as to show the median septum supporting convergent dental plates.

Chert of the Burlington limestone. *Burlington, Iowa*

It is important to observe that this shell, with the external aspect of SPIRIFERINA and the interior structure of CYSTINA, is the palæozoic precursor of numerous Triassic species passing under the name of SPIRIFERINA, though assuredly not of that genus.

CAMARELLA VOLBORTHI, Billings.

See Plate ——.

Fig. 42. A fragment of the umbonal portion of the shell, showing the spondylium of the pedicle-valve and the lateral walls of that of the brachial valve. × 3.

Black River limestone. *Paquette's Rapids, Canada.*

ANASTROPHIA VERNEUILI, Hall.

See Plate ——.

Fig. 43. Cardinal view of a normal example, represented with the pedicle-valve above.

Fig. 44. The interior of a brachial valve; showing the spondylium and adductor scars.

Lower Helderberg group. *Albany county, New York.*

CAMAROPHORIA RINGENS, Swallow.

Fig. 45 Cardinal view of an internal cast of conjoined valves, retaining the fine radial surface striæ.

Burlington limestone. *Louisiana, Missouri.*

BARRANDELLA VENTRICOSA, Hall.

See Plate ——.

Fig. 46 An internal cast of a pedicle-valve; showing divergent muscular or vascular ridges.

Niagara dolomites. *Southern Wisconsin.*