Treatise on Invertebrate Paleontology

Part H

Brachiopoda

Revised

Volume 5:
Rhynchonelliformea (part)

Alwyn Williams, C. H. C. Brunton, and S. J. Carlson with
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Prepared under Sponsorship of
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The Geological Society of America, Inc.
and
The University of Kansas
Boulder, Colorado, and Lawrence, Kansas
2006

Library of Congress Catalogue Card Number 53-12913
ISBN 0-8137-3135-6

Distributed by the Geological Society of America, Inc., P.O. Box 9140, Boulder, Colorado 80301, USA, www.geosociety.org, from which current price lists of parts in print may be obtained and to which all orders and related correspondence should be directed. Editorial office of the *Treatise:* Paleontological Institute, The University of Kansas, 1475 Jayhawk Blvd., Room 121, Lawrence, Kansas 66045-7613, USA, www.paleo.ku.edu.

The *Treatise on Invertebrate Paleontology* has been made possible by (1) funding principally from the National Science Foundation of the United States in its early stages, from The Geological Society of America through the bequest of Richard Alexander Fullerton Penrose, Jr., and from The Kansas University Endowment Association through the bequest of Raymond C. and Lillian B. Moore; (2) contribution of the knowledge and labor of specialists throughout the world, working in cooperation under sponsorship of The Geological Society of America, the Paleontological Society, the SEPM (Society for Sedimentary Geology), the Palaeontographical Society, and the Palaeontological Association; (3) acceptance by The University of Kansas of publication without any financial gain to the University; and (4) generous contributions by our individual and corporate sponsors.

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CONTENTS

INFORMATION ON TREATISE VOLUMES

Parts of the *Treatise* are distinguished by assigned letters with a view to indicating their systematic sequence while allowing publication of units in whatever order each is made ready for the press. Copies can be obtained from the Publication Sales Department, The Geological Society of America, 3300 Penrose Place, P.O. Box 9140, Boulder, Colorado 80301, www.geosociety.org.

PUBLISHED VOLUMES

Part A. Introduction: Fossilization (Taphonomy), Biogeography, and Biostratigraphy, xxiii + 569 p., 169 fig., 1979.

Part C. Protista 2 (Sarcodina, Chiefly "Thecamoebians" and Foraminiferida), Volumes 1 and 2, xxxi + 900 p., 653 fig., 1964.

Part D. Protista 3 (Protozoa: Chiefly Radiolaria, Tintinnina), xii + 195 p., 92 fig., 1954.

Part E. Archaeocyatha and Porifera, xviii + 122 p., 89 fig., 1955.

Part E, Revised. Archaeocyatha, Volume 1, xxx + 158 p., 107 fig., 1972.

Part F. Coelenterata, xx + 498 p., 358 fig., 1956.

Part F. Coelenterata, Supplement 1 (Rugosa and Tabulata), Volumes 1 and 2, xl + 762 p., 462 fig., 1981.

Part G. Bryozoa, xiii + 253 p., 175 fig., 1953.

Part G, Revised. Bryozoa, Volume 1 (Introduction, Order Cystoporata, Order Cryptostomata), xxvi + 625 p., 295 fig., 1983.

Part H. Brachiopoda, Volumes 1 and 2, xxxii + 927 p., 746 fig., 1965.

Part H, Revised. Brachiopoda, Volume 1 (Introduction), xx + 539 p., 417 fig., 40 tables, 1997.

Part H, Revised. Brachiopoda, Volumes 2 and 3 (Linguliformea, Craniiformea, Rhynchonelliformea [part]), xxx + 919 p., 616 fig., 17 tables, 2000.

Part H, Revised. Brachiopoda, Volume 4 (Rhynchonelliformea [part]), xxxix + 768 p., 484 fig., 3 tables, 2002.

Part I. Mollusca 1 (Mollusca General Features, Scaphopoda, Amphineura, Monoplacophora, Gastropoda General Features, Archaeogastropoda, Mainly Paleozoic Caenogastropoda and Opisthobranchia), xxiii + 351 p., 216 fig., 1960.

Part K. Mollusca 3 (Cephalopoda General Features, Endoceratoidea, Actinoceratoidea, Nautiloidea, Bactritoidea), xxviii + 519 p., 361 fig., 1964.

Part L. Mollusca 4 (Cephalopoda: Ammonoidea), xxii + 490 p., 558 fig., 1957.

Part L, Revised. Mollusca 4, Volume 4 (Cretaceous Ammonoidea), xx + 362 p., 216 fig., 1996.

Part N. Mollusca 6 (Bivalvia), Volumes 1 and 2 (of 3), xxxvii + 952 p., 613 fig., 1969; Volume 3, iv + 272 p., 153 fig., 1971.

Part O. Arthropoda 1 (Arthropoda General Features, Protarthropoda, Euarthropoda General Features, Trilobitomorpha), xix + 560 p., 415 fig., 1959.

Part O, Revised. ARTHROPODA 1 (Trilobita: Introduction, Order Agnostida, Order Redlichiida), xxiv + 530 p., 309 fig., 1997.
Part P. ARTHROPODA 2 (Chelicerata, Pycnogonida, Palaeoisopus), xvii + 181 p., 123 fig., 1955 [1956].
Part Q. ARTHROPODA 3 (Crustacea, Ostracoda), xxiii + 442 p., 334 fig., 1961.
Part R. ARTHROPODA 4, Volumes 1 and 2 (Crustacea Exclusive of Ostracoda, Myriapoda, Hexapoda), xxxvi + 651 p., 397 fig., 1969.
Part R. ARTHROPODA 4, Volumes 3 and 4 (Hexapoda), xxii + 655 p., 265 fig., 1992.
Part S. ECHINODERMATA 1 (Echinodermata General Features, Homalozoa, Crinozoa, exclusive of Crinoidea), Volumes 1 and 2, xxx + 650 p., 400 fig., 1967 [1968].
Part T. ECHINODERMATA 2 (Crinoidea), Volumes 1–3, xxxviii + 1,027 p., 619 fig., 1978.
Part U. ECHINODERMATA 3 (Asterozoans, Echinozoans), xxx + 695 p., 534 fig., 1966.
Part V. GRAPTOLITHINA, xvii + 101 p., 72 fig., 1955.
Part V, Revised. GRAPTOLITHINA, xxxii + 163 p., 109 fig., 1970.
Part W. MISCELLANEA (Conodonts, Conoidal Shells of Uncertain Affinities, Worms, Trace Fossils, Problematica), xxv + 259 p., 153 fig., 1962.
Part W, Revised. MISCELLANEA, Supplement 1 (Trace Fossils and Problematica), xxi + 269 p., 110 fig., 1975.
Part W, Revised. MISCELLANEA, Supplement 2 (Conodonta), xxviii + 202 p., frontis., 122 fig., 1981.

THIS VOLUME

Part H, Revised. BRACHIOPODA, Volume 5 (Rhynchonelliformea [part]), xlvi + 631 p., 398 fig., 2006.

VOLUMES IN PREPARATION

Part B. PROTISTA 1 (Chrysomonadida, Coccolithophorida, Charophyta, Diatomacea, etc.).
Part E, Revised. PORIFERA (additional volumes).
Part F, Revised. CNIDARIA (Scleractinia).
Part G, Revised. BRYOZOA (additional volumes).
Part H, Revised. BRACHIOPODA (additional volumes).
Part K, Revised. MOLLUSCA 3 (Nautiloidea).
Part L, Revised. MOLLUSCA 4 (Ammonoidea) (additional volumes).
Part M. MOLLUSCA 5 (Coleoidea).
Part O, Revised. ARTHROPODA 1 (Trilobita) (additional volumes).
Part Q, Revised. ARTHROPODA 3 (Ostracoda).
Part R, Revised. ARTHROPODA 4 (Crustacea Exclusive of Ostracoda).
Part T, Revised. ECHINODERMATA 2 (Crinoidea).
Part V, Revised. GRAPTOLITHINA.
Part W, Revised. TRACE FOSSILS.

EDITORIAL PREFACE

Roger L. Kaesler
[The University of Kansas]

From the outset the aim of the *Treatise on Invertebrate Paleontology* has been to present a comprehensive and authoritative yet compact statement of knowledge concerning groups of invertebrate fossils. Typically, preparation of early *Treatise* volumes was undertaken by a small group with a synoptic view of the taxa being monographed. Two or perhaps three specialists worked together, sometimes co-opting others for coverage of highly specialized taxa. Recently, however, both new *Treatise* volumes and revisions of existing ones have been undertaken increasingly by teams of specialists led by a coordinating author. This volume, Part H, Revised, Brachiopoda, Volume 5, has been prepared by such a team of specialists whose work prior to April 2004 was coordinated by Sir Alwyn Williams at The University of Glasgow. Subsequent coordination of this volume has been handled jointly by Dr. Howard Brunton (retired, formerly at the British Museum, Natural History) and Dr. Sandy Carlson at the University of California (Davis). Editorial matters specific to this volume are discussed near the end of this editorial preface.

ZOOLOGICAL NAMES

Questions about the proper use of zoological names arise continually, especially questions regarding both the acceptability of names and alterations of names that are allowed or even required. Regulations prepared by the International Commission on Zoological Nomenclature (ICZN) and published in 1999 in the *International Code of Zoological Nomenclature,* hereinafter referred to as the *Code,* provide procedures for answering such questions. The prime objective of the *Code* is to promote stability and universality in the use of the scientific names of animals, ensuring also that each generic name is distinct and unique, while avoiding unwarranted restrictions on freedom of thought and action of systematists. Priority of names is a basic principle of the *Code;* but, under specified conditions and by following prescribed procedures, priority may be set aside by the Commission. These procedures apply especially where slavish adherence to the principle of priority would hamper or even disrupt zoological nomenclature and the information it conveys.

The Commission, ever aware of the changing needs of systematists, revised the *Code* in 1999 to enhance further nomenclatorial stability, specifying that the revised *Code* should take effect at the start of 2000. Among other requirements, the revised *Code* is clear in Chapter 14 that the type genus of family-level taxa must be specified. In this volume we have continued the practice that has characterized most previous volumes of the *Treatise*, namely that the type genus of all family-level taxa is the first listed and diagnosed. In spite of the revisions, the nomenclatorial tasks that confront zoological taxonomists are formidable and have often justified the complaint that the study of zoology and paleontology is too often merely the study of names rather than the study of animals. It is incumbent upon all systematists, therefore, at the outset of their work to pay careful attention to the *Code* to enhance stability by minimizing the number of subsequent changes of names, too many of which are necessitated by insufficient attention to detail. To that end, several pages here are devoted to aspects of zoological nomenclature that are judged to have chief importance in relation to procedures adopted in the *Treatise,* especially in this volume. Terminology is explained, and examples are given of the style employed in the nomenclatorial parts of the systematic descriptions.

GROUPS OF TAXONOMIC CATEGORIES

Each taxon belongs to a category in the Linnaean hierarchical classification. The *Code* recognizes three groups of categories, a species-group, a genus-group, and a family-group. Taxa of lower rank than subspecies are excluded from the rules of zoological nomenclature, and those of higher rank than superfamily are not regulated by the *Code.* It is both natural and convenient to discuss nomenclatorial matters in general terms first and then to consider each of these three, recognized groups separately. Especially important is the provision that within each group the categories are coordinate, that is, equal in rank, whereas categories of different groups are not coordinate.

FORMS OF NAMES

All zoological names can be considered on the basis of their spelling. The first form of a name to be published is defined as the original spelling (*Code,* Article 32), and any form of the same name that is published later and is different from the original spelling is designated a subsequent spelling (*Code,* Article 33). Not every original or subsequent spelling is correct.

ORIGINAL SPELLINGS

If the first form of a name to be published is consistent and unambiguous, the original is defined as correct unless it contravenes some stipulation of the *Code* (Articles 11, 27 to 31, and 34) or unless the original publication contains clear evidence of an inadvertent error in the sense of the *Code,* or, among names belonging to the family-group, unless correction of the termination or the stem of the type genus is required. An original spelling that fails to meet these requirements is defined as incorrect.

If a name is spelled in more than one way in the original publication, the form adopted by the first reviser is accepted as the correct original spelling, provided that it complies with mandatory stipulations of the *Code* (Articles 11 and 24 to 34).

Incorrect original spellings are any that fail to satisfy requirements of the *Code,* represent an inadvertent error, or are one of multiple original spellings not adopted by a first reviser. These have no separate status in zoological nomenclature and, therefore, cannot enter into homonymy or be used as replacement names. They call for correction. For example, a name originally published with a diacritical mark, apostrophe, dieresis, or hyphen requires correction by deleting such features and uniting parts of the name originally separated by them, except that deletion of an umlaut from a vowel in a name derived from a German word or personal name unfortunately requires the insertion of *e* after the vowel. Where original spelling is judged to be incorrect solely because of inadequacies of the Greek or Latin scholarship of the author, nomenclatorial changes conflict with the primary purpose of zoological nomenclature as an information retrieval system. One looks forward with hope to further revisions of the *Code* wherein rules are emplaced that enhance stability rather than classical scholarship, thereby facilitating access to information.

SUBSEQUENT SPELLINGS

If a subsequent spelling differs from an original spelling in any way, even by the omission, addition, or alteration of a single letter, the subsequent spelling must be defined as a different name. Exceptions include such changes as an altered termination of adjectival specific names to agree in gender with associated generic names (an unfortunate impediment to stability and retrieval of information); changes of family-group names to denote assigned taxonomic rank; and corrections that eliminate originally used diacritical marks, hyphens, and the like. Such changes are not regarded as spelling changes conceived to produce a different name. In some instances, however, species-group names having variable spellings are regarded as homonyms as specified in the *Code* (Article 58).

Altered subsequent spellings other than the exceptions noted may be either intentional or unintentional. If "demonstrably intentional" (*Code,* Article 33), the change is designated as an emendation. Emendations may be either justifiable or unjustifiable. Justifiable emendations are corrections of incorrect original spellings, and these take the authorship and date of the original spellings. Unjustifiable emendations are names having their own status in nomenclature, with author and date of their publication. They are junior, objective synonyms of the name in its original form.

Subsequent spellings, if unintentional, are defined as incorrect subsequent spellings. They have no status in nomenclature, do not enter into homonymy, and cannot be used as replacement names.

AVAILABLE AND UNAVAILABLE NAMES

Editorial prefaces of some previous volumes of the *Treatise* have discussed in appreciable detail the availability of the many kinds of zoological names that have been proposed under a variety of circumstances. Much of that information, while important, does not pertain to the present volume, in which authors have used fewer terms for such names. The reader is referred to the *Code* (Articles 10 to 20) for further details on availability of names. Here, suffice it to say that an available zoological name is any that conforms to all mandatory provisions of the *Code.* All zoological names that fail to comply with mandatory provisions of the *Code* are unavailable and have no status in zoological nomenclature. Both available and unavailable names are classifiable into groups that have been recognized in previous volumes of the *Treatise,* although not explicitly differentiated in the *Code.* Among names that are available, these groups include inviolate names, perfect names, imperfect names, vain names, transferred names, improved or corrected names, substitute names, and conserved names. Kinds of unavailable names include naked names (see *nomina nuda* below), denied names, impermissible names, null names, and forgotten names.

Nomina nuda include all names that fail to satisfy provisions stipulated in Article 11 of the *Code,* which states general requirements of availability. In addition, they include names published before 1931 that were unaccompanied by a description, definition, or indication (*Code,* Article 12) and names published after 1930 that (1) lacked an accompanying statement of characters that differentiate the taxon, (2) were without a definite bibliographic reference to such a statement, (3) were not proposed expressly as a replacement (*nomen novum*) of a preexisting available name (*Code,* Article 13.1), or (4) for genus-group names, were unaccompanied by definite fixation of a type species by original designation or indication (*Code,* Article 13.2). *Nomina nuda* have no status in nomenclature, and they are not correctable to establish original authorship and date.

VALID AND INVALID NAMES

Important considerations distinguish valid from available names on the one hand and invalid from unavailable names on the other. Whereas determination of availability is based entirely on objective considerations guided by articles of the *Code,* conclusions as to validity of zoological names may be partly subjective. A valid name is the correct one for a given taxon, which may have two or more available names but only a single correct, hence valid, name, which is also generally the oldest name that it has been given. Obviously, no valid name can also be an unavailable name, but invalid names may be either available or unavailable. It follows that any name for a given taxon other than the valid name, whether available or unavailable, is an invalid name.

One encounters a sort of nomenclatorial no-man's land in considering the status of such zoological names as *nomina dubia* (doubtful names), which may include both available and unavailable names. The unavailable ones can well be ignored, but names considered to be available contribute to uncertainty and instability in the systematic literature. These can ordinarily be removed only by appeal to the ICZN for special action. Because few systematists care to seek such remedy, such invalid but available names persist in the literature.

NAME CHANGES IN RELATION TO GROUPS OF TAXONOMIC CATEGORIES

SPECIES-GROUP NAMES

Detailed consideration of valid emendation of specific and subspecific names is unnecessary here, both because the topic is well understood and relatively inconsequential and because the *Treatise* deals with genus-group names and higher categories. When the form of adjectival specific names is changed to agree with the gender of a generic name in transferring a species from one genus to another, one need never label the changed name as *nomen correctum.* Similarly, transliteration of a letter accompanied by a diacritical mark in the manner now called for by the *Code,* as in changing originally *bröggeri* to *broeggeri,* or eliminating a hyphen, as in changing originally published *cornu-oryx* to *cornuoryx,* does not require the designation *nomen correctum.* Of course, in this age of computers and electronic databases, such changes of name, which are perfectly valid for the purposes of scholarship, run counter to the requirements of nomenclatorial stability upon which the preparation of massive, electronic databases is predicated.

GENUS-GROUP NAMES

Conditions warranting change of the originally published, valid form of generic and subgeneric names are sufficiently rare that lengthy discussion is unnecessary. Only elimination of diacritical marks and hyphens in some names in this category and replacement of homonyms seem to furnish basis for valid emendation. Many names that formerly were regarded as homonyms are no longer so regarded, because two names that differ only by a single letter or in original publication by the presence of a diacritical mark in one are now construed to be entirely distinct (but see *Code,* Article 58).

As has been pointed out above, difficulty typically arises when one tries to decide whether a change of spelling of a name by a subsequent author was intentional or unintentional, and the decision has to be made often arbitrarily.

FAMILY-GROUP NAMES

Family-Group Names: Authorship and Date

All family-group taxa having names based on the same type genus are attributed to the author who first published the name of any of these groups, whether tribe, subfamily, or family (superfamily being almost inevitably a later-conceived taxon). Accordingly, if a family is divided into subfamilies or a subfamily into tribes, the name of no such subfamily or tribe can antedate the family name. Moreover, every family containing differentiated subfamilies must have a nominate subfamily (*sensu stricto*), which is based on the same type genus as the family. Finally, the author and date set down for the nominate subfamily invariably are identical with those of the family, irrespective of whether the author of the family or some subsequent author introduced subdivisions.

Corrections in the form of family-group names do not affect authorship and date of the taxon concerned, but in the *Treatise* recording the authorship and date of the correction is desirable because it provides a pathway to follow the thinking of the systematists involved.

Family-Group Names: Use of *nomen translatum*

The *Code* (Article 29.2) specifies the suffixes for tribe (-ini), subfamily (-inae), family (-idea) and superfamily (-oidea), the formerly widely used ending (-acea) for superfamily having been disallowed. All these family-group categories are defined as coordinate (*Code*, Article 36.1): "A name established for a taxon at any rank in the family group is deemed to have been simultaneously established for nominal taxa at other ranks in the family group; all these taxa have the same type genus, and their names are formed from the stemof the name of the type genus (Art. 29.3] with appropriate change of suffix [Art. 34.1]. The name has the same authorship and date at every rank." Such changes of rank and concomitant changes of endings as elevation of a subfamily to family rank or of a family to superfamily rank, if introduced subsequent to designation of the original taxon or based on the same nominotypical genus, are *nomina translata*. In the *Treatise* it is desirable to distinguish the valid alteration in the changed ending of each transferred family-group name by the term *nomen translatum,* abbreviated to *nom. transl.* Similarly for clarity, authors should record the author, date, and page of the alteration, as in the following example.

Family HEXAGENITIDAE Lameere, 1917

[*nom. transl.* Demoulin, 1954, p. 566, *ex* Hexagenitinae Lameere, 1917, p. 74]

This is especially important for superfamilies, for the information of interest is the author who initially introduced a taxon rather than the author of the superfamily as defined by the *Code.* For example:

Superfamily AGNOSTOIDEA M'Coy, 1849

[*nom. transl.* Shergold, Laurie, & Sun, 1990, p. 32, *ex* Agnostinae M'Coy, 1849, p. 402]

The latter is merely the individual who first defined some lower-ranked, family-group taxon that contains the nominotypical genus of the superfamily. On the other hand, the publication that introduces the superfamily by *nomen translatum* is likely to furnish the information on taxonomic considerations that support definition of the taxon.

Family-Group Names: Use of *nomen correctum*

Valid name changes classed as *nomina correcta* do not depend on transfer from one category of the family group to another but most commonly involve correction of the stem of the nominotypical genus. In addition, they include somewhat arbitrarily chosen modifications of endings for names of tribes or superfamilies. Examples of the use of *nomen correctum* are the following.

Family STREPTELASMATIDAE Nicholson, 1889

[*nom. correct.* Wedekind, 1927, p. 7, *pro* Streptelasmidae Nicholson in Nicholson & Lydekker, 1889, p. 297]

Family PALAEOSCORPIDAE Lehmann, 1944

[*nom. correct.* Petrunkevitch, 1955, p. 73, *pro* Palaeoscorpionidae Lehmann, 1944, p. 177]

Family-Group Names: Replacements

Family-group names are formed by adding combinations of letters, which are prescribed for all family-group categories, to the stem of the name belonging to the nominotypical genus first chosen as type of the assemblage. The type genus need not be the first genus in the family to have been named and defined, but among all those included it must be the first published as name giver to a family-group taxon. Once fixed, the family-group name remains tied to the nominotypical genus even if the generic name is changed by reason of status as a junior homonym or junior synonym, either objective or subjective. Seemingly, the *Code* requires replacement of a family-group name only if the nominotypical genus is found to have been a junior homonym when it was proposed (*Code,* Article 39), in which case ". . . it must be replaced either by the next oldest available name from among its synonyms [Art. 23.3.5], including the names of its subordinate family-group taxa, or, if there is no such synonym, by a new name based on the valid name . . . of the former type genus."

Authorship and date attributed to the replacement family-group name are determined by first publication of the changed family-group name. Recommendation 40A of the *Code,* however, specifies that for subsequent application of the rule of priority, the family-group name ". . . should be cited with its original author and date (see Recommendation 22A.2.2), followed by the date of its priority as determined by this Article; the date of priority should be enclosed in parentheses." Many family-group names that have been in use for a long time are *nomina nuda,* since they fail to satisfy criteria of availability (*Code,* Article 11.7). These demand replacement by valid names.

The aim of family-group nomenclature is to yield the greatest possible stability and uniformity, just as in other zoological names. Both taxonomic experience and the *Code* (Article 40) indicate the wisdom of sustaining family-group names based on junior subjective synonyms if they have priority of publication, for opinions of the same worker may change from time to time. The retention of first-published, family-group names that are found to be based on junior objective synonyms, however, is less clearly desirable, especially if a replacement name derived from the senior objective synonym has been recognized very long and widely. Moreover, to displace a widely used, family-group name based on the senior objective synonym by disinterring a forgotten and virtually unused family-group name based on a junior objective synonym because the latter happens to have priority of publication is unsettling.

A family-group name may need to be replaced if the nominotypical genus is transferred to another family group. If so, the first-published of the generic names remaining in the family-group taxon is to be recognized in forming a replacement name.

SUPRAFAMILIAL TAXA: TAXA ABOVE FAMILY-GROUP

International rules of zoological nomenclature as given in the *Code* affect only lower-rank categories: subspecies to superfamily. Suprafamilial categories (suborder to kingdom) are either not mentioned or explicitly placed outside of the application of zoological rules. The *Copenhagen Decisions on Zoological Nomenclature* (1953, Articles 59 to 69) proposed adopting rules for naming suborders and higher taxa up to and including phylum, with provision for designating a type genus for each, in such manner as not to interfere with the taxonomic freedom of workers. Procedures were outlined for applying the rule of priority and rule of homonymy to suprafamilial taxa and for dealing with the names of such taxa and their authorship, with assigned dates, if they should be transferred on taxonomic grounds from one rank to another. The adoption of terminations of names, different for each category but uniform within each, was recommended.

The Colloquium on Zoological Nomenclature, which met in London during the week just before the 15th International Congress of Zoology convened in 1958, thoroughly discussed the proposals for regulating suprafamilial nomenclature, as well as many others advocated for inclusion in the new *Code* or recommended for exclusion from it. A decision that was supported by a wide majority of the participants in the colloquium was against the establishment of rules for naming taxa above family-group rank, mainly because it was judged that such regulation would unwisely tie the hands of taxonomists. For example, a class or order defined by an author at a given date, using chosen morphologic characters (*e.g.,* gills of bivalves), should not be allowed to freeze nomenclature, taking precedence over another class or order that is proposed later and distinguished by different characters (*e.g.,* hinge teeth of bivalves). Even the fixing of type genera for suprafamilial taxa would have little, if any, value, hindering taxonomic work rather than aiding it. Beyond mere tidying up, no basis for establishing such types and for naming these taxa has yet been provided.

The considerations just stated do not prevent the editors of the *Treatise* from making rules for dealing with suprafamilial groups of animals described and illustrated in this publication. Some uniformity is needed, especially for the guidance of *Treatise* authors. This policy should accord with recognized general practice among zoologists; but where general practice is indeterminate or nonexistent, our own procedure in suprafamilial nomenclature needs to be specified as clearly as possible. This pertains especially to decisions about names themselves, about citation of authors and dates, and about treatment of suprafamilial taxa that, on taxonomic grounds, are changed from their originally assigned rank. Accordingly, a few rules expressing *Treatise* policy are given here, some with examples of their application.

1. The name of any suprafamilial taxon must be a Latin or Latinized, uninominal noun of plural form or treated as such, with a capital initial letter and without diacritical mark, apostrophe, diaeresis, or hyphen. If a component consists of a numeral, numerical adjective, or adverb, this must be written in full.

2. Names of suprafamilial taxa may be constructed in almost any manner. A name may indicate morphological attributes (*e.g.,* Lamellibranchiata, Cyclostomata, Toxoglossa) or be based on the stem of an included genus (*e.g.,* Bellerophontina, Nautilida, Fungiina) or on arbitrary combinations of letters (*e.g.,* Yuania); none of these, however, can end in -idae or -inae, which terminations are reserved for family-group taxa. No suprafamilial name identical in form to that of a genus or to another published suprafamilial name should be employed (*e.g.,* order Decapoda LATREILLE, 1803, crustaceans, and order Decapoda LEACH, 1818, cephalopods; suborder Chonetoidea MUIR-WOOD, 1955, and genus *Chonetoidea* JONES, 1928). Worthy of notice is the classificatory and nomenclatorial distinction between suprafamilial and family-group taxa that, respectively, are named from the same type genus, since one is not considered to be transferable to the other (*e.g.,* suborder Bellerophontina ULRICH & SCOFIELD, 1897 is not coordinate with superfamily Bellerophontacea MCCOY, 1851 or family Bellerophontidae MCCOY, 1851).

3. The rules of priority and homonymy lack any force of international agreement as applied to suprafamilial names, yet in the interest of nomenclatorial stability and to avoid confusion these rules are widely applied by zoologists to taxa above the family-group level wherever they do not infringe on taxonomic freedom and long-established usage.

4. Authors who accept priority as a determinant in nomenclature of a suprafamilial taxon may change its assigned rank at will, with or without modifying the terminal letters of the name, but such changes cannot rationally be judged to alter the authorship and date of the taxon as published originally. A name revised from its previously published rank is a transferred name (*nomen translatum*), as illustrated in the following.

Order CORYNEXOCHIDA
Kobayashi, 1935

[*nom. transl.* MOORE, 1959, p. 217, *ex* suborder Corynexochida KOBAYASHI, 1935, p. 81]

A name revised from its previously published form merely by adoption of a different termination without changing taxonomic rank is a *nomen correctum.*

Order DISPARIDA
Moore & Laudon, 1943

[*nom. correct.* MOORE in MOORE, LALICKER, & FISCHER, 1952, p. 613, *pro* order Disparata MOORE & LAUDON, 1943, p. 24]

A suprafamilial name revised from its previously published rank with accompanying change of termination, which signals the change of rank, is recorded as a *nomen translatum et correctum.*

Order HYBOCRINIDA
Jaekel, 1918

[*nom. transl. et correct.* MOORE in MOORE, LALICKER, & FISCHER, 1952, p. 613, *ex* suborder Hybocrinites JAEKEL, 1918, p. 90]

5. The authorship and date of nominate subordinate and supraordinate taxa among suprafamilial taxa are considered in the *Treatise* to be identical since each actually or potentially has the same type. Examples are given below.

Subclass ENDOCERATOIDEA Teichert, 1933

[*nom. transl.* Teichert in Teichert & others, 1964, p. 128, *ex* order Endoceroidea Teichert, 1933, p. 214]

Order ENDOCERIDA Teichert, 1933

[*nom. correct.* Teichert in Teichert & others, 1964, p. 165, *pro* order Endoceroidea Teichert, 1933, p. 214]

TAXONOMIC EMENDATION

Emendation has two distinct meanings as regards zoological nomenclature. These are alteration of a name itself in various ways for various reasons, as has been reviewed, and alteration of the taxonomic scope or concept for which a name is used. The *Code* (Article 33.1 and Glossary) concerns itself only with the first type of emendation, applying the term to intentional, either justified or unjustified changes of the original spelling of a name. The second type of emendation primarily concerns classification and inherently is not associated with change of name. Little attention generally has been paid to this distinction in spite of its significance.

Most zoologists, including paleontologists, who have emended zoological names refer to what they consider a material change in application of the name such as may be expressed by an importantly altered diagnosis of the assemblage covered by the name. The abbreviation *emend.* then must accompany the name with statement of the author and date of the emendation. On the other hand, many systematists think that publication of *emend.* with a zoological name is valueless because alteration of a taxonomic concept is introduced whenever a subspecies, species, genus, or other taxon is incorporated into or removed from a higher zoological taxon. Inevitably associated with such classificatory expansions and restrictions is some degree of emendation affecting diagnosis. Granting this, still it is true that now and then somewhat more extensive revisions are put forward, generally with a published statement of the reasons for changing the application of a name. To erect a signpost at such points of most significant change is worthwhile, both as an aid to subsequent workers in taking account of the altered nomenclatorial usage and to indicate where in the literature cogent discussion may be found. Authors of contributions to the *Treatise* are encouraged to include records of all especially noteworthy emendations of this nature, using the abbreviation *emend.* with the name to which it refers and citing the author, date, and page of the emendation. Examples from *Treatise* volumes follow.

Order ORTHIDA Schuchert & Cooper, 1932

[*nom. transl. et correct.* Moore in Moore, Lalicker, & Fischer, 1952, p. 220, *ex* suborder Orthoidea Schuchert & Cooper, 1932, p. 43; *emend.,* Williams & Wright, 1965, p. 299]

Subfamily ROVEACRININAE Peck, 1943

[Roveacrininae Peck, 1943, p. 465; *emend.,* Peck in Moore & Teichert, 1978, p. 921]

STYLE IN GENERIC DESCRIPTIONS

CITATION OF TYPE SPECIES

In the *Treatise* the name of the type species of each genus and subgenus is given immediately following the generic name with its accompanying author, date, and page reference or after entries needed for definition of the name if it is involved in homonymy. The originally published combination of generic and trivial names of this species is cited, accompanied by an asterisk (*), with notation of the author, date, and page of original publication, except if the species was first published in the same paper and by the same author as that containing definition of the genus of which it is the type. In this instance, the initial letter of the generic name followed by the trivial name is given without repeating the name of the author and date. Examples of these two sorts of citations follow.

Orionastraea SMITH, 1917, p. 294 [**Sarcinula phillipsi* McCOY, 1849, p. 125; OD].

Schoenophyllum SIMPSON, 1900, p. 214 [**S. aggregatum;* OD].

If the cited type species is a junior synonym of some other species, the name of this latter is given also, as follows.

Actinocyathus D'ORBIGNY, 1849, p. 12 [**Cyathophyllum crenulate* PHILLIPS, 1836, p. 202; M; =*Lonsdaleia floriformis* (MARTIN), 1809, pl. 43; validated by ICZN Opinion 419].

In some instances the type species is a junior homonym. If so, it is cited as shown in the following example.

Prionocyclus MEEK, 1871b, p. 298 [**Ammonites serratocarinatus* MEEK, 1871a, p. 429, *non* STOLICZKA, 1864, p. 57; =*Prionocyclus wyomingensis* MEEK, 1876, p. 452].

In the *Treatise* the name of the type species is always given in the exact form it had in the original publication except that diacritical marks have been removed. Where other mandatory changes are required, these are introduced later in the text, typically in the description of a figure.

Fixation of Type Species Originally

It is desirable to record the manner of establishing the type species, whether by original designation (OD) or by subsequent designation (SD). The type species of a genus or subgenus, according to provisions of the *Code,* may be fixed in various ways in the original publication; or it may be fixed subsequently in ways specified by the *Code* (Article 68) and described in the next section. Type species fixed in the original publication include (1) *original designation* (in the *Treatise* indicated by OD) when the type species is explicitly stated or (before 1931) indicated by n. gen., n. sp. (or its equivalent) applied to a single species included in a new genus, (2) defined by use of *typus* or *typicus* for one of the species included in a new genus (adequately indicated in the *Treatise* by the specific name), (3) established by *monotypy* if a new genus or subgenus has only one originally included species (in the *Treatise* indicated as M), and (4) fixed by *tautonymy* if the genus-group name is identical to an included species name not indicated as the type.

Fixation of Type Species Subsequently

The type species of many genera are not determinable from the publication in which the generic name was introduced. Therefore, such genera can acquire a type species only by some manner of subsequent designation. Most commonly this is established by publishing a statement naming as type species one of the species originally included in the genus. In the *Treatise* such fixation of the type species by subsequent designation in this manner is indicated by the letters SD accompanied by the name of the subsequent author (who may be the same person as the original author) and the publication date and page number of the subsequent designation. Some genera, as first described and named, included no mentioned species (for such genera established after 1930, see below); these necessarily lack a type species until a date subsequent to that of the original publication when one or more species is assigned to such a genus. If only a single species is thus assigned, it becomes automatically the type species. Of course, the first publication containing assignment of species to the genus that originally lacked any included species is the one concerned in fixation of the type species, and if this publication names two or more species as belonging to the genus but did not designate a type species, then a later SD designation is necessary. Examples of the use of SD as employed in the *Treatise* follow.

Hexagonaria GURICH, 1896, p. 171 [**Cyathophyllum hexagonum* GOLDFUSS, 1826, p. 61; SD LANG, SMITH, & THOMAS, 1940, p. 69].

Mesephemera HANDLIRSCH, 1906, p. 600 [**Tineites lithophilus* GERMAR, 1842, p. 88; SD CARPENTER, herein].

Another mode of fixing the type species of a genus is through action of the International

Commission of Zoological Nomenclature using its plenary powers. Definition in this way may set aside application of the *Code* so as to arrive at a decision considered to be in the best interest of continuity and stability of zoological nomenclature. When made, it is binding and commonly is cited in the *Treatise* by the letters ICZN, accompanied by the date of announced decision and reference to the appropriate numbered opinion.

Subsequent designation of a type species is admissible only for genera established prior to 1931. A new genus-group name established after 1930 and not accompanied by fixation of a type species through original designation or original indication is invalid (*Code,* Article 13.3). Effort of a subsequent author to validate such a name by subsequent designation of a type species constitutes an original publication making the name available under authorship and date of the subsequent author.

HOMONYMS

Most generic names are distinct from all others and are indicated without ambiguity by citing their originally published spelling accompanied by name of the author and date of first publication. If the same generic name has been applied to two or more distinct taxonomic units, however, it is necessary to differentiate such homonyms. This calls for distinction between junior homonyms and senior homonyms. Because a junior homonym is invalid, it must be replaced by some other name. For example, *Callophora* HALL, 1852, introduced for Paleozoic trepostomate bryozoans, is invalid because Gray in 1848 published the same name for Cretaceous–Holocene cheilostomate bryozoans. Bassler in 1911 introduced the new name *Hallophora* to replace Hall's homonym. The *Treatise* style of entry is given below.

Hallophora BASSLER, 1911, p. 325, *nom. nov. pro Callophora* HALL, 1852, p. 144, *non* GRAY, 1848.

In like manner, a replacement generic name that is needed may be introduced in the *Treatise* (even though first publication of generic names otherwise in this work is generally avoided). An exact bibliographic reference must be given for the replaced name as in the following example.

Mysterium DE LAUBENFELS, herein, *nom. nov. pro Mystrium* SCHRAMMEN, 1936, p. 183, *non* ROGER, 1862 [**Mystrium porosum* SCHRAMMEN, 1936, p. 183; OD].

Otherwise, no mention is made generally of the existence of a junior homonym.

Synonymous Homonyms

An author sometimes publishes a generic name in two or more papers of different date, each of which indicates that the name is new. This is a bothersome source of errors for later workers who are unaware that a supposed first publication that they have in hand is not actually the original one. Although the names were published separately, they are identical and therefore definable as homonyms; at the same time they are absolute synonyms. For the guidance of all concerned, it seems desirable to record such names as synonymous homonyms. In the *Treatise* the junior of one of these is indicated by the abbreviation *jr. syn. hom.*

Not infrequently, identical family-group names are published as new names by different authors, the author of the name that was introduced last being ignorant of previous publication(s) by one or more other workers. In spite of differences in taxonomic concepts as indicated by diagnoses and grouping of genera and possibly in assigned rank, these family-group taxa, being based on the same type genus, are nomenclatorial homonyms. They are also synonyms. Wherever encountered, such synonymous homonyms are distinguished in the *Treatise* as in dealing with generic names.

A rare but special case of homonymy exists when identical family names are formed from generic names having the same stem but differing in their endings. An example is the family name Scutellidae RICHTER & RICHTER, 1925, based on *Scutellum* PUSCH, 1833, a trilobite. This name is a junior homonym of Scutellidae GRAY, 1825, based on the echinoid genus *Scutella* LAMARCK, 1816.

The name of the trilobite family was later changed to Scutelluidae (ICZN, Opinion 1004, 1974).

SYNONYMS

In the *Treatise,* citation of synonyms is given immediately after the record of the type species. If two or more synonyms of differing date are recognized, these are arranged in chronological order. Objective synonyms are indicated by accompanying designation *obj.,* others being understood to constitute subjective synonyms, of which the types are also indicated. Examples showing *Treatise* style in listing synonyms follow.

Mackenziephyllum PEDDER, 1971, p. 48 [**M. insolitum;* OD] [=*Zonastraea* TSYGANKO in SPASSKIY, KRAVTSOV, & TSYGANKO, 1971, p. 85, *nom. nud.; Zonastraea* TSYGANKO, 1972, p. 21 (type, *Z. graciosa,* OD)].

Kodonophyllum WEDEKIND, 1927, p. 34 [**Streptelasma Milne-Edwardsi* DYBOWSKI, 1873, p. 409; OD; =*Madrepora truncata* LINNE, 1758, p. 795, see SMITH & TREMBERTH, 1929, p. 368] [=*Patrophontes* LANG & SMITH, 1927, p. 456 (type, *Madrepora truncata* LINNE, 1758, p. 795, OD); *Codonophyllum* LANG, SMITH, & THOMAS, 1940, p. 39, obj.].

Some junior synonyms of either the objective or the subjective sort may be preferred over senior synonyms whenever uniformity and continuity of nomenclature are served by retaining a widely used but technically rejectable name for a genus. This requires action of the ICZN, which may use its plenary powers to set aside the unwanted name, validate the wanted one, and place the concerned names on appropriate official lists.

OTHER EDITORIAL MATTERS

BIOGEOGRAPHY

Purists, *Treatise* editors among them, would like nothing better than a stable world with a stable geography that makes possible a stable biogeographical classification. Global events of the past few years have shown how rapidly geography can change, and in all likelihood we have not seen the last of such change as new, so-called republics continue to spring up all over the globe. One expects confusion among readers in the future as they try to decipher such geographical terms as U.S.S.R., Yugoslavia, or Ceylon. Such confusion is unavoidable, as books must be completed and published at some real time. Libraries would be limited indeed if publication were always to be delayed until the political world had settled down. In addition, such terms as central Europe and western Europe are likely to mean different things to different people. Some imprecision is introduced by the use of all such terms, of course, but it is probably no greater than the imprecision that stems from the fact that the work of paleontology is not yet finished, and the geographical ranges of many genera are imperfectly known.

Special considerations are necessary when referring to parts of the former Soviet Union. To some authors the term Central Asia, referring to Uzbekistan, Turkmenistan, Tadzhikistan, Kirgizistan, and sometimes all or part of Kazakhstan, has a distinct meaning from the less formal term central Asia, which is used more widely in the West. Accordingly, we have attempted to substitute the Russian term *Srednii Azii* to refer to Central Asia, as opposed to central Asia. Unfortunately, we are by no means certain that we have been fully consistent in this usage throughout the volume.

Other geographic terms can also have varying degrees of formality. In general, *Treatise* policy is to use adjectives rather than nouns to refer to directions. Thus we have used *southern* and *western* in place of *South* and *West* unless a term has been formally defined as a geographic entity (e.g., South America or West Virginia). Note that we have referred to western Texas rather than West Texas, which is said to be not a state but a state of mind.

NAMES OF AUTHORS: TRANSLATION AND TRANSLITERATION

Chinese scientists have become increasingly active in systematic paleontology in the past two decades. Chinese names cause anguish among English-language bibliographers for two reasons. First, no scheme exists for one-to-one transliteration of Chinese characters into roman letters. Thus, a Chinese author may change the roman-letter spelling of his name from one publication to another. For example, the name Chang, the most common family name in the world reportedly held by some one billion people, has been spelled more recently Zhang. The principal purpose of a bibliography is to provide the reader with entry into the literature. Quite arbitrarily, therefore, in the interest of information retrieval, the *Treatise* editorial staff has decided to retain the roman spelling that a Chinese author has used in each of his publications rather than attempting to adopt a common spelling of an author's name to be used in all citations of his work. It is entirely possible, therefore, that the publications of a Chinese author may be listed in more than one place under more than one name in the bibliography.

Second, most but by no means all Chinese list their family name first followed by given names. People with Chinese names who study in the West, however, often reverse the order, putting the family name last as is the Western custom. Thus, for example, Dr. Yi-Maw Chang, formerly of the staff of the Paleontological Institute, was Chang Yi-Maw when he lived in Taiwan. When he came to America, he became Yi-Maw Chang. In the *Treatise,* authors' names are used in the text and listed in the references as they appear in the source being cited.

Several systems exist for transliterating the Cyrillic alphabet into the roman alphabet. On the recommendation of skilled bibliographic librarians, we have adopted the American Library Association/Library of Congress romanization table for Russian and other languages using the Cyrillic alphabet.

MATTERS SPECIFIC TO THIS VOLUME

Some languages, in this volume most notably the Polish and Czech languages, are enriched with the use of diacritical marks that provide enhanced alphabetical diversity. While celebrating diversity, we have nevertheless elected to omit such marks from Polish and Czech geographical terms used in the *Treatise*. We continue to insert diacritical marks in authors' names and in such geological series names as Přídolí. Two factors have led us to this editorial decision. First, we in the *Treatise* editorial office typeset electronically all the pages, and such diacritical marks must be inserted by hand into the final computer-prepared pages. This is a costly and time-consuming operation that is fraught with the possibility of introducing errors. Second, in the burgeoning information age of the new millennium, databases and schemes for information retrieval will be of critical importance in managing paleontological information. Stability and uniformity of terminology are requisites of database-management systems, and the use of diacritical marks and computer technology are likely to remain incompatible for some time to come. We hope that linguistic purists will be tolerant of this transgression, which we have undertaken solely in the interest of expediency, consistency, and information retrieval.

False cognates are the bane of inexperienced translators. The transliterated Russian term *gorizont*, usually translated *horizon*, is one such false cognate. The term horizon, of course, has no formal status in stratigraphic nomenclature and, in fact, should be used to refer to a surface and not to a thickness of strata. Thus, fossils cannot occur in a horizon, but their ranges may begin or end at a horizon. In some places we have translated *gorizont* as *beds*; in others, where *beds* is not an adequate usage, we have translated it as *stage*.

Authorship entails both credit and responsibility. As the knowledge of paleontology grows and paleontologists become more specialized, preparation of *Treatise* volumes must necessarily involve larger and larger teams of researchers, each focusing on increasingly narrow aspects of the higher taxon under revision. In this volume, we have taken special pains to acknowledge authorship of small subsections. Readers citing the volume are encouraged to pay close attention to the actual authorship of a section or subsection.

Stratigraphic ranges of taxa have been compiled from the ranges of lower taxa. In all instances, we have used the *range-through* method of describing ranges. In instances, therefore, where the work of paleontology is not yet finished, some ranges of higher taxa will not show gaps between the ranges of their subtaxa and may seem to be more complete than the data warrant. Stratigraphic range charts typical of previous *Treatise* volumes will present a much more precise picture of the biostratigraphy of the brachiopods. The range chart for this revision on the Brachiopoda will be presented in the final volume of the series.

ACKNOWLEDGMENTS

The Paleontological Institute's Assistant Editor for Text, Jill Hardesty, and the Assistant Editor for Illustrations, Jane Kerns, have faced admirably the formidable task of moving this volume through the various stages of editing and into production. In this they have been ably assisted by other members of the editorial team including Mike Cormack with his outstanding computer skills, Denise Mayse with her work on illustrations and general support, and Sounithta Vilayvanh and Seresha Williams with their work on illustrations. The editorial team would also like to extend special thanks to Dr. Albert J. Rowell for his support and help with various taxonomic and manuscript issues and to Dr. Stephen T. Hasiotis and Dr. Bruce S. Lieberman for their support and guidance.

Many colleagues throughout the world provided invaluable assistance by scanning or photographing figures and verifying points of nomenclature and references. Our thanks to the following people, without whose help the quality of the illustrations and text in this volume would have suffered: Danielle Décrouez, Museum d'histoire naturelle de la Ville de Génève; Daniele Gaspard, Université de Paris-Sud, Orsay; Rémy Gourvennec, Université de Bretagne Occidentale; Carsten Lüter, Humboldt-Universität zu Berlin; Stephen Read, University of Otago; Tanya Smirnova, Moscow State University; Shen Shuzhong, Nanjing Institute of Geology and Palaeontology; Milos Siblík, Academy of Sciences of the Czech Republic; Sun Yuanlin, Peking University; Zhan Renbin, Chinese Academy of Sciences; Zhang Xiaoping, Nanjing Institute of Geology and Palaeontology.

This editorial preface and other, recent ones are extensive revisions of the prefaces prepared for previous *Treatise* volumes by former editors, including the late Raymond C. Moore, the late Curt Teichert, and Richard A. Robison. I am indebted to them for preparing earlier prefaces and for the leadership they have provided in bringing the *Treatise* project to its present status.

Finally, on behalf of the members of the staff of the Paleontological Institute, both past and present, it is my privilege to honor the memory of the late Sir Alwyn Williams by expressing gratitude for the unwavering scholarship, dedication to the task, and scrupulous attention to detail that marked his involvement with this project from the outset and, indeed, throughout his entire career as a specialist on the Brachiopoda.

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Roger L. Kaesler
Lawrence, Kansas
March 9, 2006

STRATIGRAPHIC DIVISIONS

The major divisions of the geological time scale are reasonably well established throughout the world, but minor divisions (*e.g.,* subseries, stages, and substages) are more likely to be provincial in application. The stratigraphical units listed here represent an authoritative version of the stratigraphic column for all taxonomic work relating to the revision of Part H. They are adapted from the International Union of Geological Sciences 1989 Global Stratigraphic Chart, compiled by J. W. Cowie and M. G. Bassett. An updated time scale was published by the IUGS and UNESCO in 2000.

Cenozoic Erathem
- **Quaternary System**
  - Holocene Series
  - Pleistocene Series
- **Neogene System**
  - Pliocene Series
  - Miocene Series
- **Paleogene System**
  - Oligocene Series
  - Eocene Series
  - Paleocene Series

Mesozoic Erathem
- **Cretaceous System**
  - Upper Cretaceous Series
  - Lower Cretaceous Series
- **Jurassic System**
  - Upper Jurassic Series
  - Middle Jurassic Series
  - Lower Jurassic Series
- **Triassic System**
  - Upper Triassic Series
  - Middle Triassic Series
  - Lower Triassic Series

Paleozoic Erathem
- **Permian System**
  - Upper Permian Series
  - Lower Permian Series

Carboniferous System
- Upper Carboniferous Subsystem
  - Stephanian Series
  - Westphalian Series
  - Namurian Series (part)
- Lower Carboniferous Subsystem
  - Namurian Series (part)
  - Viséan Series
  - Tournaisian Series

Devonian System
- Upper Devonian Series
- Middle Devonian Series
- Lower Devonian Series

Silurian System
- Prídolí Series
- Ludlow Series
- Wenlock Series
- Llandovery Series

Ordovician System
- Upper Ordovician Subsystem
  - Cincinnatian Series
  - Champlainian Series (part)
- Lower Ordovician Subsystem
  - Champlainian Series (part)
  - Canadian Series

Cambrian System
- Upper Cambrian Series
- Middle Cambrian Series
- Lower Cambrian Series

COORDINATING AUTHOR'S PREFACE

C. Howard C. Brunton

assisted by Gordon B. Curry

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Alwyn Williams, the coordinating author of both the original (Williams, 1965) and this revised brachiopod *Treatise,* died on 4 April 2004. He was a great man, a great organizer, and a dedicated brachiopodologist to the end. Those who were privileged to be among his friends and colleagues will long remember and treasure his company, inspiration, humor, and insight. We will miss him greatly, and all our sympathies go out to his widow Joan and the rest of the family.

A full appreciation of Alywn Williams's contribution to paleontology will appear in the introduction to the final volume of this series (volume 6), but it is appropriate here to reflect briefly on the pivotal role that he has played in the publication of the brachiopod *Treatise*—by any standards it is a monumental achievement. His organizational and motivational skills are readily apparent when considering the speed at which this revised brachiopod *Treatise* has been published. Work on this project started in earnest in 1990, and when the final volume appears (expected in late 2006 or early 2007), nearly 3,250 pages will have been published. It is thought that no other series of *Treatise* volumes has been published at such a rate (around 203 pages per year for 16 years); for some a rate of 50 pages per year is more usual. It is clear that without the determination and drive of Alwyn Williams, the brachiopod *Treatise* would not now be approaching a conclusion—instead we would be fortunate to be about halfway through the current revision.

The present volume, number five in the series, completes the taxonomic revision of all major groups of brachiopods; it contains the descriptions of about 1,225 genera distributed among the spire- and loop-bearing brachiopods that dominated Mesozoic to recent brachiopod faunas. Much of what Alwyn Williams wrote in the Introduction for volume 4 (Williams, 2002) about the systematics and methods of study hold good for the taxa included here. This is the only volume without cladograms as a support for classifying an order. One group in particular, the Thecideida, has attracted diverse views as to their relationships, the main contenders being the strophomenates (e.g., Rudwick, 1968; Pajaud, 1970; Grant, 1972; and Dagys, 1973) and the Spiriferida (e.g., Williams, 1973; Baker, 1990, 1991). More recently cladistic methods have been applied to this question by Jaecks (2001) and by Jaecks and Carlson (2001). The debate is focused currently on the reliability of characters used in the cladistic approach when applied to groups possibly displaying convergence, as compared to the morphological approach in which some characters that are considered important, such as differences in the processes of shell growth, lead to the support of a spiriferide relationship (see the Thecideida, p. 1,938 herein). These and other debates will undoubtedly continue, but it is an enduring tribute to Alwyn Williams that the raw data on which such scientific debates must be based has been presented so quickly and to such a high standard in these *Treatise* volumes.

One further volume of the brachiopod *Treatise* is in preparation, and this volume (number 6) will present descriptions of all genera that have been described since the *Treatise* authors submitted their final manuscripts for publication in *Treatise* volumes 2 to 5. These additional taxonomic descriptions ensure, as Alywn Williams had always planned, that when the final volume of the revised *Treatise* has been published, it will contain the most-up-to-date survey of brachiopod genera possible. This supplementary volume will also contain review and update chapters on anatomy, biochemistry, and the brachiopod shell, the genome, Holocene brachiopod distributions, some views on the evolution of the group, a complete analysis of the stratigraphic distributions of all brachiopod groups, a stratigraphic range chart of all included genera, and an extensive bibliography compiled from all previous volumes in the brachiopod series.

Although Alwyn Williams died before he could write this introduction, some of his intentions were clear. An important item was to be a single diagram showing the stratigraphic distribution of taxa described in each of the *Treatise* volumes dealing with systematic descriptions (i.e., volumes 2 to 5). Such a diagram would emerge as a direct consequence of stratigraphic information supplied from the Kansas *Treatise* office and analysis carried out in Glasgow for a review chapter in volume 6. The main difference between this diagram and those to be presented in volume 6 is that the stratigraphic ranges are presented here for all taxa in each volume, rather than for different taxonomic groupings, as will appear in volume 6. The aim, therefore, is to present a simple graphical summary of how the immense effort of compiling this data over 16 years had contributed to a uniquely complete understanding of how brachiopods were distributed through the Phanerozoic.

The diagram (Fig. 1101) summarizes this data by geological period (although each curve has 113 plot points corresponding to the stages in the 1989 International Union of Geological Sciences [IUGS] stratigraphic chart), and the vertical axis is the number of genera recorded in each stage (i.e., a simple total diversity curve). All questionable taxa and all uncertain stratigraphic occurrence records (i.e., all those marked by a question mark) were excluded from the analyses. A more detailed description of the methodology adopted for the stratigraphic analyses will be given in volume 6. In effect the graph shows total brachiopod generic diversity in each stage from the Tommotian (at the base of the Cambrian Period) through to those living in the seas today, a period of about 540 million years (based on the absolute age dates from the 1989 IUGS Stratigraphic Chart used in the compilation of these *Treatise* volumes (COWIE & BASSETT, 1989); the most recent compilation of the Geological Time Scale cites 542 million years for the base of the Cambrian Period (GRADSTEIN, OGG, & SMITH, 2004).

Volume 2 appeared in 2000 and contained the systematic descriptions of the entire subphyla Linguiformea and Craniiformea and the classes Chileida, Obollellata, and Kutorginata from the subphylum Rhynchonelliformea. It also provided stratigraphic information for all genera in the order Strophemenida and part of the order Productida (both included in the class Strophomenata). These diverse taxa were major components of the initial radiation of the brachiopods during the Cambrian Period (widely known as the Cambrian fauna; SEPKOSKI, 1981) and became even more diverse during the so-called Great Ordovician Biodiversification Event (WEBBY & others, 2004). The taxa described in volume 2 account for around half of all brachiopods present during the Ordovician Period. The sharp increase in diversity of volume 2 taxa during early stages of the Devonian Period results almost entirely from the inclusion of strophomenate stocks, as is the more gentle increase in diversity seen in the Permian Period. The increasing numbers of brachiopods recorded in volume 2 for the Permian and Devonian Periods were the first signs of the major diversification events in which brachiopods achieved their greatest recorded biodiversity during these two periods. The richness of brachiopod diversity during these times undoubtedly owes much to good fossil preservation in, and comprehensive exposure of, Devonian and Permian rocks and to the monographic work of such prolific brachiopod workers as HAVLÍČEK (in a series of papers from 1949), SARTENAER (in a series of papers from 1955), COOPER (for example, 1956), COOPER and GRANT (from 1969 to 1976), and WATERHOUSE (1964–1988, 2001, 2004). Unquestionably, however, brachiopods exhibited tremendous

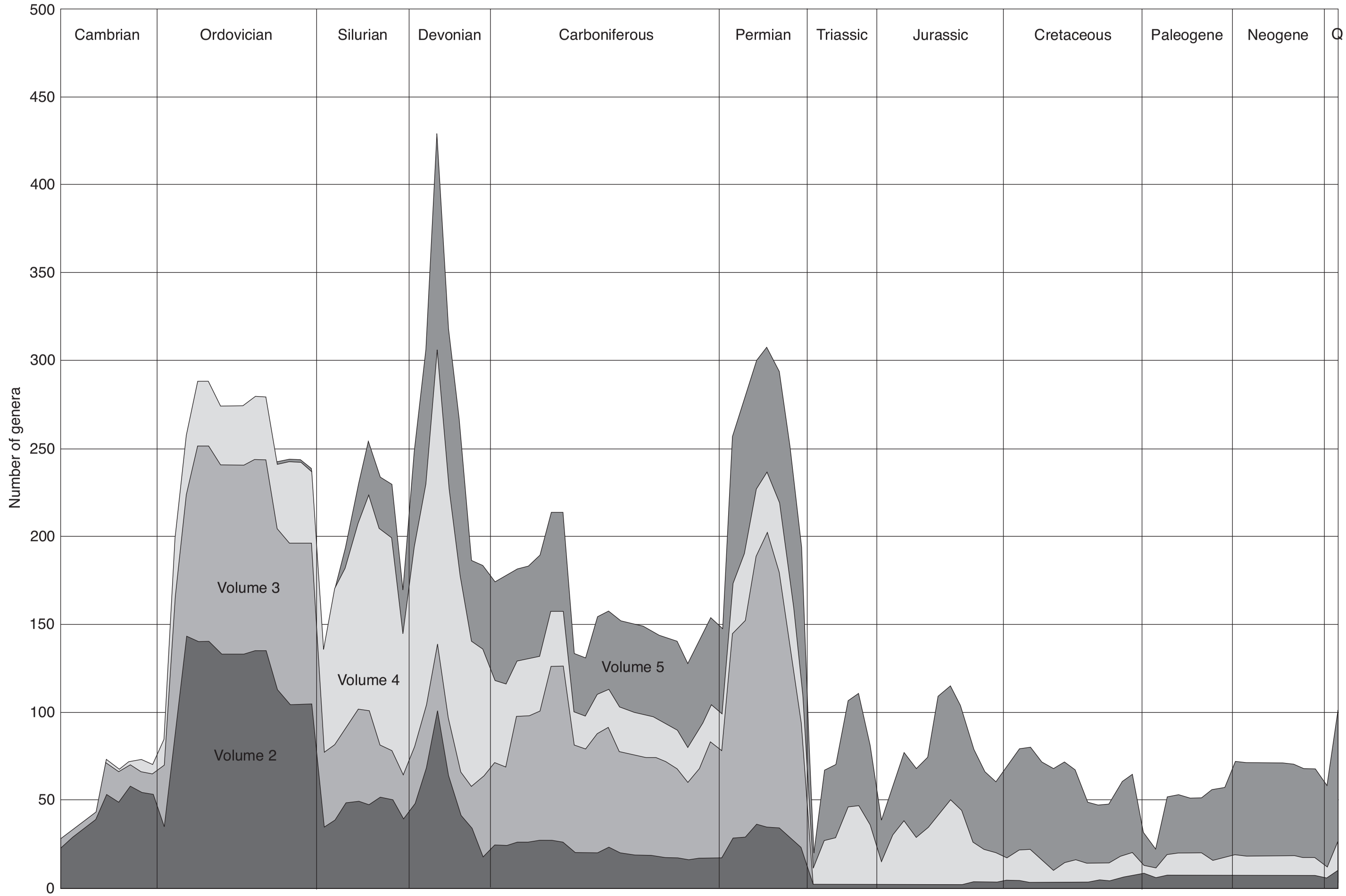

FIG. 1101. Cumulative stratigraphic distribution of the Brachiopoda in *Treatise* volumes 2–5 according to the number of genera in each of 113 stages.

morphological variability during these periods and clearly became adapted to a wide range of habitats, often as a dominant component of the fauna.

The distinction between volumes 2 and 3 is an artificial one in some respects, as both volumes were published at the same time, and the taxa in each were originally intended to be included in a single volume. The number of genera included, however, was so great as to make this impossible, and hence the remaining taxa of the order Productida were included in volume 3 along with genera in the Orthotetida, the Billingsellida (both from the class Strophomenata), and all taxa included from the rhynchonellate orders Protorthida and Orthida. The stratigraphic analysis of the volume 3 genera further emphasized the importance of the Great Ordovician Biodiversification Event; when volume 3 was published, a maximum of 250 genera were recorded from this period. This was already greater diversity than had been recorded in any period from the 1965 *Treatise* (WILLIAMS, 1965, p. 239) and is a measure of how much our knowledge of brachiopods has increased and refined in less than 40 years, despite the fact that there has been a long and distinguished history of Ordovician brachiopod research (e.g., BARRANDE, 1879). These issues will be discussed in detail in volume 6.

With the publication of volume 3, the main peaks in the stratigraphic distribution of brachiopods were already established, although the distribution was essentially bimodal in shape, and very few taxa had been recorded from post-Permian rocks. The greatest diversity recorded was in the Ordovician Period, but there was a dramatic increase in taxa during the Permian Period (to approximately 200 genera) and to a lesser extent during the Silurian, the Devonian, and the Carboniferous Periods. The diversity peaks of volume 3 in the late Lower Carboniferous and the Permian reflect the descriptions of brachiopods from various reefal environments attracting the attention of paleontologists. In addition, siliceous preservation of brachiopods occurs in some rocks of these ages, allowing the extraction of virtually complete faunas so that apparent diversity rises (see COOPER & GRANT, 1969, 1974, 1975, 1976; and WATERHOUSE in a series of publications between 1964 and 2004).

With the publication of volume 4 in 2002, the stratigraphic distributions of the orders Pentamerida, Rhynchonellida, Atrypida, and Athyridida were added to the cumulative curve shown in Figure 1101. The stocks in this volume were most abundant during the Silurian and Devonian Periods, although their range extended from the Cambrian to the recent. The Devonian now had the greatest diversity of brachiopods of any period (over 300), slightly above the number of genera recorded during the Ordovician, and around 60 genera more than were present at the maximum abundance so far recorded in the Permian. Again the apparent proliferation of brachiopods in the upper Devonian Period can at least in part be attributed to the activities of individual brachiopod specialists who concentrated their taxonomic efforts on the beautifully preserved and accessible faunas of this time.

The current volume completes the taxonomic survey of the brachiopods and presents the descriptions of genera assigned to the orders Spiriferida, Spiriferinida, Thecideida, and Terebratulida. Genera assigned to these four orders were abundant during the Devonian, the Permian, and to a lesser extent, during the early Carboniferous. The Terebratulida are the most important stocks of brachiopods in post-Permian rocks, with 50 or more genera living at the present day. The information provided in this *Treatise* indicates that the Terebratulida were not always so abundant. In the lower Jurassic and the lower Paleogene, for example, 20 or fewer terebratulide genera have been recorded, but this may be due to the fact that living taxa are more likely to be described than those preserved as fossils.

There are numerous issues that influence the use of stratigraphic data as an estimate of diversity of fossil organisms, ranging from the means of preservation, the preferences of individual workers for particular geological horizons and geographic areas, artifacts introduced by the analyses methodology, through to changes in the stratigraphic subdivision of geological history. To discuss these here would be to miss the main point of this introduction; such issues will be discussed in detail in volume 6. Rather the overall diversity curve shown in Figure 1101can be directly compared to figure 149 (Williams, 1965, p. 239) in the original brachiopod *Treatise* published in 1965. The overall shapes of the two curves are similar, confirming that brachiopods "reached their acme during the Devonian" (Alywn Williams, 1965, p. 237). The difference now, after 40 years of intensive research, is that the number of genera represented in the Devonian maxima (Fig. 1101 herein) is almost double the number presented in 1965. There are differences in detail, but the overall pattern of diversity continues to reveal a phylum that achieved its greatest diversity from the beginning of the Ordovician Period to the end of the Permian Period. Over this time scale of 240 million years of Earth history (Cowie & Bassett, 1989; or 237 million years in the most recent compilation of the Geological Time Scale, Gradstein, Ogg, & Smith, 2004), brachiopods underwent many remarkable phases of generic proliferation and some equally dramatic declines. The stratigraphic data available now as a result of the revised *Treatise* are not just more numerous, they are also much more refined (the Phanerozoic being divided into 113 stages as compared to the 28 subdivisions for the presentation in 1965), and almost certainly much more internally consistent, because the IUGS 1989 stratigraphic chart (Cowie & Bassett, 1989) was agreed from the start as the standard for stratigraphic citation in this revision of the *Treatise*.

The bringing to publication of this volume within the huge brachiopod *Treatise* project would have been impossible, following the death of Alwyn Williams, without the support and knowledge of Patricia Peters. In 2001 Patricia Peters became Alwyn Williams's secretary, and she has efficiently maintained the *Treatise* office in the University of Glasgow through difficult times following Alwyn's death and a move to her new office in the Gregory Building of the Department of Geographical and Earth Sciences. She is of immense help to me in attempting to pick up the threads of the coordinator's job.

ACKNOWLEDGMENTS

Treatise volumes do not just happen, they are the result of much work by many people; the authors of sections, their supporters in the supply of specimens, illustrations, and data; the painstaking work of the staff in the *Treatise* office on manuscripts and figures; and the patience of those who have waited for years to see their manuscripts finally published; each one deserves our corporate thanks. We thank the National Science Foundation for grants (EAR 9902984 and 02298897) to S. J. Carlson, and the Division of Sciences, University of Otago, and the Royal Society of New Zealand for grants to D. E. Lee. The University of Kansas Paleontological Institute and the University of Glasgow continue their support for the Glasgow office from where Patricia Peters provided secretarial assistance for A. Williams and currently for H. Brunton.

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OU: University of Oklahoma, Norman, USA
OUM: Oxford University Museum, United Kingdom
OU NZ: Geology Department, Otago University, Dunedin, New Zealand
PAN: see PIN
PIN: Palaeontological Institute, Russian Academy of Sciences, Moscow, Russia
PIN RAS: see PIN
PIW: Paleontological Institute, Würzburg University, Würzburg, Germany
PM (formerly PMU): Palaeontological Museum, Uppsala University, Uppsala, Sweden
PMO: Paleontologisk Museum, University of Oslo, Norway
PMU: see PM
PRI: Paleontological Research Institute, Ithaca, New York, USA
QMF: Queensland Museum, South Brisbane, Australia
RM, RMS: Swedish Museum of Natural History, Stockholm, Sweden
ROM: Royal Ontario Museum, Toronto, Ontario, Canada
RX: Rowley Collection, University of Illinois, Urbana, Illinois, USA
SAM.P: South Australian Museum, Adelaide, South Australia
SGU: Geological Survey of Sweden, Uppsala, Sweden
SIGM: Shenyang Institute of Geology and Mineral Resources, Shenyang, Liaoning, China
SM (formerly SMA): Sedgwick Museum, University of Cambridge, United Kingdom
SMF: Senckenbergische Museum, Frankfurt, Germany
SNM: Slovakian National Museum, Bratislava, Slovakia (Slovenské Narodné Múzeum, Bratislava)
SSL: see D
SUI: University of Iowa, Department of Geology, Iowa City, USA
SUP: University of Sydney, New South Wales, Australia
T: Paleontological Museum, University of Naples, Naples, Italy
TA: see D
TAGI BR: Geological Museum, Institute of Geology, Tallinn Technical University, Tallinn, Estonia
TBR: see TF
TF: Geological Survey Division, Department of Mineral Resources, Bangkok, Thailand
TsGM: see CNIGR
TsNIGRA: see CNIGR
TUG: Museum of Geology, University of Tartu, Tartu, Estonia
UA: Geology Department, University of Alberta, Edmonton, Canada
UC: Field Museum of Natural History, Chicago, Illinois, USA
UCF: The University, Calgary, Canada
UCM: University of Canterbury, Christchurch, New Zealand
UCMP: University of California, Museum of Paleontology, USA
UD: University of Dijon, Dijon, France
UHR: Hokkaido University, Sapporo, Japan
UI: University of Illinois, Urbana, Illinois, USA
UL: Department of Geology and Palaeontology, University of Ljubljana, Slovenia
UM: Museum of Paleontology, University of Michigan, Ann Arbor, Michigan, USA
UMC (formerly UMO): University of Missouri, Columbia, Missouri, USA
UMMF: Department of Geology, University of Montpellier, Montpellier, France
UMUT: University Museum of the University of Tokyo, Tokyo, Japan
UND: University of Notre Dame, Indiana, USA
U.N.E: University of New England, Armidale, Australia
UPS: Université de Paris-Sud, France
UQF: University of Queensland, Department of Geology, Brisbane, Australia
USNM: United States National Museum, Washington, D.C., USA
UT: Department of Geology, University of Texas, Austin, Texas, USA
UTC: Department of Geology, University of Toronto, Toronto, Canada
UTGD: University of Tasmania Geology Department, Hobart, Tasmania, Australia
U.W.A.: University of Western Australia, Nedlands, Western Australia
VH: see OMR
VSEGEI: Russian Geology Institute, St. Petersburg, Russia
XAGM: Xi'an Institute of Geology and Mineral Resources, Shaanxi, China
XIGMR: Xi'an Institute of Geology and Mineral Resources, Shaanxi, China
YaTGU: Geological Museum, Yakutsk, Yakutia
YIGM: Yichang Institute of Geology and Mineral Resources, Yichang, China
YPM: Yale University, Peabody Museum of Natural History, New Haven, Connecticut, USA
ZI: Zhejiang Institute of Geology and Mineralogy, Zhejiang, China
ZPAL Br: Institute of Palaeobiology, Polish Academy of Sciences, Warsaw, Poland

REPOSITORIES AND THEIR ABBREVIATIONS

Abbreviations and locations of museums and institutions holding type material, which are used throughout the systematic sections of this volume, are listed below.

AMF: Australian Museum, Sydney, Australia
AMNH: American Museum of Natural History, New York, USA
ANU: Australian National University, Canberra, Australia
AU: Geology Department, Auckland University, Auckland, Australia
BAU: Buenos Aires University, Buenos Aires, Argentina
BGS, GSM, IGS: British Geological Survey (formerly Geological Survey Museum; Institute of Geological Sciences, London) Keyworth, Nottinghamshire, United Kingdom
BMNH: The Natural History Museum, London, United Kingdom [formerly British Museum (Natural History)]
BMR: see CPC
Br: see TAGI Br
BSM: Bavarian State Museum, Munich, Germany
BU: Department of Geology, Birmingham University, Birmingham, United Kingdom
BUM: Bristol University Museum, Bristol, United Kingdom
CAGS: Institute of Geology, Chinese Academy of Geological Sciences, Beijing, China
CB: Muséum d'Histoire Naturelle, Geneva, Switzerland
CEGH: see CORD-PZ
CFP UA: Compagnie Française Petroles, Paris, France
CGS: Czech Geological Survey, Prague, Czech Republic
CIGMR: Chengdu Institute of Geology and Mineral Resources, Chengdu, China
CMNH: Carnegie Museum, Pittsburgh, USA
CNIGR: Central Scientific Geological Exploration Museum (Tschernyshev Museum), St. Petersburg, Russia
CORD-PZ: Universidad Nacional de Córdoba, Argentina
CPC: Commonwealth Palaeontological Collections, Australian Geological Survey Organisation, Canberra, Australia
D, EM, ENSM, FSI, FSL, SSL, TA: Université Claude Bernard, Lyon I, Villeurbanne, France
DNGM: Servicio Nacional Minero Geológico, Buenos Aires, Argentina
DP, DPO: Departamento de Geología, Oviedo University, Oviedo, Spain
DPO: see DP
DPUCM: Departamento de Paleontologia, Universidad Complutense, Madrid, Spain
EM: see D
ENSM: see D
FD: Geological College of Eastern China, Fuzhou, China
FSI: see D
FSL: see D
GB: Xian Institute of Geology and Mineral Resources, Xian, China
GBA: Geologisches Bundesanstalt Museum, Vienna, Austria
GIB: Geological Institute, Bonn, Germany
GIBAS: Geological Institute, Bulgarian Academy of Sciences, Sofia, Bulgaria
GIN KAZ: Institute of Geology, Kazakh Academy of Sciences, Alma-Ata, Kazakhstan
GIN TAD: Institute of Geology, Dushanbe, Tadzhikistan
GIN UZ: Institute of Geology, Uzbek Academy of Sciences, Tashkent, Uzbekistan
GLAHM: Hunterian Museum, Glasgow University, Scotland, United Kingdom
GMC, IV: Geological Museum of China, Beijing, China
GMG: State Museum of Georgia (named after S. N. Djanashia), Academy of Sciences of the Georgian SSR, Tbilisi
GMUT: see TUG
GM YaRGTS: Geological Museum of the Regional Geological Centre, Yakutsk, Yakutia
GPIBo: Palaontological Institute, Bonn, Germany
GPIT: Geological and Palaeontological Institute, University of Tübingen, Germany (Geologisch-Paläontologisches Institut, Tübingen Universität)
GPZ: Department of Geology and Palaeontology, Zagreb, Croatia
GSC: Geological Survey of Canada, Ottawa, Ontario, Canada
GSE: see IGS GSE
GSI: Geological Survey of India, Calcutta, India
GSM: see BGS
GSQ: Geological Survey, Queensland, Australia
GSV: Geological Survey of Victoria, Australia
GS YA: see CGS
HB: Bureau of Geology and Mineral Resources of Hunan Province, Hunan, China
HGI: Hungarian Geological Institut, Budapest, Hungary
HIGS: Hangzhou Institute for Geological Science, Hangzhou, China
HM: see GLAHM
HNHMB: Hungarian Natural History Museum, Budapest, Hungary
HUB: see MB
I: New York State Geological Survey, Albany, New York, USA
ICPSB: Institute of Geology, University of Padua, Italy
IGAS: Institute of Geology, Chinese Academy of Sciences, Beijing, China
IGiG: Institute of Geology and Geophysics, Siberian Branch, Academy of Sciences, Akademgorodok, Russia

IGM: Instituto de Geología, Universidad Autónoma de México, Ciudad Univesitaria, México City, Mexico
IGN: Institute of Geological Sciences, Kiev, Ukraine
IGR: Institute of Geology, University of Rennes, Rennes, France
IGS GSE: Institute of Geological Sciences, Edinburgh, United Kingdom
IGS GSM: see BGS
IMGPT: Geological-Paleontological Institute and Museum of Tübingen University, Germany
Inst. Geol.: Geological Institute, Bishkek, Kyrgyzstan
IO: P. P. Shirshov Institute of Oceanology, Moscow, Russia
IRScNB: Institut Royal des Sciences Naturelles de Belgique, Brussels, Belgium
IV: see GMC
JCF: James Cook University, Townsville, Queensland, Australia
KAS, MANK: Geological Museum of Institute of Geological Sciences, Almaty, Kazakhstan
KHGU: Kharkov State University, Ukraine
KIGLGU: Geology Faculty of Leningrad State University, Paleontology-Stratigraphy Museum, St. Petersburg, Russia
L: National Museum, Prague, Czech Republic, Barrande specimens
LGE: St. Petersburg State University, St. Petersburg, Russia
LGI: Leningrad Geological Institute, Leningrad, Russia
LM: see LO
LMT: Loodus Museum, Tallinn, Estonia
LO (formerly LM): Lund University Museum, Sweden
LPB: Laboratoire de Paléontologie, Université de Bretagne Occidentale, Brest, France
LS: Linnean Society of London, United Kingdom
MANK: see KAS
MB (formerly HUB): Humboldt University, Berlin, Germany
M.Ch: Museum Chabarovsk, Verkhoyan, eastern Siberia, Russia
MCMB: Department of Geology, University of Beijing, Beijing, China
MCZ: Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, USA
MDSGF: Museo del Dipartimento di Scienze Geolgiche dell'Università di Ferrara, Ferrara, Italy
MFLV: Museo dei Fossili della Lessinia, Verona, Italy
MFMGB: Museum of the Faculty of Mining and Geology, Belgrade University, Belgrade, Yugoslavia
MG: Institute of Geology, Ashkhabad, Turkmenistan
MGBW: Museum of the Geologische Bundesanstalt of Wien, Austria
MGRI: Moscow Geological Prospecting Institute, Moscow, Russia
MGSB: Museo Geológico del Seminario de Barcelona, Barcelona, Spain
MGU: Moscow State University, Russia
MGUP: Museum of Geology, University of Palermo, Sicily, Italy
MIP: Invertebrate Paleontology Department, La Plata Natural Sciences Museum, La Plata, Argentina
MLP: La Plata Natural Sciences Museum, La Plata, Argentina
MM: Moravian Museum, Brno, Czech Republic
MMF: Geological and Mining Museum, Department of Mines, Sydney, Australia
MNB: see MB
MNHN: Muséum National d'Histoire Naturelle, Paris, France
MONZ: see NMNZ
MPUM: Museo di Paleontologia del Dipartimento di Scienze della Terra dell'Università degli Studi di Milano, Italy
MUGT: see GIN TAD
Muz IG: Geological Museum of the Geological Institute, Warsaw, Poland
MV: see NMVP
NHMB: Natural History Museum, Basel, Switzerland (Naturhistorisches Museum Basel)
NIGP: Nanjing Institute of Geology and Palaeontology, Academia Sinica, Nanjing, China
NM: National Museum, Prague, Czech Republic
NMING: National Museum of Ireland, Dublin, Ireland
NMNZ: Te Papa, Museum of New Zealand, Wellington, New Zealand
NMVP: Victoria Museum, Melbourne, Victoria, Australia
NMW: National Museum of Wales, Cardiff, United Kingdom
NS: Northeastern Institute of Geology, Inner Mongolia
NUF: Department of Geology, University of Newcastle, New South Wales, Australia
NYSM: New York State Museum, Albany, USA
NZGS: New Zealand Geological Survey, Lower Hutt, New Zealand (presently called Institute of Geological and Nuclear Sciences)
NZOI: New Zealand Oceanographic Institute, National Institute of Water and Atmospheric Research, Wellington, New Zealand
OKGS: Oklahoma Geological Survey, Norman, Oklahoma, USA
OMR: District Museum, Rokycany, Czech Republic
OMR VH: see OMR
OSU: Orton Geological Museum, Ohio State University, Columbus, Ohio, USA

OUTLINE OF SUPRAFAMILIAL CLASSIFICATION AND AUTHORSHIP

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The following outline of the classification of the Brachiopoda is an amended version of that published at the beginning of Volume 2 of the *Treatise on Invertebrate Paleontology, Part H (Revised), Brachiopoda,* edited by R. L. Kaesler (2000, p. 22–27). It lists all suprafamilial taxa recognized and described in the three systematic volumes already published and those in preparation. The main changes are the inclusion of suprafamilial taxa of uncertain order or class. The thirty-four contributors identified in the list were responsible for authorship of diagnoses for the listed taxa. In the case of orders, suborders, and superfamilies, the authors were also responsible for all lower ranking taxa down to genera and subgenera.

Linguliformea. Lower Cambrian–Holocene.
  Alwyn Williams, S. J. Carlson, & C. H. C. Brunton
 Lingulata. Lower Cambrian–Holocene.
  L. E. Holmer & L. E. Popov
  Lingulida. Lower Cambrian–Holocene.
  L. E. Holmer & L. E. Popov
   Linguloidea. Lower Cambrian–Holocene.
  L. E. Holmer & L. E. Popov
   Discinoidea. Ordovician–Holocene.
  L. E. Holmer & L. E. Popov
   Acrotheloidea. Lower Cambrian–Lower Ordovician.
  L. E. Holmer & L. E. Popov
  Acrotretida. Lower Cambrian–Middle Devonian, ?Upper Devonian.
  L. E. Holmer & L. E. Popov
   Acrotretoidea. Lower Cambrian–Middle Devonian, ?Upper Devonian.
  L. E. Holmer & L. E. Popov
  Siphonotretida. Middle Cambrian–Ordovician.
  L. E. Holmer & L. E. Popov
   Siphonotretoidea. Middle Cambrian–Ordovician.
  L. E. Holmer & L. E. Popov
 Paterinata. Lower Cambrian–Upper Ordovician.
  J. R. Laurie
  Paterinida. Lower Cambrian–Upper Ordovician.
  J. R. Laurie
   Paterinoidea. Lower Cambrian–Upper Ordovician.
  J. R. Laurie
Craniiformea. ?Lower Cambrian, Middle Cambrian, Ordovician–Holocene.
  Alwyn Williams, S. J. Carlson, & C. H. C. Brunton
 Craniata. ?Lower Cambrian, Middle Cambrian, Ordovician–Holocene.
  L. E. Popov, M. G. Bassett, & L. E. Holmer
  Craniopsida. ?Lower Cambrian, Middle Cambrian, Ordovician–Lower Carboniferous.
  L. E. Popov & L. E. Holmer
   Craniopsoidea. ?Lower Cambrian, Middle Cambrian, Ordovician–Lower Carboniferous.
  L. E. Popov & L. E. Holmer
  Craniida. Lower Ordovician–Holocene.
  M. G. Bassett
   Cranioidea. Ordovician–Holocene.
  M. G. Bassett
  Trimerellida. Ordovician–Silurian.
  L. E. Popov & L. E. Holmer
   Trimerelloidea. Ordovician–Silurian.
  L. E. Popov & L. E. Holmer

Rhynchonelliformea. Lower Cambrian–Holocene.
Alwyn Williams, S. J. Carlson, & C. H. C. Brunton
Chileata. Lower Cambrian–Permian.
L. E. Popov & L. E. Holmer
Chileida. Lower Cambrian–Middle Cambrian.
L. E. Popov & L. E. Holmer
Matutelloidea. Lower Cambrian–Middle Cambrian.
L. E. Popov & L. E. Holmer
Dictyonellida. Upper Ordovician–Lower Permian.
L. E. Holmer
Eichwaldioidea. Upper Ordovician–Lower Permian.
L. E. Holmer
Obolellata. Lower Cambrian–Middle Cambrian.
L. E. Popov & L. E. Holmer
Obolellida. Lower Cambrian–Middle Cambrian.
L. E. Popov & L. E. Holmer
Obolelloidea. Lower Cambrian–Middle Cambrian.
L. E. Popov & L. E. Holmer
Uncertain.
L. E. Popov & L. E. Holmer
Naukatida. Lower Cambrian–Middle Cambrian.
L. E. Popov & L. E. Holmer
Naukatoidea. Lower Cambrian–Middle Cambrian.
L. E. Popov & L. E. Holmer
Kutorginata. Lower Cambrian–Middle Cambrian.
L. E. Popov & Alwyn Williams
Kutorginida. Lower Cambrian–Middle Cambrian.
L. E. Popov & Alwyn Williams
Kutorginoidea. Lower Cambrian–Middle Cambrian.
L. E. Popov & Alwyn Williams
Nisusioidea. Lower Cambrian–Middle Cambrian.
L. E. Popov & Alwyn Williams
Strophomenata. Middle Cambrian–Upper Permian.
Alwyn Williams, C. H. C. Brunton, & L. R. M. Cocks
Strophomenida. Lower Ordovician–Carboniferous.
L. R. M. Cocks & Rong Jia-yu
Strophomenoidea. Ordovician–Carboniferous.
L. R. M. Cocks & Rong Jia-yu
Plectambonitoidea. Ordovician–Devonian.
L. R. M. Cocks & Rong Jia-yu
Uncertain.
Alwyn Williams & C. H. C. Brunton
Productida. Upper Ordovician–Upper Permian, ?Lower Triassic.
C. H. C. Brunton, S. S. Lazarev, & R. E. Grant
Chonetidina. Upper Ordovician–Permian, ?Lower Triassic.
P. R. Racheboeuf
Chonetoidea. Upper Ordovician–Permian, ?Lower Triassic.
P. R. Racheboeuf
Productidina. Lower Devonian–Upper Permian, ?Lower Triassic.
C. H. C. Brunton, S. S. Lazarev, R. E. Grant, & Jin Yu-gan
Productoidea. Lower Devonian–Upper Permian, ?Lower Triassic.
C. H. C. Brunton, S. S. Lazarev, R. E. Grant, & Jin Yu-gan
Echinoconchoidea. Middle Devonian–Upper Permian.
C. H. C. Brunton, S. S. Lazarev, R. E. Grant, & Jin Yu-gan
Linoproductoidea. Lower Devonian–Upper Permian.
C. H. C. Brunton, S. S. Lazarev, R. E. Grant, & Jin Yu-gan
Uncertain.
C. H. C. Brunton, S. S. Lazarev, R. E. Grant, & Jin Yu-gan
Strophalosiidina. Lower Devonian–Upper Permian.
C. H. C. Brunton, S. S. Lazarev, R. E. Grant, & Jin Yu-gan
Strophalosioidea. Lower Devonian–Upper Permian.
C. H. C. Brunton, S. S. Lazarev, R. E. Grant, & Jin Yu-gan

Aulostegoidea. Lower Carboniferous–Upper Permian.
C. H. C. Brunton, S. S. Lazarev, R. E. Grant, & Jin Yu-gan
Richthofenioidea. Upper Carboniferous–Upper Permian.
B. R. Wardlaw, R. E. Grant, & C. H. C. Brunton
Lyttoniidina. ?Lower Carboniferous, Upper Carboniferous–Upper Permian.
Alwyn Williams, D. A. T. Harper, & R. E. Grant
Lyttonioidea. ?Lower Carboniferous, Upper Carboniferous–Upper Permian.
Alwyn Williams, D. A. T. Harper, & R. E. Grant
Permianelloidea. Permian.
Alwyn Williams, D. A. T. Harper, & R. E. Grant
Uncertain.
C. H. C. Brunton, S. S. Lazarev, R. E. Grant, & Jin Yu-gan
Orthotetida. Lower Ordovician–Upper Permian.
Alwyn Williams, C. H. C. Brunton, & A. D. Wright
Orthotetidina. Upper Ordovician–Upper Permian.
Alwyn Williams & C. H. C. Brunton
Orthotetoidea. Middle Devonian–Upper Permian.
Alwyn Williams & C. H. C. Brunton
Chilidiopsoidea. Upper Ordovician–Lower Carboniferous.
Alwyn Williams & C. H. C. Brunton
Triplesiidina. Lower Ordovician–upper Silurian.
A. D. Wright
Triplesioidea. Lower Ordovician–upper Silurian.
A. D. Wright
Billingsellida. Middle Cambrian–Upper Ordovician.
Alwyn Williams & D. A. T. Harper
Billingsellidina. Middle Cambrian–Lower Ordovician.
Alwyn Williams & D. A. T. Harper
Billingselloidea. Middle Cambrian–Lower Ordovician.
Alwyn Williams & D. A. T. Harper
Clitambonitidina. Lower Ordovician–Upper Ordovician.
Madis Rubel & A. D. Wright
Clitambonitoidea. Ordovician.
Madis Rubel & A. D. Wright
Polytoechioidea. Ordovician.
Madis Rubel & A. D. Wright
Rhynchonellata. Lower Cambrian–Holocene.
Alwyn Williams & S. J. Carlson
Protorthida. Lower Cambrian–Upper Devonian.
Alwyn Williams & D. A. T. Harper
Protorthoidea. Lower Cambrian–Middle Cambrian.
Alwyn Williams & D. A. T. Harper
Skenidioidea. Lower Ordovician–Upper Devonian.
Alwyn Williams & D. A. T. Harper
Orthida. Lower Cambrian–Upper Permian.
Alwyn Williams & D. A. T. Harper
Orthidina. Lower Cambrian–Lower Devonian.
Alwyn Williams & D. A. T. Harper
Orthoidea. Lower Cambrian–Lower Devonian.
Alwyn Williams & D. A. T. Harper
Plectorthoidea. Middle Cambrian–upper Silurian.
Alwyn Williams & D. A. T. Harper
Dalmanellidina. Lower Ordovician–Upper Permian.
D. A. T. Harper
Dalmanelloidea. Lower Ordovician–Upper Permian.
D. A. T. Harper
Enteletoidea. Lower Ordovician–Upper Permian.
D. A. T. Harper
Uncertain.
Alwyn Williams & D. A. T. Harper

Pentamerida. Lower Cambrian–Upper Devonian.
    S. J. Carlson, A. J. Boucot, Rong Jia-yu, & R. B. Blodgett
  Syntrophiidina. Lower Cambrian–Lower Devonian.
    S. J. Carlson
   Porambonitoidea. Lower Cambrian–lower Silurian.
    S. J. Carlson
   Camerelloidea. Lower Ordovician–Lower Devonian.
    S. J. Carlson
  Pentameridina. Upper Ordovician–Upper Devonian.
    A. J. Boucot, Rong Jia-yu, & R. B. Blodgett
   Pentameroidea. Upper Ordovician–Silurian.
    A. J. Boucot, Rong Jia-yu, & R. B. Blodgett
   Stricklandioidea. Silurian.
    A. J. Boucot, Rong Jia-yu, & R. B. Blodgett
   Gypiduloidea. Silurian–Upper Devonian.
    R. B. Blodgett, A. J. Boucot, & Rong Jia-yu
   Clorindoidea. lower Silurian–Middle Devonian.
    R. B. Blodgett, A. J. Boucot, & Rong Jia-yu
Rhynchonellida. Lower Ordovician–Holocene.
    N. M. Savage, M. O. Manceñido, E. F. Owen, S. J. Carlson, R. E. Grant, A. S. Dagys, & Sun Dong-li
   Ancistrorhynchoidea. Lower Ordovician–Lower Devonian.
    N. M. Savage
   Rhynchotrematoidea. Lower Ordovician–Lower Carboniferous.
    N. M. Savage
   Uncinuloidea. lower Silurian–Upper Devonian.
    N. M. Savage
   Camarotoechioidea. lower Silurian–Lower Carboniferous.
    N. M. Savage
   Pugnacoidea. Lower Devonian–Holocene.
    N. M. Savage, M. O. Manceñido, E. F. Owen, & A. S. Dagys
   Stenoscismatoidea. Lower Devonian–Upper Permian.
    S. J. Carlson & R. E. Grant
   Lambdarinoidea. Upper Devonian–Upper Carboniferous.
    N. M. Savage
   Rhynchoporoidea. Upper Devonian–Upper Permian.
    N. M. Savage
   Dimerelloidea. Upper Devonian–Holocene.
    M. O. Manceñido, E. F. Owen, N. M. Savage, & A. S. Dagys
   Rhynchotetradoidea. Upper Devonian–Middle Jurassic.
    N. M. Savage, M. O. Manceñido, E. F. Owen, & A. S. Dagys
   Wellerelloidea. Lower Carboniferous–Lower Jurassic.
    N. M. Savage, M. O. Manceñido, E. F. Owen, A. S. Dagys, & Sun Dong-li
   Rhynchonelloidea. Lower Triassic–Upper Cretaceous.
    E. F. Owen & M. O. Manceñido
   Norelloidea. Lower Triassic–Holocene.
    M. O. Manceñido, E. F. Owen, A. S. Dagys, & Sun Dong-li
   Hemithiridoidea. Middle Triassic–Holocene.
    M. O. Manceñido, E. F. Owen, Sun Dong-li, & A. S. Dagys
   Uncertain.
    M. O. Manceñido, E. F. Owen, & Sun Dong-li
Atrypida. Ordovician–Upper Devonian.
    Paul Copper
  Atrypidina. Ordovician–Upper Devonian.
    Paul Copper
   Atrypoidea. Ordovician–Upper Devonian.
    Paul Copper
   Punctatrypoidea. Silurian–Middle Devonian.
    Paul Copper
  Anazygidina. Ordovician–Silurian.
    Paul Copper
   Anazygoidea. Ordovician–Silurian.
    Paul Copper

Davidsoniidina. Silurian–Middle Devonian.
Paul Copper
Davidsonioidea. Silurian–Middle Devonian.
Paul Copper
Palaferelloidea. Silurian–Middle Devonian.
Paul Copper
Lissatrypidina. Ordovician–Upper Devonian.
Paul Copper
Lissatrypoidea. Ordovician–Middle Devonian.
Paul Copper
Glassioidea. Silurian–Upper Devonian.
Paul Copper
Protozygoidea. Ordovician–Silurian.
Paul Copper
Athyridida. Upper Ordovician–Lower Jurassic, ?Upper Jurassic.
Fernando Alvarez & Rong Jia-yu
Athyrididina. Upper Ordovician–Upper Triassic, ?Upper Jurassic.
Fernando Alvarez & Rong Jia-yu
Athyridoidea. ?Upper Ordovician–Upper Triassic, ?Upper Jurassic.
Fernando Alvarez & Rong Jia-yu
Meristelloidea. Upper Ordovician–Upper Carboniferous.
Fernando Alvarez & Rong Jia-yu
Nucleospiroidea. Silurian–Lower Permian.
Fernando Alvarez & Rong Jia-yu
Retzielloidea. Silurian–Lower Devonian.
Fernando Alvarez & Rong Jia-yu
Uncertain.
Fernando Alvarez & Rong Jia-yu
Retziidina. Silurian–Upper Triassic.
Fernando Alvarez & Rong Jia-yu
Retzioidea. Silurian–Upper Triassic.
Fernando Alvarez & Rong Jia-yu
Mongolospiroidea. Lower Devonian.
Fernando Alvarez & Rong Jia-yu
Rhynchospirinoidea. Silurian–Upper Devonian.
Fernando Alvarez & Rong Jia-yu
Koninckinidina. Middle Triassic–Lower Jurassic.
D. I. MacKinnon
Koninckinoidea. Middle Triassic–Lower Jurassic.
D. I. MacKinnon
Uncertain.
Fernando Alvarez & Paul Copper
Dayioidea. Silurian–Lower Devonian.
Fernando Alvarez & Paul Copper
Anoplothecoidea. Silurian–Middle Devonian.
Fernando Alvarez & Paul Copper
Uncitoidea. Middle Devonian.
Fernando Alvarez & Paul Copper
Uncertain.
Fernando Alvarez & Rong Jia-yu
Spiriferida. Upper Ordovician–Lower Triassic, ?Middle Triassic–?Upper Triassic.
J. L. Carter, J. G. Johnson, Rémy Gourvennec, & Hou Hong-fei
Spiriferidina. Upper Ordovician, ?Middle Triassic–?Upper Triassic.
J. L. Carter, J. G. Johnson, Rémy Gourvennec, & Hou Hong-fei
Cyrtioidea. Upper Ordovician–Lower Devonian.
J. G. Johnson & Hou Hong-fei
Adolfioidea. Silurian–Upper Devonian.
J. G. Johnson
Theodossioidea. Lower Devonian–Carboniferous.
J. G. Johnson, J. L. Carter, & Hou Hong-fei
Cyrtospiriferoidea. Lower Devonian–Upper Devonian.
J. G. Johnson

Ambocoelioidea. Silurian–Lower Triassic, ?Middle Triassic–?Upper Triassic.
J. G. Johnson, J. L. Carter, & Hou Hong-fei
Martinioidea. Silurian–Permian.
J. L. Carter & Rémy Gourvennec
Spiriferoidea. Upper Devonian–Permian.
J. L. Carter
Paeckelmanelloidea. Upper Devonian–Permian.
J. L. Carter
Brachythyridoidea. Upper Devonian–Permian.
J. L. Carter
Delthyridina. Silurian–Permian.
J. G. Johnson, Hou Hong-fei, J. L. Carter, & Rémy Gourvennec
Delthyridoidea. Silurian–Carboniferous.
J. G. Johnson & Hou Hong-fei
Reticularioidea. Silurian–Permian.
J. L. Carter & Rémy Gourvennec
Uncertain.
P. R. Racheboeuf
Spiriferinida. Lower Devonian–Lower Jurassic.
J. L. Carter & J. G. Johnson
Cyrtinidina. Lower Devonian–Lower Jurassic.
J. L. Carter & J. G. Johnson
Cyrtinoidea. Lower Devonian–Carboniferous.
J. G. Johnson
Suessioidea. Carboniferous–Lower Jurassic.
J. L. Carter
Spondylospiroidea. Middle Triassic–Upper Triassic.
J. L. Carter
Spiriferinidina. Upper Devonian–Lower Jurassic.
J. L. Carter
Syringothyridoidea. Upper Devonian–Permian.
J. L. Carter
Pennospiriferinoidea. Upper Devonian–Lower Jurassic.
J. L. Carter
Spiriferinoidea. Middle Triassic–Lower Jurassic.
J. L. Carter
Thecideida. Upper Triassic–Holocene.
P. G. Baker
Thecospiroidea. Upper Triassic.
P. G. Baker
Thecideoidea. Upper Triassic–Holocene.
P. G. Baker
Terebratulida. Lower Devonian–Holocene.
D. E. Lee, D. I. MacKinnon, T. N. Smirnova, P. G. Baker, Jin Yu-gan, & Sun Dong-li
Terebratulidina. Lower Devonian–Holocene.
D. E. Lee, A. S. Dagys, T. N. Smirnova, Sun Dong-li, & Jin Yu-gan
Stringocephaloidea. ?Silurian, Lower Devonian–Upper Devonian.
Jin Yu-gan & D. E. Lee
Cryptonelloidea. Lower Devonian–Upper Triassic.
Jin Yu-gan & D. E. Lee
Dielasmatoidea. Upper Devonian–Lower Jurassic.
Jin Yu-gan, D. E. Lee, Sun Dong-li, T. N. Smirnova, & A. S. Dagys
Terebratuloidea. ?Upper Jurassic, Lower Cretaceous–Holocene.
D. E. Lee & T. N. Smirnova
Loboidothyridoidea. Triassic–Lower Cretaceous.
D. E. Lee, T. N. Smirnova, & A. S. Dagys
Dyscolioidea. Lower Jurassic–Holocene.
D. E. Lee
Cancellothyridoidea. Lower Jurassic–Holocene.
D. E. Lee, T. N. Smirnova, & Sun Dong-li

Terebratellidina. Upper Triassic–Holocene.
D. I. MacKinnon, D. E. Lee, P. G. Baker, T. N. Smirnova, A. S. Dagys, & Sun Dong-li
Zeillerioidea. Lower Triassic–Holocene.
P. G. Baker
Kingenoidea. Middle Triassic–Holocene.
D. I. MacKinnon, T. N. Smirnova, & D. E. Lee
Laqueoidea. Upper Triassic–Holocene.
D. I. MacKinnon & D. E. Lee
Megathyridoidea. Lower Cretaceous–Holocene.
D. E. Lee, D. I. MacKinnon, & T. N. Smirnova
Bouchardioidea. Lower Cretaceous–Holocene.
D. I. MacKinnon & D. E. Lee
Platidioidea. Upper Cretaceous–Holocene.
D. I. MacKinnon & D. E. Lee
Terebratelloidea. Paleogene–Holocene.
D. I. MacKinnon & D. E. Lee
Kraussinoidea. Neogene–Holocene.
D. E. Lee & D. I. MacKinnon
Uncertain.
Gwynioidea. Middle Jurassic–Holocene.
D. I. MacKinnon
Uncertain. Middle Devonian.
Jin Yu-gan & D. E. Lee
Uncertain.
P. G. Baker
Uncertain.
Jin Yu-gan
Uncertain. Lower Jurassic.
Cadomelloidea. Lower Jurassic.
D. I. Mackinnon
Uncertain. Lower Devonian.
Jin Yu-gan and D. E. Lee
Uncertain. Permian.
Alwyn Williams & C. H. C. Brunton

SPIRIFERIDA

J. L. CARTER,[1] J. G. JOHNSON,[2] RÉMY GOURVENNEC,[3] and HOU HONG-FEI[4]

[[1]retired from Carnegie Museum of Natural History; [2]deceased, formerly of Oregon State University; [3]Université de Bretagne Occidentale; and [4]China University of Geosciences]

Order SPIRIFERIDA Waagen, 1883

[*nom. correct.* MOORE, LALICKER, & FISCHER, 1952, p. 221, *pro* order Spiriferacea KUHN, 1949, p. 104, *nom. transl. ex* suborder Spiriferacea WAAGEN, 1883a, p. 447; *emend.,* CARTER & others, 1994, p. 328]

Generally biconvex; generally transverse with moderately wide to extended straight hinge line; ribbing very fine to coarse; small dorsal and larger ventral interareas always developed; spiralia directed laterally or posterolaterally with primary lamellae parallel and close to sagittal plane; jugum absent; shell substance impunctate. *upper Upper Ordovician–Lower Triassic, ?Middle Triassic–?Upper Triassic.*

INTRODUCTION

J. L. CARTER and RÉMY GOURVENNEC

[retired from Carnegie Museum of Natural History; and Université de Bretagne Occidentale]

Spiriferids *sensu lato* consist of two large but distinct groups, namely those that are impunctate and those that are punctate. In the first edition of the *Treatise* PITRAT (1965) freely intermixed the impunctate and punctate genera, assuming punctation to have appeared independently in several groups. In the intervening years new studies (IVANOVA, 1972, 1981; CARTER, 1985; ERLANGER & SOLOMINA, 1989) have shown that the punctate genera assigned to impunctate superfamilies such as the syringothyridids are in fact unrelated and conversely that the impunctate genera such as *Punctothyris*, *Odontospirifer*, and *Spiriferinaella,* which were assigned to punctate families, are not related to them and are readily assignable to well-established impunctate superfamilies. In the classification adopted here the two groups are treated as separate orders of unknown origin, appearing cryptogenically in the Late Ordovician and earliest Devonian respectively.

The recent discovery of the genus *Eospirifer* in the Upper Ordovician of China by RONG, ZHAN, and HAN (1994) and elucidation of its internal morphology by RONG and ZHAN (1996) may give light to the origin of the Spiriferida. These authors suggested that *Eospirifer* may have been derived from some unknown ancestor similar to the atrypid *Cyclospira*. The origin of the punctate Spiriferinida is unknown. The first representative of this group, *Cyrtina*, appears at the base of the Devonian as a very morphologically complex genus and is unlikely to be the ancestral spiriferinide.

The classification used here generally follows that of CARTER and others (1994). Since the publication of that paper a new family of cyrtospiriferoids has been proposed by MA and DAY (2000), and some of the martinioids have been subdivided further by WATERHOUSE (1998) and reassigned to the Delthyridina. The Delthyridina, however, are characterized by having complicated concentric microornament that is absent from WATERHOUSE's taxa, and we retain the WATERHOUSE taxa within the Martinioidea. Numerous new genera have been proposed since 1994 and will be included in *Treatise, Part H, revised,* volume 6.

Criticism of the CARTER and others classification (1994), although invited, has been minimal. DAGYS (1996) discounted the synapomorphous nature of the crenulate hinge line (even and regular low amplitude folds of each interarea with posterior tooth-like projections that interlock, similar to interlacing the teeth of two combs) of the Spondylospiroidea and redistributed the genera into other superfamilies. Instead he placed great importance on the presence of a sessile jugum with a net in various cyrtiniform genera with a shallow dorsal valve claiming that they were unique to his superfamily Bittneruloidea, which is characterized by having a distinct spondylium, dental plates, and a sessile jugum with net. In fact the Bittnerulidae lack dental plates and a true spondylium. Furthermore, of sixty Triassic spiriferinide genera, the jugum is known for only nineteen. Finally, the sessile jugum with a net occurred early in the history of this group in the genus *Komiella* of Middle Devonian age. It is still contended here that the crenulate hinge line is a uniquely evolved character that is unlikely to have occurred in unrelated stocks. This character is not described in other brachiopod groups and manifestly does not occur in other spiriferide or spiriferinide taxa.

Several other challenges to this classification have recently been registered. Boucot, Cocks, and Racheboeuf (1999) disregarded the assignment of *Rhynchospirifer* to Rhynchospiriferinae (Ambocoeliidae) and *Prosserella* to Reticulariopsinae (Reticulariidae); we accept the justification for both assignments by Pitrat (1965) and Fagerstrom (1971). Bizzarro and Lespérance (1999) questioned our assignment of some genera to subfamilies and families within the Delthyridoidea and questioned the evidence supporting evolutionary relationships among those confamilial genera. The phylogenetic analysis that they presented, in which 9 characters were coded among 12 subfamilial taxa of ambiguous definition and scope, is insufficient to support their revision of the superfamily. Ma and Day (2000) rejected *Conispirifer* as a synonym of *Tenticospirifer* and removed it from the Cyrtospiriferidae to erect a new family Conispiriferidae. They recommended a thorough revision of the Cyrtospiriferoidea, with which we concur. Discovery of new fossils and establishment of new taxa will continue to require revision of any classification proposed; we reassert that the classification presented here accommodates best the available fossil evidence. Future analyses of spiriferide genera and higher taxa will undoubtedly clarify further the phylogenetic relationships within this diverse and interesting group of spire-bearing brachiopods.

The term spirifer is used generally to denote medium to large, strophic, biconvex, ribbed shells that internally bear a calcified spiral brachidium. As noted above, the term usually refers to both impunctate and punctate forms; but, lacking certain indication of ancestry, the two groups are treated as separate orders here, the Spiriferida and Spiriferinida, respectively. Figure 1102 shows the abundance and stratigraphic distribution of both groups.

The exterior of a typical member of the impunctate Spiriferida is generally transversely biconvex with a wide hinge line, high flattened ventral interarea, acute incurved ventral beak, distinct dorsal fold and ventral sulcus, and ribbed lateral slopes. Maximum width is attained normally at or near the hinge line. Internally, the calcified brachidium has posterolaterally directed spiralia (Fig. 1103). All Spiriferida are extinct, being restricted to the Paleozoic or possibly the basal Triassic.

Insofar as is known all Spiriferida lived either attached to the substrate or each other by means of a muscular pedicle or freely on the seafloor, resting on the umbones of the longer, heavier ventral valves. They are found in most marine sedimentary rocks of shallow to moderately deep origin but are notably absent or rare in most deep-basinal sediments such as black shales, although they do sometimes occur in starved-basin carbonates. They were cosmopolitan in distribution throughout most of their stratigraphic range, occurring in most normal-marine biotas and often dominating them in terms of both

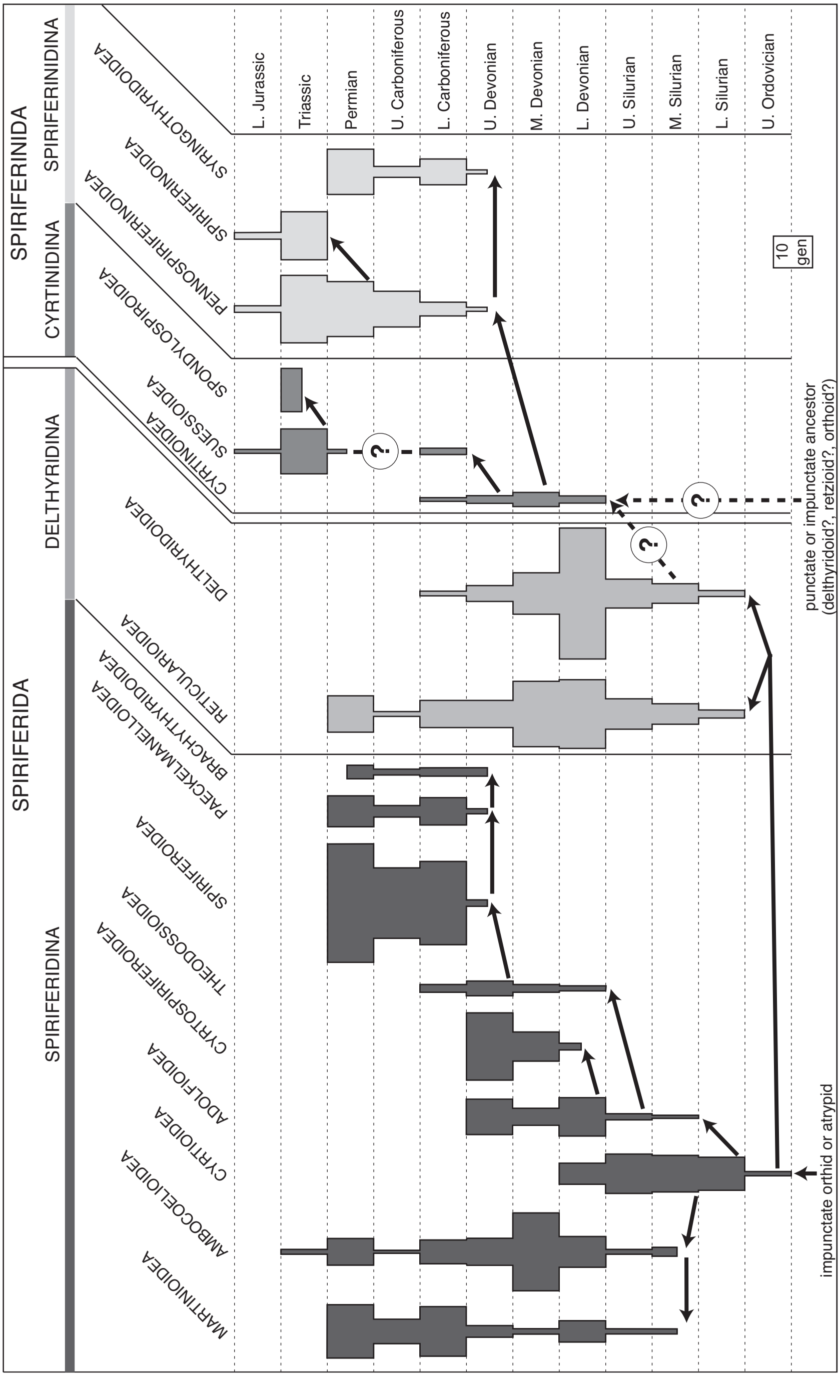

FIG. 1102. Stratigraphic distribution and relative generic abundance of the spiriferid brachiopods (new).

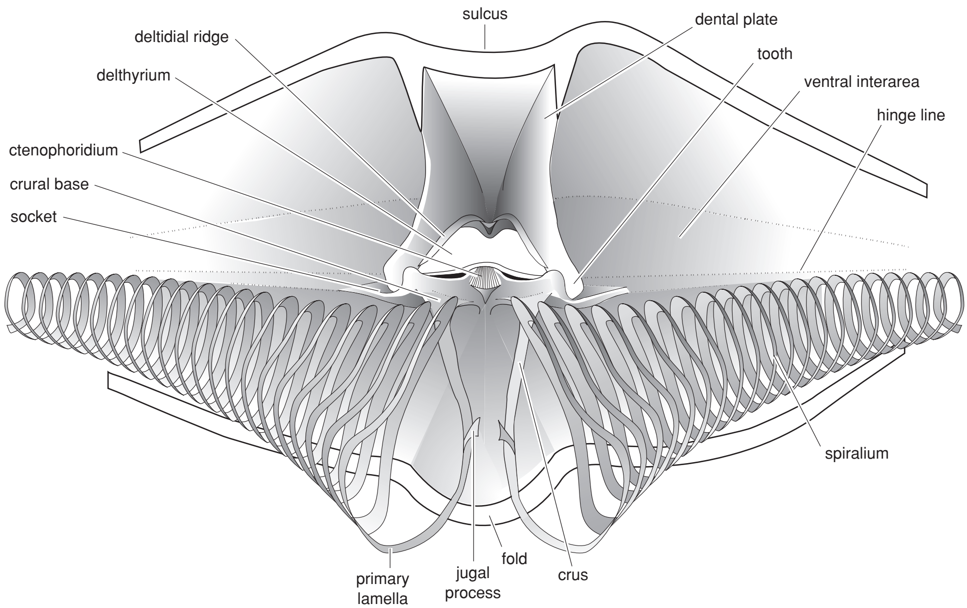

FIG. 1103. Diagrammatic representation of the internal morphology of the spiriferid shell: anterior view of the interior with ventral valve up, dorsal valve down (new).

numbers of individuals and taxonomic diversity, particularly in the Devonian and Carboniferous.

The order Spiriferida, as treated herein, consists of two suborders, the Spiriferidina and Delthyridina, with both suborders comprising over 400 distinct genera in 11 superfamilies. The Spiriferidina appeared first as the genus *Eospirifer* of the superfamily Cyrtioidea in the Upper Ordovician (middle Ashgill) of Asia and Australia. The suborder Delthyridina appeared later, in the lower Silurian (middle Llandovery), but its origin is uncertain. The delthyridines are characterized by having a fimbriate ornament, which does not occur in the Cyrtioidea, and may indicate derivation from a common ancestor with the eospiriferoids, rather than directly from them.

Our knowledge of the evolution of the Spiriferida is highly incomplete. For this reason the classification used in this edition of the *Treatise* must be viewed as a temporary progress report on a highly subjective matter. It is probable that we will never have enough information to know with certainty the exact course of evolution. In the discussion that follows we hope to point out in this group the general course of morphologic changes that occurred in the spiriferide superfamilies throughout geologic time (Fig. 1104).

The cyrtioids are the earliest and most morphologically primitive spiriferidine superfamily. They are characterized by having a finely ribbed ornament but internally are highly variable, although the early genera lack a ctenophoridium (Fig. 1104), which is a characteristic cardinal structure in most spiriferids. They radiated fairly rapidly in the Silurian, producing another 20 genera by the Early Devonian, and gave rise to the superfamilies Adolfioidea, Theodossioidea, and Ambocoelioidea in the late Silurian. The Adolfioidea became differentiated from the cyrtioids by acquiring a more coarsely ribbed

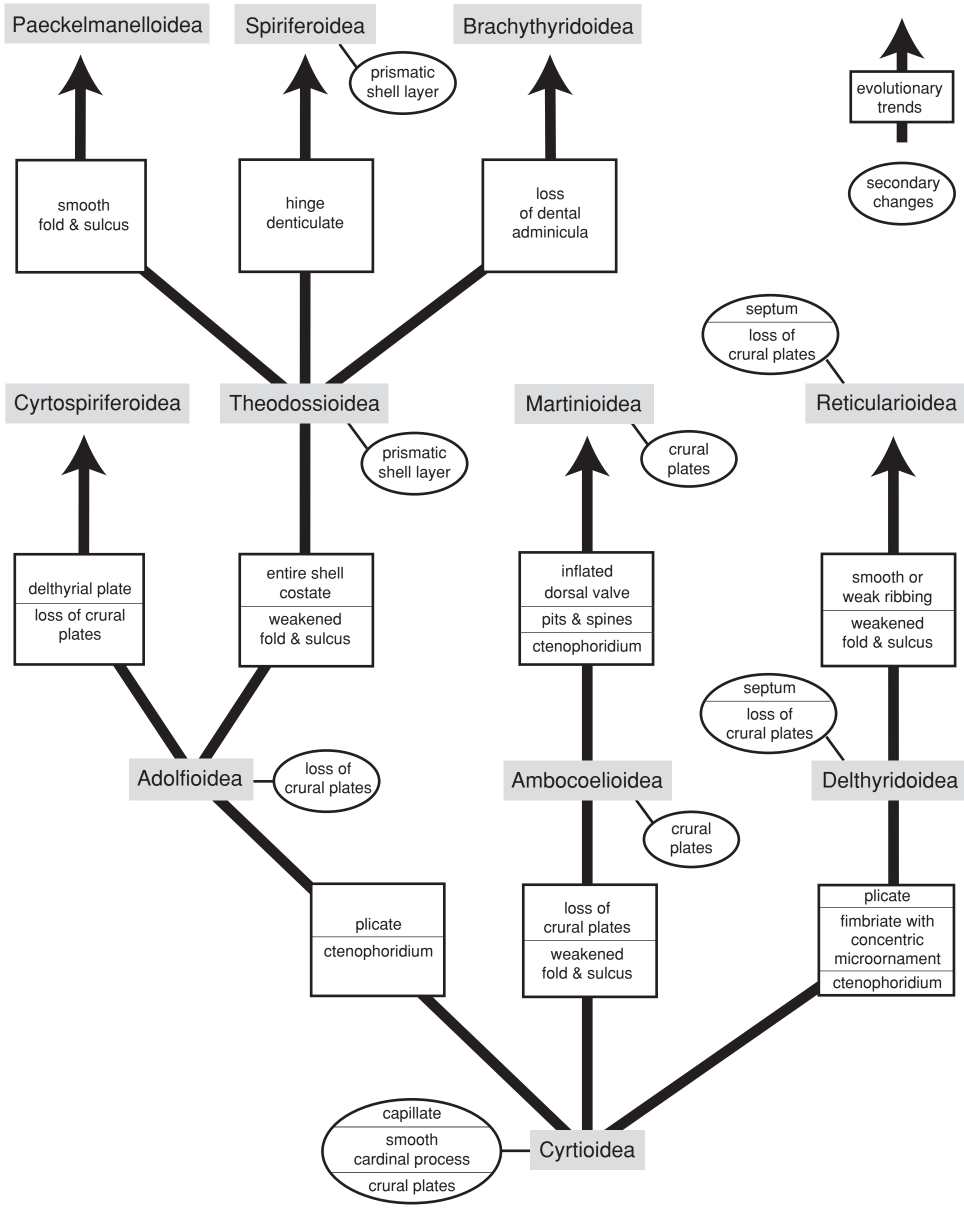

FIG. 1104. General evolutionary path within the Spiriferida with indication of primary and secondary innovations or changes (new).

ornament with capillate microornament and a consistent fold and sulcus. The theodossioids, on the other hand, retained the weak or absent fold-sulcus and uniform ribbing of many cyrtioids, but the ribbing is coarser than in most cyrtioids. The tiny, small, smooth Ambocoelioidea also evolved directly from the cyrtioids in the late Silurian by the paedomorphic loss of ribbing and fold-sulcus externally and crural and dental plates internally. These ambocoelioids in turn gave rise before the end of the Silurian to the smooth but much larger Martinioidea, which flourished mainly in the late Paleozoic.

The Spiriferidina underwent a second evolutionary radiation in the Devonian, especially in the superfamilies Adolfioidea and Theodossioidea, which lack a delthyrial plate, and the Cyrtospiriferoidea, which generally have a well-developed delthyrial plate. Near the close of the Devonian most of the Devonian spiriferidine superfamilies became extinct, but the theodossioid family Ulbospiriferidae evolved the first spiriferide inner prismatic shell layer, also found in the late Paleozoic spiriferidine superfamilies Spiriferoidea, Paeckelmanelloidea, and Brachythyridoidea. The Spiriferoidea differ from all of the early Paleozoic superfamilies in having a denticulate hinge line formed from small calcite rods that occur just below the primary shell layer of the ventral interarea. In addition, almost all the early Carboniferous spiriferoid genera have a distinctive capillate microornament. The Paeckelmanelloidea appeared at about the same time as the Spiriferoidea and are also denticulate and capillate, which may indicate derivation from a common ancestor. They are invariably strongly transverse and, unlike the Spiriferoidea, generally lack ribs on the fold-sulcus. The Brachythyridoidea differ from the other Carboniferous superfamilies in consistently having an ovate outline with concomitant narrow hinge line. Denticulation and capillation are suppressed or absent, and the interiors of both valves are devoid of plates, presumably through paedomorphosis. During the Carboniferous and Permian these three superfamilies plus the Martinioidea underwent a third and final radiation, which produced many additional families and genera before the suborder became extinct near the close of the era.

The Delthyridina evolved more or less parallel with the Spiriferidina but with less diversity and morphological innovation. There are only two superfamilies in this suborder, the Delthyridoidea and Reticularioidea, both generally with fimbriate microornament. The former, with plicate shells and well-developed fold and sulcus, appeared in the lower Silurian (middle Llandovery) of Kazakhstan with the genus *Howellella*, but the group evolved slowly until the Early Devonian when several families and numerous genera appeared. The group then flourished throughout the Devonian before becoming extinct in the early Carboniferous (Visean). The superfamily Reticularioidea generally has smooth or weakly plicated shells and poorly developed fold and sulcus. They first appeared in the upper Llandovery, but their origin within the Delthyridoidea is uncertain. The two earliest reticularioid genera, *Spirinella* from Australia and *Eohowellella* from Siberia, appeared at about the same time in the upper Llandovery. They could have been derived either from a primitive delthyridoid or from the same spiriferidine ancestor as *Howellella*. Unlike the delthyridoids, the reticularioids flourished in the late Paleozoic before becoming extinct at the end of the Permian.

Suborder SPIRIFERIDINA Waagen, 1883

[*nom. correct.* Pitrat, 1965, p. 668, *pro* suborder Spiriferacea Waagen, 1883a, p. 447; *emend.*, Carter, Johnson, & Gourvennec in Carter & others, 1994, p. 330]

Lateral slopes plicate or costate; fold and sulcus commonly well developed; fine ornament, if present, capillate, pustulose, or imbricate; spinose ornament absent; ctenophoridium absent in early forms. *upper Upper Ordovician, ?Middle Triassic–?Upper Triassic.*

CYRTIOIDEA

J. G. JOHNSON and HOU HONG-FEI

[deceased, formerly of Oregon State University; and China University of Geosciences]

Superfamily CYRTIOIDEA Frederiks, 1924

[*nom. correct.* JOHNSON, GOURVENNEC, & HOU in CARTER & others, 1994, p. 330, *pro* superfamily Cyrtiacea PITRAT, 1965, p. 668, *nom. transl. ex* Cyrtiinae FREDERIKS, 1924, p. 312]

Commonly with fold and sulcus; surface smooth or plicate; microornament of nonspinose capillae crossed by variably nodose growth lines; delthyrium occluded by deltidium, delthyrial plate, or stegidial plates; dental plates present; crural plates variably developed. *upper Upper Ordovician–Lower Devonian (Emsian).*

Family CYRTIIDAE Frederiks, 1924

[*nom. transl.* IVANOVA, 1959, p. 55, *ex* Cyrtiinae FREDERIKS, 1924, p. 312] [=Eospiriferinae SCHUCHERT, 1929, p. 20]

Delthyrial plate and stegidial plates lacking; crural plates commonly well developed. *upper Upper Ordovician–Lower Devonian (Emsian).*

Subfamily CYRTIINAE Frederiks, 1924

[Cyrtiinae FREDERIKS, 1924, p. 312]

Ventribiconvex; ventral valve hemipyramidal, with catacline or procline interarea and narrowly elongate delthyrium; deltidium with medial foramen; ctenophoridium absent. *Silurian (upper Llandovery–Ludlow).*

Cyrtia DALMAN, 1828, p. 97 [**Anomites exporrectus* WAHLENBERG, 1821, p. 64; SD DAVIDSON, 1853, p. 83]. Nontransverse to transverse; lacking plications. *Silurian (upper Llandovery–lower Ludlow):* cosmopolitan.——FIG. 1105,*1a–d.* **C. exporrecta* (WAHLENBERG), upper Llandovery, Gotland; posterior, anterior, side, and ventral views, ×3 (Boucot, 1963a).

Dongbeiispirifer LIU in LIU & HUANG, 1977, p. 58 [**D. typica;* OD]. Small, transverse, with prominent catacline ventral interarea; planoconvex, with ill-defined fold; dental plates very short; dorsal interior unknown. [No satisfactory illustrations are available for this genus.] *Silurian (Ludlow):* northeastern China.

Plicocyrtia BOUCOT, 1963a, p. 704 [**Spirifer petasus* BARRANDE, 1848, p. 183; OD]. Transverse, with plicate flanks; sulcus-bounding dental plates. *Silurian (upper Wenlock):* Czech Republic, USA (Nevada).——FIG. 1105,*2a–f.* **P. petasus* (BARRANDE), Czech Republic; *a–c,* dorsal, lateral, and ventral views, ×1; *d,* microornament, ×3; *e–f,* dorsal and ventral internal molds, ×2 (Boucot, 1963a).

Subfamily EOSPIRIFERINAE Schuchert, 1929

[Eospiriferinae SCHUCHERT, 1929, p. 20]

Biconvex with curved, commonly apsacline ventral interarea; deltidium present; cardinal process or ctenophoridium commonly absent. *upper Upper Ordovician–Lower Devonian (Emsian).*

Eospirifer SCHUCHERT, 1913, p. 411 [**Spirifer radiatus* J. de C. SOWERBY, 1835, p. 245; OD; =*Spirifer lineatus* J. de C. SOWERBY, 1825 in 1823–1825, p. 151, *non Conchyliolites anomites lineatus* MARTIN, 1809, =*Terebratula? lineata* SOWERBY, 1822 in 1821–1822, p. 39]. Smooth or with broad low plications that originate on flanks; extrasinal dental plates; cardinal process lacking; crural plates absent in some early species. *upper Upper Ordovician–Lower Devonian (upper Emsian):* cosmopolitan. ——FIG. 1106,*1a–f.* **E. radiatus* (SOWERBY), Wenlock, Gotland; *a–c,* anterior, lateral, and posterior views; *d–e,* dorsal and ventral views; *f,* posterior view of internal mold, ×1 (Boucot, 1963a).

Badainjarania ZHANG Yan, 1981, p. 388 [392] [**B. striata;* OD]. Small, subcircular, ventral interarea narrow; sulcus lacking and fold low, flat, with median groove; plications on flanks low, rounded; surface capillate; dental plates thin and long; platelike crural bases. *Lower Devonian (Emsian):* northwestern China (Inner Mongolia).——FIG. 1106,*2a–e.* **B. striata,* upper Emsian; *a–d,* ventral, dorsal, anterior, and lateral views, ×2; *e,* exterior showing fine ornament, ×5 (Zhang, 1981).

Endospirifer TACHIBANA, 1981a, p. 36 [**E. nipponicus;* OD]. Small, with deltidium; few low plications near fold and sulcus; extrasinal dental plates; rudimentary ctenophoridium. *Silurian (upper Llandovery–Wenlock, ?Ludlow):* eastern Australia, Japan, southwestern China.——FIG. 1106,*5a–g.* **E. nipponicus,* ?Ludlow, Japan; *a–d,* holotype, ventral, dorsal, posterior, and anterior views, ×5; *e,* ventral valve ornament, ×6; *f,* ventral internal mold, ×5; *g,* posterior view of dorsal mold, ×4 (Tachibana, 1981a).

Espella NILOVA, 1965, p. 102 [**E. kazachstanica;* OD] [=*Laevispirifer* USHATINSKAIA, 1977, p. 137 (type, *L. zhamankonensis* USHATINSKAIA, 1977, p. 138, OD)].

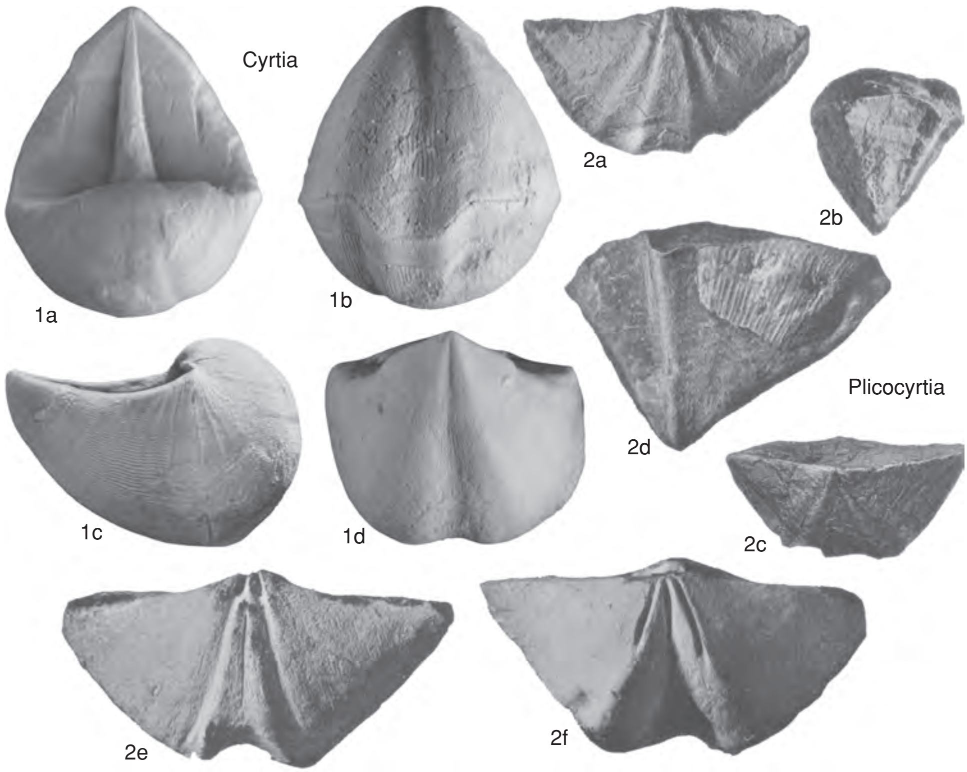

FIG. 1105. Cyrtiidae (p. 1695).

Biconvex, with obtuse cardinal angles; ventral interarea short, apsacline; fold and sulcus absent; flattened capillae; thin dental plates; long crural plates joining valve posteriorly, converging anteriorly with short median septum, forming cruralium. *Silurian (middle Llandovery–Wenlock):* central Kazakhstan.——FIG. 1107,*2a–g.* **E. kazachstanica; a–c,* holotype, ventral, dorsal, and lateral views, ×1; *d–g,* serial sections, ×2 (Nilova, 1965).

Havlicekia BOUCOT, 1963a, p. 693 [**Spirifer secans* BARRANDE, 1848, p. 168; OD]. Plicate in early growth stages, smooth in later growth stages, with narrow intercapillar grooves. *Silurian (Ludlow)–Lower Devonian (Emsian):* Europe, Salair, Gorny Altai, Bithynia, northern Africa, New Zealand.——FIG. 1107,*1a–f.* **H. secans* (BARRANDE), Pragian, Bohemia; *a–b,* dorsal and anterior views; *c–f,* ventral, dorsal, anterior, and side views, ×1 (Havlíček, 1980).

Hedeina BOUCOT, 1957b, p. 323 [**Anomia crispa* LINNAEUS, 1758, p. 702; OD]. With broad, low plications. *Silurian (upper Wenlock)–Lower Devonian (upper Emsian):* Europe, Kazakhstan.——FIG. 1107,*3a–f.* **H. crispa* (LINNAEUS), origin uncertain; *a–e,* holotype, ventral, dorsal, anterior, posterior, and lateral views, ×1; *f,* microornament, ×3.7 (Brunton, Cocks, & Dance, 1967).

Janius HAVLÍČEK, 1957a, p. 245 [**Spirifer nobilis* BARRANDE, 1848, p. 184; OD]. Strongly plicate with plications that bifurcate and intercalate; small plications may be present in sulcus. [No satisfactory illustration of the type (a damaged dorsal valve) is available.] *Silurian (upper Wenlock)–Lower Devonian (Emsian):* cosmopolitan.——FIG. 1106,*4a–d. J. exsul* (BARRANDE), upper Wenlock, Bohemia; ventral, dorsal, anterior, and side views, ×1 (Havlíček, 1980).——FIG. 1106,*4e. J. bouskai* HAVLÍČEK, Ludlow, Bohemia; ornament, ×6 (Havlíček, 1980).

Lobvia BREIVEL & BREIVEL, 1977, p. 97 [**Theodossia (L.) praesuperbus;* OD]. Smooth posteriorly, low, rounded plications anteriorly on flanks; ctenophoridium probable. *Lower Devonian (Emsian):* Urals.——FIG. 1107,*4a–d.* **L. praesuperbus* BREIVEL & BREIVEL; ventral, dorsal, lateral, and anterior views, ×1 (Breivel & Breivel, 1977).

Macropleura BOUCOT, 1963a, p. 690 [**Delthyris macropleura* CONRAD, 1840, p. 207; OD] [=*Ejnespirifer* FU, 1982, p. 176 (type, *E. styphelus* FU, 1982, p. 177, OD)]. With few prominent plications and deep, U-shaped interspaces; dental plates extrasinal. *Silurian (upper Llandovery)–Lower Devonian (Emsian):* North America, Europe, Kazakhstan, northeastern China, Australia. ——FIG. 1108,*1a–g.* **M. macropleura* (CONRAD),

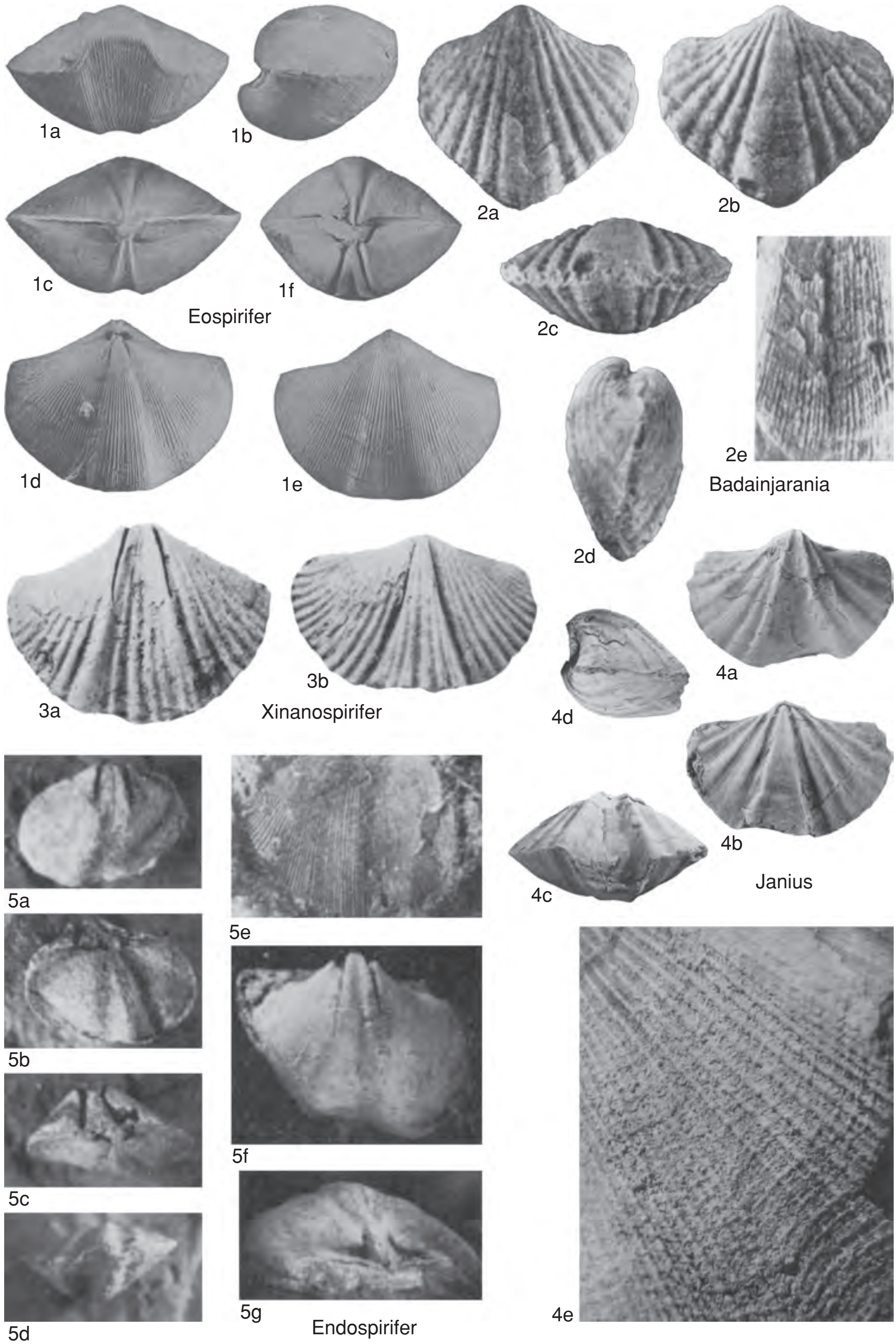

FIG. 1106. Cyrtiidae (p. 1695–1701).

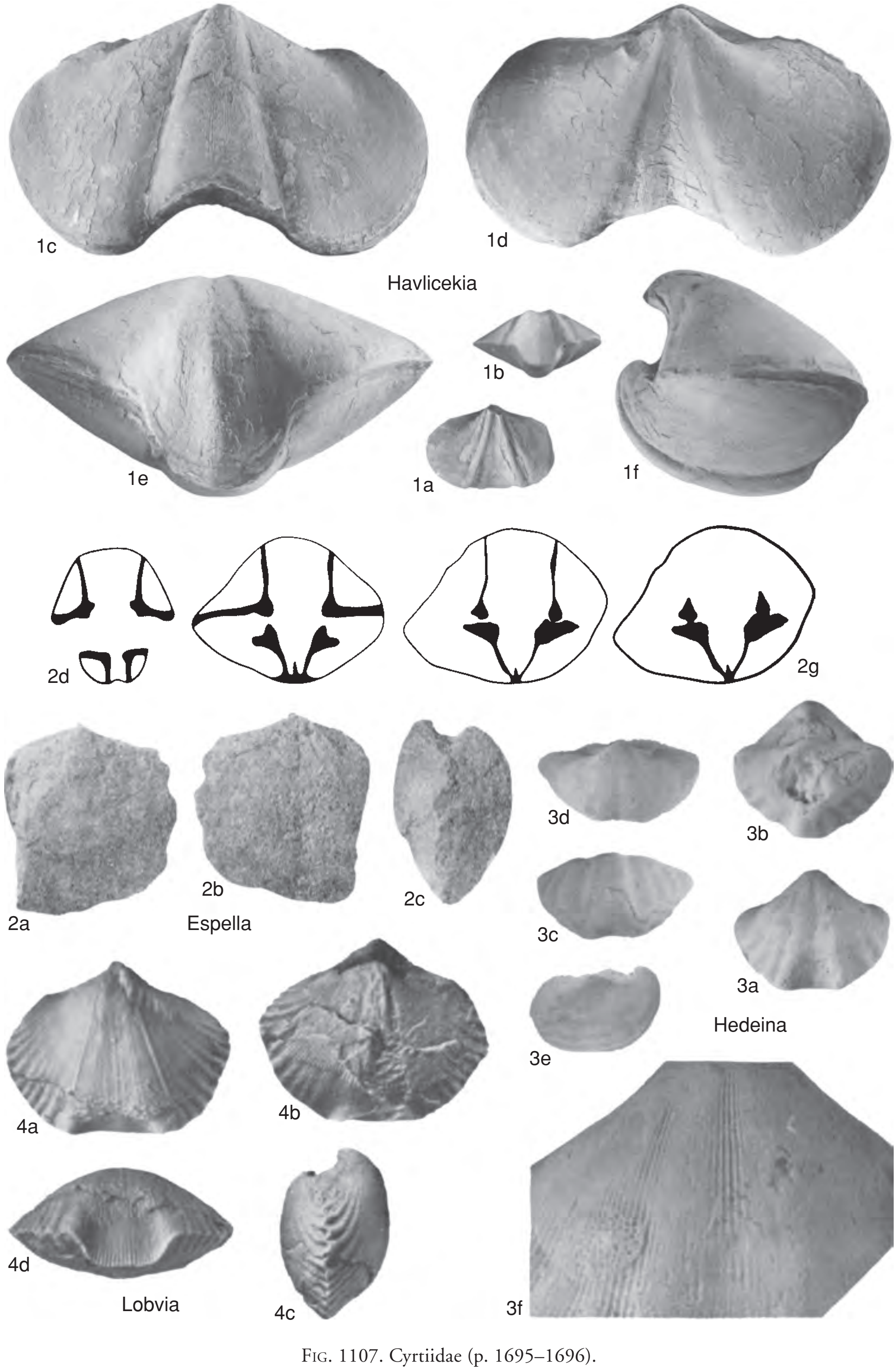

FIG. 1107. Cyrtiidae (p. 1695–1696).

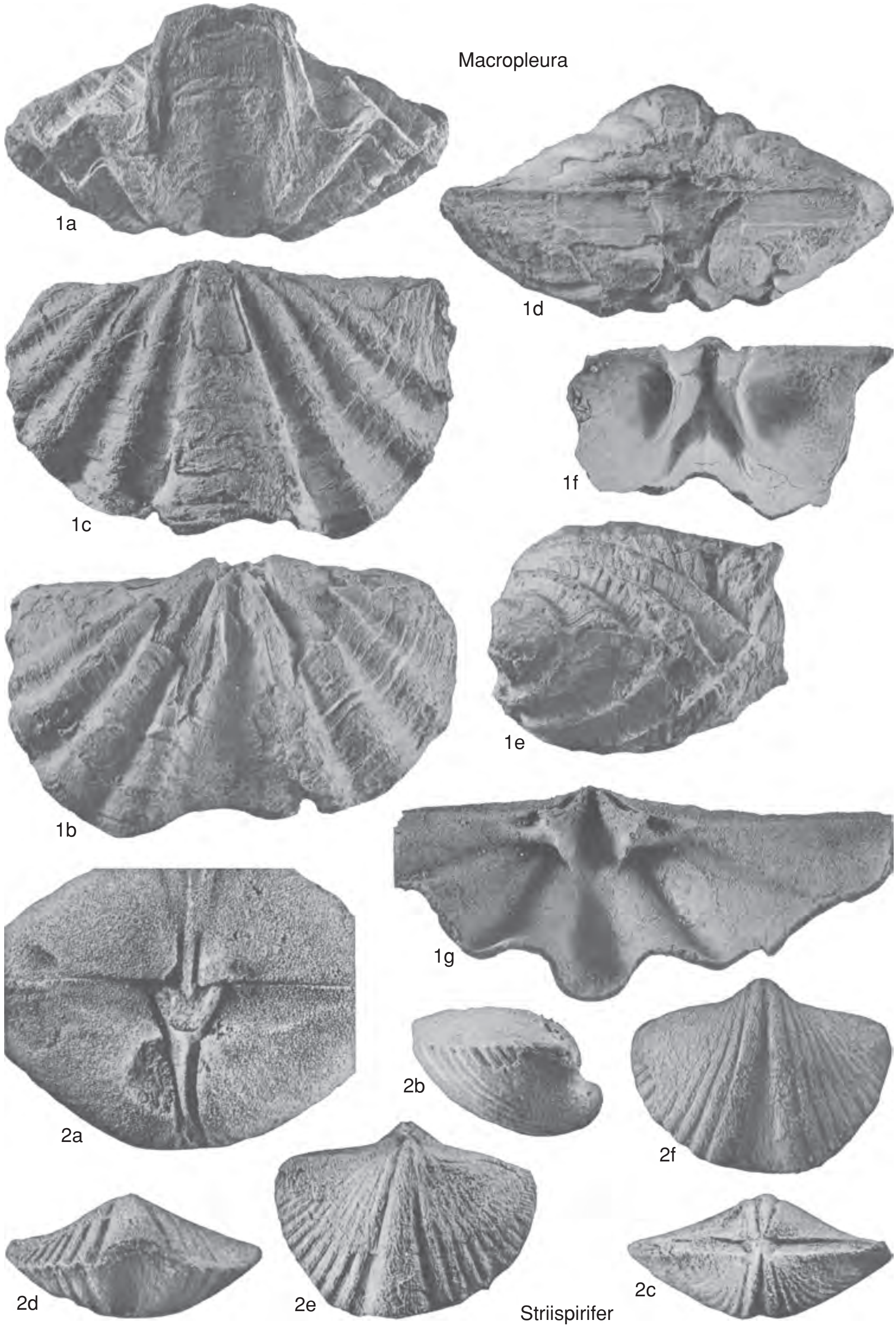

FIG. 1108. Cyrtiidae (p. 1696–1701).

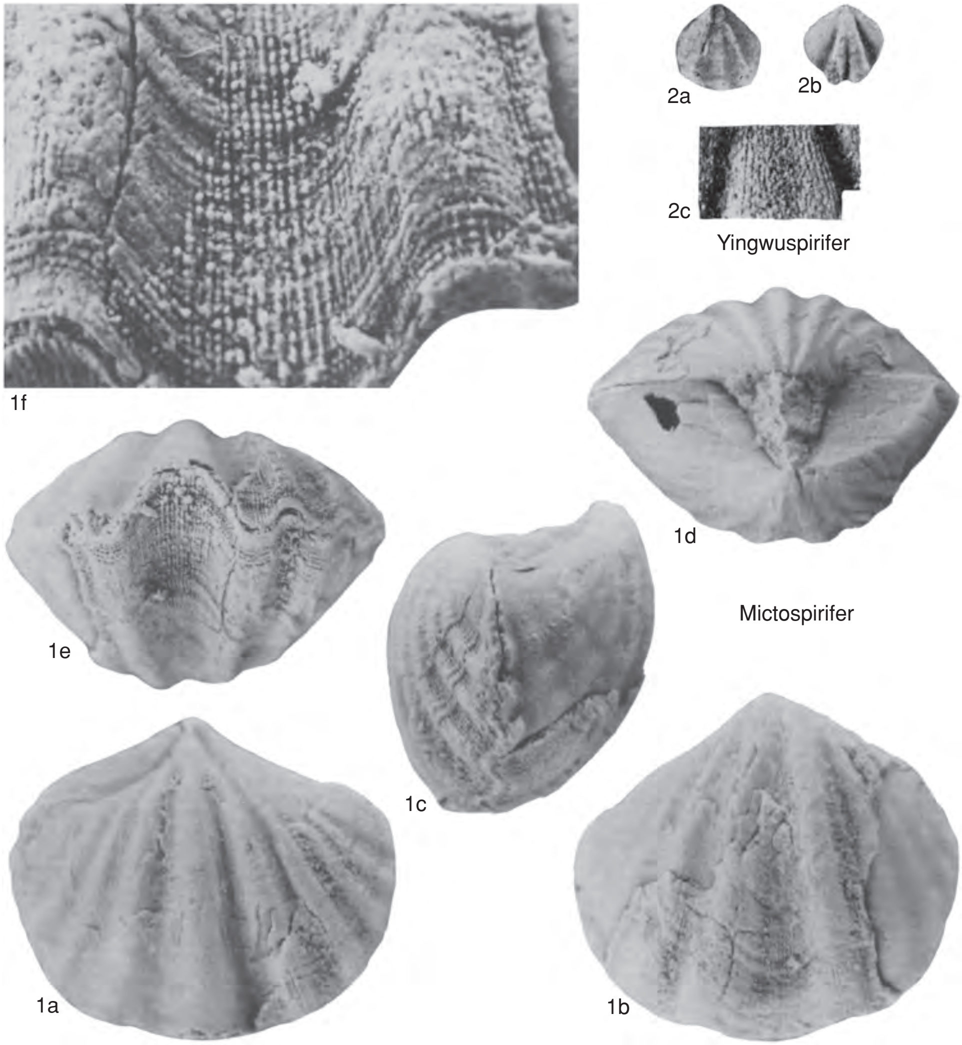

FIG. 1109. Cyrtiidae (p. 1700–1701).

Lochkovian, New York, USA; *a–e,* anterior, ventral, dorsal, posterior, and lateral views, ×1; *f,* ventral interior; *g,* dorsal interior, ×2 (Boucot, 1963a).

Mictospirifer JOHNSON, 1995b, p. 607 [**M. jini;* OD; =*Howellella elegans* JIN, CALDWELL, & NORFORD, 1993, p. 106, *non* MUIR-WOOD, 1925]. With few prominent plications and deep, U-shaped interspaces; dental plates short, extrasinal; crural plates and ctenophoridium rudimentary or evanescent. *Silurian (upper Llandovery):* Canada.——FIG. 1109,*1a–f.* **M. jini; a–e,* dorsal, ventral, lateral, posterior, and anterior views of hypotype, ×4; *f,* microornament, ×12 (Jin, Caldwell, & Norford, 1993).

Myriospirifer HAVLÍČEK, 1978, p. 105 [**M. myriofila* HAVLÍČEK, 1978, p. 106; OD] [=*Acutilineolus* AMSDEN, 1978, p. 31 (type, *Eospirifer acutolineatus* AMSDEN, 1968, p. 64, OD)]. Nonplicate, with narrow intercapillar interspaces. *Silurian (upper Llandovery)–Lower Devonian (Emsian):* cosmopolitan.——FIG. 1110,*1a–e.* **M. myriofila,* Pragian, Bohemia; *a–d,* ventral, dorsal, anterior, and side views, ×1; *e,* ornament, ×6 (Havlíček, 1980).

Nurataella LARIN, 1973, p. 135 [**N. miranda* LARIN, 1973, p. 137; OD] [=*Baterospirifer* RONG, SU, & LI, 1984, p. 64 [67] (type, *B. rectimarginatus* RONG, SU, & LI, 1984, p. 65, OD)]. Dorsal valve nearly flat but with faint posterior fold; sulcus lacking;

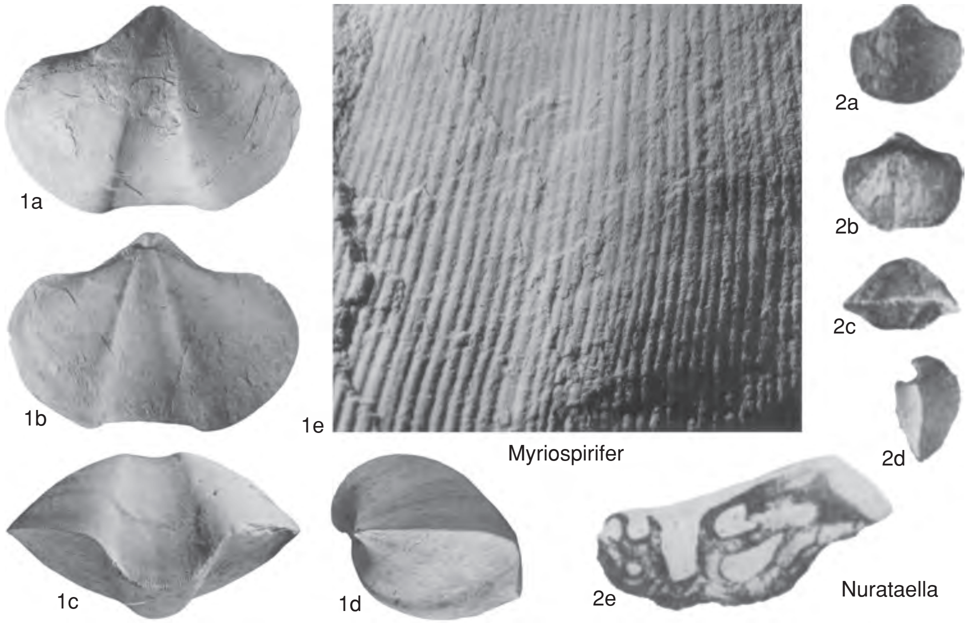

FIG. 1110. Cyrtiidae (p. 1700–1701).

rudimentary delthyrial plate present. *Silurian (upper Wenlock–Pridoli):* central Asia, China (Inner Mongolia).——FIG. 1110,*2a–e.* **N. miranda,* upper Wenlock, Russia; *a–d,* holotype, ventral, dorsal, anterior, and lateral views, ×4; *e,* transverse section of dorsal valve, ×11 (Larin, 1973).

Striispirifer COOPER & MUIR-WOOD, 1951, p. 195, *nom. nov. pro Schuchertia* FREDERIKS, 1926, p. 406, *non* GREGORY, 1899, p. 351 [**Delthyris niagarensis* CONRAD, 1842, p. 261; OD]. With numerous low, rounded, simple plications on flanks. *Silurian (upper Llandovery–lower Ludlow):* Europe, North America.——FIG. 1108,*2a–f.* **S. niagarensis* (CONRAD), New York, USA; *a,* posterior view of dorsal mold; *b–f,* lateral, posterior, anterior, dorsal, and ventral views, ×2 (Boucot, 1963a).

Yingwuspirifer RONG, XU, & YANG, 1974, p. 201 [**Y. orientalis;* OD]. Small, with single prominent plication in sulcus and median groove on fold; flanks nonplicate. *Silurian (Rhuddanian):* southern China.——FIG. 1109,*2a–c.* **Y. orientalis; a–b,* ventral and dorsal views, ×1; *c,* microornament, ×4 (Rong, Xu, & Yang, 1974).

Xinanospirifer RONG, XU, & YANG, 1974, p. 206 [**X. flabellum;* OD]. With numerous low, rounded, simple plications on flanks and same size plications, increasing by insertion, in sulcus; dental plates thin, bounding sulcus; short crural plates present. *Silurian (Telychian):* southwestern China.——FIG. 1106,*3a–b.* **X. flabellum;* ventral and dorsal valves, ×1.5 (Rong, Xu, & Yang, 1974).

Family HEDEINOPSIDAE Gourvennec, 1990

[*nom. transl.* JOHNSON in CARTER & others, 1994, p. 331, *ex* Hedeinopsinae GOURVENNEC, 1990, p. 142]

Plicate, ventribiconvex, with stegidial plates and delthyrial plate; crural plates rudimentary or absent; ctenophoridium present. *Silurian (Wenlock–Pridoli).*

Subfamily HEDEINOPSINAE Gourvennec, 1990

[Hedeinopsinae GOURVENNEC, 1990, p. 142]

Characters as for family. *Silurian (Wenlock–Pridoli).*

Hedeinopsis GOURVENNEC, 1990, p. 142 [**H. hispanica* GOURVENNEC, 1990, p. 143; OD]. Transverse, with low, apsacline ventral interarea; strong simple plications, with fine capillae; small apical delthyrial plate present; dental plates partly obscured by umbonal callus; short crural plates may be obscured by thick shell; narrow ctenophoridium present. *Silurian (Wenlock–Ludlow):* Spain, Morocco, Algeria.——FIG. 1111,*1a–b.* **H. hispanica hispanica,* Spain; *a,* mold of dorsal valve; *b,* holotype, mold of ventral valve, ×2 (Gourvennec, 1990).——FIG. 1111,*1c–d. H. hispanica*

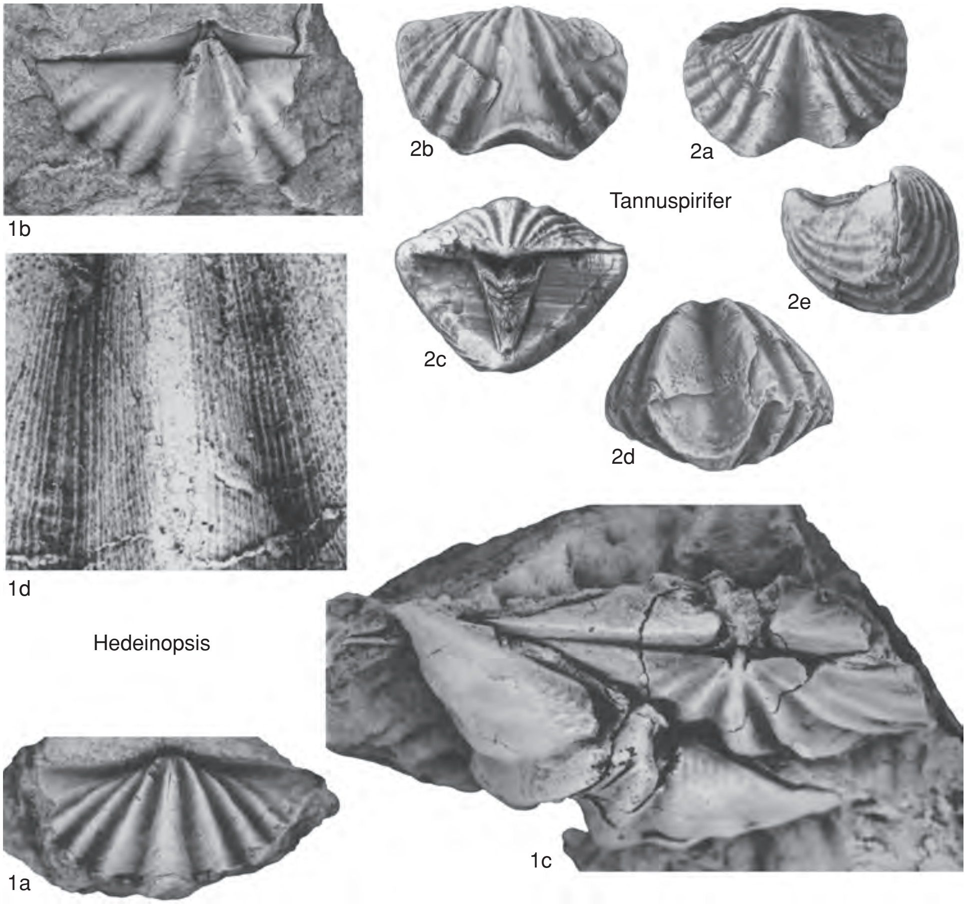

FIG. 1111. Hedeinopsidae (p. 1701–1702).

disparisulcata GOURVENNEC, Wenlock, Spain; *c,* steinkern of complete specimen, ×2; *d,* microornament, ×10 (Gourvennec, 1990).

Tannuspirifer IVANOVA, 1960, p. 267 [**Spirifer pedaschenkoi* CHERNYSHEV, 1937, p. 51; OD]. Ventral valve hemipyramidal, with high interarea; dorsal valve flat or weakly convex; fold and sulcus prominent, smooth; flanks with strong, rounded, simple plications; microornament of fine capillae and fila of reticulate pattern; thin dental plates with well-developed delthyrial plate present; ctenophoridium present; crural plates absent. [No satisfactory illustration of the type is available.] *Silurian (Ludlow–Pridoli):* Altai, Sayan, Tuva basin, Canadian Arctic Islands.——FIG. 1111,*2a–e. T. dixoni* JONES, Pridoli, Arctic Canada; ventral, dorsal, posterior, anterior, and lateral views, ×2 (new).

ADOLFIOIDEA

J. G. JOHNSON

[deceased, formerly of Oregon State University]

Superfamily ADOLFIOIDEA Sartenaer, 1966

[*nom. transl.* JOHNSON, herein, *pro* Adolfiinae SARTENAER, 1966, p. 386] [=Spinelloidea JOHNSON, 1970, p. 205]

Fold and sulcus present; surface plicate, capillate or smooth, nonfrilly; dental plates present, delthyrial plate and median septum lacking; ctenophoridium present. *Silurian (Wenlock)–Upper Devonian (upper Famennian).*

Family ADOLFIIDAE Sartenaer, 1966

[*nom. transl.* JOHNSON, herein, *pro* Adolfiinae SARTENAER, 1966, p. 386] [=Spinellidae JOHNSON, 1970, p. 205]

Multiplicate, with smooth or medially grooved fold and smooth or medially plicate sulcus. *Silurian (Wenlock)–Upper Devonian (upper Famennian).*

Subfamily ADOLFIINAE Sartenaer, 1966

[Adolfiinae SARTENAER, 1966, p. 386, *nom. nov. pro* Guerichellinae PAECKELMANN, 1931, p. 24, based on invalid junior synonym] [=Spinellinae JOHNSON, 1970, p. 205]

Capillate, with height of ventral area medium to high; crural plates short or lacking. [JOHNSON (1970) erected the subfamily Spinellinae as a *nom. nov. pro* Guerichellinae PAECKELMANN, 1931, based on the invalid genus *Guerichella.* SARTENAER (1966), in a clarification of the status of the genera *Adolfia* and *Guerichella,* had already established a new subfamily named Adolfiinae. The latter has priority and is restored here. As a consequence, the family and superfamily names are modified in order to conform with the principle of coordination.] *Lower Devonian (Pragian)–Upper Devonian (upper Famennian).*

Adolfia GÜRICH, 1909, p. 136 [**Spirifer deflexus* ROEMER, 1843, p. 13; SD SCHUCHERT, 1929, p. 27] [=*Guerichella* PAECKELMANN, 1913, p. 299, obj.; *Changshaispirifer* ZHAO in YANG De-Li & others, 1977, p. 428 (type, *C. lianhuaqiaoensis,* OD)]. Medium size, transverse, with obtuse cardinal angles; ventral interarea curved, apsacline; fold and sulcus prominent, smooth, or with a few incipient plications; flanks with numerous, bifurcating, rounded plications and narrow, U-shaped interspaces; microornament of subradial capillae; dental plates free of umbonal callus; ctenophoridium without crural plates. *Lower Devonian (upper Pragian)–Upper Devonian (Frasnian):* Europe, North America, southern China.——FIG. 1112,*2a–d.* **A. deflexa* (ROEMER), lower Frasnian, Germany; holotype, ventral, dorsal, posterior, and lateral views, ×1 (Vandercammen, 1967).

Acutatheca STAINBROOK, 1945, p. 55 [**A. proparia;* OD]. Small, ventribiconvex, equidimensional; cardinal angles obtuse; ventral interarea high, flat to slightly curved, steeply apsacline to catacline; delthyrium partially closed by apical plate; fold and sulcus smooth; flanks strongly pauciplicate, with fine capillae; slightly divergent dental plates present; hinge plates supported by median ridge. *Upper Devonian (Frasnian):* midcontinent and western North America.——FIG. 1113,*2a–b.* **A. proparia,* Iowa, USA; *a,* ventral valve, ×1.5; *b,* posterior view, ×3 (Stainbrook, 1945).

Allanella CRICKMAY, 1953b, p. 5 [**Spirifer allani* WARREN, 1944, p. 123; OD] [=*Allanaria* CRICKMAY, 1953b, p. 5, obj.; *Minutilla* CRICKMAY, 1967, p. 10 (type, *Acutatheca (M.) layeri,* OD)]. Small, ventribiconvex, equidimensional; cardinal angles obtuse to slightly acute; ventral interarea of moderate height, slightly curved, apsacline; fold and sulcus broad, fold not elevated; flanks with simple, low rounded plications; surface capillate, with fila; dental plates extrasinal; ctenophoridium and short crural plates present. [CRICKMAY erroneously considered *Allanella* as invalid and replaced this name by *Allanaria* in a section entitled Errata & Addenda. As first reviser, PITRAT (1965, p. 691) invalidated the name *Allanaria.*] *Middle Devonian (upper Givetian)–Upper Devonian (Frasnian):* North America.——FIG. 1113,*1a–e.* **A. allani* (WARREN), upper Givetian, Alberta, Canada; lectotype, ventral, dorsal, posterior, anterior, and lateral views, ×1.5 (Crickmay, 1953b).

Chimaerothyris PAULUS, STRUVE, & WOLFART, 1963, p. 463 [**C. hotzi* PAULUS, STRUVE, & WOLFART, 1963, p. 465; OD]. Ventribiconvex, transverse with acute cardinal angles; ventral interarea long, low, apsacline to orthocline; fold and sulcus prominent, unplicated; flanks with numerous, simple, rounded

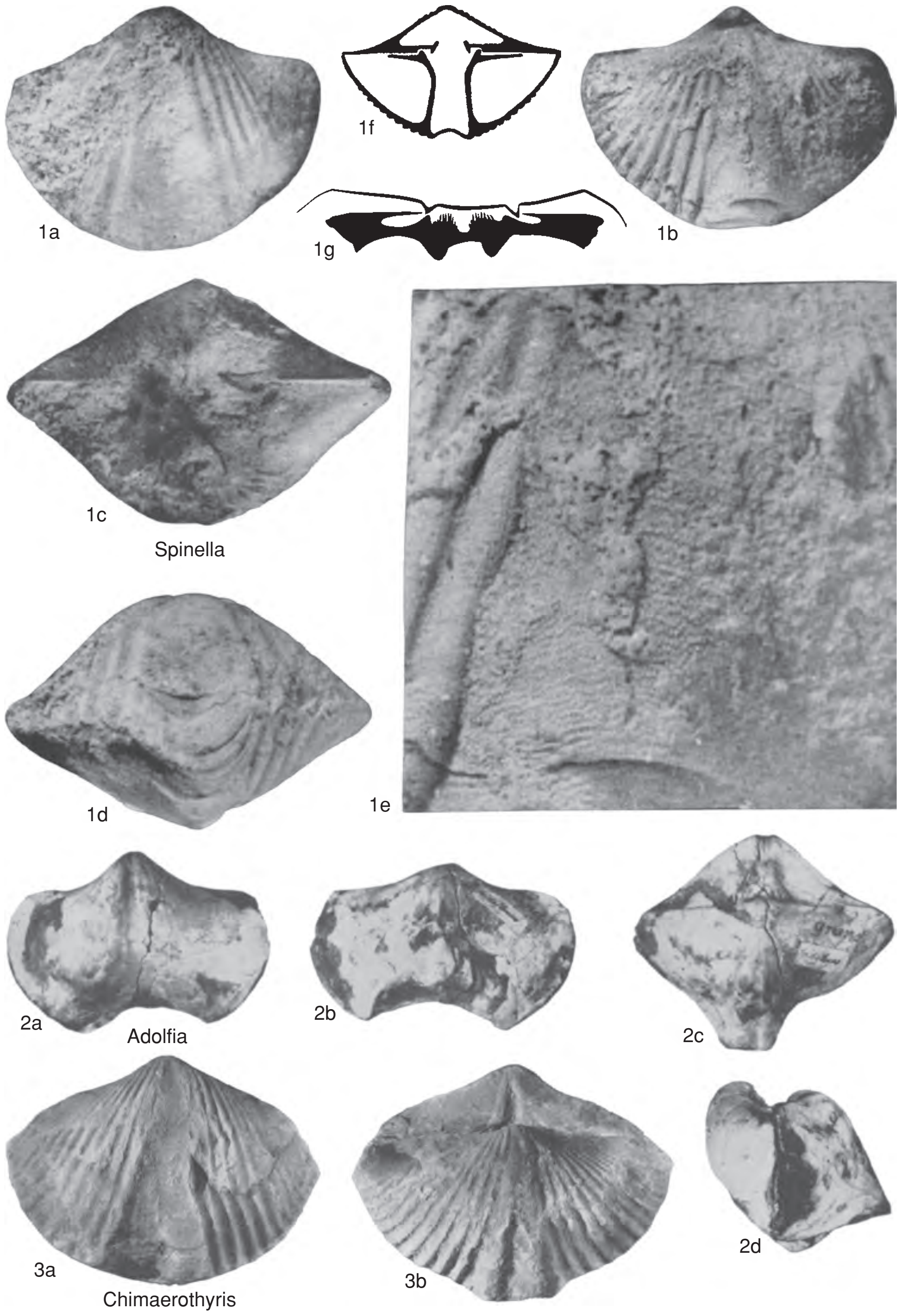

FIG. 1112. Adolfiidae (p. 1703–1707).

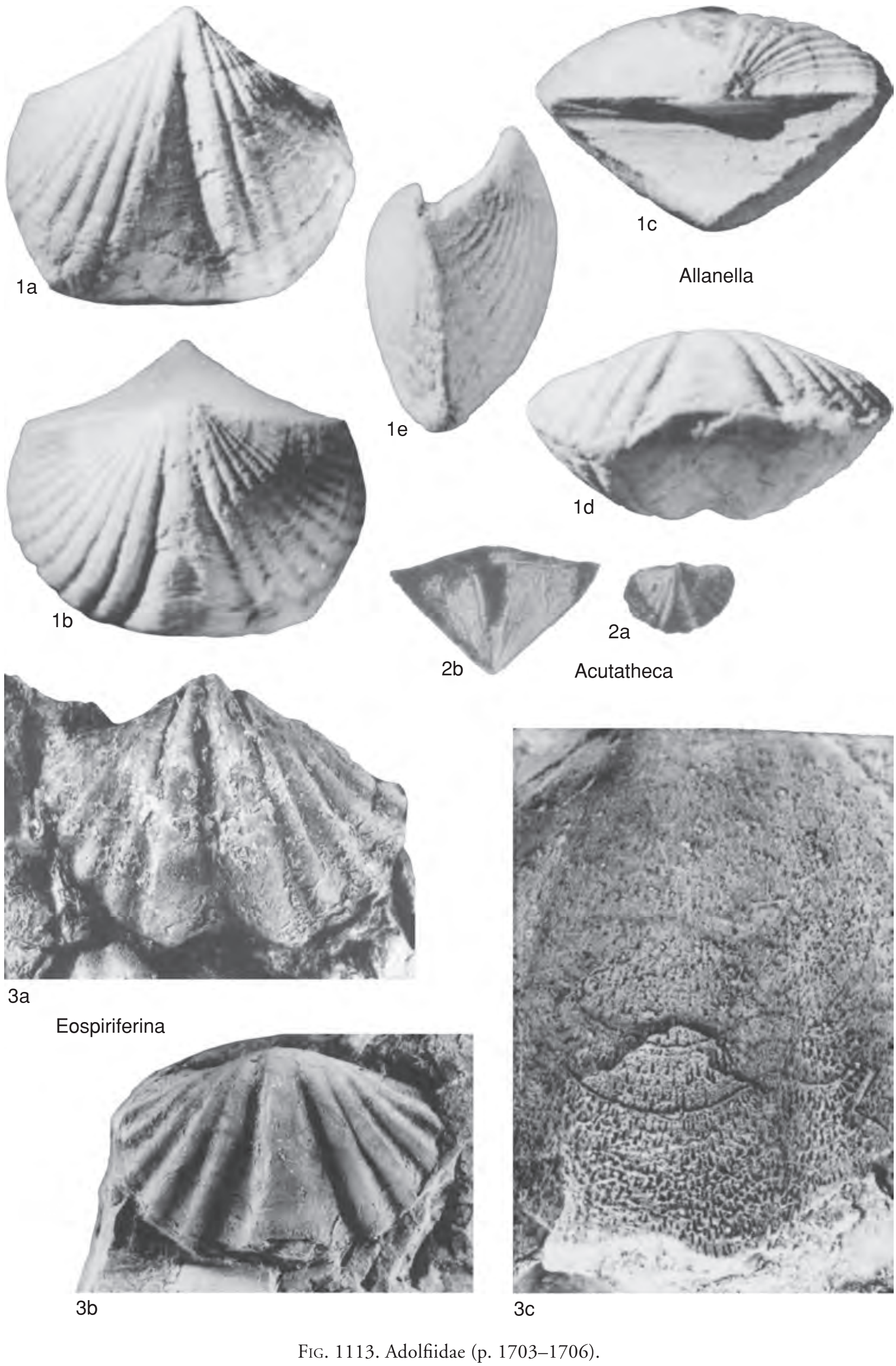

FIG. 1113. Adolfiidae (p. 1703–1706).

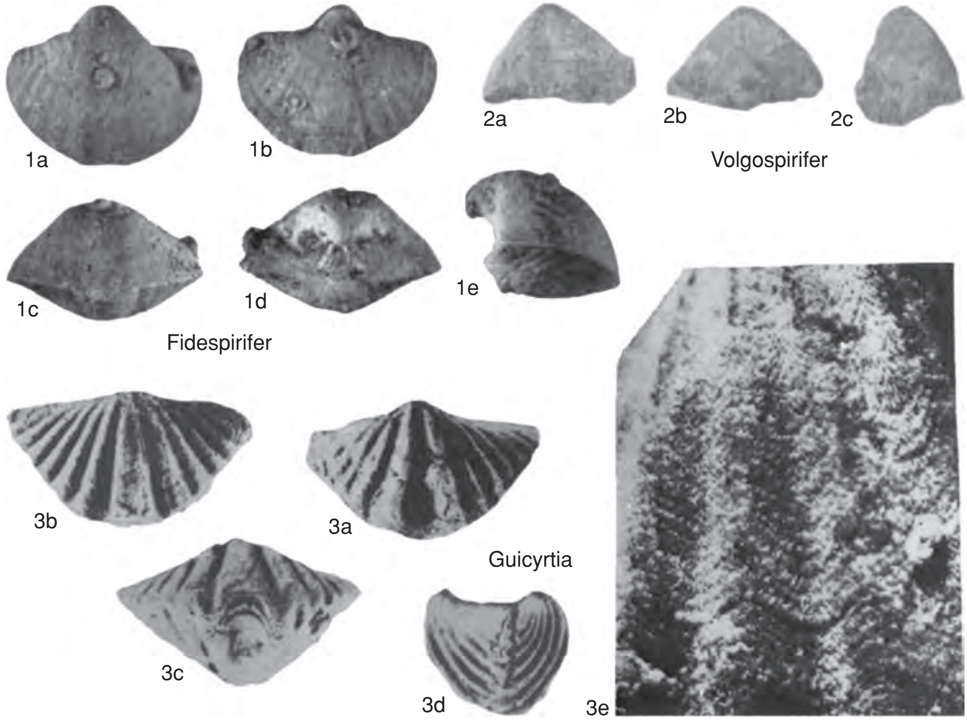

FIG. 1114. Adolfiidae (p. 1706–1707).

plications; microornament of subradial capillae crossed by irregularly spaced growth lines; dental plates straight, strong, partly obscured by umbonal callus; ctenophoridium elongate, situated on inner hinge plates. *Middle Devonian (Eifelian):* Europe.——FIG. 1112,*3a–b.* **C. hotzi,* Germany; holotype, ventral and dorsal views, ×1 (Paulus, Struve, & Wolfart, 1963).

Eospiriferina GRABAU, 1931b, p. 494 [**Spiriferina (E.) lachrymosa;* OD]. Medium size, biconvex, slightly transverse, with obtuse cardinal angles; ventral interarea curved, apsacline; fold and sulcus smooth; flanks with a few strong, rounded plications separated by U-shaped interspaces; microornament of oval to elongate-oval pustules arranged quincuncially or subradially; strong, thin, intrasinal dental plates present; anteriorly convergent crural plates present. *Lower Devonian (upper Emsian)–Middle Devonian (Eifelian):* southern China (Guangxi).——FIG. 1113,*3a–c.* **E. lachrymosa* GRABAU, Eifelian; *a–b,* ventral and dorsal internal molds, ×2; *c,* exterior showing fine ornament, ×5 (new).

Fidespirifer LIASHENKO, 1973, p. 129 [**F. striatus;* OD]. Small, ventribiconvex, slightly transverse, with obtuse cardinal angles; ventral interarea curved, apsacline; fold and sulcus smooth; flanks with few, very low, rounded plications; surface capillate; divergent dental plates present; short crural plates. *Upper Devonian (lower Frasnian):* southern Timan.——FIG. 1114,*1a–e.* **F. striatus;* holotype, ventral, dorsal, anterior, posterior, and lateral views, ×2 (Liashenko, 1973).

Guicyrtia WANG & ZHU, 1979, p. 59 [93] [**G. triangulata;* OD]. Small, transverse, with acute cardinal angles; ventral interarea high, apsacline to catacline, with deltidium; fold and sulcus narrow, rounded, with few strong, rounded plications on flanks; microornament of teardrop-shaped pustules and weak growth lines; interior unknown. *Middle Devonian:* China.——FIG. 1114,*3a–e.* **G. triangulata,* Eifelian; *a–d,* ventral, dorsal, anterior, and side views, ×2.5; *e,* exterior showing fine ornament, ×14 (new).

Spinella TALENT, 1956, p. 21 [**S. buchanensis* TALENT, 1956, p. 22; OD]. Equidimensional, with curved,

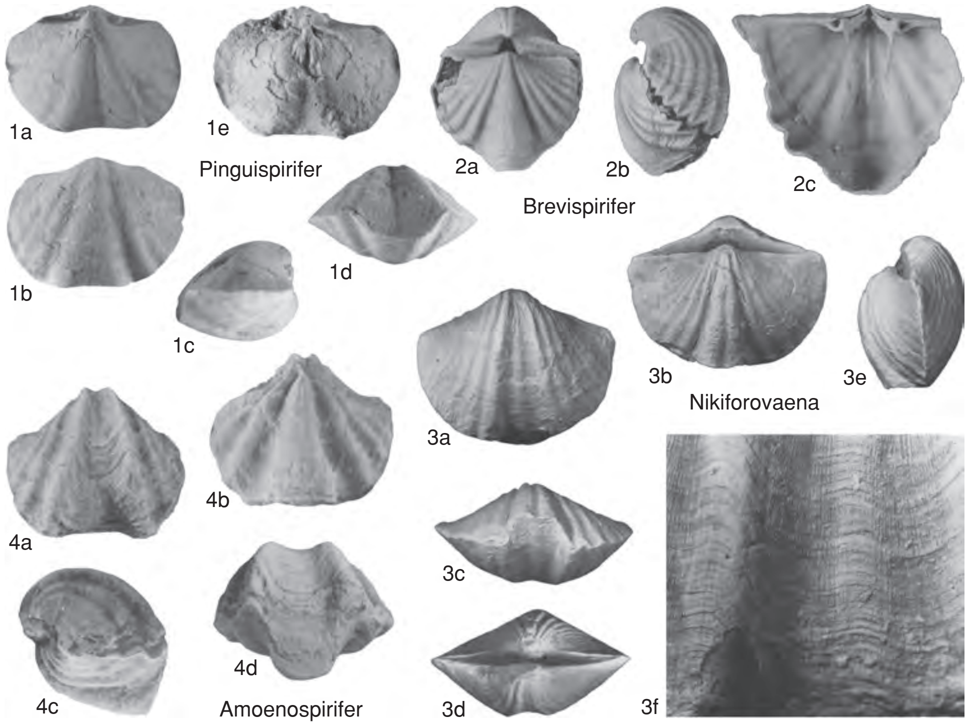

FIG. 1115. Adolfiidae (p. 1707–1709).

apsacline ventral interarea; fold and sulcus well defined, smooth; flanks with numerous, simple, rounded plications and narrow, U-shaped interspaces; microornament of very fine oval to elongate-oval spine bases arranged quincuncially or subradially; long dental plates present; bilobed ctenophoridium present; crural plates lacking. *Lower Devonian (Pragian–lower Emsian):* Australia.——FIG. 1112,*1a–g.* **S. buchanensis; a–d,* ventral, dorsal, posterior, and anterior views, ×1.5; *e,* microornament, ×10.5; *f,* transverse section, ×1; *g,* transverse section of cardinalia, enlarged (Talent, 1956).

Volgospirifer SHEVCHENKO, 1970, p. 111 [**V. volgensis* SHEVCHENKO, 1970, p. 113; OD]. Small to medium size, ventribiconvex, hemipyramidal; cardinal angles slightly acute; ventral interarea high, flat, catacline; fold and sulcus smooth, faintly developed or absent; fold with median furrow; flanks smooth or pauciplicate; surface with bifurcating capillae; dental plates and low, distally grooved median septum present. *Upper Devonian (upper Famennian):* Russian Platform.——FIG. 1114,*2a–c.* **V. volgensis;* holotype, ventral, posterior, and lateral views, ×1 (Shevchenko, 1970).

Subfamily PINGUISPIRIFERINAE Havlíček, 1971

[Pinguispiriferinae HAVLÍČEK, 1971, p. 27]

Plicate, with weak to obscure capillae, crossed by fila; crural plates short or lacking. *Silurian (Wenlock)–Middle Devonian (Eifelian).*

Pinguispirifer HAVLÍČEK, 1957a, p. 246 [**Spirifer infirmus* BARRANDE, 1879, p. 47; OD]. Fold and sulcus nonplicate; flanks with a few low, rounded plications; dental plates partly concealed by secondary shell material. *Lower Devonian (Emsian)–Middle Devonian (Eifelian):* Czech Republic.——Fig. 1115,*1a–e.* **P. infirmus* (BARRANDE), upper Emsian, Bohemia; ventral, dorsal, side, and anterior views, and ventral view of exfoliated specimen, ×1 (Havlíček, 1959).

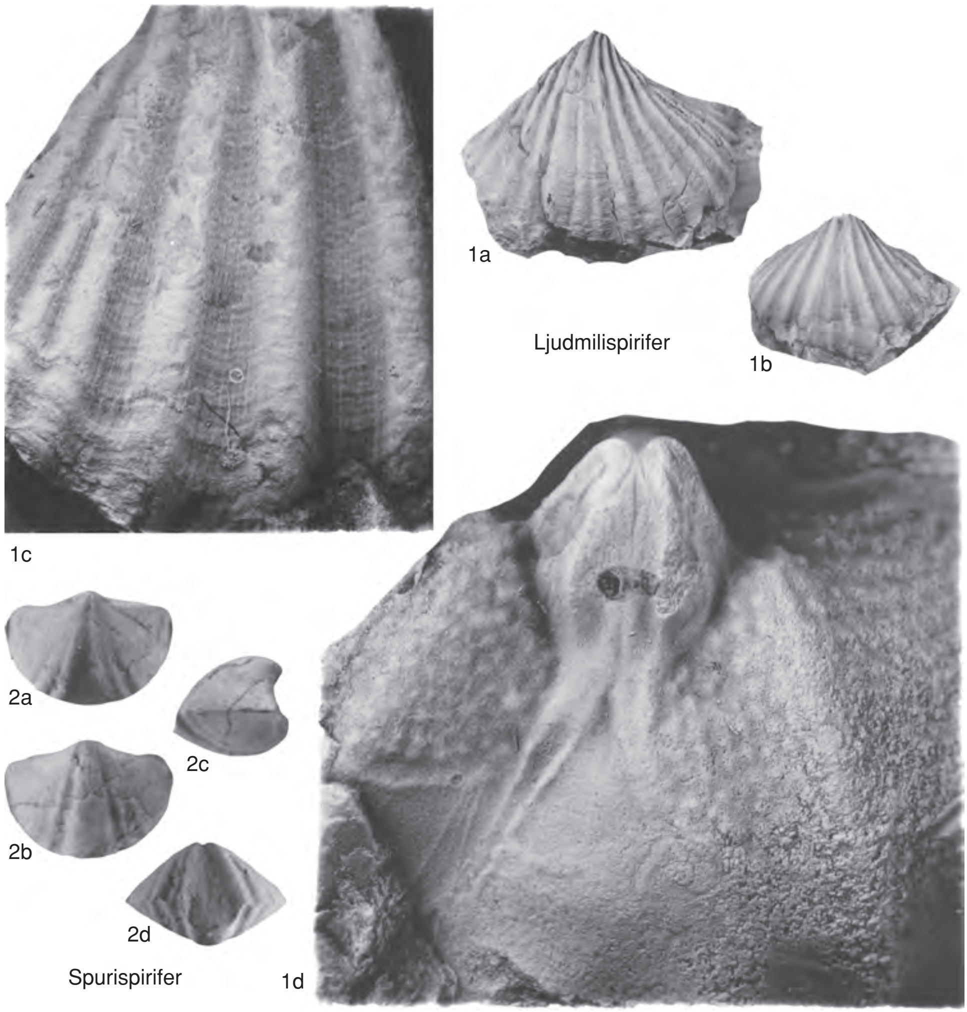

FIG. 1116. Adolfiidae (p. 1708–1709).

Amoenospirifer HAVLÍČEK, 1957b, p. 436 [**Spirifer thetidis* BARRANDE, 1848, p. 176; OD]. Fold and sulcus nonplicate; flanks with few prominent, rounded plications; dental plates lacking; ventral umbonal area with thick secondary shell material; vascular impressions strong. [No satisfactory illustration of the type is available.] *Lower Devonian (Emsian):* Czech Republic.——FIG. 1115,*4a–d. A. amoenoides* HAVLÍČEK, upper Emsian, Bohemia; ventral, dorsal, side, and anterior views, ×1.5 (Havlíček, 1959).

Brevispirifer COOPER, 1942, p. 231 [**Spirifer gregaria* CLAPP in HALL, 1857, p. 127; OD]. Equidimensional or elongate; fold and sulcus prominent, smooth, or with medial plication in sulcus; flanks with a few rounded plications; dental plates thick, partly buried in umbonal callus; crural plates short or lacking. *Middle Devonian (lower Eifelian):* eastern and midcontinent North America.——FIG. 1115,*2a–c.* **B. gregarius* (CLAPP), New York, USA; *a–b,* dorsal and lateral views, ×1; *c,* dorsal interior, enlarged (Cooper, 1944).

Ljudmilispirifer CHERKESOVA, 1976, p. 90 [**Delthyris irregularis* NALIVKIN in MARKOVSKI, 1960, p. 396; OD]. One or more plications in sulcus; flanks with few prominent, rounded plications; dental plates absent; ventral umbonal region with secondary prismatic shell; vascular impressions strong. *Lower Devonian (upper Emsian):* Russia (Novaya Zemlya). ——FIG. 1116,*1a–d.* **L. irregularis* (NALIVKIN);

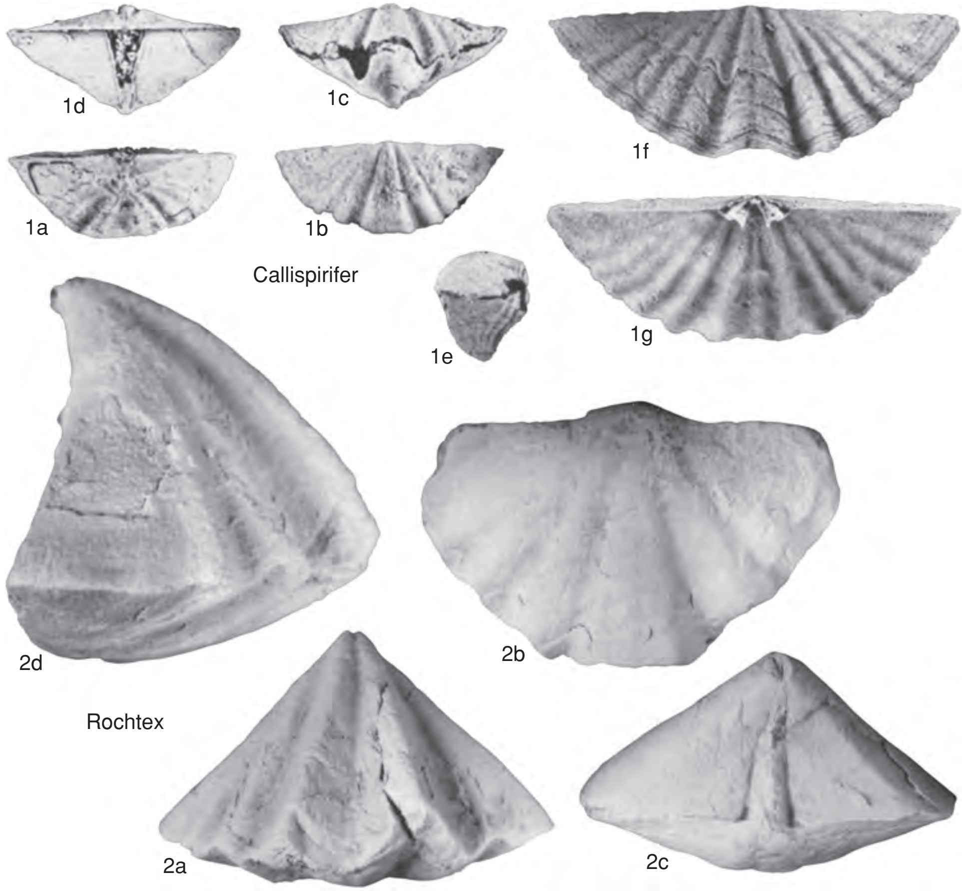

FIG. 1117. Adolfiidae (p. 1709–1710).

a–b, ventral, exterior views, ×1; *c–d,* ventral exterior showing ornament and ventral internal mold, ×5 (Cherkesova, 1976).

Nikiforovaena BOUCOT, 1963a, p. 697 [**Spirifer (Eospirifer) ferganensis* NIKIFOROVA, 1937, p. 48; OD]. One or more plications in sulcus; flanks with numerous low, rounded plications; dental plates present; ctenophoridium and short divergent crural plates present. *Silurian (Pridoli)–Lower Devonian (Emsian):* Turkestan, Salair, Altai, Yunnan, Japan, Australia.——FIG. 1115,*3a–f.* **N. ferganensis* (NIKIFOROVA), Ludlow, Ferghana; *a–e,* ventral, dorsal, anterior, posterior, and lateral views, ×1; *f,* microornament, ×5 (new).

Spurispirifer HAVLÍČEK, 1971, p. 27 [**Spirifer spurius* BARRANDE, 1848, p. 174; OD]. Deltidium apical; fold and sulcus nonplicate, or fold with median groove; flanks with few low, rounded plications. *Silurian (Wenlock)–Lower Devonian (Lochkovian):* Czech Republic, Canadian Arctic Islands.——FIG. 1116,*2a–d.* **S. spurius* (BARRANDE), Ludlow, Bohemia; ventral, dorsal, side, and anterior views, ×1.5 (Havlíček, 1959).

Subfamily CALLISPIRIFERINAE Johnson, 1994

[Callispiriferinae JOHNSON in CARTER & others, 1994, p. 332]

Noncapillate, with high, flat ventral interarea. *Lower Devonian (Emsian).*

Callispirifer PERRY, 1984, p. 115 [**C. teniostrakon;* OD]. Medium size, transverse; ventral interarea high, flat, procline or catacline, with apical deltidium; cardinal angles acute; flanks with few rounded plications; fold and sulcus smooth with fold flattened or medially grooved; growth lines may be prominent anteriorly; dental plates short, thin, closely spaced; ctenophoridium without crural plates. *Lower Devonian (lower Emsian):* Canadian

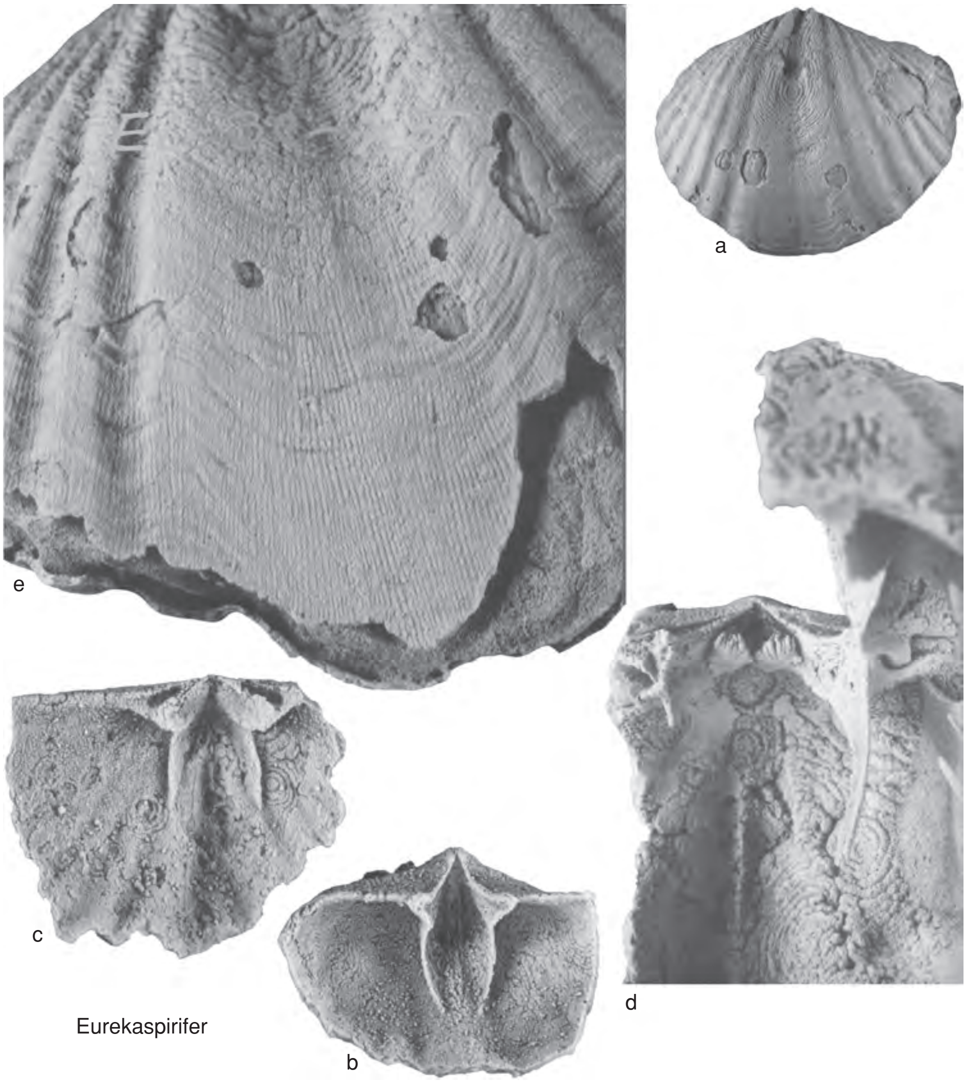

FIG. 1118. Adolfiidae (p. 1711).

Arctic Islands, USA (Alaska).——FIG. 1117,*1a–g.* **C. teniostrakon,* Yukon Territory; *a–e,* ventral, dorsal, anterior, posterior, and lateral views, ×1.3; *f–g,* holotype, exterior and interior views of dorsal valve, ×2.5 (Perry, 1984).

Rochtex HAVLÍČEK in HAVLÍČEK & KUKAL, 1990, p. 175 [**R. lissopleura* HAVLÍČEK in HAVLÍČEK & KUKAL, 1990, p. 176; OD]. Small, with hemipyramidal ventral valve; ventral interarea catacline to procline, flat or slightly curved, with large imperforate deltidium; dorsal valve flat or weakly convex; flanks with few low, rounded plications; fold and sulcus smooth; dental plates short, slightly divergent; crural plates absent. *Lower Devonian (upper Emsian):* Czech Republic.——FIG. 1117,*2a–d.* **R. lissopleura,* Bohemia; anterior, dorsal, posterior, and side views, ×2 (Havlíček & Kukal, 1990).

Subfamily EUREKASPIRIFERINAE Johnson, 1994

[Eurekaspiriferinae JOHNSON in CARTER & others, 1994, p. 332]

Capillate, with dorsal adminicula. *Lower Devonian (lower Emsian).*

Eurekaspirifer Johnson, 1966b, p. 1,045 [**Spirifer (Trigonotreta) pinyonensis* Meek, 1870, p. 60; OD]. Ventribiconvex, transverse to equidimensional, with curved, apsacline ventral interarea; fold and sulcus well defined, smooth, or with median groove on fold anteriorly; flanks with numerous, simple, rounded plications and U-shaped interspaces; growth lamellae absent or irregularly spaced, crossed by subradial capillae; dental plates long, recurving anteriorly toward midline; ctenophoridium bilobed, anterior to notothyrial chamber; dorsal adminicula long; crural plates lacking. *Lower Devonian (lower Emsian):* USA (Nevada).——Fig. 1118*a–e.* **E. pinyonensis* (Meek); *a,* ventral view, ×1; *b,* ventral interior, ×2; *c,* dorsal interior, ×3; *d,* cardinalia showing bilobed ctenophoridium; *e,* ventral view showing capillae, ×5 (Johnson, 1966b).

Family ECHINOSPIRIFERIDAE Liashenko, 1973

[Echinospiriferidae Liashenko, 1973, p. 109] [=Rigauxidae Brice, 1988, p. 371]

Multiplicate, including fold and sulcus. *Lower Devonian (Pragian)–Upper Devonian (upper Famennian).*

Echinospirifer Liashenko, 1973, p. 109 [**E. distinctus;* OD]. Medium to large, ventribiconvex, transverse with rounded acute cardinal angles; ventral interarea moderately high, curved, apsacline; prominent fold and sulcus with small plications tending to obsolescence anteriorly; flanks with simple, rounded plications; tuberculate surface with fila; dental plates thickened medially in apex; crural plates present. *Upper Devonian (lower Frasnian):* Russian Platform, Urals, Timan, Siberian Platform, Russian Arctic.——Fig. 1119,*2a–f.* **E. distinctus,* Timan; *a–e,* holotype, ventral, dorsal, anterior, posterior, and lateral views, ×1; *f,* microornament, ×10 (Liashenko, 1973).

Adolfispirifer Krylova, 1962, p. 75 [**Spirifer Jeremejewi* Chernyschev, 1887, p. 61; OD]. Medium size, ventribiconvex, transverse with rounded cardinal angles; ventral interarea moderately high, curved, apsacline; fold and sulcus plicate; flanks with simple, rarely bifurcating plications; surface with subradial capillae; dental plates thickened. *Upper Devonian (Frasnian):* Urals, Siberian Platform.——Fig. 1119,*4a–d.* **A. jeremejewi* (Chernyschev), Siberian Platform; ventral, dorsal, lateral, and anterior views, ×1 (Krylova, 1962).

Arctospirifer Stainbrook, 1950, p. 382 [**A. constrictus;* OD]. Small, biconvex, equidimensional, rarely auriculate; low, apsacline ventral interarea with apical pseudodeltidium; fold and sulcus weak, plicate; flanks with simple or bifurcating plications; microornament of intrasinal capillae and numerous tubercles mostly on crests of ribs; short dental plates present; crural plates lacking. *Upper Devonian (Famennian):* midcontinent North America.——Fig. 1119,*1a–f.* **A. constrictus,* Iowa, USA; *a–e,* holotype, ventral, dorsal, anterior, posterior, and lateral views, ×1.5; *f,* holotype, microornament, ×4 (new).

Enchondrospirifer Brice, 1971, p. 175 [**E. ghorensis;* OD]. Medium size, biconvex, slightly transverse with obtuse cardinal angles; ventral interarea moderately high, incurved, apsacline; fold, sulcus, and flanks with numerous low, rounded plications; surface capillate, becoming tuberculate; dental plates intrasinal; ctenophoridium and crural plates present. *Upper Devonian (upper Famennian):* Afghanistan.——Fig. 1120,*1a–e.* **E. ghorensis;* ventral, dorsal, posterior, anterior, and side views, ×1 (Brice, 1971).

Hispidaria Cooper & Dutro, 1982, p. 110 [**H. posterogranulosa;* OD]. Small, ventribiconvex, transverse with acute cardinal angles; ventral interarea moderately high, slightly curved, steeply apsacline; fold and sulcus plicate, with strong plications bounding sulcus; flanks with narrow, rounded simple plications and U-shaped interspaces; surface, including interarea, tuberculate; interior unknown. *Upper Devonian (Famennian):* western North America.——Fig. 1119,*3a–e.* **H. posterogranulosa,* upper Famennian, New Mexico, USA; *a–d,* holotype, anterior, ventral, lateral, and dorsal views, ×2; *e,* posterior view, ×4 (Cooper & Dutro, 1982).

Howittia Talent, 1956, p. 34 [**Spirifer howitti* Chapman, 1905, p. 18; OD] [=*Glyptospirifer* Hou & Xian, 1975, p. 72 (type, *Spirifer chui* Grabau, 1931b, p. 376, OD)]. Medium size, biconvex, transverse, with curved, apsacline ventral interarea; fold and sulcus prominent, sulcus with one or more plications; flanks with numerous, simple, rounded or subangular plications and narrow, U-shaped interspaces; growth lamellae may be prominent anteriorly; fila crossed by subradial capillae; dental plates extrasinal; ctenophoridium may be bilobed; without crural plates. *Lower Devonian (Pragian–Emsian):* Australia, Mongolia, southern China, northern Vietnam.——Fig. 1121*a–e.* **H. howitti* (Chapman), Australia; *a–c,* dorsal, anterior, and posterior views, ×1.5; *d,* transverse section of ventral valve, ×3; *e,* transverse section of dorsal valve, ×10 (Talent, 1956).

Indospirifer Grabau, 1931b, p. 359 [**Spirifer padaukpinensis* Reed, 1908, p. 101; OD] [=*Schizospirifer* Grabau, 1931b, p. 353, *nom. nud.* (type, *Spirifer aperturatus* var. *latistriatus* Frech, 1911, p. 53, OD)]. Medium size, ventribiconvex, transverse, with obtuse or acute cardinal angles; ventral interarea curved, apsacline to nearly orthocline; fold and sulcus prominent, with small, nonradial plications; flanks with rounded, elevated plications, commonly simple, less commonly branching; microornament of prominent growth lines anteriorly and subradial capillae; delthyrial cavity with some callus; dental plates extrasinal; short crural plates converging anterodorsally that may be obscured by callus and elevated ctenophoridium. *Lower Devonian (Emsian)–Middle*

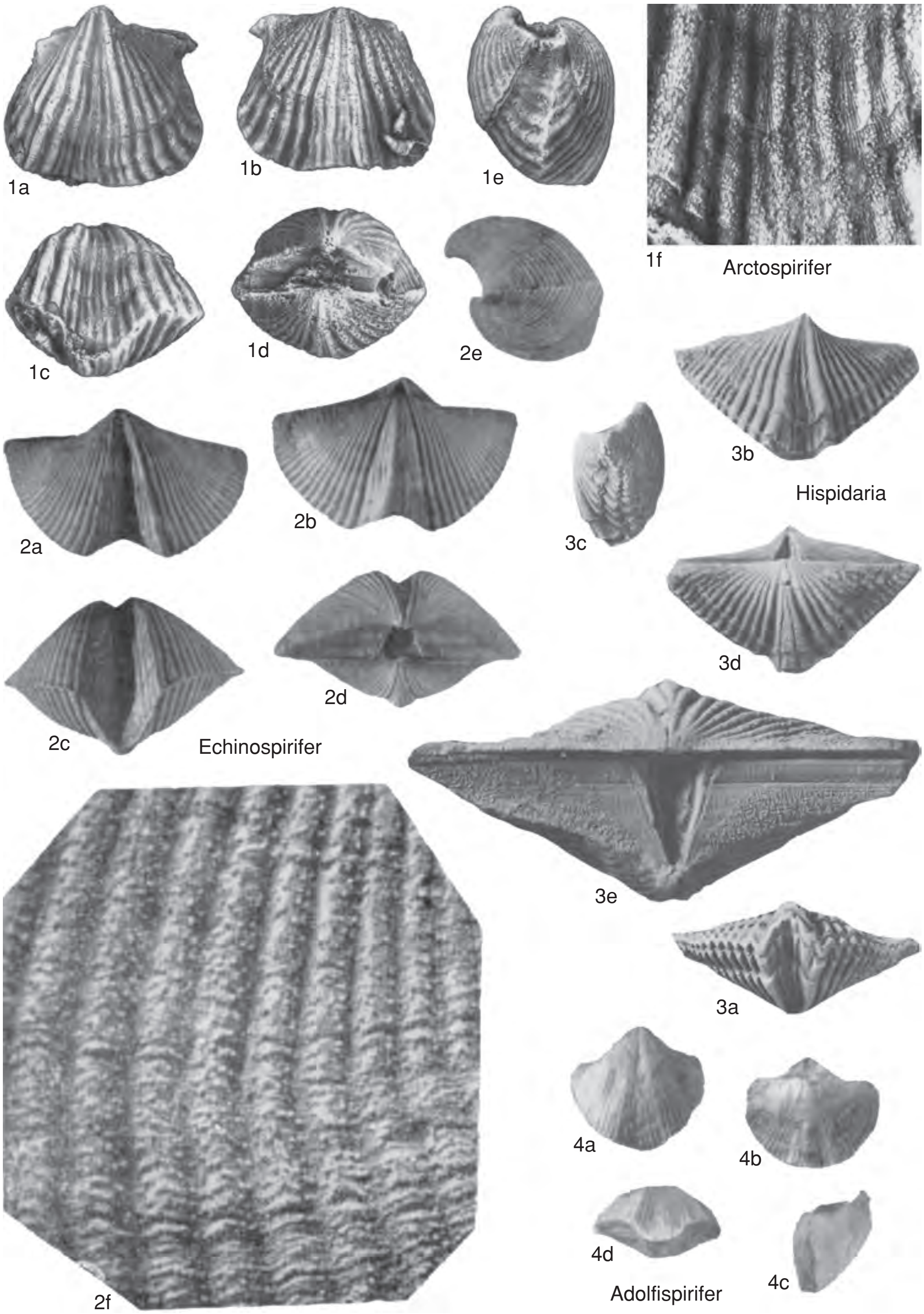

FIG. 1119. Echinospiriferidae (p. 1711).

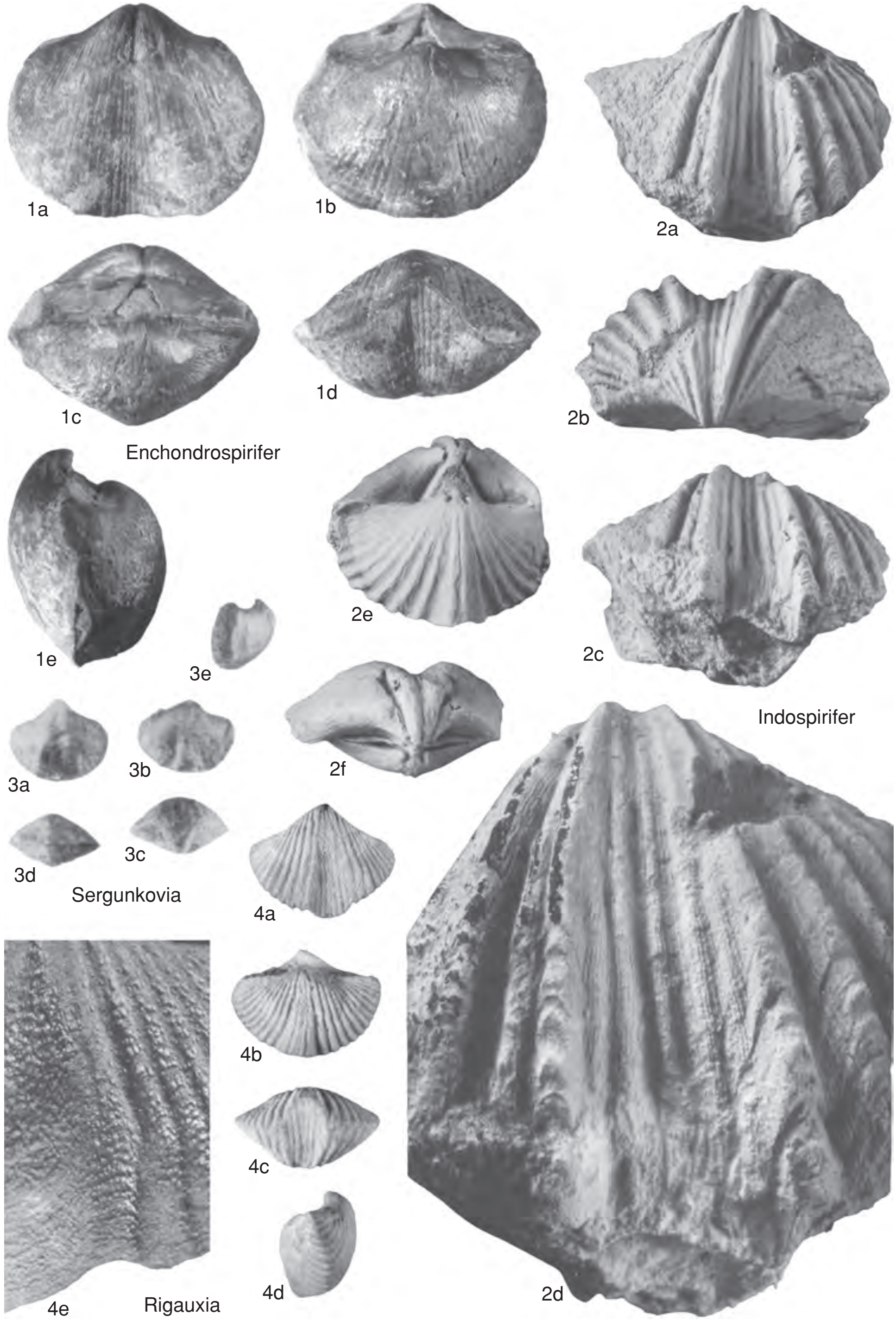

FIG. 1120. Echinospiriferidae (p. 1711–1714).

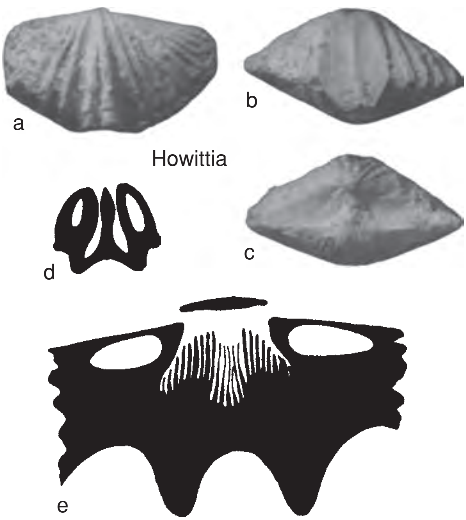

FIG. 1121. Echinospiriferidae (p. 1711).

Devonian (lower Givetian): Salair, Guangxi, northern Vietnam, Burma.——FIG. 1120,*2a–f.* **I. padaukpinensis* (REED), Eifelian, Burma; *a–c,* ventral, posterior, and anterior views, ×2; *d,* ventral sulcus showing capillae, ×5; *e–f,* dorsal and posterior views of internal mold, ×2 (Anderson, Boucot, & Johnson, 1969).

Rigauxia BRICE, 1988, p. 371 [**Spirifer acutosinu* RIGAUX, 1908, p. 15; OD]. Small to medium size, ventribiconvex, transverse, with obtuse or acute cardinal angles, commonly rounded; ventral interarea curved, apsacline; fold and sulcus with small plications; flanks with simple, rounded plications; surface with subradial capillae, becoming tuberculate; delthyrial cavity with apical callus; dental plates strong, extrasinal, weakly divergent; short crural plates may be obscured by callus and elevated ctenophoridium. *Upper Devonian (Frasnian):* cosmopolitan.——FIG. 1120,*4a–e.* **R. acutosinu* (RIGAUX), lower Frasnian, France; *a–d,* ventral, dorsal, anterior, and side views, ×2; *e,* exterior showing fine ornament, ×10 (Brice, 1988).

Sergunkovia NALIVKIN, 1979, p. 129 [**Paulonia talassica* VASILEVA in VASILEVA & POIARKOV, 1957, p. 58; OD]. Medium size, biconvex, slightly transverse; cardinal angles obtuse; ventral interarea short, curved, apsacline; fold and sulcus prominent, plicate or with plications becoming obsolescent; flanks with numerous, rounded plications; surface capillate; short dental plates present; hinge plates discrete. *Upper Devonian (upper Famennian):* Urals, Kazakhstan, northern Tian Shan, Karatau and Talassk Alatau ranges.——FIG. 1120,*3a–e.* **S. talassica* (VASILEVA), northern Tian Shan; holotype, ventral, dorsal, anterior, posterior, and lateral views, ×1 (Vasileva & Poiarkov, 1957).

THEODOSSIOIDEA

J. G. JOHNSON,[1] J. L. CARTER,[2] and HOU HONG-FEI[3]

[[1]deceased, formerly of Oregon State University; [2]retired from Carnegie Museum of Natural History; and [3]China University of Geosciences]

Superfamily THEODOSSIOIDEA Ivanova, 1959

[*nom. transl.* JOHNSON, CARTER, & HOU in CARTER & others, 1994, p. 333, *ex* Theodossiinae IVANOVA, 1959, p. 61]

Uniformly plicate or costate; fold and sulcus indistinct or lacking; delthyrial plate lacking. *Lower Devonian (Pragian)–Carboniferous (Tournaisian).*

Family THEODOSSIIDAE Ivanova, 1959

[*nom. transl.* JOHNSON, CARTER, & HOU in CARTER & others, 1994, p. 333, *ex* Theodossiinae IVANOVA, 1959, p. 61]

[Materials for this family prepared by J. G. Johnson & Hou Hong-fei]

Without inner prismatic shell layer. *Lower Devonian (Pragian)–Upper Devonian (Frasnian).*

Subfamily THEODOSSIINAE Ivanova, 1959

[Theodossiinae IVANOVA, 1959, p. 61]

Capillate. *Middle Devonian (Eifelian)–Upper Devonian (Frasnian).*

Theodossia NALIVKIN, 1925, p. 267 [**Spirifer Anossofi* DE VERNEUIL, 1845, p. 153; OD] [=*Vandergrachtella* CRICKMAY, 1953b, p. 7 (type, *V. arcuum* CRICKMAY, 1953b, p. 8, OD)]. Medium size, ventribiconvex, equidimensional to moderately transverse; cardinal angles obtusely rounded; ventral interarea strongly curved, apsacline to orthocline; fold and sulcus not prominent, blending with flanks; costae simple on fold, sulcus, and flanks, rarely bifurcating anteriorly on fold and sulcus; capillate; dental plates thin, straight, extrasinal; short crural plates obscured by callus; ctenophoridium elevated. *Upper Devonian (Frasnian):* cosmopolitan.——FIG. 1122*a–b*. **T. anossofi* (DE VERNEUIL), Russia; lectotype, dorsal and anterior views, ×1 (Vandercammen, 1959).——FIG. 1123*a–b*. **T. anossofi* (DE VERNEUIL), Russia; lectotype, lateral and ventral views, ×1 (Vandercammen, 1959).

Paralazutkinia JIANG in XIAN & JIANG, 1978, p. 314 [**P. pinghuangshanensis;* OD] [=*Pinghuangella* JIANG in XIAN & JIANG, 1978, p. 315 (type, *P. bisulcata* JIANG in XIAN & JIANG, 1978, p. 316, OD)]. Ventribiconvex, moderately transverse; ventral interarea long, curved, apsacline; surface with low, rounded plications, strongest medially, with fold and sulcus indistinct or lacking; microornament of fine capillae; shell thick with short dental plates; ctenophoridium located on cruralium and low median septum. *Middle Devonian (Eifelian):* southern China.——FIG. 1124,*2a–c*. **P. pinghuangshanensis;* ventral, dorsal, and side views, ×2 (Xian & Jiang, 1978).

Urella RZHONSNITSKAIA in MARKOVSKI, 1960, p. 402 [**U. asiatica;* OD] [=*Retzispirifer* KULKOV, 1960, p. 929 (type, *R. uriensis* KULKOV, 1960, p. 930, OD)]. Biconvex with obtuse cardinal angles; interarea curved, narrow, poorly defined; surface with numerous low, rounded, simple or bifurcating plications; fold and sulcus lacking; microornament capillate; shell thin; dental plates short; ctenophoridium with outer hinge plates attached to median ridge posteriorly, free anteriorly; crural plates absent. *Middle Devonian (Eifelian–Givetian):* Urals, Kuznets basin, Salair.——FIG. 1124,*1a–c*. **U. asiatica,* Kuznets basin; holotype, ventral, dorsal, and lateral views, ×1 (Markovski, 1960).

Subfamily BRANIKIINAE Johnson & Hou, 1994

[Branikiinae JOHNSON & HOU in CARTER & others, 1994, p. 333]

Noncapillate. *Lower Devonian (Pragian)–Middle Devonian (Eifelian).*

Branikia HAVLÍČEK, 1957b, p. 437 [**Spirifer Ascanius* BARRANDE, 1879, pl. 74, case V; OD] [=*Bidentatus* KHODALEVICH & BREIVEL, 1972, p. 202 (type, *B. strabo,* OD)]. Biconvex with obtuse cardinal angles; ventral interarea curved, nearly orthocline; surface with numerous low, rounded plications; fold and sulcus indistinct or lacking; microornament of concentric lamellae; shell thick; dental plates short; hinge plates with elevated, knoblike cardinal process, lacking crural plates. *Lower Devonian (Pragian):* Czech Republic, central Urals.——FIG. 1125,*2a–d*. **B. ascania* (BARRANDE), Czech Republic; lectotype, ventral, dorsal, anterior, and lateral views, ×1.5 (Havlíček, 1959).

Jilinospirifer SU, 1980, p. 317 [**J. yungjiensis* SU, 1980, p. 318; OD]. Small, ventribiconvex, transverse; ventral interarea high, apsacline; plications on flanks numerous, simple, but smooth posterolaterally; fold and sulcus lacking; dental plates lacking; microornament and dorsal interior unknown. *Middle Devonian (Eifelian):* China (Jilin).——FIG. 1125,*1a–e*. **J. yungjiensis;* holotype, ventral, dorsal, lateral, posterior, and anterior views, ×1 (Su, 1980).

Lenzia PERRY, BOUCOT, & GABRIELSE, 1981, p. 35 [**L. pachyostrakon;* OD]. Medium size, biconvex, equidimensional, with obtuse cardinal angles; ventral interarea slightly curved, apsacline; fold and sulcus indistinct, flaring, with 2 or 3 plications, tending to obsolescence in sulcus; flanks with few simple, strong, rounded or subangular plications; dental plates short, obsolescent in umbonal callus; cardinal process low, moundlike, without crural plates. *Lower Devonian (lower Emsian):* western North America.——FIG. 1125,*3a–d*. **L. pachyostrakon,* British Columbia; *a–b,* ventral valve exterior and interior; *c–d,* dorsal valve exterior and interior, ×1.5 (new).

Family ULBOSPIRIFERIDAE Johnson & Carter, 1994

[Ulbospiriferidae JOHNSON & CARTER in CARTER & others, 1994, p. 334]

With inner prismatic shell layer. *Upper Devonian (upper Famennian).*

Subfamily ULBOSPIRIFERINAE Johnson & Carter, 1994

[Ulbospiriferinae JOHNSON & CARTER in CARTER & others, 1994, p. 334]

[Materials for this subfamily prepared by J. G. Johnson & Hou Hong-fei]

Uniformly costate. *Upper Devonian (upper Famennian).*

Ulbospirifer GRECHISHNIKOVA, 1965, p. 33 [**U. altaicus* GRECHISHNIKOVA, 1965, p. 35; OD]. Medium to large, ventribiconvex, equidimensional or

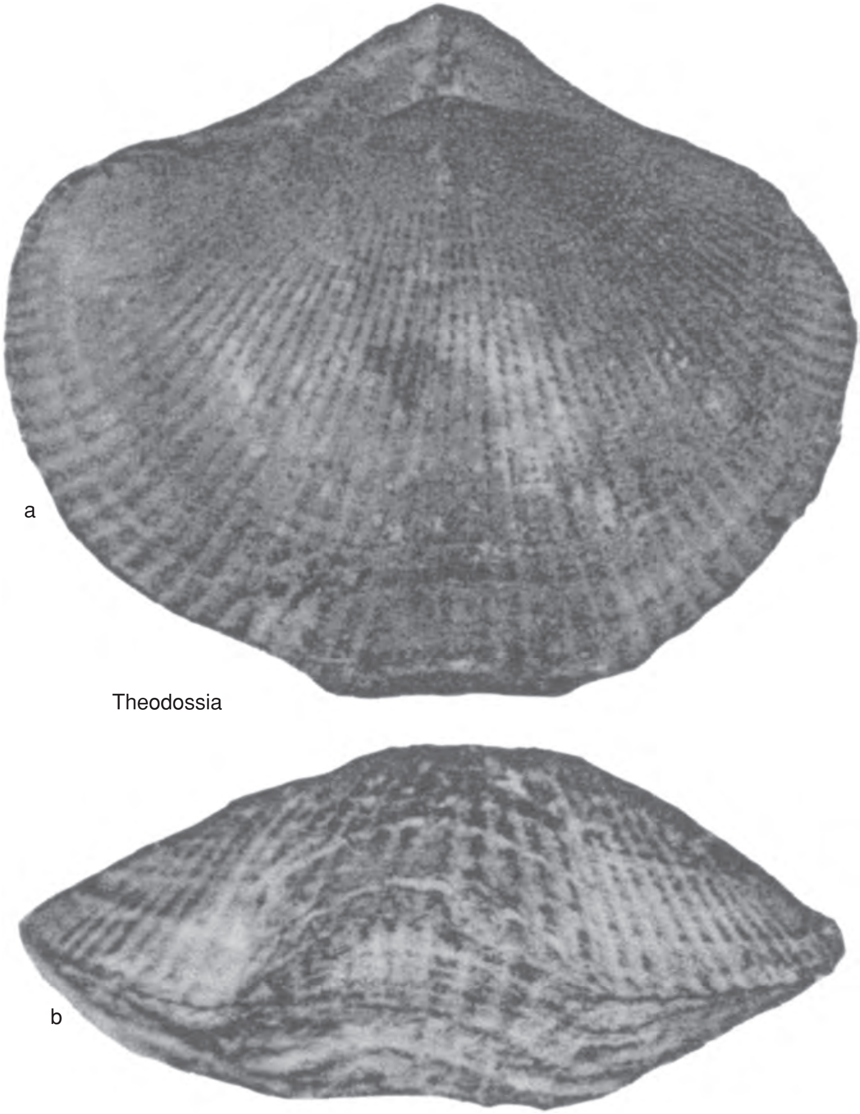

FIG. 1122. Theodossiidae (p. 1715).

slightly transverse, cardinal angles obtuse; ventral interarea of moderate height, curved, apsacline; fold and sulcus costate as on flanks, with numerous rounded costae; surface tuberculate; ventral umbones thick, with short median septum; dental plates thick and slightly recurved; hinge plates unsupported. *Upper Devonian (upper Famennian):* Rudny Altai.——FIG. 1126,*1a–g.* **U. altaicus; a,* holotype, ventral valve, ×1; *b,* microornament, ×8; *c–g,* transverse sections of ventral valve, ×1.7 (Grechishnikova, 1965).

Cyrtiorina COOPER & DUTRO, 1982, p. 111 [**Cyrtospirifer kindlei* STAINBROOK, 1947, p. 318; OD]. Medium to large, ventribiconvex,

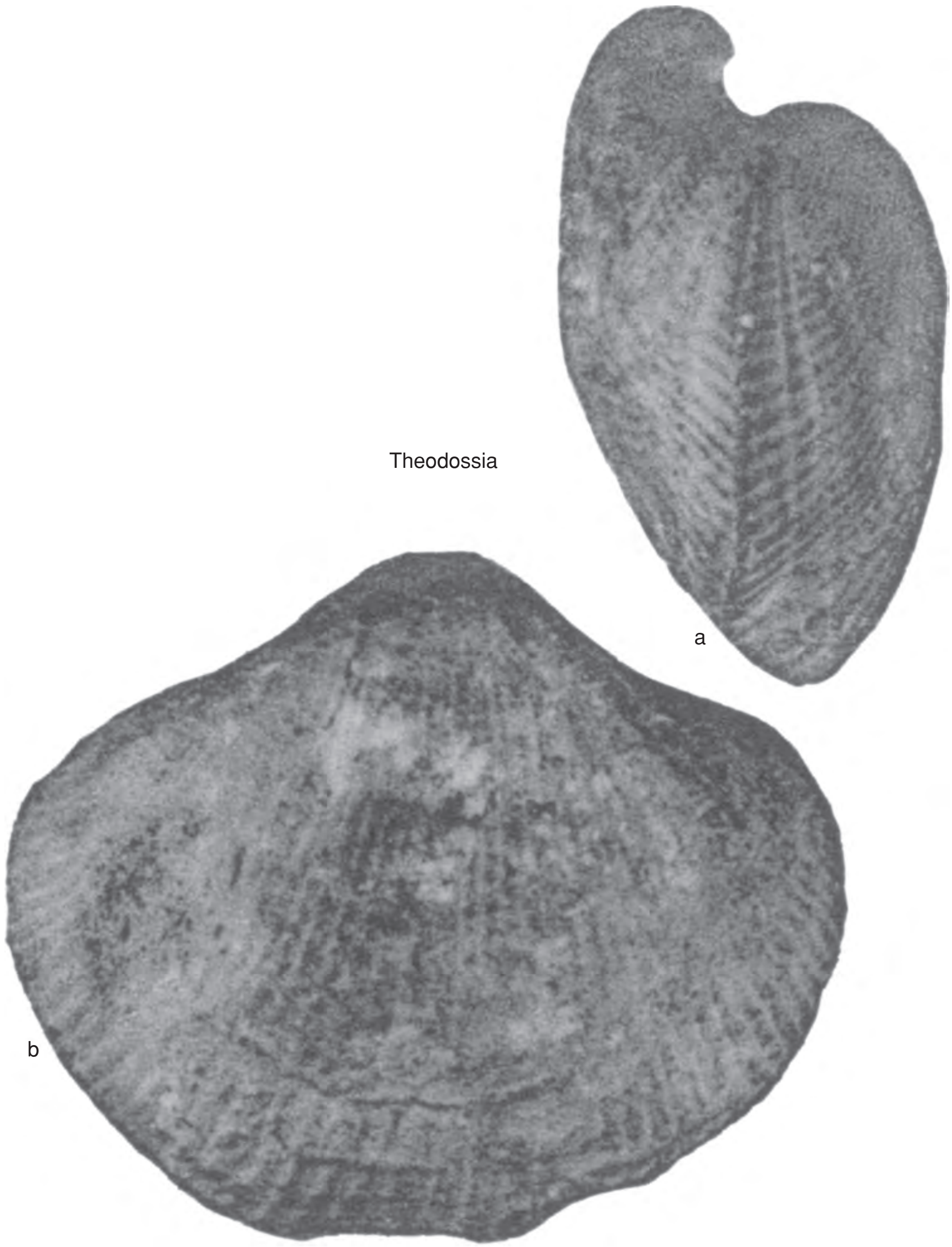

FIG. 1123. Theodossiidae (p. 1715).

equidimensional or slightly transverse, cardinal angles obtuse or slightly auriculate; ventral interarea with moderate height, curved, apsacline; fold and sulcus costate as on flanks, with numerous rounded costae, becoming flattened anteriorly; surface capillate, becoming tuberculate; dental plates long, subparallel, slightly recurving; ctenophoridium concave. *Upper Devonian (upper Famennian):* western North America.——FIG. 1126,*2a–e.* **C. kindlei* (STAINBROOK), New Mexico, USA; posterior, lateral,

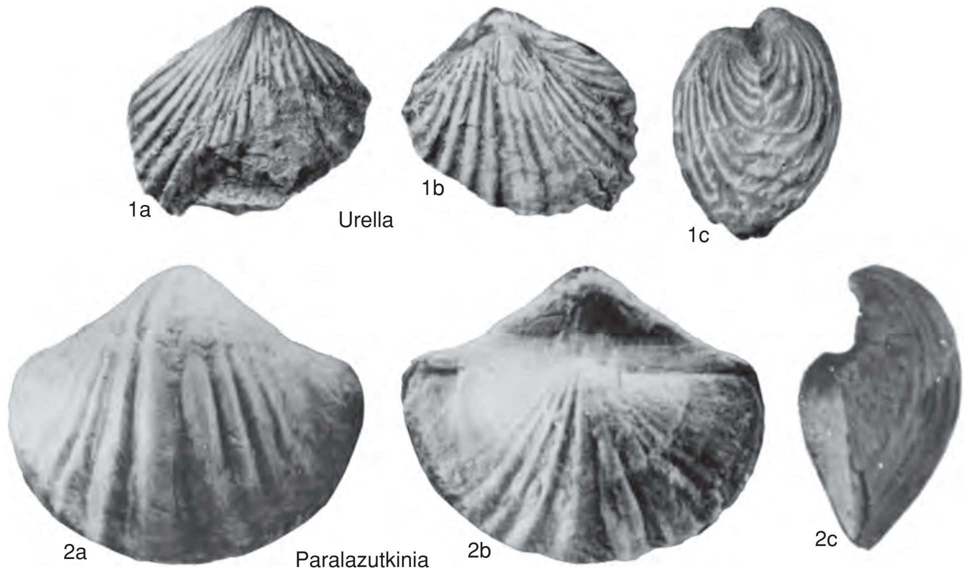

FIG. 1124. Theodossiidae (p. 1715).

anterior, ventral, and dorsal views, ×1 (Cooper & Dutro, 1982).

Tenisia MARTYNOVA, 1970, p. 68 [**Spirifer (Cyrtospirifer) dada* NALIVKIN, 1937, p. 97; OD] [=*Omolonospirifer* SIMAKOV in AFANAS'EVA & SIMAKOV, 1970, p. 86, obj.]. Medium to large, biconvex, equidimensional, cardinal angles obtuse; ventral interarea low, strongly curved; fold and sulcus absent or poorly developed, costate as on flanks, with numerous rounded costae; surface capillate; umbones thick, dental plates thick and slightly recurved; hinge plates supported by median ridge. *Upper Devonian (upper Famennian):* Kazakhstan.——FIG. 1126,*3a–b*. **T. dada* (NALIVKIN); holotype, ventral and dorsal views, ×1 (Nalivkin, 1937).

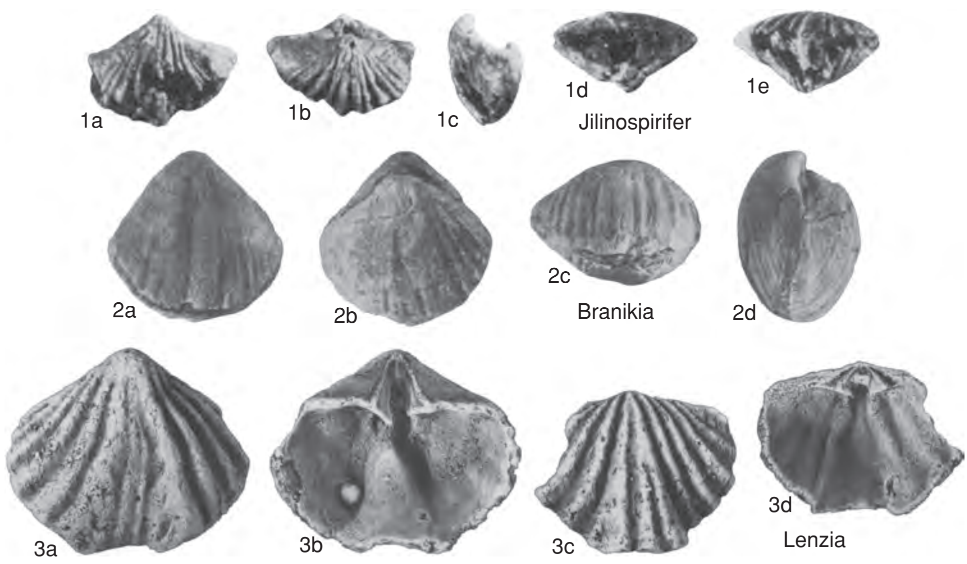

FIG. 1125. Theodossiidae (p. 1715).

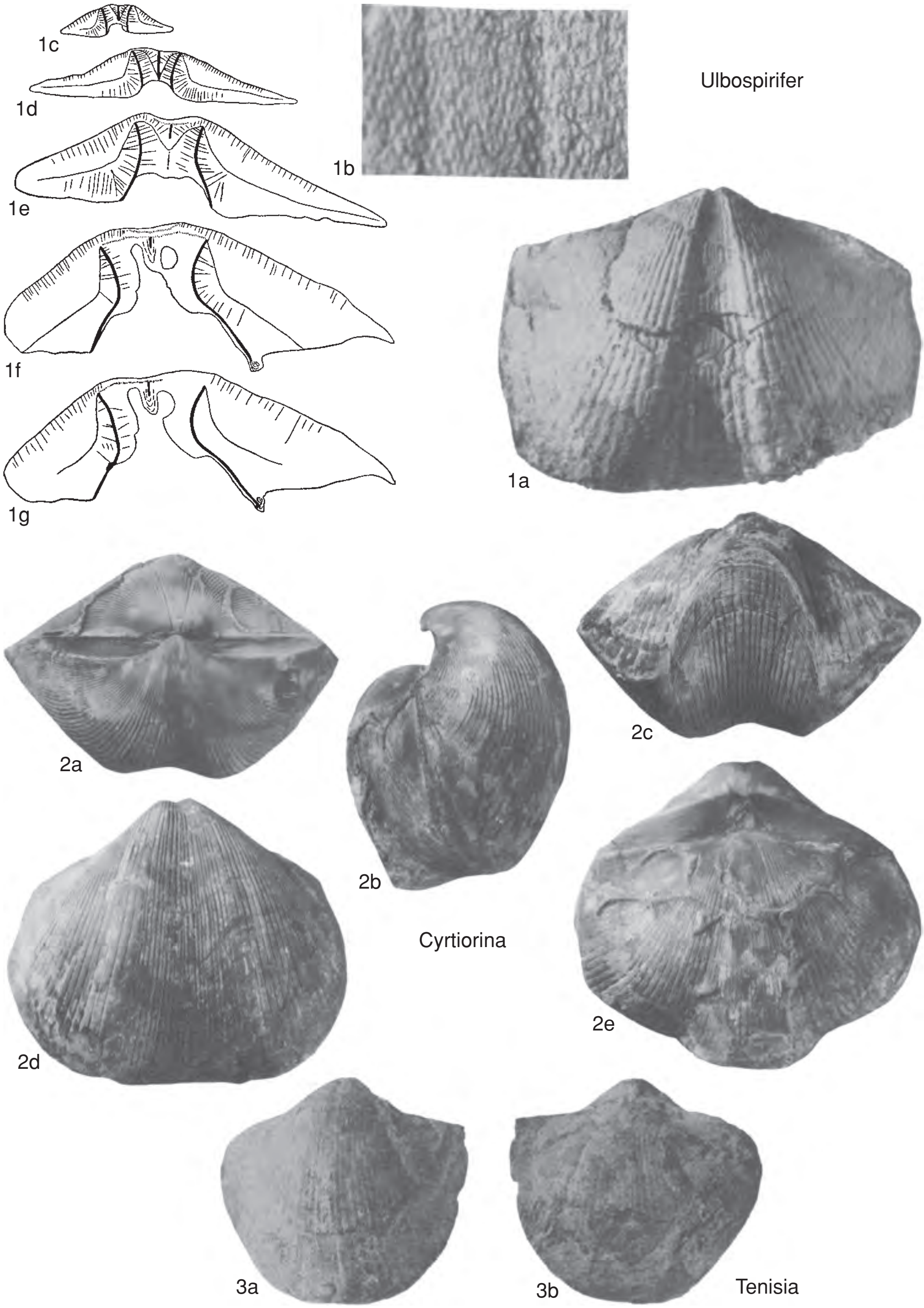

FIG. 1126. Ulbospiriferidae (p. 1715–1718).

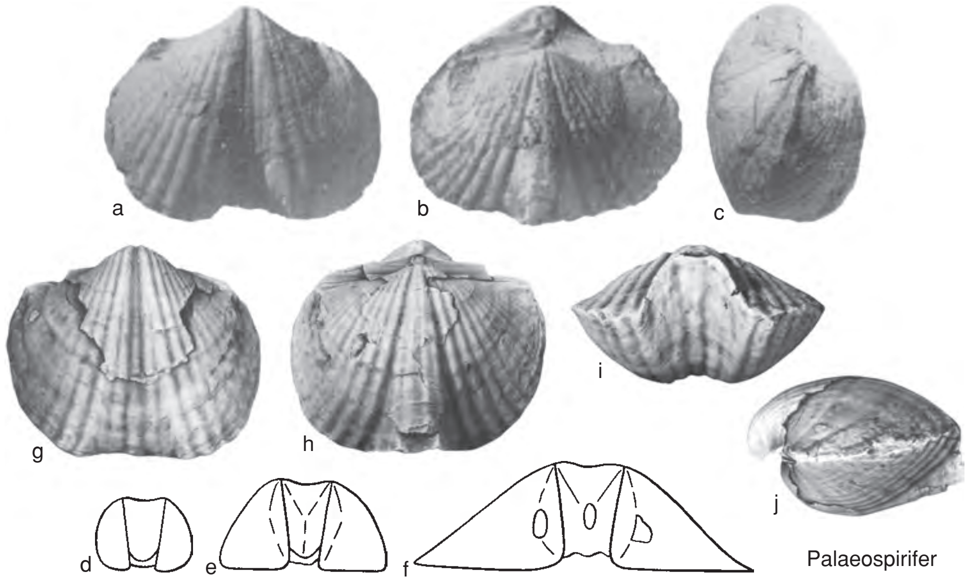

FIG. 1127. Ulbospiriferidae (p. 1720).

Subfamily PALAEOSPIRIFERINAE Carter, Johnson, and Hou, 1994

[Palaeospiriferinae CARTER, JOHNSON, & HOU in CARTER & others, 1994, p. 334]

[Materials for this subfamily prepared by J. G. Johnson, J. L. Carter, & Hou Hong-fei]

With low, rounded plications. *Upper Devonian (upper Famennian).*

Palaeospirifer MARTYNOVA & SVERBILOVA, 1968, p. 26 [**Cyrtospirifer? karagatshicus* SVERBILOVA in LITVINOVICH & SVERBILOVA, 1963, p. 286; OD] [=*Goungjunspirifer* ZHANG F. M. in ZHANG Chuan & others, 1983, p. 346 (type, *G. sinicus,* OD)]. Medium size; transversely subovate; cardinal angles well rounded; interarea low; fold and sulcus moderately developed, moderately wide; flanks with few broad rounded plications, one or more of which may bifurcate; sulcus with distinct simple median plication and 1 or 2 pairs of lateral sulcal plications; surface strongly capillate; dental plates very short, divergent. *Upper Devonian (upper Famennian):* Kazakhstan, China.——FIG. 1127*a–f.* **P. karagatshicus* (SVERBILOVA); *a–c,* ventral, dorsal, and side views, ×1; *d–f,* transverse sections, ×3 (Martynova & Sverbilova, 1968).——FIG. 1127*g–j. P. sinicus* (ZHANG), China; ventral, dorsal, anterior, and side views, ×1 (Zhang Chuan & others, 1983).

Family PALAEOCHORISTITIDAE Carter, 1994

[Palaeochoristitidae CARTER in CARTER & others, 1994, p. 334]

[Materials for this family prepared by J. L. Carter]

Cardinal extremities rounded in juveniles, outline variable in adults; with well-developed dental plates and dorsal adminicula; delthyrial plate absent; microornament absent. *Upper Devonian (upper Famennian)–Carboniferous (Tournaisian).*

Palaeochoristites SOKOLSKAYA, 1941, p. 26 [**Spirifer cinctus* KEYSERLING, 1846, p. 229; OD]. Medium to large; transversely subovate in outline; moderately and subequally biconvex; ventral umbonal region broad, evenly rounded, poorly differentiated from lateral slopes; beak small, incurved; ventral interarea acutely triangular; cardinal extremities rounded to subangular, maximum width attained anterior to hinge line; fold and sulcus absent; hinge line nondenticulate; entire surface multicostate; costae numerous, flattened, freely bifurcating or trifurcating, with narrow interspaces; ventral interior with long, slender, slightly diverging dental adminicula; dorsal interior with long, slender, subparallel, vertical dorsal adminicula; vascular impressions unknown;

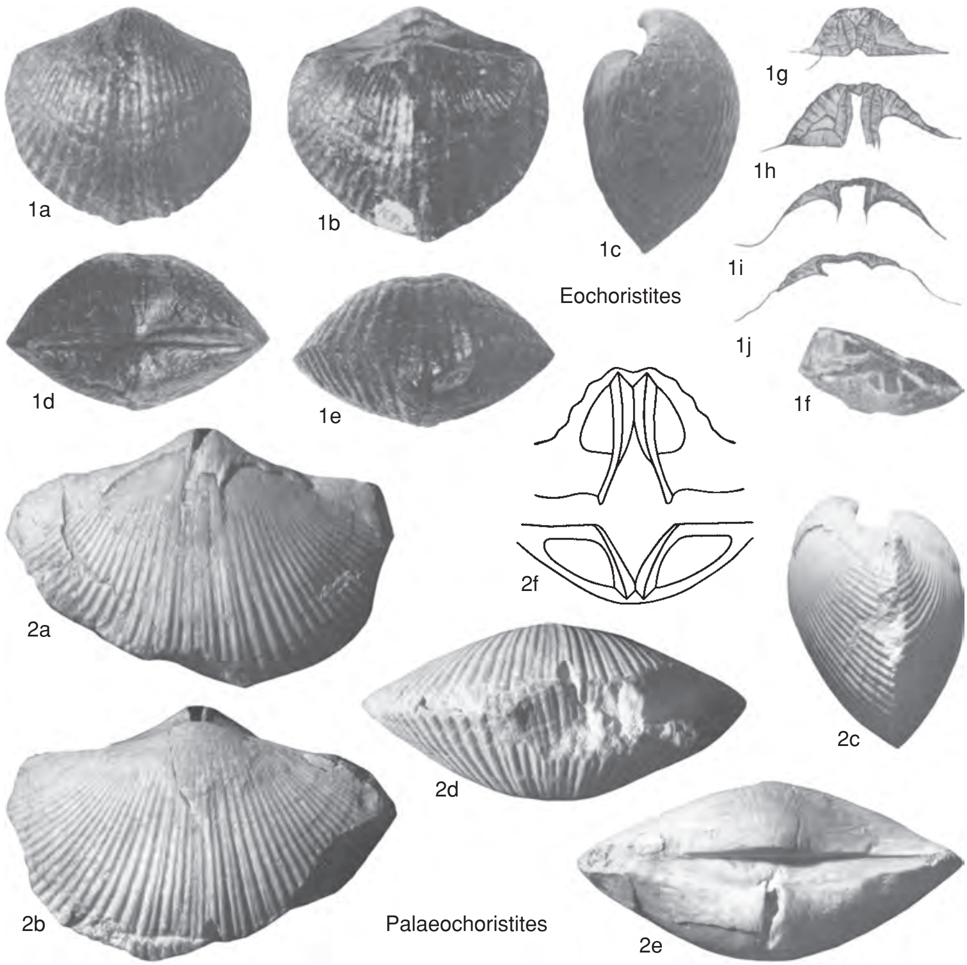

FIG. 1128. Palaeochoristitidae (p. 1720–1721).

umbonal region of ventral valve greatly thickened. *Carboniferous (Tournaisian):* Russia.——FIG. 1128,*2a–f.* **P. cinctus* (KEYSERLING), European Russia; *a–e,* holotype, ventral, dorsal, lateral, anterior, and posterior views, ×1 (new); *f,* transverse section, ×3 (Ivanova, 1960).

Eochoristites CHU, 1933, p. 28 [**E. neipentaiensis;* OD] [?=*Centrospirifer* TIEN, 1938, p. 110 (type, *Spirifer (Sinospirifer) chaoi* GRABAU, 1931b, p. 263, OD)]. Medium size; subequally and moderately biconvex; ventral umbo broad, weakly inflated; ventral beak small, moderately incurved; ventral interarea truncated; hinge line nondenticulate; fold and sulcus narrow to moderately wide, weakly developed; costae mostly simple on lateral slopes; sulcus with strong, simple, or bifurcating median costa and several, mostly simple, lateral sulcal costae that bifurcate from bounding costae; dorsal adminicula moderately long; otherwise similar to *Palaeochoristites.* [According to HOU Hong-fei (personal communication, 1993), the types of *Centrospirifer chaoi* (GRABAU, 1931b) are from the Banxiong Formation of early Tournaisian age and are from nearly the same region and beds as the types of *Eochoristites neipentaiensis* CHU. The interior of *C. chaoi* is unknown.] *Upper Devonian (upper Famennian)–Carboniferous (Tournaisian):* southeastern China.——FIG. 1128,*1a–j.* **E. neipentaiensis,* Tournaisian; *a–e,* holotype, ventral, dorsal, lateral, posterior, and anterior views, ×1; *f,* transverse section of dorsal valve; *g–j,* transverse sections of ventral valve, ×1 (Chu, 1933).

CYRTOSPIRIFEROIDEA

J. G. JOHNSON

[deceased, formerly of Oregon State University]

Superfamily CYRTOSPIRIFEROIDEA Termier & Termier, 1949

[*nom. correct.* JOHNSON in CARTER & others, 1994, p. 334, *pro* Cyrtospiriferacea IVANOVA, 1972, p. 31, *nom. transl. ex* Cyrtospiriferinae TERMIER & TERMIER, 1949a, p. 99]

Capillate or pustulose, nonfrilly; with dental plates and ctenophoridium, generally with delthyrial plate; generally without crural plates. *Lower Devonian (Emsian)–Upper Devonian (upper Famennian).*

Family SPINOCYRTIIDAE Ivanova, 1959

[*nom. transl.* PITRAT, 1965, p. 688, *ex* Spinocyrtiinae STRUVE in PAULUS, STRUVE, & WOLFART, 1963, p. 462, *nom. correct. pro* Spinocyrtinae IVANOVA, 1959, p. 59]

With numerous simple plicae on flanks; fold and sulcus smooth or with single medial ventral rib and dorsal groove. *Lower Devonian (Emsian)–Upper Devonian (Frasnian).*

Spinocyrtia FREDERIKS, 1916, p. 18 [**Delthyris granulosa* CONRAD, 1839, p. 65; SD FREDERIKS, 1926, p. 411]. Medium to large, biconvex, transverse; ventral interarea flat or slightly curved, apsacline; stegidial plates present; cardinal angles acute, auriculate; fold and sulcus prominent, smooth, with plications tending to form on parietal slopes anteriorly; fold may have median groove; flanks with numerous low, rounded plications separated by narrow interspaces; surface tuberculate, with radially arranged, tear-shaped granules on microfila; dental plates straight, divergent, mostly buried in umbonal callus with impressed muscle field; broad ctenophoridium impressed in thick shell. *Middle Devonian:* cosmopolitan.——FIG. 1129,*1a–d.* **S. granulosa* (CONRAD), Givetian, New York, USA; dorsal, ventral, anterior, and lateral views, ×1 (Ehlers & Wright, 1955).

Acutoria COOPER & DUTRO, 1982, p. 100 [**A. angulata;* OD]. Medium to large, dorsibiconvex, transverse; cardinal angles acute to rounded; ventral interarea curved, apsacline; fold and sulcus smooth, angular, becoming carinate with flanks; flanks with numerous, simple, flat plications; surface capillate; dental plates long, divergent; ctenophoridium supported by median septum. *Middle Devonian (Givetian):* western North America.——FIG. 1130,*4a–b.* **A. angulata,* New Mexico, USA; dorsal and ventral valves, ×1 (Cooper & Dutro, 1982).

Alatiformia STRUVE, 1963, p. 499 [**Spirifer alatiformis* DREVERMANN, 1907, p. 126; OD; =*Spirifer subcuspidatus* var. *alata* KAYSER, 1871, p. 573]. Medium to large, ventribiconvex, strongly transverse; ventral interarea flat, steeply apsacline to catacline; fold and sulcus prominent, smooth; flanks with numerous simple plications crossed by closely spaced, nodose growth lines; dental plates widely divergent. [DREVERMANN (1907) erected the new species (in fact gave a new name to) *alatiformis* from the "var" *subcuspidatus* var. *alata* KAYSER, 1871 that does not belong to the species *subcuspidatus.*] *Lower Devonian (Emsian)–Middle Devonian (Eifelian):* Europe, USA (Nevada).——FIG. 1129,*2a–c.* **A. alatiformis* (DREVERMANN), Emsian, Germany; posterior, ventral, and dorsal views of natural internal mold, ×1.5 (Struve, 1964).

Carpinaria STRUVE, 1982, p. 213 [**Spinocyrtia (Carpinaria) carpinensis* STRUVE, 1982, p. 213; OD]. Microornament as in *Spinocyrtia;* ventral interarea very high, nearly catacline; otherwise similar to *Orthospirifer. Middle Devonian (Givetian):* Germany, Russia.——FIG. 1130,*1a–e.* **C. carpinensis,* upper Givetian, Germany; holotype, ventral, dorsal, lateral, posterior, and anterior views, ×1 (Struve, 1982).

Duryeella BOUCOT, 1975, p. 370 [**Spirifer macra* HALL, 1857, p. 134; OD]. Medium size, strongly transverse; ventral interarea apsacline, slightly curved; cardinal angles acute; fold and sulcus smooth; flanks with numerous rounded plications; growth lines closely spaced; dental plates largely buried in umbonal callus. *Lower Devonian (upper Emsian)–Middle Devonian (lower Eifelian):* eastern North America.——FIG. 1129,*4a–c.* **D. macra* (HALL), lower Eifelian, New York, USA; *a,* ventral valve, ×1 (Hall, 1867b); *b–c,* dorsal and posterior views of dorsal internal mold, ×2 (Boucot, 1975).

Eosyringothyris STAINBROOK, 1943, p. 431 [**Spirifer aspera* HALL, 1858, p. 508; OD]. Medium size, ventribiconvex, transverse; ventral interarea high, flat, steeply apsacline to procline; stegidial plates present; cardinal angles acute; fold and sulcus broad, low, smooth; surface papillose; delthyrial plate with median anterior spine; dental plates straight or slightly curved. *Middle Devonian (upper Givetian)–Upper Devonian (lower Frasnian):* midcontinent North America.——FIG. 1129,*3a–c.* **E. aspera* (HALL), upper Givetian, Iowa, USA; ventral, dorsal, and posterior views, ×1 (Stainbrook, 1943).

Mediospirifer BUBLICHENKO, 1956, p. 102 [**Delthyris medialis* HALL, 1843, p. 208; OD; =*Delthyris audacula* CONRAD, 1842, p. 262]. Medium to large, ventribiconvex, transverse, with acute cardinal angles; ventral interarea of moderate height, slightly

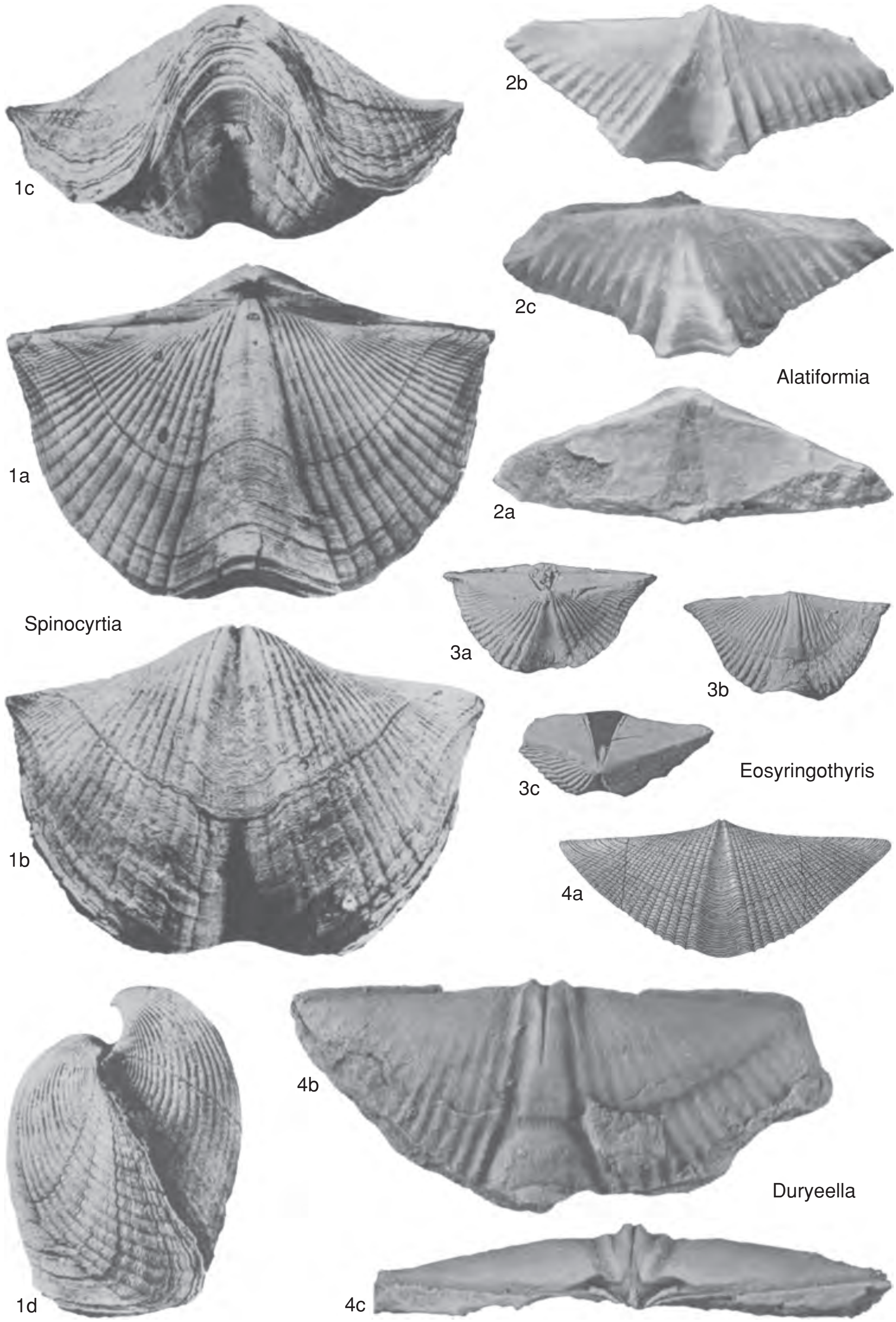

FIG. 1129. Spinocyrtiidae (p. 1722).

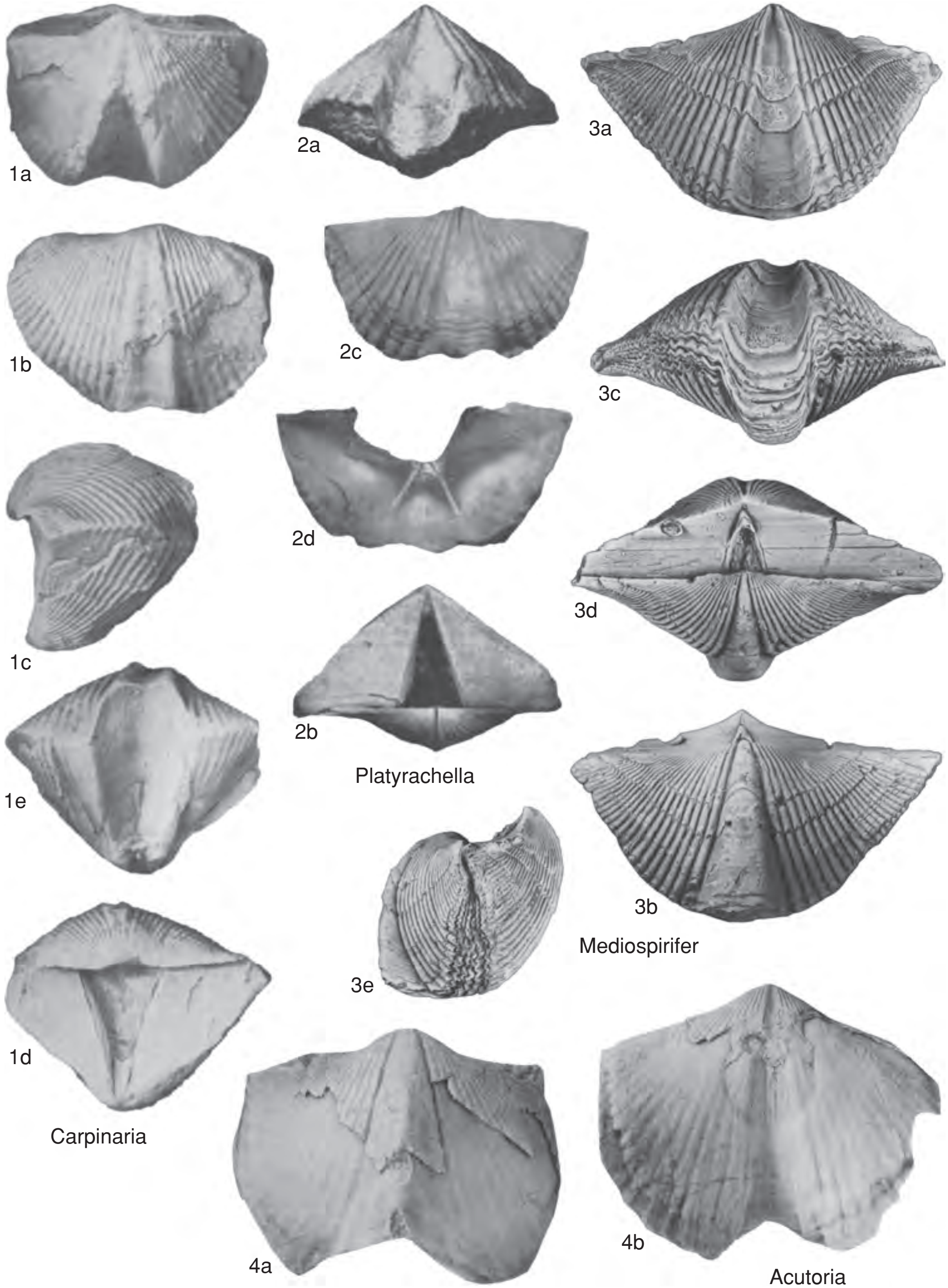

FIG. 1130. Spinocyrtiidae (p. 1722–1725).

curved, steeply apsacline; stegidial plates present; fold and sulcus prominent, smooth; flanks with numerous simple plications crossed by closely spaced growth lines. *Middle Devonian (Givetian):* North America, Germany.——FIG. 1130,*3a–e*. **M. audaculus* (CONRAD), New York, USA; ventral, dorsal, anterior, posterior, and lateral views, ×1 (new).

Orthospirifer PITRAT, 1975, p. 387 [**O. missouriensis* PITRAT, 1975, p. 389; OD]. Medium to large,

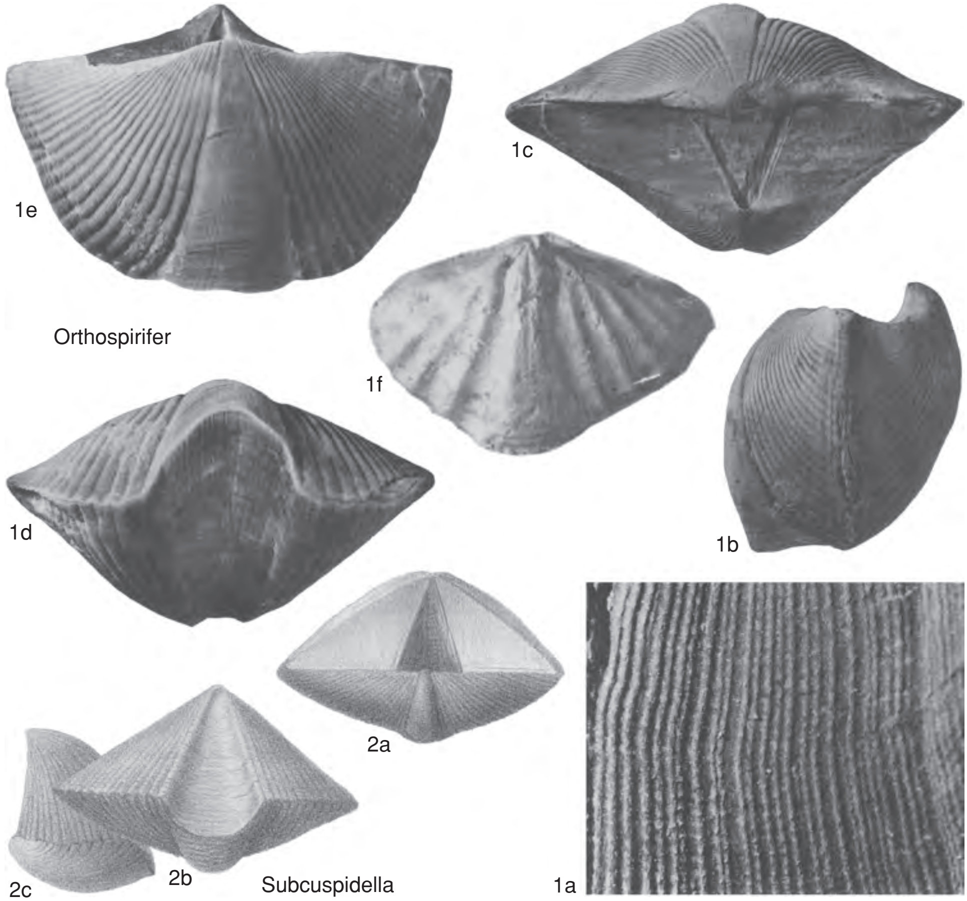

FIG. 1131. Spinocyrtiidae (p. 1724–1726).

biconvex, transverse; ventral interarea of medium height, slightly curved, apsacline; cardinal angles acute; fold and sulcus broad, low, smooth; flanks with numerous, simple, low, rounded to flat plications; surface with prominent nodose capillae; ctenophoridium supported by myophragm. *Middle Devonian (upper Givetian)–Upper Devonian (Frasnian):* eastern and midcontinent North America and western Canada.——FIG. 1131,*1a–f.* **O. missouriensis,* Frasnian, Missouri, USA; *a,* microornament, ×5; *b–f,* holotype, lateral, posterior, anterior, dorsal, and ventral views, ×1 (Pitrat, 1975).

Platyrachella FENTON & FENTON, 1924, p. 158 [**Spirifera macbridei* CALVIN, 1883, p. 433; OD]. Medium size, ventribiconvex, transverse; ventral interarea high, flat, steeply apsacline or catacline; cardinal angles acute; fold and sulcus broad, low, smooth, or with low anterior plication in sulcus; flanks with numerous, simple plications; surface with fine capillae; dental plates short, straight, divergent. *Upper Devonian (Frasnian):* midcontinent North America.——FIG. 1130,*2a–d.* **P. macbridei* (CALVIN), Iowa, USA; *a–c,* anterior, posterior, and dorsal views, ×1; *d,* ventral interior, enlarged (Fenton & Fenton, 1924).

Subcuspidella MITTMEYER, 1965, p. 80 [**Spirifer subcuspidatus* SCHNUR, 1851, p. 10; OD] [=?*Tenuicostella* MITTMEYER & GEIB, 1967, p. 40 (type, *Spirifer subcuspidatus tenuicosta* SCUPIN, 1900, p. 223, pl. 1(24),*15a–c,* OD)]. Medium size, transverse; ventral interarea high, flat, apsacline or catacline; cardinal angles acute; flanks with numerous rounded plications; fold and sulcus smooth, crossed by closely spaced, nodose growth lines; dental plates straight, divergent; ctenophoridium and short crural plates present. [Well-preserved specimens of *Subcuspidella subcuspidatus* and *Tenuicostella tenuicosta* are apparently rare. Revisionary work is required to ascertain the validity of *Tenuicostella.*] *Middle Devonian (Eifelian):* western Europe.——FIG. 1131,*2a–c.* **S. subcuspidatus*

(Schnur), Germany; posterior, anterior, and lateral views, ×1 (Schnur, 1853 in 1853–1854).

Family CYRTOSPIRIFERIDAE Termier & Termier, 1949

[*nom. transl.* Beznosova, 1958, p. 17, *ex* Cyrtospiriferinae Termier & Termier, 1949a, p. 99]

Flanks costate, nonfrilly; fold and sulcus finely costate. *Middle Devonian (upper Givetian)–Upper Devonian (upper Famennian).*

Subfamily CYRTOSPIRIFERINAE Termier & Termier, 1949

[Cyrtospiriferinae Termier & Termier, 1949a, p. 99] [=Hunanospiriferinae Beznosova, 1958, p. 17]

Wide interarea with acute cardinal angles. *Upper Devonian (Frasnian–upper Famennian).*

Cyrtospirifer Nalivkin in Frederiks, 1924, p. 312 [**Spirifer Verneuili* Murchison, 1840, p. 252; OD] [=*Hunanospirifer* Tien, 1938, p. 113 [139] (type, *Spirifer (H.) wangi,* OD); *Grabauispirifer* Gatinaud, 1949, p. 413 (type, *Spirifer (Sinospirifer) archiaciformis* Grabau, 1931b, p. 257, OD); *Eurytatospirifer* Gatinaud, 1949, p. 487 (type, *Spirifer disjunctus* Sowerby in Sedgwick & Murchison, 1840, p. 704, OD); *Deothossia* Gatinaud, 1949, p. 488 (type, *Spirifer (Sinospirifer) anossofioides* Grabau, 1931b, p. 273, OD); *Lamarckispirifer* Gatinaud, 1949, p. 489 (type, *Spirifer (Sinospirifer) hayasakai* Grabau, 1931b, p. 305, OD); *Subquadriangulispirifer* Sartenaer, 1982, p. 153 (type, *Spirifer Malaisi* Gosselet, 1894, p. 47, OD)]. Medium to large, ventribiconvex, moderately transverse; cardinal angles acute, commonly auriculate; ventral interarea high, strongly curved, apsacline; fold and sulcus broad, well defined, not prominent; costae of fold and sulcus increasing by implantation; flanks with numerous simple, rounded costae; surface with capillae and fila; dental plates extrasinal to sulcus bounding; ctenophoridium on median ridge. *Upper Devonian (Frasnian–lower Famennian):* cosmopolitan.——Fig. 1132,*1a–f.* **C. verneuili* (Murchison), Frasnian, France; *a–e,* ventral, dorsal, anterior, posterior, and lateral views; *f,* ventral valve internal mold, ×1 (new).

Austrospirifer Glenister, 1956, p. 58 [**A. variabilis* Glenister, 1956, p. 59; OD]. Small to medium size, biconvex, strongly transverse, with acute cardinal angles; ventral interarea low, orthocline to apsacline, with apical pseudodeltidium; fold and sulcus well defined, narrow, plicate; flanks with numerous simple, rounded plications and U-shaped interspaces; surface with inconspicuous growth lines; dental plates short. *Upper Devonian (Famennian):* Western Australia.——Fig. 1132,*4a–d.* **A. variabilis;* holotype, dorsal, ventral, posterior, and anterior views, ×2 (Glenister, 1956).

Geminisulcispirifer Sartenaer, 1982, p. 149 [**Spirifer bisinus* Le Hon, 1870, p. 497; OD]. Medium to large size, biconvex; transverse, with acute cardinal angles; ventral interarea low, curved, apsacline, with pseudodeltidium; fold and sulcus well defined, costate; sulcus triangular, fold with anteriorly widening median furrow; flanks with numerous simple and bifurcating costae; surface with capillae interrupted by microfila, giving rise to small granules; dental plates intrasinal in type species. *Upper Devonian (Frasnian–Famennian):* Europe, western North America.——Fig. 1132,*2a–e.* **G. bisinus* (Le Hon), Frasnian, France; lectotype, dorsal, ventral, anterior, posterior, and lateral views, ×1 (Sartenaer, 1982).

Liraspirifer Stainbrook, 1950, p. 380 [**L. tricostatus* Stainbrook, 1950, p. 381; OD]. Small to medium size, biconvex, transverse, with acute cardinal angles; ventral interarea slightly curved, apsacline; fold and sulcus plicate, well defined, with fold low; flanks with numerous low, rounded costate plications and wide interspaces (or plications flattened and longitudinally grooved); dental plates straight, divergent, extrasinal, with short delthyrial plate; broad ctenophoridium on notothyrial platform. *Upper Devonian (Famennian):* midcontinent North America.——Fig. 1133,*1a–e.* **L. tricostatus,* Iowa, USA; holotype, ventral, dorsal, anterior, posterior, and lateral views, ×1.5 (new).

Petshorospirifer Fotieva, 1985, p. 56 [**P. petshorensis;* OD]. Small to medium size, ventribiconvex, hemipyramidal; cardinal angles slightly acute; ventral interarea high, flat, catacline; flanks smooth or with faint plications; surface capillate to tuberculate; delthyrial plate short. [No satisfactory photographs are available.] *Upper Devonian (upper Famennian):* northwestern Russia (Petshora region).

Regelia Crickmay, 1952b, p. 2 [**Cyrtospirifer glaucus* Crickmay, 1952a, p. 600; OD]. Medium size, ventribiconvex, strongly transverse and mucronate; ventral interarea low, curved, apsacline; fold and sulcus costate, with prominent plications bounding sulcus; flanks with numerous, simple costae; surface with fine capillae; long, extrasinal dental plates and umbonal thickening present. *Upper Devonian (Frasnian):* western Canada.——Fig. 1132,*5a–c.* **R. glaucus* (Crickmay), Alberta; two ventral valves and one dorsal valve, ×1 (Crickmay, 1952a).

Sinospirifer Gatinaud, 1949, p. 413 (Grabau, 1931b, p. 231) [**Spirifer (Sinospirifer) chinensis* Grabau, 1923 in 1923–1924, p. 169; OD; *nom. imperf.;* =*Spirifer (Sinospirifer) sinensis* Grabau, 1931b, p. 241]. Medium to large, biconvex; transverse, with acute or auriculate cardinal angles; ventral interarea curved, apsacline, with open delthyrium; fold and sulcus well defined, costate, costae increasing by

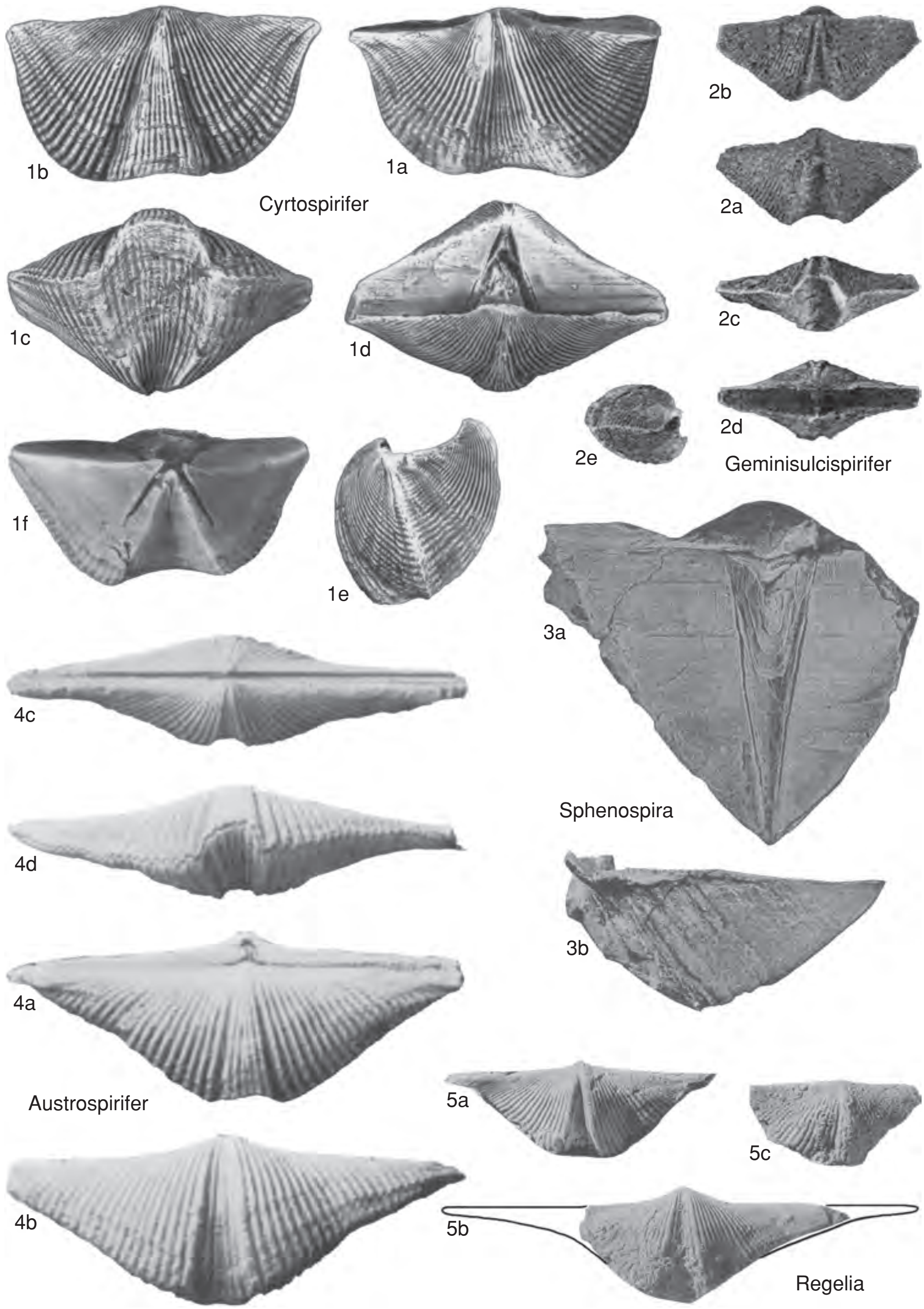

FIG. 1132. Cyrtospiriferidae (p. 1726–1729).

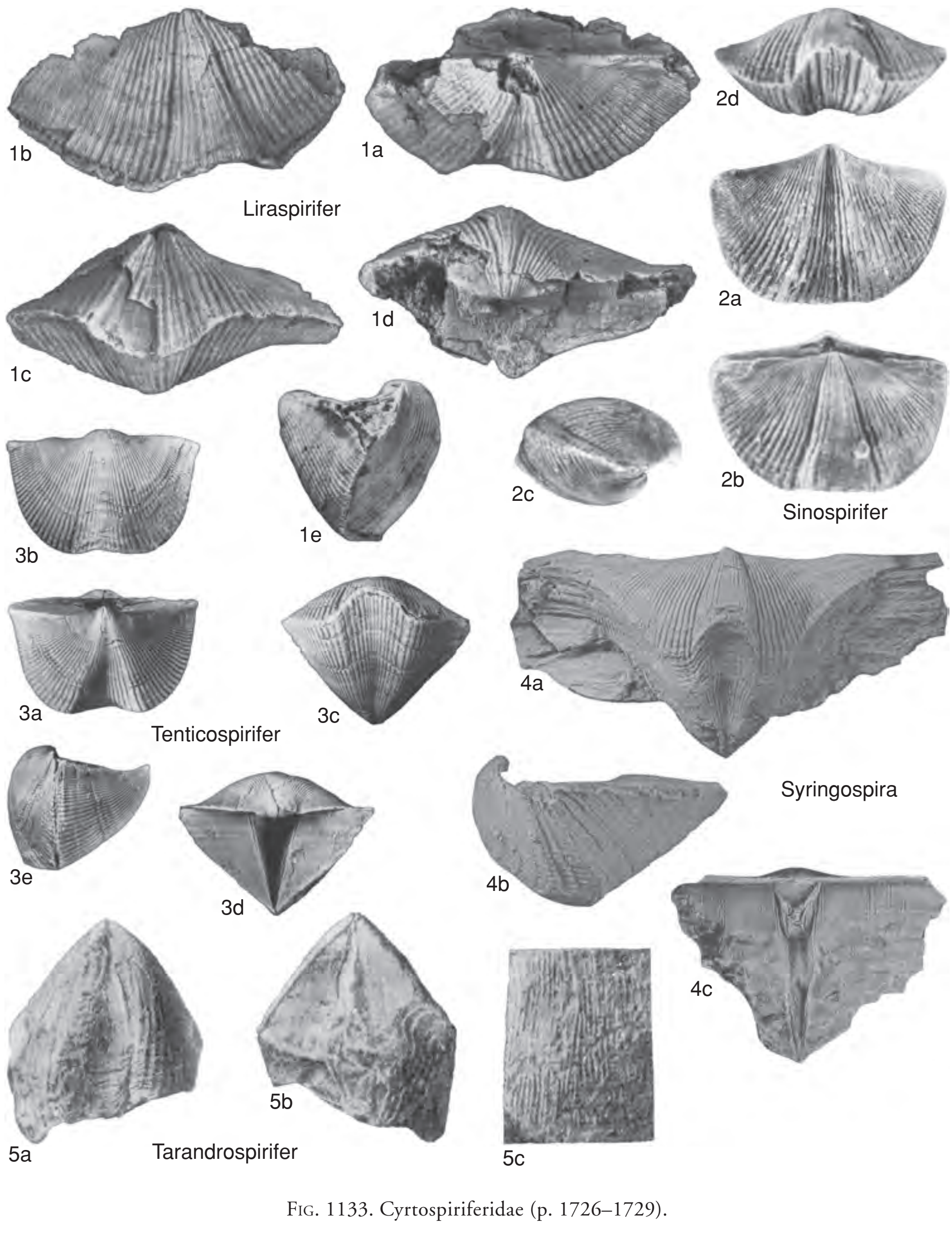

FIG. 1133. Cyrtospiriferidae (p. 1726–1729).

implantation; flanks with simple rounded costae; surface capillate; ventral interior with thickened umbonal region and myophragm; dorsal interior with strong, platelike crural bases but without crural plates. *Upper Devonian (Frasnian–Famennian):* China.——FIG. 1133,*2a–d*. **S. sinensis* (GRABAU); ventral, dorsal, side, and anterior views, ×1 (new).

Sphenospira COOPER, 1954b, p. 330 [**Spirifera alta* HALL, 1867b, p. 248; OD]. Medium size, strongly ventribiconvex, transverse, with semiconical ventral valve; ventral interarea high, flat, catacline, sometimes with frills; delthyrium occluded by long delthyrial plate and stegidium; cardinal angles acute; fold and sulcus rounded, relatively narrow;

surface tuberculate; dental plates long, divergent; ctenophoridium bilobed. *Upper Devonian (Famennian):* eastern North America.——FIG. 1132,*3a–b*. **S. alta* (HALL), Ohio; posterior and lateral views, ×1 (Cooper, 1954b).

Syringospira KINDLE, 1909, p. 28 [**S. prima* KINDLE, 1909, p. 29; OD]. Medium size, strongly ventribiconvex, transverse, with semiconical ventral valve; ventral interarea high, flat, catacline; delthyrium occluded by long delthyrial plate and stegidium; cardinal angles acute; fold and sulcus rounded, relatively narrow; surface tuberculate; dental plates short; umbonal chambers with blisterlike plates; ctenophoridium bilobed. *Upper Devonian (Famennian):* western North America.——FIG. 1133,*4a–c*. **S. prima,* upper Famennian, New Mexico, USA; anterior, lateral, and posterior views, ×1 (Cooper, 1954b).

Tarandrospirifer SIMAKOV in AFANAS'EVA & SIMAKOV, 1970, p. 88 [**Cyrtospirifer tarandrus* NALIVKIN in MARKOVSKI, 1960, p. 384; OD]. Small to medium size, ventribiconvex, hemipyramidal; cardinal angles slightly acute; ventral interarea high, flat, catacline; fold and sulcus smooth or with 1 or 2 pairs of costae in sulcus; flanks with simple, rounded plications; surface capillate; delthyrial plate short. *Upper Devonian (upper Famennian):* Omolonsk massif, Kolyma region, Pai Khoi, Arctic.——FIG. 1133,*5a–c*. **T. tarandrus* (NALIVKIN), Arctic Siberia; *a–b,* holotype, ventral valve, ventral and posterior views, ×1; *c,* microornament, ×6 (Markovski, 1960).

Tenticospirifer TIEN, 1938, p. 113 [139] [**Spirifer tenticulum* DE VERNEUIL, 1845, p. 159; OD] [=*Conispirifer* LIASHENKO, 1985, p. 16 (type, *C. rotundus,* OD)]. Small to medium size, ventribiconvex, hemipyramidal; cardinal angles slightly acute; ventral interarea high, flat, catacline; fold, sulcus, and flanks with simple, rounded plications; surface capillate; ctenophoridium elevated on median ridge. *Upper Devonian (Frasnian):* cosmopolitan.——FIG. 1133,*3a–e*. *T. tenticulum* (DE VERNEUIL), Russian Platform; ventral, dorsal, anterior, posterior, and lateral views, ×1 (new).

Subfamily CYRTIOPSINAE Ivanova, 1972

[Cyrtiopsinae IVANOVA, 1972, p. 33] [=?Uchtospiriferidae LIASHENKO, 1973, p. 87]

Interarea narrow, with rounded cardinal angles. *Middle Devonian (upper Givetian)–Upper Devonian (Famennian).*

Cyrtiopsis GRABAU, 1923 in 1923–1924, p. 194 [**C. davidsoni* GRABAU, 1923 in 1923–1924, p. 195; SD GRABAU, 1931b, p. 435] [=*Grabauicyrtiopsis* GATINAUD, 1949, p. 490 (type, *Cyrtiopsis graciosa* GRABAU, 1923 in 1923–1924, p. 195, OD); *Sinocyrtiopsis* GATINAUD, 1949, p. 491 (type, *Cyrtiopsis transversa* GRABAU, 1924 in 1923–1924, p. 466, OD)]. Small to large, biconvex to ventribiconvex, equidimensional or elongate, with obtuse cardinal angles; deltidium present; ventral interarea high, slightly curved, apsacline; fold and sulcus prominent, costate; flanks with numerous small, simple plications; surface with radial or subradial capillae, becoming tuberculate; dental plates intrasinal, subparallel, with rudimentary delthyrial plate; ctenophoridium elevated. *Upper Devonian (lower Famennian):* southern China.——FIG. 1134,*3a–e*. **C. davidsoni;* holotype, dorsal, ventral, lateral, posterior, and anterior views, ×1.5 (Ma & Day, 1999).

Acutella LIASHENKO, 1973, p. 119 [**Uchtospirifer angulosus* LIASHENKO, 1959, p. 128; OD]. Medium to large, biconvex, equidimensional to transverse, with obtuse cardinal angles; ventral interarea curved, apsacline; ventral beak prominent; fold and sulcus prominent, fold strongly arched or acuminate, costate posteriorly, costae becoming obsolescent anteriorly; flanks with numerous, low, rounded costae and narrow interspaces; surface with radial or subradial capillae and fila; dental plates extrasinal or bordering. *Upper Devonian (Frasnian):* Russian Platform, Urals.——FIG. 1135,*1a–e*. **A. angulosa* (LIASHENKO), Timan; holotype, ventral, dorsal, anterior, posterior, and lateral views, ×1 (Liashenko, 1973).

Dichospirifer BRICE, 1971, p. 192 [**D. thylakistoides* BRICE, 1971, p. 194; OD]. Medium size, biconvex, equidimensional; cardinal angles obtuse, less than maximum width; ventral interarea low, strongly curved, apsacline; fold and sulcus indistinct; fold, sulcus, and flanks with bifurcating costae; microornament of growth fila and faint capillae; dental plates extrasinal, with rudimentary delthyrial plate; dorsal interior with short crural plates. *Upper Devonian (Famennian):* Afghanistan, western North America.——FIG. 1136,*3a–f*. **D. thylakistoides,* upper Fammenian, Afghanistan; *a–e,* ventral, dorsal, posterior, anterior, and side views, ×1; *f,* exterior showing fine ornament, ×12 (Brice, 1971).

Dmitria SIDIACHENKO, 1961, p. 80 [**Spirifer (Cyrtospirifer) Romanowskii* NALIVKIN, 1930, p. 127; OD]. Medium to large, strongly biconvex; equidimensional or elongate, with obtuse cardinal angles; ventral interarea short, strongly incurved; fold and sulcus poorly differentiated; entire surface with numerous fine costellae and capillae; dental plates long, thin, intrasinal; ctenophoridium elevated on median ridge. *Upper Devonian (Famennian):* Tian Shan, Kazakhstan, western Canada.——FIG. 1134,*2a–d*. **D. romanowskii* (NALIVKIN), Tian Shan; dorsal, ventral, anterior, and lateral views, ×0.7 (Nalivkin, 1930).

Eodmitria BRICE, 1982a, p. 575 [**E. supradisjuncta boloniensis* BRICE, 1982a, p. 578; OD]. Medium to large, ventribiconvex to lenticular, transverse with obtuse to acute cardinal angles; ventral interarea low, narrow, apsacline; fold low, sulcus poorly defined, costae of fold-sulcus increasing by implantation; flanks with simple rounded costae;

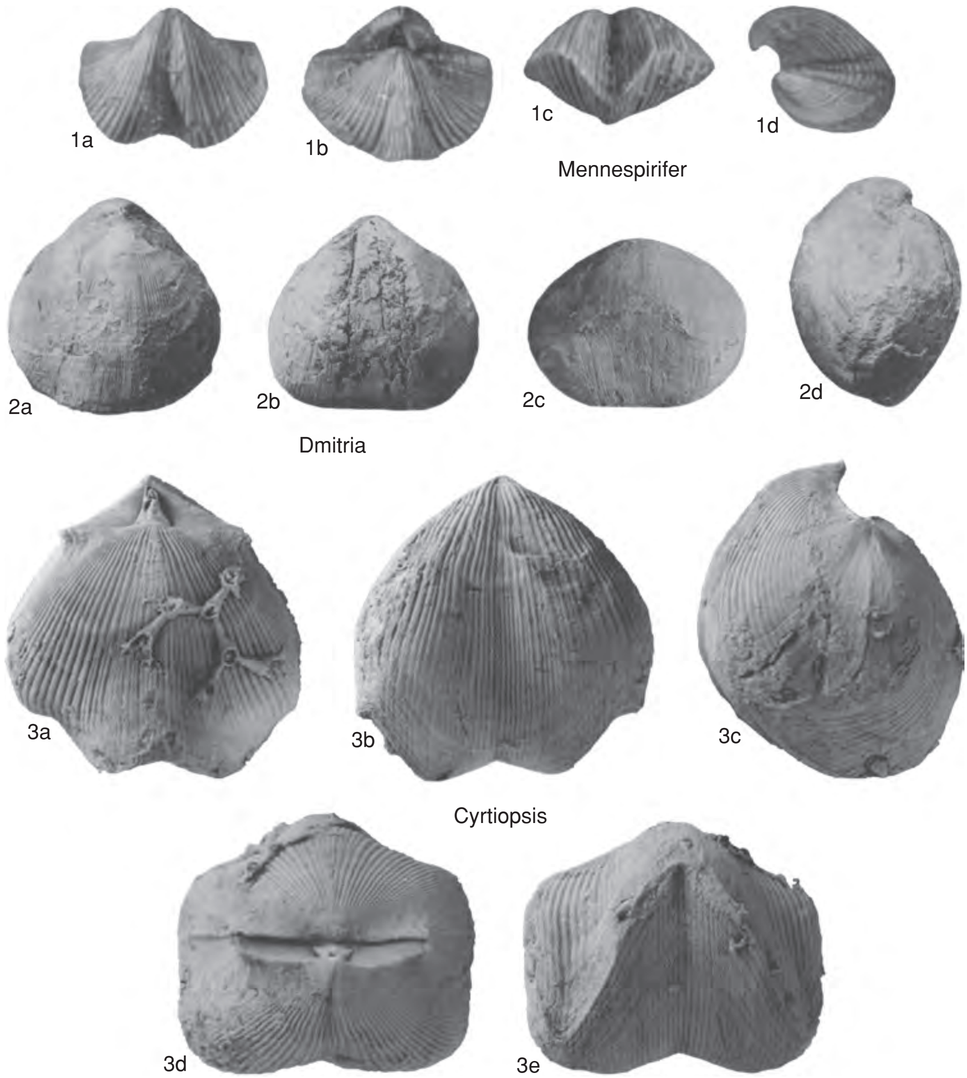

FIG. 1134. Cyrtospiriferidae (p. 1729–1731).

surface papillose; dental plates extrasinal; ctenophoridium elevated. *Upper Devonian (lower Frasnian–middle Frasnian):* western Europe.——FIG. 1135,*2a–d.* **E. supradisjuncta boloniensis,* lower Frasnian, France; holotype, ventral, dorsal, posterior, and anterior views, ×1 (Brice, 1982a).

Mennespirifer LIASHENKO, 1973, p. 101 [**Uchtospirifer menneri* LIASHENKO, 1959, p. 129] [=*Komispirifer* LIASHENKO, 1973, p. 105 (type, *Uchtospirifer formosus* LIASHENKO, 1960, p. 25, OD)]. Medium size, biconvex, transverse, with obtuse cardinal angles; ventral interarea curved, apsacline; fold and sulcus costate; flanks with low rounded costae and narrow interspaces; surface with radial or subradial capillae, becoming tuberculate; dental plates extrasinal. *Middle Devonian (upper Givetian)–Upper Devonian (Frasnian):* Russian Platform, Timan Range, Urals.——FIG. 1134,*1a–d.* **M. menneri*

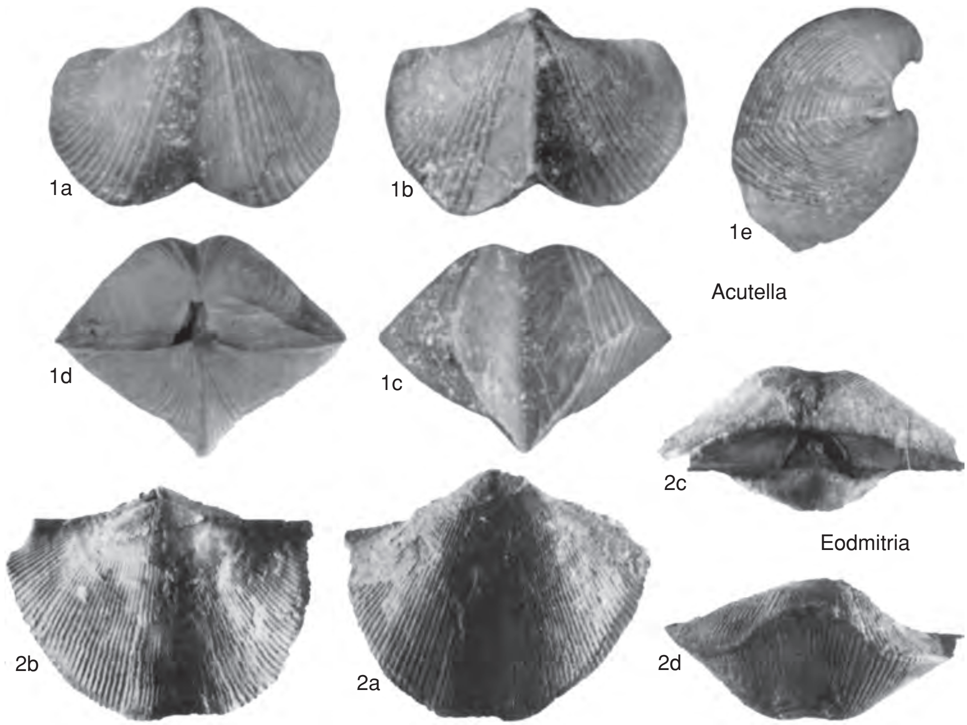

FIG. 1135. Cyrtospiriferidae (p. 1729–1730).

(LIASHENKO), lower Frasnian, Timan; holotype, ventral, dorsal, anterior, and lateral views, ×1 (Liashenko, 1973).

Platyspirifer GRABAU, 1931b, p. 355 [**Schizophoria paronai* MARTELLI, 1902, p. 365; OD]. Small to medium size, biconvex, transversely oval or equidimensional, with rounded, obtuse cardinal angles; ventral interarea low, curved, apsacline; fold low, sulcus poorly defined, costae of fold-sulcus increasing by implantation; flanks with simple rounded costae; surface capillate; dental plates thickened; ctenophoridium elevated. *Upper Devonian (Famennian):* Afghanistan, China.——FIG. 1136,*1a–e*. **P. paronai* (MARTELLI), China; ventral, dorsal, side, posterior, and anterior views, ×1 (new).

Uchtospirifer LIASHENKO, 1957, p. 885 [**U. nalivkini* LIASHENKO, 1957, p. 886; OD] [=*Timanospirifer* LIASHENKO, 1973, p. 92 (type, *Uchtospirifer timanicus* LIASHENKO, 1958, p. 147, OD); *Nordispirifer* LIASHENKO, 1973, p. 104 (type, *N. celeber,* OD); *Clivospirifer* LIASHENKO, 1973, p. 108 (type, *Uchtospirifer clivosus* LIASHENKO, 1969b, p. 53, OD)]. Medium to large, biconvex, equidimensional to transverse, with obtuse cardinal angles; ventral interarea curved, apsacline; ventral beak commonly prominent; fold and sulcus prominent, costate; flanks with numerous, fine, low, rounded costae and narrow interspaces; surface with radial or subradial capillae, becoming tuberculate; dental plates intrasinal, delthyrial plate short. *Middle Devonian (upper Givetian)–Upper Devonian (Famennian):* Russian Platform, Timan Range, Urals, western North America.——FIG. 1136,*2a–e*. **U. nalivkini,* Frasnian, Timan; ventral, dorsal, anterior, posterior, and lateral views, ×1 (Liashenko, 1973).

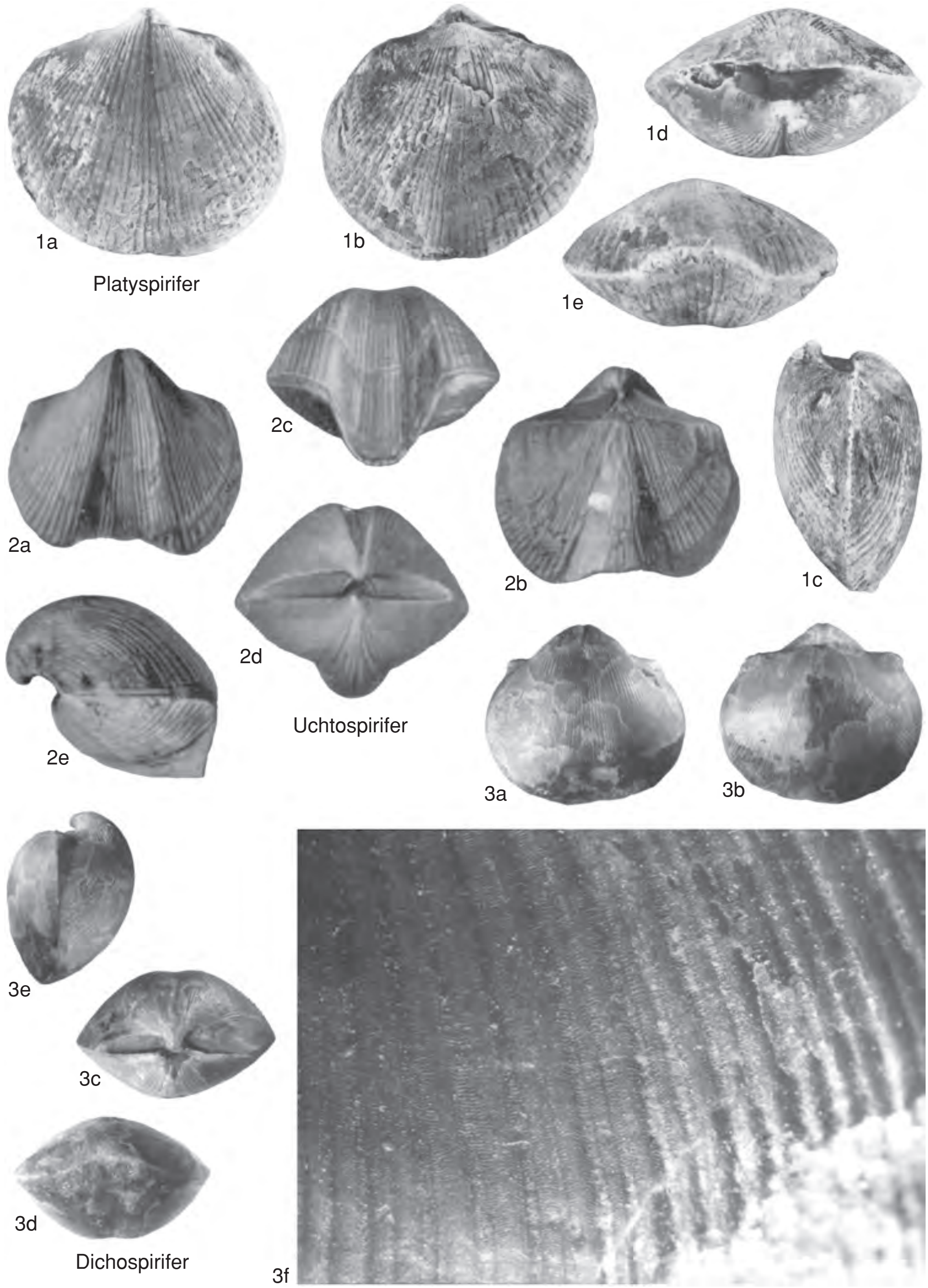

FIG. 1136. Cyrtospiriferidae (p. 1729–1731).

AMBOCOELIOIDEA

J. G. Johnson,[1] J. L. Carter,[2] and Hou Hong-fei[3]

[[1]deceased, formerly of Oregon State University; [2]retired from Carnegie Museum of Natural History; and [3]China University of Geosciences]

Superfamily AMBOCOELIOIDEA George, 1931

[*nom. transl.* Johnson & Carter in Carter & others, 1994, p. 336, *ex* Ambocoeliinae George, 1931, p. 42]

Commonly small, lacking well-developed fold and sulcus; cardinal process commonly simple, knoblike; outer hinge plates broad, well developed; cruralium variably developed. *Silurian (Wenlock)–Lower Triassic, ?Middle Triassic–?Upper Triassic.*

Family AMBOCOELIIDAE George, 1931

[*nom. transl.* Ivanova, 1959, p. 56, *ex* Ambocoeliinae George, 1931, p. 42]

Ventribiconvex smooth shells, rarely pauciplicate. *Silurian (Wenlock)–Lower Triassic, ?Middle Triassic–?Upper Triassic.*

Subfamily AMBOCOELIINAE George, 1931

[Ambocoeliinae George, 1931, p. 42]

[Materials for this subfamily prepared by J. G. Johnson, J. L. Carter, and Hou Hong-fei]

Crural plates vestigial or lacking; commonly with fine concentric growth lamellae; dental plates lacking. *Silurian (Wenlock)–Lower Triassic, ?Middle Triassic–?Upper Triassic.*

Ambocoelia Hall, 1860, p. 71 [**Orthis umbonata* Conrad, 1842, p. 264; OD]. Planoconvex to concavoconvex; megathyrid; ventral interarea low, with beak incurved; commissure uniplicate or straight; with faint growth lines and weak to obscure capillae. *Devonian:* cosmopolitan.——Fig. 1137,*1a–c.* **A. umbonata* (Conrad)*;* ventral, dorsal, lateral views, ×1.5; *d–e,* dorsal and ventral interiors, ×3 (Pitrat, 1965).

Attenuatella Stehli, 1954, p. 343 [**A. texana;* OD]. Ventral valve strongly inflated, longitudinally elongated, with strongly incurved beak and shallow sulcus; dorsal valve nearly flat, nonsulcate; ventral interior with diductor scars raised on long, low narrow ridge with low lateral flanges; dorsal interior with diverging crural bases nearly touching posterior of valve; crura very long, rodlike; spiralia absent; microornament as in *Crurithyris. Permian (Artinskian–Lopingian):* USA (Texas), Russia, Mexico, Australia, New Zealand.——Fig. 1137,*4a–d.* **A. texana,* Artinskian, Texas; ventral, posterior, lateral, and interior views of ventral valve, ×2 (Cooper & Grant, 1976a).——Fig. 1137,*4e–f. A. attenuata* (Cloud), Wordian, Mexico; internal molds of both valves, ×3 (Cooper & Grant, 1976a).

Aviformia Xian, 1988, p. 227 [**A. grandia* Xian, 1988, p. 228; OD]. Large, ventribiconvex, transversely triangular, megathyrid; fold and sulcus distinct, narrow; growth lines with capillae; umbonal callus present; hinge plates widely discrete; cardinal process not observed. *Lower Devonian (Emsian)–Middle Devonian (Eifelian):* southern China.——Fig. 1137,*3a–b.* **A. grandia,* Eifelian; ventral, dorsal views, ×1 (Xian, 1988).

Biconvexiella Waterhouse, 1983b, p. 154 [**Attenuatella convexa* Armstrong, 1968, p. 788; OD]. Ventral valve moderately inflated; dorsal valve evenly convex; ventral umbo moderately incurved, not obscuring delthyrium; ventral adductor ridge moderately developed, anterior median ridge short; crura long, rodlike, terminating in posteriorly reflexed S-shaped extensions; otherwise similar to *Attenuatella. Permian:* Australia.——Fig. 1138,*1a–e.* **B. convexa* (Armstrong); *a,* holotype, dorsal valve; *b–c,* ventral and lateral views of ventral valve; *d–e,* internal molds of both valves, ×4 (Armstrong, 1968).

Bisinocoelia Havlíček, 1953, p. 7 [**B. bisinuata* Havlíček, 1953, p. 8; OD]. Ventribiconvex with prominent ventral umbo; megathyrid; valves bisulcate; notothyrial cavity with pair of ridges that join low median septum; exterior ornament weak. *Lower Devonian–Middle Devonian:* central Bohemia.——Fig. 1137,*5a–b.* **B. bisinuata,* Pragian; ventral and anterior views of dorsal interior, ×7.8 (new).

Cruricella Grant, 1976, p. 187 [**C. couria;* OD]. Sulci lacking in either valve; cardinal extremities subangular; cardinal process knoblike, finely striate; microornament absent or of fine pustules, not spinose; otherwise similar to *Crurithyris. Carboniferous (Pennsylvanian)–Permian (Lopingian), ?Triassic:* cosmopolitan.——Fig. 1137,*2a–g.* **C. couria,* Lopingian, Thailand; *a–e,* holotype, ventral, dorsal, lateral, posterior, and anterior views; *f–g,* dorsal and ventral interiors, ×6 (Grant, 1976).

Crurithyris George, 1931, p. 42 [**Spirifer urei* Fleming, 1828, p. 376]. Ventribiconvex; both valves with weak sulci; anterior commissure emarginate; microornament of fine spinules of 2 distinct sizes, roughly concentrically arranged; cardinal process knoblike; dorsal interior with adductor scars in

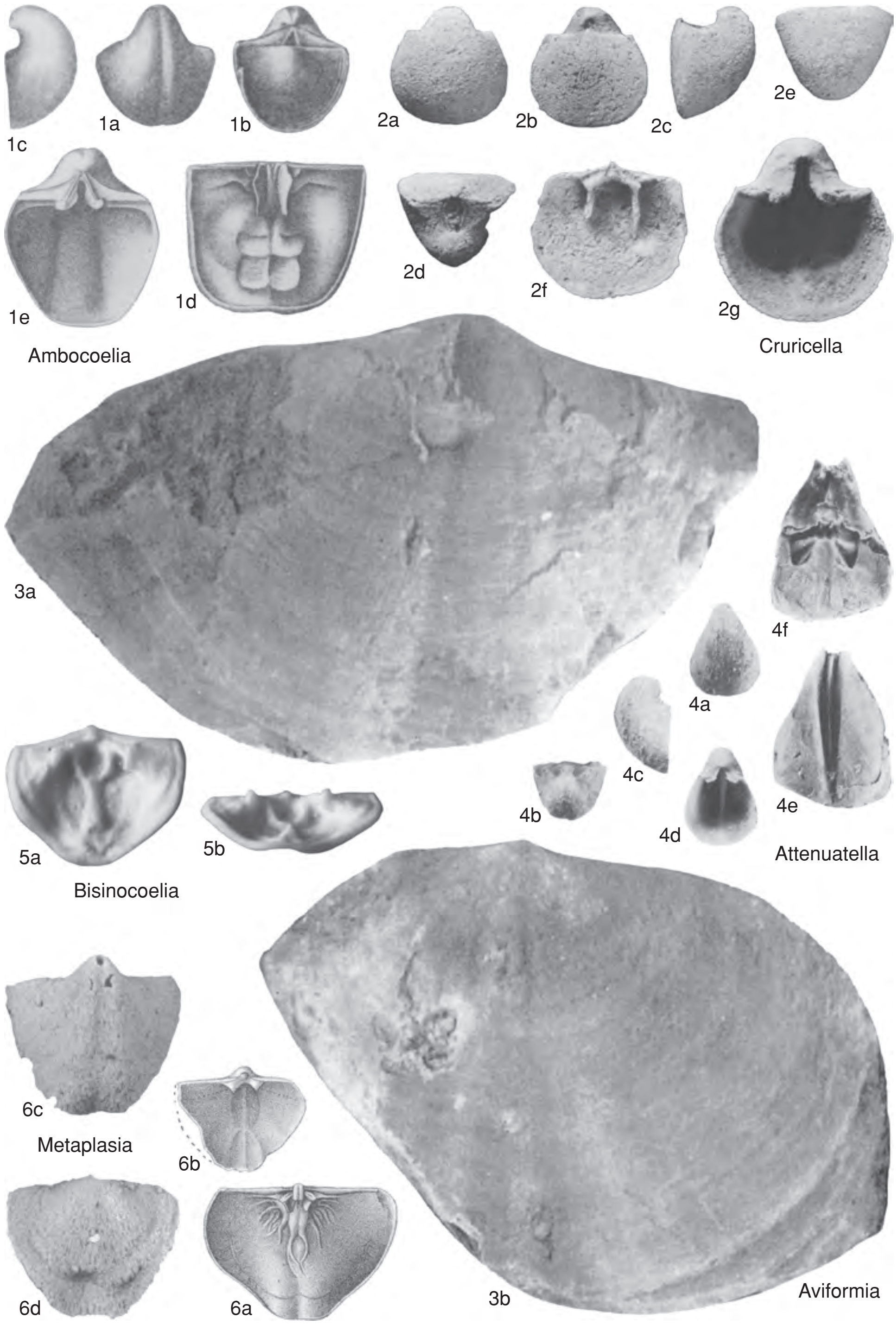

FIG. 1137. Ambocoeliidae (p. 1733–1736).

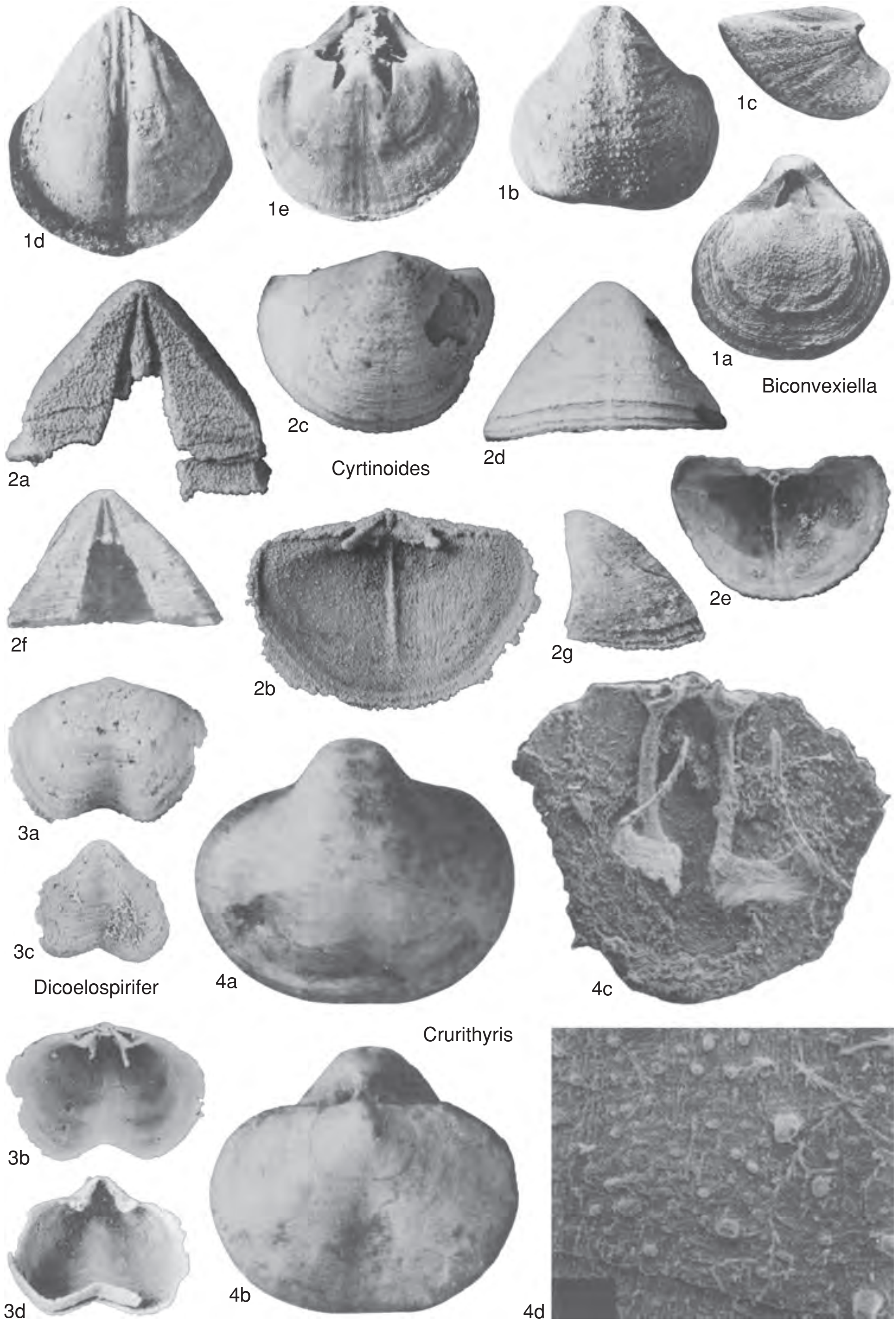

FIG. 1138. Ambocoeliidae (p. 1733–1736).

normal position; otherwise similar to *Ambocoelia. Upper Devonian–Permian:* cosmopolitan.——FIG. 1138,*4a–d.* **C. urei* (FLEMING), Mississippian, Carboniferous, Great Britain; *a–b,* lectotype, ventral and dorsal views, ×9 (George, 1931); *c,* dorsal interior, ×20; *d,* microornament, ×75 (Brunton, 1984).

Cyrtinoides IUDINA & RZHONSNITSKAIA, 1985, p. 82 [**C. ajica;* OD] [=*Mucroclipeus* GOLDMAN & MITCHELL, 1990, p. 85 (type, *M. eliei* GOLDMAN & MITCHELL, 1990, p. 88, OD)]. Ventral median septum and tichorhinum present; tichorhinum lacking dividing partition. [No satisfactory illustration of the type is available.] *Middle Devonian:* North America, Russian Platform, southern Urals.——FIG. 1138,*2a–g. C. septata* (JOHNSON), Eifelian, Nevada, USA; *a,* ventral posterior view; *b,* dorsal interior view, ×6 (Johnson, 1971); *c–g,* ventral, anterior, interior, posterior, and side views, ×4 (Johnson, Klapper, & Trojan, 1980).

Dicoelospirifer ZHANG Ning, 1989, p. 18 [**D. dicoelospirifer;* OD]. Ventribiconvex, interareas lacking; submegathyrid; valves bisulcate; concentric growth lines. *Silurian (Wenlock):* Arctic Islands, Canada.——FIG. 1138,*3a–d.* **D. dicoelospirifer; a–b,* holotype, external and interior views of dorsal valve, ×8; *c,* external view of ventral valve, ×6; *d,* interior view of ventral valve, ×8 (Zhang, 1989).

Echinocoelia COOPER & WILLIAMS, 1935, p. 844 [**E. ambocoelioides;* OD] [=*Pyramina* LIASHENKO, 1969a, p. 23 (type, *P. oskolensis* LIASHENKO, 1969a, p. 24, OD)]. Ventribiconvex with high apsacline ventral interarea; delthyrium closed by apical plate; megathyrid; with concentric growth lines and spines. [No satisfactory illustration of the type is available.] *Middle Devonian:* North America, Russian Platform, China (Guangxi), northern Africa. ——FIG. 1139,*1a–f. E. denayensis* JOHNSON, Eifelian, Nevada, USA; *a–d,* anterior, posterior, ventral, and side views; *e–f,* exterior and interior of dorsal valve, ×3 (Johnson, 1966a).

Eoplicoplasia JOHNSON & LENZ, 1992, p. 530 [**Plicoplasia acutiplicata* LENZ, 1972, p. 102; OD]. Ventribiconvex; megathyrid, cardinal extremities slightly mucronate; ventral interarea high, apsacline to catacline, curved to flat; fold and sulcus moderately expressed; valves strongly plicate, with concentric growth lines and weak to obscure capillae; commissure uniplicate to parasulcate; short rudimentary dental plates. [*Eoplicoplasia* is the oldest ambocoeliid genus and presents analogies with the eospiriferines from which it is probably derived, but it lacks crural plates, hence its assignment to the Ambocoeliinae.] *Silurian (upper Wenlock)–Lower Devonian (Pragian):* North America, Australia.——FIG. 1139,*2a–f.* **E. acutiplicata* (LENZ), upper Lochkovian, Yukon Territory; *a–c,* ventral, dorsal, and dorsal interior views, ×3; *d–f,* posterior, anterior, and side views, ×2.8 (Lenz, 1977).

Guangxiispirifer XIAN Si-yuan, 1983a, p. 12 [**G. subaequatus* XIAN Si-yuan, 1983a, p. 13; OD]. Large, ventribiconvex, submegathyrid; ventral interarea high, curved, apsacline, with deltidial plates; dorsal interarea low, flat, anacline; fold and sulcus lacking; surface with concentric growth lines and capillae; strong dental flanges; inner hinge plates united into triangular platform, with prominent cardinal process. *Middle Devonian (Eifelian–Givetian):* western Europe, southern China.——FIG. 1139,*3a–d.* **G. subaequatus,* Givetian, southern China; *a–c,* ventral, dorsal, and side views, ×1 (new); *d,* interior of dorsal valve, ×1 (Xian, 1983a).

Metaplasia HALL & CLARKE, 1893, p. 56 [**Spirifer pyxidatus* HALL, 1859 in 1859–1861, p. 428; OD]. Ventribiconvex; submegathyrid; ventral interarea low, with beak incurved; valves smooth, lacking spines; commissure intraplicate. *Lower Devonian:* North America.——FIG. 1137,*6a–b.* **M. pyxidata* (HALL), Pragian, Ontario, Canada; dorsal and ventral interiors, ×1 (Hall & Clarke, 1893).——FIG. 1137,*6c–d. M. paucicostata* (SCHUCHERT), Emsian, Nevada, USA; ventral and dorsal exteriors, ×5 (Johnson, 1970).

Orbicoelia WATERHOUSE & PIYASIN, 1970, p. 144 [**O. fraturculus;* OD]. Unequally biconvex; cardinal extremities well rounded; fold and sulcus absent; ventral interior lacking plates or ridges; cardinal process composed of 2 low lobes in juveniles, becoming low platform in adults; microornament of long, very fine spinules; otherwise similar to *Crurithyris. Permian (Roadian):* Thailand.——FIG. 1140,*5a–e.* **O. fraturculus; a–c,* holotype, ventral, dorsal, and lateral views; *d–e,* exterior and internal views of ventral valve, ×3 (Waterhouse & Piyasin, 1970).

Paracrurithyris LIAO, 1981, p. 54 [85] [**Crurithyris pygmaea* LIAO, 1980, p. 264; OD]. Dorsal valve moderately to deeply concave; dorsal interior with small, wedge-shaped cardinal process, thick socket ridges and crural bases; microornament poorly known; otherwise similar to *Ambocoelia. Permian (Lopingian)–Lower Triassic:* China.——FIG. 1140,*3a–d.* **P. pygmaea* (LIAO); *a–b,* dorsal exterior and mold of dorsal interior, ×4; *c–d,* two molds of ventral interiors, ×4 (new).

Plicoplasia BOUCOT, 1959a, p. 19 [**P. cooperi* BOUCOT, 1959a, p. 20; OD]. Ventribiconvex; megathyrid; ventral interarea low, with beak incurved; valves plicate, with weak to obscure capillae; commissure parasulcate. *Lower Devonian (Pragian):* North America, South America, South Africa.——FIG. 1140,*4a–f.* **P. cooperi,* New York, USA; *a–d,* holotype, ventral, dorsal, anterior, and lateral views; *e–f,* dorsal and ventral interiors, ×3 (Boucot, 1959a).

Spinoplasia BOUCOT, 1959a, p. 18 [**S. gaspensis;* OD]. Ventribiconvex; submegathyrid; ventral interarea low, with beak incurved; valves smooth, bearing fine spines; commissure intraplicate. *Lower Devonian:* North America.——FIG. 1140,*1a–c.* **S. gaspensis,* Lochkovian, Quebec; *a–b,* dorsal and ventral internal molds; *c,* microornament, ×10 (Boucot, 1959a).

Swaicoelia HAMADA, 1968a, p. 6 [**S. rotunda;* OD]. Ventribiconvex; submegathyrid; ventral interarea low, with beak incurved; valves smooth, bearing

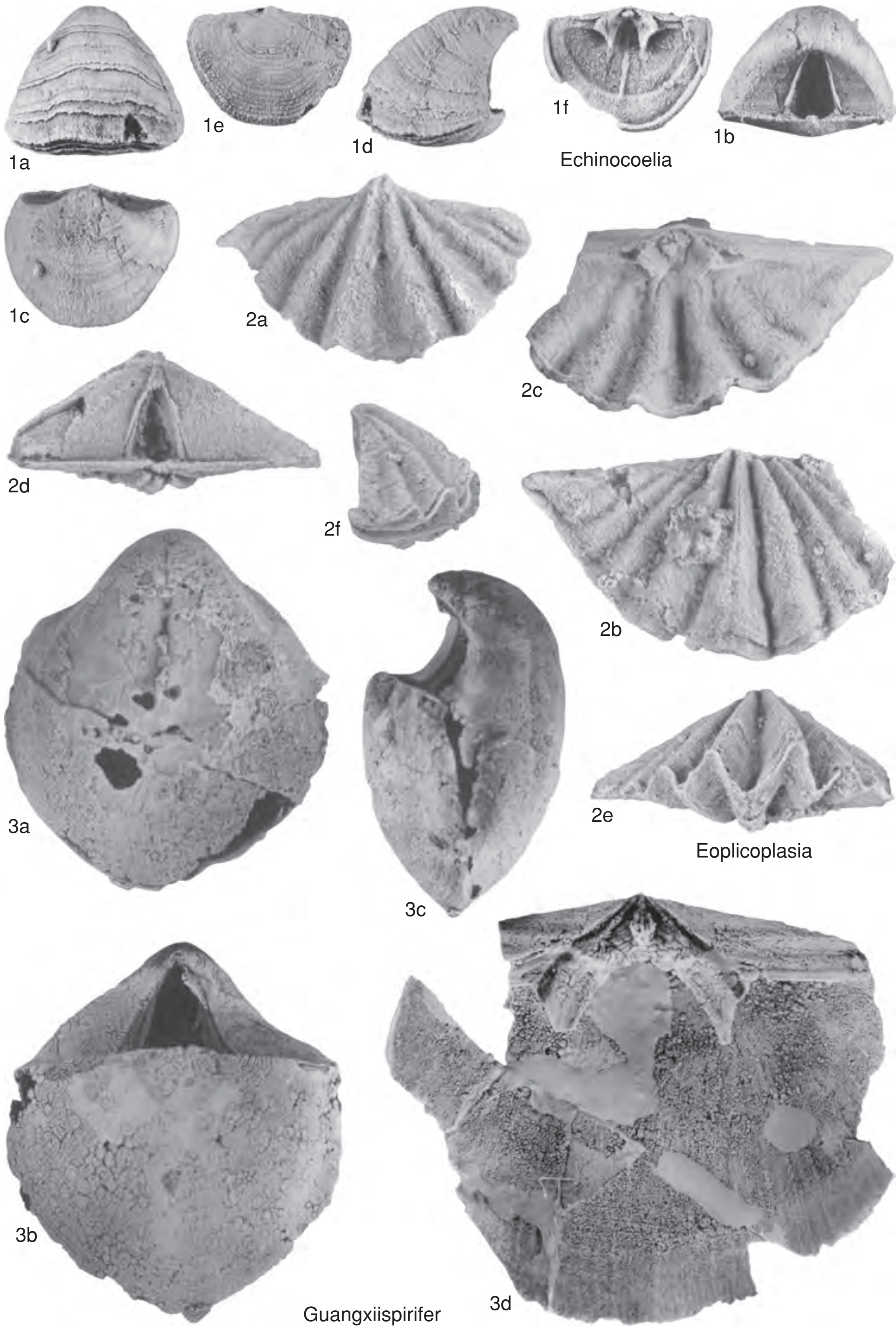

FIG. 1139. Ambocoeliidae (p. 1736).

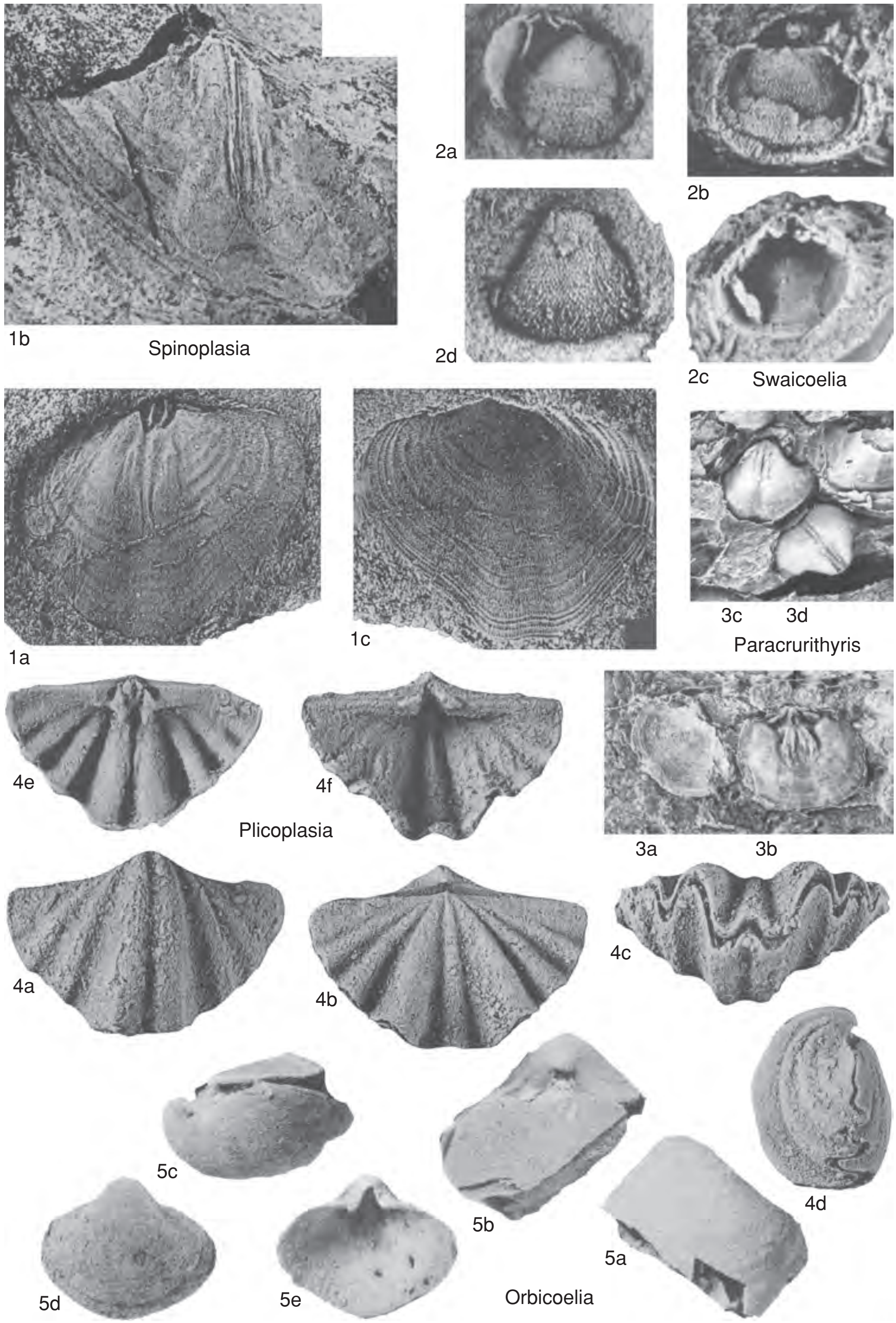

FIG. 1140. Ambocoeliidae (p. 1736–1739).

fine, erect, uniform, randomly distributed spines. *?Upper Devonian, Carboniferous (?Mississippian):* northern Thailand.——FIG. 1140,*2a–d.* **S. rotunda; a,* holotype, dorsal interior; *b–d,* dorsal exterior, ventral interior, ventral exterior, ×5 (Hamada, 1968a).

Subfamily RHYNCHOSPIRIFERINAE Paulus, 1957

[Rhynchospiriferinae PAULUS, 1957, p. 51] [=Ilmeniinae DÜRKOOP, 1970, p. 195]

[Materials for this subfamily prepared by J. G. Johnson & Hou Hong-fei]

Crural plates well developed, either discrete or joined to form a cruralium; commonly with fine capillae; dental plates variably present. *Lower Devonian (Emsian)–Upper Devonian (Frasnian).*

Rhynchospirifer PAULUS, 1957, p. 51 [**R. halleri* PAULUS, 1957, p. 52; OD] [=*Biarella* MARKOVSKI, 1988, p. 82 (type, *Orthis hians* VON BUCH, 1837, p. 64, OD)]. Strongly ventribiconvex; submegathyrid, rarely megathyrid; ventral interarea high, strongly incurved; commissure straight; capillate; dental plates thin, subparallel, closely spaced; cruralium triangular to subquadrate in outline, not anteriorly emarginate, supported by median septum. *Middle Devonian:* Europe, Asia.——FIG. 1141,*5a–f.* **R. halleri,* Eifelian, Germany; *a–e,* holotype, ventral, dorsal, anterior, posterior, and lateral views, ×2; *f,* dorsal interior, ×3.3 (Paulus, 1957).

Amboglossa WANG & ZHU, 1979, p. 59 [94] [**Ambothyris transversa* WANG & others, 1974, p. 242; OD]. Strongly ventribiconvex; submegathyrid, rarely megathyrid; ventral interarea high, flat to incurved; valves bisulcate; dental plates lacking; outer hinge plates form cruralium supported by median septum. *Lower Devonian (Emsian)–Middle Devonian (Eifelian):* Russian Platform, Urals, Timan, China.——FIG. 1141,*1a–c.* **A. transversa* (WANG & others), Eifelian, China; *a–b,* exterior and interior of ventral valve, ×2.5; *c,* interior of dorsal valve, ×6 (new).

Ambothyris GEORGE, 1931, p. 42 [**Spirifera infima* WHIDBORNE, 1893, p. 108; OD]. Ventribiconvex; submegathyrid; ventral interarea high, moderately incurved; commissure straight or slightly sulcate; surface capillate; dental plates lacking; crural plates short, discrete, anteriorly convergent. *Middle Devonian (Givetian)–Upper Devonian (Frasnian):* western Europe.——FIG. 1141,*2a–c.* **A. infima* (WHIDBORNE), Givetian, Belgium; dorsal, ventral, and lateral views, ×4 (Vandercammen, 1956).

Changtangella XIAN Si-yuan, 1983a, p. 9 [**C. bisepta* XIAN, 1983a, p. 11; OD]. Strongly ventribiconvex; submegathyrid, rarely megathyrid; ventral interarea high, strongly incurved; commissure straight; valves smooth, with variably developed capillae; dental plates converge with median septum to form spondylium; cruralium supported by median septum. *Middle Devonian (Givetian):* southern China.——FIG. 1141,*4a–d.* **C. bisepta;* ventral, dorsal, lateral, and posterior views, ×1 (new).

Choperella LIASHENKO, 1969a, p. 22 [**C. ilmenica* LIASHENKO, 1969a, p. 23; OD]. Strongly ventribiconvex; megathyrid, variably alate; ventral interarea flat, catacline; valves bisulcate; with concentric growth lines and variably developed fine capillae; dental plates lacking; crural plates short, discrete. *Middle Devonian (Eifelian)–Upper Devonian (Frasnian):* western North America, Russian platform.——FIG. 1142,*3a–e.* **C. ilmenica,* Eifelian, Russian Platform; holotype, ventral, dorsal, anterior, posterior, and lateral views, ×3 (Liashenko, 1969a).

Crurispina GOLDMAN & MITCHELL, 1990, p. 95 [**Ambocoelia spinosa* CLARKE, 1894, p. 177; OD]. Planoconvex to strongly ventribiconvex; submegathyrid; ventral interarea low, incurved; commissure uniplicate; spines randomly distributed; dental plates lacking; crural plates short, discrete. *Middle Devonian:* eastern North America.——FIG. 1142,*1a–e.* **C. spinosa* (CLARKE), Givetian, New York, USA; dorsal, ventral, lateral, posterior, and anterior views, ×5 (Goldman & Mitchell, 1990).

Diazoma DÜRKOOP, 1970, p. 195 [**Emanuella volhynica* KELUS, 1939, p. 3; OD] [=*Kelusia* MAMEDOV, 1978, p. 200, obj.]. Strongly ventribiconvex; submegathyrid; ventral interarea low, strongly incurved; commissure slightly uniplicate; secondary shell thick; concentric growth lamellae with fine, radially arranged spines; dental plates lacking; cruralium supported by median septum. *Middle Devonian (Eifelian)–Upper Devonian (Frasnian):* Europe, Asia.——FIG. 1142,*5a–f.* **D. volhynica* (KELUS), Middle Devonian, Afghanistan; *a–e,* neotype, dorsal, ventral, posterior, lateral, and anterior views, ×1; *f,* posterior view of internal mold, ×1.5 (Dürkoop, 1970).

Emanuella GRABAU, 1923 in 1923–1924, p. 192 [**Nucleospira takwanensis* KAYSER, 1883, p. 84; OD] [=*Paraemanuella* YANG, 1977, p. 415 (type, *P. orbicularia* YANG, 1977, p. 416, OD)]. Ventribiconvex; submegathyrid; ventral interarea low, strongly incurved; commissure slightly uniplicate; with concentric rows of small spines; dental plates lacking; crural plates short, discrete. *Middle Devonian:* cosmopolitan.——FIG. 1143,*2a–d.* **E. takwanensis* (KAYSER), Givetian, China; *a–c,* dorsal, side, and anterior views, ×2 (Grabau, 1931b); *d,* exterior showing fine ornament, ×25 (Veevers, 1959b).

Ilmenia NALIVKIN, 1941, p. 186 [**I. altovae* NALIVKIN, 1941, p. 187; OD]. Ventribiconvex; submegathyrid; ventral interarea low, incurved; commissure slightly uniplicate; capillate; dental plates short, divergent; crural plates short, discrete. *Middle Devonian:* cosmopolitan.——FIG. 1142,*4a–d.* **I. altovae,* Russia; ventral, dorsal, anterior, and lateral views, ×1 (Nalivkin, 1941).

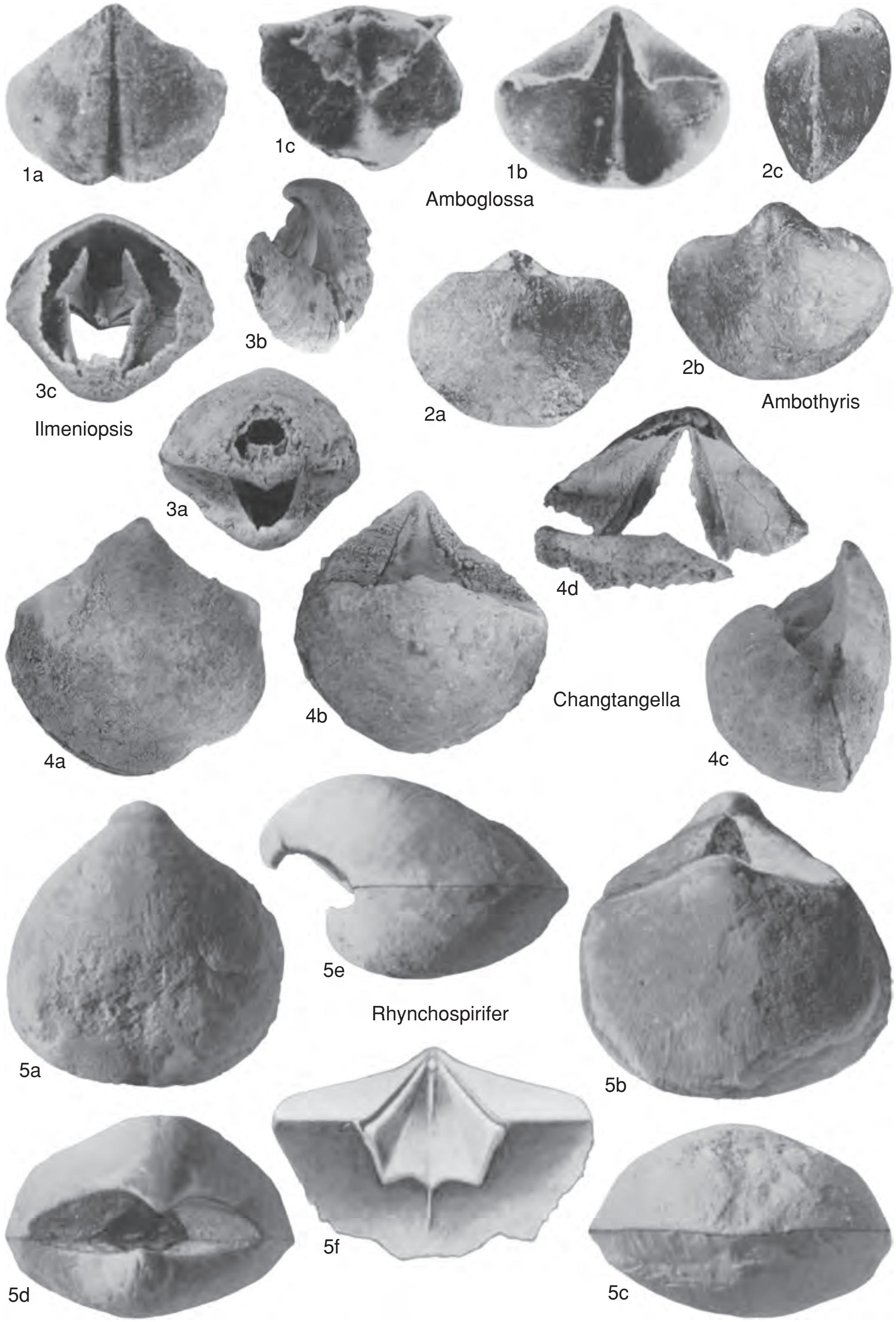

FIG. 1141. Ambocoeliidae (p. 1739–1743).

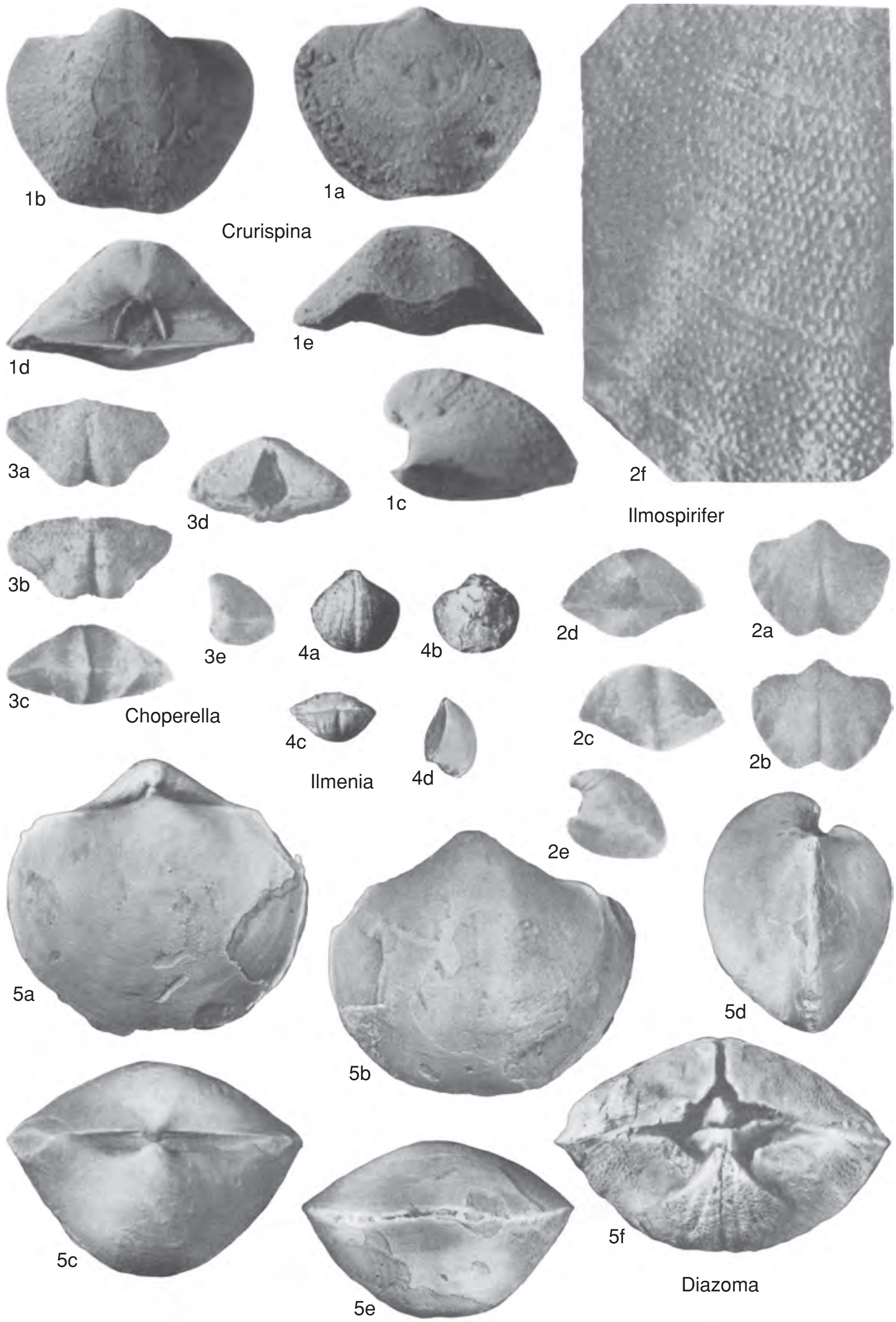

FIG. 1142. Ambocoeliidae (p. 1739–1743).

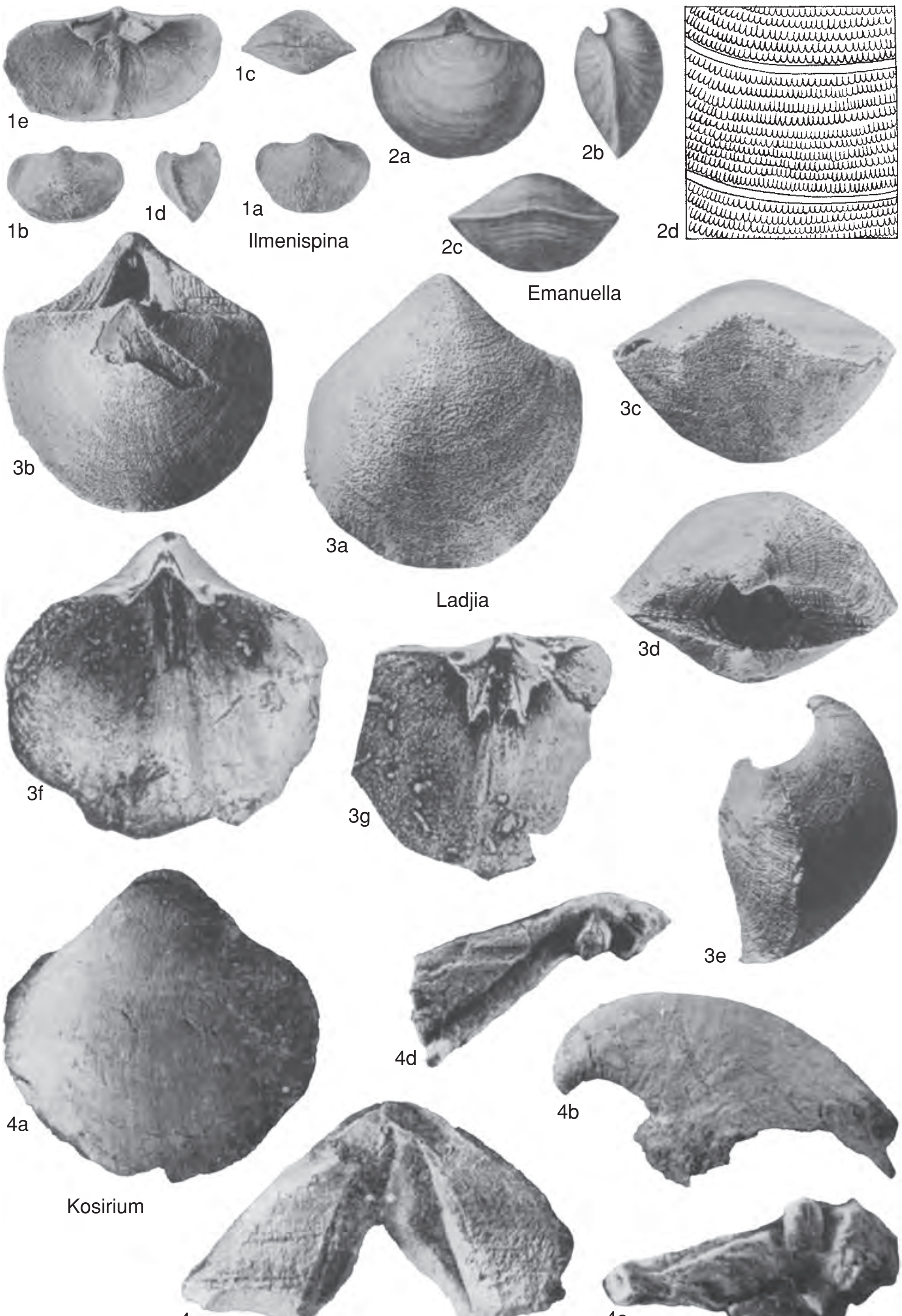

FIG. 1143. Ambocoeliidae (p. 1739–1743).

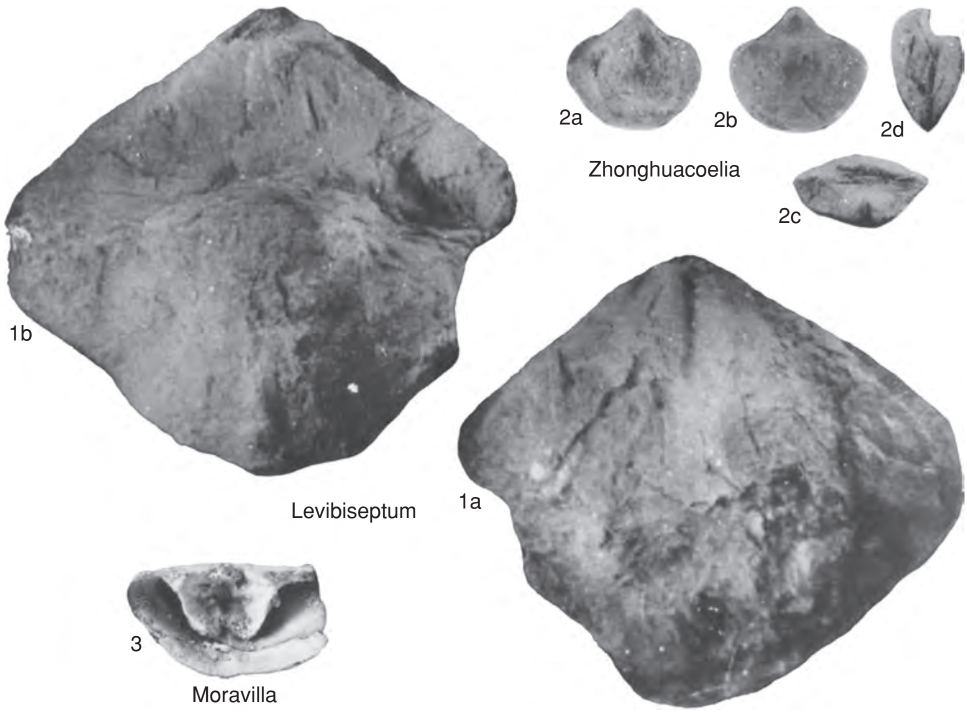

FIG. 1144. Ambocoeliidae (p. 1743–1744).

Ilmeniopsis XIAN, 1983a, p. 15 [**I. changtangensis;* OD]. Ventribiconvex; submegathyrid; ventral interarea low, incurved; commissure straight; faint concentric growth lines; dental plates short; crural plates short, discrete, connected posteriorly by suspended inner hinge plates. *Middle Devonian (Givetian):* southern China.——FIG. 1141,*3a–c.* **I. changtangensis;* posterior, lateral, and anterior views, ×1 (new).

Ilmenispina HAVLÍČEK, 1959, p. 180 [**I. hanaica* HAVLÍČEK, 1959, p. 181; OD]. Ventribiconvex; submegathyrid; ventral interarea low, incurved; commissure straight; faint capillae and spines; dental plates short, strong; crural plates broad, short, discrete or attached to low median ridge. *Middle Devonian (Givetian):* Moravia.——FIG. 1143,*1a–e.* **I. hanaica; a–d,* holotype, ventral, dorsal, anterior, and lateral views, ×2; *e,* dorsal interior, ×2.3 (Havlíček, 1959).

Ilmospirifer LIASHENKO, 1969a, p. 18 [**I. graciosus* LIASHENKO, 1969a, p. 19; OD]. Ventribiconvex; megathyrid; ventral interarea low, with beak incurved; valves plicate, commissure episulcate; microornament of concentric rows of small spines; dental plates lacking; crural plates discrete or joined to form cruralium. *Middle Devonian (Eifelian):* Russian Platform.——FIG. 1142,*2a–f.* **I. graciosus; a–e,* holotype, ventral, dorsal, anterior, posterior, and lateral views, ×3; *f,* microornament, ×20 (Liashenko, 1969a).

Kosirium FICNER & HAVLÍČEK, 1975, p. 362 [**K. turbulentum;* OD]. Dental plates very thick, moderately divergent; cruralium short, deeply emarginate anteriorly; otherwise similar to *Rhynchospirifer. Middle Devonian:* Europe.——FIG. 1143,*4a–e.* **K. turbulentum,* upper Eifelian or lower Givetian, Czech Republic; *a–b,* ventral and lateral views of ventral valve, ×1; *c,* ventral interarea, ×1.3; *d–e,* dorsal and anterior views of dorsal interior, ×1.6 (Ficner & Havlíček, 1975).

Ladjia VEEVERS, 1959a, p. 125 [**L. saltica* VEEVERS, 1959a, p. 126; OD]. Ventribiconvex; submegathyrid; ventral interarea medium height, incurved; commissure straight; capillate; dental plates lacking; crural plates discrete or joined to form a cruralium. *Middle Devonian (Givetian)–Upper Devonian (Frasnian):* western North America, Australia.——FIG. 1143,*3a–g.* **L. saltica,* Australia; *a–e,* holotype, ventral, dorsal, anterior, posterior, and lateral views, ×3; *f–g,* ventral and dorsal interiors, ×4.5 (Veevers, 1959a).

Levibiseptum XIAN in HOU & XIAN, 1975, p. 31 [**L. dushanense;* OD]. Large, transversely oval, subequally biconvex; submegathyrid; ventral interarea of medium height; sulcus narrow, fold lacking; growth lines irregular; dental plates short; cruralium supported by median septum. *Middle Devonian (Eifelian–lower Givetian):* southern China.——FIG. 1144,*1a–b.* **L. dushanense,* lower Givetian; ventral and dorsal views, ×1 (new).

Moravilla HAVLÍČEK, 1953, p. 4 [**M. ficneri* HAVLÍČEK, 1953, p. 5; OD]. Strongly ventribiconvex, transverse, megathyrid; ventral interarea catacline; commissure straight; capillate; dental plates short, high; crural plates discrete. *Middle Devonian (Givetian):* Moravia.——FIG. 1144,*3. M. ficneri,* lower Givetian; interior of dorsal valve, ×3.4 (Havlíček, 1959).

Zhonghuacoelia CHEN, 1978, p. 361 [**Z. bispina;* OD]. Ventribiconvex; submegathyrid; ventral interarea low, strongly incurved; commissure straight; concentric rows of small spines; short dental plates present; crural plates short, discrete. *Devonian (Givetian, ?Frasnian):* southern China.——FIG. 1144,*2a–d.* **Z. bispina,* ?Frasnian; ventral, dorsal, posterior, and side views, ×2.1 (new).

Family LAZUTKINIIDAE Johnson & Hou, 1994

[Lazutkiniidae JOHNSON & HOU in CARTER & others, 1994, p. 337]

[Materials for this family prepared by J. G. Johnson & Hou Hong-fei]

Entirely plicate; capillae lacking; dental plates present. *Lower Devonian (Emsian)–Middle Devonian (Givetian).*

Lazutkinia RZHONSNITSKAIA, 1952, p. 151 [**L. mamontovensis* RZHONSNITSKAIA, 1952, p. 152; OD; =*Spirifer (Yavorskiella) mamontoviensis* LAZUTKIN in IAVORSKII, 1940, p. 44, *nom. nud.*] [=*Yavorskiella* LAZUTKIN in IAVORSKII, 1940, p. 44, *nom. nud.*]. Ventribiconvex with obtuse cardinal angles; ventral interarea long, curved, apsacline; plications numerous, low, rounded; fold and sulcus indistinct or lacking; microornament of numerous concentric lamellae; dental plates short and thick or lacking; knoblike cardinal process and cruralium sited on low median septum. *Middle Devonian (Eifelian–Givetian):* Kuznetzk basin, Salair.——FIG. 1145,*1a–d.* **L. mamontovensis,* Siberia; ventral, dorsal, anterior, and lateral views, ×1 (Rzhonsnitskaia, 1955).

Prolazutkinia HOU & XIAN in XIAN Si-yuan, 1983a, p. 7 [**Lazutkinia lata* HOU & XIAN, 1975, p. 73; OD]. Ventribiconvex, transverse, with flat, steeply apsacline interarea; fold and sulcus lacking; simple and bifurcating plications numerous, rounded, with U-shaped interspaces; ventral umbonal thickening and long divergent dental plates present; crural plates dorsally converging. *Lower Devonian (Emsian):* southern China.——FIG. 1145,*2a–d.* **P. lata* (HOU & XIAN), upper Emsian; ventral, dorsal, posterior, and side views, ×2.6 (new).

Family EUDOXINIDAE Nalivkin, 1979

[*nom. correct. et transl.* CARTER in CARTER & others, 1994, p. 337, *ex* Eudoxiniinae NALIVKIN, 1979, p. 145]

[Materials for this family prepared by J. L. Carter]

Small to very large; biconvex; costate or costellate; microornament papillose in some, absent or unknown in most genera; dental adminicula and protuberent ctenophoridium absent. [Due to the great difference in size between early Carboniferous and Permian representatives of this family and the absence of intermediate forms, the homogeneity for this group cannot be easily tested.] *Upper Devonian (Famennian)–Permian (Lopingian).*

Eudoxina FREDERIKS & KRUGLOV, 1928, p. 801 [**Spirifer medius* LEBEDEV, 1912, p. 242; SD FREDERIKS, 1929, p. 382]. Medium to large; ventribiconvex, with rounded outline; fold and sulcus rounded, weakly to moderately developed; lateral extremities well rounded; entire surfaces of both valves finely costate or coarsely costellate, ribs bifurcating freely; microornament seemingly absent; inner shell layers pitted in some species; ventral interior with strong dental flanges; ventral muscle field deeply impressed; dorsal interior with concave apical area of diductor attachment, finely striate in some species, and high, divergent, inner socket ridges; brachidium unknown. *Carboniferous (Tournaisian):* Russia, Ukraine, USA (Iowa, Illinois).——FIG. 1145,*3a–e.* **E. media* (LEBEDEV), Russia; *a,* syntype, large ventral valve; *b–d,* syntype, ventral, anterior, and lateral views of smaller ventral valve; *e,* syntype, dorsal valve, ×1 (new).

Costicrura HOOVER, 1981, p. 96 [**C. minuta;* OD]. Very small, ventribiconvex, usually transverse; ventral valve hemipyramidal with high catacline to apsacline interarea; dorsal valve weakly convex; fold and sulcus absent; cardinal extremities acute to obtuse; both valves weakly costellate; ventral interior lacking plates or recognizable muscle scars; dorsal interior with bilobed cardinal process divided by coarse median ridge; crural bases arising from posterior valve floor; microornament unknown. [See note under family description.] *Permian (Lopingian):* Venezuela.——FIG. 1145,*6a–c.* **C. minuta;* holotype, dorsal, posterior, and anterior views, ×10 (Hoover, 1981).

Paulonia NALIVKIN, 1925, p. 267 [**Spirifer ranovensis* PEETZ, 1893, p. 53; OD]. Small to medium size, unequally biconvex, moderately transverse to equidimensional, outline rounded subpentagonal; fold and sulcus poorly to moderately developed; lateral extremities well rounded, hinge line much shorter than maximum width; entire surface with

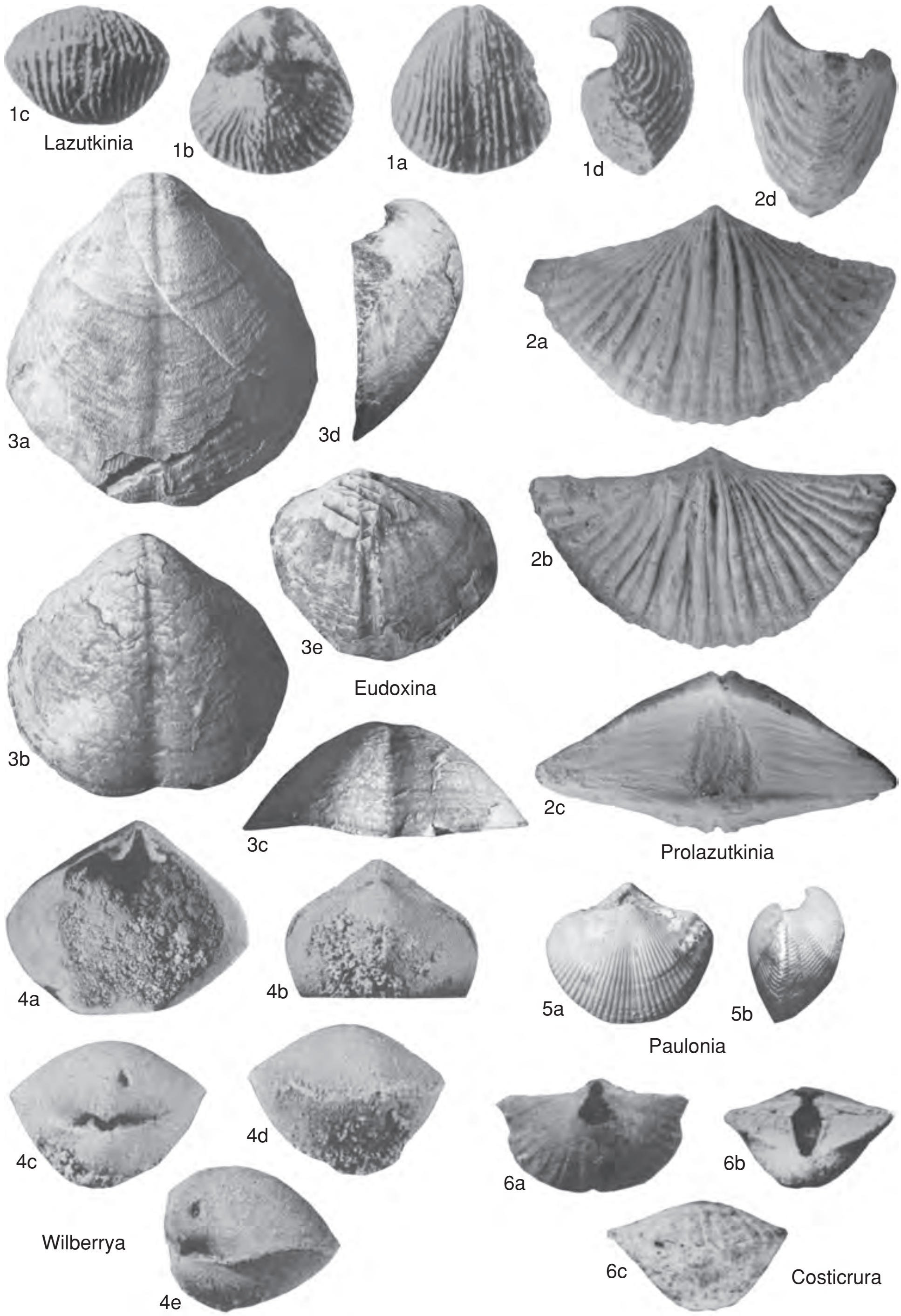

FIG. 1145. Lazutkiniidae and Eudoxinidae (p. 1744–1746).

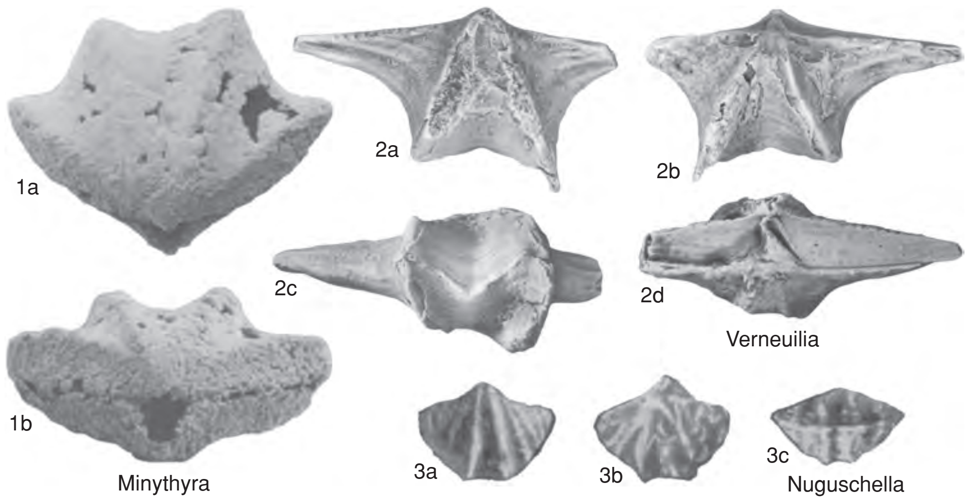

FIG. 1146. Verneuiliidae (p. 1746).

numerous fine simple costellae; microornament consisting of fine oval papillae; inner fibrous shell layer pitted; ventral interior with delthyrial plate; dorsal interior unknown. *Upper Devonian (Famennian)–Carboniferous (Tournaisian):* Russia, Ukraine.——FIG. 1145,*5a–b*. **P. ranovensis* (PEETZ); dorsal and lateral views, ×2 (new).

Wilberrya YANCEY, 1978, p. 301 [**W. fragilis;* OD]. Small, strongly biconvex, dorsal valve slightly less inflated than ventral valve; outline subpentagonal; hinge line narrow, indistinct; fold and sulcus weakly developed, anterior commissure slightly uniplicate; ornament of weakly developed irregular costellae; microornament unknown; dorsal interior with strong, high, inner socket ridges; cardinal process absent; crural bases projecting anteriorly from dorsomedial edges of inner socket ridges with long, slender crura set well above valve floor. [See note under family description.] *Permian (Cisuralian):* USA (Nevada).——FIG. 1145,*4a–e*. **W. fragilis; a,* holotype, ventral interior, ×5; *b–e,* dorsal, posterior, anterior, and lateral views, ×4 (Yancey, 1978).

Family VERNEUILIIDAE Schuchert, 1929

[*nom. transl.* BRUNTON, 1984, p. 101, *ex* Verneuiliinae SCHUCHERT, 1929, p. 21]

[Materials for this family prepared by J. G. Johnson]

Transverse to subcircular; biconvex, with opposite folding, forming ligate to metacarinate anterior margin; ventral interarea narrow to full width of valves; delthyrium open or restricted by apical deltidium. *Middle Devonian (Eifelian)–Carboniferous (Visean).*

Verneuilia HALL & CLARKE, 1893, p. 58 [**Spirifer cheiropteryx* D'ARCHIAC & DE VERNEUIL, 1842, p. 370; SD HALL & CLARKE, 1894, p. 762]. Small to medium size; very transverse with pointed cardinal extremities; flanks markedly concave; dental plates lacking; dorsal interior with small, knoblike cardinal process and short crural plates that merge with prominent, medially convergent hinge plates. [The Visean species from Belgium, *V. oceani* (D'ORBIGNY) is not congeneric with the type species, bearing strong dental flanges, a finely striated cardinal process, lacking crural plates, in having a clearly denticulate ventral interarea with wide perideltidial areas, and possibly a weakly capillate microornament. It belongs in the Spiriferoidea.] *Middle Devonian (Eifelian)–Carboniferous (Visean):* USA (Alaska), Europe, Asia.——FIG. 1146,*2a–d*. **V. cheiropteryx* (D'ARCHIAC & DE VERNEUIL), Middle Devonian, Germany; ventral, dorsal, anterior, and posterior views, ×2 (Gourvennec, 1994a).

Minythyra BRUNTON, 1984, p. 102 [**M. lopha;* OD]. Minute, subcircular; hinge line less than maximum width; interarea low, apsacline with open delthyrium; flanks with 1 or 2 plications; no median septum. *Carboniferous (Visean):* Great Britain.——FIG. 1146,*1a–b*. **M. lopha,* Ireland; *a,* posterodorsal view; *b,* posterior view, ×20 (Brunton, 1984).

Nuguschella TIAZHEVA, 1960, p. 408 [**N. polita;* OD]. Ventribiconvex; megathyrid; ventral interarea low, with beak incurved; valves bisulcate with rounded, opposed plications; capillate; dental plates lacking; crural plates closely discrete, or joined with prominent, medially convergent hinge plates to form cruralium. *Middle Devonian (Eifelian):* Ural Mountains.——FIG. 1146,*3a–c*. **N. polita;* holotype, ventral, dorsal, and anterior views, ×3 (Tiazheva, 1960).

MARTINIOIDEA

J. L. CARTER and RÉMY GOURVENNEC

[retired from Carnegie Museum of Natural History; and Université de Bretagne Occidentale]

Superfamily MARTINIOIDEA Waagen, 1883

[*nom. correct.* CARTER, JOHNSON, & GOURVENNEC in CARTER & others, 1994, p. 338, *pro* Martiniacea IVANOVA, 1972, p. 41, *nom. transl. ex* Martiniinae WAAGEN, 1883a, p. 524]

Biconvex, with broadly rounded lateral extremities and short hinge line; lateral slopes smooth or with subdued ribbing; microornament often capillate, smooth, or very finely spinulose, but not strongly lamellose or concentrically disposed; ventral median septum absent; dorsal interior with ctenophoridium in all but the earliest genera; fibrous layer commonly pitted. *Silurian (upper Wenlock)–Permian (Lopingian).*

Family TENELLODERMIDAE Carter, Johnson, & Gourvennec, 1994

[Tenellodermidae CARTER, JOHNSON, & GOURVENNEC in CARTER & others, 1994, p. 338]

[Materials for this family prepared by Rémy Gourvennec]

Ctenophoridium absent; surface pitted or simple; dental plates present. *Silurian (upper Wenlock)–Middle Devonian (Eifelian).*

Tenellodermis HAVLÍČEK, 1971, p. 11 [**T. microdermis;* OD]. Small to medium size, slightly transverse with high, catacline to procline ventral interarea; cardinal extremities rounded; sulcus and corresponding fold well delimited, shallow; commissure uniplicate; flanks smooth or bearing few (1 to 4) wide, low, rounded anterior plications; microornament of fine growth lines and minute pits either aligned between radial capillae or randomly arranged; dental plates long, thin; crural plates lacking; cardinal process consisting of simple tubercle. *Silurian (upper Wenlock)–Lower Devonian (Lochkovian):* Czech Republic, USA (Nevada).——FIG. 1147,*2a–b.* **T. microdermis,* Lochkovian, Czech Republic; dorsal and ventral views, ×2 (Havlíček, 1971).——FIG. 1147,*2c–e. T. tenellus* (BARRANDE), Ludlow, Czech Republic; *c–d,* anterior and lateral views, ×1.5 (Havlíček, 1959); *e,* ornament, ×50 (Havlíček, 1971).

Cingulodermis HAVLÍČEK, 1971, p. 15 [**C. cinctus;* OD]. Small to medium size, equidimensional to slightly transverse, with high, curved ventral interarea; fold and sulcus well defined anteriorly resulting in uniplicate commissure; flanks smooth; microornament of growth lamellae only; dental plates short; muscle field deeply impressed; crural plates short; ctenophoridium lacking; cardinal process occasionally bifid. *Lower Devonian (Lochkovian)–Middle Devonian (Eifelian):* Czech Republic, Germany, Morocco.——FIG. 1147,*1a–f.* **C. cinctus,* Pragian, Czech Republic; *a–d,* dorsal, ventral, anterior, lateral views, ×2; *e,* interior of ventral valve, ×2.6 (Havlíček, 1959); *f,* ornament, ×4.4 (Havlíček, 1971).

Family ELYTHYNIDAE Gourvennec, 1994

[Elythynidae GOURVENNEC in CARTER & others, 1994, p. 338]

[Materials for this family prepared by Rémy Gourvennec]

Flanks plicate; ornament of fine pits or spines and pits; ctenophoridium, dental plates, and crural plates or dorsal adminicula present. *Lower Devonian (Pragian)–Middle Devonian (Givetian).*

Elythyna RZHONSNITSKAIA, 1952, p. 61 [**E. salairica;* OD]. Medium to large, transverse, with rounded cardinal extremities; apsacline, rather low, curved ventral interarea; fold and sulcus distinct, some species with incipient costation on fold; flanks with 4 to 6 low, rounded, lateral plications, in some faintly expressed; microornament of concentric growth lines and randomly arranged pits; dental plates long, thick; muscle field deeply impressed; crural plates (or possible dorsal adminicula) and ctenophoridium well developed; strong apical thickening in both valves. *Lower Devonian (Emsian)–Middle Devonian (Givetian):* Turkestan, Gansu Mongol, Arctic Canada.——FIG. 1148,*1a–i.* **E. salairica,* Eifelian, Salair; *a–e,* dorsal, ventral, anterior, posterior, lateral views, ×0.7; *f,* ornament, ×6; *g–h,* dorsal, ventral views of internal mold, ×1 (Rzhonsnitskaia, 1952); *i,* transverse section, ×2 (new).

Najadospirifer HAVLÍČEK, 1957a, p. 246 [**Spirifer najadum* BARRANDE, 1848, p. 171; OD] [=*Naïadospirifer* HAVLÍČEK, 1957a, p. 246, *lapsus calami,* obj.]. Medium to large; transverse or equidimensional with rounded cardinal extremities; ventral interarea high, gently curved, apsacline to catacline; fold and sulcus absent posteriorly, more or less distinct anteriorly; anterior commissure strongly uniplicate, producing very high tongue; plicae lacking posteriorly, present only on anterior

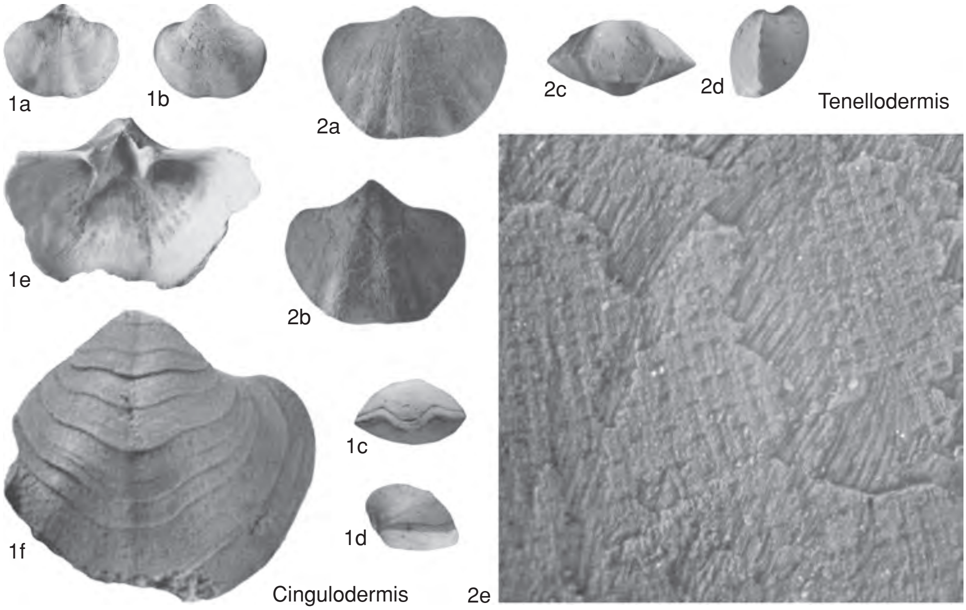

FIG. 1147. Tenellodermidae (p. 1747).

part of shell; microornament of radial rows of variably elongate minute pits and tubercles; dental plates long, divergent; crural plates short; ctenophoridium present. [In the original publication by HAVLÍČEK (1957a), the new genus is spelled *Naïadospirifer* nov. gen., but in the remaining parts of the text and in the English summary it is spelled *Najadospirifer* (and it is based on the species *najadum* BARRANDE).] *Lower Devonian (Pragian–Emsian):* Czech Republic, Germany, Carnic Alps, ?Morocco.——FIG. 1148,*3a–f.* **N. najadum* (BARRANDE), Pragian, Czech Republic; *a–d,* dorsal, ventral, anterior, lateral views, ×1; *e,* transverse section, ×1.5 (Havlíček, 1959); *f,* ornament, ×12 (Havlíček, 1971).

Tatjanaspirifer CHERKESOVA, 1991, p. 91 [**T. variabilis;* OD]. Medium size; usually elongate with apsacline curved interarea and rounded cardinal extremities; ventral valve strongly swollen; sulcus and fold distinct; flanks with 1 to 3 wide, uncommonly bifurcating plications; microornament of concentric growth lines with marginal spines and somewhat coarser, randomly distributed spines; dental plates thick; muscle field and genital markings well impressed; crural plates short; ctenophoridium bilobed. *Lower Devonian (Pragian):* Siberian Platform.——FIG. 1148,*2a–g.* **T. variabilis,* Taymyr; *a–d,* dorsal, ventral, anterior, lateral views of partially decorticated specimen, ×1; *e–f,* spinose ornament and pits, ×10; *g,* interior of ventral valve, ×2 (Cherkesova, 1991).

Family MARTINIIDAE Waagen, 1883

[*nom. transl.* IVANOVA, 1959, p. 56, *ex* subfamily Martiniinae WAAGEN, 1883a, p. 524]

[Materials for this family prepared by J. L. Carter]

Subequally biconvex; lateral slopes smooth or weakly plicate; dorsal adminicula or crural plates absent; microornament of scattered surficial pits, or capillae, or absent. *Upper Devonian (?lower Famennian–?middle Famennian, upper Famennian)–Permian (Lopingian).*

Subfamily MARTINIINAE Waagen, 1883

[Martiniinae WAAGEN, 1883a, p. 524]

Without plates or septa in either valve; microornament of fine pits only. *Carboniferous (Tournaisian)–Permian (Lopingian).*

Martinia M'COY, 1844, p. 128 [**Spirifer glaber* SOWERBY, 1820 in 1818–1821, p. 123; SD ICZN Opinion 421, 1956b, p. 171] [=*Pseudomartinia* LEIDHOLD, 1928, p. 82, obj.; *Paramartinia* REED, 1949, p. 471 (type, *Martinia (Paramartinia)*

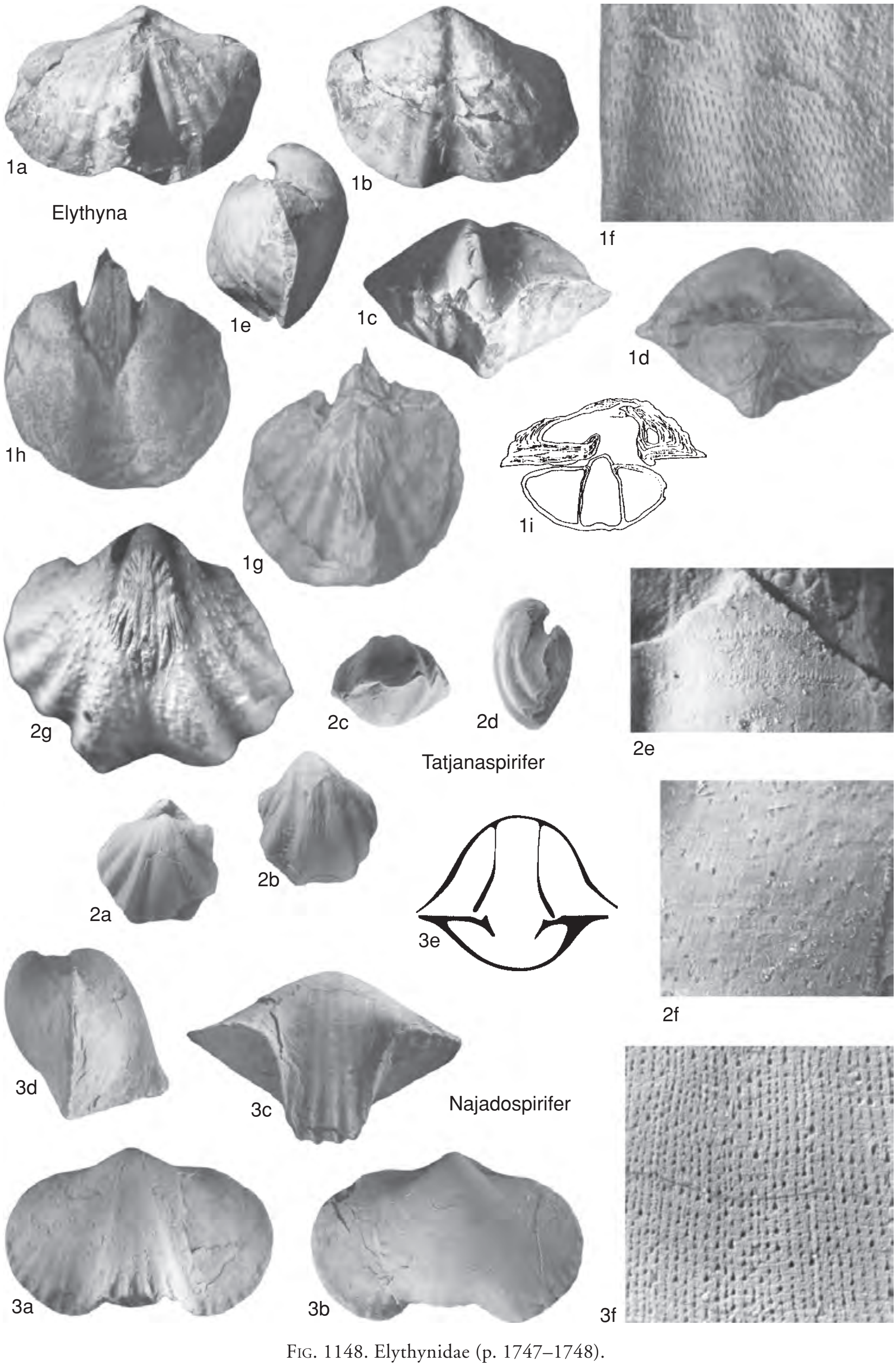

FIG. 1148. Elythynidae (p. 1747–1748).

lingulata REED, 1949, p. 471, OD)]. Unequally biconvex; outline subovate to subpentagonal; fold and sulcus weakly to moderately developed, well rounded, often poorly delimited; ventral interarea well developed, apsacline; macroornament absent; microornament often absent, rarely with shagreen (finely pitted) surface; inner shell layers more commonly pitted; ventral interior simple, with dental flanges and impressed lanceolate muscle scar bisected by weak, narrow medial groove that extends from beak region to or near anterior margin; dorsal interior simple, with small ctenophoridium and narrow medial groove similar to that of opposite valve; vascular impressions of both valves pinnate. *Carboniferous (Mississippian)–Permian (Lopingian):* cosmopolitan.——FIG. 1149,*2a–b.* **M. glabra* (SOWERBY), Visean, England; lectotype, anterior and dorsal views, ×1 (Muir-Wood, 1951).

Beschevella POLETAEV, 1975, p. 51 [**Martinia (Ella) snjatkovi* ROTAI, 1931, p. 86; OD]. Medium to large, strongly and subequally biconvex; outline transversely subrhomboidal to subpentagonal; surface smooth or vaguely ribbed; thin shelled; well-developed fold and sulcus; dorsal fold flattened or with shallow medial furrow; delthyrium partly closed by convex pseudodeltidium; microornament of numerous small pits, densely and crudely arranged in quincunx; umbonal region of ventral valve with 2 short, broad, weakly diverging ridges; vascular impressions not observed, possibly absent; otherwise similar to *Martinia. Carboniferous (Bashkirian):* Ukraine (Donets basin).——FIG. 1149,*1a–f.* **B. snjatkovi* (ROTAI); *a–e,* ventral, posterior, dorsal, lateral, and anterior views, ×1; *f,* microornament, ×8 (Poletaev, 1975).

Implexina POLETAEV, 1971, p. 79 [**Spirifer (Martiniopsis?) implex* ROTAI, 1931, p. 90; OD]. Medium to large; unequally biconvex; moderately to strongly inflated, relatively thin shelled; outline subovate; fold and sulcus absent; ventral valve with broad, posteriorly extended umbonal region; posterolateral slopes of ventral valve bent strongly inward, forming large palintrope lateral to ventral interarea; ventral interarea high, narrow, clearly defined, strongly apsacline; radial ornament absent; microornament of small, elongate pits; ventral interior with strong dental flanges; muscle field moderately impressed with pair of long narrow furrows medially separated by low median ridge and bounded laterally by low ridges; dorsal interior with analagous muscle impressions and low ridges and thick, arcuate, bilobed ctenophoridium. *Carboniferous (Tournaisian):* Ukraine.——FIG. 1150,*2a–d.* **I. implex* (ROTAI); *a–c,* ventral, posterior, and lateral views of ventral valve; *d,* dorsal valve, ×1 (new).

Jilinmartinia LI & GU, 1980, p. 488 [491] [**Brachythyris shansiensis* CHAO, 1929, p. 55] [=*Kalitvella* LAZAREV & POLETAEV, 1982, p. 92 (type, *Spirifer (Brachythyris) sokolovi* var. *laevis* LIKHAREV, 1938, p. 83, OD)]. Large; lateral plicae absent or very faint; interior with 2 vascula media and reticulate vascular pattern; otherwise similar to *Martinia. Carboniferous (?Moscovian, Kasimovian):* Ukraine (Donets basin), China.——FIG. 1151,*1a.* **J. shansiensis* (CHAO), ?Kasimovian, China; syntype, ventral valve, ×1 (Chao, 1929).——FIG. 1151,*1b–f. J. laevis* (LIKHAREV), Kasimovian, Donets basin; holotype, ventral, dorsal, lateral, anterior, and posterior views, ×1 (new).

Postamartinia WANG & YANG, 1993, p. 7 [**P. grandiplica;* OD]. Medium size; outline transversely subpentagonal; ventral interarea low; lateral slopes with 3 to 4 smooth, low, broad plicae; internally similar to *Martinia;* microornament, if any, unknown. *Permian (Sakmarian):* China (Xinjiang). ——FIG. 1151,*2a–d.* **P. grandiplica;* holotype, ventral, dorsal, lateral, and anterior views, ×1 (Wang & Yang, 1993).

Spinomartinia WATERHOUSE, 1968, p. 53 [**S. spinosa;* OD]. Microornament of fine erect spines; otherwise similar to *Martinia. Permian (Cisuralian–Lopingian):* Thailand, Australia, *Cisuralian;* New Zealand, *Lopingian.*——FIG. 1152,*2a–c.* **S. spinosa,* Cisuralian, Thailand; holotype, dorsal, posterior, and ventral views, ×2 (Waterhouse, 1968).

Tiramnia GRUNT, 1977b, p. 64 [**Martinia uralica* CHERNYSHEV, 1902, p. 183; OD]. With ramiform vascular impressions; otherwise similar to *Martinia. Carboniferous (Moscovian)–Permian (Cisuralian):* Arctic Russia, Greenland, Arctic Canada.——FIG. 1152,*1a–f.* **T. uralica* (CHERNYSHEV), Cisuralian, Arctic Russia; *a–b,* large syntype, ventral and dorsal views; *c–f,* small syntype, ventral, dorsal, anterior, and lateral views, ×1 (new).

Weiningia JIN & LIAO, 1974, p. 282 [**W. transversa;* OD] [?=*Elenchus* ALEKSANDROV in ALEKSANDROV & SOLOMINA, 1973, p. 118 (type, *E. areatus,* OD), *non* CURTIS, 1840]. Medium size; subequally biconvex; outline subovate, subtrigonal, or guttate with acuminate ventral beak; hinge line much shorter than maximum width; fold absent; valves evenly convex or with weak sulci in one or both valves; ventral interarea moderately high, triangular, concave, poorly defined; low dorsal interarea variably present; ornament absent except for growth varices and indistinct plications; microornament absent or with weak indistinct capillae; ventral interior with obscure dental flanges; ventral muscle scars deeply incised, in 2 distinct pairs, separated by low median ridge; dorsal interior with large cardinal process, thick crural bases, and median ridge; both valves greatly thickened by callus; vascular impressions pinnate. *Carboniferous (Serpukhovian–Bashkirian):* China (Guizhou), Russia (southern Urals), Japan (Akiyoshi Province).——FIG. 1150,*1a–c.* **W. transversa,* Weiningian, Guizhou, China; holotype, ventral, dorsal, and lateral views, ×1 (new).——FIG. 1150,*1d–f. W. areatus* ALEKSANDROV; holotype, ventral, dorsal, and lateral views, ×1 (Aleksandrov & Solomina, 1973).

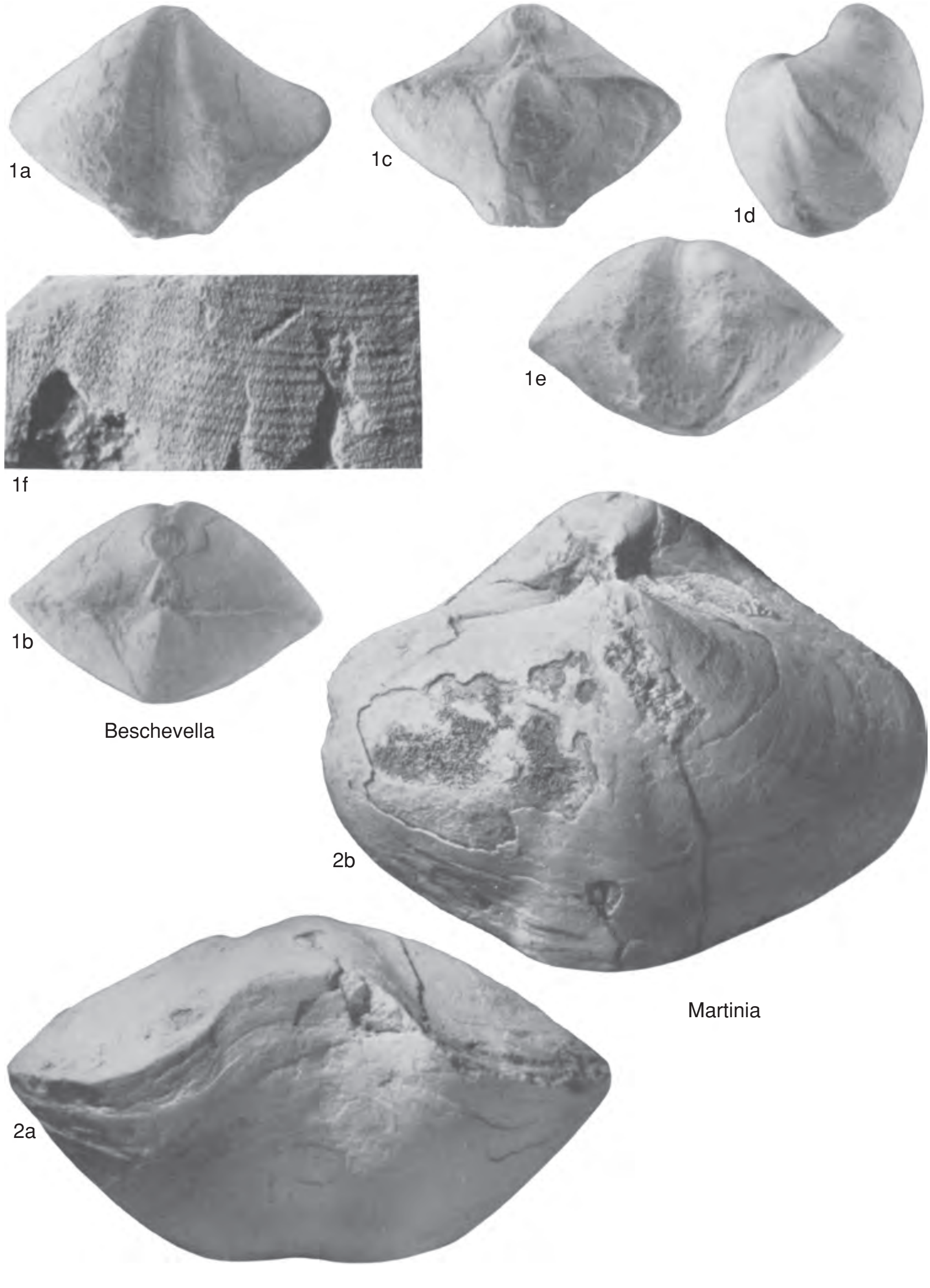

FIG. 1149. Martiniidae (p. 1748–1750).

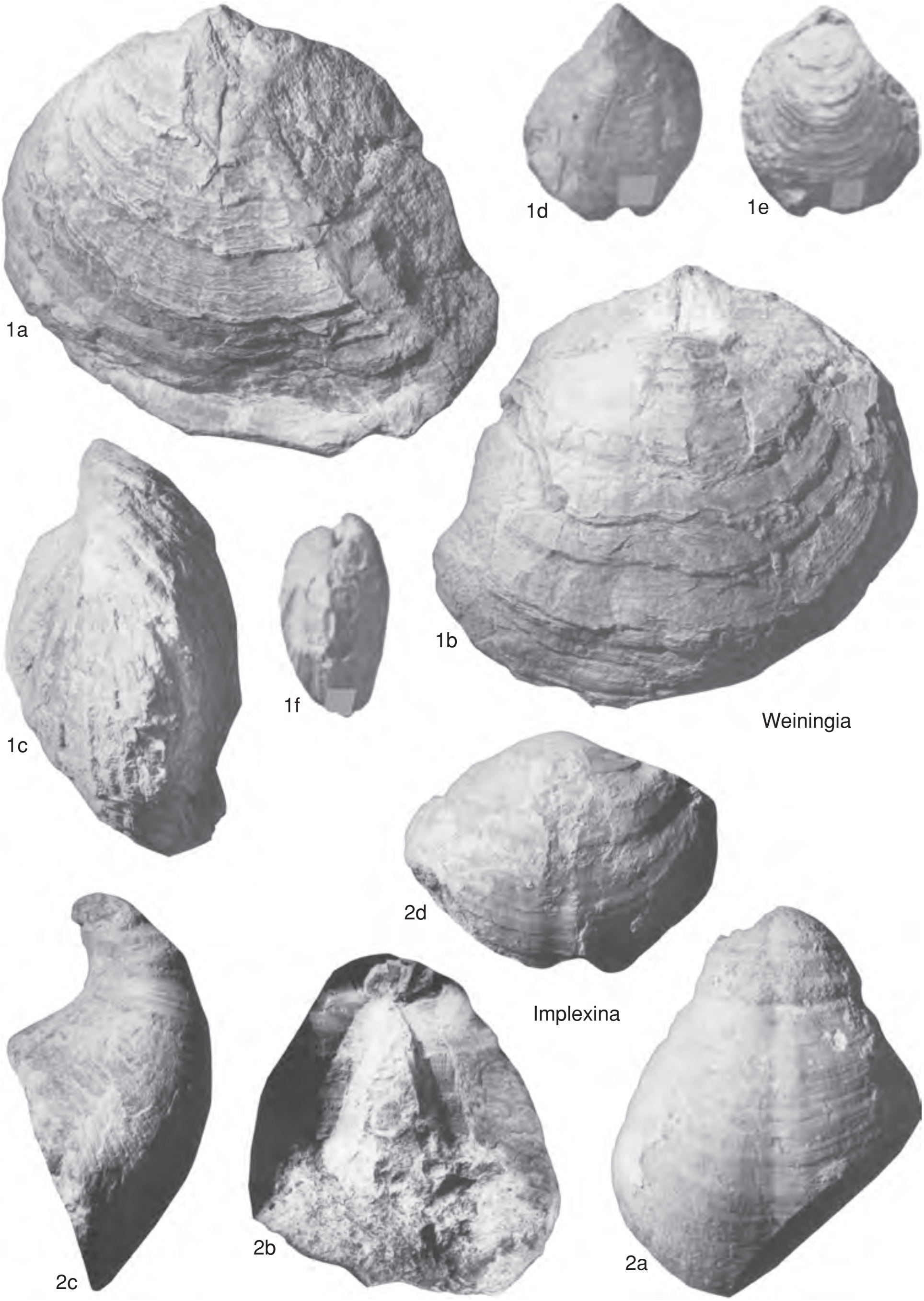

FIG. 1150. Martiniidae (p. 1750).

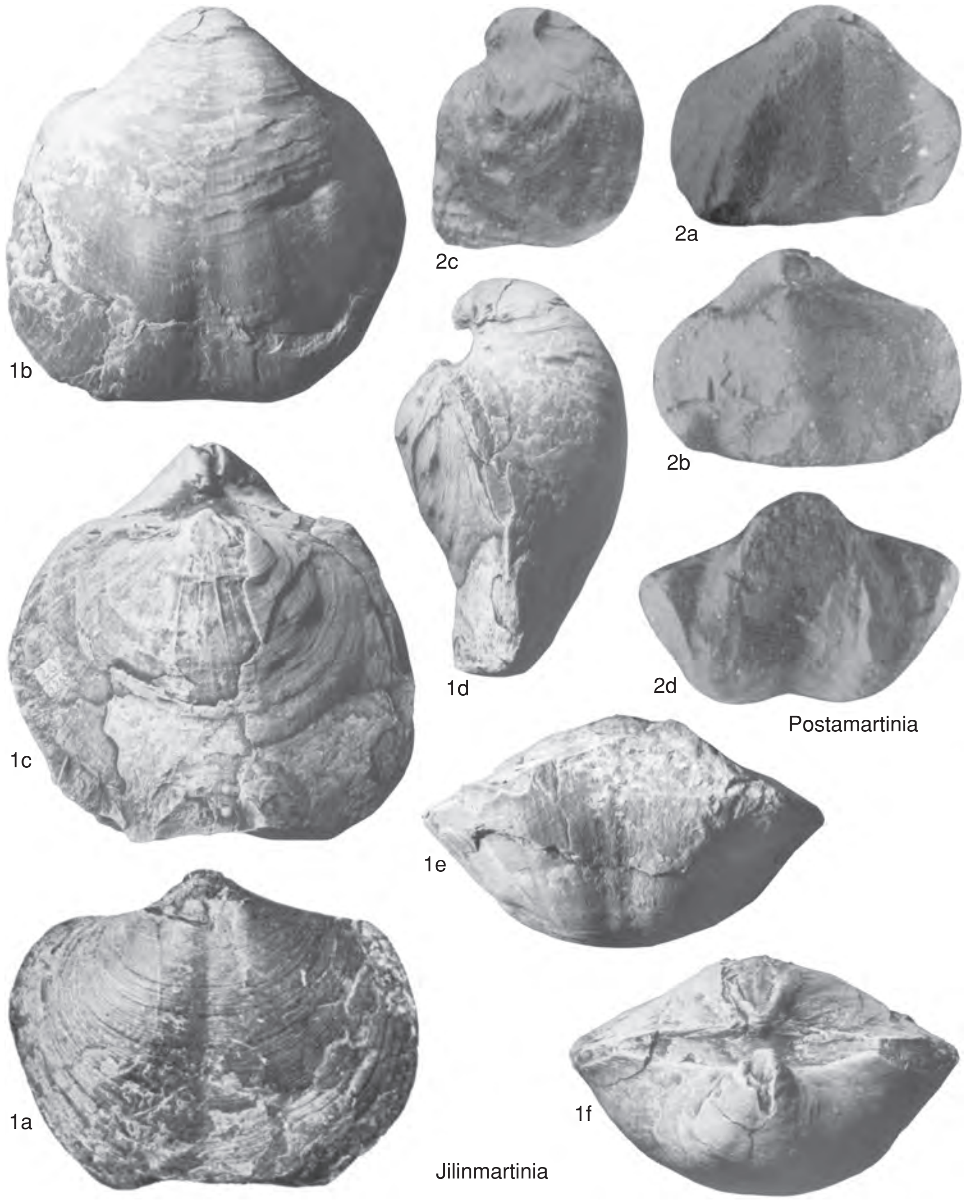

FIG. 1151. Martiniidae (p. 1750).

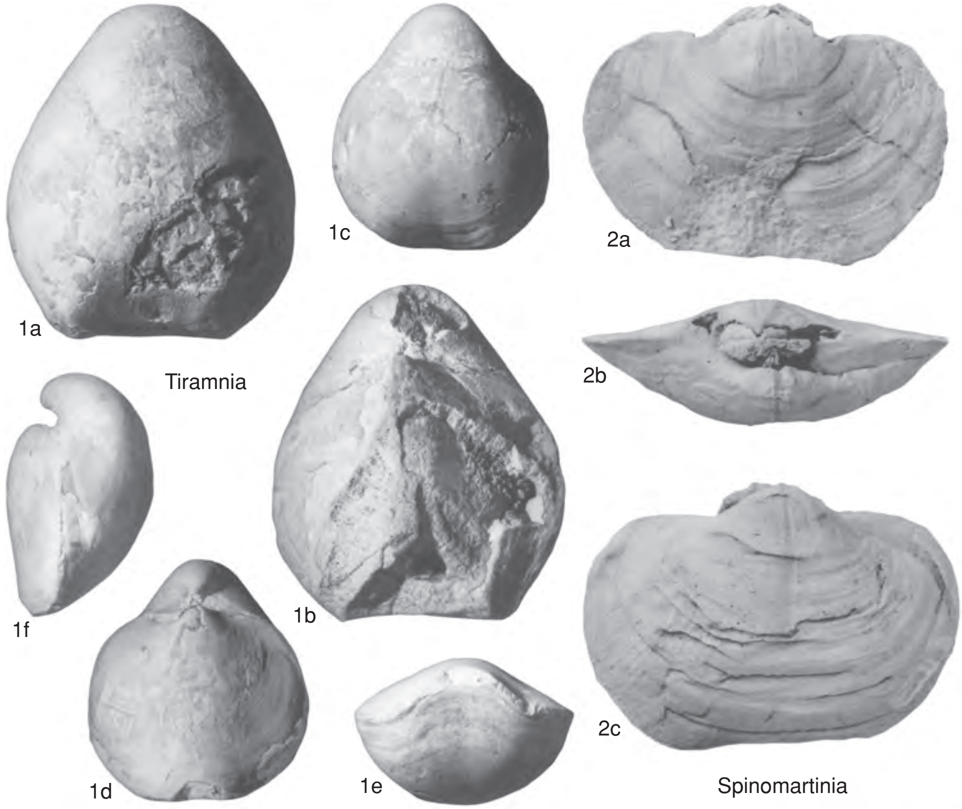

FIG. 1152. Martiniidae (p. 1750).

Subfamily EOMARTINIOPSINAE Carter, 1994

[Eomartiniopsinae CARTER in CARTER & others, 1994, p. 339]

Dental adminicula present; lateral slopes commonly weakly ribbed. *Upper Devonian (?Famennian), Carboniferous (Tournaisian)–Permian (Guadalupian).*

Eomartiniopsis SOKOLSKAYA, 1941, p. 78 [**E. elongata;* OD]. Medium size, subequally biconvex; subovate to subpentagonal in outline; fold and sulcus rounded, moderately to well developed; ornament absent or of few, very weak sinuous plications on flanks; microornament of surficial pits in some species, absent in others; inner shell layers pitted; ventral interior with well-developed dental adminicula; crural plates or dorsal adminicula probably lacking. [SOKOLSKAYA (1941) attributed very short (1 mm long) so-called septal plates to the type species. Her diagram (fig. 31) and photograph (pl. 12,*1b*) of a transversely cut thin section of the posterior dorsal interior of *E. elongata* fail to support this assertion. None of the North American or Australian species assigned to this genus possess apparent dorsal adminicula or crural plates.] *Devonian (?Famennian), Carboniferous (Tournaisian):* Europe, North America, Australia.——FIG. 1153,*1a–d*. **E. elongata,* Russia; holotype, ventral, dorsal, anterior, and lateral views, ×1 (new).

Globispirifer TACHIBANA, 1964, p. 37 [41] [**Spirifer (Martiniopsis?) nagasakaensis* TACHIBANA, 1956, p. 13; OD]. Medium size; biconvex; subovate in outline, possibly slightly elongate; ventral beak acute, incurved; ventral interarea poorly delimited; delthyrium open; venter rounded, sulcus absent; lateral slopes of ventral valve smooth; dorsal fold moderately developed; lateral slopes of dorsal valve weakly plicate; microornament not observable; ventral interior with well-developed, slightly divergent dental adminicula and deeply impressed

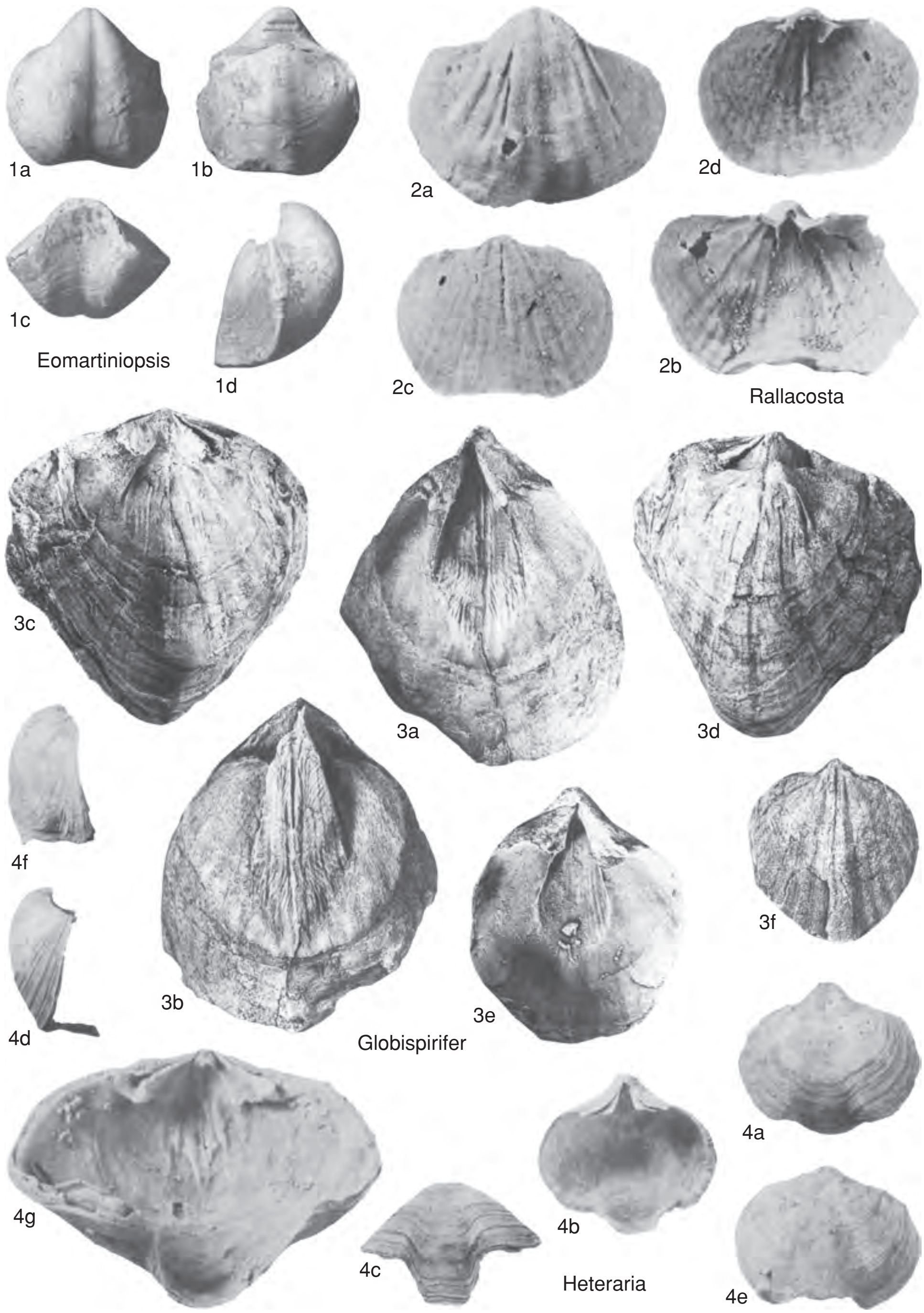

FIG. 1153. Martiniidae (p. 1754–1756).

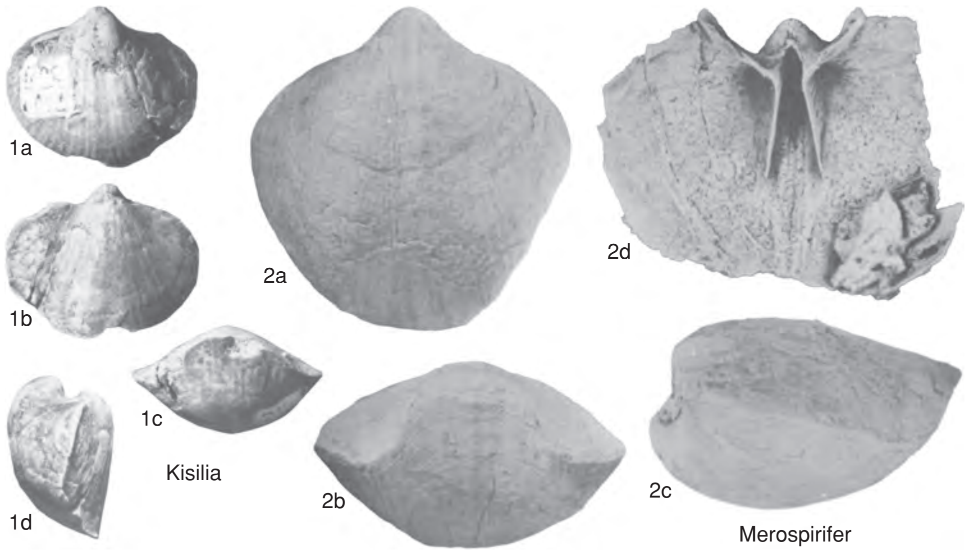

FIG. 1154. Martiniidae (p. 1756).

rhomboidal muscle field; dorsal interior with large ctenophoridium and short broad myophragm; crural bases broad, long, and bladelike; dorsal adductor field large, subovate, moderately impressed, longitudinally striated; vascular impressions finely pinnate. *Carboniferous (lower Tournaisian):* Japan. ——FIG. 1153,*3a–f.* **G. nagasakaensis* (TACHIBANA), syntype; *a–b,* mold and cast of large ventral valve; *c–d,* mold and cast of large dorsal valve; *e,* cast of small ventral valve; *f,* cast of small dorsal valve, ×1 (new).

Heteraria COOPER & GRANT, 1976a, p. 2,275 [**H. blakemorei;* OD]. Ventral valve with short, receding dental adminicula and very wide dental ridges; microornament seemingly absent but poorly known; otherwise similar to *Eomartiniopsis. Permian (Cisuralian):* USA (Texas).——FIG. 1153,*4a–g.* **H. blakemorei; a–d,* holotype, ventral, ventral interior, anterior, and lateral views of ventral valve; *e–f,* dorsal and anterior views of dorsal valve, ×1; *g,* oblique enlargement of dorsal interior, ×2 (Cooper & Grant, 1976a).

Kisilia NALIVKIN, 1979, p. 146 [**K. linguata;* OD]. Small to medium size; outline rounded, nearly equidimensional; fold moderately developed, rounded; sulcus very weakly developed, indistinct; faint, thin plicae on both valves; microornament unknown; ventral interior with short, thin dental adminicula and short, thick median ridge; dorsal interior unknown. *Carboniferous (Tournaisian):* Ural Mountains, Russia.——FIG. 1154,*1a–d.* **K. linguata;* holotype, ventral, dorsal, anterior, and lateral views, ×2 (new).

Merospirifer REED, 1949, p. 467 [**Martinia (M.) insolita* REED, 1949, p. 467; OD]. Outline broadly subovate; lateral profile rounded, transversely rhombic; lateral slopes with indistinct plicae in late ontogeny; ventral interior with subparallel dental adminicula; microornament of fine pits. *Carboniferous (Visean):* Scotland, England, and Ireland.——FIG. 1154,*2a–d.* **M. insolita* (REED)*; a–c,* lectotype, ventral, anterior, and lateral views, ×1; *d,* ventral interior, ×2 (Brunton, 1984).

Rallacosta COOPER & GRANT, 1976a, p. 2,277 [**R. imporcata;* OD]. Ventral interarea absent or much reduced; ventral interior with short dental adminicula; dorsal interior with very small ctenophoridium composed of few plates; ornament of few low plications over entire surfaces of valves, with or without weak fasciculate costae or costellae; microornament seemingly absent but preservation poor; otherwise similar to *Eomartiniopsis. Permian (Guadalupian):* Texas.——FIG. 1153,*2a–d.* **R. imporcata; a,* holotype, ventral valve; *b,* ventral interior; *c–d,* dorsal valve exterior and interior, ×2 (Cooper & Grant, 1976a).

Subfamily ELIVELLINAE Carter, 1994

[Elivellinae CARTER in CARTER & others, 1994, p. 340]

Microornament of capillae and fine pits; dental plates becoming progressively shorter

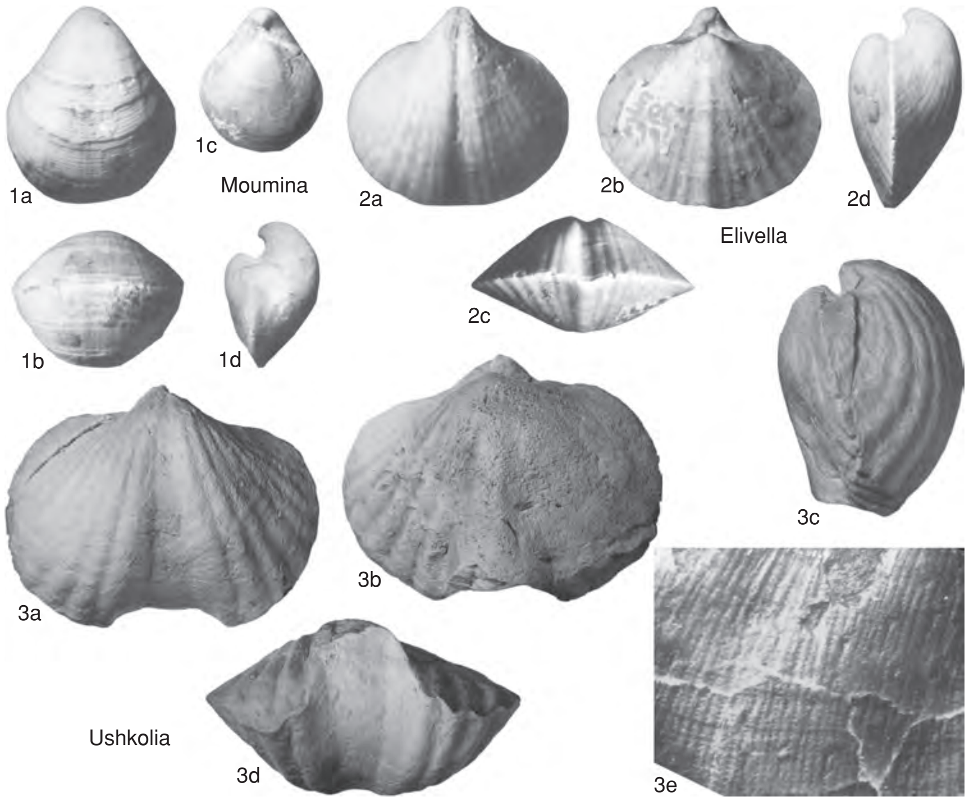

FIG. 1155. Martiniidae (p. 1757).

or absent in younger genera. *Upper Devonian (upper Famennian)–Permian (Cisuralian).*

Elivella FREDERIKS, 1924, p. 316 [**Martiniopsis baschkirica* CHERNYSHEV, 1902, p. 558; SD FREDERIKS, 1926, p. 403]. Medium size, unequally biconvex, outline subovate; ventral umbonal region short; ventral beak incurved; fold and sulcus weakly developed, narrow; entire surfaces of both valves with numerous simple, low, rounded costae; ventral interior with short dental adminicula. *Permian (Cisuralian):* Russia.——FIG. 1155,*2a–d.* **E. baschkirica* (CHERNYSHEV); holotype, ventral, dorsal, anterior, and lateral views, ×2 (new).

?Martiniella GRABAU & TIEN in GRABAU, 1931a, p. 420 [**M. nasuta, nom. nud.;* OD]. Microornament capillate; otherwise similar to *Merospirifer.* [*M. nasuta* GRABAU & TIEN is a *nomen nudum* and thus is not available, according to *Code* Article 13 (ICZN, 1999).] *Carboniferous (Mississippian):* China.

Moumina FREDERIKS, 1924, p. 321 [**Martinia incerta* CHERNYSHEV, 1902, p. 569; OD]. Small, guttate in outline; ventral umbonal region elongated; hinge line narrow; ventral sulcus absent; weak, dorsal median sulcus or groove present; anterior commissure rectimarginate; internally similar to *Martinia. Permian (Cisuralian):* Russia.——FIG. 1155,*1a–d.* **M. incerta* (CHERNYSHEV); *a–b,* large syntype, ventral and anterior views; *c–d,* small syntype, dorsal and lateral views, ×2 (new).

Ushkolia MARTYNOVA & SVERBILOVA, 1969, p. 96 [**U. litvinovitchae;* OD]. Medium to large size; biconvex, equidimensional; cardinal extremities well rounded; hinge line much narrower than maximum width; ventral interarea low, strongly curved, apsacline; fold and sulcus smooth or with faint parietal plications; flanks with broad, low, rounded, simple plications; dental adminicula straight, subparallel. *Upper Devonian (upper Famennian):* Kazakhstan.——FIG. 1155,*3a–e.* **U. litvinovitchae; a–d,* holotype, ventral, dorsal, lateral, and anterior views, ×1; *e,* microornament, ×15 (new).

Family CRASSUMBIDAE new family

[Crassumbidae CARTER, herein] [type genus, *Crassumbo* CARTER, 1967b, p. 408]

[Materials for this family prepared by J. L. Carter]

Dental and dorsal adminicula (or possibly crural plates) present; lateral slopes commonly with weak plications; microornament usually weakly to strongly capillate, rarely papillose. *Carboniferous (Tournaisian)–Permian (Guadalupian).*

Crassumbo CARTER, 1967b, p. 408 [**C. inornatus;* OD]. Small to medium size, subequally biconvex, wider than long; lateral slopes smooth or with very weak, narrow ribs; fold and sulcus poorly to well defined; ventral interarea small, acutely triangular; shell substance thick in umbonal regions of both valves; ventral interior with thin, subparallel dental adminicula, partially buried in callus; ventral muscle field deeply incised posteriorly; ventral median ridge present in juveniles; dorsal interior with strong, high crural bases (possibly adminicula) obscured by callus deposits and reaching floor of valve as crural plates in juveniles; microornament of capillae separated by very narrow interspaces, with scattered nodes or papillae. *Carboniferous (Tournaisian):* USA (Texas), Australia.——FIG. 1156,*3a–h.* **C. inornatus,* middle Tournaisian, Texas; *a–e,* holotype, ventral, dorsal, lateral, anterior, and posterior views, ×1; *f–g,* transverse sections, ×1.5; *h,* microornament, ×10 (Carter, 1967b).

Arktikina GRUNT, 1977b, p. 69 [**A. longa;* OD]. Shell large, massive, with subrhomboidal to subpentagonal outline and wide delthyrium; ventral interior with thick callus deposits and massive dental adminicula that converge to simulate delthyrial plate; broad, thick myophragm present apically; ventral muscle field deeply impressed, lanceolate; ovarian pits numerous; dorsal interior with long, diverging adminicula that delimit dorsal adductor field; microornament unknown. *Carboniferous (Pennsylvanian):* Arctic Siberia.——FIG. 1156,*2a–e.* **A. longa;* holotype, ventral, dorsal, anterior, posterior, and lateral views, ×1 (new).

Nodaea TACHIBANA, 1981b, p. 67 [**N. okuboi;* OD]. Medium size; cardinal extremities rounded; delthyrium with apical deltidium; fold and sulcus well developed, nonplicate; lateral slopes with 5 or 6 low, broad, rounded simple plicae; microornament of fine capillae; ventral interior with thin, subparallel dental adminicula, lacking median ridge or septum; dorsal interior with short, divergent adminicula; shell material thin; otherwise similar to *Crassumbo. Carboniferous (Tournaisian):* Japan.——FIG. 1156,*1a–c.* **N. okuboi; a,* holotype, ventral valve, ×0.7; *b,* dorsal valve, ×1.2; *c,* microornament, ×3.5 (Tachibana, 1981b).

Rorespirifer WATERHOUSE & PIYASIN, 1970, p. 156 [**R. ruinosus;* OD]. Small to medium, transversely subovate; fold and sulcus lacking; flanks smooth; microornament of numerous fine papillae only; dorsal adminicula long. *Permian (Guadalupian):* Thailand.——FIG. 1156,*4a–d.* **R. ruinosus; a–c,* ventral valve, dorsal interior, ventral interior, ×2; *d,* microornament, ×10 (Waterhouse & Piyasin, 1970).

Family INGELARELLIDAE Campbell, 1959

[*nom. transl.* ARCHBOLD & THOMAS, 1986, p. 582, *ex* Ingelarellinae CAMPBELL, 1959a, p. 333]

[Materials for this family prepared by J. L. Carter]

Microornament of quincuncially arranged elongate grooves and ridges; dental adminicula present. [The genera in this family are differentiated and assigned to subfamilies on the basis of microornament, the nature of which is poorly known for several genera.] *Carboniferous (Visean)–Permian (Lopingian).*

Subfamily INGELARELLINAE Campbell, 1959

[Ingelarellinae CAMPBELL, 1959a, p. 333]

Spinules absent; dorsal adminicula well developed. *Carboniferous (Visean)–Permian (Lopingian).*

Ingelarella CAMPBELL, 1959a, p. 340 [**I. angulata;* OD]. Medium to very large, biconvex, usually transverse; fold and sulcus generally present, variably developed; sulcus with or without median groove, sometimes with pair of weak plicae; lateral slopes smooth or with several broad, low plicae; microornament of elongate grooves arranged in quincunx; interior with well-developed ventral and dorsal adminicula; dorsal median septum absent, weak myophragm commonly present well anterior to cardinalia. *Permian:* Australia, New Zealand. ——FIG. 1157,*3a–e.* **I. angulata; a–c,* holotype, ventral, dorsal, and anterior views, ×1; *d–e,* transverse sections, ×1 (Campbell, 1959a).——FIG. 1157,*3f. I. profunda* (CAMPBELL); microornament, ×10 (Armstrong, 1970b).

?Ambikella SAHNI & SRIVASTAVA, 1956, p. 207 [**A. fructiformis;* OD]. Morphology inadequately known. Seemingly similar to *Ingelarella* but based on a single poorly preserved specimen. *Carboniferous (?Pennsylvanian):* India.——FIG. 1157,*2a–d.* **A. fructiformis; a–c,* ventral, dorsal, posterior views, ×1; *d,* oblique-posterior view, enlarged (Sahni & Srivastava, 1956).

Fredericksia PAECKELMANN, 1931, p. 48, *nom. nov. pro Munia* FREDERIKS, 1918a, p. 88, *non* HODGE, 1836

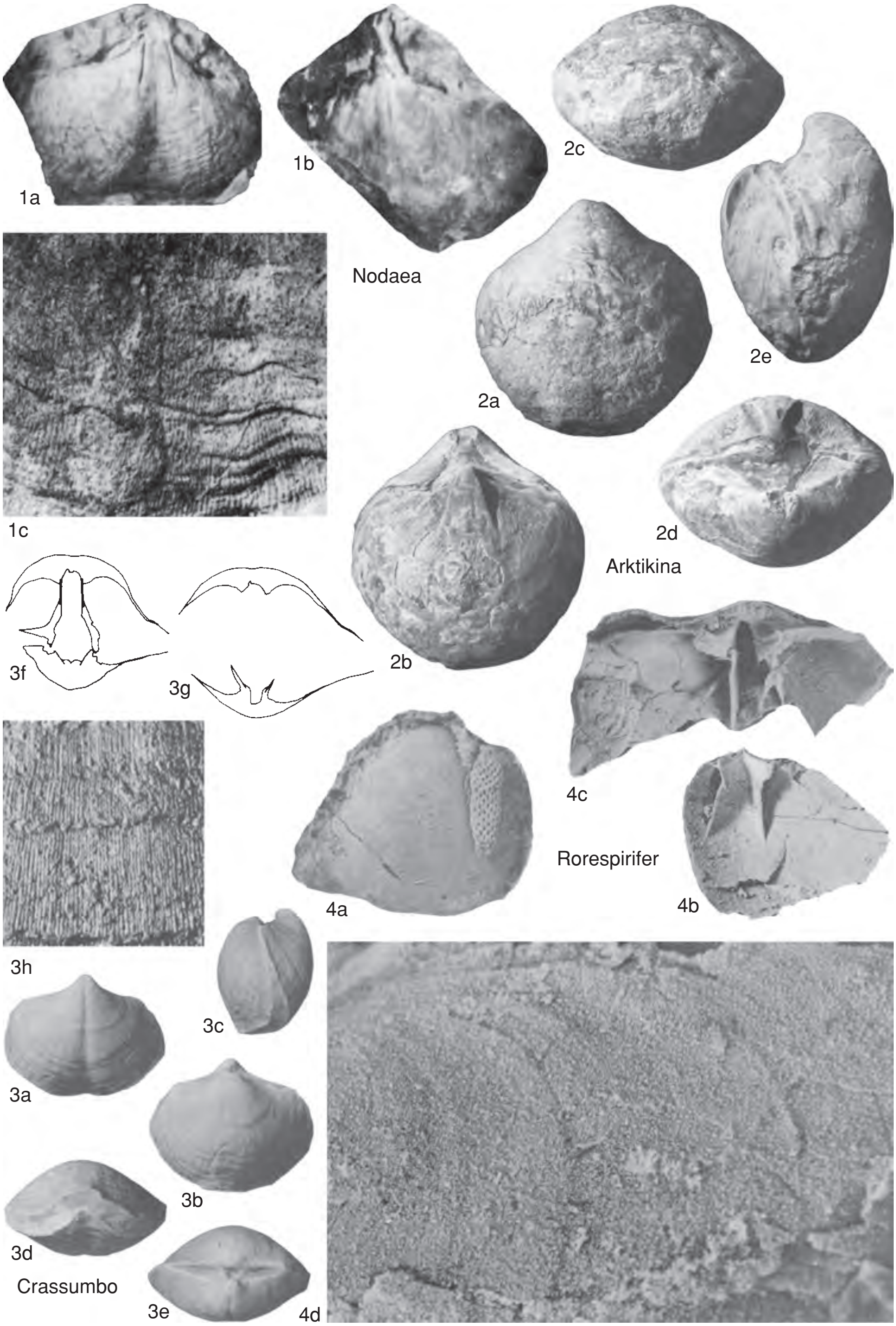

FIG. 1156. Crassumbidae (p. 1758).

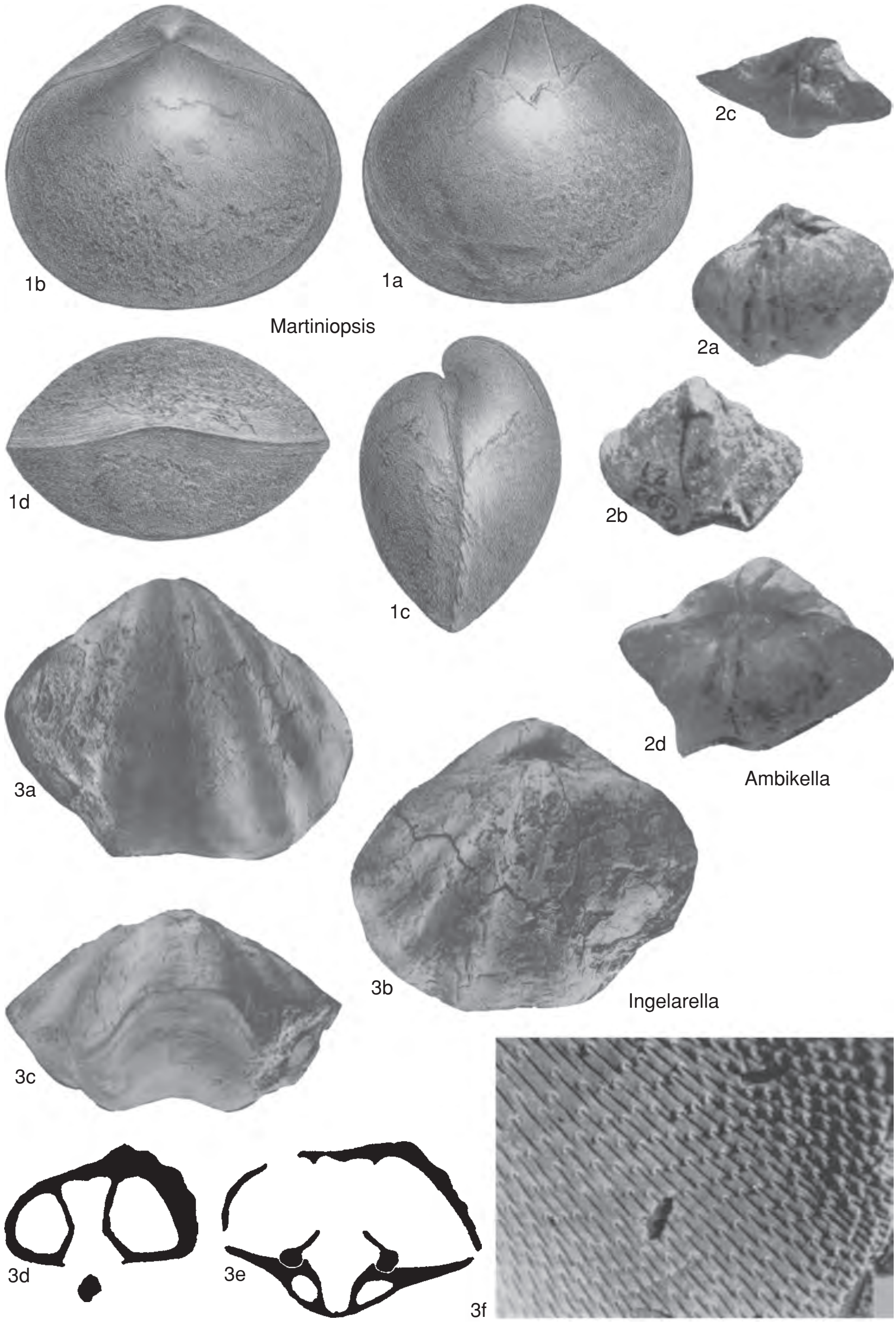

FIG. 1157. Ingelarellidae (p. 1758–1762).

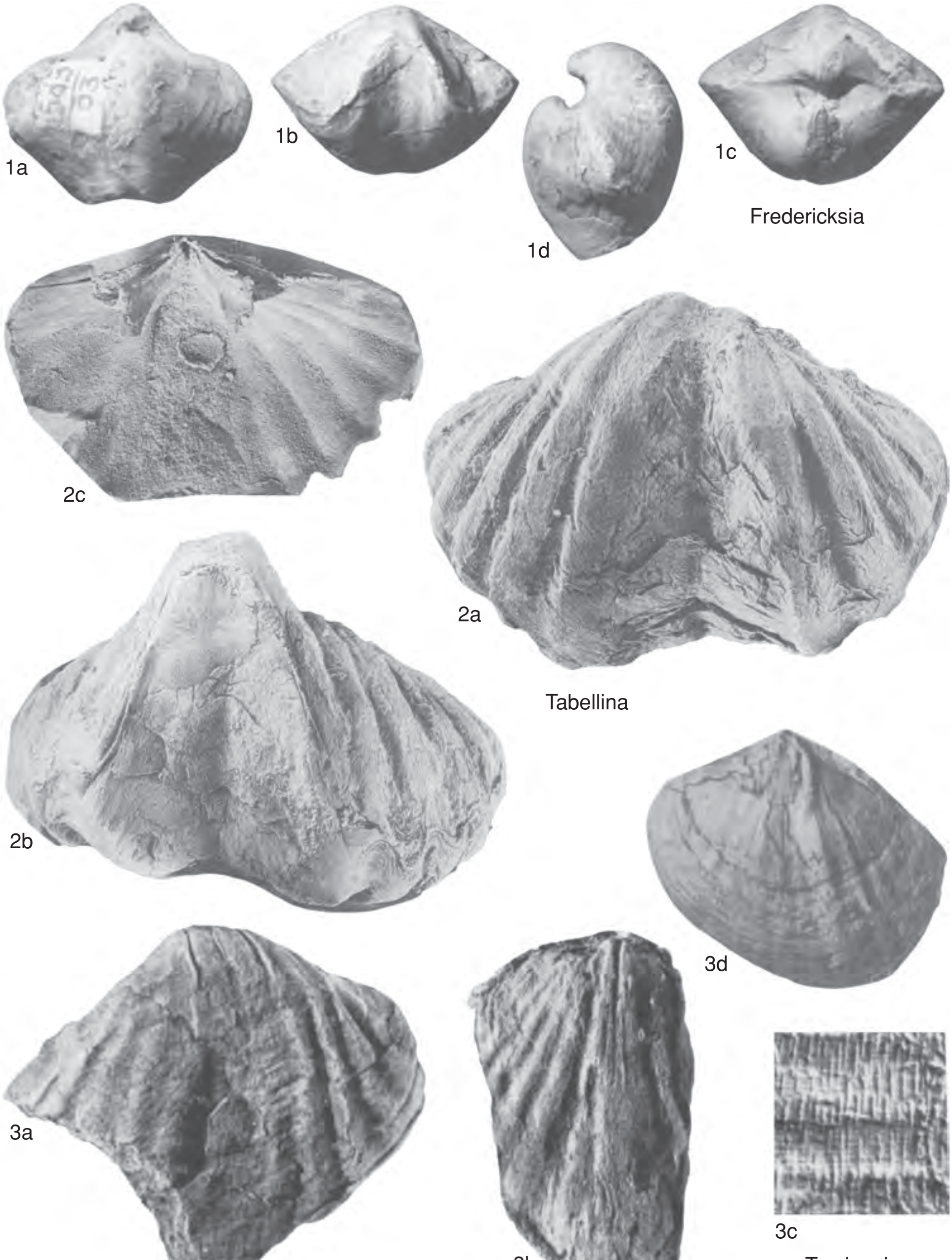

FIG. 1158. Ingelarellidae (p. 1758–1762).

[**Spiriferina (Mentzelia) simensis* CHERNYSHEV, 1902, p. 514; OD]. Small, moderately biconvex, outline subovate to subpentagonal; fold and sulcus moderately to well developed; lateral slopes with several indistinct plications; ventral interior with thin dental adminicula, septum absent; dorsal interior with moderately long dorsal adminicula; microornament of fine, discontinuous radial grooves; otherwise similar to *Tomiopsis. Carboniferous (Pennsylvanian)–Permian (Cisuralian):* Urals, Russia.——FIG. 1158,*1a–d.* **F. simensis* (CHERNYSHEV); holotype, dorsal, anterior, posterior, and lateral views, ×2 (new).

Martiniopsis WAAGEN, 1883a, p. 524 [**M. inflata;* SD ETHERIDGE in JACK & ETHERIDGE, 1892, p. 238]. Small to medium size; outline subovate; ventral interarea very small, narrow; delthyrium open; fold and sulcus weakly to moderately developed or absent; macroornament absent; microornament of fine, elongate pits or grooves and fine, regular growth lines; ventral interior with long, slender, closely set, subparallel dental adminicula; dorsal interior with short to long adminicula. *Carboniferous (Pennsylvanian)–Permian (Lopingian):* Europe, Asia.——FIG. 1157,*1a–d.* **M. inflata,* Lopingian, Pakistan; ventral, dorsal, lateral, and anterior views, ×1 (Waagen, 1883a).

Tabellina WATERHOUSE, 1986b, p. 4 [**Ingelarella denmeadi* CAMPBELL, 1961b, p. 171; OD]. Lateral slopes strongly plicate; dorsal interior lacking plates or with very short dorsal adminicula; otherwise similar to *Tomiopsis. Carboniferous (Pennsylvanian):* Australia.——FIG. 1158,*2a–c.* **T. denmeadi* (CAMPBELL); *a–b,* holotype, ventral and anterior views; *c,* dorsal interior, ×1 (Campbell, 1961b).

Tomiopsis BENEDIKTOVA, 1956, p. 169, *nom. conserv.* ICZN Opinion 1395, 1986, p. 146, *non Tomiopsis* COPE, 1893, p. 317 [**Brachythyris kumpani* YANISHEVSKY, 1935, p. 68; OD] [?=*Danzania* PAVLOVA in AFANAS'EVA & others, 1988, p. 55 (type, *D. khalginica,* OD)]. Small to medium size; outline transversely to longitudinally rounded; fold and sulcus usually developed; sulcus, when present, rounded or sometimes with 1 or 2 weak plicae; lateral slopes smooth or more commonly with several low, wide, simple plications; anterior commissure rectimarginate to uniplicate, rarely parasulcate; ventral interior with subparallel dental adminicula enclosing moderately impressed muscle field; dorsal interior with short to long subparallel dorsal adminicula and short to moderately long, stout median septum; microornament consisting of fine, simple, elongate, narrow grooves crudely to symmetrically arranged in quincunx. *Carboniferous (Visean)–Permian (Lopingian):* Russia, Asia.——FIG. 1158,*3a–c.* **T. kumpani* (YANISHEVSKY), upper Visean or Namurian, Kuznets basin; *a–b,* spalled ventral exterior and dorsal internal mold showing median septum, ×1; *c,* microornament of external mold, ×10 (Sokolskaya, 1959).——FIG. 1158,*3d. T. khalginica* PAVLOVA, Visean, Mongolia; holotype, ventral valve, ×1 (Afanas'eva & others, 1988).

Subfamily NOTOSPIRIFERINAE Archbold & Thomas, 1986

[Notospiriferinae ARCHBOLD & THOMAS, 1986, p. 584]

Fold and sulcus well developed; microornament of quincuncially arranged grooves and ridges, with anteriorly directed spinules at posterior ends of short grooves, and with deep, elongate globose pits extending into secondary layer under spinules; dorsal adminicula short or absent. *Permian.*

Notospirifer HARRINGTON, 1955, p. 115 [**Spirifer darwini* MORRIS, 1845, p. 279; OD]. Transversely subovate; fold and sulcus well developed, smooth; lateral slopes with moderately strong plicae; dorsal adminicula short or absent; pits penetrating fibrous layer under spinules. *Permian:* Australia.——FIG. 1159,*1a–e.* **N. darwini* (MORRIS); *a–d,* holotype, lateral, dorsal, ventral, and anterior views, ×1 (Harrington, 1955); *e,* microornament, ×10 (Armstrong, 1970b).

Farmerella CLARKE, 1992, p. 73 [**F. exoporosa;* OD]. Externally and internally homeomorphic with *Glendonia* but with microornament as in *Notospirifer. Permian (Sakmarian–Artinskian):* Tasmania.——FIG. 1159,*2a–c.* **F. exoporosa; a–b,* holotype, dorsal and ventral views of internal mold, ×1; *c,* external mold of microornament, ×20 (Clarke, 1992).

Subfamily GLENDONIINAE Clarke, 1992

[Glendoniinae CLARKE, 1992, p. 75]

Microornament of quincuncially arranged, shallow, elongate grooves terminated anteriorly by low, elongate spinules and shallow, elongate pits. *Upper Carboniferous (?Pennsylvanian), Permian (Lopingian).*

Glendonia MCCLUNG & ARMSTRONG, 1978, p. 2 [**G. ulladullensis;* OD]. Small to medium size, subequally biconvex; transversely subovate to subrhomboidal in outline; fold and sulcus narrow; lateral slopes with several high, subangular plicae; sulcus with single, narrow, median plica; fold usually with distinct median groove; dorsal interior usually with variably long adminicula. *Permian (Lopingian):* eastern Australia, Tasmania.——FIG. 1160,*1a–d.* **G. ulladullensis; a–c,* holotype, anterior, ventral, and dorsal views of internal mold, ×1;

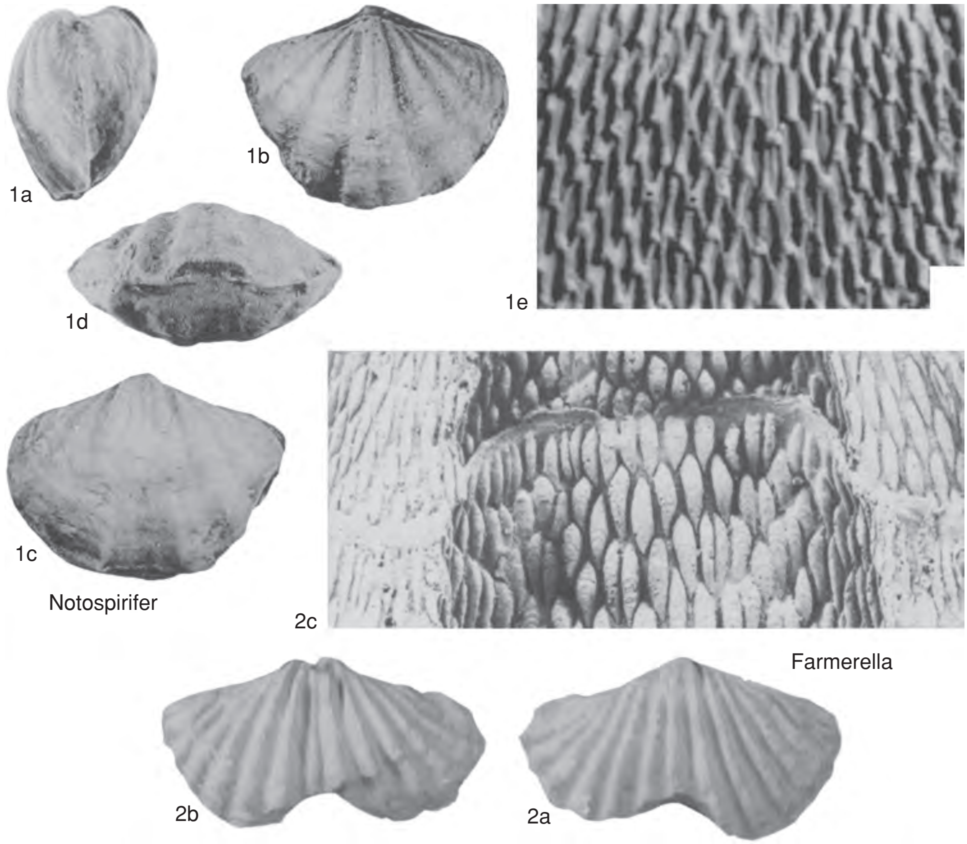

FIG. 1159. Ingelarellidae (p. 1762).

d, microornament, ×15 (McClung & Armstrong, 1978).

Birchsella CLARKE, 1987, p. 282 [**B. spinosa;* OD]. Fold and sulcus smooth, lateral slopes with few low, rounded plications; ventral valve interior with dental adminicula buried in thick callus; dorsal valve interior lacking adminicula; otherwise similar to *Glendonia. Permian (Lopingian):* Tasmania.——FIG. 1161,*2a–d.* **B. spinosa; a,* dorsal exterior; *b–c,* ventral and dorsal views of internal mold, ×1; *d,* microornament, ×10 (Clarke, 1987).

Homevalaria WATERHOUSE, 1986a, p. 110 [**Ingelarella ovata* CAMPBELL, 1961b, p. 177; OD]. Microornament of quincuncially arranged, elongate grooves posteriorly terminated by low C-spines; otherwise closely similar to *Ingelarella. Permian (Sakmarian):* Queensland.——FIG. 1160,*2a–e.* **H. ovata* (CAMPBELL); *a–c,* holotype, ventral, dorsal, and anterior views of internal mold; *d,* dorsal interior, ×1; *e,* microornament, ×8 (Campbell, 1961b).

Kelsovia CLARKE, 1990, p. 70 [**K. superba;* OD]. Small to medium size; fold and sulcus well developed, smooth or very weakly grooved, flaring anteriorly; lateral slopes with well-developed, rounded plications; ventral interior with dental adminicula and minor posterolateral thickening; dorsal interior with short, flexed dorsal adminicula and long, low myophragm; microornament as in *Glendonia. Carboniferous (?Pennsylvanian), ?lower Permian:* Tasmania.——FIG. 1161,*1a–e.* **K. superba; a–b,* holotype, dorsal exterior and dorsal internal mold counterpart, ×1; *c–e,* paratype, ventral, dorsal, and posterior views of internal mold, ×1 (Clarke, 1990).

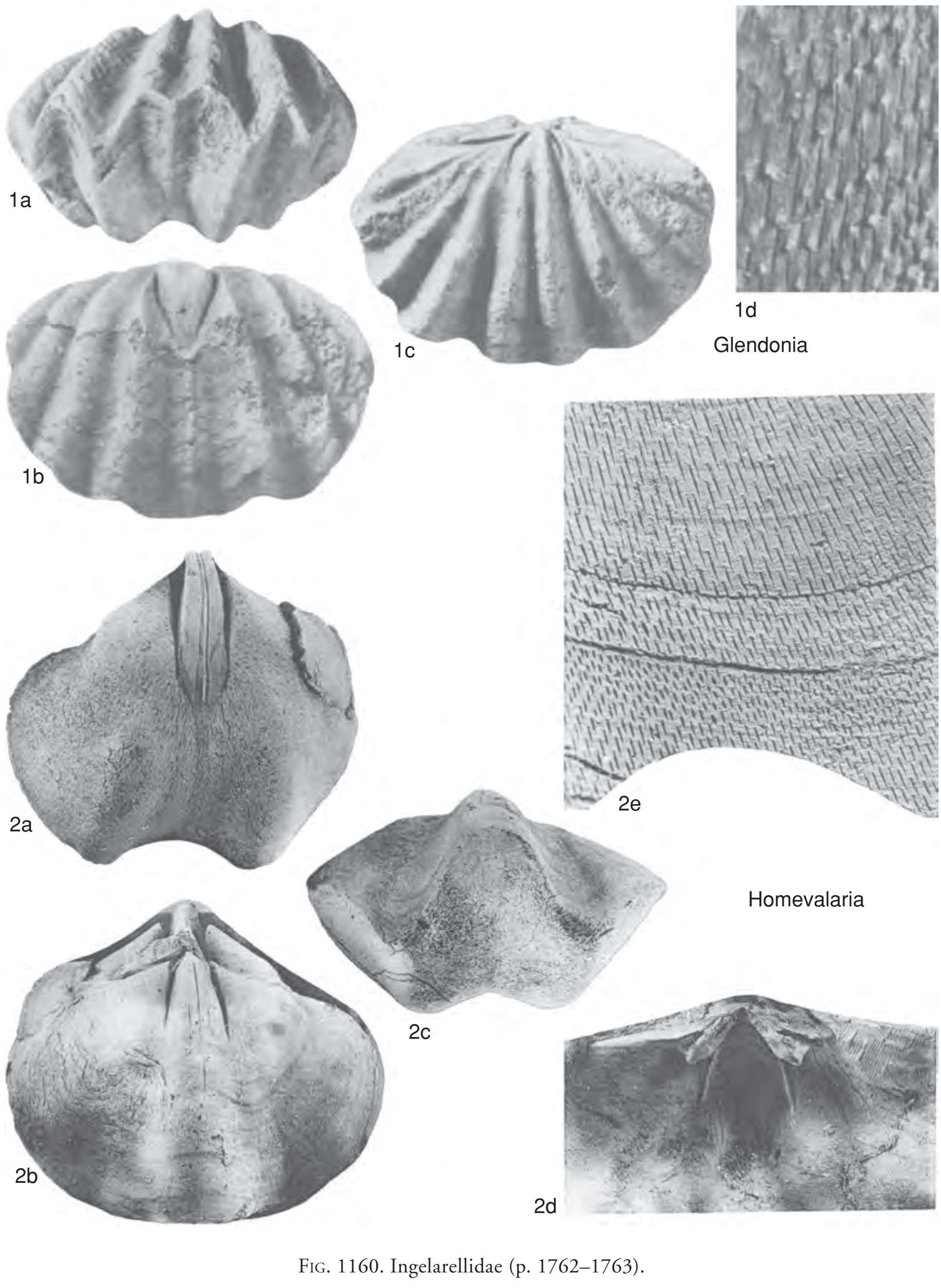

FIG. 1160. Ingelarellidae (p. 1762–1763).

Family GERKISPIRIDAE Carter, 1985

[Gerkispiridae CARTER, 1985, p. 376]

[Materials for this family prepared by J. L. Carter]

Ovate to transverse; lateral slopes costate; hinge line short; fold-sulcus moderately to well developed; delthyrium with low, thin, flaring, stegidial plates; short, thin, dental adminicula commonly with low apical myophragm; short converging crural plates and small ctenophoridium present; micro-ornament of quincuncially arranged, very

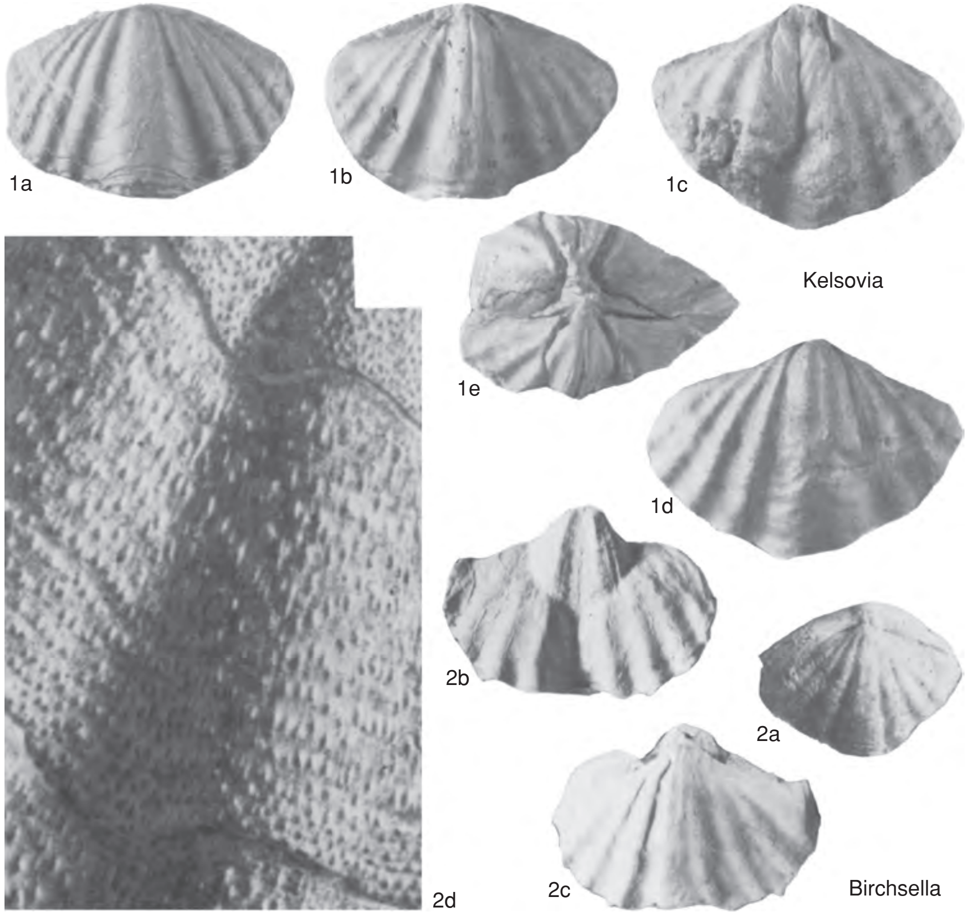

FIG. 1161. Ingelarellidae (p. 1763).

fine, uniramous, hollow spinules or papillae that originate in fibrous layer. *Upper Devonian (lower Famennian)–Carboniferous (upper Tournaisian).*

Gerkispira CARTER, 1983, p. 72 [**G. spinosa;* OD]. Small, subequally biconvex; strongly transverse with rounded lateral extremities; ventral interarea acutely triangular, moderately low, apsacline; delthyrium with narrow, laterally flaring stegidial plates; fold and sulcus moderately well developed but poorly delimited from flanks; numerous simple or rarely bifurcating costae on flanks and fold-sulcus; numerous fine, hollow, erect spinules on crests of costae. *Carboniferous (upper Tournaisian):* USA (Iowa). ——FIG. 1162,*2a–f.* **G. spinosa; a–e,* ventral, dorsal, anterior, posterior, and lateral views, ×2; *f,* microornament, ×5 (new).

Acanthospirina SCHUCHERT & LEVENE, 1929, p. 119, *nom. nov. pro Acanthospira* WELLER, 1914, p. 418, *non* REINSCH, 1877 [**Spirifer aciculifera* ROWLEY, 1893, p. 307; OD]. Very small; ventribiconvex; moderately transverse, with slightly rounded cardinal extremities; ventral interarea moderately high, flattened or weakly concave, procline; stegidium short, convex; lateral slopes with few simple, rounded costellae; fold and sulcus narrow, smooth; sulcus well developed; fold low, flattened, well delimited by deep interspaces; numerous fine, hollow spinules crudely arranged in quincunx; spinule bases extending anteriorly as longitudinally elongate tubules within primary layer; dental adminicula short, slender, subparallel; ventral septum absent; very short crural plates and median callus present. *Upper Devonian (upper Famennian):* North America.——FIG. 1162,*3a–b.* **A. aciculifera* (ROWLEY), Missouri, USA; ventral, dorsal valve, ×6 (new).

Oiosia COOPER & DUTRO, 1982, p. 117 [**Brachythyris putilla* STAINBROOK, 1947, p. 322; OD]. Small, ventribiconvex; outline subovate to subquadrate;

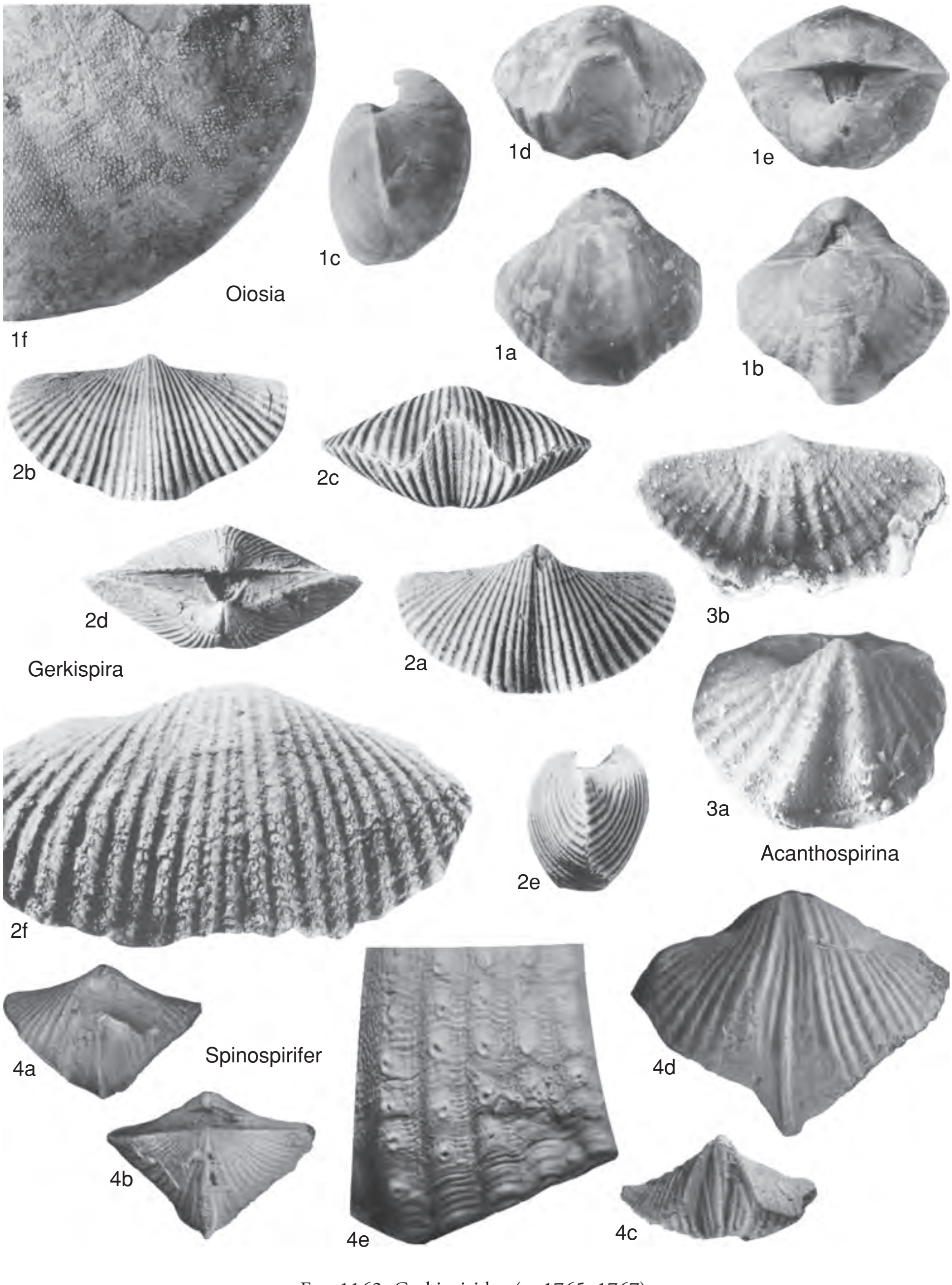

FIG. 1162. Gerkispiridae (p. 1765–1767).

cardinal extremities well rounded, ventral interarea narrow; delthyrium partially closed by stegidial plates; fold and sulcus well developed, smooth, rounded, flaring slightly anteriorly; lateral slopes with several weak, low, simple plicae; very fine hollow microspines or papillae arranged in quincunx; otherwise similar to *Punctothyris. Upper Devonian (upper Famennian):* USA (New Mexico).——FIG. 1162,*1a–f.* **O. putilla* (STAINBROOK); *a–e,* ventral, dorsal, lateral, anterior, and posterior views,

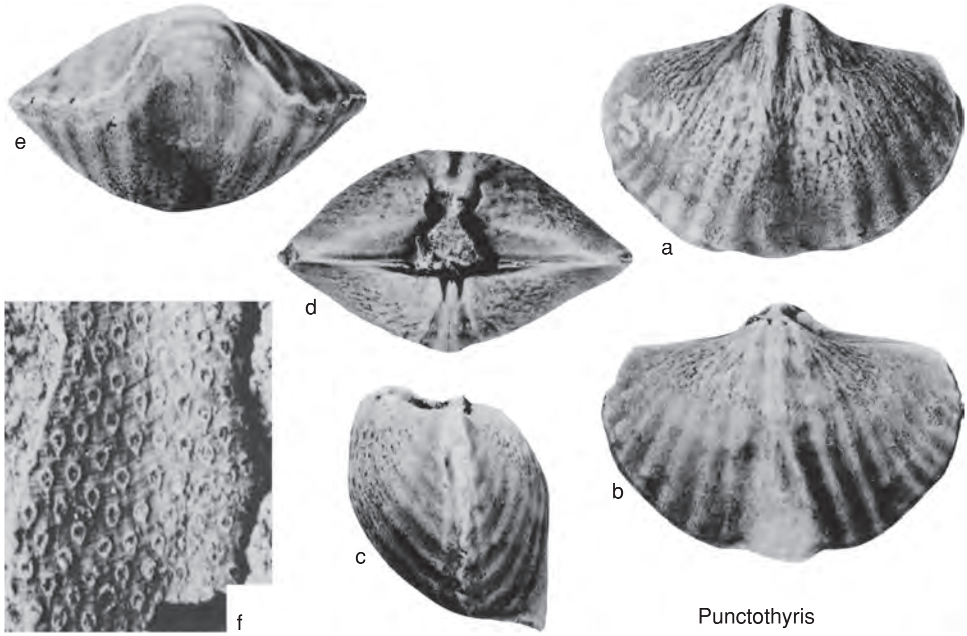

FIG. 1163. Gerkispiridae (p. 1767).

×2; *f,* microornament, ×5 (Cooper & Dutro, 1982).

Punctothyris HYDE, 1953, p. 287 [**P. argus;* OD]. Small to medium size; ovate to slightly transverse; fold and sulcus well delimited; both valves with moderate number of simple costae on lateral slopes; sulcus with one to several simple costae; sulcus-bounding costae prominent and giving rise to lateral sulcal costae, when present, and occasionally to nearest costae on flanks; numerous fine, hollow, erect or semierect spinules or papillae over entire surface, including interspaces. *Carboniferous (middle Tournaisian–upper Tournaisian):* USA (Ohio, Missouri, Oklahoma, Virginia).——FIG. 1163*a–f.* **P. argus; a–e,* holotype, ventral, dorsal, lateral, posterior, and anterior views, ×3; *f,* microornament, ×22 (Carter, 1985).

Spinospirifer MARTYNOVA, 1961, p. 106, *non Spinospirifer* BIERNAT, 1966 [**Spirifer (?Lamellispirifer) nuraensis* SIMORIN, 1956, p. 163; OD]. Small to medium size, biconvex to ventribiconvex, transverse; cardinal angles acute; ventral interarea low to medium height, curved, apsacline; fold and sulcus costate, with strong, rounded, median rib in sulcus and 1 or 2 lateral pairs added anteriorly; flanks with numerous rounded costae that may bifurcate near maximum length; crests of costae with open pustules; microornament of well-defined growth lines and weak capillae; dental plates short, thin. *Upper Devonian (lower Famennian):* Kazakhstan.——FIG. 1162,*4a–e.* **S. nuraensis* (SIMORIN); *a–c,* ventral, dorsal, and anterior views, ×1; *d,* ventral valve enlarged, ×1.5; *e,* microornament, ×12 (new).

Family PERISSOTHYRIDIDAE Carter, 1994

[Perissothyrididae CARTER in CARTER & others, 1994, p. 342]

[Materials for this family prepared by J. L. Carter]

Subequally biconvex; transversely subovate; low concave interareas present in both valves; fold moderately well developed; sulcus weak, shallow, poorly delimited; lateral slopes with weak simple ribbing; microornament absent; delthyrium very wide, partially occluded apically by so-called pseudodelthyrial plate (possibly fused dental flanges); ventral valve much thickened with callus; dental adminicula absent; large, wide, clublike teeth attached to posterolateral valve wall; wide, dorsally reflexed dental flanges directed medially from bases of teeth; dorsal interior with large ctenophoridium supported by short median ridge; inner socket

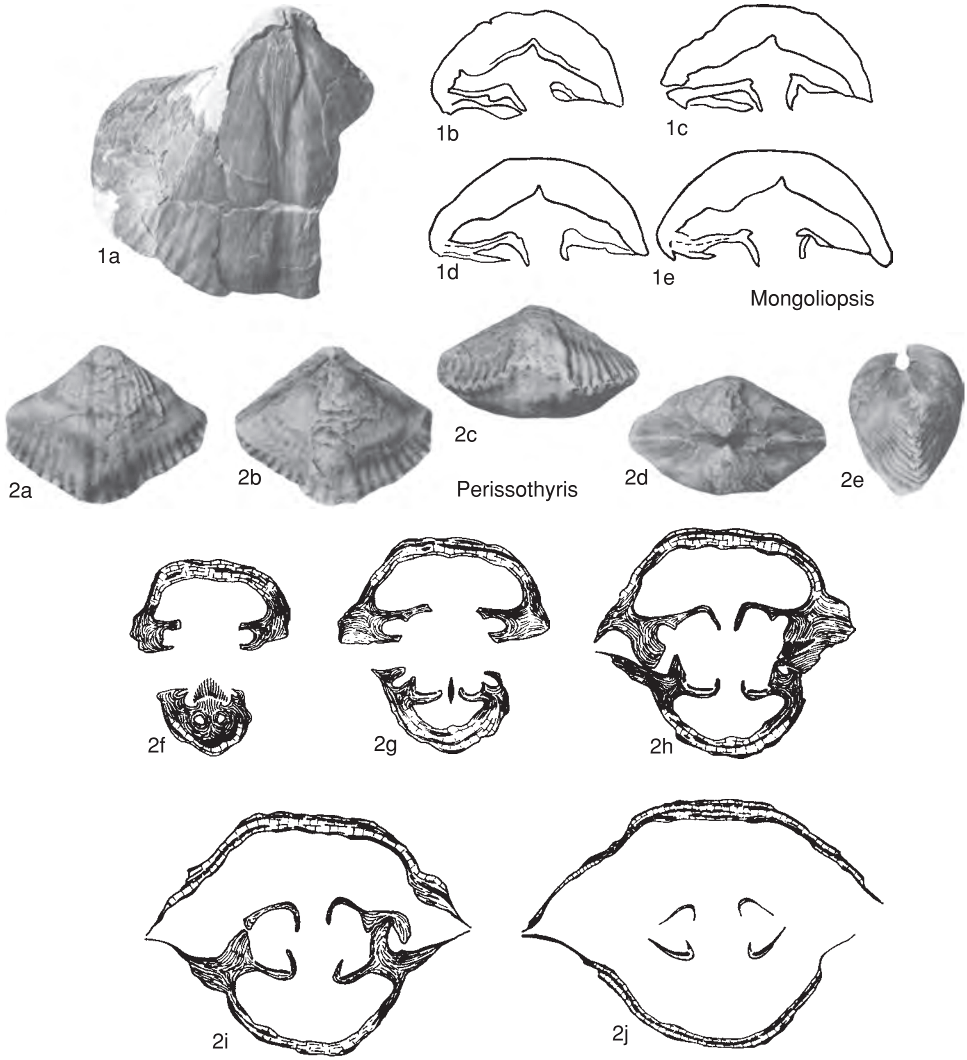

FIG. 1164. Perissothyrididae (p. 1768).

ridges thick, high; crural bases medially directed, with ventrally reflexed medial flanges. *Carboniferous (Mississippian).*

Perissothyris CARTER, 1967a, p. 587 [**P. masonensis;* OD]. Medium sized; outline asymmetrical; dorsibiconvex; both valves entirely ribbed, with numerous weak, simple costae; dorsal umbo much more inflated than ventral; both valves with large, chordate muscle fields. *Carboniferous (Visean):* USA (Texas).——FIG. 1164,*2a–j.* **P. masonensis; a–e,* holotype, ventral, dorsal, anterior, posterior, and lateral views, ×1; *f–j,* transverse sections, ×2.5 (Carter, 1967a).

Mongoliopsis GRUNT, 1977a, p. 79 [**M. orkheinensis;* OD]. Medium to large; outline subovate; lateral slopes smooth or with weak, simple plications; ventral interarea low, strongly incurved; short, very thick median ridge in ventral umbonal region; dorsal interior with short, thick median ridge and pair of subparallel longitudinal ridges; otherwise similar to *Perissothyris. Carboniferous (Mississippian):* western Mongolia.——FIG. 1164,*1a–e.* **M. orkheinensis; a,* holotype, spalled ventral valve, ×1; *b–e,* transverse sections, ×2.6 (Grunt, 1977a).

SPIRIFEROIDEA

J. L. CARTER

[retired from Carnegie Museum of Natural History]

Superfamily SPIRIFEROIDEA King, 1846

[*nom. correct.* CARTER, 1992, p. 327, *pro* Spiriferacea SCHUCHERT, 1896, p. 333, *nom. transl. ex* Spiriferidae KING, 1846, p. 28]

Ventral beak incurved, ventral interarea low, usually apsacline; hinge line denticulate; fold and sulcus usually ribbed; dorsal adminicula or crural plates rarely developed; ctenophoridium present. *Upper Devonian (Famennian)–Permian (Lopingian).*

Family SPIRIFERIDAE King, 1846

[Spiriferidae KING, 1846, p. 28]

Outline variable; hinge line coarsely denticulate except for narrow areas near delthyrium; delthyrial cover weakly developed or absent; lateral slopes and fold-sulcus costate to costellate; microornament capillate; short delthyrial plate variably developed; vascular impressions absent or simple. *Upper Devonian (Famennian)–Permian (Lopingian).*

Subfamily SPIRIFERINAE King, 1846

[*nom. transl.* WATERHOUSE, 1968, p. 9, *ex* Spiriferidae KING, 1846, p. 28]

Cardinal extremities extended in juveniles; outline variable in adults; flanks and fold-sulcus with numerous costae that commonly bifurcate; fold usually poorly delimited; dental adminicula usually developed, and when present, moderately divergent. *Carboniferous (Tournaisian)–Permian (Guadalupian).*

Spirifer J. SOWERBY, 1816 in 1815–1818, p. 41 [**Conchyliolithus (Anomia) striatus* MARTIN, 1793, pl. 23; SD ICZN Opinion 100, 1928, p. 12] [=*Spiriferus* DE BLAINVILLE, 1827 in 1825–1827, p. 291, *nom. van.; Spirifera* PHILLIPS, 1836, p. 216, *nom. van.*]. Medium to large; slightly to strongly transverse with angular to slightly mucronate cardinal extremities; ventral interarea of moderate height, concave, apsacline; delthyrium partially occluded by overlapping stegidial plates in type species, possibly open in others; sulcus variable in develpment, often weak, shallow, rounded, poorly delimited; fold well defined posteriorly by bounding interspaces but spreading anteriorly and incorporating additional costae; ornament consisting of numerous, commonly bifurcating costae over entire surface; primary costae sometimes trifurcate, producing weak fasciculations on lateral slopes; ventral interior with thick apical callus, usually with strong, diverging dental adminicula and incised muscle field; short delthyrial plate present in at least some species. *Carboniferous (Tournaisian–Visean, ?Serpukhovian, ?lower Bashkirian):* cosmopolitan.

S. (Spirifer). Strongly transverse with alate, or more rarely, widely angular cardinal extremities in all but earliest growth stages, never well rounded in adults; ventral umbonal region broad and well developed; fold and sulcus spreading anteriorly in large adults. *Carboniferous (Tournaisian–Visean, ?Serpukhovian, ?lower Bashkirian):* cosmopolitan.——FIG. 1165*a–d.* **S. (S.) striatus* (MARTIN), Lower Carboniferous, British Isles; ventral, dorsal, anterior, and posterior views, ×1 (new).

S. (Grandispirifer) YANG, 1959, p. 116 [**G. mylkensis;* OD]. Medium to large; strongly transverse with alate cardinal extremities; ventral umbonal region moderately narrow or weakly developed, extending little posteriorly; lateral slopes and fold-sulcus covered with numerous simple and bifurcating costae; fold and sulcus narrow, weakly to moderately developed, rounded, not appreciably spreading; dental adminicula obscured by thick callus or absent. *Carboniferous (Visean):* China.——FIG. 1166*a–c.* **S. (G.) mylkensis;* ventral, dorsal, and posterior views, ×1 (Yang, 1959).

S. (Mesochorispira) CARTER, 1992, p. 335 [**Spirifer grimesi* HALL, 1858, p. 604; OD]. Medium to large; outline transverse to elongate subovate; posterior growth form with double reversal from rounded cardinal extremities in juveniles, to slightly transverse and mucronate at midsize, to rounded cardinal extremities in adults; fold and sulcus spreading anteriorly, incorporating additional costae; costae fine to medium, often flattened, with moderately narrow interspaces; ventral interior with thin, divergent dental adminicula. *Carboniferous (middle Tournaisian–middle Visean):* North America, Belgium, Russia.——FIG. 1167*a–e.* **S. (M.) grimesi* (HALL), upper Tournaisian, Oklahoma, USA; ventral, dorsal, anterior, posterior, and lateral views, ×1 (new).

Ectochoristites CAMPBELL, 1957, p. 71 [**E. wattsi;* OD]. Medium size; outline subovate, slightly nasute, or subquadrate, becoming elongate in large adults, distinctly transverse in juveniles; fold and

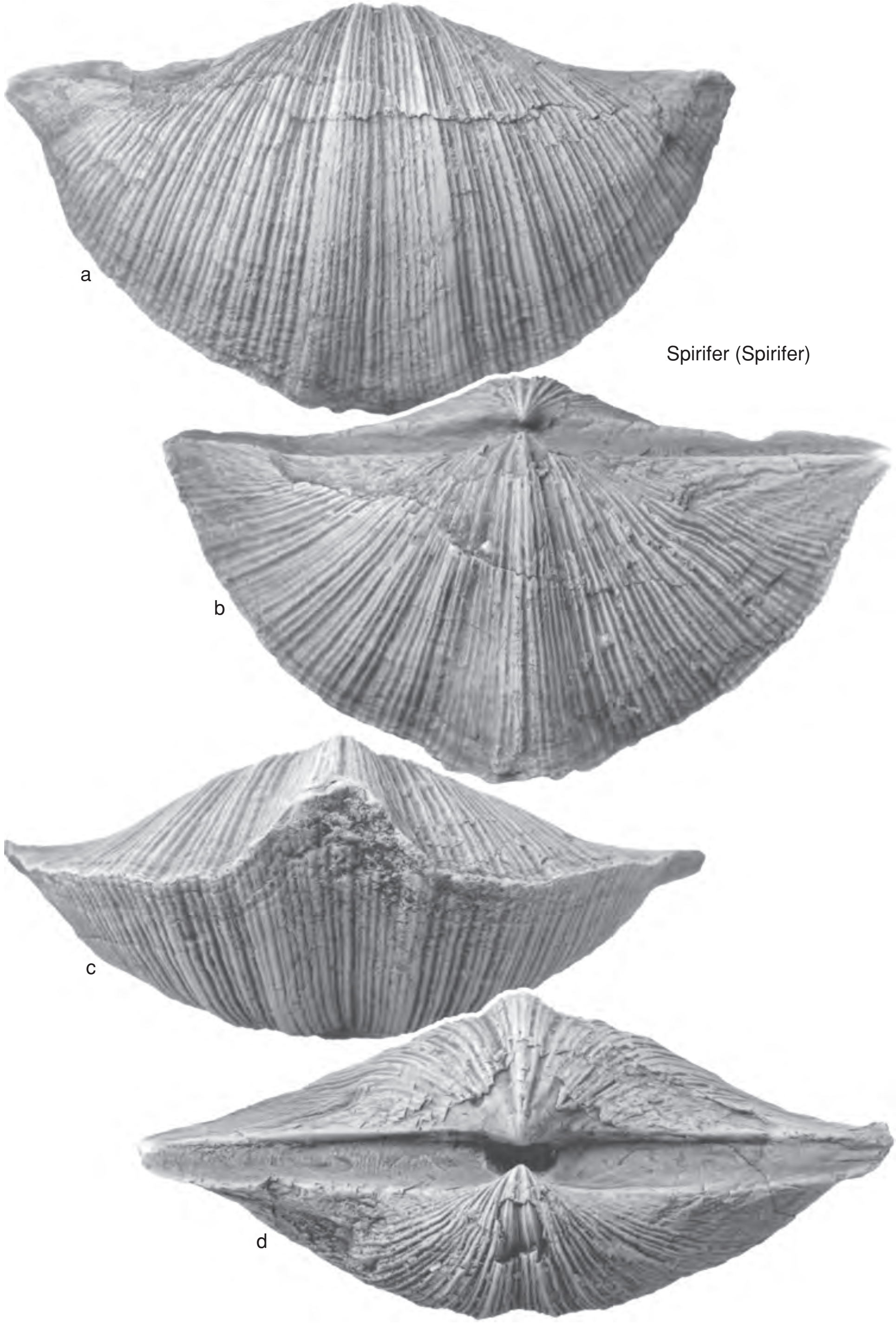

FIG. 1165. Spiriferidae (p. 1769).

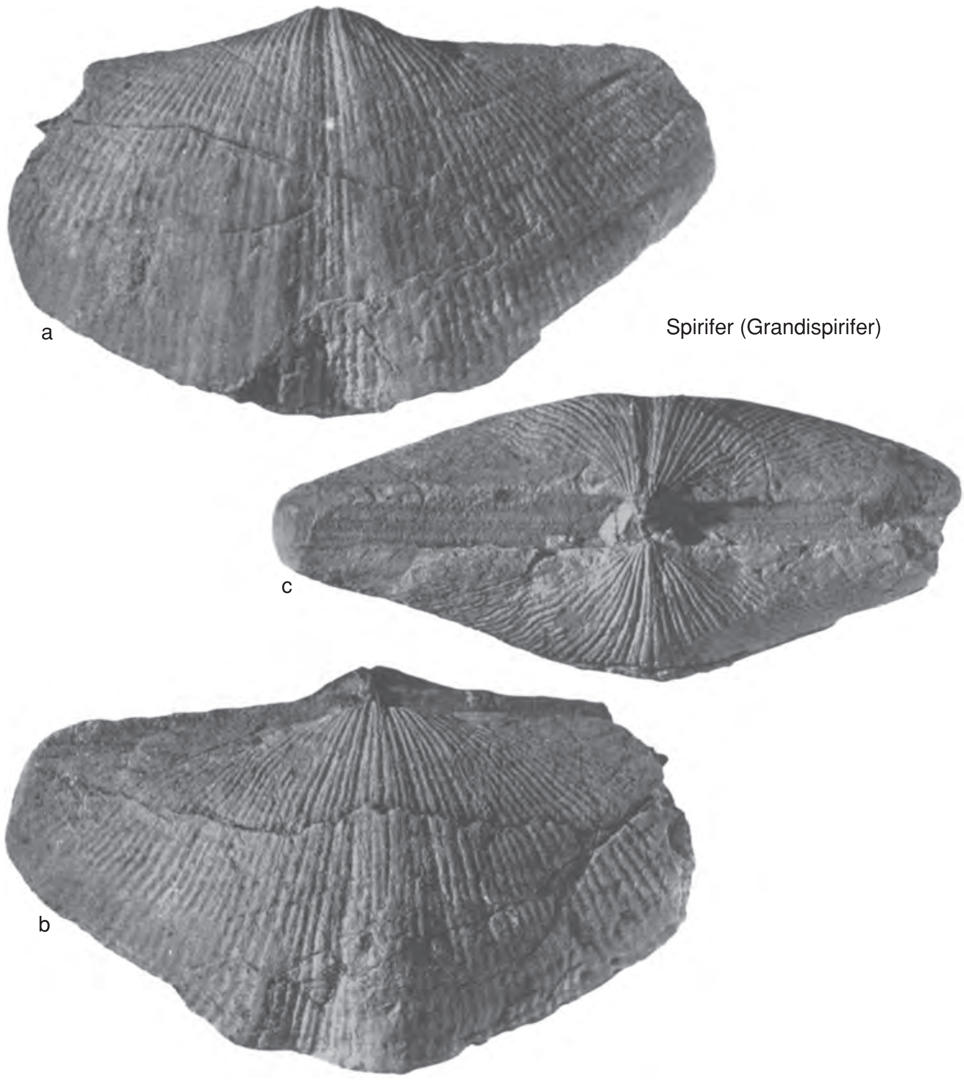

FIG. 1166. Spiriferidae (p. 1769).

sulcus moderately developed, poorly delineated; ventral umbonal region moderately inflated; ventral interarea laterally truncated, trapezoidal; entire surface multicostate; costae fine, numerous, freely bifurcating; ventral interior with moderately long, diverging dental adminicula; dorsal interior with short dorsal adminicula; vascular impressions absent. *Carboniferous (Tournaisian):* Australia, North America.——FIG. 1168,*1a–g*. **E. wattsi,* Australia; *a–d,* ventral, dorsal, lateral, and anterior views, ×1; *e–g,* transverse sections, ×1 (Campbell, 1957).

Larispirifer ENOKIAN & POLETAEV in POLETAEV, 1986, p. 68 [**Choristites jigulensis riphaeicus* EINOR in ALEKSANDROV & EINOR, 1979, p. 83; OD]. Large; moderately transverse; fold and sulcus not appreciably spreading anteriorly; costae coarse, bifurcating or trifurcating, forming fasciculations adjacent to fold-sulcus; interspaces moderately wide; ventral interior with thick parallel dental adminicula; otherwise similar to *Spirifer (Mesochorispira). Carboniferous (Kasimovian–Gzhelian):* Russia (Bashkiria, Novaya Zemlya, polar Urals, northern Timan), Ukraine (Donets basin), western Canada.——FIG. 1169,*2a–b*. **L. riphaeicus* (EINOR); holotype, ventral and dorsal views, ×1 (Aleksandrov & Einor, 1979).

Latispirifer ARCHBOLD & THOMAS, 1985, p. 270 [**L. callytharrensis;* OD]. Large; ornament consisting of

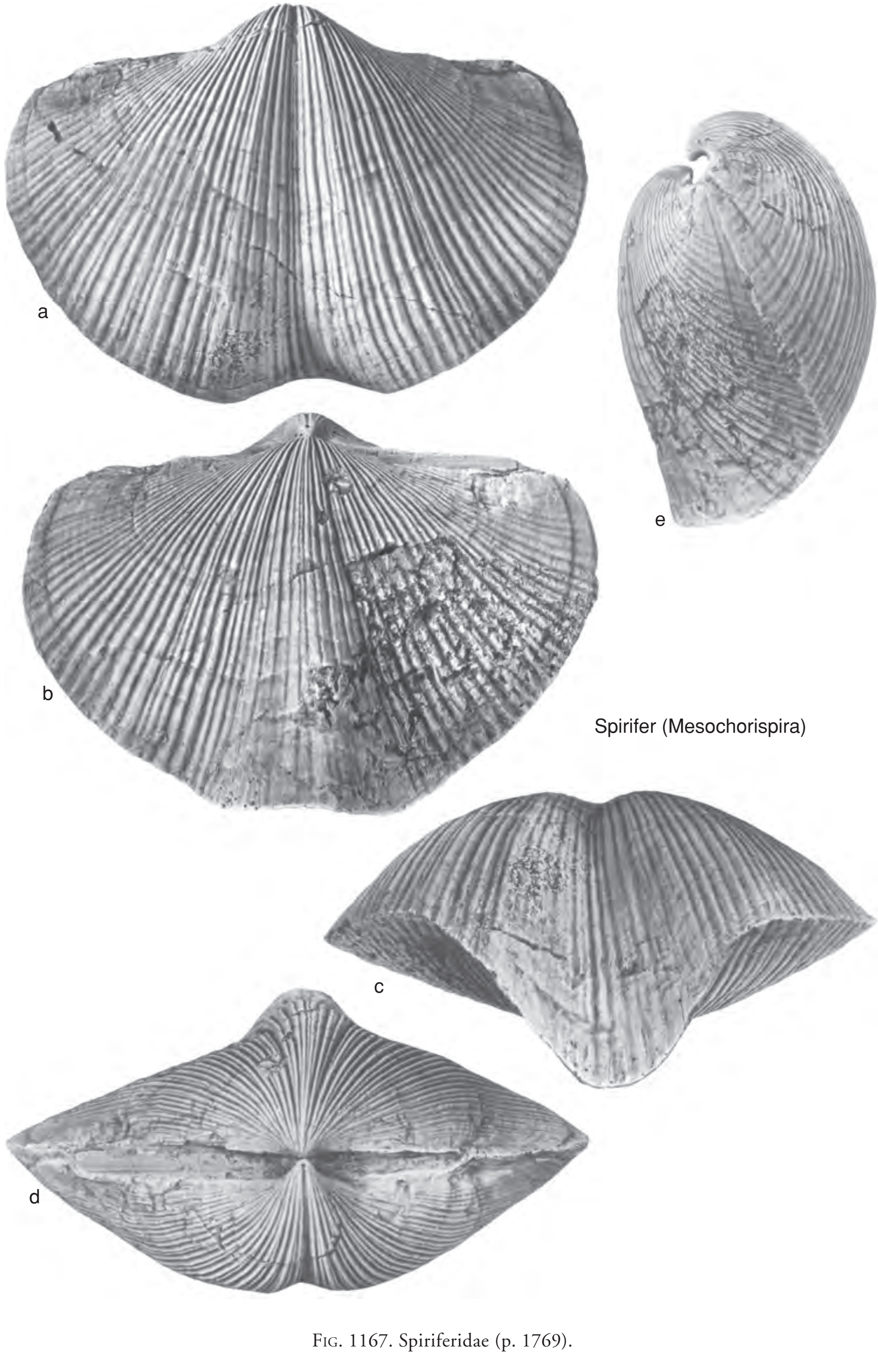

FIG. 1167. Spiriferidae (p. 1769).

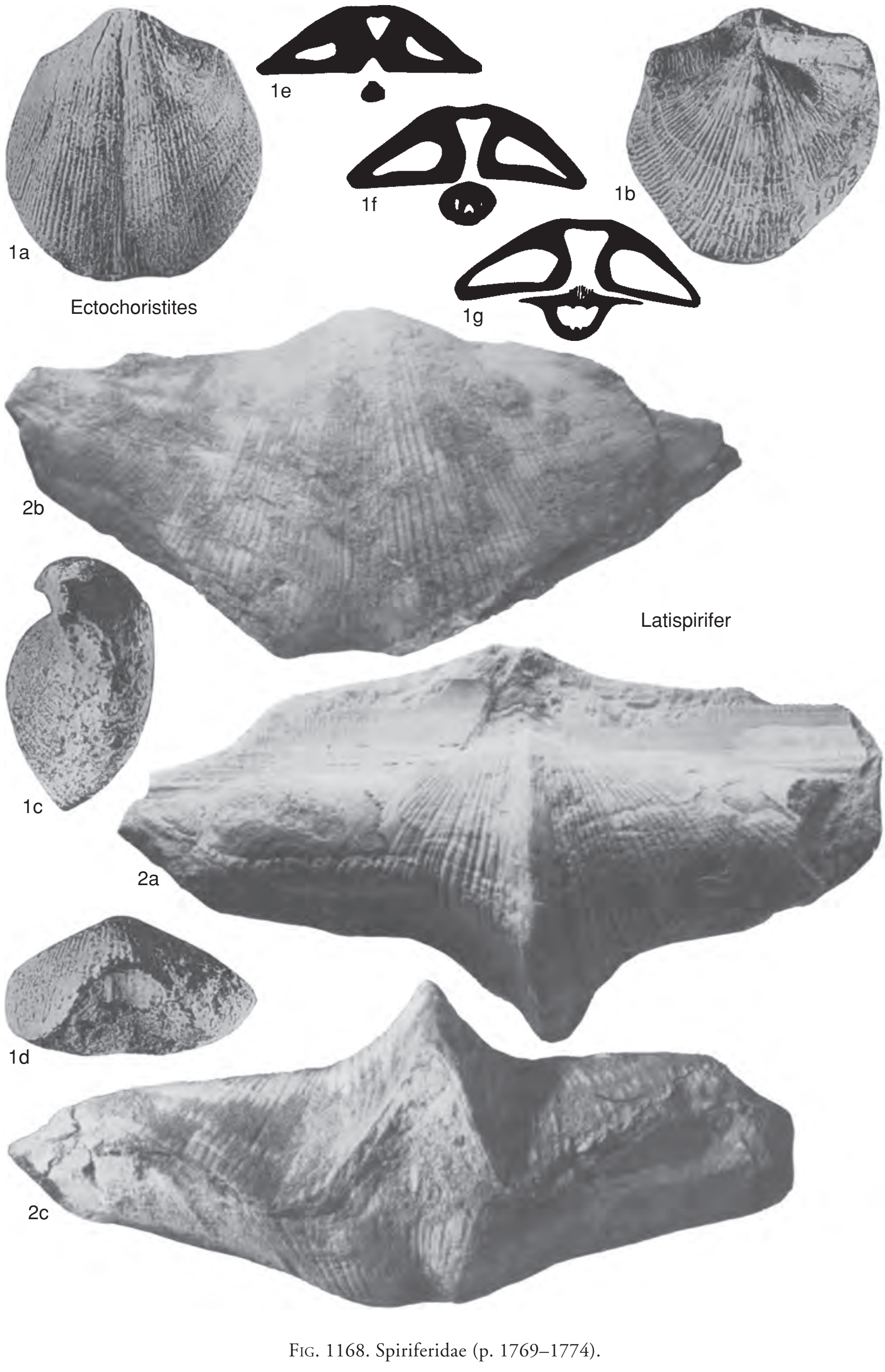

FIG. 1168. Spiriferidae (p. 1769–1774).

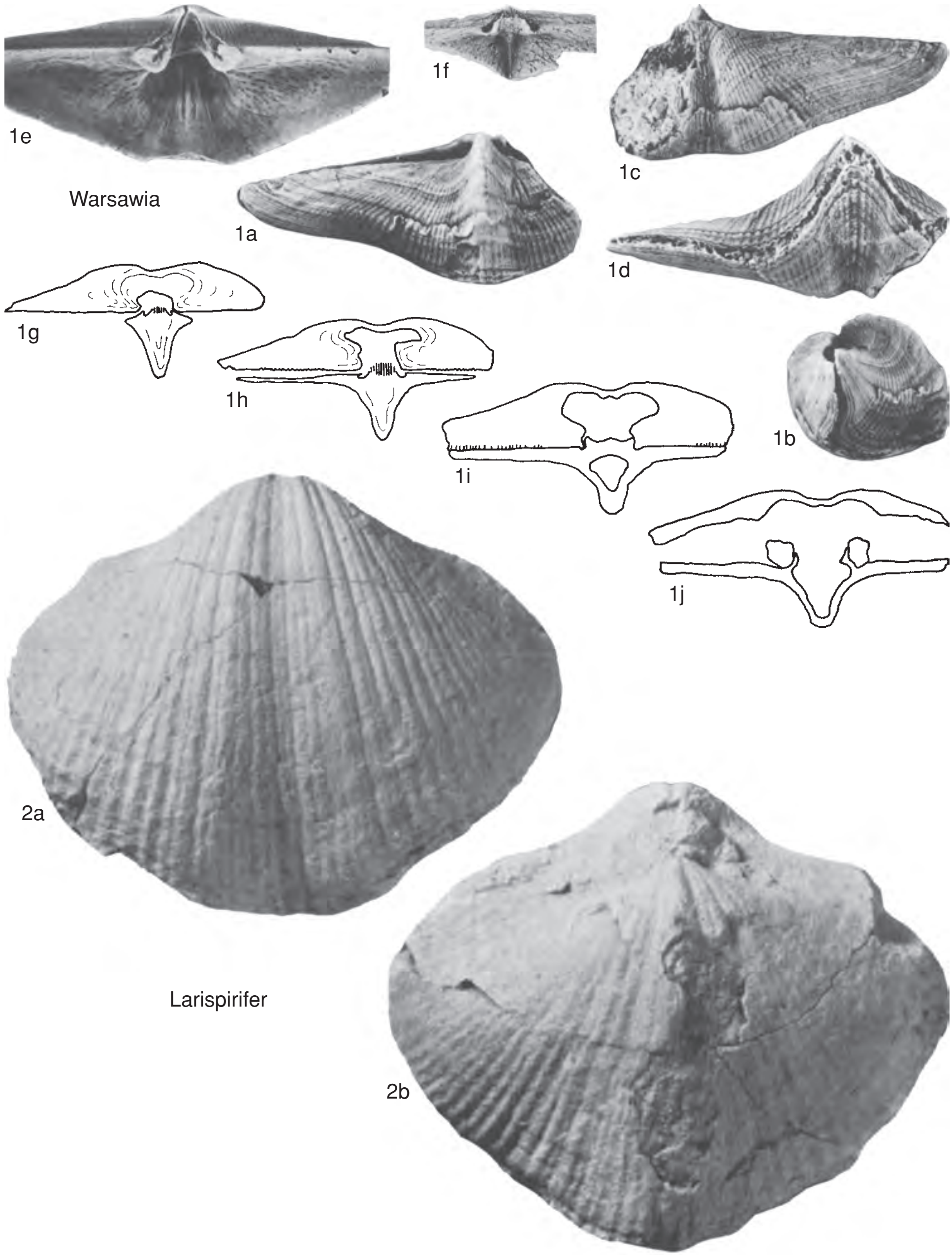

FIG. 1169. Spiriferidae (p. 1771–1775).

numerous fine, simple, bifurcating, or rarely trifurcating costae; very weak fasciculation present only in juvenile stages; ventral interior with thickened delthyrial plate; otherwise similar to *Warsawia. Permian (Sakmarian–Wordian):* Western Australia.——FIG. 1168,*2a–c*. **L. callytharrensis,* Sterlitimakian; dorsal, ventral, and anterior views, ×1 (Archbold & Thomas, 1985).

Warsawia CARTER, 1974, p. 684 [**Spirifer lateralis* HALL, 1858, p. 661; OD]. Small to medium size;

strongly transverse; thick shelled; sulcus shallow and rounded, poorly delimited; fold carinate posteriorly; ventral beak broad and short; numerous fine, simple costae or coarse costellae that rarely bifurcate on lateral slopes and fold-sulcus; ventral interior lacking dental adminicula; cardinal process supported by callus; both valves with thick posterior callus. *Carboniferous (middle Visean):* North America.——FIG. 1169,*1a–j.* **W. lateralis* (HALL); *a–d,* dorsal, lateral, ventral, and anterior views; *e,* ventral interior; *f,* dorsal interior, ×1.5; *g–j,* transverse sections, ×1.5 (Carter, 1974).

Subfamily PROSPIRINAE Carter, 1974

[Prospirinae CARTER, 1974, p. 680]

Cardinal extremities extended in juveniles; growth form variable in adults; lateral slopes with relatively few, mostly simple costae; median sulcal costa usually simple or may bifurcate once; lateral sulcal costae usually simple, not numerous, derived from sulcus-bounding costae; fold clearly delimited from lateral slopes by bounding interspaces; dental adminicula usually well developed; ventral umbonal callus usually present. *Upper Devonian (upper Famennian)–Carboniferous (Visean, ?Serpukhovian).*

Prospira MAXWELL, 1954, p. 35 [**P. typa;* OD]. Small to medium size; moderately to strongly transverse in juveniles, often becoming subquadrate or subpentagonal in adults; cardinal extremities moderately to strongly mucronate; fold and sulcus narrow, well defined with variably developed costation; sulcus usually with simple median costa originating well anterior to beak, often with 1 to 3 pairs of simple lateral sulcal costae that originate by bifurcation from sulcus-bounding costae; lateral slopes with moderate number of simple costae; ventral interior with apical callus and short dental adminicula with deeply impressed muscle field. *Carboniferous (Tournaisian):* cosmopolitan.——FIG. 1170,*1a–b.* **P. typa,* Queensland, Australia; topotype, dorsal and ventral views, ×1 (Maxwell, 1961).——FIG. 1170,*1c–d. P. laurelensis* THOMAS, Australia; ventral and dorsal views, ×1 (Thomas, 1971).

Andreaspira ABRAMOV & GRIGOR'EVA, 1986, p. 144 [**A. soanensis;* OD]. Medium size; outline transverse in juveniles, transversely to longitudinally subovate in adults; cardinal extremities angular in juveniles, usually rounded in adults; moderately numerous costae usually simple or with occasional bifurcations on both lateral slopes and fold-sulcus; median sulcal costa simple; short dental adminicula present in early growth stages, often buried in thick umbonal callus in adults; otherwise similar to *Kinghiria. Carboniferous (?Visean):* northeastern Siberia.——FIG. 1170,*2a–d.* **A. soanensis;* holotype, ventral, dorsal, anterior, and lateral views, ×1 (new).

Austrochoristites ROBERTS, 1971, p. 230 [**A. levisulcatus;* OD]. Medium size; outline subtriangular in juveniles, subovate in adults; cardinal extremities extended in juveniles, rounded or subangular in adults; fold and sulcus narrow, moderately well defined posteriorly, poorly to weakly developed anteriorly; fold clearly delimited by deep bounding interspaces; ventral interarea truncated laterally, trapezoidal; lateral slopes with moderately numerous simple or posteriorly bifurcating costae, well defined posteriorly, becoming indistinct anteriorly; floor of sulcus smooth, sides with few simple costae that bifurcate from fold-bounding costae; ventral interior with moderately long, subparallel dental adminicula and much thickened umbonal region; dorsal interior with short crural plates; vascular impressions simple, narrow, linear. *Carboniferous (Tournaisian):* Western Australia.——FIG. 1170,*4a–d.* **A. levisulcatus; a,* holotype, ventral valve; *b,* dorsal valve, ×1; *c–d,* transverse sections, ×2 (Roberts, 1971).

Finospirifer YIN, 1981, p. 240 [**F. taotangensis;* OD]. Medium size; moderately to strongly transverse; outline subsemicircular to subquadrate; cardinal extremities moderately to strongly mucronate; fold and sulcus well developed; sulcus with disproportionately strong median plication and several pairs of narrow lateral sulcal costae; fold carinate; lateral sloping with moderately numerous simple or rarely bifurcating costae; ventral interior with delthyrial plate; otherwise similar to *Unispirifer. Carboniferous (Tournaisian):* China (Hunan Province).——FIG. 1170,*5a–f.* **F. taotangensis; a–c,* dorsal, anterior, and posterior views; *d–f,* transverse sections, ×1 (Yin, 1981).

Kinghiria LITVINOVICH, 1966, p. 98 [**K. prima;* OD]. Medium size; transverse; cardinal extremities extended, subangular to alate in juveniles and adults; fold and sulcus narrow, moderately developed; costae mostly simple, moderately numerous; ventral interior with greatly thickened umbonal region; dental adminicula buried in thick massive callus; vascular impressions weakly developed. *Carboniferous (Visean):* Kazakhstan.——FIG. 1171,*2a–d.* **K. prima;* holotype, ventral, dorsal, anterior, and lateral views, ×1 (new).

Parallelora CARTER, 1974, p. 680 [**Spirifer marionensis* SHUMARD, 1855, p. 205; OD] [=*Mariona* NALIVKIN, 1975, p. 185, obj.]. Medium size; outline variable in adults, juveniles strongly transverse; cardinal extremities strongly mucronate in juveniles, less so or nearly rounded in adults; lateral slopes with moderately numerous rounded costae, several of which may bifurcate; median sulcal costa usually simple; other sulcal costae few, rarely bifurcating; hinge line and beak ridges parallel, forming wide, low, rectangular ventral interarea; thick subdelthyrial callus present; otherwise similar to *Prospira. Upper Devonian (upper Famennian)–Carboniferous (Tournaisian):* North America, Russia.

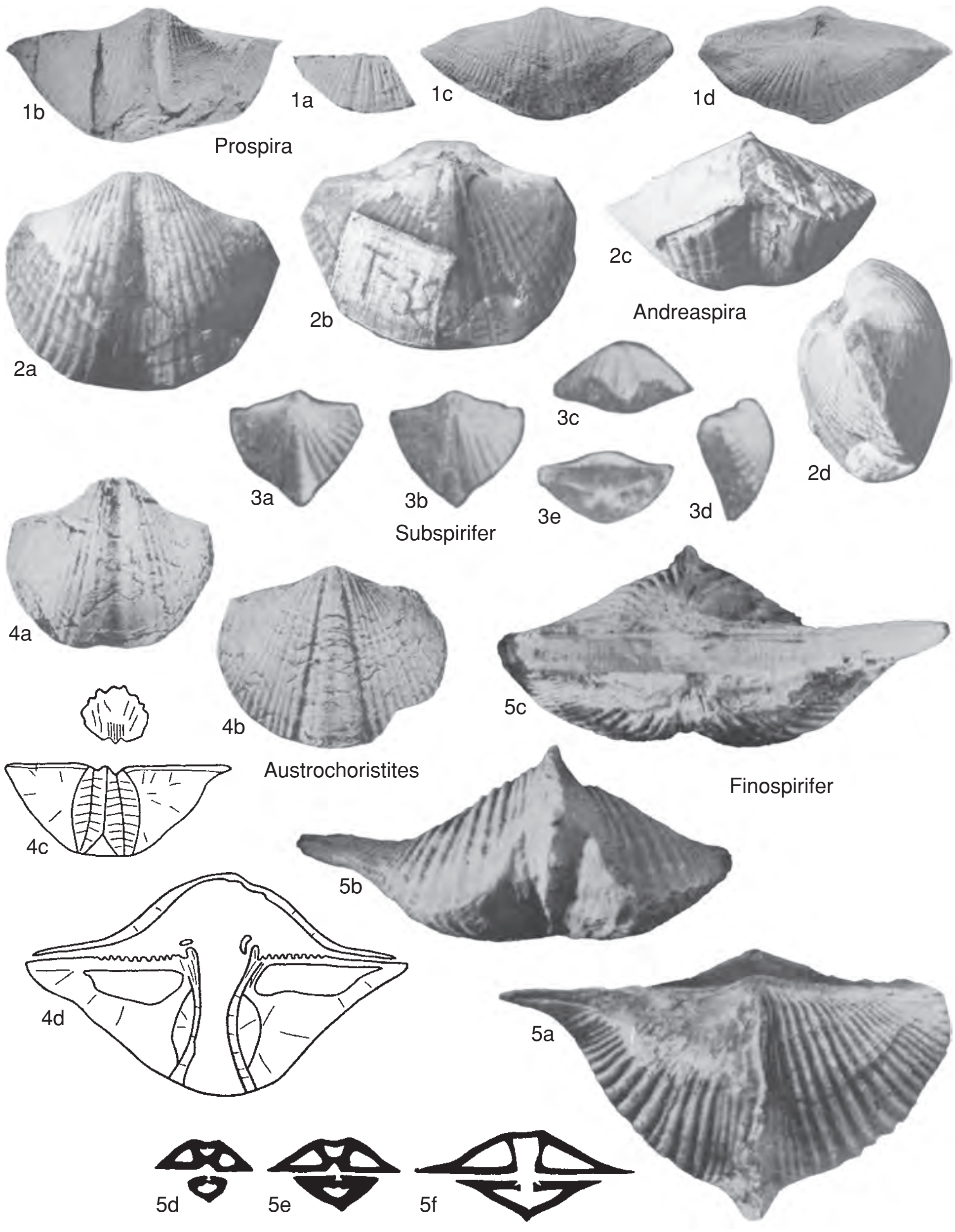

FIG. 1170. Spiriferidae (p. 1775–1777).

——FIG. 1171,*1a–g.* **P. marionensis* (SHUMARD), upper Famennian, Missouri, USA; *a–e,* ventral, dorsal, lateral, anterior, and posterior views, ×1; *f–g,* dorsal and ventral interiors, ×1 (Carter, 1974).

Subspirifer SHAN & ZHAO, 1981, p. 48 [**S. chitzechiaoensis;* OD]. Small; outline transversely subsemicircular to subtrigonal; fold and sulcus narrow, well defined; ventral umbonal region weakly inflated, beak small; lateral slopes with few low, rounded costae, separated by narrow interspaces, those bordering fold-sulcus bifurcate, all others simple; sulcus with single distinct large median costa; fold seemingly smooth, carinate anteriorly; ventral interior with short, moderately strong

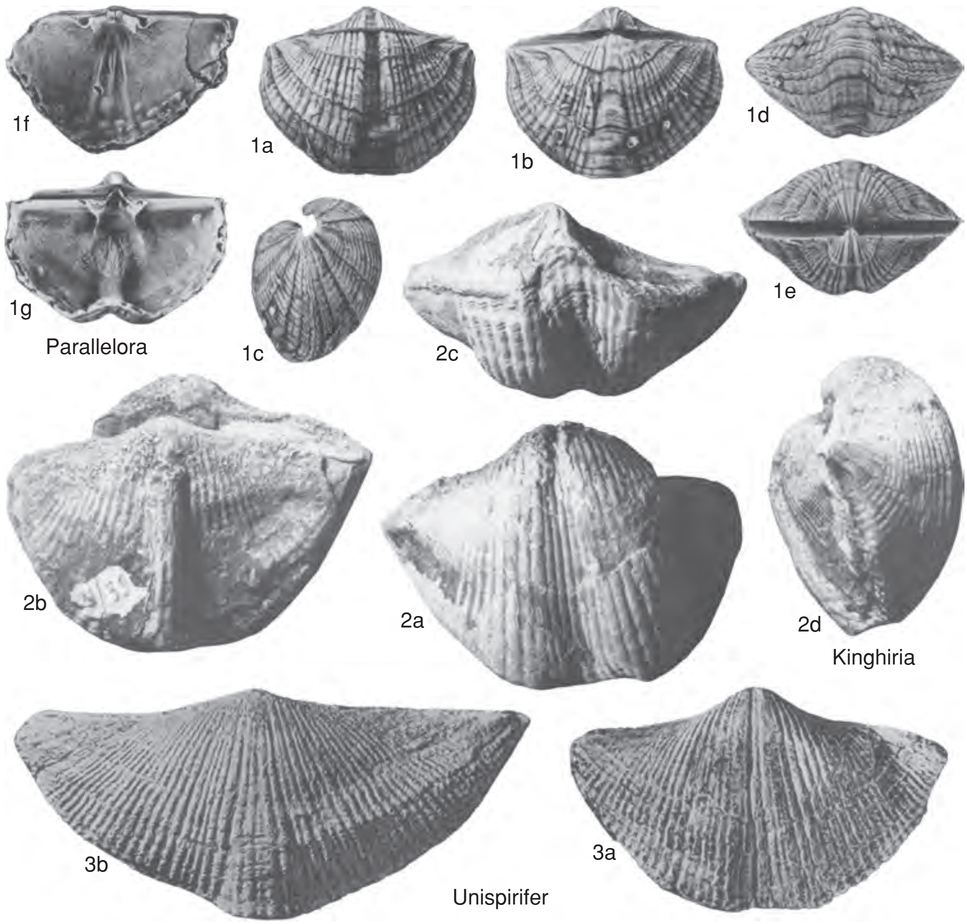

FIG. 1171. Spiriferidae (p. 1775–1777).

dental adminicula; otherwise similar to *Anthracospirifer.* [This genus may be a junior synonym of *Finospirifer* YIN, 1981.] *Carboniferous (?upper Visean, ?Serpukhovian):* China (Hunan).——FIG. 1170,*3a–e.* **S. chitzechiaoensis,* ?lower Namurian; dorsal, ventral, anterior, lateral, and posterior views, ×1 (Shan & Zhao, 1981).

Unispirifer CAMPBELL, 1957, p. 67 [**Spirifer striatoconvolutus* BENSON & DUN in BENSON, DUN, & BROWNE, 1920, p. 350; OD] [=?*Lytha* FREDERIKS, 1924, p. 298 (type, *Spiriferella? tschernyschewiana* FREDERIKS, 1916, p. 30, OD)]. Medium to large; strongly transverse with alate, not mucronate, cardinal extremities in both juveniles and adults; lateral slopes with numerous simple, or rarely bifurcating, costae; sulcus with median costa that may bifurcate and several pairs of simple, or very rarely bifurcating, lateral sulcal costae; otherwise similar to *Prospira.* [*?Lytha* FREDERICKS is poorly known but may prove to be the senior synonym.] *Carboniferous (Tournaisian–Visean):* cosmopolitan.——FIG. 1171,*3a–b.* **U. striatoconvolutus* (BENSON & DUN), Tournaisian, New South Wales, Australia; ventral and dorsal valves, ×1 (Campbell, 1957).

Subfamily SERGOSPIRIFERINAE Carter, 1994

[Sergospiriferinae CARTER in CARTER & others, 1994, p. 343]

Cardinal extremities rounded in juveniles; outline variable in adults; lateral slopes with few simple or bifurcating costae; lateral sulcal costae usually simple, derived from bounding costae; fold usually well delimited by bounding interspaces; dental adminicula well developed. *Upper Devonian (Famennian)–Permian.*

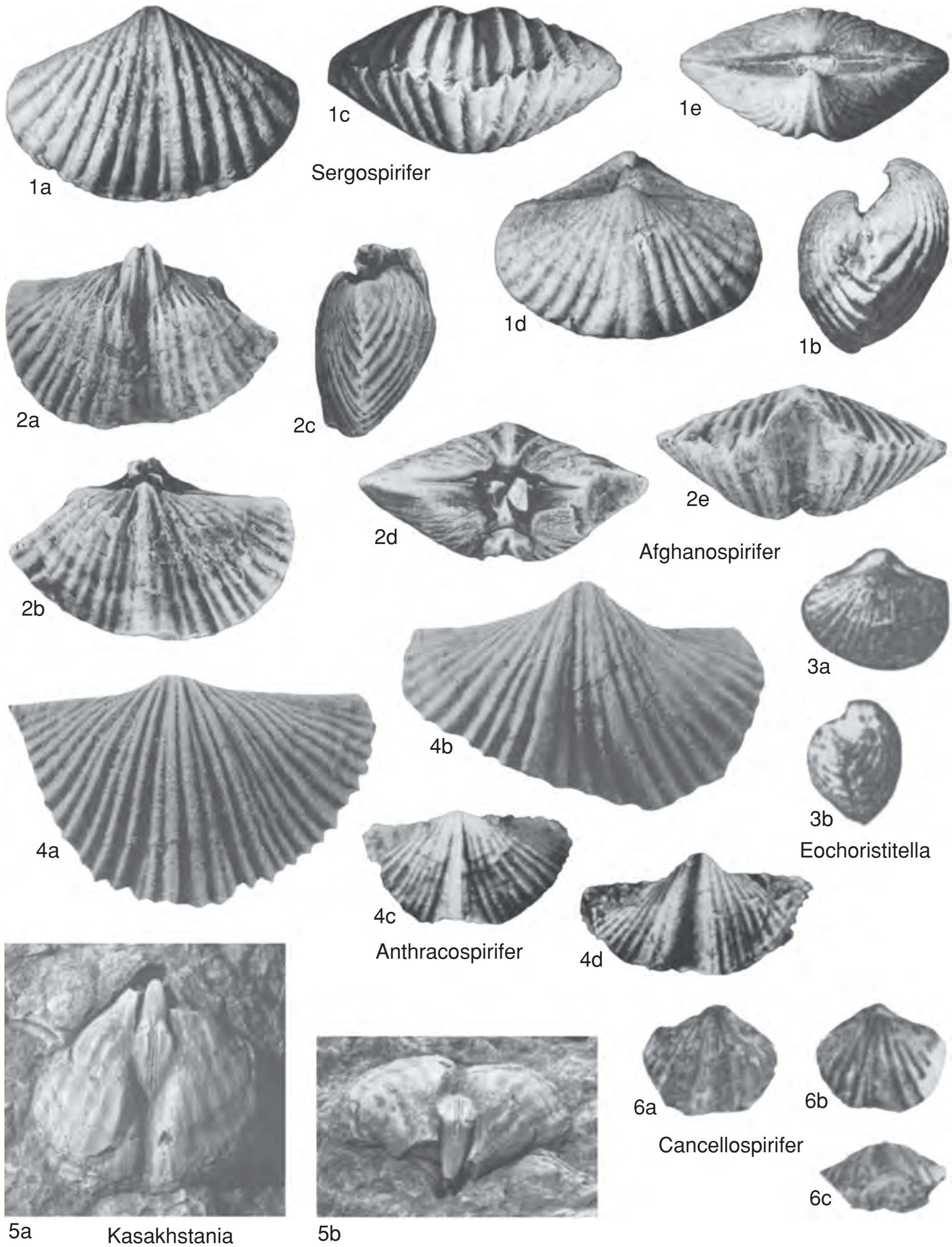

FIG. 1172. Spiriferidae (p. 1778–1779).

Sergospirifer IVANOVA, 1952, p. 190 [**Spirifer okensis* NIKITIN, 1890, p. 28; OD]. Small to medium size; fold and sulcus weakly to moderately developed; lateral slopes and fold-sulcus with few, coarse, simple, subangular costae; costae bounding fold and sulcus not bifurcating. *Carboniferous (Visean–Moscovian):* Russia (Moscow basin), central USA.——FIG. 1172,*1a–e*. **S. okensis* (NIKITIN), upper Moscovian, Moscow basin; ventral, lateral, anterior, dorsal, and posterior views of two syntypes, ×2 (new).

Afghanospirifer PLODOWSKI, 1968, p. 255 [**A. burgutschensis;* OD]. Medium size; outline transversely subovate to subquadrate; cardinal extremi-

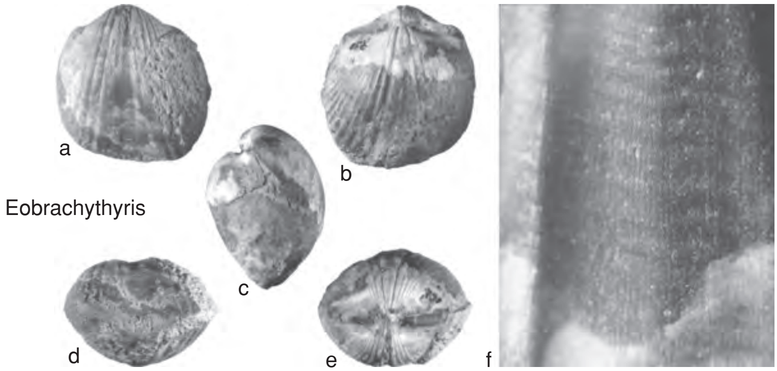

FIG. 1173. Spiriferidae (p. 1779).

ties rounded, maximum width attained slightly anterior to hinge line; fold and sulcus narrow, moderately developed; denticulation of hinge line unknown; lateral slopes with few, low, rounded, simple or bifurcating costae; ventral interior with short protuberent apical callosity and very short dental adminicula; dorsal interior with very short crural plates. *Carboniferous (Serpukhovian–lower Bashkirian):* Afghanistan.——FIG. 1172,*2a–e.* **A. burgutschensis;* holotype, ventral, dorsal, lateral, posterior, and anterior views, ×1 (Plodowski, 1970).

Anthracospirifer LANE, 1963, p. 387 [**A. birdspringensis;* OD] [=?*Plicatocyrtia* GAURI, 1965, p. 55 (type, *Spirifer zitteli* SCHELLWIEN, 1892, p. 48)]. Small to medium size; slightly to moderately transverse; outline variable from subovate to subpentagonal; cardinal extremities in adults variable from slightly rounded to slightly mucronate; costae adjacent to fold and sulcus invariably bifurcating; costae on lateral slopes few to moderately numerous, simple or more rarely bifurcating. *Carboniferous (Visean–Moscovian):* cosmopolitan.——FIG. 1172,*4a–b.* **A. birdspringensis,* Morrowan, Nevada, USA; syntype, dorsal and ventral views, ×2 (Lane, 1963).——FIG. 1172,*4c–d. A. zitteli* (SCHELLWIEN), Moscovian–Kasimovian, Austria; holotype, dorsal and ventral views, ×1 (Gauri, 1965).

Cancellospirifer CAMPBELL, 1953, p. 10 [**C. maxwelli;* OD]. Small, slightly transverse, with rounded cardinal extremities; sulcus well delimited by coarse sulcus-bounding costae; lateral slopes with few simple or rarely bifurcating costae; sulcus with 2 or 3 ribs; fold smooth or with several ribs; microornament consisting of fine, slightly imbricate growth lamellae and fine capillae; otherwise similar to *Sergospirifer. Permian:* Australia (Queensland).——FIG. 1172,*6a–c.* **C. maxwelli;* ventral, dorsal, and anterior views, ×1.1 (Campbell, 1953).

Eobrachythyris BRICE, 1971, p. 182 [**E. proovalis;* OD]. Medium size; length and width nearly equal; outline subovate to rounded subquadrate; fold and sulcus weakly developed but well differentiated; lateral slopes with few simple costae; sulcus smooth or with median costa. *Upper Devonian (Famennian):* Afghanistan.——FIG. 1173*a–f.* **E. proovalis; a–e,* holotype, ventral, dorsal, lateral, anterior, and posterior views, ×1; *f,* microornament, ×12 (new).

Eochoristitella QI, 1983, p. 405 [**E. gansuensis;* OD]. Small, transversely subovate to subpentagonal; strongly ventribiconvex; delthyrium higher than wide, with narrow stegidial plates; sulcus shallow, V-shaped; fold indistinct, delineated only by deep, bounding interspaces; lateral slopes with few simple or rarely bifurcating or trifurcating costae with moderately wide interspaces; sulcus with weak, simple median costa and several pairs of lateral costae that may bifurcate; fold with distinct deep median interspace; ventral interior with short, thin, slightly diverging dental adminicula. *Carboniferous (lower Tournaisian):* China.——FIG. 1172,*3a–b.* **E. gansuensis;* dorsal and lateral views, ×1 (Qi, 1983).

Kasakhstania BEZNOSOVA, 1968, p. 179 [**K. mikunovi;* OD]. Small to medium size; outline subovate, nearly equidimensional; cardinal extremities in adults rounded, maximum width near midlength; fold and sulcus moderately developed; lateral slopes with few broad, flattened, simple costae, those near fold and sulcus rarely bifurcating; umbonal region in ventral valve thickened by callus, delthyrial plate absent; otherwise similar to *Sergospirifer. Carboniferous (Pennsylvanian):* Kazakhstan.——FIG. 1172,*5a–b.* **K. mikunovi; a–b,* holotype, ventral and posterior views, ×2 (new).

Subfamily PURDONELLINAE Poletaev, 1986

[Purdonellinae POLETAEV, 1986, p. 65, *nom. nov. pro* Munellinae FREDERICKS, 1924, p. 313, based on invalid junior homonym]

Outline brachythyridid in all growth stages; hinge line narrow; fold and sulcus moderately to well developed, multicostate, not delineated by discontinuity in ribbing; costae on lateral slopes often flattened, simple or subfasciculate; ventral interior with delthyrial plate and diverging dental adminicula; vascular impressions indistinct. *Carboniferous (Tournaisian)–Permian (Cisuralian).*

Purdonella Reed, 1944, p. 218, *nom. nov. pro Munella* Frederiks, 1924, p. 314, *non* Bonnier, 1896 [**Spirifer nikitini* Chernyshev, 1902, p. 542; OD]. Medium to large; outline subcircular to subovate; ventral umbonal region moderately narrow, moderately inflated; hinge line narrow, not exceeding half of maximum width; fold and sulcus weakly developed, poorly delimited from lateral slopes; entire surface multicostate with numerous, low, flattened, simple or bifurcating costae; ventral interior with short, very thin, subparallel dental adminicula and distinct delthyrial plate; shell substance relatively thin with weak development of prismatic secondary layer in umbonal region. *Carboniferous (Moscovian)–Permian (Cisuralian):* southern Urals, Arctic Russia.——Fig. 1174,*3a–d.* **P. nikitini* (Chernyshev), Cisuralian, southern Urals; ventral, dorsal, posterior, and lateral views, ×1 (new).

Ala Nalivkin, 1979, p. 135 [**A. tau;* OD]. Large, transverse; cardinal extremities rounded in all growth stages; fold and sulcus strongly developed, spreading anteriorly; multicostate with several primary umbonal costae trifurcating to form weak fasciculations on lateral slopes, and numerous freely bifurcating costae on fold-sulcus. *Carboniferous (Tournaisian):* Ural Mountains, Russia.——Fig. 1174,*2a–c.* **A. tau;* holotype, ventral, dorsal, and anterior views, ×1 (new).

Domokhotia Abramov & Grigor'eva, 1983, p. 130 [**D. laticosta;* OD]. Fold and sulcus moderately developed; lateral slopes with few, broad, flattened simple, or rarely bifurcating, costae; costae in sulcus often narrower than those on lateral slopes; otherwise similar to *Purdonella. Carboniferous (Pennsylvanian):* Verkhoian'ia, Siberia.——Fig. 1175,*1a–d.* **D. laticosta,* ?Bashkirian, Verkhoian'ia; ventral, dorsal, anterior, and lateral views, ×1 (new).

Eliva Frederiks, 1924, p. 319 [**Spirifer lyra* Kutorga, 1844, p. 92; OD]. Small for subfamily; longitudinally guttate in outline; otherwise similar to *Purdonella. Permian (Cisuralian):* Russia, USA (Texas).——Fig. 1175,*2a–d.* **E. lyra* (Kutorga), southern Urals; syntype, dorsal, anterior, lateral, and ventral views, ×1 (Chernyshev, 1902).——Fig. 1175,*2e–f. E. shumardi* Cooper & Grant; dorsal and ventral interiors, ×2 (Cooper & Grant, 1976a).

Mirifusella Carter, 1971, p. 250 [**M. fortunata;* OD]. Medium size; adults usually longer than wide; outline longitudinally subovate; hinge line less than maximum width; cardinal extremities rounded to subangular; ventral umbonal region elongated and inflated; fold and sulcus weakly to poorly developed; ornament of few simple, rounded costae on lateral slopes; sulcus with median costa that may bifurcate; other sulcal costae, if present, bifurcate from sulcus-bounding costae; capillae forming faintly reticulate pattern with fine growth lines; ventral interior with short delthyrial plate and moderately to widely divergent dental adminicula; umbonal region thickened in adults. *Carboniferous (middle Tournaisian):* central United States.——Fig. 1175,*3a–g.* **M. fortunata,* Kinderhookian, Iowa, USA; *a–c,* ventral, lateral, and anteriors views of ventral valve; *d–e,* lateral and dorsal views of dorsal valve, ×1.5; *f–g,* ventral and dorsal interiors, ×2 (Carter, 1971).

Neomunella Ozaki, 1931, p. 24 [**Spirifer (N.) chaoi* Ozaki, 1931, p. 68; OD]. Medium size; with thick prismatic secondary layer; hinge line always exceeding half of maximum width; fold and sulcus moderately well developed; ventral interior with strong, divergent dental adminicula; otherwise similar to *Purdonella. Carboniferous (Pennsylvanian)–Permian (Cisuralian):* northern China, northern Urals, Yukon.——Fig. 1174,*1a–c.* **N. chaoi* (Ozaki), Pennsylvanian, northern China; ventral, dorsal, and posterior views, ×1 (Ozaki, 1931).

Podtsheremia Kalashnikov, 1966, p. 50 [**P. prima;* OD]. Medium size, slightly transverse; outline subovate to subrhomboidal; fold and sulcus moderately developed posteriorly, fold becoming very strong and rising sharply anteriorly in adults; cardinal extremities well rounded in early stages, becoming subangular in adults; hinge line equal to or less than maximum width in adults; entire surface multicostate; costae numerous, simple or bifurcating, rarely trifurcating; ventral interior with slightly convergent dental flanges, long slender diverging dental adminicula, and strong delthyrial plate; shell substance thin. *Carboniferous (Visean):* middle and northern Urals, Moscow basin, central Kazakhstan, England, French Pyrenees.——Fig. 1175,*4a–g.* **P. prima; a–b,* holotype, ventral and dorsal views, ×1 (Kalashnikov, 1966); *c–g,* transverse sections, ×2.25 (Kalashnikov, 1974).

Family CHORISTITIDAE Waterhouse, 1968

[*nom. transl. et correct.* Ivanova, 1972, p. 40, *ex* Choristitidinae Waterhouse, 1968, p. 9]

Cardinal extremities rounded in juveniles, variable in large adults; denticulation usually well developed; numerous simple or bifurcating costae usually present on entire surface; microornament capillate; delthyrial plate absent; distinctive vascular impressions commonly present, especially in younger genera. *Carboniferous (Mississippian)–Permian.*

Subfamily ANGIOSPIRIFERINAE Legrand-Blain, 1985

[Angiospiriferinae Legrand-Blain, 1985, p. 574]

Dental adminicula short and close set or absent; vascular impressions ramiform or

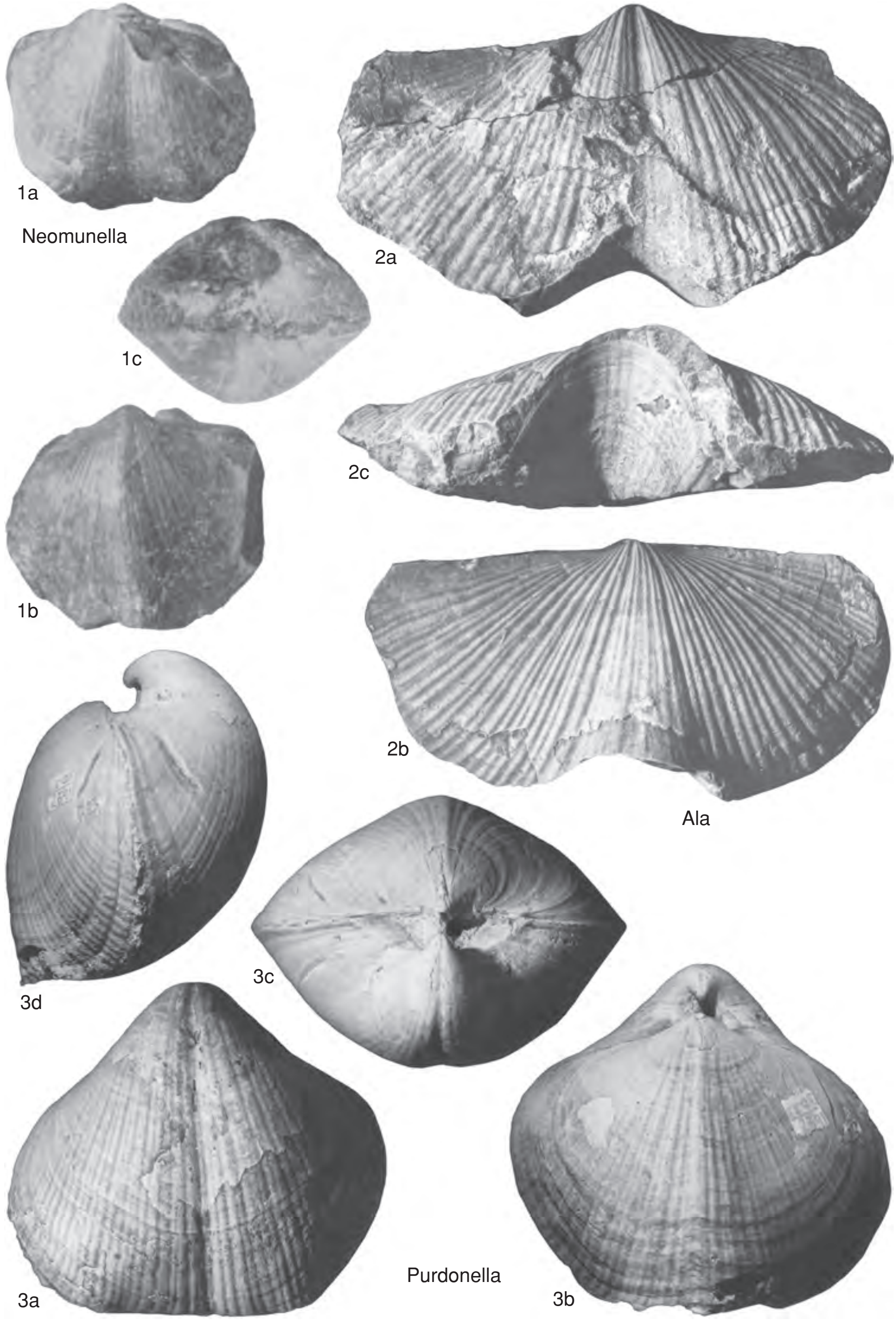

FIG. 1174. Spiriferidae (p. 1780).

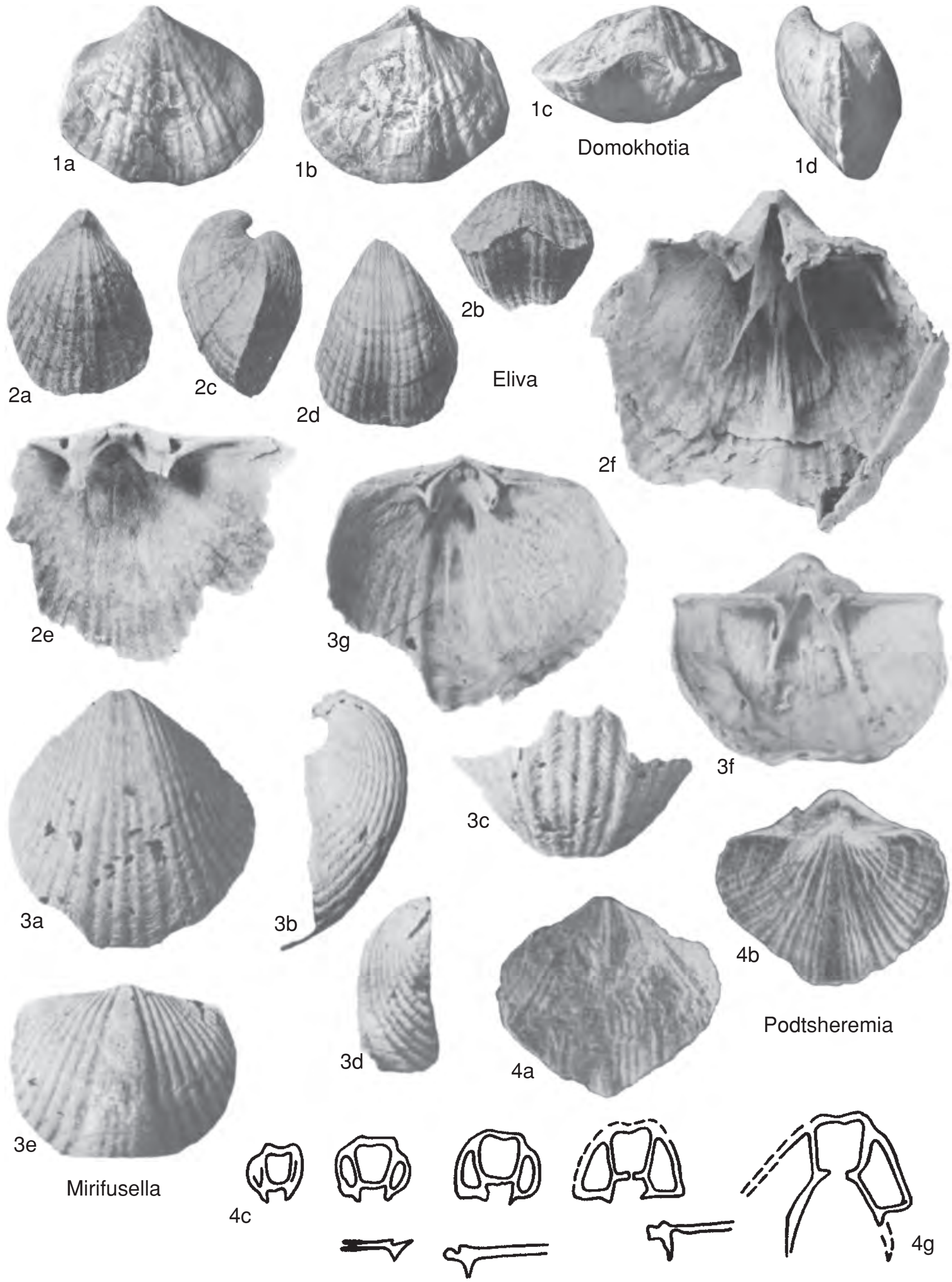

FIG. 1175. Spiriferidae (p. 1780).

weakly to moderately reticulate; micro-ornament finely cancellate, formed by weak capillae and fine, slightly lamellose growth lines. *Carboniferous (Mississippian)–Permian.*

Angiospirifer LEGRAND-BLAIN, 1985, p. 567 [**Spirifer trigonalis* MARTIN, 1809, pl. 36; OD]. Medium size; outline transversely subtrigonal to subquadrate; cardinal extremities well rounded in juveniles, becoming angular to alate in adults; ventral umbonal region broad, moderately inflated; fold and sulcus moderately developed, fold well delineated anteriorly; lateral slopes with few simple or rarely bifurcating rounded costae separated by moderately broad, rounded interspaces; sulcus with anteriorly prominent, simple median costa and 1 to 3 pairs of simple or rarely bifurcating lateral costae; ribs bifurcating immediately adjacent to fold-sulcus; microornament of very weak capillae and slightly lamellose growth lines forming faint, radially arranged, weakly granulose texture; ventral interior with short, close set, intrasulcal dental adminicula and thick, elongate internally and externally convex delthyrial callus; vascular markings crudely reticulate. *Carboniferous (Visean–lower Bashkirian):* Europe, northern Africa, Russia.——FIG. 1176,*2a–e.* **A. trigonalis* (MARTIN), upper Visean, Great Britain; *a–c,* neotype, dorsal, lateral, and anterior views, ×1 (Dunlop, 1962); *d,* vascular markings on ventral valve, ×2.3 (Legrand-Blain, 1985); *e,* transverse section, ×15 (Dunlop, 1962).

Anthracothyrina LEGRAND-BLAIN, 1984, p. 308 [**Brachythyrina (A.) perextensa;* OD]. Vascular impressions reticulate; otherwise similar to *Brachythyrina. Carboniferous (upper Serpukhovian–Bashkirian):* central Pyrenees.——FIG. 1176,*3a–b.* **A. perextensa* (LEGRAND-BLAIN); *a,* holotype, ventral valve, ×1; *b,* ventral interior, ×2.5 (Legrand-Blain, 1984).

Brachythyrina FREDERIKS, 1929, p. 385, *nom. nov. pro Anelasma* IVANOV, 1925, p. 109, *non* DARWIN, 1851, *nec* SOERENSEN, 1873, *nec* COSSMANN, 1889 [**Spirifer strangwaysi* DE VERNEUIL, 1845, p. 164; OD] [=*Anelasmina* SEMIKHATOVA, 1939, p. 324, obj.]. Small to medium size; outline usually transverse; cardinal extremities well rounded in juveniles, becoming angular to alate or mucronate in adults; fold and sulcus moderately narrow, well delineated; lateral slopes with moderately numerous, flattened, simple costae, bifurcations rare; interspaces moderately narrow, subangular; sulcus usually with about 5 simple costae, median rib very rarely bifurcating; ribs adjacent to fold-sulcus bifurcating in umbonal region of both valves; microornament finely and regularly cancellate; dental adminicula absent; vascular impressions ramiform. *Carboniferous (Mississippian)–Permian:* Europe, Asia.——FIG. 1177,*3a–c.* **B. strangwaysi* (DE VERNEUIL), Pennsylvanian, Moscow basin; ventral, dorsal, and posterior views, ×1 (Sarycheva & Sokolskaya, 1952).

Elinoria COOPER & MUIR-WOOD, 1951, p. 195, *nom. nov. pro Elina* FREDERIKS, 1924, p. 321, *non* BLANCHARD, 1852, *nec* FERRARI, 1878 [**Spirifer rectangulus* KUTORGA, 1844, p. 90; OD]. Medium to large; transverse; cardinal extremities rounded in juveniles, becoming subangular to mucronate in adults; ribs on lateral slopes coarse, rounded, simple, bifurcating, or more rarely, trifurcating; valves greatly thickened posteriorly by callus; otherwise similar to *Brachythyrina. Carboniferous (Moscovian)–Permian (Cisuralian):* Eurasia and Canadian Arctic Islands.——FIG. 1176,*1a–d.* **E. rectangula* (KUTORGA), Cisuralian, Urals; holotype, dorsal, lateral, ventral, and anterior views, ×1 (Chernyshev, 1902).

Eobrachythyrina LAZAREV & POLETAEV, 1982, p. 92 [**Spirifer varians* ROTAI, 1931, p. 79; OD]. Medium to large; growth form transverse with rounded cardinal extremities in juveniles, becoming elongated in adults with truncated cardinal extremities; lateral slopes with moderately numerous coarse simple or bifurcating ribs; fold and sulcus moderately well developed and delineated; microornament of fine, regularly spaced growth lines and faint capillae; vascular impressions absent in adults, ramiform in juveniles; dental adminicula absent; ventral muscle scars deeply impressed. *Carboniferous (upper Serpukhovian):* Ukraine (Donets basin).——FIG. 1177,*1a–e.* **E. varians* (ROTAI); *a–b,* syntype, ventral and dorsal views; *c–d,* syntype, ventral and interior views; *e,* large ventral valve, ×1 (new).

Prochoristitella LEGRAND-BLAIN, 1969, p. 220 [**P. afghanensis;* OD]. Lateral slopes with moderately numerous, simple costae with moderately narrow interspaces; sulcal costae simple, distinctly finer than those on lateral slopes; ventral interior with short, close-set dental adminicula largely buried in callus; vascular impressions weakly reticulate; dorsal valve unknown; otherwise similar to *Angiospirifer. Carboniferous (?upper Visean–?lower Bashkirian):* Afghanistan.——FIG. 1177,*2a–b.* **P. afghanensis;* ventral valve, ventral interior, ×1 (Legrand-Blain, 1969).

Quizhouspirifer XIAN Si-yuan, 1979, p. 116, *non Quizhouspirifer* XIAN Si-yuan, 1983b, p. 69 (type, *Q. ziyunensis,* OD) [**Spirifer rectangulus triplicata* MANSUY, 1913, p. 67; OD]. Medium size; transverse; sulcus with 1 to 5, usually 2 or 3, very strong angular plicae, occasionally with 1 or 2 pairs of weak additional costae or costellae on sides of sulcus; microornament seemingly absent; dental flanges high; vascular impressions unknown; otherwise similar to *Brachythyrina. Carboniferous (Bashkirian), ?lower Permian:* Vietnam, China.——FIG. 1176,*4a–g.* **Q. triplicata* (MANSUY), Vietnam, ?lower Permian; *a–d,* dorsal, ventral, posterior, and anterior views, ×1 (Mansuy, 1913); *e–g,* transverse sections, ×1.25 (Xian, 1979).

Subfamily CHORISTITINAE Waterhouse, 1968

[*nom. correct.* CARTER, herein, *pro* Choristitidinae WATERHOUSE, 1968, p. 9]

Dental adminicula close set, subparallel; dorsal adminicula absent; vascular impressions reticulate. *Carboniferous (?Mississippian, Pennsylvanian)–Permian (Cisuralian).*

Choristites FISCHER DE WALDHEIM, 1825, p. 7 [**C. mosquensis;* SD BUCKMAN, 1908, p. 30] [=*Yatsengina* SEMIKHATOVA, 1936, p. 216 (type, *Y. plana*); *Betachoristites* GATINAUD, 1949, p. 492 (type, *Choristites kschemyschensis* SEMIKHATOVA, 1941,

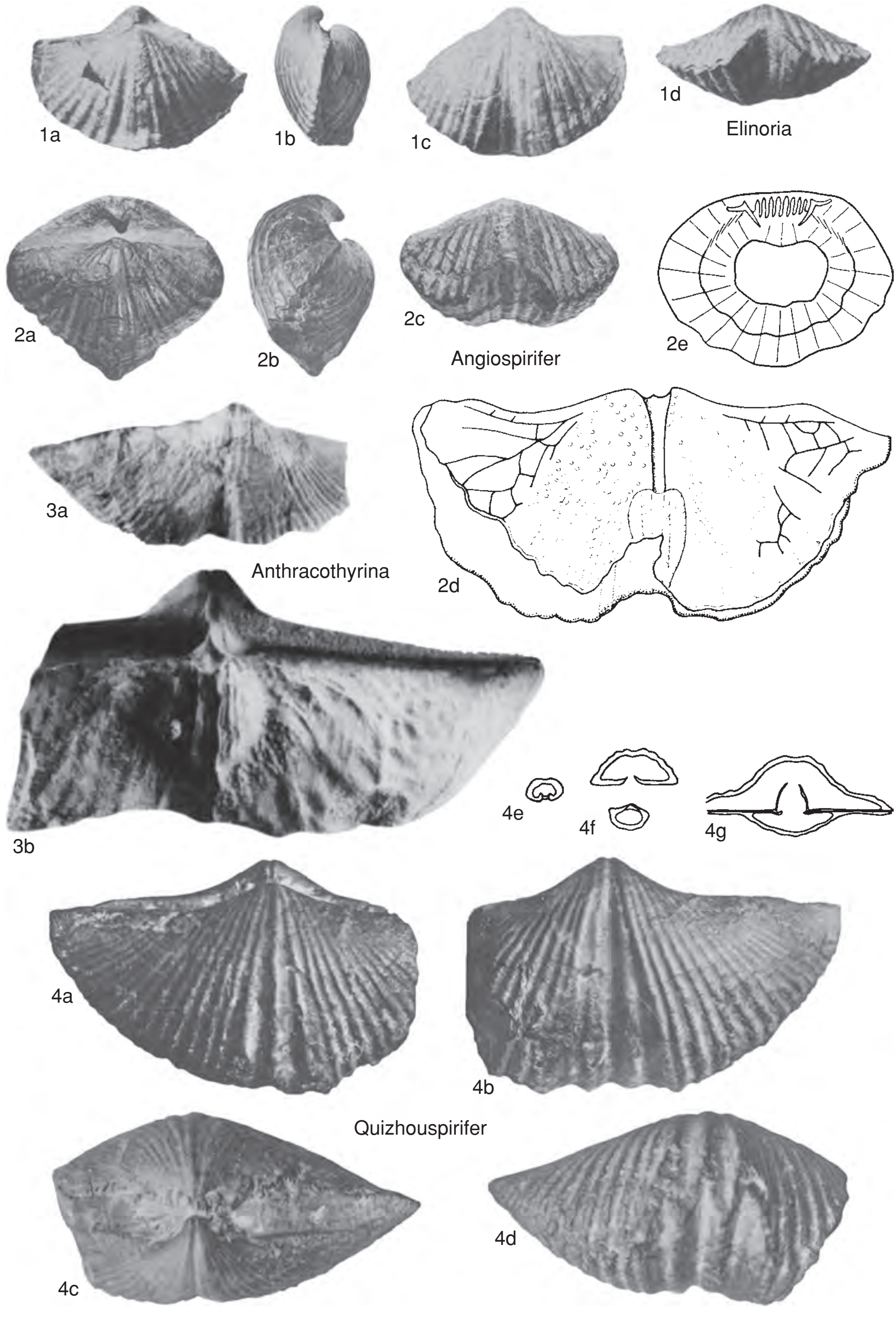

FIG. 1176. Choristitidae (p. 1782–1783).

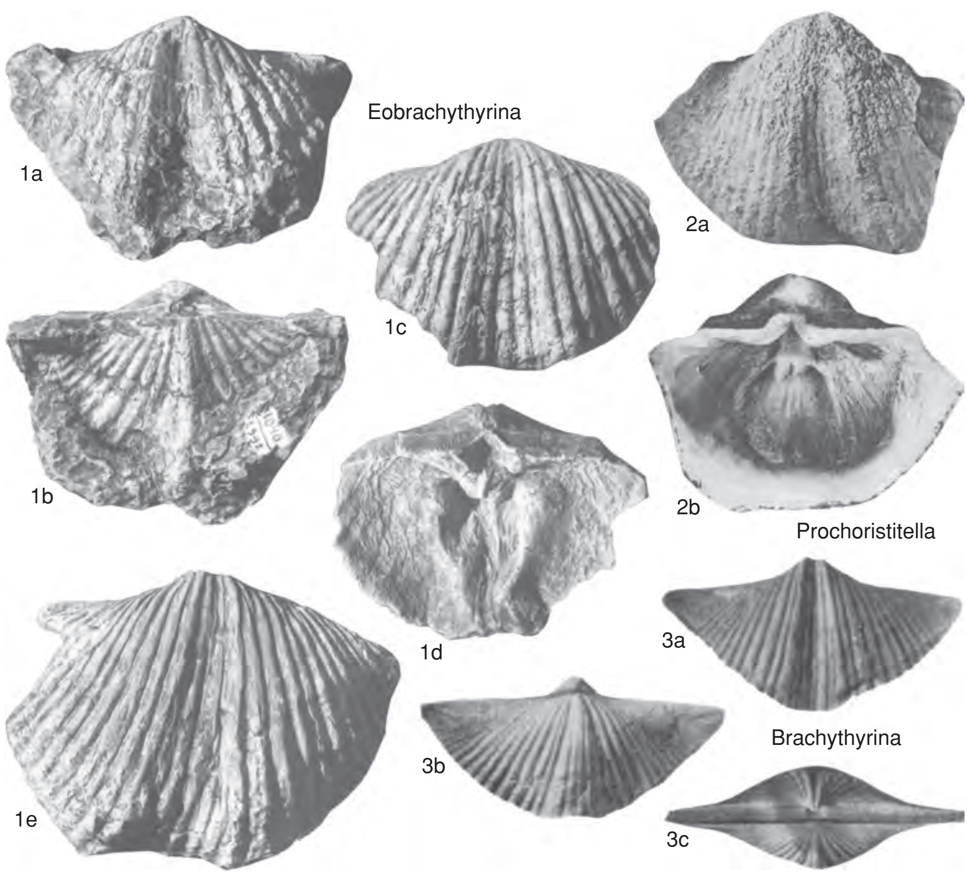

FIG. 1177. Choristitidae (p. 1783).

p. 80); *Jatsengina* IVANOVA, 1960, p. 270, *nom. null.*]. Medium to large; outline longitudinally to transversely subovate, often nearly equidimensional; ventral valve strongly inflated; umbonal region strongly incurved; cardinal extremities abruptly truncated laterally, interarea trapezoidal; hinge line usually less than maximum width; entire surface with numerous flattened, simple or bifurcating costae with narrow interspaces; microornament capillate; fold and sulcus well developed, spreading anteriorly, incorporating additional costae; ventral interior with long, slender, nearly parallel dental adminicula; adductors enclosed within adminicula; adminicula surrounded by small, rounded area of impressed pits, function unknown. *Carboniferous (?Mississippian, Pennsylvanian), Permian (?Cisuralian):* Eurasia.——FIG. 1178,*1a–c*. **C. mosquensis,* Moscovian, Moscow basin; ventral and dorsal valves, ventral interior, ×1 (Ivanov & Ivanova, 1937).

Alphachoristites GATINAUD, 1949, p. 492 [**Choristites bisulcatiformis* SEMIKHATOVA, 1934b, p. 84; OD] [=*Trautscholdia* USTRITSKII, 1967, p. 37 (type, *Spirifer trautscholdi* STUCKENBERG, 1905, p. 47, OD), *non* COX & ARKELL, 1948]. Large; fold and sulcus well developed, rounded; costae coarse, bifurcating, well rounded, with moderately broad interspaces; otherwise similar to *Choristites. Carboniferous (Pennsylvanian):* Russia.——FIG. 1179,*2a*. **A. bisulcatiformis* (SEMIKHATOVA), holotype; ventral valve, ×1 (Semikhatova, 1941).——FIG. 1179,*2b–d. A. trautscholdi* (STUCKENBERG), holotype; ventral, dorsal, and lateral views, ×1 (Likharev, 1939a).

Choristitella IVANOV & IVANOVA, 1937, p. 163 [**Choristites podolskensis* IVANOV & IVANOVA, 1937, p. 170; OD]. Cardinal extremities rounded, ventral interarea triangular; umbonal region narrow, slightly elongated; ventral interior with short, close-set, subparallel dental adminicula that do not reach muscle field; otherwise similar to *Choristites. Carboniferous (Pennsylvanian):* Russia.——FIG. 1178,*2a–f*. **C. podolskensis* (IVANOV & IVANOVA), Moscow basin; *a–b,* holotype, ventral and dorsal views, ×1; *c–f,* paratype, ventral, dorsal, posterior, and lateral views, ×2 (new).

Parachoristites BARKHATOVA, 1968, p. 164 [**P. volongaensis;* OD]. Small to large; outline variable, often transversely subtrapezoidal or subovate; both valves moderately to strongly inflated; fold and sulcus moderately well developed, often spreading anteriorly and incorporating additional costae; cardinal extremities may be alate or slightly mucronate in later growth stages; entire surface multicostate; costae on lateral slopes moderately numerous, flattened, simple or bifurcating with narrow interspaces; those on fold and sulcus similar but slightly finer and less likely to bifurcate; ventral interior with long, diverging dental adminicula that posteriorly enclose wide, impressed, ovate muscle field; dorsal interior with short crural plates; vascular impressions reticulate in at least some species. *Carboniferous (Bashkirian)–Permian (Cisuralian):* Timan, Russia.——FIG. 1179,*1a–e.* **P. volongaensis,* Bashkirian, Timan; *a–d,* holotype, ventral, dorsal, anterior, and lateral views; *e,* ventral interior, ×1 (new).

Settedabania ABRAMOV, 1970, p. 148 [**S. stepanovi;* OD]. Medium size; strongly inflated, subequally biconvex; outline subovate to transversely subtrigonal; cardinal extremitities rounded, hinge line much less than maximum width; fold and sulcus weakly to moderately developed, poorly delineated; entire surface multicostate; costae numerous, simple or bifurcating, flattened, with narrow interspaces; ventral interior with short, parallel, closely set dental adminicula; chordate ventral muscle field enclosed laterally by distinctive high ridges that converge anteriorly as thick median ridge; no indication of vascular impressions. *Carboniferous (Pennsylvanian):* Siberia.——FIG. 1178,*3a–c.* **S. stepanovi; a,* holotype, internal mold; *b–c,* dorsal and ventral valves, ×1 (Abramov, 1970).

Subfamily TANGSHANELLINAE Carter, 1994

[Tangshanellinae CARTER in CARTER & others, 1994, p. 345]

Outline subovate with rounded cardinal extremities; dental and dorsal adminicula absent; vascular impressions poorly developed or unknown. *Carboniferous (Pennsylvanian)–Permian.*

Tangshanella CHAO, 1929, p. 57 [**T. kaipingensis;* OD]. Medium size; greatest width near midlength; fold and sulcus moderately well developed; sulcus spreading anteriorly and with distinctive V-shaped profile; ventral interarea acutely triangular; entire surface multicostate; lateral slopes with few to moderately numerous bifurcations; vascular impressions unknown; externally similar to *Choristites. Carboniferous (Pennsylvanian):* China.——FIG. 1180*a–e.* **T. kaipingensis;* syntype, ventral, dorsal, anterior, posterior, and lateral views, ×1 (new).

Alphaneospirifer GATINAUD, 1949, p. 491 [**Spirifer mahaensis* HUANG, 1933, p. 41; OD] [=*Semibrachythyrina* YANG & CHANG in YANG & others, 1962, p. 104 (type, *S. fasciculata,* OD, =*S. mahaensis* HUANG, 1933, p. 41)]. Ribs fine, numerous, with narrow interspaces, bifurcating freely, sometimes forming weak fasciculations posteriorly; fold and sulcus weakly to moderately well developed, broadly flaring anteriorly; otherwise similar to *Tangshanella.* [*Semibrachythyrina* and its type species are both junior subjective synomyms of *Alphaneospirifer* and its type species.] *Permian:* China.——FIG. 1181,*2a–d.* **A. mahaensis* (HUANG); syntype, dorsal, ventral, lateral, and posterior views, ×1 (Huang, 1933).

Capillispirifer ZHANG F. M. in ZHANG Chuan & others, 1983, p. 357 [**C. xinjiangensis;* OD]. Small, transversely subovate, unequally biconvex; hinge line slightly shorter than maximum width; fold and sulcus well developed and well delineated; lateral slopes with few, mostly simple costae separated by moderately wide interspaces; sulcus with simple median costa and 1 or 2 pairs of lateral sulcal costae that bifurcate from sulcus-bounding costae; microornament densely capillate, forming cancellate pattern with fine growth lines. *Carboniferous (Pennsylvanian):* China.——FIG. 1181,*1a–e.* **C. xinjiangensis;* holotype, ventral, dorsal, anterior, posterior, and lateral views, ×2 (new).

Zhejiangospirifer LIANG, 1982, p. 243 [**Z. depressus;* OD]. Small to medium sized; fold and sulcus variably developed, moderately wide, slightly flaring anteriorly; ornament consisting of few strong, rounded costae, with numerous bifurcations, rare trifurcations; interspaces wide; otherwise similar to *Alphaneospirifer. Carboniferous (?Gzhelian), Permian (Cisuralian–Lopingian):* Asia.——FIG. 1181,*3a–i.* **Z. depressus,* Cisuralian, China; *a–e,* holotype, ventral, lateral, dorsal, anterior, and posterior views; *f–i,* transverse sections, ×2 (Liang, 1990).

Family IMBREXIIDAE Carter, 1992

[Imbrexiidae CARTER, 1992, p. 327]

Outline transversely subquadrate; maximum width at hinge line or midlength; fold and sulcus well developed, often medially subangular, flaring anteriorly in some genera; ventral interior with short to moderately long dental adminicula and short delthyrial plate; ornament of moderately numerous simple or bifurcating costae on both flanks and fold-sulcus; microornament of weak capillae and regularly imbricate growth lamellae. *Carboniferous (?middle Tournaisian, upper Tournaisian–Visean).*

Imbrexia NALIVKIN, 1937, p. 105 [**Spirifer imbrex* HALL, 1858, p. 601; OD]. Medium to large; transversely subquadrate in outline with slightly mucronate to subangular cardinal extremities in adults; juveniles mucronate; maximum width variably

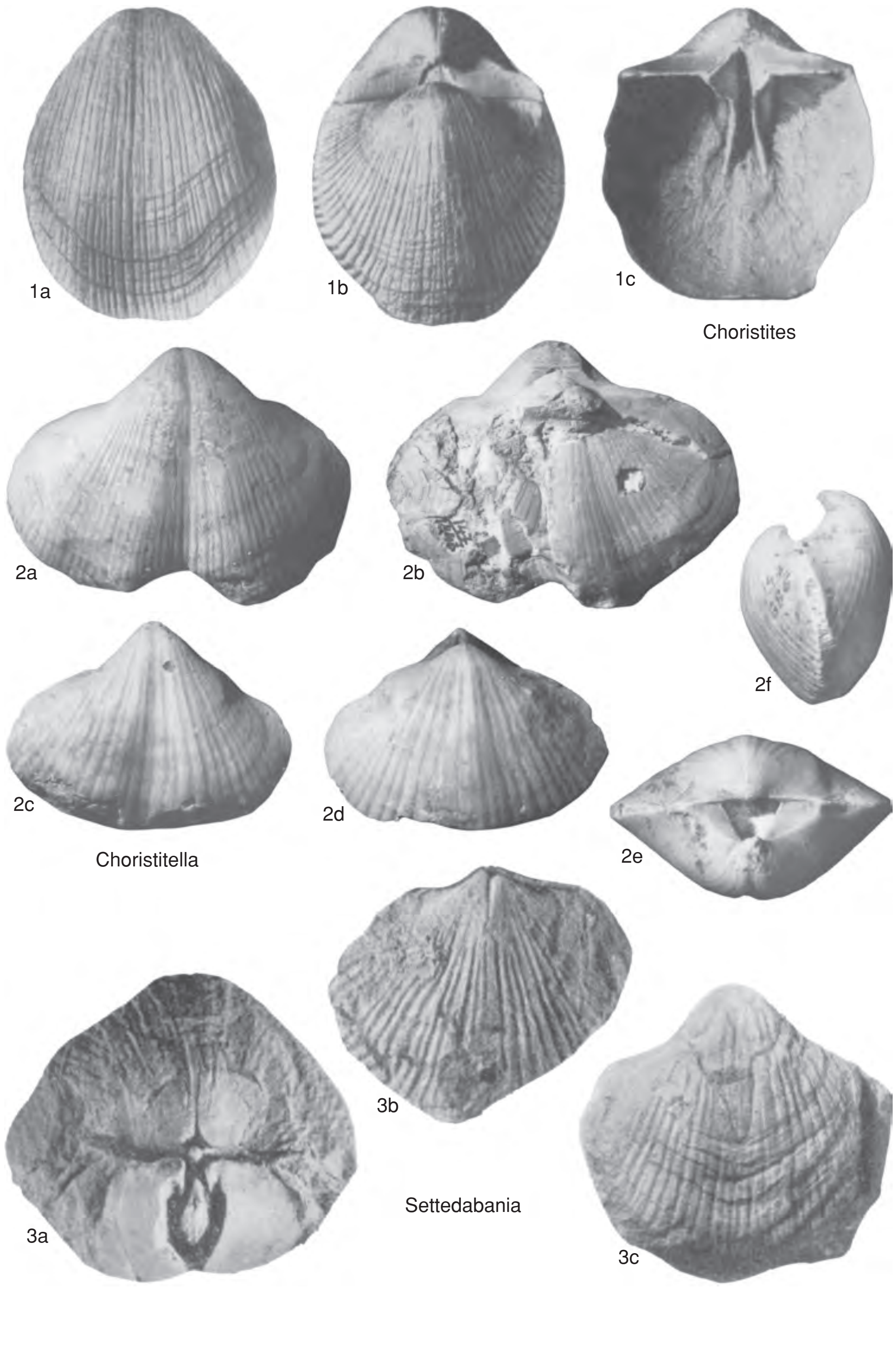

FIG. 1178. Choristitidae (p. 1783–1786).

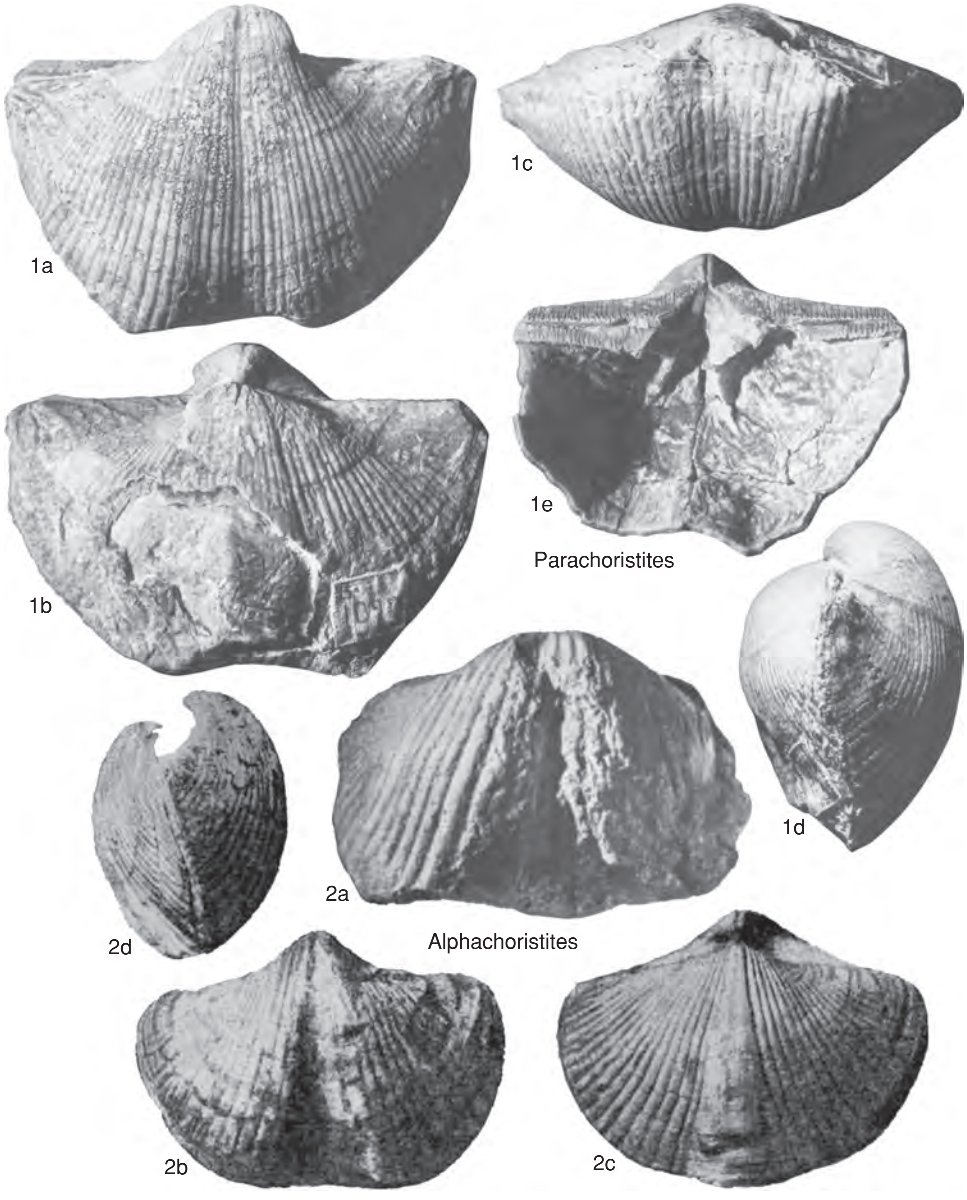

FIG. 1179. Choristitidae (p. 1785–1786).

attained, often at hinge line; fold low, subangular to weakly carinate, flaring anteriorly and incorporating additional costae from flanks; sulcus V-shaped, moderately deep, flaring anteriorly, with simple or bifurcate median costa; other sulcal costae simple or bifurcating; lateral slopes of ventral valve convex, those of dorsal valve compressed and concave near lateral extremities; lateral slopes with numerous binary lateral costae, most formed by bifurcation in umbonal region; microornament consisting of weak capillae and imbricate growth lamellae; ventral valve interior with short, divergent dental adminicula and short delthyrial plate. *Carboniferous (upper Tournaisian–Visean):* North America, Russia.——FIG. 1182*a–h*. **I. imbrex* (HALL); *a–e,* ventral, dorsal, lateral, anterior, and posterior views; *f,* holotype, oblique posterior view of dorsal valve, ×1; *g–h,* transverse sections, ×1.5 (Carter, 1974).

Fernglenia CARTER, 1992, p. 329 [**Spirifer vernonensis* SWALLOW, 1860, p. 644; OD]. Medium size; outline transversely subquadrate to subelliptical; cardinal extremities mucronate in juveniles, truncated or slightly mucronate in adults, rarely alate; maximum width at hinge line or near midlength; both valves well inflated, profile robust; fold and sulcus well defined, usually with 7 or more costae and simple median costa; lateral slopes with moderately numerous, mostly simple, strong costae; first lateral costa bounding fold invariably bifurcates in umbonal region; dental adminicula long for family. *Carboniferous (?middle Tournaisian, upper Tournaisian):* North America.——FIG. 1183*a–t.* **F. vernonensis* (SWALLOW), upper Tournaisian, Missouri, USA; *a–e,* topotype, ventral, dorsal, anterior, posterior, and lateral views, ×1; *f,* microornament, ×4 (new); *g–t,* transverse sections, ×1.5 (Carter, 1992).

Tegulocrea CARTER, 1992, p. 331 [**Spirifer incertus* HALL, 1858, p. 602; OD]. Slightly smaller than average for family; outline subquadrate to subsemicircular; lateral profile lenticular, only moderately inflated; cardinal extremities subangular to slightly mucronate in adults; maximum width at or near hinge line; fold and sulcus moderately developed, width variable, flaring anteriorly in large adults; sulcus with rounded shoulders; fold well defined anteriorly, occasionally subcarinate; ornament of numerous simple, bifurcating, or more rarely trifurcating costae; costae in sulcus moderately numerous, median costa simple; first lateral costae bounding fold invariably bifurcate in umbonal region; dental adminicula short or rudimentary. *Carboniferous (upper Tournaisian):* North America, Russia.——FIG. 1184*a–s.* **T. incertus* (HALL), Oklahoma, USA; *a–e,* ventral, dorsal, anterior, posterior, and lateral views, ×1 (new); *f–s,* transverse sections, ×2.5 (Carter, 1992).

Family TRIGONOTRETIDAE Schuchert, 1893

[*nom. transl.* CARTER in CARTER & others, 1994, p. 345, *ex* Trigonotretinae SCHUCHERT, 1893, p. 156]

Usually strongly transverse in adult growth stage; fold and sulcus well developed; denticulate hinge line well developed; entire surface ribbed, often plicate; lateral slopes commonly fasciculate. *Carboniferous (Visean)–Permian (Lopingian).*

Subfamily NEOSPIRIFERINAE Waterhouse, 1968

[Neospiriferinae WATERHOUSE, 1968, p. 9]

Weakly to strongly fasciculate; costae medium to fine, nearly uniform in size anteriorly; microornament weakly capillate, often lamellose or imbricate; ventral interior with delthyrial plate. *Carboniferous (Pennsylvanian)–Permian (Lopingian).*

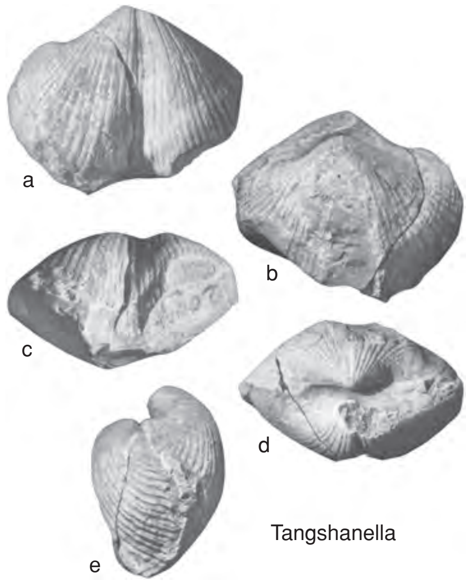

FIG. 1180. Choristitidae (p. 1786).

Neospirifer FREDERIKS, 1924, p. 311 (NIKITIN, 1900, p. 385, *nom. nud.*) [**Spirifer fasciger* KEYSERLING, 1846, p. 231; OD]. Medium size; thin shelled; transverse with fasciculate and plicate lateral slopes; cardinal extremities rounded in all growth stages of type species; ventral interarea narrowly triangular in type species; subangular fold and sulcus well developed; sulcal costae numerous, not fasciculate; costae on lateral slopes not coarse, bifurcating near beaks, again in umbonal region, continuing to branch anteriorly, resulting in fascicles of 6 to 8 or more at anterior margin; costae nearly equidimensional anteriorly; ventral interior with very short delthyrial plate and short dental adminicula; microornament unknown in type species. [An accurate diagnosis of this genus cannot be made until the microornament of the type species is ascertained.] *Permian:* Russia, Pakistan.——FIG. 1185,*1a–c.* **N. fasciger* (KEYSERLING), Cisuralian, Russia; *a,* lectotype, dorsal internal mold, ×1 (Archbold & Thomas, 1984b); *b–c,* paralectotype, ventral and posterior views of ventral valve, ×1 (new).

?Betaneospirifer GATINAUD, 1949, p. 491 [**Spirifera moosakhailensis* DAVIDSON, 1862, p. 28; OD]. Medium to large; strongly transverse; cardinal extremities slightly rounded to mucronate or alate; ventral interarea widely triangular; lateral slopes moderately to strongly plicate and fasciculate; costae numerous on each plica, almost uniform in width anteriorly;

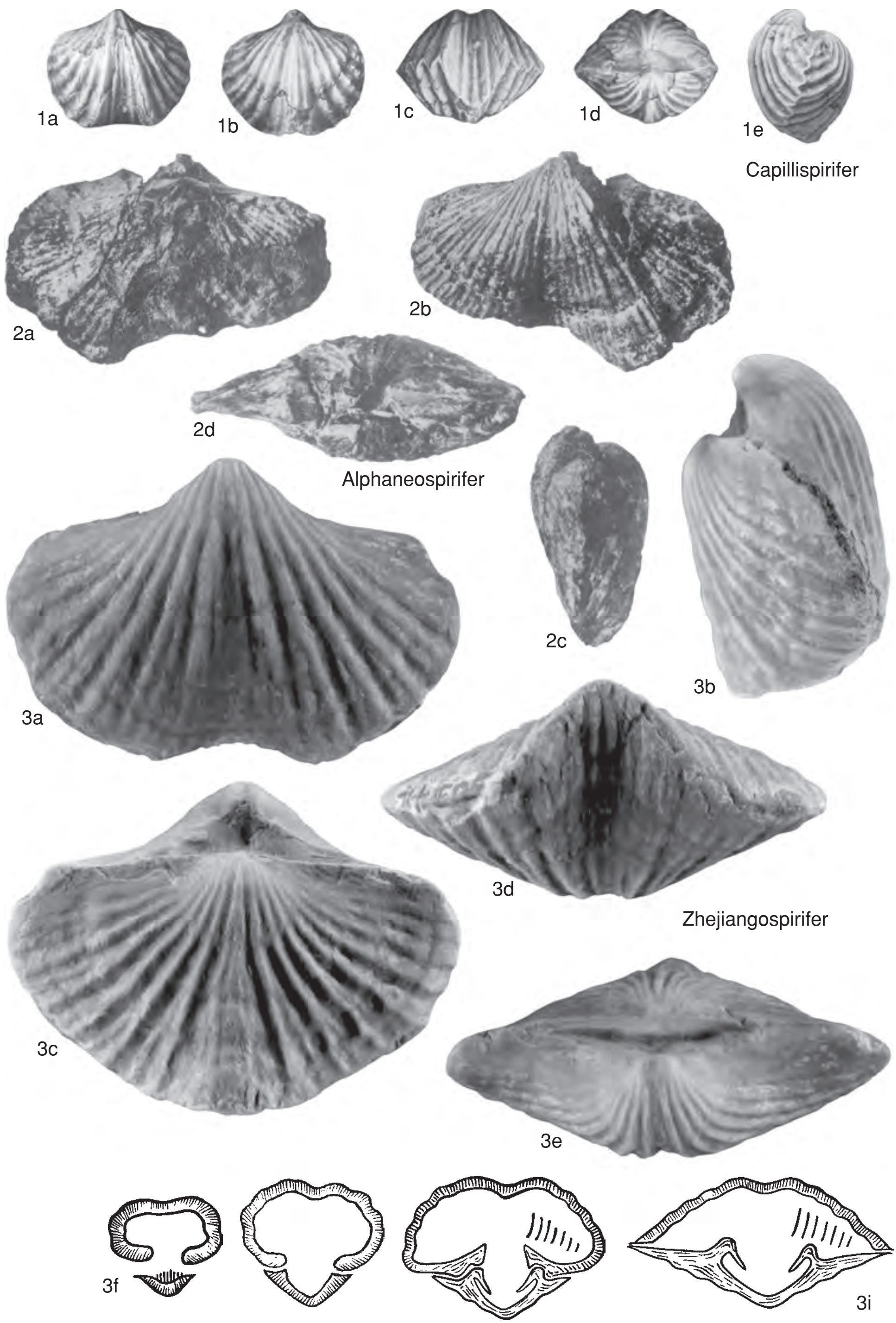

FIG. 1181. Choristitidae (p. 1786).

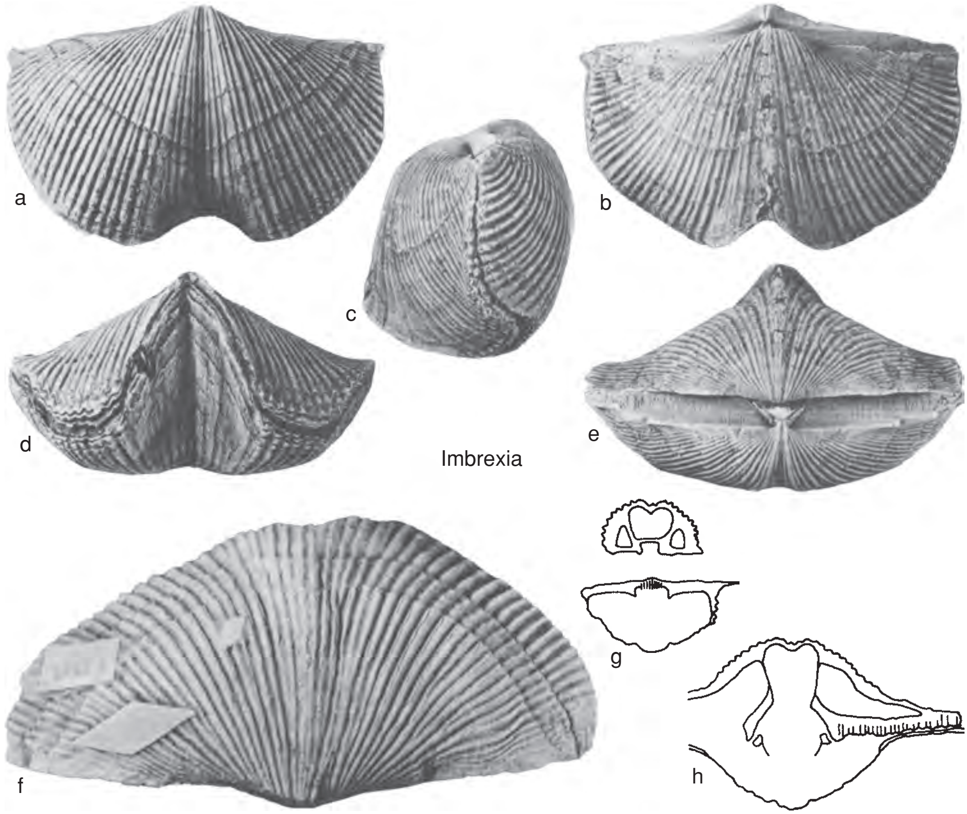

FIG. 1182. Imbrexiidae (p. 1786–1789).

microornament regularly imbricate. [The validity of this genus is contingent on confirmation and completion of the diagnosis of *Neospirifer.*] *Carboniferous (Pennsylvanian)–Permian (Lopingian):* Pakistan, Russia.——FIG. 1185,*2a–e.* **B. moosakhailensis* (DAVIDSON), Cisuralian, Pakistan; lectotype, ventral, dorsal, anterior, posterior, and lateral views, ×1 (new).

Blasispirifer KULIKOV, 1950, p. 6 [**Spirifer blasii* DE VERNEUIL, 1845, p. 168; OD]. Small; outline subovate to subrhomboidal; cardinal extremities rounded; hinge line shorter than maximum width; ventral interarea short, concave; ventral interior lacking dental adminicula; presence of delthyrial plate unknown; macroornament consisting of costae, some of which may form fasciculate plicae; microornament unknown. *Permian (Kungurian–Roadian):* European Russia.——FIG. 1186,*3a–c.* **B. blasii* (DE VERNEUIL), Kazanian; dorsal, ventral, and lateral views, ×1 (Likharev, 1939b).

Cartorhium COOPER & GRANT, 1976a, p. 2,191 [**C. retusum;* OD]. Medium to large; outline subcircular to transversely subelliptical; cardinal extremities well rounded in juveniles, rounded to subangular in adults; maximum width anterior to hinge line; fold and sulcus well developed, fold low; ventral interior with short dental adminicula, sometimes partially buried in callus; delthyrial plate absent; ornament consisting of coarse, rounded, asymmetrically fasciculate costae, sometimes forming weak plicae; microornament of weak, irregularly spaced growth lamellae and capillae. *Permian (Cisuralian–Guadalupian):* USA (Texas).——FIG. 1186,*1a–d.* **C. retusum,* Guadalupian; *a–b,* holotype, ventral valve exterior and interior; *c–d,* dorsal valve exterior and interior, ×1 (Cooper & Grant, 1976a).

Costatispirifer ARCHBOLD & THOMAS, 1985, p. 278 [**C. gracilis;* OD]. Medium sized; strongly transverse; cardinal extremities usually rounded, more rarely subangular; maximum width attained slightly anterior to hinge line; sulcus shallow, rounded; fold moderately high, subangular, almost carinate; ventral interarea high; presence of delthyrial plate not established; macroornament consisting of fine, equidimensional, simple or bifurcating costellae that may or may not form weak fasciculations on weak lateral plicae; microornament unknown; otherwise similar to *Lepidospirifer. Permian (Kungurian):* Western Australia.——FIG. 1186,*4a–d.* **C. gracilis; a–b,* dorsal and anterior views of dorsal

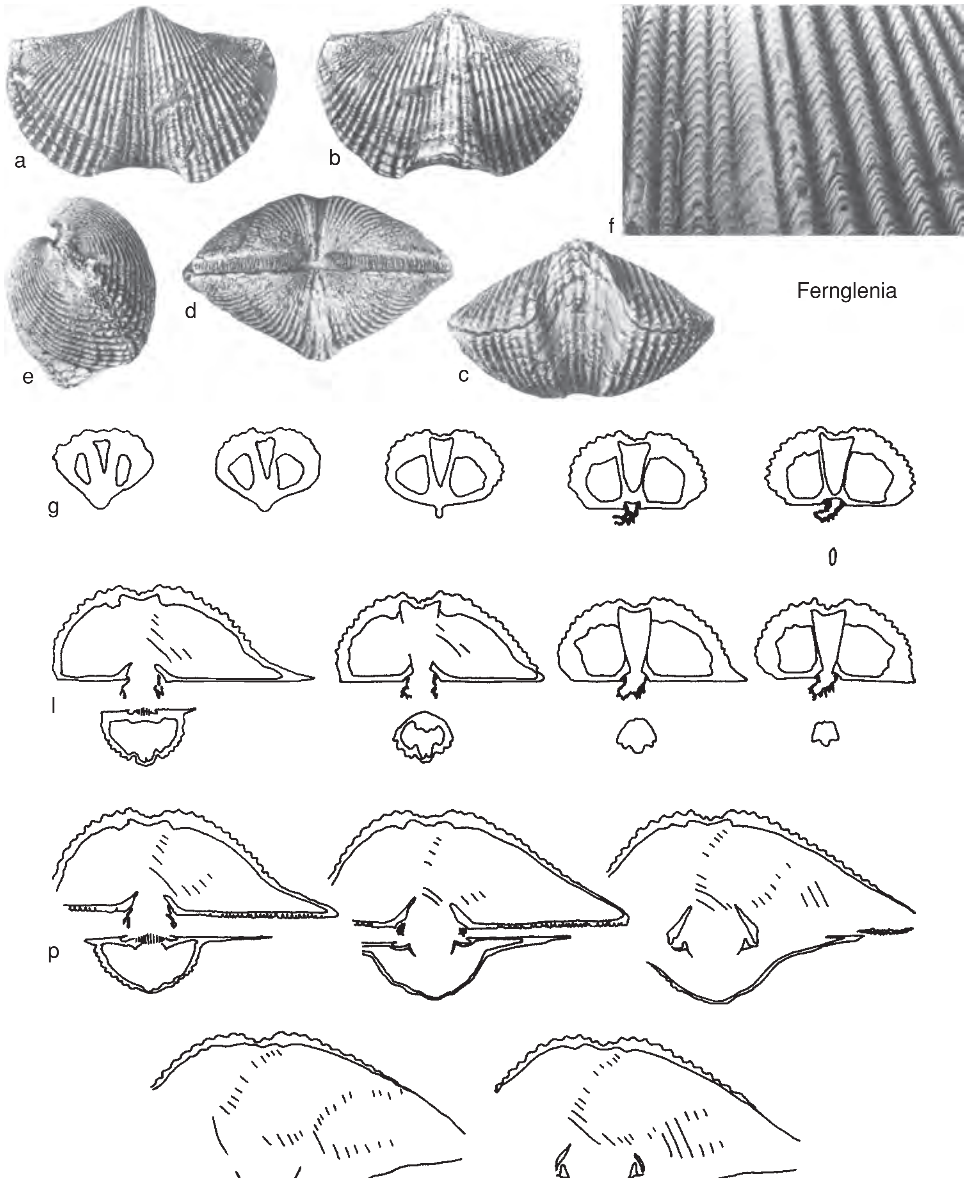

FIG. 1183. Imbrexiidae (p. 1789).

valve; *c–d,* ventral valve exterior and interior, ×1 (Archbold & Thomas, 1985).

Crassispirifer ARCHBOLD & THOMAS, 1985, p. 282 [**Spirifer rostalinus* HOSKING, 1931, p. 24; OD]. Medium to large; strongly transverse in juveniles, becoming more truncated laterally in adults; outline subquadrate to subtrigonal; cardinal extremities acutely alate in juveniles, becoming subangular to rounded in adults; ventral umbonal region and beak weakly produced; sulcus shallow, rounded, moderately broad; fold moderately high, subangular to narrowly rounded; lateral slopes with subequidimensional, rounded or slightly flattened costae forming fasciculations on low plicae; sulcus with

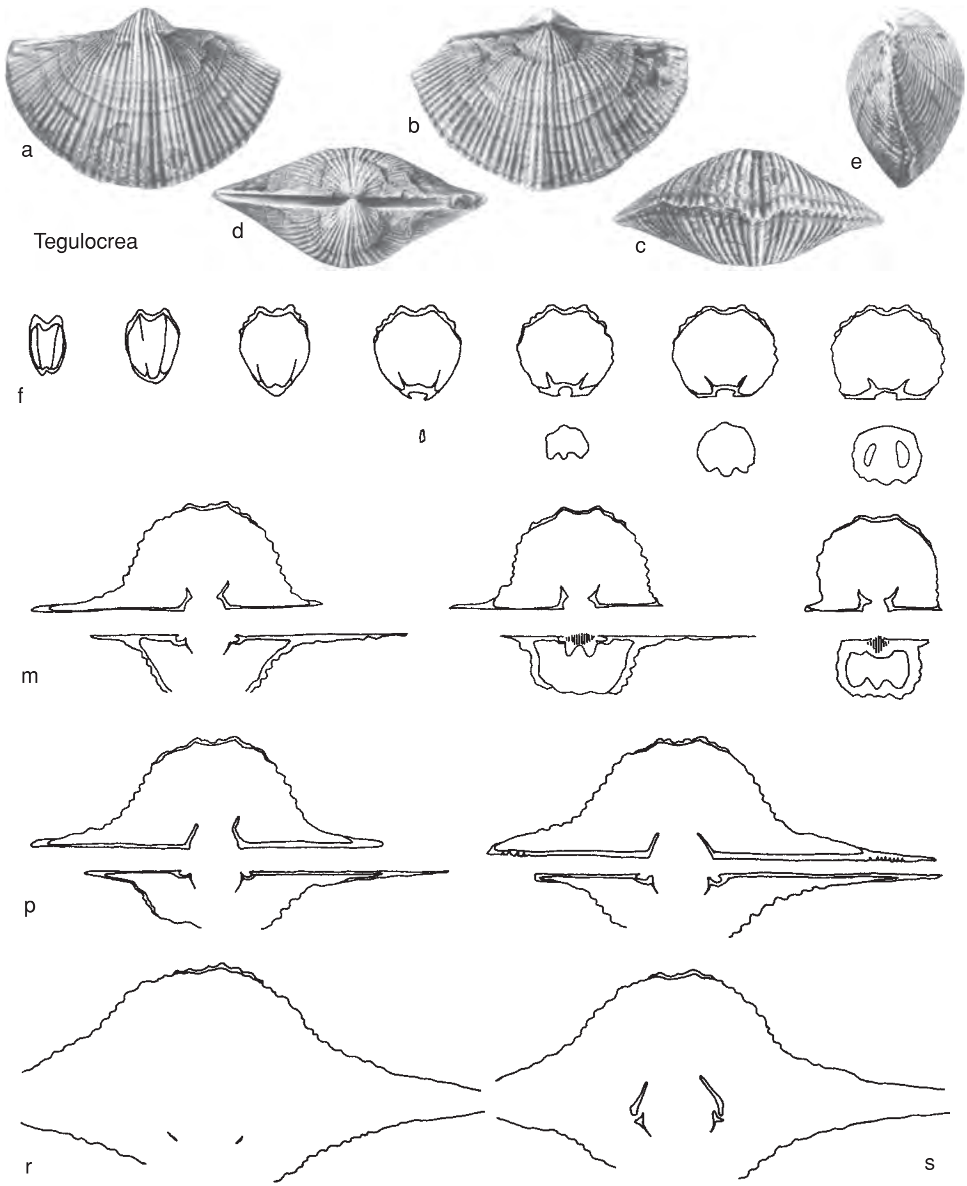

FIG. 1184. Imbrexiidae (p. 1789).

prominent median sulcal costa; microornament of fine cancellate capillae and growth laminae. *Permian (Artinskian–Roadian):* Western Australia, Tibet, ?northeastern Siberia.——FIG. 1187*a–e*. **C. rostalinus* (HOSKING), Artinskian, Western Australia; dorsal, lateral, ventral, posterior, and anterior views, ×1 (Archbold & Thomas, 1985).

Cratispirifer ARCHBOLD & THOMAS, 1985, p. 280 [**C. nuraensis;* OD]. Large; transverse; ventral interarea high; cardinal extremities acutely alate in early growth stages, poorly known in adults; sulcus narrow, shallow; fold moderately high, narrow, subangular; posterior of valves massively thickened; flanks with low, broad plications with fascicles of 3 or 4 coarse, flattened, equidimensional costae; microornament unknown; otherwise similar to *Fusispirifer. Permian (Sakmarian):* Western Australia.——FIG. 1188,*2a–d*. **C. nuraensis;* dorsal,

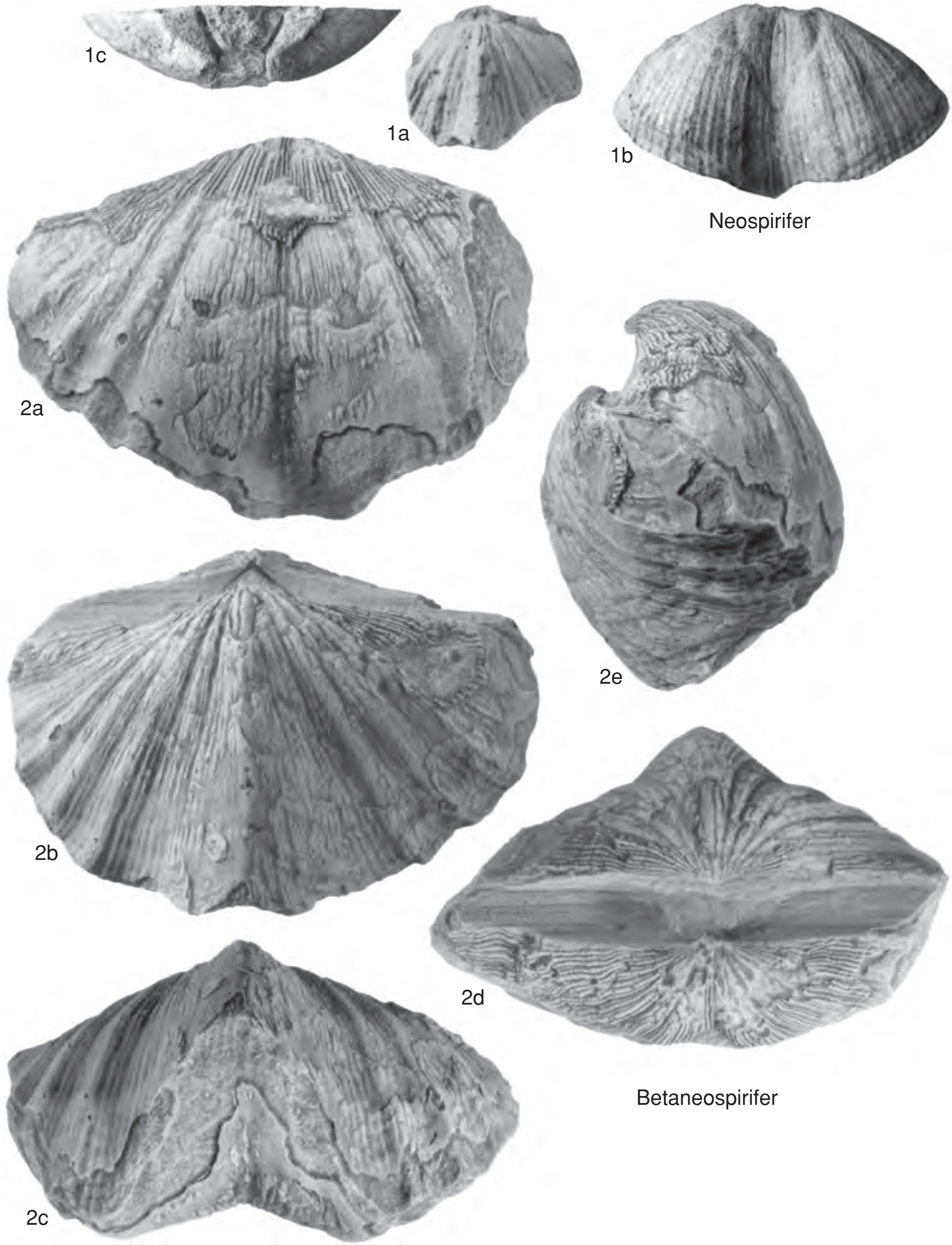

FIG. 1185. Trigonotretidae (p. 1789–1791).

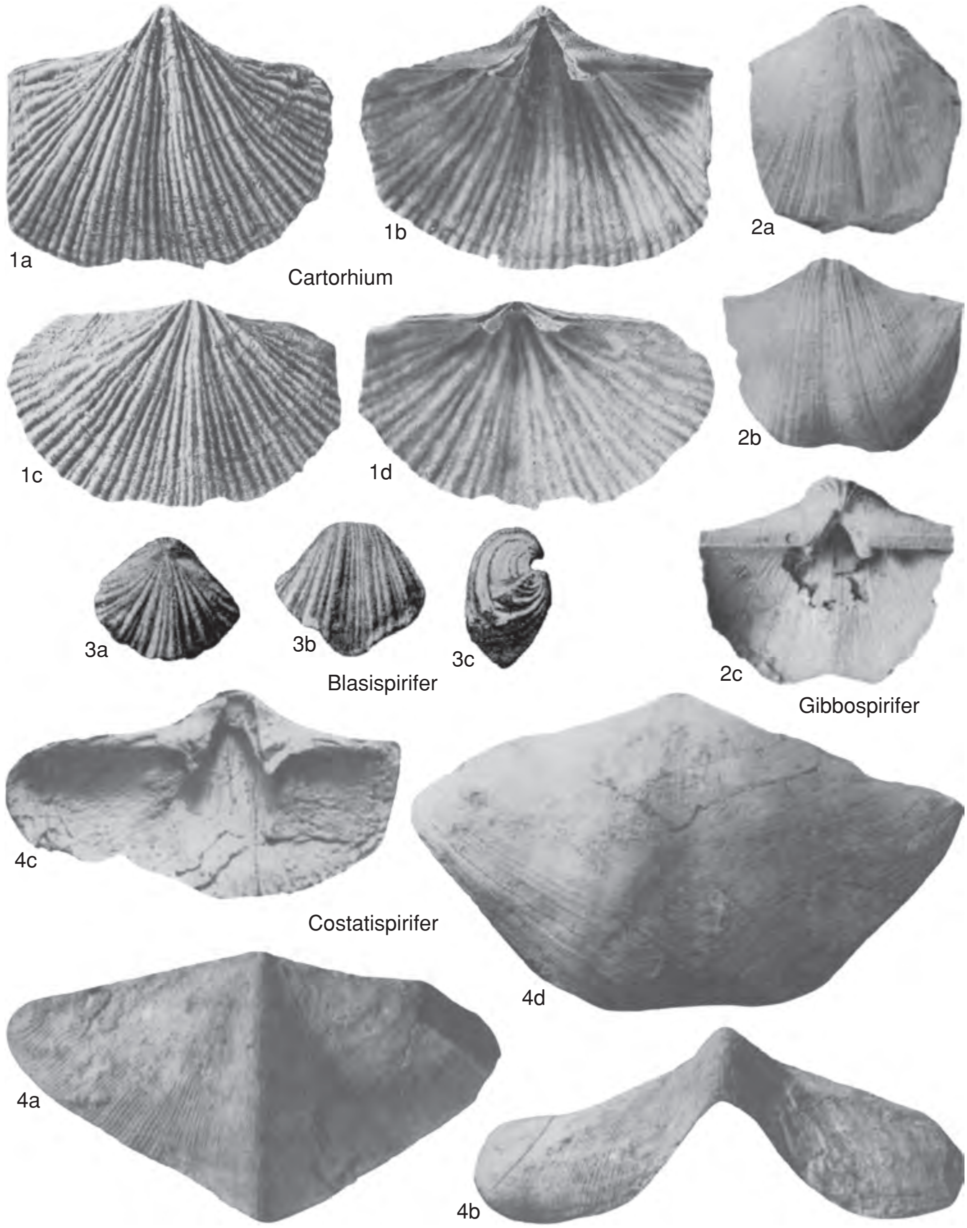

FIG. 1186. Trigonotretidae (p. 1791–1799).

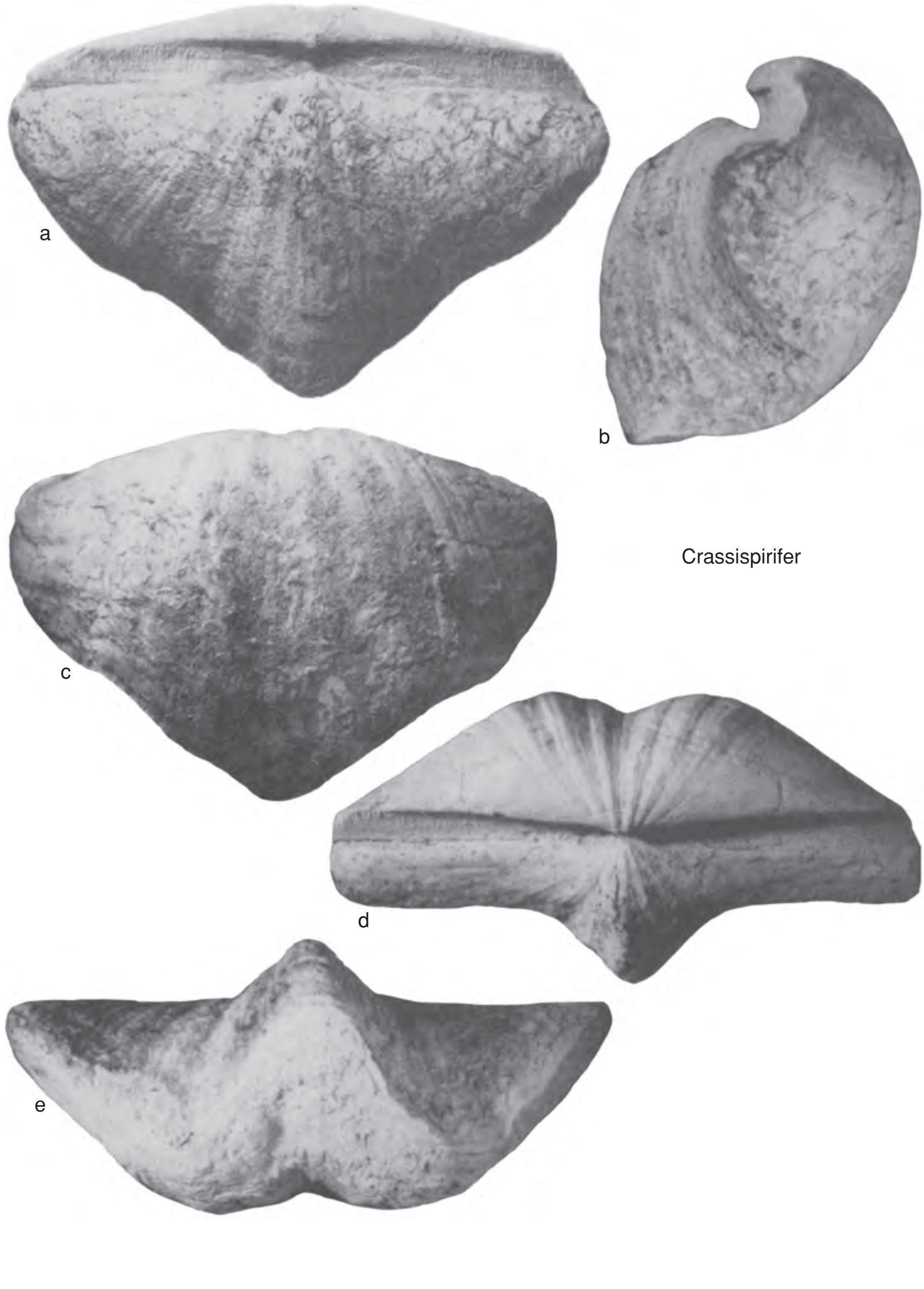

FIG. 1187. Trigonotretidae (p. 1792–1793).

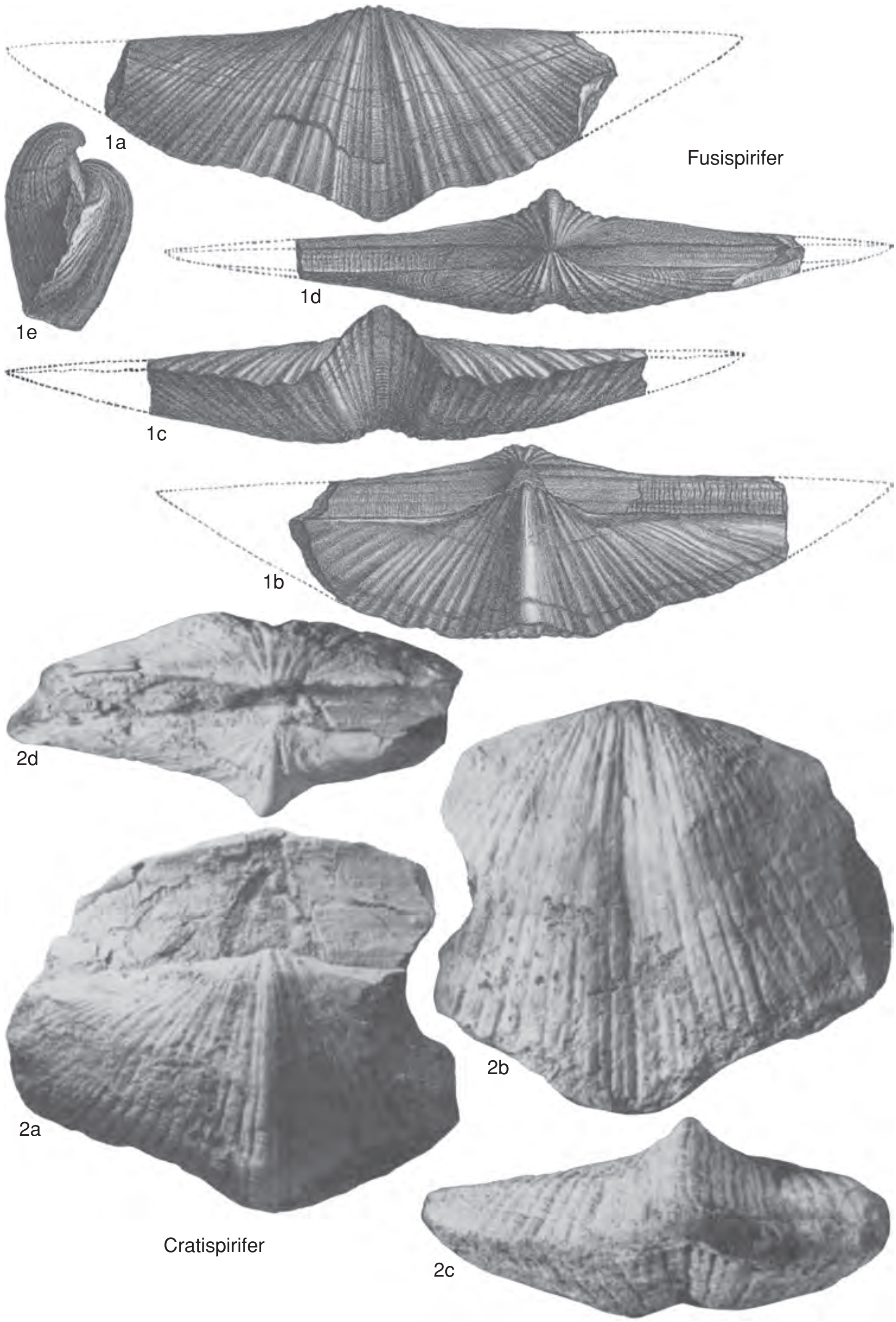

FIG. 1188. Trigonotretidae (p. 1793–1799).

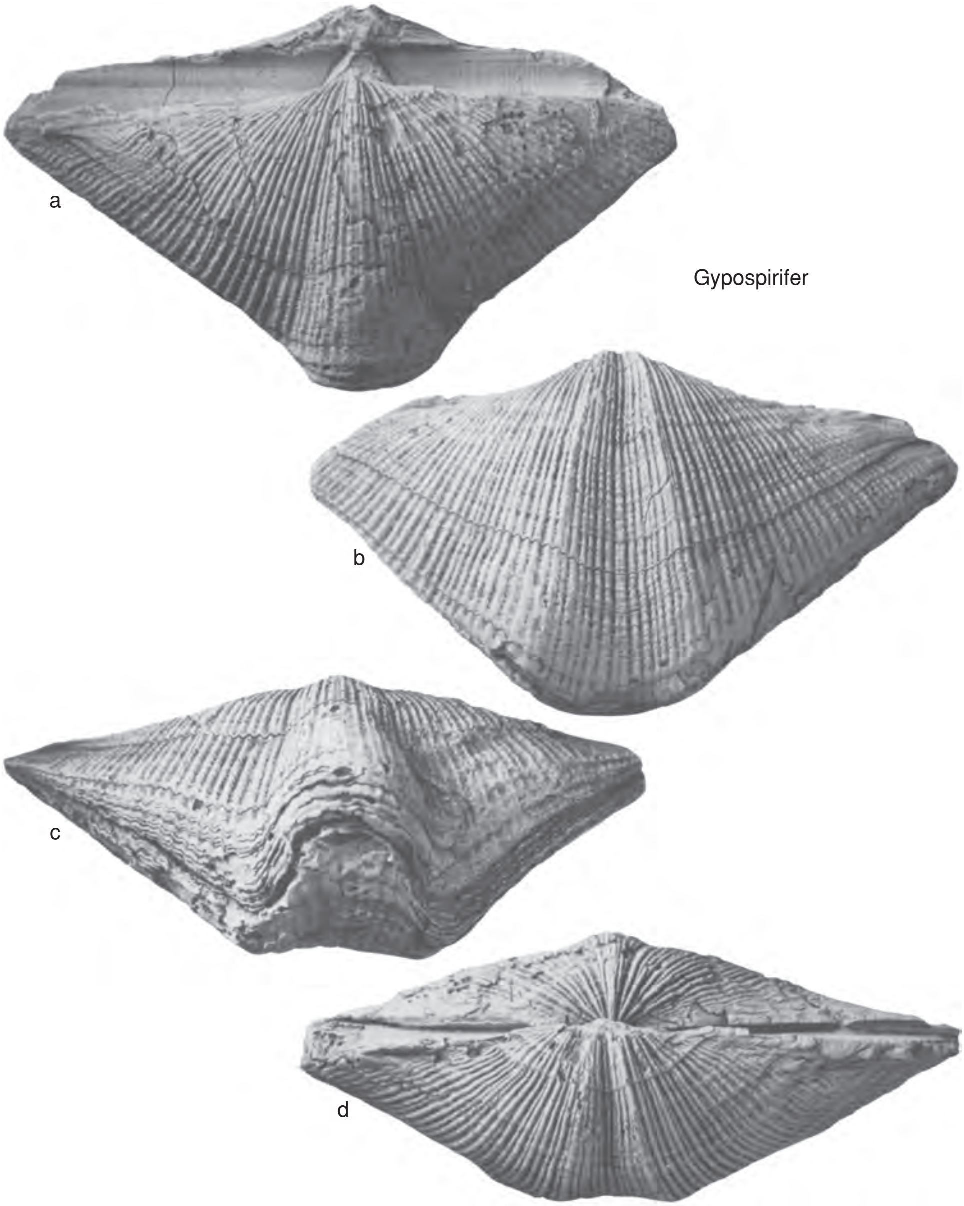

FIG. 1189. Trigonotretidae (p. 1799).

ventral, anterior, and posterior views, ×1 (Archbold & Thomas, 1985).

Fusispirifer Waterhouse, 1966, p. 43 [**Spirifer nitiensis* Diener, 1897b, p. 41; OD] [=*Transversaria* Waterhouse & Gupta, 1983, p. 240 (type, *Fusispirifer marcouiformis* Ching in Zhang & Ching, 1976, p. 209, OD)]. Strongly transverse throughout ontogeny; weakly biconvex; beak small, umbonal region poorly differentiated; cardinal extremities acutely alate in most growth stages, becoming rounded in adults of some species; sulcus narrow, with broad, commonly bifurcating median costa; fold narrow, moderately high; ventral interior much thickened by callus; delthyrial plate thickened, large; delthyrium partially occluded by stegidial plates; costae coarse to fine, nearly equidimensional, arranged in weak fascicles of 3 to 5 costae; microornament capillate, some species weakly lamellose. *Permian (Asselian–Lopingian):* cosmopolitan.——Fig. 1188,*1a–e.* **F. nitiensis* (Diener), Lopingian, Nepal; syntype, ventral, dorsal, anterior, posterior, and lateral views, ×1 (Diener, 1897b).

Gibbospirifer Waterhouse, 1971, p. 221 [**G. ettrainensis;* OD]. Outline elongate; ventral valve arched, dorsal valve gently convex; cardinal extremities angular in adults; ventral sulcus shallow, narrow; dorsal fold low; ventral interarea moderately high; delthyrium open; ornament on lateral slopes consisting of low, indistinct plicae with bundled costae with rounded crests posteriorly, fading anteriorly; microornament reticulate, concentric lamellae dominant over capillae; dental adminicula short; ventral valve thickened with apical callus. *Carboniferous (Moscovian–Gzhelian):* Yukon Territory, Canada.——Fig. 1186,*2a–c.* **G. ettrainensis; a,* holotype, ventral valve; *b–c,* paratype, ventral valve and interior, ×1 (Bamber & Waterhouse, 1971).

Gypospirifer Cooper & Grant, 1976a, p. 2,209 [**G. nelsoni;* OD]. Medium to large; transverse; cardinal extremities alate, subangular or slightly mucronate, especially in early growth stages; fold and sulcus well developed; fold well rounded; delthyrium partially or completely closed by imbricating stegidial plates; ornament consisting of numerous, fine, well rounded, almost uniform, simple or bifurcating costae that sometimes form weak fascicles posteriorly; fascicles, when present, not producing plicae; growth lamellae regularly to irregularly spaced, sometimes tegulate; ventral interior with dental adminicula usually buried in callus; delthyrial plate absent or obscured by thick callus. *Carboniferous (Bashkirian)–Permian (Cisuralian):* USA (Texas), Bolivia, Russia.——Fig. 1189*a–d.* **G. nelsoni,* Wolfcampian, Texas; dorsal, ventral, anterior, and posterior views, ×1 (Cooper & Grant, 1976a).

Imperiospira Archbold & Thomas, 1993, p. 314 [**I. franzjosefi;* OD]. Large; outline transversely irregularly subquadrate; lateral margins ventrally recurved and anteriorly extended to form thin, curved flanges; strong fold and sulcus producing long tongue and deeply emarginate anterior commissure; lateral slopes weakly to moderately plicate with numerous fine, even, fasciculate costae; microornament capillate and variably imbricate; dental adminicula short, buried in thick callus; true delthyrial plate very short or absent. *Permian (Sakmarian–Kungurian):* Western Australia.——Fig. 1190*a–b.* **I. franzjosefi;* holotype, ventral and dorsal views, ×1 (Archbold & Thomas, 1993).——Fig. 1191*a–b.* **I. franzjosefi;* holotype, posterior and anterior views, ×1 (Archbold & Thomas, 1993).

Kaninospirifer Kulikov & Stepanov in Stepanov, Kulikov, & Sultanaev, 1975, p. 63 [**Spirifer kaninensis* Likharev, 1943b, p. 279; OD]. Dental adminicula absent; otherwise similar to *Betaneospirifer;* poorly known. *Permian (Roadian):* Russia (Kanin Peninsula).——Fig. 1192*a–d.* **K. kaninensis* (Likharev); ventral, dorsal, anterior, and posterior views, ×1 (new).

Lepidospirifer Cooper & Grant, 1969, p. 14 [**L. angulatus;* OD]. Cardinal extremities well rounded in juveniles, rounded to subangular in adults; lateral slopes costellate to finely costate and weakly fasciculate, often lacking plicae; delthyrial plate very short or absent; growth lamellae finely imbricate and capillate; otherwise similar to *Neospirifer. Permian (Wordian):* USA (Texas).——Fig. 1193,*1a–e.* **L. angulatus;* holotype, dorsal, ventral, anterior, posterior, and lateral views, ×1 (Cooper & Grant, 1976a).

Pondospirifer Waterhouse, 1978, p. 93 [**P. magnificus;* OD]. Very large, thick, transverse, unequally biconvex; outline subquadrate; cardinal extremities subangular or slightly rounded in adults; ventral umbonal region and beak much reduced, poorly differentiated; ventral lateral extremities swollen; fold and sulcus very large, with sulcus engulfing lateral as well as anterior portion of shell; fold high, sloping gradually to each lateral margin; lateral slopes with very low, short, inconspicuous plicae and entire surface covered with fine, distinct, well-rounded costae; microornament of capillae and fine growth lines; ventral interior with dental adminicula; presence of delthyrial plate not confirmed; muscle platform as in *Neospirifer. Permian (Lopingian):* Nepal.——Fig. 1194*a–c.* **P. magnificus;* ventral, dorsal, and posterior views, ×1 (Waterhouse, 1978).

Septospirifer Waterhouse, 1971, p. 222 [**S. tatondukensis;* OD]. Strongly transverse in all observable growth stages; cardinal extremities mucronate; lateral slopes weakly plicate and weakly fasciculate; ventral interior with distinct myophragm in anterior portion of ventral muscle field; otherwise similar to *Neospirifer. Permian (Asselian):* Canada (Yukon Territory).——Fig. 1193,*2a–b.* **S.*

FIG. 1190. Trigonotretidae (p. 1799).

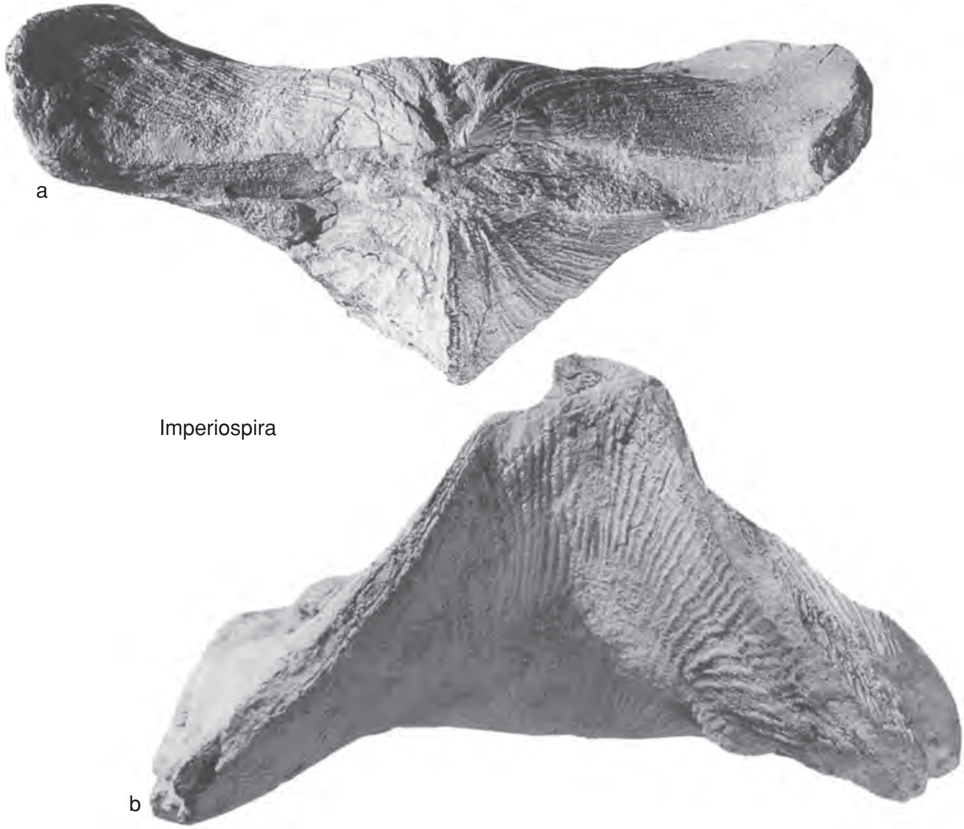

FIG. 1191. Trigonotretidae (p. 1799).

tatondukensis; ventral and dorsal valves, ×1 (Bamber & Waterhouse, 1971).

Tibetospirifer LIU & WANG, 1990, p. 388 [**T. xizangensis;* OD]. Medium size; transverse, maximum width at or near hinge line; lateral slopes with moderately numerous plicae separated by broad interspaces, each plica with 2 finer costae; sulcus with several costae, median costa bifurcating; microornament unknown; ventral interior simple, dental adminicula and delthyrial plate apparently absent. *Carboniferous (Pennsylvanian)–Permian:* Tibet, Siberia.——FIG. 1193,*3a–c.* **T. xizangensis,* Pennsylvanian, Tibet; dorsal, ventral, and posterior views, ×1 (Liu & Wang, 1990).

Subfamily TRIGONOTRETINAE Schuchert, 1893

[Trigonotretinae SCHUCHERT, 1893, p. 156]

Transverse; commonly thick shelled; fold and sulcus moderately developed; lateral slopes weakly to strongly plicate, variably fasciculate; finer ribbing medium to coarse, often forming unequal ribs anteriorly; microornament capillate and variably cancellate; ventral interior with dental adminicula, obscured by thick, apical, commonly bulbous, delthyrial callus. *Carboniferous (Visean)–Permian (Kungurian).*

Trigonotreta KÖNIG, 1825, p. 3 [**T. stokesi;* SD HALL & CLARKE, 1893, p. 8] [=*Grantonia* BROWN, 1953, p. 60 (type, *G. hobartensis,* OD)]. Medium to large, thick shelled, moderately to strongly transverse; cardinal extremities highly variable; maximum width variable; fold and sulcus moderately developed; lateral slopes strongly plicate with 3 to 5 fasciculate, unequal costae per plica; variably lamellose; ventral interior much thickened by callus; delthyrium occluded by bulbous callus; dental adminicula buried in callus in adults; muscle field

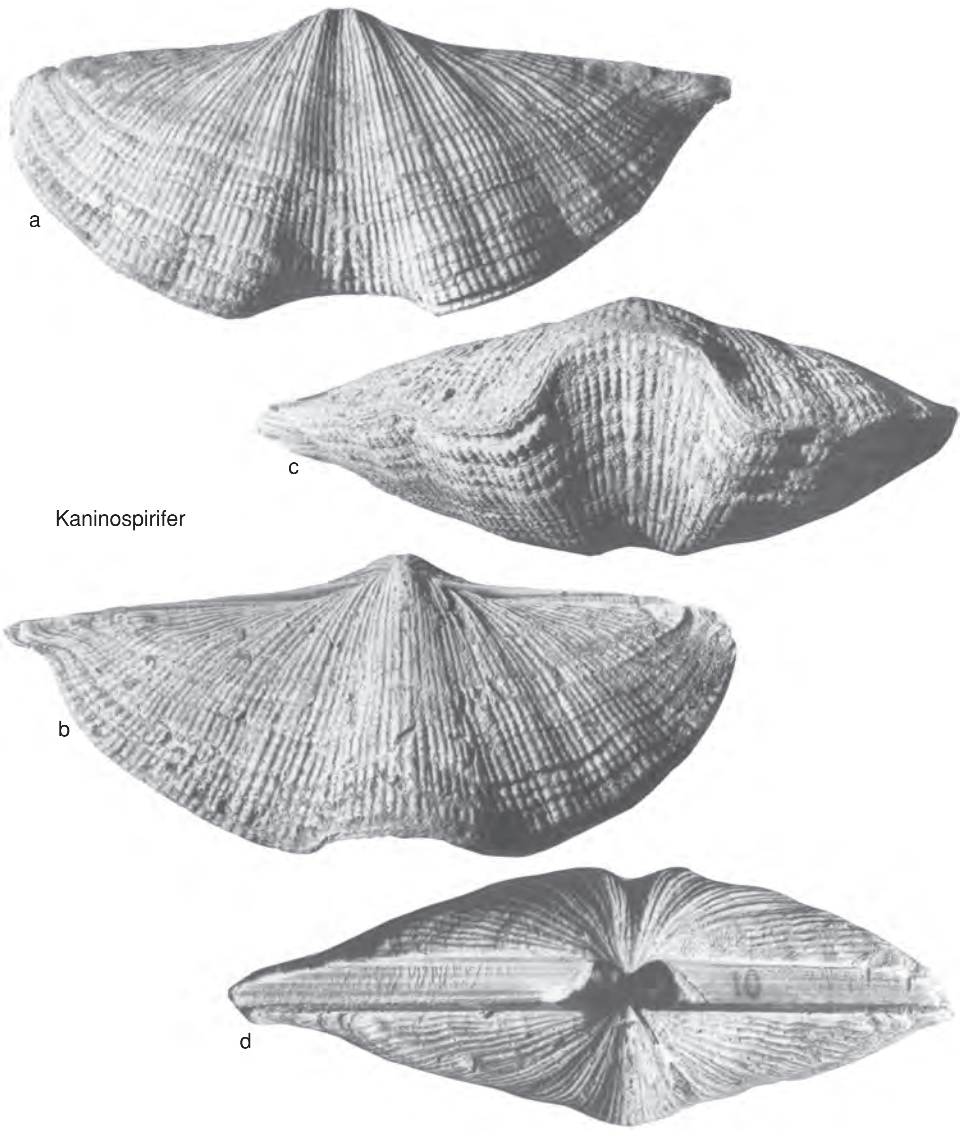

FIG. 1192. Trigonotretidae (p. 1799).

deeply incised. *Permian (?Asselian–?Kungurian):* Australia.——FIG. 1195,*2a–e*. **T. stokesi,* Tamarian, Tasmania; *a,* ventral valve; *b–c,* lectotype, dorsal and lateral views; *d–e,* ventral interior, dorsal interior, ×1 (Clarke, 1979).

Aperispirifer WATERHOUSE, 1968, p. 35 [**Neospirifer wairakiensis* WATERHOUSE, 1964, p. 127; OD]. Medium to large, transverse, alate in early growth stages; cardinal extremities variable in adults; lateral slopes with weak plicae that become weaker or disappear anteriorly; entire surface covered with numerous bifurcating subequal costae; some species lamellose; otherwise similar to *Trigonotreta. Permian (Artinskian–Kungurian):* New Zealand, Australia. ——FIG. 1196*a–e*. **A. wairakiensis* (WATERHOUSE), Ufimian, New Zealand; *a,* holotype, ventral valve; *b–d,* paratype, ventral, dorsal, and anterior views, ×1; *e,* ventral interior, ×2 (Waterhouse, 1964).

Brachythyrinella WATERHOUSE & GUPTA, 1978, p. 425 [**Spirifer narsarhensis* REED, 1928, p. 379; OD]. Small, thin shelled for family; outline transversely subovate; cardinal extremities rounded; lateral

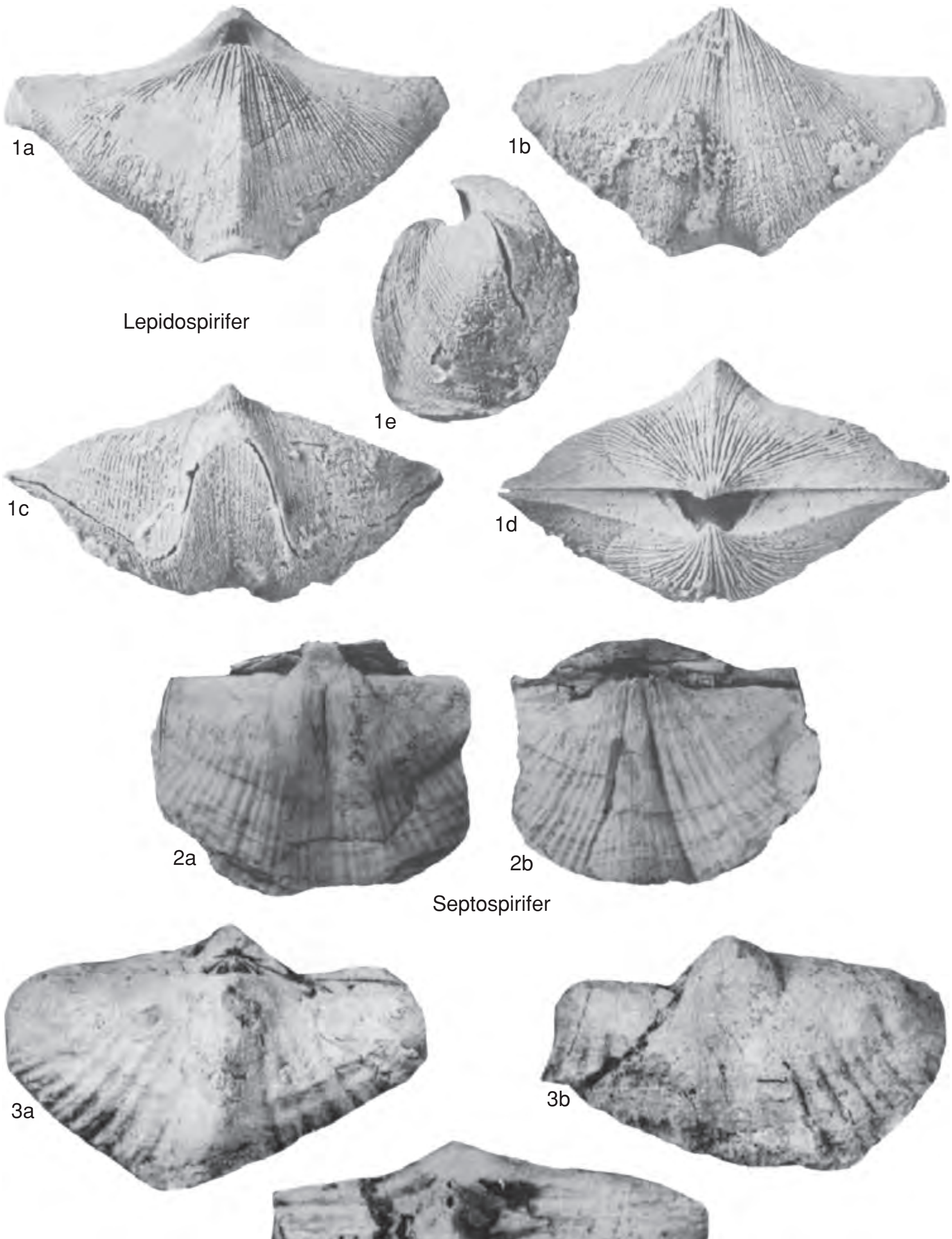

FIG. 1193. Trigonotretidae (p. 1799–1801).

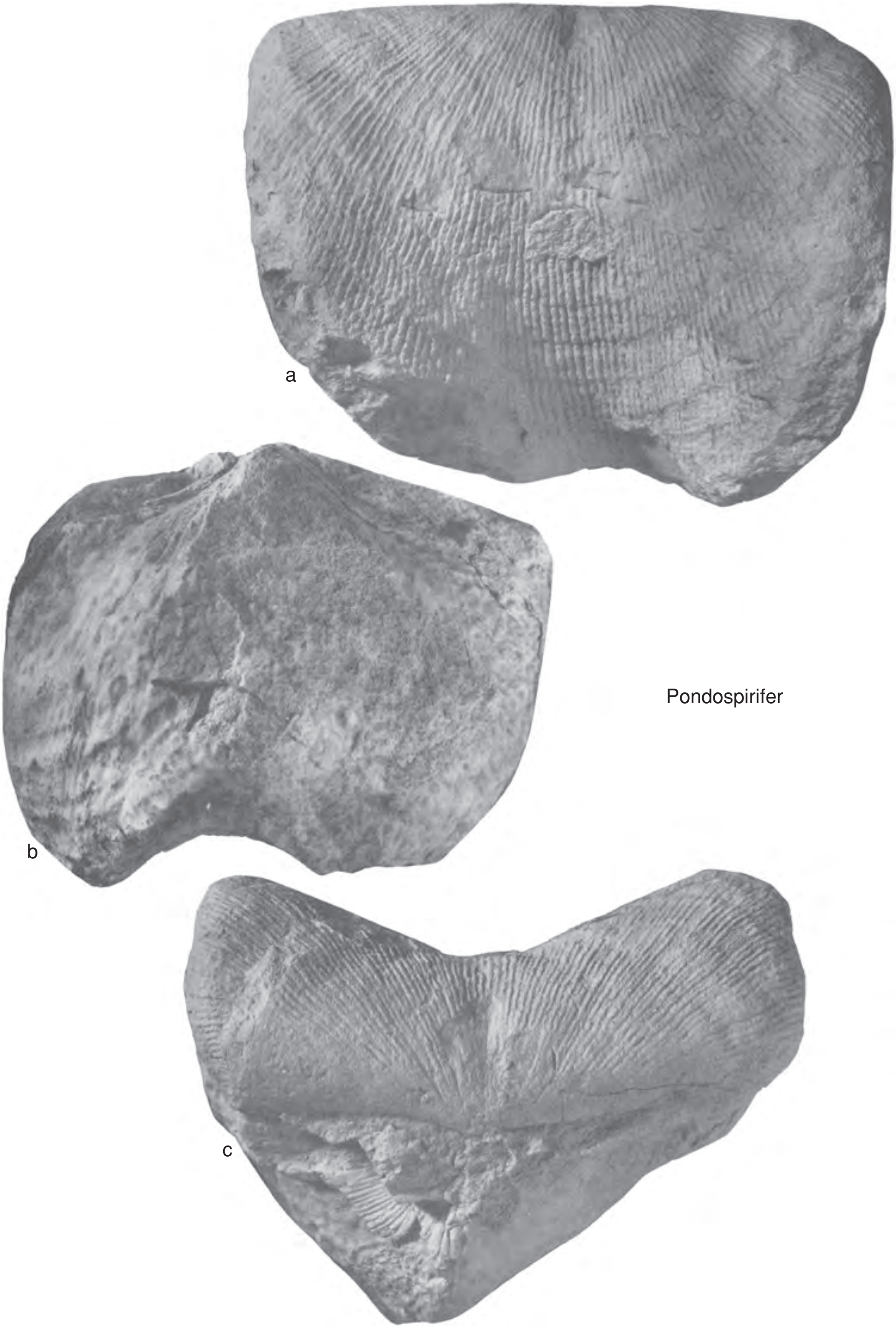

FIG. 1194. Trigonotretidae (p. 1799).

slopes with several plicae, several of which may weakly bifurcate or trifurcate anteriorly; fold and sulcus plicate; sulcus with coarse median plica and one or more pairs of weak subplicae that split from sulcus-bounding plicae; slightly lamellose; ventral interior with short dental adminicula; lacking delthyrial plate or umbonal callus. *Permian (Cisuralian):* India, Western Australia.——FIG. 1195,*1a–e.* **B. narsarhensis* (REED), India; *a–c,* syntype, dorsal, ventral, and anterior views, ×2 (Reed, 1928); *d–e,* topotype, ventral valve and interior, ×2 (Thomas, 1971).

Frechella LEGRAND-BLAIN, 1986, p. 32 [**Neospirifer fascicostatus gwinneriformis* LEGRAND-BLAIN, 1971, p. 203; OD]. Medium to large, strongly transverse, outline subtrigonal to subsemicircular; greatest width at hinge line; cardinal extremities alate to mucronate; lateral slopes with several weak plicae and numerous costae forming fascicles of 3, rarely 2 or 4, unequal ribs per plica; ventral interior with short dental adminicula and thick umbonal callus; microornament finely reticulate. *Carboniferous (Visean–Serpukhovian):* northern Africa.——FIG. 1197,*1.* **F. gwinneriformis* (LEGRAND-BLAIN), upper Visean, Algeria; holotype, ventral valve, ×1 (Legrand-Blain, 1971).

Sulciplica WATERHOUSE, 1968, p. 25 [**S. transversa;* OD]. Large to very large; strongly transverse; cardinal extremities alate; fold and sulcus narrow, moderately well developed; lateral slopes with moderately numerous, usually simple, subangular plicae; costae absent; fold and sulcus with several coarse simple plicae; ventral interarea moderately high, flattened; ventral interior with thick apical callus obscuring internal structures; delthyrium occluded by large, bulbous apical callus; microornament subcancellate, growth lamellae subimbricate. *Permian (Kungurian):* New Zealand, eastern Australia.——FIG. 1197,*2a–d.* **S. transversa; a–b,* ventral and dorsal valves, New South Wales, Australia, ×1 (Waterhouse, 1968); *c–d,* ventral and dorsal valves, Tasmania, ×1 (Clarke, 1987).

Family SPIRIFERELLIDAE Waterhouse, 1968

[*nom. transl.* TERMIER & others, 1974, p. 136, *ex* Spiriferellinae WATERHOUSE, 1968, p. 9]

Lateral slopes plicate, coarsely costate, or fasciculate; fold usually with median furrow; delthyrium commonly partially or completely occluded by convex stegidial plates; denticulation poorly developed in narrow-hinged genera; microornament pustulose, commonly capillate; ventral interior with strong, short dental adminicula; ventral umbonal region often greatly thickened by callus with deeply impressed ventral muscle field. *Carboniferous (Bashkirian)–Permian (Capitanian).*

Spiriferella CHERNYSHEV, 1902, p. 121 [**Spirifer saranae* DE VERNEUIL, 1845, p. 169; OD]. Medium to large, usually elongate; hinge line moderately wide, cardinal extremities rounded in juveniles, variably mucronate or rounded in adults; maximum width usually anterior to hinge line; ventral umbonal region greatly inflated; delthyrium partially or completely covered by stegidia; ribbing in sulcus highly variable; lateral slopes strongly plicate; plicae broad, rounded, simple to costate, with fasciculate costae in some species; fold normally with median groove; microornament consisting of capillae, concentrically arranged pustules, and fine, regular growth lines; ventral valve greatly thickened with secondary shell matter; ventral interior with short, diverging dental adminicula, thick umbonal callus, and deeply impressed muscle field. *Carboniferous (Bashkirian)–Permian (Capitanian):* cosmopolitan.——FIG. 1198,*1a–d.* **S. saranae* (DE VERNEUIL), Cisuralian, Russia; *a–c,* ventral, lateral, and posterior views of ventral valve; *d,* dorsal valve, ×1 (Chernyshev, 1902).

Alispiriferella WATERHOUSE & WADDINGTON, 1982, p. 30 [**Spirifer (Spiriferella) keilhavii* var. *ordinaria* EINOR, 1939, p. 140; OD]. Medium size, moderately transverse; cardinal extremities alate in early growth stages, rounded in adults; outline subrectangular to subovate; fold with wide, well-defined median groove; otherwise similar to *Spiriferella. Permian (Asselian–Capitanian):* Russia (Novaya Zemlya), Yukon Territory, Canada (Arctic Islands).——FIG. 1198,*4a–c.* **A. ordinaria* (EINOR), Cisuralian, Novaya Zemlya; *a,* syntype, ventral valve; *b–c,* syntype, dorsal and anterior views, ×1 (new).

Arcullina WATERHOUSE, 1986b, p. 4 [**Spiriferina polaris* WIMAN, 1914, p. 39; OD]. Fold lacking median groove or sulcus; plicae on lateral slopes possibly lacking costae; otherwise similar to *Spiriferella. Permian (Artinskian–Roadian):* Urals, Western Australia, Arctic Islands.——FIG. 1198,*3a–d.* **A. polaris* (WIMAN), Kungurian, Spitzbergen; *a,* ventral interior; *b–d,* anterior, lateral, and dorsal views, ×1 (Wiman, 1914).

Elivina FREDERIKS, 1924, p. 315 [**Spirifer tibetanus* DIENER, 1897a, p. 45; OD] [=*Dienerina* OZAKI, 1931, p. 25, obj.]. Small to medium size; outline longitudinally ovate to chordate; hinge line narrow; microornament of capillae and fine growth lamellae, pustules variably present; otherwise similar to *Spiriferella. Permian (Sakmarian–Roadian):* India, Australia, Yukon Territory, USA (Texas).——FIG. 1199,*2a–e.* **E. tibetanus* (DIENER), Chhidruan–Kalabaghian, Himalayas; syntype, ventral, dorsal, lateral, posterior, and anterior views, ×1 (Diener, 1897a).

Eridmatus BRANSON, 1966, p. 75 [**Spirifer (?Trigonotreta) texanus* MEEK, 1871, p. 179; OD]. Small,

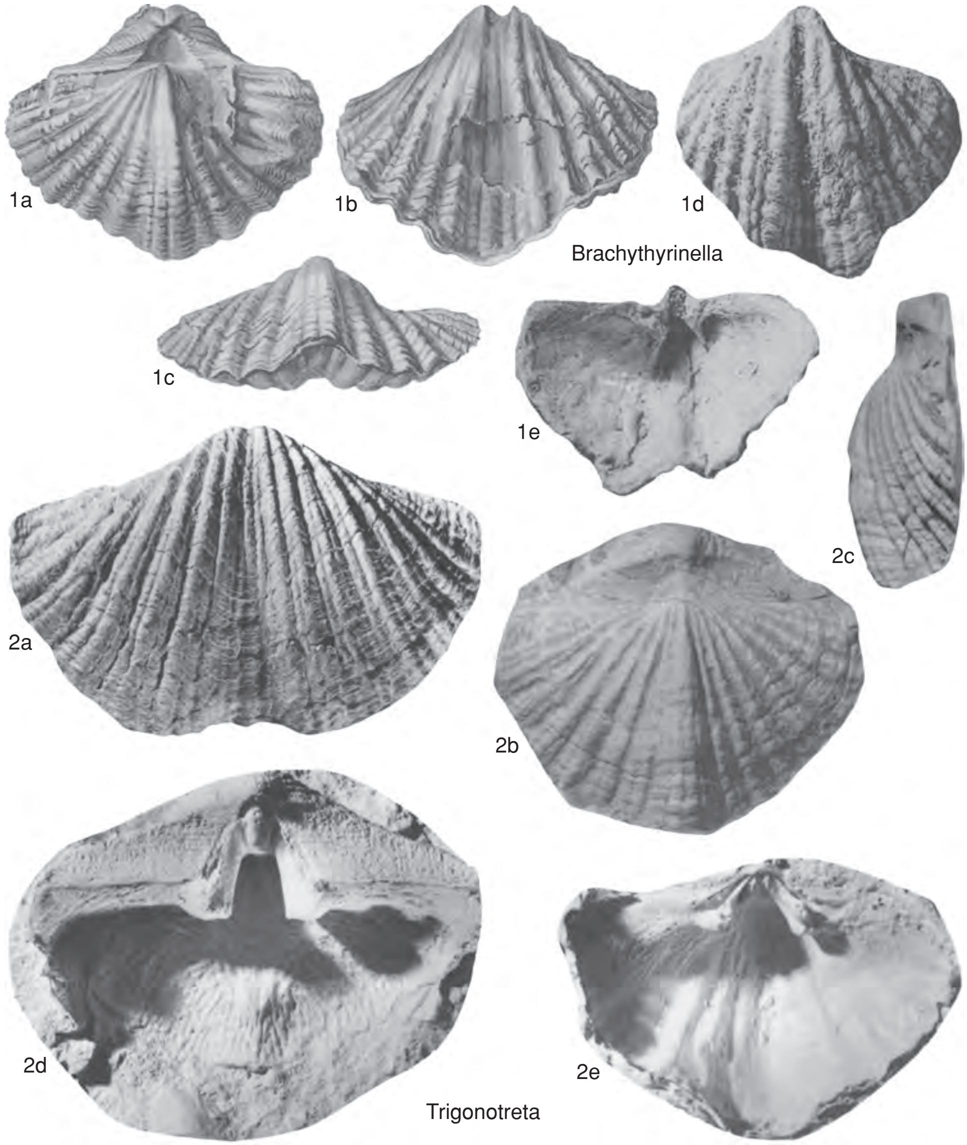

FIG. 1195. Trigonotretidae (p. 1801–1805).

elongate; hinge line extended, about equal to maximum width; cardinal extremities abruptly terminated, angular or slightly mucronate; apex of delthyrium with small, convex stegidium; fold and sulcus V-shaped, strongly developed; fold with shallow median groove posteriorly; lateral slopes with numerous strong, rounded, nearly uniform costae arranged in fascicles, forming plicae posteriorly; otherwise similar to *Spiriferella. Carboniferous (Moscovian), Permian (Asselian):* North America, Russia.——FIG. 1199,*1a–d*. **E. texanus* (MEEK), Desmoinesian, Kansas, USA; dorsal, ventral, lateral, and anterior views, ×1 (Spencer, 1967).

Plicatospiriferella WATERHOUSE & WADDINGTON, 1982, p. 34 [**P. canadensis;* OD]. Small, with 6 or more simple plications on each lateral slope that extend to anterior margin; few costae except in sul-

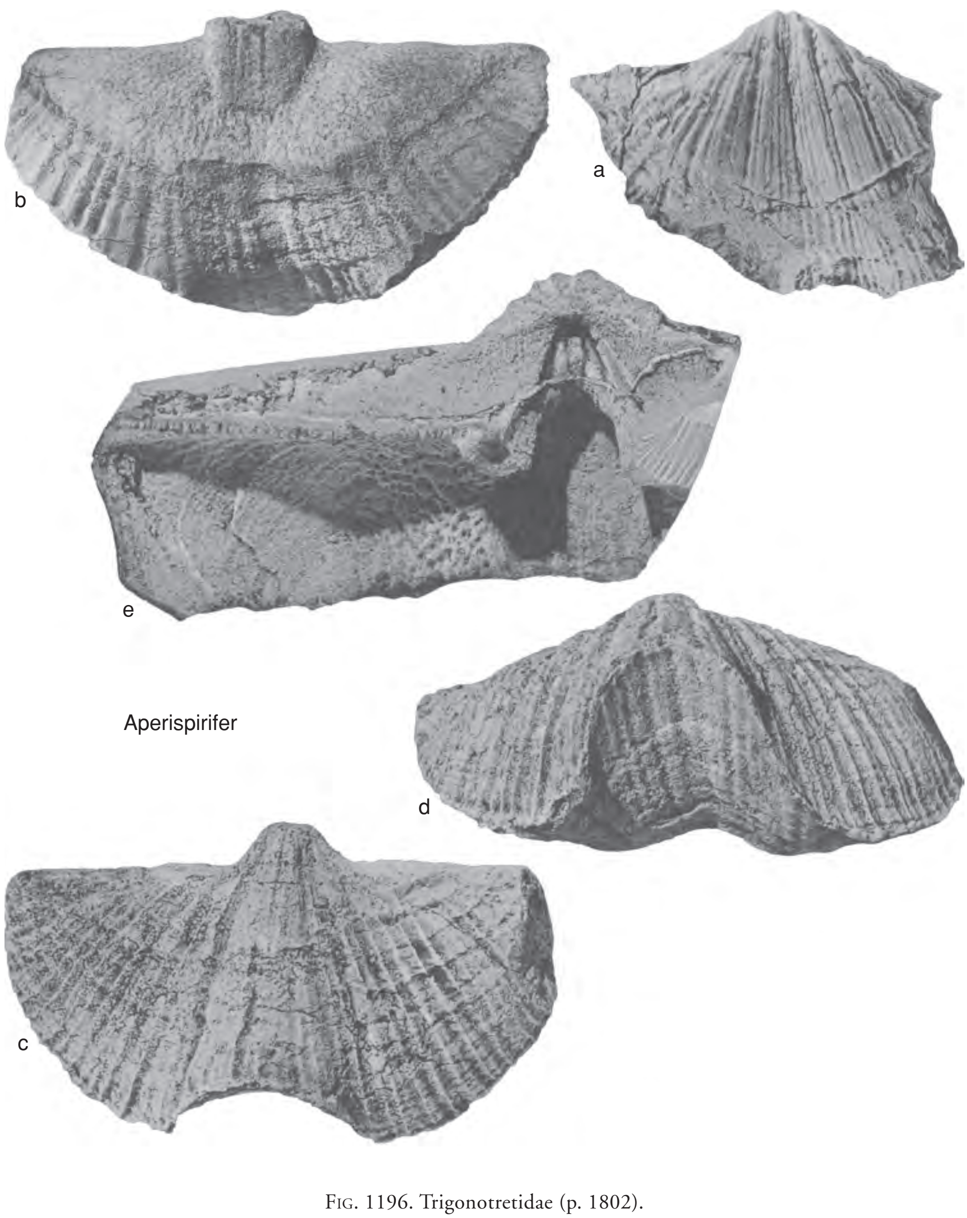

FIG. 1196. Trigonotretidae (p. 1802).

cus; fold and sulcus moderately developed; otherwise similar to *Eridmatus. Carboniferous (Moscovian, ?Gzhelian):* Canada (Yukon Territory).——FIG. 1199,*4a–c.* **P. canadensis,* Moskovian; holotype, dorsal, lateral, and ventral views, ×2 (Waterhouse & Waddington, 1982).

Rhombospirifer DUAN & LI, 1985, p. 134 [**R. zhesiensis;* OD]. Large, transversely rhomboidal in outline, with alate cardinal extremities; delthyrium covered by stegidium; fold and sulcus well defined, smooth or with very weak costae; crest of fold slightly flattened, grooved; lateral slopes with few plicae; plicae with bifurcating or trifurcating, slightly fasciculate costae; both valves greatly thickened by secondary shell material; otherwise similar to *Timaniella. Permian (Cisuralian):* Inner

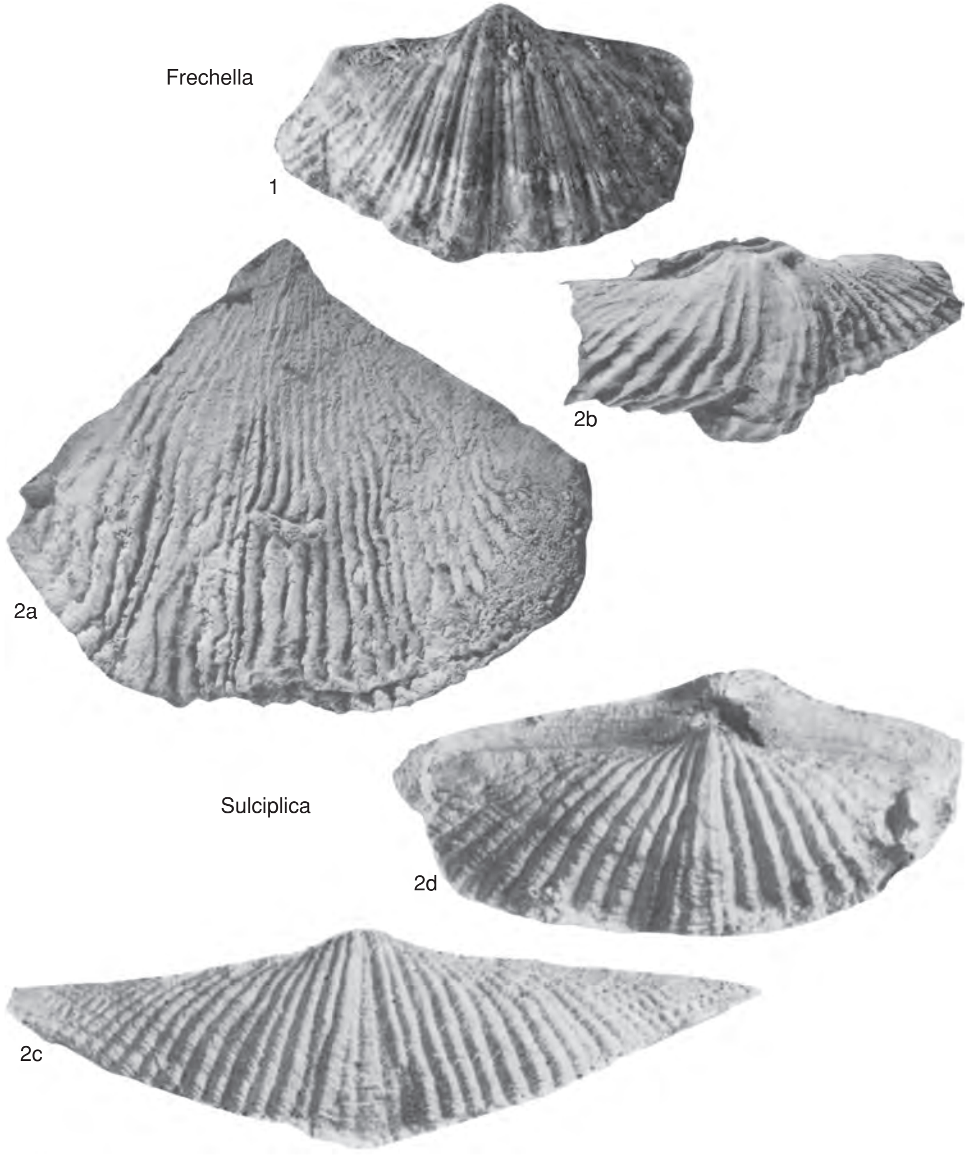

FIG. 1197. Trigonotretidae (p. 1805).

Mongolia.——FIG. 1200*a–d.* **R. zhesiensis;* ventral, dorsal, lateral, and anterior views, ×1 (Duan & Li, 1985).

?Spiriferelloides LI, GU, & LI in LI & GU, 1985, p. 125 [**S. xiuqienensis;* OD] [=*Spiriferellaoides* LI, GU, & LI, 1980, p. 26, *nom. nud.* (type, *S. xiujumuqinensis,* OD)]. Large; ventral interarea high; delthyrium large; fasciculate costae on lateral slopes complexly bifurcated; ventral muscle scars sagittate; otherwise similar to *Spiriferella.* [This genus is based on a single poor specimen and is virtually unrecognizable.] *Permian (Cisuralian):* Inner Mongolia.

Timaniella BARKHATOVA, 1968, p. 162 [**T. festa;* OD]. Medium size; outline transversely subsemicircular to subtrigonal; cardinal extremities alate to slightly mucronate; delthyrium partially closed by narrow stegidial plates; lateral slopes moderately to strongly plicate; medial plicae costate, fasciculate; fold and sulcus moderately narrow, well delimited; sulcus

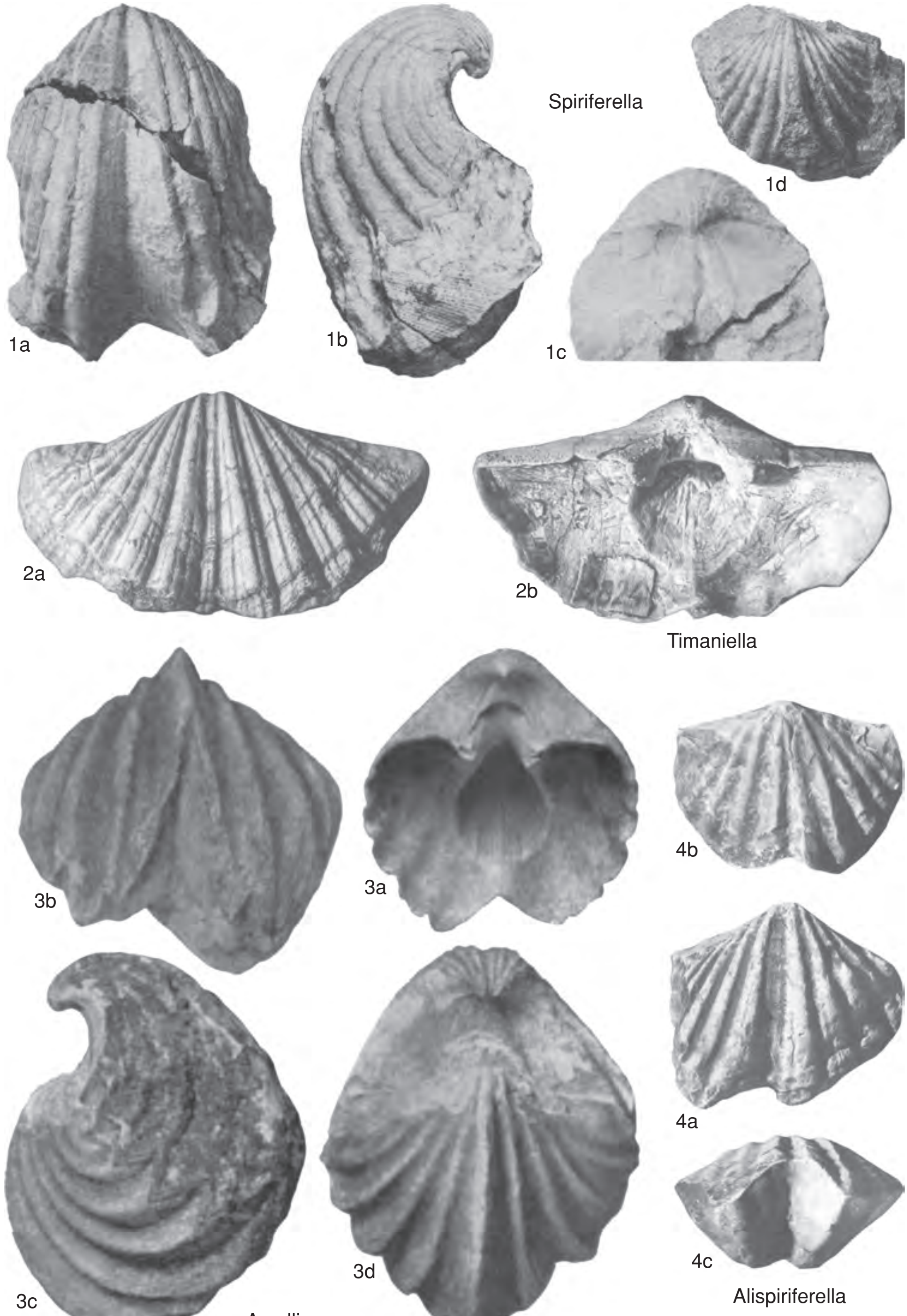

FIG. 1198. Spiriferellidae (p. 1805–1811).

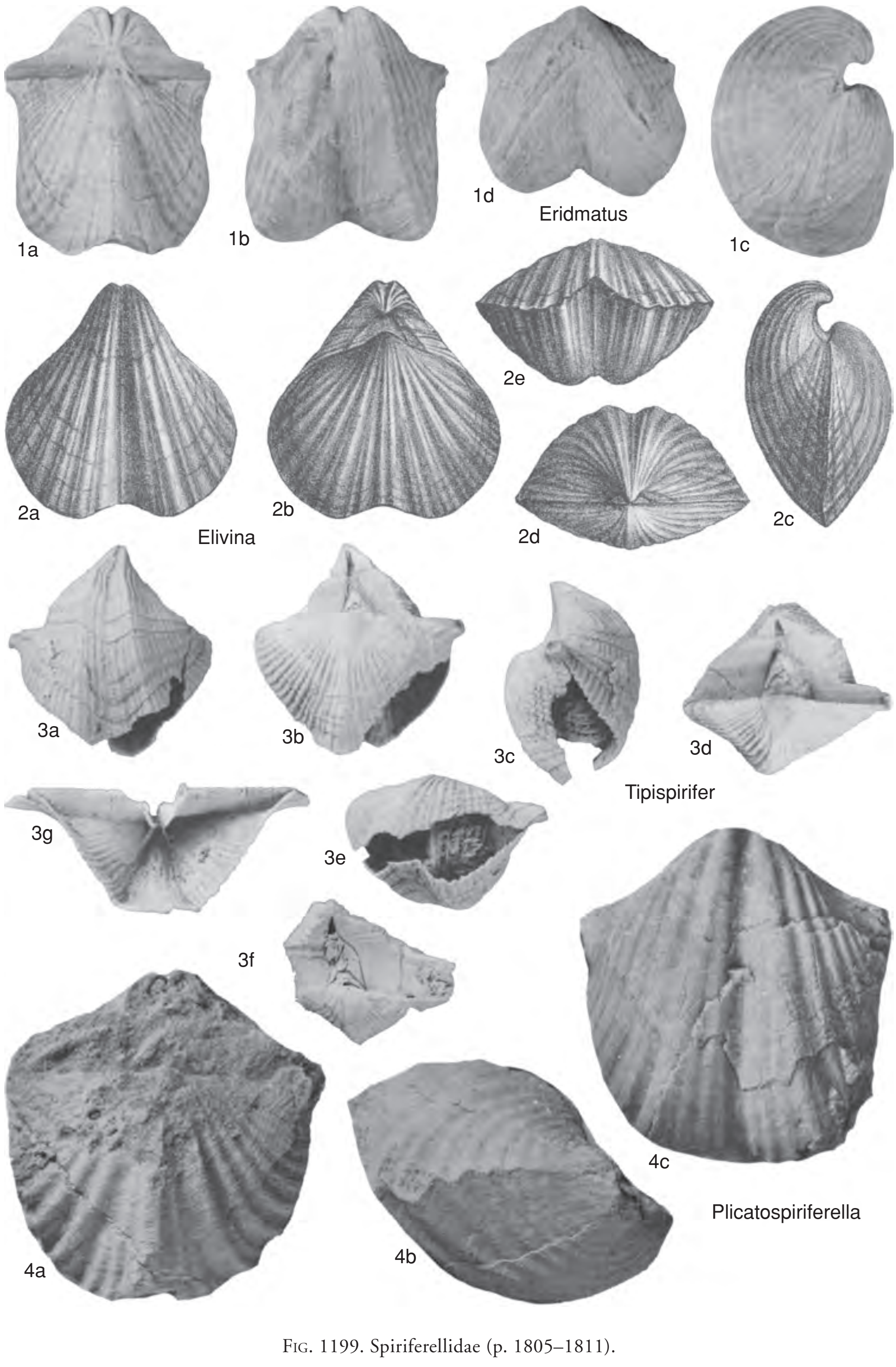

FIG. 1199. Spiriferellidae (p. 1805–1811).

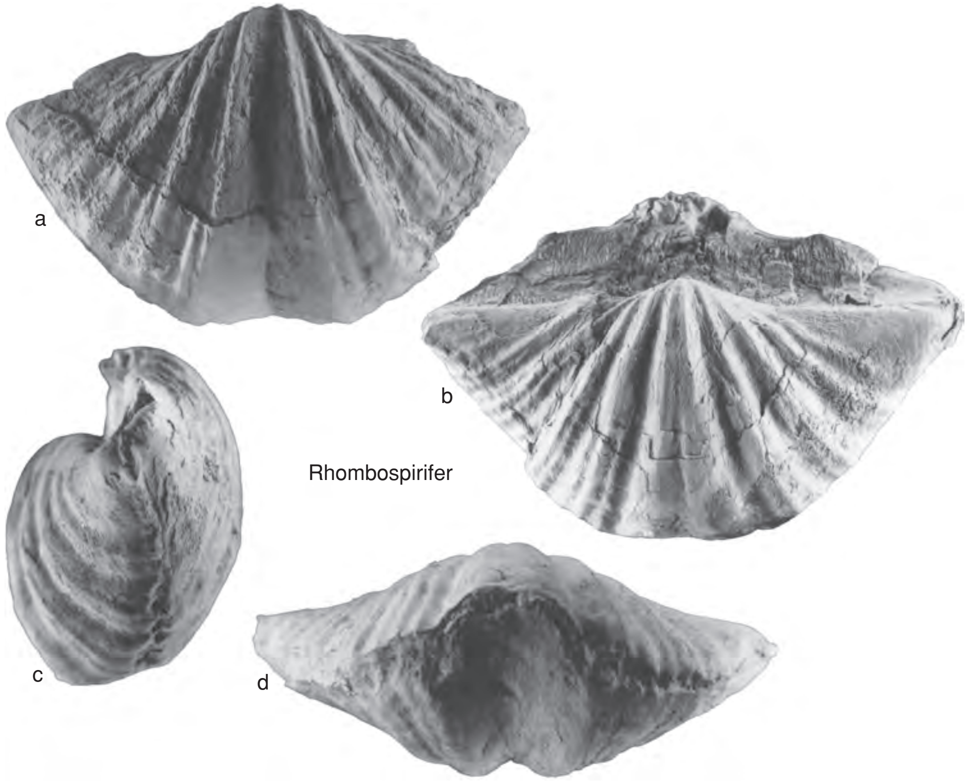

FIG. 1200. Spiriferellidae (p. 1807–1808).

with median plica and several lateral costae; fold with distinct median groove; ventral interior with thick delthyrial callus; muscle field moderately impressed, adductor scars long, narrow; diductor scars broad, longitudinally striated. *Permian (Kungurian–Roadian):* Russia (northern Timan), Canadian Arctic Islands.——FIG. 1198,*2a–b*. **T. festa,* Kungurian, northern Timan; holotype, ventral exterior and interior, ×1 (new).

Tipispirifer GRANT, 1976, p. 213 [**T. oppilatus;* OD]. Small for family; outline transversely subtrigonal to subrhomboidal; hinge line wide, denticulate; cardinal extremities greatly extended, mucronate; ventral beak and umbonal region narrow, slightly incurved; ventral interarea high, slightly concave; delthyrium narrow, occluded by imbricating stegidial plates; fold and sulcus moderately developed, narrow, well delimited; entire surface costate with numerous fine, well-defined, rounded costae with narrow interspaces, increasing by both intercalation and bifurcation; microornament finely pustulose; ventral interior with false spondylium formed by converging dental flanges; dental adminicula short, divergent. *Permian (Artinskian):* Thailand.——FIG. 1199,*3a–g*. **T. oppilatus; a–e,* holotype, ventral, dorsal, lateral, posterior, and anterior views; *f,* posterior view showing stegidial plates; *g,* ventral interior, ×2 (Grant, 1976).

PAECKELMANELLOIDEA

J. L. Carter

[retired from Carnegie Museum of Natural History]

Superfamily PAECKELMANELLOIDEA Ivanova, 1972

[*nom. correct.* Carter in Carter & others, 1994, p. 347, *pro* Paeckelmanellacea Ivanova, 1981, p. 22, *nom. transl. ex* Paeckelmanellidae Ivanova, 1972, p. 40]

Moderately to strongly transverse with maximum width at hinge line; ribs usually simple on flanks but geologically younger forms sometimes with bifurcations; fold and sulcus smooth or with median rib in sulcus, or more rarely, multicostate; ventral interarea usually moderately to very high, often catacline to slightly procline or weakly apsacline; hinge line denticulate; microornament usually consisting of capillae and anteriorly free growth lamellae; dental adminicula usually present; vascular markings simple, radial; crural plates and dorsal adminicula lacking; ctenophoridium present. *Upper Devonian (Famennian)–Permian (Lopingian).*

Family STROPHOPLEURIDAE Carter, 1974

[*nom. transl.* Carter in Carter & others, 1994, p. 347, *ex* Strophopleurinae Carter, 1974, p. 677]

Ventral septum absent. *Upper Devonian (Famennian)–Permian (Lopingian).*

Subfamily STROPHOPLEURINAE Carter, 1974

[Strophopleurinae Carter, 1974, p. 677]

Small, with simple lateral ribs; sulcus smooth or with median rib. *Upper Devonian (Famennian)–Carboniferous (Pennsylvanian).*

Strophopleura Stainbrook, 1947, p. 324 [**Spirifer notabilis* Kindle, 1909, p. 26; OD]. Small, transverse, subequally biconvex; beak ridges nearly parallel; ventral interarea apsacline; fold and sulcus narrow, rounded, smooth; flanks with numerous strong, simple costae that become discordant and nearly perpendicular to hinge laterally; growth lamellae strong and regularly spaced; short dental adminicula buried in thick callus. *Upper Devonian (Famennian):* USA (New Mexico, Colorado).——Fig. 1201,*1a–e.* **S. notabilis* (Kindle); anterior, dorsal, ventral, posterior, and lateral views, ×1 (Cooper & Dutro, 1982).

Acuminothyris Roberts, 1963, p. 15 [**A. triangularis;* OD]. Medium size; very strongly transverse, alate, subequally biconvex; ventral interarea low, apsacline to nearly orthocline; flanks with numerous simple ribs; fold and sulcus smooth; fold-bounding ribs disproportionately strong; sulcus-bounding interspaces very deep; capillae faint; subimbricate growth lamellae regularly spaced; ventral interior with short, divergent dental adminicula. *Carboniferous (upper Tournaisian–middle Visean):* Australia, USA (Missouri).——Fig. 1201,*4a–c.* **A. triangularis; a–b,* dorsal valve, ventral valve; *c,* holotype, posterior view of natural mold, ×1.5 (Roberts, 1963).

Avisyrinx Martinez-Chacon, 1975, p. 33 [**A. obsoleta;* OD]. Small, strongly transverse, alate, with high, concave, nearly catacline ventral interarea; lateral slopes with numerous weak, simple costae; fold and sulcus well differentiated; both fold and sulcus with very strong median plications producing bicarinate anterior profile; ventral interior with closely set dental adminicula, and short umbonal callosity that simulates delthyrial plate or syrinx; delthyrium nearly closed by stegidium. *Carboniferous (Pennsylvanian):* Spain.——Fig. 1201,*2a–f.* **A. obsoleta; a–d,* holotype, ventral, dorsal, lateral, and anterior views, ×2; *e–f,* transverse sections, ×4 (Martinez-Chacon, 1975).

Calvustrigis Carter, 1987, p. 68 [**Spirifer rutherfordi* Warren, 1932, p. 247; OD]. Medium size; strongly transverse with slightly mucronate cardinal extremities; smooth, rounded fold and sulcus moderately developed, well defined; ventral interarea nearly orthocline, strongly longitudinally grooved; ornament consisting of low, uniform, simple, straplike costae with narrow interspaces on flanks; microornament consisting of strong capillae only, imbricate growth lamellae absent; ventral interior with strong, slightly divergent dental adminicula and short delthyrial plate; posterior portions of both valves thickened with callus. *Carboniferous (middle Tournaisian):* Canada.——Fig. 1202,*2a–e.* **C. rutherfordi* (Warren); *a–c,* syntype, ventral, dorsal, and lateral views; *d–e,* ventral and dorsal valves, ×1 (Carter, 1987).

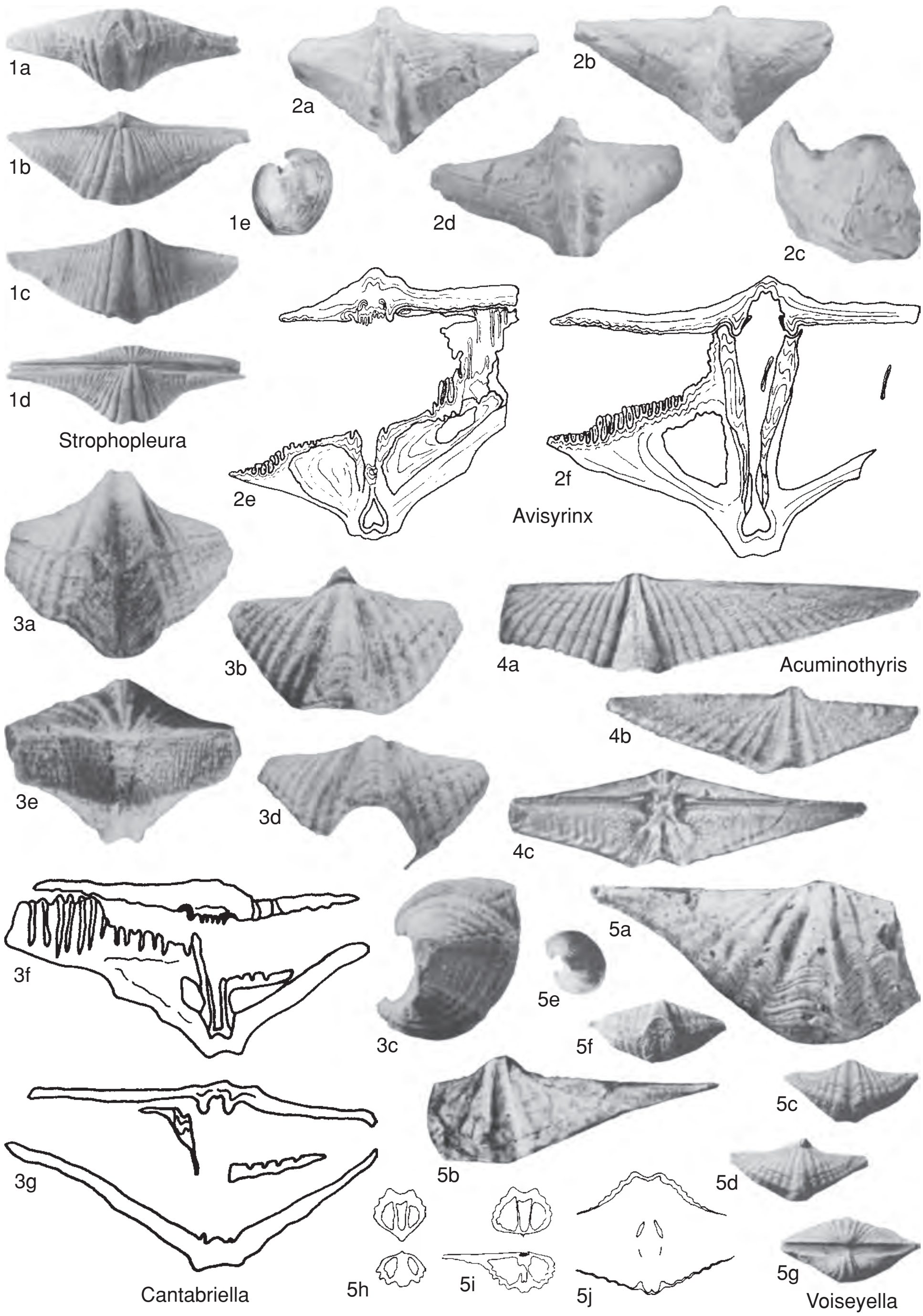

FIG. 1201. Strophopleuridae (p. 1812–1815).

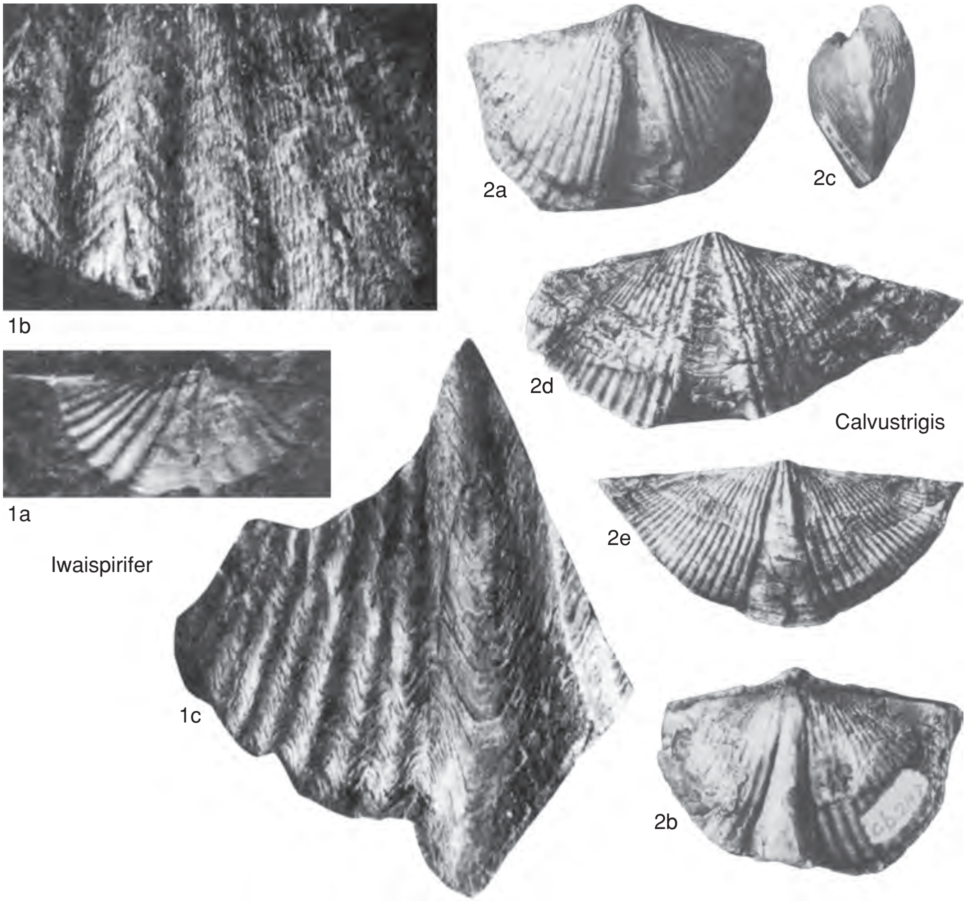

FIG. 1202. Strophopleuridae (p. 1812–1814).

Cantabriella MARTINEZ-CHACON & RIO-GARCIA, 1987, p. 21 [**Orulgania schulzi* MARTINEZ-CHACON, 1978a, p. 323; OD]. Fold and sulcus moderately broad, well developed, noncostate; ventral interarea moderately high; ventral interior with long, high, parallel dental adminicula placed within sulcus; otherwise similar to *Voiseyella. Carboniferous (Bashkirian):* northern Spain.——FIG. 1201,*3a–g.* **C. schulzi* (MARTINEZ-CHACON); *a–e,* holotype, ventral, dorsal, lateral, anterior, and posterior views, ×2; *f–g,* transverse sections, ×4 (Martinez-Chacon, 1978a).

?Iwaispirifer TACHIBANA, 1964, p. 39 [**I. striatolamellosus;* OD]. Small; transversely subtrigonal; cardinal extremities mucronate; fold and sulcus moderately developed; lateral slopes with 6 to 8 simple rounded ribs; sulcus with or without median rib; growth lamellae moderately lamellose; ventral interior with short dental adminicula fused by callus. [A denticulate hinge line has not been established for this genus.] *Upper Devonian (Famennian)–Carboniferous (Tournaisian):* Japan. ——FIG. 1202,*1a–c.* **I. striatolamellosus,* Famennian; *a,* internal mold of ventral valve, ×1.2; *b,* microornament, ×6; *c,* ventral exterior enlarged, ×2.5 (Tachibana, 1981b).

Voiseyella ROBERTS, 1964, p. 187 [**Strophopleura anterosa* CAMPBELL, 1957, p. 79; OD] [=*Amesopleura* CARTER, 1967b, p. 363 (type, *Spirifera novamexicana* MILLER, 1881, p. 314, OD)]. Small, strongly biconvex; strongly transverse, with mucronate cardinal extremities; fold and sulcus narrow, noncostate and rounded; sulcus delimited by disproportionately large sulcus-bounding costae and fold by disproportionately deep and wide fold-bounding interspaces; flanks with moderately numerous simple ribs that become smaller or indistinct laterally; growth lamellae becoming crowded and lamellose anteriorly; ventral interior with short, slender dental adminicula that follow margins of sulcus; dorsal interior with thick apical callus supporting cardinal process and long, platelike ridges that extend forward along inner crests of fold-bounding grooves. *Carboniferous (middle Tournaisian–middle Visean):* Australia, USA (Texas, Missouri, New Mexico), Canada (Alberta).——FIG. 1201,*5a–b*. **V. anterosa* (CAMPBELL); *a,* dorsal valve exterior, ×2.5; *b,* ventral exterior, ×2 (Roberts, 1964).——FIG. 1201,*5c–j*. *V. novamexicana* (MILLER), upper Tournaisian, New Mexico; *c–g,* ventral, dorsal, lateral, anterior, and posterior views, ×1; *h–j,* transverse sections, ×2 (Carter, 1967b).

Subfamily BASHKIRIINAE Nalivkin, 1979

[*nom. transl.* CARTER in CARTER & others, 1994, p. 348, *ex* Bashkiriidae NALIVKIN, 1979, p. 143]

Small to medium size; lateral ribs simple; fold and sulcus ribbed; ventral interarea moderately high to very high, often flattened, catacline to procline. *Carboniferous (Tournaisian–Visean).*

Bashkiria NALIVKIN, 1979, p. 144 [**B. gemma;* OD]. Costation weak or obscure; otherwise similar to *Celsifornix*. *Carboniferous (Tournaisian):* Russia (southern Urals).——FIG. 1203,*2a–d*. **B. gemma;* holotype, ventral, dorsal, anterior, and posterior views, ×2 (new).

Adminiculoria WATERHOUSE & GUPTA, 1979, p. 133 [**Spirifer middlemissi* DIENER, 1915, p. 41; OD]. Medium size; moderately transverse with moderately high, concave, apsacline ventral interarea; lateral slopes covered with strong, simple, subangular, regularly lamellose plicae; fold and sulcus with several weaker, bifurcating costae; ventral interior with apical callosity and short dental adminicula that may be buried in callus; denticulation not established. *Carboniferous (?Visean):* Kashmir.——FIG. 1203,*3*. **A. middlemissi* (DIENER); lectotype, dorsal valve exterior, ×2 (Diener, 1915).

Celsifornix CARTER, 1974, p. 677 [**C. rowleyi;* OD]. Medium size; strongly transverse, outline acutely trigonal, cardinal extremities alate; ventral interarea high, flattened, moderately apsacline to slightly procline; fold and sulcus well defined but moderately developed; entire surface covered with simple costae; sulcus with simple median costa; other sulcal costae simple, if present, derived from sulcus-bounding ribs; growth lamellae subimbricate, regularly spaced; ventral interior with long, slender, moderately divergent dental adminicula placed outside sulcus and very short delthyrial plate; ctenophoridium supported by stout callus. *Carboniferous (Tournaisian):* USA (Missouri, Illinois).——FIG. 1203,*4a–h*. **C. rowleyi;* holotype, ventral, dorsal, posterior, anterior, and lateral views, ×1; *f–h,* transverse sections, ×1.5 (Carter, 1974).

Fusella M'COY, 1844, p. 128 [**Spirifera fusiformis* PHILLIPS, 1836, p. 217; OD]. Small; fold and sulcus with several weak costae; growth lamellae not imbricate; ventral interior with high, subparallel dental adminicula placed well within sulcus; otherwise similar to *Voiseyella*. *Carboniferous (Visean):* British Isles.——FIG. 1203,*1a–e*. **F. fusiformis* (PHILLIPS); holotype, ventral, lateral, dorsal, posterior, and anterior views, ×1 (Waterhouse, 1970).——FIG. 1203,*1f–g*. *F. rhomboidea* (PHILLIPS); *f,* dorsal interior, ×4; *g,* ventral interior, ×3 (Brunton & Rissoné, 1976).

Subfamily PTEROSPIRIFERINAE Waterhouse, 1975

[Pterospiriferinae WATERHOUSE, 1975, p. 15]

Medium to large; ribs on flanks simple or bifurcating, rarely fasciculate; fold and sulcus smooth or with median rib, rarely costate; dental adminicula short and divergent. *Carboniferous (Pennsylvanian)–Permian (Lopingian).*

Pterospirifer DUNBAR, 1955, p. 128 [**Spirifer alatus* VON SCHLOTHEIM, 1813, p. 58; OD]. Medium size, strongly transverse with alate to mucronate cardinal extremities; ventral interarea moderately high, apsacline; delthyrium closed by strongly convex stegidium in large adults; fold and sulcus smooth, or sulcus with weak median rib; lateral slopes with moderately numerous simple or rarely bifurcating costae; growth lamellae fine and regularly spaced; ventral interior with short, divergent dental adminicula and apical callus simulating delthyrial plate. *Permian (Cisuralian–Lopingian):* Europe, Greenland, Siberia.——FIG. 1204,*2a–b*. **P. alatus* (VON SCHLOTHEIM), Germany; ventral valve, dorsal view, ×1 (Dunbar, 1955).——FIG. 1204,*2c–d*. *P. terechovi* ZAVODOVSKII, Cisuralian, Siberia; ventral and dorsal views, ×1 (Zavodovskii, 1968a).

Alispirifer CAMPBELL, 1961a, p. 434 [**A. laminosa;* OD]. Plicae on flanks rather coarse, not numerous, rarely bifurcating; fold and sulcus narrow, usually smooth, rarely with faint median costa and corresponding shallow groove on fold; stegidial cover absent; otherwise similar to *Pterospirifer*. *Carboniferous (Pennsylvanian):* Australia, South America. ——FIG. 1204,*1a–f*. **A. laminosa,* New South Wales; *a–d,* ventral valve mold, dorsal valve exterior, dorsal interior, ventral valve exterior, ×1; *e,* microornament, ×7; *f,* ventral interior, ×1 (Campbell, 1961a).

Haplospirifer LI & GU, 1976, p. 280 [**H. typicus;* OD]. Large, transversely subpentagonal to subovate in outline; ventral valve more inflated than dorsal; ventral interarea high, flattened, vertically grooved; delthyrium open; ventral beak slightly incurved; fold and sulcus strongly developed; sulcus with prominent, dorsally directed tongue; dorsal valve

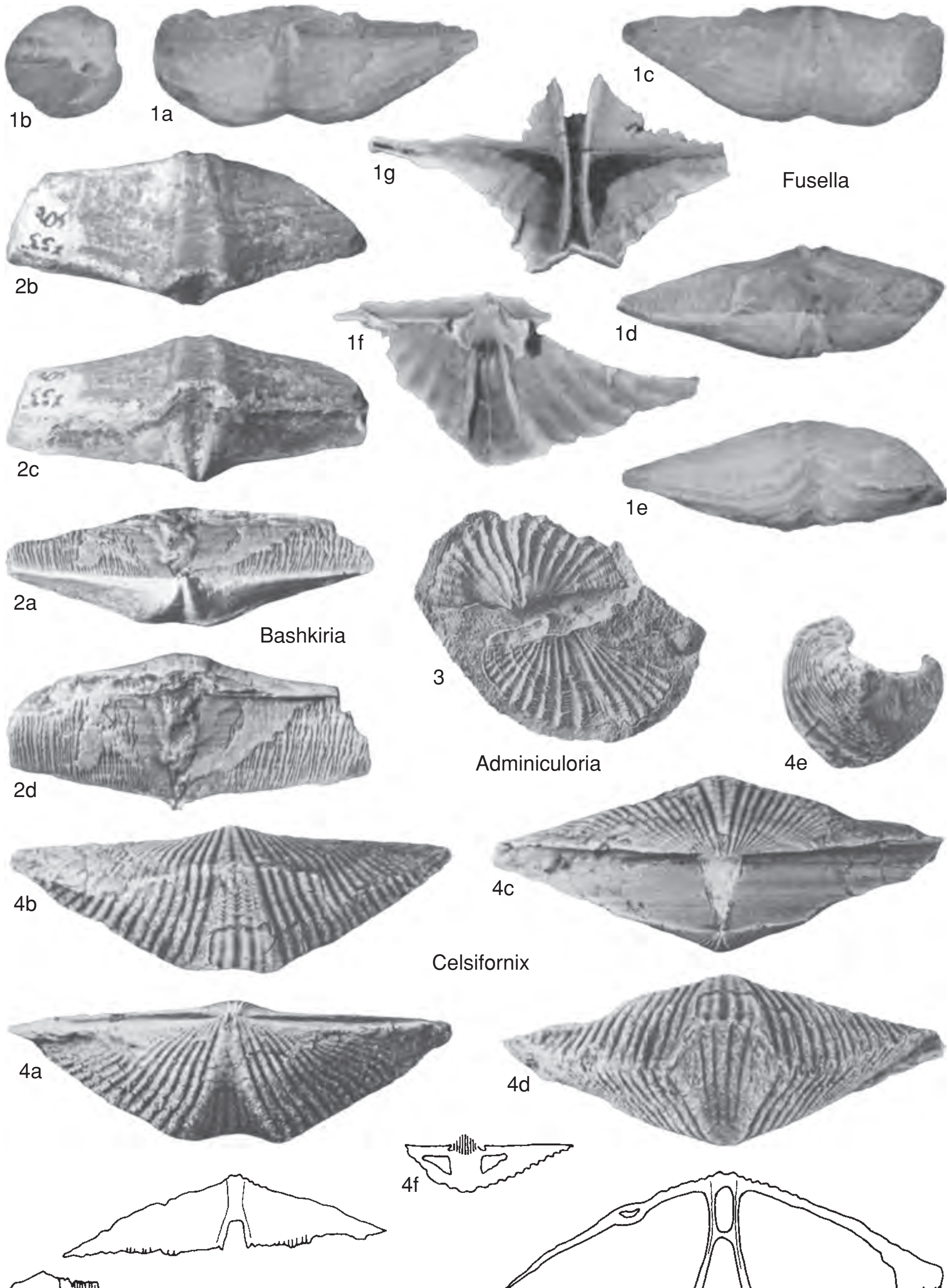

FIG. 1203. Strophopleuridae (p. 1815).

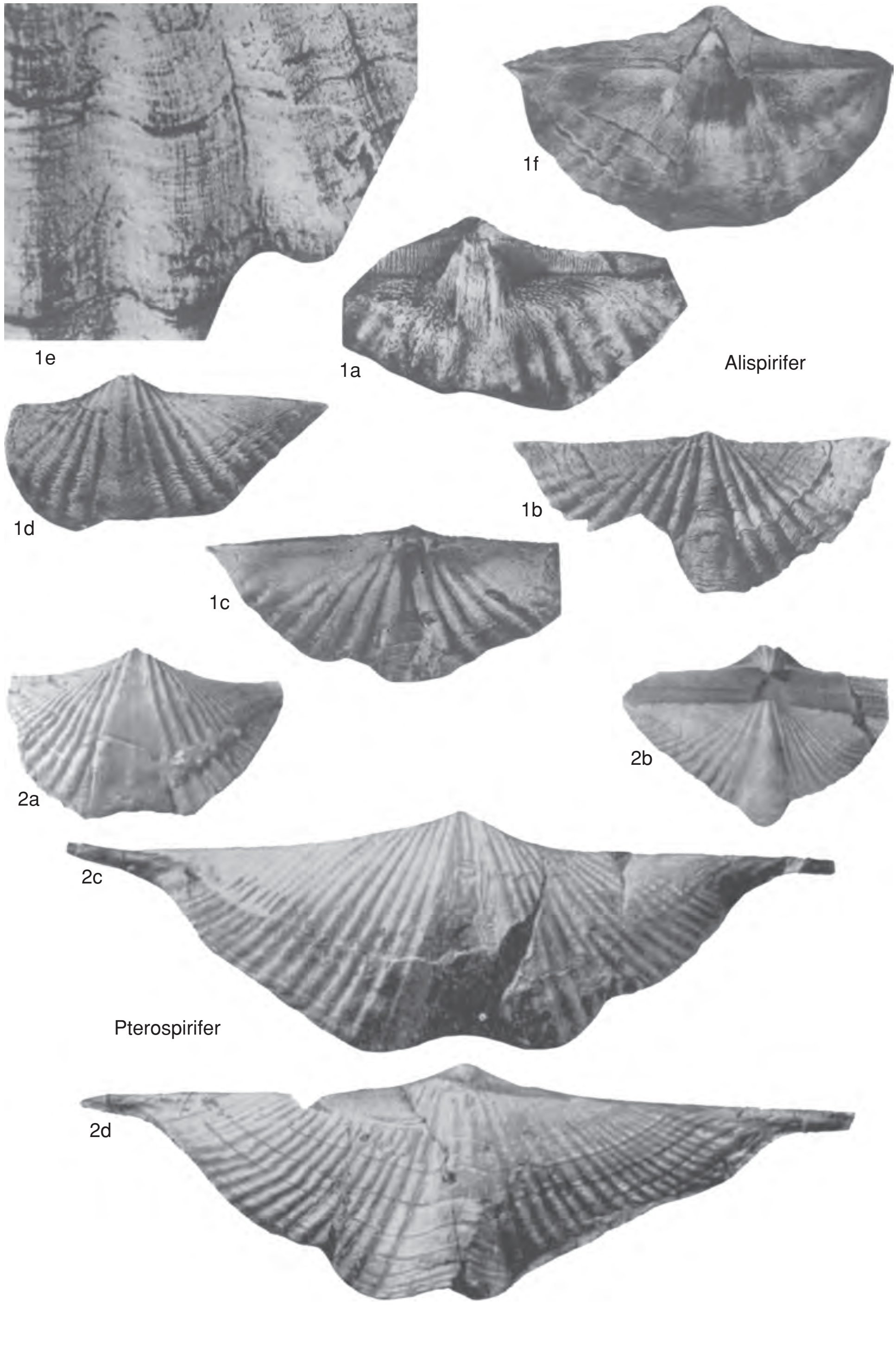

FIG. 1204. Strophopleuridae (p. 1815).

with shallow sulci adjacent to fold; lateral slopes with moderately numerous, mostly simple costae; ribs near fold-sulcus trifurcate, few others bifurcate; fold and sulcus smooth; ventral interior with short dental adminicula and large muscle scars. *Permian (Cisuralian):* China.——FIG. 1205,*4a–d*. **H. typicus;* ventral, dorsal, anterior, and posterior views, ×1 (Li & Gu, 1976).

Pteroplecta WATERHOUSE, 1978, p. 56 [**P. laminatus;* OD]. Medium to large; transverse; cardinal extremities alate; ventral interarea high; fold and sulcus well defined; flanks with few broad plicae anteriorly covered with bundled costae; fold and sulcus with several weaker costae; surface regularly lamellose and strongly capillate; ventral interior with divergent dental adminicula. *Permian (Lopingian):* Nepal.——FIG. 1205,*2a–b*. **P. laminata; a,* holotype, dorsal valve; *b,* ventral valve, ×2 (Waterhouse, 1978).

Spiriferinaella FREDERIKS, 1926, p. 407 [**Spirifer artiensis* STUCKENBERG, 1898, p. 266; OD]. Moderately to strongly transverse with alate cardinal extremities; fold and sulcus narrow, noncostate; sulcus well defined by disproportionately large bounding ribs; flanks with few simple, rounded plications; growth lamellae regularly spaced and imbricate; ventral interior with high, subparallel dental adminicula that follow margins of sulcus; apical region filled with thick callus. *Carboniferous (lower Moscovian)–Permian (Guadalupian):* southeastern Alaska, *lower Moscovian;* Russia, *Cisuralian;* USA (Texas), *Guadalupian*.——FIG. 1205,*3a*. **S. artiensis* (STUCKENBERG), Cisuralian, Russia; syntype, ventral valve, ×2 (new).——FIG. 1205,*3b–e*. *S. scalpata* COOPER & GRANT, Guadalupian, Texas; dorsal interior, dorsal, ventral, and ventral interior views, ×1 (Cooper & Grant, 1976a).

Xizispirifer LIANG, 1990, p. 323 [475] [**X. zhejiangensis;* OD]. Medium size; outline subtrigonal; strongly inequivalved, nearly planoconvex; ventral valve subconical, dorsal flattened; maximum width at hinge line; cardinal extremities angular; ventral interarea high, procline, slightly concave; perideltidial areas well defined; delthyrium open; fold and sulcus moderately well developed; lateral slopes with moderately numerous simple costae; fold smooth, well rounded; sulcus with broad median plica; surface lamellose; dental adminicula absent; ctenophoridium very wide. *Permian (Guadalupian):* China (Zhejiang).——FIG. 1205,*1a–d*. **X. zhejiangensis;* holotype, ventral, posterior, lateral, and dorsal views, ×2 (Liang, 1990).

Family PAECKELMANELLIDAE Ivanova, 1972

[Paeckelmanellidae IVANOVA, 1972, p. 40]

With ventral median septum; lateral ribs simple. *Permian (Cisuralian–Lopingian).*

Subfamily PAECKELMANELLINAE Ivanova, 1972

[*nom. transl.* WATERHOUSE, 1975, p. 15, *ex* Paeckelmanellidae IVANOVA, 1972, p. 40]

With short, divergent dental adminicula. *Permian (Cisuralian–Lopingian).*

Paeckelmanella LIKHAREV, 1934, p. 212 [**Spirifer dieneri* CHERNYSHEV, 1902, p. 535; OD]. Strongly transverse with mucronate to alate cardinal extremities; lateral slopes with increasingly weak, broad, simple plications; ventral interarea moderately high; fold smooth, carinate; sulcus with weak to strong median rib; ventral valve interior with short, divergent dental adminicula, delthyrial plate, and long, high median septum. *Permian (Cisuralian):* Russia.——FIG. 1206,*1a–f*. **P. dieneri* (CHERNYSHEV); *a,* syntype, large dorsal valve; *b–c,* dorsal and posterior views of smaller syntype; *d–f,* ventral, dorsal, and anterior views of medium syntype, ×1 (new).

Darvasia LIKHAREV, 1934, p. 212 [**D. edelsteini;* OD]. Medium size, transverse; maximum width at hinge line; ventral valve subconical, dorsal valve much thinner, weakly convex; ventral interarea very high, flattened, vertically grooved, catacline or procline, with smooth perideltidial areas; fold and sulcus narrow, moderately developed, seemingly smooth; lateral slopes with numerous narrow, weak costae; microornament unknown; ventral interior with widely divergent dental adminicula, delthyrial plate and low median septum; dorsal interior unknown. *Permian (Cisuralian):* Tajikistan.——FIG. 1206,*2a–g*. **D. edelsteini; a–e,* holotype, ventral, dorsal, anterior, posterior, and lateral views, ×1; *f–g,* enlargements of views *b* and *d,* ×2 (new).

Odontospirifer DUNBAR, 1955, p. 154 [**O. mirabilis;* OD]. Small, moderately transverse, with slightly alate cardinal extremities; sulcus moderately narrow, with single, simple median rib; fold narrow, high, rounded; flanks with few coarse, high, rounded, simple plicae; growth lamellae irregularly imbricate; ventral interior with very short dental adminicula and long, high median septum. *Permian (Lopingian):* Greenland.——FIG. 1206,*4a–e*. **O. mirabilis; a–d,* holotype, dorsal, ventral, lateral, and anterior views, ×2; *e,* ventral valve posterior, ×5 (Dunbar, 1955).

Subfamily SCENESIINAE Carter, 1994

[Scenesiinae CARTER in CARTER & others, 1994, p. 348]

With short, apical delthyrial plate; dental adminicula absent. *Permian (Cisuralian).*

Scenesia COOPER & GRANT, 1976b, p. 2,756 [**S. extensa;* OD]. Small; transversely subtriangular in outline; cardinal extremities widely extended, alate; fold and sulcus well delineated by strong, coarse plicae on ventral valve and deep, wide interspaces or sulci on dorsal valve; fold high, rounded carinate;

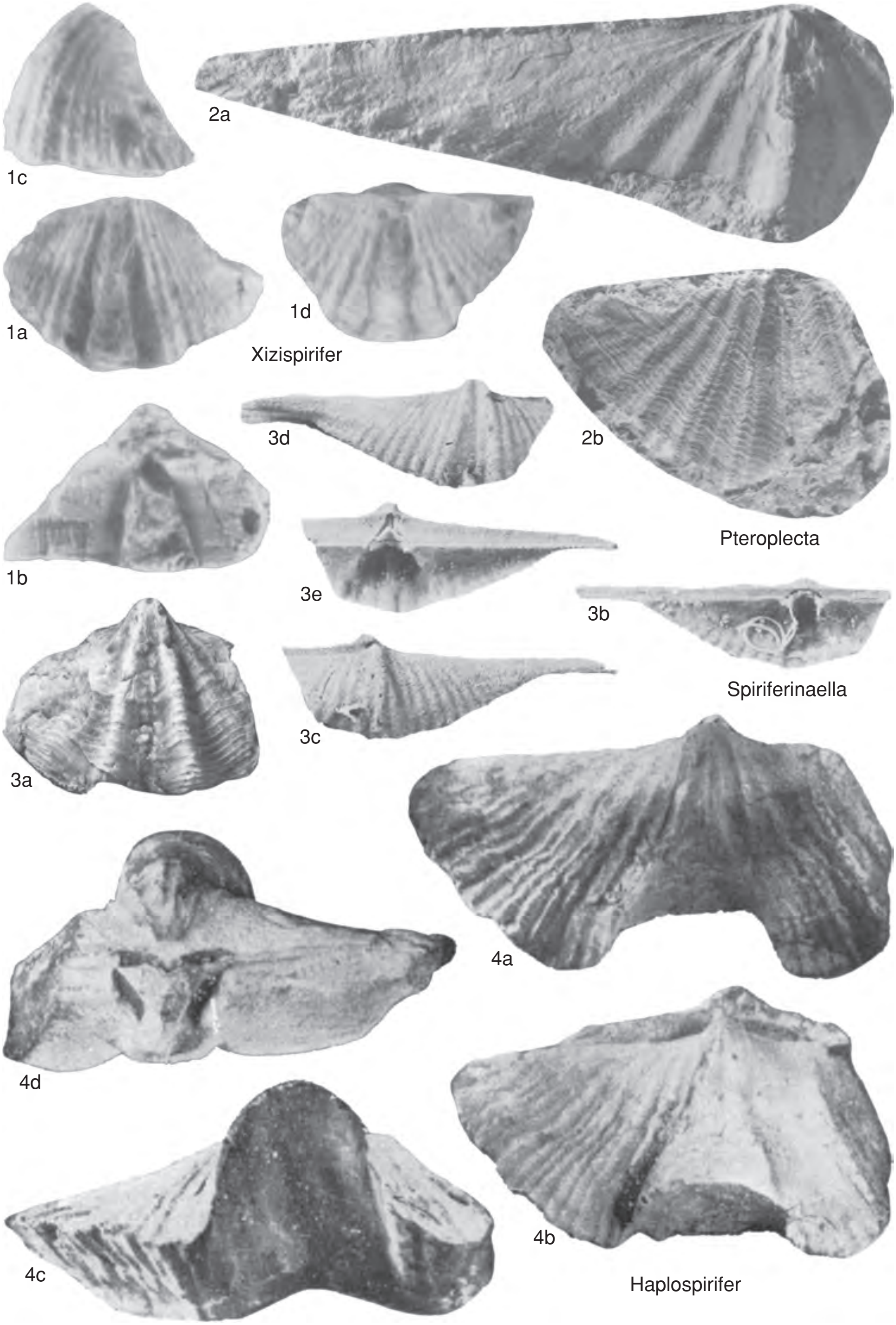

FIG. 1205. Strophopleuridae (p. 1815–1818).

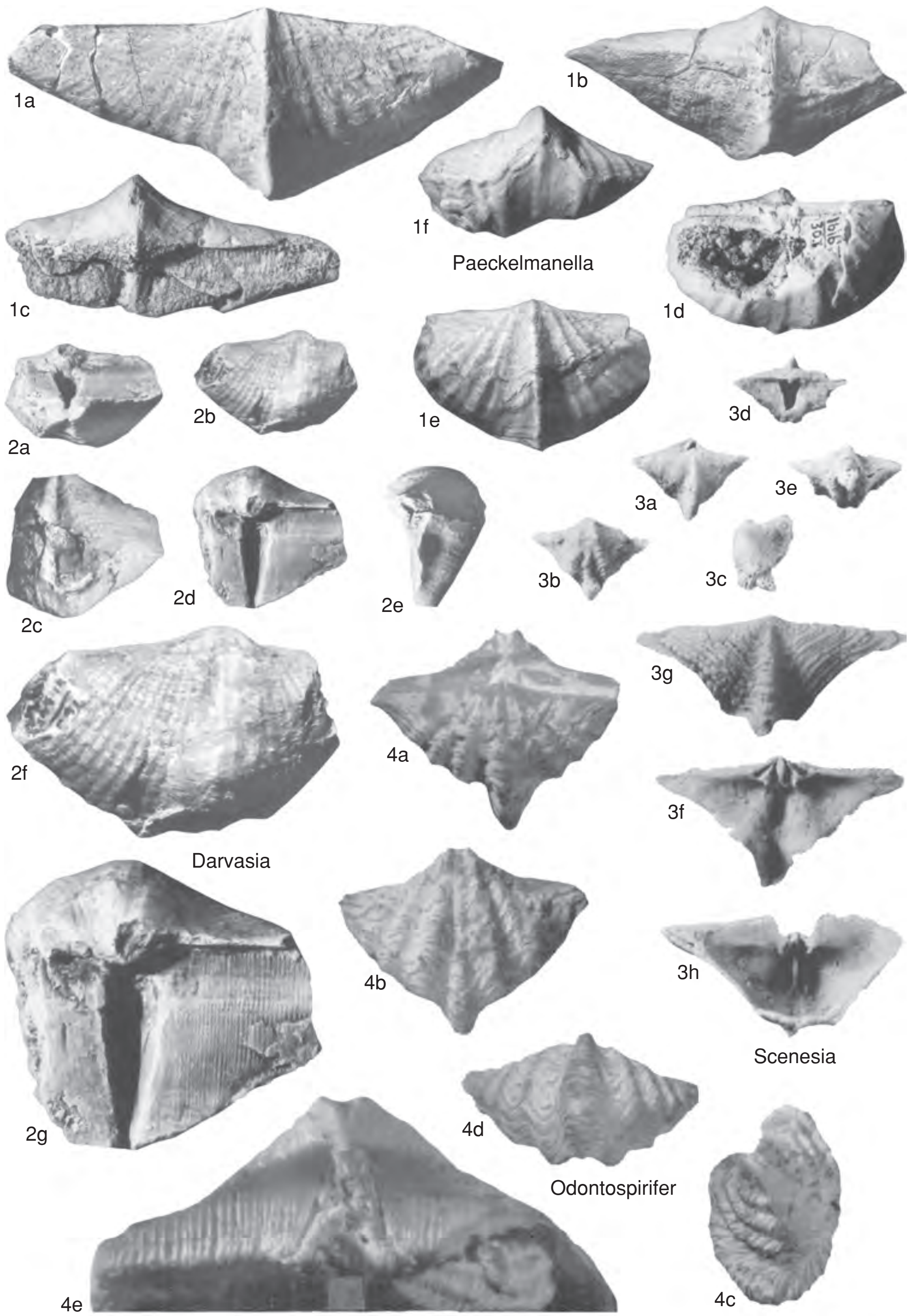

FIG. 1206. Paeckelmanellidae (p. 1818–1821).

sulcus with anteriorly projecting median plica; other ribbing absent; growth lamellae regularly spaced, moderately lamellose; microornament absent. *Permian (Cisuralian):* USA (Texas).——FIG. 1206,*3a–h.* **S. extensa; a–e,* holotype, dorsal, ventral, lateral, posterior, and anterior views, ×2; *f–g,* dorsal interior, dorsal exterior, ×5; *h,* oblique view of ventral interior, ×2 (Cooper & Grant, 1976b).

BRACHYTHYRIDOIDEA

J. L. CARTER

[retired from Carnegie Museum of Natural History]

Superfamily BRACHYTHYRIDOIDEA Frederiks, 1924

[*nom. transl. et correct.* CARTER in CARTER & others, 1994, p. 348, *ex* Brachithyrinae FREDERIKS, 1924, p. 316]

Outline ovate; hinge line narrow; cardinal extremities rounded in all growth stages; lateral slopes with coarse, usually simple ribbing; fold-sulcus weakly to moderately developed; denticulation not present in younger genera; microornament absent or weakly developed; delthyrium partially covered by thin deltidium or stegidial plates; dental adminicula, subdelthyrial plate, and dorsal adminicula or crural plates absent. *Upper Devonian (Famennian)–Permian (Lopingian).*

Family BRACHYTHYRIDIDAE Frederiks, 1924

[*nom. transl. et correct.* PITRAT, 1965, p. 706, *ex* Brachithyrinae FREDERIKS, 1924, p. 316]

Primary median costa in sulcus absent. *Upper Devonian (Famennian)–Permian (Lopingian).*

Brachythyris M'COY, 1844, p. 128 [**Spirifera ovalis* PHILLIPS, 1836, p. 219; SD BUCKMAN, 1908, p. 30] [=*Ovalia* NALIVKIN, 1937, p. 107, obj.]. Small to medium size; fold and sulcus moderately narrow, well delimited; sulcus smooth or with faint costae on sides of sulcus; fold smoothly rounded; lateral slopes with broad, rounded, simple plications separated by moderately narrow interspaces; some species faintly capillate; hinge line commonly denticulate. *Upper Devonian (Famennian)–Carboniferous (Mississippian):* cosmopolitan.——FIG. 1207,*1a–d.* **B. ovalis* (PHILLIPS), Visean, England; lectotype, ventral, dorsal, anterior, and posterior views, ×1 (new).

Cathayspirina LIANG, 1990, p. 339 [478] [**C. fenshuijiangensis;* OD]. Small, strongly and subequally biconvex; lateral slopes coarsely plicate with broad, well-rounded interspaces; fold and sulcus weakly developed, smooth, poorly delimited; shell substance thick; otherwise similar to *Brachythyris. Permian (Lopingian):* China (Zhejiang).——FIG. 1207,*4a–e.* **C. fenshuijiangensis;* anterior, posterior, ventral, lateral, and dorsal views, ×3 (Liang, 1990).

Dalaia PLODOWSKI, 1968, p. 256 [**D. tardiplicata;* OD]. Small to medium; outline transversely subovate; ventral umbonal region and beak poorly produced; fold and sulcus weakly developed, smooth; lateral slopes weakly plicate with narrow interspaces; ventral interior with short apical callus; microornament of faint capillae; otherwise similar to *Brachythyris. Permian (Cisuralian):* central Afghanistan.——FIG. 1207,*2a–f.* **D. tardiplicata; a,* holotype, ventral valve; *b–f,* paratype, ventral, dorsal, lateral, posterior, and anterior views, ×1 (Plodowski, 1970).

Ella FREDERIKS, 1918a, p. 87 [**Martinia simensis* CHERNYSHEV, 1902, p. 569; OD]. Small, subovate to guttate in outline; ventral umbonal region elongated; fold and sulcus with several faint costae; otherwise similar to *Brachythyris. Permian (Cisuralian):* Russia.——FIG. 1207,*5a–d.* **E. simensis* (CHERNYSHEV), Urals; syntype, ventral, dorsal, anterior, and lateral views, ×2 (new).

Meristorygma CARTER, 1974, p. 689 [**M. arctica;* OD]. Medium size; fold and sulcus moderately developed, well defined, forming subquadrate tongue; lateral ribs few, poorly defined; sulcus with median

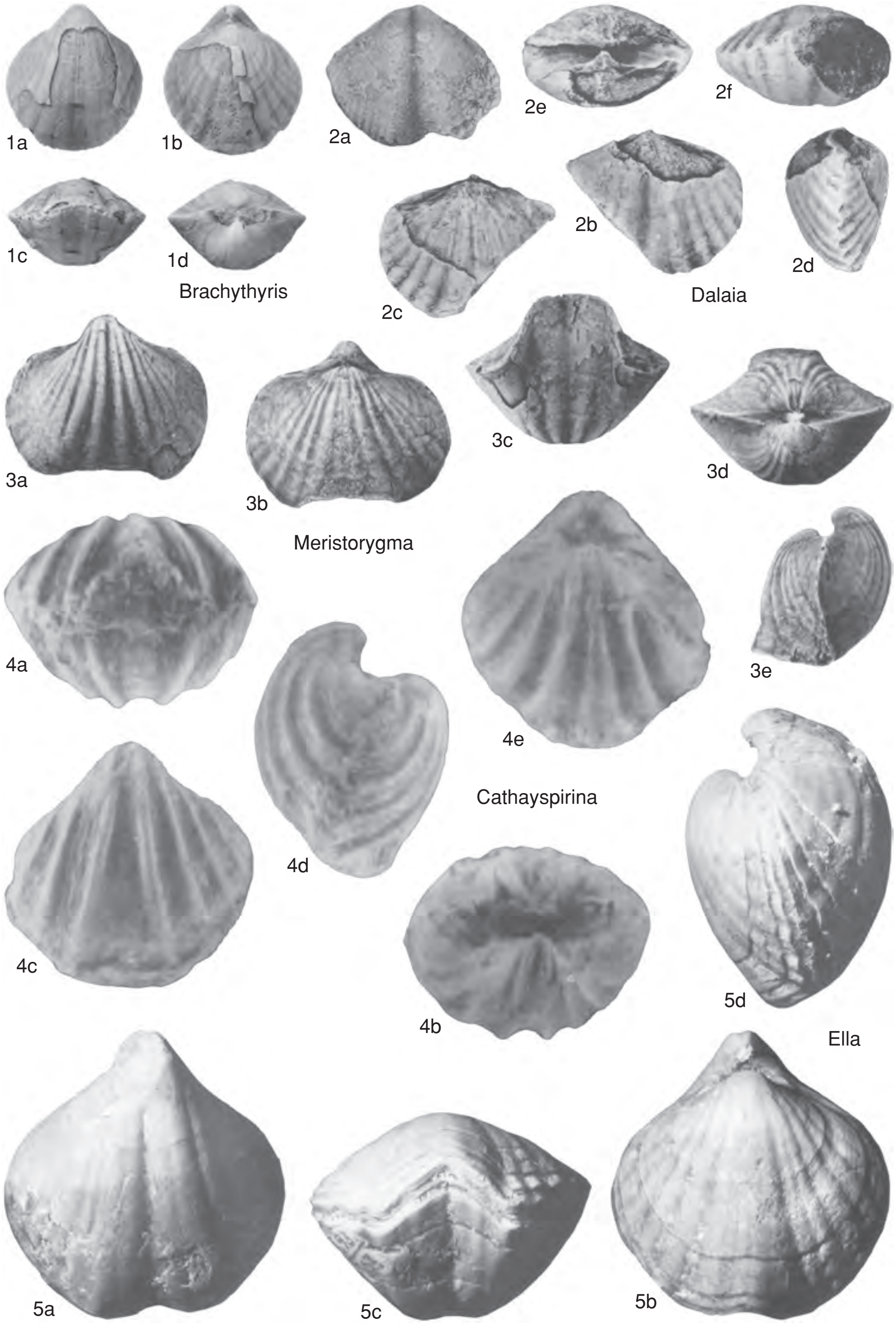

FIG. 1207. Brachythyrididae (p. 1821–1823).

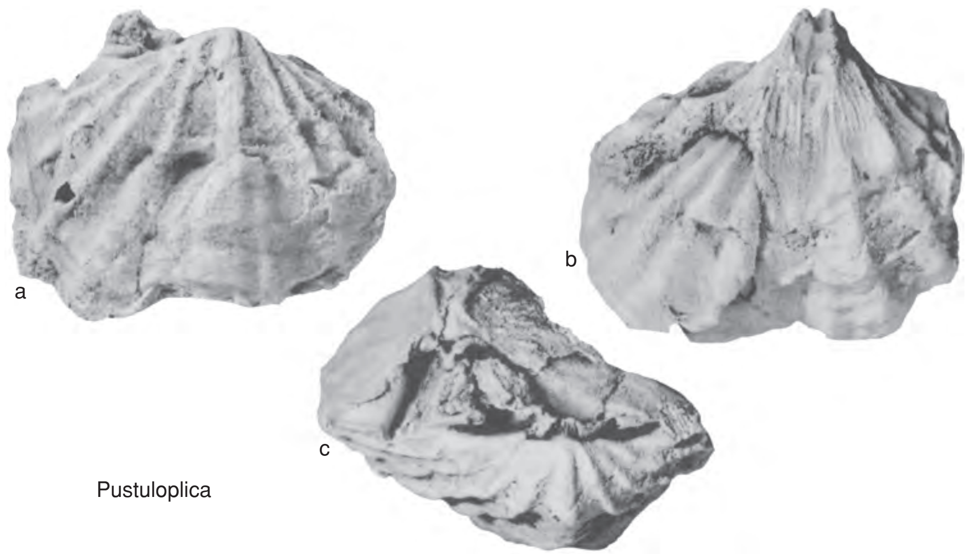

FIG. 1208. Brachythyrididae (p. 1823).

furrow and 2, or rarely, 4 primary sulcal costae that bifurcate from coarse, sulcus-bounding costae; fold with 3 distinct costae, lateral 2 of which may weakly bifurcate; interspaces wide; hinge line nondenticulate; microornament absent; shell substance thick; ventral muscle field deeply impressed. *Carboniferous (?Mississippian, Pennsylvanian)–Permian (Cisuralian):* Arctic of Canada and Russia.——FIG. 1207,*3a–e*. **M. arctica,* Atokan, Pennsylvanian, Ellesmere Island; holotype, ventral, dorsal, anterior, posterior, and lateral views, ×1 (Carter, 1974).

Pustuloplica WATERHOUSE, 1968, p. 45 [**P. baccata;* OD]. Small; strongly and subequally biconvex; fold and sulcus moderately developed; lateral slopes with several strong, coarse, simple plicae with broad interspaces; fold and sulcus with weak ribs on sides; microornament of discontinuous strong capillae or very elongated pustules, and fine growth lamellae; ventral interior with short umbonal callosity. *Permian (Sakmarian):* New Zealand, Australia.——FIG. 1208*a–c*. **P. baccata,* New Zealand; holotype, dorsal, ventral, and posterior views, ×3 (Waterhouse, 1968).

Family SKELIDORYGMIDAE Carter, 1994

[Skelidorygmidae CARTER in CARTER & others, 1994, p. 349]

Sulcus with primary median costa, often with additional sulcal costae that bifurcate from sulcus-bounding ribs. *Upper Devonian (Famennian)–Carboniferous (Bashkirian).*

Skelidorygma CARTER, 1974, p. 692 [**Spirifer subcardiiformis* HALL, 1858, p. 660; OD]. Fold and sulcus moderately to poorly developed; surface entirely costate; lateral costae few, broad, flattened, well defined, simple; interspaces narrow; sulcus with simple median costa and 1 or 2 pairs of simple, lateral sulcal costae that bifurcate from sulcus-bounding costae in umbonal region; hinge line weakly to nondenticulate; microornament absent. *Carboniferous (upper Tournaisian–Bashkirian):* North America, Russia.——FIG. 1209,*2a–e*. **S. subcardiiformis* (HALL), Visean, Illinois, USA; holotype, ventral, lateral, dorsal, posterior, and anterior views, ×1 (Carter, 1974).——FIG. 1209,*2f–j*. *S. bamberi* CARTER, upper Tournaisian, Alberta; *f,* ventral exterior, ×1; *g,* enlarged anterior view of ventral interior; *h,* enlarged ventral interior; *i,* enlarged posterior view of ventral valve, ×2; *j,* ventral valve, ×1 (Carter, 1987).

Litothyris ROBERTS, 1971, p. 237 [**L. alticostata;* OD]. Entire surface with numerous low, well-rounded, mostly simple costae with narrow interspaces; costae adjacent to or on fold-sulcus occasionally bifurcating; ventral valve with very short delthyrial plate. *Upper Devonian (Famennian):* Australia (Bonaparte Gulf basin).——FIG. 1209,*1a–e*. **L. alticostata;* holotype, ventral, dorsal, posterior, anterior, and lateral views, ×1 (Roberts, 1971).

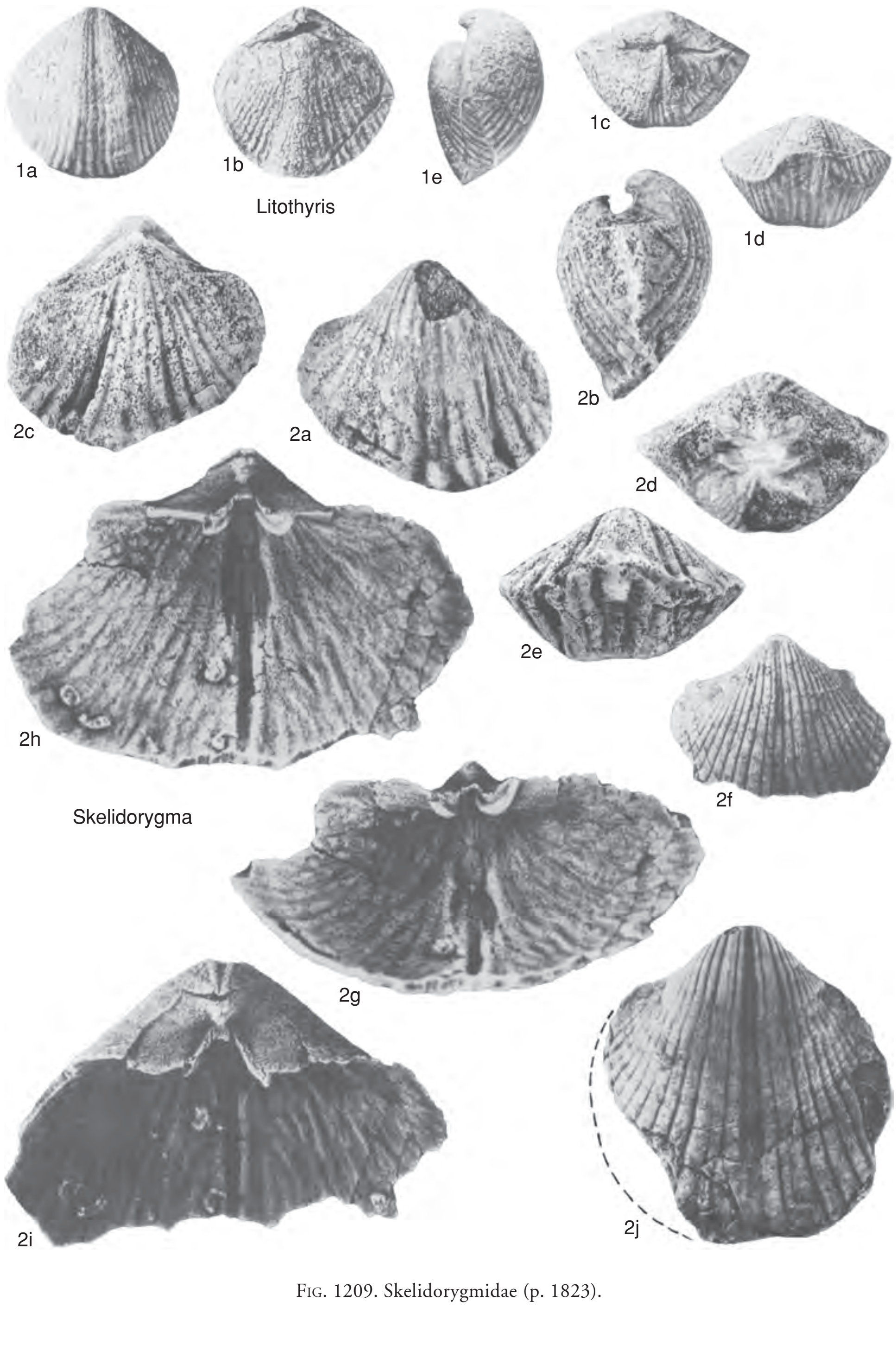

FIG. 1209. Skelidorygmidae (p. 1823).

DELTHYRIDINA

J. G. Johnson,[1] Hou Hong-fei,[2] J. L. Carter,[3] and Rémy Gourvennec[4]

[[1]deceased, formerly of Oregon State University; [2]China University of Geosciences; [3]Carnegie Museum of Natural History; and [4]Université de Bretagne Occidentale]

Suborder DELTHYRIDINA Ivanova, 1972

[Delthyridina Ivanova, 1972, p. 41]

Radial ornament, if present, plicate, rarely costate; concentric ornament lamellose, if present; microornament, if any, capillate, spinulose or exopunctate; early forms with internal plates and septa, tending to become paedomorphically simple in some geologically younger forms; dorsal diductor attachment site usually striate. *Silurian (upper Llandovery)–Permian (Lopingian).*

DELTHYRIDOIDEA

J. G. Johnson and Hou Hong-fei

[deceased, formerly Oregon State University; and China University of Geosciences]

Superfamily DELTHYRIDOIDEA Phillips, 1841

[*nom. correct.* Johnson, 1970, p. 184, *pro* Delthyroidea Ivanova, 1959, p. 56, *nom. transl. ex* Delthyridae Phillips, 1841, p. 54]

Biconvex, with fold and sulcus; flanks plicated; ornament of growth lamellae bearing radially arranged spines (fimbriate), or radial ornament absent; dental plates and ctenophoridium commonly present. *Silurian (upper Llandovery)–Carboniferous (Visean).*

Family DELTHYRIDIDAE Phillips, 1841

[*nom. correct.* Johnson, 1970, p. 184, *pro* Delthyridae Phillips, 1841, p. 54]

Small to medium size, pauciplicate, fimbriate; commonly with crural plates. *Silurian (upper Llandovery)–Middle Devonian (Eifelian).*

Subfamily DELTHYRIDINAE Phillips, 1841

[*nom. transl. et correct.* Johnson, 1970, p. 184, *ex* Delthyridae Phillips, 1841, p. 54]

Ventral median septum present. *Silurian (?upper Llandovery, Wenlock)–Middle Devonian (Eifelian).*

Delthyris Dalman, 1828, p. 99 [**D. elevata* Dalman, 1828, p. 120; SD Schuchert, 1897, p. 206]. Medium to large, ventribiconvex; equidimensional or transverse; ventral interarea apsacline; fold and sulcus smooth; flanks with few strong, simple plications; growth lamellae closely spaced; dental plates long, thin, subparallel to ventral median septum; crural plates present. *Silurian (?upper Llandovery, Wenlock)–Middle Devonian (Eifelian).*

D. (**Delthyris**). Medium size, equidimensional or transverse; ventral interarea curved. *Silurian (?upper Llandovery, Wenlock)–Middle Devonian (Eifelian):* cosmopolitan.——Fig. 1210,*1a–d*. **D. (D.) elevata,* Wenlock, Gotland; holotype, dorsal, ventral, lateral, and anterior views, ×2 (Bassett & Cocks, 1974).

D. (**Quadrifarius**) Fuchs, 1923, p. 854 [**Spirifer (Quadrifarius) loculatus* Fuchs, 1923, p. 854; SD Paeckelmann, 1931, p. 31; =*Spirifer dumontianus* de Koninck, 1876, p. 39]. Medium to large, transverse; ventral interarea flat to curved; fold with strong median groove, sulcus narrow, flattened medially. *Silurian (Pridoli)–Lower Devonian (Lochkovian):* Europe.——Fig. 1210,*2a–c*. **D. (Q.) dumontianus* (de Koninck), Lochkovian, Belgium; anterior, posterior, and dorsal views, ×1 (Asselberghs, 1930).

Ivanothyris Havlíček, 1957b, p. 438 [**Spirifer gibbosus* Barrande, 1879, pl. 2,*7–8;* OD]. Medium size, strongly biconvex, transversely oval; ventral interarea curved, low, apsacline to orthocline; fold and sulcus smooth; flanks with few strong, simple plications; growth lamellae closely spaced; dental plates and ventral median septum buried in umbonal callus; crural plates obsolete. *Lower Devonian*

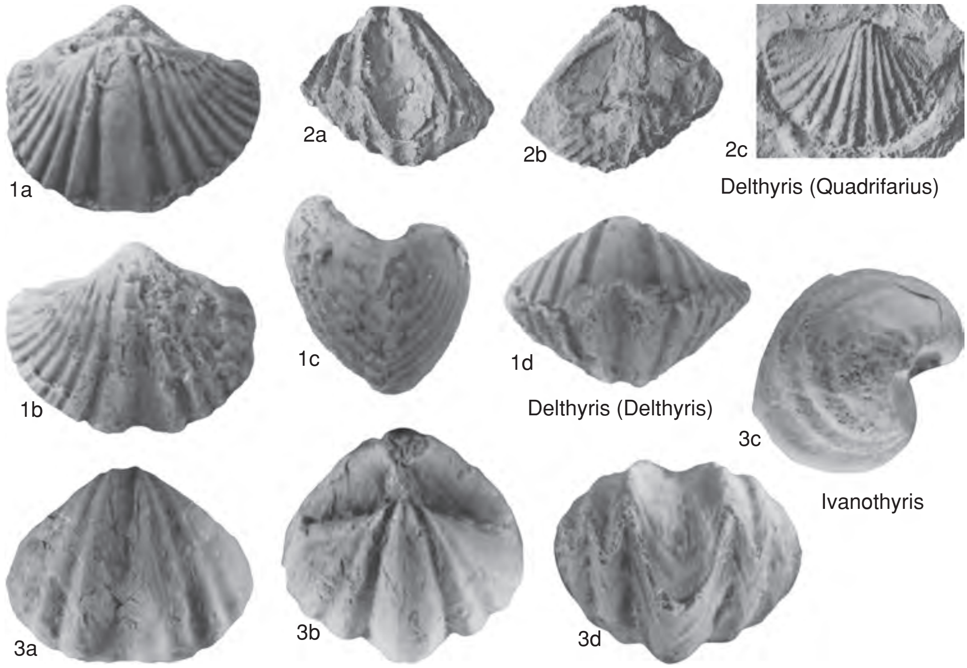

FIG. 1210. Delthyrididae (p. 1825–1826).

(Lochkovian)–Middle Devonian (Eifelian): Europe, Kazakhstan, western Siberian plain.——FIG. 1210,*3a–d.* **I. gibbosa* (BARRANDE), Lochkovian, Bohemia; ventral, dorsal, side, and anterior views, ×1.5 (Havlíček, 1959).

Subfamily HOWELLELLINAE Johnson & Hou, 1994

[Howellellinae JOHNSON & HOU in CARTER & others, 1994, p. 350]

Ventral median septum absent. *Silurian (upper Llandovery)–Middle Devonian (Eifelian).*

Howellella KOZLOWSKI, 1946, p. 295, *nom. nov. pro Crispella* KOZLOWSKI, 1929, p. 189, *non* GRAY, 1870, p. 25 [**Terebratula crispus* VON HISINGER, 1826, pl. 7,*4;* OD; *non Anomia crispa* LINNAEUS, 1758, p. 702, =*Delthyris elegans* MUIR-WOOD, 1925, p. 90]. Small to medium size, biconvex, transversely oval; ventral interarea curved, apsacline; fold and sulcus smooth; flanks with strong, simple plications; growth lamellae closely spaced; dental plates and crural plates present. *Silurian (upper Llandovery)–Lower Devonian (Emsian):* cosmopolitan.

H. (**Howellella**). Small; flanks with few plications; dental plates thin to relatively thick, divergent. *Silurian (upper Llandovery)–Lower Devonian (Emsian):* cosmopolitan.——FIG. 1211,*1a–d.* **H. (H.) elegans* (MUIR-WOOD), upper Llandovery, Gotland; holotype, dorsal, ventral, lateral, and anterior views, ×4 (Bassett & Cocks, 1974).

H. (**Hysterohowellella**) CARLS, 1985, p. 310 [**Howellella cortazari* CARLS, 1969, p. 343; OD]. Medium size; dental plates thin; umbonal callus lacking. *Lower Devonian (Lochkovian):* cosmopolitan.——FIG. 1211,*3a–b.* **H. (H.) cortazari* CARLS, Spain; ventral and dorsal molds, ×2 (Carls, 1969).

H. (**Iberohowellella**) CARLS, MEYN, & VESPERMANN, 1993, p. 248 [**H. (I.) hollmanni;* OD]. Medium to large; dental plates and minor umbonal callus present. *Lower Devonian (Lochkovian–lower Pragian):* cosmopolitan.——FIG. 1211,*2a–b.* **H. (I.) hollmanni,* upper Lochkovian, Spain; holotype, ventral and lateral views, ×2 (Carls, Meyn, & Vespermann, 1993).

Acanthospirifer MENAKOVA, 1964, p. 34 [**A. edelschteini* MENAKOVA, 1964, p. 35; OD]. Medium size, biconvex, equidimensional; ventral interarea low, curved, apsacline; fold with median groove anteriorly; flanks with few strong, simple or, uncommonly, bifurcating plications; growth lamellae closely spaced; dental plates thin, short; crural plates present. *Silurian (upper Wenlock)–Lower Devonian (Lochkovian):* Tajikistan (Zeravshan-Gissarsk area).——FIG. 1211,*4a–e.* **A. edelschteini,* upper Wenlock, Tajikistan; *a–d,* holotype, dorsal, ventral, lateral, and anterior views, ×1; *e,* microornament, ×4 (Menakova, 1964).

Aldanispirifer ALEKSEEVA, 1967, p. 96 [**A. helenae* ALEKSEEVA, 1967, p. 97; OD] [=*Holcospirifer* BASSETT, COCKS, & HOLLAND, 1976, p. 620 (type, *Spirifer bigugosus* M'COY, 1846, p. 36, OD)]. Medium size, biconvex, transverse, with rounded or acute cardinal angles; slightly curved, apsacline ventral interarea; fold with strong median groove; flanks with prominent plications and deep, U-shaped interspaces; dental plates thin, widely spaced; crural plates absent. *Silurian (upper Wenlock)–Lower Devonian (Lochkovian):* Ireland, Sette Daban area, Canadian Arctic Islands.——FIG. 1212,*1a–e.* **A. helenae,* Lochkovian, Sette Daban; holotype, ventral, dorsal, lateral, posterior, and anterior views, ×1 (Alekseeva, 1967).

Howelloidea SU, 1980, p. 314 [**H. rostrata;* OD]. Medium size, ventribiconvex, transverse; fold and sulcus distinct, smooth or with plication in sulcus; flanks with low, rounded plications; ornament of spines on concentric lamellae; dental plates short, partly obscured by secondary shell material, with muscle field deeply impressed; crural plates short, divergent. *Lower Devonian (Emsian):* northeastern China (Heilongjiang province).——FIG. 1211,*7a–d.* **H. rostrata;* ventral, dorsal, anterior, posterior, and lateral views of internal mold, ×1 (Su, 1980).

Orientospirifer HOU & XIAN, 1975, p. 49 [**Eospiriferina nakaolingensis* HOU, 1959b, p. 452; OD]. Small, transverse with rounded cardinal angles; ventral interarea low, apsacline; fold and sulcus smooth; lateral plications simple, subrounded; microornament of irregular spines and closely spaced concentric lamellae, prominent anteriorly; well-developed, divergent dental plates; ctenophoridium present; crural plates absent. *Lower Devonian (Pragian–Emsian):* southern China, northern Vietnam.——FIG. 1212,*5a–d.* **O. nakaolingensis* (HOU), Pragian, southern China; ventral, dorsal, anterior, and side views, ×1.5 (Hou & Xian, 1975).

Pseudokymatothyris CHEN, 1979, p. 22 [**P. sinensis;* OD]. Medium to large, subquadrate, with rounded cardinal angles; ventral interarea low, curved, apsacline to orthocline; fold and sulcus prominent, smooth, rounded; flanks with few strong, rounded plications and U-shaped interspaces; concentric lamellae widely spaced; dental plates and thick umbonal callus present; short crural plates present. *Lower Devonian (upper Pragian–lower Emsian):* China (northern Sichuan).——FIG. 1211,*5a–d.* **P. sinensis,* lower Emsian; ventral, dorsal, anterior, and posterior views, ×1 (new).

Qiansispirifer YANG in YANG & others, 1977, p. 422 [**Q. speciosus* YANG in YANG & others, 1977, p. 423; OD]. Small, biconvex, equidimensional; ventral interarea curved, apsacline; fold and sulcus distinct, smooth; flanks pauciplicate; growth lamellae closely spaced; slender dental plates present; ctenophoridium present; crural plates absent, platelike crural bases attached to median ridge posteriorly, free anteriorly. *Middle Devonian (Eifelian):* southern China.——FIG. 1211,*6a–d.* **Q. speciosus; a–c,* ventral, dorsal, and side views, ×1; *d,* exterior showing fine ornament, ×5 (Yang & others, 1977).

Quiringites STRUVE, 1992, p. 564 [**Spirifera elegans* STEININGER, 1853, p. 72; OD]. Small, biconvex, transverse; ventral interarea curved, apsacline; fold and sulcus distinct, smooth; flanks strongly pauciplicate; growth lamellae closely spaced, with swollen spine bases; ventral myophragm and extrasinal dental plates present; ctenophoridium present; crural plates short, joining notothyrial thickening. *Lower Devonian (Emsian)–Middle Devonian (Eifelian):* western Europe, Canadian Arctic.——FIG. 1212,*4a–d.* **Q. elegans* (STEININGER); *a–b,* dorsal and posterior views (Quiring, 1915); *c–d,* posterior and ventral views of steinkern, ×1 (Scupin, 1900).

Rufispirifer HAVLÍČEK, 1987, p. 242 [**Spirifer nucula* BARRANDE, 1879, pl. 2,*1–2;* OD]. Small, strongly biconvex, slightly transverse, with obtuse cardinal angles; ventral interarea low, apsacline; fold and sulcus distinct, smooth; flanks with few, strong, rounded plications; growth lamellae closely spaced; dental plates short, thin; crural plates absent. *Silurian (upper Wenlock–Ludlow):* Czech Republic.——FIG. 1212,*2a–e.* **R. nucula* (BARRANDE), upper Wenlock, Bohemia; *a–d,* ventral, dorsal, side, and anterior views, ×1.5; *e,* ventral view showing fine ornament, ×4.5 (Havlíček, 1959).

Xenospirifer HOU & XIAN, 1975, p. 69 [**Spirifer (Plectospirifer) fongi* GRABAU, 1931b, p. 380; OD]. Medium to large, equidimensional with subquadrate cardinal angles; ventral interarea long, curved, apsacline; fold and sulcus distinct; flanks with few strong, rounded, simple plications; concentric lamellae crossed by short radial spines or rows of granules anteriorly; long dental plates present; ctenophoridium present. *Lower Devonian (Emsian)–Middle Devonian (Eifelian):* Salair, western Siberian plain, southern China.——FIG. 1212,*3a–d.* **X. fongi* (GRABAU), Eifelian, southern China; ventral, dorsal, anterior, and side views, ×1.5 (new).

Family HYSTEROLITIDAE Termier & Termier, 1949

[*nom. transl.* JOHNSON & HOU in CARTER & others, 1994, p. 350, *ex* Hysterolitinae TERMIER & TERMIER, 1949a, p. 95]

Medium to large; fold and sulcus smooth or plicate; flanks commonly multiplicate; fimbriate; crural plates variably present. *Lower Devonian (upper Lochkovian)–Middle Devonian (lower Givetian).*

Subfamily HYSTEROLITINAE Termier & Termier, 1949

[Hysterolitinae TERMIER & TERMIER, 1949a, p. 95] [=Paraspiriferinae PITRAT, 1965, p. 684]

Fold and sulcus smooth; ctenophoridium present; generally lacking crural plates. *Lower Devonian (upper Lochkovian)–Middle Devonian (Eifelian).*

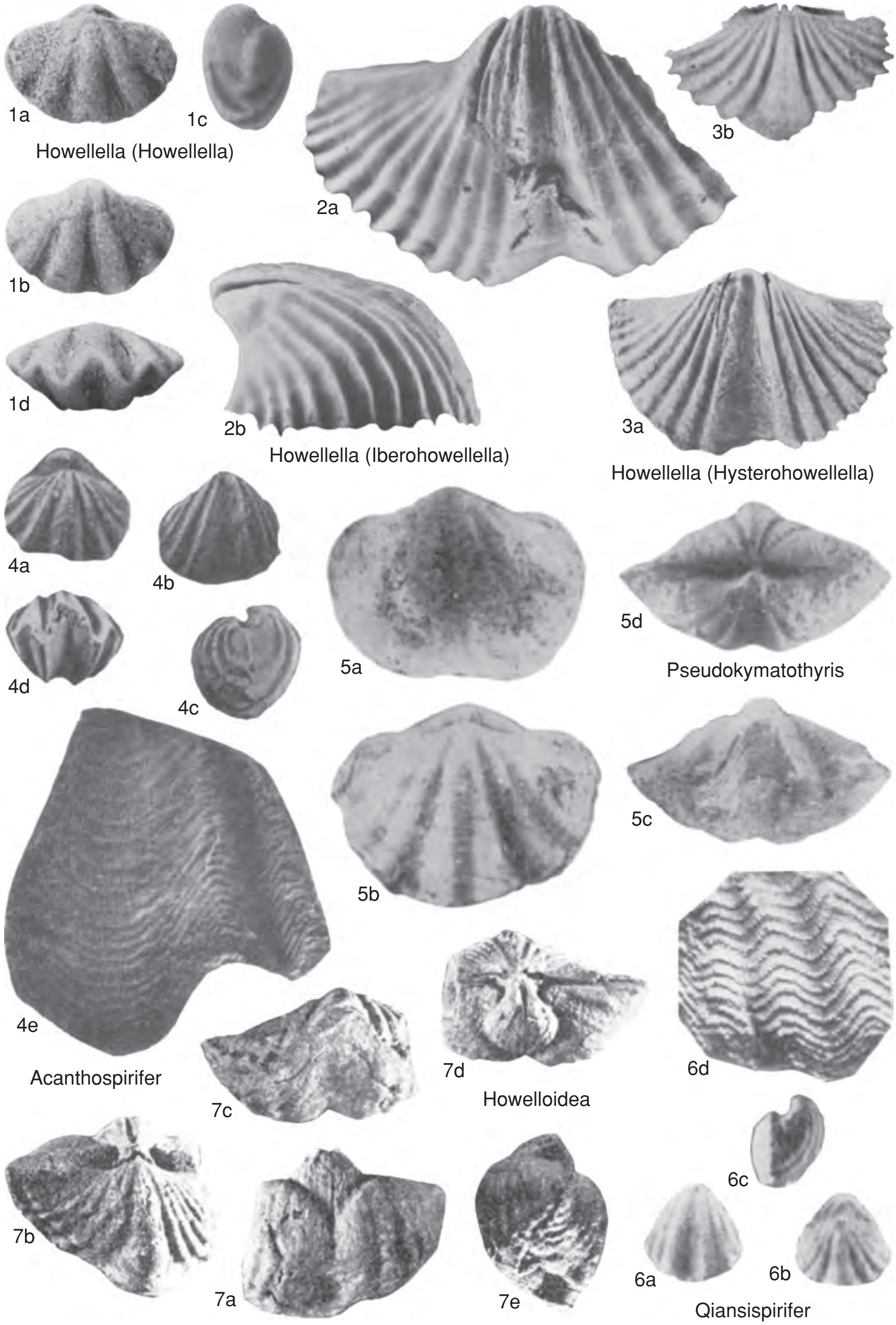

FIG. 1211. Delthyrididae (p. 1826–1827).

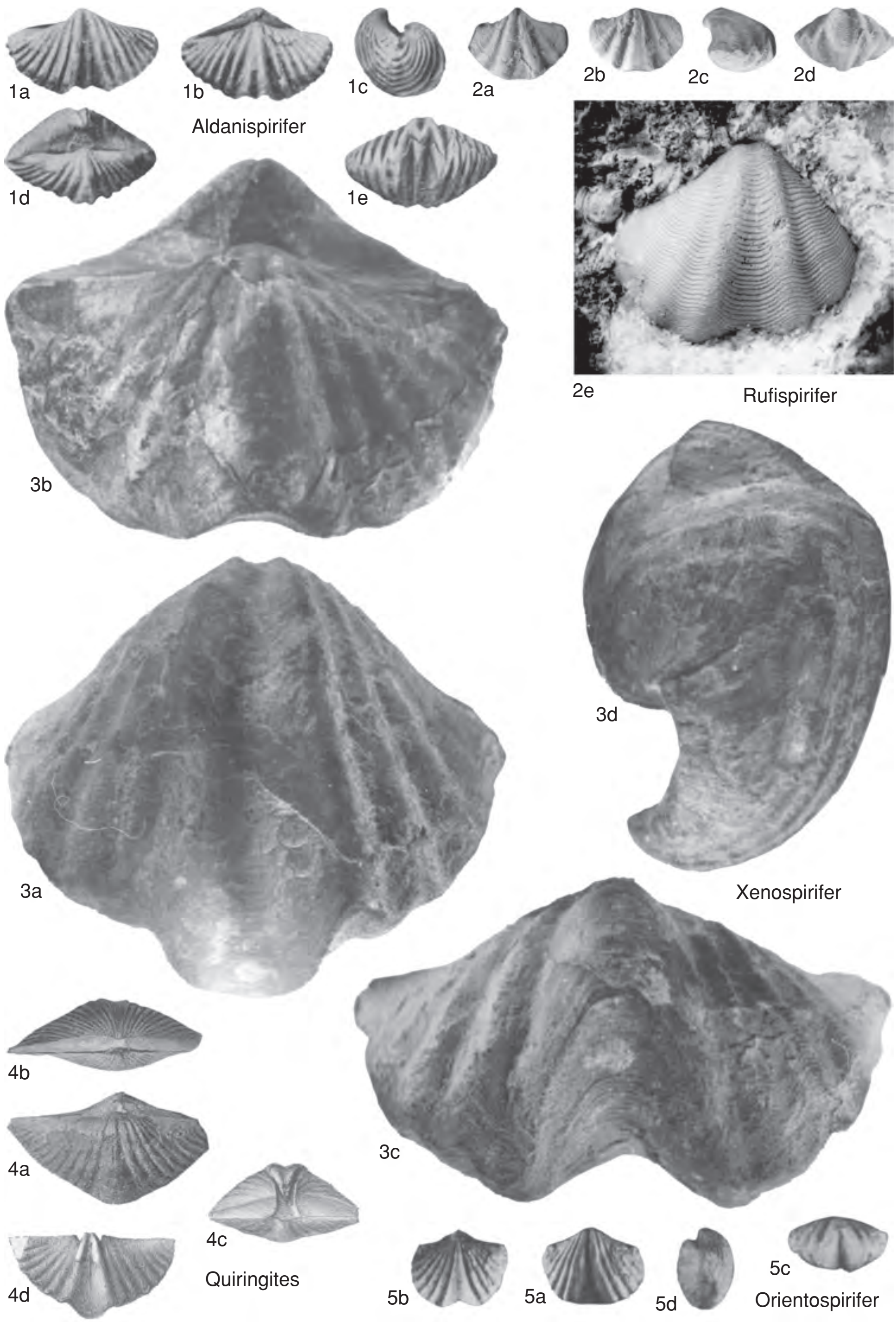

FIG. 1212. Delthyrididae (p. 1827).

Hysterolites von Schlotheim, 1820, p. 247 [**H. hystericus* von Schlotheim, 1820, p. 249; SD Dall, 1877a, p. 38]. Medium size, biconvex, transverse, with acute to rounded cardinal angles; ventral interarea curved, apsacline; fold and sulcus smooth; flanks with simple, rounded plications and U-shaped interspaces; growth lines numerous, strong; dental plates strong, tending to recurve medially, with little umbonal callus; ctenophoridium may be elevated; no crural plates. *Lower Devonian (Pragian–Emsian):* Europe, western USA (Nevada).——Fig. 1213,*2a–c*. **H. hystericus hystericus,* Pragian, Germany; *a,* mold of ventral interior, ×1.5; *b,* mold of dorsal interior, ×1; *c,* ventral exterior, ×1.5 (Solle, 1963).

Antispirifer Williams & Breger, 1916, p. 114 [**A. harroldi* Williams & Breger, 1916, p. 116; OD]. Small, dorsibiconvex or dorsiplanar, transverse, with rounded, obtuse cardinal angles; ventral interarea low, apsacline, nearly flat; fold and sulcus low, narrow, smooth; flanks with few simple, rounded plications; growth lines numerous, strong; dental plates mostly buried in umbonal callus. *Lower Devonian (Pragian):* eastern USA (Maine), ?Colombia.——Fig. 1214,*3a–b*. **A. harroldi,* Maine; ventral and dorsal exteriors, ×1.5 (Williams & Breger, 1916).

Arduspirifer Mittmeyer, 1972, p. 101 [**Spirifer Arduennensis* Schnur, 1853 in 1853–1854, p. 199; OD]. Medium size, transverse, with acute, commonly alate, cardinal angles; ventral interarea curved, low, apsacline; fold and sulcus distinct, smooth; flanks with simple, rounded plications; dental plates mostly buried in umbonal callus. *Lower Devonian (Emsian)–Middle Devonian (Eifelian):* Europe, North Africa.——Fig. 1214,*2*. **A. arduennensis* (Schnur), upper Emsian, Germany; internal mold of ventral valve, ×1 (Mittmeyer, 1972).

Australospirifer Caster, 1939, p. 159 [**Spirifer keyserianus* Clarke, 1913b, p. 252; OD]. Large, transverse, with acute to rounded cardinal angles; ventral interarea of medium height, apsacline, nearly flat; fold and sulcus not prominent; flanks with rounded plications, rarely bifurcating anteriorly; surface fimbriate posteriorly, capillate anteriorly; dental plates mostly buried in umbonal callus that may fill delthyrial cavity. *Lower Devonian (Emsian):* Brazil, Argentina, Falklands, South Africa, Antarctica.——Fig. 1213,*3a–c*. **A. keyserianus* (Clarke), Brazil; *a,* microornament, ×5; *b–c,* dorsal exterior, ventral exterior, ×1 (Clarke, 1913b).

Brachyspirifer Wedekind, 1926, p. 198 [**Spirifer carinatus* Schnur, 1853 in 1853–1854, p. 202; OD]. Medium to large, biconvex, transverse to equidimensional with rounded to acute cardinal extremities; ventral interarea curved, apsacline; fold and sulcus smooth; flanks with numerous simple, rounded plications; crural plates present or absent. *Lower Devonian (Pragian–Emsian).*

B. (**Brachyspirifer**). Transverse to equidimensional with rounded cardinal angles; dental plates strong, tending to recurve medially, with little umbonal callus. *Lower Devonian (Emsian):* Europe, western North America (Nevada).——Fig. 1213,*4a–d*. **B. (B.) carinatus* (Schnur), Germany; holotype, ventral, dorsal, posterior, and lateral views, ×1 (Vandercammen, 1967).

B. (**Torosospirifer**) Gourvennec, 1989, p. 158 [**Spirifer Rousseau* Rouault, 1846, p. 322; OD]. Transverse with acute to rounded cardinal angles; dental plates mostly buried in umbonal callus, with large, deeply impressed, ventral diductor muscle field; crural plates present, occasionally buried in umbonal callus. *Lower Devonian (Pragian–lower Emsian):* Europe, Morocco.——Fig. 1213,*5a–d*. **B. (T.) rousseaui* (Rouault), Pragian, France; *a–b,* neotype, dorsal and ventral views of internal molds, ×1.2 (Gourvennec, 1989); *c,* neotype, lateral view of internal mold, ×1.2 (new); *d,* microornament, ×15 (Gourvennec, 1989).

Costellispirifer Boucot, 1973, p. 51 [**Spirifer perimele* Clarke, 1907, p. 253; OD] [=*Concinnispirifer* Boucot, 1975, p. 367 (type, *Spirifer concinna* Hall, 1857, p. 60, OD)]. Medium size, biconvex, transverse, with acute to rounded cardinal angles; ventral interarea curved, low, apsacline; fold and sulcus low, smooth, angular; flanks with low, rounded, simple or anteriorly grooved plications; dental plates partly buried in umbonal callus. *Lower Devonian (upper Lochkovian–lower Emsian):* eastern North America.——Fig. 1214,*4a–d*. **C. perimele* (Clarke), lower Emsian, Maine, USA; *a–b,* latex casts of dorsal and ventral exteriors; *c,* latex cast of dorsal interior; *d,* mold of ventral interior, ×1 (Boucot, 1973).

Dixonella Gourvennec, 1989, p. 132 [**Acrospirifer? rouaulti* Gourvennec, 1988, p. 153; OD]. Medium to large, dorsibiconvex, transverse, with acute to rounded cardinal angles; ventral interarea curved, apsacline; fold and sulcus smooth, angular; flanks with simple, subangular plications; dental plates mostly buried in umbonal callus, with large, deeply impressed, ventral diductor muscle field. *Lower Devonian (Pragian):* Europe.——Fig. 1214,*5a–c*. **D. rouaulti* (Gourvennec), France; holotype, dorsal, anterior, and lateral views, ×1.5 (Gourvennec, 1989).

Dyticospirifer Johnson, 1966b, p. 1,043 [**D. mccolleyensis* Johnson, 1966b, p. 1,044; OD]. Medium to large, slightly transverse, with slightly obtuse cardinal angles; ventral interarea curved, low, apsacline; fold and sulcus distinct, smooth; flanks with few strong, rounded plications, some of which split on dorsal valve; dental plates short, divergent, mostly buried in umbonal callus; ctenophoridium bilobed or forming enlarged mound. *Lower Devonian (Pragian):* North America.——Fig. 1214,*1a–f*. **D. mccolleyensis,* Nevada, USA; *a–b,* ventral and side views; *c,* ventral interior; *d–e,* dorsal exterior and interior, ×1.5; *f,* ventral exterior of sulcus showing fimbriate ornament, ×8 (Johnson, 1966b).

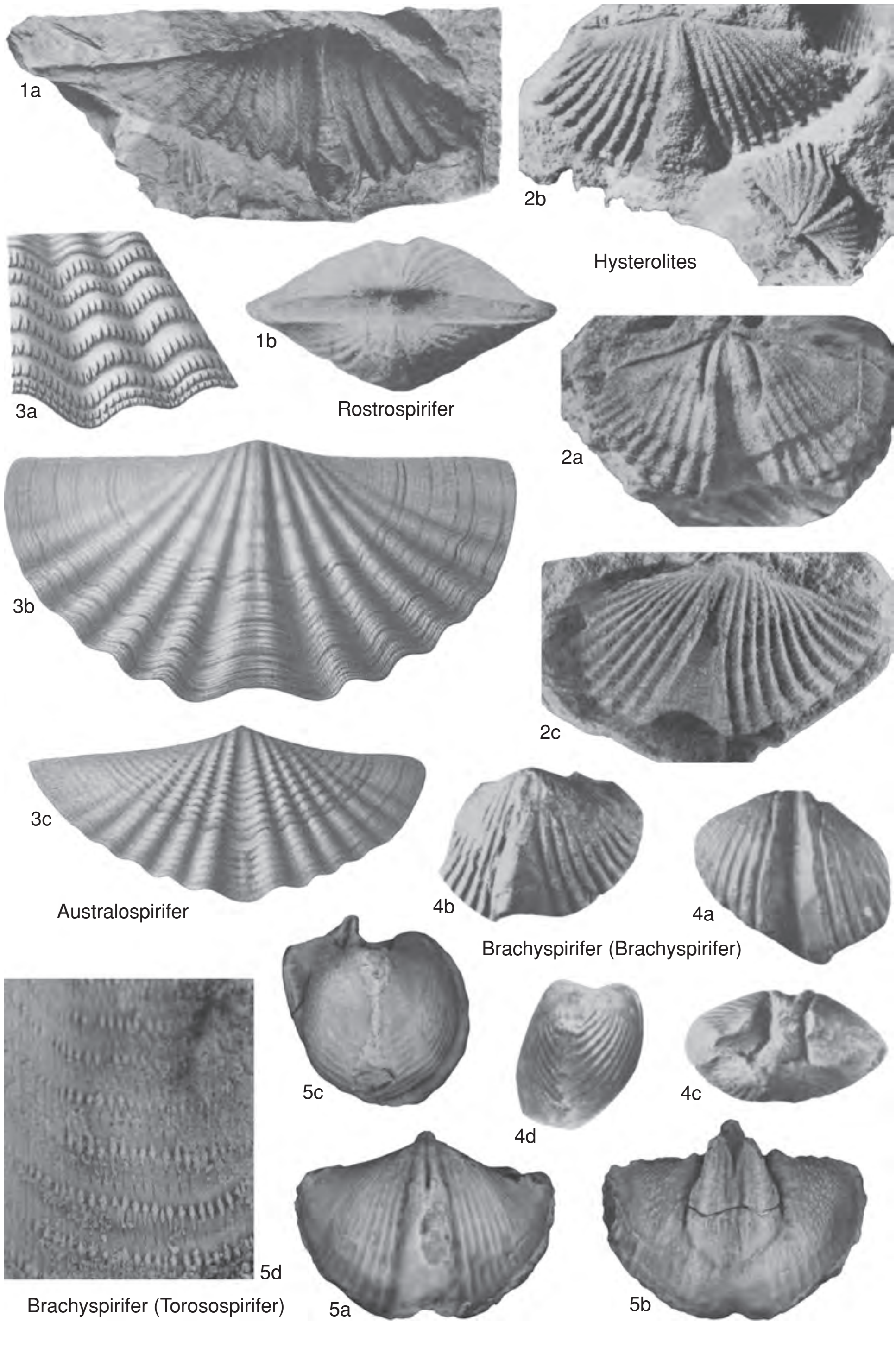

FIG. 1213. Hysterolitidae (p. 1830–1836).

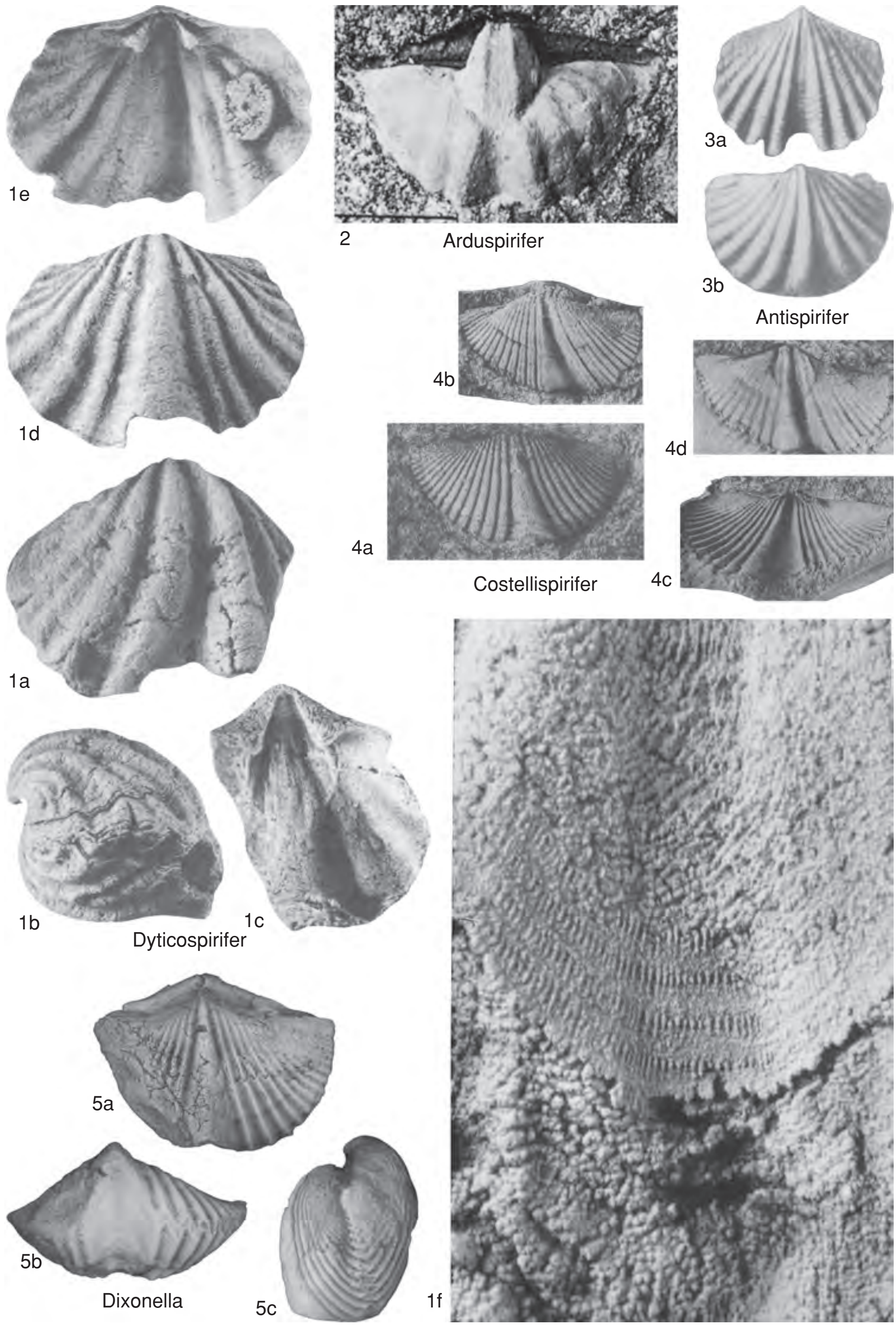

FIG. 1214. Hysterolitidae (p. 1830).

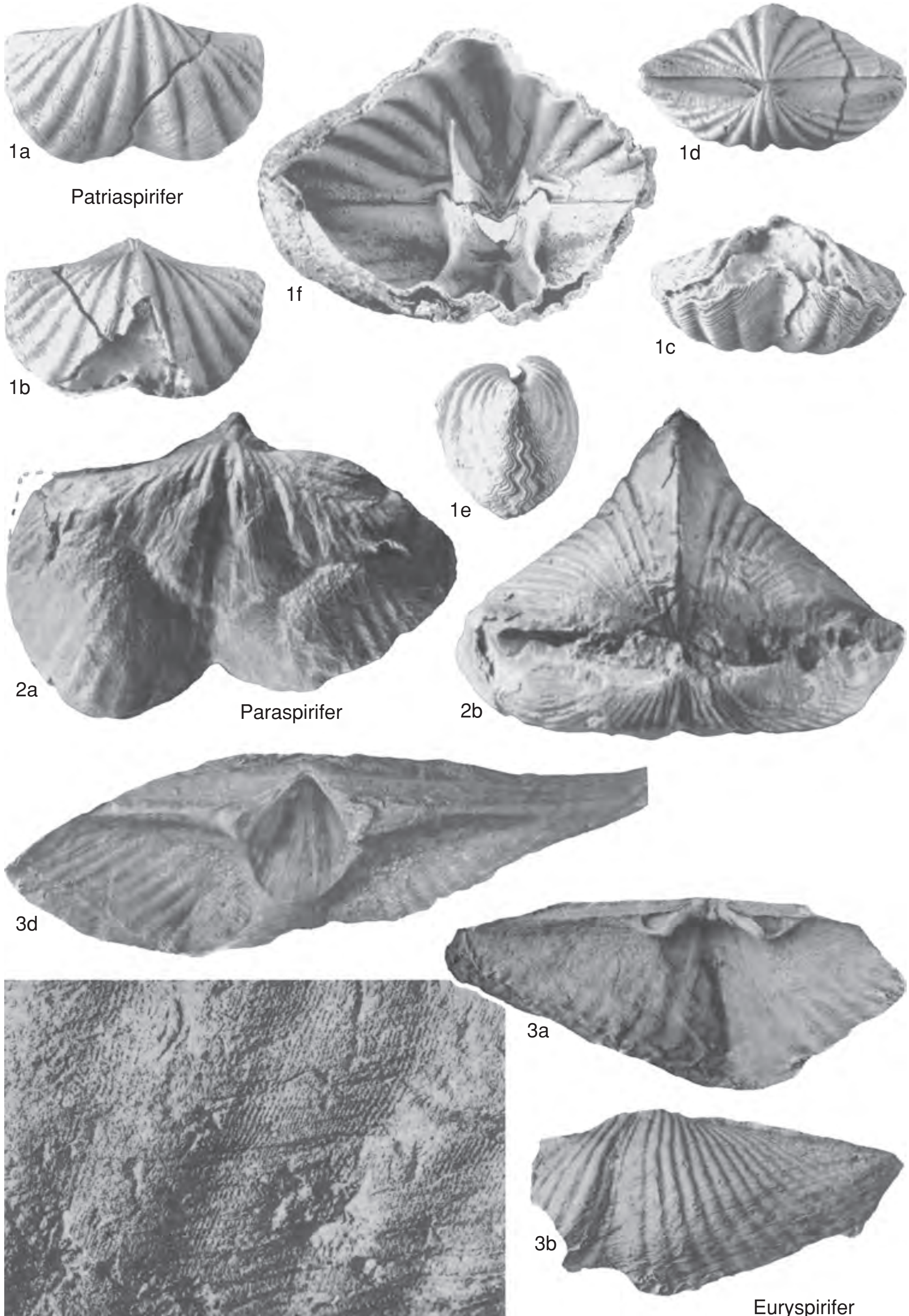

FIG. 1215. Hysterolitidae (p. 1834–1835).

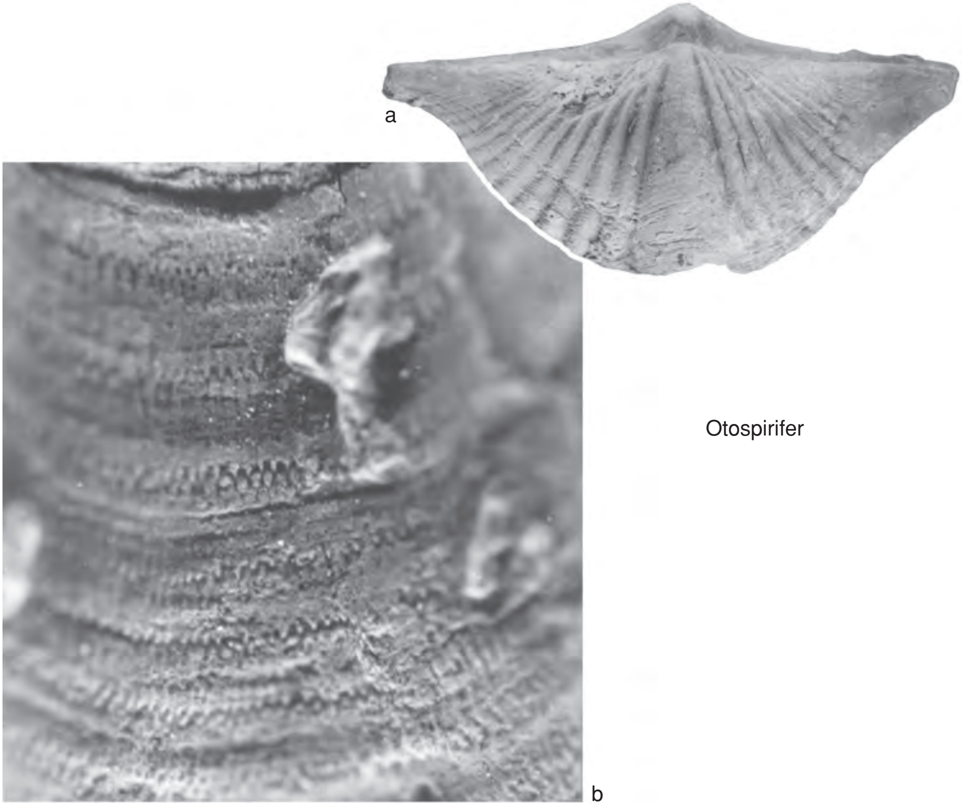

FIG. 1216. Hysterolitidae (p. 1834).

Euryspirifer WEDEKIND, 1926, p. 202 [**Terebratulites paradoxus* VON SCHLOTHEIM, 1813, p. 28; OD] [=*Rhenospirifer* MITTMEYER, 1972, p. 99 (type, *Spirifer Dunensis* KAYSER, 1889, p. 33, OD)]. Large, biconvex, strongly transverse, with acute cardinal angles; ventral interarea curved, low, apsacline; fold and sulcus smooth, or with median rib in sulcus; flanks with numerous simple plications; microornament of fine capillae and fila, becoming fimbriate; ventral diductor muscle field variably impressed in callus; crural plates lacking. *Lower Devonian (Pragian–Emsian):* Europe, eastern USA (Maine), northern Africa.——FIG. 1215,*3a–d*. **E. paradoxus* (VON SCHLOTHEIM), Emsian, Belgium; *a–b,* casts of dorsal interior, ventral exterior, ×1; *c,* microornament, ×6.5; *d,* cast of ventral interior, ×1 (Vandercammen, 1963).

Otospirifer HOU & XIAN, 1975, p. 65 [**O. shipaiensis;* OD]. Medium to large, transverse, with acute cardinal angles; ventral interarea low, apsacline; fold and sulcus smooth; lateral plications numerous, simple; concentric lamellae with double rows of granules; long, divergent dental plates present, with some umbonal callus; ctenophoridium broad; crural plates lacking. *Lower Devonian (Emsian):* southern China.——FIG. 1216*a–b*. **O. shipaiensis,* upper Emsian; *a,* dorsal view, ×1.5; *b,* exterior showing fine ornament, ×5 (new).

Paraspirifer WEDEKIND, 1926, p. 198 [**Spirifer cultrijugatus* ROEMER, 1844, p. 70; OD]. Medium to large, dorsibiconvex, transverse, with acute to rounded cardinal angles; ventral interarea curved, apsacline; fold and sulcus smooth, angular, becoming carinate; flanks with numerous, simple or anteriorly bifurcating plications; dental plates mostly buried in umbonal callus, with large, deeply impressed, ventral diductor muscle field. *Lower Devonian (Emsian)–Middle Devonian (Eifelian):* cosmopolitan.——FIG. 1215,*2a–b*. **P. cultrijugatus* (ROEMER), Eifelian, Germany; holotype, ventral and posterior views, ×1 (Solle, 1971).

Patriaspirifer JOHNSON, 1995a, p. 198 [**Spirifer kobehana* MERRIAM, 1940, p. 86; OD]. Medium to large, transverse, with cardinal angles rounded or at right angle, rarely acute; ventral interarea low, curved, apsacline; fold and sulcus smooth; flanks with few broad, low, simple plications and U-shaped interspaces; microornament of concentric growth lamellae with rows of simple spines (fimbriate); dental plates partly buried in umbonal

FIG. 1217. Hysterolitidae (p. 1836).

callus; crural plates lacking. *Lower Devonian (Pragian–lower Emsian):* eastern and western conterminous United States, eastern Canada.——FIG. 1215,*1a–f.* **P. kobehana* (MERRIAM), lower Emsian, Nevada, USA; *a–e,* ventral, dorsal, anterior, posterior, and lateral views, ×1; *f,* interior view of both valves, ×1.5 (Johnson, 1970).

Rostrospirifer GRABAU, 1931a, p. 407 [**Spirifer tonkinensis* MANSUY, 1908, p. 41; OD] [=*Neodelthyris* HOU, 1963, p. 413 (type, *N. sinensis*

HOU, 1963, p. 414, OD)]. Medium to large, transverse, with acute cardinal angles; ventral interarea curved, low, apsacline; fold and sulcus smooth; flanks with strong, simple plications; dental plates well developed, divergent, partly buried in umbonal callus; crural plates short or lacking. *Lower Devonian (Emsian):* southern China, northern Vietnam, New Zealand.——FIG. 1213,*1a–b*. **R. tonkinensis* (MANSUY), lower Emsian, northern Vietnam; cast of ventral valve exterior and cast of posterior view exterior, ×1 (Mansuy, 1908).

Trigonospirifer WANG, RONG, & CHEN, 1987, p. 132 [**Subcuspidella trigonata* HOU & XIAN, 1975, p. 68; OD]. Large, biconvex, transverse, with acute cardinal angles; ventral interarea moderately high, steeply apsacline, with apical deltidium; fold and sulcus prominent, smooth, rounded; flanks with few strong, rounded plications and U-shaped interspaces; concentric lamellae widely to closely spaced; dental plates thick, with umbonal callus; crural plates lacking. *Lower Devonian (upper Emsian):* China (central Guangxi).——FIG. 1217,*1a–d*. **T. trigonata* (HOU & XIAN); ventral, dorsal, anterior, and side views, ×1 (new).

Xinjiangospirifer HOU & ZHANG, 1983, p. 362 [**X. moriensis;* OD; =*Acrospirifer primaevus kazakhstanica* KAPLUN, 1961, p. 101]. Medium to large, equidimensional to moderately transverse with quadrate cardinal angles; ventral interarea long, orthocline, with deltidium; fold distinct, smooth; sulcus smooth or with single median plication; lateral plications numerous, simple, forming flat cross section with narrow interspaces; concentric lamellae widely spaced; dental plates short, commonly with thick umbonal callus; ctenophoridium in notothyrial chamber. *Lower Devonian (Emsian):* Kazakhstan, northeastern China (Xinjiang).——FIG. 1217,*2a–c*. **X. primaevus kazakhstanica* (KAPLUN), China; ventral, dorsal, and side views, ×1 (new).

Subfamily FIMBRISPIRIFERINAE Pitrat, 1965

[*nom. transl.* WANG in WANG & ZHU, 1979, p. 77, *ex* Fimbrispiriferidae PITRAT, 1965, p. 687]

Fold, sulcus, and flanks plicate; crural plates variably present. *Lower Devonian (Pragian)–Middle Devonian (lower Givetian).*

Fimbrispirifer COOPER, 1942, p. 231 [**Spirifer venustus* HALL, 1860, p. 82; OD]. Medium to large, biconvex, equidimensional; ventral interarea curved, apsacline; fold, sulcus, and flanks with numerous bifurcating plications of U-shaped cross section and U-shaped interspaces; microornament of closely spaced, zigzag concentric lamellae with small spines along edges; strong dental plates present; crural plates present. *Lower Devonian (Emsian)–Middle Devonian (lower Givetian):* eastern North America.——FIG. 1218,*1a–f*. **F. venustus* (HALL), lower Givetian, eastern USA; *a–e,* ventral, dorsal, anterior, posterior, and side views; *f,* ventral external mold showing concentric ornament, ×1 (Jones & Boucot, 1983).

Struveina BOUCOT, 1975, p. 364 [**Spirifer daleidensis* STEININGER, 1853, p. 71; OD]. Medium size, biconvex, transverse; ventral interarea curved, apsacline; fold, sulcus, and flanks with numerous bifurcating plications that may be bundled, or sulcus may be smooth at venter; concentric lamellae closely spaced; dental plates without umbonal callus. *Lower Devonian (Emsian):* Europe.——FIG. 1218,*2a–d*. **S. daleidensis* (STEININGER), Belgium; *a,* microornament, ×5.5; *b–d,* dorsal, ventral, and posterior views of internal mold, ×1 (Vandercammen, 1963).

Vandercammenina BOUCOT, 1975, p. 363 [**Spirifer trigeri* DE VERNEUIL, 1850b, p. 781; OD]. Medium to large, biconvex, transversely quadrate; ventral interarea curved, apsacline; fold, sulcus, and flanks with numerous simple plications; concentric lamellae closely spaced; dental plates long, with little umbonal callus. *Lower Devonian (Pragian–Emsian):* Europe, Turkey, eastern Canada (Nova Scotia).——FIG. 1219*a–e*. **V. trigeri* (DE VERNEUIL); *a–d,* lectotype, dorsal, ventral, posterior, and lateral views, Néhou Formation, France, ×1 (Gourvennec, 1989); *e,* mold of ventral interior, middle Siegenian, Belgium, ×1 (Vandercammen, 1963).

Family ACROSPIRIFERIDAE Termier & Termier, 1949

[*nom. transl.* JOHNSON & HOU in CARTER & others, 1994, p. 351, *ex* Acrospiriferinae TERMIER & TERMIER, 1949a, p. 96]

Medium to large, transverse; capillate with fila; crural plates variably present. *Lower Devonian (upper Lochkovian)–Middle Devonian (Eifelian).*

Subfamily ACROSPIRIFERINAE Termier & Termier, 1949

[Acrospiriferinae TERMIER & TERMIER, 1949a, p. 96]

Flanks strongly plicate; delthyrium lacking apical deltidium; dental plates strong or partly buried in umbonal callus; ctenophoridium on floor of notothyrial chamber attached to myophragm, or elevated. *Lower Devonian (upper Lochkovian–Emsian).*

Acrospirifer HELMBRECHT & WEDEKIND, 1923, p. 952 [**Spirifera primaeva* STEININGER, 1853, p. 72; SD WEDEKIND, 1926, p. 202]. Large, biconvex, with obtuse cardinal angles; ventral interarea curved, apsacline; fold and sulcus smooth; flanks with few strong, simple plications; dental plates divergent; ventral diductor muscle field impressed in thick callus; broad ctenophoridium may be slightly elevated. *Lower Devonian (Pragian–Emsian):* Europe, northern Africa.——FIG. 1220,*1a–d*. **A. primaevus*

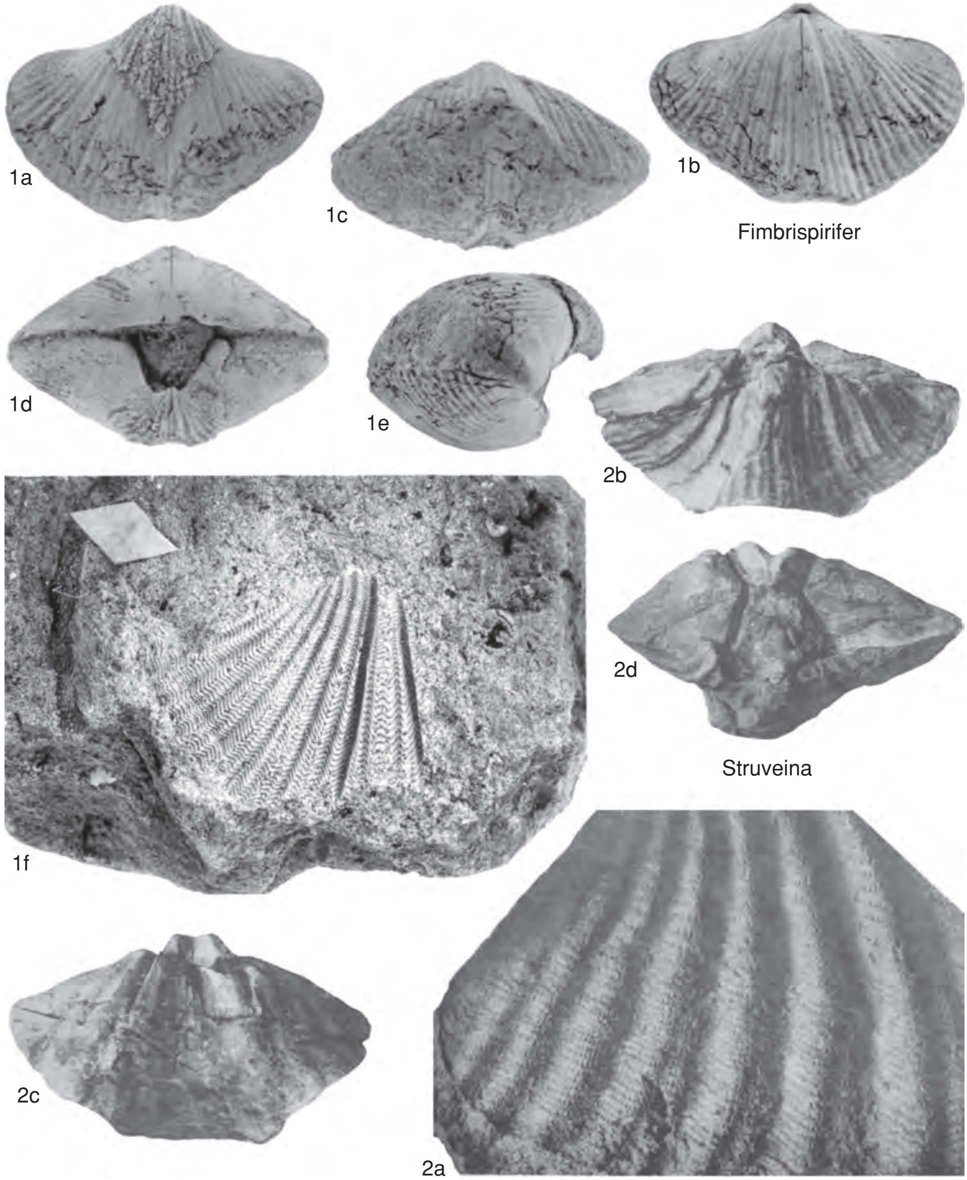

FIG. 1218. Hysterolitidae (p. 1836).

(STEININGER), Pragian, Germany; *a–b,* ventral and dorsal exteriors; *c–d,* molds of ventral and dorsal interiors, ×1 (Maillieux, 1931).

Mauispirifer ALLAN, 1947, p. 445 [**M. hectori;* OD]. Small to medium, biconvex, with slightly acute cardinal angles; ventral interarea curved, low, apsacline; fold and sulcus distinct; flanks with strong, rounded, simple plications; capillae interrupted anteriorly by concentric lamellae; dental plates short, thin, free of umbonal callus; ctenophoridium elevated. *Lower Devonian (upper Lochkovian–Emsian):* Europe, Australia, New Zealand.——FIG. 1221*a–b.* **M. hectori,* New Zealand; *a,* dorsal valve, ×1; *b,* ventral valve, ×3 (Allan, 1947).

Xerospirifer HAVLÍČEK, 1978, p. 103 [**X. excelsus* HAVLÍČEK, 1978, p. 104; OD]. Medium size, biconvex, with obtuse cardinal angles; ventral interarea curved, apsacline; fold and sulcus smooth, angular; flanks with numerous, strong, rounded, simple

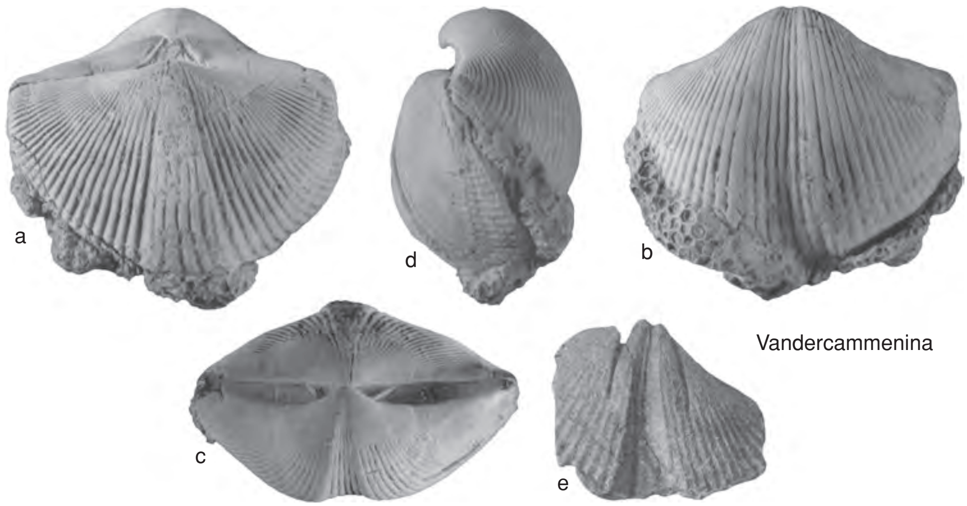

FIG. 1219. Hysterolitidae (p. 1836).

plications; strong dental plates present, recurving medially, free of umbonal callus. *Lower Devonian (Pragian):* Czech Republic.——FIG. 1220,*2a–g.* **X. excelsus,* Bohemia; *a–e,* ventral, dorsal, posterior, anterior, and side views, ×1.8; *f,* ventral internal mold, ×1.8; *g,* dorsal exterior showing fine ornament, ×10 (Havlíček, 1978).

Subfamily COSTISPIRIFERINAE Termier & Termier, 1949

[Costispiriferinae TERMIER & TERMIER, 1949a, p. 98]

Multiplicate, with narrow interspaces; ventral interarea low, trapezoidal; delthyrium broad with apical deltidium; dental plates short, widely spaced, partly buried in umbonal callus; sockets strong, simple, curved; ctenophoridium not built up. *Lower Devonian (Pragian).*

Costispirifer COOPER, 1942, p. 232 [**Spirifer arenosus planicostatus* SWARTZ, 1929, p. 56; OD]. Fold and sulcus inconspicuous, plicate; simple plications on flanks. *Lower Devonian (Pragian):* eastern North America, USA (Nevada).——FIG. 1222,*2a–e. C. arenosus* (CONRAD), Maryland; *a–c,* exterior, interior, and interior oblique views of ventral valve; *d–e,* exterior and interior views of dorsal valve, ×1 (new).

Cumberlandina BOUCOT, 1975, p. 371 [**Spirifer cumberlandiae* HALL, 1857, p. 63; OD]. Fold and sulcus low, smooth; simple plications on flanks. *Lower Devonian (Pragian):* eastern North America.——FIG. 1222,*1a–d.* **C. cumberlandiae* (HALL), Maryland, USA; *a–b,* dorsal and ventral views; *c–d,* dorsal and ventral interiors, ×1 (Hall, 1859).

Subfamily ELYMOSPIRIFERINAE Johnson & Hou, 1994

[Elymospiriferinae JOHNSON & HOU in CARTER & others, 1994, p. 352]

Fold and sulcus plicate; flanks with bifurcating plications. *Lower Devonian (Pragian)–Middle Devonian (Eifelian).*

Elymospirifer WANG in WANG, YU, & WU, 1974, p. 40 [**Indospirifer kwangsiensis* HOU, 1959b, p. 458; OD]. Medium to large, biconvex, transversely quadrate; ventral interarea curved, apsacline; fold, sulcus, and flanks with numerous bifurcating plications of U-shaped cross section and U-shaped interspaces; microornament of variably developed radial lirae interrupted by fine growth lines; dental plates long, extrasinal, without umbonal callus; ctenophoridium bilobed; short crural plates present. *Lower Devonian (lower Emsian):* Taimyr, southern China.——FIG. 1223,*3a–e.* **E. kwangsiensis* (HOU), southern China; *a–d,* ventral, dorsal, anterior, and side views, ×1.5; *e,* exterior showing fine ornament, ×5 (Wang & Rong, 1986).

Borealispirifer HOU & SU in SU & HOU, 1993, p. 140 [**Eospirifer (Multispirifer) bifurcatus* KAPLUN, 1961, p. 91; OD]. Medium to large, biconvex, flattened ventrally, with slightly acute cardinal angles; ventral interarea low; fold and sulcus broad, not sharply bounded, plicate; flanks with bifurcating plications; dental plates intrasinal, with some umbonal callus; ctenophoridium and vestigial crural plates present. *Lower Devonian (Pragian–lower Emsian):* Kazakhstan.——FIG. 1224*a–d.* **B. bifurcatus*

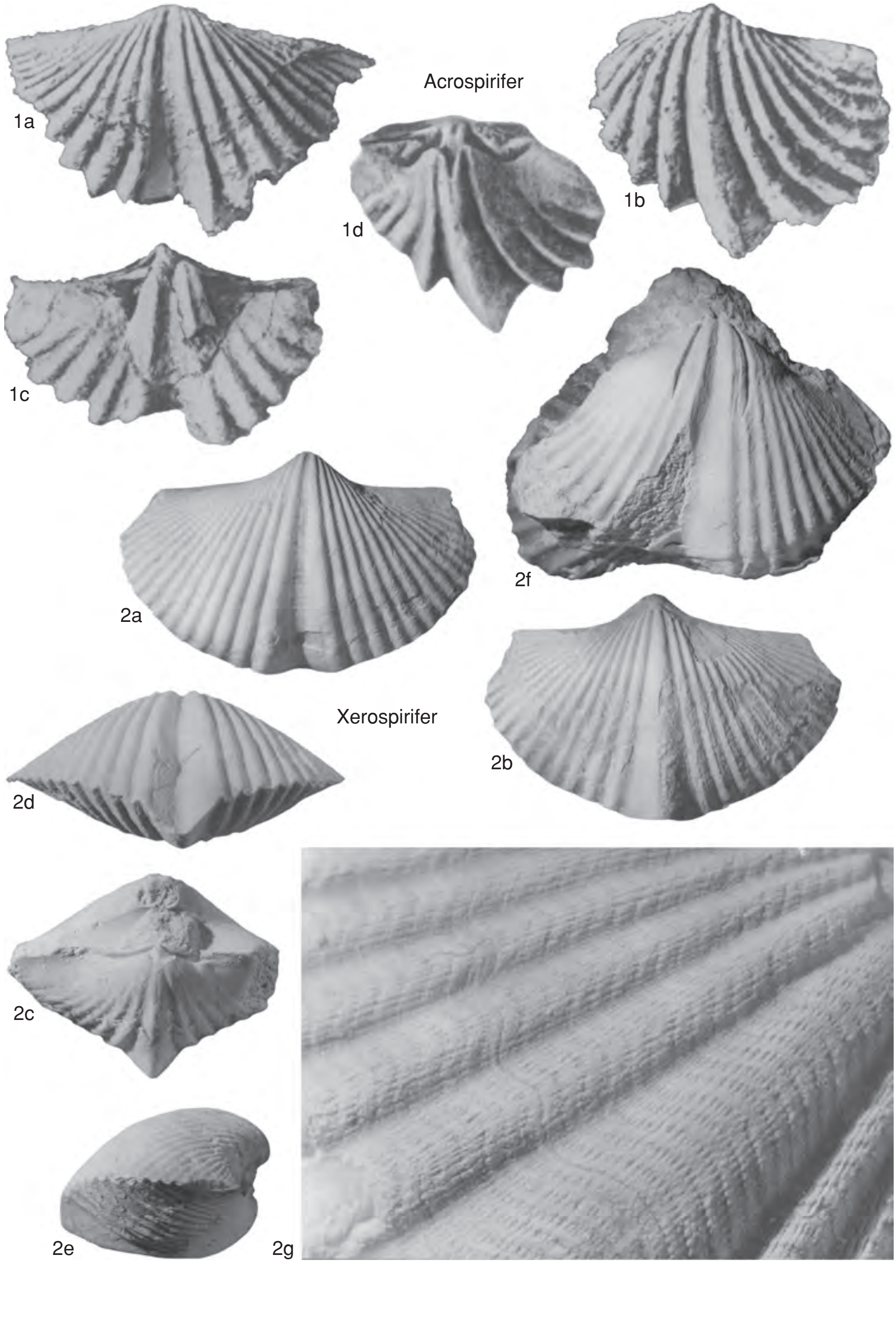

FIG. 1220. Acrospiriferidae (p. 1836–1838).

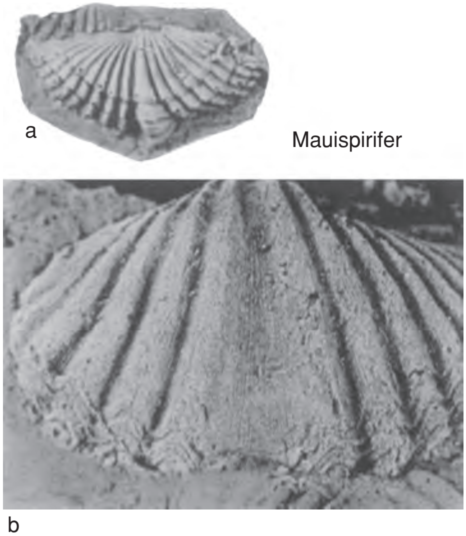

FIG. 1221. Acrospiriferidae (p. 1837).

(KAPLUN); *a,* holotype, ventral valve internal mold; *b–c,* dorsal valve internal mold, ventral valve exterior, ×1; *d,* microornament, ×8 (Kaplun, 1961).

Multispirifer KAPLUN, 1961, p. 88 [**Spirifer solitarius* KRANTZ, 1857, p. 152; OD]. Medium to large, biconvex, with slightly acute cardinal angles; ventral interarea curved, low, apsacline; fold and sulcus plicate; flanks with subangular plications that may bifurcate; strong dental plates, free of umbonal callus; ctenophoridium elevated. *Lower Devonian (Pragian–lower Emsian):* Europe.——FIG. 1223,*1a–b.* **M. solitarius* (KRANTZ), Germany; ventral valve internal mold and dorsal valve exterior, magnification unknown, probably ×1 (Krantz, 1857).

Perryspirifer JONES & BOUCOT, 1983, p. 339 [**Spirifer scheii* MEYER, 1913, p. 25; OD]. Medium size, biconvex, with rounded cardinal angles; fold and sulcus prominent; bifurcating plications on fold, sulcus, and flanks; capillae fine; dental plates and ventral callus present; ctenophoridium and vestigial crural plates present. *Lower Devonian (Emsian)–Middle Devonian (Eifelian):* Canadian Arctic Islands.——FIG. 1223,*2a–e.* **P. scheii* (MEYER), Emsian; ventral, dorsal, side, and anterior views, ventral interior, ×1 (Jones & Boucot, 1983).

Family CYRTINOPSIDAE Wedekind, 1926

[*nom. transl.* BOUCOT, 1957a, p. 38, *ex* Cyrtinopsinae WEDEKIND, 1926, p. 198]

Growth lamellae frilly, capillae interrupted; ctenophoridium lacking or, in younger genera, rudimentary. *Silurian (Wenlock)–Middle Devonian (Givetian).*

Subfamily CYRTINOPSINAE Wedekind, 1926

[Cyrtinopsinae WEDEKIND, 1926, p. 198] [=Kozlowskiellininae BOUCOT, 1958, p. 1,031, *nom. correct. pro* Kozlowskiellinae BOUCOT, 1957b, p. 317]

With ventral median septum; crural plates lacking. *Silurian (Wenlock)–Middle Devonian (Givetian).*

Cyrtinopsis SCUPIN, 1896, p. 247 [**Spirifer undosus* SCHNUR, 1853, p. 204; OD]. Medium to large, transverse, cardinal angles acute; ventral interarea moderately high, flat to curved, catacline or apsacline, with open delthyrium; fold and sulcus smooth; flanks with strong plications; capillae take form of crenulations crossed by fila; dental plates and median septum forming spondylium; bilobed cardinal process, becoming striate ctenophoridium in some. *Lower Devonian (Lochkovian)–Middle Devonian (Eifelian):* Europe, Salair, Russia (Gorno-Altay), western USA (Nevada), Australia, New Zealand.——FIG. 1225,*1a–f.* **C. undosa* (SCHNUR), Eifelian, Germany; *a–d,* dorsal, anterior, posterior, and lateral views, ×1; *e,* microornament, ×3; *f,* transverse section of ventral valve, ×5 (Boucot, 1957a).

Kozlowskiellina BOUCOT, 1958, p. 1,031, *nom. nov. pro Kozlowskiella* BOUCOT, 1957b, p. 318, *non* PRIBYL, 1953 [**Kozlowskiella strawi* BOUCOT, 1957b, p. 320; OD]. Small, transverse, cardinal angles acute; ventral interarea moderately high, flat to curved, catacline or apsacline; deltidial plates apically perforate, medially conjunct; fold and sulcus smooth; flanks with strong plications; capillae crossed by fila; dental plates and discrete median septum present; bilobed cardinal process, can become ctenophoridium. *Silurian (Wenlock–Ludlow):* Britain, Gotland, eastern North America.——FIG. 1225,*3a–e.* **K. strawi* (BOUCOT), Wenlock, British Isles; holotype, ventral, dorsal, anterior, posterior, and lateral views, ×1.5 (Boucot, 1957b).

Megakozlowskiella BOUCOT, 1957b, p. 322 [**Spirifer perlamellosus* HALL, 1857, p. 57; OD]. Medium to large, transverse to equidimensional; ventral interarea moderately high, flat to curved, apsacline; deltidial plates apically perforate, medially conjunct; fold and sulcus smooth; flanks with strong plications; capillae crossed by fila; dental plates and discrete median septum present. *Lower Devonian (Lochkovian)–Middle Devonian (Givetian):* eastern North America, USA (New York, Nevada).——FIG. 1225,*2a.* **M. perlamellosus* (HALL), Albany, New York, Lower Devonian; dorsal view, ×1 (Hall, 1857).——FIG. 1225,*2b–h. M. magnapleura* JOHNSON, Pragian, Nevada; *b,* ventral interior, ×2; *c,* dorsal interior, ×3; *d–h,* ventral, dorsal, side, posterior, and anterior views, ×1.5 (Johnson, 1970).

Plicocyrtina HAVLÍČEK, 1956, p. 608 [**Cyrtina (Plicocyrtina) sinuplicata* HAVLÍČEK, 1956, p. 608; OD]. Medium size, transverse, with acute cardinal angles; ventral interarea moderately high, flat to

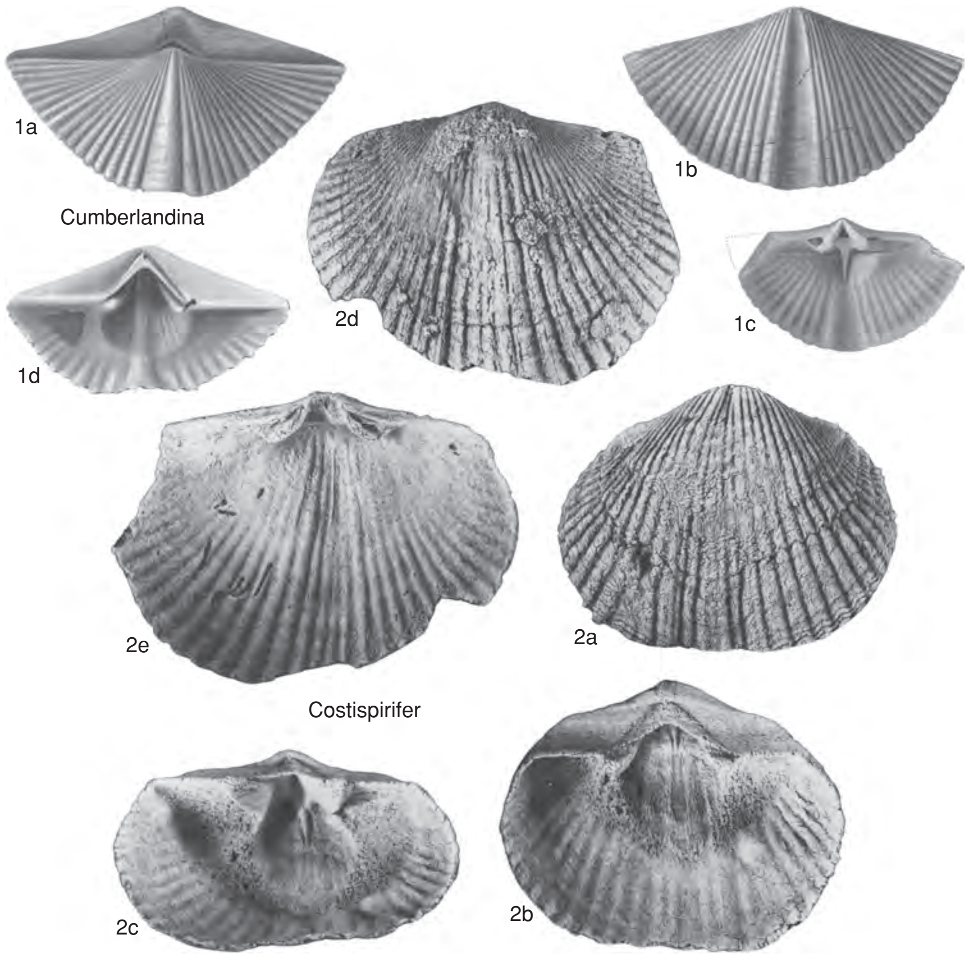

FIG. 1222. Acrospiriferidae (p. 1838).

curved, apsacline, with open delthyrium; fold and sulcus prominent, with median plication in sulcus; flanks with strong plications; short dental plates and median septum form spondylium; bilobed cardinal process, can become ctenophoridium. *Lower Devonian (Pragian–Emsian):* Czech Republic, northern Africa, eastern North America (Yukon). ——FIG. 1225,*4a–c*. **P. sinuplicata* (HAVLÍČEK), Emsian, Czech Republic; *a–b,* ventral and dorsal valves, ×1.5; *c,* posterior view of dorsal valve, enlarged (Havlíček, 1956).

Subfamily ARASPIRIFERINAE Johnson, 1994

[Araspiriferinae JOHNSON in CARTER & others, 1994, p. 352]

Without ventral median septum; crural plates present. *Silurian (Wenlock–Ludlow).*

Araspirifer HAVLÍČEK, 1987, p. 242 [**A. araneus;* OD]. Small, transverse, with square cardinal angles; ventral interarea curved, apsacline, with open delthyrium; fold and sulcus smooth; flanks with strong plications, capillae faintly developed or lacking; strong teeth tracks, dental plates without median septum; crural plates closely spaced; ctenophoridium lacking. *Silurian (Wenlock–Ludlow):* Bohemia.——FIG. 1226,*2a–d*. **A. araneus,* upper Wenlock; *a–c,* ventral, dorsal, and anterior views, ×3; *d,* dorsal view, ×1.5 (Havlíček, 1959).

Boucotinskia BRUNTON & COCKS in BRUNTON, COCKS, & DANCE, 1967, p. 179 [**Delthyris sulcata* VON HISINGER, 1831, p. 140; OD; =*Delthyris sulcata* VON HISINGER, 1828, p. 228, *nom. nud.*]. Small, transverse, cardinal angles acute; ventral interarea curved, apsacline; deltidial plates discrete; fold and sulcus smooth; flanks with strong plications; dental

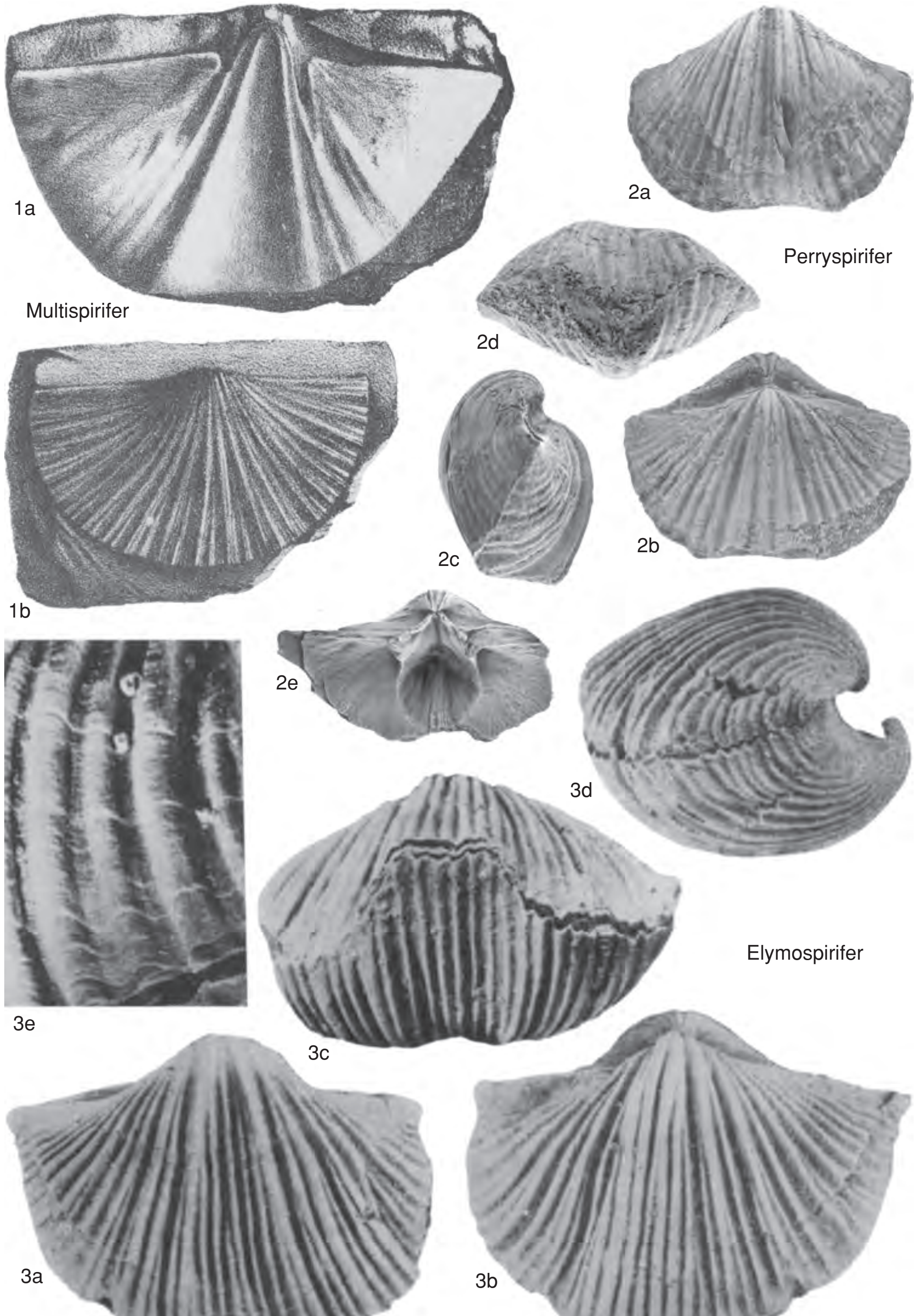

FIG. 1223. Acrospiriferidae (p. 1838–1840).

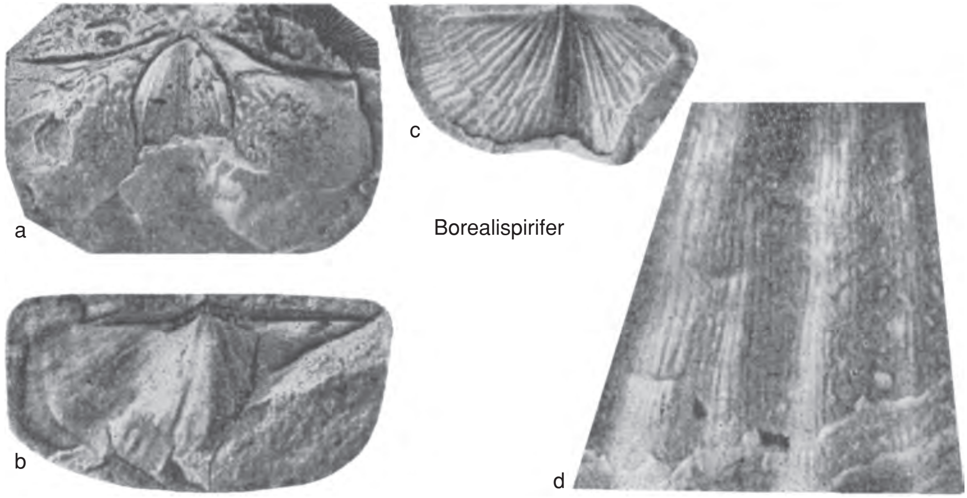

FIG. 1224. Acrospiriferidae (p. 1838–1840).

plates without median septum; crural plates short; ctenophoridium present. *Silurian (Wenlock–Ludlow):* Britain, Gotland, eastern North America.——FIG. 1226,*1a–e*. **B. sulcata* (VON HISINGER), Ludlow, Gotland; lectotype, posterior, anterior, lateral, dorsal, and ventral views, ×3 (Boucot, 1957b).

Family MUCROSPIRIFERIDAE Boucot, 1959

[*nom. transl.* JOHNSON & CARTER in CARTER & others, 1994, p. 352, *ex* Mucrospiriferinae BOUCOT, 1959b, p. 745]

Growth lines lamellose; ctenophoridium present; crural plates absent. *Middle Devonian (Eifelian)–Carboniferous (Visean).*

Subfamily MUCROSPIRIFERINAE Boucot, 1959

[Mucrospiriferinae BOUCOT, 1959b, p. 745]

Transverse, multiplicate; without median septum. *Middle Devonian (Eifelian)–Upper Devonian (Famennian).*

Mucrospirifer GRABAU, 1931a, p. 408 [**Delthyris mucronatus* CONRAD, 1841, p. 54; OD] [=*Lamellispirifer* NALIVKIN, 1937, p. 87, obj.; *Khinganospirifer* SU, 1976, p. 221 (type, *Mucrospirifer paradoxiformis* HOU, 1959a, p. 154, OD)]. Medium to large, biconvex, transverse, mucronate; ventral interarea low, curved, apsacline to orthocline; stegidial plates present; fold and sulcus well defined, smooth or with a median groove in fold; flanks with numerous, simple plications, crossed by numerous growth lamellae, some with fila crossed by fine capillae; wedge-shaped umbonal thickening; dental plates short. *Middle Devonian (Eifelian–Givetian):* Germany, Poland, northeastern China (Heilongjiang Province), eastern North America.——FIG. 1227,*4a–b*. **M. mucronatus* (CONRAD), Givetian, New York; ventral and dorsal valves, ×1 (Cooper, 1944).

Apousiella CARTER, 1972, p. 732 [**Spirifer bouchardi* MURCHISON, 1840, p. 253; OD] [=*Bouchardopsis* MAILLIEUX, 1933, p. 80, *nom. nud.*]. Medium size, planoconvex to ventribiconvex, transverse, mucronate; ventral interarea low, curved, orthocline; fold and sulcus well defined, with median groove in fold; ventral flanks concave to flattened in profile; flanks with numerous, simple plications, crossed by numerous imbricate growth lamellae and fila; dental plates absent. *Upper Devonian (Frasnian):* western Europe.——FIG. 1227,*2a–c*. **A. bouchardi* (MURCHISON), middle Frasnian, Belgium; dorsal, ventral, and lateral views, ×1 (Vandercammen, 1963).——FIG. 1227,*2d–h*. *A. belliloci* (RIGAUX), middle Frasnian, France; ventral, dorsal, anterior, posterior, and lateral views, ×1.5 (Carter, 1972).

Eleutherokomma CRICKMAY, 1950, p. 219 [**E. hamiltoni* CRICKMAY, 1950, p. 220; OD] [=*Dmitrispirifer* LIASHENKO, 1973, p. 126 (type, *D. nalivkini* LIASHENKO, 1973, p. 127, OD); *Sculptospirifer* SU, 1980, p. 318 (type, *Eleutherokomma acutiplicatus* SU, 1976, p. 214, OD)]. Small to medium, biconvex, transverse, mucronate; ventral interarea low, curved, apsacline to orthocline; fold and sulcus well defined, smooth; flanks with simple plications, crossed by numerous growth lamellae, with fila crossed by capillae; wedge-shaped umbonal thickening present; dental plates long, divergent. *Middle Devonian (Givetian)–Upper Devonian (Frasnian):*

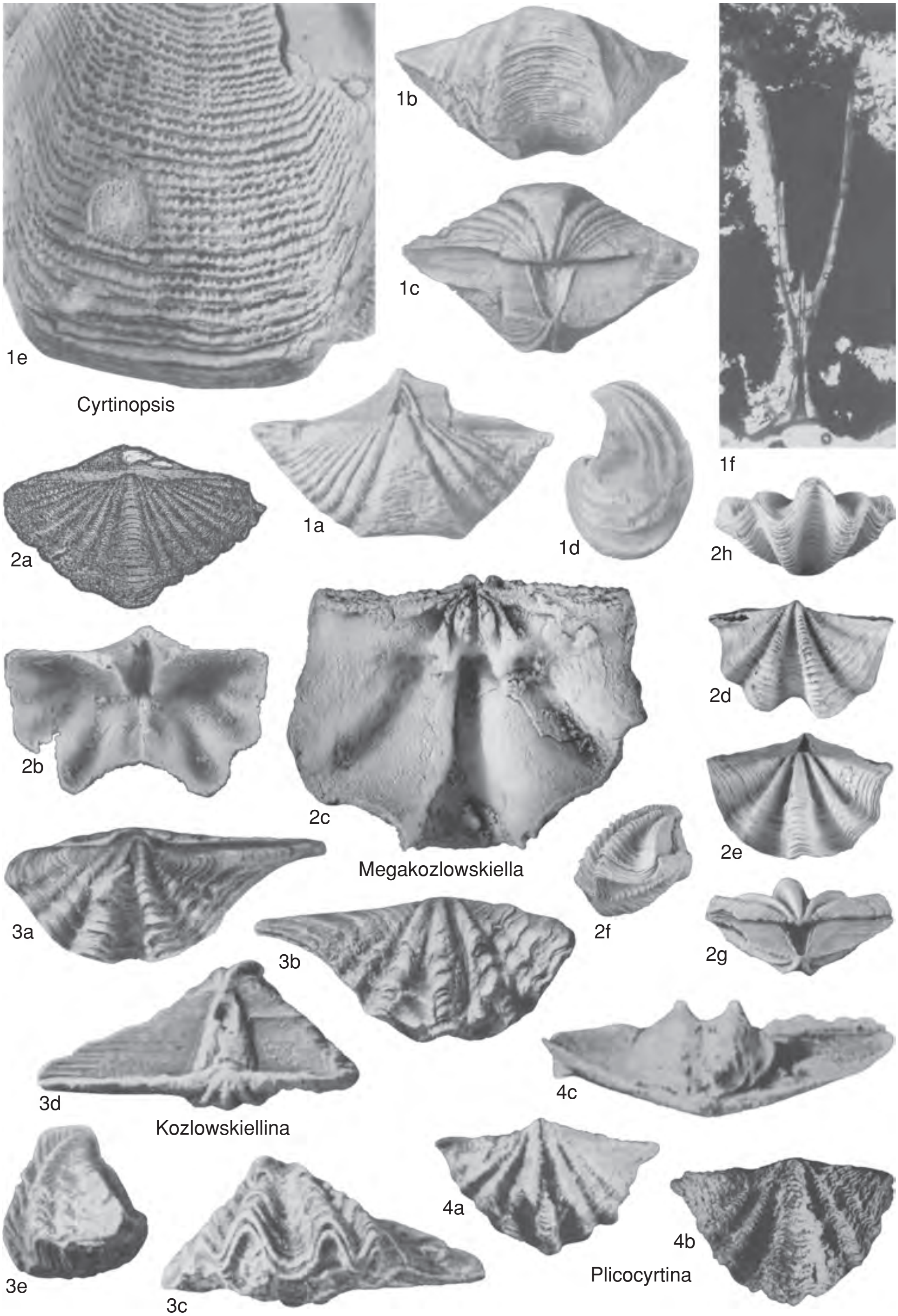

FIG. 1225. Cyrtinopsidae (p. 1840–1841).

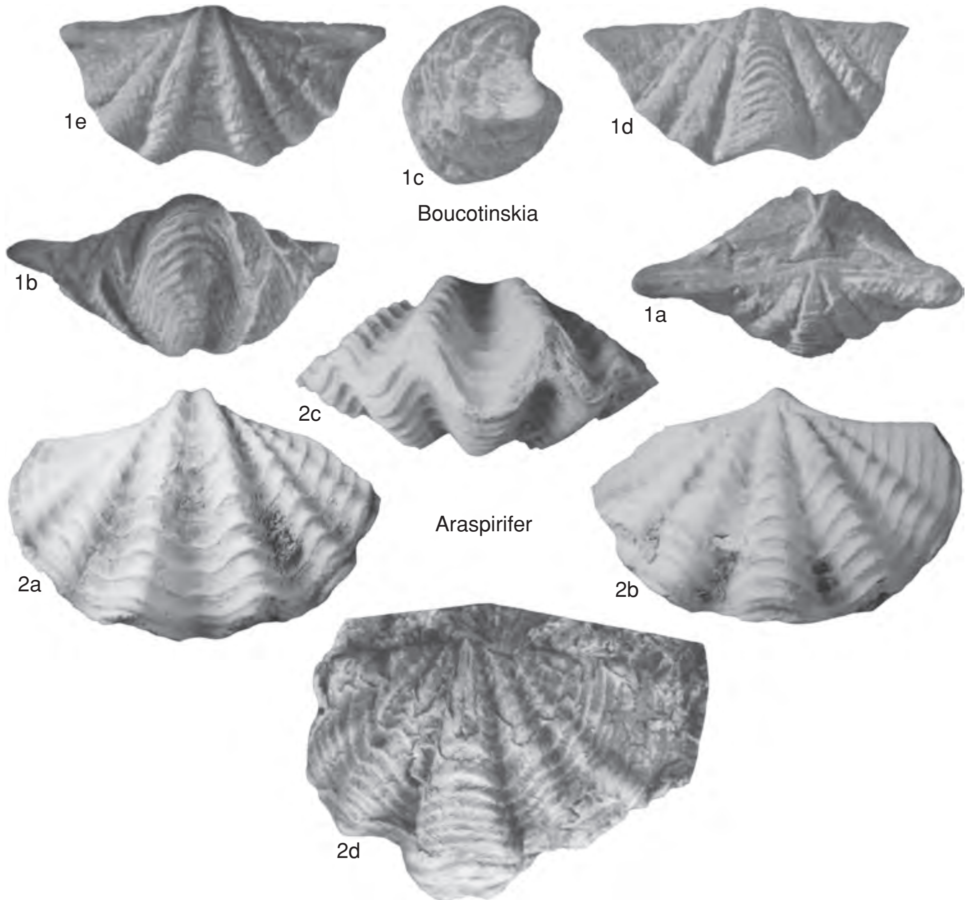

FIG. 1226. Cyrtinopsidae (p. 1841–1843).

western North America, eastern Europe, northern Africa, Afghanistan, northeastern China.——FIG. 1227,*1a–c*. **E. hamiltoni,* Givetian, Alberta; *a,* holotype, ventral valve, ×1.8; *b,* dorsal valve, ×2; *c,* microornament, ×5 (Crickmay, 1950).

Sulcatospirifer MAXWELL, 1954, p. 11 [**S. primus;* OD]. Medium size, biconvex, transverse, with acute cardinal angles; ventral interarea curved, moderately high apsacline; fold and sulcus prominent, rounded, with wide furrow on fold, otherwise smooth or with faint parietal plications; flanks with numerous simple plications crossed by lamellose growth lines; microornament of interrupted capillae and scattered tubercles; dental plates thin, divergent. *Upper Devonian (Famennian):* eastern Australia.——FIG. 1227,*3a–c*. **S. primus; a–b,* holotype, internal and external molds of dorsal valve, ×2; *c,* microornament of ventral valve, ×5 (new).

Subfamily TYLOTHYRIDINAE Carter, 1972

[Tylothyridinae CARTER, 1972, p. 730]

Outline variable, with moderately numerous lateral costae; radial microornament lacking; with dental plates and ventral median septum. *Middle Devonian (upper Givetian)–Carboniferous (Visean).*

Tylothyris NORTH, 1920, p. 195 [**Cyrtia laminosa* M'COY, 1844, p. 137; OD] [=*Welleria* MAILLIEUX,

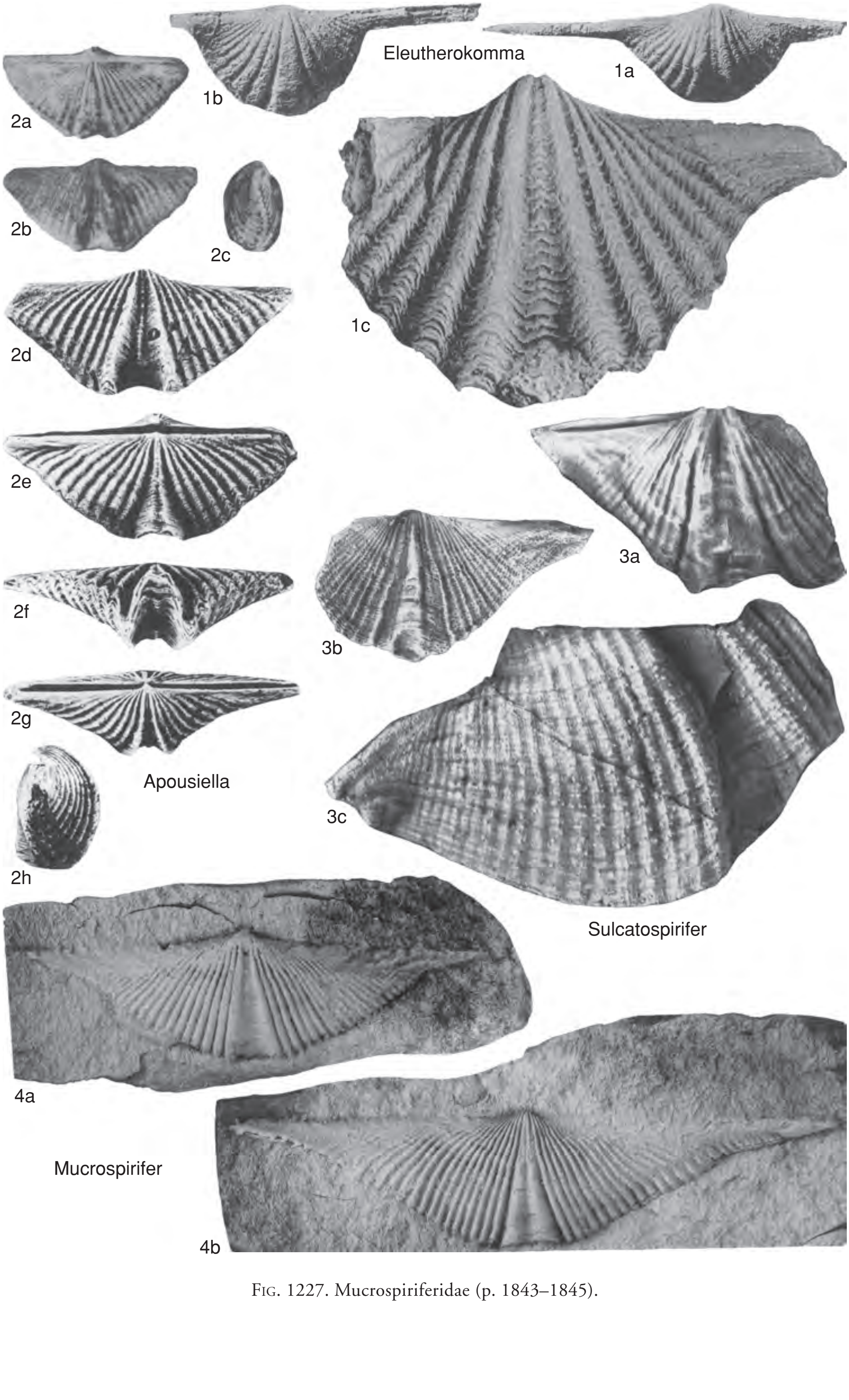

FIG. 1227. Mucrospiriferidae (p. 1843–1845).

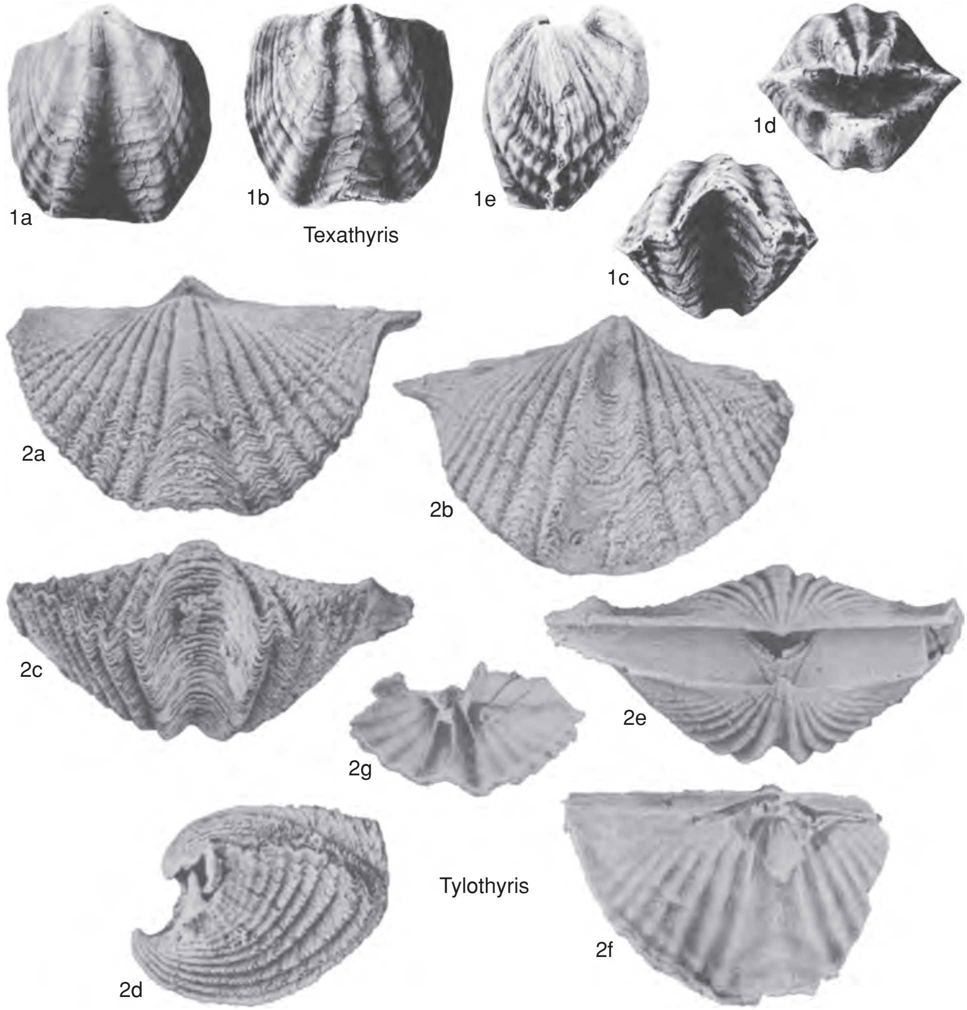

FIG. 1228. Mucrospiriferidae (p. 1845–1847).

1931, p. 35, *nom. nud.*]. Small to medium, biconvex, transverse, with angular to rounded cardinal extremities; ventral interarea low to high, apsacline to catacline; fold and sulcus smooth; flanks with simple, rounded plications and numerous imbricate growth lamellae; dental plates and median septum partly buried in callus. *Middle Devonian (upper Givetian)–Carboniferous (Visean):* cosmopolitan.——FIG. 1228,*2a–g*. **T. laminosa* (M'COY), Visean, Ireland; *a–f,* dorsal, ventral, anterior, lateral, and posterior views, dorsal interior; *g,* oblique anterior view of ventral interior, ×1.5 (Brunton, 1984).

Texathyris CARTER, 1972, p. 730 [**T. elegantula;* OD]. Small, biconvex, elongate; cardinal angles rounded, obtuse; ventral interarea short, curved, apsacline; fold and sulcus smooth, well defined by strong bounding plications; flanks with a few nearly obsolescent plications and prominent growth lamellae; dental plates and median septum present; ctenophoridium lacking crural plates. *Carboniferous (lower Tournaisian–middle Tournaisian):* southern USA (Texas).——FIG. 1228,*1a–e*. **T. elegantula;* holotype, ventral, dorsal, anterior, posterior, and lateral views, ×3 (Carter, 1972).

RETICULARIOIDEA

J. L. CARTER and RÉMY GOURVENNEC

[retired from Carnegie Museum of Natural History; and Université de Bretagne Occidentale]

Superfamily RETICULARIOIDEA Waagen, 1883

[*nom. correct.* GOURVENNEC & CARTER in CARTER & others, 1994, p. 353, *pro* Reticulariacea PITRAT, 1965, p. 717, *nom. transl. ex* Reticulariinae WAAGEN, 1883a, p. 538]

Subequally biconvex; outline generally transversely subovate to equidimensional; hinge line short, lateral extremities rounded; fold and sulcus generally present, generally weakly developed; ribbing absent or weak, rarely multicostate; microornament often lamellose, commonly with fine spines or granules. *Silurian (upper Llandovery)–Permian.*

Family RETICULARIIDAE Waagen, 1883

[*nom. transl.* IVANOVA, 1959, p. 56, *ex* Reticulariinae WAAGEN, 1883a, p. 538]

Lateral slopes usually smooth, rarely plicate; fold and sulcus, if present, smooth; microornament concentrically arranged, consisting of growth lamellae and generally uniramous spinules or tubercles; dental adminicula generally present, true ventral septum absent but median ridge or myophragm present in some genera. *Silurian (upper Llandovery)–Permian.*

Subfamily RETICULARIINAE Waagen, 1883

[Reticulariinae WAAGEN, 1883a, p. 538]

[Materials for this subfamily prepared by J. L. Carter & Rémy Gourvennec]

Generally pauciplicate; lacking delthyrial plates, delthyrial ridges, or any kind of apical thickening; commonly lacking crural plates. *Lower Devonian (upper Pragian)–Permian.*

Reticularia M'COY, 1844, p. 142 [**Terebratula? imbricata* SOWERBY, 1822 in 1821–1822, p. 40; SD DAVIDSON, 1882, p. 80]. Medium to large; unequally biconvex; fold and sulcus weakly to strongly developed; cardinal extremities well rounded; ornament of narrow, imbricate, growth lamellae fringed with fine, uniramous spines; exfoliated surfaces radially striated; ventral interior with dental adminicula and median ridge; dorsal interior with crural bases not touching valve floor; spiralia directed posterolaterally. *Carboniferous (Visean–Namurian):* Europe, Asia.——FIG. 1229,*2a–d.* **R. imbricata* (SOWERBY), Visean, England; lectotype, dorsal, ventral, lateral, and anterior views, ×1 (George, 1932).

Georgethyris MINATO, 1953, p. 68 [**Reticularia alexandri* GEORGE, 1932, p. 553; OD]. Fold and sulcus strongly developed; ventral interior seemingly lacking median ridge; otherwise similar to *Reticularia. Carboniferous (Visean):* British Isles. ——FIG. 1229,*1a–d.* **G. alexandri* (GEORGE); holotype, dorsal, ventral, lateral, and anterior views, ×1 (George, 1932).

Parareticularia LI & GU, 1976, p. 298 [**P. spiriferiformis;* OD]. Small to medium size; outline transversely spiriferoid with widely extended lateral extremities; ventral interarea moderately high; delthyrium wide, open; fold and sulcus strongly developed; lateral slopes with pair of wide shallow sulci; ornament consisting of lamellose growth lamellae fringed with numerous fine, uniramous, radial spines; ventral interior with short dental adminicula and long median ridge; dorsal interior lacking median ridge or septum. *Permian (Cisuralian):* China.——FIG. 1229,*3a–e.* **P. spiriferiformis;* ventral, dorsal, anterior, posterior, and lateral views, ×1 (Li & Gu, 1976).

Squamularia GEMMELLARO, 1899, p. 189 [**S. rotundata;* OD]. Medium size; almost equally biconvex; outline subovate; ventral umbonal region broad, beak incurved; ventral interarea indistinct; ornament lamellose with widely spaced, undulating, squamose growth lamellae fringed with closely spaced, fine, uniramous spines; ventral interior simple, dental adminicula and septa absent; spiralia directed posterolaterally. *Permian (Lopingian):* Sicily.——FIG. 1229,*4a–f.* **S. rotundata; a–e,* topotype, ventral, dorsal, anterior, posterior, and lateral views, ×1; *f,* microornament, ×10 (new).

?Undispirifer HAVLÍČEK, 1957b, p. 439 [**Spirifer undiferus* ROEMER, 1844, p. 73; OD] [=*Nakazatothyris* MINATO & KATO, 1977, p. 623 (type, *Undispirifer (Nakazatothyris) vandercammeni* MINATO & KATO, 1977, p. 623, OD); ?*Gerolsteinites* STRUVE, 1990, p. 268 (type, *Spirifera gerolsteinensis* STEININGER, 1853, p. 76, OD)]. Medium to large size, transverse, with catacline to apsacline interarea and rounded cardinal extremities; narrow, well-developed fold and sulcus; flanks with 5 to 8 low

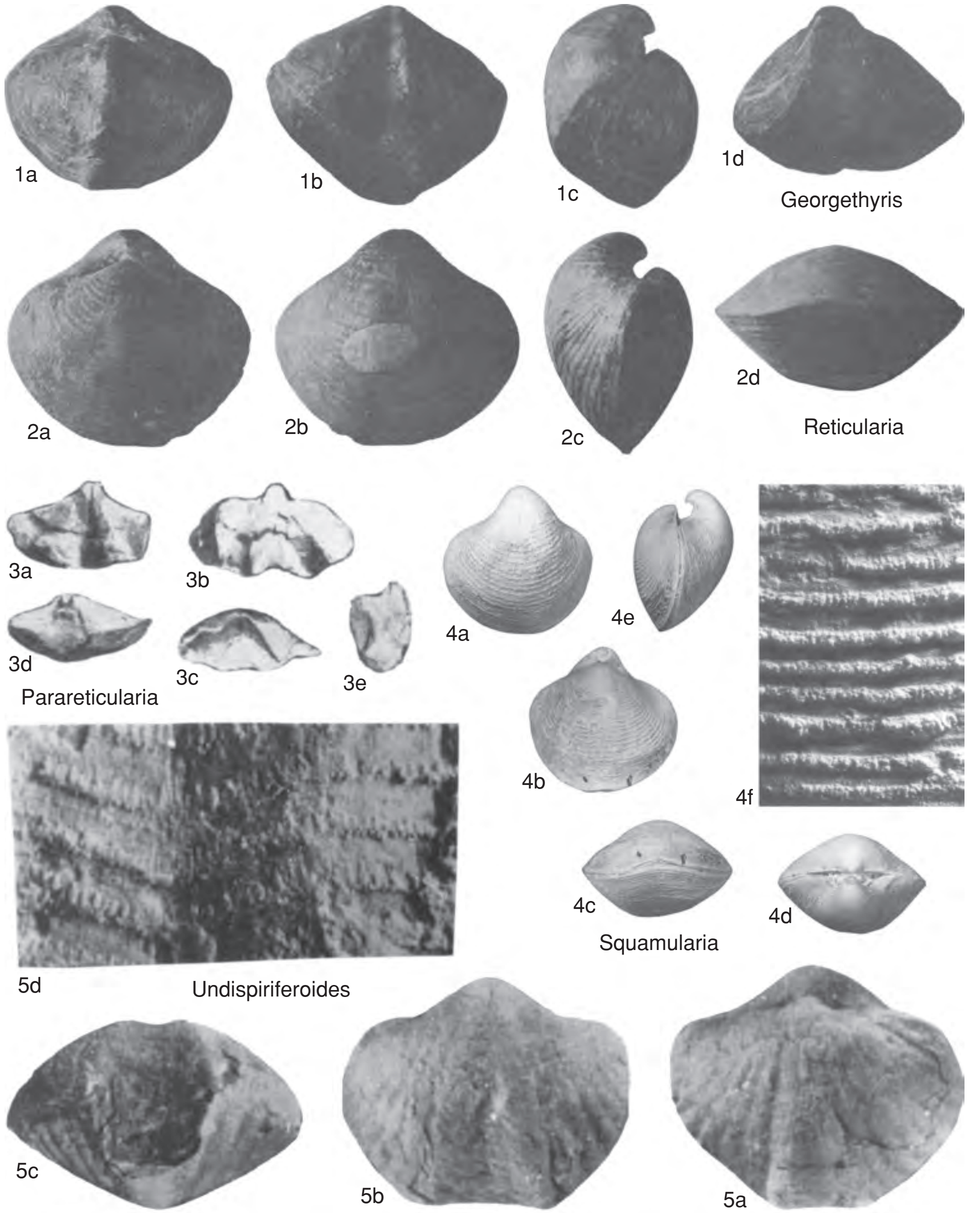

FIG. 1229. Reticulariidae (p. 1848–1850).

plications; microornament of concentric growth lamellae and marginal spines; dental plates long; crural plates short or lacking; ctenophoridium present. [The genus *Undispirifer* is here accepted with a broad definition, awaiting revision of the undispiriferoid stock(s), especially interiors, in Germany and immediate environs. *?Gerolsteinites* STRUVE, 1990, was diagnosed as having stronger ribs and a narrower ventral interarea than *Undispirifer.* After revision it might be revived as a subgenus of *Undispirifer,* or it could be a synonym of the genus *Corylispirifer* GOURVENNEC, 1989, to which it is also similar.] *Lower Devonian (upper Pragian)–Upper Devonian (Frasnian):* cosmopolitan.——FIG. 1230*a–f.* **U. undiferus* (ROEMER); dorsal, ventral, anterior, lateral views, lower

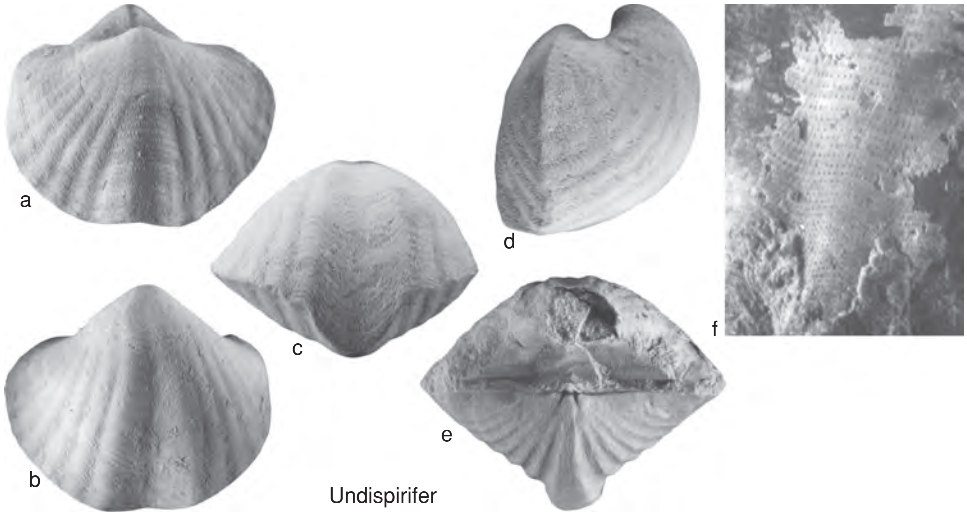

FIG. 1230. Reticulariidae (p. 1848–1850).

Givetian, Moravia, Czech Republic, ×1.8 (new); *e,* posterior view of internal mold, Givetian, Eifel, Germany, ×1.5; *f,* ornament, Givetian, Eifel, Germany, ×5 (Johnson, 1974).

?Undispiriferoides XIAN in XIAN & JIANG, 1978, p. 330 [**U. huishuiensis;* OD]. Medium to large size, subcircular; cardinal extremities rounded; sulcus and fold distinct, smooth; lateral costae low; microornament of concentric lamellae with 2 or 3 rows of spines; dental plates thin; crural bases platelike. [The interior of this genus is poorly known and has never been illustrated.] *Middle Devonian (Givetian):* southern China.——FIG. 1229,*5a–d.* **U. huishuiensis; a–c,* dorsal, ventral, anterior views, ×1; *d,* ornament, ×10 (Xian & Jiang, 1978).

Subfamily RETICULARIOPSINAE Gourvennec, 1994

[Reticulariopsinae GOURVENNEC in CARTER & others, 1994, p. 355]

[Materials for this subfamily prepared by Rémy Gourvennec]

Generally pauciplicate; lacking delthyrial plates, delthyrial ridges, or any kind of apical thickening; dental plates, crural plates, and ctenophoridium present. *Silurian (Wenlock)–Middle Devonian (Givetian).*

Reticulariopsis FREDERIKS, 1916, p. 17 [**Spirifer (Reticularia) dereimsi* OEHLERT, 1901, p. 236; SD FREDERIKS, 1918a, p. 87] [=*Tingella* GRABAU, 1931b, p. 406 (type, *T. reticularioides,* OD)]. Small to medium size, slightly transverse, with rounded cardinal angles; low, short, gently curved, apsacline interarea; weak, narrow, well-delimited fold and sulcus; flanks smooth or with 3 to 4 incipient, low plications; microornament of concentric growth lamellae and marginal spines; dental plates high, rather short; ctenophoridium and long crural plates. *Silurian (Wenlock)–Middle Devonian (Givetian):* cosmopolitan.——FIG. 1231,*4a–h.* **R. dereimsi* (OEHLERT), Emsian; *a–e,* dorsal, ventral, anterior, posterior, lateral views, Spain, ×2; *f,* posterior view of internal mold, Spain, ×3; *g–h,* ornament, unweathered spines, Massif Armoricain, France, ×10 (Gourvennec, 1994b).

Corylispirifer GOURVENNEC, 1989, p. 191 [**C. monicae;* OD]. Medium to large size, moderately transverse, with moderately high, slightly curved ventral interarea; cardinal angles rounded; fold and sulcus well marked, smooth; flanks bearing 2 to 5 rather low, wide, rounded plications; microornament of concentric, regularly spaced growth lamellae and closely spaced, marginal, uniramous spine bases; dental plates long, divergent, posteriorly thickened; ctenophoridium and long crural plates. *Lower Devonian (Pragian–Emsian):* western France, Spain.——FIG. 1231,*1a–g.* **C. monicae,* Pragian, Massif Armoricain, western France; *a–e,* dorsal, ventral, anterior, posterior, lateral views, ×1.5; *f,* ornament, ×10; *g,* posterior view of decorticated shell showing internal characters, ×3 (Gourvennec, 1989).

Kymatothyris STRUVE, 1970, p. 533 [**K. kroemmelbeini;* OD] [=*Fallaxispirifer* SU, 1976, p. 226 (type, *Spirifer pseudofallax* KHALFIN, 1935, p. 18, OD)]. Large, transverse, with rounded cardinal angles; ventral interarea apsacline, high, curved; sulcus and fold well expressed, wide; dorsal valve with 2 to 5 low, wide, lateral plications weakening anteriorly; plications of ventral valve commonly

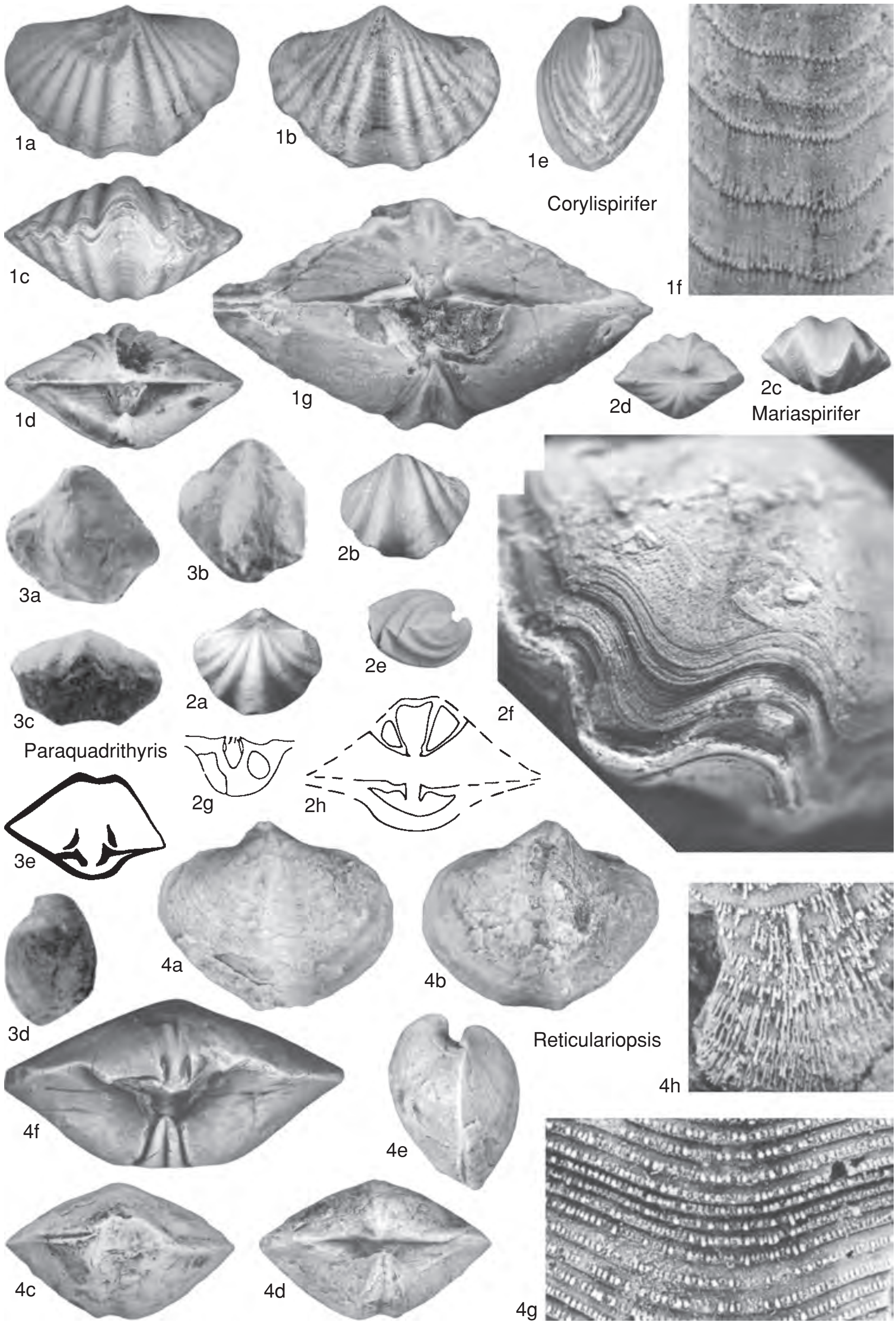

FIG. 1231. Reticulariidae (p. 1850–1852).

weaker or absent; microornament of concentric growth lines and simple spine bases; dental plates long, thin, slightly divergent to subparallel; crural plates short. *Lower Devonian (?upper Pragian, Emsian)–Middle Devonian (Eifelian):* Germany.——FIG. 1232,*1a–c*. **K. kroemmelbeini,* Eifelian, Salmerwald Mulde; dorsal, ventral, posterior views, ×0.7 (Struve, 1970).——FIG. 1232,*1d–f*. *K. bornicensis* (FUCHS), lower Emsian, Hunsrück; lateral, posterior views, interior of ventral valve, ×0.7 (Struve, 1970).

Mariaspirifer CHERKESOVA, 1991, p. 97 [**M. dolganensis;* OD]. Small size, equidimensional to slightly transverse with low, curved interarea; delthyrium with possible deltidial plate; fold and sulcus well marked; flanks commonly with 2 narrow plications; spinose microornament; dental plates short; massive ctenophoridium on cardinal platform and long crural plates. *Lower Devonian (lower Emsian):* Taimyr.——FIG. 1231,*2a–h*. **M. dolganensis; a–e,* dorsal, ventral, anterior, posterior, lateral views, ×1; *f,* ornament, ×5; *g–h,* serial sections, magnification unknown (Cherkesova, 1991).

?Paraquadrithyris YANG in ZHANG & others, 1983, p. 367 [**P. kashgarensis;* OD]. Medium size, with rhomboidal outline; sulcus and fold present, smooth; lateral plications few (1 to 2), low, and wide; microornament of growth lines and marginal spine bases; dental plates long, thin. [Poorly known genus, possibly synonym of *Reticulariopsis*.] *Middle Devonian:* China.——FIG. 1231,*3a–e*. **P. kashgarensis,* Xingjiang; *a–d,* dorsal, ventral, anterior, lateral views, ×1; *e,* transverse section, ×2 (Zhang & others, 1983).

Pavdenia BREIVEL & BREIVEL, 1988, p. 114 [**Spirifer (?Eospirifer) pavdensis* SHTREIS, 1951, p. 242; OD]. Medium to large size, equidimensional to slightly transverse, with widely rounded cardinal extremities; ventral interarea high, gently curved, apsacline; sulcus and fold sharply delimited from flanks in mature specimens; entire shell smooth; microornament of closely spaced growth lamellae bearing radially aligned marginal spines; dental plates long, thin; crural plates short. *Silurian (Wenlock):* Urals.——FIG. 1232,*2a–f*. **P. pavdensis* (SHTREIS); *a–d,* dorsal, ventral, anterior, lateral views, ×1; *e,* ornament, ×5; f, transverse section, ×2 (Breivel & Breivel, 1988).

Prosserella GRABAU in GRABAU & SHERZER, 1910, p. 138 [**P. modestoides;* SD BASSLER, 1915, p. 1,102]. Small to medium size, equidimensional to slightly transverse, with short, relatively high, gently curved ventral interarea; fold and sulcus absent or moderately developed, smooth; flanks smooth or bearing 4 to 5 low, rounded plications on anterior half of shell; rectimarginate to uniplicate commissure; microornament of growth lines only; dental lamellae long, thin, parallel, closely spaced; ctenophoridium with short, closely spaced crural plates. *Lower Devonian (?upper Emsian), Middle Devonian (Eifelian):* eastern North America.——FIG. 1232,*3a–f*. **P. modestoides,* ?upper Emsian, lower Eifelian, Ontario, Canada; *a–b,* dorsal, lateral views, ×3; *c,* anterior view, ×2; *d,* posterior view of internal mold showing crural plates, cardinal process, and short myophragm, ×2; *e,* interior of ventral valve showing closely spaced dental plates, ×1.3; *f,* ventral interior of costate morphotype, ×2 (Fagerstrom, 1971).

Yeothyris STRUVE, 1992, p. 582 [**Tingella bicollina* STRUVE, 1961, p. 332; OD]. Large size, equidimensional to transverse, with well-delimited, wide, ventral interarea; cardinal extremities rounded; fold and sulcus small, well defined; flanks smooth; microornament of growth lines and marginal spines; dental plates long, moderately divergent, strong; ctenophoridium with short crural plates. *Middle Devonian (middle Eifelian):* Germany, Belgium.——FIG. 1232,*4a–g*. **Y. bicollina* (STRUVE), Eifel, Germany; *a–e,* dorsal, ventral, anterior, posterior, lateral views, ×1 (Struve, 1970); *f,* ornament, ×10 (Struve, 1961); *g,* posterior view of internal mold, ×1 (Struve, 1970).

Subfamily RHENOTHYRIDINAE Gourvennec, 1994

[Rhenothyridinae GOURVENNEC in CARTER & others, 1994, p. 355]

[Materials for this subfamily prepared by Rémy Gourvennec]

With delthyrial plate, ridge, or ventral apical thickening; dental plates and ctenophoridium present. *Silurian (upper Llandovery)–Upper Devonian (Frasnian).*

Rhenothyris STRUVE, 1970, p. 460 [**R. rhenana;* OD]. Large size, transverse, with low ventral interarea; deltidial plates joining apically in a short deltidium; cardinal extremities rounded; fold and sulcus wide, high to strongly developed; entire shell devoid of plications; regularly spaced growth lamellae with marginal spines; dental plates long, divergent; ctenophoridium and long, thick crural plates. *Lower Devonian (upper Emsian)–Middle Devonian (lower Eifelian, ?Givetian):* Germany, Belgium, ?northern Africa, ?Kazakhstan.——FIG. 1233,*1a–h*. **R. rhenana,* lower Eifelian, Eifel, Germany; *a–e,* dorsal, ventral, anterior, posterior, lateral views, ×0.7; *f,* ornament, ×5.75; *g,* posterior view of steinkern showing internal structures, ×1.3; *h,* section showing delthyrial plate, ×3 (Struve, 1970).

Deltospirifer WANG & RONG, 1986, p. 208 [263] [**Elytha transversa* WANG, 1956, p. 378; OD]. Medium to large size, transverse to equidimensional, with slightly acute to rounded cardinal extremities; low, curved, apsacline ventral interarea; delthyrium entirely covered by deltidium; fold and sulcus well defined; anterior commissure uniplicate; lateral plications few (1 to 3), low and weakening anteriorly; microornament of growth lamellae and marginal spine bases; dental plates long, thin; ctenophoridium without crural plates. *Lower Devonian*

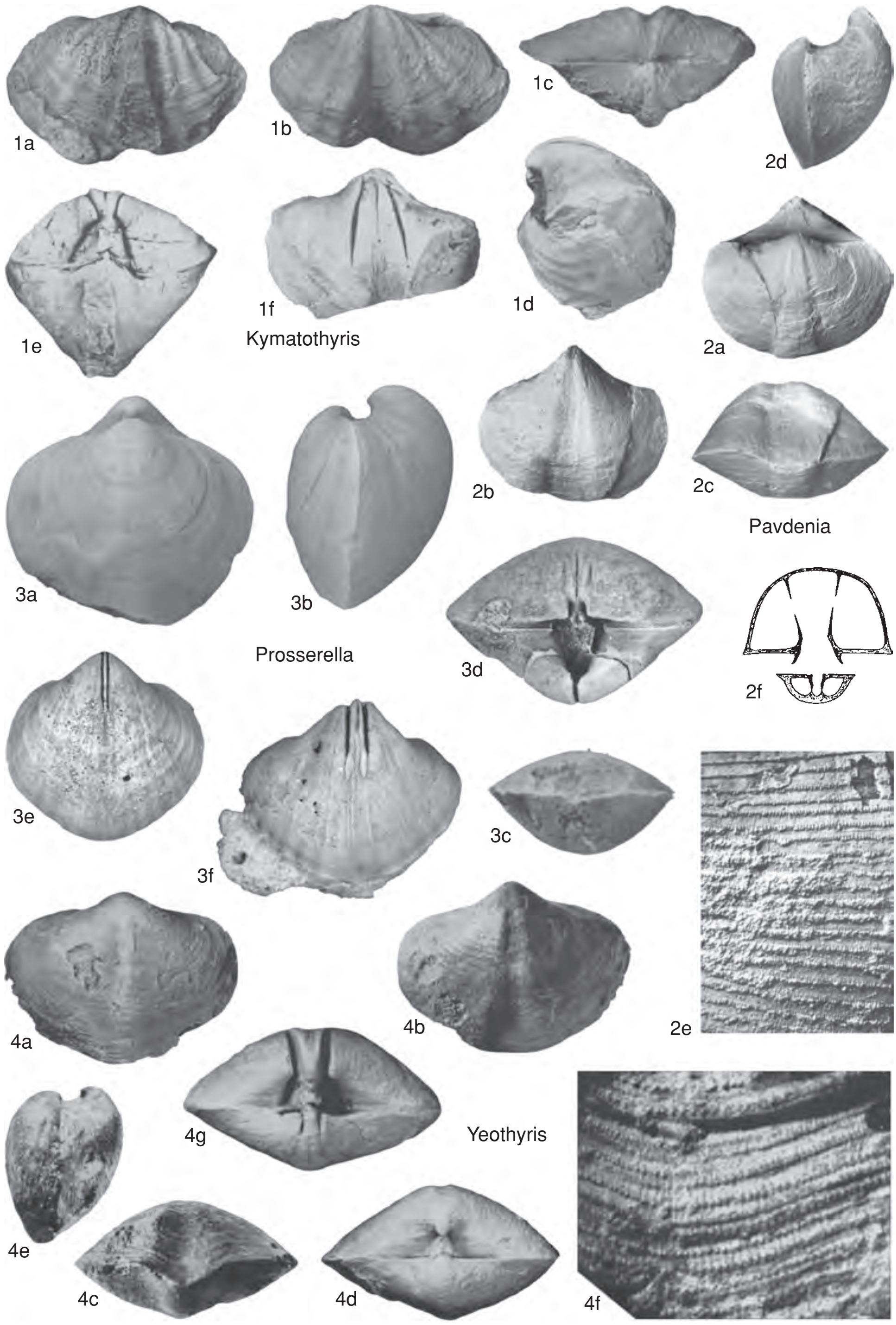

FIG. 1232. Reticulariidae (p. 1850–1852).

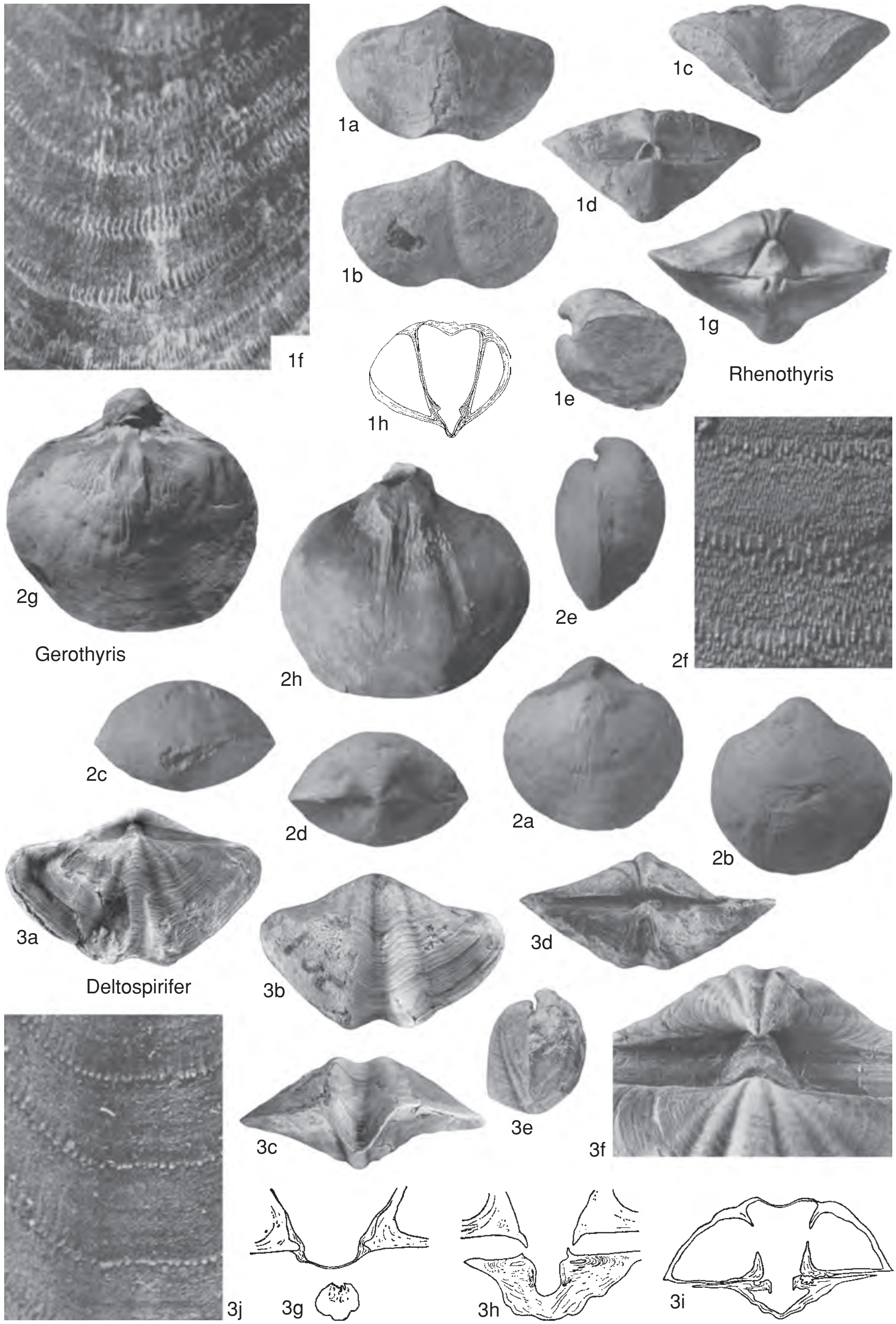

FIG. 1233. Reticulariidae (p. 1852–1855).

(Emsian)–Middle Devonian (Eifelian): China.——FIG. 1233,*3a–i*. **D. transversus* (WANG), Emsian, Guangxi; *a–e,* dorsal, ventral, anterior, posterior, lateral views, ×1; *f,* detail of deltidial cover, ×3; *g–h,* serial sections, ×3.8; *i,* serial section, ×1.5 (Wang & Rong, 1986).——FIG. 1233,*3j*. *D. ovatus* (WANG), Emsian; ornament, ×6 (Wang & Rong, 1986).

?Eohowellella LOPUSHINSKAIA, 1976, p. 79 [**Eomartiniopsis(?) minimus* LOPUSHINSKAIA, 1965, p. 30; OD]. Very small, unequally biconvex, equidimensional, with rounded cardinal angles; ventral interarea relatively high; sulcus narrow and shallow; fold well delimited by wide sulci; microornament of growth lines and radial striae; dental plates uniting in rudimentary septum (spondylium?); crural plates. [The definition of *Eohowellella* is imprecise and not in accordance with the original illustrations. For example, the so-called ventral septum recorded in the diagnosis is absent on the serial sections; if such a septum is really present, *Eohowellella* would better be assigned to the Quadrithyridinae. The comparison with *Howellella* suggests that a ctenophoridium is present although not reported in the diagnosis. The mention of a finely punctate shell in the description is probably erroneous; such a character would necessitate removal of *Eohowellella* from the Reticularioidea.] *Silurian (upper Llandovery–lower Ludlow):* Siberian Platform.——FIG. 1234,*1a–c*. **E. minima* (LOPUSHINSKAIA), Wenlock; dorsal, ventral, anterior views, ×1.5 (Lopushinskaia, 1976).

Gerothyris STRUVE, 1970, p. 537 [**Spirifer laevigatus eiflianus* QUENSTEDT, 1871 in 1868–1871, p. 514; OD]. Medium size, equidimensional to slightly transverse, with widely rounded cardinal angles; ventral interarea short, low, orthocline to catacline; sulcus and fold lacking but anterior commissure slightly uniplicate; flanks smooth; microornament of growth lines obscure or lacking and roughly concentric rows of papillae alternating with smaller, randomly distributed papillae; dental plates short, thickened with apical callosity and excavated muscle field; ctenophoridium and long, thin crural plates. *Middle Devonian (Eifelian):* Germany, Belgium.——FIG. 1233,*2a–h*. **G. eifliana* (QUENSTEDT), Eifel, Germany; *a–e,* dorsal, ventral, anterior, posterior, lateral views, ×1; *f,* ornament, ×10; *g–h,* dorsal, ventral views of internal mold, ×1.5 (Struve, 1970).

Grebenella MODZALEVSKAIA & BEZNOSOVA, 1992, p. 8 [**Spirifer parvulus* CHERNYSHEV & IAKOVLEV, 1898, p. 352; OD]. Small, rounded to slightly transverse, with high, apsacline, curved, ventral interarea; cardinal extremities rounded to acutely rounded; fold and sulcus well defined, weak; flanks with 2 to 3 low plicae; microornament of growth lamellae only; dental plates strong, long, and small delthyrial plate or ridges; well-developed crural plates and ctenophoridium; dorsal apical thickening of shell. *Silurian (Pridoli):* northeastern Russia (Arctic Islands).——FIG. 1234,*2a–g*. **G. parvula* (CHERNYSHEV & IAKOVLEV); *a–c,* dorsal, ventral, anterior views, ×3.5 (Modzalevskaia & Beznosova, 1992); *d–e,* posterior, lateral views, ×3.5 (new); *f,* transverse section showing short delthyrial plate, ×3 (Modzalevskaia & Beznosova, 1992); *g,* transverse section showing crural plates, ×2 (Modzalevskaia, 1981).

?Nordella LIASHENKO, 1973, p. 135 [**Elytha orbiculata* LIASHENKO, 1959, p. 142; OD]. Medium to large size, equidimensional, subcircular; ventral interarea low and short, with delthyrium mostly covered by convex deltidium; fold and sulcus poorly expressed, smooth; anterior commissure slightly uniplicate; flanks smooth or bearing 4 to 10 very weak, wide plications near anterolateral commissure; microornament of growth lines bearing marginal spine bases; dental plates long, divergent; crural plates lacking. [A ctenophoridium is not reported in the diagnosis of *Nordella,* but the comparison with *Elita* suggests close analogies in the internal structures, and we admit the presence of a ctenophoridium; should this not be the case, *Nordella* would be better placed in the Eoreticulariinae.] *Upper Devonian (lower Frasnian):* Russia (Siberia).——FIG. 1234,*5a–g*. **N. orbiculata* (LIASHENKO), Russian Platform; *a–e,* dorsal, ventral, anterior, posterior, lateral views, ×0.7; *f,* ornament, ×10; *g,* transverse section, magnification unknown (Liashenko, 1973).

Pseudoundispirifer ZHANG, 1987a, p. 144 [**P. yiwaensis;* OD]. Small, equidimensional to slightly transverse, with curved ventral interarea; fold and sulcus weak; lateral plications rare, low; microornament of growth lamellae and marginal spines; dental plates long, thin, and well-developed delthyrial plate; crural plates and ctenophoridium on cardinal platform. [This poorly known genus is probably a synonym of *Eoreticularia.*] *Middle Devonian (Givetian):* China.——FIG. 1234,*4a–h*. **P. yiwaensis; a–d,* dorsal, ventral, anterior, lateral views, ×1; *e–h,* serial sections, ×3 (Zhang, 1987a).

?Puanospirifer JIANG in XIAN & JIANG, 1978, p. 329 [**P. guanziyaoensis;* OD]. Medium size, triangular in outline; flanks smooth or with weak plications; microornament with marginal spines; short dental plates and ventral apical thickening; crural plates lacking. [This genus is poorly known and is possibly a synonym of *Deltospirifer.*] *Lower Devonian (Emsian):* southern China.——FIG. 1234,*3a–b*. **P. guanziyaoensis,* Guizhou; dorsal, ventral views, ×0.7 (Xian & Jiang, 1978).——FIG. 1234,*3c–e*. *P. transversus* JIANG, Guizhou; anterior, posterior, lateral views, ×1 (Xian & Jiang, 1978).

Spirinella JOHNSTON, 1941, p. 161 [**S. caecistriata;* OD] [=*Ectatoglossa* CHU, 1974, p. 419 (type, *E. biplicata,* OD)]. Medium size; equidimensional to slightly transverse, smooth, inequivalve with apsacline, curved ventral interarea; cardinal angles rounded; fold and sulcus smooth, very low, poorly defined except near weakly uniplicate commissure; flanks lacking plications; numerous closely spaced growth lamellae with marginal spine bases or papillae; moderately long, divergent dental plates, short delthyrial plate, and variably impressed muscle field; ctenophoridium and short crural plates.

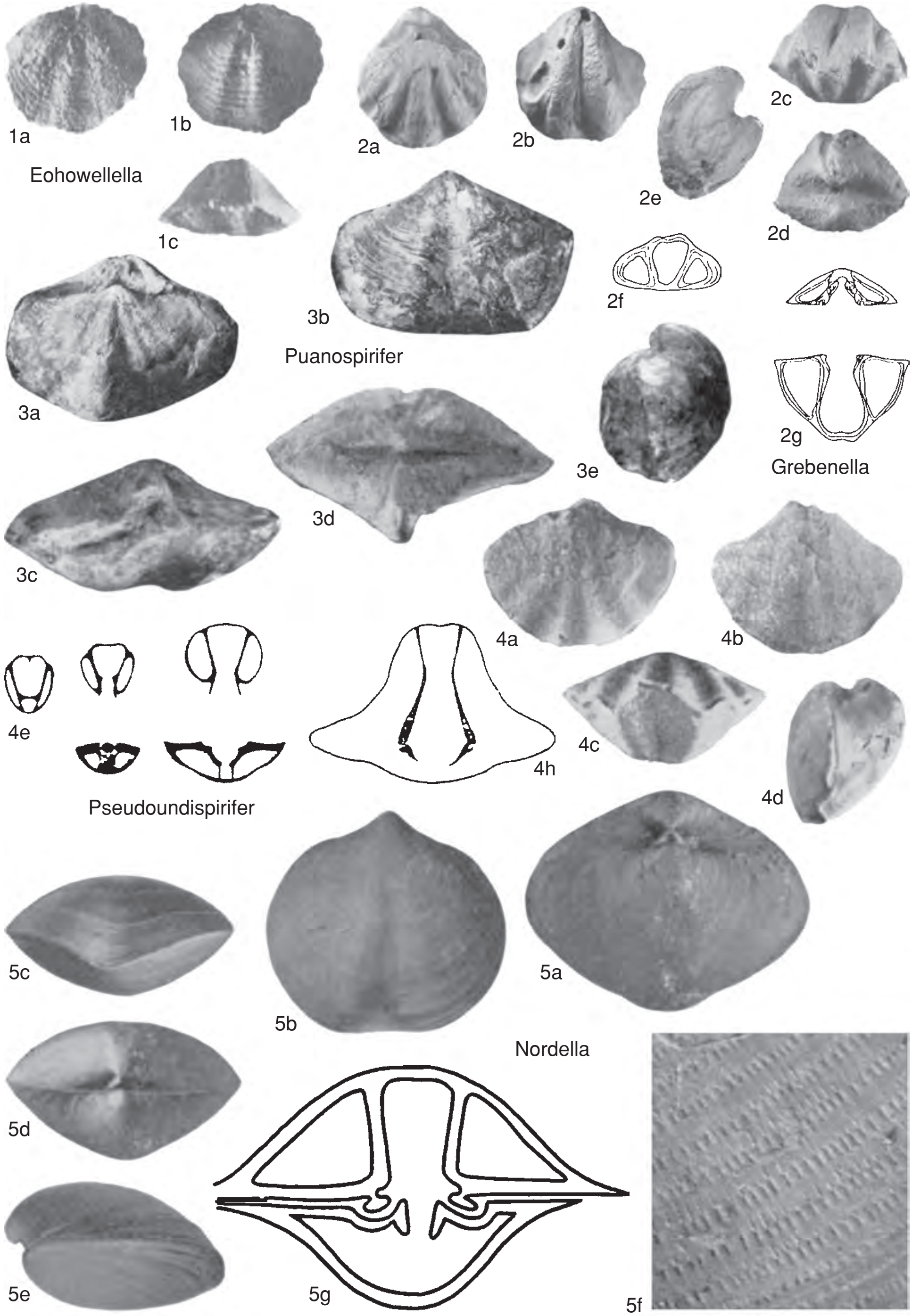

FIG. 1234. Reticulariidae (p. 1855).

Silurian (upper Llandovery)–Lower Devonian (upper Emsian): Australia, western North America, Altai, China, Czech Republic.——FIG. 1235,*1a–j.* **S. caecistriata,* lower Ludlow, New South Wales, Australia; *a–e,* dorsal, ventral, anterior, posterior, lateral views, ×1.5; *f,* ornament, ×16 (Strusz, 1984); *g,* detail of cardinalia, ×5 (Strusz, 1985); *h–j,* dorsal, ventral, posterior views of internal mold, ×1.5 (new).

Uexothyris STRUVE, 1992, p. 572 [**U. convergens;* OD]. Medium size, transverse to equidimensional, with rounded cardinal extremities; low to moderately high, wide ventral interarea; sulcus and fold lacking or very weak; flanks smooth; microornament of marginal papillae; dental plates possibly lacking or short; strongly excavated muscle field; closely spaced, short crural plates and ctenophoridium. [No satisfactory illustrations are available for this genus.] *Middle Devonian (Eifelian):* Germany.

Warrenella CRICKMAY, 1953a, p. 596 [**W. eclectea;* OD] [=*Minatothyris* VANDERCAMMEN, 1957, p. 178 (type, *Spirifer euryglossus* SCHNUR, 1851, p. 11, OD)]. Medium to large, elongate; low, curved, apsacline ventral interarea; apex of delthyrium with short deltidium; cardinal angles rounded; fold and sulcus poorly expressed but generally distinct; closely spaced growth lamellae with marginal spine bases; strong apical callus; closely spaced, subparallel dental plates and deeply impressed muscle field; ctenophoridium and highly variable crural plates. *Lower Devonian (upper Pragian)–Upper Devonian (Frasnian).*

W. (Warrenella). Lateral plications lacking or incipient near commissure. *Lower Devonian (upper Pragian)–Upper Devonian (Frasnian):* cosmopolitan.——FIG. 1235,*2a–g.* **W. eclectea,* Frasnian, Alberta, Canada; *a–e,* dorsal, ventral, anterior, posterior, lateral views, ×1.5 (Crickmay, 1953); *f–g,* ventral, posterior views of internal mold, ×1.5 (new).

W. (Warrenellina) BRICE, 1982b, p. 103 [**W. (W.) extensa;* OD]. Medium size, with 0 to 5 low, obsolescent plications in vicinity of commissure; uncommonly with 1 faint median rib in sulcus and corresponding groove on fold. *Lower Devonian (Emsian)–Upper Devonian (Frasnian):* western and arctic North America.——FIG. 1235,*3a–h.* **W. (W.) extensa,* Eifelian, Northwest Territories, Canada; *a–e,* dorsal, ventral, anterior, posterior, lateral views, ×1; *f,* ornament, ×4; *g–h,* serial sections, ×2 (Brice, 1982b).

Subfamily OBESARIINAE Gourvennec, 1994

[Obesariinae GOURVENNEC in CARTER & others, 1994, p. 356]

[Materials for this subfamily prepared by Rémy Gourvennec]

Smooth; lacking dental plates and ctenophoridium; apical thickening in ventral valve. *Silurian (upper Wenlock)–Middle Devonian (Eifelian), Carboniferous (?Mississippian).*

Obesaria HAVLÍČEK, 1957b, p. 438 [**Spirifer indifferens* var. *obesa* BARRANDE, 1848, p. 159; OD] [=*Obessaria* HAVLÍČEK, 1957b, p. 438, obj., *lapsus calami*]. Medium size, slightly transverse, with rounded cardinal angles; short, low, ventral interarea; fold absent; sulcus narrow and shallow near umbo, rapidly deepening and widening anteriorly; anterior commissure strongly uniplicate; flanks smooth; microornament of faint growth lines and concentric, radial rows of minute granules; deeply impressed ventral muscle field, lacking dental plates; strong apical callosity; crural plates and ctenophoridium lacking. [In the original publication by HAVLÍČEK (1957b), the new genus is spelled *Obessaria* nov. gen., but in the remaining parts of the text and in the English summary it is spelled *Obesaria.*] *Middle Devonian (Eifelian):* Czech Republic.——FIG. 1236,*1a–g.* **O. obesa* (BARRANDE); *a–e,* dorsal, ventral, anterior, posterior, lateral views, ×1.5; *f,* ornament, ×10; *g,* internal mold showing muscle field and lack of dental plates, ×1 (Havlíček, 1959).

Alaskospira KIRK & AMSDEN, 1952, p. 61 [**A. dunbari;* OD] [=*Proreticularia* HAVLÍČEK, 1957a, p. 247 (type, *Spirifer carens* BARRANDE, 1879, p. 218, OD)]. Medium size, equidimensional to slightly transverse, with apsacline, curved ventral interarea; cardinal angles rounded; fold and sulcus ill defined except near anterior commissure; shell surface smooth; microornament of closely spaced growth lines and radial rows of spines; dental plates lacking; strong apical thickening; muscle field deeply impressed, divided by a median ridge extending nearly to anterior margin; ctenophoridium and crural plates lacking; low myophragm. *Silurian (upper Wenlock)–Lower Devonian (Emsian):* USA (Alaska), Czech Republic, Urals, Australia (New South Wales).——FIG. 1236,*2a–i.* **A. dunbari,* upper Wenlock, Alaska, USA; *a–d,* dorsal, ventral, posterior, lateral views, ×2; *e,* ornament, ×6; *f–i,* serial sections, ×1.5 (Kirk & Amsden, 1952).

Echinocoeliopsis HAMADA, 1968b, p. 17 [**E. sculpta;* OD]. Very small to small, strongly inequivalve, equidimensional with rounded cardinal angles; low and short interarea; sulcus obscure; fold distinctly separated from flanks by wide sulci; commissure rectimarginate; flanks smooth; microornament of growth lamellae and marginal spine bases; dental plates and crural plates lacking; cardinal process bifid. *?Upper Devonian, Carboniferous (?Mississippian):* Malaysia.——FIG. 1236,*4a–e.* **E. sculpta; a,* dorsal valve showing ornament, ×8; *b,* ventral valve, approximately ×3; *c,* anterior view of ventral valve, ×3; *d,* lateral view of ventral valve, ×5; *e,* interior of dorsal valve, ×5 (Hamada, 1968b).——FIG. 1236,*4f. E. ladjioidea* HAMADA; interior of ventral valve, ×3 (Hamada, 1968b).

Quasimartinia HAVLÍČEK, 1959, p. 179 [**Q. rectimarginata;* OD] [=*Candispirifer* HAVLÍČEK,

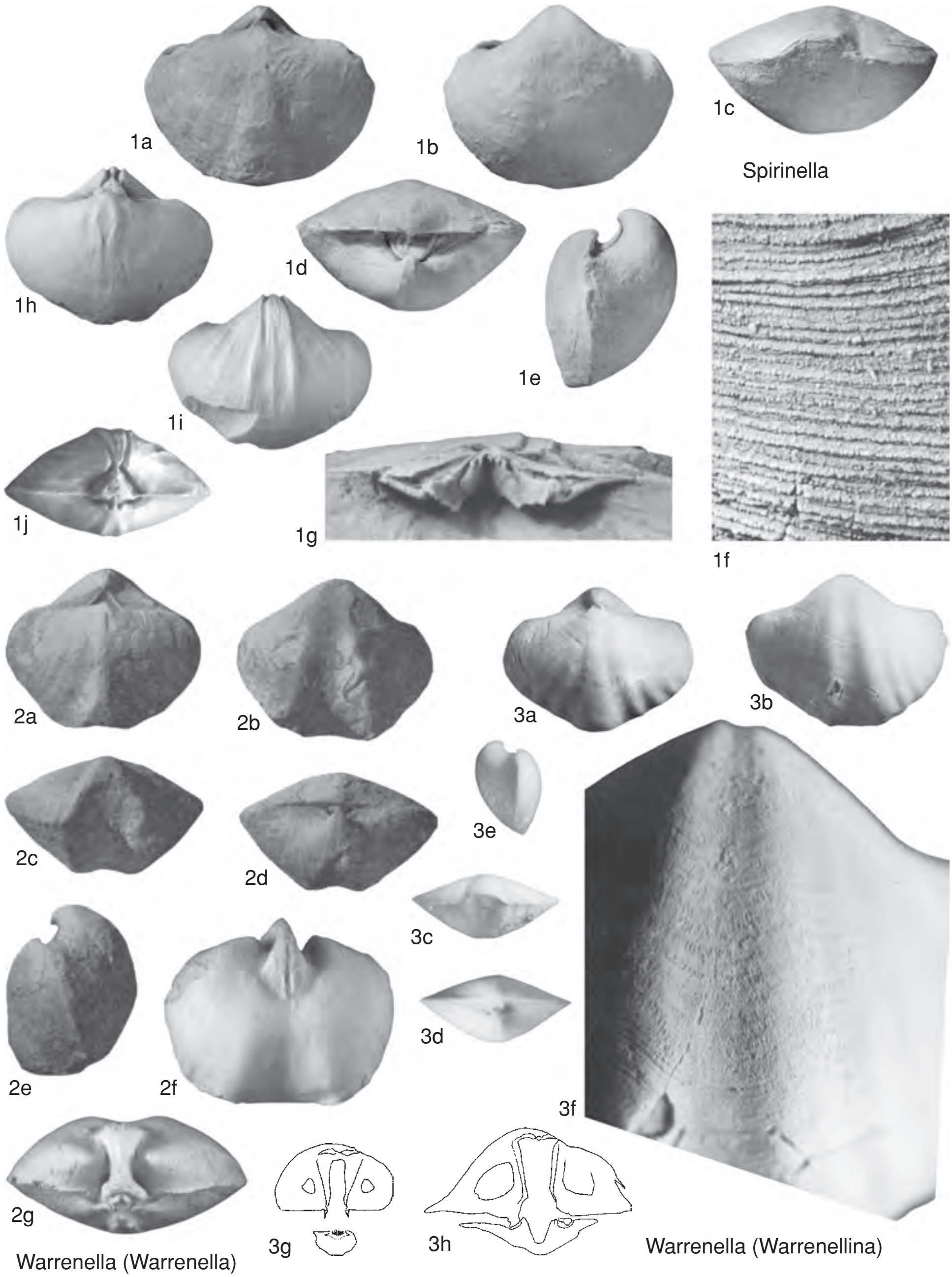

FIG. 1235. Reticulariidae (p. 1855–1857).

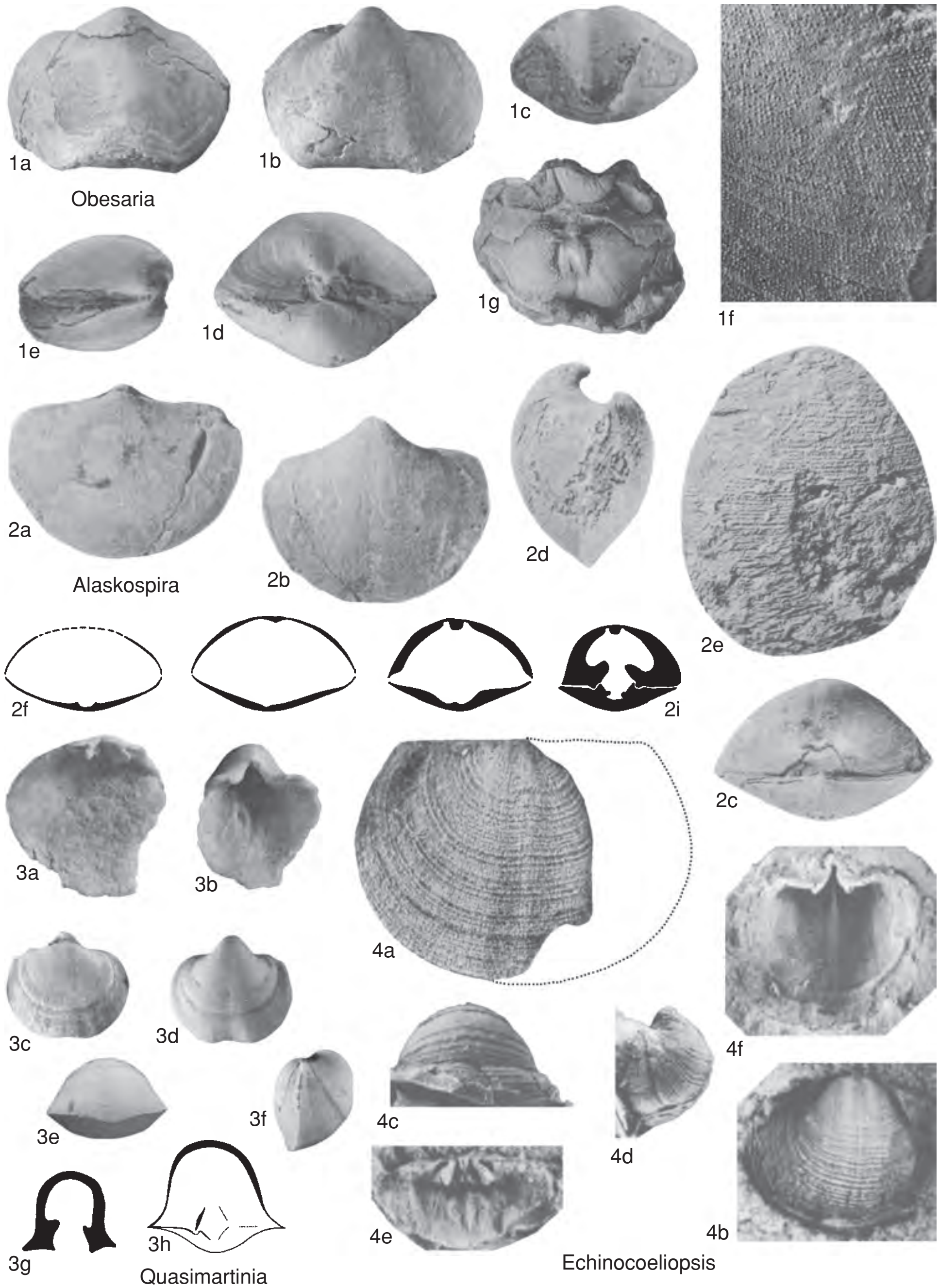

FIG. 1236. Reticulariidae (p. 1857–1860).

1971, p. 26 (type, *Proreticularia candida* HAVLÍČEK, 1959, p. 155, OD)]. Small size, equidimensional, strongly inequivalve; ventral valve high with low, curved, apsacline interarea and strong beak; cardinal angles rounded; fold and sulcus absent or scarcely marked near anterior commissure; entire shell smooth; microornament lacking; dental plates, septum, and crural plates lacking; cardinal process bilobed. *Lower Devonian (Pragian)–Middle Devonian (Eifelian):* Czech Republic.——FIG. 1236,*3a–b*. **Q. rectimarginata,* Pragian; interior of dorsal valve, interior of ventral valve, ×3.5 (Havlíček, 1959).——FIG. 1236,*3c–h*. *Q. candida* (HAVLÍČEK), Pragian; *c–f,* dorsal, ventral, anterior, lateral views, ×1.5; *g–h,* serial sections, ×3 (Havlíček, 1959).

Subfamily EORETICULARIINAE Gourvennec, 1994

[Eoreticulariinae GOURVENNEC in CARTER & others, 1994, p. 356]

[Materials for this subfamily prepared by Rémy Gourvennec]

Smooth; with cardinal platform or septalium; lacking ctenophoridium. *Silurian (Wenlock)–Upper Devonian (Frasnian).*

Eoreticularia NALIVKIN in FREDERIKS, 1924, p. 314 [**Spirifer indifferens* BARRANDE, 1848, p. 159; OD]. Medium to large, equidimensional to slightly transverse, with rounded cardinal extremities; low, curved ventral interarea; fold obscure, sulcus shallow, deepening anteriorly and producing uniplicate commissure; lateral plications generally lacking or very faintly expressed; microornament of growth lamellae and minute granules arranged in radial rows, lacking spines; long, thin dental plates and delthyrial plate or ridge; short crural plates joining median septum or ridge; cardinal process smooth. *Silurian (Ludlow)–Upper Devonian (Frasnian):* Czech Republic, Poland, Germany, Kazakhstan, Urals, China, Morocco, Algeria, Mauritania.——FIG. 1237,*1a–e*. **E. indifferens* (BARRANDE), Emsian, Czech Republic; *a–d,* dorsal, ventral, anterior, lateral views, ×1.5; *e,* transverse section of dorsal valve, ×3 (Havlíček, 1959).——FIG. 1237,*1f*. *E. fraterna* (BARRANDE), Emsian, Czech Republic; transverse section showing delthyrial plate, ×3 (Havlíček, 1959).

Chnaurocoelia JOHNSON, BOUCOT, & MURPHY, 1976, p. 95 [**C. transversa;* OD]. Very small to small, slightly transverse, with apsacline ventral interarea; cardinal angles acutely rounded; very shallow sulcus and obscure fold; 5 to 6 low, ill-defined plications on each flank; microornament unknown; dental lamellae short, thin; ctenophoridium and crural plates lacking. *Silurian (Ludlow):* USA (Nevada). ——FIG. 1237,*3a–g*. **C. transversa; a–e,* dorsal, ventral, anterior, posterior, lateral views; *f,* interior of dorsal valve; *g,* interior of ventral valve, ×5 (Johnson, Boucot, & Murphy, 1976).

?Protoreticularia SU, 1980, p. 323 [**P. fimbriata;* OD]. Small, subpentagonal, with rounded cardinal extremities and high, curved ventral interarea; lateral plications, fold and sulcus lacking or shallow median depression on ventral valve; microornament of growth lamellae and marginal spines; interior poorly investigated, with short, thin dental plates, lacking crural plates. [Apparently this genus lacks crural plates, but the interior is poorly known and needs further investigation for a solid assignment to the subfamily.] *Silurian (Ludlow):* China.——FIG. 1237,*2a–d*. **P. fimbriata,* northeastern China; *a–c,* dorsal valve, ventral, posterior views of ventral valve, ×3; *d,* ornament, ×10 (Su, 1980).

Vadum STRUSZ, 1982, p. 136 [**V. coppinsense;* OD]. Very small, slightly transverse, with rounded cardinal extremities; high, catacline ventral interarea; fold and sulcus distinct or very subdued; flanks lacking plications; growth lamellae few, bearing both radially and concentrically arranged papillae; dental plates thin, moderately long; crural plates short, cardinal process bilobed. *Silurian (Wenlock):* Australia.——FIG. 1237,*4a–e*. **V. coppinsense,* New South Wales; *a–b,* dorsal, ventral views, ×5; *c,* lateral view, ×8; *d,* detail of cardinalia, ×12; *e,* internal mold of ventral valve, ×6 (Strusz, 1982).

Family XENOMARTINIIDAE Havlíček, 1971

[Xenomartiniidae HAVLÍČEK, 1971, p. 24]

[Materials for this subfamily prepared by Rémy Gourvennec]

With ventral median septum. *Silurian (upper Wenlock)–Middle Devonian (Givetian).*

Subfamily XENOMARTINIINAE Havlíček, 1971

[*nom. transl.* GOURVENNEC in CARTER & others, 1994, p. 357, *ex* Xenomartiniidae HAVLÍČEK, 1971, p. 24]

Smooth; lacking dental plates and ctenophoridium. *Lower Devonian (Pragian)–Middle Devonian (Eifelian).*

Xenomartinia HAVLÍČEK, 1953, p. 6 [**X. monosepta;* OD] [=*Sinothyris* MINATO, 1953, p. 68 (type, *S. maureri,* OD, =*Reticularia maureri sensu* GRABAU, 1931b, p. 394, *non* HOLZAPFEL, 1896)]. Small, equidimensional, biconvex; short, moderately high ventral interarea; fold and sulcus lacking; anterior commissure slightly uniplicate; entire shell smooth; microornament of concentric lamellae crossed by fine radial capillae; ventral median septum; lacking

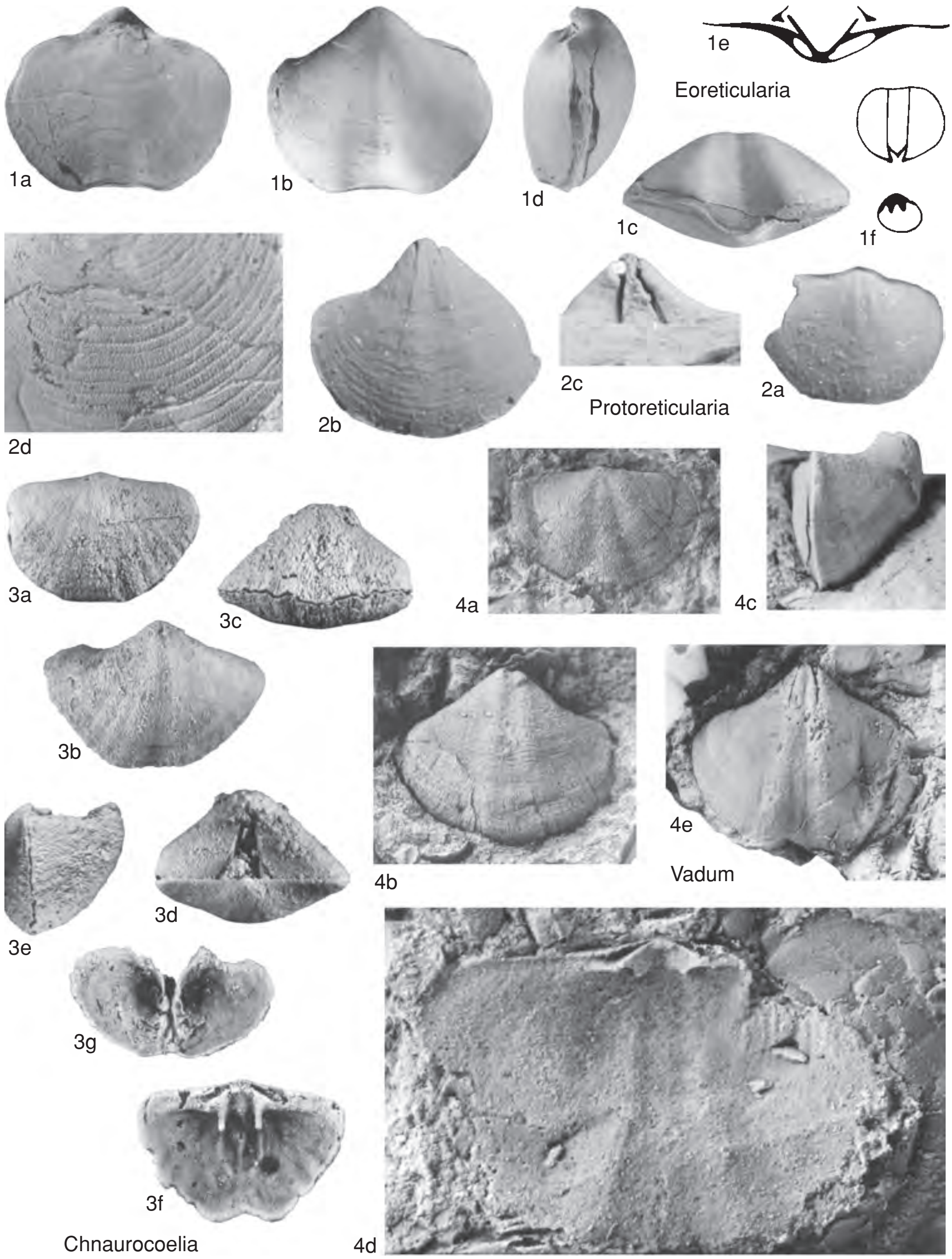

FIG. 1237. Reticulariidae (p. 1860).

dental plates; crural plates lacking; cardinal process trilobed. *Lower Devonian (Pragian)–Middle Devonian (Eifelian):* Czech Republic, Turkestan, China.——FIG. 1238,*1a–f.* **X. monosepta,* Pragian, Czech Republic; *a–d,* dorsal, ventral, anterior, lateral views, ×2; *e–f,* dorsal interior, ventral interior, ×3 (Havlíček, 1959).——FIG. 1238,*1g. X. monoseptoides* HAVLÍČEK, ?upper Emsian, Czech Republic; transverse section, ×2.5 (Havlíček, 1959).

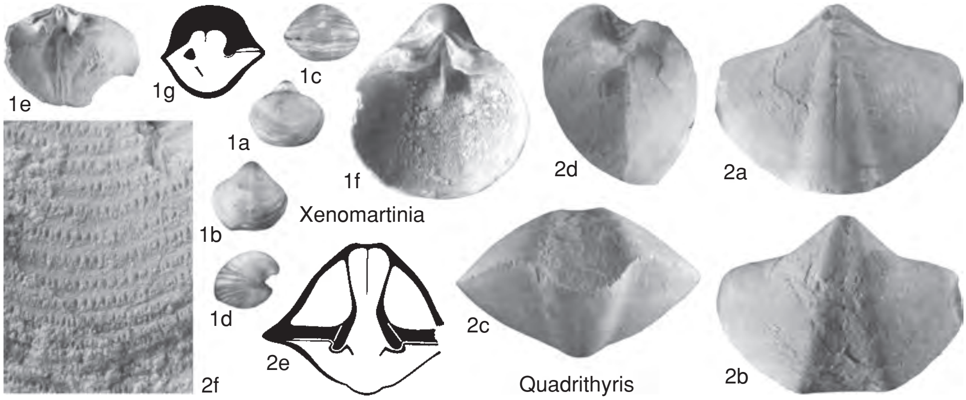

FIG. 1238. Xenomartiniidae (p. 1860–1864).

Subfamily BOJOTHYRIDINAE Havlíček, 1990

[*nom. transl.* GOURVENNEC in CARTER & others, 1994, p. 357, *ex* Bojothyrididae HAVLÍČEK in HAVLÍČEK & KUKAL, 1990, p. 186]

Dental plates converging to median septum, commonly producing spondylium or spondylium-like structure. *Silurian (upper Ludlow)–Middle Devonian (Eifelian).*

Bojothyris HAVLÍČEK, 1959, p. 147 [**B. nikiforovae;* OD]. Small, transverse-oval, with low, curved, apsacline interarea; cardinal angles rounded; fold and sulcus indistinct, developed anteriorly, smooth; flanks lacking plications; surface with fine, concentric growth lines; thin dental plates forming spondylium supported and pierced by median septum; crural plates lacking. *Lower Devonian (Emsian)–Middle Devonian (Eifelian):* Czech Republic.——FIG. 1239,*4a–e.* **B. nikiforovae,* Eifelian; *a–c,* dorsal, ventral, anterior views; *d,* damaged shell showing ventral septum, ×3 (new); *e,* transverse section showing spondylium, ×3 (Havlíček, 1959).

Altajella KULKOV, 1962, p. 653 [**A. contorta;* OD]. Small, transverse-oval to equidimensional, with high, curved, apsacline interarea; cardinal angles rounded; fold and sulcus prominent, smooth; flanks with 1 or 2 strong, rounded plications; surface with fine, concentric growth lines; thin dental plates forming spondylium supported and pierced by median septum; short crural plates and ctenophoridium on incipient notothyrial platform. *Silurian (upper Ludlow)–Lower Devonian (Lochkovian):* Altai, Salair.——FIG. 1239,*3a–f.* **A. contorta,* Lochkovian; *a–d,* dorsal, ventral, anterior, lateral views, Altai, ×1 (Kulkov, 1963); *e–f,* serial sections, Salair, approximately ×2 (Alekseeva & others, 1970).

Quadrithyrina HAVLÍČEK, 1959, p. 136 [**Q. ivanovae;* OD]. Small or medium size, slightly transverse, with rounded cardinal extremities and almost catacline, high ventral interarea; fold and sulcus well developed, smooth; lateral plications lacking; microornament of concentric growth lines and radial capillae; high, narrow, ventral median septum and apical callus, lacking dental plates; crural plates short or obsolescent; ctenophoridium lacking. [Despite its strong affinities with the Xenomartiniinae, *Quadrithyrina* is assigned here because of the presence of rudimentary dental ridges converging toward the median septum.] *Lower Devonian (Pragian)–Middle Devonian (Eifelian):* Czech Republic, Turkestan, Australia (New South Wales, Queensland).——FIG. 1239,*1a–e.* **Q. ivanovae,* upper Emsian, Czech Republic; *a–d,* dorsal, ventral, anterior, lateral views, ×3; *e,* transverse section, ×2 (Havlíček, 1959).

Spondylothyris SU, 1980, p. 324 [**S. pinguis;* OD]. Small, subglobular, with rounded cardinal extremities; ventral valve subpyramidal with high, catacline interarea; fold and sulcus well developed; flanks smooth or with 1 to 2 low, broad plications; microornament of densely crowded, concentric growth lamellae and marginal spines; dental plates joining high median septum to form spondylium; crural plates joining together on valve floor in a septalium-like structure; ctenophoridium present. *Lower Devonian (Emsian):* northeastern China.——FIG. 1239,*5a–f.* **S. pinguis; a–d,* dorsal, anterior, posterior, lateral views of internal mold, ×2; *e,* posterior view of dorsal internal mold showing cardinalia, ×2; *f,* transverse section, magnification unknown (Su, 1980).

Uralospirifer HAVLÍČEK, 1959, p. 142 [**Spirifer (Delthyris) mansy* KHODALEVICH, 1951, p. 96; OD]. Medium size, slightly transverse, with curved, apsacline interarea; cardinal angles rounded; fold and sulcus prominent, smooth; flanks with 3 to 4 strong, rounded plications; fimbriate ornament, with closely spaced growth lines; thick tooth tracks forming shallow spondylium, supported posteriorly by median septum; crural plates lacking. *Lower Devonian (Emsian), Middle Devonian (?Eifelian):* northern Urals.——FIG. 1239,*2a–e.* **U. mansy* (KHODALEVICH), upper Emsian or ?lower Eifelian; *a–d,* dorsal, ventral, anterior, lateral views, ×1

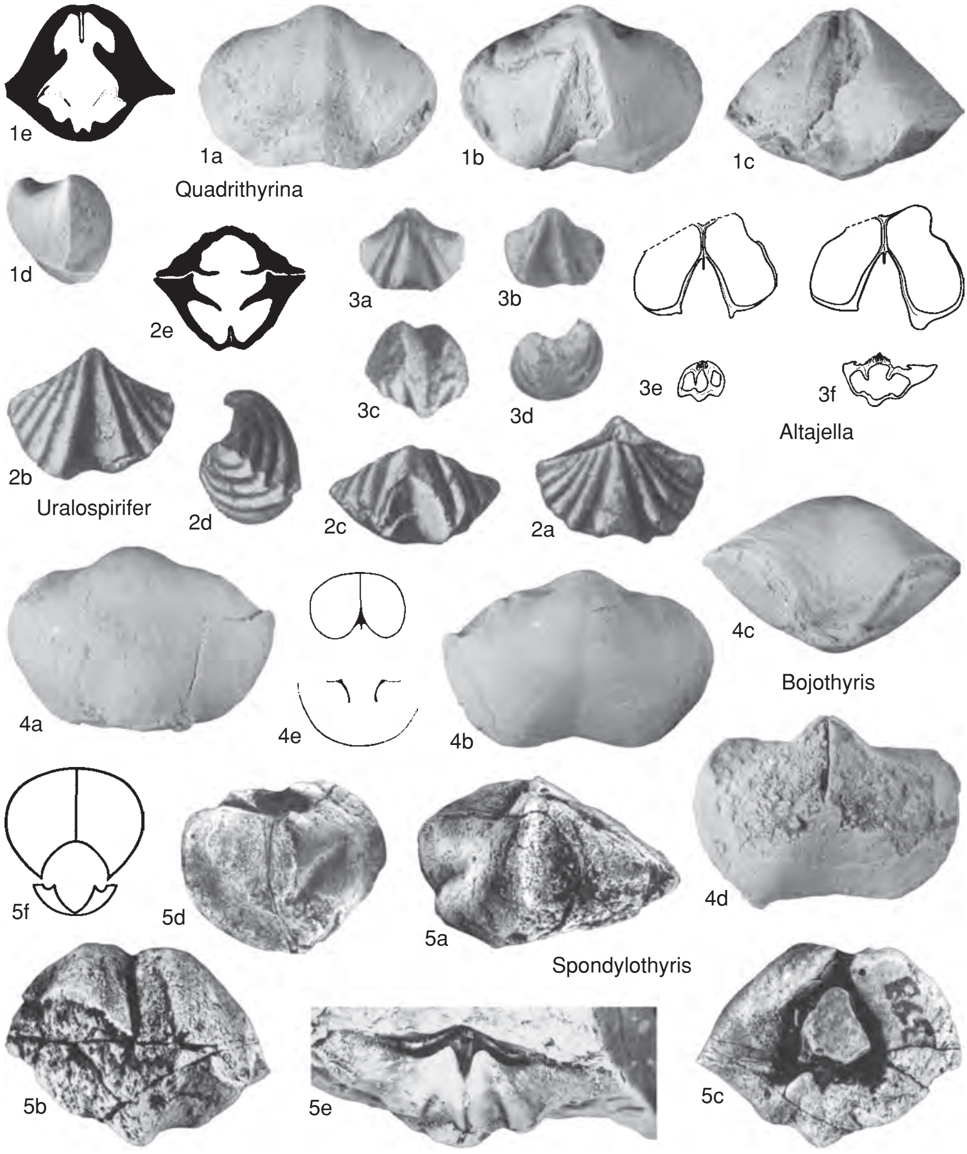

FIG. 1239. Xenomartiniidae (p. 1862–1863).

(Khodalevich, 1951); *e,* transverse section, magnification unknown (Havlíček, 1959).

Subfamily QUADRITHYRIDINAE Gourvennec, 1994

[Quadrithyridinae GOURVENNEC in CARTER & others, 1994, p. 358]

With divergent or subparallel dental plates. *Silurian (upper Wenlock)–Middle Devonian (Givetian).*

Quadrithyris HAVLÍČEK, 1957b, p. 437 [**Spirifer robustus* BARRANDE, 1848, p. 162; OD]. Size variable, medium to large, slightly transverse, with rounded cardinal angles; apsacline to catacline, gently curved ventral interarea; sulcus and fold distinctly marked, smooth; flanks generally smooth, occasionally bearing 1 to 3 low, wide, rounded plications; microornament of growth lamellae and marginal spine bases; dental plates and high median septum; ctenophoridium with crural plates lacking. *Silurian (upper Wenlock)–Middle Devonian (Givetian):* cosmopolitan.——FIG. 1238,*2a–e.* **Q. robusta* (BARRANDE), Pragian, Czech Republic; *a–d,* dorsal, ventral, anterior, lateral views, ×1.5; *e,* transverse section, ×2 (Havlíček, 1959).——FIG.

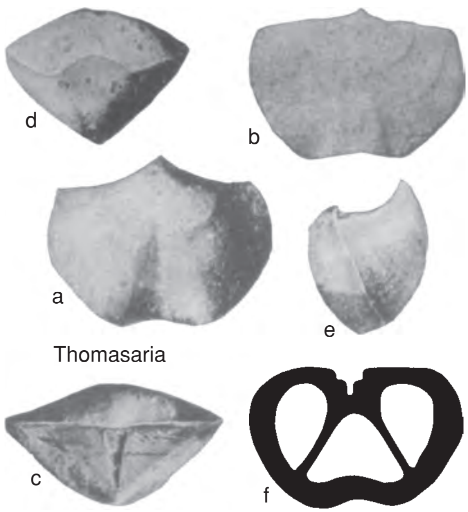

FIG. 1240. Thomasariidae (p. 1864).

1238,*2f. Q. falco* (BARRANDE), Pragian, Czech Republic; ornament, ×10 (Havlíček, 1971).

Family THOMASARIIDAE Cooper & Dutro, 1982

[Thomasariidae COOPER & DUTRO, 1982, p. 102]

[Materials for this family prepared by J. G. Johnson]

Small, hemipyramidal, with strong, long dental plates and pair of conjunct apical plates; ctenophoridium present, crural plates lacking; surface with fine spines. *Upper Devonian (Frasnian).*

Thomasaria STAINBROOK, 1945, p. 57 [**T. altumbona* STAINBROOK, 1945, p. 58; OD]. Small, ventribiconvex, equidimensional; cardinal angles acute or at right angles; ventral interarea high, flat to slightly curved, steeply apsacline to catacline; delthyrium partially closed by apical plates that join below level of interarea; fold and sulcus smooth; flanks smooth or weakly pauciplicate; dental plates divergent. *Upper Devonian (Frasnian):* midcontinental and western North America.——FIG. 1240*a–f.* **T. altumbona;* ventral, dorsal, posterior, anterior, lateral, and ventral section, ×1 (Stainbrook, 1945).

Family ELYTHIDAE Frederiks, 1924

[*nom. transl.* PITRAT, 1965, p. 721, *ex* subfamily Elythinae FREDERIKS, 1924, p. 304]

[Materials for this family prepared by J. L. Carter]

Lateral slopes smooth or with low plications; fold and sulcus, if present, usually weakly developed; microornament of fine, biramous spines. *Lower Devonian (Pragian)–Permian (Lopingian).*

Subfamily ELYTHINAE Frederiks, 1924

[Elythinae FREDERIKS, 1924, p. 304]

Spines biramous but not elaborate; ventral interior with dental adminicula and median ridge; dorsal interior with ctenophoridium. *Lower Devonian–Carboniferous (Tournaisian).*

Elita FREDERIKS, 1918a, p. 87 [**Delthyris fimbriata* CONRAD, 1842, p. 263; OD] [=*Elytha* FREDERIKS, 1924, p. 304, *nom. van.; Elyta* IVANOVA, 1960, p. 277, *nom. null.*]. Medium to large, transverse, with rounded cardinal extremities and apsacline ventral interarea; fold and sulcus well delimited, rounded, smooth; lateral slopes with 5 to 7 low, rounded, simple plicae; microornament of well-marked growth lamellae and moderately coarse marginal biramous spines; ventral interior with long dental adminicula and septum; dorsal interior with massive, inconsistently bilobed ctenophoridium on cardinal platform, short or absent crural plates, and generally strong myophragm. *Lower Devonian (Pragian)–Upper Devonian (Frasnian, ?Famennian):* Western Hemisphere, Russia.——FIG. 1241,*1a–c.* **E. fimbriata* (CONRAD), Hamilton, Middle Devonian, New York; *a–b,* dorsal and lateral views, ×1 (Cooper, 1944); *c,* microornament, approximately ×4 (Hall & Clarke, 1894).

Kitakamithyris MINATO, 1951, p. 374 [**Torynifer (Kitakamithyris) tyoanjiensis* MINATO, 1951, p. 374; OD]. Small to medium size; moderately transverse to subovate; cardinal extremities well rounded; ventral sulcus very weak and shallow, dorsal fold absent; lateral slopes smooth; interior surfaces of valves finely radially grooved; dorsal interior with small ctenophoridium and weak myophragm; some species possibly with very short crural plates or small apical callus. *Carboniferous (Tournaisian):* Japan, Russia, Australia, North America.——FIG. 1241,*5a–b.* **K. tyoanjiensis* (MINATO), Japan; *a,* posterior view, ×1; *b,* microornament, ×2 (Minato, 1952).

Subfamily MARTINOTHYRIDINAE Carter, 1994

[Martinothyridinae CARTER in CARTER & others, 1994, p. 358]

Ventral interior with dental adminicula; ventral median ridge absent; spines elaborate. *Carboniferous (Mississippian)–Permian (Cisuralian).*

Martinothyris MINATO, 1953, p. 70 [**Terebratula? lineata* SOWERBY, 1822 in 1821–1822, p. 39; OD; =*Conchyliolites (Anomites) lineatus* MARTIN, 1809, pl. 36,*3,* ICZN Opinion 420, 1956a, p. 132]. Ven-

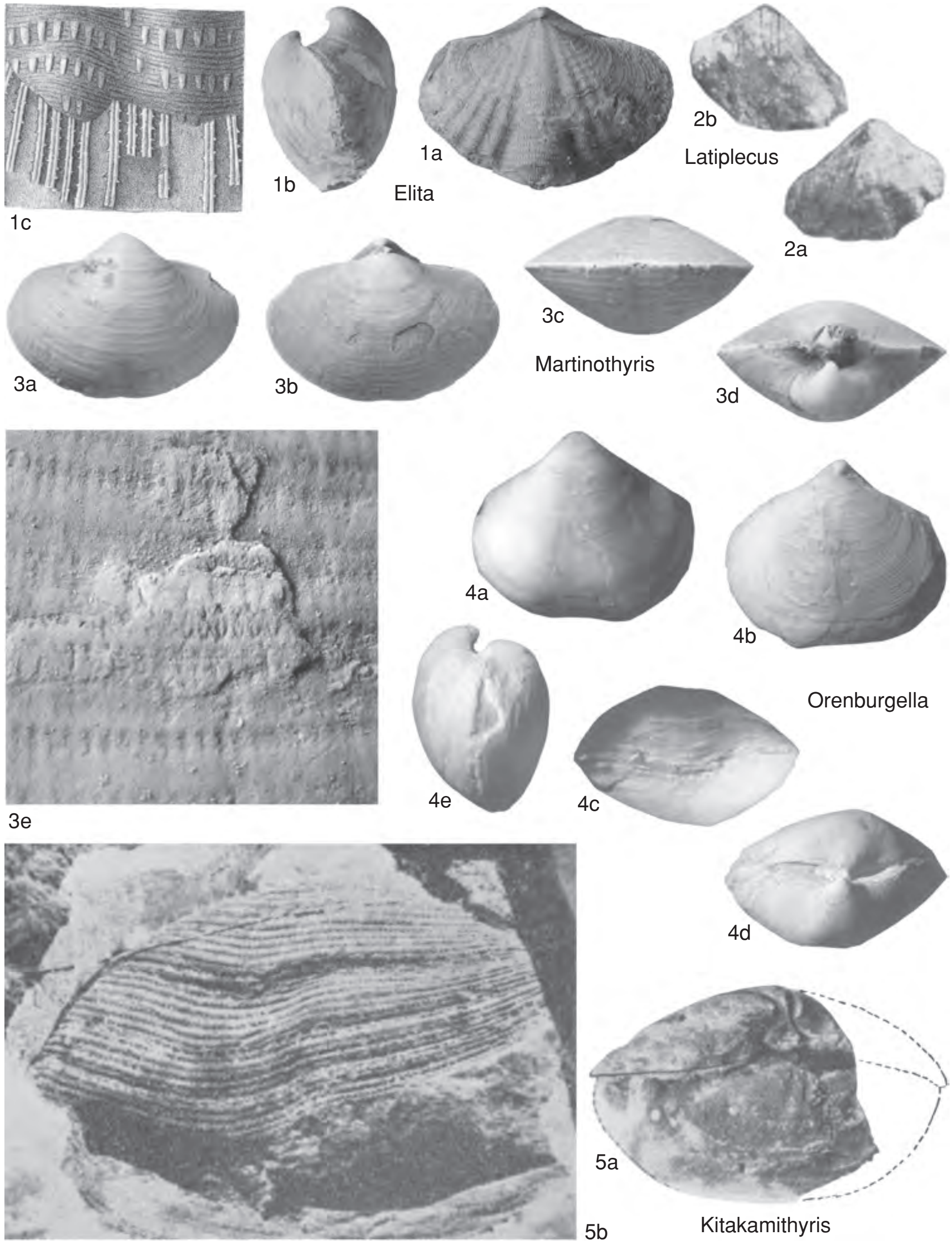

FIG. 1241. Elythidae (p. 1864–1866).

tral valve interior with short dental adminicula; dorsal interior possibly with short adminicula or crural plates; otherwise similar to *Phricodothyris. Carboniferous (Mississippian):* British Isles.——FIG. 1241,*3a–e*. **M. lineata* (SOWERBY); *a–d,* lectotype, ventral, dorsal, anterior, posterior views, ×1; *e,* microornament, ×10 (new).

Latiplecus LI & GU, 1976, p. 299 [**L. typicus;* OD]. Small to medium size; outline transversely subovate to subtrigonal; fold and sulcus moderately developed; lateral slopes with 2 pair of broad low plicae; ventral interior with long, parallel dental adminicula; dorsal interior with cardinal process. *Permian (Cisuralian):* China.——FIG. 1241,*2a–b*.

**L. typicus;* dorsal and ventral views, ×1 (Li & Gu, 1976).

Orenburgella Pavlova, 1969, p. 76 [**O. uralica;* OD]. Both valves with umbonal thickening; deltidial plates absent; dorsal interior with discrete crural bases not touching valve floor; otherwise similar to *Martinothyris. Carboniferous (Visean):* Russia (southern Urals).——Fig. 1241,*4a–e.* **O. uralica;* holotype, ventral, dorsal, anterior, posterior, and lateral views, ×1 (new).

Subfamily PHRICODOTHYRIDINAE Caster, 1939

[*nom. correct.* Carter in Carter & others, 1994, p. 359, *pro* Phricodothyriinae Caster, 1939, p. 145]

Lacking dental adminicula and ventral median ridge; spines elaborate. *Carboniferous (Mississippian)–Permian (Lopingian).*

Phricodothyris George, 1932, p. 524 [**P. lucerna;* OD] [=*Neophricadothyris* Likharev, 1934, p. 211 (type, *Squamularia asiatica* Chao, 1929, p. 91, OD); *Condrathyris* Minato, 1953, p. 69 (type, *Spirifer perplexa* McChesney, 1860, p. 43, OD)]. Small to medium size; unequally biconvex; outline subovate; fold and sulcus absent; anterior commissure rectimarginate; ribbing absent; ventral interarea well delimited, finely vertically striated only in primary layer; short flat deltidial plates nearly at right angle to interarea; ventral interior with very low dental flanges; dorsal interior with dental sockets nearly parallel to cardinal margin; crural bases broad, flattened, directed dorsomedially; sometimes forming short crural plates; dorsal septum and adminicula absent, low myophragm present in some species; minute bulbous ctenophoridium present in at least some species; microornament including very fine interspinous pustules or spinules; spiralia directed slightly posterolaterally. *Carboniferous (Mississippian)–Permian:* cosmopolitan.——Fig. 1242,*1a–d.* **P. lucerna,* Visean, Great Britain; holotype, dorsal, ventral, lateral, and anterior views, ×1 (George, 1932).——Fig. 1242,*1e–f.* *P. verecunda* George; dorsal and ventral interiors, ×4 (Brunton, 1984).

Astegosia Cooper & Grant, 1969, p. 16 [**Squamularia guadalupensis subquadrata* Girty, 1909, p. 369; OD]. Ventral interarea narrow, poorly defined; pseudodeltidium or deltidial plates not present; ventral interior with well-developed, concave dental flanges medially converging to fuse with short, apical, subdelthyrial plate; dorsal interior with finely striate, bosslike ctenophoridium; otherwise similar to *Phricodothyris. Permian (Guadalupian):* USA (Texas).——Fig. 1242,*4a–g.* **A. subquadrata* (Girty), western Texas; *a–e,* dorsal, ventral, lateral, posterior, and anterior views, ×1; *f–g,* dorsal and ventral interiors, ×2 (Cooper & Grant, 1976a).

Bajkuria Ustritskii in Ustritskii & Cherniak, 1963, p. 116 [**B. dorsosinuata* Ustritskii in Ustritskii & Cherniak, 1963, p. 117; OD]. Dorsal interior with short adminicula; dorsal muscle scars delineated by low ridges; otherwise similar to *Phricodothyris. Permian (Lopingian):* Arctic Siberia.——Fig. 1242,*2a–d.* **B. dorsosinuata;* holotype, ventral, dorsal, posterior, and lateral views, ×1 (Ustritskii & Cherniak, 1963).

Bullarina Jin & Sun, 1981, p. 153 [**Neophricadothyris bullata* Cooper & Grant, 1976a, p. 2,248; OD]. Medium size for family; longitudinally to transversely subovate or guttate; weak fold and sulcus usually developed; anterior commissure usually weakly uniplicate; spiralia directed posterolaterally; cardinal process bulbous; otherwise similar to *Phricodothyis. Permian (Lopingian):* USA (Texas), China.——Fig. 1242,*3a–d.* **B. bullata* (Cooper & Grant), lower Guadalupian, Texas; dorsal, ventral, posterior, and anterior views, ×1 (Cooper & Grant, 1976a).

Nebenothyris Minato, 1953, p. 72 [**N. lineatus;* OD]. With median ridges or septa in both valves; otherwise similar to *Phricodothyris. Carboniferous (Mississippian)–Permian:* Western Europe, Japan, *Mississippian;* China, Russia, *Permian.*——Fig. 1243,*2.* **N. lineata,* Mississippian, Japan; ventral valve, ×1 (Nebe, 1911).

Permophricodothyris Pavlova, 1965, p. 134 [**P. ovata* Pavlova, 1965, p. 135; OD]. Medium to large; umbonal regions often broad; dorsal interior with very long, subparallel crura and elongated, posteriorly directed spiralia with numerous whorls; otherwise similar to *Phricodothyris. Permian (Lopingian):* Sicily, Armenia, Iran, Mongolia, Timor, Indochina, China, Salt Range, Caucasus Mountains.——Fig. 1243,*1a–e.* **P. ovata,* Djulfian, Caucasus Mountains; ventral, dorsal, anterior, posterior, and lateral views, ×1 (new).

Subfamily TORYNIFERINAE Carter, 1994

[Toryniferinae Carter in Carter & others, 1994, p. 359]

Dental adminicula and low median ridge present in ventral valve; ctenophoridium generally absent; spines elaborate. *Carboniferous (Mississippian)–Permian.*

Torynifer Hall & Clarke, 1894, p. 943, pl. 84 [**T. criticus;* OD; =*Spirifer pseudolineatus* Hall, 1858, p. 645]. Small to large; fold and sulcus variably developed; outline transversely subovate; spine-bearing growth lamellae broadly spaced; lacking interspinous pustules or spinules; ventral interior with well-developed, long, diverging dental adminicula, short delthyrial plate and long, low median ridge; dorsal interior with long, complete hinge plate with apical pit supported by variably strong median septum; spiralia directed posterolaterally. *Carboniferous*

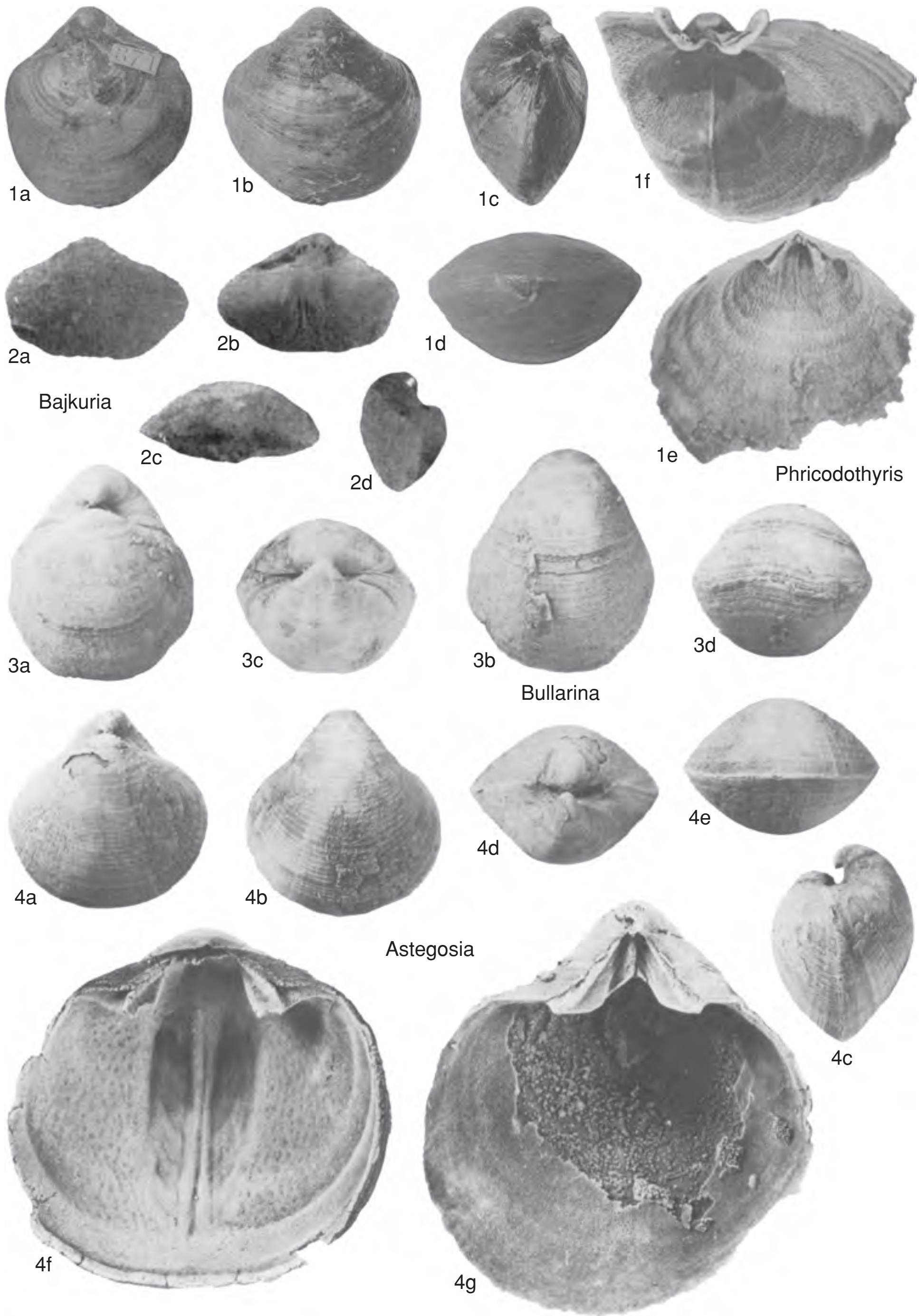

FIG. 1242. Elythidae (p. 1866).

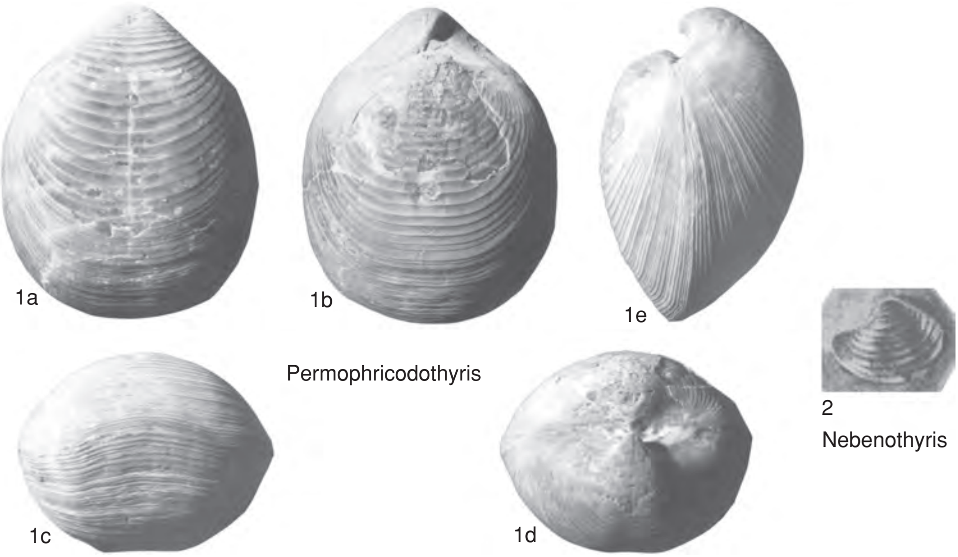

FIG. 1243. Elythidae (p. 1866).

(Mississippian): cosmopolitan.——FIG. 1244,*3a–g.* **T. pseudolineatus* (HALL), upper Tournaisian, Iowa, USA; *a–b,* ventral and dorsal interiors, ×2 (Cooper, 1944); *c–g,* ventral, dorsal, posterior, anterior, and lateral views, ×1 (Weller, 1914).

Plicotorynifer ABRAMOV & SOLOMINA in ABRAMOV, 1970, p. 153 [**P. simakovi;* OD]. Lateral slopes with 1 or 2 shallow, broad plicae; ventral interior with stout median septum; dorsal interior with short median septum and short adminicula; otherwise similar to *Taimyrella. Carboniferous (Moscovian–Kasimovian):* Siberia.——FIG. 1244,*6.* **P. simakovi;* holotype, ventral valve, ×1 (Abramov, 1970).

Spirelytha FREDERIKS, 1924, p. 304 [**S. pavlovae* ARCHBOLD & THOMAS, 1984a, p. 313; OD; *nom. nov. pro Spirifer scheii* CHERNYSHEV in CHERNYSHEV & STEPANOV, 1916b, p. 45, *non* MEYER, 1913]. Fold and sulcus variably developed; lateral slopes lacking plications; ventral interior with dental adminicula and median ridge; dorsal interior with delicate myophragm, adminicula absent or weakly developed; otherwise similar to *Torynifer. Permian:* Arctic.——FIG. 1244,*5a–c.* **S. pavlovae* ARCHBOLD & THOMAS, Arctic Siberia; lectotype, ventral, lateral, and posterior views, ×1 (Chernyshev & Stepanov, 1916b).

Stepanoviina ZAVODOVSKII, 1968b, p. 170 [**Neophricodothyris(?) larini* ZAVODOVSKII, 1958, p. 134; OD]. Large; weak but distinct fold and sulcus present; ventral interior with dental adminicula and low median ridge; dorsal valve interior with low median ridge; otherwise similar to *Spirelytha. Permian (Cisuralian):* northeastern Asia.——FIG. 1244,*4a–b.* **S. larini* (ZAVODOVSKII), Russia; dorsal and ventral valves, ×1 (Zavodovskii, 1968b).

Taimyrella USTRITSKII in USTRITSKII & CHERNIAK, 1963, p. 115 [**Martiniopsis (?) pseudodarwini* EINOR, 1946, p. 55; OD]. Each lateral slope with single, broad, rounded, sulcuslike depression on each side of fold-sulcus; ventral valve interior with low median ridge; otherwise similar to *Spirelytha. Permian (Cisuralian):* northern Siberia.——FIG. 1244,*2a–b.* **T. pseudodarwini* (EINOR), Taimyr; dorsal and ventral valves, ×1 (new).

Toryniferella WEYER, 1967, p. 435 [**Kitakamithyris globosa* MAXWELL, 1961, p. 101; OD]. Dorsal valve with very thin, complete, unsupported hinge plate; dorsal median septum absent; otherwise similar to *Torynifer. Carboniferous (upper Visean):* Australia (Queensland).——FIG. 1244,*1a–f.* **T. globosa* (MAXWELL); *a–b,* holotype, posterior and dorsal views, ×1; *c–f,* transverse sections, approximately ×2 (Maxwell, 1961).

Subfamily ANOMALORIINAE Cooper & Grant, 1976

[*nom. transl.* CARTER in CARTER & others, 1994, p. 359, *ex* Anomaloriidae COOPER & GRANT, 1976a, p. 2,260]

Delthyrium covered with convex pseudodeltidium; ventral interior with converging, thickened dental flanges that fuse apically; dorsal interior with notothyrial

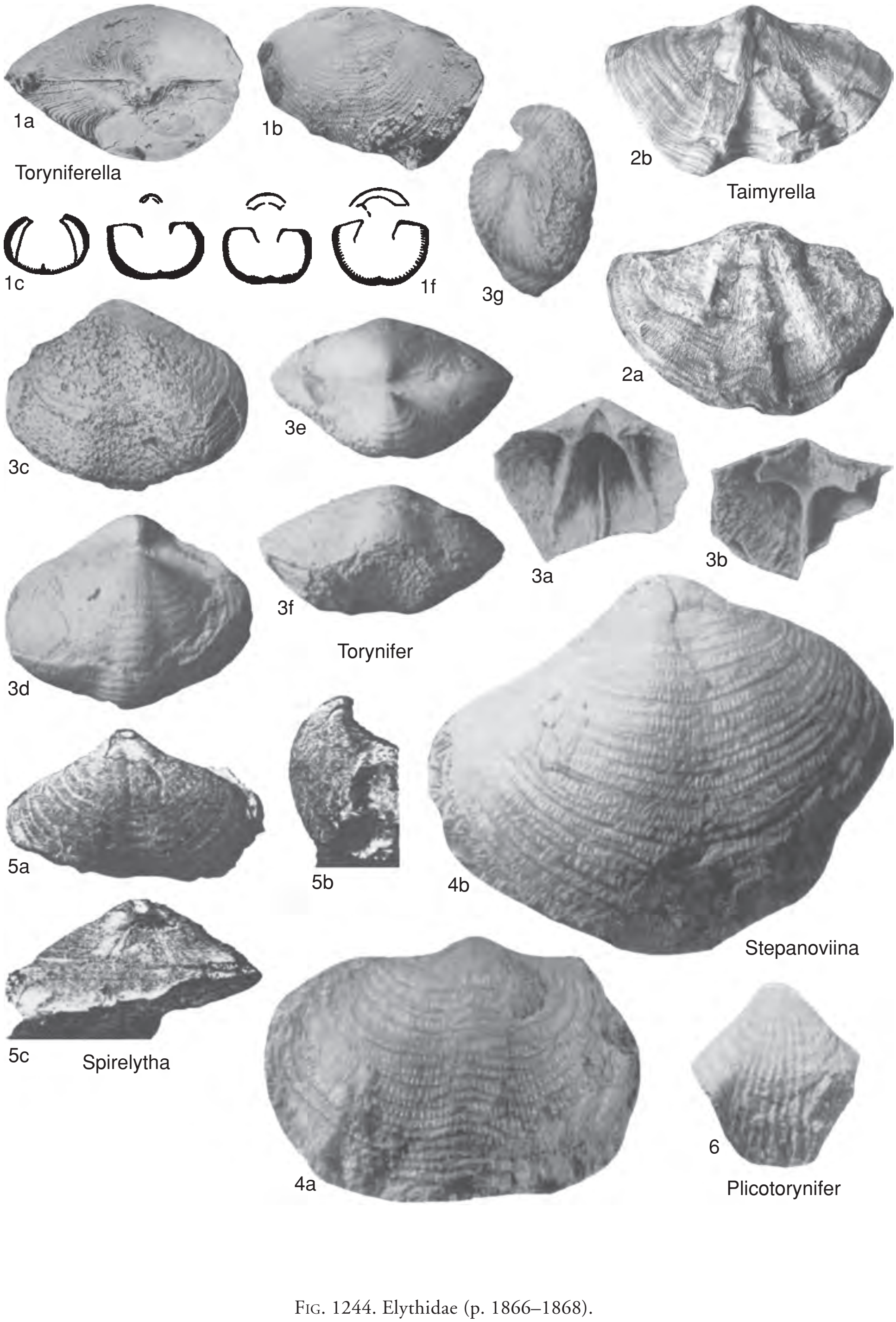

FIG. 1244. Elythidae (p. 1866–1868).

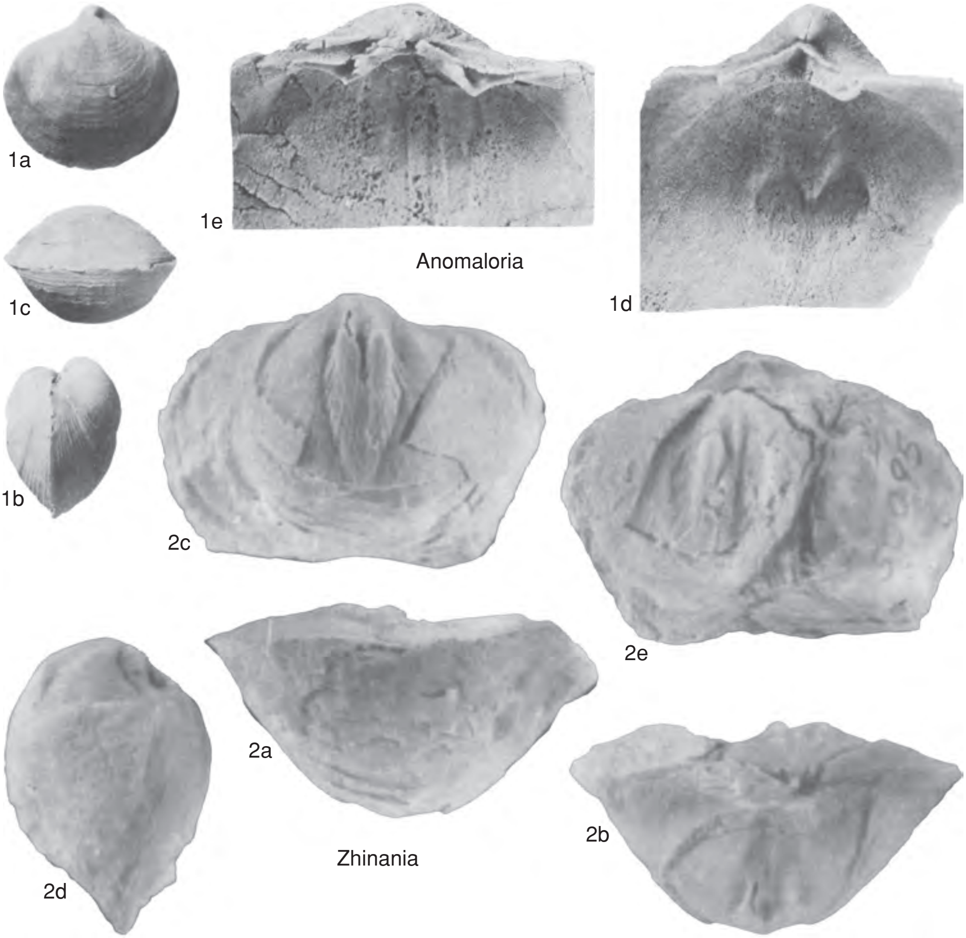

FIG. 1245. Elythidae (p. 1870).

flanges fused to inner socket ridges that partially obscure sockets medially. *Permian (Guadalupian).*

Anomaloria COOPER & GRANT, 1969, p. 16 [*A. anomala; OD]. Medium size; outline subovate; both valves strongly and nearly equally inflated; dorsal interior with narrow socket ridges; crural bases indistinct; cardinal process absent, replaced by apical pit. *Permian (Guadalupian):* Texas.——FIG. 1245,*1a–e*. **A. anomala; a–c,* holotype, dorsal, lateral, and anterior views, ×1; *d–e,* ventral and dorsal interiors, ×3 (Cooper & Grant, 1976a).

Zhinania LIANG, 1990, p. 308 [473] [*Z. eximiusa; OD]. Medium size; outline transversely subovate to subquadrate; unequally biconvex, dorsal valve flattened and much thinner than opposite; dorsal interior with small, thin cardinal process; presence of apically fused dental flanges and notothyrial flanges not known. *Permian (Guadalupian):* China (Zhejiang).——FIG. 1245,*2a–e*. **Z. eximiusa;* anterior, posterior, ventral, lateral, and dorsal views, ×1.5 (Liang, 1990).

UNCERTAIN

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INTRODUCTION

Representatives of the superfamily Plicanoplitacea *sensu* GARRATT (1980) cannot be definitely or clearly assigned to any of the brachiopod orders. It is evident that they can no longer be considered as members of the Chonetoidea as GARRATT (1980) thought: they lack hinge spines and anderidia, and they exhibit a peculiar ornament. These small, paedomorphic shells can be divided into two morphological groups, however, based on their dorsal valve internal features, almost corresponding respectively to the families Notanopliidae and Plicanoplitidae *sensu* GARRATT, 1980. The first group is highly enigmatic; it could possibly be allied to the Orthida or to some orthotetidine-like *?Fardenia,* while the second group might be related to the Anoplothecidae.

Most of the materials are decalcified, preserved as internal and external molds, or silicified, both preservations that preclude any reliable microstructural analysis of the shell structure. Some well-preserved specimens of *Serrulatrypa* from Germany, however, have an impunctate shell with fibrous secondary shell microstructure (F. LANGENSTRASSEN, written communication, 1992), which suggests a close relationship with the Spiriferida. Moreover, internal characters, such as the development of inner peripheral ridges in one or both valves of several genera, are reminiscent of the Thecideida.

These minute Siluro-Devonian shells for now are regarded as a taxonomically uncertain group.

SUBORDER UNCERTAIN

Boucotia GILL, 1969, p. 1,227 [**Anoplia australis* GILL, 1942, p. 38; OD]. Shell small, subcircular; ventral interarea apsacline; surface smooth or finely capillate; crested septa in both ventral and dorsal valves or in ventral valve only. *Lower Devonian (Lochkovian–Emsian):* southeastern Australia, Argentine Precordillera.——FIG. 1246,*1a–d.* **B. australis* (GILL), Humevale Formation; *a–b,* exterior, interior of articulated shell; *c,* ventral valve interior; *d,* dorsal valve interior, ×8 (Gill, 1969).

Callicalyptella BOUCOT & JOHNSON, 1972, p. 301 [**C. empelia;* OD]. Shell subcircular, convexoconcave; ventral interarea absent; surface with faint radial costae; ventral interior multiseptate; dorsal interior with only median septum. *Lower Devonian (Lochkovian):* USA (Nevada).——FIG. 1246,*2a–d.* **C. empelia,* Roberts Mountains Formation; *a,* ventral valve exterior; *b,* dorsal valve exterior; *c,* ventral, dorsal valve interiors; *d,* ventral valve interior, ×5 (Boucot & Johnson, 1972).

Costanoplia XU, 1977a, p. 65 [**C. faceta;* OD]. Differs from *Notanoplia* in the development of strong radial costate ornament only. *Lower Devonian (upper Emsian)–Middle Devonian (Eifelian):* southern China.——FIG. 1247,*1a–b.* **C. faceta,* Tangxiang Formation, Eifelian, Guangxi; ventral valve external mold, internal mold of both valves, ×5 (Xu, 1977a).

Guixiella XIAN, 1987, p. 74 [**G. lamellosa;* OD]. Shell small, subcircular to subquadrate, gently convexoconcave; hinge wide; fold, sulcus absent; radial ornament of narrow costae with wide, flat interspaces; interior of both valves with long, narrow median septum; no lateral septa but well-differentiated brachial ridges in dorsal valve interior. [No suitable figures are available for illustration.] *Lower Devonian (Emsian):* western Guangxi, China.

Hollardiella DROT, 1967, p. 877 [**H. akkaensis;* OD]. Very small shell, subquadrate or slightly elongate; planoconvex or subbiconvex posteriorly, concavoconvex anteriorly; ventral interarea apsacline; dorsal interarea anacline; ventral valve sulcate; radial ornament of narrow, low, thin, numerous costellae with wide, flat interspaces; ventral valve interior with three stout septa; dorsal valve interior with well-developed peripheral ridge, median septum. *Lower Devonian (Emsian)–Middle Devonian (Eifelian):* Morocco, Spain.——FIG. 1246,*3a–d.* **H. akkaensis,* Formation de Timrhanrhart, lowermost Eifelian, Morocco; *a–b,* articulated shell, ventral, dorsal views; *c,* juvenile ventral valve; *d,* anterior view, ×8 (Drot, 1967).——FIG. 1246,*3e–g. H. drotae* RACHEBOEUF, Tamajoso Formation, Emsian, southwestern Spain; ventral valve exterior, ventral valve internal mold, dorsal valve interior, ×5 (Racheboeuf & Robardet, 1986).

Jacetanella RACHEBOEUF, FERRER BATET, & MAGRANS, 1994, p. 9 [**J. bruguesensis;* OD]. Shell plano- to concavoconvex; ventral interior with median

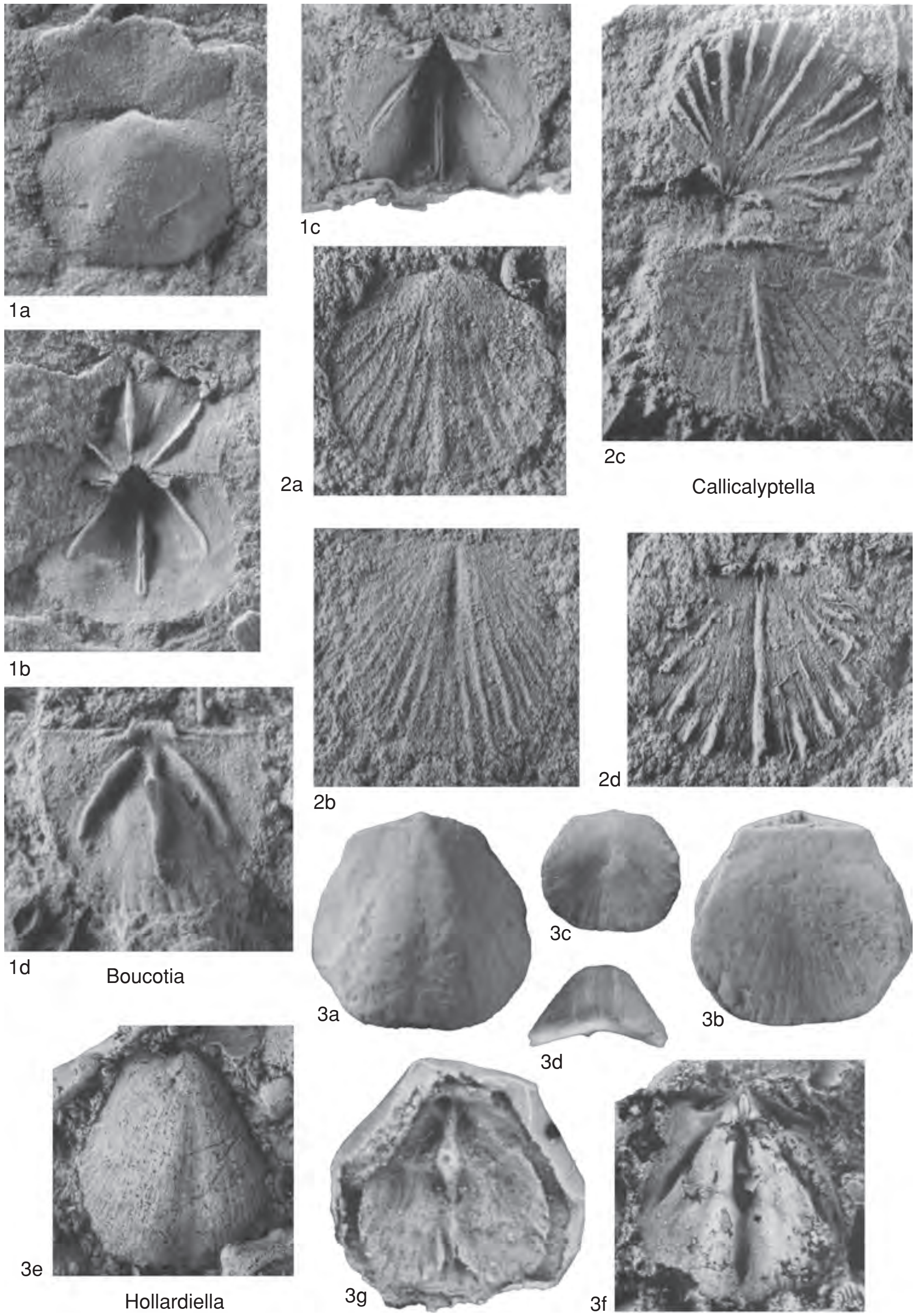

FIG. 1246. Uncertain (p. 1871).

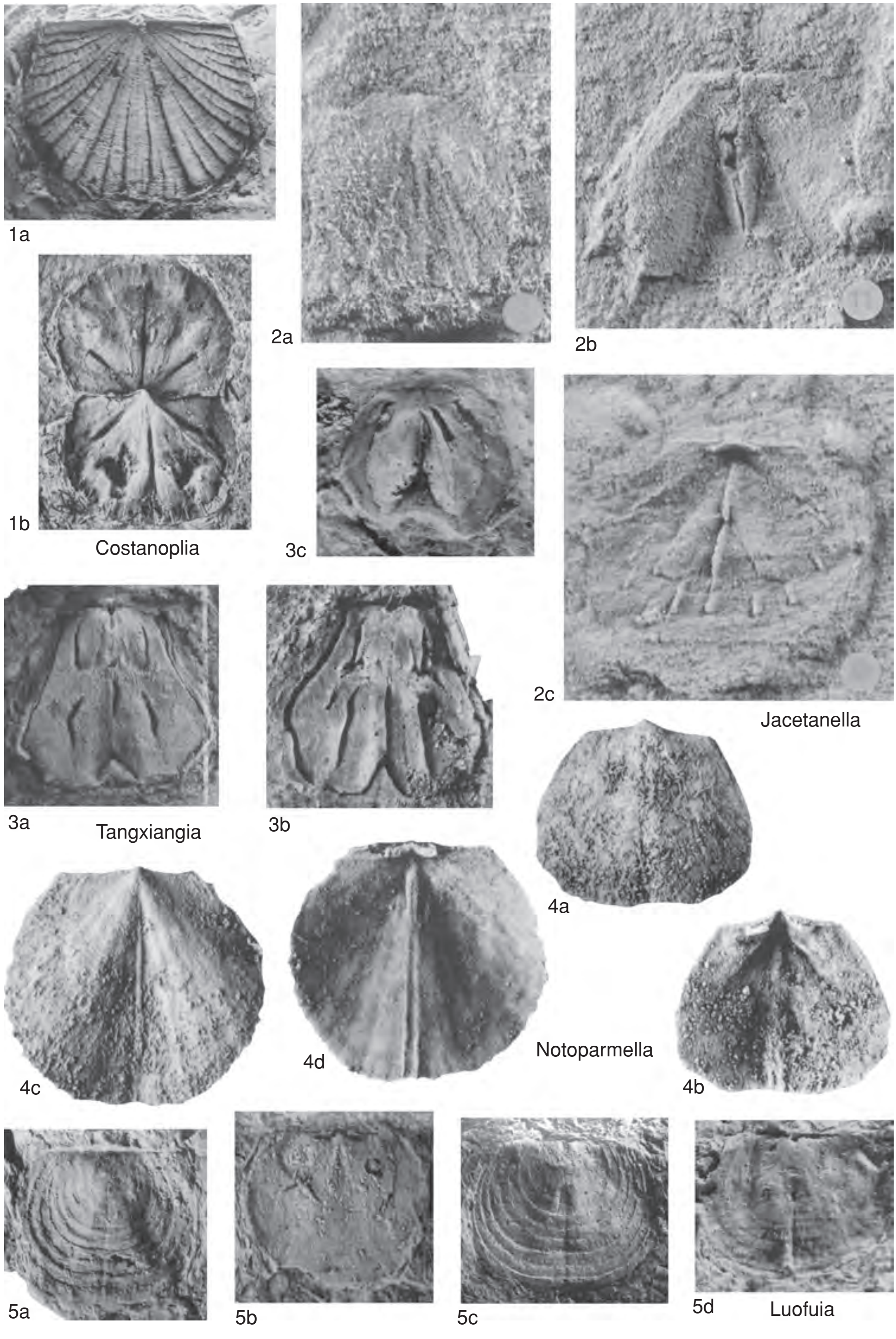

FIG. 1247. Uncertain (p. 1871–1876).

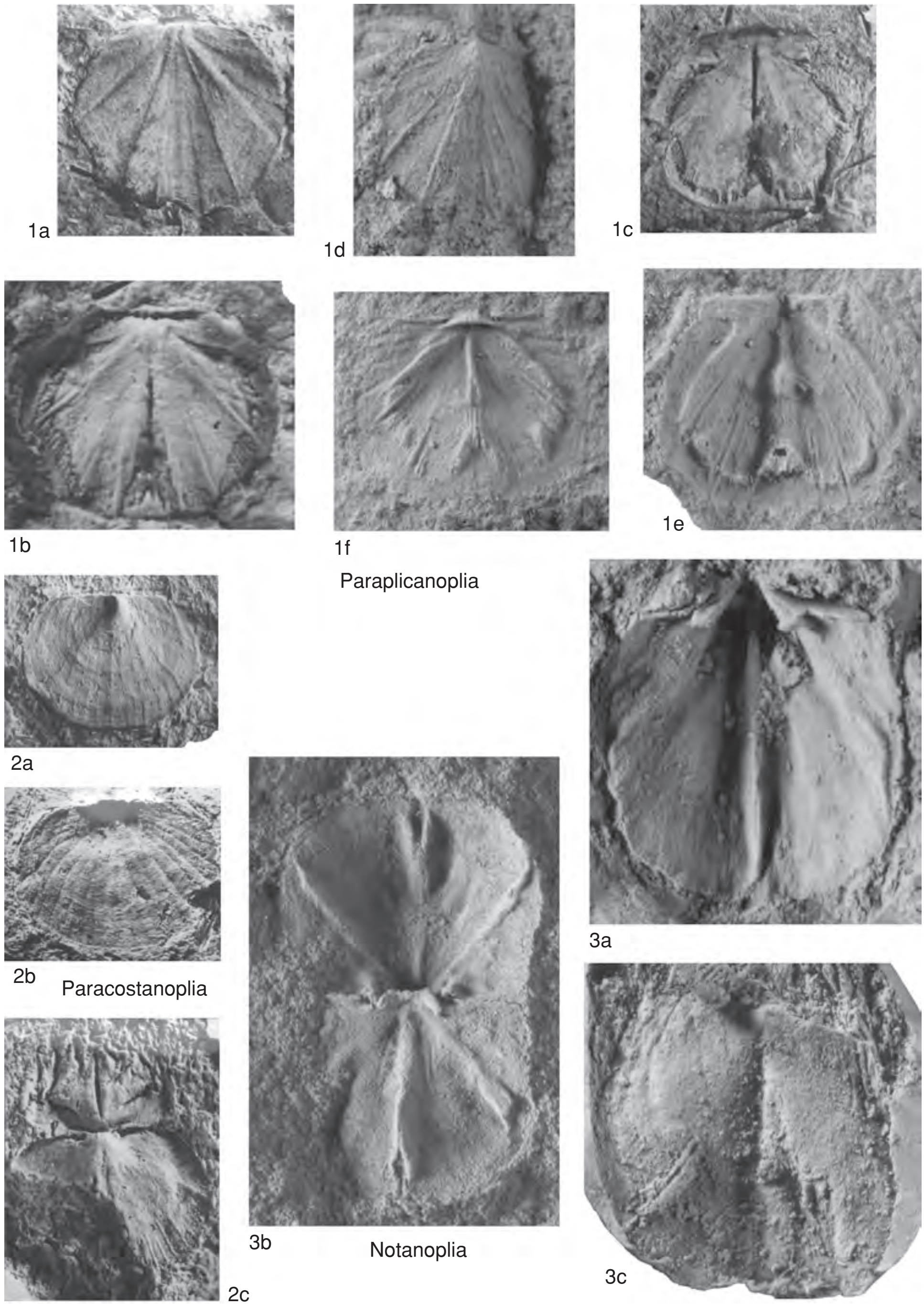

FIG. 1248. Uncertain (p. 1875).

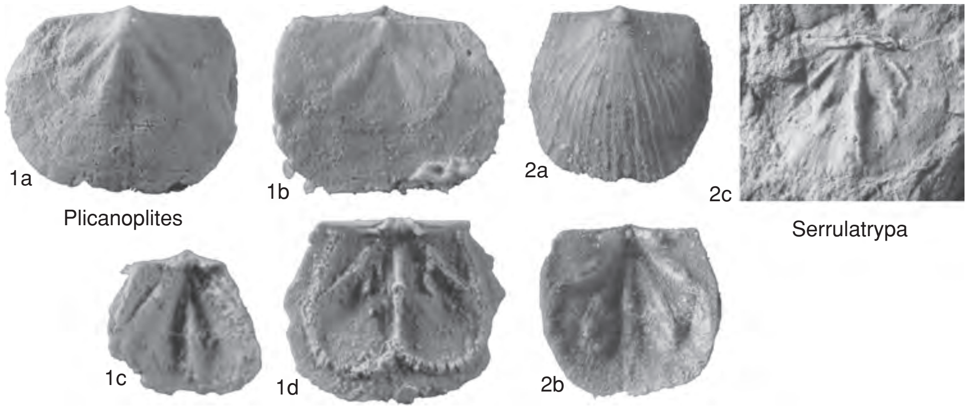

FIG. 1249. Uncertain (p. 1875–1876).

septum, pair of brevisepta; dorsal interior with long median septum, three to four pairs of brevisepta; radial ornament with median costa, one or two pairs of anteriorly divergent lateral costae. *Lower Devonian (Lochkovian):* northeastern Spain.——FIG. 1247,*2a–c.* **J. bruguesensis,* Catalonia; ventral valve exterior, ventral valve interior, dorsal valve interior, ×8 (Racheboeuf, Ferrer Batet, & Magrans, 1994).

Luofuia XU, 1977a, p. 66 [**L. delicata;* OD]. Shell planoconvex; surface without radial ornament, but with dense concentric lamellae; interior of both valves without septa. [The concentric external ornament as well as the lack of septa in both valve interiors make *Luofuia* a peculiar genus within this group of brachiopods.] *Middle Devonian (Eifelian):* southern China.——FIG. 1247,*5a–d.* **L. delicata,* Tangxiang Formation, Guangxi; *a–b,* dorsal valve exterior, latex external mold; *c–d,* ventral valve interior, dorsal valve interior, ×5 (Xu, 1977a).

Notanoplia GILL, 1950, p. 250 [**N. pherista;* OD]. Exterior smooth to finely costellate; ventral interarea apsacline; periphery of ventral interior with more or less developed radial costae; interiors with bladelike, not crested septa. *upper Silurian (Pridoli)–Lower Devonian (Pragian):* southeastern Australia.——FIG. 1248,*3a–c.* **N. pherista,* Bell Shale, Pragian; ventral valve interior, interior of both valves, dorsal valve exterior, ×6 (Gill, 1950).

Notoparmella JOHNSON, 1973b, p. 1,026 [**N. gilli;* OD]. Thin-shelled, shield-shaped concavoconvex shell; no interarea, but sometimes pair of flat apsacline plates; radial ornament of very low, faint costae, or finely costellate; ventral valve with variably developed median furrow; dorsal valve with threadlike median rib; interiors aseptate; ventral diductors impressed; simple, discrete pair of socket plates. *upper Silurian (Ludfordian)–Lower Devonian (lower Lochkovian):* USA (Nevada), Canadian Arctic Archipelago, eastern Australia, far eastern Russia.——FIG. 1247,*4a–d.* **N. gilli,* Windmill Limestone, lower Lochkovian, central Nevada; *a,* ventral valve exterior; *b,* ventral valve interior; *c,* dorsal valve exterior; *d,* dorsal valve interior, ×5 (Johnson, 1973b).

Paracostanoplia XU, 1977a, p. 65 [**P. mirabilis;* OD] [=*Paranotanoplia* XU, 1977a, pl. 3,*10,* obj.]. Differs externally from *Costanoplia* in having weak radial costellae instead of well-developed, rounded, anteriorly widening costellae; differs internally in its lack of ventral septa. *Middle Devonian (Eifelian):* southern China.——FIG. 1248,*2a–c.* **P. mirabilis,* Tangxiang Formation, Guangxi; ventral valve exterior, ventral valve external mold, internal mold of both valves, ×5 (Xu, 1977a).

Paraplicanoplia XU, 1977a, p. 67 [**P. nana;* OD] [=*Imatrypa* HAVLÍČEK, 1977, p. 300 (type, *I. infima,* OD)]. Very small shell, subquadrate or slightly elongate; planoconvex or subbiconvex posteriorly, concavoconvex anteriorly; ventral interarea apsacline; dorsal interarea anacline; ventral valve variably sulcate; radial ornament of narrow costae with wide, flat interspaces; interior of both valves with well-developed peripheral ridge, median septum. *Lower Devonian (upper Pragian)–Middle Devonian (lower Eifelian):* Bohemia, China.——FIG. 1248,*1a–c.* **P. nana,* Tangxiang Formation, lower Eifelian, Guangxi, southern China; dorsal valve exterior, ventral valve interior; dorsal valve interior, ×10 (Xian, 1987).——FIG. 1248,*1d–f. P. infima* (HAVLÍČEK), Chotec Limestone, lower Eifelian, Bohemia; ventral valve exterior, ventral valve interior, dorsal valve interior, ×7 (Havlíček, 1977).

Plicanoplites HAVLÍČEK, 1974, p. 170, *nom. nov. pro Plicanoplia* HAVLÍČEK, 1973, p. 337, obj., *non* BOUCOT & HARPER, 1968 [**Plicanoplia peculiaris* HAVLÍČEK, 1973, p. 338; OD]. Shell very small, subpolygonal; apsacline, low ventral interarea; steeply anacline, very low dorsal interarea; internally, shell almost similar to *Hollardiella,* but with pair of dorsal, variably developed septa oblique to lateral branches of peripheral ridge; differs externally by presence of wide, rounded, radially arranged ribs instead of radial costae; ribs sometimes bifurcating or intercalating. *Lower Devonian (Pragian–Emsian):* Bohemia.——FIG. 1249,*1a–d.* **P. peculiaris* (HAVLÍČEK), Dvorce-Prokop Limestone, Pragian; *a–b,* articulated shell, ventral, dorsal sides; *c,* ventral valve interior; *d,* dorsal valve interior, ×7 (Havlíček, 1973).

Septaparmella SU, 1976, p. 184 [**S. sinica;* OD]. Differs from *Notoparmella* in development of ventral interarea; ventral valve smooth with median furrow developed posteriorly, bearing median rib; dorsal exterior parvicostellate, with wide, ill-defined sinus; interior of both valves with long median septum only. [No suitable figures are available for illustration.] *Lower Devonian (Pragian):* southern China.

Serrulatrypa HAVLÍČEK, 1977, p. 299 [**Boucotia incognita* LANGENSTRASSEN, 1972, p. 49; OD]. Differs externally from *Boucotia* by development of narrow, rounded radial costae, not deflected posteriorly; interior of both valves with five crested septa. *Middle Devonian (Eifelian):* Germany, Bohemia. ——FIG. 1249,*2a–c.* **S. incognita* (LANGENSTRASSEN), Stöppeler Tonschiefer, Sauerland, Germany; ventral valve exterior, ventral valve interior, dorsal valve interior, ×4 (Havlíček, 1977).

Tangxiangia XU, 1977a, p. 68 [**T. delicata;* OD]. Shell surface without radial ornament but with thin, weak, concentric lamellae; ventral peripheral ridge deeply bilobate anteriorly; dorsal interior with median septum not fusing anteriorly with peripheral ridge, pair of septa subparallel to lateral branches of peripheral ridge. *Middle Devonian (Eifelian):* southern China.——FIG. 1247,*3a–c.* **T. delicata,* Tangxiang Formation, Guangxi; *a–b,* ventral valve interiors; *c,* dorsal valve interior, ×10 (Xu, 1977a).

SPIRIFERINIDA

J. L. CARTER and J. G. JOHNSON

[retired from Carnegie Museum of Natural History; and deceased, formerly of Oregon State University]

Order SPIRIFERINIDA Ivanova, 1972

[*nom. transl.* CARTER & JOHNSON in CARTER & others, 1994, p. 359, *ex* Spiriferinidina IVANOVA, 1972, p. 41] [=Spiriferinida COOPER & GRANT, 1976b, p. 2,666]

Hinge line strophic; commonly transverse and biconvex; flanks ribbed, rarely smooth; ventral valve inflated and thicker than dorsal valve; ventral interarea commonly well developed; brachidium, where present, spiraliform, spiralia directed laterally or posterolaterally; jugum generally present; shell punctate. *Lower Devonian (Lochkovian)–Lower Jurassic.*

INTRODUCTION

J. L. CARTER and RÉMY GOURVENNEC

[retired from Carnegie Museum of Natural History; and Université de Bretagne Occidentale]

This group of 116 genera comprises all of the punctate spiriferids formerly classified within the impunctate order Spiriferida and includes the syringothyridids and licharewiidines, which are now known to be punctate (ERLANGER, 1989). They appeared near the Siluro-Devonian boundary and disappeared in the Early Jurassic. Many of these shells resemble the impunctate Spiriferida in external growth form and in having a calcified spiral brachidium. In addition to different shell structure, however, this group differs in generally having a jugum (Fig. 1250) in the oldest genera (and in many younger genera); and, unlike most of the Spiriferida, most punctate genera have structures to shorten the length of the ventral adductors. These structures may take the form of a ventral septum, a depressed delthyrial plate or syrinx, or a spondylium or false spondylium (the functional equivalent of a spondylium but with the dental adminicula simulated by callus deposits).

The typical spiriferinide is smaller than its impunctate counterpart, transverse, with coarse plications on the flanks, a high to very high flattened apsacline to procline ventral interarea, a smooth fold and sulcus, and a jugum uniting the primary lamellae of the spiralia. Punctae are coarse and easily detected in some genera or fine and very difficult to detect in others, often requiring complex preparation techniques for observation. Unlike many large impunctate spiriferides, which probably lay freely on the sea floor, these animals seem to have been attached always by means of a pedicle. In general, these shells are much less common in Paleozoic faunas than are the impunctate spiriferides.

All spiriferinides seem to have lived either attached to the substrate or to each other by means of a muscular pedicle. They are found in many normal marine sedimentary rocks of shallow to moderately deep origin. They are rare or absent in most deep basinal sediments such as black shales and were cosmopolitan in distribution throughout most of their stratigraphic range, occurring in many normal marine biotas.

The origin of the punctate spiriferinides is uncertain. *Cyrtina*, the earliest genus, first appeared near the Silurian-Devonian boundary with several complex internal structures, a fully punctate shell, and no complex microornament, although there are a few scattered spinules in some species. *Cyrtina* bears a ventral spondylium with

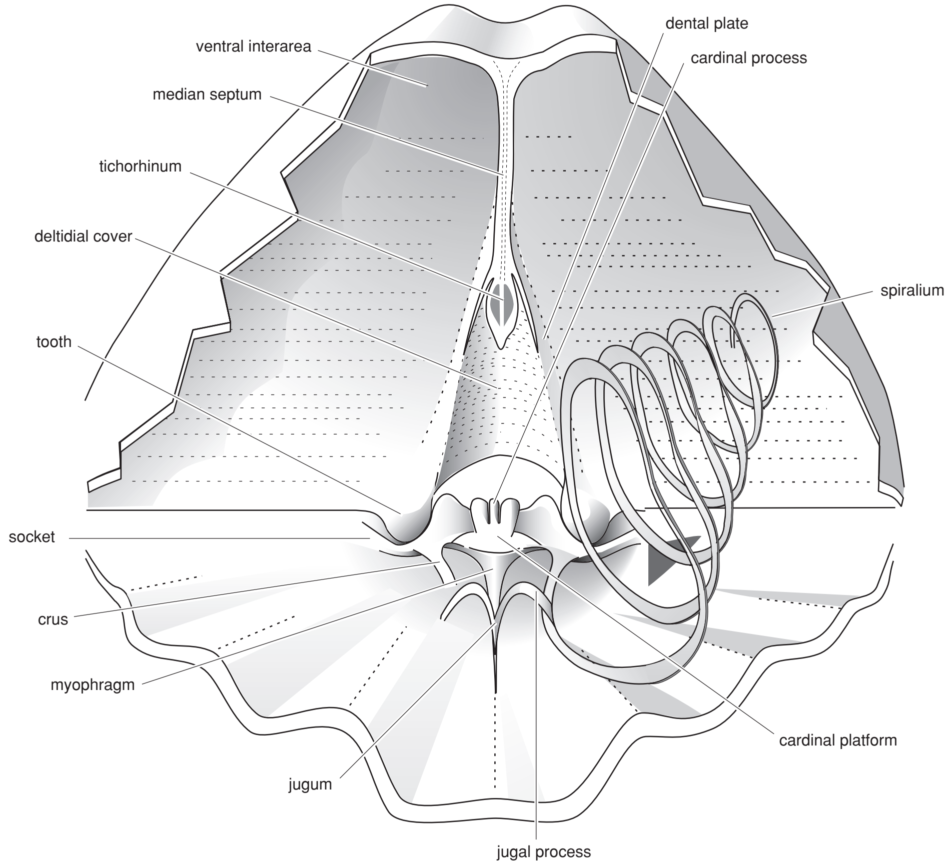

FIG. 1250. Diagrammatic representation of morphology of the cyrtinid shell: anterior view of the interior with ventral valve up, dorsal valve down (new).

tichorhinum (Fig. 1250) in the ventral valve, a knoblike or striated cardinal process situated on a low platform, and a jugum connecting the primary lamellae of the spiralium in the dorsal valve. The impunctate genera *Cyrtinopsis* and *Kozlowskiellina* are somewhat similar to *Cyrtina* both externally and internally but differ significantly, in addition to having different shell structure, in having a more complex microornament and in lacking a jugum or tichorhinum. The simultaneous appearance of endopunctation, a complete jugum, a tichorhinum, and the loss of delthyridine microornament in *Cyrtinopsis*, characters needed in order to produce *Cyrtina*, seems unlikely. It does, however, seem likely that *Cyrtina* is much too morphologically complex to have been the first of the Spiriferinida.

Two other possibilities for the origin of the punctate spirifers are 1) derivation by parallel or convergent evolution from some unknown punctate orthid by acquisition of calcareous spiralia, and 2) derivation from some unknown transverse endopunctate retzioid by acquisition of interareas and loss of the rostrate growth form and the complex jugum in the dorsal valve. There is no fossil evidence for either of these possibilities. Figure 1251 indicates the general evolutionary path of the Spiriferinida.

This order is composed of two suborders, the Cyrtinidina and Spiriferinidina, each with three superfamilies. The Cyrtinidina are

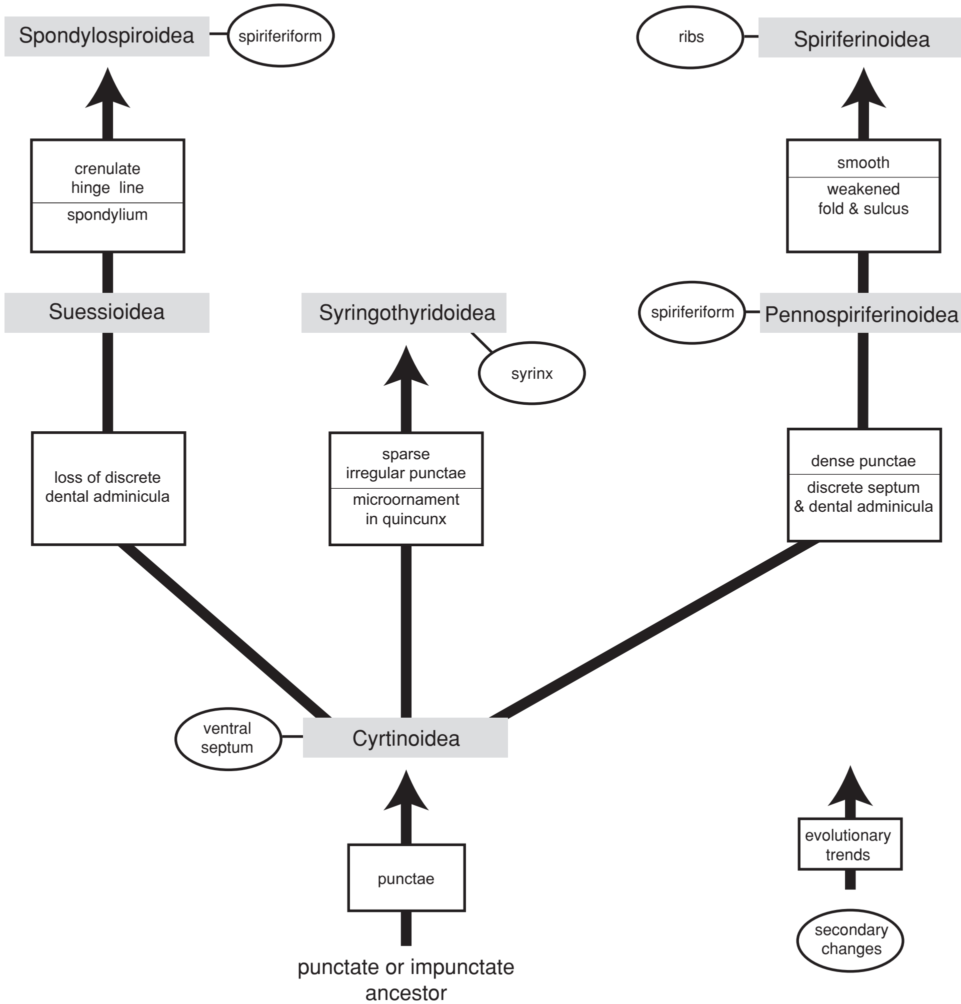

FIG. 1251. General evolutionary path within the Spiriferinida with indication of primary and secondary innovations or changes (new).

characterized by having a spondylium or spondylium-like structure in the ventral valve and the Spiriferinidina by having only a delthyrial plate, syrinx, or ventral septum for adductor attachment. The cyrtinidines ranged from near the Siluro-Devonian boundary beds to the Lower Jurassic, giving rise in the Famennian to the spiriferinidines, which also ranged through the Lower Jurassic (see Fig. 1102).

In the Devonian the cyrtinidines evolved slowly, producing only five additional genera, one of which, *Komiella*, gave rise in the Middle or Late Devonian to the lineage that produced the large superfamilies Syringothyridoidea and Pennospiriferinoidea, both of which appeared at about the same time in the late Famennian. The main cyrtinidine lineage evolved very slowly in the Late Devonian and late Paleozoic, producing a sparse stratigraphic record. Only three cyrtinidine genera are known from rocks of this age, but one of these, *Eolaballa* from the upper Permian of China and Sicily, is clearly an antecedent of the Mesozoic cyrtinidines of the superfamily Suessioidea.

The Suessioidea were probably derived from the cyrtinoids in the early Carboniferous, but there is no undoubted fossil record of this lineage before that of *Eolaballa* in the upper Permian. Except for this long apparent hiatus in occurrences, the startling external and internal similarity of this group with the cyrtinioids could justify combining these groups, as has been done by other authors.

The Spondylospiroidea appeared in the Middle Triassic with a unique innovation, the development of crenulate interareas and an interlocking hinge line. Many of these unusual genera are otherwise similar to the suessioid family Laballidae, and it is assumed that their ancestry was within that stock. After a brief evolutionary radiation that produced 14 genera, the group disappeared at the end of the Triassic.

Two stocks of the suborder Spiriferinidina appeared at nearly the same time in the Upper Devonian (upper Famennian). One lineage, the Syringothyridoidea, is characterized by its large size, wide and high procline ventral interarea, subdelthyrial plate or syrinx within the ventral valve, and distinctive microornament. This superfamily flourished in the Carboniferous and early Permian but became extinct by the end of the Permian.

The other stock, the Pennospiriferinoidea, lacks a delthyrial plate or syrinx but achieved the same effect of shortening the adductor muscles by using a high apical ventral median septum. This lineage evolved slowly in the early part of the Carboniferous but produced four new families and a number of new genera starting in the Visean. There is no record of this order in the Lower Triassic, but a final radiation commenced in the Middle Triassic and culminated in the Late Triassic.

In the Middle Triassic a pennospiriferinoid stock gave rise to the Spiriferinoidea, the last of the spiriferinidine superfamilies. This group mimics the Paleozoic reticulariioids in having an ovate outline, weakly developed fold-sulcus, and weak or absent ribbing. Only five cyrtinidine and spiriferinidine genera occur in the Lower Jurassic, after which the entire order became extinct.

CYRTINIDINA

J. L. CARTER and J. G. JOHNSON

[retired from Carnegie Museum of Natural History; and deceased, formerly of Oregon State University]

Suborder CYRTINIDINA Carter & Johnson, 1994

[Cyrtinidina CARTER & JOHNSON in CARTER & others, 1994, p. 360]

Lateral slopes plicate or smooth; ventral valve high, subconical or hemipyramidal in early forms, variable in later ones; delthyrium commonly covered in early genera, variably covered in late genera; ventral interior generally with complex, elevated adductor attachment structures. *Lower Devonian (Lochkovian)–Lower Jurassic.*

CYRTINOIDEA

J. G. JOHNSON

[deceased, formerly Oregon State University]

Superfamily CYRTINOIDEA Frederiks, 1911

[*nom. correct.* JOHNSON in CARTER & others, 1994, p. 360, *pro* superfamily Cyrtinacea JOHNSON, 1966a, p. 177, *nom. transl. ex* Cyrtininae FREDERIKS, 1911, p. 5]

Ventral valve hemipyramidal, with high interarea; dorsal valve flat or weakly convex; surface nonfimbriate and noncapillate; with ventral median septum. *Lower Devonian (Lochkovian)–Carboniferous (Visean).*

Family CYRTINIDAE Frederiks, 1911

[*nom. transl.* STEHLI, 1954, p. 350, *ex* Cyrtininae FREDERIKS, 1911, p. 5]

Deltidium stout, apically perforated; spondylium and divided tichorhinum present; with bilobed, commonly nonstriate cardinal process, but ctenophoridium may form in older growth stages. *Lower Devonian (Lochkovian)–Carboniferous (Visean).*

Cyrtina DAVIDSON, 1859 in 1858–1863, p. 66 [**Calceola heteroclita* DEFRANCE, 1828b, p. 156; SD OEHLERT, 1887a, p. 40] [=*Spinocyrtina* FREDERIKS, 1916, p. 18 (type, *Cyrtina lachrymosa* HALL & CLARKE, 1895, p. 362, SD FREDERIKS, 1918b, p. 145, =*Cyrtia hamiltonensis* HALL, 1857, p. 166); *Cyrtinaellina* FREDERIKS, 1926, p. 414 (type, *Cyrtia acutirostris* SHUMARD, 1855, p. 204, OD); *Trochalocyrtina* WRIGHT, 1975, p. 175 (type, *T. flemingi* WRIGHT, 1975, p. 175, OD)]. Flanks plicate; fold and sulcus smooth; with or without prominent growth lines and, rarely, with fine pustules; cardinal platform present; jugum with prominent median process. [PITRAT (1965, p. 678) suggested that the "first unequivocal designation of the type-species" for *Cyrtina* was that of HALL and CLARKE (1893, p. 44), but this is subsequent to the designation of *C. heteroclita* by OEHLERT (1887a, p. 40). In 1916, FREDERICKS designated two species for the genus *Spinocyrtina* (*S. lachrimosa* HALL & CLARKE and *S. hamiltonensis* HALL), neither of them being clearly designated as type species. Later, in 1918b and 1926, FREDERICKS designated different type species. In 1918b (p. 145), the type species is listed as *C. lachrimosa* HALL & CLARKE. In 1926 (p. 413), the type species is listed as *C. hamiltonensis* HALL. The species that should be retained is *lachrimosa,* which does not appear in the body of FREDERICKS's 1918b paper but in an appendix at the end of the volume entitled "Diagnoses generum et speciorum novorum"; nevertheless this designation seems valid.] *Lower Devonian (lower Lochkovian)–Carboniferous (Visean):* cosmopolitan.——FIG. 1252,*1a–e.* **C. heteroclita* (DEFRANCE), Middle Devonian, western Europe; *a–c,* ventral, posterior and lateral views, ×1.5 (Davidson, 1864); *d,* ventral interior, ×3; *e,* section of ventral valve, approximately ×2 (Oehlert, 1901).

Cyrtinaella FREDERIKS, 1916, p. 18 [**Cyrtia biplicata* HALL, 1857, p. 165; OD]. Entire surface smooth, or with incipient plications bounding sulcus; ventral valve transverse, wider than high. *Lower Devonian (Lochkovian)–Middle Devonian:* North America.——FIG. 1252,*2a–c.* **C. biplicata* (HALL), Lower Devonian, USA; ventral, anterior, and posterior views, ×1 (Hall, 1867b).——FIG. 1252,*2d–i.*

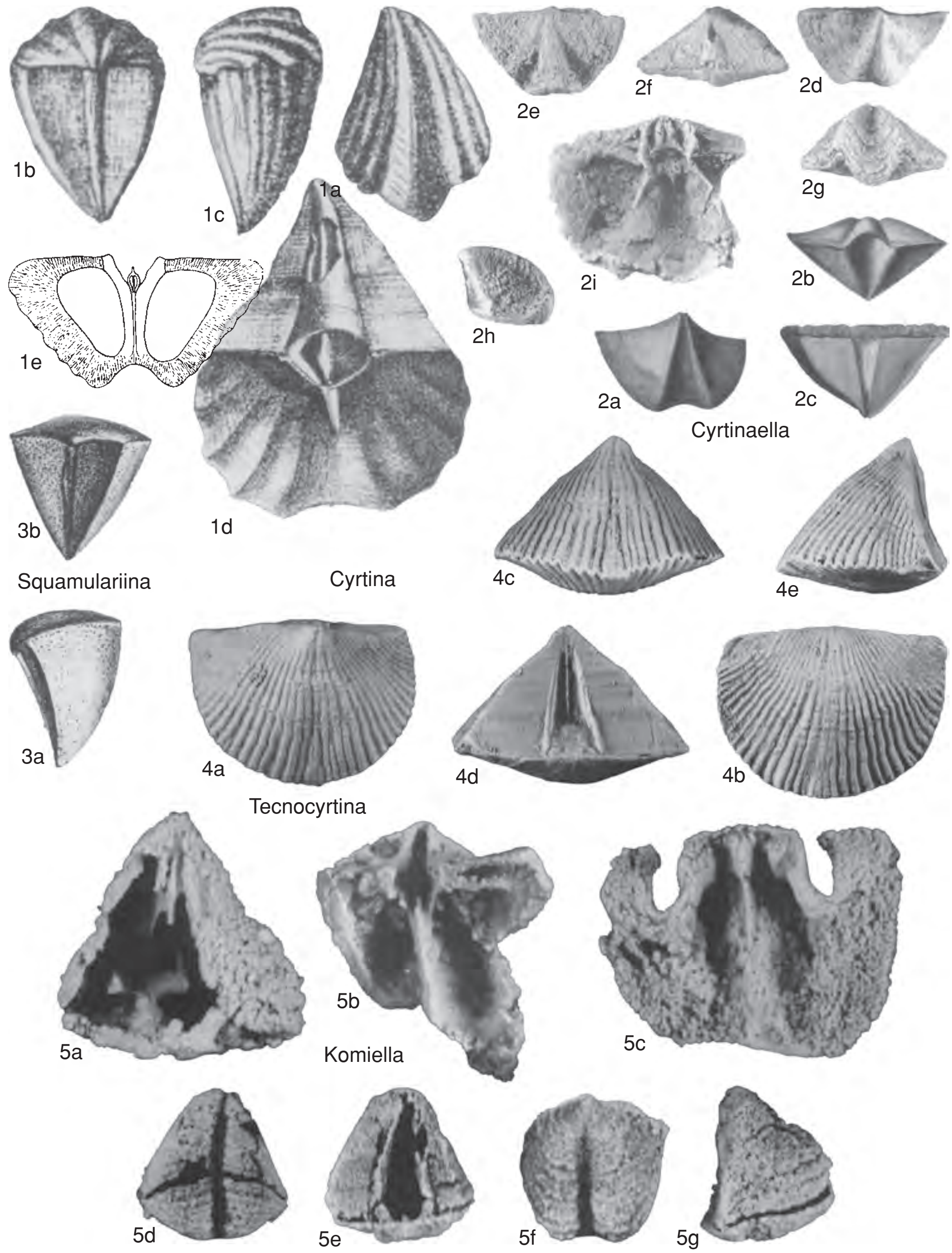

FIG. 1252. Cyrtinidae and Komiellidae (p. 1881–1883).

C. causa JOHNSON, Pragian, Nevada, USA; *d–h,* ventral, dorsal, posterior, anterior, and lateral views, ×1.5; *i,* dorsal interior, ×3 (Johnson, 1970).

Squamulariina FREDERIKS, 1916, p. 19 [**Cyrtina parva* GÜRICH, 1896, p. 266; OD] [=*Pyramidalia* NALIVKIN, 1947, p. 124 (type, *Spirifera simplex* PHILLIPS, 1841, p. 71, OD)]. Entire surface smooth; width less than height of ventral interarea. *Middle Devonian:* Europe, south Fergana, Salair, China (Guizhou).——FIG. 1252,*3a–b.* **S. parva* (GÜRICH), Poland; lateral and posterior views, ×2.5 (Gürich, 1896).

Tecnocyrtina Johnson & Norris, 1972, p. 566 [**Cyrtina billingsi* Meek, 1868, p. 97; OD]. Entire surface plicate, commonly multiplicate. *Middle Devonian (upper Givetian)–Upper Devonian (lower Frasnian):* North America, Europe.——Fig. 1252,*4a–e.* **T. billingsi* (Meek), upper Givetian, Alberta, Canada; ventral, dorsal, anterior, posterior, and side views, ×2.5 (Johnson & Norris, 1972).

Family KOMIELLIDAE Johnson & Blodgett, 1993

[Komiellidae Johnson & Blodgett, 1993, p. 952]

Spondylium incomplete, or dental flanges and median septum not connected, and lacking a tichorhinum; cardinal process simple, nonstriate; jugum sessile. *Lower Devonian (Emsian)–Upper Devonian (Frasnian).*

Komiella Liashenko, 1985, p. 14 (Barkhatova, 1970, p. 62, *nom. nud.*) [**K. devonica;* OD]. Entire surface smooth; bisulcate; teeth and sockets widely spaced. [No satisfactory illustration of the type is available.] *Lower Devonian (Emsian)–Upper Devonian (Frasnian):* western USA (Alaska, Nevada), western Canada (Yukon Territory), Timan.——Fig. 1252,*5a–c. K. gilberti* Johnson & Blodgett, lower Eifelian, west-central Alaska; posterior showing jugum, ventral interior, and dorsal interior views, ×10 (Johnson & Blodgett, 1993).——Fig. 1252,*5d–g. K. stenoparva,* upper Givetian, Nevada; anterior, posterior, dorsal, and side views, ×10 (Johnson & Blodgett, 1993).

SUESSIOIDEA

J. L. Carter

[retired from Carnegie Museum of Natural History]

Superfamily SUESSIOIDEA Waagen, 1883

[*nom. correct.* Carter in Carter & others, 1994, p. 361, *pro* Suessiacea Pitrat, 1965, p. 675, *nom. transl. ex* Suessiinae Waagen, 1883a, p. 498]

Usually cyrtiniform; ventral valve usually hemipyramidal to subconical with high interarea; ventral median septum present, discrete dental adminicula absent; endopunctae or so-called hemipunctae obscure in some genera. *Carboniferous (Mississippian)–Lower Jurassic.*

Family DAVIDSONINIDAE Ivanova, 1972

[Davidsoninidae Ivanova, 1972, p. 41]

Lateral slopes ribbed; ventral interior with false spondylium composed of median septum and high dental flanges; ventral adminicula absent; shell substance punctate, but punctae possibly not penetrating primary layer (hemipunctate); jugum and jugal processes absent; brachidium unknown, possibly absent. *Carboniferous (Mississippian).*

Davidsonina Schuchert in Schuchert & LeVene, 1929a, p. 120, *nom. nov. pro Cyrtinopsis* Frederiks, 1916, p. 17, *non* Scupin, 1896; *nom. nov. pro Davidsonella* Frederiks, 1926, p. 413, *non* Munier-Chalmas, 1880, *nec* Waagen, 1885 [**Spirifera septosa* Phillips, 1836, p. 216; OD]. Medium to very large; outline variable; ventral valve strongly inflated and evenly convex; interarea high, flattened to concave, apsacline; deltidial plates rarely preserved; sulcus narrow, shallow; dorsal valve much less convex or flattened; dorsal interior lacking septa or plates; ornament consisting of numerous uniform, rounded costae with frequent bifurcations and narrow interspaces over entire surface; micro-ornament unknown. *Carboniferous (Mississippian):* Eurasia.——Fig. 1253,*1a–b.* **D. septosa* (Phillips), Visean, British Isles; *a,* holotype, ventral valve; *b,* transverse section of ventral valve, ×1 (Davidson, 1858 in 1858–1863).——Fig. 1253,*1c–e. D. carbonaria* (M'Coy); dorsal, ventral, and ventral interiors, ×1 (Davidson, 1858 in 1858–1863).

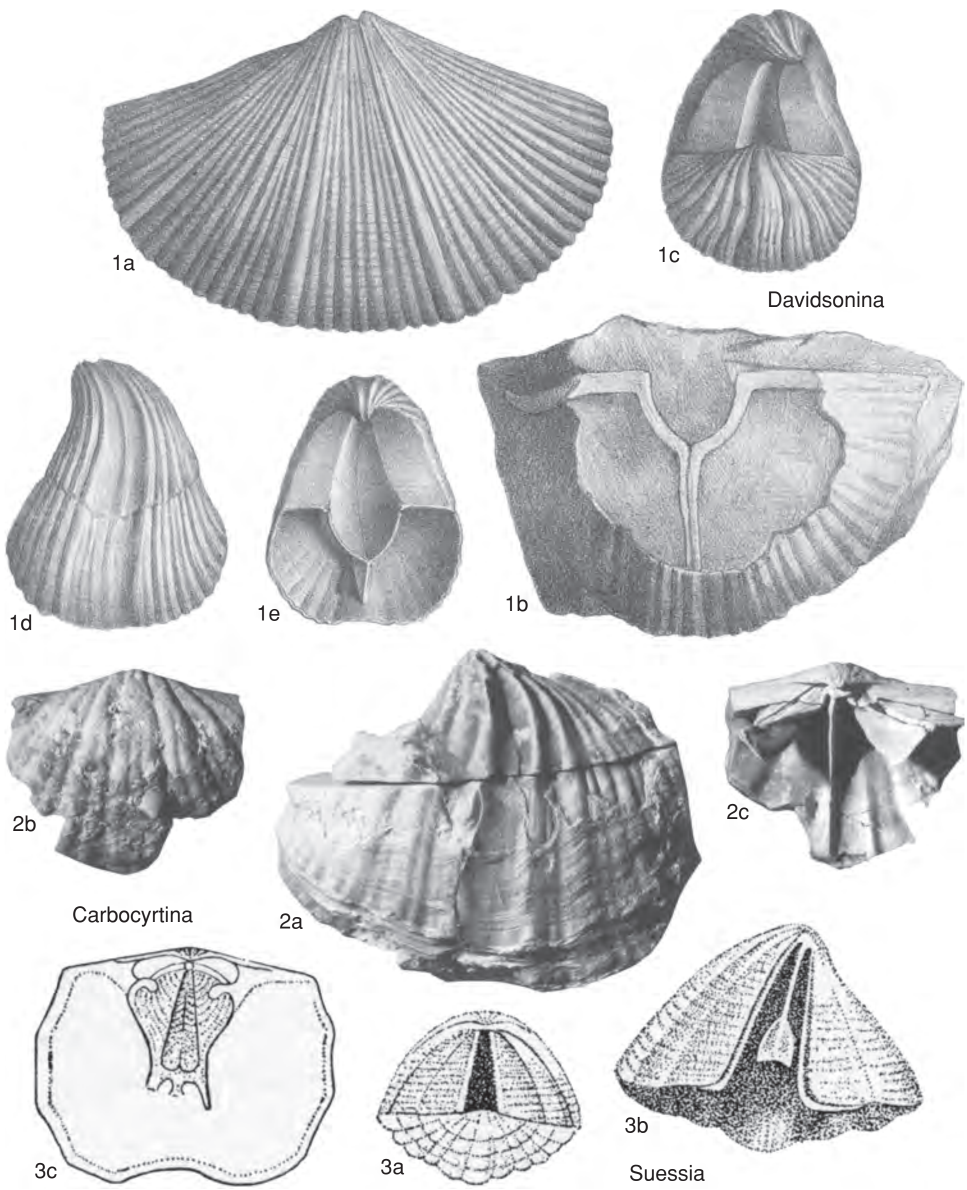

FIG. 1253. Davidsoninidae and Suessiidae (p. 1883–1890).

Carbocyrtina IVANOVA, 1975, p. 81 [**C. triplicata;* OD]. Medium size; transverse; ventral interarea high, irregular, concave; delthyrium with convex deltidium; ornament consisting of several rounded plications with fasciculate costae on flanks; fold and sulcus smooth, or with 1 prominent plication, or with several weak ribs; microornament consisting of very fine, recumbent papillae that may produce fimbriate growth lamellae; dorsal valve interior with small, weakly striate ctenophoridium, diverging crural bases, and thin, high median septum; otherwise similar to *Davidsonina. Carboniferous (Visean):* Russia (Moscow basin).——FIG. 1253,*2a–c.* **C. triplicata; a,* holotype, ventral valve; *b–c,* dorsal valve exterior and interior, ×1 (new).

Family LABALLIDAE Dagys, 1962

[*nom. transl.* DAGYS, 1965, p. 91, *ex* Laballinae DAGYS, 1962, p. 49]

Cyrtiniform; spondylium bisected by high median septum. *Permian (Changhsingian)–Upper Triassic.*

Subfamily LABALLINAE Dagys, 1962

[Laballinae DAGYS, 1962, p. 49]

Fold and sulcus well defined; lateral slopes smooth or with 1 or 2 faint plicae; delthyrium open. *Permian (Changhsingian)–Upper Triassic.*

Laballa MOISSEEV, 1962, p. 51 [**Spiriferina suessi* WINKLER, 1859, p. 22; OD]. Medium size; outline subtrigonal to subpentagonal; strongly ventribiconvex, subpyramidal; ventral umbonal region elongated, beak straight or slightly incurved; ventral interarea high, flattened or slightly concave, weakly apsacline to catacline; delthyrum open; fold and sulcus moderately well developed, rounded, smooth; lateral slopes smooth or very gently folded; microornament of short spinules; ventral interior with very high, short median septum bisecting high, shallow, anteriorly free spondylium; dorsal interior with ctenophoridium and long, high, subparallel dorsal adminicula; jugum free, flattened, fimbriate. *Upper Triassic:* Tethys, northeastern Siberia, New Zealand, New Caledonia.——FIG. 1254,*3a–j.* **L. suessi* (WINKLER), Rhaetian, eastern Alps; *a–b,* dorsal and lateral views, ×1 (new); *c–g, h–j,* transverse sections of 2 specimens, ×2 (Dagys, 1963).

Eolaballa LIAO & MENG, 1986, p. 86 [94] [**E. pristina;* OD]. Medium size; lateral slopes with 1 or 2 very weak, low, undulating plicae; ventral interarea very narrow with much wider, false interareas laterally, strongly apsacline in adults, catacline in juveniles; jugum unknown; otherwise similar to *Laballa. Permian (Changhsingian):* China (Hunan), Sicily.——FIG. 1254,*1a–e.* **E. pristina,* Hunan; ventral, dorsal, anterior, posterior, and lateral views, ×2 (new).

Pseudolaballa DAGYS, 1974, p. 145 [**Laballa bittneri* DAGYS, 1965, p. 93; OD]. Medium size; transversely subovate to subquadrate in outline; ventribiconvex; ventral valve subpyramidal; cardinal extremities rounded; ventral interarea high, flattened, smooth, catacline to procline; fold and sulcus well defined, variably wide, rounded, smooth; lateral slopes smooth or obscurely plicate; microornament unknown; ventral interior with moderately deep high spondylium bisected by median septum; dorsal interior with apical callus, low ctenophoridium, and thin, low ridges bounding adductor field; jugum unknown. *Upper Triassic (Carnian):* northeastern Siberia, New Zealand, New Caledonia.——FIG. 1254,*2a–f.* **P. bittneri* (DAGYS), northeastern Siberia; *a–c,* paratype, ventral, posterior, and lateral views, ×1 (new); *d–f,* transverse sections, ×1 (Dagys, 1965).

Subfamily SPINOLEPISMATININAE Carter, 1994

[Spinolepismatininae CARTER in CARTER & others, 1994, p. 362]

Lateral slopes distinctly plicate; fold and sulcus smooth; microornament densely spinulose. *Upper Triassic.*

Spinolepismatina DAGYS, 1974, p. 147 [**Lepismatina rara* DAGYS, 1963, p. 97; OD]. Small to medium sized; ventral valve subconical; ventral interarea high, flattened, smooth; fold and sulcus smooth; lateral slopes with several rounded plicae; ventral interior with elevated spondylium; dorsal interior with jugum supported by sessile net. *Upper Triassic:* Caucasus Mountains.——FIG. 1255,*4a–g.* **S. rara* (DAGYS); *a–d,* holotype, posterior, ventral, dorsal, and lateral views, ×1; *e–g,* transverse sections, approximately ×2 (Dagys, 1963).

Klipsteinella DAGYS, 1974, p. 150 [**Spirifer calceola* KLIPSTEIN, 1845, p. 227; OD]. Small; strongly ventribiconvex, ventral valve acutely extended and very high, dorsal valve flattened or concave; ventral interarea high, flattened, delthyrium closed by convex deltidium with small apical foramen; fold and sulcus very narrow but well defined, smooth; lateral slopes with few rounded plicae; microornament of small spinules; dorsal interior unknown. *Upper Triassic (Carnian):* western Tethys.——FIG. 1255,*1a–d.* **K. calceola* (KLIPSTEIN), southern Alps; dorsal, ventral, lateral, and posterior views, ×3 (Dagys, 1974).

Klipsteinelloidea SUN, 1981, p. 209 [**K. tibetica;* OD; =*K. xizangensis* SUN, 1981, p. 210]. Small; outline subovate; profile subtrigonal; ventral valve very high, subconical, with high, flat, catacline or slightly procline interarea; beak acute, straight; delthyrium narrow, open; dorsal valve thinly convex; fold and sulcus narrow, smooth, poorly defined; cardinal extremities rounded, maximum width attained anterior to hinge line; lateral slopes with few rounded, coarse plicae; microornament unknown; dorsal interior with posteriorly sessile low ctenophoridium; dorsal adminicula short, slightly divergent; jugum unknown. *Upper Triassic:* China.——FIG. 1255,*2a–h.* **K. tibetica,* Tibet; *a–d,* anterior, posterior, lateral, and ventral views, ×3 (new); *e–h,* transverse sections, approximately ×2 (Sun, 1981).

Subfamily PARALEPISMATININAE Carter, 1994

[Paralepismatininae CARTER in CARTER & others, 1994, p. 362]

Fold and sulcus poorly developed; entirely ribbed; microornament absent. *Middle Triassic (Anisian).*

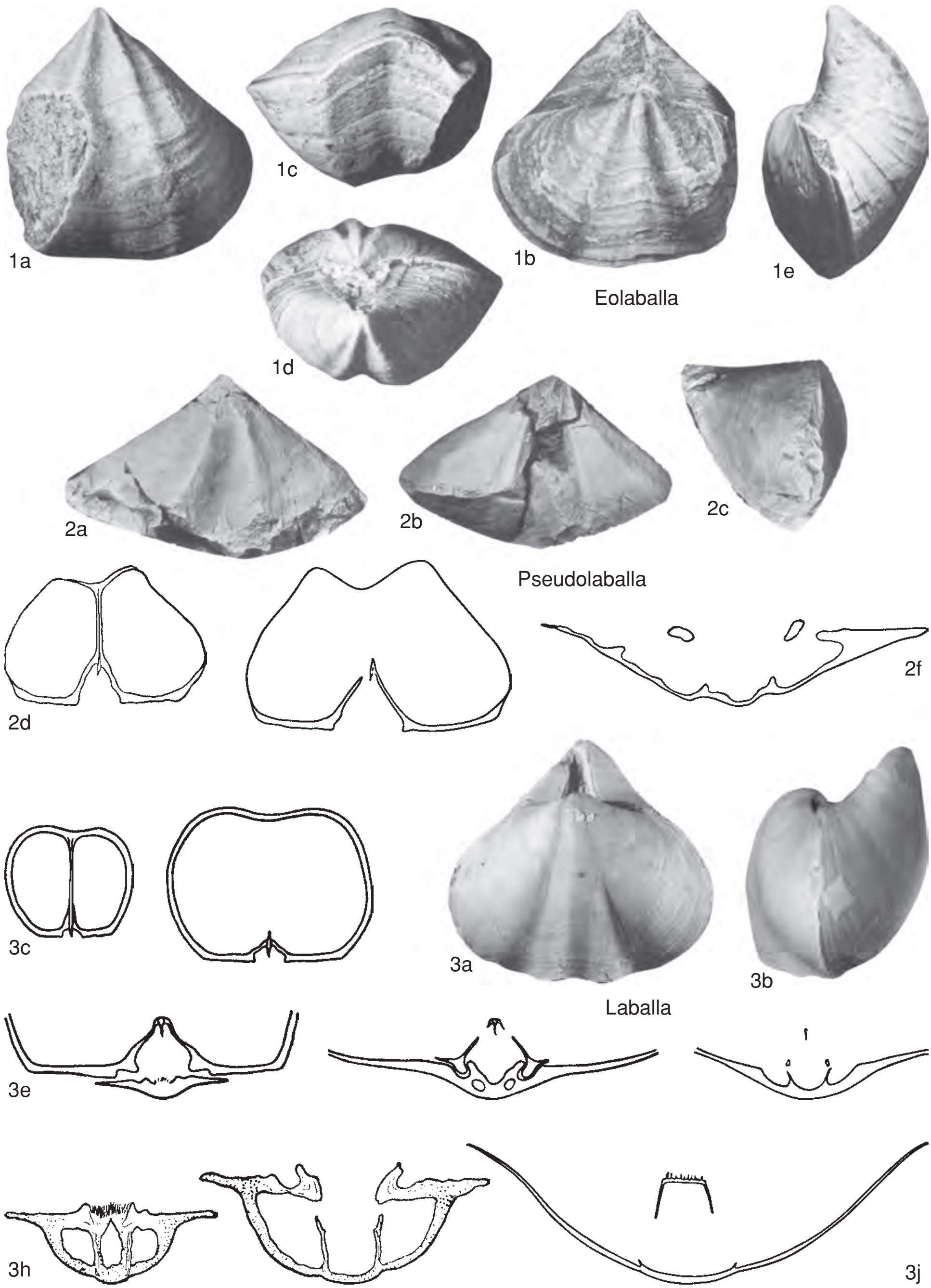

FIG. 1254. Laballidae (p. 1885).

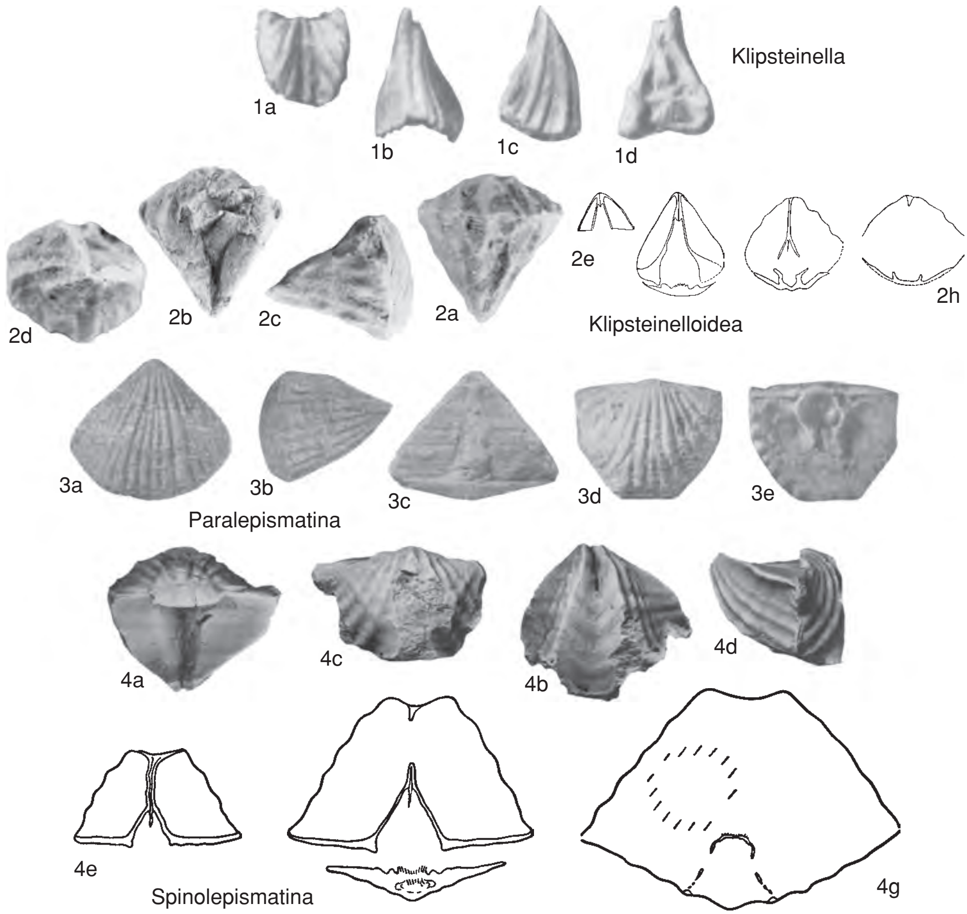

FIG. 1255. Laballidae (p. 1885–1887).

Paralepismatina YANG & XU, 1966, p. 38 [**P. semiconica;* OD]. Small; strongly ventribiconvex, ventral valve subconical, dorsal valve weakly convex; cardinal extremities angular, maximum width at hinge line; ventral beak straight, acute; ventral interarea high, flattened, nearly catacline; delthyrium narrow, open; fold and sulcus absent or very poorly developed; entire surfaces of valves with fine, rounded, simple costellae and fine, regular growth lamellae; microornament seemingly absent; ventral interior with short spondylium supported by high, long median septum; ctenophoridium present; jugum unknown. *Middle Triassic (Anisian):* China (Guizhou).——FIG. 1255,*3a–e.* **P. semiconica; a–c,* paratype, ventral, lateral, and posterior views; *d–e,* exterior and interior views of dorsal valve, ×2 (Yang & Xu, 1966).

Family BITTNERULIDAE Schuchert, 1929

[*nom. transl.* CARTER in CARTER & others, 1994, p. 362, *ex* Bittnerulinae SCHUCHERT, 1929, p. 21] [=Thecocyrtellinae DAGYS, 1965, p. 105]

Cyrtiniform; dental adminicula and spondylium absent; ventral septum and dental flanges fused by apical callus or short transverse plate. *Middle Triassic–Upper Triassic.*

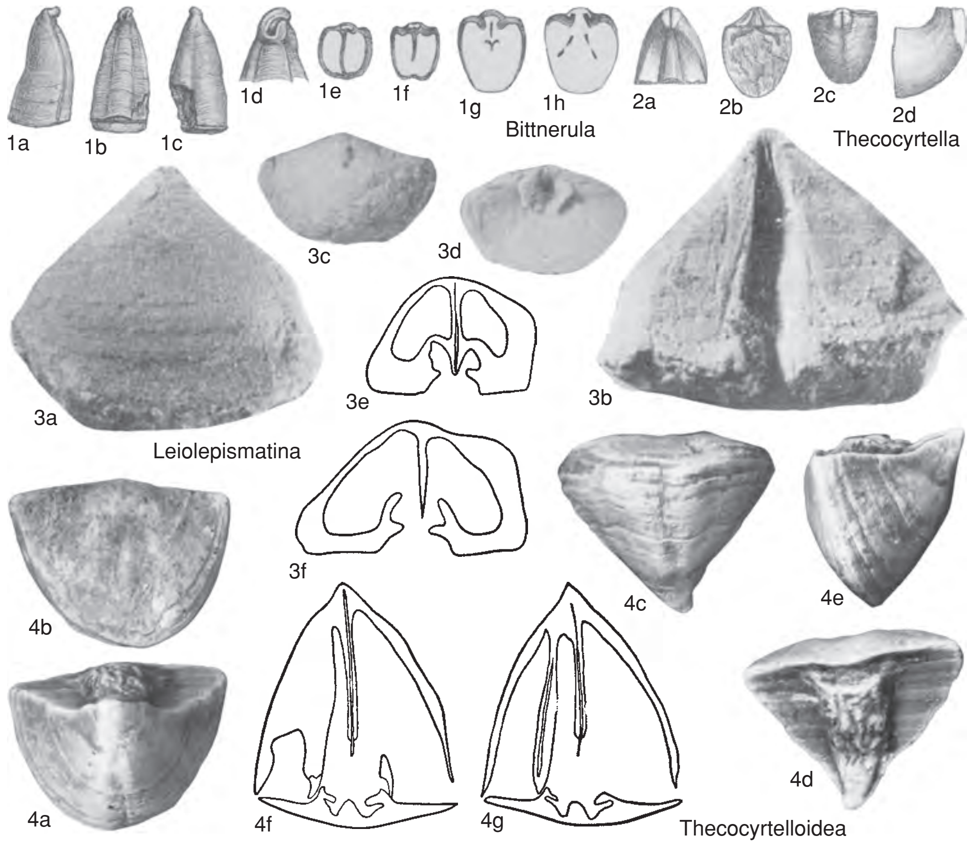

FIG. 1256. Bittnerulidae (p. 1888–1889).

Subfamily BITTNERULINAE Schuchert, 1929

[Bittnerulinae SCHUCHERT, 1929, p. 21]

Smooth or obscurely ribbed; fold and sulcus absent or very weak; delthyrium closed by convex deltidium. *Middle Triassic–Upper Triassic.*

Bittnerula HALL & CLARKE, 1894, p. 764 [**Cyrtina zitteli* BITTNER, 1890, p. 117; OD]. Small; very strongly inequivalved; ventral valve very high, subconical; dorsal valve weakly convex; ventral beak twisted, asymmetrical; ventral interarea very high, flattened, catacline; delthyrium covered by convex deltidium (possible symphytium) pierced by tiny apical foramen; cardinal extremities subangular, maximum width anterior to hinge line, at midlength in type species; lateral slopes of ventral valve rounded in type species, flattened in some species; weak sulcus present; microornament of fine, dense spinules in some species; interior with high median septum fused to dental flanges by thin transverse plate or callus; dorsal interior in type species with complete jugum bearing short anterior process; short dorsal adminicula and jugal net present in some species. *Upper Triassic (Carnian):* western Tethys.——FIG. 1256,*1a–h*. **B. zitteli* (BITTNER), southern Alps; *a–d,* lateral, posterior, anterior, and enlarged ventral beak; *e–h,* longitudinal sections, ×1 (Bittner, 1892).

Leiolepismatina YANG & XU, 1966, p. 39 [**L. semiconula;* OD]. Small; transversely subsemicircular in outline; strongly ventribiconvex, ventral valve high, subconical, dorsal valve moderately convex; cardinal extremities rounded; ventral interarea very high, flat, catacline; delthyrium open; fold and sulcus absent; shell lacking macro- or microornament; high median septum connected to dental flanges by bisected transverse band of callus; presence of functional spondylium not certain; dorsal interior with small ctenophoridium; jugum unknown. *Middle Triassic:* China (Guizhou).——FIG. 1256,*3a–f*. **L. semiconula; a–b,* ventral and posterior views of ventral valve, ×4; *c–d,* exterior and interior views of dorsal valve, ×2; *e–f,* transverse sections, approximately ×4 (Yang & Xu, 1966).

Thecocyrtella Bittner, 1892, p. 15, *nom. nov. pro Cyrtotheca* Bittner, 1890, p. 116, *non* Hicks, 1872 [**Cyrtotheca ampezzana* Bittner, 1890, p. 116; OD]. Very small; strongly ventribiconvex; ventral valve high, symmetrical, beak incurved; dorsal valve probably slightly concave; widest at hinge line, cardinal extremities angular; ventral interarea well defined, concave; delthyrium completely closed by convex deltidium; fold and sulcus absent; microornament of fine growth lines only; ventral interior with long median septum; other internal details unknown. *Upper Triassic:* western Tethys.——Fig. 1256,*2a–d.* **T. ampezzanaa* (Bittner), Alps; holotype, posterior, dorsal (showing part of brachidium), ventral, and lateral views, ×3 (Bittner, 1890).

Thecocyrtelloidea Yang & Xu, 1966, p. 58 [**T. tubulosa;* OD]. Small, ventribiconvex, ventral valve strongly subconical, dorsal weakly convex; ventral beak commonly asymmetrical; ventral interarea high, flattened, weakly convex or concave, catacline to procline; deltidium widely convex with numerous fine tubules; semicircular pedicle foramen seemingly present proximally; fold and sulcus narrow, very weakly developed; microornament unknown; ventral interior with long median septum; ventral adminicula possibly absent or very short; spondylium absent; dorsal interior with broad, bilobed ctenophoridium; jugum unknown. *Middle Triassic (Anisian):* China (Guizhou).——Fig. 1256,*4a–g.* **T. tubulosa; a–e,* topotype, ventral, dorsal, anterior, posterior, and lateral views, ×4 (new); *f–g,* transverse sections, approximately ×3 (Yang & Xu, 1966).

Subfamily HIRSUTELLINAE Xu & Liu, 1983

[Hirsutellinae Xu & Liu, 1983a, p. 82]

Lateral slopes ribbed; fold and sulcus weakly to moderately developed; delthyrium open or partially occluded by various plates. *Middle Triassic–Upper Triassic (Carnian).*

Hirsutella Cooper & Muir-Wood, 1951, p. 195, *nom. nov. pro Hirsutina* Kirchner, 1933, p. 106, *non* Tutt, 1909 [**Spirifer? hirsutus* Alberti, 1864, p. 156; OD]. Small to medium size; outline transversely subovate; usually strongly ventribiconvex; ventral valve subpyramidal, dorsal valve flattened or weakly convex; cardinal extremities subangular to rounded; ventral interarea high, catacline; fold and sulcus weakly developed; entire surface covered with moderately numerous, rounded, simple costae; microornament unknown; ventral interior with high median septum laterally fused to valve wall and dental flanges by callus; dorsal interior with stout, thick ctenophoridium supported by thick callus; jugum unknown. *Middle Triassic:* western Tethys.——Fig. 1257,*1a–b.* **H. hirsuta* (Alberti), Germany; exterior and interior views of ventral valve, ×1 (Kirchner, 1933).——Fig. 1257,*1c–g. H. multicostata* Yang & Yin; dorsal, ventral, lateral, anterior, and posterior views, ×1 (Xu & Liu, 1983a).

Flabellocyrtia Chorowicz & Termier, 1975, p. 235 [**F. flabellum;* OD]. Small; strongly ventribiconvex; ventral valve high, subconical; dorsal valve flattened; ventral interarea high, slightly concave, smooth, catacline; delthyrium completely closed by deltidium; fold and sulcus weakly developed, narrow; lateral slopes with few rounded plicae, sulcus with weak median rib; microornament unknown; dorsal interior with fine, radiating grooves anteriorly; jugum unknown. *Middle Triassic (Ladinian):* Yugoslavia.——Fig. 1257,*3a–e.* **F. flabellum; a–c,* lateral, dorsal, and ventral views, ×5.3; *d,* ventral interior, ×5.45; *e,* dorsal interior, ×7.3 (Chorowicz & Termier, 1975).

Neocyrtina Yang & Xu, 1966, p. 62 [**N. mixodeltidiumosa;* OD]. Small, with subconical ventral valve and weakly convex dorsal valve; maximum width at hinge line, cardinal extremities angular; ventral interarea high, flattened, catacline to procline; delthyrial cover bipartite with imbricating plates proximally and irregular solid nodules or tubules apically; fold and sulcus weakly delimited, smooth; fold with medial depression; lateral slopes with few plicae; growth lamellae closely imbricate, other microornament absent; punctae fine; ventral interior with thick callus uniting dental flanges and high, strong median septum; dorsal interior with short, broad ctenophoridium; jugum unknown. *Middle Triassic:* China (Guizhou).——Fig. 1257,*2a–i.* **N. mixodeltidiumosa; a,* holotype, posterior view; *b,* dorsal interior, ×4; *c–f,* dorsal, ventral, lateral, and posterior views, ×2; *g–i,* transverse sections, approximately ×4 (Yang & Xu, 1966).

Spiriferinoides Tokuyama, 1957, p. 101 [**S. sakawanus* Kobayashi & Tokuyama in Tokuyama, 1957, p. 101; OD]. Small; outline transversely subovate to subsemicircular; ventribiconvex; ventral valve strongly convex, dorsal valve flattened, weakly convex; cardinal extremities rounded; ventral interarea moderately high, concave, apsacline; ventral beak moderately incurved; fold and sulcus well developed, rounded, smooth; lateral slopes with few rounded, simple plicae; microornament of dense, fine spinules; internally similar to *Hirsutella;* jugum unknown. *Upper Triassic (Carnian):* Japan, Primorye (Siberia).——Fig. 1257,*4a–d.* **S. sakawanus* (Kobayashi & Tokuyama); holotype, dorsal, ventral, posterior, and lateral views, ×2 (Tokuyama, 1957).

Family SUESSIIDAE Waagen, 1883

[*nom. transl.* Pitrat, 1965, p. 679, *ex* Suessiinae Waagen, 1883a, p. 498]

Entirely plicate; delthyrium open; dental adminicula and spondylium absent; large,

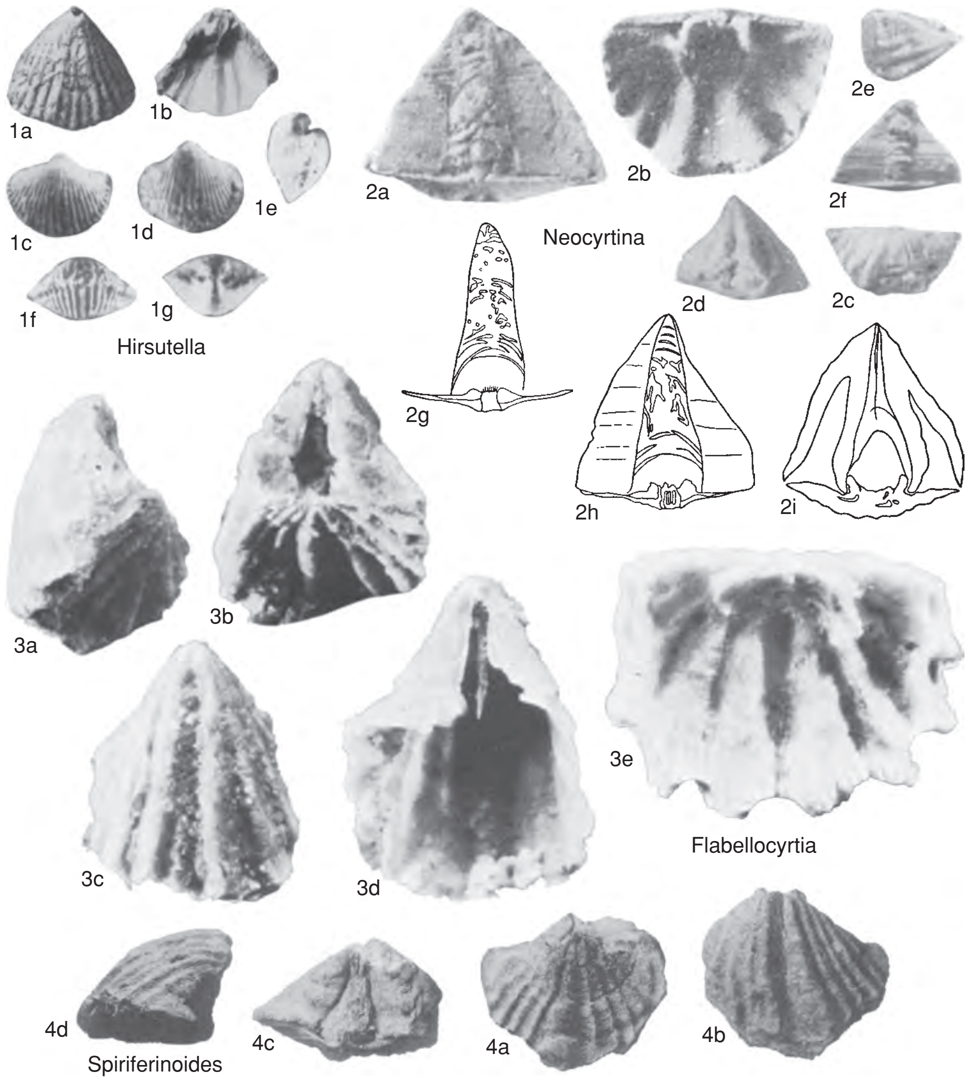

FIG. 1257. Bittnerulidae (p. 1889).

elongate hinge plate bearing adductors. *Lower Jurassic.*

Suessia EUDES-DESLONGCHAMPS, 1855, p. 6 [**S. costata;* SD DAVIDSON, 1854, p. 28]. Strongly ventribiconvex; ventral valve high, strongly convex; dorsal valve much less convex; ventral interarea high, concave; fold and sulcus present; microornament unknown; ventral interior with high median septum horizontally expanded at posterodorsal margin; dorsal interior with complete jugum, bearing anterior process. *Lower Jurassic:* Europe.——FIG. 1253,*3a–c.* **S. costata;* posterior, ventral valve posterior, and dorsal interior views, magnification unknown (Hall & Clarke, 1894).

SPONDYLOSPIROIDEA

J. L. CARTER

[retired from Carnegie Museum of Natural History]

Superfamily SPONDYLOSPIROIDEA Hoover, 1991

[*nom. transl.* CARTER in CARTER & others, 1994, p. 363, *ex* Spondylospiridae HOOVER, 1991, p. 75]

Spiriferiform to cyrtiniform; hinge line partially to completely crenulate; dental adminicula converging or forming spondylium; punctation well developed. *Middle Triassic (Ladinian)–Upper Triassic (Rhaetian).*

Family SPONDYLOSPIRIDAE Hoover, 1991

[Spondylospiridae HOOVER, 1991, p. 75]

Cyrtiniform to globose; lateral slopes ribbed; spondylium bisected by high median septum; jugum complete, supported by sessile jugal net. *Upper Triassic (Carnian–Rhaetian).*

Subfamily SPONDYLOSPIRINAE Hoover, 1991

[Spondylospirinae HOOVER, 1991, p. 80]

Dental adminicula and ventral interarea complete, not pierced by paired pedicle foramena. *Upper Triassic (Carnian–Rhaetian).*

Spondylospira COOPER, 1942, p. 232 [**S. reesidei;* OD]. Medium size; strongly ventribiconvex, ventral valve high, subconical, dorsal gently convex; hinge line less than maximum width; ventral interarea high, flattened, apsacline to procline, vertically grooved, commonly covered with multipartite punctate cover (cooperculum); entire hinge line crenulate; delthyrium open or partially closed by disjunct deltidial plates leaving apical foramen; fold and sulcus well developed; valves entirely costate, costae increasing by bifurcation, those on fold-sulcus weakest; microornament unknown; spondylium high, short; sessile jugum supported by net; ctenophoridium present. *Upper Triassic (Carnian–Norian):* western North America, western South America.——FIG. 1258,*3a–i.* **S. reesidei,* Norian, Idaho, USA; *a–e,* lectotype, lateral, dorsal, ventral, posterior, and anterior views; *f–g,* dorsal and ventral views; *h,* dorsal interior; *i,* ventral interior, ×1 (Hoover, 1991).

Phenacozugmayerella HOOVER, 1991, p. 89 [**P. mimuncinata;* OD]. Medium size; ventral valve high, subpyramidal; ventral interarea high, flattened to moderately concave, entirely crenulate; delthyrium long, narrow, open; fold and sulcus moderately well developed, subangular, smooth; lateral slopes with 3 to 5 coarse subangular plicae; microornament very finely cancellate with fine capillae and slightly lamellose growth lamellae; spondylium bisected by long, high median septum; jugum unknown. *Upper Triassic (upper Carnian–middle Norian):* USA (Alaska, Nevada, Oregon). ——FIG. 1258,*2a–e.* **P. mimuncinata;* middle Norian, Nevada; paratype, anterior, posterior, dorsal, ventral, and lateral views, ×1 (Hoover, 1991).

Vitimetula HOOVER, 1991, p. 85 [**V. parva;* OD]. Small; extremely ventribiconvex; ventral valve very high, subconical; dorsal valve much thinner, moderately convex; ventral interarea high, flattened, narrow, catacline, entirely crenulate; delthyrium very narrow, open; fold and sulcus weakly developed, narrow, smooth, fold sometimes absent; lateral slopes with few very weak ribs; microornament unknown; spondylium shallow; jugum unknown. *Upper Triassic (Norian):* USA (Idaho).——FIG. 1258,*1a–g.* **V. parva; a–e,* holotype, anterior, posterior, dorsal, ventral, and lateral views; *f–g,* dorsal and ventral interiors, ×3 (Hoover, 1991).

Yanospira DAGYS, 1977, p. 11 [**Y. bychkovi;* OD]. Medium size; ventribiconvex; cardinal extremities rounded; ventral interarea orthocline to slightly apsacline, bipartite, outer part smooth, inner part vertically grooved; hinge line partially crenulate; fold and sulcus well defined, moderately developed, smooth; lateral slopes with few rounded plicae; microornament absent; spondylium deep; dorsal interior with ctenophoridium supported by short, thick median septum or callus; low adductor platform bounded by lateral ridges present; jugum unknown. *Upper Triassic (Norian):* northeastern Siberia.——FIG. 1258,*5a–g.* **Y. bychkovi; a–d,* holotype, dorsal, ventral, posterior, and lateral views, ×1; *e–g,* transverse sections, ×2.7 (Dagys, 1977).

Zugmayerella DAGYS, 1963, p. 99 [**Spiriferina koessenensis* ZUGMAYER, 1882, p. 354; OD]. Medium size; ventral valve subconical; ventral interarea high, slightly concave, vertically grooved; hinge line entirely crenulate; delthyrium partially closed by deltidium with apical foramen; fold and sulcus well developed, rounded, smooth, or with weak, low median rib; lateral slopes with few rounded plicae; microornament of short spinules; spondylium elevated; jugum sessile. *Upper Triassic (Norian–*

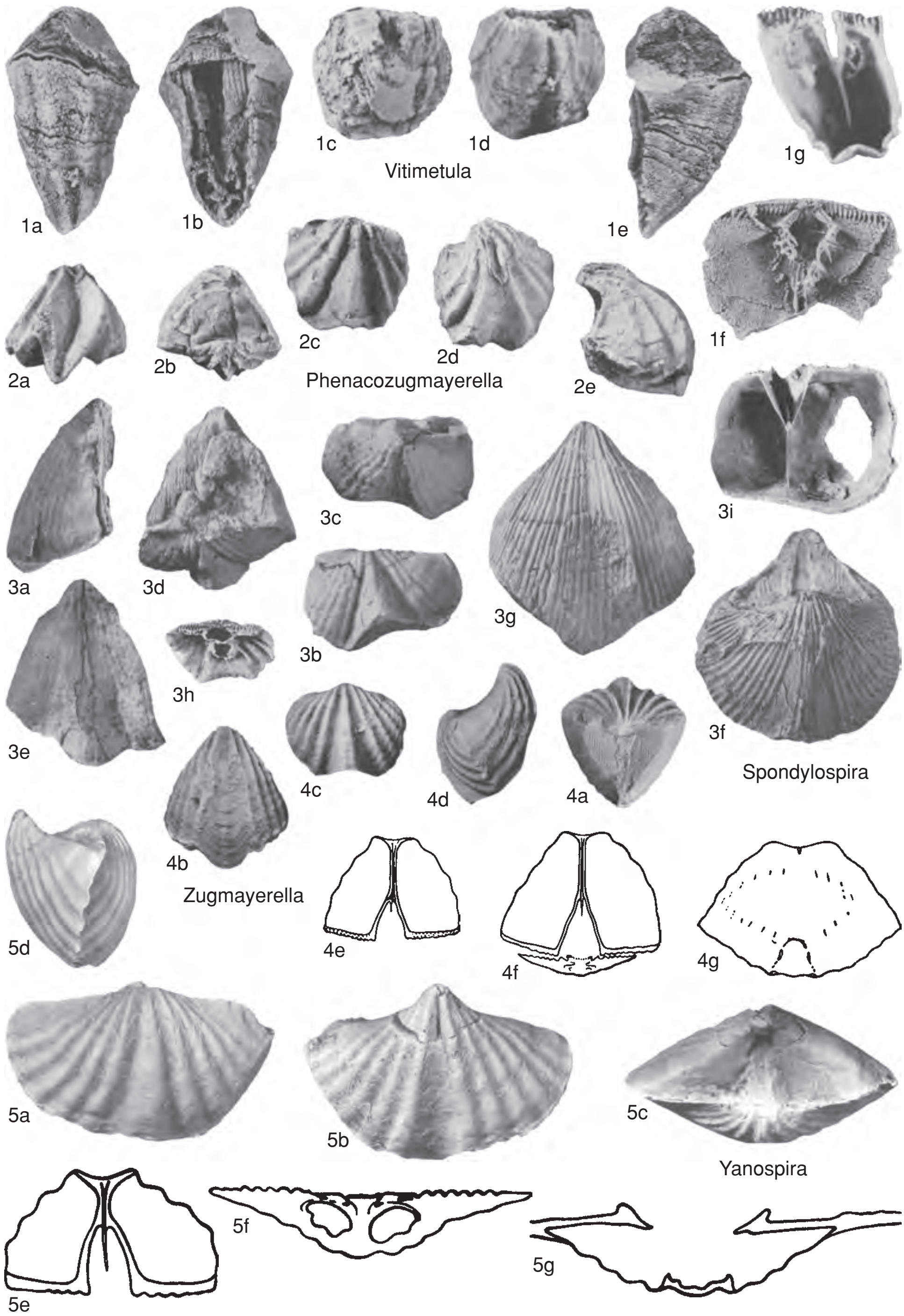

FIG. 1258. Spondylospiridae (p. 1891–1893).

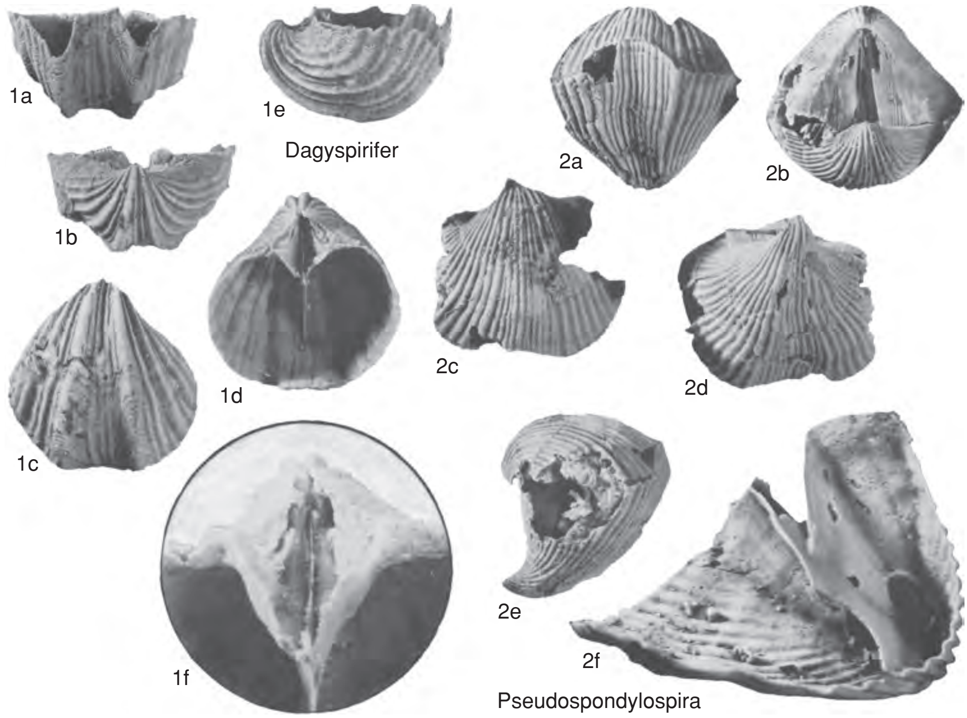

FIG. 1259. Spondylospiridae (p. 1893).

Rhaetian): Tethyan seaway, northeastern Siberia, South America.——FIG. 1258,*4a–g.* **Z. koessenensis* (ZUGMAYER); *a–d,* posterior, ventral, dorsal, and lateral views, ×1; *e–g,* transverse sections, approximately ×2 (Dagys, 1963).

Subfamily DAGYSPIRIFERINAE Hoover, 1991

[Dagyspiriferinae HOOVER, 1991, p. 77]

Globose to cyrtiniform; entirely ribbed; apex of spondylium and ventral interarea pierced by paired elongate foramena. *Upper Triassic (Carnian–Norian).*

Dagyspirifer HOOVER, 1991, p. 77 [**D. fascicostata;* OD]. Medium size; spiriferoid with subglobose, arched ventral valve and incurved umbo; dorsal valve unknown; cardinal extremities well rounded, hinge line much less than maximum width; ventral interarea narrow, concave, partially crenulate; delthyrium possibly with narrow deltidial plates; sulcus moderately wide and deep, well delimited by strong bounding plicae; entire surface with several coarse ribs, each with bundles of several much finer, fasciculate costae; microornament finely pustulose; dental adminicula long and close set, bisected by long, high median septum. *Upper Triassic (lower Norian):* USA (Alaska).——FIG. 1259,*1a–f.* **D. fascicostata; a–e,* anterior, posterior, ventral, ventral interior, and lateral views, ×1; *f,* enlargement of apical portion of ventral interior, ×3 (Hoover, 1991).

Pseudospondylospira HOOVER, 1991, p. 78 [**P. perplexa;* OD]. Medium size, cyrtinoid; ventral valve high, subpyramidal, beak slightly incurved; dorsal valve moderately convex; cardinal extremities rounded, maximum width posterior to midlength; ventral interarea high, flattened but apically concave, partially crenulate, apically pierced by foramena; delthyrium long and narrow, with very narrow deltidial plates; fold and sulcus moderately developed and delineated; entire surface with numerous simple and bifurcating costae; microornament unknown; ventral interior with delicate spondylium; dorsal interior with bilobate ctenophoridium and jugum supported by jugal net. *Upper Triassic (Carnian–Norian):* USA (Alaska, Nevada, Oregon).——FIG. 1259,*2a–f.* **P. perplexa,* lower Carnian, Alaska; *a–e,* holotype, anterior, posterior, dorsal, ventral, and lateral views, ×1; *f,* oblique view of ventral interior, ×3 (Hoover, 1991).

Family RASTELLIGERIDAE Carter, 1994

[Rastelligeridae CARTER in CARTER & others, 1994, p. 364]

Spiriferiform; usually transverse; fold and sulcus smooth; lateral slopes usually plicate;

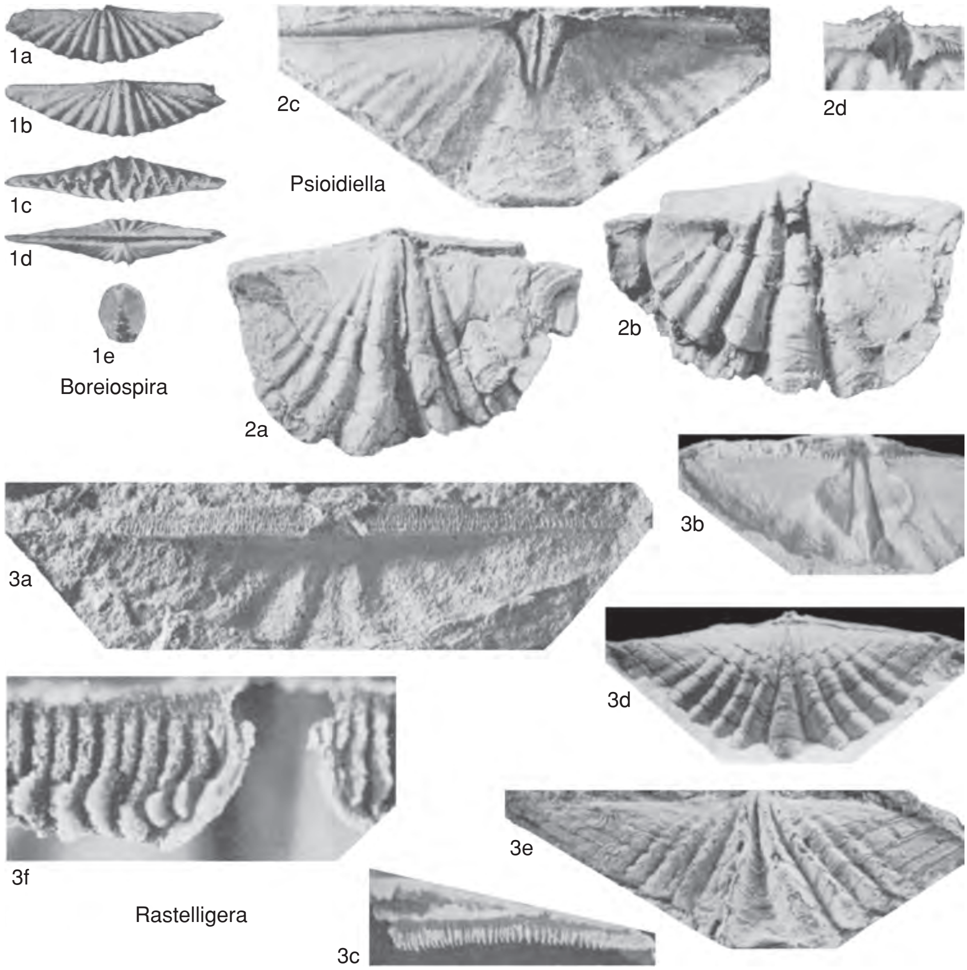

FIG. 1260. Rastelligeridae (p. 1894–1895).

dental adminicula subparallel or convergent. *Middle Triassic (Ladinian)–Upper Triassic (Rhaetian).*

Subfamily RASTELLIGERINAE Carter, 1994

[Rastelligerinae CARTER in CARTER & others, 1994, p. 364]

Strongly transverse; cardinal extremities extended; lateral slopes strongly plicate; dental adminicula convergent or forming sessile spondylium. *Middle Triassic (Ladinian)–Upper Triassic (Rhaetian).*

Rastelligera HECTOR, 1879, p. 538 [**R. elongata* HECTOR in THOMSON, 1913, p. 50; SD THOMSON, 1913, p. 50]. Medium to large; transverse, cardinal extremities alate to mucronate; subequally biconvex, moderately inflated; fold and sulcus well defined, smooth; both interareas vertically grooved; hinge line almost entirely crenulate; flanks strongly plicate; microornament not pustulose; ventral interior with dental adminicula convergent but not meeting median septum to form spondylium; teeth, dental adminicula, and socket ridges lost in some younger species; median septum low, thin; muscle field large, well defined in species lacking dental adminicula; dorsal interior with small, sessile, diamond-shaped ctenophoridium; jugum complete, simple. *Upper Triassic (Carnian–Rhaetian):* New Zealand.——FIG. 1260,*3a–c*. **R. elongata,* Rhaetian; *a,* holotype, cast of ventral valve; *b,* cast of ventral interior, ×1; *c,* ventral interarea, ×2 (J. D. Campbell, 1968).——FIG. 1260,*3d–f. R. malingi* CAMPBELL; *d–e,* dorsal and ventral views, ×1; *f,* ventral interarea, ×10 (J. D. Campbell, 1968).

Boreiospira DAGYS, 1974, p. 126 [**Spiriferina lundgreni* BOEHM, 1903, p. 13; OD]. Medium size; much wider than long, outline transversely subtrigonal; cardinal extremities alate; both valves weakly and subequally convex; ventral umbonal region poorly differentiated, beak inconspicuous; ventral interarea low, apsacline or nearly orthocline; entire hinge line crenulate; fold and sulcus poorly delineated, rounded, slightly wider than lateral ribbing; lateral slopes with few strong, rounded plicae separated by slightly narrower, subangular interspaces; microornament of densely spaced spinules; ventral interior with very short dental adminicula that converge toward long, stout median septum at umbo; spondylium absent; jugum probably incomplete. *Middle Triassic (Ladinian)–Upper Triassic (Carnian):* Spitzbergen, Arctic Canada, Siberia (Medvezhi Islands, Yakutia).——FIG. 1260,*1a–e*. **B. lundgreni* (BOEHM), Ellesmere Island; dorsal, ventral, anterior, posterior, and lateral views, ×1 (Logan, 1967).

Psioidiella CAMPBELL, 1968, p. 33 [**Spiriferina otamitensis* TRECHMANN, 1918, p. 225; OD]. Medium to large, alate to mucronate, cardinal extremities acute; moderately and subequally biconvex; fold and sulcus narrow, rounded; flanks with several strong, rounded plications; microornament apparently absent; both interareas partially crenulate near delthyium and notothyrium; ventral interior with sessile spondylium; median septum high anteriorly; dorsal interior with well-developed sockets and low ctenophoridium; jugum unknown. *Upper Triassic (Carnian–Rhaetian):* New Zealand, New Caledonia.——FIG. 1260,*2a–b*. **P. otamitensis* (TRECHMANN); holotype, ventral and dorsal views, ×2 (J. D. Campbell, 1968).——FIG. 1260,*2c–d. P. drotae* CAMPBELL; ventral internal mold and ventral interarea, ×1 (J. D. Campbell, 1968).

Subfamily DENTOSPIRIFERININAE Carter, 1994

[Dentospiriferininae CARTER in CARTER & others, 1994, p. 364]

Cardinal extremities subangular to rounded; lateral slopes smooth or with few weak plicae; dental adminicula subparallel to convergent. *Upper Triassic (Carnian–Norian).*

Dentospiriferina DAGYS, 1965, p. 109 [**D. pepeliaevi;* OD]. Medium size; outline subovate; subequally biconvex; cardinal extremities well rounded, hinge line narrower than maximum width; ventral umbonal region broad, beak slightly incurved; ventral interarea moderately high, bipartite, outer area smooth, inner area marked with coarse vertical grooves; hinge line crenulate medially, noncrenulate laterally; fold and sulcus well delineated, moderately developed, smoothly rounded; lateral slopes with weak or obscure plicae; microornament of fine, dense, regularly arranged spinules; ventral interior with stout, long, dental adminicula, median septum, and thick apical callus; jugum complete. *Upper Triassic (Carnian):* northeastern Siberia.——FIG. 1261,*1a–g*. **D. pepeliaevi; a–d,* holotype, dorsal, ventral, lateral, and anterior views, ×1; *e,* posterior view of ventral valve, ×3; *f–g,* transverse sections, approximately ×1.5 (Dagys, 1965).

Canadospira DAGYS, 1972a, p. 40 [**Spiriferina (Psioidia) canadensis* LOGAN, 1967, p. 26; OD]. Medium size; outline transversely subovate; strongly ventribiconvex; ventral valve strongly inflated, subpyramidal; cardinal extremities rounded, maximum width near midlength; ventral interarea high, moderately concave, strongly apsacline to catacline, vertically grooved; hinge line entirely crenulate; fold and sulcus rounded, strongly developed, moderately wide, well defined by strong ventral bounding plicae and deep dorsal interspaces; lateral slopes with few low, rounded plicae separated by wide, rounded interspaces; microornament unknown; ventral interior with long, subparallel dental adminicula and long, high median septum; ctenophoridium supported by short, thin median septum; jugum complete. *Upper Triassic (Carnian):* Arctic Canada.——FIG. 1261,*3a–g*. **C. canadensis* (LOGAN); *a–e,* holotype, ventral, dorsal, anterior, posterior, and lateral views, ×1; *f–g,* transverse sections, ×2 (Logan, 1967).

Orientospira DAGYS, 1965, p. 101 [**O. gregaria;* OD]. Medium size; moderately transverse to slightly elongate; outline subquadrate to subovate; subequally biconvex, ventral valve usually more convex than dorsal, both valves moderately inflated; hinge line slightly less than maximum width, cardinal extremities subangular; ventral umbonal region broad, beak incurved; ventral interarea low, apsacline, vertically grooved; hinge line almost entirely crenulate; fold and sulcus well defined, moderately wide, rounded; lateral slopes with few coarse plicae separated by narrow interspaces; microornament absent; both valves much thickened by callus posteriorly; ventral interior with converging dental adminicula fused to median septum near floor of valve, forming low spondylium; jugum sessile anteriorly, supported by elongate ridges and net. *Upper Triassic (Norian):* northeastern Siberia.——FIG. 1261,*4a–f*. **O. gregaria; a–c,* holotype, dorsal, ventral, and lateral views, ×1 (new); *d–f,* transverse sections, approximately ×1.5 (Dagys, 1965).

Psioidea HECTOR, 1879, p. 538 [*Spiriferina suessi* var. *australis* TRECHMANN, 1918, p. 225; SD THOMSON,

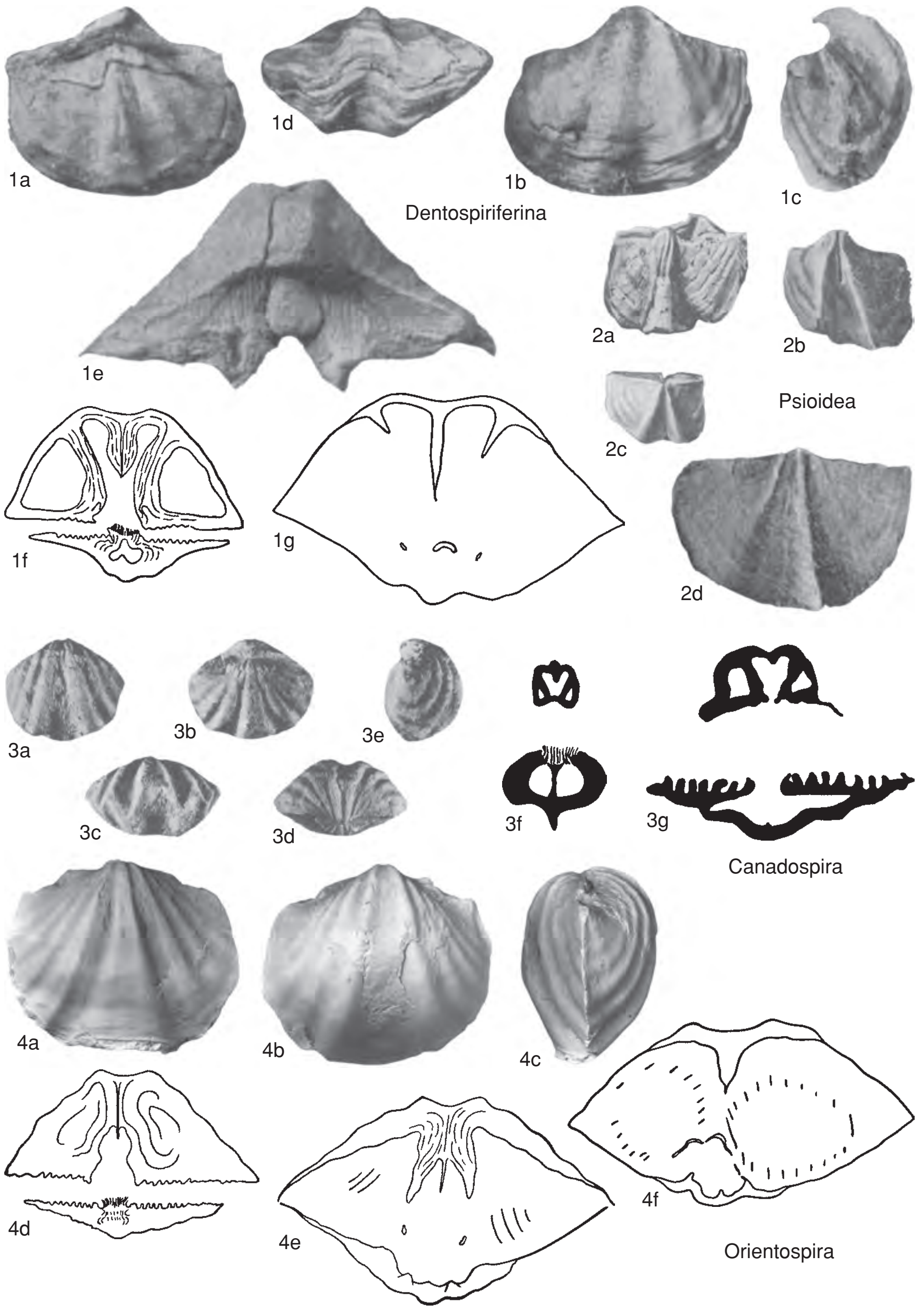

FIG. 1261. Rastelligeridae (p. 1895–1897).

1919, p. 413]. Medium size; nonalate; cardinal extremities angular, maximum width attained at or anterior to hinge line; ventral interarea bipartite with vertically grooved crenulate portions bordering delthyrium and smooth lateral portions; dorsal umbo overhanging hinge line; lateral slopes smooth; fold and sulcus narrow, rounded, sharply defined; microornament unknown; ventral interior with spondylium; jugum unknown. *Upper Triassic (Carnian):* New Zealand.——FIG. 1261,*2a–d.* **P. australis* (TRECHMANN); *a–b,* dorsal and ventral views of steinkern; *c,* cast of ventral valve, ×1 (Trechmann, 1918); *d,* mold of dorsal valve, ×1.5 (Marwick, 1953).

SPIRIFERINIDINA

J. L. CARTER

[retired from Carnegie Museum of Natural History]

Suborder SPIRIFERINIDINA Ivanova, 1972

[Spiriferinidina IVANOVA, 1972, p. 41] [=Spiriferinidina COOPER & GRANT, 1976b, p. 2,666]

Subequally biconvex; lateral slopes generally well ribbed, especially in early forms, ribbing weak or absent in youngest forms; ventral interarea high, planar in early forms, low, concave in later genera; ventral beak generally incurved; ventral adductor-raising structures simple, generally consisting only of delthyrial plate or median septum. *Upper Devonian (upper Famennian)–Lower Jurassic.*

Superfamily SYRINGOTHYRIDOIDEA Frederiks, 1926

[*nom. correct.* CARTER in CARTER & others, 1994, p. 365, *pro* Syringothyridacea IVANOVA, 1972, p. 40 [319], *nom. imperf., nom. transl. ex* Syringothyrinae FREDERIKS, 1926, p. 411]

Outline usually spiriferiform; moderately to strongly transverse; generally strongly ventribiconvex; fold and sulcus invariably developed; lateral slopes with simple ribbing; microornament of fine, short, radial striae with fine, elongate pustules or spinules arranged in quincunx between striae, producing textilelike appearance; dental adminicula present; ventral septum generally lacking; cardinalia usually stout and wide; punctae highly variable in size, commonly sparsely or irregularly distributed. *Upper Devonian (upper Famennian)–Permian.*

Family SYRINGOTHYRIDIDAE Frederiks, 1926

[*nom. correct.* PITRAT, 1965, p. 691, *pro* Syringothyridae IVANOVA, 1959, p. 55, *nom. imperf., nom. transl. ex* Syringothyrinae FREDERIKS, 1926, p. 411]

Cardinal extremities subangular to slightly rounded; lateral slopes with moderately numerous simple ribs; interspaces narrow and subangular to moderately broad; fold and sulcus smooth medially; ventral interarea high to very high; perideltidial areas present. *Upper Devonian (upper Famennian)–Permian.*

Subfamily SYRINGOTHYRIDINAE Frederiks, 1926

[*nom. correct.* PITRAT, 1965, p. 692, *pro* Syringothyrinae FREDERIKS, 1926, p. 411]

Delthyrial plate and syrinx present. *Upper Devonian (upper Famennian)–Carboniferous (Mississippian, ?Pennsylvanian).*

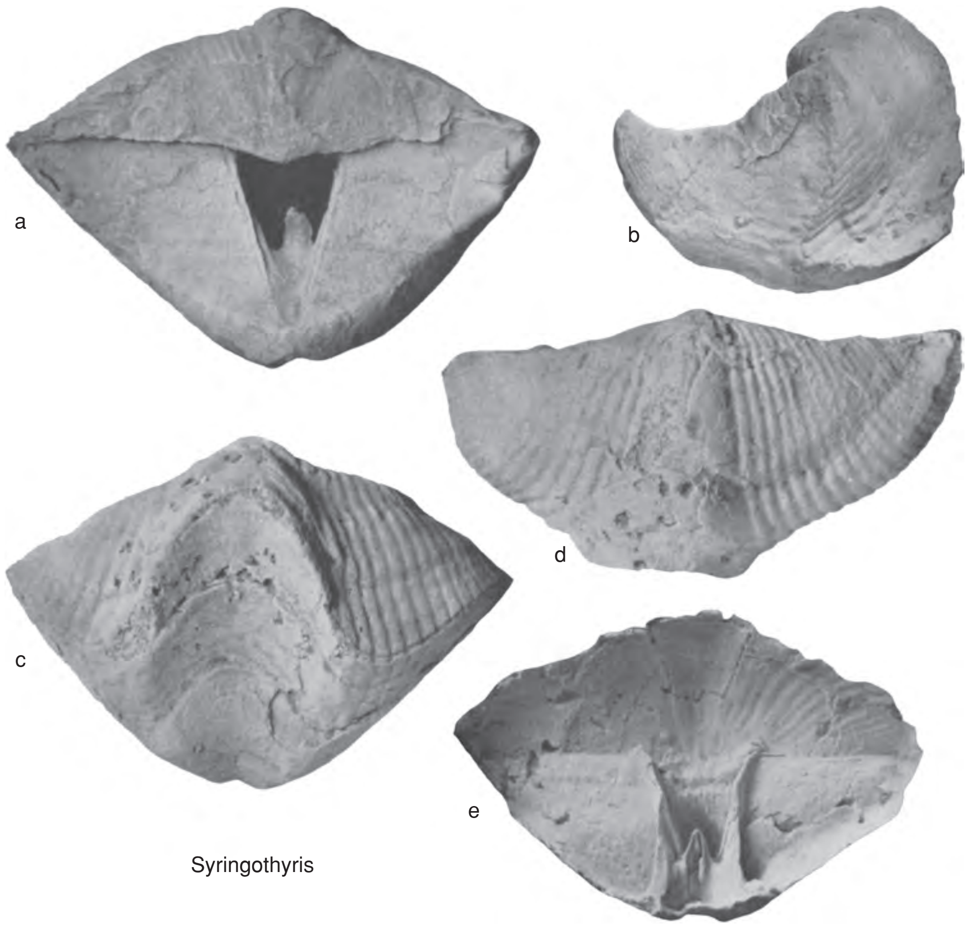

FIG. 1262. Syringothyrididae (p. 1898).

Syringothyris WINCHELL, 1863, p. 6 [**S. typa;* SD ICZN Opinion 100, 1928, p. 12; =*Spirifer carteri* HALL, 1857, p. 170] [=*Syringopleura* SCHUCHERT, 1910, p. 224 (type, *Spirifer randalli* SIMPSON, 1890, p. 441, OD); *Prosyringothyris* FREDERIKS, 1916, p. 51 (type, *P. northi,* OD); *Protosyringothyris* FREDERIKS, 1918a, p. 88, *nom. null.*]. Dental adminicula long, subparallel; pedicle valve often subconical or hemipyramidal with high, flattened interarea; beak straight or rarely slightly incurved; delthyrium largely covered by stegidial plates, forming tubular foramen in some species; perideltidial areas well developed. *Upper Devonian (upper Famennian)–Carboniferous (Mississippian):* cosmopolitan.——FIG. 1262*a–d.* **S. carteri* (HALL), upper Tournaisian, Iowa, USA; posterior, lateral, anterior, and dorsal views, ×1 (Weller, 1914).——FIG. 1262*e. S. bedfordensis* HYDE, upper Famennian, Ohio, USA; ventral interior, ×1 (Hyde, 1953).

Subfamily SEPTOSYRINGOTHYRIDINAE Termier & Termier, 1974

[*nom. transl.* CARTER in CARTER & others, 1994, p. 365, *ex* Septosyringothyrididae LEGRAND-BLAIN, 1974, p. 120, *nom. correct. pro* Septosyringothyridae TERMIER & TERMIER in MASSA, TERMIER, & TERMIER, 1974, p. 168]

Median septum and syrinx present in ventral valve. *Carboniferous (Mississippian).*

Septosyringothyris VANDERCAMMEN, 1955, p. 2 [**S. demaneti;* OD]. Syrinx suspended between delthyrial plate and floor of valve by bifid median septum; otherwise similar to *Syringothyris. Carboniferous (Mississippian):* Europe, South America.——FIG. 1263,*1a–d.* **S. demaneti,* Tournaisian, Belgium; *a–b,* holotype, ventral and posterior views, ×1; *c–d,* transverse sections of ventral valves, ×4.5 (Vandercammen, 1955).

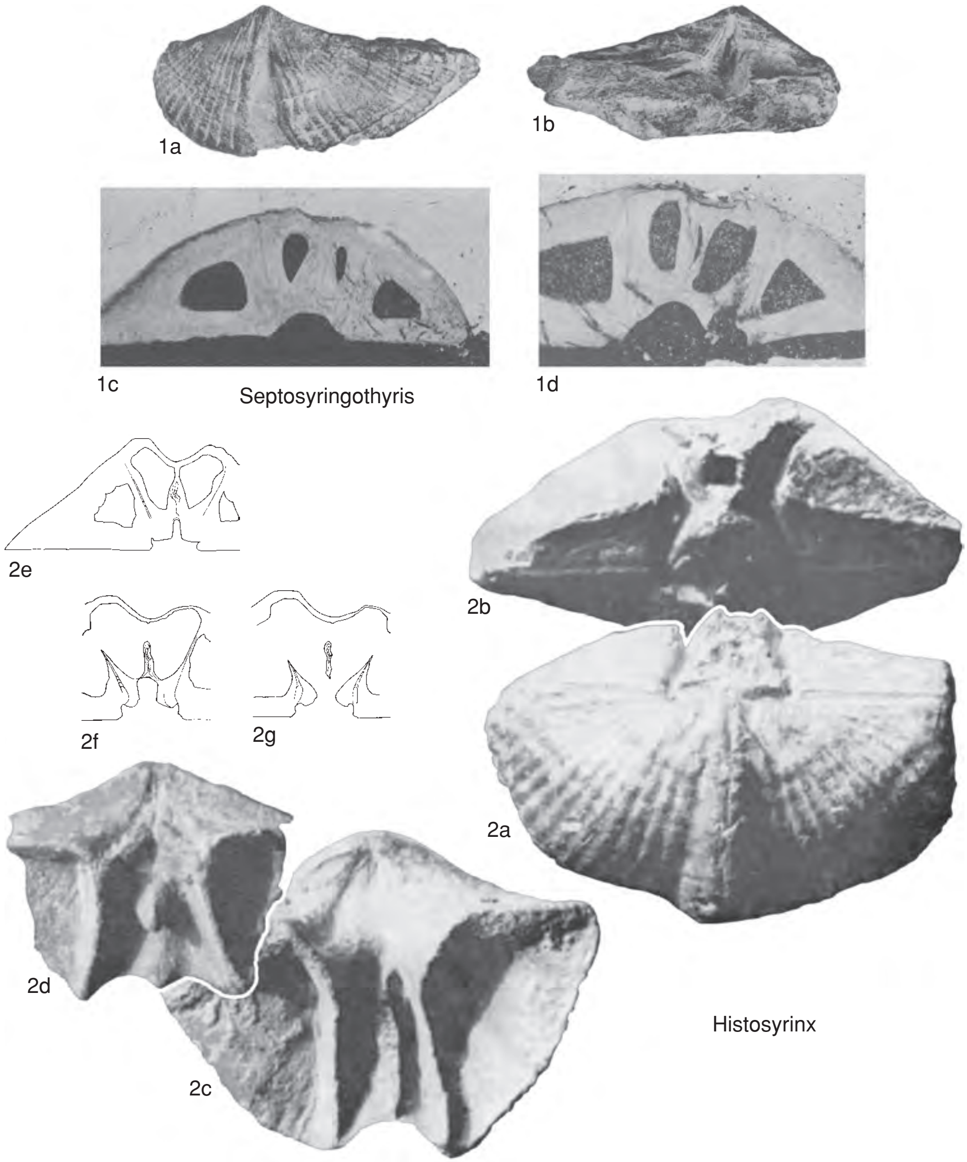

FIG. 1263. Syringothyrididae (p. 1898–1899).

Histosyrinx TERMIER & TERMIER in MASSA, TERMIER, & TERMIER, 1974, p. 168 [**H. vautrini;* OD]. Dental adminicula greatly thickened by callus deposits that converge to simulate delthyrial plate; syrinx supported by short, stout median septum; otherwise similar to *Septosyringothyris. Carboniferous (upper Tournaisian):* Libya.——FIG. 1263,*2a–g.* **H. vautrini; a–b,* syntype, dorsal and posterior views, ×1.33; *c,* ventral interior, ×1.2; *d,* ventral interior, ×1.36 (Massa, Termier, & Termier, 1974); *e–g,* transverse sections, ×1 (Legrand-Blain, 1974).

Subfamily PERMASYRINXINAE Waterhouse, 1986

[Permasyrinxinae WATERHOUSE, 1986b, p. 3]

Syrinx absent. *Carboniferous (lower Tournaisian)–Permian.*

Permasyrinx WATERHOUSE, 1983b, p. 155 [**Subansiria procera* ARMSTRONG, 1970a, p. 149; OD]. Moderately transverse with rounded cardinal extremities;

ventral interarea moderately high, concave, apsacline; beak incurved in some species; fold and sulcus smooth; flanks with moderately numerous plicae; dental adminicula short; delthyrial plate well developed; adductor field on floor of valve. *Carboniferous (Kasimovian)–Permian (upper Artinskian):* Australia.——FIG. 1264,*1a–d.* **P. procera* (ARMSTRONG), ?Aktastinian, Cisuralian, Queensland; holotype, ventral, dorsal, posterior, and anterior views, ×1 (Armstrong, 1970a).

Asyrinxia CAMPBELL, 1957, p. 80 [**Spirifera lata* M'COY, 1847, p. 233; OD]. Strongly transverse; moderately high ventral interarea with well-defined perideltidial areas; ventral interior with parallel dental adminicula; delthyrial plate absent. *Carboniferous (upper Tournaisian):* Australia (New South Wales).——FIG. 1265,*2a–c.* **A. lata* (M'COY); *a,* lectotype, ventral mold; *b,* ventral interarea, ×1; *c,* dorsal view, ×0.9 (Campbell, 1957).

Cyrtella FREDERIKS, 1924, p. 312 [**Cyrtia kulikiana* FREDERIKS, 1916, p. 43; OD] [=*Asyrinx* HUDSON & SUDBURY, 1959, p. 46 (type, *A. haushensis,* OD); *Punctocyrtella* PLODOWSKI, 1968, p. 252 (type, *P. spinosa,* OD); ?=*Kungaella* SOLOMINA, 1988, p. 44 (type, *Pseudosyringothyris inopinatus* SOLOMINA, 1970, p. 101, OD)]. Strongly transverse; ventral interarea moderately high, flattened; perideltidial areas well developed; flanks with moderately numerous ribs; delthyrial plate absent but simulated by thick callus; dental adminicula short, widely divergent; dorsal fold with distinctive median furrow. *Permian (Cisuralian):* Russia, Afghanistan.——FIG. 1266,*2a–e.* **C. kulikiana* (FREDERIKS), Russia; ventral, dorsal, anterior, posterior, and lateral views of large syntype, ×1 (new).

Myodelthyrium THOMAS, 1985, p. 164 [**Pseudosyringothyris dickensi* THOMAS, 1971, p. 140; OD]. Large; ventral interior with short, divergent dental adminicula and well-developed delthyrial plate; underside of delthyrial plate with pair of elongate oval muscle scars separated by median longitudinal ridge; substantial apical callosity present; dorsal cardinalia massive; otherwise similar to *Pseudosyrinx. Permian (Sakmarian–Artinskian):* Western Australia.——FIG. 1265,*1a–e.* **M. dickensi* (THOMAS); *a–c,* holotype, anterior, dorsal, and posterior views, ×1; *d,* dorsal interior, ×1.5; *e,* posterior view showing perideltidial areas, ×1 (Thomas, 1971).

Primorewia LIKHAREV & KOTLJAR, 1978, p. 71 [**P. reshetnikov;* OD]. Large, very transverse, moderately biconvex; cardinal extremities alate; umbonal region narrow, short; ventral interarea moderately high, weakly concave; delthyrium wide; lateral slopes with few wide, simple, rounded plicae; sulcus smooth, fold with distinct median furrow; ventral interior with moderate apical callus, moderately long, diverging dental adminicula, delthyrial plate and short, stout median ridge in apical portion of ventral muscle field; otherwise similar to *Cyrtella. Permian (Kungurian–Roadian):* northeastern Siberia.——FIG. 1264,*2a–e.* **P. reshetnikov; a–d,* holotype, ventral, dorsal, anterior, and posterior views; *e,* natural mold of ventral interior, ×1 (new).

Pseudosyringothyris FREDERIKS, 1916, p. 51 [**P. karpinskii;* OD]. Delthyrial plate with median longitudinal thickening; otherwise similar to *Cyrtella.* [GRIGOR'EVA (1977) states that the validity of *P. karpinskii,* and hence of this genus, is in doubt because intensive collecting for topotypes has failed to produce specimens internally similar to FREDERIKS's description of the type.] *Permian (Cisuralian):* Russia.——FIG. 1266,*1a–b.* **P. karpinskii; a,* ventral interarea, ×0.7; *b,* transverse section of ventral valve, ×2 (Frederiks, 1916).

Pseudosyrinx WELLER, 1914, p. 404 [**P. missouriensis;* OD]. Medium to large; externally similar to *Syringothyris;* ventral interarea high, flattened, usually procline, more rarely catacline to slightly apsacline; delthyrial plate large, slightly below plane of interarea, syrinx absent; position of adductor attachment unknown. *Carboniferous (upper Tournaisian–lower Visean):* cosmopolitan.——FIG. 1267,*1a–e.* **P. missouriensis,* upper Tournaisian, Missouri, USA; holotype, anterior, posterior, lateral, ventral, and dorsal views, ×1 (Weller, 1914).

Subansiria SAHNI & SRIVASTAVA, 1956, p. 212 [**S. ranganensis;* OD]. Valves subequally biconvex with low, strongly concave, apsacline ventral interarea; syrinx lacking; delthyrial plate near inner valve surface; otherwise similar to *Cyrtella. Carboniferous (?Pennsylvanian):* India.——FIG. 1267,*3a–b.* **S. ranganensis;* holotype, dorsal and ventral views, ×1 (Sahni & Srivastava, 1956).

Sulcicosta WATERHOUSE, 1983b, p. 156 [**Pseudosyrinx plicata* ARMSTRONG, 1970a, p. 142; OD]. Medium size; outline variable from transverse to elongate; ventribiconvex; ventral interarea moderately high, apsacline; broad, shallow sulcus moderately well defined; narrow fold well defined; fold and sulcus bearing several low but distinct ribs on sides; fold with median furrow; lateral slopes with few strong, simple ribs; interspaces narrow; ventral interior with short delthyrial plate that bears lateral ridges along sides of dental adminicula; dental adminicula high, very thin, moderately long, divergent; callus deposits absent; dorsal valve with low median ridge; otherwise similar to *Cyrtella. Permian:* eastern Australia.——FIG. 1267,*2a–d.* **S. plicata* (ARMSTRONG); holotype, dorsal, ventral, posterior, and anterior views, ×1 (Armstrong, 1970a).

Verkhotomia SOKOLSKAYA, 1963, p. 280 [**V. plenoides;* OD]. Medium to large, strongly inflated, subequally biconvex; ventral interarea moderately low, moderately concave, apsacline; lateral slopes with few to moderately numerous simple ribs with

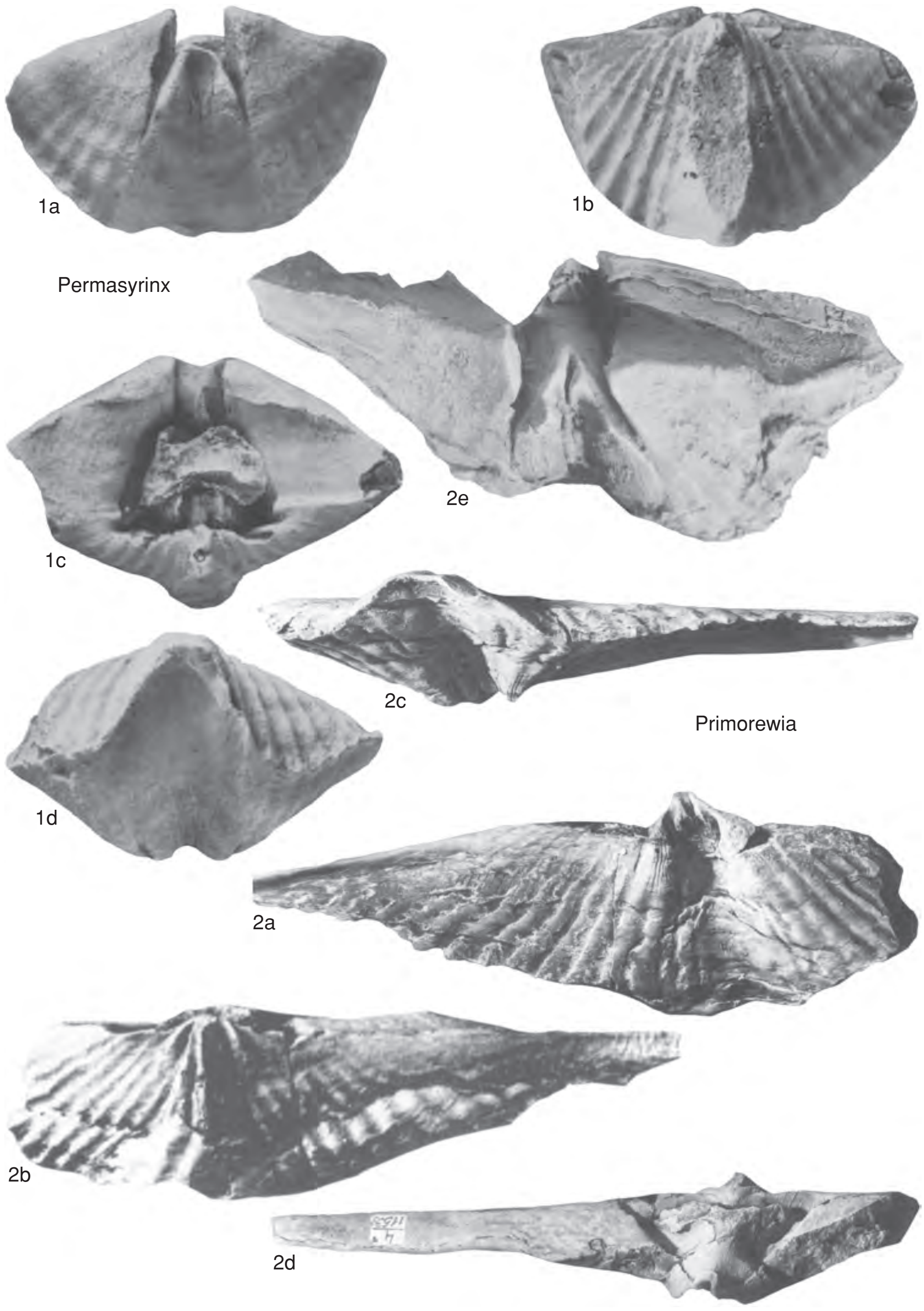

FIG. 1264. Syringothyrididae (p. 1899–1900).

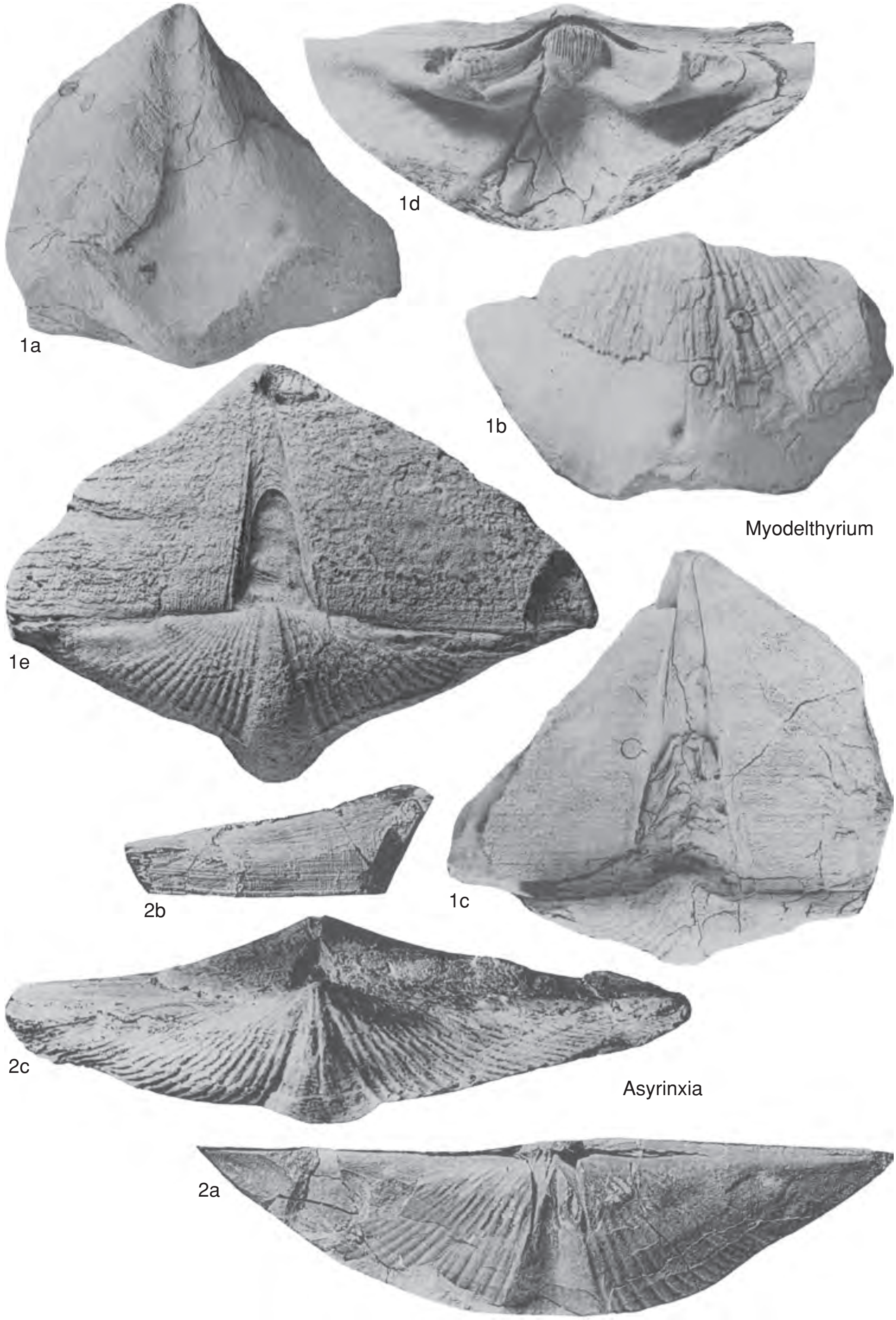

FIG. 1265. Syringothyrididae (p. 1900).

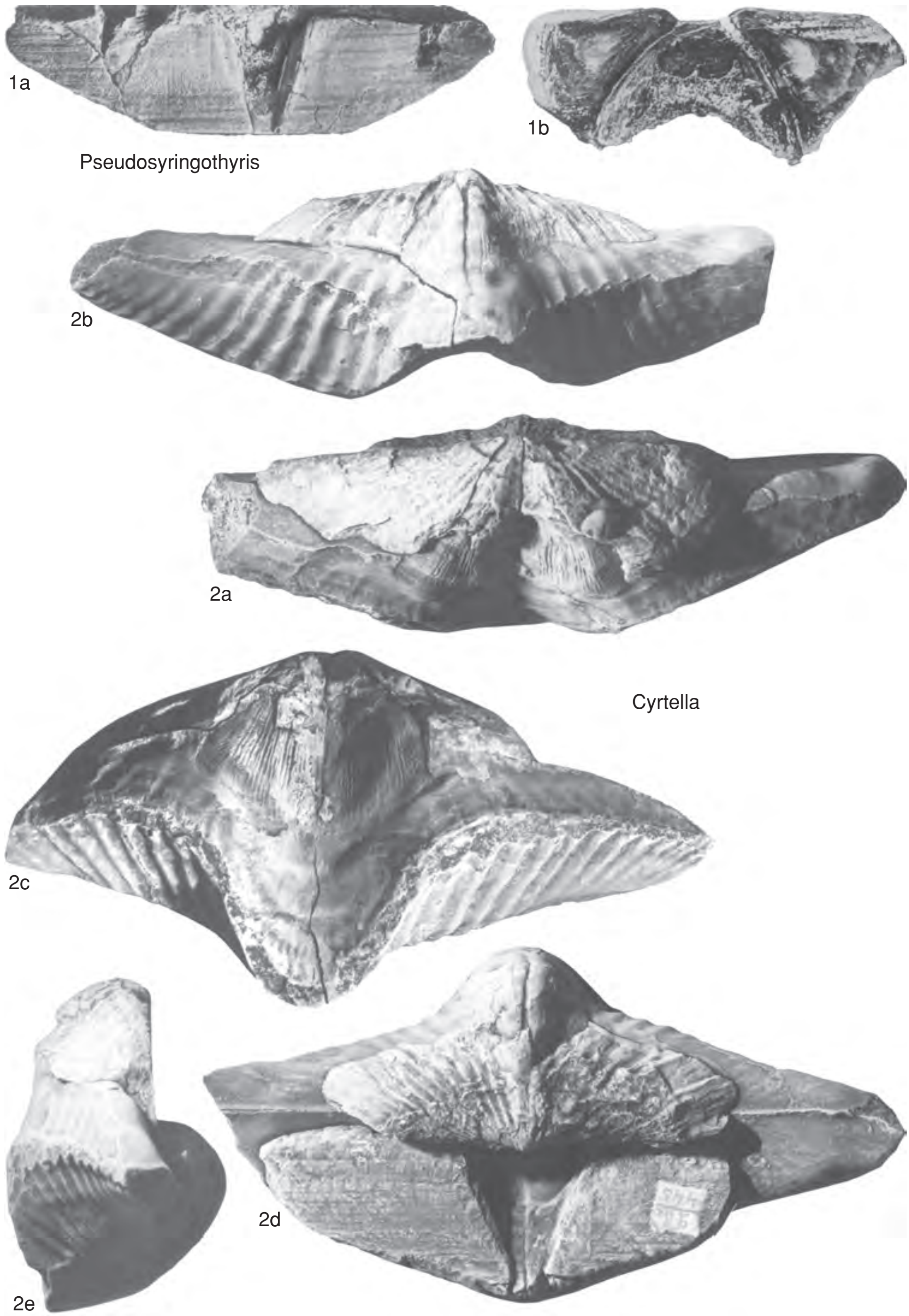

FIG. 1266. Syringothyrididae (p. 1900).

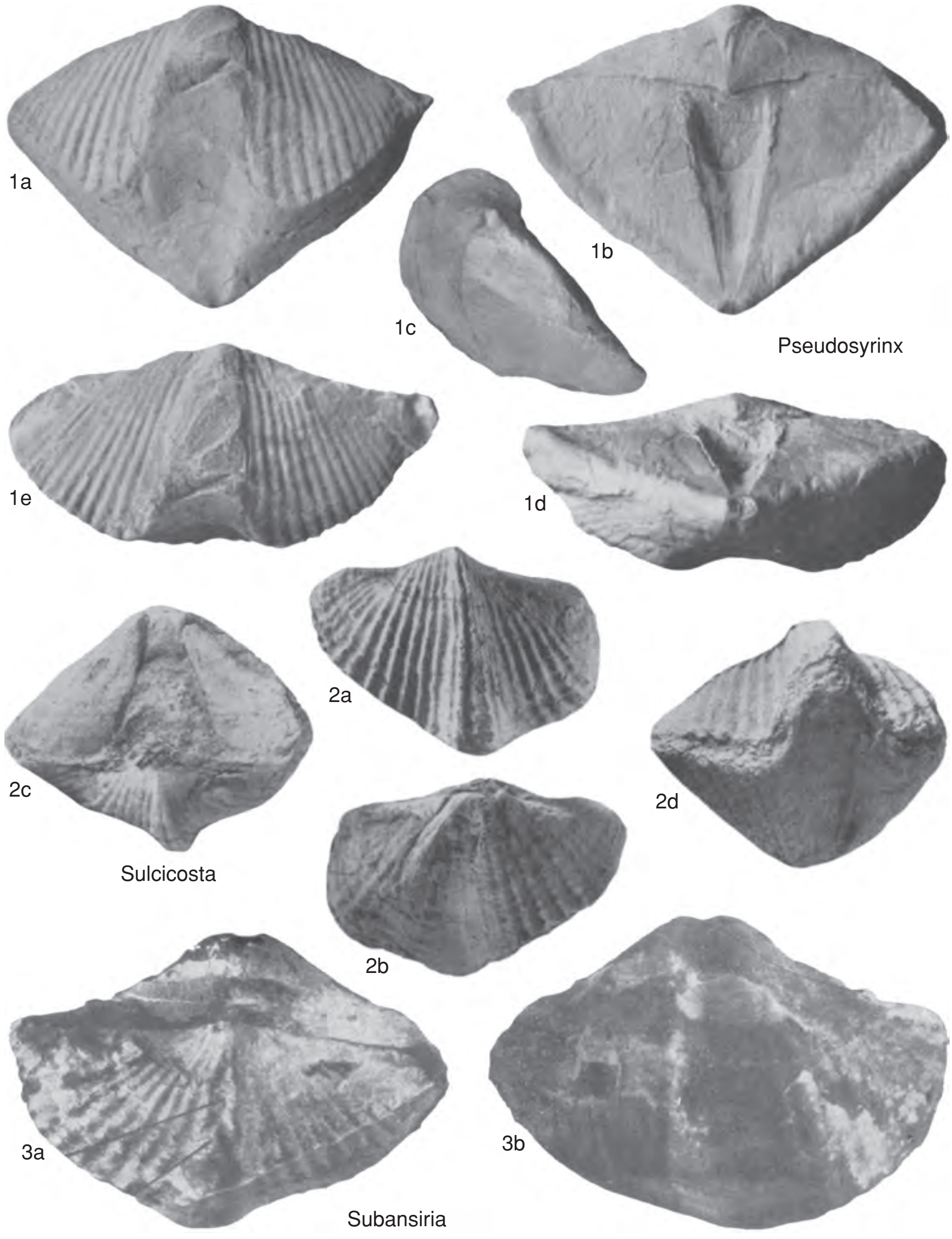

FIG. 1267. Syringothyrididae (p. 1900).

narrow interspaces; sulcus commonly with few weak ribs on sides; fold smooth or weakly ribbed; dental adminicula long, thick; delthyrial plate moderately long; adductor scars on floor of valve; cardinal process supported by long, low median ridge or septum. *Carboniferous (lower Tournaisian–Visean):* Russia, North America.——FIG. 1268*a–d*. **V. plenoides,* Visean, Kuznets basin, Siberia; *a–c,* ventral, dorsal, and lateral views, ×1 (new); *d,* ventral interior, ×1 (Sokolskaya, 1963).

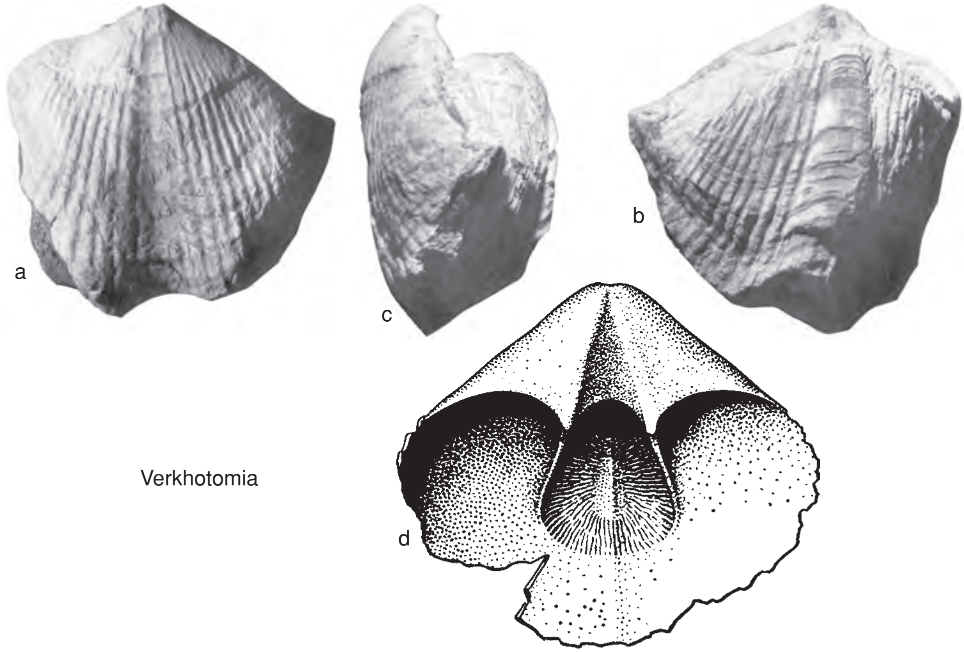

FIG. 1268. Syringothyrididae (p. 1900–1904).

Family DIMEGELASMIDAE Carter, 1994

[Dimegelasmidae CARTER in CARTER & others, 1994, p. 366]

Cardinal extremities well rounded; ventral interarea low to moderately high; lateral slopes with few plications separated by broad, rounded interspaces; sulcus sparsely plicate or costate; perideltidial areas present; syrinx absent; delthyrial plate small or absent; shell substance thin. *Upper Devonian (upper Famennian)–Carboniferous (Visean).*

Dimegelasma COOPER, 1942, p. 232 [**Spirifer neglectus* HALL, 1858, p. 643; OD] [?=*Doescherella* ABRAMOV & GRIGOR'EVA, 1987, p. 121, *nom. nov. pro Crassispirifer* ABRAMOV & GRIGOR'EVA, 1986, p. 162, *non* ARCHBOLD & THOMAS, 1985 (type, *C. grandicostatus,* OD)]. Medium to large, strongly biconvex, subovate in outline; hinge line much less than maximum width; beak ridges absent; ventral interarea moderately high, concave, apsacline, consisting essentially of narrow perideltium and laterally rounded, poorly defined, false interareas; fold and sulcus moderately well developed; sulcus with broad median plica and often with pair of weaker lateral plicae; fold usually well rounded; lateral slopes with few broad plicae; delthyrial plate short, thin; dental adminicula very long, slender, slightly diverging; cardinalia wide, elevated, supported by low, stout median septum. *Carboniferous (Visean):* North America, northeastern Siberia.——FIG. 1269,*1a–f.* **D. neglecta* (HALL), Iowa, USA; *a–d,* ventral, lateral, dorsal, and anterior views, ×1 (Weller, 1914); *e–f,* ventral and dorsal interiors, ×0.7 (Cooper, 1944).——FIG. 1269,*1g. D. grandicostatus* (ABRAMOV & GRIGOR'EVA); holotype, ventral valve, ×1 (new).

Guilinospirifer XU & YAO, 1988, p. 306 [**G. obscurus;* OD]. Small, subequally biconvex, outline transversely subovate, lateral extremities well rounded; fold and sulcus poorly developed; flanks with 3 to 5 simple, flattened plications, with sulcus-bounding plications notably stronger than other lateral ribs; sulcus simple or with very broad median and 2 narrower, lateral sulcal plications; delthyrial plate absent; dental adminicula long. *Upper Devonian (upper Famennian)–Carboniferous (lower Tournaisian):* China (Guilin Province).——FIG. 1269,*3a–c.* **G. obscurus; a,* holotype, dorsal valve interior; *b–c,* two dorsal valve exteriors, ×1 (new).——FIG. 1269,*3d. G. peregrinus* XU & YAO; ventral valve, ×1.5 (Xu & Yao, 1988).

Zeugopleura CARTER, 1988, p. 71 [**Spirifer jeffersonensis* WELLER, 1906, p. 444; OD]. Small to medium size, with pair of simple costae in sulcus that rarely bifurcate; lateral extremities rounded; ventral interarea moderately high, concave, procline; perideltidial areas large; lateral slopes with

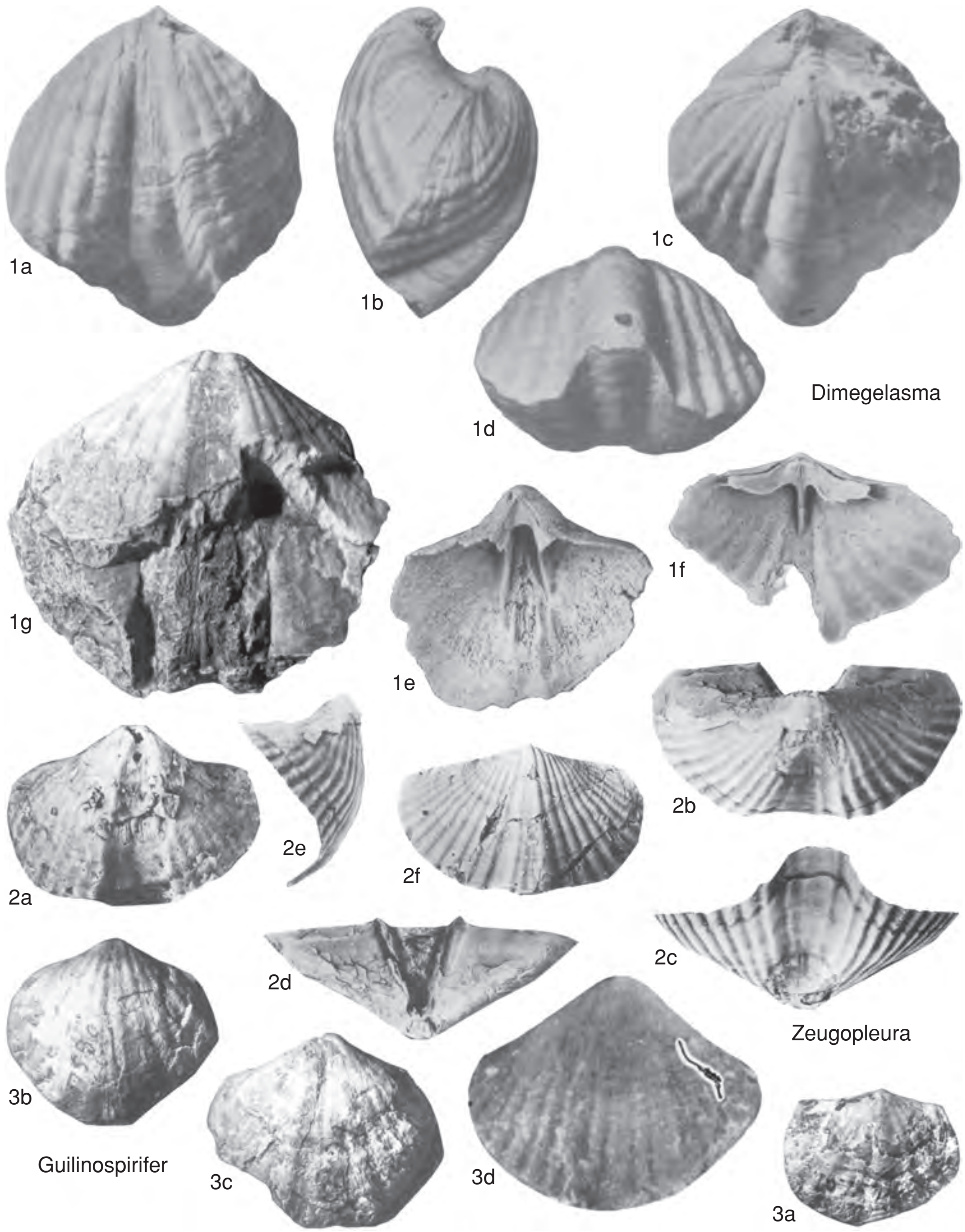

FIG. 1269. Dimegelasmidae (p. 1905–1906).

moderately numerous flattened plicae; ventral interior with very small, apical delthyrial plate and slender, moderately long dental adminicula. *Carboniferous (lower Tournaisian):* North America.——FIG. 1269,*2a–f.* **Z. jeffersonensis* (WELLER); *a,* lectotype, ventral valve; *b–e,* ventral, anterior, posterior, and lateral views of large ventral valve; *f,* dorsal valve, ×1.5 (new).

Family LICHAREWIIDAE Sliusareva, 1958

[*nom. transl.* SOLOMINA, 1988, p. 44, *ex* Licharewiinae SLIUSAREVA, 1958, p. 582]

Perideltidial areas absent; syrinx absent; moderate to thick callus deposits in ventral

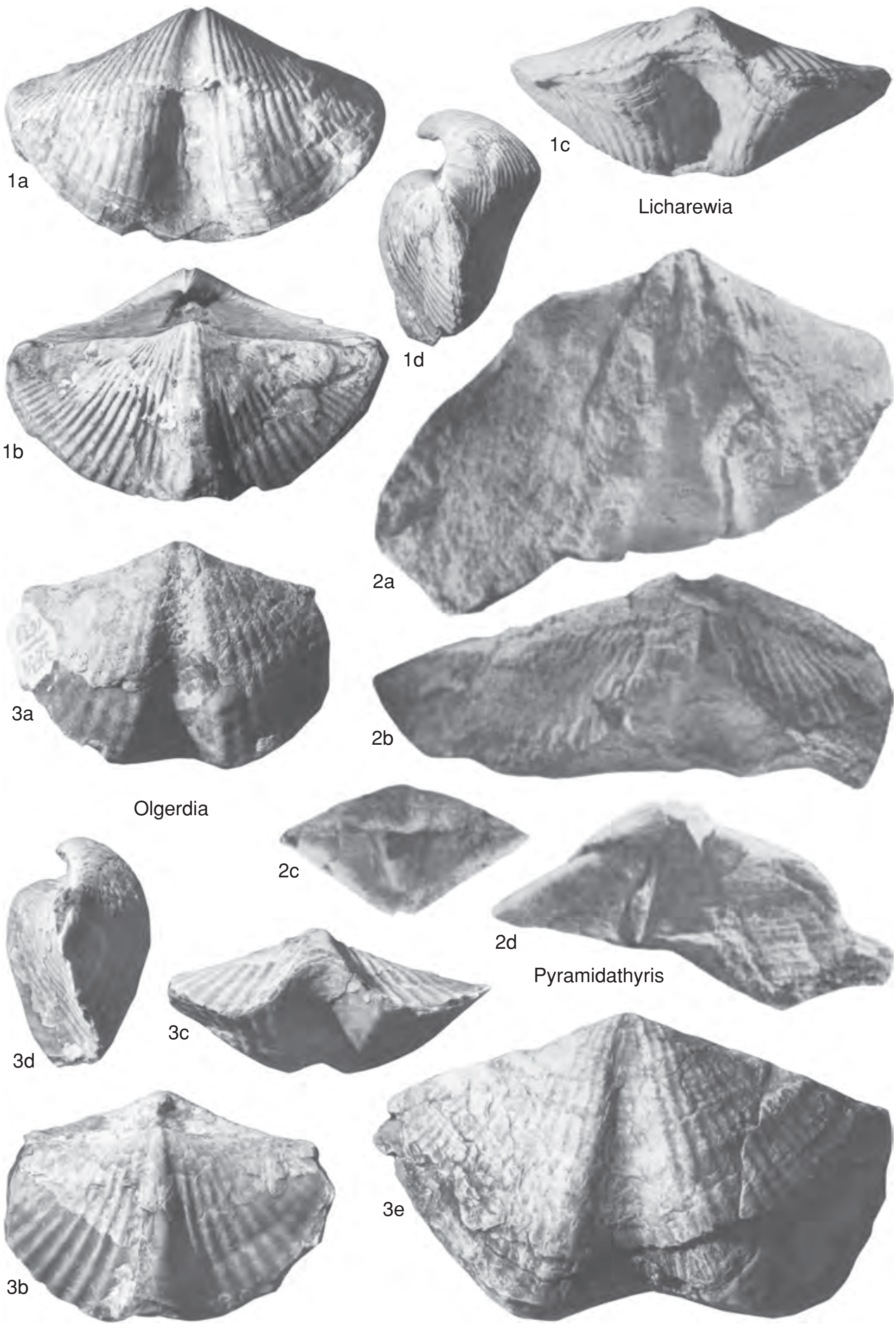

FIG. 1270. Licharewiidae (p. 1908).

umbonal region commonly present. *Carboniferous (Pennsylvanian)–Permian (Lopingian).*

Licharewia EINOR, 1939, p. 69 [**Spirifer stuckenbergi* NECHAEV, 1900, p. 18; OD] [=*Rugulatia* SOKOLSKAYA, 1952, p. 187 (type, *Spirifer rugulatus* KUTORGA, 1842, p. 22, OD)]. Medium size; usually transverse with greatest width at or near hinge line; umbonal region moderately inflated and defined; cardinal extremities subangular to rounded; ventral beak moderately incurved; ventral interarea low to moderately high, concave, apsacline to orthocline; floor of sulcus smooth, sides of sulcus sometimes with weak ribs; fold smooth; flanks with moderately numerous rounded, simple, or very rarely bifurcating costae; microornament of short, weak striae crudely arranged in quincunx; dental adminicula stout, curved, diverging, much thickened by layered callus deposits, simulating delthyrial plate; sparsely punctate. *Permian (Lopingian):* Russia.——FIG. 1270,*1a–d*. **L. stuckenbergi* (NECHAEV); holotype, ventral, dorsal, anterior, and lateral views, ×1 (new).

Olgerdia GRIGOR'EVA, 1977, p. 50 [**O. zavodowskii;* OD]. Outline transversely oval or rounded to widely triangular; width usually exceeding length; subequally biconvex; ventral interarea nearly orthocline, flattened to evenly concave; fold and sulcus distinct, smooth; lateral slopes with moderately numerous simple ribs; ventral interior with curved dental adminicula, obscurely seen in transverse section, buried in very thick, seemingly nonlayered callus in adults; dental flanges medially arcuate in transverse section; thick, archlike callus simulates delthyrial plate in adults; otherwise similar to *Licharewia. Permian (Lopingian):* northeastern Russia.——FIG. 1270,*3a–e*. **O. zavodowskii;* paratype, ventral, dorsal, anterior, and lateral views, large ventral valve, ×1 (new).

Orulgania SOLOMINA & CHERNIAK, 1961, p. 61 [**O. naumovi;* OD]. Medium size; outline variable, usually transverse; umbonal region broad, poorly delineated, beak slightly incurved; sulcus smooth to weakly ribbed; fold usually with median furrow; lateral slopes with moderately numerous flattened, simple ribs; ventral interarea moderately high, flattened to moderately concave, apsacline; ventral interior with very long, straight, evenly thickened dental adminicula; delthyrial plate recessed well below plane of ventral interarea; umbonal callus moderate. *Carboniferous (Pennsylvanian):* Russia. ——FIG. 1271,*1*. **O. naumovi;* holotype, ventral view, ×1 (new).

Penzhinella SOLOMINA, 1985, p. 119 [**Licharewia micluchomaclayi* ZAVODOVSKII in ZAVODOVSKII & STEPANOV, 1971, p. 136; OD]. Medium size; transversely subovate to subpentagonal; subequally biconvex; umbonal region of both valves narrow and extended with moderately incurved beaks; ventral interarea moderately high, flattened or concave, delthyrium occluded in umbonal region by true delthyrial plate; fold and sulcus well delineated; fold smooth, sulcus smooth or with weak ribs on sides of sulcus; flanks with few coarse, simple ribs; ventral interior with short, arcuately curved dental adminicula thickened by callus; muscle field poorly distinguished, with oval diductors and short narrow adductors separated by myophragm; dorsal interior unknown. *Permian (Lopingian):* northeastern Russia.——FIG. 1271,*2a–d*. **P. micluchomaclayi* (ZAVODOVSKII), Siberia; ventral, dorsal, lateral, and posterior views, ×1 (Solomina, 1985).

Permospirifer KULIKOV, 1950, p. 5 [**Spirifer keyserlingi* NECHAEV, 1911, p. 84; OD]. Medium size; ventral umbo reduced, poorly defined; beak tiny, scarcely incurved; ventral interarea moderately high, flattened or weakly concave, strongly apsacline to orthocline; microornament pustulose; otherwise similar to *Licharewia. Permian (Lopingian):* Russia.——FIG. 1271,*4a–d*. **P. keyserlingi* (NECHAEV); *a–b,* syntype, exterior and interior views of large ventral valve; *c–d,* dorsal and lateral views of crushed specimen, ×1 (new).

Pyramidathyris HU, 1983, p. 106 [**P. aliensis;* OD]. Small to medium size; outline semipyramidal; presence or absence of perideltidial areas unknown; delthyrium narrow; externally similar to small *Syringothyris;* microornament of concentrically arranged, fine pustules; lacking delthyrial plate, syrinx, or median ridge; dental adminicula long, thin, subparallel. *Permian (Cisuralian):* China.——FIG. 1270,*2a–d*. **P. aliensis;* ventral, dorsal, and posterior views, ×1 (Hu, 1983).

Tumarinia SOLOMINA & GRIGOR'YEVA in GRIGOR'EVA & SOLOMINA, 1973, p. 35 [**T. orientalis* GRIGOR'EVA in GRIGOR'EVA & SOLOMINA, 1973, p. 36; OD]. Medium to large; transversely subpentagonal in outline; both valves moderately inflated; ventral umbonal region rounded, beak incurved; ventral interarea high, concave, apsacline, or nearly catacline; fold and sulcus well defined, smooth or with faint costae on sides; lateral slopes with few simple, flattened ribs; dental adminicula long, straight, divergent; delthyrial plate slightly below plane of interarea; delthyrium covered by slightly concave, rugose stegidium that may be in contact with delthyrial plate; presence or absence of perideltidial areas not determined; otherwise similar to *Licharewia. Permian (Lopingian):* Russia.——FIG. 1271,*3a–d*. **T. orientalis* GRIGOR'EVA; *a–c,* holotype, ventral, posterior, and lateral views; *d,* posterior view of ventral valve, ×1 (new).

Tuotalania HU, 1983, p. 105 [**T. rostrata;* OD]. Medium to large; moderately transverse; delthyrium very wide; otherwise externally similar to *Syringothyris;* ventral interior with long, low median ridge; delthyrial plate lacking; presence or absence of perideltidial areas unknown. *Permian (Cisuralian):* China.——FIG. 1271,*5a–c*. **T. rostrata; a–b,* dorsal and posterior views, ×1; *c,* transverse section, ×2 (Hu, 1983).

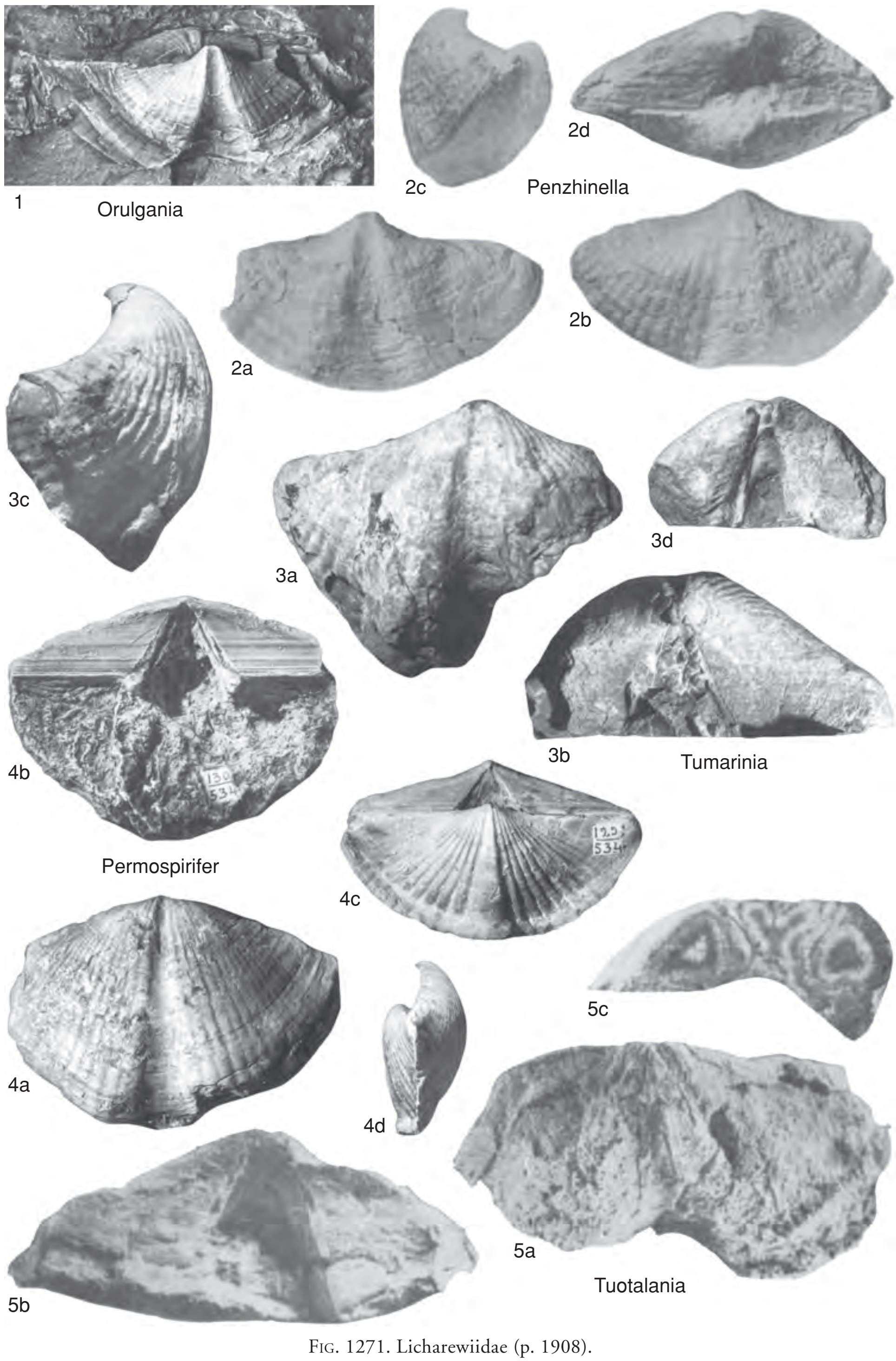

FIG. 1271. Licharewiidae (p. 1908).

PENNOSPIRIFERINOIDEA

J. L. CARTER

[retired from Carnegie Museum of Natural History]

Superfamily PENNOSPIRIFERINOIDEA Dagys, 1972

[*nom. transl.* CARTER in CARTER & others, 1994, p. 366, *ex* Pennospiriferininae DAGYS, 1972a, p. 36]

Spiriferiform to cyrtiniform; ventral interarea usually low or only moderately high; lateral slopes ribbed; dental adminicula and median septum discrete; punctae well developed, usually densely spaced. *Upper Devonian (upper Famennian)–Lower Jurassic.*

Family PUNCTOSPIRIFERIDAE Waterhouse, 1975

[*nom correct.* CARTER in CARTER & others, 1994, p. 366, *pro* Punctospiriferinidae WATERHOUSE, 1987, p. 44, *nom. transl. ex* Punctospiriferinae WATERHOUSE, 1975, p. 17]

Usually transverse; fold and sulcus narrow, weakly to moderately developed; dental adminicula short, subparallel to slightly divergent; microornament capillate and usually regularly lamellose or subimbricate. *Upper Devonian (upper Famennian)–Middle Triassic.*

Punctospirifer NORTH, 1920, p. 212 [**P. scabricosta;* OD]. Small to medium size; outline variable, usually transverse; cardinal extremities subangular, rounded, or rarely slightly mucronate; fold and sulcus narrow to moderately wide, rounded, smooth or with single rib, often slightly flaring anteriorly; ventral interarea moderately high, weakly concave, usually apsacline; lateral slopes with moderately numerous strong, rounded plicae separated by narrow, subangular interspaces; growth varices irregularly spaced; microornament of closely spaced, imbricate growth laminae and fine, discontinuous capillae that rise and become wider with imbrications anteriorly as tiny U-shaped crenulations of lamellae in some species and sometimes terminating in minute, semierect pseudospines; dental adminicula short, slightly divergent; median septum long, high, slender; apical callus variably thick; ctenophoridium large, supported by short callus; dorsal adminicula absent or very short; adductors separated by long myophragm and bounded laterally in some species by low ridges; punctae moderately coarse; jugum probably absent. *Upper Devonian (?upper Famennian), Carboniferous (Tournaisian–Visean):* cosmopolitan.——FIG. 1272,*1a–i.* **P. scabricosta,* Visean, England; *a–e,* ventral, dorsal, posterior, anterior, and lateral views, ×2; *f–i,* transverse sections, ×1.5 (Campbell, 1959b).

Alipunctifera WATERHOUSE, 1975, p. 17 [**Spiriferina kaihikuana* TRECHMANN, 1918, p. 220; OD]. Medium to large; unequally biconvex, moderately inflated; transversely semicircular in outline; cardinal extremities extended, moderately mucronate; ventral interarea moderately high, apsacline, slightly concave, transversely striated, nondenticulate; beak incurved; delthyrium open; fold and sulcus moderately narrow, well defined, smooth; lateral slopes with several low, rounded, broad plicae that become much fainter laterally; microornament possibly weakly capillate; dental adminicula and high median septum discrete; posteriorly much thickened with callus; jugum unknown. *Middle Triassic (Ladinian):* New Zealand.——FIG. 1272,*2a–c.* **A. kaihikuana* (TRECHMANN); *a,* holotype, dorsal valve, ×1 (Trechmann, 1918); *b–c,* dorsal exterior and ventral interior, ×1 (Marwick, 1953).

Lamnaespina WATERHOUSE, 1976, p. 244 [**L. transennata;* OD]. Medium size, moderately inflated; transverse with rounded cardinal extremities; fold and sulcus poorly differentiated; lateral slopes with few low, rounded, undulating plicae; growth varices coarse, irregularly spaced; microornament of regularly spaced, slightly lamellose growth laminae, capillae, and very fine pustules; punctae fine, closely spaced; ventral interior with high dental adminicula and moderately long median septum. *Permian (Wordian):* New Zealand.——FIG. 1273,*2a–c.* **L. transennata; a–b,* holotype, internal and external views of mold of dorsal valve, ×3; *c,* microornament, ×15 (Waterhouse, 1976).

Liriplica CAMPBELL, 1961a, p. 440 [**L. alta;* OD]. Medium size; strongly biconvex; ventral umbo strongly inflated, beak incurved; outline subovate, cardinal extremities well rounded; fold and sulcus weakly to moderately developed, sulcus with median plica, fold with median furrow; lateral slopes with few broad, rounded plicae, separated by somewhat narrower interspaces; microornament of fine, regular growth laminae and discontinuous capillae; ventral interior with thick apical callus, short dental adminicula buried in callus and long median septum; jugum unknown; punctae irregularly arranged. *Carboniferous (?Pennsylvanian):* Australia.——FIG. 1273,*1a–c.* **L. alta; a–b,* ventral and dorsal valves, ×1; *c,* microornament, ×10 (Campbell, 1961a).

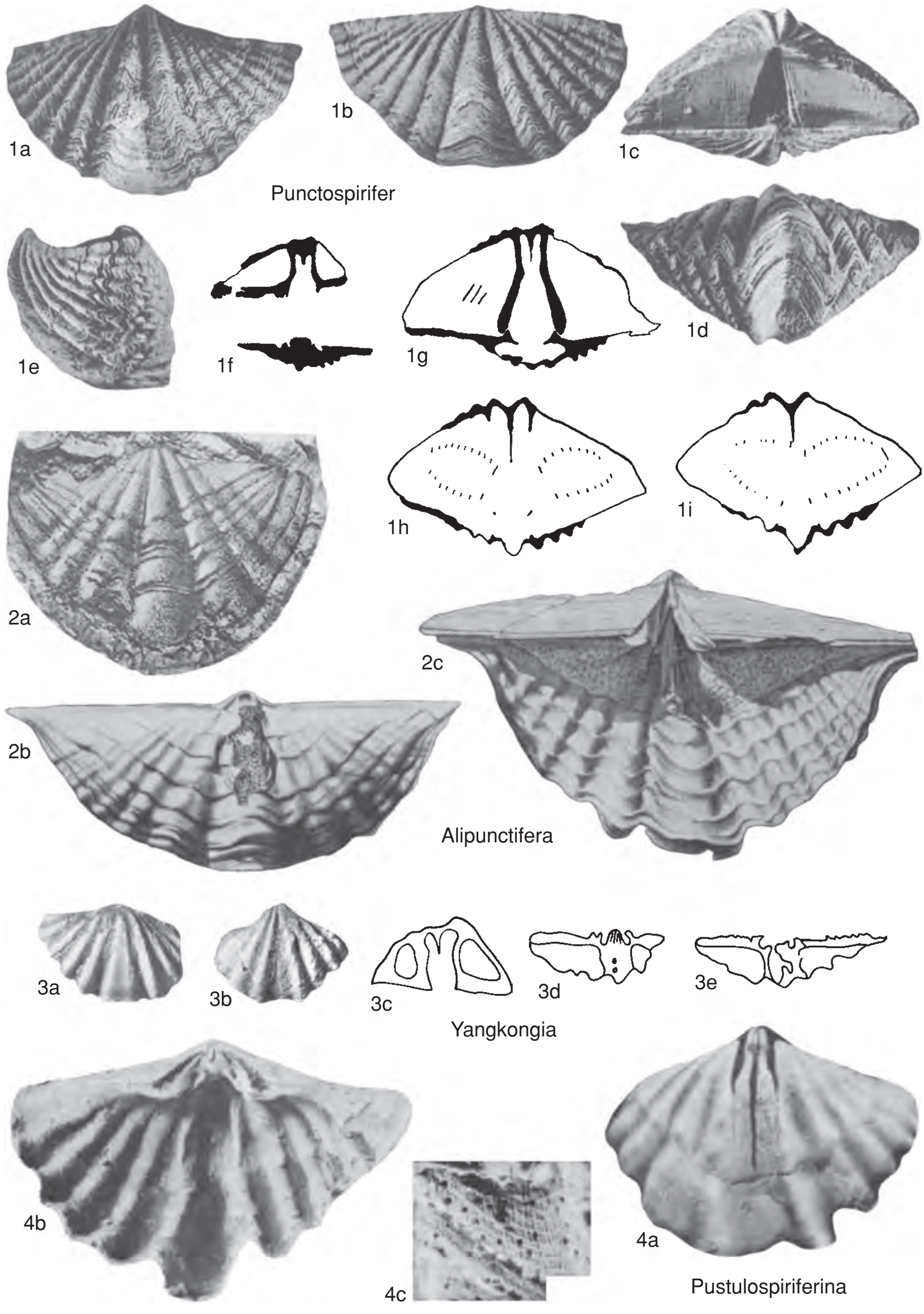

FIG. 1272. Punctospiriferidae (p. 1910–1913).

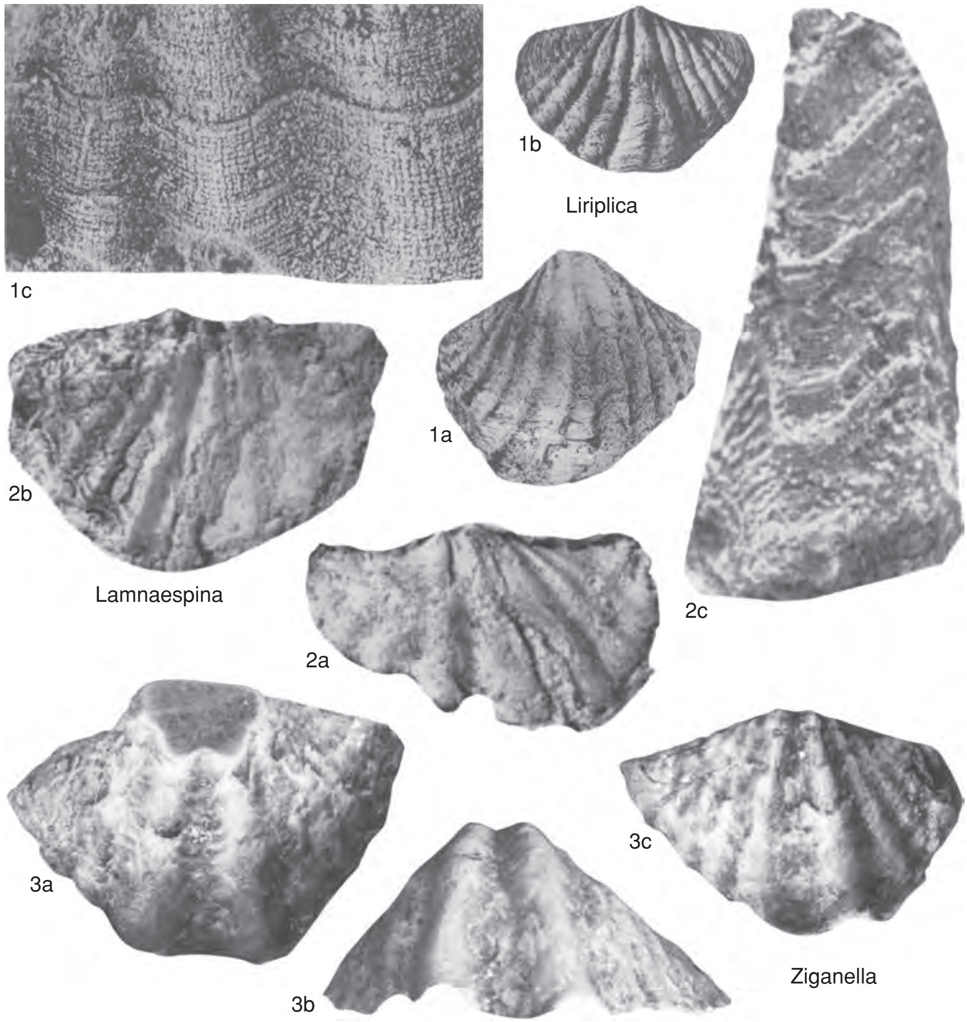

FIG. 1273. Punctospiriferidae (p. 1910–1913).

Pustulospiriferina WATERHOUSE in WATERHOUSE, CAMPBELL, & WILLIAMS, 1983, p. 303 [**Punctospirifer etheridgei* ARMSTRONG, 1970c, p. 317; OD]. Medium size; subequally biconvex; transversely subtrigonal to subquadrate in outline; cardinal extremities subangular to rounded; maximum width anterior to hinge line; fold and sulcus narrow, well developed and defined, smoothly rounded; ventral interarea high, apsacline; lateral slopes with 4 to 6 subangular plicae; microornament of capillae and fine growth lines; ventral interior with long, high median septum and shorter subparallel dental adminicula; jugum unknown. *Permian (Artinskian):* Australia.——FIG. 1272,*4a–c*. **P. etheridgei* (ARMSTRONG); *a,* holotype, mold of ventral interior; *b,* dorsal interior, ×1.8; *c,* cast of microornament, ×9 (Armstrong, 1970c).

Yangkongia XU & LIU, 1983b, p. 115 [**Y. planofolda;* OD]. Medium size; transversely subsemicircular to subtrigonal in outline; cardinal extremities subangular to slightly rounded; subequally biconvex, both valves moderately inflated; ventral beak acute, incurved; ventral interarea high, delthyrium open; hinge line less than or equal to maximum width; fold narrow, low, flattened or with weak median sinus, delineated mainly by wide interspaces; sulcus shallow, with flattened bottom, or rarely with weak rib; lateral slopes with few strong, rounded to subangular costae, separated by narrow angular interspaces; microornament faintly capillate; dorsal interior with cardinalia supported by short median callus and short dorsal adminicula; jugum unknown. *Middle Triassic:* China (Qinghai).——FIG. 1272,*3a–e*. **Y. planofolda; a,*

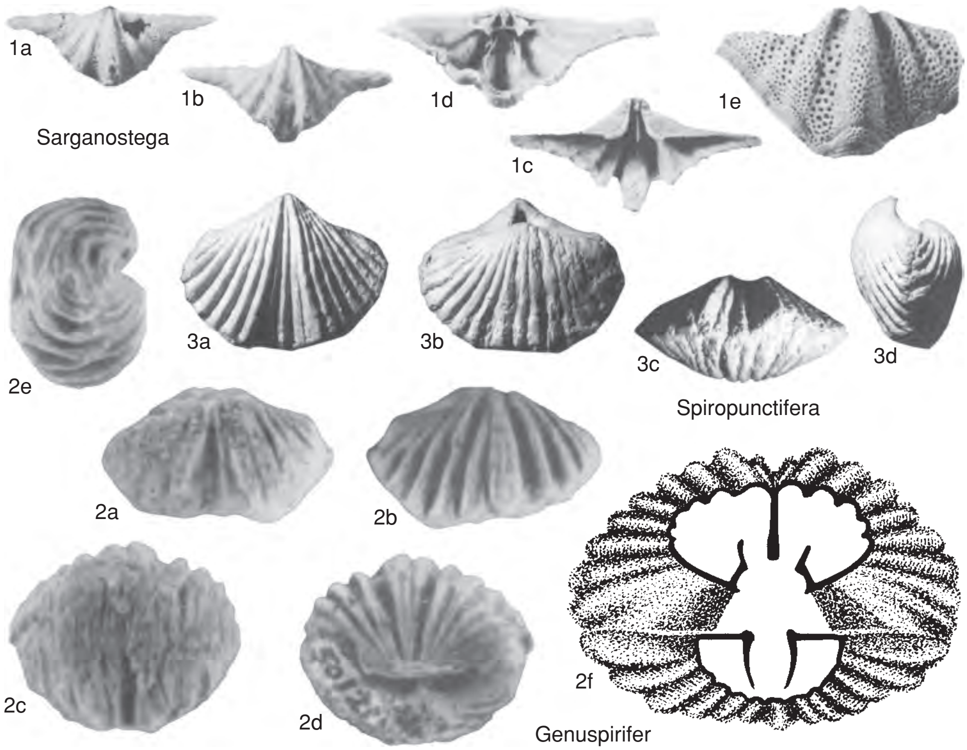

FIG. 1274. Spiropunctiferidae and Sarganostegidae (p. 1913–1921).

holotype, dorsal valve; *b,* paratype, ventral valve, ×1 (new); *c,* transverse section of ventral valve; *d–e,* transverse sections of dorsal valve, approximately ×1.5 (Xu & Liu, 1983b).

Ziganella NALIVKIN in IVANOVA, 1960, p. 280 [**Z. ziganensis;* OD]. Small; transversely subtriangular in outline; greatest width at hinge line; ventral umbonal region inflated, beak small; interarea high, weakly concave; sulcus narrow, smooth; fold low, well defined, well rounded; lateral slopes with few (5 to 6) ribs; microornament unknown; ventral interior with low median septum and very short dental adminicula buried in apical callus; dorsal interior unknown; punctae small, sparsely distributed; otherwise similar to *Punctospirifer. Upper Devonian (upper Famennian):* Russia.——FIG. 1273,*3a–c.* **Z. ziganensis,* Urals; *a–b,* ventral and anterior views of large syntype, beak removed; *c,* ventral view of smaller syntype, ×2 (new).

Family SPIROPUNCTIFERIDAE Carter, 1994

[Spiropunctiferidae CARTER in CARTER & others, 1994, p. 367]

Cardinal extremities well rounded; fold and sulcus plicate; microornament absent. *Carboniferous (upper Visean)–Permian (Lopingian).*

Spiropunctifera IVANOVA, 1971, p. 120 [**S. tulensis;* OD]. Medium size; transversely subelliptical in outline; almost equally biconvex; ventral interarea moderately low, nearly orthocline; fold and sulcus moderately developed and narrow; entire surface ribbed, lateral slopes with moderately numerous strong, subangular, very rarely bifurcating plicae separated by narrower interspaces, fold with several bifurcating plicae; sulcus with strong, rarely bifurcating, median plica and 1 or 2 pairs of weaker plicae that bifurcate from sulcus-bounding plicae; dental adminicula short, nearly parallel; median septum long, thin, wedge shaped, rising anteriorly and abruptly terminating past midlength; dorsal adminicula short, merging with adductor bounding ridges; jugum large, apparently complete; punctae moderately dense, sometimes branching. *Carboniferous (upper Visean):* Russia (Moscow basin).——FIG. 1274,*3a–d.* **S. tulensis;* holotype, ventral, dorsal, anterior, and lateral views, ×1 (new).

Genuspirifer LIANG, 1990, p. 388 [490] [**G. tongluensis;* OD]. Small to medium size; strongly biconvex; outline subelliptical; maximum width attained near midlength; fold and sulcus narrow, well delineated; ventral interarea moderately low, strongly concave, apsacline; lateral slopes with few strong, slightly rounded, simple plicae and equally wide, deeply rounded interspaces; sulcus with pair of strong, simple plicae, or rarely, with additional weaker pair on walls of sulcus; fold with 3 plicae; fine growth laminae closely and regularly spaced; dental adminicula very short, divergent; median septum long, high; cardinal process low, inconspicuous; crural bases high, medially concave, nearly vertical, nearly touching valve floor; densely punctate. *Permian (Guadalupian–Lopingian):* China.——FIG. 1274,*2a–f.* **G. tongluensis; a–e,* ventral, dorsal, anterior, posterior, and lateral views, ×2; *f,* transverse section, ×3 (Liang, 1990).

Family RETICULARIINIDAE Waterhouse, 1975

[*nom. transl.* WATERHOUSE, 1983a, p. 138, *ex* Reticulariininae WATERHOUSE, 1975, p. 15]

Outline tranverse; cardinal extremities usually extended, rarely rounded; fold and sulcus narrow, usually well delimited; sulcus smooth or with weak median rib; dental adminicula divergent; microornament of coarse, hollow spines. *Carboniferous (upper Visean)–Permian (Lopingian).*

Reticulariina FREDERIKS, 1916, p. 16 [**Spirifer spinosus* NORWOOD & PRATTEN, 1855, p. 71; OD]. Small to medium size; moderately to strongly transverse; outline usually widely subtrigonal; cardinal extremities angular, or often alate or mucronate; ventral interarea of moderate height, concave, apsacline; delthyrium open or with apical callus; fold and sulcus narrow, well delimited; lateral slopes with few to moderately numerous, strong, simple, rounded plicae; fold and sulcus smooth or with faint median rib, rarely with additional weak ribs on sides of fold and sulcus; microornament of numerous coarse, erect, hollow spines and irregularly spaced growth laminae; dental adminicula short, divergent; median septum long, high, thin; elongate or knoblike ctenophoridium supported by convergent crural bases forming notothyrial platform; adductor field delimited by low, narrow, longitudinal ridges; shell substance coarsely punctate. *Carboniferous (upper Visean)–Permian (Lopingian):* cosmopolitan.——FIG. 1275,*2a–h.* **R. spinosa* (NORWOOD & PRATTEN), Chesterian, Illinois, USA; *a–e,* ventral, dorsal, anterior, posterior, and lateral views, ×1 (Weller, 1914); *f–h,* transverse sections, ×2 (Campbell, 1959b).

Altiplecus STEHLI, 1954, p. 349 [**A. cooperi;* OD]. Small to medium size, strongly transverse; outline transversely subtrigonal to subrhombic; cardinal extremities usually mucronate or alate; fold and sulcus narrow but wider than lateral interspaces; fold high; fold and sulcus often producing characteristic subangular anterior extension; lateral slopes with very few, usually 2 or 3, rounded plicae; sulcus usually with weak median plica; microornament of few long, thick, hollow spines arranged in concentric rows along growth lines; growth varices strong, irregularly spaced, almost tegulate in some species; dental adminicula short; median septum high, thin, short; apical callosity supporting ctenophoridium; adductor field bounded laterally by low, outwardly bowed ridges; punctae regularly arranged in rhombs of four. *Permian (Cisuralian):* North America.——FIG. 1275,*4a–c.* **A. cooperi,* Wolfcampian, Texas, USA; ventral, dorsal, and lateral views, ×1.5 (Cooper & Grant, 1976b).——FIG. 1275,*4d–e. A. trapezoidalis* COOPER & GRANT, Lopingian, Texas, USA; ventral and dorsal interiors, ×1.5 (Cooper & Grant, 1976b).

Gjelispinifera IVANOVA, 1975, p. 86 [**G. gerasimovi;* OD]. Spines arranged in 1 or 2 rows along crests of plicae and on floor of sulcus; ventral septum low and thin; otherwise similar to *Reticulariina. Carboniferous (Pennsylvanian):* Russia (Moscow basin).——FIG. 1275,*1a–e.* **G. gerasimovi; a–d,* holotype, ventral, dorsal, anterior, and posterior views; *e,* paratype, ventral valve, ×1 (new).

Spinuliplica CAMPBELL, 1961a, p. 442 [**S. spinulosa;* OD]. Medium size; outline transversely subovate to subpentagonal; cardinal extremities rounded; fold and sulcus moderately developed, rounded; beak ridges rounded but ventral interarea clearly defined, moderately high, apsacline; lateral slopes with few rounded, simple plicae, sulcus with weak median plica; microornament consisting of numerous irregularly arranged, fine, hollow, anteriorly directed spinules; dental adminicula strong, thick, diverging; median septum massive; ctenophoridium supported by callus and variably developed, short dorsal adminicula; punctae irregularly arranged. *Carboniferous (?Pennsylvanian):* Australia (New South Wales).——FIG. 1275,*3a–d.* **S. spinulosa; a,* holotype, mold of ventral interior; *b–c,* exterior and internal views of dorsal valve, ×1; *d,* microornament, ×10 (Campbell, 1961a).

Family PARASPIRIFERINIDAE Cooper & Grant, 1976

[Paraspiriferinidae COOPER & GRANT, 1976b, p. 2,729]

Outline transversely subelliptical; cardinal extremities well rounded; fold and sulcus usually well delimited; dental adminicula short, usually divergent; microornament regularly and finely lamellose, with lamellae bearing fine, hairlike spinules in some genera. *Carboniferous (?Moscovian, Kasimovian)–Permian (Lopingian).*

Paraspiriferina REED, 1944, p. 252 [**Spiriferina (Paraspiriferina) ghundiensis;* OD]. Small, strongly biconvex, outline transversely subelliptical, cardinal extremities well rounded; fold and sulcus well differentiated, moderately broad, rounded, smooth; sulcus subangular in some species; beak ridges lack-

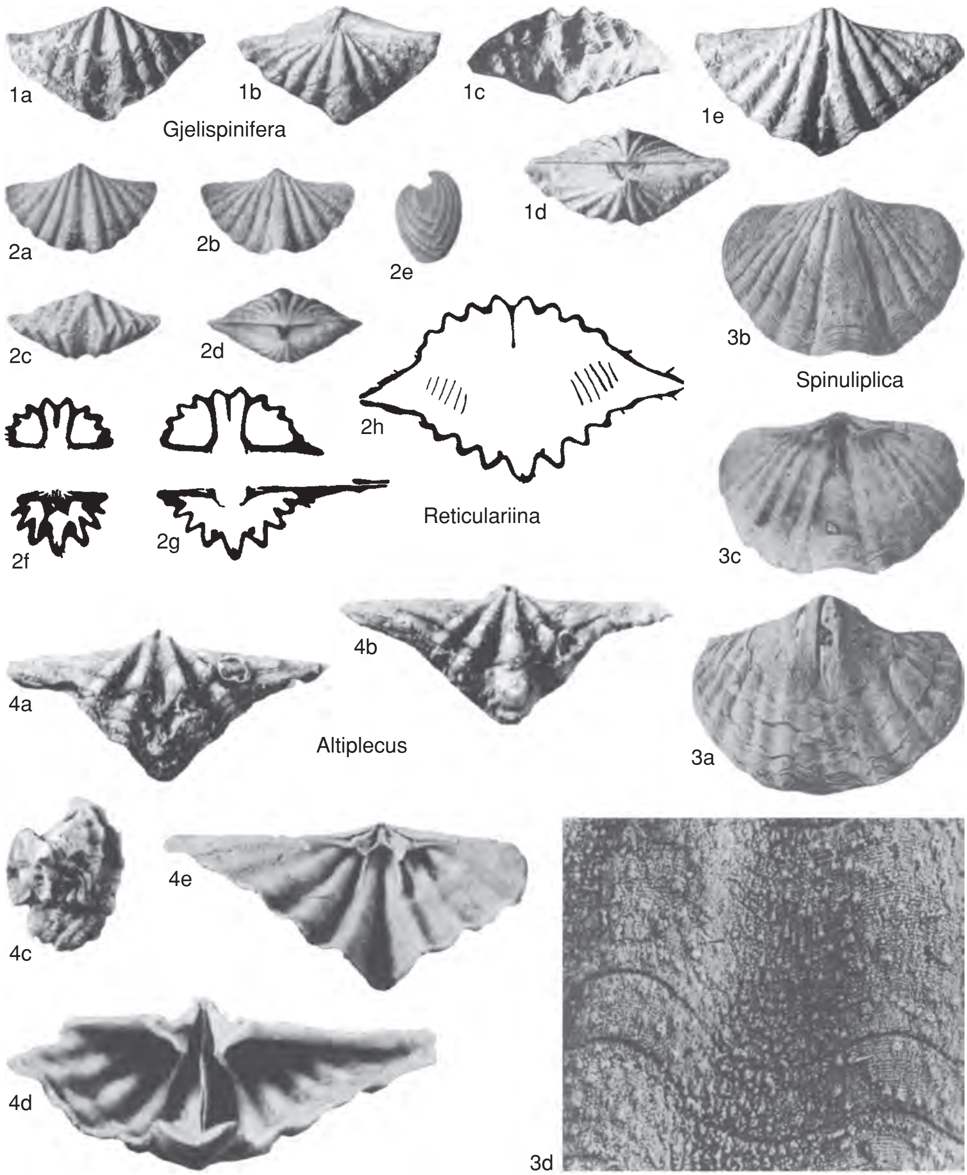

FIG. 1275. Reticulariinidae (p. 1914).

ing; ventral interarea narrow, concave; delthyrium narrow, high, with imbricating stegidial plates at edges; lateral slopes with numerous low, narrow, rounded plicae separated by narrow interspaces; microornament of lamellose, regularly and closely spaced growth laminae with numerous anteriorly directed, fine, short, hollow spinules or papillae; dental adminicula short, slightly divergent; median septum long, high, thin, commonly united with dental adminicula by small apical callosity; dorsal adminicula thin, sometimes high, enclosing dorsal adductor field; punctae fine, closely spaced. *Permian:* India, USA (western Texas).——FIG. 1276,*1a–c.* **P. ghundiensis* (REED), Guadalupian, India; dorsal, ventral, and lateral views, ×1.5 (Reed, 1944).——FIG. 1276,*1d–g. P. paginata* COOPER & GRANT, Guadalupian, western Texas, USA; *d,* exterior view of ventral valve, ×1; *e,* internal view of ventral valve, ×2; *f–g,* exterior and internal views of dorsal valve, ×1.5 (Cooper & Grant, 1976b).

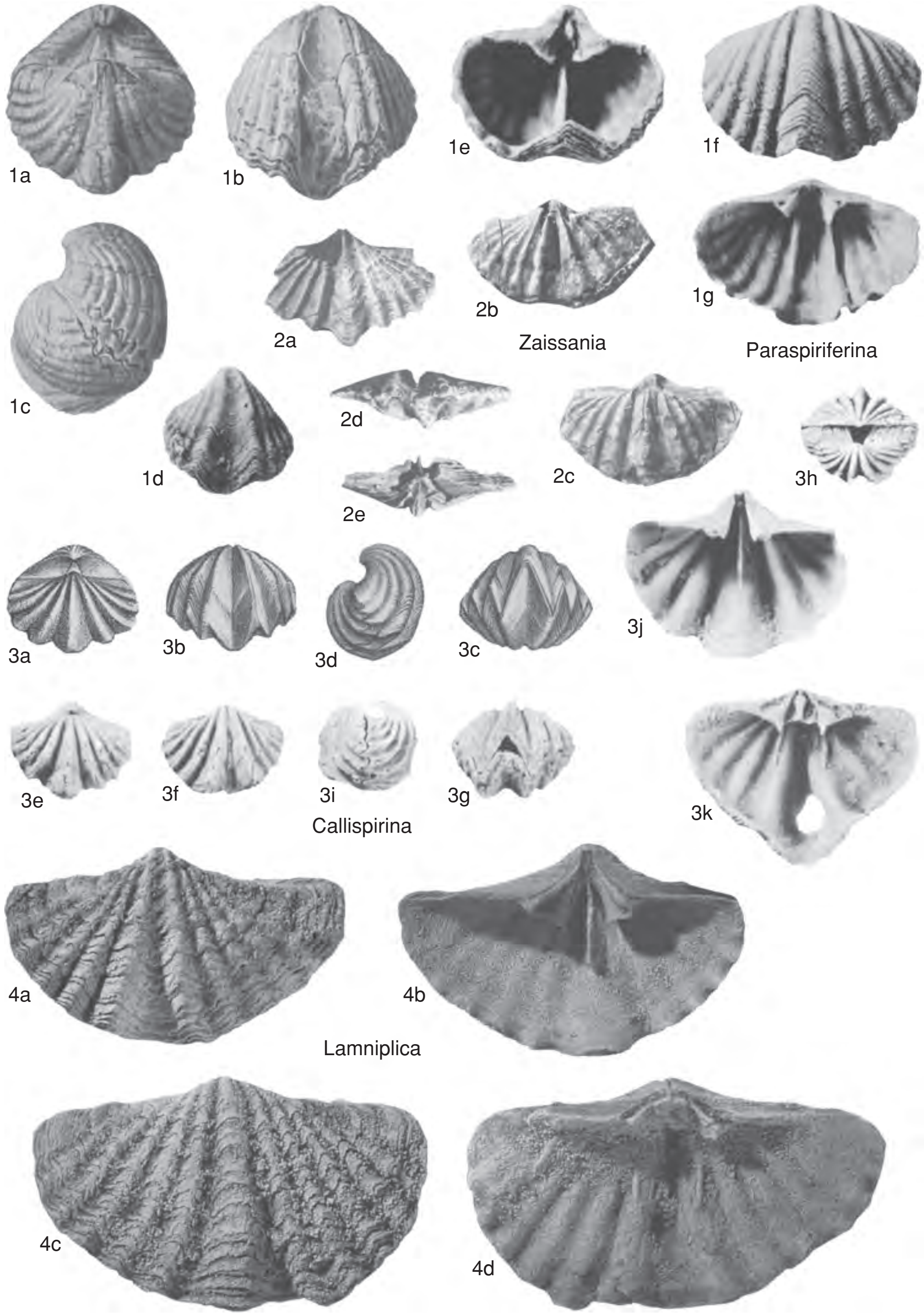

FIG. 1276. Paraspiriferinidae (p. 1914–1918).

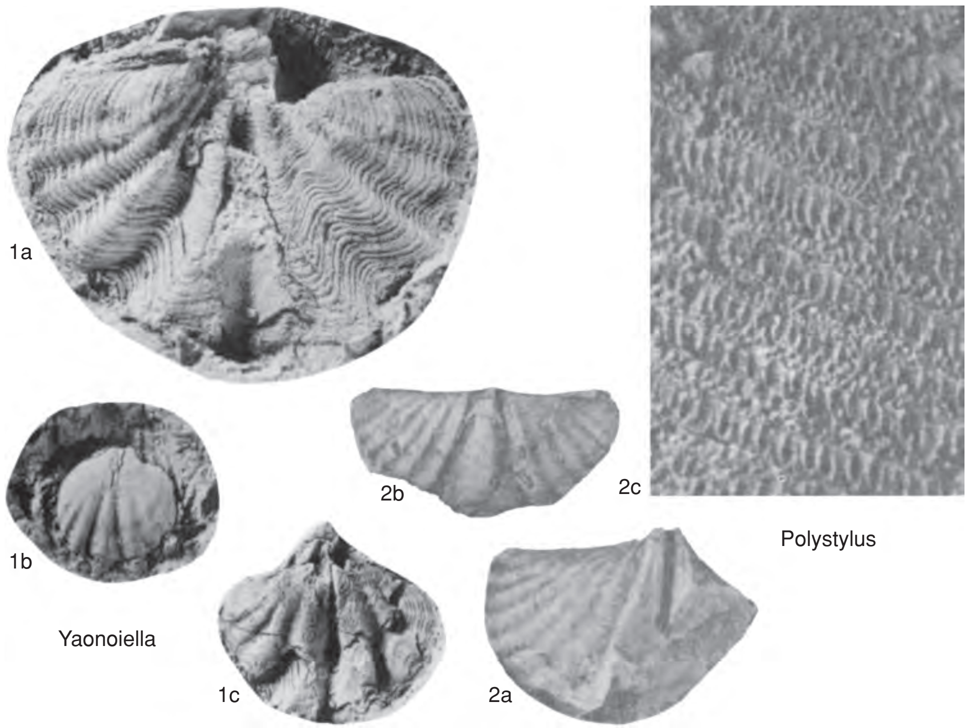

FIG. 1277. Paraspiriferinidae (p. 1917–1918).

Callispirina COOPER & MUIR-WOOD, 1951, p. 195, *nom. nov. pro Mansuyella* REED, 1944, p. 249, *non* ENDO, 1937 [**Spiriferina ornata* WAAGEN, 1883a, p. 505; OD] [=*Maia* FREDERIKS, 1924, p. 298, *non* LAMARCK, 1801, *nec* REICHENBACH, 1850, obj.; *Maya* RAKUSZ, 1932, p. 77, *non* BLATTNY, 1925, obj.]. Small to medium size, strongly biconvex; outline transversely subovate; lateral slopes with few strong, angular plicae separated by angular interspaces; fold and sulcus moderately differentiated, angular, slightly wider than lateral plicae or interspaces; microornament of regularly and closely spaced, slightly lamellose growth laminae fringed with single row of few short, solid spinules and bearing 2 rows of punctae; cardinal process raised, knoblike, supported by low dorsal adminicula that border dorsal adductor field; otherwise similar to *Paraspiriferina. Permian (Guadalupian–Lopingian):* Pakistan, USA (Texas).——FIG. 1276,*3a–d.* **C. ornata* (WAAGEN), Guadalupian, Pakistan; holotype, dorsal, ventral, anterior, and lateral views, ×1 (Waagen, 1883a).——FIG. 1276,*3e–k. C. rotunda* COOPER & GRANT, Guadalupian, Texas; *e–i,* holotype, dorsal, ventral, anterior, posterior, and lateral views, ×1; *j–k,* ventral and dorsal interiors, ×2 (Cooper & Grant, 1976b).

Lamniplica WATERHOUSE & RAO, 1989, p. 32 [**L. punctata;* OD]. Medium size; fold and sulcus narrow, well delineated, smoothly rounded; lateral slopes with several (5 to 7) rounded plicae and prominent coarse growth varices; microornament of fine growth lines, rarely disrupted by punctae, but no spinules; low dorsal adminicula bounding adductor field; otherwise similar to *Paraspiriferina. Permian (Asselian):* India.——FIG. 1276,*4a–d.* **L. punctata; a–b,* holotype, exterior and interior views of ventral valve, ×2; *c–d,* exterior and interior views of dorsal valve, ×2 (Waterhouse & Rao, 1989).

Polystylus KLETS, 1993, p. 123 [**P. kentshaensis;* OD]. Medium size; transversely subelliptical in outline; cardinal extremities rounded; ventral beak incurved over low, slightly concave interarea; fold and sulcus well differentiated from lateral slopes, subangular in profile, flaring anteriorly; each lateral slope with 5 to 8 coarse, rounded ribs separated by narrow interspaces; microornament of regularly imbricate growth lamellae bearing 1 row of relatively coarse, low, solid, tapered spines and up to 4 rows of much finer spines crudely arranged in quincunx; long dorsal median ridge and short crural plates present. *Carboniferous (?Moscovian):* Russia (eastern Siberia).——FIG. 1277,*2a–c.* **P. kentshaensis,* Mishkinskoi Suite; *a–b,* ventral valves, ×1.5; *c,* microornament, ×13 (Klets, 1993).

Yaonoiella WATERHOUSE, 1983a, p. 142 [**Y. mantajiti;* OD]. Small; fold and sulcus narrow; lateral slopes with few subrounded plicae; microornament of closely and regularly spaced growth laminae, each bearing 2 to 4 rows of fine spinules; otherwise similar to *Paraspiriferina. Permian (Capitanian):* Nepal.——FIG. 1277,*1a–c.* **Y. mantajiti; a,* holotype, ventral valve, ×2; *b,* ventral valve, ×5; *c,* dorsal valve, ×1 (Waterhouse, Pitakpaivan, & Mantajit, 1981).

Zaissania SOKOLSKAYA, 1968, p. 197 [**Z. zaissanica;* OD]. Medium size; outline transversely subtriangular; moderately biconvex; cardinal extremities angular to alate; fold and sulcus narrow, well developed, rounded, smooth; lateral slopes with moderately numerous, strong, rounded plicae separated by narrow, subangular interspaces; microornament of regularly spaced, subimbricate growth lamellae, each lamella fringed with minute, hairlike spinules that project anteriorly over elongate grooves or pits of adjacent growth lamellae, all arranged in quincunx; dental adminicula short, stout, slightly divergent; median septum very long, stout; very long dorsal myophragm reaching almost to anterior margin; dorsal adminicula thick, long; punctae large, widely spaced. *Carboniferous (?Moscovian* or *Kasimovian–Gzhelian), Permian (Cisuralian):* Kazakhstan.——FIG. 1276,*2a–e.* **Z. zaissanica,* ?Moscovian or Kasimovian–Gzhelian; *a,* holotype, mold of ventral exterior; *b–e,* holotype, ventral, dorsal, anterior, and posterior views of steinkern, ×1 (new).

Family SPIRIFERELLINIDAE Ivanova, 1972

[Spiriferellinidae IVANOVA, 1972, p. 41] [=Crenispiriferidae COOPER & GRANT, 1976b, p. 2,709]

Outline usually transversely subelliptical to subtrigonal; fold and sulcus usually narrow and poorly to moderately delimited; lateral slopes with few strong, lateral plicae and subimbricate growth varices; dental adminicula very short; microornament finely pustulose. *Carboniferous (Mississippian)–Upper Triassic.*

Spiriferellina FREDERIKS, 1924, p. 299 [**Terebratulites cristatus* VON SCHLOTHEIM, 1816, p. 28; OD] [=*Tylotoma* GRABAU, 1934, p. 100, obj.]. Small; outline variable, usually moderately transverse; cardinal extremities variably rounded, angular or slightly mucronate; fold and sulcus narrow, delineated by coarse sulcus-bounding plicae and deep, wide, fold-bounding interspaces; ventral interarea moderately high, slightly concave, apsacline; lateral slopes with few high, coarse, subangular plicae separated by deep, subangular interspaces; sulcus smooth and rounded or sometimes flat bottomed, rarely with weak median rib; fold rounded; microornament of very fine, hollow pustules arranged in quincunx and covering external termination of punctae; growth laminae irregularly spaced, imbricate anteriorly; some species also with fine, hollow spinules; dental adminicula short, slightly divergent; median septum high, long; elongate ctenophoridium supported by umbonal callus; crural bases broad, converging below and in front of cardinal process in some species; dorsal adductor field bordered by low, thin ridges; jugum complete; punctae moderately coarse and regularly spaced. *Carboniferous (Mississippian)–Permian (Lopingian):* cosmopolitan.——FIG. 1278,*1a–b.* **S. cristata* (VON SCHLOTHEIM), Lopingian, Germany; *a,* lectotype, ventral valve, ×2; *b,* microornament, ×5 (Campbell, 1959b).——FIG. 1278,*1c–h. S. tricosa* COOPER & GRANT, Guadalupian, Texas, USA; *c–e,* dorsal, ventral, and lateral views, ×3; *f–g,* ventral and dorsal interiors, ×1.5; *h,* jugum, ×3 (Cooper & Grant, 1976b).

Crenispirifer STEHLI, 1954, p. 347 [**Spiriferina angulata* KING, 1931, p. 122; OD]. Small to medium size; strongly biconvex; outline transversely subelliptical; profile subovate; cardinal extremities slightly to moderately rounded; fold and sulcus narrow, rounded, poorly delimited from lateral slopes; lateral slopes with few strong, very high, subangular plicae separated by deep, angular interspaces; microornament of close-set pustules or low spinules arranged in quincunx; growth varices irregularly spaced, subimbricate in some species; dental adminicula very short; jugum incomplete; punctae medium sized to coarse, arranged in quincunx. *Carboniferous (Pennsylvanian)–Permian (Lopingian):* North America.——FIG. 1278,*2a–h.* **C. angulata* (KING), Cisuralian, Texas, USA; *a–e,* dorsal, ventral, lateral, posterior, and anterior views, ×1; *f,* dorsal interior; *g–h,* ventral interior and oblique view, ×1.5 (Cooper & Grant, 1976b).

Lancangjiangia JIN & FANG, 1977, p. 50 [**L. spinosa;* OD]. Small to medium size; outline transversely subovate; moderately inflated; ventribiconvex; cardinal extremities rounded; fold and sulcus moderately developed, smooth, rounded, wider than bounding ventral plicae and dorsal interspaces; fold high and carinate; lateral slopes with few (3 to 4) strong, rounded or subangular plicae; growth lamellae imbricate; microornament of numerous strong spinules; dental adminicula discrete, short; median septum long, stout; ctenophoridium high, broad; jugum unknown. *Upper Triassic:* China.——FIG. 1278,*3a–b.* **L. spinosa;* ventral and dorsal valves, ×2 (new).

Metriolepis COOPER & GRANT, 1976b, p. 2,716 [**M. pulvinata;* OD]. Small, ventribiconvex, ventral valve subconical in some species; usually widest at hinge line; cardinal extremities often angular or alate, rarely rounded; ventral interarea flattened, moderately high to very high; delthyrium closed by imbricating stegidial plates in at least some species; fold and sulcus moderately wide, well defined by coarse ribs and deep interspaces; lateral slopes with few to very few rounded plicae that drastically decrease in

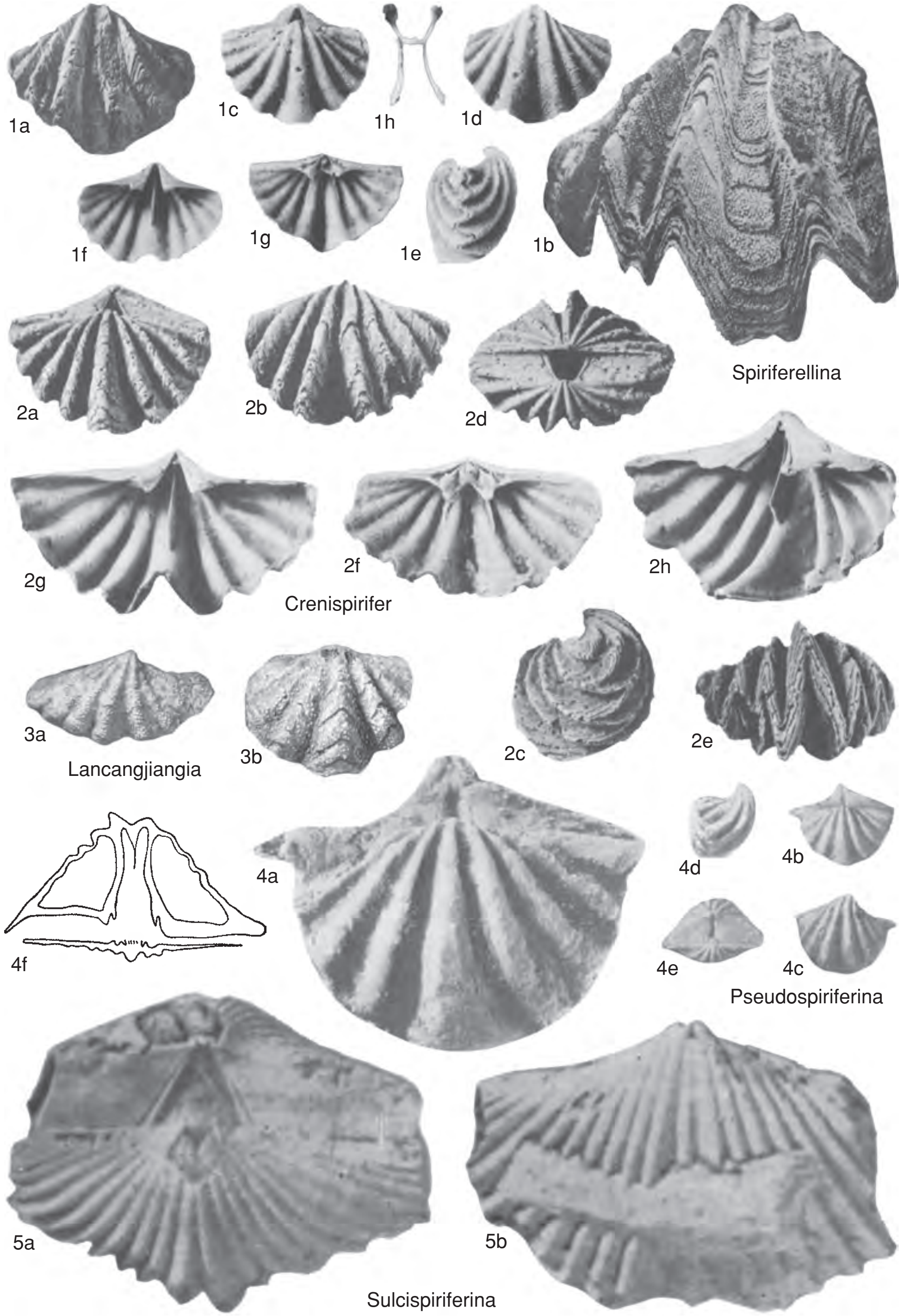

FIG. 1278. Spiriferellinidae (p. 1918–1920).

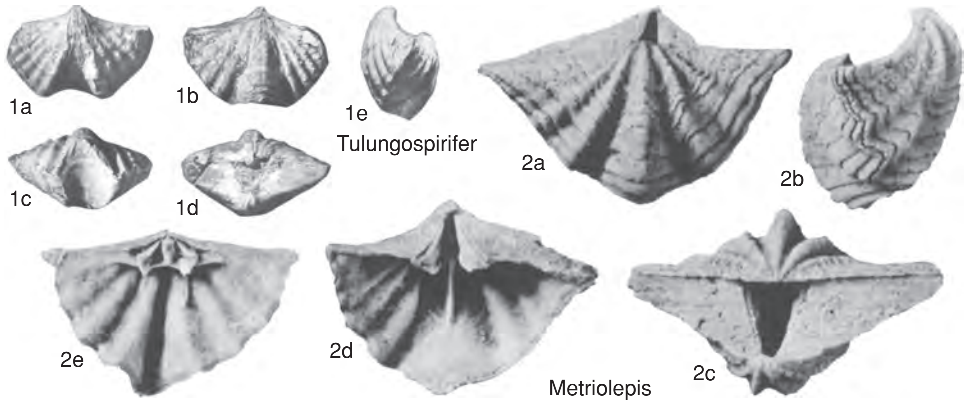

FIG. 1279. Spiriferellinidae (p. 1918–1920).

amplitude laterally; interspaces wide, rounded; sulcus rounded, flattened or with weak median rib; growth varices strong, imbricate, regularly or moderately irregularly spaced; microornament of low, rounded pustules arranged concentrically or in quincunx; dental adminicula very short; crural bases joined to base of cardinal process by short, medially convergent plates forming short, low platform; jugum complete; punctae finely to moderately dense, arranged in quincunx. *Permian:* USA (Texas).——FIG. 1279,*2a–e.* **M. pulvinata,* Guadalupian; *a–c,* dorsal, lateral, and posterior views; *d–e,* ventral and dorsal interiors, ×1.5 (Cooper & Grant, 1976b).

Pseudospiriferina YANG & XU, 1966, p. 41 [**P. variabilis;* OD]. Small to medium size; transversely to longitudinally subovate; unequally biconvex; cardinal extremities often mucronate or angular, rarely rounded; maximum width usually at hinge line; ventral valve strongly inflated with acute, incurved beak and sharp, angular beak ridges; ventral interarea moderately high, concave, apsacline or nearly catacline; fold and sulcus well defined, smooth, usually rounded, wider than lateral plications; fold may be flattened or with weak median groove; lateral slopes with few (3 to 4, rarely 5 to 6) strong, rounded plicae separated by interspaces almost as wide; anterior growth varices crowded, slightly lamellose; microornament of fine, densely spaced pustules; dental adminicula and median septum discrete; punctae densely and evenly distributed. *Middle Triassic:* southwestern China.——FIG. 1278,*4a–f.* **P. variabilis,* Guizhou; *a,* holotype, dorsal view, ×4; *b–e,* dorsal, ventral, lateral, and posterior views, ×1; *f,* transverse section, approximately ×3 (Yang & Xu, 1966).

Sulcispiriferina WATERHOUSE & GUPTA, 1981, p. 390 [**Spirifera vihiana* DAVIDSON, 1866, p. 41; OD]. Medium size; moderately transverse; outline subpentagonal; cardinal extremities subangular, maximum width at hinge line; ventral interarea moderately high, apsacline; fold and sulcus narrow, moderately developed; lateral slopes with moderately numerous, simple, strong, subangular plicae separated by narrow, angular interspaces; microornament of fine, low pustules only; jugum and nature of punctae unknown. *Permian (Guadalupian):* Kashmir, India.——FIG. 1278,*5a–b.* **S. vihiana* (DAVIDSON), Kalabaghian, Kashmir; ventral and posterior views, ×2 (Waterhouse & Gupta, 1981).

Tulungospirifer CHING & SUN in CHING, SUN, & RONG, 1976, p. 316 [**Spiriferina stracheyi* SALTER in SALTER & BLANFORD, 1865, p. 72; OD]. Medium size; outline transversely subtrigonal; widest at hinge line, cardinal extremities alate to mucronate; fold and sulcus narrow, strongly developed, rounded, smooth; ventral interarea moderately high, concave, apsacline; lateral slopes with few to moderately numerous, low, rounded, simple plicae, separated by narrower, rounded interspaces; microornament consisting of fine, alternating radial grooves and fine spinules; dental adminicula short, divergent; median septum long, low; umbonal callus thick; dorsal umbonal callus present; jugum unknown. *Middle Triassic (Anisian):* China.——FIG. 1279,*1a–e.* **T. stracheyi* (SALTER); ventral, dorsal, anterior, posterior, and lateral views, ×1 (new).

Family SARGANOSTEGIDAE Cooper & Grant, 1976

[Sarganostegidae COOPER & GRANT, 1976b, p. 2,743]

External surface with quincuntially arranged, very coarse punctae; microornament absent. *Permian (Guadalupian–Lopingian).*

Sarganostega COOPER & GRANT, 1969, p. 15 [**S. transversalis;* OD]. Small; transversely subtrigonal to

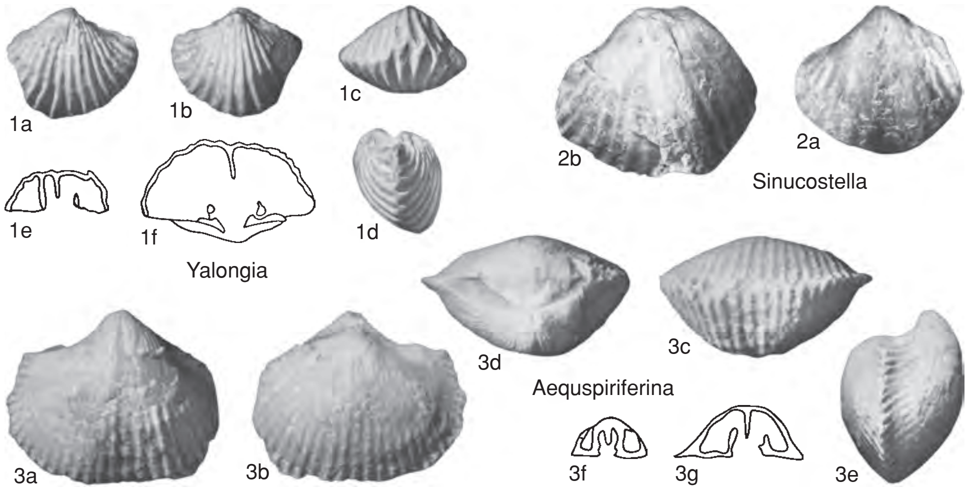

FIG. 1280. Balatonospiridae (p. 1921–1922).

subovate in outline; ventral interarea high, flattened, strongly apsacline to catacline; fold and sulcus narrow to moderately broad, moderately well defined by strong bounding plicae and interspaces; lateral slopes with few (2 to 3) strong, rounded plicae separated by wide, rounded interspaces; microornament absent; dental adminicula variably developed; ventral median septum long, high, thin; crural bases convergent, connected to anterior base of cardinal process by pair of thin transverse plates and forming pair of shallow apical recesses; jugum unknown; punctae very coarse externally, very fine internally. *Permian (Guadalupian–Lopingian):* USA (Texas).——FIG. 1274,*1a–d.* **S. transversalis,* Lopingian; *a–b,* dorsal and ventral valves; *c–d,* ventral and dorsal interiors, ×1.5 (Cooper & Grant, 1976b).——FIG. 1274,*1e. S. pressa* COOPER & GRANT; microornament, ×3 (Cooper & Grant, 1976b).

Family BALATONOSPIRIDAE Dagys, 1974

[*nom. transl.* CARTER in CARTER & others, 1994, p. 368, *ex* Balatonospirinae DAGYS, 1974, p. 137] [=Nudispiriferininae Xu & LIU, 1983a, p. 82]

Outline transversely subelliptical to subquadrate or subpentagonal; fold and sulcus poorly developed; entire surface usually ribbed. *Middle Triassic, ?Upper Triassic.*

Subfamily YALONGIINAE Carter, 1994

[Yalongiinae CARTER in CARTER & others, 1994, p. 368]

Dental adminicula discrete. *Middle Triassic, ?Upper Triassic.*

Yalongia XU & LIU, 1983b, p. 112 [**Y. angulocostata;* OD]. Medium size; subequally biconvex, both valves moderately inflated; outline transversely subovate; cardinal extremities subangular or slightly rounded, greatest width slightly anterior to hinge line; ventral beak strongly incurved, interarea low; fold and sulcus poorly differentiated, weakly developed, anterior commissure almost rectimarginate; entire surface plicate; plicae strong, simple, subangular, moderately numerous, separated by moderately narrow subangular interspaces; microornament unknown; dental adminicula short, discrete; ventral median septum long, high; jugum unknown. *Middle Triassic:* Tibet.——FIG. 1280,*1a–f.* **Y. angulocostata; a–d,* holotype, ventral, dorsal, anterior, and lateral views, ×1 (new); *e–f,* transverse sections, approximately ×1.5 (Xu & Liu, 1983b).

Aequspiriferina YANG & YIN in YANG & others, 1962, p. 109 [**A. multiplicata;* OD]. Small to medium size; strongly ventribiconvex; transversely subovate to subquadrate in outline; ventral beak incurved; hinge line equal to maximum width; cardinal extremities subangular to acute; ventral interarea distinct, slightly concave, catacline to slightly apsacline; fold and sulcus weakly to moderately developed; entire surfaces of both valves with numerous broadly rounded costae; microornament unknown; dental adminicula discrete; ventral median septum thickened, high distally; very short dorsal median septum; jugum unknown. *?Middle Triassic, ?Upper Triassic:* China.——FIG. 1280,*3a–g.* **A. multiplicata; a–e,* ventral, dorsal, anterior, posterior, and lateral views, ×2 (new); *f–g,* transverse sections, approximately ×1.3 (Xu & Liu, 1983b).

Sinucostella XU & LIU, 1983b, p. 108 [**Aequspiriferina obscura* YANG & YIN in YANG & others, 1962, p. 110; OD]. Small to medium size; outline subovate to subpentagonal; cardinal extremities slightly rounded to subangular; subequally biconvex; ventral beak strongly incurved; interarea apsacline; hinge line nearly equal to maximum width; fold and sulcus weakly developed, poorly delineated; entire surface costate with 2 to 3 low, rounded costae on fold-sulcus and 6 to 8 on lateral slopes; microornament unknown; dental adminicula very short, discrete; ventral median septum long, high; jugum unknown. *Middle Triassic:* China (Qinghai).——FIG. 1280,*2a–b*. **S. obscura* (YANG & YIN); ventral and dorsal valves, ×2 (new).

Subfamily BALATONOSPIRINAE Dagys, 1974

[Balatonospirinae DAGYS, 1974, p. 137]

Dental adminicula reduced or absent; dental flanges and median septum fused by transverse plate or callus. *Middle Triassic (Anisian)–Upper Triassic.*

Balatonospira DAGYS, 1974, p. 137 [**Spiriferina lipoldi* BITTNER, 1890, p. 139; OD]. Small; subequally biconvex; cardinal extremities subangular; ventral umbo incurved; ventral interarea narrow, apsacline; disjunct deltidial and chilidial plates present; fold and sulcus narrow, poorly developed; lateral slopes and fold-sulcus with few strong plicae; microornament unknown; dental adminicula lacking; long, high, ventral median septum connected to dental flanges by very short transverse plate or callus; cardinal process nonstriate, bladelike, supported by apical callus; crural bases fused medially to form complete hinge plate; jugum complete, flattened. *Upper Triassic (Carnian):* Alps, Carpathian Mountains, Caucasus.——FIG. 1281,*1a–n*. **B. lipoldi* (BITTNER), Alps; *a–e,* syntype, dorsal, ventral, lateral, anterior, and posterior views, ×1 (Bittner, 1890); *f–i,* topotype, ventral, anterior, posterior, and lateral views, ×2 (new); *j–n,* transverse sections, approximately ×1.5 (Dagys, 1974).

Dinarispira DAGYS, 1974, p. 131 [**Spiriferina pia* var. *dinarica* BITTNER, 1890, p. 35; OD]. Medium size; outline transversely subquadrate; inequivalved, ventral valve moderately to strongly convex, dorsal valve weakly convex or flattened; cardinal extremities subangular; ventral umbonal region slightly compressed, overhanging hinge line, beak incurved; ventral interarea low, apsacline, concave; fold and sulcus weakly to moderately developed, moderately narrow; entire surface plicate; microornament of thick, short spinules; dental adminicula lacking; strong high, ventral median septum connected to lateral walls of umbonal region by thin plate or callus; true spondylium absent; ctenophoridium high, supported by callus; crural bases medially converging; jugum unknown. *Middle Triassic:* European Tethys.——FIG. 1281,*2a–i*. **D. dinarica* (BITTNER), Anisian, Alps and Caucasus; *a,* holotype, dorsal valve, ×1 (Bittner, 1890); *b–e,* dorsal, ventral, lateral, and posterior views, ×1; *f–i,* transverse sections, approximately ×1.5 (Dagys, 1974).

Koeveskallina DAGYS, 1965, p. 172 [**Spiriferina koeveskalliensis* BOECKH, 1873, p. 175; OD; =*Spiriferina koeveskalyensis* STUR, 1865, p. 245]. Small to medium size, moderately ventribiconvex; reticularioid in aspect; outline transversely subovate to subrhomboidal; cardinal extremities rounded, maximum width anterior to hinge line; ventral interarea low, concave, apsacline; fold and sulcus lacking or very weakly developed; entire surfaces of both valves covered with numerous fine, mostly simple, costae; microornament of very fine, dense spinules; short, high spondylium formed by short dental adminicula and long, high median septum; dental flanges moderately high; ctenophoridium supported by thin callus; crural bases converge medially, apically fused to floor by callus; jugum incomplete. *Middle Triassic (Anisian)–Upper Triassic (Carnian):* Tethyan geosyncline.——FIG. 1281,*3a–h*. **K. koeveskalyensis* (STUR), Anisian, Caucasus; *a–d,* dorsal, ventral, lateral, and anterior views, ×1; *e–h,* transverse sections, approximately ×2 (Dagys, 1974).

Nudispiriferina YANG & XU, 1966, p. 47 [**N. minima;* OD]. Strongly inequivalved with high, strongly convex ventral and weakly convex dorsal valves; cardinal extremities angular; ventral beak incurved; fold and sulcus poorly delineated, rounded, smooth; lateral slopes with few rounded plicae; microornament absent; dental adminicula and spondylium absent; dental flanges and median septum connected by very short, transverse callus or plate; cardinal process nonstriate, knoblike, sessile; jugum unknown. *Middle Triassic:* southwestern China.——FIG. 1281,*4a–k*. **N. minima,* Guizhou; *a–e,* dorsal, ventral, lateral, posterior, and anterior views; *f,* enlarged dorsal view, ×4; *g–k,* transverse sections, approximately ×2 (Yang & Xu, 1966).

Tylospiriferina XU, 1978, p. 297 [**T. typica;* OD]. Small; outline transversely subpentagonal; subequally biconvex, ventral valve thicker than dorsal, hemipyramidal; beak slightly incurved; cardinal extremities subangular or slightly rounded; ventral interarea moderately high, slightly concave, nearly catacline, delthyrium open; fold and sulcus well delineated, narrow, rounded, smooth; lateral slopes with few strong, simple, rounded plicae with narrow interspaces; microornament densely spinulose and widely lamellose; possibly with very short dental adminicula buried in callus; long, ventral median septum anteriorly fused with and bisecting very high dental flanges to form short but deep, false spondylium; stout, high ctenophoridium and complete hinge plate supported by high, thin median septum and possibly very short dorsal adminicula; jugum unknown. *Upper Triassic:* China.——FIG. 1281,*5a–h*. **T. typica; a–d,* dorsal, ventral, lateral, and anterior views, ×1; *e,* enlargement of dorsal valve, ×2; *f–h,* transverse sections, approximately ×2.4 (Xu, 1978).

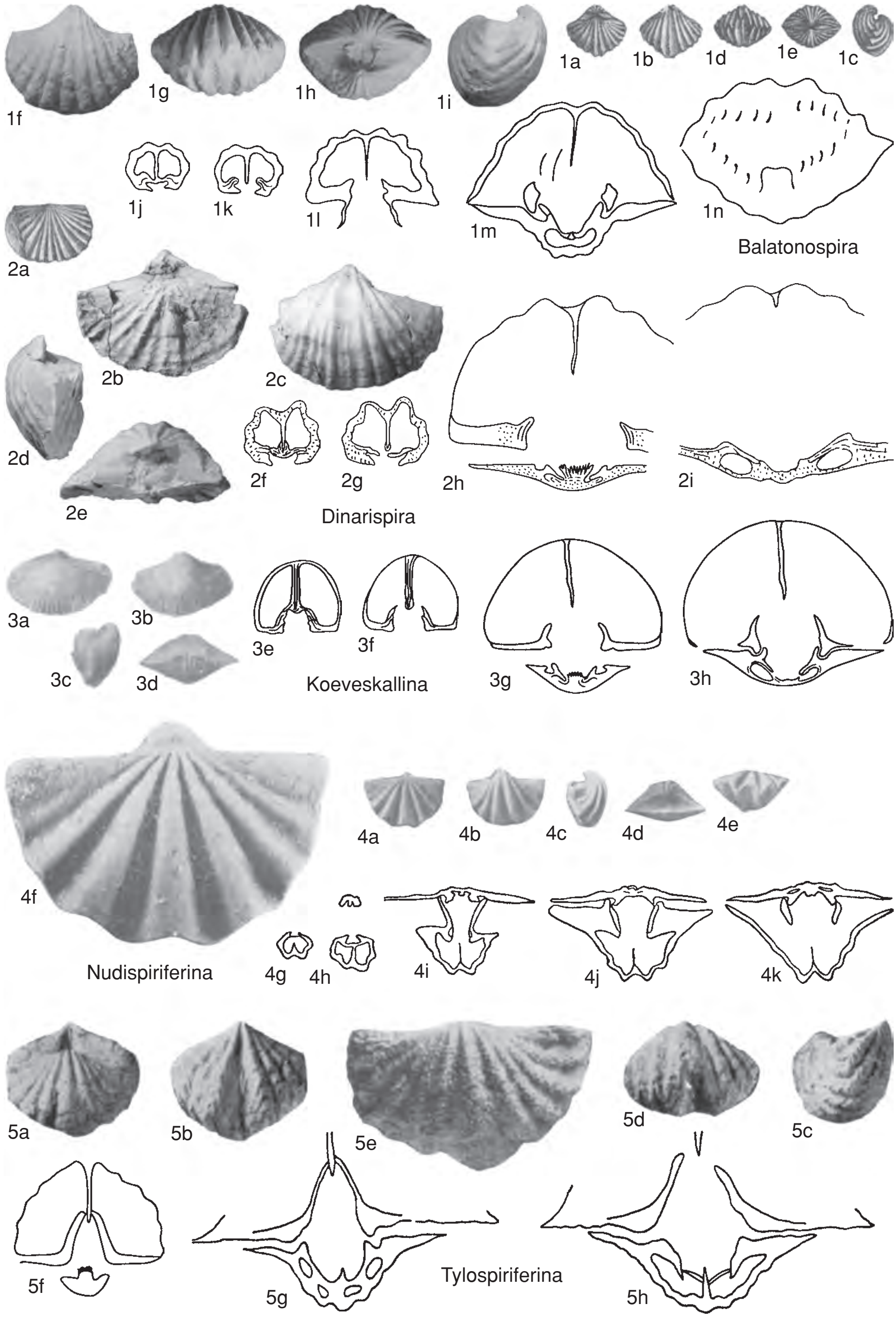

FIG. 1281. Balatonospiridae (p. 1922).

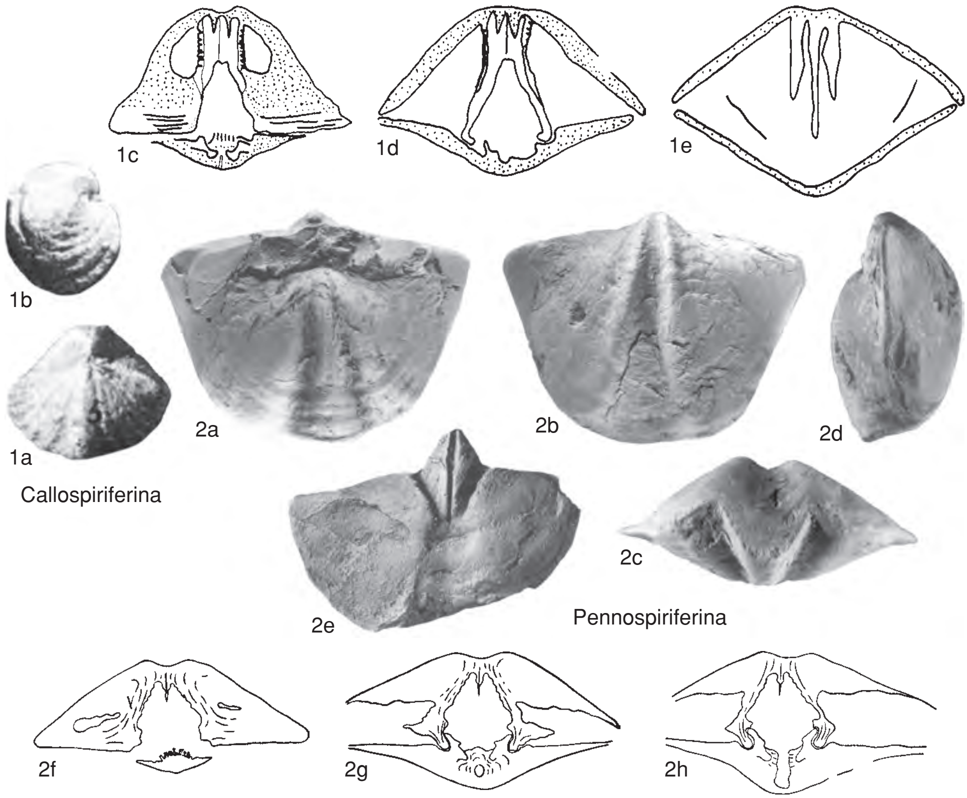

FIG. 1282. Pennospiriferinidae (p. 1924–1925).

Family PENNOSPIRIFERINIDAE Dagys, 1972

[*nom. transl.* CARTER in CARTER & others, 1994, p. 368, *ex* Pennospiriferininae DAGYS, 1972a, p. 36]

Transverse, usually with angular or extended lateral extremities; dental adminicula subparallel or converging; microornament absent. *Carboniferous (Pennsylvanian)–Lower Jurassic.*

Subfamily PENNOSPIRIFERININAE Dagys, 1972

[Pennospiriferininae DAGYS, 1972a, p. 36]

Fold and sulcus smooth; dental adminicula converging, fused with median septum by thick callus. *Middle Triassic (Ladinian)–Lower Jurassic.*

Pennospiriferina DAGYS, 1965, p. 112 [**P. popovi;* OD]. Large; strongly transverse with alate to mucronate cardinal extremities; moderately ventribiconvex, moderately inflated; fold and sulcus well defined, smooth, rounded; ventral interarea low, smooth, apsacline; lateral slopes with variably developed plicae; posterior portions of both valves much thickened with callus; jugum incomplete. *Middle Triassic (Ladinian)–Upper Triassic (Rhaetian):* northeastern Siberia.——FIG. 1282,*2a–h.* **P. popovi,* Ladinian; *a–e,* dorsal, ventral, anterior, lateral, and natural mold of ventral interior, ×1 (new); *f–h,* transverse sections, approximately ×1 (Dagys, 1965).

Callospiriferina ROUSSELLE, 1977, p. 157 [**Spirifer tumidus* BUCH, 1837, p. 52; OD; *nom. nov. pro Spirifer pinguis* VON ZIETEN, 1830 in 1830–1833, pl. 38,*5, non* SOWERBY, 1820]. Small, moderately transverse; strongly biconvex; hinge line less than maximum width; ventral interarea moderately high, concave, apsacline to catacline; fold and sulcus smooth; flanks with several simple, rounded ribs;

microornament unknown, possibly absent; dental adminicula long, close set, subparallel; ventral median septum high, fused with callus to form muscle platform; ctenophoridium large, supported by callus but no septum; jugum unknown; shell substance densely punctate. *Lower Jurassic:* Western Europe, northern Africa.——FIG. 1282,*1a–e*. **C. tumidus* (BUCH), Lias, Morocco; *a–b,* dorsal and lateral views, ×1; *c–e,* transverse sections, approximately ×1.6 (Rousselle, 1977).

Subfamily PUNCTOSPIRELLINAE Dagys, 1974

[Punctospirellinae DAGYS, 1974, p. 135] [=Xestotrematidae COOPER & GRANT, 1976b, p. 2,748]

Fold and sulcus smooth or weakly ribbed; dental adminicula discrete, usually short, not converging. *Carboniferous (Pennsylvanian)–Middle Triassic.*

Punctospirella DAGYS, 1974, p. 136 [**Terebratulites fragilis* VON SCHLOTHEIM, 1813, p. 104; OD]. Small; transversely subtrigonal to subovate in outline; subequally biconvex, moderately inflated; cardinal extremities angular, maximum width attained at hinge line; fold and sulcus moderately narrow, well defined, smooth, rounded; ventral interarea moderately high, apsacline; lateral slopes with few rounded, strong plicae separated by moderately narrow interspaces; dental adminicula discrete, short; ventral median septum long, high; ctenophoridium minute, knoblike, weakly striate; jugum incomplete. *Middle Triassic:* Germany, Russia, Greenland, Canada, Japan, Himalayas.——FIG. 1283,*1a–g*. **P. fragilis* (VON SCHLOTHEIM), Germany; *a–d,* dorsal, ventral, lateral, and anterior views, ×1; *e–g,* transverse sections, approximately ×2 (Dagys, 1974).

Arionthia COOPER & GRANT, 1976b, p. 2,750 [**A. blothrhachis;* OD]. Medium size; usually strongly transverse; cardinal extremities variable, usually alate to mucronate, rarely rounded; lateral slopes with few to moderately numerous, simple or, more rarely, bifurcating plicae; fold and sulcus usually with several weaker ribs, or more rarely, smoothly rounded; dental adminicula short, often partially buried in callus; otherwise similar to *Xestotrema. Permian (Lopingian):* USA (Texas).——FIG. 1283,*2a–g*. **A. blothrhachis; a–e,* holotype, dorsal, ventral, posterior, anterior, and lateral views, ×1; *f–g,* dorsal and ventral interiors, ×1.5 (Cooper & Grant, 1976b).

Laioporella IVANOVA, 1975, p. 83 [**L. modesta;* OD]. Medium to large; outline transversely rhomboidal; ventral valve inflated, with high, flattened interarea and small beak; cardinal extremities angular, alate; fold and sulcus well developed and delineated; fold high, rounded; sulcus moderately deep with simple, low median rib; lateral slopes with few rounded plications; dental adminicula short, thin; ventral median septum high, thin, long; dorsal adductor scar bounded laterally by distinct ridges; brachidium unknown; punctae sparsely distributed. *Carboniferous (Pennsylvanian):* Russia (Moscow basin).——FIG. 1283,*3a–g*. **L. modesta; a–e,* holotype, ventral, dorsal, lateral, anterior, and posterior views, ×1; *f–g,* ventral and dorsal interiors, ×2 (new).

Xestotrema COOPER & GRANT, 1969, p. 16 [**Spirifera pulchra* MEEK, 1860, p. 310; OD] [=*Mucrospiriferinella* WATERHOUSE, 1982b, p. 48 (type, *M. undulosa,* OD)]. Large, strongly transverse, cardinal extremities mucronate or alate in large adults; fold and sulcus narrow, rounded, smooth; ventral interarea moderately high, apsacline; lateral slopes with numerous rounded plicae separated by narrow, angular interspaces; microornament absent except for minute spinules or pustules in some juveniles; dental adminicula long; ventral median septum thin, high; punctae fine, dense. *Carboniferous (Pennsylvanian), Permian (Lopingian):* Thailand, *Pennsylvanian;* USA (Idaho, Utah, Wyoming), *Lopingian.*——FIG. 1283,*4a–e*. **X. pulchrum* (MEEK), Lopingian, Wyoming; ventral, dorsal, lateral, anterior, and posterior views, ×1 (Cooper & Grant, 1976b).

Family LEPISMATINIDAE Xu & Liu, 1983

[Lepismatinidae XU & LIU, 1983a, p. 82]

Cyrtiniform or globose; lateral slopes ribbed; fold and sulcus well developed; delthyrium open; dental adminicula discrete. *Triassic–Lower Jurassic.*

Subfamily LEPISMATININAE Xu & Liu, 1983

[*nom. transl.* CARTER in CARTER & others, 1994, p. 369, *ex* Lepismatinidae XU & LIU, 1983a, p. 82]

Fold and sulcus smooth; microornament of dense spinules; cardinalia sessile. *Triassic.*

Lepismatina WANG, 1955, p. 353 [**L. hsui;* OD] [=*Costispiriferina* DAGYS, 1974, p. 127 (type, *Spiriferina shalshalensis* BITTNER, 1899, p. 42, OD)]. Small; transversely subquadrate in outline; strongly inequivalved with high, subpyramidal ventral and low, weakly convex dorsal valves; ventral interarea high, flattened, apsacline to procline; maximum width at subangular cardinal extremities; fold and sulcus smooth, rounded; lateral slopes with few rounded plicae; microornament of regularly spaced, imbricate growth lamellae and fine, dense granules; dental adminicula moderately long, apically fused by callus to high long median septum; ctenophoridium short, broad; jugum complete with posteriorly directed process. *Middle Triassic–Upper Triassic:* China, *Middle Triassic;* western Tethys, *Upper Triassic.*——FIG. 1284,*2a–i*. **L. hsui,* Middle

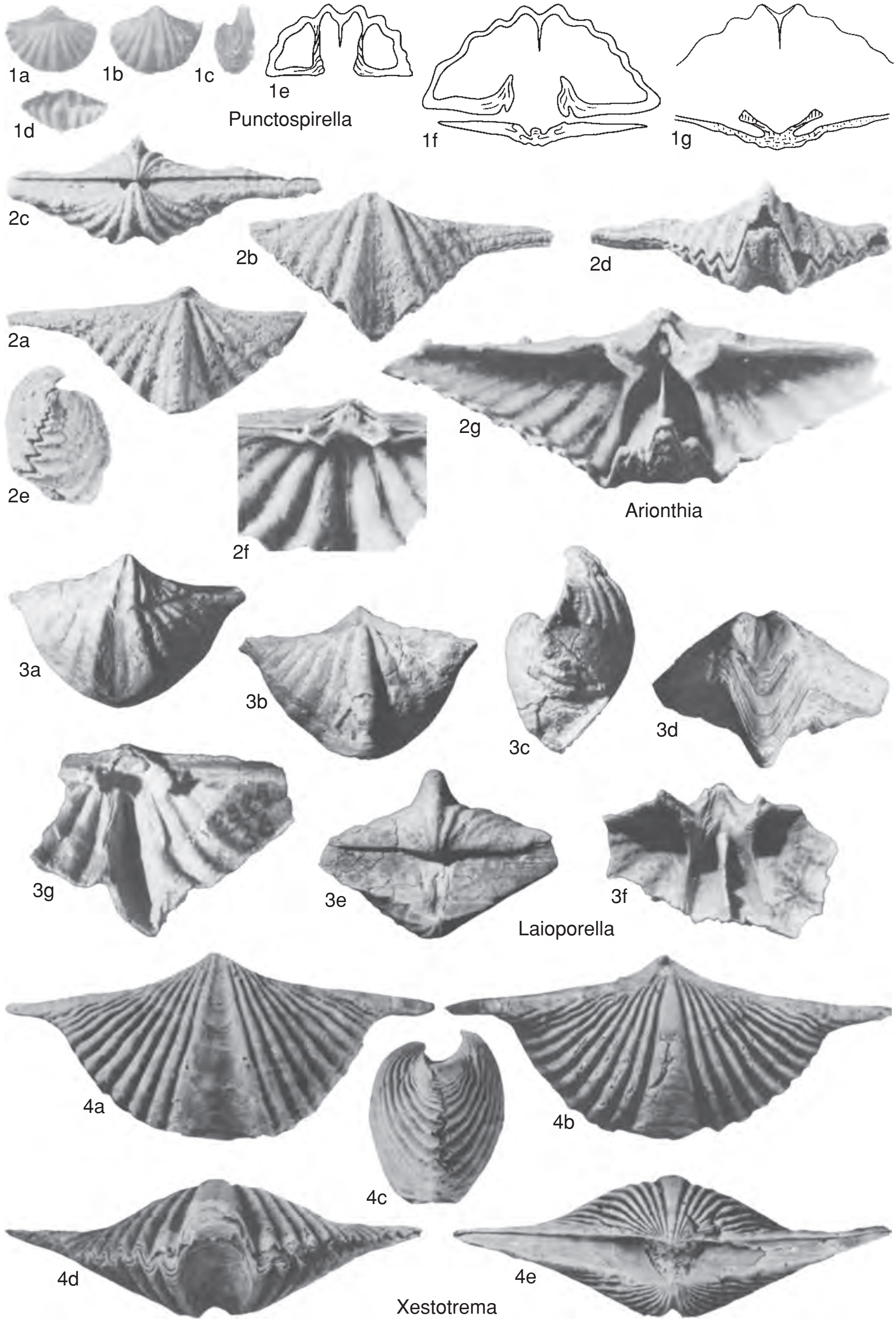

FIG. 1283. Pennospiriferinidae (p. 1925).

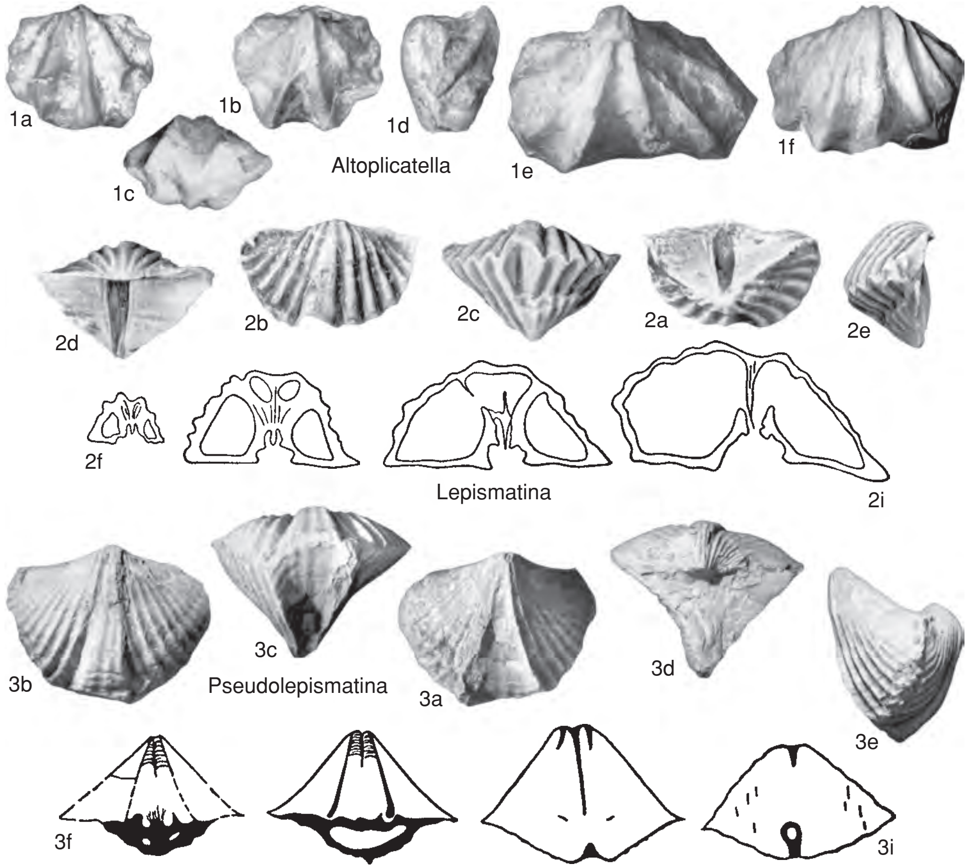

FIG. 1284. Lepismatinidae (p. 1925–1927).

Triassic, China; *a–e,* holotype, ventral, dorsal, anterior, posterior, and lateral views, ×2 (new); *f–i,* transverse sections, approximately ×3 (Yang & Xu, 1966).

Altoplicatella XU & LIU, 1983b, p. 114 [**A. altiarea;* OD]. Small to medium size; outline subpentagonal to subovate, almost equidimensional; unequally biconvex, ventral valve much more inflated, subpyramidal, dorsal valve gently convex; ventral interarea high, smooth, concave, catacline to procline; cardinal extremities well rounded, hinge line narrow; fold and sulcus moderately well defined, angular, smooth, wider than lateral plicae and interspaces; lateral slopes with 2 to 3 strong, coarse, subangular plicae; microornament unknown; high, long median septum fused to dental adminicula by callus; dorsal interior poorly known. *Middle Triassic:* China (Qinghai).——FIG. 1284,*1a–f.* **A. altiarea; a–d,* holotype, ventral, dorsal, anterior, and lateral views; *e,* large ventral valve; *f,* large dorsal valve, ×2 (new).

Pseudolepismatina CHING & SUN in CHING, SUN, & RONG, 1976, p. 321 [**P. nyalamensis;* OD]. Medium size; strongly inequivalved; ventral valve subconical, dorsal much thinner, moderately convex; cardinal extremities subangular; ventral interarea high, flattened, catacline; fold and sulcus sharply delimited, smooth; lateral slopes with moderately numerous, simple, rounded to subangular costae with narrow interspaces; microornament densely spinulose, slightly lamellose anteriorly; discrete dental adminicula and median septum fused by callus to form muscle platform; hinge plate complete with high, knoblike ctenophoridium; jugum narrowly rounded, supported by thick callus. *Triassic:* Tibet.——FIG. 1284,*3a–i.* **P. nyalamensis; a–e,* holotype, ventral, dorsal, anterior, posterior, and lateral views, ×1 (new); *f–i,* transverse sections, approximately ×1 (Ching, Sun, & Rong, 1976).

Subfamily PSEUDOCYRTININAE Carter, 1994

[Pseudocyrtininae CARTER in CARTER & others, 1994, p. 369]

Fold and sulcus smooth; cardinalia supported by short median septum; microornament absent. *Upper Triassic.*

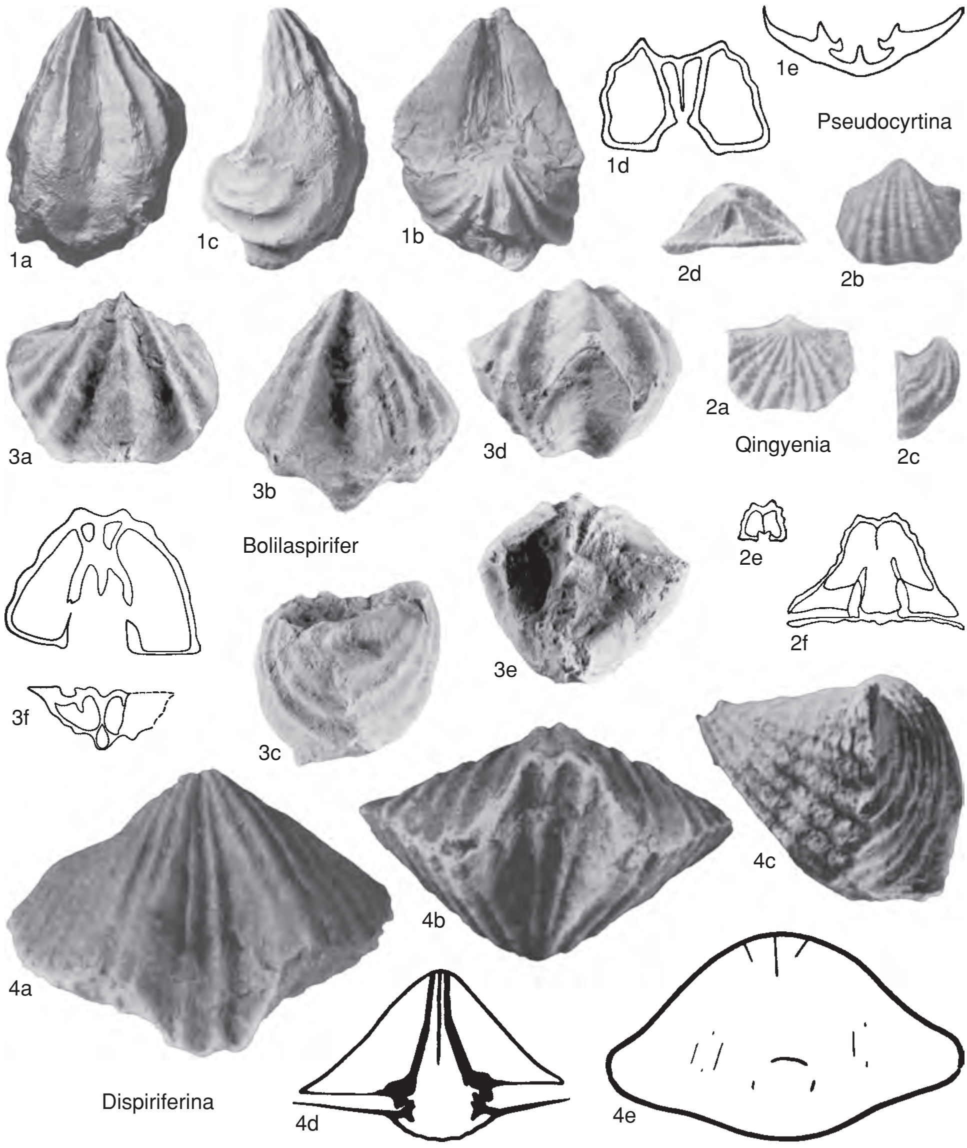

FIG. 1285. Lepismatinidae (p. 1928–1929).

Pseudocyrtina DAGYS, 1962, p. 54 [**P. norica;* OD]. Medium size; strongly and unequally biconvex; ventral valve greatly inflated, subrhomboidal; dorsal valve thinner, evenly convex; ventral interarea high, flattened, catacline or weakly apsacline; fold and sulcus well defined, rounded; lateral slopes with few, coarse, angular plicae; microornament unknown; dental adminicula short, discrete; ventral median septum long, high; ctenophoridium wide, stout; crural bases thickened; jugum unknown. *Upper Triassic (Norian):* Caucasus, Georgia.——FIG. 1285,*1a–e.* **P. norica; a–c,* holotype, ventral, posterior, and lateral views, ×1 (new); *d–e,* transverse sections, approximately ×1 (Dagys, 1963).

Bolilaspirifer SUN, 1981, p. 205 [**B. jomdaensis;* OD]. Small, unequally biconvex; outline transversely subpentagonal; lateral profile subquadrate; cardinal extremities slightly rounded, hinge line slightly less than maximum width; ventral interarea high, slightly concave, nearly catacline; beak acute, slightly incurved; delthyrium open; fold and sulcus well developed, sharply delineated; lateral slopes with few rounded plicae; growth lines imbricate; microornament of imbricate growth lamellae only; high, stout median septum and subparallel dental adminicula united by thin, transverse delthyrial plate; hinge plate complete, concave; jugum unknown. *Upper Triassic:* China.——FIG. 1285,*3a–f.* **B. jomdaensis; a–e,* holotype, dorsal, ventral, lateral, anterior, and posterior views, ×2 (new); *f,* transverse section, approximately ×2.5 (Sun, 1981).

Subfamily DISPIRIFERININAE Carter, 1994

[Dispiriferininae CARTER in CARTER & others, 1994, p. 369]

Entirely ribbed; no dorsal septum. *Middle Triassic–Lower Jurassic.*

Dispiriferina SIBLÍK, 1965, p. 79 [**Spiriferina davidsoni* EUDES-DESLONGCHAMPS, 1855, p. 542; OD]. Medium size; transversely subovate in outline; widest at or near hinge line; cardinal extremities subangular; ventral valve high and subpyramidal; interarea high, flattened, procline; ventral beak straight or slightly incurved; dorsal valve much thinner; fold and sulcus moderately wide; plicae on lateral slopes moderately strong, rounded, well defined, rarely bifurcating, separated by subangular or moderately rounded interspaces; sulcus with pair of simple plicae; microornament apparently absent; dental adminicula very long, close set; ventral median septum long; ctenophoridium small, not bifurcated; jugum simple; punctae poorly known. *Lower Jurassic:* France, Slovakia, Morocco.——FIG. 1285,*4a–e.* **D. davidsoni* (EUDES-DESLONGCHAMPS), Slovakia; *a–c,* ventral, anterior, and lateral views, ×2; *d–e,* transverse sections, ×2 (Siblík, 1965).

Qingyenia YANG & XU, 1966, p. 50 [**Q. spinosa;* OD]. Small; outline subquadrate; ventral valve strongly convex, dorsal valve weakly concave; cardinal extremities subangular or slightly mucronate; maximum width at hinge line; ventral interarea moderately high, concave; delthyrium open; very weak ventral sulcus, fold absent; entire surface of valves covered with few coarse, rounded plicae; each plica with 1 or 2 rows of fine spinules; dental adminicula very short, discrete, subparallel; high median septum connected apically to dental flanges by thin transverse plate, forming very short, false spondylium; ctenophoridium very low; jugum unknown. *Middle Triassic:* China (Guizhou).——FIG. 1285,*2a–f.* **Q. spinosa; a–d,* holotype, dorsal, ventral, lateral, and posterior views, ×2; *e–f,* transverse sections, approximately ×2 (Yang & Xu, 1966).

SPIRIFERINOIDEA

J. L. Carter

[retired from Carnegie Museum of Natural History]

Superfamily SPIRIFERINOIDEA Davidson, 1884

[*nom. correct.* Carter in Carter & others, 1994, p. 370, *pro* superfamily Spiriferinacea Ivanova, 1959, p. 57, *nom. transl. ex* subfamily Spiriferinidae Davidson, 1884, p. 354]

Reticulariiform and subequally biconvex; cardinal extremities well rounded; ventral beak incurved; fold and sulcus usually weakly developed; lateral slopes smooth or obscurely ribbed, rarely with moderately developed ribbing; ventral septum invariably present. *Middle Triassic–Lower Jurassic.*

Family SPIRIFERINIDAE Davidson, 1884

[*nom. transl.* Ivanova, 1959, p. 57, *ex* subfamily Spiriferinidae Davidson, 1884, p. 354]

Lateral slopes smooth or obscurely ribbed. *Middle Triassic–Lower Jurassic.*

Subfamily SPIRIFERININAE Davidson, 1884

[*nom. correct.* Schuchert, 1929, p. 21, *pro* subfamily Spiriferinidae Davidson, 1884, p. 354] [=Spiriferellinae Paeckelmann, 1931, p. 25; Spiriferininae Schuchert, 1929, p. 21]

Reticulariiform; dental adminicula discrete. *Middle Triassic–Lower Jurassic.*

Spiriferina d'Orbigny, 1847, p. 268 [**Spirifer walcotti* J. de C. Sowerby, 1823 in 1823–1825, p. 106; SD Dall, 1877a, p. 64]. Small to medium size; unequally biconvex, ventral valve usually much thicker than dorsal; outline variable from transversely to longitudinally subelliptical; cardinal extremities rounded; ventral umbonal region usually inflated, beak incurved; ventral interarea narrow, concave, apsacline, usually low to moderately high; beak ridges rounded; delthyrium restricted by rarely preserved stegidial plates; fold and sulcus smooth, subangular, moderately wide, moderately developed, moderately well delimited; lateral slopes with few, subangular plicae; dental adminicula short; ventral median septum long; ctenophoridium stout, supported by median septum forming septalium with crural bases in type species; jugum unknown; microornament of dense, fine spinules; punctae moderately fine, not densely spaced. [Davidson (1884) proposed the subfamily Spiriferinidae. Schuchert (1929) proposed a subfamily Spiriferininae as a unit in Davidson's family. Paeckelmann (1931) proposed Spiriferellinae (an incorrect spelling) to replace Schuchert's Spiriferininae for unknown reasons.] *Lower Jurassic:* Europe, North Africa, Saudi Arabia, USA (Alaska).——Fig. 1286,*3a–b.* **S. walcotti* (Sowerby), Liassic, British Islands; dorsal and anterior views, ×1 (Pitrat, 1965).

Calyptoria Cooper, 1989, p. 65 [**C. extensa;* OD] [=*Cingolospiriferina* Pozza, 1992, p. 211 (type, *C. cingolana,* OD)]. Fold and sulcus well developed; lateral slopes with obscure plicae; spinules or other microornament absent; punctae fine; dorsal median septum extending to midvalve; jugum unknown in type species; otherwise similar to *Spiriferina. Lower Jurassic:* Saudi Arabia.——Fig. 1287,*1a–e.* **C. extensa;* holotype, anterior, lateral, dorsal, posterior, and ventral views, ×1 (Cooper, 1989).

Liospiriferina Rousselle, 1977, p. 164 [**Terebratulites rostratus* Schlotheim, 1822, p. 260; OD]. Small to medium; flanks and sulcus not ribbed, smooth; fold and sulcus weakly to moderately developed, often only discernable at anterior commissure; ctenophoridium stout, supported by median septum forming short septalium with crural bases in some specimens of type species; jugum complete, high, and rounded; microornament of anteriorly directed, fine, hollow spinules arranged in quincunx; punctae large and densely spaced. *Lower Jurassic:* Europe, North Africa, Saudi Arabia.——Fig. 1286,*1a–g.* **L. rostrata* (Schlotheim), Germany; *a–e,* holotype, ventral, dorsal, lateral, anterior, and posterior views, ×1 (Logan, 1964); *f–g,* transverse sections, approximately ×1.8 (Rousselle, 1977).

Mentzelioides Dagys, 1974, p. 130 [**Mentzeliopsis meridialis* Dagys, 1963, p. 76; OD]. Medium to large; outline transversely subovate; cardinal extremities well rounded; subequally biconvex; ventral beak acute, slightly incurved; ventral interarea high, nearly catacline; fold poorly developed; sulcus produced anteriorly, smoothly rounded, shallow; anterior margin slightly emarginate; macroornament lacking; microornament of numerous irregularly arranged, hollow spinules that penetrate secondary layer; dental adminicula short, divergent; ventral median septum long, moderately thick apical callus present; short callus suporting ctenophoridium; jugum unknown. *Upper Triassic:* Caucasus, ?Alps, Carpathians.——Fig. 1286,*4a–h.* **M. meridialis* (Dagys), Caucasus; *a–c,* holotype, posterior, ventral, and lateral views, ×1; *d,* microornament, enlarged (new); *e–h,* transverse sections, approximately ×1.5 (Dagys, 1963).

Qinghaispiriferina Sun & Ye, 1982, p. 159 [**Q. obovata;* OD]. Medium size; outline subovate; cardinal extremities well rounded; valves subequally

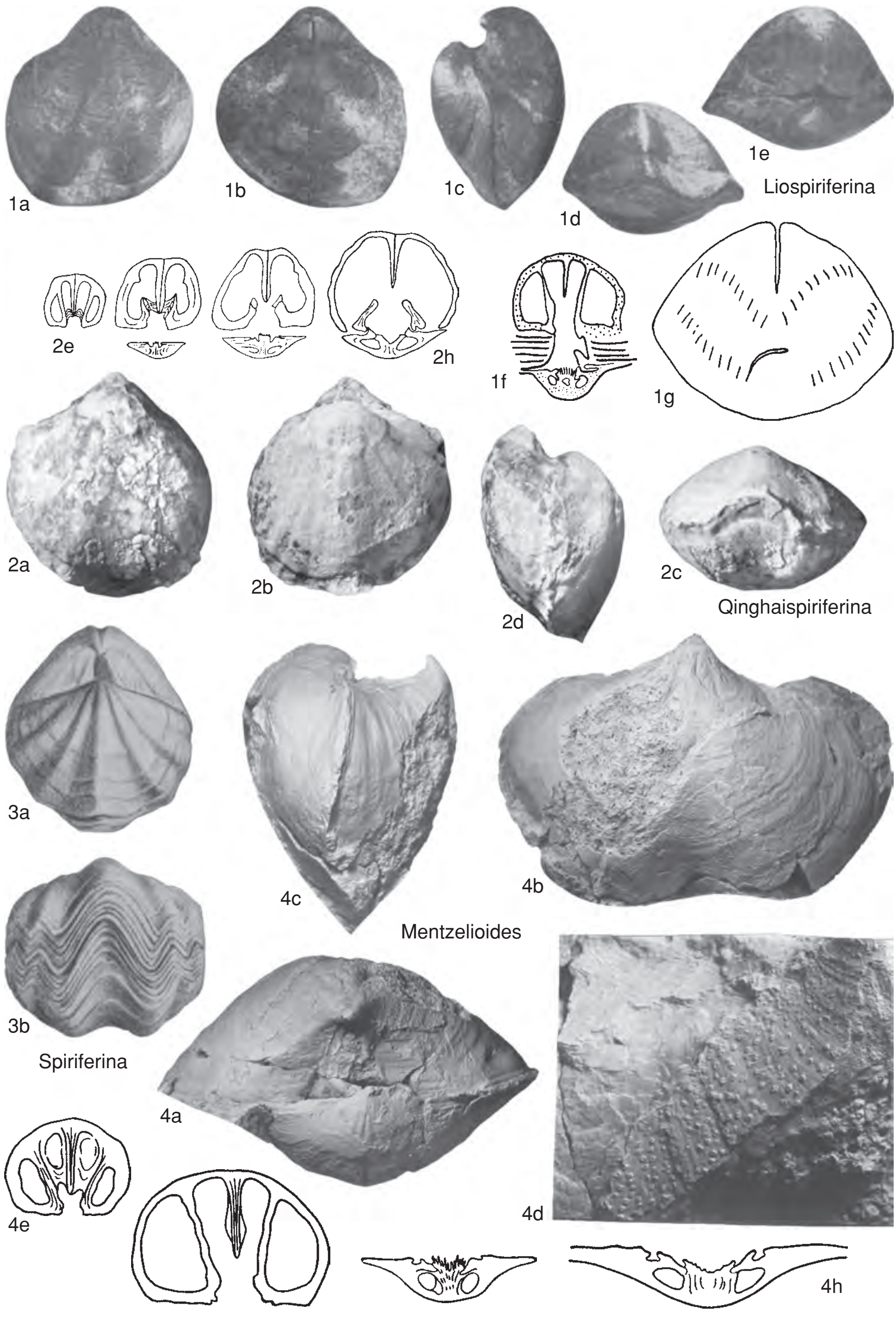

FIG. 1286. Spiriferinidae (p. 1930–1933).

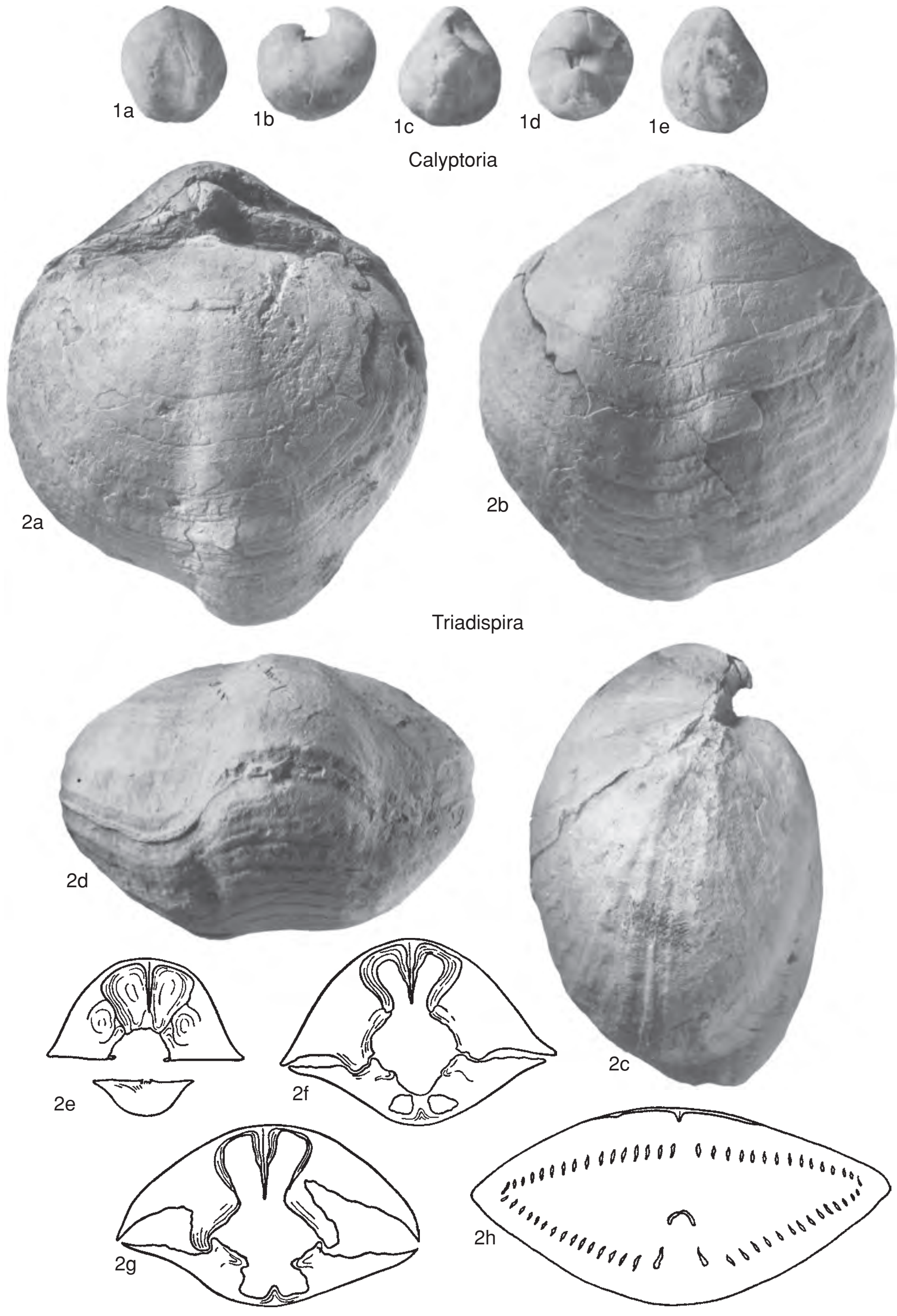

FIG. 1287. Spiriferinidae (p. 1930–1933).

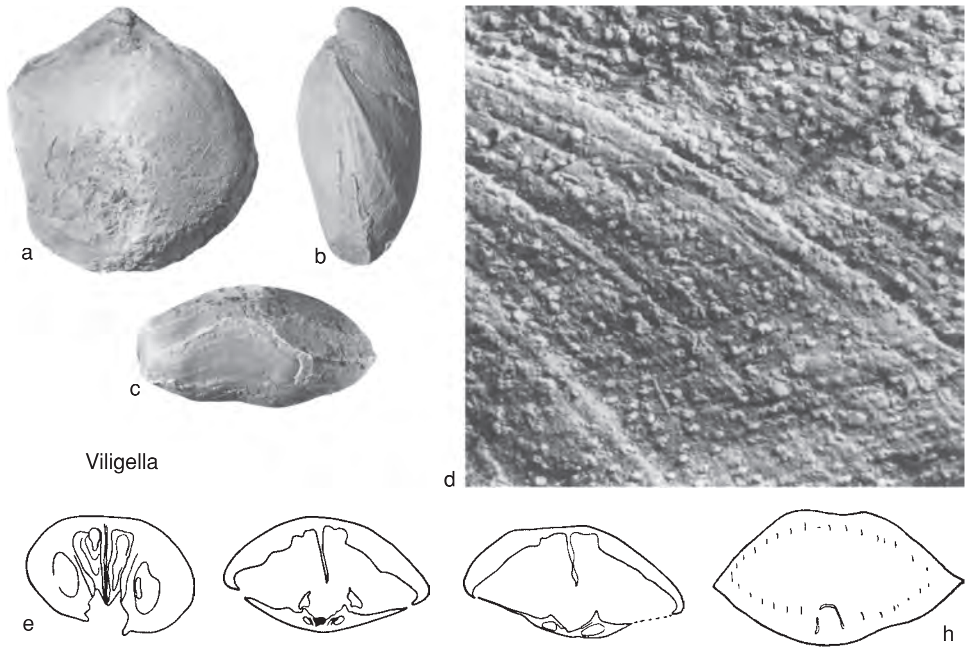

FIG. 1288. Spiriferinidae (p. 1933).

biconvex, ventral valve slightly thicker; ventral beak short, incurved; ventral interarea narrow, concave, apsacline; delthyrium open; fold and sulcus weakly developed, rounded, smooth; anterior commissure uniplicate; lateral slopes with few faint, low ribs; strong growth varices irregularly developed; microornament finely and regularly reticulate; dental adminicula short, stout; stout, high median septum united with dental flanges by short, transverse callus deposit; spondylium absent; dorsal interior posteriorly thickened with callus; ctenophoridium and converging crural bases supported by thick, low median septum or callus; jugum indistinct, apparently broadly V-shaped. *Middle Triassic:* China (Qinghai).——FIG. 1286,*2a–h.* **Q. obovata; a–d,* holotype, ventral, dorsal, anterior, and lateral views, ×2 (new); *e–h,* transverse sections, ×1.7 (Sun & Ye, 1982).

Triadispira DAGYS, 1961, p. 457 [**T. caucasica;* OD]. Large; outline subovate; subequally biconvex; cardinal extremities well rounded, hinge line short; ventral interarea low, concave, strongly apsacline to orthocline; ventral umbonal region broadly inflated, beak incurved; fold and sulcus moderately narrow, rounded, smooth, well defined; macroornament lacking; microornament of fine spinules; both valves with thick apical callus; dental adminicula short, divergent, buried in callus with long, massive median septum; cardinalia supported by short median septum; jugum complete; spiralia with numerous whorls. *Upper Triassic (Norian–Rhaetian):* Georgia (Caucasus Mountains).——FIG. 1287,*2a–h.* **T. caucasica; a–d,* holotype, dorsal, ventral, lateral, and anterior views, ×1 (new); *e–h,* transverse sections, approximately ×1 (Dagys, 1963).

Viligella DAGYS, 1965, p. 116 [**Mentzelia rotunda* TUCHKOV, 1956, p. 180; OD]. Medium size; weakly inflated; outline ovate; fold and sulcus obscurely developed, smooth; hinge line narrow, cardinal extremities well rounded; ventral umbo reduced, broad, beak small, slightly incurved; ventral interarea narrow, low, strongly apsacline; macroornament absent or lateral slopes very obscurely plicate; microornament of fine, dense spinules; dental adminicula very short, with long median septum and thick apical callus; crural bases broadly converging, extending to valve floor; jugum complete, rounded, free. *Upper Triassic (Norian):* northeastern Siberia.——FIG. 1288*a–h.* **V. rotunda* (TUCHKOV); *a–c,* dorsal, lateral, and anterior views, ×1; *d,* microornament, ×10 (new); *e–h,* transverse sections, approximately ×1.2 (Dagys, 1965).

Subfamily PARALABALLINAE Carter, 1994

[Paralaballinae CARTER in CARTER & others, 1994, p. 370]

Cyrtiniform; fold and sulcus weakly developed; ornament absent; dental adminicula discrete, thin, short, subparallel. *Upper Triassic.*

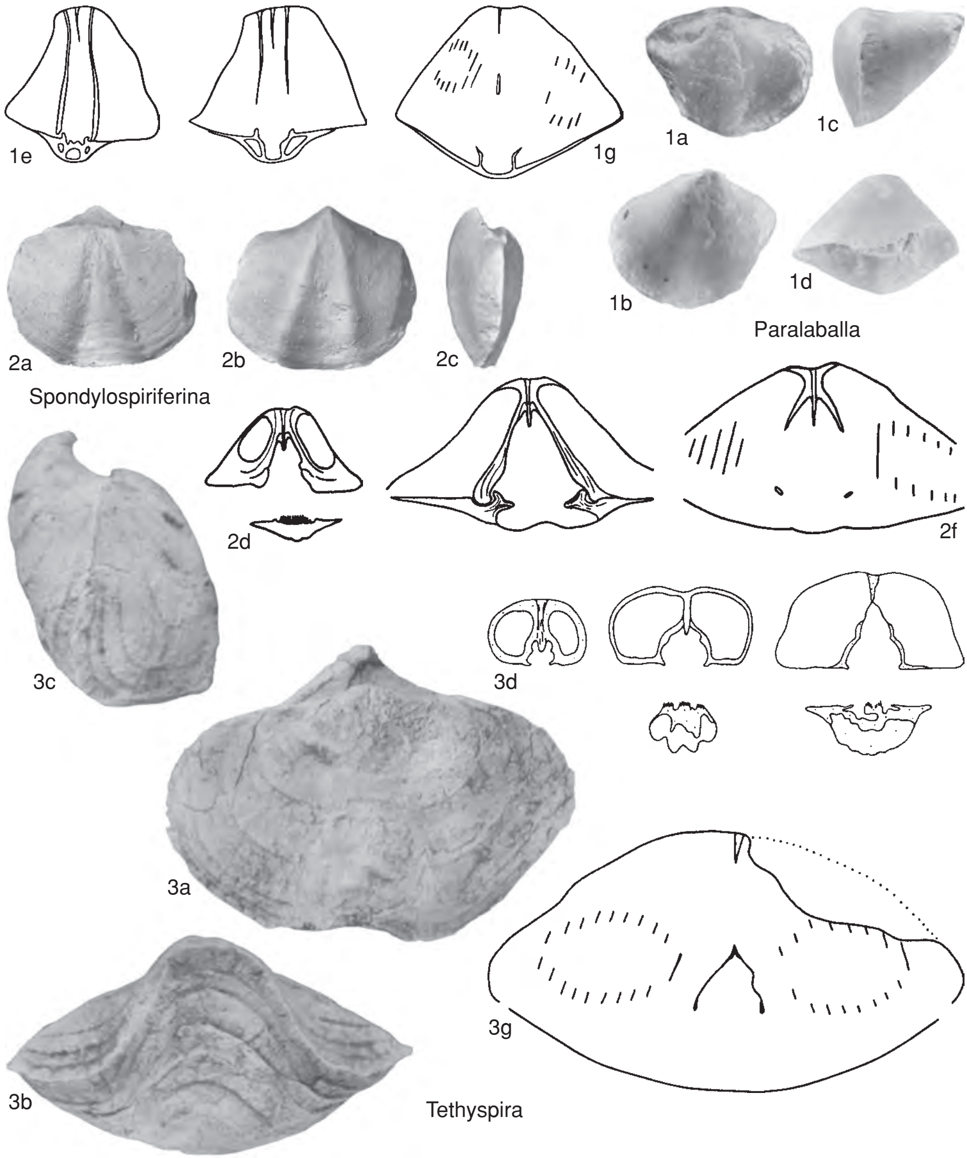

FIG. 1289. Spiriferinidae (p. 1934–1936).

Paralaballa SUN, 1981, p. 204 [**P. zangbeinensis;* OD]. Medium size; roundly rhomboidal in outline, semipyramidal in lateral profile; fold and sulcus weakly developed; hinge line shorter than maximum width, cardinal extremities obtusely rounded; ventral interarea high, flat, catacline; delthyrium open, narrow; dorsal interarea very low; ornament absent; dental adminicula thin, short, subparallel, with high median septum; hinge plate complete with subparallel dorsal adminicula fused to crural bases; ctenophoridium low; jugum unknown. *Upper Triassic:* Tibet.——FIG. 1289,*1a–g.* **P. zangbeinensis; a–d,* dorsal, ventral, lateral, and anterior views, ×1 (new); *e–g,* transverse sections, approximately ×1.5 (Sun, 1981).

Subfamily MENTZELIINAE Dagys, 1974

[Mentzeliinae DAGYS, 1974, p. 138]

Dental adminicula absent. *Middle Triassic–Upper Triassic.*

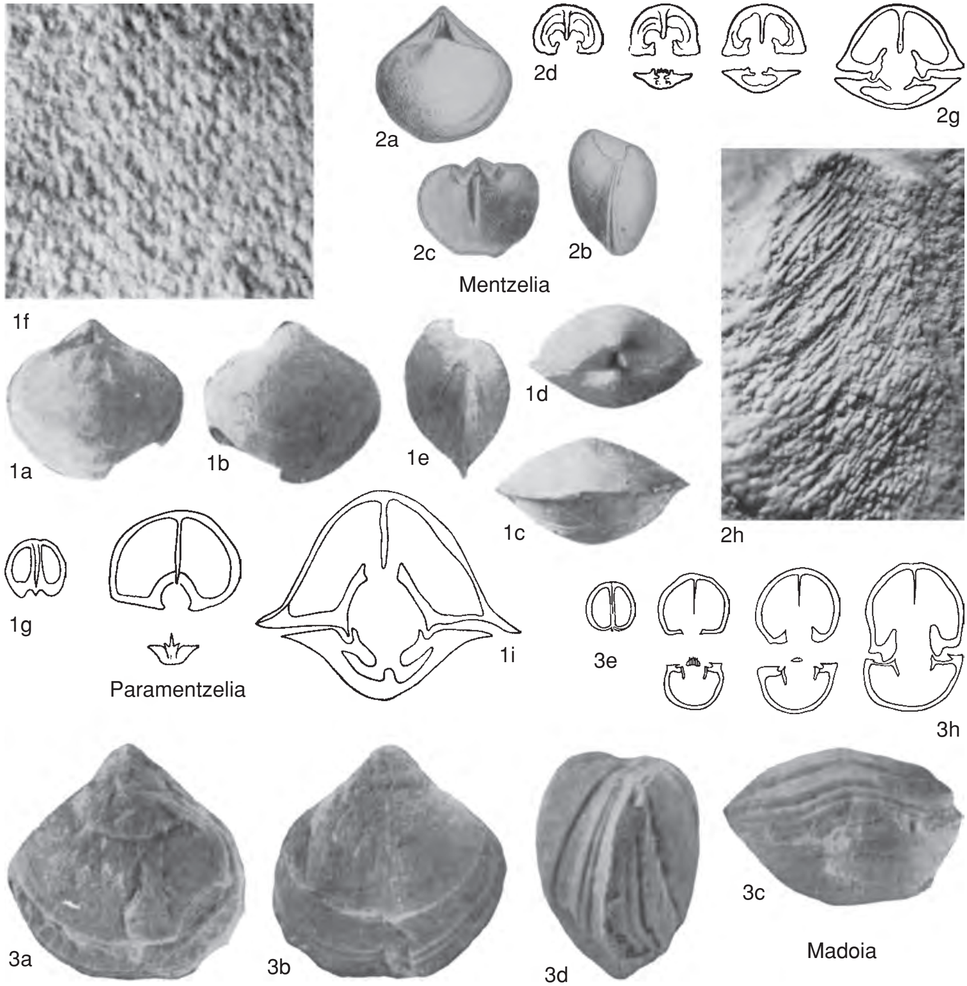

FIG. 1290. Spiriferinidae (p. 1935–1936).

Mentzelia QUENSTEDT, 1871 in 1868–1871, p. 522 [**Spirifer medianus* QUENSTEDT, 1852 in 1849–1875, p. 482; OD; =*Spirifer mentzeli* DUNKER, 1851, p. 287]. Medium size; subequally biconvex; outline subovate, cardinal extremities well rounded; ventral umbonal region slightly compressed, beak incurved; ventral interarea low to moderately high, smooth, concave, apsacline; fold and sulcus lacking or variably developed, smooth and rounded, if present; macroornament usually lacking, rarely with few obscure plicae; microornament of very dense, fine spinules; high median septum apically fused with short dental flanges forming false spondylium; jugum incomplete. *Middle Triassic–Upper Triassic:* Tethyan geosyncline.——FIG. 1290,*2a–h*. **M. mentzeli* (DUNKER), Middle Triassic, Germany; *a–c,* dorsal, lateral, and ventral interior views, approximately ×1 (Quenstedt, 1871 in 1868–1871); *d–g,* transverse sections, approximately ×2 (Dagys, 1963); *h,* microornament, ×12 (new).

Madoia SUN & YE, 1982, p. 162 [**M. rostrata;* OD]. Small to medium size; outline subovate to rounded subpentagonal; cardinal extremities well rounded; valves equally biconvex; hinge line narrow; ventral interarea narrow, concave, low, delthyrium open; ventral umbonal region broad, short, slightly compressed, beak incurved; fold and sulcus lacking posteriorly, poorly developed anteriorly, anterior commissure weakly uniplicate; surface smooth except for strong subimbricate growth varices; microornament absent; dental adminicula and true spondylium absent; small, false spondylium formed in beak by fusion of median septum and dental flanges; median septum long, thick; ctenophoridium with discrete, vertically inclined crural bases; jugum unknown. *Middle Triassic:* China

(Qinghai).——Fig. 1290,*3a–h.* **M. rostrata; a–d,* dorsal, ventral, anterior, and lateral views, ×2; *e–h,* transverse sections, ×3.3 (Sun & Ye, 1982).

Paramentzelia Xu, 1978, p. 293 [**P. ovata;* OD]. Medium size; fold and sulcus absent or weakly developed anteriorly; microornament densely papillose; false spondylium very short, high, shallow; dental adminicula absent; moderately long, stout median septum supporting cardinalia; cardinal process bladelike; jugum unknown; otherwise similar to *Mentzelia. Upper Triassic:* China.——Fig. 1290,*1a–i.* **P. ovata; a–e,* dorsal, ventral, anterior, posterior, and lateral views, ×1; *f,* microornament, ×10; *g–i,* transverse sections, approximately ×2 (Xu, 1978).

Subfamily TETHYSPIRINAE Carter, 1994

[Tethyspirinae Carter in Carter & others, 1994, p. 370]

Spondylium present. *Middle Triassic (Ladinian)–Upper Triassic (Carnian).*

Tethyspira Siblík, 1991, p. 167 [**T. persis;* OD]. Medium to large; moderately and subequally biconvex; outline transversely subelliptical, cardinal extremities well rounded; ventral beak small, incurved; ventral interarea apsacline, sharply delimited; fold and sulcus well developed, moderately wide, rounded; macroornament generally lacking except for strong growth varices; very faint costae may be present on whole surface in some specimens; microornament absent; spondylium long, deep, moderately elevated, bisected by very long median septum; ctenophoridium and complete V-shaped jugum present. *Middle Triassic (Ladinian):* Iran.——Fig. 1289,*3a–g.* **T. persis; a–c,* holotype, dorsal, anterior, and lateral views, ×1; *d–g,* transverse sections, approximately ×1.4 (Siblík, 1991).

Spondylospiriferina Dagys, 1972a, p. 38, *nom. transl.* Carter, herein, *ex Pennospiriferina (Spondylospiriferina)* Dagys, 1972a, p. 38 [**Pennospiriferina (Spondylospiriferina) glabra;* OD]. Medium size; unequally biconvex, ventral valve moderately inflated, dorsal valve flattened; slightly wider than long, outline subovate; cardinal extremities weakly rounded or rarely subangular; fold and sulcus well defined, rounded, smooth; ventral interarea low, concave, smooth; lateral slopes smooth; microornament absent; converging dental adminicula bisected by median septum slightly above floor of valve, forming low, deep spondylium; wide, low ctenophoridium supported by callus; jugum, if any, unknown. *Middle Triassic (Ladinian)–Upper Triassic (Carnian):* northeastern Siberia, Japan, New Zealand.——Fig. 1289,*2a–f.* **S. glabra,* Carnian, northeastern Siberia; *a–c,* holotype, dorsal, ventral, and lateral views, ×1 (new); *d–f,* transverse sections, approximately ×2 (Dagys, 1972a).

Family SINUCOSTIDAE Xu & Liu, 1983

[*nom. transl.* Carter in Carter & others, 1994, p. 370, *ex* Sinucostinae Xu & Liu, 1983b, p. 112]

Lateral slopes ribbed; dental adminicula discrete. *Middle Triassic–Upper Triassic, ?Lower Jurassic.*

Subfamily SINUCOSTINAE Xu & Liu, 1983

[Sinucostinae Xu & Liu, 1983b, p. 112]

Dorsal septum absent. *Middle Triassic–Upper Triassic, ?Lower Jurassic.*

Sinucosta Dagys, 1963, p. 104 [**Spirifer emmrichi* Suess, 1854, p. 52; OD] [?=*Guseriplia* Dagys, 1963, p. 107 (type, *G. multicostata,* OD)]. Small; outline subovate; cardinal extremities rounded, hinge line narrow; unequally biconvex, ventral valve strongly inflated, subconical; ventral interarea high, concave, smooth; fold and sulcus very weakly developed, poorly differentiated; entire surface multicostate, ribs numerous, mostly simple; microornament of densely spaced, short spinules; dental adminicula short; median septum long, high, with anterior process; cardinalia sessile with nearly vertical, short dorsal adminicula; jugum complete, flattened, fimbriate. *Middle Triassic–Upper Triassic, ?Lower Jurassic:* Tethyan geosyncline.——Fig. 1291,*2a–g.* **S. emmrichi* (Suess); *a–c,* dorsal, ventral, and lateral views, ×1 (new); *d–g,* transverse sections, approximately ×2 (Dagys, 1963).

Mentzeliopsis Trechmann, 1918, p. 229 [**M. spinosa;* OD]. Small to medium size; outline subovate; cardinal extremities rounded, hinge line less than maximum width; ventral interarea low, delthyrium open; fold and sulcus well delineated, moderately wide, rounded; lateral slopes with few weak to moderately strong, low, rounded plicae; growth varices strong, irregularly spaced, moderately lamellose; microornament of concentrically arranged, coarse, hollow spinules; dental adminicula stout, divergent, with strong median septum; jugum unknown. *Middle Triassic (Ladinian):* New Zealand.——Fig. 1291,*1a–e.* **M. spinosa; a–b,* dorsal and ventral valves; *c,* dorsal view of internal mold, ×1 (Trechmann, 1918); *d,* dorsal valve, ×1; *e,* ventral valve, ×0.75 (Marwick, 1953).

Qispiriferina Xu & Liu, 1983b, p. 117 [**Q. subrotunda;* OD]. Medium size; outline subovate; subequally biconvex, moderately inflated; cardinal extremities well rounded, hinge line narrow; ventral beak incurved, interarea apsacline, delthyrium open; fold and sulcus weakly to moderately developed and delineated, smooth; sulcus shallow, bottom flattened; fold low, flattened; lateral slopes with

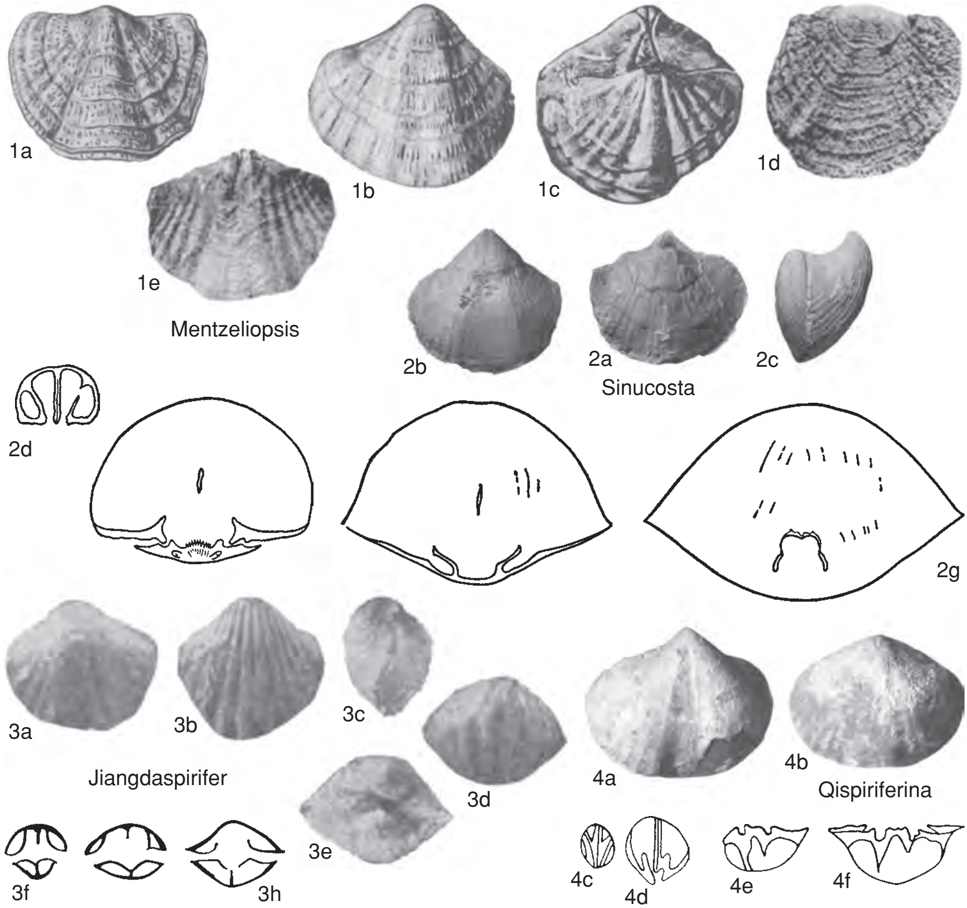

FIG. 1291. Sinucostidae (p. 1936–1937).

moderately numerous, weak, low, rounded costae; microornament unknown; dental adminicula very short with long, high median septum and short apical callus; cardinalia supported by thin callus, with variably developed short, vertical dorsal adminicula; jugum unknown. *Middle Triassic:* China (Qinghai).——FIG. 1291,*4a–f.* **Q. subrotunda; a–b,* syntypes, ventral and dorsal valves, ×1 (new); *c–f,* transverse sections, magnification unknown (Xu & Liu, 1983b).

Subfamily JIANGDASPIRIFERINAE Carter, 1994

[Jiangdaspiriferinae CARTER in CARTER & others, 1994, p. 371]

With dorsal median septum. *Upper Triassic.*

Jiangdaspirifer CHEN & others, 1986, p. 74 [**J. tongpuensis;* OD]. Very small, subovate, subequally biconvex; maximum width near midlength; maximum thickness attained slightly posterior to midlength; delthyrium open; hinge line short, interarea triangular; fold and sulcus weakly developed, sometimes indistinct; dental adminicula widely set, diverging, with long median septum; cardinal process indistinct; hinge plate complete, supported by thin, high median septum; spiralia with 3 to 4 whorls; jugum and microornament unknown. *Upper Triassic:* Tibet.——FIG. 1291,*3a–h.* **J. tongpuensis; a–e,* ventral, dorsal, lateral, anterior, and posterior views, ×4; *f–h,* three transverse sections, approximately ×1 (Chen & others, 1986).

THECIDEIDA

PETER G. BAKER

[University of Derby]

Order THECIDEIDA Elliott, 1958

[*nom. transl.* WILLIAMS & others, 1996, p. 1,193, *ex* suborder Thecideidina ELLIOTT, 1965c, p. 858, *nom. correct. pro* Thecideoidea ELLIOTT, 1958, p. 373]

Small articulates, shell usually attached by cementation, without pedicle, rarely free, outline variable and irregular, cicatrix of variable size; valves hinged by unsupported cyrtomatodont teeth and sockets, permitting abnormally wide gape, usually smooth externally, commonly tuberculate internally; no obvious mantle canal markings or ovarian scars; ventral valve usually with well-developed, normally apsacline interarea with convex or flat pseudodeltidium, geniculation commonly sharp at anterior boundary of cicatrix, giving rise to well-developed, free ventral wall, 2 diductor muscle scars prominent, 2 median and 2 lateral, adductor muscle scars usually less conspicuous, sessile or raised hemispondylium commonly present, housing diductor and median adductor muscle scars; dorsal valve essentially lidlike, commonly with small, hypercline interarea with undifferentiated chilidium, square usually bilobed cardinal process, well-developed, inner socket ridges, crura usually converging and uniting to form bridge, subperipheral rim usually present and tuberculate, simple or divided median septum, or digitate, or exceptionally with spiralia, brachial lobes and lophophore grooves commonly present, lateral adductor muscle scars usually conspicuous; shell thick, sculptured internally by shell resorption, fibrous secondary shell forming a continuous lining in all early representatives, progressively replaced by granular shell in later representatives, usually with endopunctae. Mantle thin, outer mantle lobe with periostracal slot, without marginal setae in adult, spicules present or absent in mantle; lophophore thin, centripetal, schizolophous or ptycholophous (exceptionally trocholophous or spirolophous); muscles paired, not branching, muscle scars smooth. *Upper Triassic–Holocene.*

INTRODUCTION

The typical thecideide shell (Fig. 1292,*1–3*) is strongly ventribiconvex with clearly marked growth lines and a rectimarginate, anterior commissure. The ventral valve is characterized by a variably sized cicatrix of attachment and a well-developed, apsacline interarea with differentiated pseudodeltidium. The dorsal valve is essentially lidlike, commonly with a small interarea that is usually hypercline. Internally, the principal features of the ventral valve are unsupported cyrtomatodont teeth and sessile or raised hemispondylium (Fig. 1292,*4–5*). The dorsal valve (Fig. 1292,*6–9*) is characterized by a well-developed cardinal process, conspicuous, lateral, adductor muscle scars, subperiperal rim, and crura converging and uniting to form a bridge (or supporting exceptionally the spiralia in *Thecospira*) (Fig. 1292,*6*). Anteriorly, the mantle cavity is partitioned normally by a simple or divided median septum to form brachial cavities that house a schizolophous, ptycholophous, or exceptionally spirolophous lophophore. The lophophore is commonly confined to channels formed by the development of skeletal, brachial lobes. The brachial lobes are fragile and have considerable and often confusing variation in morphology resulting from both original form and damage due to transportation (Fig. 1292,*7–8*).

The full taxonomic potential of shell microstructure remains to be realized. The shell is thick, commonly tuberculate, and normally endopunctate. In most genera the shell microstructure differs in dorsal and ventral

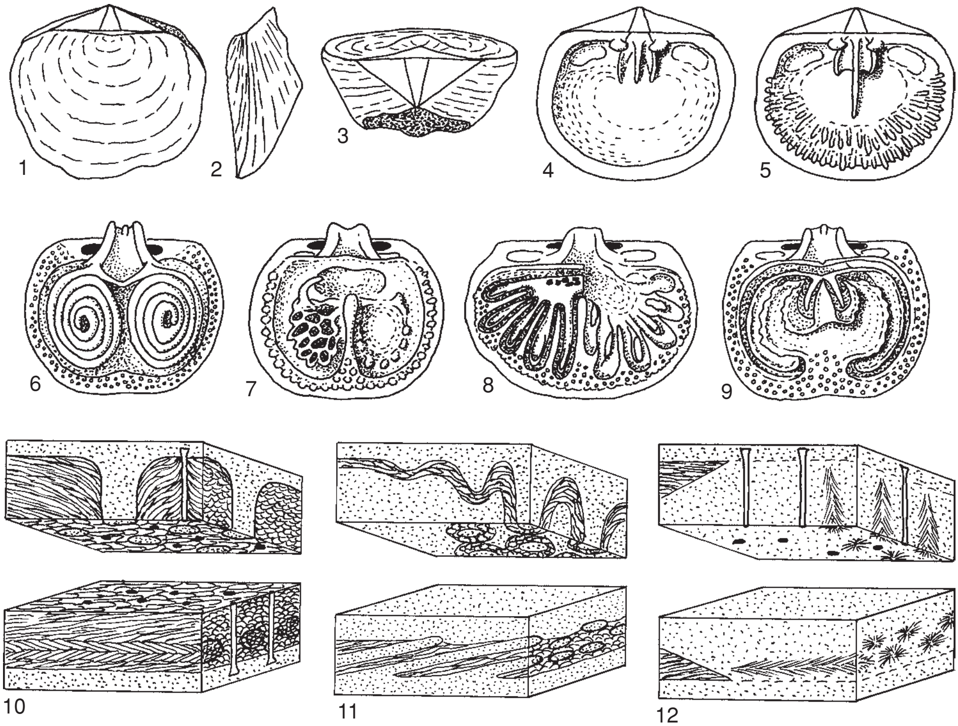

FIG. 1292,*1–12.* Various thecideide morphological and shell microstructural characters; *1–3,* dorsal, lateral, and posterior views of shell; *4–5,* ventral valve interiors showing *4,* sessile and *5,* raised hemispondylium; *6–9,* dorsal valve interiors showing *6,* crura supporting spiralium in *Thecospira; 7,* monoseptate condition with bridge and canopied brachial lobes, undamaged (left) and damaged (right) in *Eothecidellina; 8,* polyseptate condition with reticulum and undamaged brachial lobes interdigitating with septa (left) and typically preserved, damaged state (right) in *Thecidiopsis; 9,* ramulate condition with interdigitating brachial lobes in *Lacazella; 10–12,* block diagrams showing microstructure of dorsal and ventral valves; *10,* continuous lining of secondary shell, typical of Upper Triassic and Lower Jurassic genera; *11,* fibrous secondary shell partially suppressed but well represented in many Middle Jurassic to Lower Cretaceous genera; *12,* fibrous secondary shell sporadic in occurrence, almost completely replaced by granular calcite, typical of Upper Cretaceous to Holocene genera (new).

valves (Fig. 1292,*10–12*). Fibrous secondary shell formed a continuous lining in all early representatives of the group. Fibrous secondary shell was progressively replaced by granular cacite in all taxa from the Middle Jurassic to Early Cretaceous. By the Late Cretaceous fibrous secondary shell had been almost completely suppressed or reduced to vestigial patches associated with the hinge teeth and inner socket ridges. The changes proceeded at different rates and had been largely accomplished by the end of the Jurassic in the Lacazellinae and Thecideinae; but fibrous secondary shell layers persisted into the Early Cretaceous in the Moorellininae and to the end of the Cretaceous in the Thecidellininae.

Their small size, cemented habit, and strongly convergent, external morphological similarity have always posed problems for classification of thecideide brachiopods. The abnormally wide gape facilitates postmortem disarticulation of valves, and even limited transportation ensures the spatial separation of dorsal from attached ventral valves. Traditionally, therefore, classification relied heavily on the internal morphology of the more commonly available, separated dorsal valves (Fig. 1292,*6–9*) and, to a much lesser extent, on ventral valves (Fig. 1292,*4–5*).

Particular attention has always been paid to the lophophore skeletal supports preserved in the dorsal valve. Unfortunately, the brachial lobes almost always failed to survive transportation without damage but were described as diagnostic without reference to their damaged state. The confusion in thecideide taxonomy resulting from previous failure to differentiate between damaged and undamaged lophophore skeletal supports should not be underestimated. Diagnoses unsupported by evidence from sectioned, whole shells must always remain open to suspicion.

A number of studies, notably those of ELLIOTT (1948a, 1953a), BACKHAUS (1959), RUDWICK (1968), SMIRNOVA (1969a, 1984), WILLIAMS (1973), and BAKER (1990, 1991), enable us to establish the general course of evolution within the Thecideida, although major gaps in our knowledge of Early Triassic to Early Jurassic events remain. Because of their supposed neotenous origin, however, the sytematic position of thecideides has remained a matter of controversy, with the Terebratulida (ELLIOTT, 1965c), Spiriferida (WILLIAMS, 1973; BAKER, 1990) and Strophomenida (RUDWICK, 1968; BAKER, 1970a; PAJAUD, 1970; GRANT, 1972; DAGYS, 1972c; BENIGNI & FERLIGA, 1989) being favored as the main ordinal contenders. All the foregoing opinions were reviewed comprehensively by BAKER (1990, 1991). The assignment of the group to the Spiriferida derived from the more recent studies detailing comprehensively the morphology, ontogeny, and shell microstructure, which enabled us to see more clearly the general drift of genetic change within the group. Previous opinions regarding the systematic position of thecideides had focused too rigidly on the importance of cementation and the presence of a pseudodeltidium. The significance of cyrtomatodont teeth, fibrous secondary shell, and tubercles and the importance of shell resorption in sculpturing the broad configuration of lophophore supports had received too little consideration. The current assignment of ordinal status to the group (WILLIAMS & others, 1996) takes into account the recent understanding of the anatomy, molecular biology, shell morphology, ontogeny, and phylogeny of the phylum and avoids the difficulty of identifying which of the several widely recognized orders of spire bearers should contain thecideides included in a taxon of subordinal rank.

Recent investigations of thecideide origin have resurrected the historically favored idea of a terebratulide or strophomenate ancestor, but so far phylogenetic analyses using parsimony have failed to identify a sister group of the thecideides. This may be explained by the lack of fossils with the key morphological features preserved. Difficulties are exacerbated by the lack of a solid phylogenetic framework for the thecideides as a whole.

Molecular-sequence data using terebratulides (COHEN & GAWTHROP, 1997; COHEN, GAWTHROP, & CAVALIER-SMITH, 1998) tentatively identified thecideides as a sister group of the short-looped terebratulidines. Unfortunately, the results from 18S rDNA analysis failed to realize their early promise (B. L. COHEN, personal communication, in JAECKS, 2001, p. 243). Parsimony-based studies were conducted (JAECKS, 2001; JAECKS & CARLSON, 2001) using terebratulide, strophomenate, and spire-bearing outgroups. Although the outgroups used together or separately show thecideides to be consistently monophyletic, it has not proved possible to root specifically the thecideide tree. Most terebratulide-rooted trees have the Jurassic genus *Eudesella* basal and result in the stratigraphic inversion of many distal clades within the oldest members in derived positions. These problems together with doubt regarding the 18S rDNA analysis indicate that terebratulides and thecideides appear to share relatively little beyond fibrous shell structure and the possession of endopunctae. Endopunctae with perforated canopies, however, are characteristic of terebratulides throughout their geological history and also permeate the shells of thecideides and Jurassic spiriferinoids (MACKINNON, 1971), although being sporadically suppressed in some thecideides. It is considered that the cytological (as well as the microstructural) complexities of terebratulide and thecideide caeca and endopunctae rule out homoplasy. The coincidence of the uniqueness of character of endopunctae with perforated canopies suggests that terebratulides, thecideides, and some endopunctate spiriferides are monophyletic with a stem group of pre-Devonian age; and also that endopunctae with perforated canopies represent evidence of an ancestral link (WILLIAMS, 1973, 1997) between thecideides and spiriferides. Differences between strophomenate and spire-bearer rooted phylogenies are suprisingly minor and mainly infer differing synapomorphies. Choice of outgroup taxa seems to have relatively little effect on the first-order pattern of relationships, perhaps because these or any other outgroup taxa that might have been chosen share too few characters with the ingroup to afford them much power to polarize characters.

Parsimony-based phylogenies do, however, provide useful information regarding ingroup relationships and show that the general categorization of thecideides as paedomorphic is open to challenge. Although results support the traditional interpretation of decrease in body size and reduction or loss of fibrous secondary shell as paedomorphic patterns, other characters such as the evolution of more complex brachidia from smaller, more simple forms may be regarded as an example of peramorphosis. Typically thecideide characters such as the dorsal median septum do not appear with the origins of the Thecideida but appear later in its evolution. A narrow, bladelike septum (thecidelliniform) is broadly paraphyletic, but trees where it is paraphyletic with respect to the Thecideidae (lacazelliform) imply a large stratigraphic gap, although lacazelliform and thecidelliniform morphotypes have coexisted since the Jurassic.

Unweighted cladograms reveal clearly a complex mosaic of different evolutionary processes affecting thecideides since their appearance but unfortunately reveal little about their origin, possibly because early thecideides and their ancestors share too few characters to make the link possible. In the absence of a clear pointer from the evolution of thecideide shell fabric, basic shell microstructure again emerges as a critical factor. In all cladistic analyses, species nearest the root all retain a full complement of fibrous secondary shell, inferring that this represented the thecideide ancestral state and that the reduction or loss of the secondary layer is a derived feature. A comprehensive review of shell microstructure (WILLIAMS, 1997) clearly establishes the structural and functional differences between the pseudopunctae of strophomenides and the endopunctae of thecideides and also the essential differences between strophomenide and thecideide shell fabrics. Spiral arc growth patterns and the orthodox stacking (WILLIAMS, 1968a, 1968b; BAKER, 1970a) of calcitic fibers of fibrous secondary shell so characteristic of terebratulides, spire-bearing brachiopods, and early Mesozoic thecideides contrast sharply with the laminar secondary fabric of strophomenides in which the basic building blocks of laminae are sets of lath or blade-shaped crystallites contiguously aligned with their lateral junctions in various stages of amalgamation. Traces of blade sets may be disposed at acute angles to one another in successive laminae to form a cross-bladed fabric. Even so far as fibrous-shelled strophomenide plectambonitoids such as *Aegiromena* are concerned, the orthodoxly stacked fibers dominating the outer secondary shell fabric soon give way to an inner layer composed of lathlike fibers with their edges commonly overlapping in a way very similar to the Silurian chonetidine laminar sheet precursor (BRUNTON, 1972). In addition their wide geochronological separation offers little reassurance of the probability of a link between the shell microstructure of plectambonitoids and thecideides. In any event, forms such as *Aegiromena* indicate a progression toward laminar shell rather than progression toward the granular calcite shell seen in thecideides.

Pseudopunctae are an unmistakable feature of the strophomenide shell and resemble superficially thecideide tubercles, probably because both are initiated by a similar sort of spiral dislocation, i.e., spirally arranged laminae (or fibers) around a cylindroid core in the former and rosettes of spirally arranged fibers around a cylindroid core in the latter. A pseudopuncta typically appears as an anteriorly inclined trail of cone-in-cone deflections affecting the entire secondary laminar (or fibrous in plectambonitoids) fabric and emerging on the internal surface of the valve as a tubercle.

In early strophomenoids the rosettes of conically disposed laminae form a concentric layering around a core of solid calcite or of tilted fragments of discrete laminar sets (WILLIAMS & BRUNTON, 1993). In many other strophomenoids and especially in plectambonitoids, the pseudopunctae have a distinctive rod of calcite (taleola) with a calcified surface patina that sharply separates it from the surrounding laminae. Contrary to earlier belief, the taleola is not composed of crystalline calcite as etched taleolae are found to have a porous fabric permeating the entire structure.

Tubercle cores in thecideides and denticles in spiriferides are composed of granular calcite and are continguous with the granular primary layer. They may be considered to have arisen from small clusters of epithelial cells that continued to secrete (primary) granular calcite. Tubercles originate near the outer boundary of the subperipheral rim and deflect adjacent fibrous shell material. As the shell increases in size they are truncated by shell resorption and buried beneath subsequently deposited shell. Although it is probable that strophomenide pseudopunctae lacking taleolae originated on a thin, granular primary layer, pseudopunctae with taleolar cores show the taleola base resting unconformably on laminar shell (or fibrous in plectambonitoids; WILLIAMS & BRUNTON, 1993). As strophomenates lack the ability to resorb shell, taleolae are never truncated and continue to penetrate laminae as internal tubercles until they are overdraped by subsequently deposited laminae. As yet no thecideide with tubercle cores composed of perforated calcite has been discovered. Thus although the morphological expression of tubercles and taleolae is similar, tubercles are structurally and functionally different from psuedopunctae.

From the point of view of structure, location, and capacity for resorption, the internal tubercles of terebratelloid kraussinids and megathyrids are arguably homologous with those of thecideide thecospiroids (SMIRNOVA & POPIEL-BARCZYK, 1991). If the physiological implication is considered, thecideide tubercles and spire-bearer denticles are genetically much more similar to each other than either are to strophomenate taleolae. Leaving aside differences in shell microstructure and the fact that the secretory processes involved in the formation of tubercles and taleolae are fundamentally different, the actual fabrication of the whole shell needs to be considered. The strophomenate shell is fashioned principally by the process of accretion (as exemplified by the deltidiodont teeth). In thecideides, in addition to the sculpturing of cyrtomatodont teeth, the physiological processes involved in the simultaneous accretion and resorption of large tracts of shell in maintaining the relative position of the subperipheral rim during enlargement of the brachial cavities, the configuration of the brachial lobes, and the development and relative displacement of lateral septa must have been complex.

Identical processes appear to have operated in the fabrication of the shell and spiralia of spire-bearers. The main differences between strophomenates, thecideides, and spire-bearers therefore appear to lie in the basic shell microstructure pattern and the fabrication of the shell itself. The precisely controlled accretion-resorption regime operative during the fashioning of the thecideide and spire-bearer shells must be regarded as being far more sophisticated than the simple accretion regime adopted by strophomenates. Admittedly the mechanism and genetics of shell resorption remain unknown, but added to the established differences in shell microstructure, the complex physiological processes involved in fashioning their shells surely places thecideides closer to a cyrtomatodont fibrous-shelled spire-bearer than to a strophomenate ancestor.

Enallothecidea remains problematical as it tends to root with the rhynchonellate outgroups, and its inclusion in analyses affects the rooting position of *Thecospira.* Its exclusion is equally problematical because although trees are stabilized with *Thecospira* returned to a basal position, its removal to a rhynchonellate outgroup jeopardizes the view that cementation is diagnostic (GRANT, 1972) of strophomenates. *Enallothecidea* may be important as a link with the thecideide ancestor as current research shows that very early juvenile thecideides also lacked a median septum, and the subperipheral rim was initially confined to posterolateral sectors of the dorsal valve, indicating that *Enallothecidea* is probably paedomorphic (neotenous).

It may be concluded that the complex of contemporaneous paedomorphic and peramorphic patterns, complicated by homoplasy and heterotopy, which parsimony-based analyses reveal, must include a number of environmentally induced and geographically sustainable adaptations. Thecideides are possibly not an appropriate experimental group since, without doubt, niche constraints result in a high level of homoplasy both in contemporaneously associated and geographically isolated but stratigraphically concurrent populations. The addition of data on new genera will increase the coherence of ingroup evolutionary patterns.

In addition, new data on early ontogeny may result in a clearer picture of thecideide origin. It may be possible eventually to test the hypothesis that the emergence of thecideides resulted from a catastrophic late Permian or Early Triassic event during which a population (of juveniles) survived in a protected (cryptic) niche to subsequently evolve paedomorphically into a form that bore little resemblance to their adult ancestors. In any event, the paucity of our knowledge of the number of early thecideide representatives and the almost complete absence of information regarding their early ontogeny, together with, at best, a hazy recognition of diagnostic ancestral characters, means that establishing a link between Thecideida and its sister group remains a distant prospect.

THECOSPIROIDEA

Peter G. Baker

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Superfamily THECOSPIROIDEA Bittner, 1890

[*nom. transl.* Dagys, 1972c, p. 96, *ex* Thecospiridae Bittner, 1890, p. 310]

Shell smooth, less frequently pustulose, cemented by ventral umbo, cicatrix relatively large; ventral interarea variably developed, variably inclined, commonly with undifferentiated pseudodeltidium; dorsal interarea not develped or vestigial, hemispondylium rarely developed, subperipheral rim thickened and commonly tuberculate, crura variably developed, median septum variably developed; lophophore supported by calcareous brachidia of variable structure, brachial lobes not developed, lophophore grooves present exceptionally, lateral adductor muscle scars not developed; fibrous secondary shell continuous or well represented in both valves. *Upper Triassic.*

Family THECOSPIRIDAE Bittner, 1890

[Thecospiridae Bittner, 1890, p. 310]

Shell commonly with traces of pustulose ornament; ventral interarea moderate, orthocline to apsacline; pseudodeltidium undifferentiated; dorsal valve initially weakly convex, later shallowly concave; dorsal interarea vestigial, hypercline; ventral muscle scars small, separated by low myophragm; cardinal process high, functionally bilobed but united medianly to form tripartite structure; inner socket ridges recurved; subperipheral rim tuberculate; well-demarcated adductor muscle field divided by poorly developed, median septum; crura short, supporting a pair of spirally coiled, calcareous ribbons directed ventrolaterally, brachial ribbons sharply folded throughout length to give asymmetrically U-shaped cross section; commonly impunctate; fibrous secondary shell forming continuous lining in both valves; lophophore spirolophous. *Upper Triassic.*

Thecospira Zugmayer, 1880, p. 152 [**Thecidea haidingeri* Suess, 1854, p. 43; OD] [=*Thecospiropsis* Dagys, 1974, p. 75 (type, *Thecospira semseyi* Bittner, 1912, p. 41)]. Outline transversely elliptical, pseudodeltidium usually precisely flush with interarea, ornament in form of small, tear-shaped pustules with faint traces of radial costellae commonly present on well-preserved specimens; subperipheral rim strongly thickened, spicules possibly associated with spiralia. [*Thecospiropsis* is morphologically inseparable from *Thecospira,* its separation being based solely on the absence of endopunctae in *Thecospiropsis* ("only pseudopunctate forms" of Dagys, 1974, p. 75). In view of the known variation in the distribution of endopunctae in other thecideidine genera and the uncertainty regarding their occurrence in *Thecospira* species (Benigni & Ferliga, 1989), it is considered that separation is unjustified. *Thecospiropsis* is therefore considered to be a synonym of *Thecospira.*] *Upper Triassic:* Europe.——Fig. 1293,*1a–f.* **T. haidingeri* (Suess); *a–d,* dorsal, ventral, lateral, posterior views, Rhaetian, Kitsberg, Austria, ×3; *e,* oblique posterior view of spiral brachidium exposed by grinding and polishing, showing crus (*c*) and jugum (*j*), Rhaetian, Kitsberg, Austria, ×4.5 (Rudwick, 1968); *f,* dorsal valve interior, Carnian, Cortina D'Ampezzo, Italy, ×4 (Benigni & Ferliga, 1989).——Fig. 1293,*1g. T. tenuistriata* Bittner, Carnian, Cortina D'Ampezzo, Italy; ventral valve interior, ×5 (Benigni & Ferliga, 1989).——Fig. 1293,*1h–i. T. semseyi* Bittner, Carnian, Vesprem, Hungary; *h,* dorsal view of ventral valve showing detached spiral brachidium, ×4; *i,* possible spicules associated with brachidium, ×8 (Dagys, 1974).——Fig. 1293,*1j–p. T. tyrolensis* (Loretz), Carnian, Cortina D'Ampezzo, Italy; serial transverse sections through posterior part of shell, 0.5, 1.05, 2.1, 3.4, 4.6, 6.6, 7.2 mm from umbo, ×7 (adapted from Benigni & Ferliga, 1989).

Family THECOSPIRELLIDAE Dagys, 1972

[Thecospirellidae Dagys, 1972c, p. 97]

Shell markedly inequivalve; ventral valve very deep, pseudodeltidium convex, with ventral median septum extended posterodorsally to unite with pseudodeltidium; dorsal valve flattened or concave,

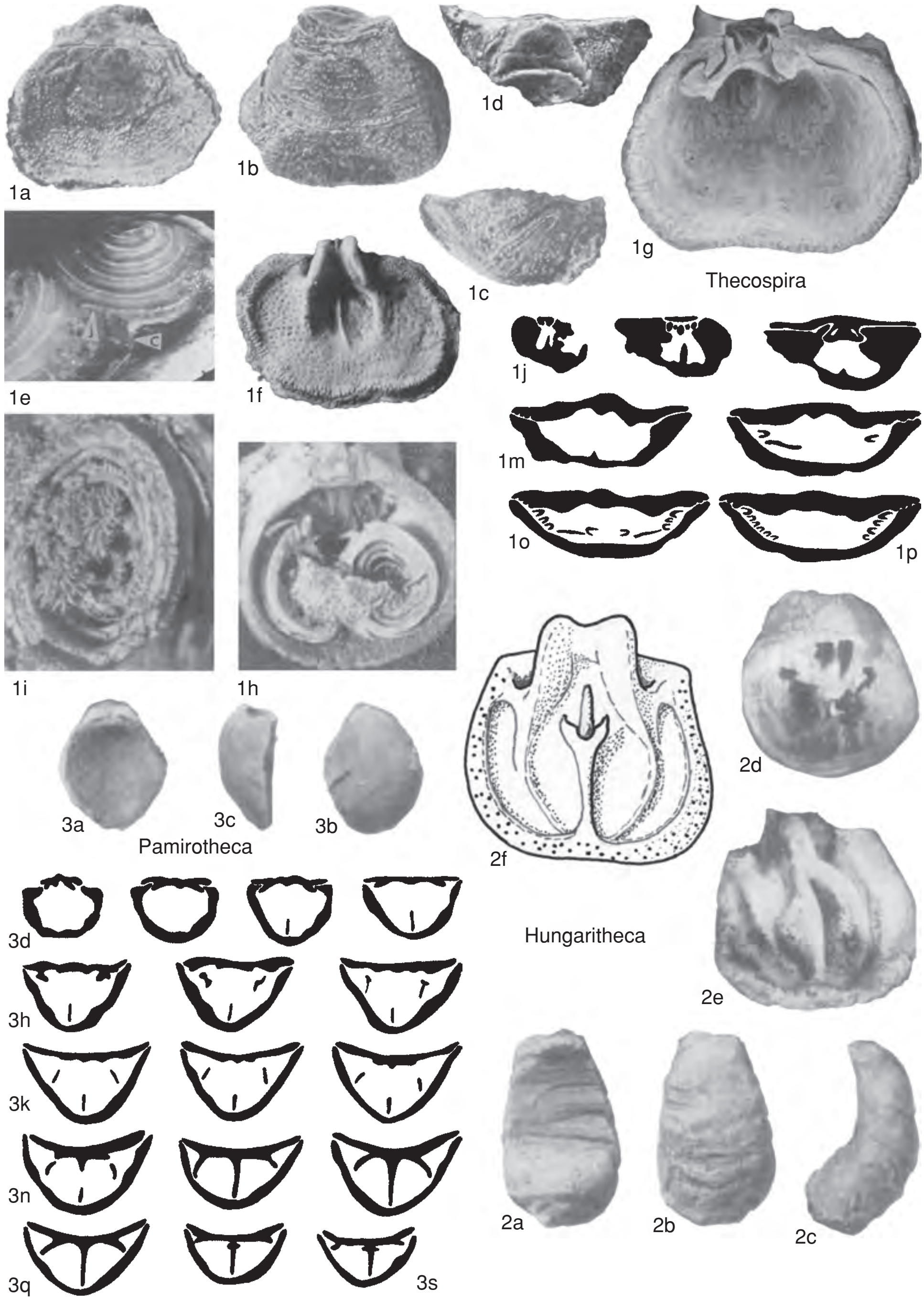

FIG. 1293. Thecospiridae and Hungarithecidae (p. 1944–1947).

without interarea, socket ridges short, subperipheral rim commonly with scalloped ornament, median septum low and divided, and relatively complex brachidium consisting essentially of pair of double, slightly divergent, slender, hamate structures connected by jugum and directed posteroventrally over body cavity; endopunctate; lophophore probably ptycholophous. *Upper Triassic.*

Thecospirella Bittner, 1912, p. 46 [**T. loczyi;* OD]. Shell elongate-pyriform, relatively small; ventral valve commonly with shallow, anterior sulcus; subperipheral rim with scalloped ornament; brachial apparatus consisting of pair of anterolaterally placed septa arising from subperipheral rim and of short, completely bifurcated, median septum (from walls of which hamate structures arise); regularly endopunctate. [Previous citations of *Thecospirella* as 1900 are erroneous. The 1912 citation is the first mention by Bittner of the genus.] *Upper Triassic (Carnian):* southern Alps, Hungary.——Fig. 1294,*1a–v.* **T. loczyi,* Vesprem, Hungary; *a–c,* dorsal, lateral views, ventral valve interior, ×5; *d,* lateral view of breached shell, showing partially preserved, brachial apparatus, ×6; *e,* young dorsal valve interior, showing partially preserved, brachial apparatus, ×10 (Dagys, 1974); *f,* dorsal valve interior, reconstruction, ×9 (adapted from Dagys, 1972c); *g–v,* serial transverse sections, 0.2, 0.6, 0.9, 1.2, 1.3, 1.5, 1.9, 2.1, 2.3, 2.6, 2.8, 2.9, 3.1, 3.4, 3.5, 3.6 mm from umbo, ×5 (adapted from Dagys, 1974).

Bittnerella Dagys, 1974, p. 77 [**B. bittneri;* OD]. Larger than *Thecospirella;* ventral valve almost conical without anterior sulcus, almost catacline interarea and pseudodeltidium clearly differentiated; brachial apparatus delicate without anterolateral elements, brachial supports arising from short, posteriorly bifurcating, median septum; endopunctae extensively branching. *Upper Triassic:* southern Alps, Hungary, Pamir.——Fig. 1294, *2a–q.* **B. bittneri,* Carnian, Shindy Gorge, Pamir; *a–d,* dorsal, anterior, lateral, posterior views, ×3 (Dagys, 1974); *e–q,* serial horizontal sections, 1.4, 1.7, 1.8, 2.1, 2.4, 2.6, 2.8, 2.9, 3.1, 3.2, 3.4, 3.6, 3.8 mm from origin, ×3.5 (adapted from Dagys, 1974).

Family HUNGARITHECIDAE Dagys, 1972

[Hungarithecidae Dagys, 1972c, p. 97]

Shell inequivalve, ventral interarea and pseudodeltidium variable; ventral valve without median septum; dorsal valve normally without interarea, cardinal process relatively massive, brachidium consisting of possible crural plates of different height, fully or partly joined to floor of valve, extending from inner socket ridges and merging at anterior margin with high, median septum; endopunctate; lophophore probably schizolophous. *Upper Triassic (Carnian).*

Subfamily HUNGARITHECINAE Dagys, 1972

[*nom. transl.* Dagys, 1974, p. 80, *pro* Hungarithecidae Dagys, 1972c, p. 97]

Shells ventribiconvex, ventral interarea high, pseudodeltidium flush with surface; structure resembling sessile hemispondylium present; brachidium in form of low plates united with valve floor for their entire length; possibly endopunctate; shell microstructure unknown. *Upper Triassic (Carnian).*

Hungaritheca Dagys, 1972c, p. 97 [**Thecospira andreaei* Bittner, 1912, p. 44; OD]. Elongate with hinge line approximately equal to maximum width; ventral valve strongly convex with relatively small cicatrix, ventral muscle field on platform slightly elevated anteriorly and divided by septal ridge; dorsal valve moderately convex, with low structure resembling interarea, median septum high, sometimes bifurcating along posterior, ventral edge, subperipheral rim ornamented by pits thought to represent endopunctae. *Upper Triassic (Carnian):* Hungary.——Fig. 1293,*2a–f.* **H. andreaei* (Bittner), Vesprem; *a–c,* dorsal, ventral, lateral views, ×3; *d–e,* ventral valve, dorsal valve interiors, ×4 (Dagys, 1974); *f,* dorsal valve interior, reconstruction, ×5 (adapted from Dagys, 1972c).

Subfamily PAMIROTHECINAE Dagys, 1974

[Pamirothecinae Dagys, 1974, p. 79]

Shells concavoconvex, ventral interarea low, pseudodeltidium obscured, cicatrix strongly developed; brachidium in form of high, subhorizontal plates free posteriorly but coalescing with floor of valve anteriorly; endopunctate; fibrous secondary shell well represented in both valves. *Upper Triassic (Norian–Rhaetian).*

Pamirotheca Dagys, 1974, p. 79 [**P. aulacothyridiformis;* OD]. Shell elongately oval; ventral valve moderately convex; dorsal valve uniformly concave,

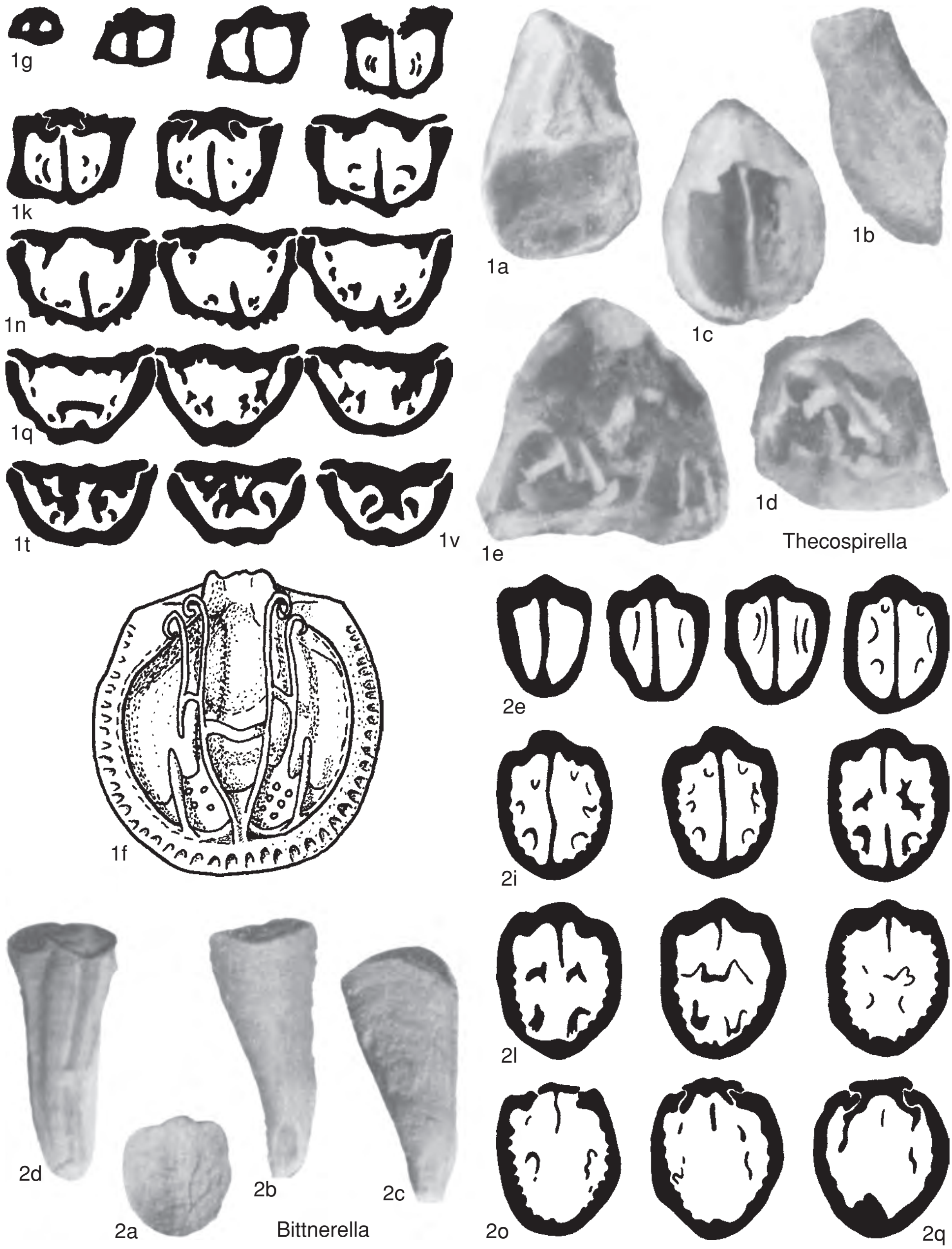

FIG. 1294. Thecospirellidae (p. 1946).

median septum very high, posteriorly free. *Upper Triassic (Norian–Rhaetian):* Pamir.——FIG. 1293,*3a–s*. **P. aulacothyridiformis; a–c,* dorsal, ventral, lateral views, ×3 (Dagys, 1974); *d–s,* serial transverse sections, 0.4, 0.55, 0.65, 0.75, 0.95, 1.15, 1.45, 1.65, 1.85, 2.25, 2.65, 3.15, 3.55, 4.15, 5.15, 5.55 mm from umbo, ×4 (adapted from Dagys, 1974).

THECIDEOIDEA

PETER G. BAKER

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Superfamily THECIDEOIDEA Gray, 1840

[*nom. transl.* TERMIER & TERMIER, 1949b, p. 59, *ex* Thecideidae GRAY, 1840, p. 151]

Typically smooth, ventribiconvex shells, ventral interarea normally well developed, normally apsacline with pseudodeltidium normally well differentiated, usually tuberculate internally; hemispondylium normally present, variably developed; dorsal valve normally weakly convex, dorsal interarea variably developed, sockets defined by pair of prominent inner socket ridges fused medially with undifferentiated wedge of shell material to form bilobed cardinal process, complete bridge over dorsal body cavity, absent exceptionally, median septum simple or divided or exceptionally lacking, with or without lateral septa extending from anterior margin to terminate posteriorly, brachial lobes and lophophore grooves usually present, lateral adductor muscle scars normally conspicuous; usually endopunctate; fibrous secondary shell forming continuous lining in Triassic and Lower Jurassic representatives, or rarely in Middle to Upper Jurassic representatives; lophophore schizolophous or ptycholophous or exceptionally trocholophous; marsupium present in some species. *Upper Triassic–Holocene.*

Family ENALLOTHECIDEIDAE Baker, 1983

[*nom. transl.* BAKER, herein, *ex* Enallothecideinae BAKER, 1983, p. 664]

Minute shells, strongly ventribiconvex, pyriform, with small, apical cicatrix, ventral interarea orthocline to anacline; interior undivided, without tubercles, ventral valve without hemispondylium; dorsal valve without interarea, crura, median septum, brachial lobes, or lophophore grooves, lateral adductor muscle scars inconspicuous; endopunctate; fibrous secondary shell continuous in both valves; lophophore probably trocholophous. *Middle Jurassic (upper Aalenian)–Upper Jurassic (middle Oxfordian).*

Enallothecidea BAKER, 1983, p. 664 [**Thecideum pygmaeum* MOORE, 1861, p. 96; OD]. Ventral valve with characteristic, ladle-shaped, lateral profile, cicatrix tuberose, ventral interarea poorly defined, pseudodeltidium small, not completely closing delthyrium anteriorly; subperipheral rim incomplete, confined to lateral and posterolateral regions of dorsal valve; densely endopunctate. *Middle Jurassic (upper Aalenian)–Upper Jurassic (middle Oxfordian):* southern England, *upper Aalenian.*——FIG. 1295*a–e.* **E. pygmaea* (MOORE), upper Aalenian, Cotswolds; *a–c,* dorsal, anterior, lateral views; *d–e,* dorsal valve, ventral valve interiors, ×50 (Baker, 1983).

Family THECIDELLINIDAE Elliott, 1958

[Thecidellinidae ELLIOTT, 1958, p. 373]

Small, monoseptate forms, ventral interarea apsacline, pseudodeltidum rarely convex, usually internally tuberculate, dorsal mantle cavity bilobed, arising from development of simple, bladelike median septum, persistent throughout ontogeny, brachial lobes with or without intrabrachial cavities; usually endopunctate; fibrous secondary shell usually forming continuous lining in Middle to Upper Jurassic representatives, well represented to heavily suppressed but present in both valves from Lower Cretaceous to Holocene; lophophore schizolophous; spicules present in mantle of some species. *Upper Triassic–Holocene.*

Subfamily THECIDELLININAE Elliott, 1953

[Thecidellininae ELLIOTT, 1953a, p. 700]

Ventral interarea anacline exceptionally; dorsal interarea absent exceptionally, tuberculate forms with brachial lobe skeletal elements arising from base of dorsal median septum and floor of valve usually anastomosing to form canopies over intrabrachial cavi-

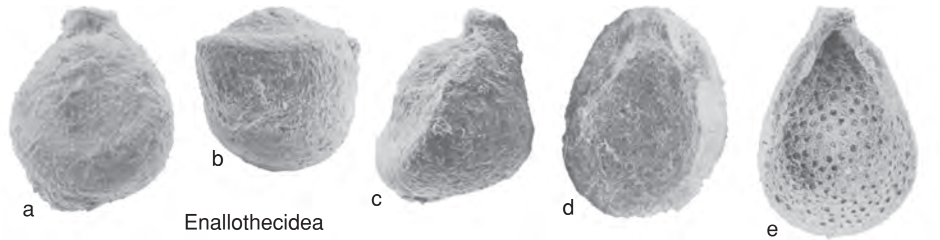

FIG. 1295. Enallothecideidae (p. 1948).

ties, brachial lobes exceptionally extended posteriorly as reticulum overarching body cavity; impunctate exceptionally. *Middle Jurassic (upper Bathonian)–Holocene.*

Thecidellina THOMSON, 1915d, p. 462 [**Thecidium barretti* DAVIDSON, 1864, p. 17; OD] [=*Thecidellella* HAYASAKA, 1938, p. 9 (type, *T. japonica*)]. Ventral interarea clearly developed with poorly differentiated pseudodeltidium, hemispondylium U-shaped sessile or raised without supporting septum; dorsal valve with wide, peripheral flange, long, relatively thick, median septum arching over body cavity, almost reaching bridge, bridge with posteriorly directed spur reaching base of cardinal process, brachial lobes elongate with brachial ridges secondarily elaborated by spiny processess that may anastomose to form canopies, fragile reticulum present, lophophore muscle scars present; fibrous secondary shell heavily suppressed in both valves with acicular crystallite tracts present; spicules present. [*Thecidellella* resembles *Thecidellina* except for the accessory shelly structure ("reversed spondylium" of HAYASAKA, 1938, p. 10) between the bridge and posterior end of the median septum in the dorsal valve. The distinction is slight and the structure also occurs in *Thecidellina* spp. (COOPER, 1954a); *Thecidellella* therefore is considered to be a synonym of *Thecidellina.*] *Paleogene (Eocene)–Holocene:* Alabama, *Eocene;* West Indies, southeastern North Atlantic (Cape Verde Islands), *Holocene;* Pacific Ocean, Indian Ocean, *Miocene–Holocene.*——FIG. 1296,*2a–h.* **T. barretti* (DAVIDSON), Holocene, off Rio Bueno, north-central Jamaica; *a–c,* dorsal, anterior, lateral views; *d,* hypotype, posterior view, USNM 461945, ×10 (new); *e,* dorsal valve interior; *f,* dorsal valve anterior view; *g,* dorsal valve profile, lateral view; *h,* hypotype, dorsal valve, oblique posterior view, USNM 461946, ×10 (new).——FIG. 1296,*2i–j. T. blochmanni* (DALL), Holocene, Christmas Island; *i,* ventral valve interior; *j,* hypotype, ventral valve interior showing hemispondylium, BMNH BD9139, ×15 (new).

Bifolium ELLIOTT, 1948a, p. 2 [**Thecidium faringdonense* DAVIDSON, 1874, p. 23; OD]. Pyriform with small cicatrix, ventral interarea indistinct and curved laterally, pseudodeltidium weakly convex and flush with interarea, hinge line very short, hemispondylium sessile, formed from low median ridge flanked by parallel pair of higher lateral ridges; dorsal valve moderately convex without interarea, relatively strongly thickened, lateral adductor muscle scars constricted by root of prostrate, relatively massive cardinal process, bridge with posteriorly directed spur, females with marsupial notch, brachial ridges almost circular, brachial lobe skeletal elements forming loosely reticulate canopies; fibrous secondary shell strongly suppressed in both valves, acicular crystallite tracts present in dorsal valve. [Endopunctae, with scattered distribution, occur in juvenile dorsal valves only; adult shells are apparently impunctate.] *Lower Cretaceous (Hauterivian–upper Aptian):* southwestern Asia, *Hauterivian;* Europe, *upper Aptian.*——FIG. 1297,*2a–t.* **B. faringdonense* (DAVIDSON), upper Aptian, Faringdon, southern England; *a,* dorsal view; *b,* oblique anterior view; *c,* oblique lateral view; *d,* posterior view; *e,* dorsal valve interior, ×13 (Baker, 1991); *f,* dorsal valve posterior view; *g,* hypotype, dorsal valve interior showing typical state of brachial lobe preservation, BMNH BD9134; *h,* ventral valve interior, ×13; *i,* hypotype, ventral valve interior showing profile view of hemispondylium, BMNH BD9135, ×25; *j–t,* serial horizontal sections showing morphology of brachial lobes, 0.375, 0.425, 0.475, 0.5, 0.55, 0.6, 0.625, 0.675, 0.7, 0.725, 0.75 mm from free ventral wall, ×9 (new).

Eothecidellina BAKER, 1991, p. 816 [**Thecidiopsis (Thecidiopsis) bohemica imperfecta* NEKVASILOVÁ, 1967, p. 115; OD]. Roughly pyriform with shallow, ventral, anterior sulcus, cicatrix rounded triangular, relatively large, free ventral wall well developed, giving characteristic triangular lateral profile, ventral interarea anacline to apsacline, well defined with flat pseudodeltidium; dorsal valve with interarea, cardinal process with pronounced dorsal deflection, brachial lobes similar to *Bifolium* but canopy anterior perforations sealed by subsequent thickening, lophophore muscle scars present; fibrous secondary shell continuous in ventral valve, heavily suppressed in dorsal valve. [In *Eothecidellina,* as in *Bifolium,* the brachial lobes are invariably broken in separated valves so that intrabrachial cavities are exposed as two roughly oval depressions, characteristically ringed by damaged canopy skeletal

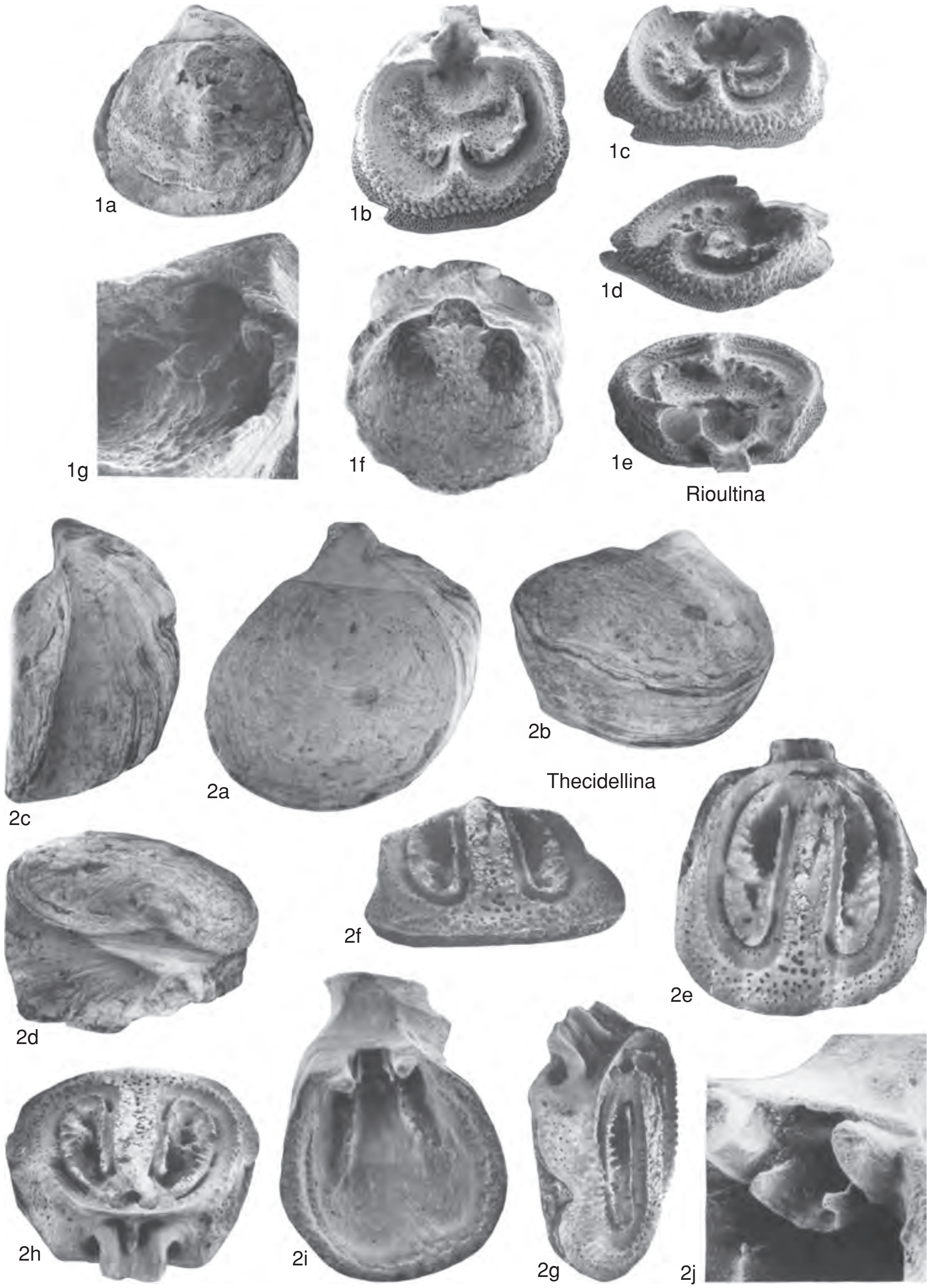

FIG. 1296. Thecidellinidae (p. 1949–1953).

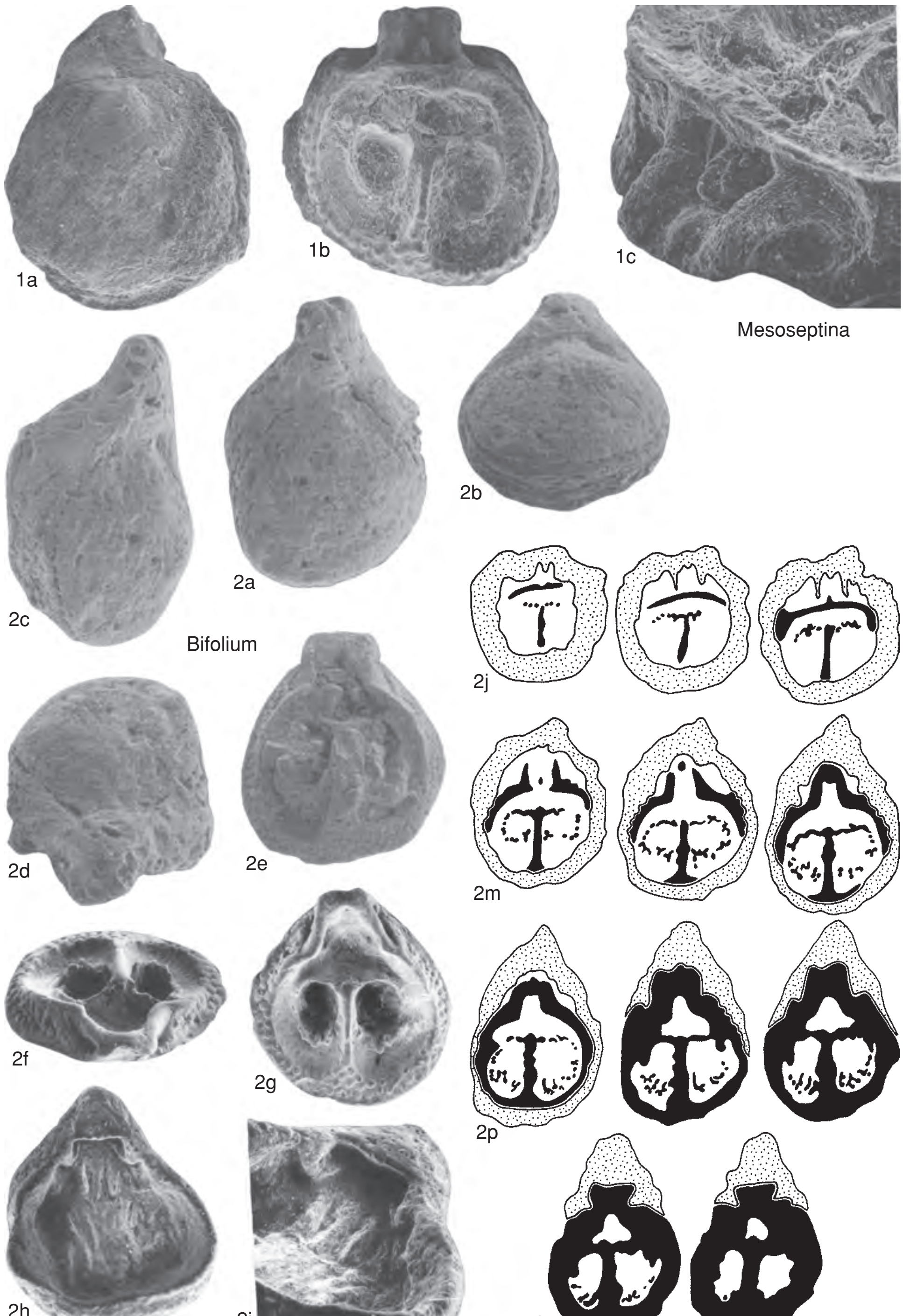

FIG. 1297. Thecidellinidae (p. 1949–1953).

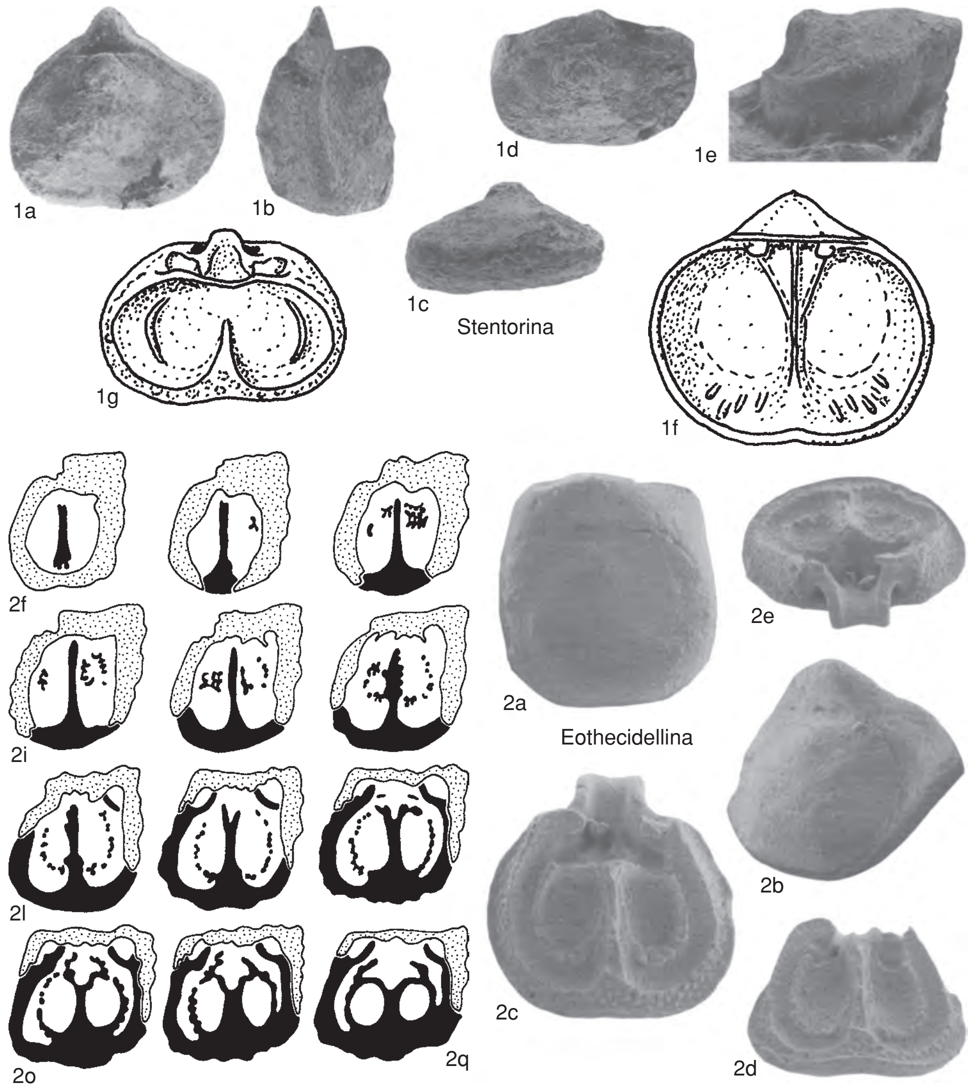

FIG. 1298. Thecidellinidae (p. 1949–1953).

supports (BAKER, 1991).] *Upper Cretaceous (upper Cenomanian):* Czech Republic, Slovakia.——FIG. 1298,*2a–q.* **E. imperfecta* (NEKVASILOVÁ), Zbyslav, Bohemia, Czech Republic; *a,* dorsal view; *b,* oblique lateral view, ×12; *c,* dorsal valve interior; *d,* dorsal valve anterior view; *e,* dorsal valve posterior view, ×13 (Baker, 1991); *f–q,* serial horizontal sections showing morphology of brachial lobes, 0.18, 0.22, 0.26, 0.28, 0.32, 0.34, 0.38, 0.42, 0.46, 0.48, 0.52, 0.56 mm from free ventral wall, ×10 (new).

Mesoseptina MUÑOZ, 1994, p. 167 [**M. minima;* OD] [=*Midiseptina* MUÑOZ, 1989, *nom. nud.*]. Pyriform with relatively small cicatrix and well-developed free ventral wall, ventral interarea flat with undifferentiated pseudodeltidium, internally with sessile, myophore-like hemispondylium with low median and lateral ridges; dorsal valve subcircular with small, hypercline interarea exceptionally, cardinal process incipiently trilobed, bridge with well-developed, dorsal, posteriorly directed apophysis, brachial lobes superficially similar to *Bifolium* but ridgelike without tuberculate elaboration, intrabrachial cavities not developed or vestigial, anteriorly placed depressions exceptionally, lophophore muscle scars present; fibrous secondary shell heavily suppressed, restricted to inner socket ridges of dorsal valve, possibly endopunctate. *Upper Cretaceous (Santonian–lower Maastrichtian):* northeastern Spain, *Santonian.*——FIG. 1297,*1a–c.* **M. minima,* Santonian, Serra del Montsec, south central Pyrenees; *a,* dorsal view; *b,* dorsal valve interior, ×30; *c,* dorsal valve interior, oblique posterior view showing apophysis, ×60 (Muñoz, 1994).

Rioultina PAJAUD, 1966b, p. 631 [**Thecidea triangularis* D'ORBIGNY, 1847 in 1847–1851, p. 316; OD]. Small, rounded triangular, hinge line relatively short, ventral interarea clearly demarcated, flat, acutely triangular, pseudodeltidium undifferentiated, hemispondylium wide, sessile, relatively massive; dorsal valve subcircular, cardinal process relatively large, brachial lobes small, auriform, each consisting of ring of spiny, often connected processes with nearest being obliquely divergent from base of median septum; fibrous secondary shell continuous in both valves. *Middle Jurassic (upper Bathonian)–Upper Jurassic (upper Oxfordian):* England, France, Germany, *upper Bathonian.*——FIG. 1296,*1a–g.* **R. triangularis* (D'ORBIGNY), upper Bathonian, Luc-sur-Mer, Normandy, France; *a,* hypotype, dorsal view, BMNH BD9131, ×13 (new); *b,* dorsal valve interior; *c,* dorsal valve, oblique anterior view; *d,* dorsal valve, oblique lateral view; *e,* hypotype, dorsal valve, oblique posterior view, BMNH BD9132, ×13 (new); *f,* ventral valve interior; *g,* hypotype, ventral valve, oblique anterior view showing hemispondylium, BMNH BD9133, ×20 (new).

Stentorina BAKER & WILSON, 1999, p. 887 [**S. sagittata;* OD]. Small, hinge line relatively short, ventral interarea small, flat, poorly defined, pseudodeltidium indistinct, relatively large attachment scar, shallow anterior sulcus commonly developed; ventral valve with sessile hemispondylium with pronounced median ridge; dorsal valve with prominent umbo, cardinal process small, brachial lobes represented by low, curved ridges; fibrous secondary shell continuous in both valves. *Middle Jurassic (Bajocian or lower Bathonian):* USA (Utah).——FIG. 1298,*1a–g.* **S. sagittata,* Washington County, southwestern Utah, BMNH BD9372; *a–d,* dorsal, lateral, anterior, posterior views; *e,* holotype, three-quarters profile, lateral view, ×20 (Baker & Wilson, 1999); *f,* ventral valve interior, reconstruction; *g,* dorsal valve interior, reconstruction, ×20 (new).

Subfamily MOORELLININAE Pajaud, 1966

[Moorellininae PAJAUD, 1966a, p. 618]

Forms with ridgelike, lateral extensions from posterior end of dorsal median septum, usually with tuberculate, brachial lobes; endopunctate. *Upper Triassic–Lower Cretaceous.*

Moorellina ELLIOTT, 1953a, p. 693 [**Thecideum duplicatum* MOORE, 1854, p. 118; OD] [=*Elliottina* PAJAUD, 1963, p. 996 (type, *Thecidea deslongchampsii* DAVIDSON, 1852b, p. 258)]. Typically rounded triangular, cicatrix commonly triangular, geniculation producing low to high, free, ventral wall, ventral interarea flat, with pseudodeltidium flush with surface; dorsal valve typically with small, hypercline interarea, median septum relatively short with lateral ridges arranged in Y-shaped configuration, brachial lobes varying from incomplete arcuate lines to tuberculate ridges surrounding shallow, intrabrachial depressions; fibrous secondary shell continuous in both valves. [Distinction between *Elliottina* and *Moorellina* rests essentially on shape of ventral interarea, which does not merit taxonomic distinction.] *Upper Triassic–Middle Jurassic:* western Europe, *Middle Jurassic.*——FIG. 1299,*3a–e.* **M. duplicata* (MOORE), Cotswolds, southern England; *a,* dorsal valve interior, upper Aalenian; *b,* dorsal valve, oblique lateral view, upper Aalenian; *c,* hypotype, dorsal valve, oblique posterior view, upper Aalenian, BMNH BD9129, ×10; *d,* hypotype, juvenile dorsal valve interior, upper Aalenian, BMNH BD9130, ×25 (new); *e,* ventral valve interior, Bajocian, ×10 (Moore, 1854).

Bosquetella SMIRNOVA, 1969a, p. 83 [**Thecidium campichei* DE LORIOL in PICTET, 1872, p. 146; OD]. Elongately semioval, markedly ventribiconvex, cicatrix variable but never large, ventral interarea poorly developed with undifferentiated pseudodeltidium; dorsal valve without interarea, cardinal process with median protruberance giving incipiently trilobed appearance, brachial lobes in form of tuberculate ridges, asymmetrically pyriform with apices curving toward body cavity, median septum long with lateral ridges in T-shaped configuration; fibrous secondary shell partially suppressed in ventral valve, heavily suppressed in dorsal valve. *Lower Cretaceous:* Crimea, Switzerland.——FIG. 1299,*1a–d.* **B. campichei* (DE LORIOL); *a,* dorsal view, Valanginian, Crimea, ×10.5 (Smirnova, 1969a); *b,* dorsal valve interior, upper Valanginian, Auberson, Switzerland; *c,* dorsal valve, profile lateral view, upper Valanginian, Auberson, Switzerland; *d,* dorsal valve, posterior view, upper Valanginian, Auberson, Switzerland, ×9 (Baker, 1991).

Pachymoorellina BAKER, 1989a, p. 56 [**Thecideum bouchardii* MOORE, 1854, p. 116, *non* DAVIDSON, 1851; OD; =*Thecidea (Davidsonella) dundriensis* ROLLIER, 1915, p. 53]. Ventral interarea well developed, convex pseudodeltidium, relatively large cicatrix and conspicuously thickened, free, ventral wall, internally with deeply impressed, diductor muscle scars forming an inverted V; dorsal interarea not developed or vestigial, valve with fragile, very wide, peripheral flange usually not preserved and high, median septum separating brachial cavities devoid of brachial lobes, lateral ridges weakly developed, lophophore grooves shallow and indistinct; fibrous secondary shell strongly suppressed in both valves, acicular crystallite tracts well developed in ventral

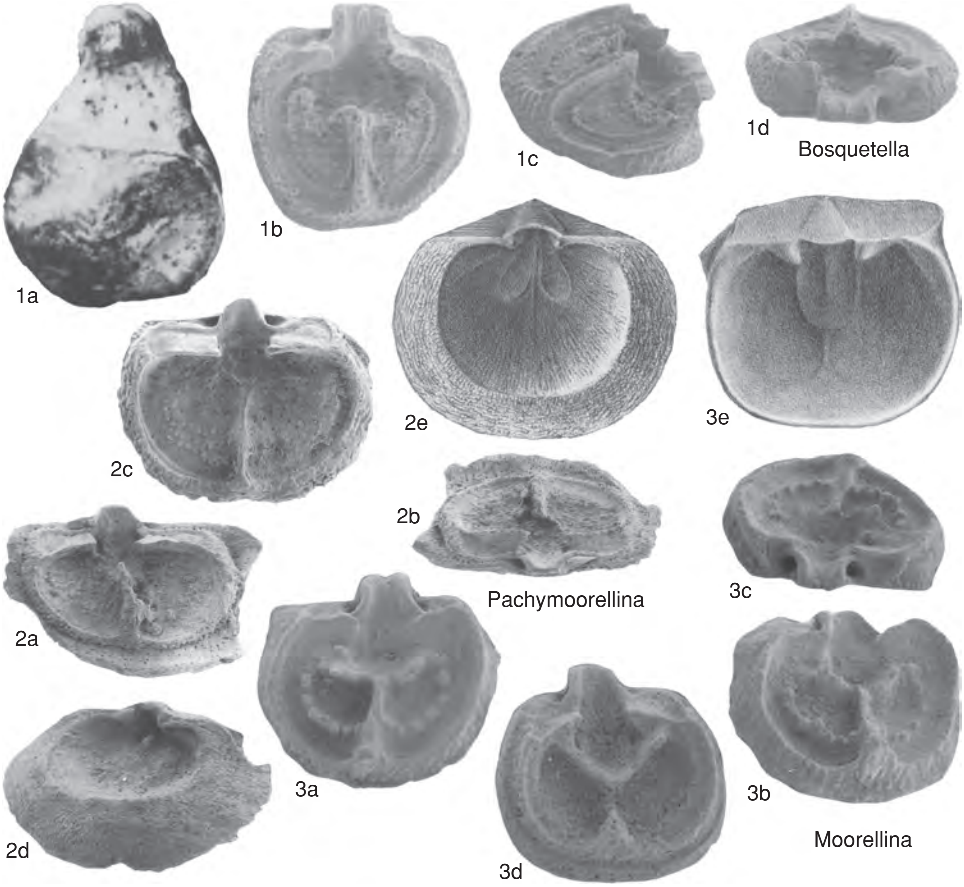

FIG. 1299. Thecidellinidae (p. 1953–1954).

valve. *Middle Jurassic (upper Aalenian–Bajocian):* southern England, *upper Aalenian.*——FIG. 1299,*2a–e. *P. dundriensis* (ROLLIER), Cotswolds; *a–b,* dorsal valve interior, dorsal valve posterior view, upper Aalenian; *c,* dorsal valve showing typical destruction of peripheral flange, upper Aalenian, ×10; *d,* immature ventral valve profile, interior view, upper Aalenian, ×8.5 (Baker, 1989a); *e,* ventral valve interior, Bajocian, ×8 (Moore, 1854).

Family BACTRYNIIDAE Williams, 1965

[Bactryniidae WILLIAMS, 1965, p. 521]

Concavoconvex, elongate-oval shells attached by ventral apex, ventral interarea and pseudodeltidium variably developed, internally tuberculate; dorsal valve with small, indistinctly bilobed cardinal process, inner socket ridges low, defining shallow sockets, lateral adductor muscle scars present, other muscle impressions obscure, long, low, median septum divided by shallow sinus, dorsal mantle cavities occupied by pustulose brachial lobes; impunctate; fibrous secondary shell forming continuous lining in both valves; lophophore ptycholophous or incipiently ptycholophous. *Upper Triassic (Rhaetian)–Upper Jurassic (upper Oxfordian).*

Subfamily BACTRYNIINAE Williams, 1965

[*nom. transl.* BAKER, herein, *ex* Bactryniidae WILLIAMS, 1965, p. 521]

Dorsal valve with long, low, possibly catacline interarea, subperipheral rim with numerous pairs of weakly developed, lateral septa, dorsal mantle cavities shallow, brachial lobes interdigitating with lateral septa, brachidium digitate; lophophore ptycholophous. *Upper Triassic (Rhaetian).*

Bactrynium EMMRICH, 1855, p. 449 [**B. bicarinatum;* OD] [=*Pterophloios* GUMBEL, 1861, p. 411, obj.]. Ornamented by fine growth lines, hinge line approximately equal to maximum width of shell, ventral interarea obscure, possibly apsacline, pseudodeltidium obscure; dorsal valve longitudinally semioval with low, plane interarea, bridge possibly present, strongly thickened subperipheral rim with 8 to 10 pairs of lateral septa, median septum ridgelike, extending posteriorly over body cavity, septa complementary to lateral and long, median ridges in ventral valve. *Upper Triassic (Rhaetian):* Austria.——FIG. 1300,*1a–f.* **B. bicarinatum,* Kossener Schichten; *a,* dorsal valve interior; *b,* dorsal valve posterior view, ×3 (Williams, 1965); *c,* dorsal valve, lateral view, ×3; *d,* dorsal valve fragment, interior view showing pustulose brachial lobes; *e,* dorsal valve fragment, interior view showing lateral adductor muscle scar to left of cardinal process; *f,* posterior view of view *e,* ×6 (Rudwick, 1968).

Subfamily DAVIDSONELLINAE Pajaud, 1966

[Davidsonellinae PAJAUD, 1966a, p. 618]

Dorsal interarea absent or vestigial, relatively broad median septum divided by an anterior sinus for much of its length; lophophore incipiently ptycholophous (extended schizolophe functionally equivalent to ptycholophe). *Upper Triassic (Rhaetian)–Upper Jurassic (upper Oxfordian).*

Davidsonella MUNIER-CHALMAS, 1880, p. 279, *non* WAAGEN, 1885, *nec* FREDERIKS, 1926 [**Thecidea sinuata* EUDES-DESLONGCHAMPS, 1853, p. 242; OD]. Small, longitudinally subrectangular, emarginate, ventral interarea flat, almost orthocline, acutely triangular, pseudodeltidum convex, relatively large; ventral valve deep with relatively pronounced anterior sulcus continuous with well-defined, broad, median ridge, hemispondylium raised thickened and supported by lateral connections with valve wall; dorsal valve with small, prostrate cardinal process and anterior sulcus continuous with shallow sinus dividing median septum for almost entire length, brachial lobes may form fragile reticulum, lophophore grooves conspicuous. *Upper Triassic (Rhaetian)–Lower Jurassic (Toarcian):* Austria, *Rhaetian;* Wales, *Hettangian;* Normandy, southern England, *Toarcian.*——FIG. 1300,*3a–h.* **D. sinuata* (EUDES-DESLONGCHAMPS), Toarcian, May-sur-Orne, Normandy, France; *a,* dorsal view; *b,* hypotype, lateral view, BMNH BD9356, ×8; *c,* dorsal valve interior; *d,* dorsal valve anterior view; *e,* dorsal valve, oblique lateral view; *f,* hypotype, dorsal valve, oblique posterior view, BMNH BD9357, ×9; *g,* ventral valve interior; *h,* hypotype, ventral valve tilted showing hemispondylium, BMNH BD9358, ×12 (new).

Agerinella PATRULIUS in PAJAUD & PATRULIUS, 1964, p. 582 [**A. lyrata* PATRULIUS in PAJAUD & PATRULIUS, 1964, p. 583; OD]. Small; ventral valve with large cicatrix giving sharply triangular lateral profile, interarea reduced, pseudodeltidium undifferentiated, hemispondylium relatively massive, formed from 3 nearly touching columns united by transverse bar; dorsal valve subcircular with pronounced convexity at umbo, internal characters imperfectly known but brachial apparatus simple and apparently similar to *Davidsonella. Upper Jurassic (upper Oxfordian):* Romania.——FIG. 1300,*2a–c.* **A. lyrata,* Visterna Valley; *a,* dorsal view of damaged shell showing internal characters; *b,* drawing of *a; c,* drawing of frontal view of *a,* ×8 (Pajaud & Patrulius, 1964).

Family THECIDEIDAE Gray, 1840

[Thecideidae GRAY, 1840, p. 151]

Small to larger forms, secondarily free exceptionally, ventral interarea normally not well defined, with clearly convex pseudodeltidium, dorsal interarea variably developed, usually tuberculate internally; in ontogeny brachial supports developing from thickened, triangular plate at anterior margin of dorsal valve, commonly leading to much divided brachial interiors, brachial lobes commonly with reticulum, intrabrachial cavities not developed; impunctate exceptionally; fibrous secondary shell normally suppressed, continuous lining in only Jurassic representatives, present or absent in one or both valves in Lower Cretaceous to Holocene representatives; lophophore ptycholophous. *Lower Jurassic–Holocene.*

Subfamily THECIDEINAE Gray, 1840

[Thecideinae GRAY, 1840, p. 151]

Shell with costellate ornament exceptionally, rarely with ridged and grooved, internal ornament; polyseptate, without anterior sinus, median septum repeatedly divided during growth to form lateral septa or divided anterolaterally to form septules, commonly a combination of both; Jurassic forms digitate, usually without brachial lobes or lophophore

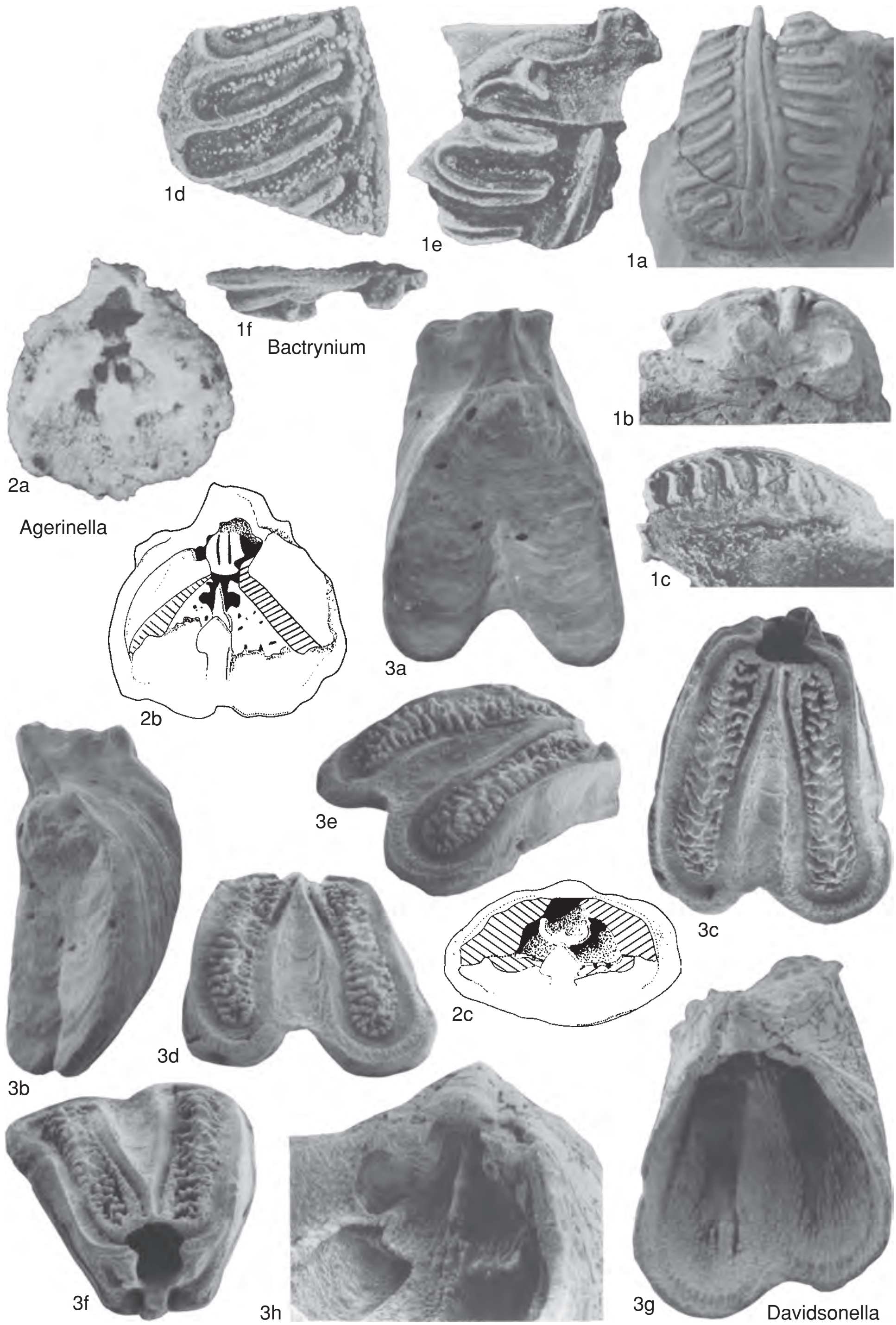

FIG. 1300. Bactryniidae (p. 1955).

grooves; Cretaceous forms with brachial lobes interdigitating with lateral septa and septules, lophophore grooves well developed. *Lower Jurassic (Toarcian)–Neogene (Tortonian).*

Thecidea DEFRANCE, 1822, p. 325 [**Terebratulites papillatus* SCHLOTHEIM, 1813, p. 113; OD; =*Thecidea radians* DEFRANCE, 1822, p. 325] [=*Thecidium* G. B. SOWERBY, 1823, p. 248, *nom. null.; Thecidaea* KEFERSTEIN, 1829, p. 82, *nom. null.; Thecideum* FISCHER DE WALDHEIM, 1834, p. 279, *nom. null.; Thecedea* D'ORBIGNY, 1847 in 1847–1851, p. 249, *nom. null.*]. Relatively large, symmetrical, with minute cicatrix at rostral extremity, high ventral interarea with clear growth lines and narrow convex pseudodeltidium with longitudinal ridge on ventral surface, costellate radial ornament; ventral valve thick with densely tuberculate border, internal median ridge, supported hemispondylium and conspicuous lateral adductor muscle scars; dorsal valve almost circular with wide, densely tuberculate border and small, acutely triangular, longitudinally grooved interarea, cardinal process, small, square, obscurely bilobed, with longitudinal groove extended on dorsal surface, complementing ridge on underside of pseudodeltidium, bridge with marsupial notch, median septum divided into regularly incurving septules, brachial lobes interdigitating with septules, reticulum weakly developed; fibrous secondary shell completely suppressed, acicular crystallite tracts in ventral valve. *Upper Cretaceous (upper Maastrichtian):* Denmark, The Netherlands, Germany, Belgium, France, Spain.——FIG. 1301,*4a–i.* **T. papillata* (SCHLOTHEIM), Ciply, Belgium; *a,* dorsal view; *b,* oblique lateral view; *c,* hypotype, oblique posterior view, BMNH BD9402; ×6.5; *d,* dorsal valve interior; *e,* dorsal valve anterior view; *f,* dorsal valve, oblique lateral view; *g,* hypotype, dorsal valve, oblique posterior view, BMNH BD9403, ×7; *h,* ventral valve interior, ×6.5; *i,* hypotype, ventral valve interior showing hemispondylium, BMNH BD9404, ×12 (new).

Backhausina PAJAUD, 1966d, p. 125 [**Thecidea rugosa* D'ORBIGNY, 1847 in 1847–1851, p. 153; OD]. Medium size, outline subtrigonal, cicatrix well developed, ventral interarea indistinct with convex pseudodeltidium; ventral valve interior ornamented by tuberculate ridges; dorsal valve subcircular but with longer hinge line than *Thecidea,* 1 or 2 lateral septa, median septum divided to form almost straight septules, brachial lobes interdigitating, reticulum depressed. *Lower Cretaceous (Albian)–lower Paleogene (Paleocene):* France, Switzerland, Germany, *Albian;* Sweden, Germany, *Campanian;* Denmark, Germany, Belgium, France, *Paleocene.* ——FIG. 1301,*1a–b.* **B. rugosa* (D'ORBIGNY), Cenomanian, Le Mans, France; *a,* dorsal valve interior, ×7.5 (Pajaud, 1970); *b,* ventral valve interior, ×6 (Backhaus, 1959).

Eudesella MUNIER-CHALMAS, 1880, p. 279 [**Thecidea mayalis* EUDES-DESLONGCHAMPS, 1853, p. 234; OD]. Medium size, transversely oval with long hinge line, ventral interarea large with well-developed, convex pseudodeltidium; dorsal valve characteristically transverse, without interarea, with relatively small cardinal process and variable number of septa, commonly more than 8, extending from valve margin to terminate near body cavity, brachial lobes pustulose, interdigitating with septa and occasionally forming reticulum united with posterior termination of median septum; fibrous secondary shell continuous in both valves. *Lower Jurassic (Toarcian):* France (Normandy).——FIG. 1301,*3a–c.* **E. mayalis* (EUDES-DESLONGCHAMPS), May-sur-Orne; *a,* dorsal view, ×4 (Elliott, 1965c); *b,* dorsal valve interior, ×6.5 (Pajaud, 1970); *c,* ventral valve interior, ×3 (Elliott, 1965c).

Glazewskia PAJAUD, 1964, p. 259 [**G. demarcqui;* OD]. Medium size, rounded outline, ventral interarea clearly differentiated with broad, convex pseudodeltidium; dorsal valve wider than long with relatively large cardinal process, 2 or 3 septa in frontal position, brachial lobes irregularly developed. *Neogene (?lower Burdigalian, upper Burdigalian–Tortonian):* southeastern France.——FIG. 1301,*2a–b.* **G. demarcqui,* Serravallian, Saint Fons; *a,* dorsal valve interior; *b,* ventral valve interior, ×6 (Pajaud, 1970).

Konstantia PAJAUD, 1970, p. 189 [**Glazewskia* sp. GLAZEWSKI & PAJAUD, 1964, p. 263; OD; *nom. nov. pro Eudesella podolica ex* GLAZEWSKI MS, 1938] [=genus *X* PAJAUD, 1966d, p. 124 (type, genus *X* sp. *A,* OD)]. Small, subtrigonal, ventral interarea flat with undifferentiated pseudodeltidium; dorsal valve subcircular to transversely elliptical, cardinal process prostrate, usually 4 lateral septa with the most centrally placed being commonly bifid, brachial cavities with a few nodelike tubercles, without brachial lobes. [The genus is known only from a collection of 135 shells, later destroyed or lost, described and figured in an unpublished manuscript. Subsequently transferrred incorrectly to *Glazewskia* sp. and then temporarily to genus *X,* the form was finally assigned to *Konstantia,* validated by the publication of a figure (graphotype) and a photograph (phototype) from the original manuscript.] *Upper Jurassic (Tithonian):* Podolia. ——FIG. 1302,*4a–b.* **K. podolica* (GLAZEWSKI MS), Bukowna; *a,* dorsal valve exterior; *b,* dorsal valve interior, ×10 (Glazewski & Pajaud, 1964).

Mimikonstantia BAKER & ELSTON, 1984, p. 778 [**M. sculpta;* OD]. Shell larger than *Konstantia,* wider than long, outline transversely elliptical, ventral interarea ill defined, pseudodeltidium weakly convex; ventral valve with relatively large cicatrix and characteristic marginal rim with tuberculate inner and smooth outer zones, hemispondylium supported by septum; dorsal valve with wide, peripheral flange, without interarea, interior with septum in an approximately median position and usually 4

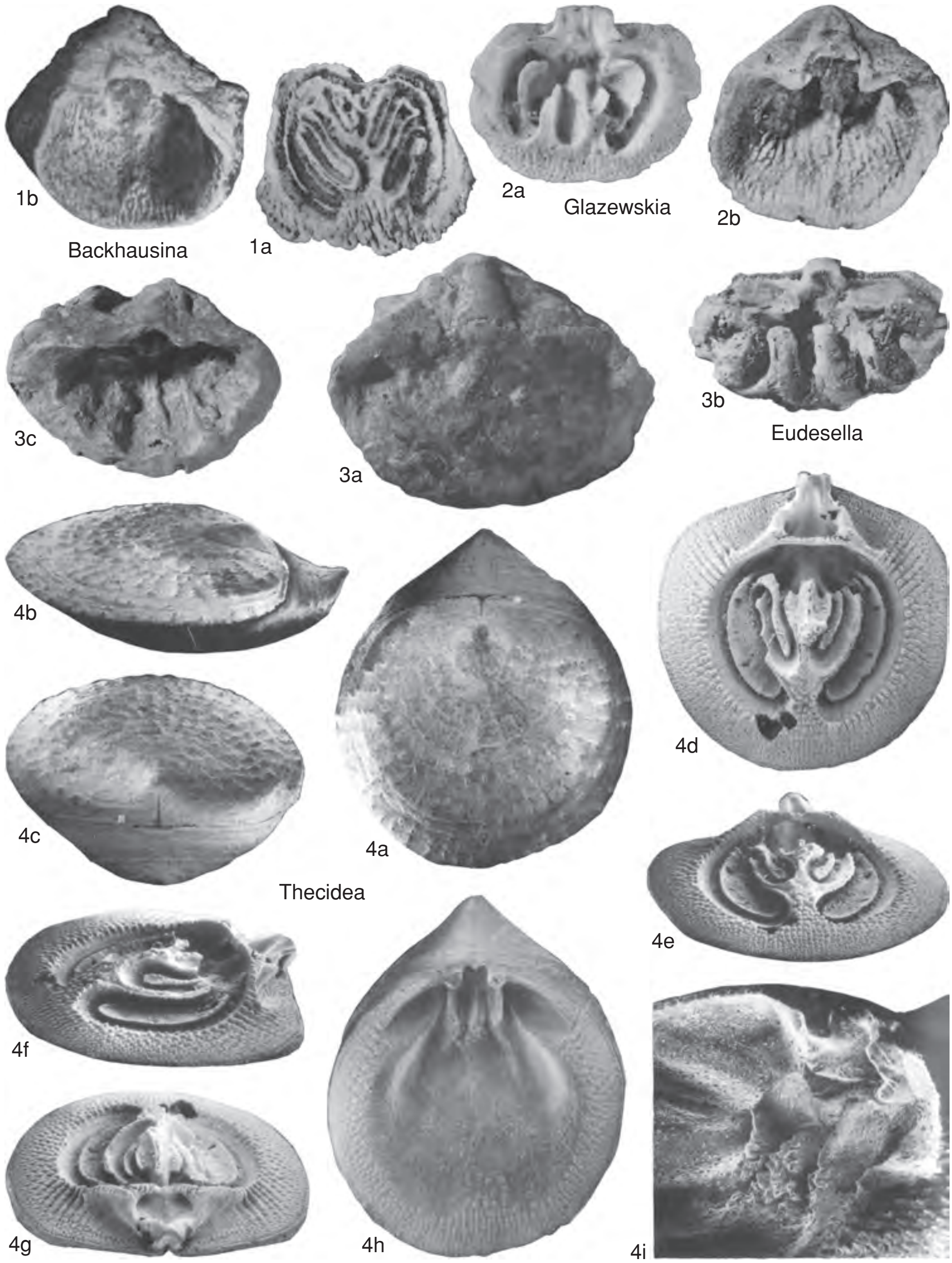

FIG. 1301. Thecideidae (p. 1957).

lateral septa, without brachial lobes; fibrous secondary shell partially suppressed in both valves; impunctate. *Middle Jurassic (Aalenian):* southern England.——FIG. 1302,*3a–e.* **M. sculpta,* Stroud, Cotswolds; *a,* complete shell, dorsal view; *b,* dorsal valve interior showing usual state of preservation; *c,* dorsal valve, anterior oblique view, ×12.5; *d,* dorsal valve interior showing undamaged septa, ×15; *e,* ventral valve interior, ×12.5 (Baker & Elston, 1984).

Parathecidea BACKHAUS, 1959, p. 55 [**Thecidea hieroglyphica* GOLDFUSS, 1840, p. 290; OD].

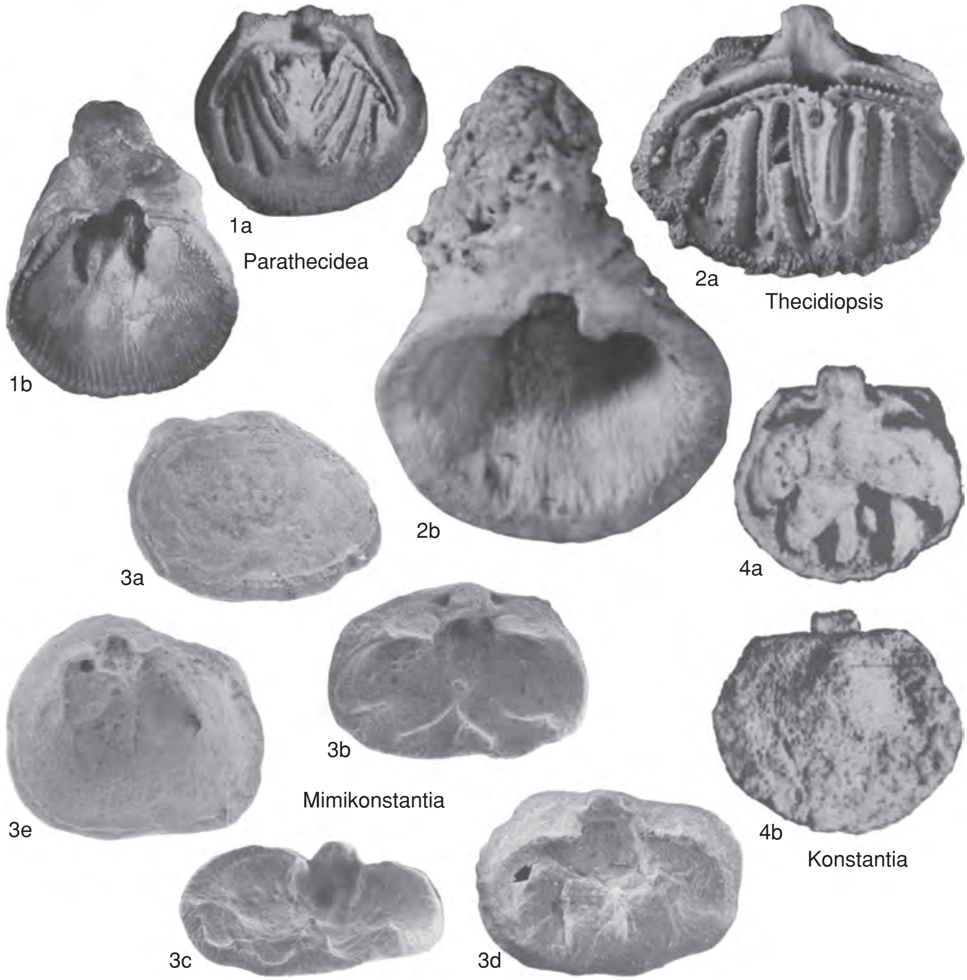

FIG. 1302. Thecideidae (p. 1957–1959).

Medium size to large; ventral valve with several irregular, longitudinal-radial, internal ridges, adductor muscle scars deeply impressed, and hemispondylium supported by thin septum; dorsal valve with wide border commonly ornamented by short, radial grooves, median septum divided to form long, approximately straight septules, 3 or 4 lateral septa, brachial lobes interdigitate with septa and septules, narrow reticulum present in some. *Upper Cretaceous (upper Campanian–upper Maastrichtian):* Sweden, *upper Campanian;* Germany, The Netherlands, Switzerland, *upper Maastrichtian.*——Fig. 1302,*1a–b.* **P. hieroglyphica* (GOLDFUSS), upper Maastrichtian, Maastricht, The Netherlands; *a,* dorsal valve interior; *b,* ventral valve interior, ×3 (Backhaus, 1959).

Thecidiopsis MUNIER-CHALMAS, 1887, p. 40 [**Thecidium digitatum* G. B. SOWERBY, 1823, p. 249; OD]. Size variable, commonly large; normally transversely elliptical with ventral and dorsal interareas clearly developed; ventral valve with large hemispondylium with robust supporting septum; dorsal valve with up to 12 (usually 8 to 10) lateral septa and median septum more or less divided to form septules, brachial lobe interdigitations bordered by spinules, narrow reticulum; fibrous secondary shell strongly suppressed in both valves, acicular crystallite tracts present in both valves. *Lower Cretaceous (Valanginian)–Upper Cretaceous (Maastrichtian):* Switzerland, France, Russia, *Valanginian;* Germany, *Barremian;* Czech Republic, Slovakia, *Cenomanian–Turonian;* The Netherlands, *Maastrichtian.*——FIG. 1302,*2a–b.* **T. digitata* (SOWERBY), upper Maastrichtian, Maastricht, The Netherlands; *a,* dorsal valve interior; *b,* ventral valve interior, ×4.5 (Elliott, 1965c).

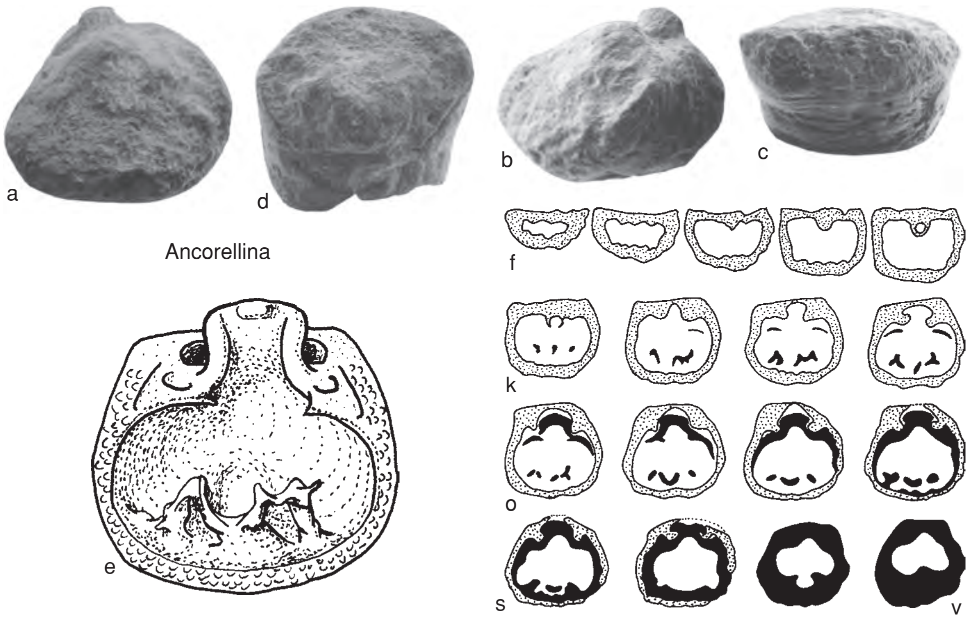

FIG. 1303. Thecideidae (p. 1960).

Subfamily ANCORELLININAE Baker & Manceñido, 1997

[Ancorellininae BAKER & MANCEÑIDO, 1997, p. 192]

Median septum resorbed posteriorly, brachidium consisting of anterior, distally bifurcated, median column supported by pair of anterolaterally placed pillars and directed posteroventrally; lophophore grooves not developed; endopunctate; fibrous secondary shell continuous in both balves. *Lower Jurassic.*

Ancorellina MANCEÑIDO & DAMBORENEA, 1990, p. 89 [**A. ageri;* OD]. Small, subcircular, cicatrix relatively large, free ventral wall well developed, ventral interarea reduced, pseudodeltidium indistinct, hinge line short; hemispondylium sessile, anteriorly raised to form spoonlike termination, diductor muscle scars impressed posteriorly; cardinal process relatively massive, incipiently trilobed, crura possibly not uniting to form bridge, median septum reduced to anteroposteriorly flattened, distally bifurcated column, each limb united laterally with pillar arising from anterior of brachial cavities. *Lower Jurassic:* Argentina.——FIG. 1303*a–v.* **A. ageri,* upper Pliensbachian, Neuquén, Piedra Pintada area, west-central Argentina; *a–d,* dorsal, lateral, anterior, posterior views, ×15; *e,* dorsal valve interior, reconstruction, ×20; *f–v,* hypotype, serial horizontal sections 0.280, 0.392, 0.448, 0.504, 0.560, 0.588, 0.644, 0.672, 0.700, 0.756, 0.784, 0.840, 0.868, 0.896, 0.952, 1.064, 1.092 mm from free ventral wall, MLP PB3257, ×6 (new).

Subfamily LACAZELLINAE Backhaus, 1959

[Lacazellinae BACKHAUS, 1959, p. 19]

Commonly with ridged and grooved, internal ornament; anterior sinus developed to divide median septum longitudinally, commonly with posterior convolution to form ramuli, jugal pillar present or absent, brachial lobes usually with interdigitation, lophophore grooves present in most; spicules present in mantle of some species. *Lower Jurassic (Toarcian)–Holocene.*

Lacazella MUNIER-CHALMAS, 1880, p. 279 [**Thecidea mediterranea* RISSO, 1826, p. 394; OD]. Relatively small, irregular with convex pseudodeltidium; interior of ventral valve papillose to spinose except over muscle scars, hemispondylium projecting anteriorly as two spurs; dorsal valve with hypercline interarea, bridge with marsupial notch, median septum divided to form trifurcating structure consisting of pair of lateral ramuli and posterior median ridge uniting with jugal pillar, brachial lobes interdigitating with ramuli; shell granular except for superficial

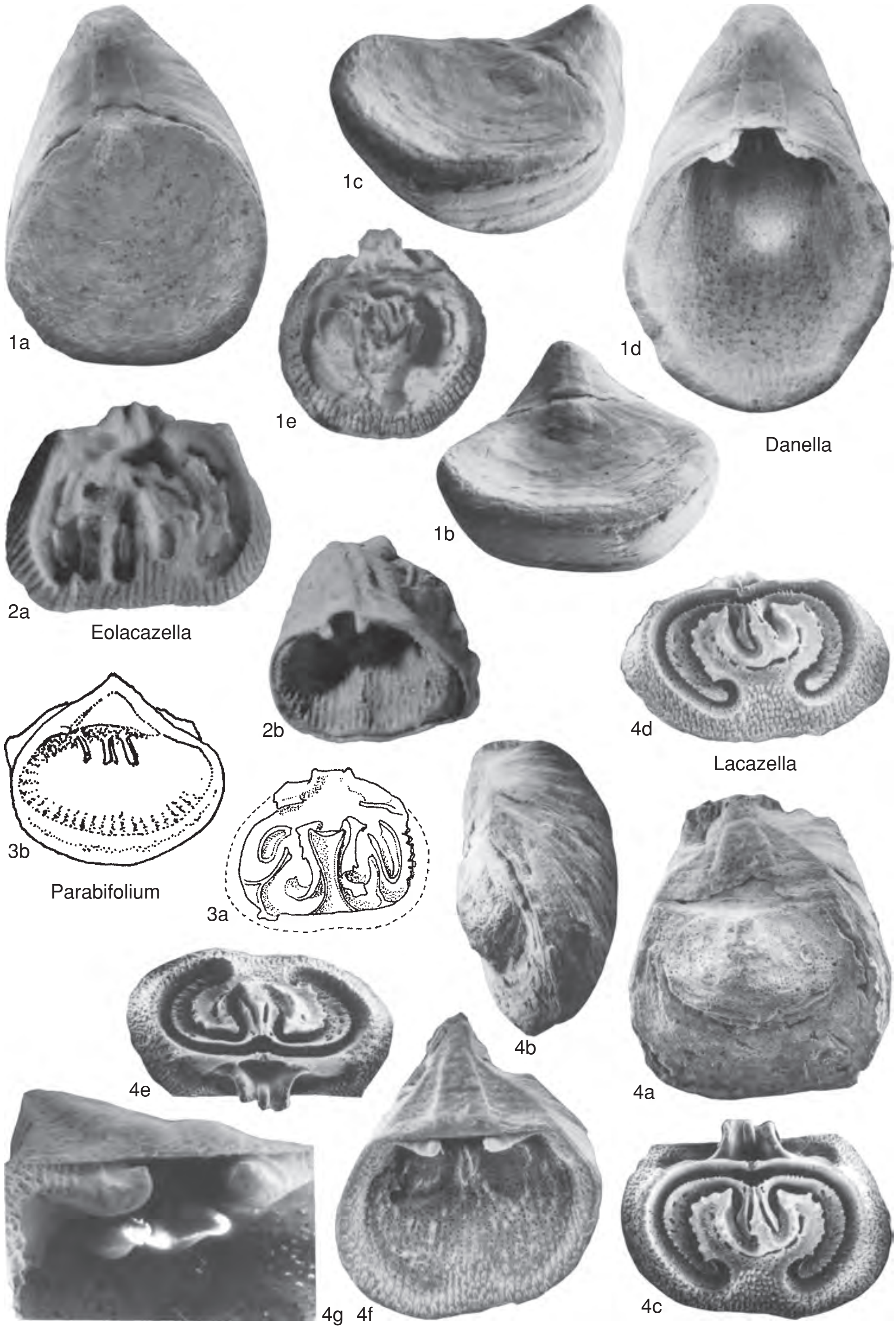

FIG. 1304. Thecideidae (p. 1960–1962).

traces of fibrous secondary shell on dorsal surface of teeth; mantle thin, coarsely spicular. *Eocene–Holocene:* Europe, ?Australia, *Eocene;* Mediterranean, West Indies, Mauritius, Pacific, *Holocene.* ——FIG. 1304,*4a–g.* **L. mediterranea* (RISSO), Holocene, La Calle, Mediterranean, Algeria; *a,* dorsal view; *b,* hypotype, lateral view, BMNH BD9399; *c,* dorsal valve interior; *d,* dorsal valve, oblique anterior view; *e,* hypotype, dorsal valve, oblique posterior view, BMNH BD9400; *f,* ventral valve interior, ×8; *g,* hypotype, ventral valve, oblique anterior view showing hemispondylium, BMNH BD9401, ×15 (new).

Danella PAJAUD, 1966c, p. 70 [**D. fragilis;* OD]. Small to medium size, outline commonly pyriform, externally smooth, cicatrix small to minute, rostral extremity strongly recurved in some species, ventral interarea obscure, pseudodeltidium clearly convex; hemispondylium sessile with low median and very high lateral ridges; dorsal valve convex at umbo, otherwise shallowly concave with narrow, acute, almost procline interarea, circular with relatively wide border ornamented by fine ribbing, median septum folded into 4 to 6 ramuli with spinose borders, brachial lobes large with well-developed reticulum and elaborate interdigitation with ramuli. [Preservation of detail in the type material is poor. Generic characters are more clearly illustrated in the species figured herein.] *Upper Cretaceous (upper Campanian)–Paleogene (middle Danian):* England, France, The Netherlands, Denmark, Belgium, Germany, *upper Campanian.*——FIG. 1304,*1a–d. D. recurvirostris* (DEFRANCE), ?upper Maastrichtian, Nehou, France; *a,* dorsal view; *b,* anterior view; *c,* hypotype, oblique lateral view, BMNH BD9359; *d,* hypotype, ventral valve interior, BMNH BD9360, ×8.5 (new).——FIG. 1304,*1e. D. longirostris* (BOSQUET), middle Danian, Geulheim, The Netherlands; dorsal valve interior, ×7.5 (Backhaus, 1959).

Eolacazella ELLIOTT, 1953a, p. 694 [**Thecidium affine* BOSQUET, 1860, p. 25; OD]. Small; irregular to trigonal; ventral valve with high, narrow pseudodeltidium; internal ventral median ridge spinose; dorsal valve laterally subrectangular, border ornamented by fine ribbing, median septum with few short ramuli, and sinus obscured by development of pair of lateral septa originating anteriorly; fibrous secondary shell completely suppressed, whole shell granular. *Upper Cretaceous (upper Maastrichtian):* The Netherlands, Belgium.——Fig. 1304,*2a–b.* **E. affine* (BOSQUET), Saint-Pierre de Maastricht, The Netherlands; *a,* dorsal valve interior, ×10 (Backhaus, 1959); *b,* ventral valve interior, ×12 (Elliott, 1965c).

Neothecidella PAJAUD, 1970, p. 108 [**Thecidea antiqua* GOLDFUSS, 1840, p. 290; OD]. Small, with large cicatrix, ventral interarea indistinct with convex pseudodeltidium, hinge line relatively short; ventral valve interior ornamented by longitudinal ridges; dorsal valve with flattened area behind umbo, which may represent interarea, border with ribbed ornament, cardinal process small, median septum with well-developed sinus not fully open posteriorly, termination united with jugal pillar, brachial lobes small, reniform; occurrence of fibrous secondary shell restricted to teeth and tooth ridges of ventral valve in at least one species. [Preservation of detail in the type material is poor. Generic characters are more clearly illustrated in *N. parviserrata.*] *Upper Jurassic (middle Oxfordian)–Lower Cretaceous (upper Aptian):* France, Germany, Switzerland, *middle Oxfordian;* southern England, *upper Aptian.*——FIG. 1305,*2a–e. N. parviserrata* BAKER & LAURIE, upper Aptian, Faringdon, southern England; *a,* dorsal valve interior; *b,* dorsal valve, oblique anterior view; *c,* dorsal valve lateral view; *d,* dorsal valve posterior view; *e,* ventral valve, oblique posterior view, ×20 (Baker & Laurie, 1978).

Pajaudina LOGAN, 1988, p. 546 [**P. atlantica* LOGAN, 1988, p. 550; OD]. Relatively large, elongate with convex pseudodeltidium; hemispondylium with supporting septum; dorsal interarea hypercline, cardinal process incipiently trilobed, bridge with marsupial notch, brachial apparatus consisting of 2 crescentic, lateral ramuli, and posterior, upraised, median ridge divided into short septules, troughs of ramuli perforate, brachial lobes interdigitating with ramuli and septules; shell granular except for superficial, fibrous secondary layer on teeth; mantle spiculate. *Holocene:* southeastern North Atlantic (Canary Islands, Salvage Islands).——FIG. 1305, *1a–d.* **P. atlantica,* off Palma, Canary Islands; *a,* dorsal view; *b,* dorsal valve interior; *c,* dorsal valve interior, lateral oblique view; *d,* ventral valve interior, ×4 (Logan, 1988).

Parabifolium PAJAUD, 1966c, p. 70 [**P. priscum;* OD]. Small, externally similar to *Neothecidella;* dorsal valve interior with median septum divided over entire length with thin, lateral septum on either side converging posteriorly, brachial lobes well developed. *Upper Jurassic (lower Kimmeridgian):* Germany.——FIG. 1304,*3a–b.* **P. priscum,* Nattheim; *a,* dorsal valve interior; *b,* ventral valve interior, ×10 (Pajaud, 1970).

Praelacazella SMIRNOVA, 1969a, p. 81 [**Thecidium valangiense* DE LORIOL, 1868, p. 59; OD]. Small to medium size, elongately to rounded subtriangular with greatest width close to anterior margin, large cicatrix, ventral interarea obscure with convex pseudodeltidium; dorsal valve circular-tetragonal, dorsal interarea hypocline, cardinal process with pronounced dorsal deflection, median septum with wide sinus divided posteriorly to form pair of ramuli and central, jugal pillar, brachial lobes reniform with lanceolate interdigitation with ramuli; fibrous secondary shell partially supressed in ventral valve, heavily suppressed in dorsal valve, acicular crystallite tracts in dorsal valve. *Lower Cretaceous (upper Valanginian)–Upper Cretaceous (Maastrichtian):* Switzerland, *upper Valanginian;* Crimea, western Germany, *Hauterivian;* France, Czech Republic, Slovakia, *Cenomanian–Santonian;* southern

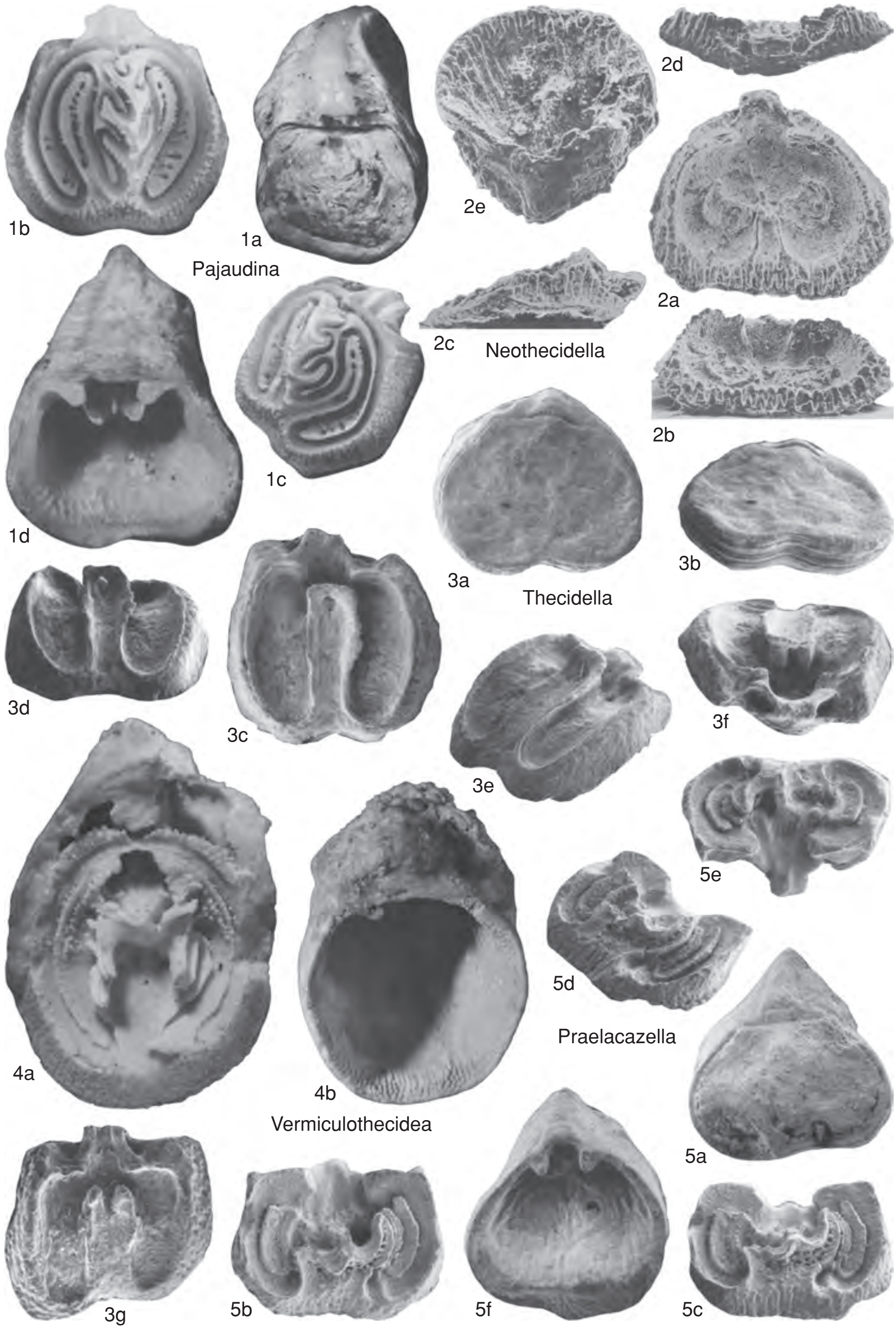

FIG. 1305. Thecideidae (p. 1962–1964).

England, Germany, *Maastrichtian;* Denmark, *Coniacian.*——FIG. 1305,*5a–f. P. lacazelliformis* (ELLIOTT), upper Cenomanian, Zbyslav, Bohemia, Czech Republic; *a,* hypotype, dorsal view, BMNH BD9136; *b,* dorsal valve interior; *c,* dorsal valve, oblique anterior view; *d,* dorsal valve, interior oblique lateral view; *e,* hypotype, dorsal valve, interior oblique posterior view, BMNH BD9137; *f,* hypotype, ventral valve interior, BMNH BD9138, ×12 (new).

Thecidella MUNIER-CHALMAS, 1887, p. 40 [**Thecidea rustica* DAVIDSON, 1851, p. 15; OD; =*Thecidea (Thecidella) normaniana* MUNIER-CHALMAS in OEHLERT, 1887b, p. 1,331]. Small, with large cicatrix, ventral interarea obscure, broad, with strongly convex pseudodeltidium; dorsal valve quadrangular to transversely rectangular, anterior margin with shallow sulcus, dorsal interarea vestigial, cardinal process prostrate and relatively small, median septum wide, divided by sinus over its entire length, variable in outline with denticulate margins, walls commonly uniting to form posterior, centrally perforate termination, brachial cavities without brachial lobes or lophophore grooves; fibrous secondary shell forming continuous lining in both valves. *Lower Jurassic (Toarcian)–Middle Jurassic (middle Bajocian):* southern England, France, *Toarcian;* Germany, *middle Bajocian.*——FIG. 1305,*3a–g.* **T. rustica* (DAVIDSON), lower Toarcian, May-sur-Orne, France; *a,* dorsal view; *b,* hypotype, oblique anterior view, BMNH BD9362, ×7; *c,* dorsal valve interior; *d,* dorsal valve, oblique anterior view; *e,* dorsal valve, oblique lateral view; *f,* hypotype, dorsal valve, oblique posterior view, BMNH BD9363, ×10; *g,* hypotype, dorsal valve interior showing typical state of preservation of median septum, BMNH B36895, ×10 (new).

Vermiculothecidea ELLIOTT, 1953a, p. 694 [**Terebratulites vermicularis* SCHLOTHEIM, 1813, p. 113; OD]. Large, irregularly elongate, ventral interarea and pseudodeltidium poorly differentiated; ventral valve deep with interior ornamented by small tubercles; dorsal valve subcircular to longitudinally oval, brachial apparatus elaborate, sinus very wide with septum free from valve floor posteriorly, folded into up to 12 ramuli with spinose edges, brachial lobes well developed with large reticulum and rodlike interdigitation with ramuli. *Upper Cretaceous (Cenomanian–upper Maastrichtian):* The Netherlands, Belgium, Germany, Denmark, Switzerland, France, Romania, *upper Maastrichtian;* southern England, *Cenomanian.*——FIG. 1305,*4a–b.* **V. vermicularis* (SCHLOTHEIM), upper Maastrichtian, Maastricht, The Netherlands; *a,* dorsal valve interior; *b,* ventral valve interior, ×6 (Elliott, 1965c).

TERebratulida

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Order TEREBRATULIDA Waagen, 1883

[*nom. correct.* Moore, 1952, p. 220, *pro* order Terebratulacea Kuhn, 1949, p. 105, *nom. transl. ex* suborder Terebratulacea Waagen, 1883a, p. 447; *emend.,* Lee & Mackinnon, herein]

Small to large, endopunctate articulated brachiopods with functional pedicle, shell commonly biconvex, smooth, but may be costate or costellate; with astrophic hinge line, hinge teeth cyrtomatodont; delthyrium partially or completely closed by deltidial plates or symphytium; dental plates present or absent; lophophore supported by morphologically variable calcareous loop arising from crura alone, or in conjuction with septal pillar; lophophore commonly plectolophous but may be trocholophous, schizolophous, zygolophous, or ptycholophous; calcareous spicules may be present in mantle and lophophore in some families. *Lower Devonian–Holocene.*

INTRODUCTION

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Terebratulides are a very large, distinctive, and important group of middle Paleozoic to Holocene articulated brachiopods that includes more than 600 genera. Terebratulides could be considered the most successful of all brachiopods since they have persisted from their origins in the Early Devonian through the end-Devonian and end-Permian extinctions to become the dominant group of brachiopods in the Mesozoic, and they remain so to the present day. Figure 1306 provides a generalized histogram of terebratulide generic diversity through time. In modern oceans, terebratulides make up about three-quarters of all living brachiopod genera (20 percent of the rest are rhynchonellides) and most brachiopod individuals living in the ocean today. Living terebratulides occur in most parts of the world's oceans down to depths of more than 5,000 m but are most abundant in shelf environments. Most of the information on the biology and ecology of fossil brachiopods comes from study of the living members of this long-ranging order.

Members of the morphologically diverse order Terebratulida can be distinguished from all other brachiopods by the possession of endopunctae, a loop, and a generally functional pedicle. Terebratulides range in size from very small to very large, have a narrow astrophic hinge line, and possess a moderately large functional pedicle opening in a partly or completely closed delthyrium. The exterior of a typical terebratulide is biconvex, elongate oval in outline, generally smooth or occasionally ribbed, and commonly with a rectimarginate, sulcate, or plicate anterior commissure. The lophophore in terebratulides is supported by a morphologically variable, short or long calcareous loop that may arise either from the crura alone (Terebratulidina) or from crura and septal pillar combined (Terebratellidina).

HIGHER-LEVEL CLASSIFICATION

A brief history of the classification of Brachiopoda was given by MUIR-WOOD (1955), and a revised classification for genera placed in the order Terebratulida was provided by MUIR-WOOD and STEHLI (1965). The classification presented herein has been revised substantially, and a single introduction is provided that encompasses all Paleozoic and Mesozoic to Holocene genera in order to emphasize the unifying features of the order Terebratulida.

We now recognize two suborders, the Terebratulidina and the Terebratellidina, and have discarded the third suborder, Centronellidina, which was erected by STEHLI (1965). In preparing our revision of the Paleozoic terebratulides, we realized that only one superfamily, the Devonian Stringocephaloidea, could be assigned to the Centronellidina and that the distinction made by STEHLI was invalid. We thus follow DAGYS (1972b) and COOPER and GRANT (1976b) in assigning all Paleozoic terebratulides to the suborder Terebratulidina, which ranges in age from Early Devonian to Holocene. The second suborder, Terebratellidina, ranges from the Early Triassic to Holocene and includes the largest number of living genera in any brachiopod order. Sixteen superfamilies are now recognized; seven are included in suborder Terebratulidina; and the remaining nine are placed in suborder Terebratellidina (Fig. 1307).

SUBORDER TEREBRATULIDINA

Differentiation of superfamilies within the suborder Terebratulidina is based on presence or absence of dental plates, presence or absence of a perforate cardinal plate, loop size and shape, loop ontogenetic stages, and final loop form in adult brachiopods. As redefined herein, this suborder now includes all short-looped and some long-looped terebratulides in which the loop develops by extension of the crura without the involvement of either a septal pillar or a median septum. Suborder Terebratulidina includes seven superfamilies, three of which, Stringocephaloidea, Cryptonelloidea, and Dielasmatoidea, appear first in the Lower Devonian (Fig. 1307). The Stringocephaloidea, in which the adult loop is commonly acuminate, were widespread during the Devonian but became extinct in the Frasnian. The Cryptonelloidea, which are characterized by an undivided and commonly perforate hinge plate, include forms with short loops (Cranaenidae) and less commonly long loops (Cryptonellidae). This superfamily, while never dominant in the upper Paleozoic, ranges into the Lower Triassic.

The Dielasmatoidea, in which the loop developed commonly from the acuminate to deltiform condition, are the only terebratulides to cross the Permian-Triassic boundary with little loss of diversity, and the superfamily ranges up into the Lower Jurassic. The diverse families included within the Dielasmatoidea may be the precursors of all other short-looped terebratulides. Thus, the Heterelasminidae, in which the deltiform loop is formed by fusion of the descending branches, may lead to the Terebratuloidea, the Cancellothyridoidea, and the Dyscolioidea. The family Pseudodielasmatidae, in which the short deltiform loop undergoes a complex development, may be the precursor of the most diverse superfamily of all, the Mesozoic Loboidothyridoidea, which is characterized by short to moderately long loops that are commonly long flanged.

One of the most substantive changes in systematic placing has involved transfer to the Loboidothyridoidea of many Jurassic short-looped taxa, which were previously included in superfamily Terebratulacea (now Terebratuloidea) in the 1965 *Treatise* (MOORE, 1965). Most were placed in family Terebratulidae along with such living and Cenozoic short-looped genera as *Liothyrella, Gryphus,* and *Terebratula s.s.* DAGYS (1968, 1974) and SMIRNOVA (1990a), among others,

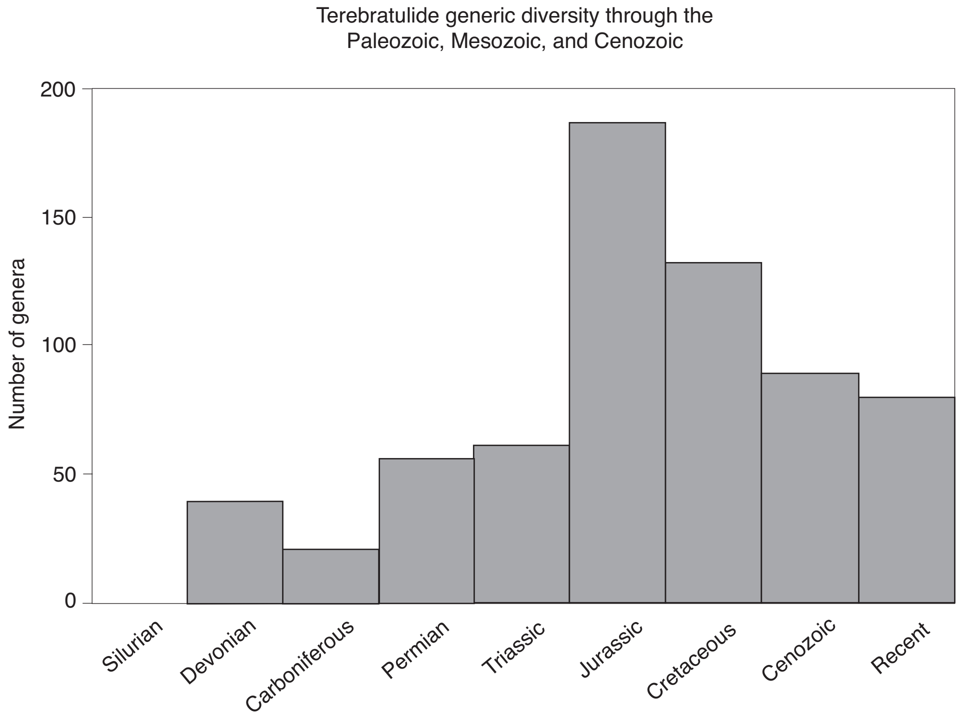

FIG. 1306. Generalized histogram of terebratulide generic diversity through time; all genera present during each time period are included; thus, where a genus, e.g, *Dielasma,* spans more than one period (Carboniferous and Permian), it is counted in both; not to scale; all periods or epochs shown as equal in length (new).

however, demonstrated that some of these long-flanged genera pass through a complex loop development during early ontogeny. Unfortunately, loop development is known for only a few genera (*Viligothyris, Lobothyris*), and until the early stages are studied further, the true affinities of many genera placed in superfamily Loboidothyridoidea remain unknown. Thus, superfamily Loboidothyridoidea, which ranges from Lower Triassic to Lower Cretaceous, is most likely polyphyletic and with further study may prove to incorporate a number of different groups.

SUBORDER TEREBRATELLIDINA

The second suborder, Terebratellidina, may have arisen from the family Angustothyrididae, now included in superfamily Dielasmatoidea, during the late Permian to Early Triassic. In this suborder, loop ontogeny is complex and always involves the median septum or septal pillar. Differentiation of superfamilies within the suborder Terebratellidina is based on such features as presence or absence of dental plates, presence or absence of a septal pillar and its part in loop development, loop ontogenetic stages, and final loop form in adult brachiopods.

All nine superfamilies included in suborder Terebratellidina have living representatives, including the Zeillerioidea, Kingenoidea, and Laqueoidea that first appeared in the Late Triassic. Although laqueoids are still relatively common in modern seas, zeillerioids and kingenoids are each now represented by a single living genus. *Macandrevia,* which is widespread in modern oceans, is the only post-Cretaceous survivor of the diverse Mesozoic zeillerioids, and the enigmatic

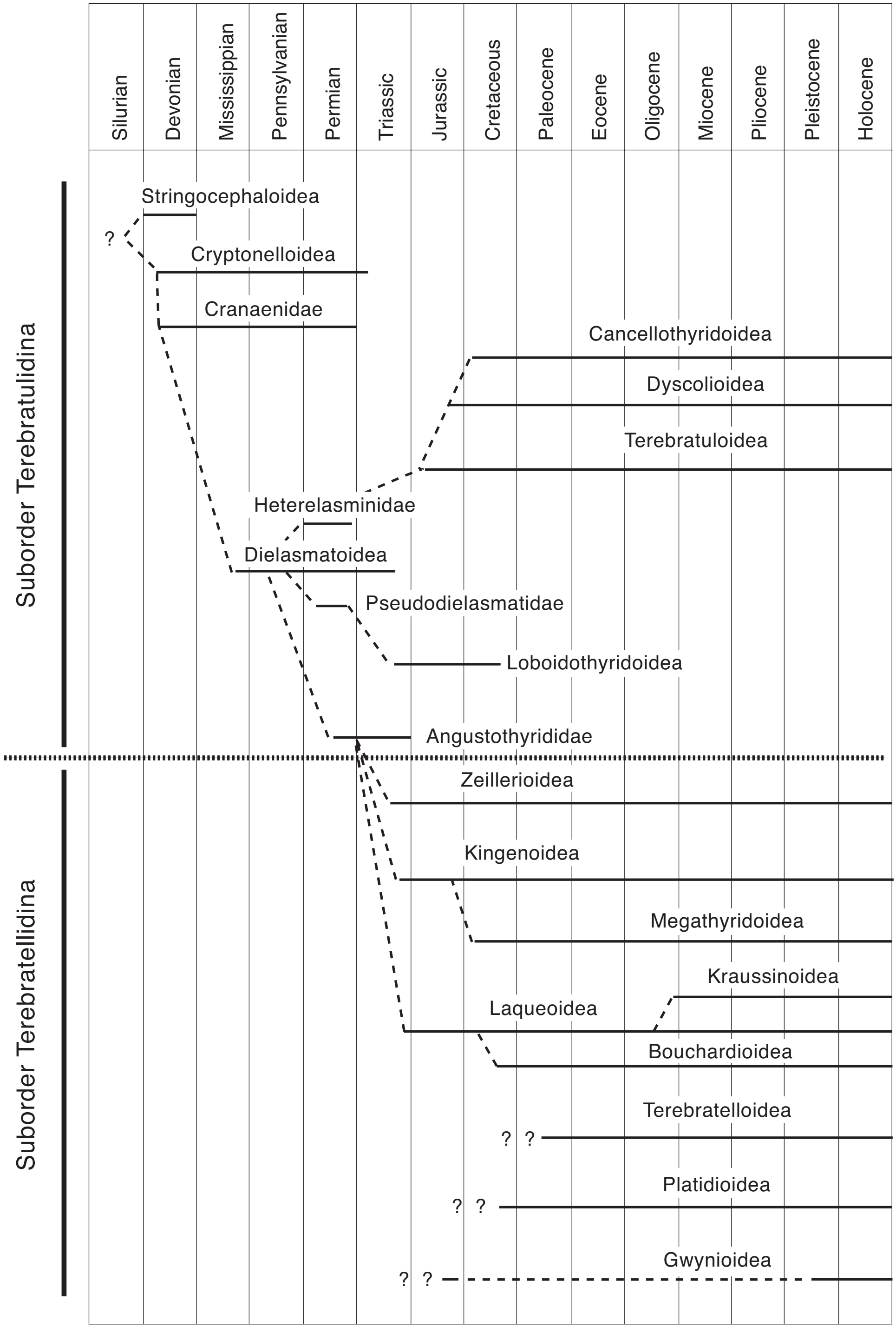

FIG. 1307. Stratigraphic ranges and phylogeny for terebratulide superfamilies and selected families; not to scale; all periods or epochs shown as equal in length (new).

genus *Ecnomiosa* appears to be the only remaining taxon of the superfamily Kingenoidea. Megathyridoids may have been derived from kingenoids in the Late Jurassic–Early Cretaceous (MacKinnon, 2001). Both bouchardioids, which first appeared in the Early Cretaceous, and kraussinoids, which are known from the Miocene to the Holocene, may have evolved independently from Laqueoidea. The ancestral stocks from which the platidioids (Late Cretaceous onward) and terebratelloids (Paleocene onward) arose have not yet been established. The origin and affinities of the Gwynioidea are not clear.

Note that superfamily Dallinoidea as used by Smirnova (1990a) and many others has been discarded. MacKinnon (1996) confirmed the earlier observations of Atkins (1960b) that *Dallina septigera,* the type species of *Dallina,* lacks dental plates throughout ontogeny and is not closely related phylogenetically to the many other genera and families previously assigned to the former superfamily Dallinoidea.

ORIGINS

The oldest representatives of order Terebratulida occur in rocks of earliest Devonian age, although their origins must extend back into the latest Silurian. Boucot (in Boucot & Wilson, 1994) suggested that the primitive earliest terebratulides have morphological features consistent with an origin from the Atrypoidea and in particular *Nalivkinia,* a late Silurian impunctate atrypoid with discrete hinge plates, short dental plates, and spiralia and jugum. *Mutationella* and *Podolella,* among the earliest known terebratulides placed into superfamily Stringocephaloidea, are morphologically similar to *Nalivkinia,* but possess endopunctae and lack spiralia.

The discovery by Jin and Chatterton (1996) of a late Wenlockian silicified brachiopod, *Microbilobata avalanchensis,* which may possess a centronelliform (acuminate) loop and is possibly endopunctate, raises the possibility that the terebratulides are polyphyletic. Doubts about the presence of endopunctae and very different external morphology, however, suggest that *Microbilobata* should be considered at present as an independent taxon that did not give rise to the terebratulides.

TEREBRATULIDE MORPHOLOGY

The classification of order Terebratulida is based on both external and internal morphological features. As emphasized by Stehli (1965, p. 732), external variation in terebratulide shells "is limited, and both parallelism and convergence are common. Thus, it is absolutely mandatory that the internal structures of all shells be studied if inordinate taxonomic confusion is to be avoided."

We illustrate the dorsal, lateral, and anterior views of most genera, together with the dorsal interior. Where a loop illustration is not available, we provide serial transverse sections. Stehli (1965) illustrated most Paleozoic terebratulides by means of stylized or composite line drawings. Here we have provided photographs showing external and internal features for all taxa for which these are available. Note that the loop is unknown for about a third of Paleozoic terebratulide genera, and most Paleozoic terebratulide workers have not made use of serial sections. We have included photographs of the actual loop in preference to serial sections or loop reconstructions. Cooper (1983, p. 1–3) commented in some detail on the lack of correspondence between some loop reconstructions and the actual dissected loop.

EXTERNAL FEATURES

Most terebratulides are ovate, biconvex, and smooth or less commonly ribbed, with a conspicuous open foramen with the delthyrium partly or wholly closed by deltidial plates or a symphytium. "Notwithstanding the risks involved in making taxonomic assignments on the basis of external features alone, there is considerable variation in the shape, size, and ornamentation of terebratulide shells which is useful in their study. Differences in size can be important, but are notoriously subject to error of interpretation, since environmental factors during life and after death may have influenced size distributions. Before size may be used as a taxonomic criterion, ontogenetic sequences and the range of variation within and between populations must be known with some certainty" (STEHLI, 1965, p. 732). This statement can be applied also to the study of internal variation in terebratulides, and it is unfortunate that more students of terebratulide brachiopods did not heed STEHLI's caution before describing a number of genera that are undoubtedly synonyms of existing taxa.

During preparation of this work, it has become apparent that in spite of the advances made since the 1965 *Treatise* (MOORE, 1965), a large number of terebratulide genera are incompletely known.

Because of the substantial amount of variability of external features and probably of most internal features, we stress here that a large number of individuals, including representatives of different ontogenetic stages, must be studied before adequate understanding of true taxonomic placing can be made. Thus, study of the loop by means of serial sections or dissected loops in the case of fossil species is required to describe adequately a new genus. A substantial number of genera listed in this volume are imperfectly understood; loop structure may be entirely unknown (e.g., *Magharithyris, Moisseevia, Moraviatura, Phymatothyris*) or imperfectly known (*Eogryphus, Miogryphus, Waisiuthyrina*); serial sections may be incomplete (e.g., *Naradanithyris, Weldonithyris*). In some cases, only a single specimen was available for study (e.g., *Mayothyris*), and this is an inadequate basis for naming a new genus. Of the Paleozoic terebratulides included herein, the loops of 85 genera are known with some certainty, while 50 other genera are classified on the basis of external morphology or features of the cardinalia alone. Many older genera, such as those described by BITTNER (1888, 1890, 1892) and BUCKMAN (1918), need to be reexamined as some newly described genera are undoubtedly synonyms of older but poorly known taxa. Similarly, comparisons between genera must be detailed, and full justification of the proposed new genus must be provided, taking into account the known variation in other related species or, better still, in living terebratulides.

Overall size and shape

Shells of adult terebratulides range in length from 1 mm to >100 mm, although most are in the 20 to 50 mm class. To standardize size terminology, adult shells <3 mm in length are described as very small, between 3 to 10 mm as small, 10 to 25 mm as medium, 25 to 50 mm as large, and >50 mm as very large. Although arbitrary, these size ranges correlate in part to superfamily groupings: thus, most species of Platidioidea are very small; most members of Cancellothyridoidea are of small to medium size; whereas most members of Terebratuloidea are medium to large. Some terebratulides are among the largest of all brachiopods: some Devonian genera including *Stringocephalus* and *Scaphiocoelia* reached 120 mm in length, and late Cenozoic species of *Terebratula s.s.* were up to 95 mm long. The maximum size that can be achieved by terebratulides with particular types of lophophores may be set by scaling factors (PECK, 1992). As PECK and HOLMES (1989, p. 141) pointed out, "Large brachiopods may suffer space constraints because of the volume needed to house the lophophore." Thus, in some species, more than 75 percent of total body volume may be occupied by the lophophore and mantle cavity. Terebratulides are commonly ventribiconvex, although most platidioids are planoconvex (*Platidia, Amphithyris*), as are occasional members of other superfamilies (*Centronella, Antiptychina*).

Many terebratulides are subcircular in outline as juveniles, becoming subpentagonal, subcircular, elongate oval, or rarely transverse as adults. A few have distinctive outlines (e.g., *Agulhasia, Bouchardia, Pygope, Trigonellina, Trigonosemus*), but in most the shell shape alone is not a reliable diagnostic feature. "Variations in shell shape are quite likely to express a true genotypic variation and are, thus, more likely to be taxonomically significant than size alone. Because of the nature of growth in most brachiopod shells (RUDWICK, 1959; WILLIAMS, 1956), most changes in shape are simply changes in growth rate or in proportion. These changes generally affect the relations between length, width, and thickness of the shell but also commonly affect the length or attitude of the beak, changes in shell curvature, and the development of major folding" (STEHLI, 1965, p. 732).

Folding

The type of folding has been widely used to discriminate terebratulide genera. As pointed out by STEHLI (1965, p. 732), "Since folding is apparently related to nature and disposition of the lophophore within the shell and the efficient control of incurrent and excurrent water streams, it may reflect important changes in soft parts and be of considerable taxonomic significance."

There have been few studies of the variation in folding within and between species and genera. From the limited studies available (e.g., GASPARD, 1988), it seems that the degree of folding may be variable even within a single species of living terebratulide, and care is needed in using folding alone as a diagnostic character.

Most brachiopods are rectimarginate as juveniles, and folding may develop in tandem with sexual maturity. Most Paleozoic terebratulides are rectimarginate to uniplicate. Mesozoic terebratulides are more commonly unisulcate or sulciplicate; only a few are characterized by uniplicate folding. Living terebratulides are commonly unisulcate, and gerontic adults may have accentuated sulciplication of the commissure. The main types of commissure folding are illustrated in WILLIAMS, 2000 (see fig. 289, p. xxx).

Ornament

Most terebratulides are externally smooth; the spacing of comarginal growth bands or growth halts on brachiopod shells reflects the ecological conditions under which the animals were living and possibly their longevity. It is unlikely to be of taxonomic value, though it is mentioned sometimes in older descriptions. Some of the earliest Devonian terebratulides (e.g., *Podolella, Rensselaerina*) have smooth umbones but develop peripheral costae, while others (e.g., *Cloudella, Rhipodothyris*) are entirely costellate. All members of the Cancellothyridoidea are finely capillate (e.g., *Terebratulina, Eucalathis*); some kraussinoids are costellate (e.g., *Kraussina, Megerlia*); and most megathyridoids (e.g., *Argyrotheca, Megathiris*) carry broad costae. A small number of Mesozoic zeillerioids (e.g., *Eudesia, Flabellothyris*) and a few genera placed in superfamily Loboidothyridoidea (e.g., *Striithyris, Plectoidothyris*) are costate, costellate, or semicostate. *Kingena* has an unusual ornament of spinose pustules or granules.

Some laqueoids are costate (e.g., *Gemmarcula, Trigonosemus, Dereta*), as are a few terebratelloids, although closely related genera within the same family may be costate or smooth (e.g., *Terebratella* and *Calloria*).

Shell Structure

All members of the order Terebratulida are endopunctate, with primary and secondary shell layers largely of low-magnesium calcite. A few terebratulides (e.g., *Gryphus* and *Liothyrella*) possess a tertiary shell layer modified from the secondary layer. Although some workers (e.g., KATZ & POPOV, 1974a, 1974b) have used the presence of a tertiary layer in generic discrimination, the taxonomic value of this feature has not been demonstrated. The highly thickened modified secondary shell (perhaps the tertiary layer) of the Devonian stringocephalids is a consistent feature of the family.

Beak and Foramen

Beak characters of terebratulides are generally conservative. In juvenile terebratulides the pedicle emerges from a triangular delthyrium that may become restricted by disjunct or conjunct deltidial plates or by a symphytium. As growth proceeds, attrition in the apical region of the umbo where the shell is in direct contact with the substrate commonly leads to breaching of the posteromedian apex of the delthyrium by the pedicle in varying degrees. The foramen is submesothyrid, mesothyrid, or permesothyrid in most Mesozoic and Cenozoic terebratulides but may be amphithyrid (*Amphithyris, Platidia*) or rarely hypothyrid (*Malleia*) (see WILLIAMS, BRUNTON, & MACKINNON, 1997, p. 356, fig. 318). Rarely, the beak is elongated to produce a distinctive rostrum as in the Cretaceous *Terebrirostra* and Miocene to Holocene *Agulhasia.*

The foramen varies in size from a pinhole, as in the Upper Cretaceous terebratuloid genus *Gibbithyris,* to a large, circular to subcircular or oval opening, which accommodated an always functional pedicle. Deltidial plates are commonly conjunct, although in cancellothyridoids these are characteristically disjunct. Members of such Paleozoic families as Notothyrididae and Cranaenidae possess a labiate foramen that is also present in a few Cenozoic genera such as *Liothyrella.*

Color

Shell coloration is a characteristic feature of many living terebratulides, and color patterns are not uncommonly preserved in some Paleozoic and Mesozoic brachiopods (e.g., *Cranaena, Beachia, Coenothyris*) (CLOUD, 1942; BLODGETT, BOUCOT, & KOCH, 1988; HAGDORN & SANDY, 1998). The most distinctive colors are shades of pink, red, pale orange, or red-brown; the entire shell exterior may be colored (e.g., *Argyrotheca, Bouchardia, Kraussina, Neothyris*), or there may be a radiating pattern characteristic of a particular species (e.g., *Frenulina sanguinolenta, Calloria variegata*). Bright colors are characteristic of species living in shallow water (usually less than 50 m). The pigments are derived from the algae ingested by the living brachiopod (CUSACK & others, 1992), and thus it is probable that fossil species exhibiting shell coloration were also inhabitants of shallow water. Deep-water terebratulides are commonly white, cream, or pale gray. Color may have some deterrent effect on predators.

INTERNAL STRUCTURES

Spiculation

Spicules are variably developed in a number of terebratulide families. Typical spicule morphology is shown in WILLIAMS, BRUNTON, and MACKINNON (1997, fig. 339 and 340). Well-developed spiculation in the lophophore and mantle is characteristic of most living members of superfamilies Cancellothyridoidea, Dyscolioidea, Terebratuloidea, Platidioidea, and Kraussinoidea. Some genera of Kingenoidea and Laqueoidea may be weakly spiculate. Spicules are preserved occasionally in fossil shells (e.g., STEINICH, 1963) and are assumed to have been present in other fossil examples of the strongly spiculate groups. Spicules appear to be most abundant in families with small, short loops and may have provided additional support for the lophophore.

Ventral Valve Interior

The ventral valve of most terebratulides is relatively simple. Apart from the presence or absence of a pedicle collar, hinge teeth, and differences in definition of muscle scars (which may produce a myophragm), the feature of major importance at a higher taxonomic level is the presence or absence of dental plates. In a few superfamilies, the teeth are supported by well-defined dental plates of secondary shell that extend to the floor of the ventral valve. The presence of well-developed dental plates is a diagnostic character of Zeillerioidea, Laqueoidea, and Kingenoidea. Short dental plates, although quite common in Paleozoic genera, are not used usually in taxonomic discrimination. The significance of presence or absence of dental plates as a possible family-level character in Dielasmatoidea needs to be reassessed.

A ventral median septum is present in some stringocephalid genera but absent from most other Devonian taxa. Occasionally, a very distinctive ventral muscle field allows separation of genera with similar cardinalia (e.g., *Rhenorensselaeria* and *Globithyris*). Within the Terebratellidina, only members of the Megathyridoidea possess a median septum in the ventral valve. Pedicle collars are absent or indistinct in most Paleozoic forms but are commonly present in Mesozoic and Cenozoic genera.

Hinge Teeth

All terebratulides bear well-defined cyrtomatodont hinge teeth on an astrophic hinge line. Some Cenozoic and living terebratellids are characterized by extremely swollen hinge teeth bases (e.g., *Neothyris, Stethothyris*) that may be related to strong posterior shell thickening. Such swollen bases may be grooved to accommodate the socket ridges as in *Bouchardia.* A few genera (e.g., *Dyscolia*) have seemingly disproportionately small hinge teeth for large adult shells.

DORSAL VALVE INTERIOR

Cardinalia

Almost all adult terebratulide brachiopods, with the exception of the Zeillerioidea, possess a small, often thin, flattened, ridgelike or bosslike cardinal process to which the diductor muscles were attached (Brunton, Alvarez, & MacKinnon, 1996). In most terebratulides the cardinal process is a transverse, semielliptical structure that is sometimes bilobed and occasionally becomes heavily thickened to form a protuberant myophore. The cardinal process of Paleozoic terebratulides is highly variable and in some Devonian brachiopods (e.g., *Stringocephalus*) may be very large, rodlike, and terminally bifid (Boucot, Johnson, & Struve, 1966). Heavily thickened cardinal processes occur in terebratulides of Cretaceous age (e.g., the short-looped *Carneithyris* and long-looped *Terebrirostra* and *Trigonosemus*), and in some Cenozoic and extant terebratellids (e.g., *Rhizothyris, Neothyris*).

A cardinal plate perforated by a dorsal foramen is characteristic of many Paleozoic stringocephaloids and cryptonelloids, and features of the cardinalia are important diagnostic characters in cryptonelloids and dielasmatoids. The presence of outer or less commonly inner hinge plates is an important diagnostic feature in short-looped terebratulidines.

Socket Ridges

"Socket ridges are seldom of importance in generic definition" (Cooper, 1983, p. 23). Sockets are related to the size and shape of the hinge teeth and are of diagnostic value for cancellothyridoid brachiopods (e.g., *Terebratulina*) in which crural bases are directly attached to the well-developed socket ridges.

LOOP MORPHOLOGY AND TERMINOLOGY IN TERεBRATULIDA

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Studies of living brachiopods of the order Terebratulida have shown that most adult taxa possess a plectolophous lophophore that is supported internally by a brachidium that may vary markedly in size, shape, and preservability. Depending on whether support for both the side arms and central coil of the plectolophe is provided by a twisted ribbon composed of secondary layer fibers and brachiotest (Mackay, MacKinnon, & Williams, 1993) or a spicular meshwork (Schumann, 1973), the brachidium of terebratulide brachiopods may be broadly categorized as either long looped or short looped. (Note, however, that although the terms short loop and long loop provide a quick and ready means of discriminating between adult brachiopods of the suborders Terebratulidina and Terebratellidina, they indicate nothing of the phylogenetically significant complexities of loop ontogenetic development that may occur within both suborders.)

Just as the terebratulide lophophore may undergo ontogenetic change from trocholophe to schizolophe, zygolophe, and ultimately plectolophe (Williams, Brunton, & MacKinnon, 1997, p. 115, fig. 114), so also may the supporting brachidium; and for more than a century brachiopod workers have grappled with the complexities of brachidial development, particularly in long-looped Terebratellidina. Following the lead of Friele (1877), succeeding workers chose to avoid long and detailed morphological descriptions by indicating the sequential forms of loop displayed in different species by means of adjectival names derived from typical genera. Each term was defined initially on the final, adult stage of loop development in the genus chosen, but the term was then applied in other taxa to any morphologically comparable stage of loop development, not necessarily the final stage. In particular Fischer and Oehlert (1892), Beecher (1893), and Thomson (1915a) were influential in both the development of a genus-name–based terminology and in establishing patterns of loop development as the principal basis for recognizing and differentiating groups of genera at both family and subfamily levels.

As the ontogenies of an increasing number of fossil and living brachiopods were investigated and as new taxonomic groupings were established, many new and different patterns of loop development were reported in the literature. Often, reports of loop development were accompanied by additional, new loop terminology (Cooper, 1957a; Elliott, 1965a; Elliott & Hatai, 1965; Hatai, 1965b; Dagys, 1968, 1972b, 1974; Baker, 1972; Smirnova, 1984; Smirnova & Dagys, 1986; Zezina, 1985). Elliott (1965a, p. 835), for example, considered that members of the subfamily Dallininae were characterized by loops that passed through some or all growth stages described as "precampagiform, campagiform, frenuliniform, terebrataliiform and dalliniform" (alluding to adult loop configurations in the genera *Campages, Frenulina, Terebratalia,* and *Dallina*). Similarly Elliott and Hatai (1965, p. 847) diagnosed members of the family Terebratellidae as passing through all or part of a loop development sequence termed "premagadiniform, magadiniform, magelliform, terebratelliform and magellaniform" (alluding to adult loop configurations in the genera *Magadina, Magella, Terebratella,* and *Magellania*). In terms of basic loop morphology, however, the adult loops of *Terebratalia* and *Terebratella* (and for that matter *Dallina* and *Magellania*) are virtually indistinguishable. Thus the loop terminology applied to any particular taxon was

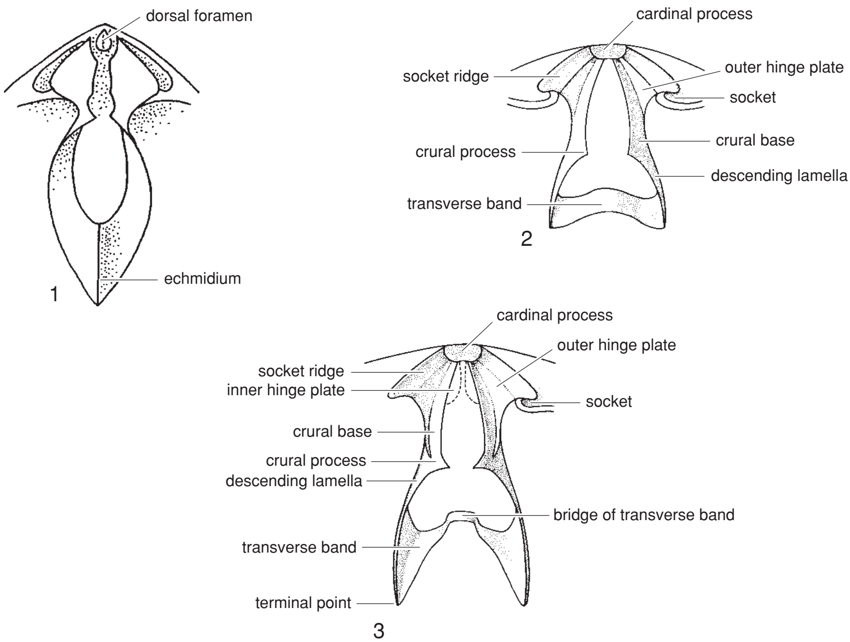

FIG. 1308. Internal morphology of representative short-looped terebratulidine brachiopods: *1,* acuminate loop typical of many Paleozoic terebratulides (adapted from Stehli, 1965); *2,* deltiform loop typical of many Mesozoic-Holocene short-looped terebratulides; *3,* long-flanged deltiform loop typical of Mesozoic Loboidothyridoidea (adapted from Cooper, 1983).

largely dependent on preconceived taxonomic affinities.

At the time of the publication of the 1965 *Treatise* (MOORE, 1965), few full sequences of loop development were known. In most, the limitations on resolution imposed by light microscopy precluded the recognition of a number of important distinctions in both early and late stages of loop development revealed by subsequent investigations using scanning electron microscopy. These latest studies (MACKINNON, 1993, 1996; MACKAY, MACKINNON, & WILLIAMS, 1993; MACKINNON & GASPARD, 1996; SAITO, 1996; MACKINNON, SAITO, & ENDO, 1997; SAITO & ENDO, 2001) have led to major taxonomic revisions that render many of the genus-name-based terms redundant.

For example, loop development studies of a variety of taxa that were previously assigned to the family Dallinidae, as constituted in the 1965 *Treatise* (MOORE, 1965), have identified at least three quite distinct and unrelated patterns of loop development in the genera *Dallina, Macandrevia,* and *Terebratalia.* Indeed, the type species of the genus *Dallina* [*D. septigera* (LOVÉN)] is characterized by an array of morphological characters, including loop development, that suggests closer affinities to Terebratellidae than to most other taxa hitherto assigned to the family Dallinidae (MACKINNON, 1996). *Macandrevia,* on the other hand, has a loop ontogeny comparable to that of Mesozoic zeillerioids (MACKINNON & GASPARD, 1996), and *Terebratalia* has a loop ontogeny suggesting closer affinities with laqueoids (SAITO, 1996; SAITO & ENDO, 2001).

TERMINOLOGY

The long-standing and up to now still widely used scheme based on names of

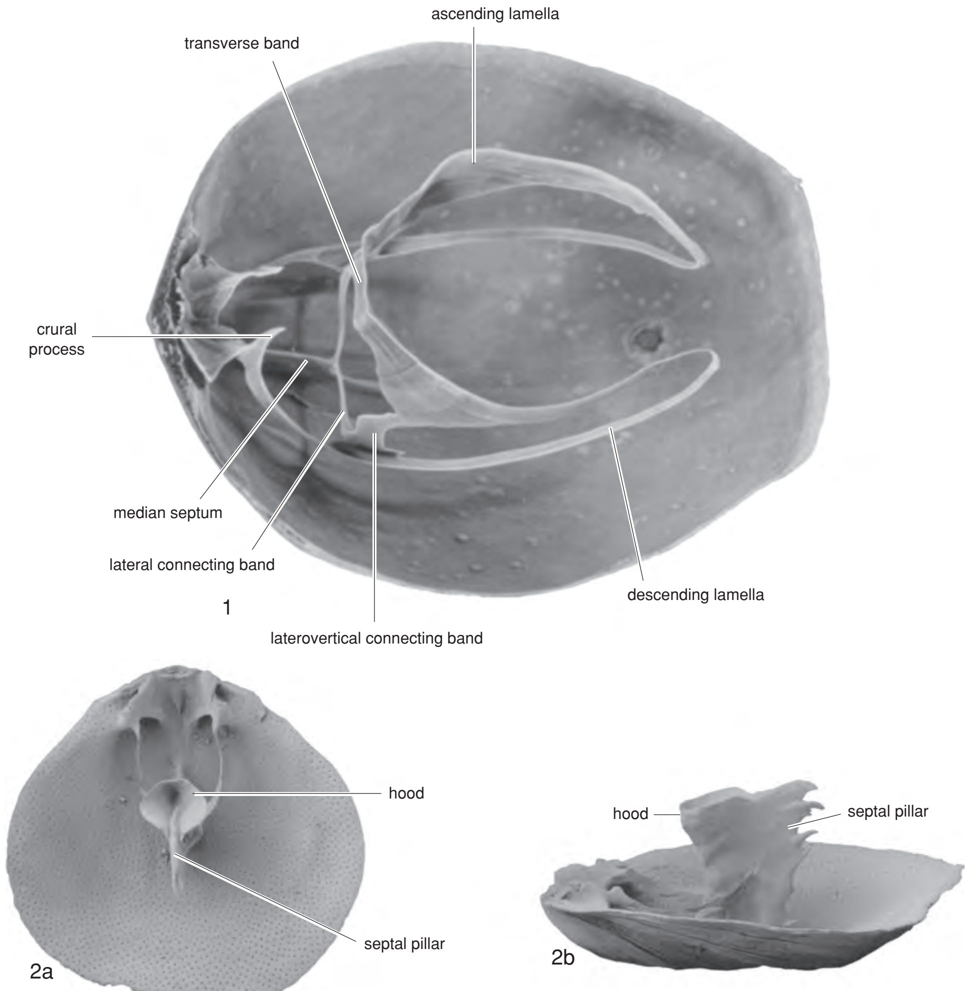

FIG. 1309. Terminology of the loop: *1, Laqueus erythraeus* DALL, oblique lateral view of adult dorsal interior showing bilateral loop phase, ×2 (new); *2a–b, Calloria inconspicua* (SOWERBY), *a–b*, dorsal and lateral views of very small juvenile showing cucullate loop phase, ×8 (new).

genera has become increasingly unworkable, and we here advocate the adoption of an alternative simpler terminology that may be applied to morphologically comparable stages of loop growth in unrelated stocks. A key advantage of a scheme eschewing a taxon-based etymology is that of being unaffected by subsequent taxonomic revision.

The terminology first applied by RICHARDSON (1975a) to post-Paleozoic long-looped terebratulides is now modified to correct some ambiguities and expanded to apply to all members of the order (see Fig. 1310–1311). The term axial is now restricted to a stage before development of a hood, and the new term cucullate is introduced for the phase coinciding with development of a hood. It should be noted that two sets of terminology are used in discussions of terebratulide brachidia. One set of terms (see Fig. 1309–1311; e.g., septal pillar) is used to describe particular loop components or supporting structures that may persist through several phases of loop development. The second set of terms (see Fig. 1310–1312; e.g., acuminate) applies to the transient (juvenile) or terminal (adult) phases of loop development themselves. Apart from the teloform loop phase, which is always a terminal phase, loop phases may be either transient or terminal.

SHORT-LOOPED TEREBRATULIDA

In short-looped terebratulidines, diagnostic features are based in part on external characters and, more importantly, on morphological features of the loop and cardinalia (Fig. 1308). In short-looped terebratulides, support for the loop is provided only by the crura. Thus, directly or indirectly, descending (as well as any ascending) loop elements are derived entirely from extensions of the cardinalia. The simplest form of support that occurs in Paleozoic terebratuloids is formed by a pair of gently curved descending lamellae that extend anteriorly from the crura and fuse anteromedially; the site of fusion of the descending branches may become enlarged to form a broad, pointed blade, the echmidium (Cooper, 1957a). This loop form has been variously referred to in the literature as centronellid, centronelloid, or centronelliform; the nongeneric term acuminate is introduced herein for this form of loop (Fig. 1308.1 and Fig. 1311.1). In various Paleozoic taxa, an acuminate loop persisted in adult shells with little modification other than a general increase in size. Indeed, an acuminate loop developed to such large size in some Stringocephalidae, for example, that, technically, such loops could be regarded as long rather than short. Furthermore, in some Paleozoic and Mesozoic terebratulides, a ventrally projecting, medially aligned, vertical plate developed normal to the echmidium. In most short-looped brachiopods, such as dielasmatoids and terebratuloids, a juvenile acuminate phase (with or without a vertical plate) gave rise to an adult, deltiform phase consisting of a variably disposed transverse band extending between the distal ends of two relatively short, divergent, descending lamellae (Fig. 1308.2, 1313.3a–e, and 1314.1a–f).

Some Jurassic and Early Cretaceous genera have a long-flanged deltiform loop that differs from a typical deltiform loop in the anterior extension of the terminal points beyond the transverse band as two long flanges (Fig. 1308.3 and 1311.3). In some Mesozoic Loboidothyridoidea with an adult long-flanged deltiform loop, more complicated intermediate phases of loop metamorphosis occur (Dagys, 1968, 1972b) that involve the development of a vertical plate bisecting the echmidium. In several genera (e.g., *Viligothyris*) the intermediate phases of loop development involving the vertical plate paralleled to a remarkable degree the intermediate phases of loop development involving a septal pillar in many long-looped taxa (see Fig. 1314.2). Thus, even though the vertical plate and septal pillar are not truly homologous structures, due to strong similarities in their metamorphoses much of the descriptive terminology may be readily applied to taxa with both kinds of loop development.

Although there are some published studies (Beecher & Schuchert, 1893; Watson, 1909; Stehli, 1956; Dagys, 1958, 1968, 1972b, 1974; Steinich, 1965; Carter, 1967b; Cooper & Grant, 1976b), general patterns of loop development in many short-looped brachiopods are unknown. In particular, general patterns of loop development in the 140 or so long-flanged genera (mainly of Jurassic age) placed presently into superfamily Loboidothyridoidea are yet to be established.

LONG-LOOPED TEREBRATULIDA

In long-looped terebratellidines, the loop structures and associated terminology are commonly more complex because of the major developmental changes that take place during ontogeny (Fig. 1310–1312). Post-Paleozoic long-looped brachiopods

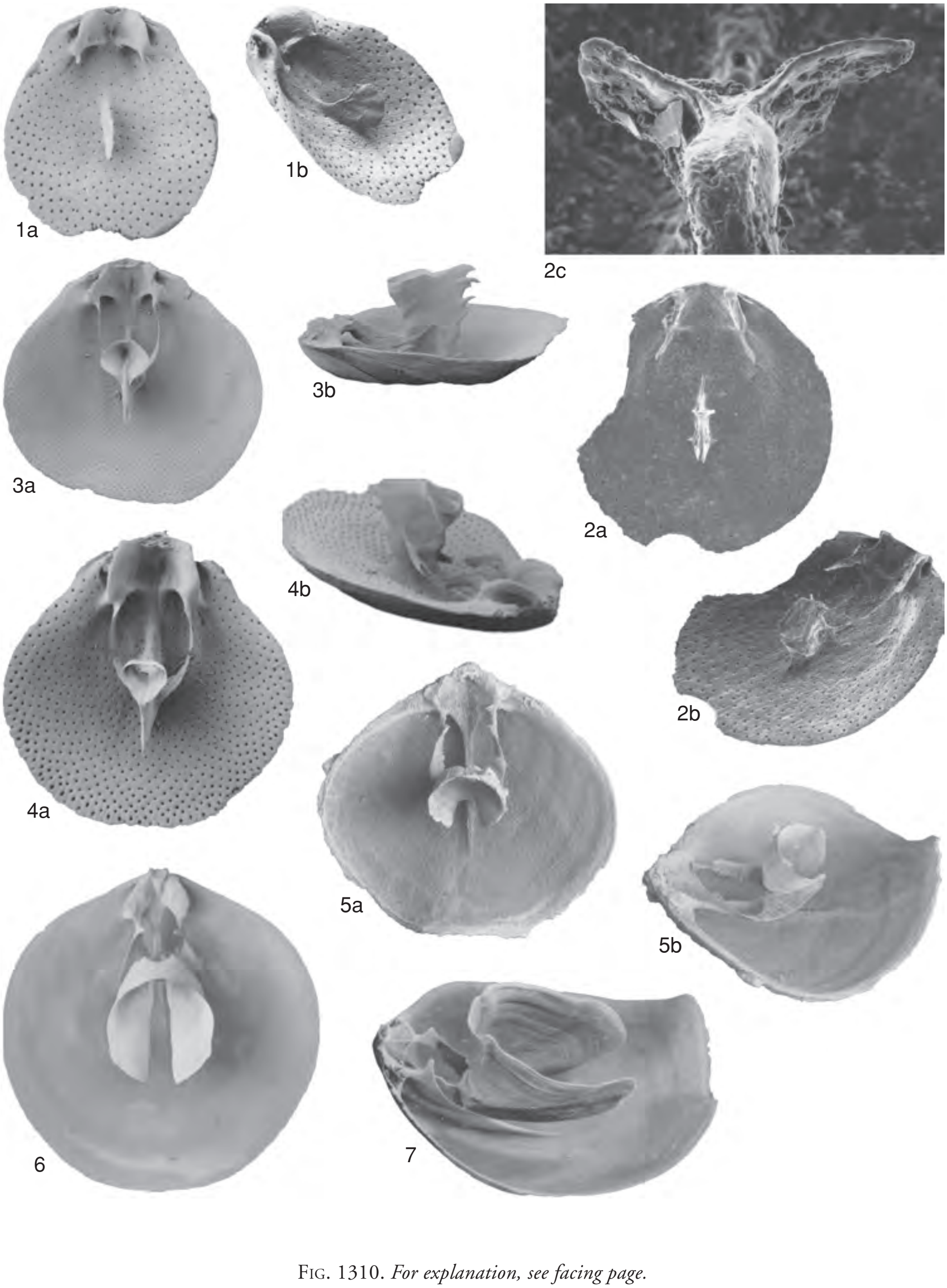

FIG. 1310. *For explanation, see facing page.*

(Terebratellidina) are characterized early in ontogeny by the development of a median septal pillar that grows from the floor of the dorsal valve (Fig. 1310.1a–b). Characteristic of Laqueoidea is the development of a pair of laterally directed septal flanges (Fig. 1310.2a–c) on the posterior edge of the septal pillar. The septal pillar is generally involved intimately in the early ontogenetic development of the ascending loop elements, which develop first as a hood (Fig. 1310.3a–b) and second as a ring (Fig. 1310.4a–b), before uniting with the descending elements (incipient descending lamellae), which also develop in part from the septal pillar. Later in ontogeny, the septal pillar may grow into a full median septum from which the loop may become detached.

In *Laqueus* (Fig. 1309), the adult loop consists of a pair of gently curved and partially twisted descending lamellae that terminate posteriorly as a pair of pointed crural processes close to the point of union of the descending lamellae with the crura. At their anterior extremities the descending lamellae bend tightly through approximately 180° and extend posteriorly as rather more strongly curved and twisted ascending lamellae that are united posteriorly by a transverse band. A pair of lateral connecting bands joins the descending lamellae to the median septum, and the ascending and descending lamellae are braced by a pair of laterovertical connecting bands. In *Ecnomiosa,* a pair of mediovertical connecting bands extend between the transverse band and median septum (see Fig. 1311.11a–b).

In the post-Paleozoic Terebratellidina for which full developmental sequences are known (but excluding, most notably, the

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FIG. 1310. New terminology and illustrations of terebratulide developmental phases, with synonyms.

Annular phase: with a ring formed by resorption of the posterior apex of the hood. The ring and descending lamellae are attached separately to the septal pillar, but are not yet united (see haptoid phase); syn: cryptacanthiform (early), magadiniform, premagadiniform; syncampagiform; *4a–b, Magellania flavescens* (LAMARCK), ventral and oblique lateral views of dorsal valve interior, ×18 (new).

Axial phase: with a vertical plate (Paleozoic forms) or septal pillar (post-Paleozoic forms); descending lamellae complete in Paleozoic forms, rudimentary in most post-Paleozoic forms; syn: centronelliform, platidiiform, preparamagadiniform; *1a–b, Calloria inconspicua* (SOWERBY), ventral and oblique lateral views of dorsal valve interior, ×10 (new).

Cucullate phase: with a hood on either vertical plate or septal pillar. Descending lamellae complete in Paleozoic forms, commonly incomplete in post-Paleozoic forms; syn: early cryptacanthiform, paramagadiniform, precampagiform, premagadiniform, quasipremagadiniform; *3a–b, Calloria inconspicua* (SOWERBY), ventral and oblique lateral views of dorsal valve interior, ×8 (new).

Diploform phase: with adjacent ascending and descending elements fused and free of the septum except at their posterior extremities. At this stage (early diploform) the transverse band and posterior sections of the ascending lamellae are defined. The descending branches are defined (late diploform) with resorption of the anterior segments of the ascending branches; syn: campagiform, cryptacanthiform, ismeniform, magadiform, pre-ismeniform; *6, Jaffaia jaffaensis* BLOCHMANN, ventral view of dorsal valve interior, ×3; *7, Campages furcifera* HEDLEY, lateral oblique of dorsal valve interior, ×2 (new).

Haptoid phase: with anterior fusion of ascending and descending elements and their accompanying separation from the vertical plate or septal pillar. Posterior sections of the ascending and descending elements are still separately attached to vertical plate or septal pillar; syn: cryptacanthiform (in part), dictyothyridiform, magelliform, magaselliform; *5a–b, Magella carinata* THOMSON, ventral and oblique lateral views of dorsal valve interior, ×4 (new).

Septal flange: 2*a–b*, ventral and oblique views, ×20, *2c,* closeup of septal flanges in *Laqueus erythraeus* DALL, ×40 (new).

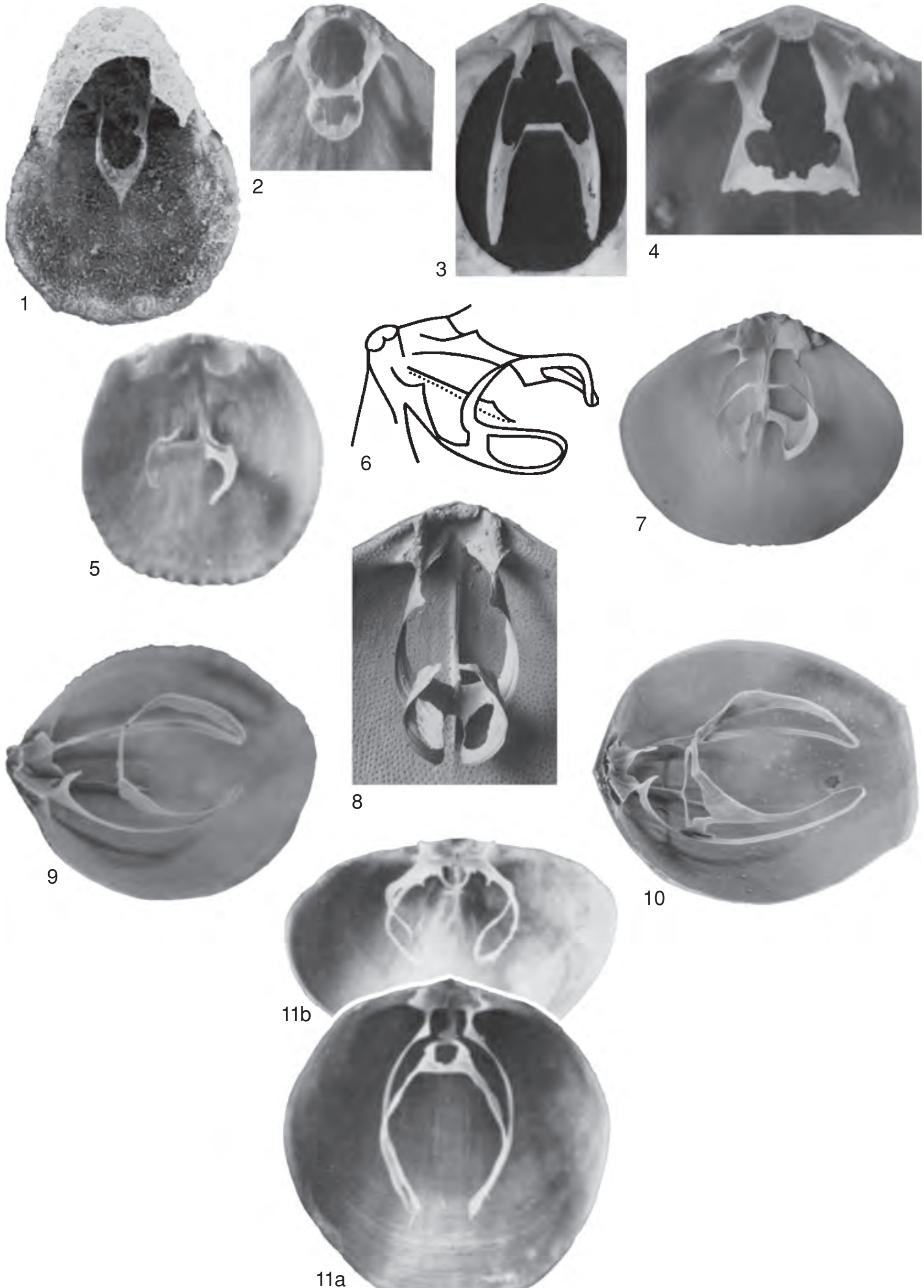

FIG. 1311. *For explanation, see facing page.*

genera *Macandrevia* and *Ecnomiosa* and the Megathyridoidea), only the posterior sections of the descending lamellae arise from the cardinalia but all other parts of the loop, including anterior segments of the descending lamellae, derive from a septal pillar (BAKER, 1972, 1989b; RICHARDSON, 1975b; MACKINNON, 1993; MACKINNON & GASPARD, 1996).

In the Terebratelloidea, Laqueoidea, Zeillerioidea, and Kingenoidea, the following sequential phases of loop development occur.

1. Formation of a septal pillar on the dorsal valve floor (axial phase) (Fig. 1310.1a–b).

2. Formation of a hood on the ventral or posteroventral crest of the septal pillar (cucullate phase) (Fig. 1310.3a–b).

3. Enlargement of the hood and resorption of its apex to form a ring, segments of which ultimately form the ascending lamellae and transverse band (annular phase) (Fig. 1310.4a–b).

4. Fusion of the growing (anterior) edges of the descending lamellae and ring, followed by the progressive detachment in an anterior direction of the fused elements from the septal pillar or septum (haptoid phase) (e.g., *Magella,* Fig. 1310.5a–b). In several genera the haptoid phase may be succeeded by a phase in which the hood becomes enormously expanded anteriorly, while the descending lamellae retain points of attachment to a median septum (diploform phase) (e.g., *Campages, Jaffaia,* Fig. 1310.7 and 1310.6).

Up to the haptoid or diploform phases, development of the loop is comparable in all four of the above superfamilies, but thereafter the development proceeds along different routes that are determined primarily by subsequent resorptive and accretionary processes.

In Terebratelloidea, the ascending loop elements continue to expand through accretion along the anterior (outward-facing)

FIG. 1311. New terminology and illustrations of terebratulide developmental phases, with synonyms.

Acuminate phase: with laterally bowed, descending lamellae extending from crura but otherwise unsupported and uniting anteromedially to form an echmidium; syn: centronelliform; *1, Dielasma zebratum* COOPER & GRANT*,* ventral view of dorsal valve interior, ×10 (new).

Bifurcate phase: with Y-shaped median septum (characteristic of Kraussinidae); syn: kraussinid; *5, Kraussina rubra* (PALLAS), ventral view of dorsal valve interior, ×1.5 (Cooper, 1973b).

Bilacunar phase: with two lacunae in the dorsal segments of the band forming the ring; syn: frenuliform, frenuliniform, ismeniform, kingeniform; *8, Frenulina sanguinolenta* (GMELIN), ventral view of dorsal valve interior of slightly damaged loop, ×5 (new).

Bilateral phase: with two pairs of connecting bands, lateral and laterovertical; syn: laqueiform; *10, Laqueus erythraeus* DALL, lateral oblique view of dorsal valve interior, ×1 (new).

Deltiform phase: with a variably disposed transverse band extending between the distal ends of two relatively short, divergent, descending lamellae; syn: chilidonophorid, cranaeniform, dielasmoid, pygopid, terebratuloid, terebratuliform, terebratuliniform, sulcatinelliform; *2, Terebratulina latifrons* DALL, ventral view of loop, ×4 (Cooper, 1983); *4, Liothyrella neozelanica* THOMSON, ventral view of loop, ×2 (Cooper, 1983).

Laterovertical phase: with laterovertical connecting bands only; syn: pictothyridiform; *6, Pictothyris picta* (DILLWYN), lateral view of loop, ×3 (after Saito & Endo, 2001).

Long-flanged deltiform: deltiform loop in which descending branches are extended as flanges beyond the transverse band; syn: loboidothyrid; *3, Monsardithyris ventricosa* (ZIETEN), ventral view of dorsal valve interior, ×1.5 (new).

Mediovertical phase: with a pair of mediovertical connecting bands extending from the median septum to the transverse band; syn: belothyridiform, megerliiform, muehlfeldtiform; *11a–b, Ecnomiosa gerda* COOPER, ventral and anterior views of loop showing mediovertical connecting bands, ×1.6 (Cooper, 1977).

Teloform phase: with loop free of septum; syn: aulacothyroidiform, cryptonelliform, dalliniform, glossothyropsiform, glossothyropsidiform, magellaniform, zeilleriform, zeilleriid; *9, Magellania flavescens* (LAMARCK), oblique lateral view of dorsal valve interior, ×2 (new).

Trabecular phase: with lateral connecting bands only; syn: terebratelliform, terebrataliiform; *7, Calloria inconspicua* (SOWERBY), ventral view of dorsal valve interior, ×4 (new).

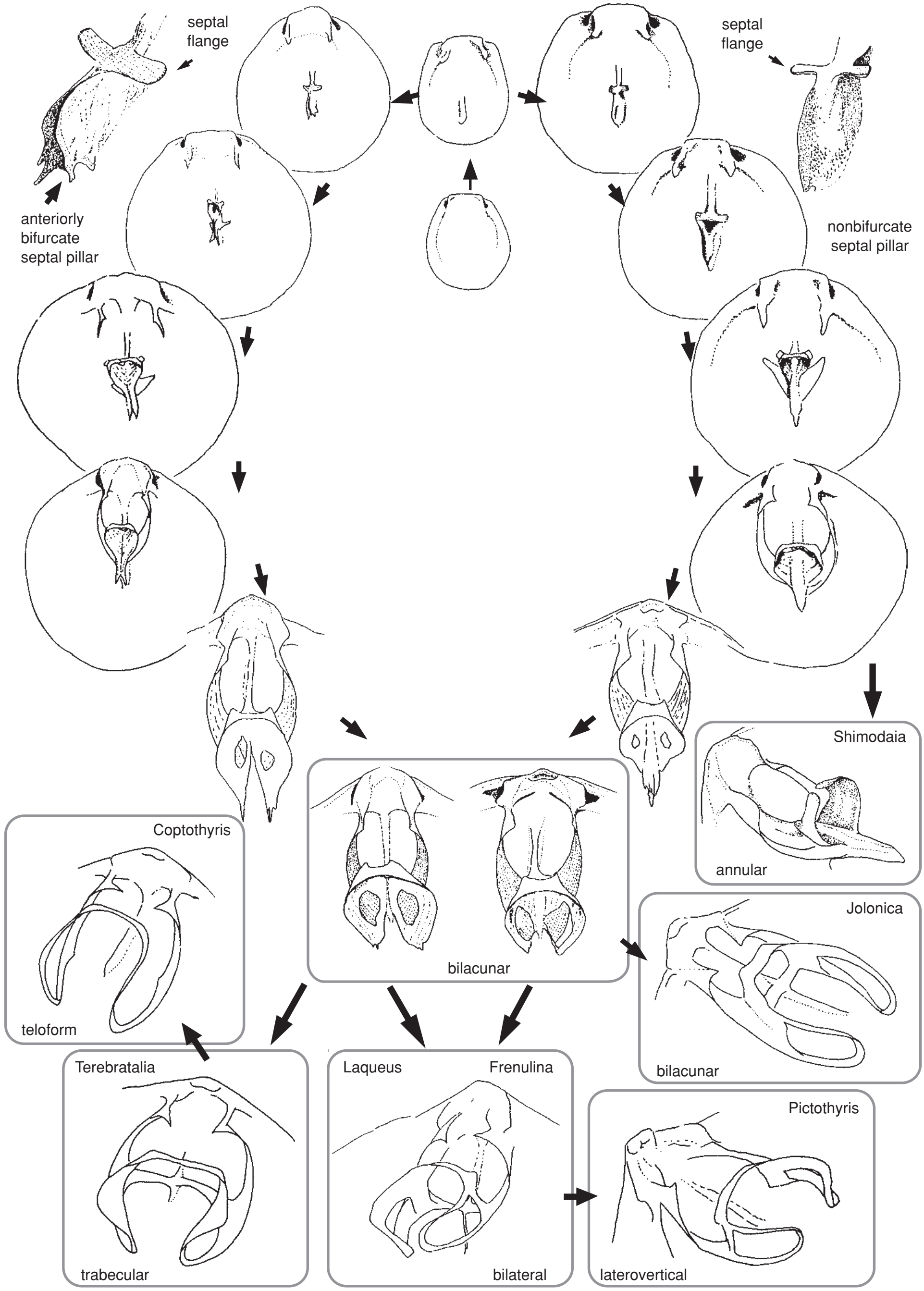

FIG. 1312. Loop ontogeny of selected recent Laqeoidea; drawings not to scale; Laqueoidea are characterized by presence of a pair of flanges on septal pillar at axial phase. The route to transient bilacunar phase may follow one of two paths: one with, and one without, anterior bifurcation of the median septum. Various terminal adult loop phases, following on from the transient bilacunar phase, are shown (adapted from Saito & Endo, 2001).

edge and resorption along the posterior (inward-facing) edge. Detachment of the descending lamellae from the median septum by resorption of the junction gives rise to a long, reflected loop free of attachments (teloform phase; e.g., *Magellania,* Fig. 1311.9). In certain Terebratelloidea (e.g., *Calloria*), the descending lamellae, although well separated from the median septum, are braced by a pair of narrow, lateral connecting bands formed from lateral extensions of the median septum (trabecular phase) (Fig. 1311.7).

Following the haptoid phase of some Laqueoidea, Zeillerioidea, and Kingenoidea, a pair of lacunae may form within the ascending lamellae as a result of localized resorption (bilacunar phase) (e.g., *Frenulina,* Fig. 1311.8). The pair of steeply inclined loop segments immediately posterior of the resorption lacunae are conveniently referred to as vertical connecting bands that feature in various later loop phases. The adult loop of the genus *Laqueus* (Laqueoidea) is characterized by the development of two pairs of connecting bands, lateral and laterovertical (bilateral phase) (Fig. 1311.10). The adult loop of the genus *Pictothyris* (Laqueoidea) is characterized by only laterovertical connecting bands (laterovertical phase) (Fig. 1311.6). The adult loop of *Ecnomiosa* (Kingenoidea) is characterized by only mediovertical connecting bands (mediovertical phase) (Fig. 1311.11a–b).

UNUSUAL OR ABERRANT POST-PALEOZOIC LONG-LOOPED BRACHIOPODS

Several Cenozoic terebratulide superfamilies contain unusual and commonly micromorphic species in which a loop is either absent, rudimentary, or in a form that is not readily comparable with the growth stages common to other loop-bearing superfamilies.

KRAUSSINOIDEA

A distinctive Y-shaped median septum is characteristic of all Kraussinoidea. In the past, the two ventrally divergent branches of the septum have been termed ascending lamellae (Thomson, 1927; Elliott, 1949; Richardson, 1975a), but scanning electron microscopy has revealed that these projections have an origin and shell ultrastructure quite different from the ascending lamellae of typical long-looped terebratulides.

Consequently the standard kraussinoid brachidium is recognized as a unique loop form, herein termed bifurcate (Fig. 1311.5). In *Megerlia truncata,* however, further loop development is apparent. First, in juvenile *M. truncata,* the distal extremities of the Y-shaped median septum become united by a narrow transverse band to form a ring, i.e., an annular phase (but of very different origin from the annular phase of most other long-looped brachiopods). Thereafter, rudiments of descending branches grow from both the ring and crura, eventually uniting and giving rise to a hybrid diploform loop phase resembling that of the terebratellid *Campages* but formed by a very different growth process (see Fig. 1317.4).

PLATIDIOIDEA

Various genera of Platidioidea are characterized by a high septal pillar from which narrow lamellae may extend posterolaterally to connect with crura, and thus their adult loop phase might nominally be termed axial (see Fig. 1317.2). The variably coiled lophophores occurring in these taxa, however, are supported principally by dense spicular meshworks more comparable to that found in, for example, Cancellothyrididae, rather than ribbonlike lamellae composed of secondary layer fibers and brachiotest (Mackay, MacKinnon, & Williams, 1993); thus Platidiidae currently defy easy categorization.

MEGATHYRIDOIDEA

Megathyridoidea are commonly characterized by a pair of arcuate descending branches that, after descending to fuse with the dorsal valve floor, rise again to unite anteromedially on a high septal pillar (see Fig. 1316.3). Compared with other long-looped forms, the axial stage of megathyroids is unusual in that the descending elements are commonly fully developed at this stage. The megathyroid brachidium is comparable to the earliest loop phase in both *Macandrevia* and *Ecnomiosa* (MacKinnon & Gaspard, 1996).

PALEOZOIC LONG-LOOPED CRYPTONELLOIDEA

An initial acuminate phase characterizes the loop development of the upper Paleozoic–lower Mesozoic long-looped Cryptonelloidea described by Cooper (1957) and Cooper and Grant (1976b). No vertical plate is developed, and the ascending loop elements arise directly from the echmidium (Fig. 1313.2). A median septum, if present, is never involved in the loop development of Cryptonelloidea (Cooper & Grant, 1976b).

These differences in the origins of parts of the cryptonelloid loop result in distinctly different developmental sequences from those found in post-Paleozoic long-looped forms. In Cryptonelloidea, as in the long-flanged Loboidothyridoidea, the initial development of the descending lamellae is complete before the ascending elements appear. In most post-Paleozoic long-looped terebratulides both ascending and descending elements develop concurrently. In most other respects, however, the patterns and processes of loop formation in both Paleozoic and post-Paleozoic taxa are remarkably similar. Similarities include those listed below.

1. Formation of a vertical plate on either an echmidium or a septal pillar on the dorsal valve floor.

2. Formation of a hood on either the ventral surface of an echmidium or on the ventral crest of either a vertical plate or septal pillar.

3. Enlargement of the hood and resorption of its apex to form a ring, segments of which ultimately form the ascending lamellae and transverse band.

4. Combining of anterior growing edges of ascending and descending loop elements, followed by progressive anterior growth and divergence of the leading edges away from the septal pillar.

5. Retention of a posterior connection between the descending lamellae either directly (in Paleozoic forms) or as a pair of lateral connecting bands fused to a septum.

6. Resorption of the direct connection (in Paleozoic forms) or lateral connecting bands (in post-Paleozoic forms) to give a long, reflected loop free of attachments.

METHODS OF STUDYING LOOPS

Understanding loop morphology and ontogenetic development is essential in terebratulide classification. Several methods of obtaining information on loops are used.

Manual preparation of loops of living brachiopods, after dissolution of the tissue, is straightforward except for highly spiculate genera where attempts to remove the spicules may damage or destroy delicate loop structures. Acid treatment and etching of silicified Paleozoic specimens facilitated study of growth series of entire loops (Cloud, 1942; Cooper & Grant, 1976b). For many sediment-infilled Mesozoic and Cenozoic terebratuloids, Cooper (1983) demonstrated that it is possible with patience and care to dissect the loops of many brachiopods preserved in weakly lithified sediments. Because of the time-consuming effort required, however, only one or a few examples of a species (where possible the type species) are usually prepared.

For most Mesozoic terebratulides, the principal method of establishing loop morphology has been by the preparation of transverse serial sections of oriented shells (Sandy, 1986b) and reconstructions of loops using distances between sections. [Note that in the 1965 *Treatise* (Moore, 1965), sections were oriented with the ventral valve uppermost, and distances between successive sections were not supplied.] Previous attempts to reconstruct loops from serial sections have exhibited varying degrees of accuracy (Cooper, 1983b, p. 1); computer-drawn three-dimensional reconstructions based on serial sections should eventually provide more accurate information on the disposition of loops.

It is emphasized that understanding of loop ontogeny may be critical for correct taxonomic placing of terebratulides, and juveniles as well as adults need to be studied. And, although variability in external morphology is adequately known for a few terebratulides (even if rarely taken into account when new putative genera are described), it must be recognized that the degree of variability in internal structures of terebratulides is almost completely unknown. Where a large number of loops of well-preserved specimens from a single species and locality have been figured [e.g., *Colosia* in COOPER (1983, pl. 35); *Liothyrella* in LEE, CARLSON, & others (2001)], the variability is considerable.

Because the information on loops derived from serial sectioning and from dissection differs in terminology, it is difficult to make comparisons between loop morphological information obtained by these different methods. Some workers have preferred to use only information from serial sections (e.g., MIDDLEMISS, 1959, 1980; ALMÉRAS, 1971; AGER, 1990); others, notably COOPER (1983), have used serial sections only when dissection failed. In this work, we have used illustrations of actual exposed loops wherever possible. Where genera, particularly Mesozoic taxa, are studied principally using serial sections, at least the name bearer of each family or subfamily is illustrated by means of sections. Loop reconstructions from serial sections are provided where no actual loop is available, but these should be used with caution.

HOMOPLASY

As MUIR-WOOD (1965a, p. 767) stressed, homoplasy (or homeomorphy) occurs repeatedly among Paleozoic, Mesozoic, and Cenozoic terebratulides and constitutes one of the major problems in their identification and classification. Without careful examination of internal structures, it may be impossible to distinguish between some representatives of the Terebratuloidea, Zeillerioidea, and Terebratelloidea. As examples of such external morphological similarity (convergence), MUIR-WOOD (1965a) listed four Late Jurassic genera: *Cheirothyris* (Zeillerioidea), *Trigonellina* and *Ismenia* (Laqueoidea), and the short-looped *Cheirothyropsis* (Loboidothyridoidea). Similarly, unless internal structures and punctation are examined, it may be difficult to distinguish between Late Triassic terebratuloids, zeillerioids, spiriferoids, and rhynchonelloids that have smooth shells and unisulcate dorsal valves. Homeomorphy poses particular problems in the many Paleozoic forms where the loop is unknown. At least one Devonian terebratulide, *Scaphiocoelia,* was thought to be a rhynchonellide until endopunctae were observed. A similar type of homoplasy occurs in some Holocene brachiopods, including the short-looped *Dallithyris* and the long-looped *Dallina.* And, as described above, identical adult loops in many terebratulide superfamilies may be arrived at from very different ontogenetic pathways.

SUBORDER TEREBRATULIDINA

Differentiation of superfamilies within suborder Terebratulidina is based upon presence or absence of dental plates, presence or absence of a perforate cardinal plate, loop size and shape, loop ontogenetic stages, and final loop form in adult brachiopods.

Stringocephaloids (Fig. 1313.1) are small to very large, commonly ventribiconvex or rarely planoconvex, subcircular to elongate oval in outline, and smooth, although some are finely striate, costellate, or peripherally costate. The anterior commissure is usually rectimarginate but may be uniplicate, plicosulcate, or unisulcate. The foramen may be submesothyrid or hypothyrid, with conjunct or disjunct deltidial plates. Dental plates vary from well developed to obsolete. A cardinal process may be well developed or absent. Hinge plates are commonly discrete

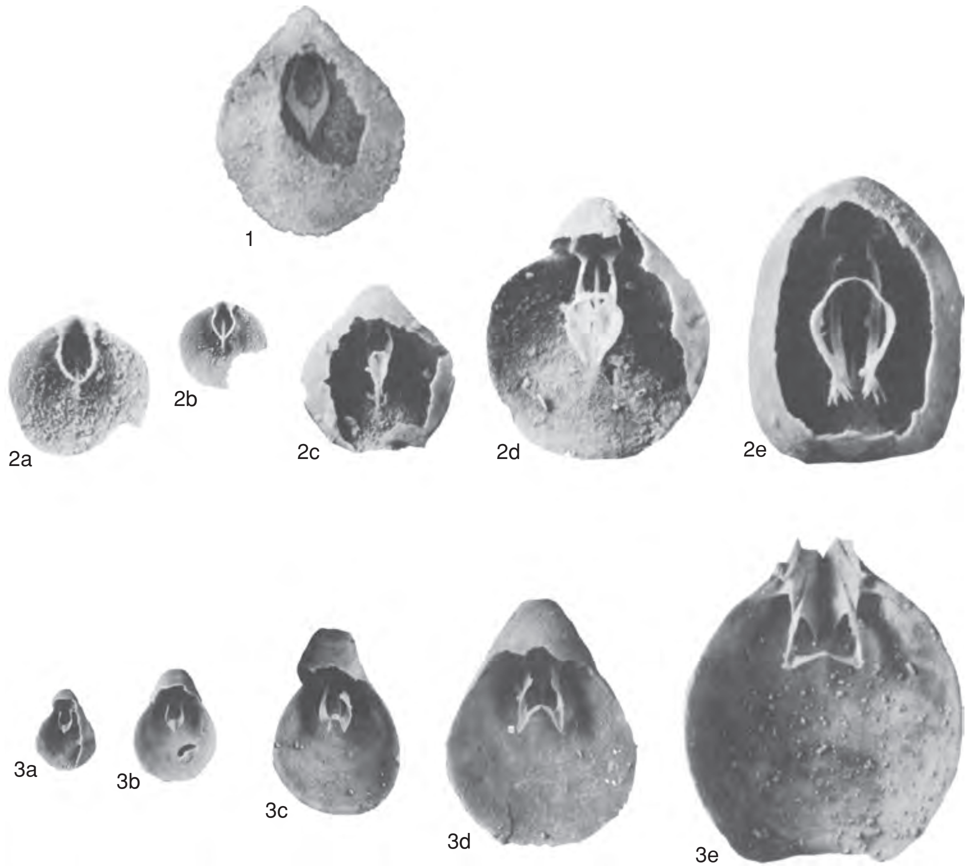

FIG. 1313. Loop ontogeny or adult loop morphology for terebratulide superfamilies; *1*, Stringocephaloidea, Centronellidae; adult loop morphology in *Nanothyris mutabilis,* ×4 (Boucot & Wilson, 1994); *2a–e,* Cryptonelloidea, Cryptonellidae; loop ontogeny in *Glossothyropsis rectangulata; a–d*, ×5, *e,* ×3 (Cooper & Grant, 1976b); *3a–e*, Dielasmatoidea, Dielasmatidae; loop ontogeny in *Dielasma zebratum*, ×2 (Cooper & Grant, 1976b).

but may be united to form a septalium. A perforate or imperforate cardinal plate may be present, and it may be supported by crural plates. A median septum may be absent, present in the dorsal valve, in the ventral valve, or in both valves. The adult loop is usually acuminate and may be marginal, with or without spines; rarely the loop is teloform.

Cryptonelloids (Fig. 1313.2) are small to medium, ventribiconvex, elongate oval to subpentagonal in outline, and smooth or sometimes plicate anteriorly. The anterior commissure may be rectimarginate, unisulcate, or sulciplicate. The foramen is typically permesothyrid or submesothyrid and is often labiate. Deltidial plates are usually conjunct, and a pedicle collar and dental plates may be present or absent. The hinge plate is commonly undivided and perforate, and a median septum and crural plates are rarely developed. The adult loop is highly variable and may be short and acuminate, deltiform or diploform, or long and teloform.

The Dielasmatoidea (Fig. 1313.3) are a large and complex, probably polyphyletic group of terebratulides. Adult shells are small to medium in size, biconvex, elongate oval to subcircular or subpentagonal in outline, and usually smooth or sometimes anteriorly plicate. The highly variable anterior commissure may be rectimarginate to uniplicate, unisulcate, bisulcate, or sulciplicate. The foramen is usually medium in size, permesothyrid or mesothyrid, and often labiate. A pedicle collar is commonly present, and dental plates are present in some families. The cardinal process is small, and a dorsal median septum may be present or absent. Outer hinge plates are weakly developed, and inner hinge plates may be absent, present and discrete, joined near the valve floor, or joined to median septum to form a septalium. The loop is usually short, acuminate in juveniles, and becoming deltiform in adults by fission and resorption of echmidium and insertion of transverse lamellae. Some families have more complex developmental stages, and in some taxa the loop is moderately long with descending and ascending lamellae.

Terebratuloids (Fig. 1314.1) are small to very large, commonly smooth or rarely capillate, subpentagonal to elongate oval in outline, and usually biconvex or ventribiconvex. The anterior commissure is rectimarginate in juveniles, but adults may be uniplicate, paraplicate, bisulcate, or sulciplicate. The foramen is usually medium to large and mesothyrid or permesothyrid. Deltidial plates may be conjunct, disjunct, or form a symphytium that may be visible or concealed. There are no dental plates nor a dorsal median septum. A variable cardinal process is commonly present. The loop is short and deltiform, with simple development of the loop as an extension of the crura. Other hinge plates are generally present, but inner hinge plates are rare. Crural processes may be short or very long, and the transverse band of the loop is commonly arched. The lophophore is plectolophous, and spicules are present in living species.

The Loboidothyridoidea (Fig. 1314.2) are a very large and complex, probably polyphyletic group of brachiopods that are difficult to classify because the ontogenetic development of most genera is unknown. They vary in size from small to very large and are commonly smooth, although a few are capillate or anteriorly costate. Most are ventribiconvex and subpentagonal to elongate oval in outline. The anterior commissure varies from rectimarginate to biplicate or sulciplicate. The foramen is commonly large and permesothyrid. There are no dental plates nor median septum. A cardinal process and outer hinge plates are commonly well developed, but inner hinge plates are rare. The adult loop is deltiform, extending for 0.4 to 0.6 of the dorsal valve length, and is commonly long flanged with a strongly arched transverse band. The loop ontogeny may be complex, but developmental stages of most genera are not known.

Dyscolioids (Fig. 1314.3) are small to very large, commonly biconvex, and subtriangular to subcircular or elongate oval in outline. They are smooth or very finely capillate with a large, mesothyrid to permesothyrid foramen. The anterior commissure may be rectimarginate or deeply unisulcate and may develop as two lateral lobes in juveniles, which fuse in adults to enclose a median perforation. There is no median septum nor dental plates; the cardinal process is commonly small; and hinge plates are poorly defined. The deltiform loop is very short, commonly wide, and anteriorly rounded with inconspicuous crural processes. The lophophore may be plectolophous or trocholophous (in living *Dyscolia*), and living species are strongly spiculate.

Cancellothyridoids (Fig. 1314.4) share a number of features that differentiate them from other terebratulides, particularly their capillate, costate, or costellate ornament; short loop; and crural processes that may be disjunct or unite to form a short, ringlike loop or tube. They are typically small to medium in size, elongate oval, subcircular or subtrigonal in outline, and commonly rectimarginate. There are no dental plates nor median septum, and outer and inner hinge plates are rarely developed. Crural bases are attached to strong, elevated socket ridges; and dorsal pedicle muscles are attached to the floor of the dorsal valve between the

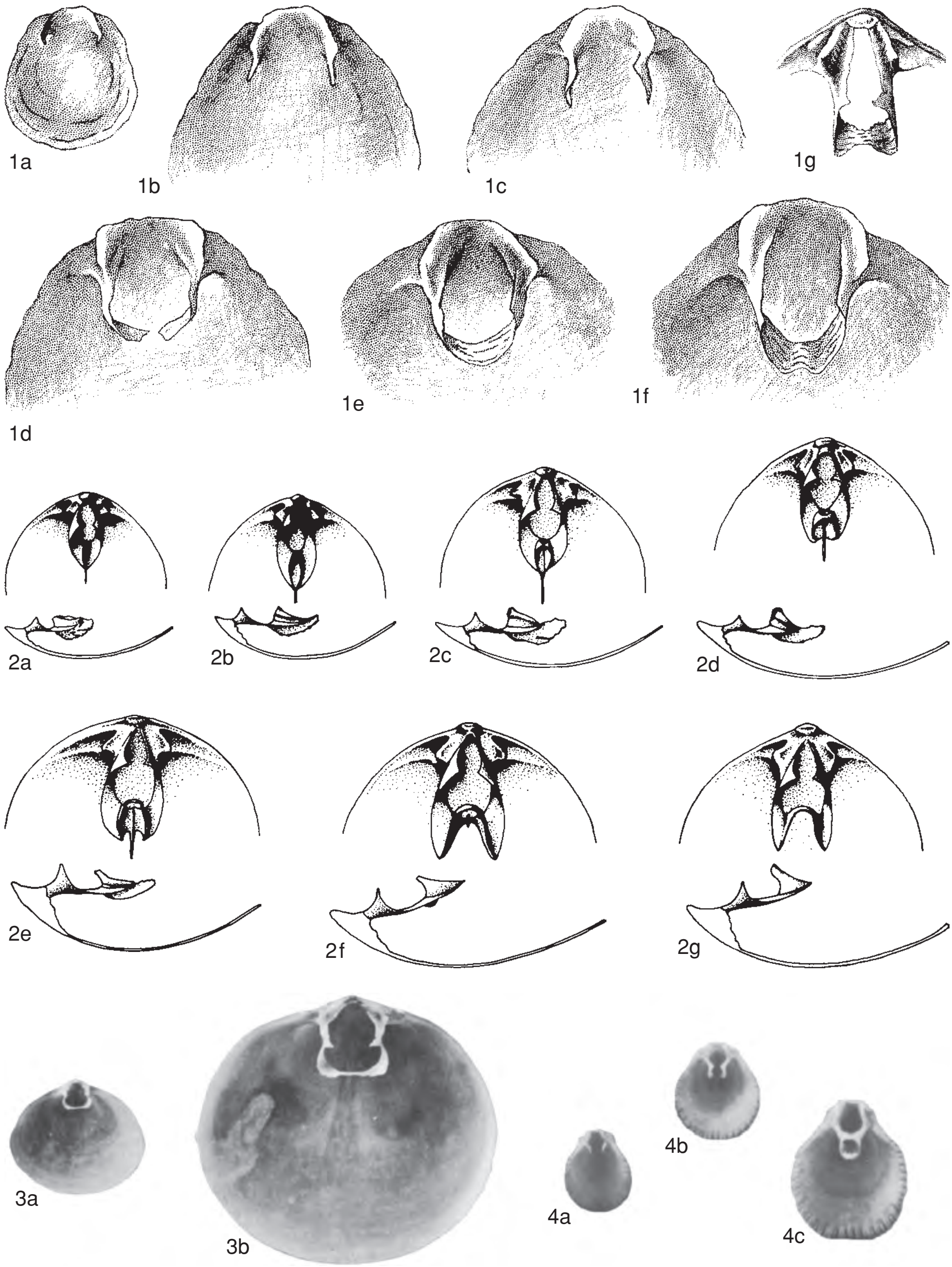

FIG. 1314. Loop ontogeny or adult loop morphology for terebratulide superfamilies: *1*, Terebratuloidea, Terebratulidae; loop ontogeny in *Liothyrella blochmanni, 1a–f*, ×14; *1g*, ×4; *2a–g*, Loboidothyridoidea, Triadithyrididae; loop ontogeny in *Viligothyris viligaensis*, ×3 (Dagys, 1968); *3a–b*, Dyscolioidea, Dyscoliidae; loop ontogeny in *Dyscolia ewingi*, ×1 (Cooper, 1973a); *4a–c*, Cancellothyridoidea, Cancellothyrididae; loop ontogeny in *Terebratulina retusa*, ×2 (Logan, 1979).

adductor muscles. The lophophore may be spirolophous or plectolophous, and mantle and body wall are usually strongly spiculate.

SUBORDER TEREBRATELLIDINA

Differentiation of superfamilies within suborder Terebratellidina is based on such features as presence or absence of dental plates, presence or absence of a septal pillar and its part in loop development, loop ontogenetic stages, and final loop form in adult brachiopods.

Zeillerioids (Fig. 1315) are small to large, subpentagonal, oval to elongate oval in outline, biconvex or ventribiconvex, and smooth, although costae or rugae may be developed rarely. The anterior commissure may be rectimarginate, unisulcate, or uniplicate. Deltidial plates are commonly conjunct or may be disjunct or form a symphytium. The foramen may be small to large and mesothyrid to permesothyrid, and beak ridges are commonly well developed. A pedicle collar may be present, but a cardinal process is rarely developed. Dental plates are invariably present and may be partly or wholly enveloped in callus. The adult loop is teloform, commonly long and slender, with or without spines. Development of the loop may be associated with a septal pillar very early in ontogeny, but there is no adult connection of the loop with the median septum.

Kingenoids (Fig. 1316.1) are small to medium, smooth or granular, generally subcircular to subpentagonal in outline, and rectimarginate, unisulcate, or intraplicate. Deltidial plates may be conjunct or disjunct. They have a broad, sessile pedicle collar and well-developed dental plates. Outer hinge plates are commonly well developed, and inner hinge plates are united to form a septalium. The septal pillar is retained throughout ontogeny, commonly developing as a long, thin median septum. The lophophore is plectolophous, and the mantle may be spiculate.

Laqueoids (Fig. 1316.2) are small to large, subcircular to transverse or elongate oval in outline, and rectimarginate to unisulcate. Most are smooth, but a few are multicostate. Deltidial plates may be conjunct, disjunct, or form a symphytium. As with kingenoids, they have a broad sessile pedicle collar and well-developed dental plates. A dorsal septal pillar or median septum is present. Outer hinge plates are well developed, but inner hinge plates may be disjunct, united to form a septalium, or absent. The adult loop stage is highly variable and may be axial, annular, haptoid, trabecular, bilacunar, bilateral, or laterovertical (Fig. 1312). Septal flanges are present on the septal pillar during axial, cucullate, and annular phases of loop ontogeny. The lophophore is plectolophous, and the mantle may be spiculate.

Megathyridoids (Fig. 1316.3) are commonly small, subquadrate in outline, and commonly multiplicate with a wide hinge line and well-developed interareas. The beak is attrite and the foramen large. The pedicle collar is long, wide, and elevated; and a short low ventral median septum is commonly present. Dental plates are absent in living species and obscured by later thickening in Early Cretaceous taxa. A narrow, dorsal median septum is commonly present. There are no outer hinge plates, but conjunct inner hinge plates may form a low septalium. The loop is axial, consisting only of laterally arcuate, ribbonlike descending branches derived from short crura and commonly fused to valve floor. The distal end of the loop converges on a high, triangular median septum, but there are no ascending loop elements. The lophophore is schizolophous or ptycholophous, and spicules are rarely present.

Bouchardioids (Fig. 1317.1) are small to medium, smooth, oval to elongate oval in outline, and unisulcate with a pronounced ventral carina. The beak is straight with a small, commonly permesothyrid apical foramen. The strong hinge teeth have swollen

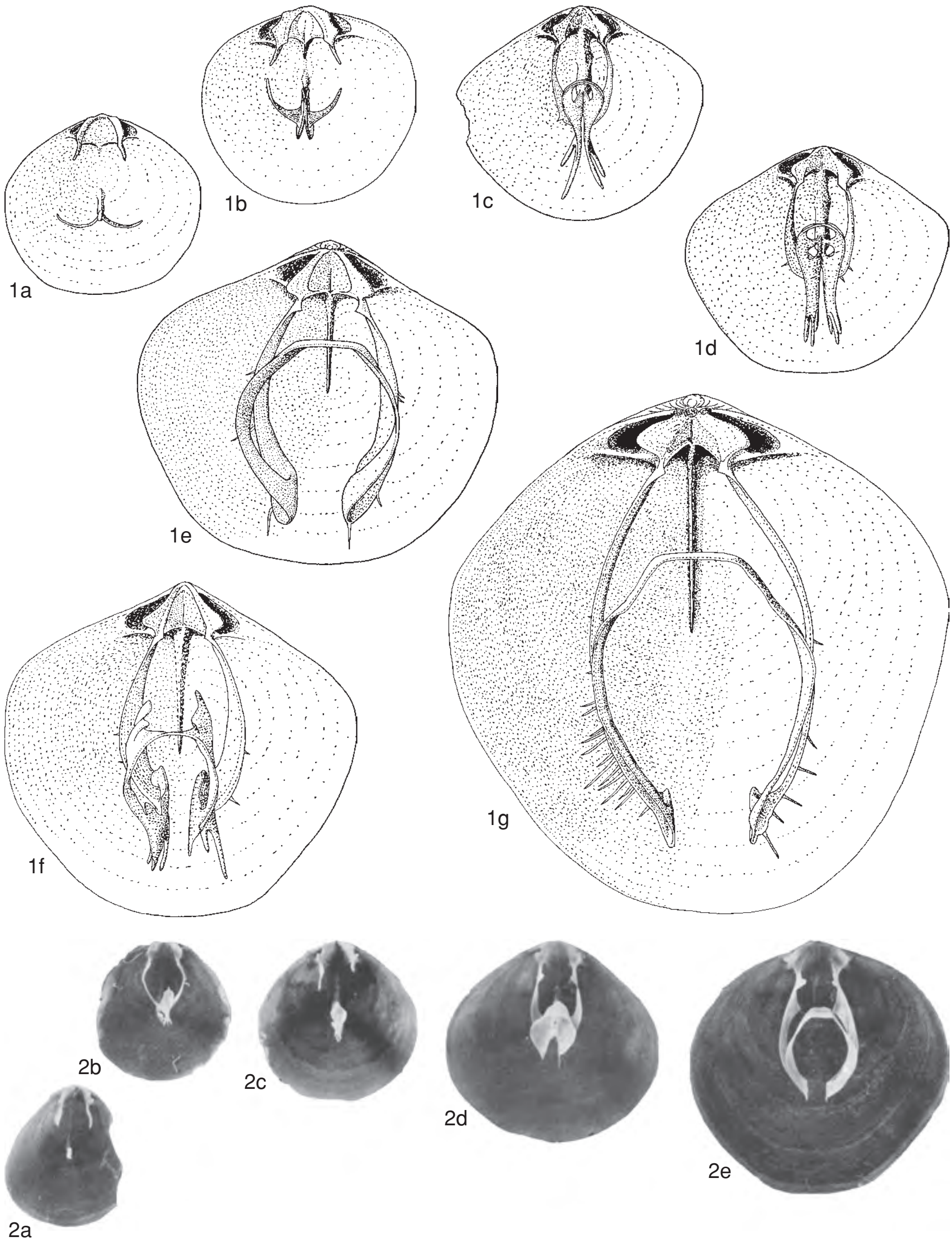

FIG. 1315. Loop ontogeny or adult loop morphology for terebratulide superfamilies; *1a–g*, Zeilleroidea, Zeilleriidae; loop ontogeny in *Zeilleria leckenbyi; a*, L = 1.5 mm; *b*, L = 2.1 mm; *c*, L = 3.0 mm; *d*, L = 3.9 mm; *e*, L = 5.9 mm; *f*, L = 12.2 mm; *g*, L = 23.5 mm (Baker, 1972); *2a–e*, loop ontogeny in *Macandrevia africana*, ×5 (Cooper, 1975).

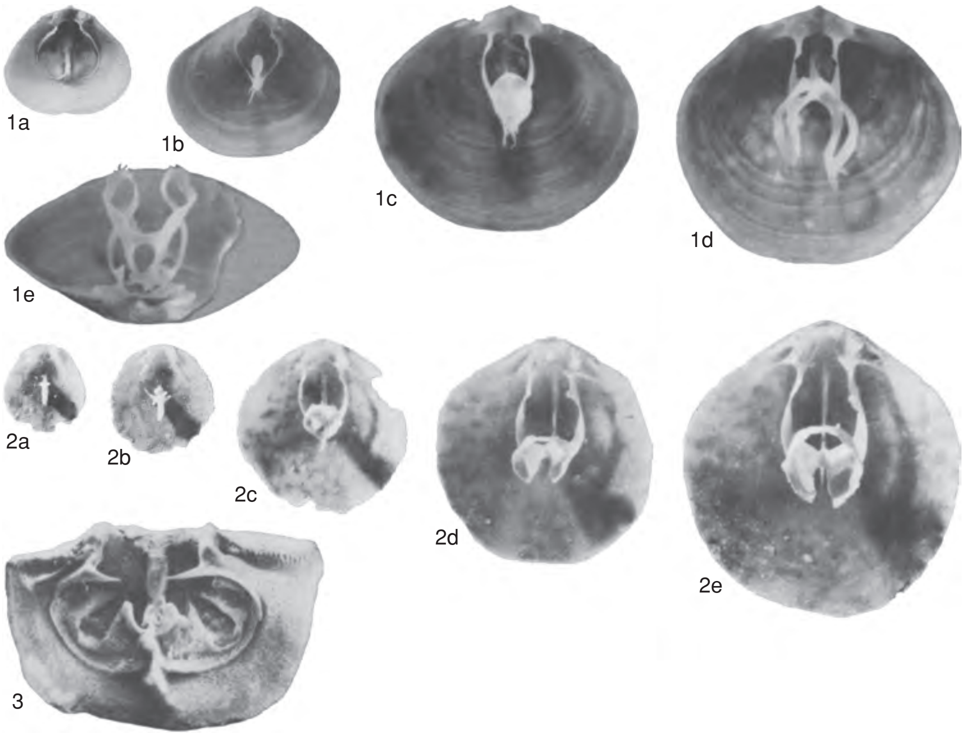

FIG. 1316. Loop ontogeny or adult loop morphology for terebratulide superfamilies; *1a–e*, Kingenoidea, Kingenidae; loop ontogeny in *Ecnomiosa inexpectata, a–c*, ×4, *d–e*, ×2 (Cooper, 1981); *2a–e*, Laqueoidea, Frenulinidae; loop ontogeny in *Frenulina sanguinolenta*, ×9 (Cooper, 1973a); *3,* Megathyridoidea, Megathyrididae; adult loop morphology in *Argyrotheca cuneata*, ×20 (Logan, 1979).

bases with a groove to accommodate socket ridges. Crura are vestigial to absent with no descending branches. The cardinal process and inner socket ridges are fused commonly to form a solid hinge platform bearing a deep diductor muscle scar impression. The septal pillar is high, and brachidial supports are incomplete. The lophophore is plectolophous, and spicules are absent.

Platidioids (Fig. 1317.2) are small or very small, planoconvex, convexoplane or slightly biconvex, subcircular or ovate in outline, and rectimarginate. Most examples are smooth, but faint capillae or small spines may be present. The foramen is large and amphithyrid or hypothyrid, and most living species are closely pressed to the substrate. The pedicle collar is short and sessile, and dental plates are weak or absent. Hinge plates are not developed. Crura, when present, are long and slender, extending from inner socket ridges. Descending branches, or a high triangular septal pillar that may have posterolateral septal flanges, may be developed. The lophophore is schizolophous or zygolophous, and the lophophore and mantle are strongly spiculate.

Terebratelloids (Fig. 1317.3) are the most abundant, diverse, and best-known group of brachiopods in modern oceans. They are generally medium to large, biconvex, subcircular to elongate oval in outline, and rectimarginate to unisulcate. Most are smooth, although a few genera are

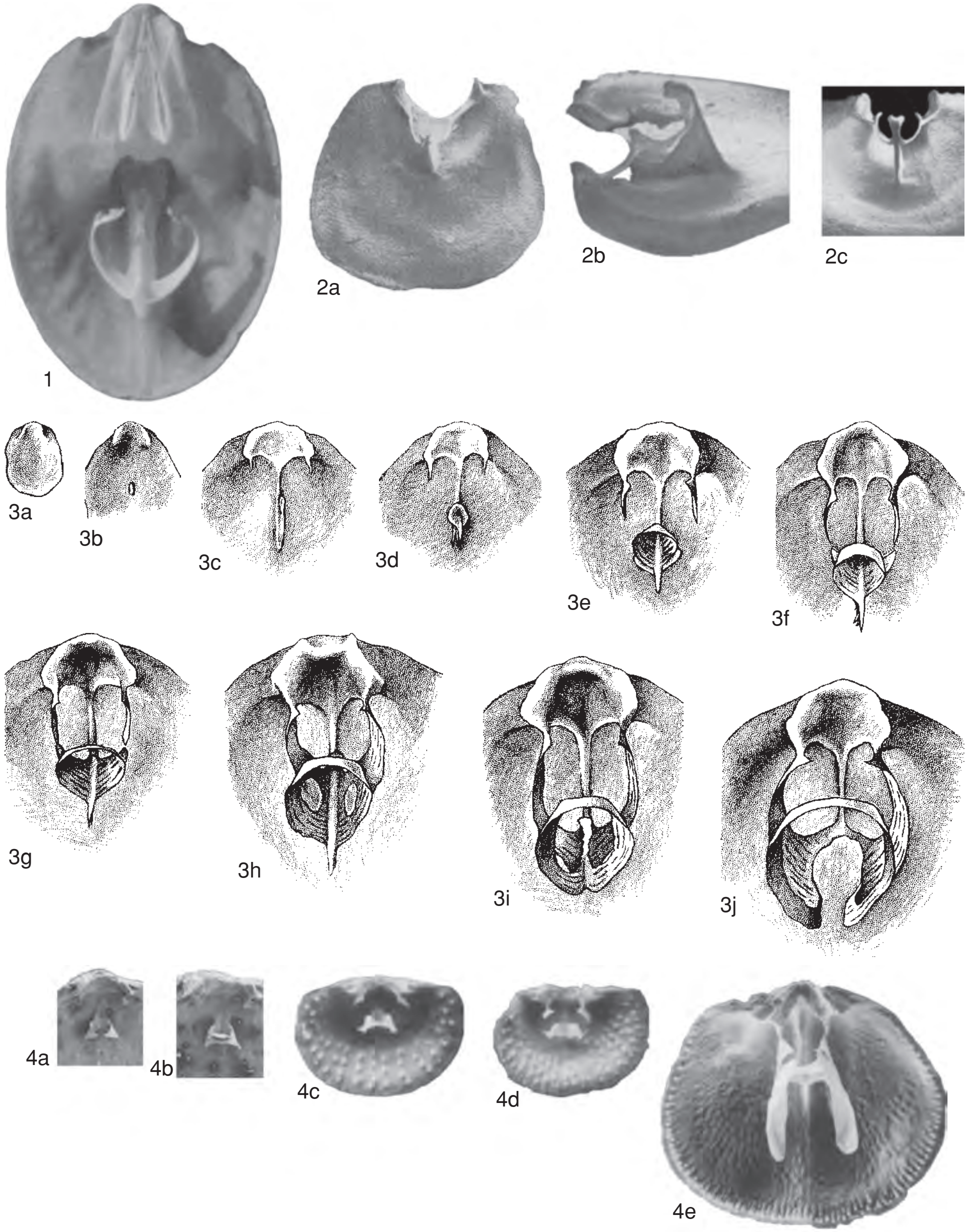

FIG. 1317. Loop ontogeny or adult loop morphology for terebratulide superfamilies; *1*, Bouchardioidea, Bouchardiidae; adult loop morphology in *Bouchardia rosea*, ×5 (Brunton, 1996); *2a–c,* Platidioidea, Platiidae; adult loop morphology in *Platidia anomioides, a–b,* ×9, *c*, ×10 (Logan, 1979)*; 3a–j*, Terebratelloidea, Terebratellidae; preadult loop ontogeny in *Magellania macquariensis, a–i*, ×10, *j,* ×5 (Foster, 1974); *4a–e*, Kraussinoidea, Kraussinidae, loop ontogeny in *Megerlia truncata; a–b,* ×9; *c–d,* ×6, *e,* ×1.5 (Logan, 1979).

multicostate. The foramen is small to large, mesothyrid to permesothyrid, and deltidial plates may be conjunct, disjunct, or form a symphytium. Dental plates are absent, and the pedicle collar is short and sessile. The septal pillar is retained throughout ontogeny and commonly develops as a median septum, with hinge plates uniting to form a septalium. The adult loop is commonly teloform but may be annular, haptoid, diploform, or trabecular. The lophophore is plectolophous, and spicules are absent.

Kraussinoids (Fig. 1317.4) are small to medium, biconvex or sometimes planoconvex, costate, and rectimarginate or unisulcate. The beak is attrite and the foramen usually large, with disjunct deltidial plates. The pedicle collar is short and sessile, and dental plates are absent. The interiors of both dorsal and ventral valves are commonly tuberculate. Inner socket ridges are prominent and divergent, and hinge plates may not be differentiated. Crura and descending lamellae may be present or absent. Septal flanges expand during ontogeny to form a strongly bifurcate septal pillar, which may have slender distal extensions that may unite to form a ring. The lophophore is zygolophous or plectolophous, and the mantle is moderately to strongly spiculate.

Gwynioids (see Fig. 1494,*1f* herein)are minute, smooth, subcircular to subquadrate, slightly strophic, planoconvex or biconvex, rectimarginate shells whose affinities are uncertain. The dorsal umbo is larger than that of the ventral valve, and the foramen is large and amphithyrid. The pedicle collar is weakly developed, and dental plates are absent. Inner and outer socket ridges are well developed. The trocholophous or schizolophous lophophore is supported by bladelike, arcuate submarginal ridges that are fused to the valve floor.

ACKNOWLEDGMENTS

The authors of order Terebratulida wish to acknowledge assistance from many colleagues without whose help this research could not have been completed. In particular, we acknowledge the contribution of A. J. Boucot, who provided diagnoses for the majority of Devonian terebratulides. In addition, we would like to thank Y. Alméras, F. Alvarez, M. A. Bitner, C. H. C. Brunton, S. Calzada Badia, S. J. Carlson, the late J. D. Campbell, R. A. Doescher, K. Endo, M. Florence, M. W. Foster, D. Gaspard, R. Gourvennec, E. Gradinaru, the late R. E. Grant, N. Hiller, Jisuo Jin, J. Kerns, A. Logan, C. Lueter, S. J. Long, M. O. Manceñido, D. A. B. Macfarlan, F. A. Middlemiss, E. F. Owen, S. Read, E. Ruggiero, J. H. Robinson, M. Saito, M. Siblík, E. Simon, G. Steinich, A. Vörös, O. N. Zezina, and the Science Librarians at the University of Otago, for providing access to collections, arranging the loan of type and other material, providing books and reprints, reading and commenting on drafts of parts of the manuscript, lending and/or scanning illustrations, and checking numerous references in often obscure publications. P. K. Tubbs and J. D. D. Smith provided help with nomenclatorial problems. Finally, we are indebted to the late Sir Alwyn Williams for guidance and support during the course of preparation of this volume and to Jill Hardesty for her exemplary editorial assistance and encouragement.

TEREBRATULIDINA

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Suborder TEREBRATULIDINA Waagen, 1883

[*nom. correct.* MUIR-WOOD & STEHLI, 1965, p. 730, *pro* suborder Terebratulacea WAAGEN, 1883a, p. 447]

All short-looped, and some long-looped terebratulides, in which the loop develops by extension of the crura without the involvement of either a septal pillar or median septum. *Lower Devonian–Holocene.*

STRINGOCEPHALOIDEA

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[University of Otago]

Superfamily STRINGOCEPHALOIDEA King, 1850

[*nom. transl.* STEHLI, 1965, p. 740, *ex* Stringocephalidae DAVIDSON, 1853, p. 51, *nom. correct. pro* Strigocephalidae KING, 1850, p. 141]

Adult shells small to very large; commonly ventribiconvex, rarely planoconvex; subcircular to elongate oval; commonly smooth, but may be finely striate, costate, costellate, or peripherally costate; anterior commissure commonly rectimarginate, but may be uniplicate, intraplicate, or unisulcate; ventral foramen may be submesothyrid to hypothyrid; deltidial plates may be conjunct or disjunct. Dental plates may be well developed, obsolescent, or obsolete. Cardinal process may be well developed or absent; hinge plates commonly discrete, but may be united to form a septalium; perforate or imperforate cardinal plate may be present, and may be supported by crural plates; median septae may be absent, present in both valves, or in one valve only. Adult loop commonly acuminate (centronelliform), and may be marginal, with or without spines; rarely teloform (cryptonelliform). *Silurian (?Pridoli), Lower Devonian (Lochkovian)–Upper Devonian (Frasnian).*

Family CENTRONELLIDAE Waagen, 1882

[*nom. transl.* HALL & CLARKE, 1895, p. 356, *ex* Centronellinae WAAGEN, 1882, p. 331]

Cardinal plate supported by long crural plates in large specimens, no crural plates in minute specimens; crural plates commonly not apparent in specimens with sessile cardinal plate; loop acuminate (centronelliform). *Lower Devonian (Lochkovian)–Middle Devonian (Givetian).*

Subfamily CENTRONELLINAE Waagen, 1882

[Centronellinae WAAGEN, 1882, p. 331]

Small to medium, smooth, planoconvex to unequally biconvex, naviculate; gently unisulcate dorsal valve; obsolete cardinal plates and dental plates; ponderous hinge teeth; sessile cardinal plate, concave; loop acuminate (centronelliform). *Lower Devonian (Pragian)–Middle Devonian (Givetian).*

Centronella BILLINGS, 1859, p. 131 [**Rhynchonella glans-fagea* HALL, 1857, p. 125; SD HALL, 1863, p. 45]. Small; concavoconvex, naviculate; sessile, swollen hinge plates medially divided by cleft, but forming part of a basally sessile cardinal plate; small cardinal process apically situated; dental plates obsolete, swollen hinge teeth; loop acuminate (0.5–

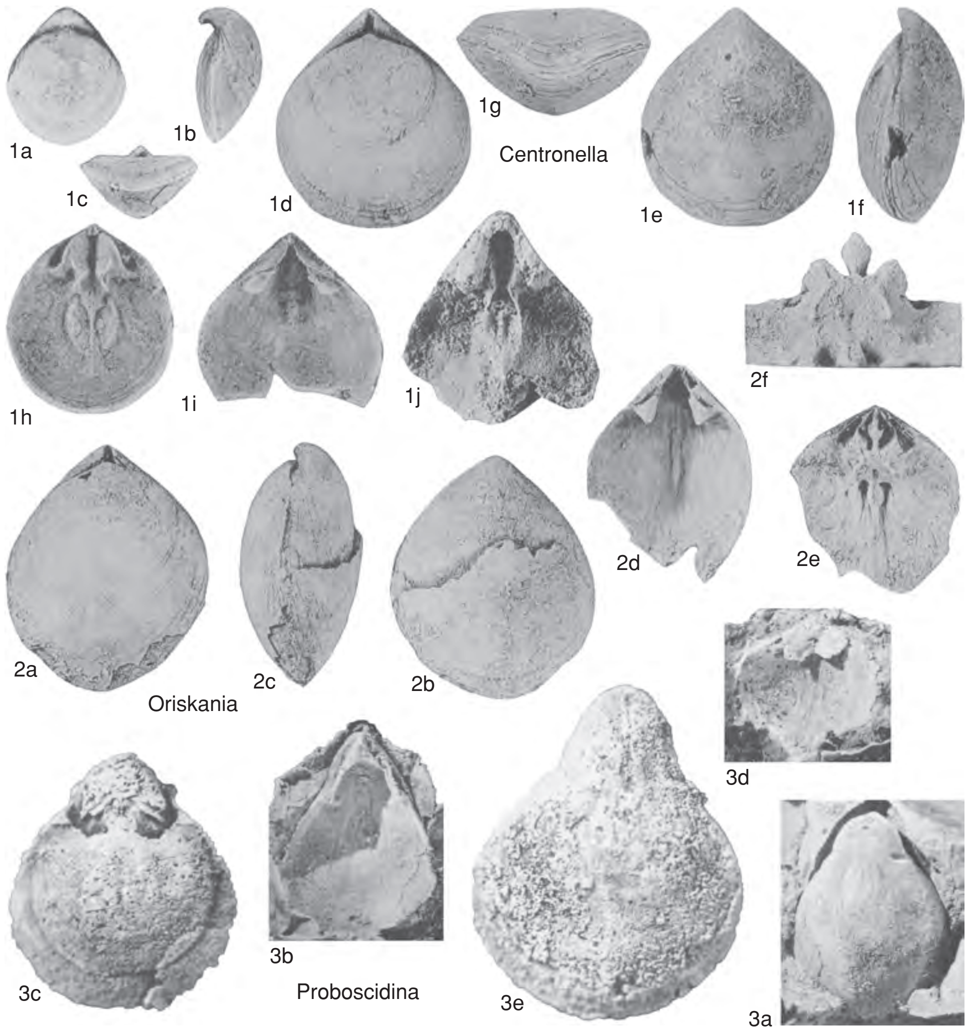

FIG. 1318. Centronellidae (p. 1994–1995).

0.6 dorsal valve length). *Lower Devonian (Emsian)–Middle Devonian (Givetian):* North America.——FIG. 1318,*1a–c*. **C. glansfagea* (HALL), New York, USA; dorsal, lateral, and ventral views, ×2 (Cloud, 1942).——FIG. 1318,*1d–j*. *C. campbelli* CLOUD, Indiana, USA; *d–g,* holotype, dorsal, ventral, lateral, and anterior views, USNM 109028A; *h–i,* interior of dorsal and ventral valves, ×2; *j,* ventral view of loop, ×4 (Cloud, 1942).

Oriskania HALL & CLARKE, 1893, p. 269 [**O. navicella;* OD]. Medium; ventribiconvex, naviculate; subcircular to elongate; dorsal valve gently unisulcate; thickened, sessile cardinal plate; cardinal process linear. *Lower Devonian (Pragian):* eastern North America, USA (Nevada).——FIG. 1318,*2a–f*. **O. navicella,* New York, USA; *a–c,* dorsal, ventral, and lateral views; *d,* interior of ventral valve; *e,* ventral view of dorsal valve interior, ×1; *f,* cardinalia, ×2 (Cloud, 1942).

Proboscidina ISAACSON, 1977, p. 192 [**Centronella arcei* ULRICH, 1892, p. 53; OD]. Small; elongate, dorsibiconvex, rectimarginate; hinge teeth massive; large ventral valve muscle field; cardinal plate nonsessile, medially grooved; loop unknown. *Lower Devonian (Emsian):* Bolivia, South Africa.——FIG. 1318,*3a–e*. **P. arcei* (ULRICH), Bolivia; *a–b,* impression of ventral valve interior, and latex replica of ventral valve interior, ×1.7; *c,* dorsal view of steinkern; *d,* latex replica of dorsal valve; *e,* ventral view of steinkern, ×2 (Isaacson, 1977).

Subfamily RENSSELAERIINAE Raymond, 1923

[Rensselaeriinae RAYMOND, 1923, p. 467]

Small to large, smooth to costellate; umbones may be radially ornamented; moderately to strongly biconvex; dental plates discrete, obsolescent; cardinal plate perforate in large specimens, discrete plates in small ones; long crural plates in large specimens. *Lower Devonian (Lochkovian–Emsian).*

Rensselaeria HALL, 1859, p. 39 [**Terebratula ovoides* EATON, 1832, p. 45, *non* SOWERBY, 1812, p. 227; SD HALL & CLARKE, 1893, p. 257; =*Atrypa elongata* CONRAD, 1839, p. 65]. Large; shell entirely costellate, costellae moderately strong; shell elongate, subovate to subcircular; ventribiconvex; commissure rectimarginate. Long dental plates obsolescent, largely submerged in secondary material laterally; thick, foramenate cardinal plate sessile posteriorly; thick crural plates; loop long, transverse plate long. *middle Lower Devonian:* North America.——FIG. 1319,*3a–c*. **R. elongata* (CONRAD), New York, USA; *a–b,* dorsal and lateral views, dorsal valve slightly crushed, ×1; *c,* rubber replica of dorsal interior, ×1 (Cloud, 1942).——FIG. 1319,*3d–h*. *R. marylandica* HALL, Maryland, USA; *d–f,* dorsal, lateral, and posterior views; *g,* interior of posterior part of ventral valve; *h,* reconstructed loop, ×1 (Cloud, 1942).

Etymothyris CLOUD, 1942, p. 59 [**Rensselaeria ovoides gaspensis* CLARKE, 1909, p. 238; OD]. Large; exterior and dorsal interior as in *Rensselaeria;* dental plates not obsolete, subparallel. *Lower Devonian (Emsian):* eastern North America.——FIG. 1319,*1a–g*. **E. gaspensis* (CLARKE), Quebec, Canada; *a–b,* dorsal and lateral views, ×1; *c–d,* interior of dorsal and ventral valves, ×1; *e–g,* lateral, anterior, and posterior views of steinkern of immature specimen, ×1 (Cloud, 1942).

Nanothyris CLOUD, 1942, p. 45 [**Meganteris mutabilis* HALL, 1857, p. 97; OD]. Small to medium; ventribiconvex; smooth umbones, costellate peripherally, commissure rectimarginate. Dental plates discrete; cardinal plate posteriorly foramenate; crural plates long in large specimens, commonly absent in minute specimens. *Lower Devonian (Lochkovian–Pragian):* eastern North America.——FIG. 1319,*2a–g*. **N. mutabilis* (HALL), New York, USA; *a–c,* dorsal, lateral, and anterior views, ×2; *d–e,* posterior and dorsal views of steinkern showing dental and crural plates, ×2 (Cloud, 1942); *f,* oblique view of loop; *g,* interior of dorsal valve, ×3.5 (Boucot & Wilson, 1994).

Rensselaerina DUNBAR, 1917, p. 466 [**R. medioplicata;* OD]. Small to medium; smooth umbones, ventribiconvex, anteromedial radial ornamentation, strong costae, rectimarginate and crenulate commissure; dental plates obsolescent in larger specimens, partially to completely sessile, posteriorly foramenate, massive cardinal plate; crural plates secondarily thickened to submerged; loop variable. *Lower Devonian (Lochkovian):* eastern North America.——FIG. 1320*a–e*. **R. medioplicata,* Tennessee, USA; *a,* interior of ventral valve, ×2; *b–c,* ventral and anterior views of cardinal plates, ×2 (Cloud, 1942); *d–e,* ventral and lateral views of reconstructed loop, ×0.5 (Dunbar, 1917).——FIG. 1320*f–h*. *R. haraganana* CLOUD, Oklahoma, USA; *f–g,* dorsal and anterior views; *h,* ventral view of loop, ×1 (Cloud, 1942).

Subfamily AMPHIGENIINAE Cloud, 1942

[Amphigeniinae CLOUD, 1942, p. 77]

Centronellidae with ventral valve spondylium duplex supported by median septum formed from continuation of conjunct dental plates. Spondylium supported posterolaterally by pair of mystrochial plates. *Lower Devonian (Emsian)–Middle Devonian (Eifelian).*

Amphigenia HALL, 1867b, p. 374 [**Pentamerus elongata* VANUXEM, 1842, p. 132; OD]. Medium to large; subcircular to elongate; ventribiconvex; umbonal region smooth, anterolateral regions may be faintly costellate; anterior commissure rectimarginate, may be weakly crenulate; cardinal plate posteriorly sessile, foramenate posteriorly in smaller specimens; crural plates; ventral valve spondylium supported by median septum and mystrochial plates, both formed from convergent dental plates, except in oldest form where plates barely unite anteriorly. *Lower Devonian (Emsian)–Middle Devonian (Eifelian):* central and eastern North America, northwestern Africa, France, Brazil (Amazon Basin), Venezuela.——FIG. 1321*a–f*. **A. elongata* (VANUXEM), New York, USA; *a–b,* dorsal and lateral views; *c,* posterior view of interior of conjoined valves; *d–e,* interior views of dorsal valves, ×1 (Cloud, 1942); *f,* interior of silicified ventral valve, ×1 (Boucot, 1959b).

Subfamily EURYTHYRIDINAE Cloud, 1942

[*nom. correct.* STEHLI, 1965, p. 743, *pro* Eurythyrinae CLOUD, 1942, p. 60]

Small to medium sized; ventribiconvex; smooth to finely costellate peripherally; introverted lateral margins; outline circular to moderately elongate; rectimarginate; conjunct deltidial plates; obsolete dental plates; cardinal plate perforate in small specimens and sessile in larger specimens; crural plates

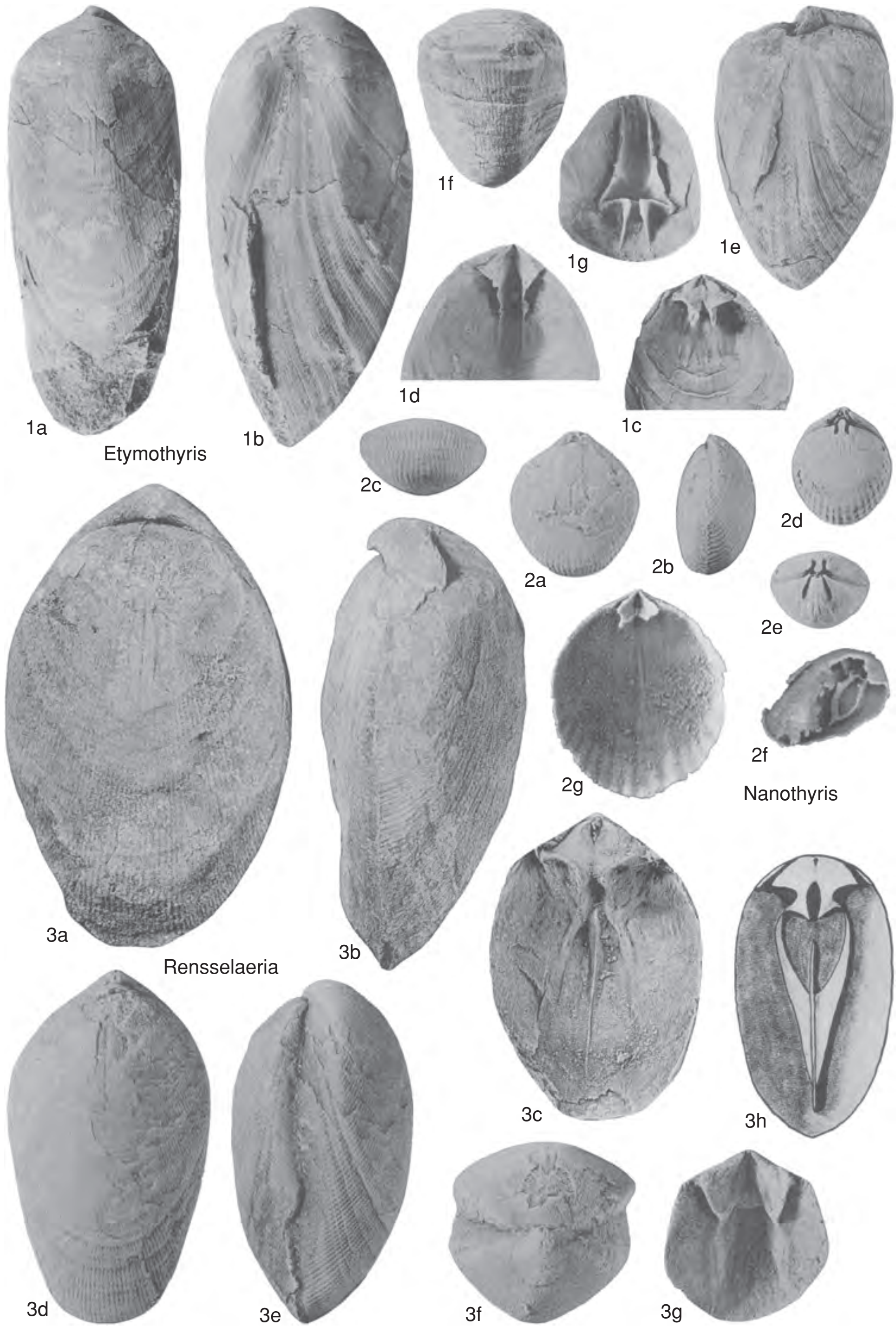

FIG. 1319. Centronellidae (p. 1996).

FIG. 1320. Centronellidae (p. 1996).

commonly submerged in secondary material. *Lower Devonian (Pragian–Emsian).*

Eurythyris CLOUD, 1942, p. 63 [**Oriskania lucerna* SCHUCHERT in SCHUCHERT & MAYNARD, 1913, p. 390; OD]. Smooth to peripherally finely costellate; naviculate; dental plates obsolete; cardinal plate sessile, swollen; linear cardinal process. *Lower Devonian (Pragian):* east-central North America.——FIG. 1322,*1a–b.* **E. lucerna* (SCHUCHERT), Maryland; *a,* interior of ventral valve posterior, ×1; *b,* ventral view of loop, ×1 (Cloud, 1942).——FIG. 1322,*1c–f. E. dunbari* CLOUD, Maryland, USA; holotype, dorsal, ventral, lateral, and anterior views, YPM S3369, ×1 (Cloud, 1942).

Beachia HALL & CLARKE, 1893, p. 260 [**Meganteris suessana* HALL, 1857, p. 100; OD]. Umbones smooth, peripherally finely costellate; subcircular to moderately elongate; dental plates free in small specimens, obsolescent to obsolete in large specimens; cardinal plate perforate in small specimens, imperforate in large specimens; cardinal plate free in small to medium specimens, moundlike to swollen in large; crural plates free in small specimens, submerged in large specimens. *Lower Devonian (Pragian):* eastern North America.——FIG. 1322,*4a–h.* **B. suessana* (HALL), Maryland, USA; *a–d,* dorsal, ventral, lateral, and anterior views, ×1; *e,* posterior of dorsal valve, ×1; *f,* cardinal plate, ×2; *g–h,* ventral views of loops, ×1 (Cloud, 1942).

Cloudothyris BOUCOT & JOHNSON, 1968, p. 19 [**C. postovalis;* OD]. Smooth; subcircular; dental plates obsolescent to obsolete; cardinal plate supporting a massive, medially clefted, elongate cardinal process; crural plates visible in small specimens, submerged in sessile, larger cardinal plate; loop unknown. *Lower Devonian (Emsian):* North America (Maine, New York, ?New Hampshire, ?Gaspé).——FIG.

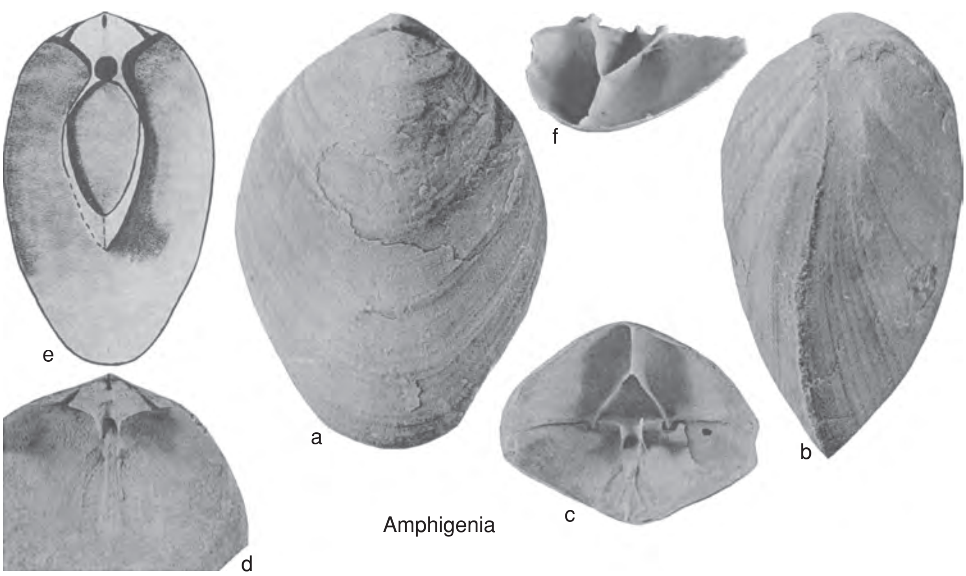

FIG. 1321. Centronellidae (p. 1996).

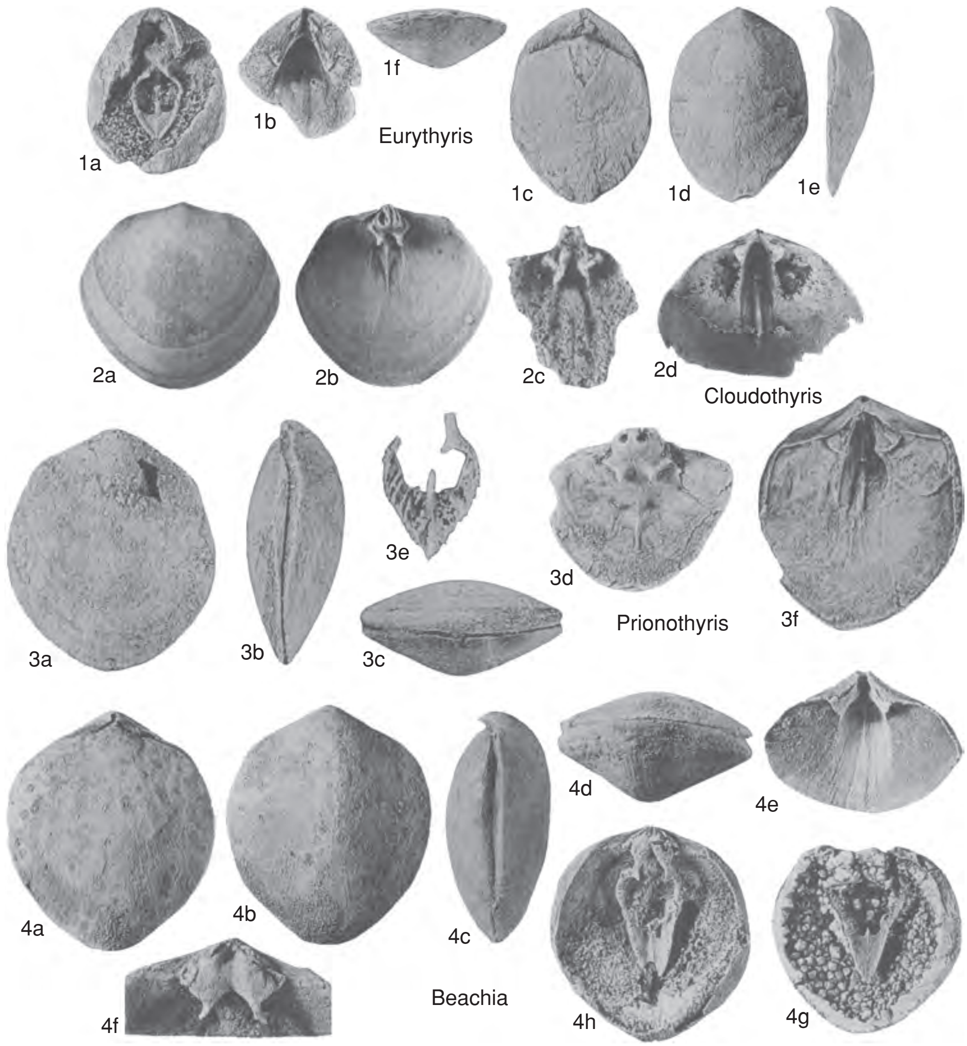

FIG. 1322. Centronellidae (p. 1998–1999).

1322,*2a–d.* **C. postovalis,* New York, USA; *a,* dorsal valve exterior, ×1; *b,* interior of dorsal valve, ×1; *c,* interior of dorsal valve, ×3; *d,* interior of ventral valve, ×1 (Boucot & Johnson, 1968).

Prionothyris CLOUD, 1942, p. 66 [**P. perovalis;* OD]. Umbones smooth, peripherally finely costellate; subcircular to moderately elongate; dental plates obsolescent to obsolete; massive, sessile, imperforate cardinal plate; posteriorly trifid, striate. *Lower Devonian (Pragian–Emsian):* eastern North America, Colombia.——FIG. 1322,*3a–f.* **P. perovalis,* New York, USA; *a–c,* holotype, ventral, lateral, and anterior views, USNM 108481, ×1; *d,* posterior of dorsal valve, ×1; *e,* ventral view of free loop, ×2; *f,* interior of ventral valve, ×1 (Cloud, 1942).

Family STRINGOCEPHALIDAE King, 1850

[*nom. correct.* DAVIDSON, 1853, p. 51, *pro* Strigocephalidae KING, 1850, p. 141]

Very large; thick shelled; commonly smooth; rectimarginate; dental plates obsolescent to obsolete; median septae may be absent, present in both valves, or present in one valve only; hinge plates discrete; crural plates present in some forms; loop long, marginal, acuminate (centronelliform). *Middle Devonian (upper Eifelian–Givetian).*

Subfamily STRINGOCEPHALINAE King, 1850

[*nom. transl. et correct.* CLOUD, 1942, p. 104, *ex* Strigocephalidae KING, 1850, p. 141]

Subglobular; outline subcircular; smooth; may have prominent beak; prominent median septae in both valves; long, stalklike, terminally bifid, cardinal process; no crural plates. *Middle Devonian (upper Eifelian–Givetian).*

Stringocephalus DEFRANCE in DE BLAINVILLE, 1827 in 1825–1827, p. 511, *nom. nov.* SANDBERGER, 1842, p. 386, *pro Strygocephale* DEFRANCE in DE BLAINVILLE, 1825 in 1825–1827, p. 511, ICZN Opinion 807, 1967, p. 81; see STEHLI, 1965, p. 748 for discussion about name history [**Terebratula Burtini* DEFRANCE in DE BLAINVILLE, 1825 in 1825–1827, p. 511; OD] [=*Strygocephalus* DEFRANCE in DE BLAINVILLE, 1827 in 1825–1827, pl. 53,*1,* obj.; *Strigocephalus* J. DE C. SOWERBY, 1840b, pl. 56,*10,* obj.]. Very large; subglobular; ventribiconvex; ventral valve beak large, pointed, slightly asymmetrical; dental plates obsolescent; henidium in gerontic adults; median septae in both valves; cardinal process stout, stalklike, distally bifid; long, marginal loop with or without posteriorly directed spines. *Middle Devonian (upper Eifelian–Givetian):* Asia, northwestern Africa, Europe, extra-Appalachian North America, Australia.——FIG. 1323*a–g.* **S. burtini* (DEFRANCE), Germany; *a–b,* dorsal and posterior views, ×1; *c,* posterior interior of ventral valve, ×1; *d,* ventral view, ×0.5 (Cloud, 1942); *e,* anterior view, ×0.5; *f,* anterior oblique view of latex impression of ventral median septum, dorsal cardinal process, and crura, ×1 (Boucot, Johnson, & Struve, 1966); *g,* drawing of partly restored loop, ×0.5 (Cloud, 1942).

Parastringocephalus STRUVE, 1965, p. 467 [**Strygocephalus dorsalis* D'ARCHIAC & DE VERNEUIL, 1842, p. 369; OD]. Similar to *Stringocephalus,* but bisulcate and finely striate; loop unknown. *Middle Devonian (Givetian):* Eurasia, USA (Nevada).——FIG. 1324,*1a–b.* **P. dorsalis* (D'ARCHIAC & DE VERNEUIL), Germany; dorsal and ventral views, ×0.5 (Torley, 1934).

Stringodiscus STRUVE, 1982, p. 221 [**Strigocephalus giganteus* J. de C. SOWERBY, 1840b, pl. 56,*10–11;* OD]. Large, moderately ventribiconvex (so-called disclike); interior undescribed; otherwise similar to *Stringocephalus. Middle Devonian (Givetian):* Europe, North America, Asia.——FIG. 1324,*2a–b.* **S. giganteus* (J. de C. SOWERBY), Germany; dorsal and lateral views, ×0.5 (Torley, 1934).

Subfamily KAPLEXINAE Sun & Boucot, 1999

[Kaplexinae SUN & BOUCOT, 1999, p. 866]

Moderately large, smooth, rectimarginate, may have prominent beak, no cardinal process or crural plates; dental plates obsolete; median septum in ventral valve only. *Middle Devonian (upper Eifelian–Givetian).*

Kaplex FICNER & HAVLÍČEK, 1975, p. 362 [**K. obesissimus;* OD]. Moderately ventribiconvex; hinge plates anteriorly discrete; loop unknown. *Middle Devonian (upper Eifelian–lower Givetian):* Moravia.——FIG. 1325,*1a–d.***K. obesissimus; a–b,* exterior and interior views of incomplete dorsal valve, ×1.3; *c–d,* exterior and lateral views of ventral valve, ×1 (Ficner & Havlíček, 1978).

Erectocephalus XIAN in XIAN & JIANG, 1978, p. 333 [**E. trigonus;* OD]. Circular to elongate; ventral valve median septum low; massive hinge plates; loop unknown. *Middle Devonian (Givetian):* China (Guizhou).——FIG. 1325,*3a–b.* **E. trigonus; a,* dorsal view; *b,* sectioned specimen, ×1 (Xian & Jiang, 1978).

Subfamily OMOLONINAE Sun & Boucot, 1999

[Omoloninae SUN & BOUCOT, 1999, p. 866]

Smooth or finely striate; large; no dorsal median septum, ventral median septum present, cardinal process present, commonly discrete hinge plates, may have spondylium. *Middle Devonian (Givetian).*

Omolonia ALEKSEEVA in ALEKSEEVA & NUZHDINA, 1967, p. 138 [**O. antiqua;* OD]. Smooth; strongly biconvex; terminally biconvex cardinal process; conjunct hinge plates; large dental plates; loop unknown. *Middle Devonian (Givetian):* Asia, western North America.——FIG. 1326*a–c.* **O. antiqua,* Yukagir Plateau, northeastern Russia; holotype, dorsal, lateral, and ventral views, IGiG 280, ×1 (Alekseeva & Nuzhdina, 1967).

Hemistringocephalus SMIRNOV, 1985, p. 31 [**H. mirabilis;* OD] Smooth; planoconvex; posterior portion of ventral valve unknown; prominent ventral median septum; terminally bifid cardinal process; hinge plates unite medially with cardinal process; no dorsal valve median septum; loop unknown. *Middle Devonian (Givetian):* central Asia (Tian Shan).——FIG. 1327,*1a–f.* **H. mirabilis; a–d,* dorsal, ventral, posterior, and anterior views, ×1; *e–f,* sectioned specimen, ×1 (Smirnov, 1985).

Kumbella KHODALEVICH, 1975, p. 137 [**K. kumbensis;* OD]. Smooth to finely striate, ventribiconvex, subcircular, spondylium duplex supported by median septum, bulbous cardinal process, septal and crural plates, loop unknown. *Middle Devonian*

FIG. 1323. Stringocephalidae (p. 2000).

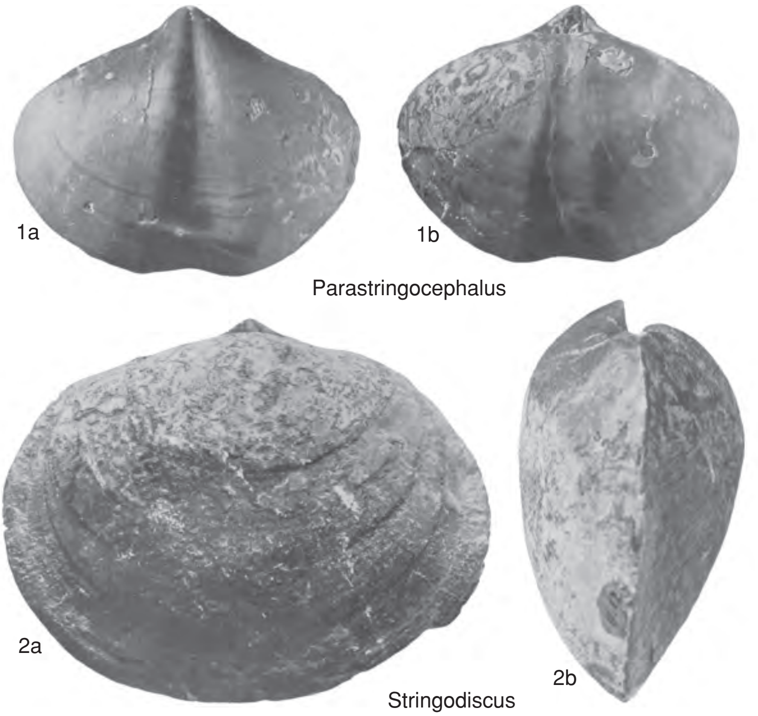

FIG. 1324. Stringocephalidae (p. 2000).

(Givetian): east-central Urals.——FIG. 1327,*2a–d.* **K. kumbensis; a–b,* holotype, ventral and lateral views; *c,* dorsal view, ×1; *d,* transverse section of posterior of dorsal valve, ×3 (Khodalevich, 1975).

Subfamily GERANOCEPHALINAE Johnson, 1975

[Geranocephalinae JOHNSON, 1975, p. 981]

Medium size; ventral valve beak straight; moderately ventribiconvex; crural plates may be present; moderate-sized cardinal process; no median septae. *Middle Devonian (Givetian).*

Geranocephalus CRICKMAY, 1954, p. 157 [**G. inopinus;* OD] [=*Acrothyris* HOU, 1963, p. 419 (type, *A. kwangsiensis* HOU, 1963, p. 432, OD); *Catacephalus* YANG in ZHANG, FU, & DING, 1983, p. 381 (type, *C. tianshanensis,* OD); *Conomimus* JOHNSON, BOUCOT, & GRONBERG, 1968, p. 406 (type, *C. truncatus,* OD)]. Medium, smooth, ventribiconvex; dental plates short; median septae absent in both valves; crural plates absent; cardinal plate formed from conjunct hinge plates; large, terminally bifid cardinal process; loop unknown. *Middle Devonian (Givetian):* North America, Europe, Asia, Australia.——FIG. 1328,*1a–f.* **G. inopinus,* Nevada, USA; *a,* dorsal view, ×3; *b–c,* ventral and lateral views, ×2; *d,* interior of ventral valve, ×4; *e,* anterodorsal view of dorsal valve; *f,* interior of dorsal valve, ×3 (Johnson, Boucot, & Gronberg, 1968).

Paracrothyris WU in WANG, YU, & WU, 1974, p. 42 [**P. distorta;* OD]. Similar to *Geranocephalus* except for the presence of crural plates. *Middle Devonian (Givetian):* China, North America.——FIG. 1328,*4a–b.* **P. distorta,* China; dorsal and lateral views, ×1 (Wang, Yu, & Wu, 1974).——FIG. 1328,*4c. P.* sp., Nevada, USA; interior of dorsal valve, ×3 (Johnson, 1975).

Stringomimus STRUVE, 1965, p. 461, *nom. transl.* JIN & LEE, herein, *ex Geranocephalus (Stringomimus)* STRUVE, 1965, p. 463 [**Geranocephalus (Stringomimus) pseudopaedicus* STRUVE, 1965, p. 463; OD]. Similar to *Geranocephalus* except that ventral valve beak is less attenuated, and cardinal process more slender; remainder of interior unknown. *Middle Devonian (Givetian):* Europe.——FIG. 1328,*3a–d.* **S. pseudopaedicus,* Germany; dorsal, ventral, lateral, and posterior views, ×1 (Struve, 1965).

Xiangzhounia NI & YANG, 1977, p. 464 [**X. typica;* OD]. Similar to *Geranocephalus* except for presence of short dental plates. *Middle Devonian (Givetian):* Asia.——FIG. 1328,*2a–b.* **X. typica,* China; dorsal and lateral views, ×1 (Ni & Yang, 1977).

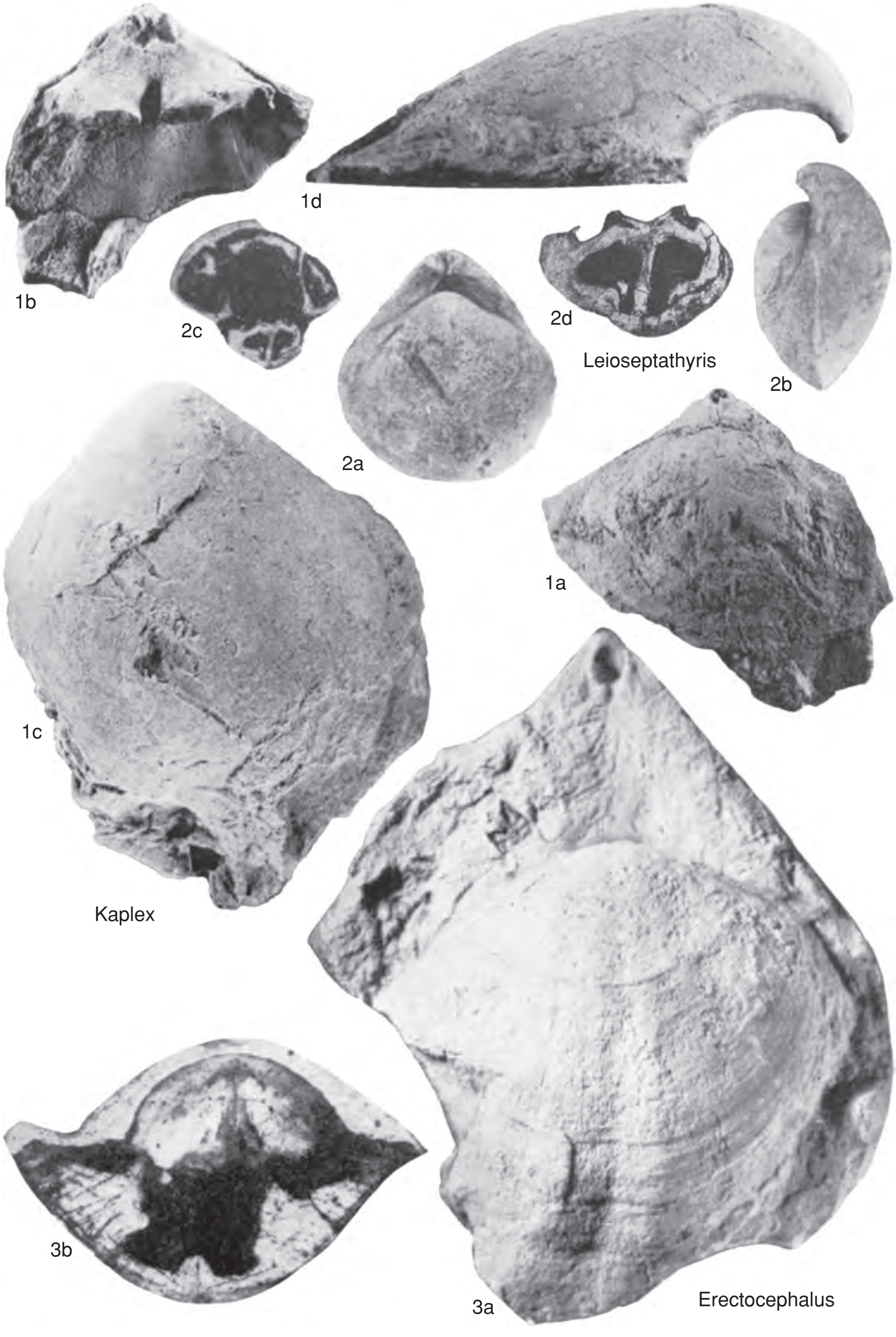

FIG. 1325. Stringocephalidae (p. 2000–2004).

FIG. 1326. Stringocephalidae (p. 2000).

Subfamily LEIOSEPTATHYRIDINAE Sun & Boucot, 1999

[*nom. correct.* JIN & LEE, herein, *pro* Leioseptathyrinae SUN & BOUCOT, 1999, p. 866]

Medium, smooth, dorsal median septum present. *Middle Devonian (Givetian).*

Leioseptathyris WU in WANG, YU, & WU, 1974, p. 42 [**L. modica;* OD]. Subcircular, ventribiconvex; dental plates present; conjunct hinge plates forming cardinal plate; low cardinal process formed from laterally directed processes; loop unknown. *Middle Devonian (Givetian):* Asia.——FIG. 1325,*2a–d*. **L. modica,* China; *a–b,* dorsal and lateral views, ×1; *c,* sectioned specimen, ×2; *d,* sectioned specimen, ×5 (Wang, Yu, & Wu, 1974).

Subfamily RENSSELANDIINAE Cloud, 1942

[Rensselandiinae CLOUD, 1942, p. 92]

Medium to large; subcircular to elongate; ventribiconvex; rectimarginate or uniplicate;

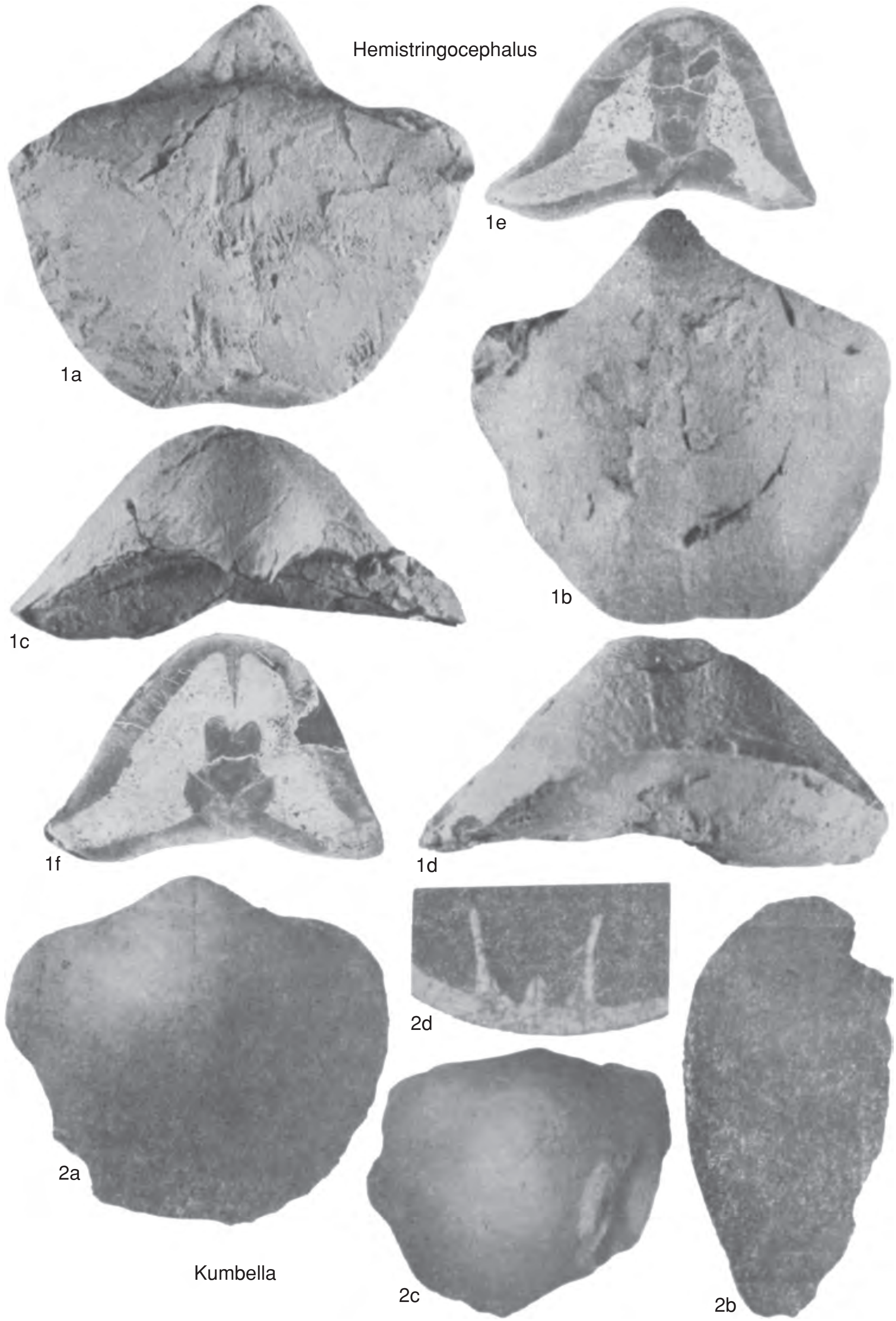

FIG. 1327. Stringocephalidae (p. 2000–2002).

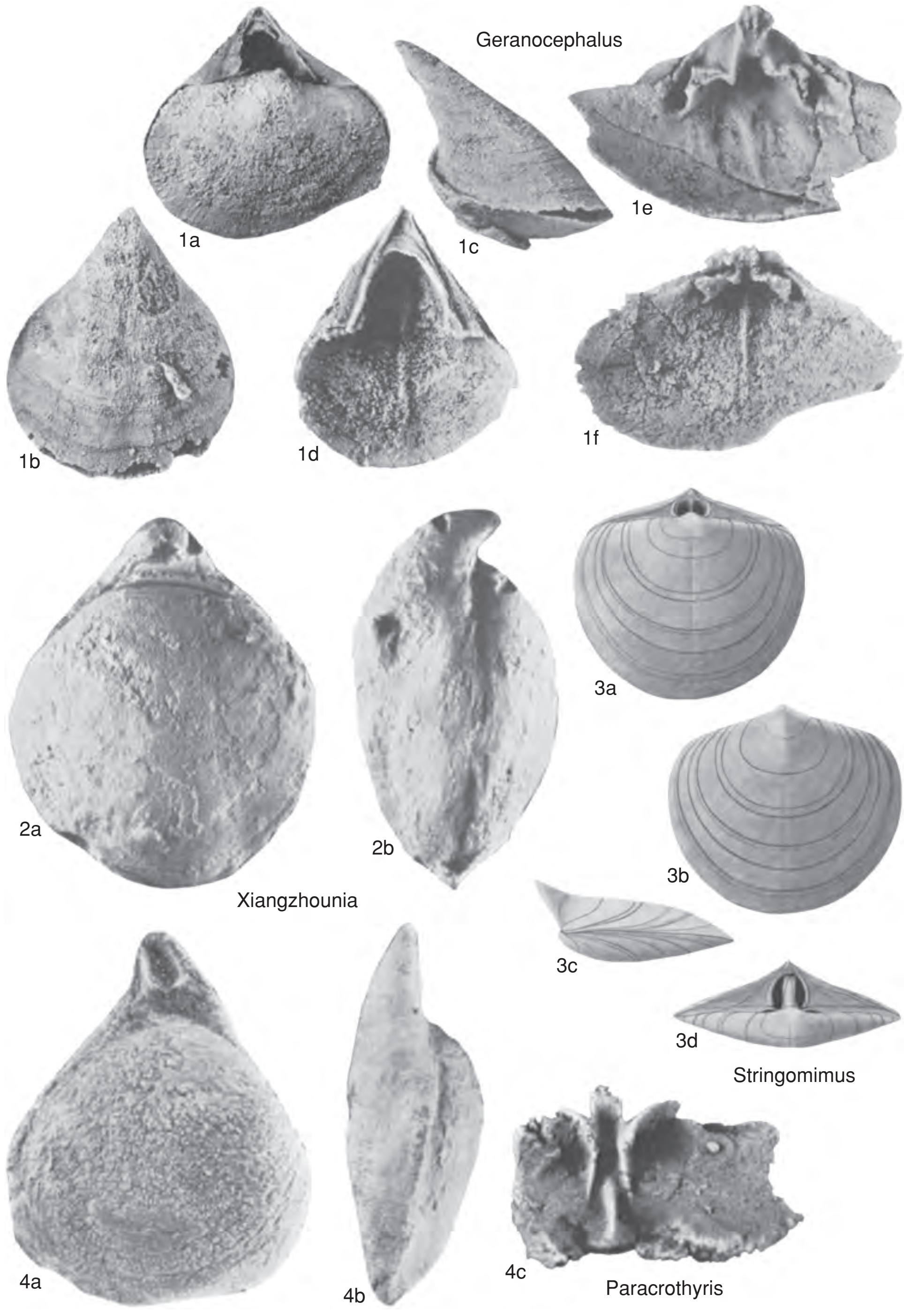

FIG. 1328. Stringocephalidae (p. 2002).

beak small and strongly incurved; no median septae, with the exception of *Rensselandioidea,* which has a dorsal median septum; cardinal process commonly absent; hinge plates may be supported by crural plates; long, marginal, acuminate (centronelliform) loop. *Middle Devonian (upper Eifelian–Givetian).*

Newberria HALL in WHITEAVES, 1891, p. 236 [**Rensselaeria? johanni* HALL, 1867b, p. 385; SD SCHUCHERT, 1897, p. 271] [=*Rensselandia* HALL, 1867b, p. 385, obj., *nom. cond.; Macroplectane* COSSMANN, 1909, p. 215 (type, *Denckmannia circularis* HOLZAPFEL, 1912, p. 119, SD SCHUCHERT & LEVENE, 1929a, p. 51), *nom. nov. pro Denckmannia* HOLZAPFEL, 1912, p. 115, *non* BUCKMAN, 1898; *Denckmannella* SCHUCHERT & LEVENE, 1929b, p. 120 (type, *Denckmannia circularis* HOLZAPFEL, 1912, p. 119, SD SCHUCHERT & LEVENE, 1929a, p. 51), *nom. nov. pro Denckmannia* HOLZAPFEL, 1912, p. 115, *non* BUCKMAN, 1898]. Medium to large; smooth; rectimarginate; dental plates obsolete or obsolescent; well impressed muscle field; no cardinal process; discrete hinge plates; crural plates absent except in some small specimens; loop long, marginal; may have median plate. *Middle Devonian (Givetian):* North America, Europe, Asia.——FIG. 1329,*1a–e.* **N. johanni* (HALL), Iowa, USA; *a–d,* dorsal, lateral, posterior, and anterior views; *e,* ventral view of loop, ×1 (Cloud, 1942).

Chascothyris HOLZAPFEL, 1895, p. 234 [**C. barroisi;* SD SCHUCHERT & LEVENE, 1929a, p. 40]. Medium to large; smooth; ventral sulcus and dorsal fold; uniplicate; subcircular; interior as in *Newberria. Middle Devonian (Givetian):* Europe, Asia.——FIG. 1329,*3a–b.* **C. barroisi,* Germany; dorsal and lateral views, ×1 (Cloud, 1942).

Ectorensselandia JOHNSON, 1973a, p. 1,105 [**Rensselaeria laevis* MEEK, 1868, p. 108; OD]. Large, smooth, elongate; rectimarginate, short, obsolete dental plates; hinge plates fuse posteriorly to form cardinal plate; no crural plates; bilobed cardinal process; loop peripheral (anterior half unknown). *Middle Devonian (Givetian):* Canada (District of Mackenzie).——FIG. 1329,*6a–c.* **E. laevis* (MEEK), Mackenzie River; dorsal, lateral, and anterior views, ×1 (McLaren, Norris, & McGregor, 1962).

Elmaria NALIVKIN, 1947, p. 133 [**E. glabra;* OD]. Small, rounded to elongate; smooth or peripherally costate; similar to *Newberria;* interior poorly known. *Middle Devonian (Givetian):* southern Urals.——FIG. 1329,*5a–b.* **E. glabra;* dorsal and lateral views, ×1 (Nalivkin, 1947).

Rensselandioidea YANG, 1983, p. 34 [**R. maanshanensis;* OD]. Similar to *Newberria* but with dorsal valve median septum. *Middle Devonian (Givetian):* Asia.——FIG. 1329,*4a–b.* **R. maanshanensis,* China; dorsal and lateral views, ×1 (Yang, 1973).

Subrensselandia CLOUD, 1942, p. 92 [**Newberria claypolii* HALL, 1891, p. 97; OD]. Medium to large; smooth; subcircular to elongate; rectimarginate; short dental plates; small teeth; broad, well-impressed muscle field; discrete hinge plates; crural plates; loop long, marginal. *Middle Devonian (upper Eifelian–lower Givetian):* North America, Europe.——FIG. 1329,*2a–e.* **S. claypolii* (HALL), lower Givetian, Pennsylvania; *a–c,* dorsal, lateral, and posterior views of steinkern, ×1; *d,* latex replica of *c,* ×1; *e,* latex replica of ventral valve interior, ×1 (Cloud, 1942).

Subfamily BORNHARDTININAE Cloud, 1942

[Bornhardtininae CLOUD, 1942, p. 100]

Large, rectimarginate, smooth; beak asymmetrical, incurved; with or without dental plates; stout hinge teeth; dental lamellae obsolete; discrete hinge plates; cardinal process and median septae absent; loop long, marginal, acuminate (centronelliform). *Middle Devonian (upper Eifelian–Givetian).*

Bornhardtina SCHULZ, 1914, p. 363 [**B. uncitoides;* SD CLOUD, 1942, p. 101] [=*Parabornhardtina* HOU & XIAN, 1964, p. 416 (type, *P. yunnanensis,* OD)]. Description as for subfamily, dental plates absent. *Middle Devonian (upper Eifelian–Givetian):* Europe, Asia.——FIG. 1330,*3a–d.* **B. uncitoides,* Germany; *a–c,* dorsal, lateral, and anterior views; *d,* latex replica of dorsal interior, ×1 (Cloud, 1942).

Hessenhausia STRUVE, 1982, p. 226 [**Rauffia pseudocaiqua* SCHULZ, 1914, p. 371; SD CLOUD, 1942, p. 102]. Similar to *Bornhardtina,* but with posterior sulcus on dorsal valve. *Middle Devonian (Givetian):* Germany.——FIG. 1330,*1a–c.* **H. pseudocaiqua* (SCHULZ); dorsal, lateral, and anterior views, ×0.5 (Schulz, 1914).

Pseudobornhardtina YANG, 1977, p. 460 [**P. xiangzhouensis;* OD]. Similar to *Bornhardtina* but with dental plates. *Middle Devonian (Givetian):* Asia.——FIG. 1330,*2a–d.* **P. xiangzhouensis; a–b,* dorsal and lateral views; *c–d,* serial transverse sections showing dental plates, ×1 (Yang, 1977).

Family MEGANTERIDIDAE Schuchert & LeVene, 1929

[*nom. correct.* JIN & LEE, herein, *pro* Meganteridae SCHUCHERT & LEVENE, 1929a, p. 23]

Small to large; crural plates commonly absent, except in entirely smooth forms; rarely present in some larger specimens, short, if present; loop acuminate or teloform (centronelliform or cryptonelliform). *Silurian (?Pridoli), Lower Devonian (Lochkovian)–Middle Devonian (Givetian).*

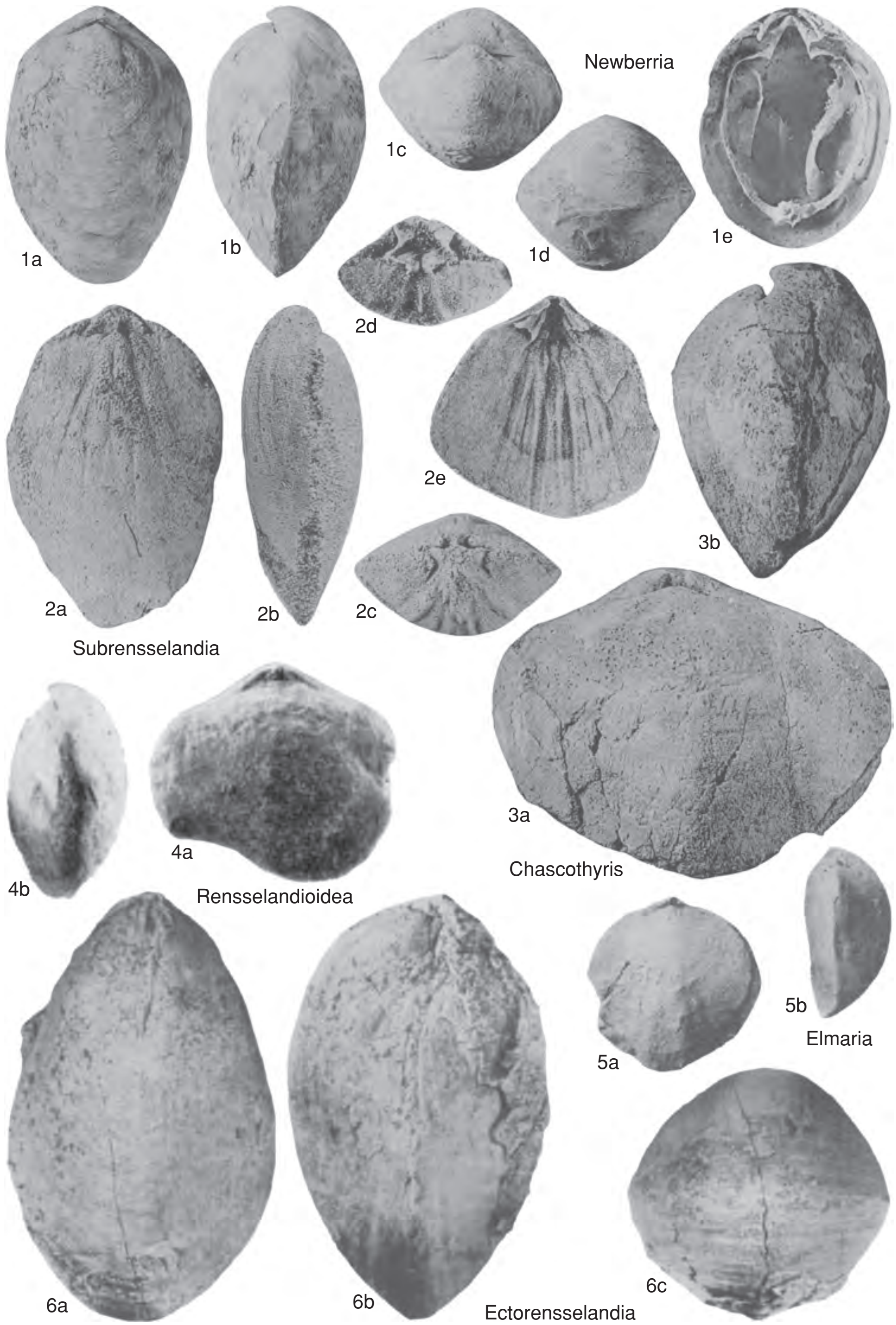

FIG. 1329. Stringocephalidae (p. 2007).

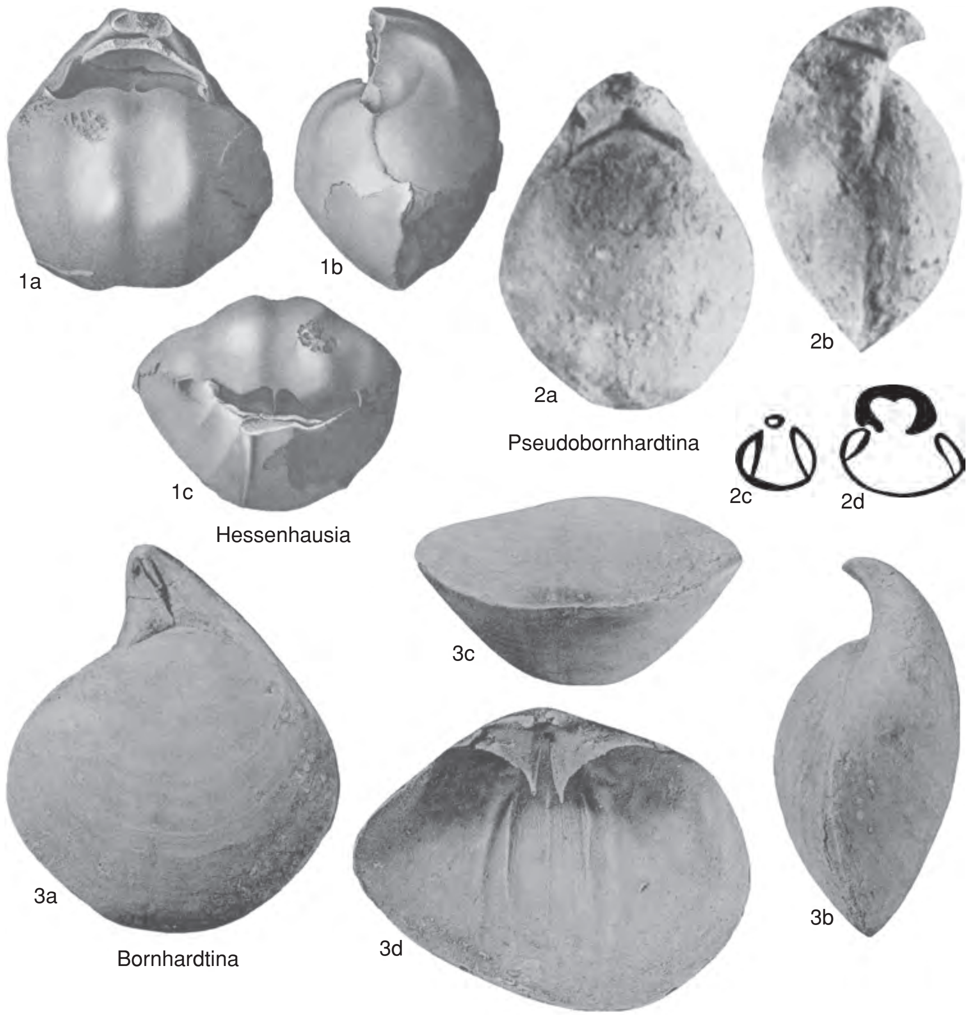

FIG. 1330. Stringocephalidae (p. 2007).

Subfamily MEGANTERIDINAE Schuchert & LeVene, 1929

[*nom. correct.* STEHLI, 1965, p. 744, *pro* Meganterinae BOUCOT, 1959b, p. 766, *nom. transl. ex* Meganteridae SCHUCHERT & LEVENE, 1929a, p. 23]

Medium to large; smooth; subcircular; ventribiconvex; rectimarginate; hinge teeth large; cardinal plate; cardinal process and crural plates present. *Lower Devonian (Pragian–Emsian).*

Meganteris SUESS, 1855a, p. 51 [**Terebratula archiaci* DE VERNEUIL, 1850a, p. 175–176; SD SUESS, 1856, p. 43] [=*Megalanteris* OEHLERT, 1887b, p. 1,319, obj.; *Vltavothyris* HAVLÍČEK, 1956, p. 642 (type, *V. svobodai,* OD)]. Medium to large; subcircular; obsolete or obsolescent dental plates except in small specimens; crural plates in earlier growth stages; massive cardinal plate; bosslike cardinal process; hinge plates massive in large specimens; crural plates submerged in secondary material except in smaller specimens; loop teloform (cryptonelliform). *Lower Devonian (Pragian–Emsian):* Europe, Canada (Nova Scotia).——FIG. 1331,*1a.* **M. archiaci* (DE VERNEUIL), France; incomplete dorsal interior of holotype, ×1 (Hall & Clarke, 1893).——FIG. 1331,*1b–g. M. suessi* DREVERMANN, Germany; *b–d,* latex replicas of dorsal and ventral interiors and lateral view of steinkern from which they were taken, ×0.5; *e–f,* anterior and ventral views of fragment of dorsal interior, ×1; *g,* reconstruction of loop, ×0.5 (Cloud, 1942).

Meganterella BOUCOT, 1959b, p. 767 [**M. finksi;* OD]. Medium; subcircular to elongate; short dental plates; cardinal plate sessile posteriorly; crural

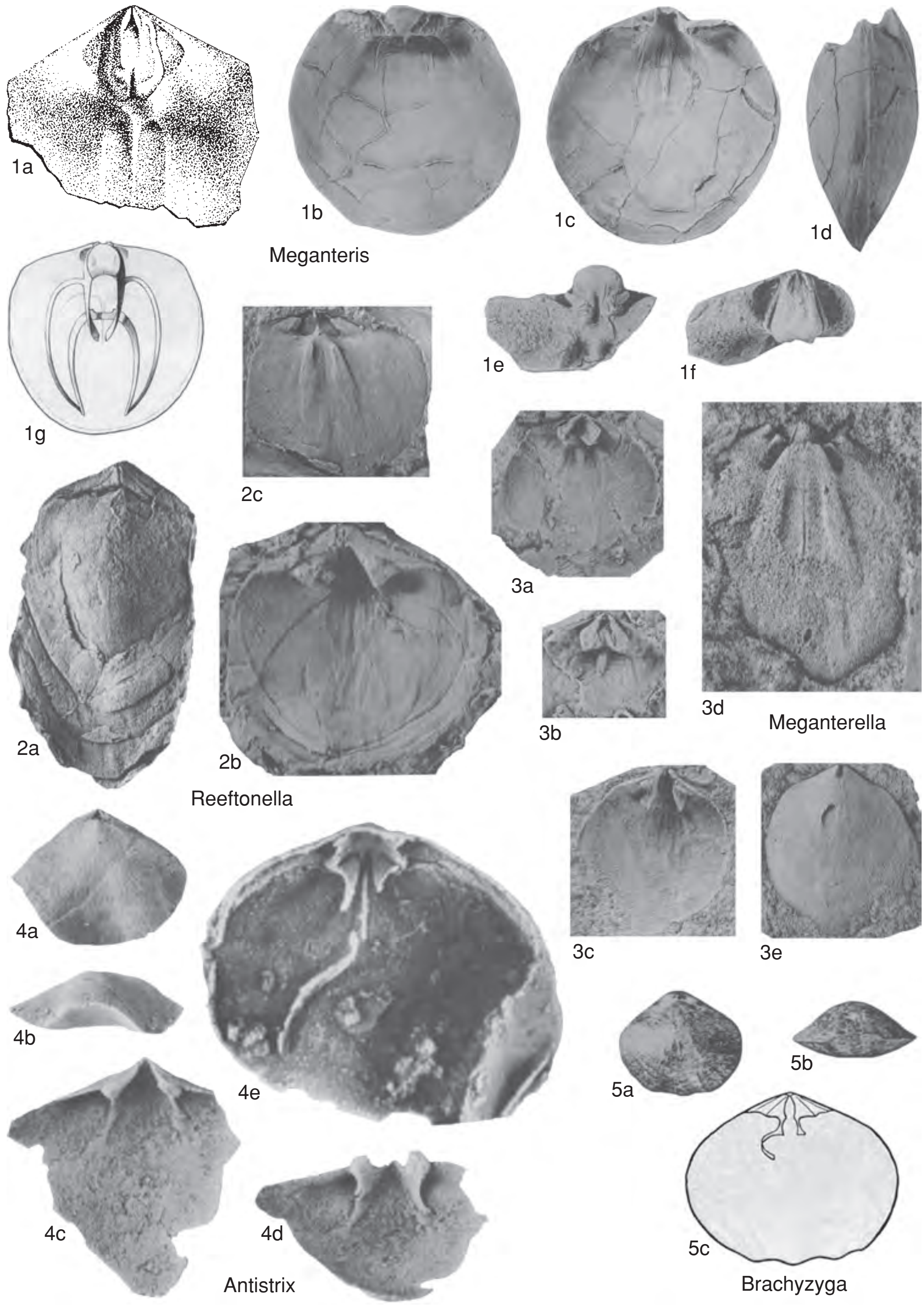

FIG. 1331. Meganterididae (p. 2009–2016).

plates; small cardinal process posteriorly; loop unknown. *Lower Devonian (Emsian):* USA (New York).——FIG. 1331,*3a–e*. **M. finksi,* Highland Mills; *a,* latex cast of dorsal valve interior, ×1; *b,* latex cast of dorsal valve interior, ×1; *c,* latex cast of ventral valve interior, ×1; *d,* impression of dorsal valve interior, ×3; *e,* latex cast of ventral valve exterior, ×1 (Boucot, 1959b).

Reeftonella BOUCOT, 1959b, p. 768 [**Meganteris neozelanica* ALLAN, 1935, p. 23; OD]. Subcircular to elongate oval; short dental plates in small shells to obsolete in large; stout hinge teeth; cordate muscle field; crural plates in smaller specimens to submerged in sessile cardinal plate in larger examples; no cardinal process; loop unknown. *Lower Devonian (Emsian):* New Zealand.——FIG. 1331,*2a–c*. **R. neozelanica* (ALLAN); *a,* latex replica of dorsal valve exterior, ×1 (Boucot & others, 1963); *b,* latex replica of interior of ventral valve, ×1 (Boucot, 1959b); *c,* impression of dorsal valve interior, ×1 (Boucot & others, 1963).

Subfamily MUTATIONELLINAE Cloud, 1942

[Mutationellinae CLOUD, 1942, p. 114]

Small to large; costate or costellate to peripherally costate; commonly rectimarginate; dental plates short; loop acuminate to deltiform (centronelliform to terebratuliform); hinge plates or cardinal plate; crural plates absent except in a few large specimens. *Lower Devonian (Lochkovian–Emsian).*

Mutationella KOZLOWSKI, 1929, p. 236 [**Waldheimia podolica* SIEMIRADZKI, 1906, p. 177; OD]. Small to medium; subcircular; ventribiconvex; costellate, short dental plates; weakly impressed muscle field; discrete hinge plates; short, anterior connecting band in large specimens; crural plates absent except for short examples in very rare, large specimens; loop acuminate to deltiform, but highly variable. *Lower Devonian (Lochkovian–Emsian):* Europe, eastern North America, South America, South Africa.——FIG. 1332,*1a–g*. **M. podolica* (SIEMIRADSKI), Poland; *a–c,* dorsal, lateral, and anterior views, ×2; *d–g,* drawings of 4 loops, ×4 (Cloud, 1942).——FIG. 1332,*1h–i*. *M. parlinensis* BOUCOT & others, Maine, USA; impressions of posterior and dorsal views, ×2 (Boucot, 1973).

Cloudella BOUCOT & JOHNSON, 1963, p. 123, *nom. nov. pro Pleurothyris* CLOUD, 1942, p. 123, *non* LOWE, 1843, *nec* SCHRAMMEN, 1912 [**Rensselaeria stewarti* CLARKE, 1907, p. 239; OD]. Medium; subcircular to elongate; costellate; costellae may increase partly by bifurcation; crenulate; ventribiconvex; short dental plates, obsolescent in larger individuals; muscle field deeply impressed in larger specimens; foramenate hinge plate or discrete hinge plates; muscle field deeply impressed in larger specimens; loop unknown. *Lower Devonian (Lochkovian–Pragian):* eastern North America.——FIG. 1332,*2a–e*. **C. stewarti* (CLARKE), Dalhousie, Canada; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* posterior of ventral valve interior, ×1; *e,* posterior of dorsal valve interior, ×2 (Cloud, 1942).

Derbyina CLARKE, 1913b, p. 212, *non* GRABAU, 1931c [**Notothyris? smithi* DERBY, 1895, p. 81; SD CLARKE, 1913b, p. 212] [=*Paranaia* CLARKE, 1913a, pl. 21,*7–8* (type, *Centronella*? *margarida* DERBY, 1895, p. 84, OD); *Brasilica* GREGER, 1920, p. 70, *nom. null.; Chapadella* GREGER, 1920, p. 70 (type, *Centronella margarida* DERBY, 1895, p. 84, OD), *nom. nov. pro Brasilia* CLARKE, 1913b, p. 213, *non* BUCKMAN, 1898; *Brasilina* CLARKE, 1921, p. 138 (type, *Centronella margarida* DERBY, 1895, p. 84, OD), *nom. nov. pro Brasilia* CLARKE, 1913b, p. 213, *non* BUCKMAN, 1898; *Oliveirella* DE OLIVEIRA, 1934, p. 167 (type, *Centronella margarida* DERBY, 1895, p. 84, OD), *nom. nov. pro Brasilia* CLARKE, 1913b, p. 213, *non* BUCKMAN, 1898; *Chapadella* QUADROS, 1981, p. 88 (type, *C. mendesi* QUADROS, 1981, p. 89, OD)]. Small, umbones smooth; otherwise similar to coarsely costate *Mutationella.* [In 1920 GREGER named *Chapadella* as a substitute for *Brasilia* (see CLOUD, 1942, p. 122). In 1981 QUADROS named a new genus *Chapadella* in ignorance of GREGER's item. Adding to the confusion is the problem that the Malvinokaffric Realm costate mutationellinids are mostly represented by poor samples. Early growth stages of the genera (i.e., *Mendathyris, Cloudella, Scaphiocoelia,* and *Pleurothyrella*) look like *Mutationella* but develop their unique characters later in life as they become large. Therefore QUADROS's *Chapadella* could be the young of *Pleurothyrella* or just another synonym of the poorly known *Derbyina-Paranaia* confusion.] *Lower Devonian (Emsian):* central and southern South America.——FIG. 1332,*4a–c*. **D. smithi* (DERBY), Brazil; *a–b,* dorsal and lateral views, ×2; *c,* reconstruction of loop, approximately ×4 (Cloud, 1942).

Mendathyris CLOUD, 1942, p. 125 [**Rensselaeria mainensis* WILLIAMS, 1900, p. 80; OD]. Medium; subcircular to slightly elongate; subglobose, ventribiconvex; costellate; crenulate; short dental plates free in small specimens, obsolete in large specimens; muscle field deeply impressed in large specimens; discrete hinge plates in small specimens; swollen, perforate cardinal plate in large specimens; deeply impressed muscle field; loop unknown. *Lower Devonian (Lochkovian):* eastern North America.——FIG. 1332,*3a–e*. **M. mainensis* (WILLIAMS), Maine, USA; *a–b,* dorsal and lateral views; *c,* ventral view; *d,* latex replica of ventral valve interior; *e,* latex replica of dorsal valve interior, ×1 (Cloud, 1942).

Paulinella BOUCOT & RACHEBOEUF, 1987, p. 99 [**Terebratula guerangeri* DE VERNEUIL, 1850b, p. 780; OD]. Small; subcircular; costate to costellate; crenulate; gently ventribiconvex; short dental plates; discrete hinge plates or a foramenate cardinal plate; well-impressed muscle field. *Lower*

Devonian (Pragian–Emsian): Europe, Turkey.——FIG. 1333,*4a–d.* **P. guerangeri* (DE VERNEUIL), France; *a–b,* lectotype, dorsal and lateral views, ×2; *c,* interior of dorsal valve, ×2; *d,* reconstruction of loop, ×2 (Boucot & Racheboeuf, 1987).

Pleurothyrella BOUCOT & others, 1963, p. 89 [**Scaphiocoelia? africana* REED, 1906, p. 306; OD]. Large; subcircular to elongate; ventribiconvex; costate to costellate; costae may bifurcate; crenulate; short dental plates to obsolete; muscle field deeply impressed; discrete hinge plates in medium specimens to almost sessile, swollen cardinal plate in large specimens; posterior, small cardinal process may be present; muscle field deeply impressed; loop unknown. *Lower Devonian (Emsian):* Antarctica, New Zealand, South Africa, South America (Malvinokaffric Realm).——FIG. 1332,*6a–c.* **P. africana* (REED); *a,* latex replica of ventral valve; *b,* impression of dorsal valve interior; *c,* posterior view, ×1 (Boucot & others, 1963).——FIG. 1332,*6d–f. P. antarctica* BOUCOT & others, Antarctica; dorsal, lateral, anterior views, ×1 (Boucot & others, 1963).

Podolella KOZLOWSKI, 1929, p. 232 [**P. rensselaeroides;* OD]. Small, subcircular to elongate; umbonal region smooth; peripheral costae; short dental plates; perforate cardinal plate; no crural plates; loop acuminate. *Lower Devonian (Lochkovian):* Europe, Canada (Nova Scotia).——FIG. 1332,*5a–c.* **P. rensselaeroides,* Bohemia, Czech Republic; *a–b,* dorsal and anterior views, ×2; *c,* drawing of loop, ×3 (Cloud, 1942).

Prorensselaeria RAYMOND, 1923, p. 467 [**P. nylanderi;* OD]. Medium; subcircular; smooth umbo; costellate; crenulate; short dental plates; no crural plates in small specimens, to short crural plates in large specimens; discrete hinge plates; muscle field deeply impressed in large specimens; loop unknown. *Lower Devonian (Lochkovian):* eastern North America (Maine).——FIG. 1333,*1a–g.* **P. nylanderi,* New Brunswick; *a,* holotype, wax replica of exterior of ventral valve of steinkern (Cloud, 1942); *b,* impression of exterior; *c–f,* ventral, dorsal, posterior, and lateral views of internal mold; *g,* dorsal view of internal mold, ×1 (Boucot & Wilson, 1994).

Scaphiocoelia WHITFIELD in WENDT, 1891, p. 106 [**S. boliviensis;* OD]. Large; subcircular to elongate; naviculate, with ventral valve deep and dorsal valve gently sulcate; broadly unisulcate anterior commissure; costate; short dental plates in medium specimens to obsolete in large specimens; muscle field deeply impressed in large specimens; discrete hinge plates in medium specimens to posteriorly sessile, swollen cardinal plate in large individuals; bosslike cardinal process; loop present. *Lower Devonian (Emsian):* central and southern South America and southern Africa (Malvinokaffric Realm).——FIG. 1333,*3a–d.* **S. boliviensis,* Icla, Bolivia; *a,* impression of dorsal valve interior; *b,* impression of ventral interior; *c,* posterior view of impression of ventral interior; *d,* latex replica of ventral valve interior, ×1 (BOUCOT & others, 1963).

Xana GARCÍA-ALCALDE, 1972, p. 5 [**X. bubo;* OD]. Small; laterally elongate; naviculate; ventral valve gently convex; dorsal valve gently unisulcate, concave; coarsely costate; crenulate; short dental plates; discrete hinge plates united anteriorly by a median band; loop short, with recurved anteromedian vertical lamina. *Lower Devonian (Emsian):* northern Spain.——FIG. 1333,*2a–c.* **X. bubo; a–b,* holotype, dorsal and lateral views, DPO 284, ×1; *c,* reconstruction of loop, ×2 (García-Alcalde, 1972).

Subfamily BRACHYZYGINAE Cloud, 1942

[Brachyzyginae CLOUD, 1942, p. 113]

Small, smooth, broad, ventribiconvex, with dorsal sulcus and ventral fold; anterior commissure intraplicate; dental plates short; discrete, sessile hinge plates; no crural plates; loop short, acuminate. *Silurian (?Pridoli), Lower Devonian (Lochkovian).*

Brachyzyga KOZLOWSKI, 1929, p. 243 [**B. pentameroides;* OD]. Description as for subfamily. *Silurian (?Pridoli), Lower Devonian (Lochkovian):* Podolia, *Lochkovian;* central Asia, *?Pridoli.*——FIG. 1331,*5a–c.* **B. pentameroides,* Lochkovian, Podolia, Poland; *a–b,* holotype, dorsal and anterior views, ×1; *c,* drawing of loop, ×2 (Cloud, 1942).

Subfamily ADRENINAE Boucot, 1994

[Adreninae BOUCOT in BOUCOT & WILSON, 1994, p. 1,018]

Small, commonly ventribiconvex, smooth to strongly costate; unisulcate dorsal valve and opposing, ventral valve fold; loop acuminate (centronelliform). *Lower Devonian (Lochkovian–Emsian).*

Adrenia CHATTERTON, 1973, p. 126 [**A. expansa;* OD]. Subcircular to elongate; very weak dorsal valve sulcus and low ventral valve fold; ventribiconvex to subglobular; costate; rectimarginate to unisulcate, crenulate anterior margin; deltidial plates forming deltidial sheath; short dental plates; median septum supporting conjunct hinge plates to form a septalium. *Lower Devonian (Emsian):* eastern Australia.——FIG. 1334,*5a–f.* **A. expansa; a–d,* holotype, dorsal, ventral, lateral, and anterior views, ANU 18986, ×3.8; *e,* close-up of beak, ×11; *f,* reconstruction of dorsal valve interior, ×8 (Chatterton, 1973).

Barbarothyris WANG Yü & RONG, 1986, p. 264 [**B. glabra;* OD]. Elongate; ventribiconvex; smooth umbos; periphery weakly to strongly costate; dorsal valve sulcus and ventral valve fold; ventral valve fold may be deeply plicate; anterior commissure unisulcate to uniplicate, crenulate; short dental plates; foramenate cardinal plate; loop with median plate. *Lower Devonian (Emsian):* China (Guangxi).——FIG. 1334,*6a–d.* **B. glabra; a–c,* holotype, dorsal, lateral, and anterior views, ×6; *d,* reconstruction of

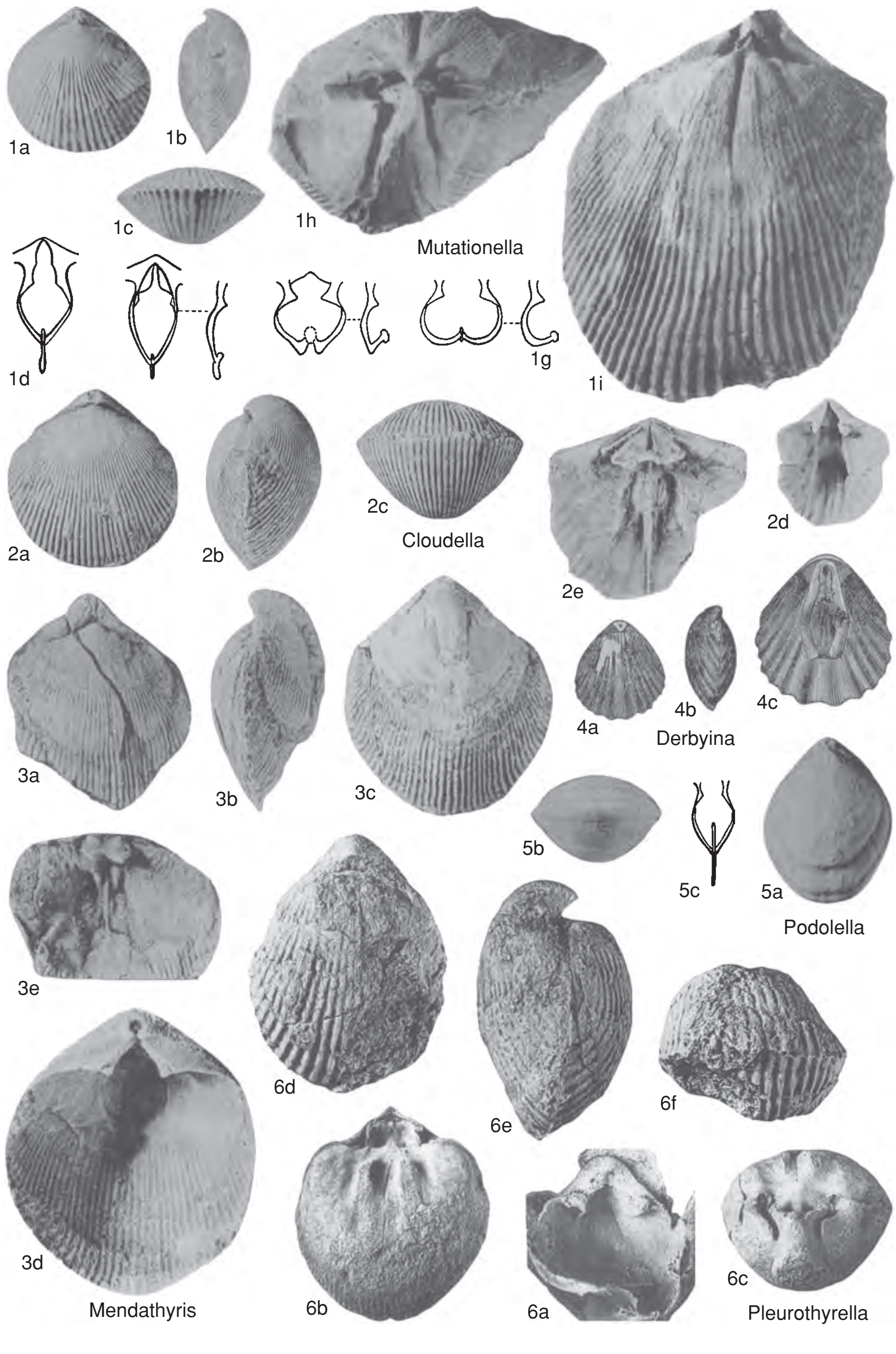

FIG. 1332. Meganterididae (p. 2011–2012).

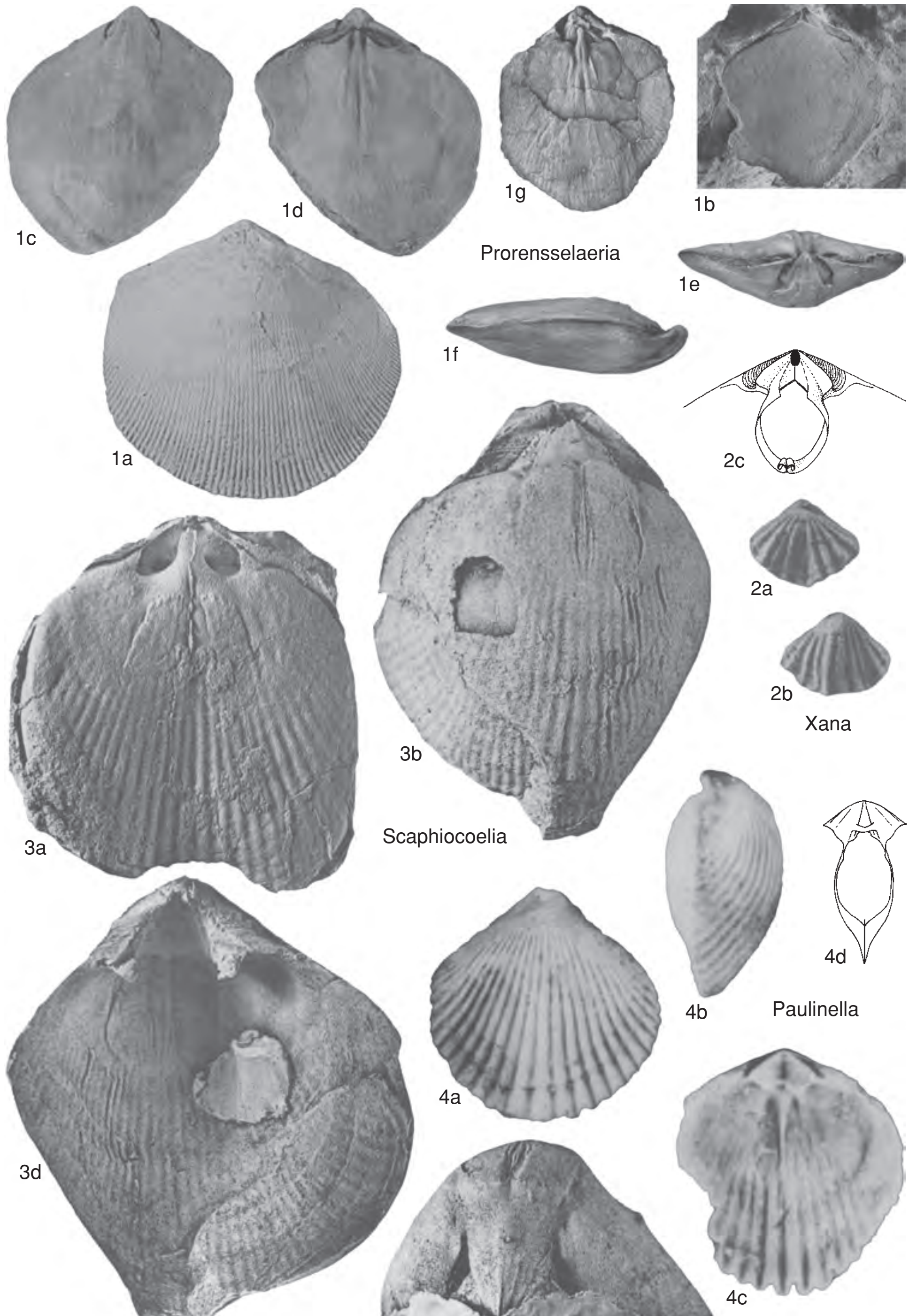

FIG. 1333. Meganterididae (p. 2011–2012).

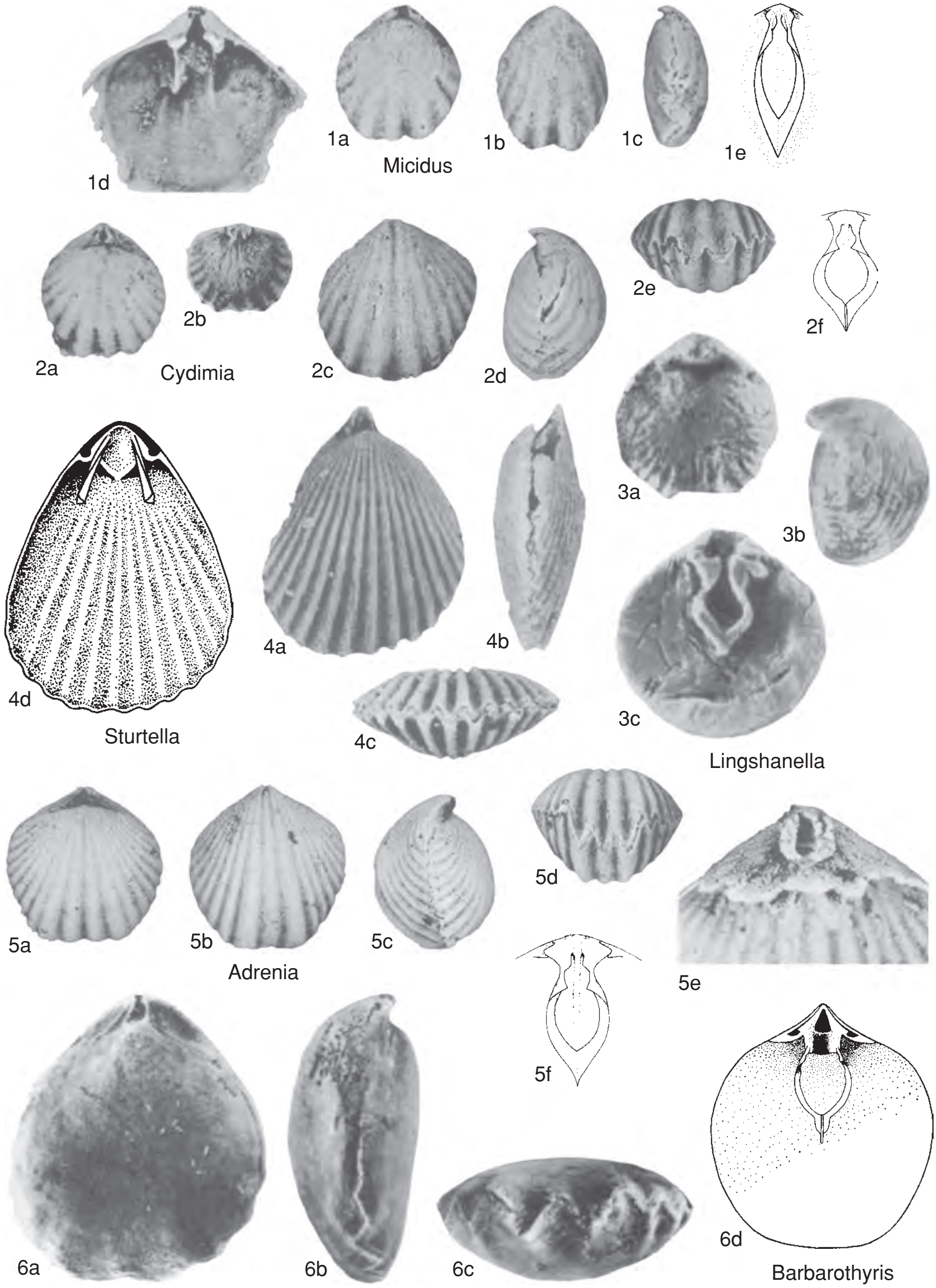

FIG. 1334. Meganterididae (p. 2012–2016).

interior of dorsal valve, ×5 (Wang Yü & Rong, 1986).

Cydimia Chatterton, 1973, p. 131 [**C. robertsi;* OD]. Subcircular to elongate; ventribiconvex; costate except for smooth umbonal region in some forms; broad, weak dorsal valve sulcus and corresponding ventral valve fold; unisulcate, crenulate anterior margin; deltidial plates forming deltidial sheath; short dental plates; hinge plates forming a septalium supported by a low median septum; loop with vertical median plate. *Lower Devonian (Emsian):* New South Wales, Australia, *Emsian;* China (Guangxi), *?Emsian.*——Fig. 1334,*2a–f.* **C. robertsi,* New South Wales; *a–b,* external and internal views of dorsal valves, ×3.5; *c–e,* holotype, ventral, lateral, and anterior views, ANU 18992, ×3.6; *f,* reconstruction of dorsal valve interior, ×8 (Chatterton, 1973).

Lingshanella Xu & Yao, 1986, p. 174 [**L. convexa;* OD]. Subcircular; naviculate with flat to concave dorsal valve and very convex ventral valve; costate with smooth umbos; dorsal sulcus and ventral valve fold; anterior margin unisulcate, crenulate; short dental plates; hinge plates fused posteriorly, discrete anteriorly. *Lower Devonian (Emsian):* China (Guangxi).——Fig. 1334,*3a–b.* **L. convexa;* dorsal and lateral views of holotype, ×2 (Xu & Yao, 1986).——Fig. 1334,*3c. L. changlingensis;* interior of dorsal valve, ×2 (Xu & Yao, 1986).

Micidus Chatterton, 1973, p. 134 [**M. shandkyddi;* OD]. Elongate; ventribiconvex; umbos smooth, periphery smooth or plicate; weak dorsal sulcus and corresponding ventral valve fold; weakly unisulcate, crenulate anterior margin; short dental plates; discrete hinge plates. *Lower Devonian (Emsian):* Australia (New South Wales), USA (southeastern Alaska).——Fig. 1334,*1a–e.* **M. shandkyddi,* New South Wales; *a,* holotype, dorsal view, ANU 18988, ×4.7; *b–c,* ventral and lateral views, ×4.7; *d,* interior of ventral valve, ×11.3; *e,* reconstruction of dorsal valve interior, ×8 (Chatterton, 1973).

Sturtella Savage, 1971, p. 417 [**S. mandageriensis;* OD]. Ventribiconvex; elongate; weak dorsal valve sulcus; rectimarginate, costellate; anterior commissure crenulate; dental plates well developed; medially conjunct hinge plates resting on valve floor as a septalium; long crura; loop unknown. *Lower Devonian (Lochkovian):* Australia (New South Wales).——Fig. 1334,*4a–d.* **S. mandageriensis; a–c,* dorsal, lateral, and anterior views, ×8; *d,* drawing of dorsal valve interior, ×10 (Savage, 1971).

Subfamily ANTISTRIXINAE Johnson, 1972

[*nom. transl.* Jin & Lee, herein, *ex* Antistrixidae Johnson, 1972, p. 121]

Small, smooth, transverse, outline oval, strongly unisulcate dorsal valve and corresponding fold on ventral valve; unisulcate anterior commissure; short dental plates; discrete hinge plates; ventrally directed spine in valve posterior; acuminate (centronelliform) loop with median plate. *Middle Devonian (Givetian).*

Antistrix Johnson, 1972, p. 121 [**A. invicta;* OD]. Description as for subfamily. *Middle Devonian (Givetian):* USA (Nevada).——Fig. 1331,*4a–e.* **A. invicta; a–b,* dorsal and anterior views, ×3; *c–d,* interior views of ventral valve, ×5 (Johnson, 1972); *e,* dorsal valve interior showing incomplete loop, ×5 (Johnson, 1976).

Family RHIPIDOTHYRIDIDAE Cloud, 1942

[*nom. correct.* Stehli, 1965, p. 748, *pro* Rhipidothyridae Cloud, 1942, p. 80]

Small to large; smooth or costate, rectimarginate; ventral foramen submesothyrid to hypothyrid; dental plates well developed to obsolescent; hinge plates discrete or united to form a septalium supported by a median septum duplex formed from crural plates; loop unknown. *Lower Devonian (Lochkovian)–Upper Devonian (Frasnian).*

Subfamily RHIPIDOTHYRIDINAE Cloud, 1942

[*nom. correct.* Stehli, 1965, p. 749, *pro* Rhipidothyrinae Cloud, 1942, p. 87]

Small to medium, smooth or costate, moderately ventribiconvex; ventral foramen submesothyrid; septalium formed from conjunct hinge plates; supported by median septum formed from fused, long crural plates; dental plates free; loop probably acuminate (centronelliform). *Middle Devonian (Eifelian)–Upper Devonian (Frasnian).*

Rhipidothyris Cooper & Williams, 1935, p. 846 [**R. plicata;* OD]. Small to medium, costate, subcircular to subovate, ventribiconvex; dental plates short; imperforate cardinal plate forming septalium supported by median septum; loop unknown. *Middle Devonian (Eifelian–Givetian):* eastern North America, USA (Nevada), Bolivia, Libya, South Africa.——Fig. 1335,*3a.* **R. plicata,* New York, USA; holotype, internal impression of dorsal valve, USNM 89771c, ×2 (Cloud, 1942).——Fig. 1335,*3b–d. R. lepida* (Hall), New York; dorsal, lateral, and anterior views, ×2 (Cloud, 1942).

Neoglobithyris Havlíček, 1984, p. 59 [**N. tmisanensis;* OD]. Medium; smooth umbones, costellate anteriorly, costae and interspaces rounded in cross section, 30 to 40 costae, subcircular outline, weakly ventribiconvex, anterior margin rectimarginate, crenulate, rounded; small deltidial plates border open delthyrium, dental lamellae short, ventral

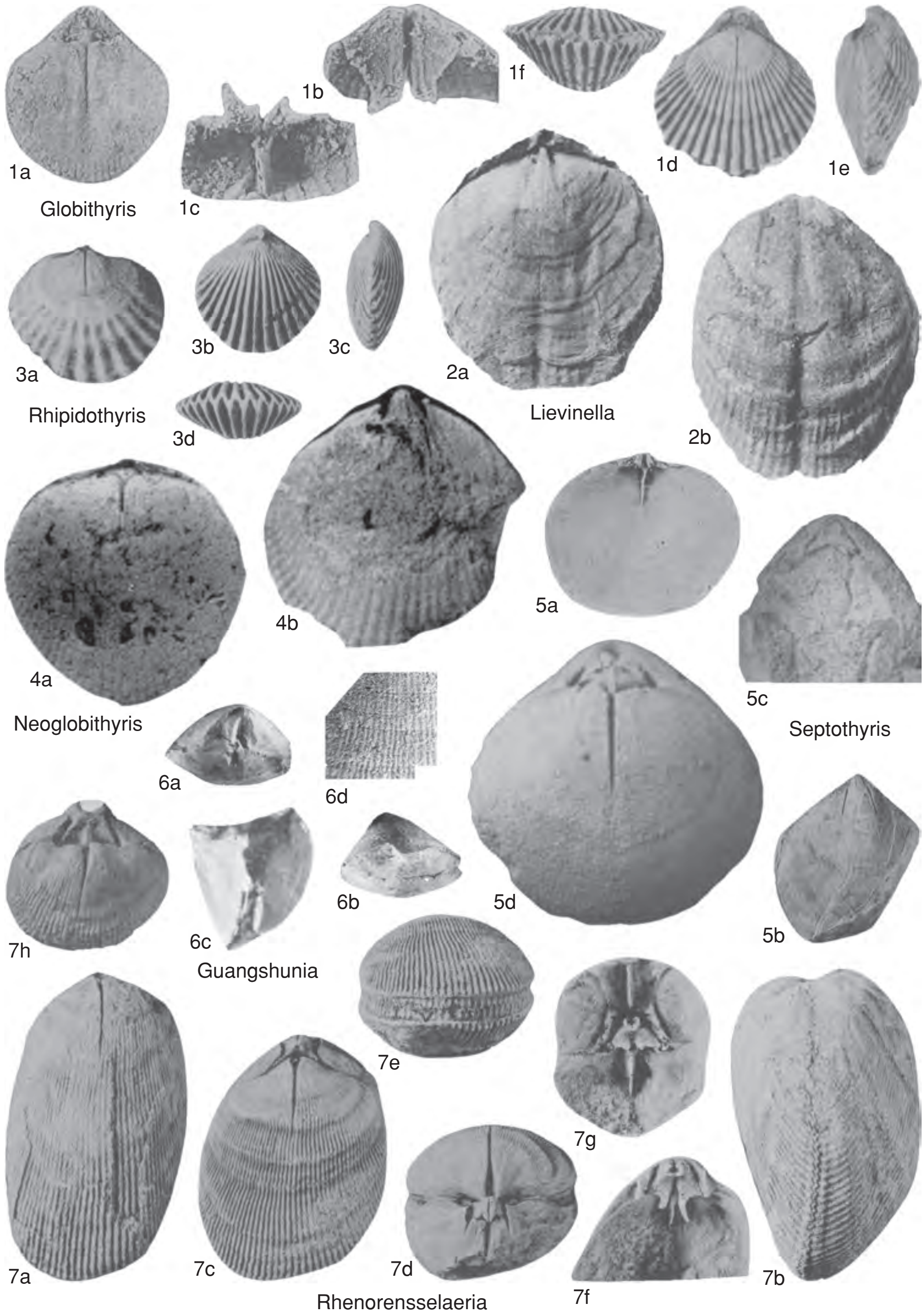

FIG. 1335. Rhipidothyrididae and Uncertain (p. 2016–2018).

muscle field variably impressed, dorsal median septum, short to moderately long, supporting small cruralium. *Middle Devonian (Givetian):* Libya.——FIG. 1335,*4a–b.* **N. tmisanensis; a,* internal mold of dorsal valve, ×1.8; *b,* holotype, internal mold of ventral valve, ×2.8 (Havlíček, 1984).

Septothyris COOPER & WILLIAMS, 1935, p. 848 [**S. septata;* OD]. Small to medium, smooth, subcircular to subovate, ventribiconvex; free dental plates; septalium formed from conjunct hinge plates supported by a median septum formed from fused crural plates; loop probably acuminate (centronelliform). *Middle Devonian (Givetian)–Upper Devonian (Frasnian):* eastern North America, Libya, Bolivia, South Africa.——FIG. 1335,*5a–b.* **S. septata,* New York, USA; *a,* holotype, latex replica of impression of dorsal valve, USNM 89775, ×2; *b,* impression of ventral interior, ×1 (Cloud, 1942).——FIG. 1335,*5c–d. S. boucoti* MERGL & MASSA, Frasnian, Libya; *c,* internal mold showing shape of loop, ×4; *d,* internal mold, ×5 (Mergl & Massa, 1992).

Subfamily GLOBITHYRIDINAE Cloud, 1942

[*nom. correct.* STEHLI, 1965, p. 750, *pro* Globithyrinae CLOUD, 1942, p. 81]

Small to large, moderately to strongly biconvex, subcircular to suboval; ventral foramen hypothyrid, hinge plates conjunct to form a septalium in larger specimens, supported by median septum formed from crural plates; no cardinal process; free dental plates; loop unknown. *Lower Devonian (Pragian)–Upper Devonian (Frasnian).*

Globithyris CLOUD, 1942, p. 82 [**Rensselaeria callida* CLARKE, 1907, p. 241; OD]. Costate, ventribiconvex; free dental plates; discrete crural plates in juveniles, medially conjunct to form median septum when larger; medially fused hinge plates forming septalium supported by median septum in larger specimens; loop unknown. *Lower Devonian (Pragian)–Upper Devonian (Frasnian):* eastern North America, northern Europe.——FIG. 1335,*1a–c.* **G. callida* (CLARKE), Emsian, Maine, USA; *a,* dorsal view of steinkern; *b–c,* ventral and anterior views of cardinal plate of young specimen, ×4 (Cloud, 1942).——FIG. 1335,*1d–f. G. diania* (CLARKE), Emsian, Maine, USA; dorsal, lateral, and anterior views, ×2 (Boucot, 1973).

Subfamily RHENORENSSELAERINAE Boucot, 1975

[*nom. transl.* JIN & LEE, herein, *pro* Rhenorensselaeridae BOUCOT, 1975, p. 372]

Small to large, subcircular to elongate, costellate, ventribiconvex, rectimarginate, crenulate, dental plates obsolescent to obsolete; ventral valve muscle field deeply impressed and subdivided, hinge plates either discrete or conjoined medially; discrete crural plates or median septum formed from conjunct crural plates; loop unknown. *Lower Devonian (Lochkovian–Emsian).*

Rhenorensselaeria KEGEL, 1913, p. 126 [**Terebratula strigiceps* ROEMER, 1844, p. 58; SD SCHUCHERT & LEVENE, 1929a, p. 107]. Medium to large; dental plates obsolete to obsolescent; ventral valve muscle field deeply impressed and subdivided; cardinal plate formed from conjunct hinge plates, supported by median septum formed from fused crural plates; small, bifid cardinal process; loop unknown. *Lower Devonian (Pragian–Emsian):* eastern North America (Gaspé), northern Europe.——FIG. 1335,*7a–g.* **R. strigiceps* (ROEMER), Pragian, Germany; *a–b,* dorsal and lateral views of steinkern; *c–e,* dorsal, posterior, and anterior views of steinkern; *f–g,* latex replicas of posterior of steinkern, ×1 (Cloud, 1942).——FIG. 1335,*7h. R. macgerriglei* BOUCOT, Gaspé, Canada; dorsal view of internal impression, ×1 (Boucot, Cumming, & Jaeger, 1967).

Lievinella BOUCOT, 1975, p. 372 [**Rensselaerina primaeva* BARROIS, PRUVOST, & DUBOIS, 1920, p. 102; OD]. Small to medium; bisulcate; obsolescent dental plates; ventral valve muscle field deeply impressed; discrete crural plates; discrete hinge plates; loop unknown. *Lower Devonian (Lochkovian):* northern France.——FIG. 1335,*2a–b.* **L. primaeva* (BARROIS, PRUVOST, & DUBOIS); *a,* internal mold of dorsal valve, ×1; *b,* internal mold of ventral valve, ×1 (Barrois, Pruvost, & Dubois, 1920).

Family UNCERTAIN

?Guangshunia XIAN & JIANG, 1978, p. 317 [**G. pagodiformis* XIAN & JIANG, 1978, p. 318; OD]. Small to medium, hemipyramidal; very fine radial costellae; hinge line straight, less than maximum width; long ventral interarea, triangular, catacline; open delthyrium; no fold or sulcus; stout dental plates; faint median ridge; stout, undivided hinge plate supported by high median septum; stout cardinal process, circular cross section, comblike process posteriorly, which is bosslike anteriorly. *Middle Devonian (Givetian):* southern China (southern Guizhou).——FIG. 1335,*6a–d.* **G. pagodiformis; a–c,* posterior, anterior, and lateral views of holotype, GB451, ×1; *d,* close-up view of shell ornament, ×3 (Xian & Jiang, 1978).

CRYPTONELLOIDEA

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[Nanjing Institute of Geology and Paleontology; and University of Otago]

Superfamily CRYPTONELLOIDEA Thomson, 1926

[*nom. transl.* STEHLI, 1965, p. 762, *ex* Cryptonellinae THOMSON, 1926, p. 529]

Adult shells commonly small to medium in size; commonly ventribiconvex, elongate oval or subpentagonal in outline; smooth or plicate anteriorly; anterior margin rectimarginate, unisulcate, or sulciplicate; ventral foramen commonly permesothyrid or submesothyrid, often labiate; deltidial plates commonly conjunct; dental plates present or absent; hinge plate commonly undivided and perforate; median septum and crural plates rarely developed; adult loop variable, acuminate (centronelliform), deltiform (terebratuliform), diploform (cryptacanthiiform), or teloform (cryptonelliform). *Lower Devonian (Emsian)–Upper Triassic (Norian).*

Family CRANAENIDAE Cloud, 1942

[*nom. transl.* STEHLI, 1965, p. 754, *ex* Cranaeninae CLOUD, 1942, p. 131]

Shell moderately biconvex; ventral foramen commonly permesothyrid and labiate; pedicle collar present, loop short, deltiform (terebratuliform), undivided hinge plate extending between socket ridges without support from crural plates and typically perforate, but imperforate when plate apically sessile or median septum present. *Lower Devonian (Emsian)–Permian.*

Subfamily CRANAENINAE Cloud, 1942

[Cranaeninae CLOUD, 1942, p. 131]

Small to medium in size; commonly smooth, but may be peripherally costate; hinge plate extending as apically perforate plate between socket ridges free of valve floor, or as imperforate plate apically united with valve floor, dental plates commonly present; loop deltiform. *Lower Devonian (Emsian)–Permian (Wordian).*

Cranaena HALL & CLARKE, 1893, p. 297 [**Terebratula romingeri* HALL, 1863, p. 48; OD] [=*Eunella* HALL & CLARKE, 1893, p. 290 (type, *Terebratula sullivanti* HALL, 1867b, p. 387, OD); *Cranaenella* FENTON & FENTON, 1924, p. 129 (type, *Terebratula navicella* HALL, 1867b, p. 391, OD)]. Small to medium, smooth, subcircular to elongate; ventribiconvex; sulcus on ventral valve and corresponding fold on dorsal valve fold may be present; anterior commissure rectimarginate to slightly uniplicate; foramen permesothyrid; dental plates short; hinge plate free, perforate; muscle field well impressed; loop deltiform (terebratuliform). *Lower Devonian (Emsian)–Carboniferous (Upper Mississippian):* cosmopolitan (extra-Malvinokaffric Realm).——FIG. 1336,*1a–d.* **C. romingeri* (HALL), Devonian, Michigan, USA; dorsal, lateral, posterior, and anterior views, ×2 (Cloud, 1942).——FIG. 1336,*1e–f. C. lincklaeni* (HALL), New York, USA; *e,* ventral view of dorsal interior; *f,* ventral view of nearly complete loop, ×3 (Cloud, 1942).

Anomalesia COOPER & GRANT, 1976b, p. 2,818 [**A. perplexa* COOPER & GRANT, 1976b, p. 2,819; OD]. Medium size, subpentagonal, ventribiconvex; foramen telate, anterior commissure strongly sulciplicate; dental plates divergent; hinge plate gently concave; loop short and wide. *Permian (Guadalupian):* USA (western Texas).——FIG. 1336,*2a–c.* **A. perplexa,* Leonardian; *a–b,* dorsal and lateral views of holotype, USNM 153376, ×1, ×2; *c,* interior of dorsal valve, ×2 (Cooper & Grant, 1976b).

Asiacranaena KAPLUN & KRUPCHENKO, 1991, p. 142, *nom. transl.* JIN & LEE, herein, *ex Cranaena (Asiacranaena)* KAPLUN & KRUPCHENKO, 1991, p. 142 [**Cranaena (Asiacranaena) koldarensis;* OD]. Medium in size, biconvex, weakly uniplicate; hinge plate united with floor, free anteriorly, with low ridge ventrally. *Lower Devonian (Emsian):* central Kazakhstan.——FIG. 1336,*7a–b.* **C. koldarensis,* ventral valve and internal mold of dorsal valve, 55/12737, ×1 (Kaplun & Krupchenko, 1991).

Costacranaena JOHNSON & PERRY, 1976, p. 631 [**C. marlenae;* OD]. Medium size; smooth posteriorly but costate peripherally; rectimarginate, crenulate; elongate; ventribiconvex; dental plates prominent, vertical; hinge plate perforate; muscle field well impressed; loop deltiform with extended anterior portion. *Middle Devonian (Eifelian):* Arctic Canada.——FIG. 1336,*9a–f.* **C. marlenae; a–d,* dorsal, ventral, lateral, and anterior views of holotype, GSC 42743, ×2; *e,* ventrioblique view of rubber replica of dental lamellae and cardinalia, ×2; *f,* reconstruction of loop, ×2 (Johnson & Perry, 1976).

Hamburgia WELLER, 1911, p. 445 [**H. typa;* M] [=*Stuartella* BELANSKI, 1928, p. 24 (type, *S. vera,*

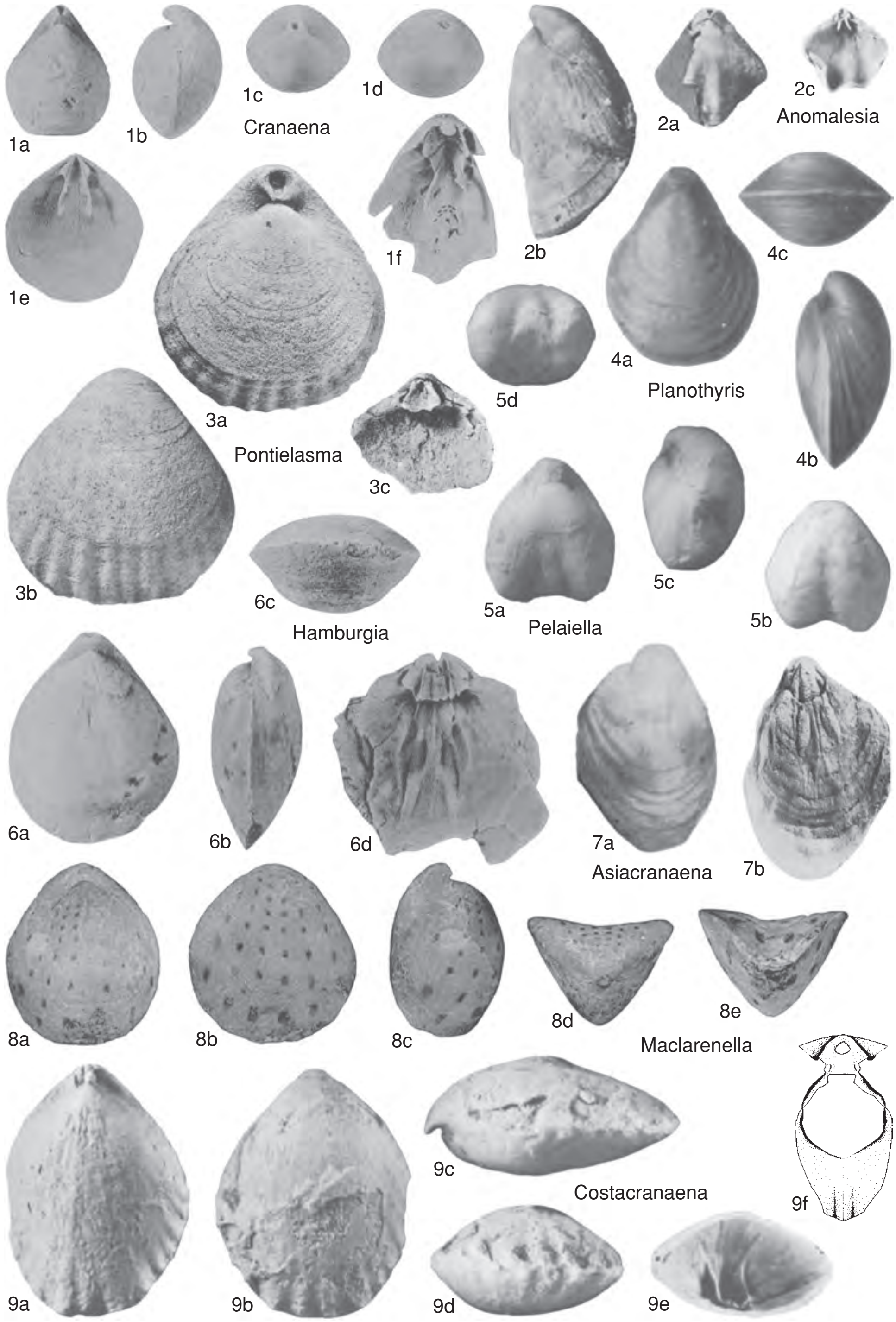

FIG. 1336. Cranaenidae (p. 2019–2021).

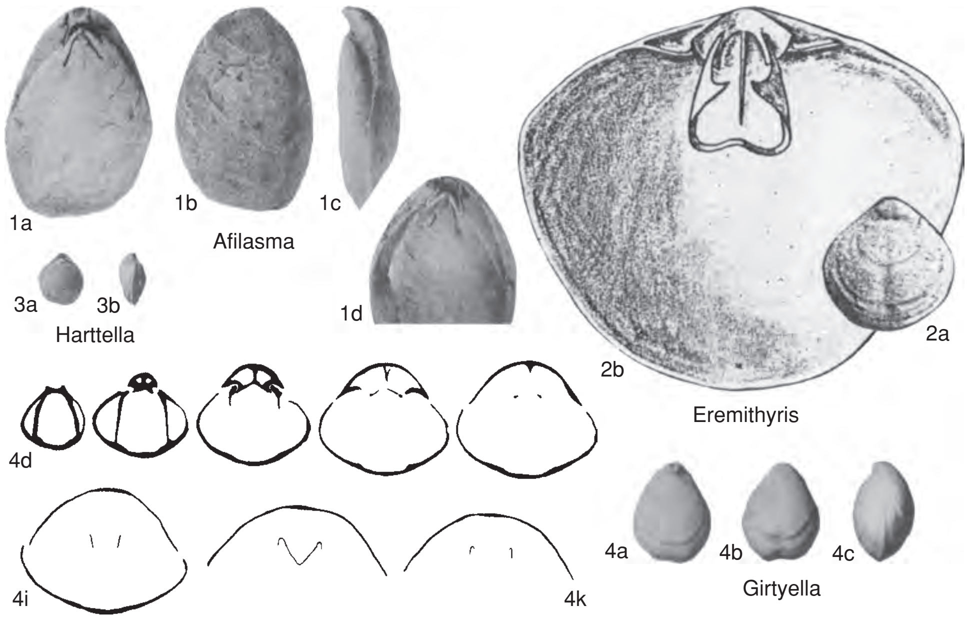

FIG. 1337. Cranaenidae (p. 2021–2022).

OD)]. Externally homeomorphous with *Cranaena,* internally similar to *Cranaena* except for apically sessile and imperforate hinge plate. *Upper Devonian–Carboniferous (Mississippian):* USA.——FIG. 1336,*6a–c.* **H. typa,* Upper Devonian, Illinois; dorsal, lateral, and anterior views, ×2 (Cloud, 1942).——FIG. 1336,*6d. H.* sp., Iowa; posterior of dorsal valve interior, ×2 (Cloud, 1942).

Maclarenella STEHLI, 1955, p. 868 [**M. maculosa;* OD]. Medium size; subcircular to oval; smooth, with color markings preserved as radial rows of spots; dorsal valve triangular in cross section; ventral valve transversely concave; anterior commissure strongly uniplicate; dental plates strong; hinge plate free and perforate. *Upper Devonian (Frasnian):* Canada.——FIG. 1336,*8a–e.* **M. maculosa,* Athabaska River, Alberta; dorsal, ventral, lateral, posterior, and anterior views, ×1 (Stehli, 1955).

Pelaiella MARTÍNEZ-CHACÓN, 1991, p. 84 [**P. exigua;* OD]. Small, subpentagonal; both valves sulcate, anterior commissure biplicate; no dental plates; hinge plate imperforate; fulcral plates broad; socket ridges high; loop deltiform, transverse band narrow. *Carboniferous (upper Moscovian):* Spain.——FIG. 1336,*5a–d.* **P. exigua;* dorsal, ventral, lateral, and anterior views of holotype, DPO 112770, ×3 (Martínez-Chacón, 1991).

Planothyris GLUSHENKO, 1975, p. 107 [**P. idonea;* OD]. Medium size, smooth, biconvex, oval; anterior commissure rectimarginate; dental plates and pedicle collar present; hinge plate imperforate; loop deltiform with long vertical plate. *Permian (Asselian):* Ukraine (Peri-Donets Depression).——FIG. 1336,*4a–c.* **P. idonea;* dorsal, lateral, and anterior views, ×3 (Glushenko, 1975).

Pontielasma WATERHOUSE & PIYASIN, 1970, p. 163 [**P. praeundatum;* OD]. Medium size, smooth; ventral sulcus shallow; anterior commissure uniplicate; costate anteriorly; foramen epithyrid; hinge plate supported by fulcral plates, imperforate and raised high above commissure plane. *Permian (Wordian):* Thailand.——FIG. 1336,*3a–c.* **P. praeundatum; a–b,* dorsal and ventral views of holotype, ROM B513, ×2; *c,* internal view of incomplete dorsal valve, ×2 (Waterhouse & Piyasin, 1970).

Subfamily AFILASMATINAE new subfamily

[Afilasmatinae JIN, herein] [type genus, *Afilasma* STEHLI, 1961b, p. 460]

Smooth, with divided or undivided, inner hinge plate; pedicle collar and dental plates present. *Upper Devonian (Frasnian).*

Afilasma STEHLI, 1961b, p. 460 [**A. beecheri;* OD]. Medium size; externally homeomorphous with *Cranaena;* unfolded, cardinal plate apically perforate, extending free of valve floor between crural plates; loop not known, probably deltiform. [This genus is based on 2 specimens, both internal molds.] *Upper Devonian (Frasnian):* USA (New York).——FIG. 1337,*1a–d.* **A. beecheri; a–c,* dorsal, ventral, and lateral views of holotype, YPM S-1420; *d,* latex impression of dorsal view of holotype, ×1 (Stehli, 1961b).

Subfamily GIRTYELLINAE Stehli, 1965

[Girtyellinae Stehli, 1965, p. 755]

Very small to medium in size; smooth; with or without dental plates; imperforate hinge plate supported by median septum; loop deltiform (terebratuliform). *Carboniferous (Mississippian)–Permian (Lopingian).*

Girtyella Weller, 1911, p. 442 [**Harttina indianensis* Girty, 1909, p. 293; OD]. Small to medium size; anterior commissure rectimarginate or modified by rounded plications; dental plates present. *Carboniferous (Mississippian):* North America, Europe, Australia.——Fig. 1337,*4a–k*. **G. indianensis* (Girty); *a–c,* dorsal, ventral, and lateral views, Mississippi Valley, USA, ×1 (Weller, 1914); *d–k,* serial transverse sections 0.25, 1.25, 1.75, 2.25, 2.50, 3.25, 4.25, 4.75 mm from initial section, Pella Beds, Iowa, ×2 (Campbell, 1965).

Eremithyris Bruegge, 1973, p. 197 [**E. muhlbergensis* Bruegge, 1973, p. 199; OD]. Broadly subpentagonal, greatest width at midlength; anterior commissure rectimarginate to uniplicate; beak erect; foramen mesothyrid; palintrope relatively wide; inner hinge plates supported by median septum forming septalium in apical region; crural bases arising from ventral side of hinge plate; dental plates present. *Permian (Lopingian):* Germany (Zechstein).——Fig. 1337,*2a–b*. **E. muhlbergensis; a,* dorsal view; *b,* interior of dorsal valve, ×2 (Bruegge, 1973).

Harttella Bell, 1929, p. 149 [**H. parva;* OD]. Very small, similar to *Girtyella* except in being folded and lacking dental plates. *Carboniferous (Upper Mississippian):* North America.——Fig. 1337,*3a–b*. **H. parva,* Nova Scotia; dorsal and lateral views of holotype, NMC7498, ×1 (Bell, 1929).

Family NOTOTHYRIDIDAE Licharew, 1960

[*nom. transl. et correct.* Stehli, 1965, p. 758, *ex* Notothyrinae Licharew in Licharew, Makridin, & Rzhonsnitskaya, 1960, p. 288]

Commonly small, smooth or anteriorly plicate; ventral foramen permesothyrid and labiate; ventribiconvex; anterior commissure rectimarginate to unisulcate; perforate hinge plate unsupported between inner socket ridges; loop acuminate (centronelliform) with vertical median plate and various supplemental lamellae in advanced forms; dental plates commonly absent. *Carboniferous (Bashkirian)–Permian (Changhsingian).*

Notothyris Waagen, 1882, p. 336 [375] [**Terebratula subvesicularis* Davidson, 1862, p. 27; SD Hall & Clarke, 1893, p. 275]. Small to medium size, anteriorly plicate; anterior commissure rectimarginate to slightly unisulcate; adult shells commonly with abruptly bent anteriors and broadly truncated anterior margin; hinge plate apically perforate; loop with broad descending lamellae, incipient median vertical plate. *Permian (Wordian–Changhsingian):* USA (Texas), Italy, Pakistan, southern China, Thailand.——Fig. 1338,*4a–c*. **N. subvesicularis* (Davidson), Salt Range, Pakistan; dorsal, lateral, and anterior views, approximately ×1.5 (Waagen, 1882).——Fig. 1338,*4d*. *N.* sp., Salt Range, Pakistan; interior of dorsal valve, ×2 (Cooper & Grant, 1976b).

Alwynia Stehli, 1961b, p. 464 [**Dielasma vesiculare* de Koninck, 1887, p. 30; OD]. Small, subpentagonal, ventral valve convex, dorsal valve planar; anterior commissure biplicate; loop deltiform but modified by close approach of main bands anteriorly and small transverse band. *Carboniferous (Visean):* Belgium, England.——Fig. 1338,*2a–f*. **A. vesiculare* (de Koninck), Isle of Man, England; *a–e,* dorsal, ventral, lateral, posterior, and anterior, ×1.5; *f,* reconstruction of loop, ×2 (Stehli, 1961b).

Chondronia Cooper & Grant, 1976b, p. 2,854 [**C. bella;* OD]. Small, elongate oval, rectimarginate to paraplicate; foramen strongly labiate, deltidial plates concealed; smooth or faintly costate near anterior commissure; loop consisting of two broad, descending lamellae, no median fold or plate. *Permian (Guadalupian):* USA (Texas).——Fig. 1338,*7a–d*. **C. bella,* Leonardian, Roadian; *a–c,* dorsal, lateral, and anterior views of holotype, USNM 153385a, ×4; *d,* interior of dorsal valve showing partly encrusted loop, ×8 (Cooper & Grant, 1976b).

Enallosia Cooper & Grant, 1976b, p. 2,859 [**E. rotundovata;* OD]. Small to medium size, oval, smooth; lateral and anterior commissures straight, pedicle collar strong; dental plates erect, stout; hinge plate imperforate; loop long with incomplete anterior end. *Permian (Guadalupian):* USA (Texas).——Fig. 1338,*6a–d*. **E. rotundovata,* Leonardian, holotype; *a–c,* dorsal, lateral, and anterior views, USNM 155136a, ×1; *d,* ventral view of incomplete loop, ×1.5 (Cooper & Grant, 1976b).

Gefonia Licharew, 1936, p. 264 [**G. cubanica;* OD]. Small, subpentagonal; anterior commissure biplicate; loop acuminate, but modified by union of main bands through transverse band anterior to midlength and their subsequent separation with rise of diverging, recurving bands that end without uniting. *Permian (Lopingian):* North Caucasus. ——Fig. 1338,*9a–d*. **G. cubanica; a–c,* dorsal, ventral, and lateral views, ×1.5 (Licharew, Makridin, & Rzhonsnitskaya, 1960); *d,* reconstruction of loop, approximately ×6 (Dagys, 1972b).

Ligatella Martínez-Chacón, 1978b, p. 29 [**Notothyris (Ligatella) sarytchevae* Martínez-Chacón, 1978b, p. 29; OD]. Small, subpentagonal; anterior commissure rectimarginate, bent slightly dorsally or ventrally; both valves with median sinus bounded by strong plicae; internal characters as for *Notothyris. Carboniferous (Bashkirian):*

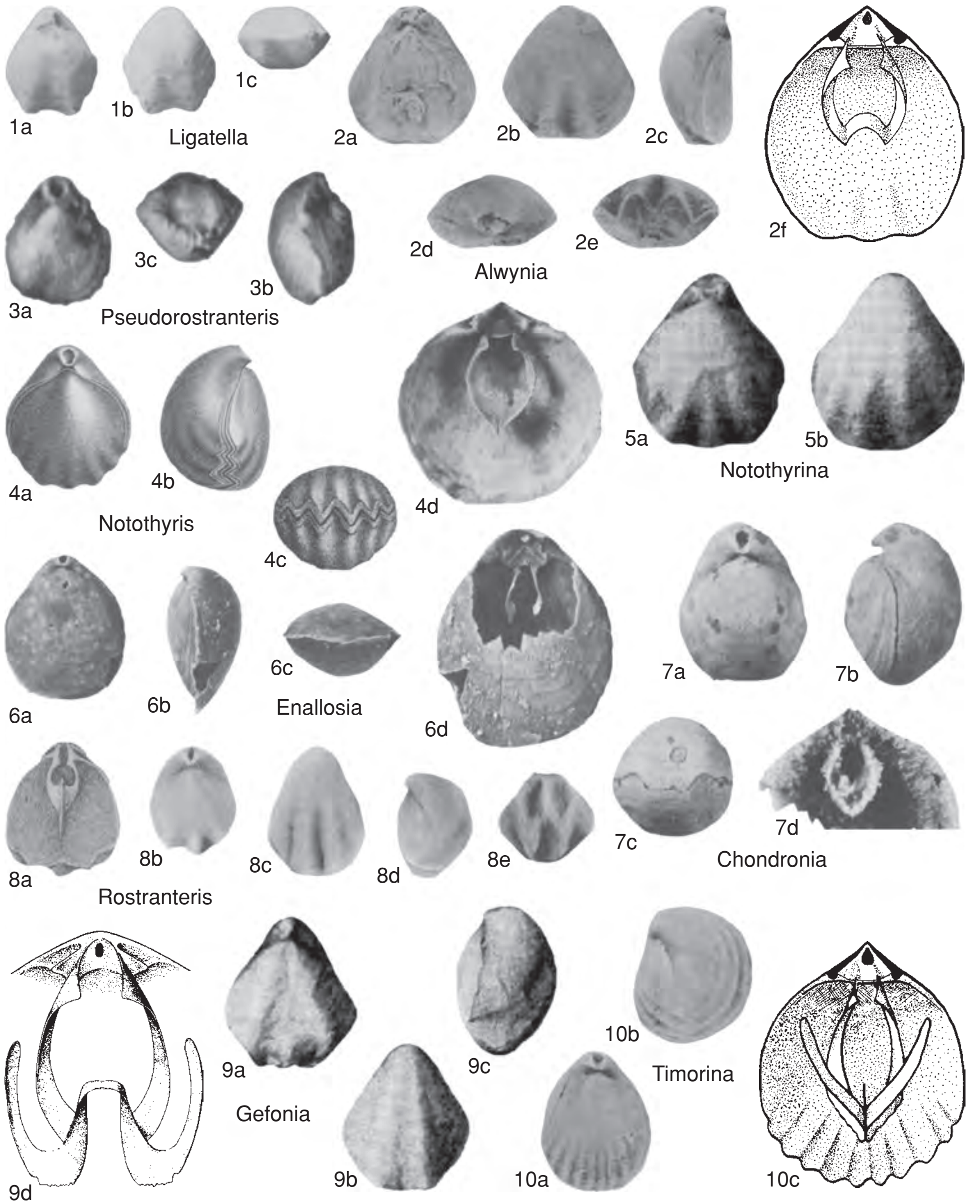

FIG. 1338. Notothyrididae (p. 2022–2024).

Spain.——FIG. 1338,*1a–c.* **N. sarytchevae;* dorsal, ventral, and anterior views of holotype, DOP13438, ×3 (Martínez-Chacón, 1978b).

Notothyrina LICHAREW, 1936, p. 271, *nom. transl.* JIN & LEE, herein, *ex Notothyris (Notothyrina)* LICHAREW, 1936, p. 271 [**Notothyris (Notothyrina) pontica;* OD]. Very small, ventral valve with two strong folds each bordered by weak lateral folds; internal structures identical to *Notothyris* except for loop thickened by secondary shell material. *Permian (Lopingian):* North Caucasus (Nikitin Formation).——FIG. 1338,*5a–b.* **N. pontica;* dorsal and ventral views, ×3 (Licharew, Makridin, & Rzhonsnitskaya, 1960).

Pseudorostranteris GLUSHENKO, 1975, p. 114 [**P. schebelinkaensis;* OD]. Subpentagonal, ventral valve strongly arched with flat slopes; anterior commissure uniplicate; pedicle collar well developed; outer hinge plates thick, inner hinge plates divided, recurved ventrally; loop acuminate with high median plate. *Permian (Asselian):* Ukraine (Slavinsk Formation).——FIG. 1338,*3a–c.* **P. schebelinkaensis;* dorsal, lateral, and anterior views, ×3 (Glushenko, 1975).

Rostranteris GEMMELLARO, 1899, p. 104 [**Dielasma adrianense* GEMMELLARO, 1894, p. 5; OD]. Small to medium size, anterior commissure commonly plicosulcate, rarely unisulcate; loop acuminate with high median plate extending anteriorly and posteriorly beyond union of main bands. *Permian (Guadalupian):* North America, Europe, Asia.——FIG. 1338,*8a.* **R. adrianense* (GEMMELLARO), Sicily; dorsal interior, ×2 (Stehli, 1962).——FIG. 1338,*8b–e. R. inflatum* GEMMELLARO, Sicily; dorsal, ventral, lateral, and anterior views, ×1.5 (Stehli, 1962).

Timorina STEHLI, 1961b, p. 465 [**Notothyris minuta* BROILI, 1916, p. 69; OD; *non* WAAGEN, 1882; =*Timorina broili* STEHLI, 1961b, p. 465]. Small, externally similar to *Notothyris* but with 2, 3, or more median plications on ventral valve raised into slight fold; loop acuminate, but with a median vertical plate modified by diverging, recurved bands that end without uniting. *Permian (Capitanian–Changhsingian):* Timor, Pakistan; USA (Texas), *Capitanian.*——FIG. 1338,*10a–c.* **T. broili,* Capitanian, Timor; *a–b,* dorsal and lateral views, ×2; *c,* reconstruction of loop, ×1 (Stehli, 1961b).

Family LABAIIDAE Licharew, 1960

[*nom. correct.* STEHLI, 1965, p. 755, *pro* Labaidae LICHAREW in LICHAREW, MAKRIDIN, & RZHONSNITSKAYA, 1960, p. 293]

Small, smooth, commonly folded anteriorly; dental plates absent; loop modified acuminate with supplemental lamellae; hinge plate perforate; may be obscured by secondary shell thickening; crura arising from margins of socket ridges. *Permian (Lopingian).*

Labaia LICHAREW, 1956, p. 65 [**L. Muir-Woodae;* OD]. Elongate suboval to subrhomboidal, rectimarginate; outer hinge plate not developed; crural bases fused with socket ridges; loop acuminate with auxiliary bands developing from distal part of vertical plate. *Permian (Lopingian):* North Caucasus.——FIG. 1339,*2a–d.* **L. muirwoodae; a–c,* dorsal, ventral, and lateral views, ×2 (Licharew, 1960b); *d,* reconstruction of loop, ×2 (Dagys, 1969).

Family CRYPTONELLIDAE Thomson, 1926

[*nom. transl.* STEHLI, 1965, p. 762, *ex* Cryptonellinae THOMSON, 1926, p. 529]

Shell small to medium, smooth, rarely plicate anteriorly, foramen small, commonly mesothyrid or submesothyrid; beak ridges prominent, deltidial plates conjunct, dental plates present; pedicle collar present or absent; inner hinge plate commonly undivided, commonly perforate and generally unsupported by median septum; loop long, acuminate (centronelliform), diploform (cryptacanthiiform), or teloform (cryptonelliform). *upper Lower Devonian–Upper Triassic (Norian).*

Subfamily CRYPTONELLINAE Thomson 1926

[Cryptonellinae THOMSON, 1926, p. 529]

Small to medium, commonly smooth, biconvex or dorsibiconvex, anterior commissure rectimarginate, uniplicate or sulciplicate, foramen small, telate; pedicle collar commonly absent; loop narrow ribboned with distinct ascending and descending branches developed from acuminate (centronelliform) through diploform (cryptacanthiiform) to teloform (cryptonelliform) stage. *upper Lower Devonian–Permian.*

Cryptonella HALL, 1861, p. 101 [**Terebratula rectirostra* HALL, 1860, p. 88; SD HALL & CLARKE, 1894, p. 861]. Small to medium; subcircular to elongate; ventribiconvex; smooth or anteriorly faintly plicate; anterior commissure rectimarginate to sulciplicate; foramen submesothyrid; dental plates short to obsolescent; muscle field well impressed; free, perforate or imperforate hinge plate extending unsupported between socket plates; adult loop teloform (cryptonelliform). *upper Lower Devonian–Upper Devonian:* North America, South America, Europe, ?New Zealand.——FIG. 1340,*6a–c.* **C. rectirostra* (HALL), Middle Devonian, New York, USA; dorsal, lateral, and anterior views of lectotype, AMNH FI 25373, ×1 (new).——FIG. 1340,*6d. C. planirostra* (HALL), Middle Devonian, New York; ventral view of loop, ×2 (Cloud, 1942).

?Booralia CAMPBELL, 1961a, p. 449 [**B. ovata* CAMPBELL, 1961a, p. 450; OD]. Medium in size, ovate, anterior commissure rectimarginate or slightly unisulcate; foramen mesothyrid to submesothyrid; pedicle collar long, dorsally placed, attached to deltidial plates; hinge plates deeply concave and perforate; dental plates long; loop unknown. *Carboniferous (?Moscovian):* Australia (New South Wales).——FIG. 1340,*7.* **B. ovata;* dorsal view of latex cast, ×1 (Campbell, 1961a).

Dielasmella WELLER, 1911, p. 446 [**Eunella compressa* WELLER, 1906, p. 442; OD]. Small, subcircular to pentagonal, anterior commissure rectimarginate; foramen mesothyrid; deltidial plates disjunct; perforate hinge plate unsupported between socket

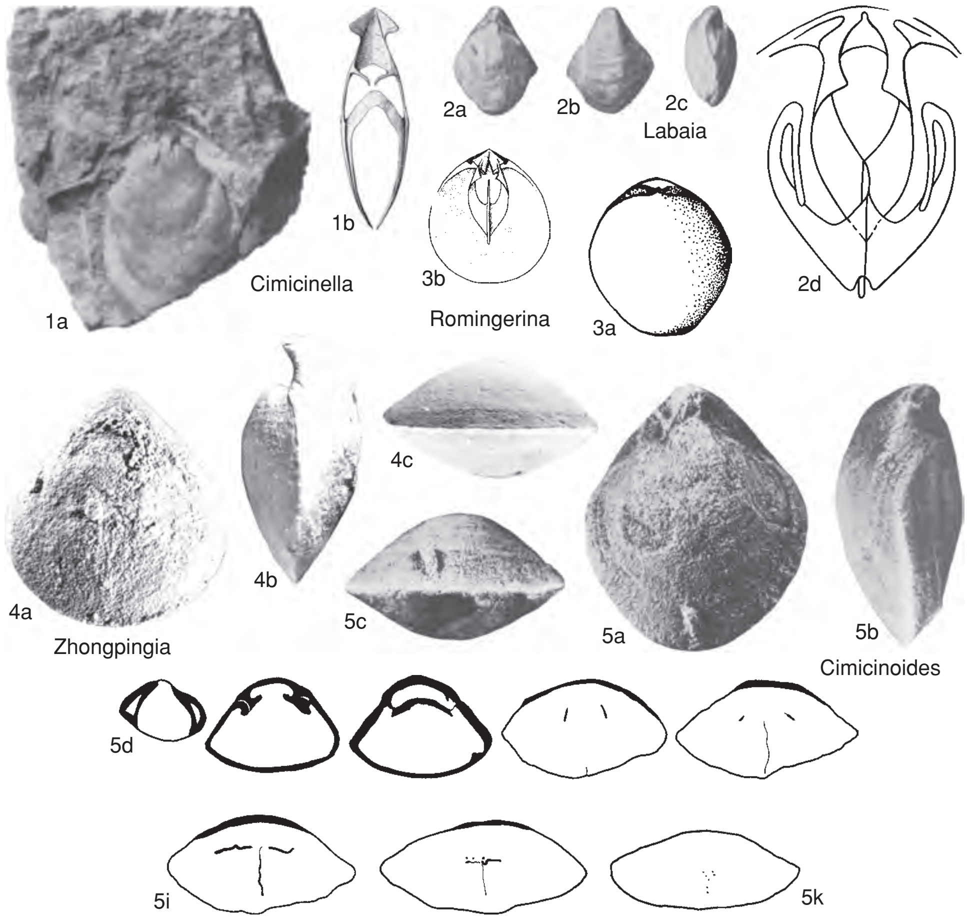

FIG. 1339. Labaiidae, Cimicinellidae, and Uncertain (p. 2024–2028).

plates; loop long, teloform. *Carboniferous (Mississippian):* USA.——FIG. 1340,*2a–c.* **D. compressa* (WELLER), Mississippi Valley; *a–b,* dorsal and ventral views, ×2; *c,* interior of transparent specimen infilled with clear calcite, ×1.5 (Weller, 1914).

Gacina STEHLI, 1961b, p. 458 [**G. moorefieldensis;* M]. Medium size, elongate or subpentagonal to elliptical, dorsal valve with distinct sulcus; hinge plate free, perforate; loop long, descending lamellae uniting near midlength with a vertical plate at front. *Carboniferous (Visean):* North America, Europe. ——FIG. 1340,*3a–e.* **G. moorefieldensis,* Meramecian, Oklahoma, USA; *a–d,* dorsal, ventral, lateral, and anterior views, ×1; *e,* reconstruction of loop, ×1 (Stehli, 1961b).

Heterelasma GIRTY, 1909, p. 337 [**H. shumardianum;* OD]. Small to medium, planoconvex to concavoconvex in profile, anterior commissure uniplicate to strongly sulciplicate; dental plates united on floor by callus, median ridge extending nearly to anterior margin; hinge plate generally imperforate and may be supported apically by short median septum. *Permian:* North America.——FIG. 1340,*1a–d.* **H. shumardianum,* Texas, USA; dorsal, ventral, lateral, and anterior views of holotype, USNM 118584, ×1 (Cooper & Grant, 1976b).——FIG. 1340,*1e–h. H. concavum* COOPER & GRANT, Texas, USA; *e–g,* dorsal, lateral, and anterior views of holotype, USNM 153396a, ×2; *h,* interior of dorsal valve, ×3 (Cooper & Grant, 1976b).

Petriathyris LEE & JIN, herein, p. 2,254, *nom. nov. pro Petria* MENDES, 1961b, p. 21, *non* SEMENOV, 1894 [**Waldheimia coutinhoana* DERBY, 1874, p. 3; OD]. Medium size, oval to subelliptical, beak strongly recurved, with sharp beak ridges, foramen submesothyrid, symphytium complete; anterior commissure rectimarginate, dental plates subparallel; hinge plate perforate, loop extending to front of shell, recurving lamellae broad, thin and long, with lamellar spines at its extremities; median septum very short. *Carboniferous (Pennsylvanian):* Brazil

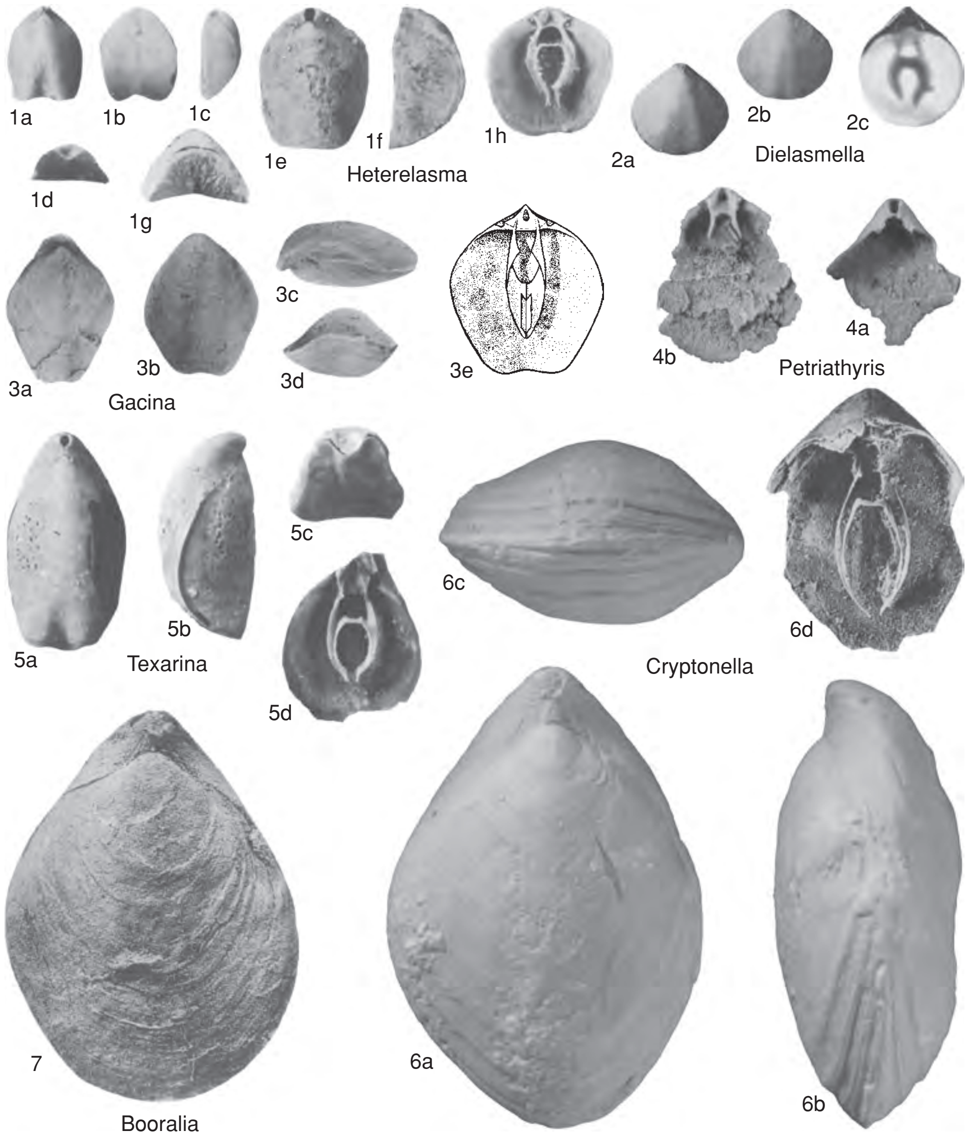

FIG. 1340. Cryptonellidae (p. 2024–2026).

(Para).——FIG. 1340,*4a–b*. **P. coutinhoana* (DERBY)*; a,* interior of ventral valve, ×3; *b,* interior of dorsal valve, USNM 249883, ×3 (new).

Texarina COOPER & GRANT, 1970, p. 579, *nom. nov. pro Texasia* COOPER & GRANT, 1969, p. 17, *non* REESIDE, 1932 [**Texasia oblongata* COOPER & GRANT, 1969, p. 17; OD]. Small, elongate, beak erect, foramen nonlabiate, symphytium completely exposed; anterior commissure sulciplicate; dental plates short; median ridge poorly developed in ventral valve; loop long with spinose anterior extremities, no median septum in dorsal valve. *Permian (Wordian):* USA (Texas), Venezuela, ?Europe.——FIG. 1340,*5a–c.* **T. oblongata* (COOPER & GRANT)*,* Texas, USA; *a–c,* dorsal, lateral, and anterior views of holotype, USNM 153415, ×1 (Cooper & Grant, 1976b).——FIG. 1340,*5d. T. elongata;* interior of dorsal valve, ×3 (Cooper & Grant, 1976b).

Subfamily CRYPTACANTHIINAE Stehli, 1965

[Cryptacanthiinae STEHLI, 1965, p. 752]

Commonly small, smooth, ventral valve convex, dorsal valve gently convex to concave, anterior commissure rectimarginate to unisulcate; beak erect, with sharp beak ridges; pedicle collar present; dental plates strong, hinge plates may be divided, may be perforate apically, and may be supported by small median septum; loop long, with broad-banded, hoodlike ascending lamellae and transverse ribbon developed from acuminate (centronelliform) stage through diploform (cryptacanthiiform) to teloform (cryptonelliform) stage. *Carboniferous (middle Pennsylvanian)–Upper Triassic (Norian).*

Cryptacanthia WHITE & ST. JOHN, 1867, p. 119 [**Waldheimia? compacta* WHITE & ST. JOHN, 1867, p. 119; OD]. Small, biconvex to concavoconvex, unisulcate; median septum usually absent or present apically, hinge plate concave to nearly flat, perforate; loop with hoodlike ascending lamellae and transverse band, descending lamellae becoming independent very late, anterior extremities of loop spinose. [No suitable illustrations of type are available.] *Carboniferous (middle Pennsylvanian)–Permian (Sakmarian):* North America, Europe, Asia.——FIG. 1341,*1a–g. C. prolifica* COOPER, upper Pennsylvanian, New Mexico; *a–d,* dorsal, ventral, lateral, and anterior views of holotype, USNM 127066, ×3; *e–g,* dorsal, ventral, and lateral views of loop, ×3 (Cooper, 1957a).

Anadyrella DAGYS, 1974, p. 185 [**A. infrequens;* OD]. Small, subpentagonal, unisulcate, dorsal valve slightly flattened; beak short, incurved, foramen mesothyrid; pedicle collar distinct, dental plates short, divergent; cardinal process low, crural plates joined to floor of dorsal valve; no septum or septalium; loop long, with narrow lamellae, anteriorly spinose. *Middle Triassic (Ladinian)–Upper Triassic (Norian):* Siberia.——FIG. 1341,*4a–d.* **A. infrequens,* Norian, northern Siberia; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* reconstruction of loop, ×2 (Dagys, 1974).

Anaptychius HOOVER, 1981, p. 106 [**A. minutus;* OD]. Small, suboval, smooth; moderately biconvex, anterior commissure rectimarginate; dental plates strong; outer hinge plates low, inner hinge plates conjunct with apical perforation; median septum absent; loop diploform (cryptacanthiiform). *Permian (Roadian–Wordian):* Venezuela.——FIG. 1341,*2a–d.* **A. minutus; a–c,* dorsal, lateral, and anterior views of holotype, USNM 221552, ×3; *d,* interior of dorsal valve, ×3 (Hoover, 1981).

Glossothyropsis GIRTY, 1934, p. 251 [**Cryptacanthia? robusta* GIRTY, 1934, p. 251; OD]. Small to medium size, outline subquadrate, planoconvex to slightly concavoconvex; anterior commissure strongly unisulcate; beak ridges telate, interarea distinct; dental plates strong; cardinalia complex, with broad outer hinge plate, inner hinge plates separate in early growth stages but grow medially to form undivided inner hinge plate in adult specimens; supported by strong median septum extending anteriorly to beyond midvalve; loop long, fringed laterally by long spines, ascending lamellae and transverse band forming a broad-ribboned ring. *Permian (?Cisuralian, Wordian, ?Lopingian):* USA, *Guadalupian;* Australia, *?Permian.*——FIG. 1341,*5a–d.* **G. robusta* (GIRTY), Capitanian, Delaware basin, western Texas, USA; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* interior of dorsal valve, ×3 (Cooper & Grant, 1976b).——FIG. 1341,*5e. G. rectangulata* COOPER & GRANT, Wordian, Glass Mountains, western Texas, USA; interior of dorsal valve, ×3 (Cooper & Grant, 1976b).

Obnixia HOOVER, 1979, p. 11 [**Terebratula thaynesiana* GIRTY, 1927, p. 435; OD]. Small, smooth, outline subtrigonal to subpentagonal; ventribiconvex, anterior commissure unisulcate, beak ridges strong, foramen small, mesothyrid, deltidial plates thin, conjunct; dental plates variable, pedicle collar short; outer hinge plates narrow; inner hinge plates absent; loop long, variably spinose. *Lower Triassic:* western United States.——FIG. 1341,*3a–d.* **O. thaynesiana* (GIRTY), California; *a–c,* dorsal, lateral, and anterior views, ×2; *d,* interior of dorsal valve, ×4 (Hoover, 1979).

Family CIMICINELLIDAE Stehli, 1965

[*nom. transl.* JIN & LEE, herein, *ex* Cimicinellinae STEHLI, 1965, p. 752]

Medium size, smooth, dental plates short; hinge plate perforate, loop teloform. *Lower Devonian (Emsian)–Middle Devonian (Eifelian).*

Cimicinella SCHMIDT, 1946, p. 67 [**Terebratula cimex* RICHTER & RICHTER, 1918, p. 156; OD]. Elongate; ventribiconvex; rectimarginate; crural plates present. *Lower Devonian (Emsian):* Germany.——FIG. 1339,*1a–b.* **C. cimex* (RICHTER & RICHTER); *a,* steinkern of dorsal valve, ×1; *b,* reconstruction of loop, ×1 (Schmidt, 1946).

?Cimicinoides ANDERSON, BOUCOT, & JOHNSON, 1969, p. 156 [**C. struvei;* OD]. Small; externally like *Cimicinella;* crural plates absent; acuminate loop with anterior attached to vertical plate; vertical plate and anterior band anteriorly spinose. *Middle Devonian (Eifelian):* Burma.——FIG. 1339,*5a–k.* **C. struvei; a–c,* dorsal, lateral, and anterior views of holotype, BMNH BB55586, ×4; *d–k,* serial

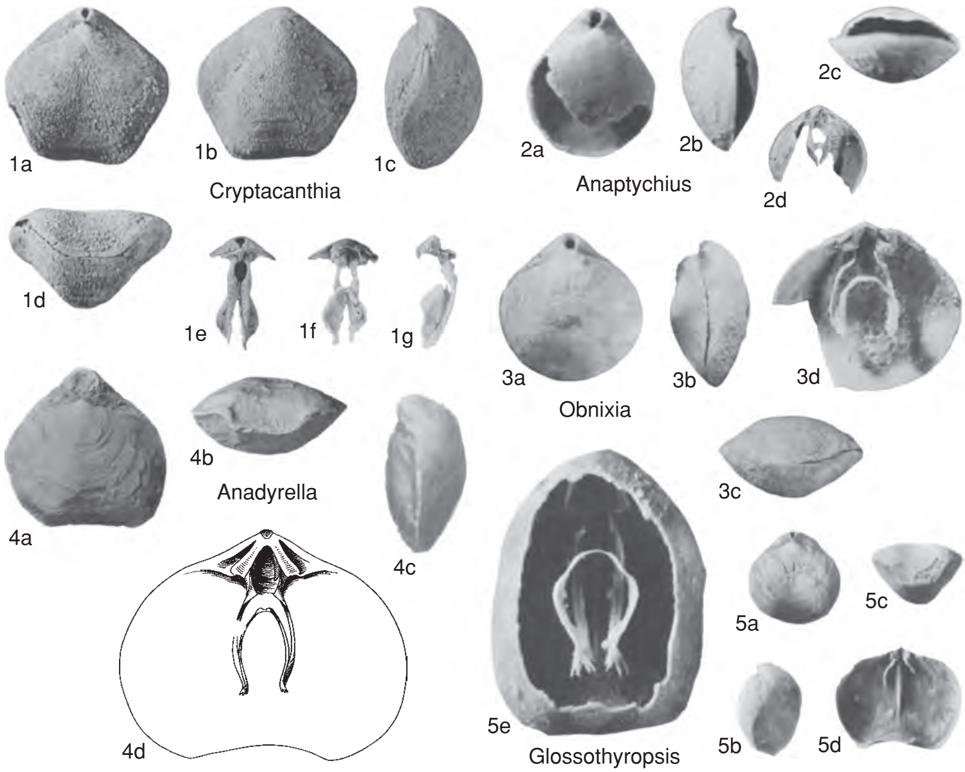

FIG. 1341. Cryptonellidae (p. 2027).

transverse sections 9.10, 8.45, 8.00, 6.69, 6.24, 5.94, 5.59, 4.99, ×4 (Anderson, Boucot, & Johnson, 1969).

Family UNCERTAIN

Romingerina HALL & CLARKE, 1893, p. 272 [**Centronella julia* WINCHELL, 1862, p. 405; OD] [=*Harttina* HALL & CLARKE, 1893, p. 292 (type, *Centronella anna* HARTT, 1868, p. 300–301, OD)]. Small, smooth, circular; ventribiconvex, ventral beak short, deltidial plates conjunct; foramen submesothyrid; small dental plates may be present; hinge plate sessile; apparently divided; crural plates seemingly absent; loop long, acuminate, with large vertical plate. *Carboniferous (Mississippian):* North America.——FIG. 1339,*3a–b*. **R. julia* (WINCHELL); *a,* composite figure, ×2; *b,* reconstruction of loop, ×2 (Stehli, 1965).

?Zhongpingia YANG, 1983, p. 35 [**Z. cimicinoidesiformis;* OD] [=*Xenocryptonella* ZHANG in ZHANG, FU, & DING, 1983, p. 148 (type, *X. intraplicata* ZHANG in ZHANG, FU, & DING, 1983, p. 424)]. Small, circular, deltidial plates present, no cardinal process; dental plates present, short crural plates and hinge plates, simple (possibly acuminate) loop. [Interior structures are imperfectly known.] *Middle Devonian (Givetian):* southern China.——FIG. 1339,*4a–c*. **Z. cimicinoidesiformis,* Jide Formation, Maanshan, Xiangzhou; holotype, ventral, lateral, and anterior views of conjoined shell, YI-IV 47297, ×5 (Yang, 1983).

DIELASMATOIDEA

JIN YU-GAN,[1] D. E. LEE,[2] SUN DONG-LI,[1] T. N. SMIRNOVA,[3] A. S. DAGYS,[4] and M. R. SANDY[5]

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Superfamily DIELASMATOIDEA Schuchert, 1913

[*nom. correct.* LEE & others, herein, *pro* Dielasmatacea STEHLI, 1965, p. 754, *nom. transl. ex* Dielasmatinae SCHUCHERT, 1913, p. 402]

Adult shells small to large; commonly biconvex, rarely planoconvex; elongate oval, subcircular, or subpentagonal in outline; commonly smooth, but may develop plicae in anterior part of shell; hinge line nonstrophic; dorsal foramen very rare; beak ridges angular or rounded; pedicle foramen commonly permesothyrid or mesothyrid, commonly medium in size and often labiate; anterior commissure highly variable, may be uniplicate, unisulcate, bisulcate, sulciplicate, or rectimarginate. Pedicle collar commonly present; teeth small, cyrtomatodont; dental plates present in some families; ventral valve without median septum. Cardinal process commonly small; median septum present or absent; outer hinge plates commonly narrow, weakly developed, may be fused with socket ridges; inner hinge plates may be absent, present and separate, or joined near union with valve floor, or to median ridge to form a septalium; crural plates may be present and joined with floor of valve, or enveloping septum to form septalium; loop normally short, acuminate (centronelliform) in juveniles to deltiform (terebratuliform) in adults, modified by fission and resorption of echmidium and insertion of transverse lamellae, or by more complex developmental stages; but in some taxa long, with descending and ascending lamellae; color banding may be present. *Upper Devonian (Frasnian)–Lower Jurassic.*

Family DIELASMATIDAE Schuchert, 1913

[*nom. transl.* SCHUCHERT & LEVENE, 1929a, p. 23, *ex* Dielasmatinae SCHUCHERT, 1913, p. 402]

Shell small to large; subrounded, elongate oval, or subpentagonal in outline; commonly biconvex; smooth to slightly plicate, anterior commissure variable, may be uniplicate, unisulcate, sulciplicate, or rectimarginate, may be geniculate; foramen commonly permesothyrid and labiate; pedicle collar present; cardinal process small, low; dental plates usually present; outer hinge plates variable, joined to socket ridges or directly to valve wall; inner hinge plates converging on valve floor, or uniting to form a septalium or forming entire plate, raised above valve floor; juvenile loop acuminate, adult loop commonly short (0.3 to 0.5 dorsal valve length), deltiform; transverse band developed through resorption of echmidium. *Carboniferous (Mississippian)–Upper Triassic, ?Lower Jurassic.*

Subfamily DIELASMATINAE Schuchert, 1913

[Dielasmatinae SCHUCHERT, 1913, p. 402]

Dental plates present; pedicle collar complete; inner hinge plates meeting on valve floor or septum. *Carboniferous (Mississippian)–Upper Triassic.*

Dielasma KING, 1859, p. 256 [**Terebratulites elongatus* SCHLOTHEIM, 1816, p. 27; OD] [=*Dielasmoides* WELLER, 1911, p. 443 (type, *D. binsinuata* WELLER, 1911, p. 444, OD)]. Small to large, smooth, elongate oval to subpentagonal in outline, generally dorsibiconvex, narrowly domed to keeled, and ventral valve flatly convex to medially concave; anterior commissure uniplicate to sulciplicate; beak ridges rounded; foramen permesothyrid, small to large, often labiate, symphytium often hidden; pedicle collar short; fulcral plates strong, outer hinge plates vary from absent to fairly broad; inner hinge plates separate or joined near union with valve floor or to a median ridge; juvenile loop acuminate; adult loop developed by fission and resorption of echmidium and insertion of transverse band; loop 0.4 to 0.5 dorsal valve length, transverse band narrow, strongly folded medially. *Carboniferous (Upper Mississippian)–Permian:* cosmopolitan.——FIG. 1342,*1a–d.* **D. elongatum* (SCHLOTHEIM), upper Permian, Pössneck, Thuringia, Germany; *a–c,* dorsal, lateral, and anterior views of neotype, USNM 124226, ×1; *d,* calcite encrusted loop, ×1 (Stehli, 1956a).——FIG. 1342,*1e–g. D. zebratum* COOPER & GRANT, Permian, western Texas, USA; *e,* dorsal view of holotype, USNM 1533426, ×1; *f–g,* juvenile and adult loops, respectively, ×2 (Cooper & Grant, 1976b).

Adygella DAGYS, 1959a, p. 25 [**A. cubanica;* OD]. Small to medium, rounded to pentagonal in outline, biconvex with incipiently uniplicate, anterior commissure; beak short, incurved, beak ridges rounded, foramen small, permesothyrid; dental plates short, diverging; no cardinal process; outer hinge plates horizontal, crural bases distinct, directed ventrally; septalium deep, supported by thin, short septum; loop short (less than 0.3 dorsal valve length), transverse band low, slightly arched. *Upper Triassic:* Alps, Carpathians, northwestern Caucasus, China.——FIG. 1342,*5a–n.* **A. cubanica,* Norian, northwestern Caucasus; *a–c,* dorsal, lateral, and anterior views of holotype, ×1; *d–m,* transverse serial sections 0.4, 1.7, 1.8, 2.2, 2.7, 3.0, 3.6, 4.2, 4.5, 5.8 mm from ventral umbo, ×1; *n,* reconstruction of loop, ×2 (Dagys, 1974; courtesy of the late A. S. Dagys).

Amygdalocosta WATERHOUSE, 1967, p. 101 [**A. rara;* OD]. Medium size, almond shaped, differs from *Dielasma* in possessing dorsal sulcus and anterior costae; dental plates short, subparallel; hinge plates uniting on valve floor; crura and loop unknown. *Permian (Guadalupian–Lopingian):* New Zealand. ——FIG. 1342,*3a–b.* **A. rara; a,* ventral internal mold, ×2.5; *b,* dorsal internal mold of holotype, BR 844, ×2.5 (Waterhouse, 1967).

Aspidothyris DIENER, 1908, p. 58 [**A. kraffti;* OD]. Small, biconvex, anterior commissure rectimarginate or incipiently uniplicate, beak incurved; dental plates strong, septum and crural plates developed; loop acuminate, about 0.5 dorsal valve length, with long, vertical plate extending dorsally and possibly ventrally. [Genus may be based on immature specimens.] *Upper Triassic (Carnian):* Himalayas.——FIG. 1342,*2a–d.* **A. kraffti; a–c,* dorsal, lateral, and anterior views; *d,* reconstructed loop, ×1 (Muir-Wood, 1965a).

Coenothyris DOUVILLÉ, 1879, p. 270 [**Terebratulites vulgaris* SCHLOTHEIM, 1820, p. 275; OD] [=*Praerhaetina* UROSEVIC, 1988, p. 351 (type, *P. radulovici,* OD)]. Medium to large, elongate oval to subpentagonal in outline; biconvex, usually with prominent dorsal fold, anterior commissure uniplicate or rarely bisulcate, beak suberect or incurved, beak ridges angular, foramen permesothyrid; radiating color banding often present; pedicle collar present, dental plates short, may be fused with thickened shell wall; cardinal process broad, concave; outer hinge plates subhorizontal in section; median septum high, about 0.3 dorsal valve length, septalium present; adult loop deltiform with long crural processes, 0.3 dorsal valve length, transverse band fragile, rarely preserved. *Middle Triassic–Upper Triassic:* Europe, Afghanistan, Himalayas, China, *Middle Triassic;* Yugoslavia, Bulgaria, Israel, *Upper Triassic.*——FIG. 1342,*4a–o.* **C. vulgaris* (SCHLOTHEIM), Muschelkalk; *a–c,* dorsal, lateral, and anterior views of topotype from Schlotheim's original collection, Germany, ×1 (new; courtesy of the late A. S. Dagys); *d,* dorsal valve with characteristic color banding, Lagoubran, France, ×1; *e–o,* transverse serial sections 1.2, 3.9, 4.8, 5.4, 7.0, 7.4, 7.7, 8.8, 10.8, 11.6, 16.0 mm from ventral umbo, Lagoubran, France, ×1 (Hagdorn & Sandy, 1998).

Cruratula BITTNER, 1890, p. 66 [**Waldheimia eudora* LAUBE, 1866, p. 8; OD]. Medium size, subtriangular or pear shaped, planoconvex, dorsal valve with broad sulcus; anterior commissure unisulcate to incipiently parasulcate; beak prominent, erect to incurved, beak ridges rounded, foramen permesothyrid; dorsal septum strong, about 0.5 shell length, septalium present; loop imperfectly known. *Middle Triassic (Ladinian)–Upper Triassic (Norian):* northern Alps, southern Alps, Dinarids, ?Asia.——FIG. 1343,*1a–d.* **C. eudora* (LAUBE), Carnian, southern Alps; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* incomplete loop, ×1 (Bittner, 1890).

Dareithyris SIBLÍK, 1991, p. 171 [**D. vulgaris;* OD]. Medium in size, biconvex with shallow sulcus on dorsal valve, beginning at cardinal margin; anterior commissure rectimarginate or slightly unisulcate, beak erect to incurved, beak ridges angular, foramen permesothyrid; dental plates short, subparallel, cardinal process short, undivided; outer hinge plates subhorizontal in section, crural bases distinct, directed ventrally; septalium shallow, dorsal septum long, about 0.5 valve length; loop with diverging, descending lamellae, about 0.5 dorsal valve length, transverse band unknown. *Middle Triassic (Anisian):* Iran.——FIG. 1343,*2a–o.* **D. vulgaris; a–c,* dorsal, lateral, and anterior views of holotype, GBA1982/8/10, ×1; *d–o,* transverse serial sections 1.2, 2.5, 3.9, 5.1, 5.4, 7.0, 7.2, 8.3, 9.1, 10.0, 10.6, 11.0 mm from ventral umbo, ×1 (Siblík, 1991).

Dielasmina WAAGEN, 1882, p. 335 [**D. plicata;* OD]. Medium to large, external homeomorph of *Hemiptychina,* dorsal valve geniculated sharply near midlength; dental plates and pedicle collar well developed; cardinal process shelflike; fulcral plates high, outer hinge plates very narrow; inner hinge plates converging medially from apex of valve to form a narrow septalium; median ridge extending from anterior end of septalium to midlength; crural

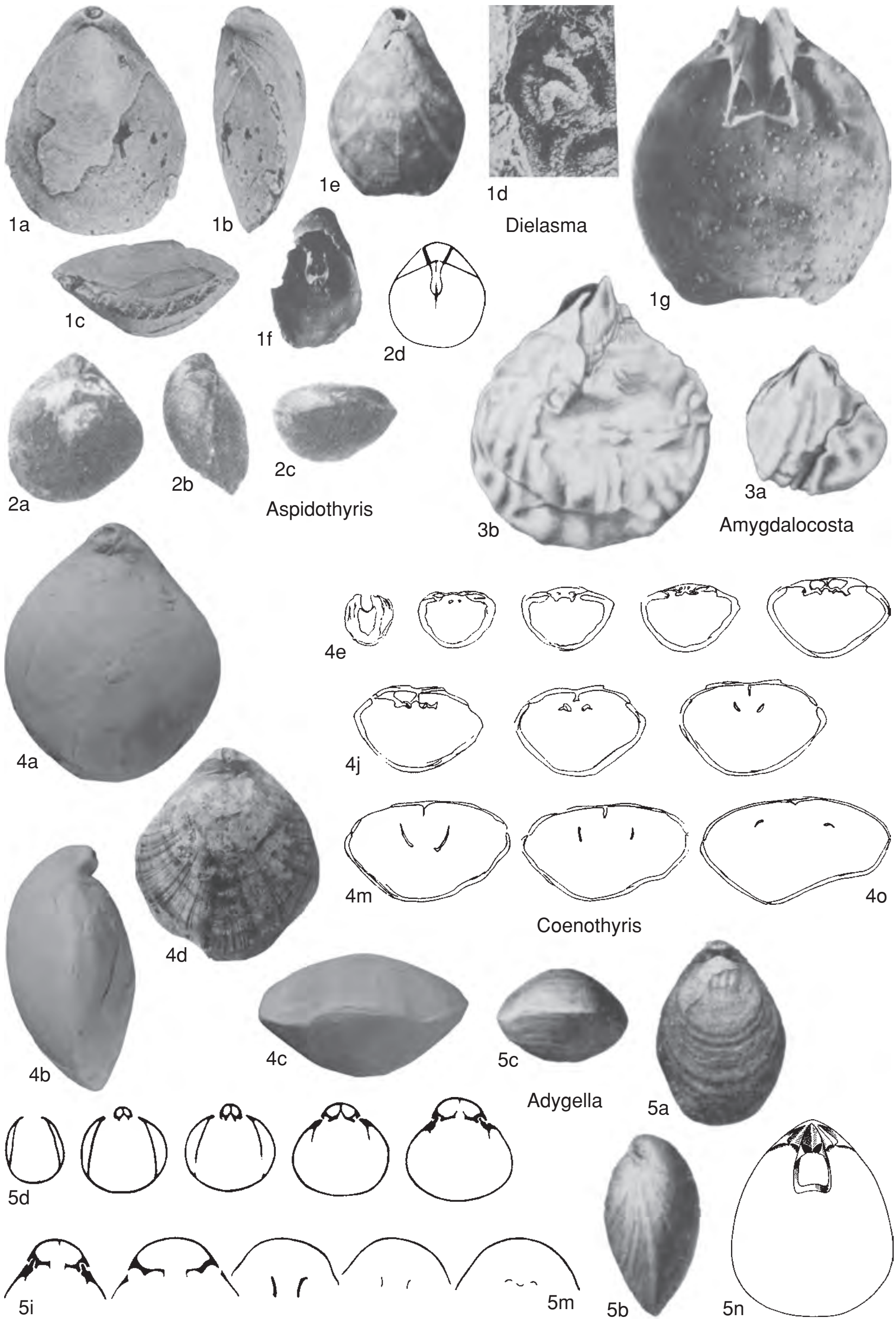

FIG. 1342. Dielasmatidae (p. 2029–2030).

processes low; descending lamellae of loop short and narrow, reaching valve midlength. *Permian (Capitanian, middle Lopingian):* Pakistan (Salt Range).——FIG. 1343,*4a–d.* **D. plicata,* Capitanian, Wuchiapingian; dorsal, ventral, lateral, and anterior views, ×1 (Waagen, 1882).——FIG. 1343,*4e. D.* sp.; interior of dorsal view with broken transverse band, USNM 489614, ×3 (new).

Dongbaella JIN & YE in JIN & others, 1979, p. 127 [**D. planata;* OD]. Small, biconvex, anterior commissure rectimarginate; foramen hypothyrid; dental plates thin, ending behind hinge line; inner socket ridges high, outer hinge plates narrow, converging toward valve floor, united with long, inner hinge plates; loop long, descending lamellae parallel, recurving lamellae arched ventrally and connected medially by small band. *Carboniferous (Visean):* China (Qinghai).——FIG. 1343,*5a–h.* **D. planata; a,* dorsal view, ×1; *b–h,* serial transverse sections 0.8, 2.2, 3.4, 4.8, 5.1, 5.4, 5.8 mm from ventral umbo, ×1 (Jin & others, 1979).

Ectoposia COOPER & GRANT, 1976b, p. 2,898 [**E. wildei;* OD]. Medium, thin shelled, elongate oval in outline, dorsibiconvex, anterior commissure broadly uniplicate, beak suberect, foramen labiate; dental plates erect; inner hinge plates well separated, uniting on valve floor; loop reaching 0.6 dorsal valve length, crura very short, crural processes long, descending lamellae connected with long, recurving band to form troughlike anterolateral branches, spinules on anterior extremities, transverse band broad. *Permian (Wordian):* USA (Texas).——FIG. 1343,*3a–c.* **E. wildei; a–b,* dorsal and lateral views of holotype, USNM 153446; *c,* interior view showing loop, ×1 (Cooper & Grant, 1976b).

Elasmata WATERHOUSE, 1982a, p. 349 [**E. retusus;* OD]. Large, elongate, anterior commissure slightly uniplicate; dental plates present; inner hinge plates uniting on valve floor, forming sessile septalium; low median ridge; crura rising from septalium. *Permian (Asselian):* Thailand.——FIG. 1343,*7.* **E. retusus;* dorsal internal mold of holotype, TBR 527, ×1 (Waterhouse, 1982a).

Fletcherithyris CAMPBELL, 1965, p. 24, *nom. nov. pro Fletcherina* STEHLI, 1961a, p. 452, *non* LANG, SMITH, & THOMAS, 1955, p. 261 [**Terebratula amygdala* DANA, 1847, p. 152; OD]. Small to medium size, folded or unfolded; when folded, dorsal valve with median sulcus flanked by folds; anterior commissure rectimarginate to sulciplicate; foramen labiate; dental plates and pedicle collar well developed; inner hinge plates uniting on floor of valve or joining to form a low median septum or septalium; loop deltiform but transverse band not preserved. *Permian (Sakmarian–Wordian):* Australia, New Zealand.——FIG. 1344,*1a–d.* **F. amygdala* (DANA), New South Wales; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* latex cast of internal mold, ×1 (Stehli, 1961a).——FIG. 1344,*1e. F. reidi;* reconstruction of dorsal valve interior, ×1 (Campbell, 1965).

?Paradygella LIAO & SUN, 1974, p. 352 [**P. magna;* OD]. Similar to *Adygella,* but larger with a thick pedicle collar, angular beak ridges, and a median ridge in septalium. [Serial transverse sections of type species are not available. Details of interior characters are needed to confirm the status of this genus.] *Middle Triassic (Ladinian):* China (Sichuan).

Pirithyris SUN & YE, 1982, p. 167 [172] [**P. pius;* OD]. Small, pear shaped, biconvex; beak ridges rounded, palintrope small, delthyrium with discrete deltidium, anterior commissure unisulcate; pedicle collar present; dental plates long, slightly inclined outwardly; hinge plates merged with inner socket ridges; septalium well developed, widely V-shaped; median septum high, stout, extending nearly to anterior margin; crural bases triangular, crural processes inconspicuous; loop short, consisting of only platelike, descending branches. Differs from *Praecubanothyris* in possessing dental plates and lacking transverse band in loop. *Middle Triassic (Anisian):* China (Qinghai).——FIG. 1344,*2a–c.* **P. pius;* dorsal, lateral, and anterior views, ×1 (Sun & Ye, 1982).

Plectelasma COOPER & GRANT, 1969, p. 16 [**P. kingi* COOPER & GRANT, 1969, p. 17; OD]. Medium size, elongate oval; anterior margin parasulcate, surface semicostate; foramen strongly labiate, permesothyrid; dental plates strong, cardinal process thick, inner hinge plates uniting on valve floor. *Permian (Guadalupian):* USA (Texas).——FIG. 1343,*6a–e.* **P. kingi; a–d,* dorsal, ventral, lateral, and anterior views of holotype, USNM 153355a, ×2; *e,* interior of dorsal valve, ×2 (Cooper & Grant, 1976b).

Sulcatinella DAGYS, 1974, p. 177 [**S. sulcata;* OD]. Small, planoconvex with flattened dorsal valve bearing broad sulcus; anterior commissure unisulcate; beak with sharp ridges, foramen small, mesothyrid; pedicle collar short, dental plates divergent. Cardinal process low but distinct; outer hinge plate horizontal in section, connected with septum by crural plates to form a septalium; loop about 0.5 dorsal valve length, with high, arcuate transverse band that is spinose anteriorly. *Middle Triassic (Anisian):* Balkans, Crimea, northwestern Caucasus.——FIG. 1345,*3a–aa.* **S. sulcata,* northwestern Caucasus; *a–c,* dorsal, lateral, and anterior views, ×2; *d,* reconstructed loop, ×2 (Dagys, 1974; courtesy of the late A. S. Dagys); *e–aa,* serial tranverse sections 0.0, 0.2, 0.3, 0.4, 0.6, 0.7, 0.9, 1.1, 1.3, 1.4, 1.5, 1.7, 1.9, 2.1, 2.3, 2.5, 2.8, 3.0, 3.4, 3.8, 4.1, 4.2, 4.4 mm from first section, ×2 (adapted from Dagys, 1974; courtesy of the late A. S. Dagys).

Tibetothyris CHING, SUN, & RONG, 1976, p. 327 [**T. depressa;* OD]. Medium size, roundly pentagonal, biconvex; anterior commissure sulciplicate to bisulcate; beak short, erect; beak ridges rounded; delthyrium open or covered by deltidial plates; foramen circular, permesothyrid; pedicle collar present; dental plates long, slightly divergent; teeth thin; cardinal process short, flattened, with fine, longitudinal grooves; inner socket ridges high, fused with short, dorsally inclined, outer hinge plates; crural plates converging on valve floor, forming

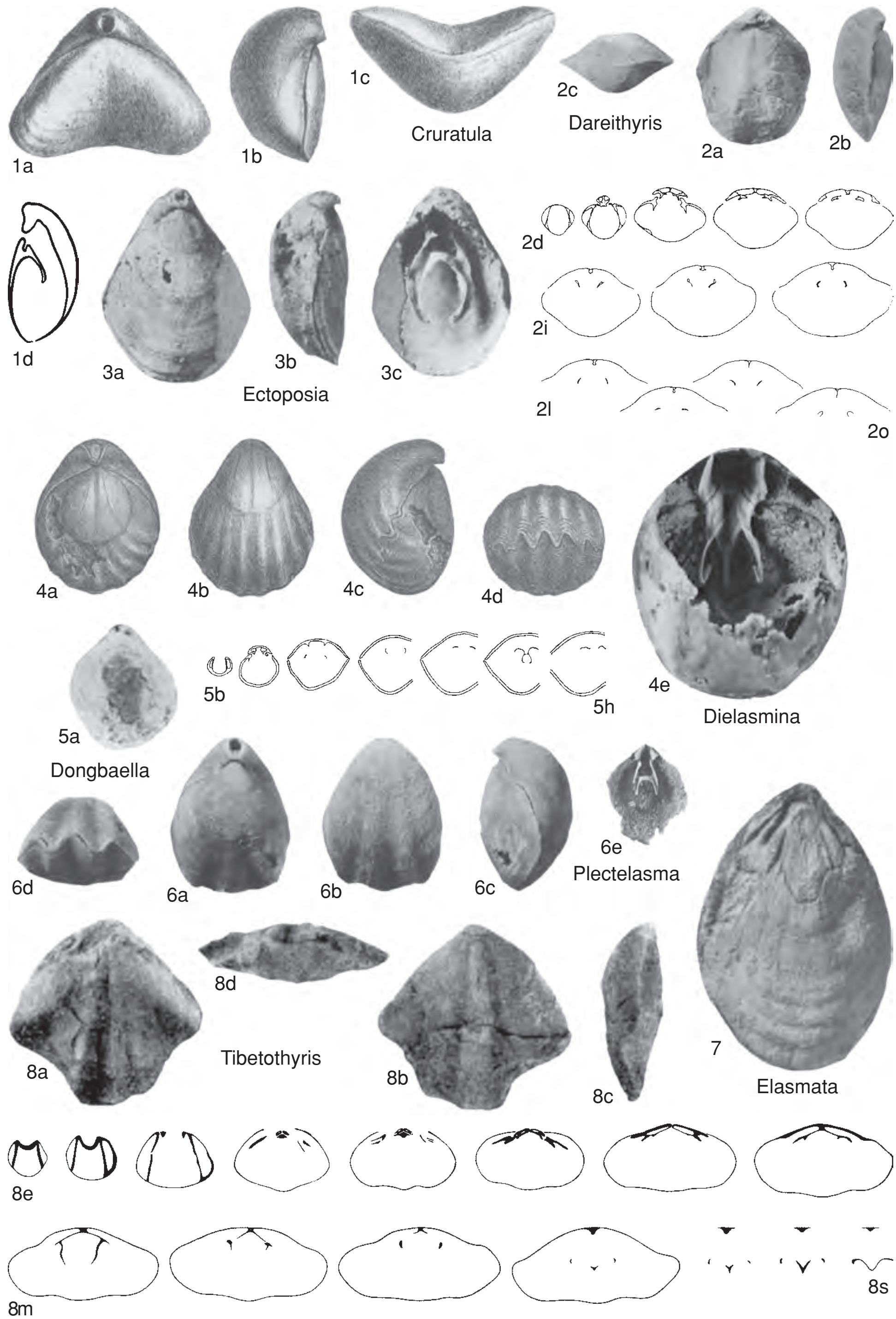

FIG. 1343. Dielasmatidae (p. 2030–2035).

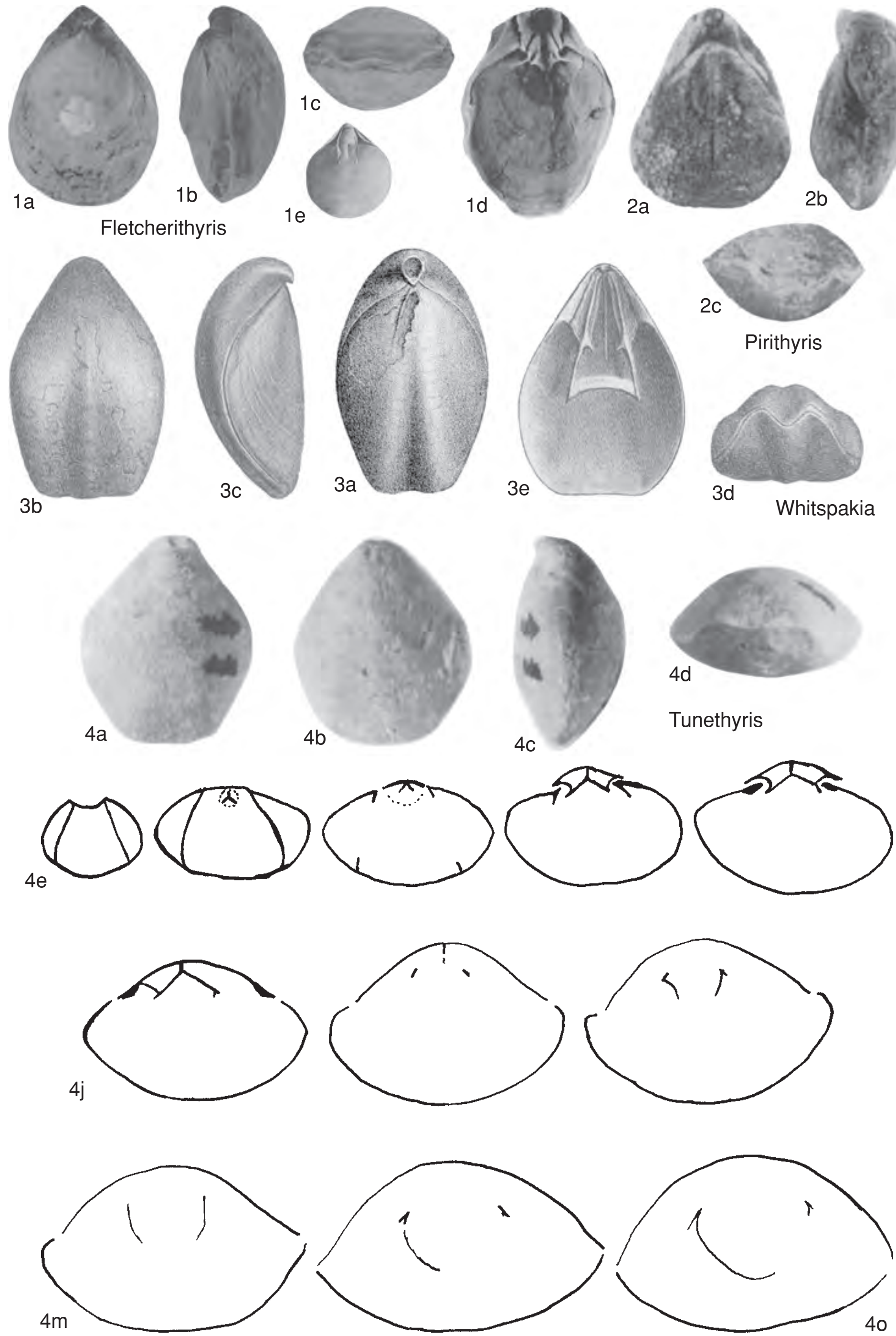

FIG. 1344. Dielasmatidae (p. 2032–2036).

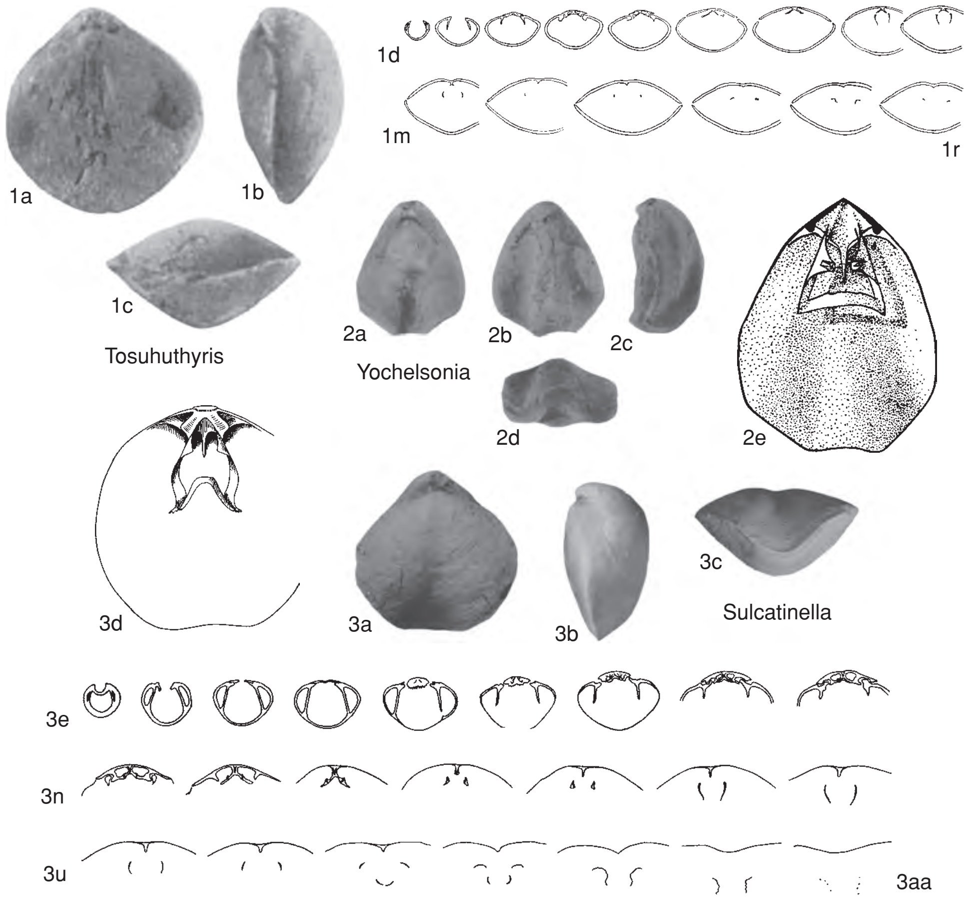

FIG. 1345. Dielasmatidae (p. 2032–2036).

wide septalium, supported by low median ridge anteriorly; crura of *Dielasma* type; crural bases long, trigonal, attached to inner end of outer hinge plates; crura very short, crural processes high; loop short, narrowly triangular, about 0.3 dorsal valve length; descending branches long, thin; plate-shaped transverse band a broad, depressed arch with narrow crest projecting posteriorly; median septum low, reaching 0.5 dorsal valve length. *Upper Triassic (Carnian–Norian):* Alps and Himalayas.——FIG. 1343,*8a–s*. **T. depressa,* Norian, Tibet, China; *a–d,* dorsal, ventral, lateral, and anterior views, ×1; *e–s,* serial transverse sections 0.5, 1.7, 2.8, 3.7, 4.6, 5.5, 7.1, 7.6, 8.7, 9.3, 10.2, 11.3, 11.5, 11.7, 11.8 mm from ventral umbo, ×1 (Ching, Sun, & Rong, 1976).

Tosuhuthyris SUN & YE, 1982, p. 166 [171] [**T. sulcus;* OD]. Small, subcircular; planoconvex to biconvex; beak short, incurved, foramen large, mesothyrid; beak ridges distinct; dorsal sulcus wide, shallow in valve anterior; pedicle collar present; dental plates discrete; outer hinge plates narrow, merged with inner socket ridges; septalium V-shaped, formed by bifurcation of median septum; median septum low, thick, 0.3 to 0.5 dorsal valve length; crural bases triangular, rising from ventral edge of hinge plates; crural processes high; loop short, about 0.3 to 0.5 dorsal valve length; only descending branches present (possible fragile transverse band not preserved). *Middle Triassic:* China (Qinghai).——FIG. 1345,*1a–r*. **T. sulcus; a–c,* dorsal, lateral, and anterior views, ×1; *d–r,* transverse serial sections 0.6, 1.3, 1.9, 2.1, 2.3, 2.8, 3.2, 3.7, 4.1, 4.7, 5.1, 5.5, 6.2, 6.5, 7.1 mm from ventral umbo, ×1 (Sun & Ye, 1982).

Tunethyris CALZADA BADIA & others, 1994, p. 118 [**T. punica;* OD]. Medium, ovate in outline; biconvex; anterior commissure sulciplicate; foramen large, permesothyrid; pedicle collar short; inner hinge plates joining short, strong median septum to form septalium. Differs from *Whitspakia,* which lacks a persistant median septum. *Upper Triassic (Norian):* Tunisia.——FIG. 1344,*4a–o.* **T. punica; a–d,* dorsal, ventral, lateral, and anterior views of holotype, MGSB46587.11, ×2; *e–o,* transverse serial sections 0.0, 2.4, 2.8, 3.1, 3.7, 4.3, 5.1, 5.5, 6.1, 8.5, 9.1 mm from first section, ×2 (Calzada Badia & others, 1994).

Whitspakia STEHLI, 1964, p. 610, *nom. nov. pro Pakistania* STEHLI, 1961b, p. 462, *non* EAMES, 1952 [**Dielasma biplex* WAAGEN, 1882, p. 349; OD]. Medium to large, outline subpentagonal to oval; ventral sulcus variable in length, with strong median plica, anterior and lateral commissure nongeniculate; anterior commissure sulciplicate; beak erect; foramen permesothyrid; dental plates and pedicle collar well developed; cardinal process small; outer hinge plates broad; inner hinge plates uniting on valve floor and diverging anteriorly; crural processes very long, developed directly from crural bases and supported posteriorly by inner hinge plates; descending lamellae broad anteriorly; transverse band recurved. *Permian:* North America, Europe, Asia.——FIG. 1344,*3a–d.* **W. biplex* (WAAGEN), Salt Range, Pakistan; dorsal, ventral, lateral, and anterior views, ×1 (Waagen, 1882).——FIG. 1344,*3e. W. breviplicatum* WAAGEN; interior of dorsal valve, ×1 (Waagen, 1882).

Yochelsonia STEHLI, 1961a, p. 454 [**Y. thomasi;* OD]. Small to medium, outline subtriangular to subpentagonal; dorsal valve longitudinally flattened to concave, with pronounced median sulcus; ventral valve with high median fold bordered by sulci; anterior commissure strongly sulciplicate, anterior and lateral commissure geniculate; beak suberect, foramen permesothyrid, nonlabiate; dental plates well developed; inner hinge plates forming short, sessile septalium; crural processes very long. *Permian (Lopingian):* Western Australia.——FIG. 1345,*2a–e.* **Y. thomasi; a–d,* dorsal, ventral, lateral, and anterior views, ×1; *e,* reconstruction of loop, approximately ×2 (Stehli, 1961a).

Subfamily CENTRONELLOIDEINAE Stehli, 1965

[Centronelloideinae STEHLI, 1965, p. 758]

Small, smooth, somewhat aberrant dielasmatids with unisulcate anterior commissure and elongate ventral beak; foramen permesothyrid, deltidial plates conjunct; dental plates present, partial pedicle collar strong, cardinal process V-shaped in transverse section; cardinal plate medially sessile; adult loop deltiform but modified by spinose, anterior projections of main bands beyond transverse band. *Carboniferous (Upper Mississippian).*

Centronelloidea WELLER, 1914, p. 246 [**Terebratula rowleyi* WORTHEN, 1884, p. 23; M]. Description as for subfamily. *Carboniferous (Upper Mississippian):* USA.——FIG. 1346,*3a–e.* **C. rowleyi* (WORTHEN), Missouri; *a–b,* dorsal and ventral views, ×2; *c,* loop of immature specimen, ×2; *d,* adult loop seen in transmitted light, ×2; *e,* view of reconstructed loop, approximately ×2 (Stehli, 1962).

Subfamily NUCLEATULINAE Muir-Wood, 1965

[Nucleatulinae MUIR-WOOD, 1965a, p. 772]

Description as for Dielasmininae but dental plates weakly developed or absent. *Lower Permian–Upper Triassic (Norian), ?Lower Jurassic.*

Nucleatula BITTNER, 1888, p. 126 [**Rhynchonella retrocita* SUESS, 1855b, p. 29; SD HALL & CLARKE, 1894, p. 858]. Small, rounded pentagonal in outline, strongly biconvex, anterior commissure unisulcate, beak acute, incurved, beak ridges rounded, foramen minute, mesothyrid; septum not developed; loop about 0.5 valve length, acuminate, with anteroventrally directed, high vertical plate bearing spines. *Upper Triassic (Carnian, Norian):* eastern Alps.——FIG. 1346,*2a–f.* **N. retrocita* (SUESS), Norian; *a–d,* dorsal, ventral, lateral, and anterior views, ×1.5 (Bittner, 1890); *e–f,* drawings of loop, ×1.5 (Bittner, 1888).

Arctothyris DAGYS, 1965, p. 140 [**A. solitus;* OD]. Medium, oval in outline, biconvex, uniplicate; beak short, incurved; beak ridges rounded, foramen mesothyrid; cardinal process distinct, undivided; outer hinge plates horizontal, crural bases directed ventrally; crural plates envelop septum, forming septalium; septum low, very short; loop about 0.5 dorsal valve length. *Middle Triassic (Ladinian):* northeastern Siberia.——FIG. 1346,*1a–p.* **A. solitus; a–c,* dorsal, lateral, and anterior views, ×1; *d–p,* transverse serial sections 0.0, 0.5, 0.7, 1.0, 1.3, 1.5, 1.7, 2.0, 3.0, 4.0, 5.3, 9.1, 10.7 mm from first section, ×1 (Dagys, 1965; courtesy of the late A. S. Dagys).

Dinarella BITTNER, 1892, p. 24 [**D. haueri;* OD]. Small, planoconvex, dorsal valve with anterior sulcus, anterior commissure unisulcate; beak acute, beak ridges angular, foramen small, possibly submesothyrid, dental plates weak; dorsal septum with possible septalium; loop acuminate with short, descending lamellae and long, vertical plate, directed ventrally. *Upper Triassic (Norian):* Europe (Dinarids).——FIG. 1346,*4a–e.* **D. haueri; a–d,* dorsal, ventral, lateral, and anterior views, ×2; *e,* loop, ×2 (Muir-Wood, 1965a).

Propygope BITTNER, 1890, p. 210 [**Terebratula (Propygope) hagar;* OD]. Small, planoconvex to concavoconvex, dorsal valve with broad sulcus, anterior commissure unisulcate; beak suberect, foramen small, possible mesothyrid beak ridges angular;

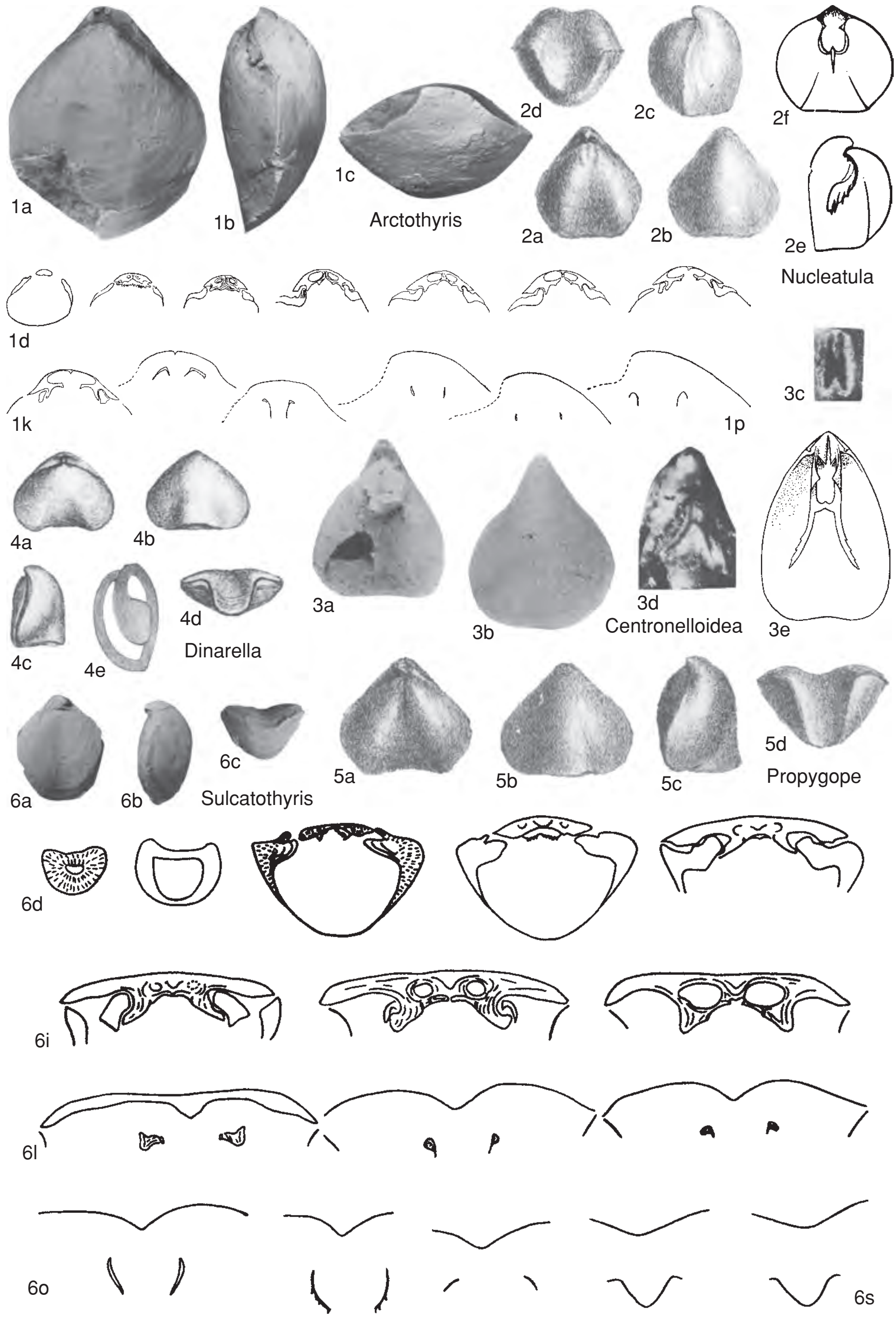

FIG. 1346. Dielasmatidae (p. 2036–2038).

no dental plates; dorsal septum strong, less than 0.5 valve length; loop almost ringlike, about 0.3 valve length. *Upper Triassic (Carnian–Norian), ?Lower Jurassic:* eastern Alps, Austria, Yugoslavia.——FIG. 1346,*5a–d*. **P. hagar,* eastern Alps; *a–d,* dorsal, lateral, anterior, and ventral views, ×2 (Muir-Wood, 1965a).

Sulcatothyris DAGYS, 1974, p. 176 [**S. tkhachensis;* OD] [=*Ninglangothyris* JIN & FANG, 1977, p. 60 (type, *N. subcircularis,* OD)]. Small, planoconvex, dorsal valve with sulcus beginning at cardinal margin, anterior commissure unisulcate; beak short, beak ridges rounded, foramen mesothyrid, no dental plates; cardinal process low, bilobed; septum thick, short, septalium shallow; loop about 0.3 valve length, with subparallel descending lamellae and weakly arched, transverse band. *Upper Triassic (Carnian):* Alps, Carpathians, northwestern Caucasus, China (Yunnan).——FIG. 1346,*6a–s*. **S. tkhachensis,* northwestern Caucasus; *a–c,* dorsal, lateral, and anterior views, ×1; *d–s,* transverse serial sections 0.0, 0.4, 1.4, 1.6, 2.0, 2.2, 2.6, 3.0, 3.2, 3.4, 3.6, 3.9, 4.4, 4.9, 5.1, 5.4 mm from first section, ×1 (Dagys, 1974; courtesy of the late A. S. Dagys).

Family HETERELASMINIDAE Licharew, 1956

[Heterelasminidae LICHAREW, 1956, p. 68]

No dental plates, adult loop deltiform, crura arising directly from crural plates; inner hinge plate perforate apically, free of valve floor and supported by crural plates, or separate, but obsolete between them and socket ridges in advanced genera. *Permian.*

Heterelasmina LIKHAREV, 1939b, p. 120 [**Hemiptychina dieneri* GEMMELLARO, 1899, p. 100; OD]. Small to medium, elongate oval, straight sided; planoconvex; smooth posteriorly with a few plicae developing anteriorly; anterior commissure emarginate, uniplicate to sulciplicate; foramen permesothyrid, strongly labiate; pedicle collar present; hinge plates obsolete, crura arising from crural plates. *Permian (Guadalupian–Lopingian):* Sicily, northern Caucasus, Tajikistan, Mongolia, Pakistan, Laos.——FIG. 1347,*4a*. **H. dieneri* (GEMMELLARO); interior of dorsal valve, ×1 (Gemmellaro, 1899).——FIG. 1347,*4b–e*. *H. genuflexa* GEMMELLARO, Palermo, Sicily; *b–c,* dorsal and ventral views; *d,* lateral view; *e,* interior of dorsal valve, ×1.5 (Stehli, 1962).

Amurothyris KOCZYRKEVICZ, 1976, p. 77 [**A. costulata;* OD]. Small, oval, anterior commissure rectimarginate, costellate, foramen permesothyrid; hinge plate obsolete, crura rising from crural plates. *Permian (Capitanian):* Russia (Primorya).——FIG. 1347,*6a–j*. **A. costulata; a–c,* dorsal, lateral, and anterior views, ×1.5 (Koczyrkevicz, 1976); *d–j,* serial transverse sections 1.2, 1.8, 2.0, 2.4, 2.7, 2.9, 3.2 mm from first section, ×1 (adapted from Koczyrkevicz, 1976).

Gundarolasmina SMIRNOVA & GRUNT, 2003, p. 139 [**G. gundarensis;* OD]. Medium size, elongate oval, smooth or with single fold, anterior commissure broadly uniplicate; outer hinge plates discrete, slender, short; crural plates attached to dorsal valve for a long distance, crural outgrowths connected, loop ringlike, 0.3 dorsal valve length; descending branches connecting to crural plates. Differs from *Heterelasmina* in larger size, plications, slender beak, ringlike loop, and connected descending branches. *Permian (Roadian):* Tajikistan (Darvaz).——FIG. 1347,*2a–d*. **G. gundarensis;* dorsal, lateral, and anterior views of holotype, PIN 4104/619, ×1; d, reconstruction of loop, ×2 (Smirnova & Grunt, 2003).

Mimaria COOPER & GRANT, 1976b, p. 2,907 [**Dielasma lepton* GEMMELLARO, 1894, p. 5; OD]. Medium size, oval to elongate triangular, ventral valve concave, dorsal valve strongly convex, beak small with strong beak ridges, foramen permesothyrid, anterior commissure sulciplicate, lateral commissure ventrally directed, hinge plates obsolete, crural bases attached directly to socket ridges, loop short, with strongly angular, delicate transverse ribbon. *Permian (Guadalupian):* Sicily.——FIG. 1347,*1a–c*. **M. lepton* (GEMMELLARO), Sosio Formation, Sicily; dorsal, lateral, and anterior views, ×1 (Cooper & Grant, 1976b).

Permicola KOCZYRKEVICZ, 1976, p. 75 [**P. plicatus;* OD]. Small, oval, folded anteriorly, anterior commissure truncate or parasulcate; foramen mesothyrid; hinge plates obsolete; crural plates short, separated from descending lamellae, loop with strongly recurved band. *Permian (Capitanian):* Russia (Primorya).——FIG. 1347,*7a–n*. **P. plicatus; a–c,* dorsal, lateral, and anterior views, ×2 (Koczyrkevicz, 1976); *d–n,* serial transverse sections 0.4, 0.6, 0.7, 1.25, 1.4, 1.5, 1.6, 1.8, 2.2, 2.5, 3.0 mm from first section, ×1.5 (adapted from Koczyrkevicz, 1976).

Pseudolabaia JIN & YE in JIN & others, 1979, p. 130 [**P. curvatum;* OD]. Medium size, elongate oval, subequally biconvex, smooth; anterior commissure sulciplicate, foramen epithyrid, outer hinge plates broad and flattened; crural plates long; loop short, with highly arched and strongly recurved transverse band. *Permian (Lopingian):* southern China.——FIG. 1347,*5a–k*. **P. curvatum; a–c,* dorsal, ventral, and lateral views, ×1; *d–k,* serial transverse sections 1.9, 2.8, 3.5, 4.7, 7.1, 8.0, 9.6, 12.1 mm from ventral umbo, ×1 (Jin & others, 1979).

Qinglongia LIAO, 1980, p. 270 [**Q. zhongyingensis;* OD] [=*Chuanyanella* ZHU, ZENG, & CHEN in ZENG, CHEN, & CHANG, 1986, p. 61 (type, *C. chuanyanensis,* OD); *Zhongliangshania* SHEN, HE, & ZHU, 1992, p. 191 (type, *Z. zhongliangshanensis,* OD)]. Small to medium size, elongate oval, foramen permesothyrid, anterior commissure bisulcate; plicate; hinge plates divided, crural plates strong, supporting descending lamellae, transverse band of loop recurved strongly. *Permian (Changhsingian):*

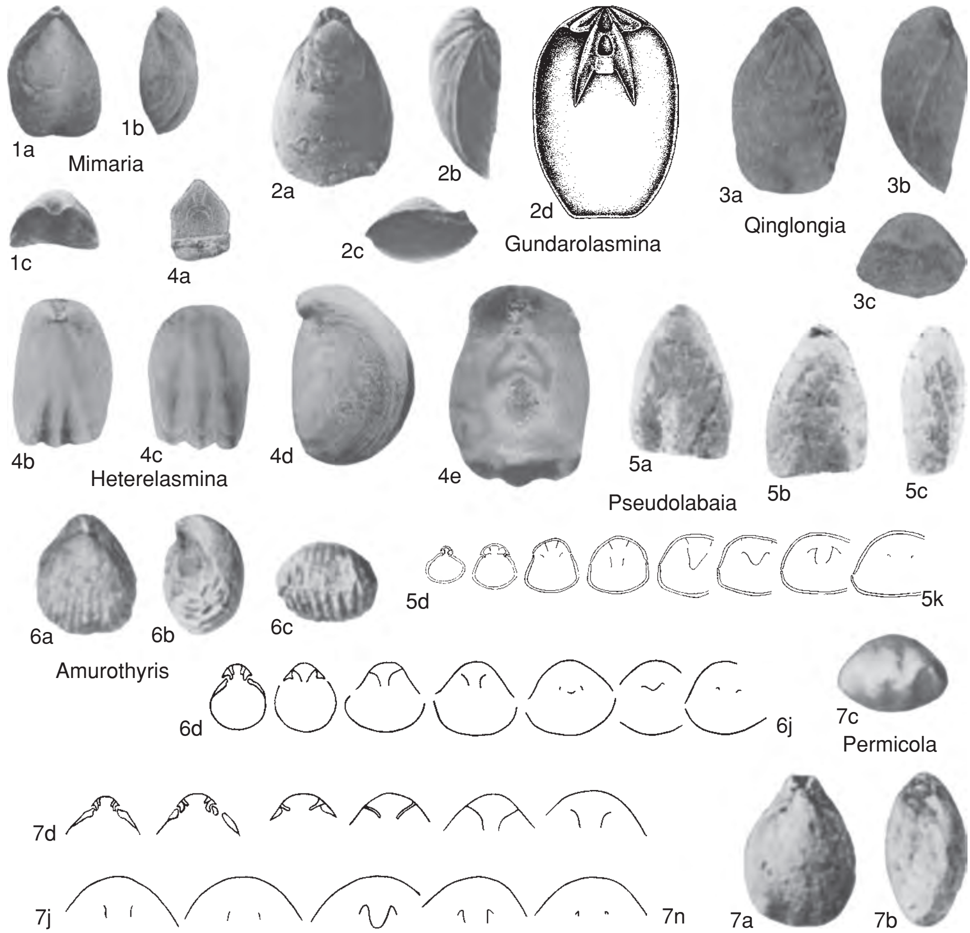

FIG. 1347. Heterelasminidae (p. 2038–2039).

southwestern China (western Guizhou Province). ——FIG. 1347,*3a–c*. **Q. zhongyingensis,* Zhongying, Qinglong; dorsal, lateral, and anterior views of holotype, NIGP 43801, ×2 (Liao, 1980).

Family BEECHERIIDAE Smirnova, 2004

[Beecheriidae SMIRNOVA, 2004, p. 166] [type genus, *Beecheria* HALL & CLARKE, 1893, p. 300]

Shell smooth, dental plates present; outer hinge plates present only at early growth stages, inner hinge plates uniting to form septalium or joining separately on floor of valve, or forming entire plate raised above valve floor; crural plates attached to dorsal valve, crura developing from crural plates; loop narrow. Differs from Dielasmatidae in weakly developed, outer hinge plates, crural plates attached to floor of dorsal valve, and crura developing from crural plates. *Carboniferous (Lower Mississippian)–Permian (Lopingian).*

Beecheria HALL & CLARKE, 1893, p. 300 [**B. davidsoni;* OD]. Small to large, elongate, subspatulate; dorsibiconvex; anterior commissure uniplicate; foramen small, permesothyrid, labiate; outer hinge plates attached to valve floor and supporting crural bases, inner hinge plates convergent with valve floor or low septum, forming a shallow chamber; loop long, narrow, with broad crural processes, transverse band angularly arched and recurved. *Carboniferous (Lower Mississippian)–Permian (Lopingian):* cosmopolitan.——FIG. 1348,*1a–k*. **B. davidsoni,* Windsor Series, Nova Scotia; *a,* close-up view of calcite-encrusted loop, approximately ×2 (Stehli, 1956a); *b–k,* transverse

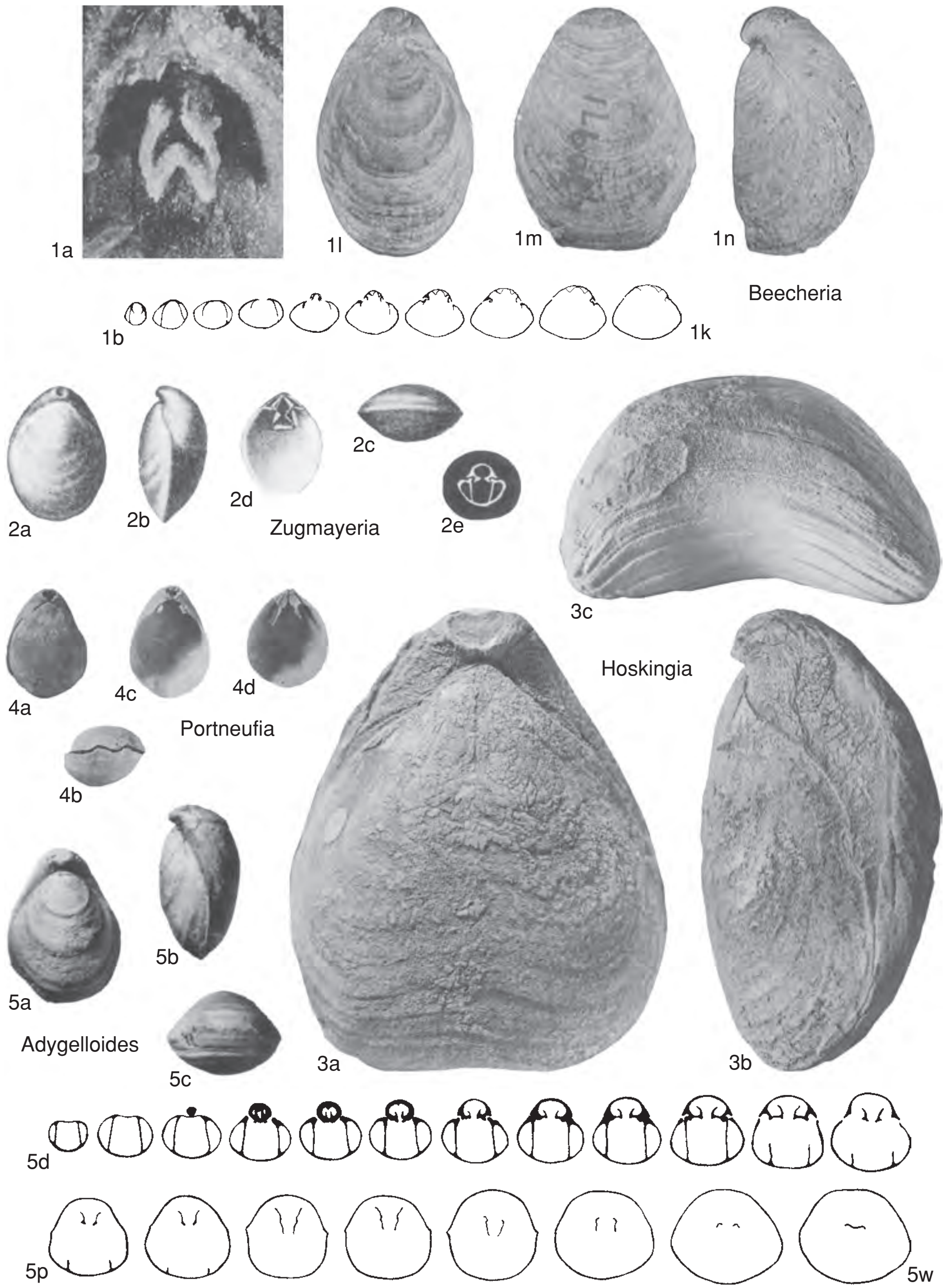

FIG. 1348. Beecheriidae and Zugmayeriidae (p. 2039–2052).

serial sections 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5 mm from first section, ×1 (Campbell, 1965).——FIG. 1348,*1l–n. B. bovidens* MORTON, Pennsylvanian, Kansas City, Missouri, USA; dorsal, ventral, and lateral views, ×1.5 (Stehli, 1956a).

Hoskingia CAMPBELL, 1965, p. 52 [**Dielasma trigonopsis* HOSKING, 1933, p. 44; OD]. Medium to very large, unisulcate to sulciplicate; deltidial plates conjunct; foramen labiate; dental plates and pedicle collar present; inner hinge plates uniting on valve floor to form a long, sessile septalium. *Permian (Cisuralian):* Western Australia.——FIG. 1348,*3a–c.* **H. trigonopsis* (HOSKING); dorsal, lateral, and anterior views of lectotype, G.S.W.A. 1/4950, ×1 (Campbell, 1965).

Family GILLEDIIDAE Campbell, 1965

[Gillediidae CAMPBELL, 1965, p. 70]

Small to large; elongate oval to subpentagonal in outline; deltidial plates conjunct; foramen commonly permesothyrid, labiate; no dental plates; outer hinge plates attached to socket ridges or directly to valve floor; inner hinge plates absent, or small and joined directly to floor of valve along their inner edges, or broad and uniting to form a sessile septalium. *Carboniferous (Tournaisian)–Upper Triassic.*

Subfamily GILLEDIINAE Campbell, 1965

[Gillediinae CAMPBELL, 1965, p. 70]

Smooth or plicate. *Carboniferous (Tournaisian)–Permian (Lopingian).*

Gilledia STEHLI, 1961a, p. 451 [**Terebratula cymbaeformis* MORRIS, 1845, p. 278; OD]. Small to large, surface sometimes ornamented with faint, wavy costae; anterior commissure uniplicate to bisulcate; pedicle collar present; outer hinges usually fused to inner socket ridges but may be joined to shell wall anteriorly; inner hinge plates discrete and joined to shell wall, crural points long. *Permian (Cisuralian):* Australia, New Zealand.——FIG. 1349,*1a–d.* **G. cymbaeformis* (MORRIS); dorsal, ventral, lateral, and anterior views, ×1 (Stehli, 1961a).——FIG. 1349,*1e. G. homevalensis* CAMPBELL; reconstruction of dorsal valve interior, ×1 (Campbell, 1965).

Aneuthelasma COOPER & GRANT, 1976b, p. 2,906 [**A. amygdalinum;* OD]. Small, elongate oval, profile lenticular, anterior commissure rectimarginate to slightly uniplicate, beak erect with prominent ridges, foramen circular, slightly labiate, deltidial plates conjunct, visible; pedicle collar present; no cardinal process, inner plates nearly erect, loop narrow, reaching 0.5 valve length, with subparallel, descending branches and broadly bowed, transverse ribbon. *Permian (Capitanian):* USA (Texas).——FIG. 1350,*1a–c.* **A. amygdalinum; a–b,* dorsal and lateral views of holotype, USNM 153374a, ×2; *c,* interior of dorsal valve, ×2 (Cooper & Grant, 1976b).

Balanoconcha CAMPBELL, 1957, p. 86 [**B. elliptica;* OD]. Medium size, external homeomorph of *Dielasma,* but without dental plates. *Carboniferous (Tournaisian):* eastern Australia.——FIG. 1350,*3a–c.* **B. elliptica;* dorsal, ventral, and anterior views of holotype, U.N.E. F. 2825, ×1 (Campbell, 1957).

Camarelasma COOPER & GRANT, 1976b, p. 2,900 [**C. neali;* OD]. Small, elongate oval, dorsibiconvex, rectimarginate to gently uniplicate, beak strongly labiate, deltidial plates conjunct, concealed under beak lip, inner hinge plates attached to median septum and forming a shallow chamber, loop narrow with subparallel sides, extending about 0.5 dorsal valve length. *Permian (Artinskian):* USA (Texas).——FIG. 1349,*3a–e.* **C. neali,* Leonardian; *a–c,* dorsal, lateral, and anterior views of holotype, USNM 153381c, ×2; *d,* ventral valve interior, ×2; *e,* dorsal valve interior, ×2 (Cooper & Grant, 1976b).

Lowenstamia STEHLI, 1961b, p. 460 [**L. texana;* OD]. Small, smooth, biconvex, elongate oval; sulcus well marked on anterior part of ventral valve, anterior margin uniplicate; beak strong, with permesothyrid labiate foramen; outer hinge plates small to obsolete, inner hinge plates short, separate, and becoming free of valve floor anteriorly; crural bases troughlike. *Permian (Asselian–Sakmarian):* USA (Texas).——FIG. 1349,*4a–d.* **L. texana,* Wolfcampian; *a–c,* dorsal, ventral, and lateral views, ×2; *d,* reconstruction of dorsal valve interior, C.I.T. 5965, approximately ×2 (Stehli, 1961b).

Maorielasma WATERHOUSE, 1964, p. 175 [**M. imperatum;* OD]. Large, anterior commissure rectimarginate or weakly uniplicate; pedicle collar thick, outer hinge plates narrow; inner hinge plates broad, converging on valve floor to form a V-shaped, sessile, long septalium. *Permian (Guadalupian–Lopingian):* New Zealand, Australia.——FIG. 1349,*2a–b.* **M. imperatum,* New Zealand; dorsal and lateral views of internal mold, NZGS BR896, ×1 (Waterhouse, 1964).——FIG. 1349,*2c–d. M. globosum,* Queensland; dorsal and lateral views, ×1 (Campbell, 1965).

Pyandzhelasma SMIRNOVA & GRUNT, 2002, p. 41 [**Hemiptychina juresanensiformis* LIKHAREV, 2002, p. 41; OD]. Medium to large, biconvex, rounded pentagonal or ovate with a narrow ventral sulcus; pedicle collar present; outer hinge plates wide, steeply inclined; septal plates attached to valve floor, septalium deep, supporting hinge plates throughout its length; crural bases indistinct; crural processes well developed; loop narrow, transverse band widely trapezoidal. *Permian (Roadian):* northern Pamirs, Tajikistan.——FIG. 1349,*5a–v.* **P. juresanensiformis* (LICHAREV); *a–c,* dorsal, lateral, and anterior views of holotype, TsNIGR 23/340, ×1; *d–t,* transverse serial sections 0.5, 1.3, 1.9, 2.8, 3.9, 4.4, 4.8, 6.1, 6.8, 8.3, 8.5, 8.9, 9.9, 10.4, 12.2, 12.4, 12.7 mm from ventral umbo, ×1; *u–v,* reconstructions of dorsal valve interior, ×2 (Smirnova & Grunt, 2002).

Tacinia GLUSHENKO, 1975, p. 116 [**T. modesta* GLUSHENKO, 1975, p. 117; OD]. Medium size, moderately biconvex, anterior commissure parasulcate, with two short folds on ventral valve; crural bases crescentic, outer hinge plates short, inner hinge plates grooved, attached to median septum; loop deltiform. *Permian (Cisuralian):* Ukraine (Donetz basin).——FIG. 1350,*2a–c.* **T. modesta;* dorsal, ventral, and lateral views, ×2 (Glushenko, 1975).

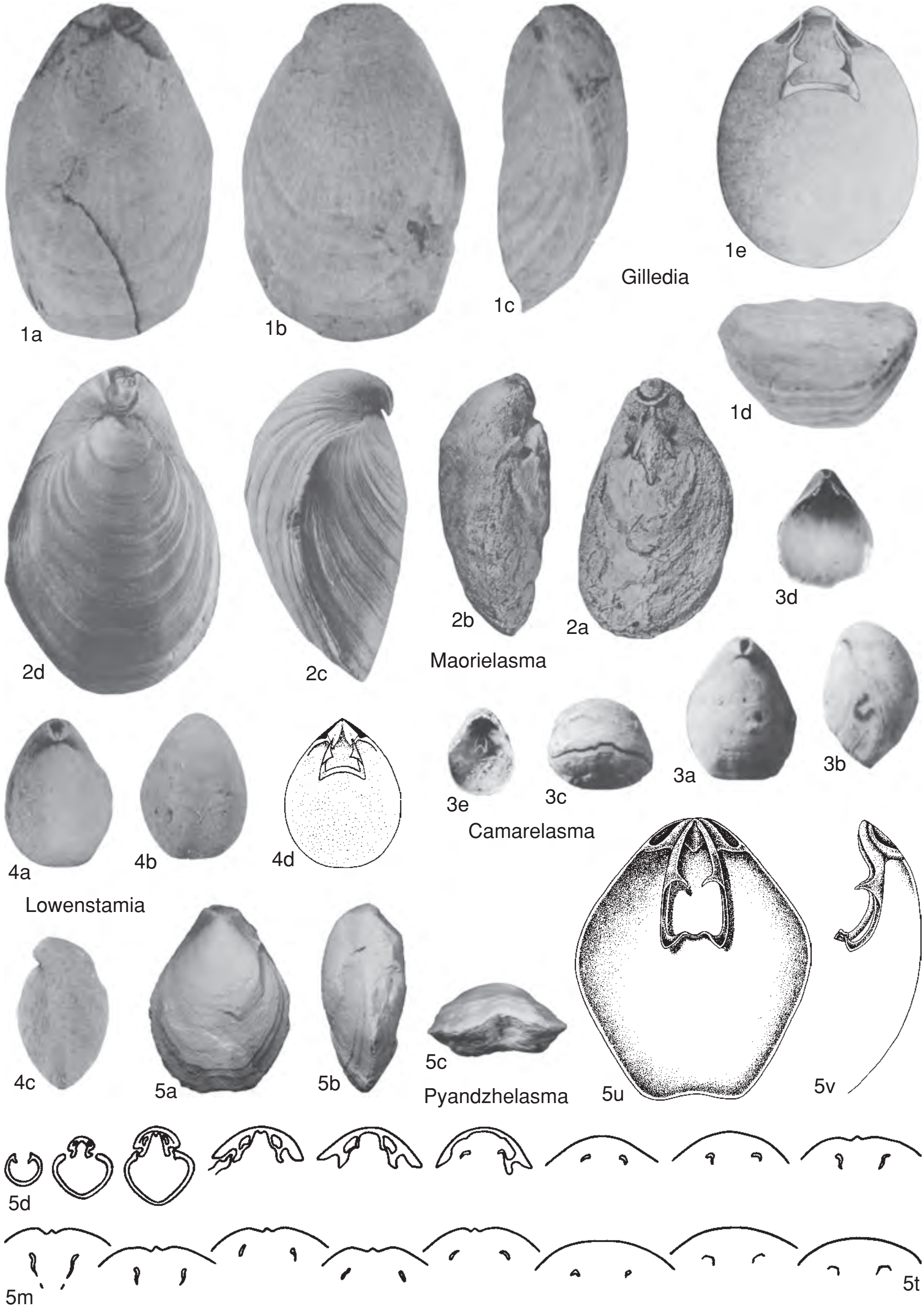

FIG. 1349. Gillediidae (p. 2041).

Subfamily HEMIPTYCHININAE Campbell, 1965

[Hemiptychininae CAMPBELL, 1965, p. 103]

Anterior margins commonly multiplicate. *Permian (Guadalupian)–Upper Triassic.*

Hemiptychina WAAGEN, 1882, p. 335 [**Terebratula himalayensis* DAVIDSON, 1862, p. 27; OD] [=*Morrisina* GRABAU, 1931c, p. 97 (type, *Hemiptychina sparsiplicata* WAAGEN, 1882, p. 366); *Jisuina* GRABAU, 1931c, p. 105 (type, *J. elegantula* GRABAU, 1931c, p. 106, OD)]. Medium size, biconvex to subglobular; dorsal valve and some ventral valves geniculate anteriorly; anterior commissure rectimarginate; strongly plicate anteriorly; cardinal process shelflike, fulcral plates broad, conjunct with narrow, outer hinge plates, or directly connected with crural bases; inner hinge plates short, joining valve floor independently along their inner edges; crura short, conjunct with outer hinge plates; descending lamellae narrow; transverse band gently bent to V-shaped. *Permian (Guadalupian–Lopingian):* Asia.——FIG. 1351,*1a–e*. **H. himalayensis* (DAVIDSON), Salt Range, Pakistan; *a–d,* dorsal, ventral, lateral, and anterior views, ×1; *e,* interior of dorsal valve, approximately ×1.5 (Waagen, 1882).

Costoconcha JIN, SUN, & YE in Jin & others, 1979, p. 193 [**C. zigaensis;* OD]. Medium size, oval to enlongate oval; biconvex; anterior commissure rectimarginate to slightly uniplicate; surface smooth posteriorly, with ornament of short, angular, or round costae anteriorly; beak incurved, foramen epithyrid; delthyrium covered by thick henidium; pedicle collar developed; dental plates absent; cardinal process gently arched, platelike; hinge plates divided; crural plates oblique, fused with valve floor or joining median septum to form septalium; loop short, deltiform, about 0.4 shell length; transverse band arched ventrally. *Upper Triassic:* China (Tibet, Qinghai, Sichuan).——FIG. 1351,*7a–m*. **C. zigaensis,* Tibet; *a–d,* dorsal, ventral, lateral, and anterior views, ×1 (Jin & others, 1979); *e–m,* serial transverse sections 2.95, 3.50, 4.05, 5.25, 5.95, 7.95, 9.05, 11.05, 11.65 mm from ventral umbo, ×1 (adapted from Jin & others, 1979).

Latiflexa KOCZYRKEVICZ, 1984, p. 14 [**L. pentagona* KOCZYRKEVICZ, 1984, p. 15; OD]. Small to medium, outline subpentagonal; ventral valve geniculate; folded anteriorly, parasulcate anterior commissure; foramen epithyrid; outer hinge plates oblique, crura supported by separate inner hinge plates; loop short, with thin, transverse band. *Permian (Capitanian):* Russia (Primorya).——FIG. 1351,*2a–c*. **L. pentagona;* dorsal, lateral, and anterior views, ×1.5 (Koczyrkevicz, 1984).

Mongolina GRABAU, 1931c, p. 102 [**M. subdieneri;* OD]. Small, biconvex, strongly plicate anteriorly; septal plates joining valve floor, loop deltiform. *Permian (Guadalupian):* Mongolia.——FIG. 1351,*4a–o*. **M. subdieneri; a–c,* dorsal, lateral, and anterior views, ×2 (Stehli, 1962); *d–o,* transverse serial sections 0.0, 1.1, 1.8, 2.1, 3.0, 3.7, 3.9, 5.1, 5.6, 6.7, 8.4, 8.7 mm from first section (Smirnova & Grunt, 2001).

Parahemiptychina CHEN & others, 1986, p. 77 [**P. hemiptyca;* OD]. Small to medium, oval to subtriangular to subpentagonal in outline, ventribiconvex, smooth in early stages but becoming strongly plicate anteriorly; anterior commissure rectimarginate to weakly unisulcate, foramen permesothyrid, no cardinal process, hinge plates discrete, crural plates inclined and reaching floor of valve; median ridge absent or raised in wide, deep septalium; loop short, transverse band with high arch. *Upper Triassic:* China (Tibet, Sichuan).——FIG. 1351,*5a–j*. **P. hemiptyca; a–d,* dorsal, ventral, lateral, and anterior views of holotype, SC245, ×1; *e–j,* serial transverse sections 1.5, 2.6, 4.0, 5.9, 8.5,

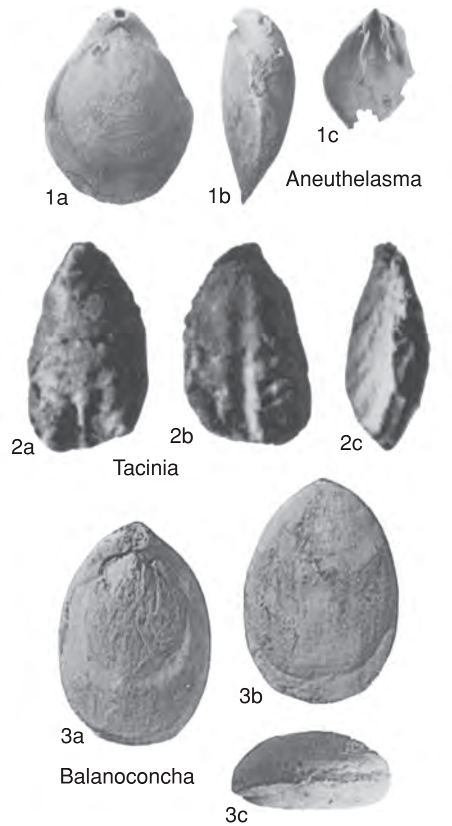

FIG. 1350. Gillediidae (p. 2041).

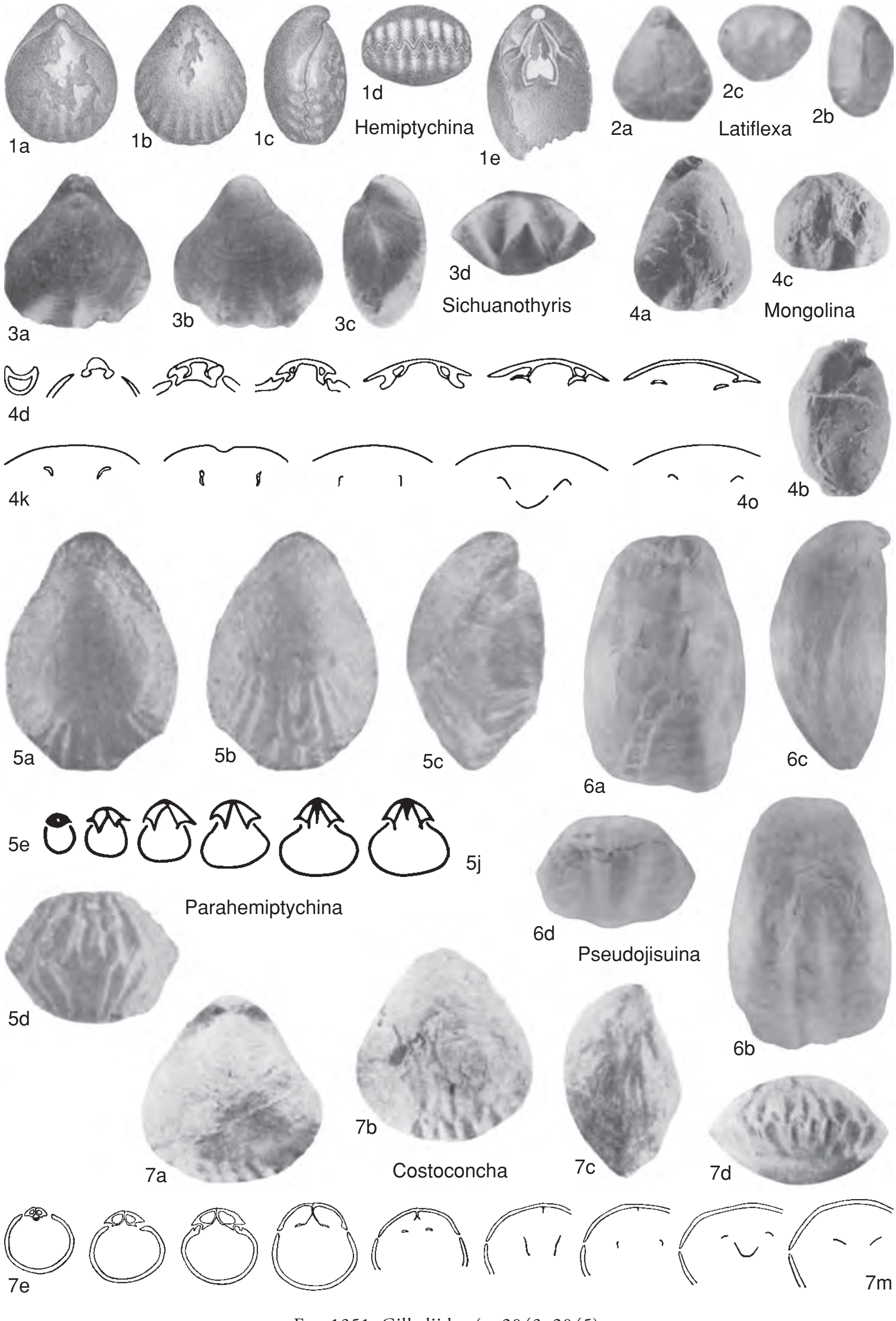

FIG. 1351. Gillediidae (p. 2043–2045).

11.7 mm from ventral umbo, ×1 (Chen & others, 1986).

Pseudojisuina LIANG, 1990, p. 416 [493] [**P. lengwuensis* LIANG, 1990, p. 417; OD] [=*Lengwuella* LIANG, 1990, p. 419 (type, *L. spadeformis,* OD); *Phyllolasma* LIANG, 1990, p. 426 (type, *P. lamina,* OD)]. Medium to large; elongate oval; anterior commissure rectimarginate to sulciplicate; lateral commissure moderately sinuate; pedicle collar strong; outer hinge plates wide, joined to inner socket ridges; inner hinge plates forming short, sessile septalium; crura short; crural processes long; loop with high, V-shaped, transverse band. *Permian (Guadalupian–Lopingian):* southern China.——FIG. 1351,*6a–d.* **P. lengwuensis;* dorsal, ventral, lateral, and anterior views, ×1 (Liang, 1990).

Sichuanothyris SHEN, HE, & ZHU, 1992, p. 191 [*?*Notothyris dapaichongensis* LIAO & MENG, 1986, p. 89; OD]. Medium to large, elongate oval; foramen epithyrid, sulcus on anterior half of ventral valve, bounded by parallel plicae; inner hinge plates converging medially on floor. *Permian (Changhsingian):* southern China.——FIG. 1351,*3a–d.* **S. dapaichongensis* (LIAO & MENG); dorsal, ventral, lateral, and anterior views, ×1.5 (Liao & Meng, 1986).

Family PSEUDODIELASMATIDAE Cooper & Grant, 1976

[Pseudodielasmatidae COOPER & GRANT, 1976b, p. 2,910]

Medium to small, commonly elongate oval; smooth or with anterior plication, foramen commonly mesothyrid, nonlabiate; no dental plates; outer hinge plates weakly developed or absent; no inner hinge plates; no crural plates or median septum; crural bases attached to socket plates; loop short with reduced crural processes; adult loop deltiform with complex developmental stages. *Carboniferous (Middle Pennsylvanian)–Permian.*

Pseudodielasma BRILL, 1940, p. 317 [**P. perplexa;* OD]. Small, elliptical to oval, dorsibiconvex, sulcus bounded by low plicae in dorsal valve, anterior commissure paraplicate to biplicate; beak suberect, foramen circular, deltidial plates visible; folds arising near anterior; pedicle collar well developed; loop short (about 0.4 dorsal valve length); crural processes weak, transverse band with median angulation projecting anteriorly. *Permian (Wordian–Capitanian):* USA (Texas), Australia.——FIG. 1352,*1a–c.* **P. perplexa,* Wordian, Texas; *a–b,* dorsal and anterior views of holotype, YPM 15278, ×3; *c,* close-up of loop, ×10 (Brill, 1940).——FIG. 1352,*1d–e. P. ovatum* COOPER & GRANT, Wordian, Texas; interiors of ventral and dorsal valves, ×3 (Cooper & Grant, 1976b).

Fredericksolasma SMIRNOVA, 2001a, p. 37 [**Hemiptychina pseudoelongata* var. *lata* LIKHAREV, 1939b, p. 119; OD]. Small to medium, rounded or elongate oval, biconvex; rarely with shallow ventral sulcus; anterior commissure uniplicate; no cardinal process; outer hinge plate divided, narrow; socket ridges high; loop deltiform, short (less than 0.3 dorsal valve length); transverse band widely trapezoidal or rounded triangular. *Permian (Roadian):* Tajikistan, Pakistan, Austria.——FIG. 1353*a–nn.* **F. lata* (LICHAREW), Tajikistan; *a–c,* dorsal, lateral, and anterior views, ×1; *d–t,* transverse serial sections of juvenile shell (length 5.5 mm), 0.0, 0.1, 0.2, 0.4, 0.6, 0.7, 0.8, 0.9, 1.1, 1.13, 1.18, 2.23, 2.3, 2.4, 2.5, 2.6, 2.7 mm from first section, ×1; *u–jj,* transverse serial sections of adult shell (length 14.5 mm), 0.0, 1.3, 2.1, 2.5, 2.8, 3.3, 3.6, 4.0, 4.2, 4.6, 5.0, 5.4, 6.0, 6.3, 6.6, 6.8 mm from first section, ×1; *kk–nn,* reconstructions of adult and juvenile loops, respectively, ×2 (Smirnova, 2001a).

Levenolasma SMIRNOVA & GRUNT, 2003, p. 138 [**L. concava;* OD]. Medium to large, elongate oval to subpentagonal in outline, ventral valve flat with elongate sulcus; anterior commissure uniplicate with a few small folds; outer hinge plates discrete, parallel to floor of dorsal valve; crural processes join to form high transverse band of short loop. *Permian (Roadian):* Sicily, Tajikistan (North Pamirs).——FIG. 1352,*5a–f.* **L. concava,* Tajikistan; *a–d,* dorsal, ventral, lateral, and anterior views of holotype, PIN 4101/283b, ×1; *e–f,* reconstructions of loop and cardinalia, ×2 (Smirnova & Grunt, 2003).

?Marinurnula WATERHOUSE, 1964, p. 177 [**M. rugulata;* OD]. Medium size, elongate, nonplicate, anterior commissure uniplicate; cardinal process slightly striate; hinge plates diverging anteriorly; loop unknown. *Permian:* New Zealand, Australia.——FIG. 1352,*2a–b.* **M. rugulata;* dorsal and lateral views of internal mold of holotype, GS4651[BR900], ×1 (Waterhouse, 1964).

Oligothyrina COOPER, 1956, p. 525 [**O. alleni;* OD]. Small, biconvex, anterior commissure weakly to strongly intraplicate; folds arising anterior to midlength; transverse band not projecting anteriorly. *Carboniferous (Middle Pennsylvanian)–Permian (Guadalupian):* USA.——FIG. 1352,*4a–d.* **O. alleni; a–c,* dorsal, lateral, and anterior views of holotype, USNM 124409a, ×3; *d,* interior of dorsal valve, ×3 (Cooper, 1956).

Pleurelasma COOPER & GRANT, 1976b, p. 2,922 [**P. costatum* COOPER & GRANT, 1976b, p. 2,923; OD]. Medium size, oval, anterior commissure rectimarginate to slightly unisulcate; anterior multicostate; pedicle collar small; crural bases attached to strong socket ridges and attached to valve floor; loop triangular with median, angulated transverse ribbon. *Permian (Capitanian):* USA (Texas).——FIG. 1352,*3a–d.* **P. costatum; a–c,* dorsal, lateral,

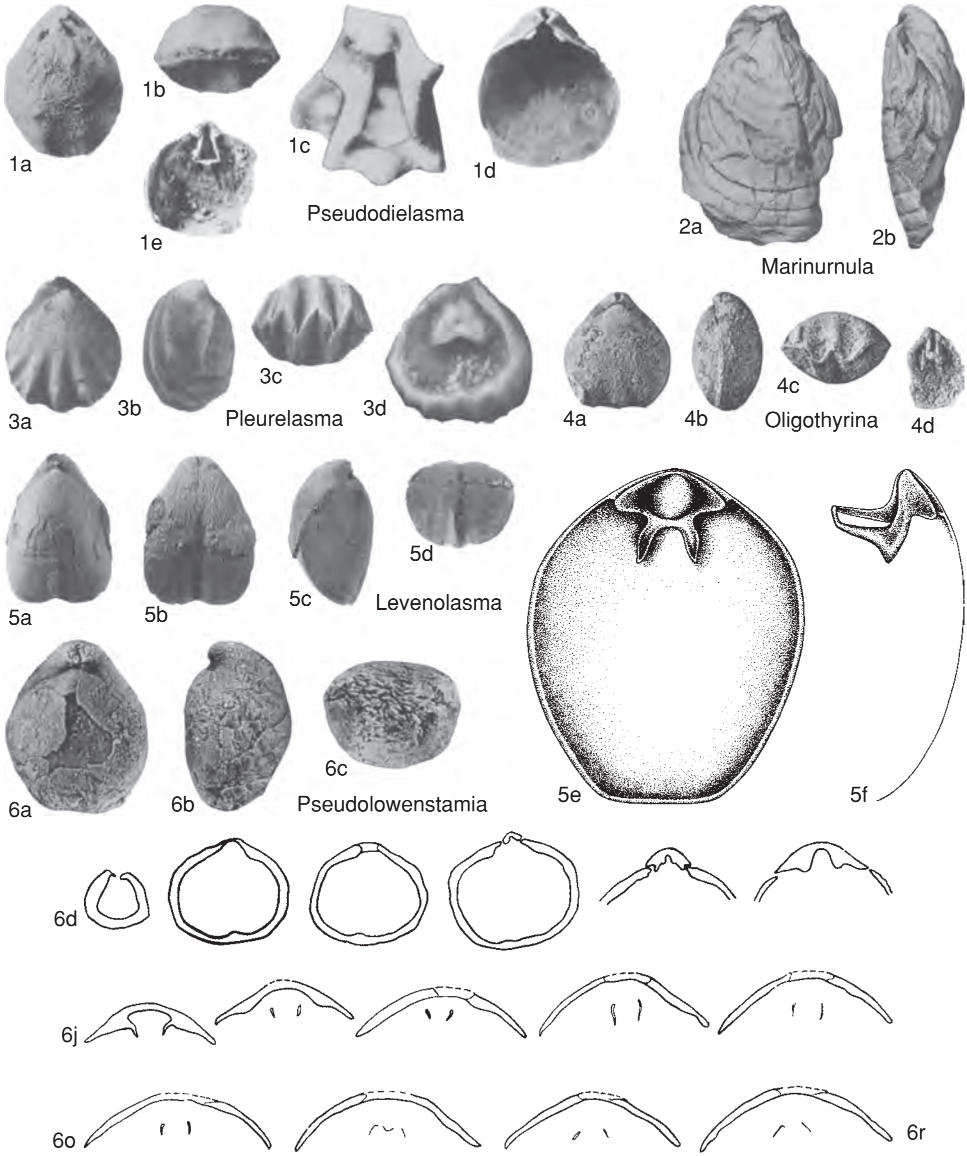

FIG. 1352. Pseudodielasmatidae (p. 2045–2046).

and anterior views, ×2; *d,* interior of dorsal valve, ×2 (Cooper & Grant, 1976b).

Pseudolowenstamia SUN, 1991b, p. 258 [**P. xizangensis;* OD]. Small, oval to subpentagonal, ventribiconvex; smooth; beak incurved, erect; foramen permesothyrid, symphytium present; anterior commissure rectimarginate to slightly uniplicate, no pedicle collar; crural bases attached to socket ridge, loop short, narrow. Differs from *Lowenstamia* in lacking hinge plates. *Permian (Cisuralian):* China (Tibet).——FIG. 1352,*6a–r.* **P. xizangensis; a–c,* dorsal, lateral, and anterior views, ×2; *d–r,* transverse serial sections 0.2, 1.6, 2.2, 2.6, 3.1, 3.5, 3.7, 3.8, 4.0, 4.4, 4.5, 4.6, 4.8, 5.0, 5.2 mm from ventral umbo, ×3 (Sun, 1991).

Family ANGUSTOTHYRIDIDAE Dagys, 1972

[Angustothyrididae DAGYS, 1972b, p. 51]

Small to large in size, biconvex or planoconvex; smooth or plicate anteriorly; no dental plates; foramen mesothyrid or per-

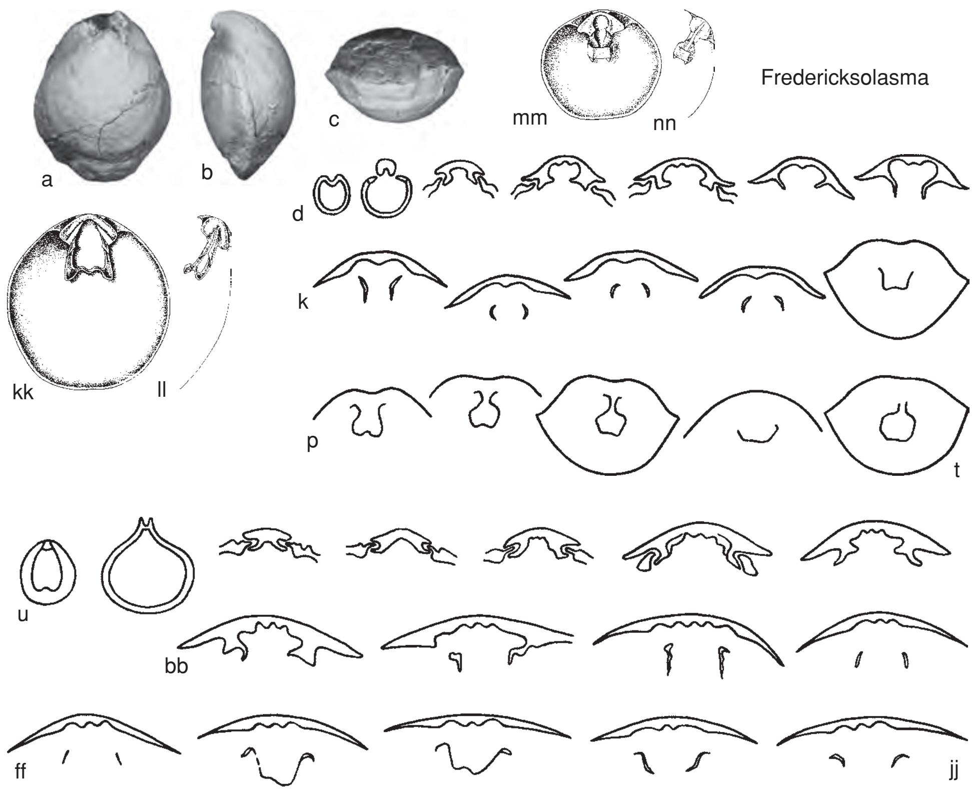

FIG. 1353. Pseudodielasmatidae (p. 2045).

mesothyrid; septum commonly developed; adult loop deltiform, usually with long flanges; transverse band derived from secondary elements developing from ventral part of vertical plate; during ontogeny loop passing through acuminate and possibly haptoid growth stages. *Permian (Capitanian)–Upper Triassic, ?Lower Jurassic.*

Angustothyris DAGYS, 1972b, p. 53 [**Waldheimia angustaeformis* BOECKH, 1873, p. 160; OD]. Small, unisulcate, biconvex with slightly flattened dorsal valve; beak short with rounded ridges, foramen mesothyrid; pedicle collar distinct; narrow outer hinge plates joined to high inner socket ridges; crural bases indistinct; no cardinal process; crural plates supported by thin septum forming septalium; loop about 0.5 dorsal valve length, with high, arched transverse band. *Middle Triassic (Anisian):* Alps, Carpathians, Balkans, Crimea, northwestern Caucasus.——FIG. 1354,*1a–t*. **A. angustaeformis* (BOECKH), northwestern Caucasus; *a–c,* dorsal, lateral, and anterior views, ×2 (Dagys, 1972b); *d–h,* reconstructions of loop stages of juvenile specimens, ×5; *i–t,* serial transverse sections 0.0, 0.7, 1.2, 1.6, 1.85, 2.1, 2.3, 2.8, 3.6, 4.3, 4.7, 5.1 mm from first section, ×2 (Popiel-Barczyk & Senkowiczowa, 1983).

Caucasothyris DAGYS, 1974, p. 192 [**C. angustiplicatus;* OD]. Small, plicosulcate, planoconvex, anterior commissure parasulcate; beak short, with rounded ridges, foramen mesothyrid; pedicle collar short; cardinal process low, laminated; short crural plates lie in commissural plane and join septum without forming septalium; septum high, long (up to 0.6 dorsal valve length); loop about 0.5 dorsal valve length, with high, arched transverse band. *Upper Triassic (Norian):* northwestern Caucasus.——FIG. 1355,*3a–d*. **C. angustiplicatus; a–c,* dorsal, ventral, and anterior views, ×2; *d,* reconstruction of loop, ×2.5 (Dagys, 1974).

Cubanothyris DAGYS, 1959a, p. 35 [**C. elegans* DAGYS, 1959a, p. 36; OD]. Small to medium size, thick shelled, biconvex, anterior commissure rectimarginate; beak thick, incurved, with rounded ridges, foramen mesothyrid; pedicle collar present; outer hinge plates narrow, septalium deep, septum short; loop acuminate, with vertical plate expanding ventrally. *Upper Triassic (Norian–Rhaetian):* Crimea, northwestern Caucasus, Pamir.——FIG.

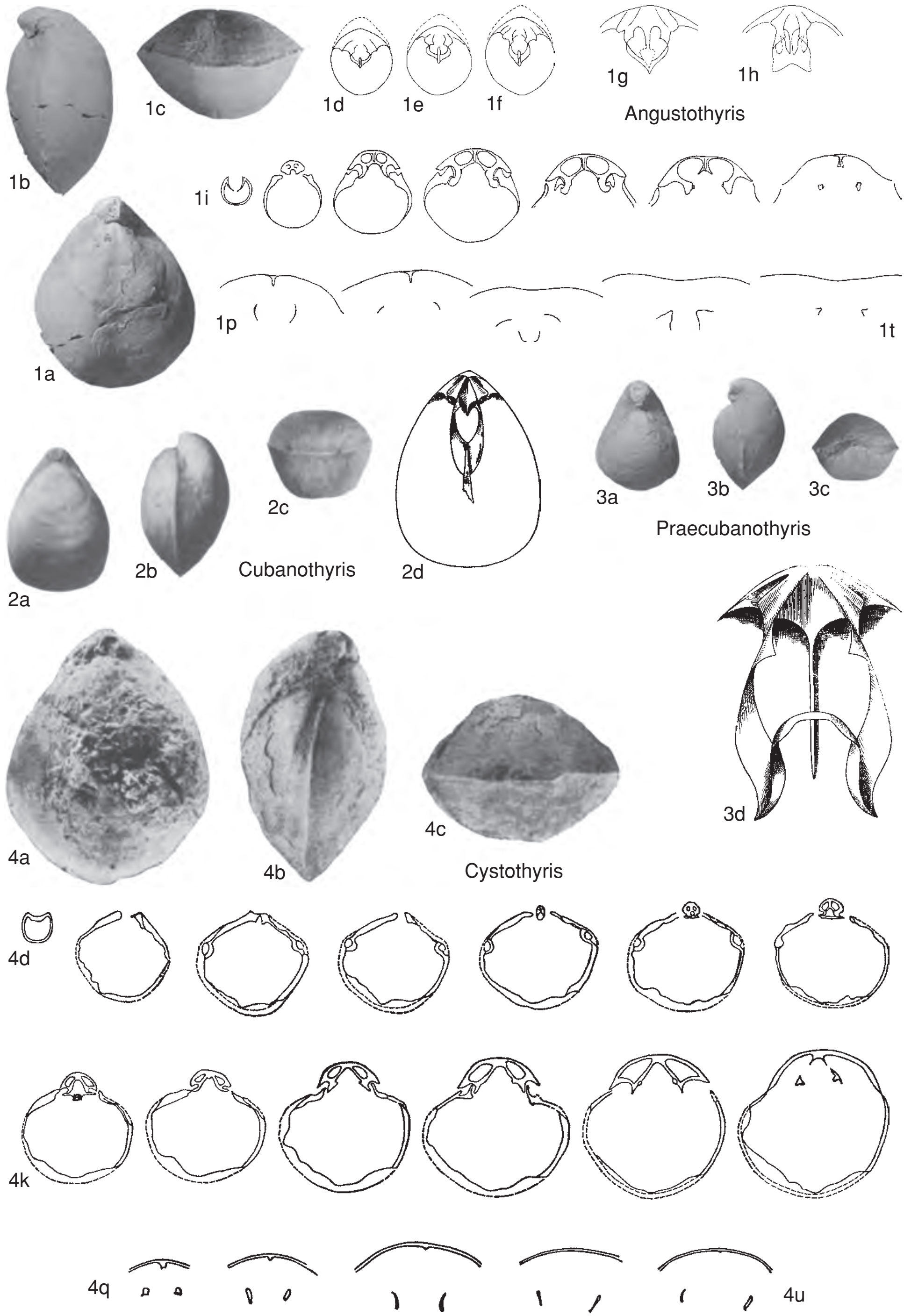

FIG. 1354. Angustothyrididae (p. 2047–2050).

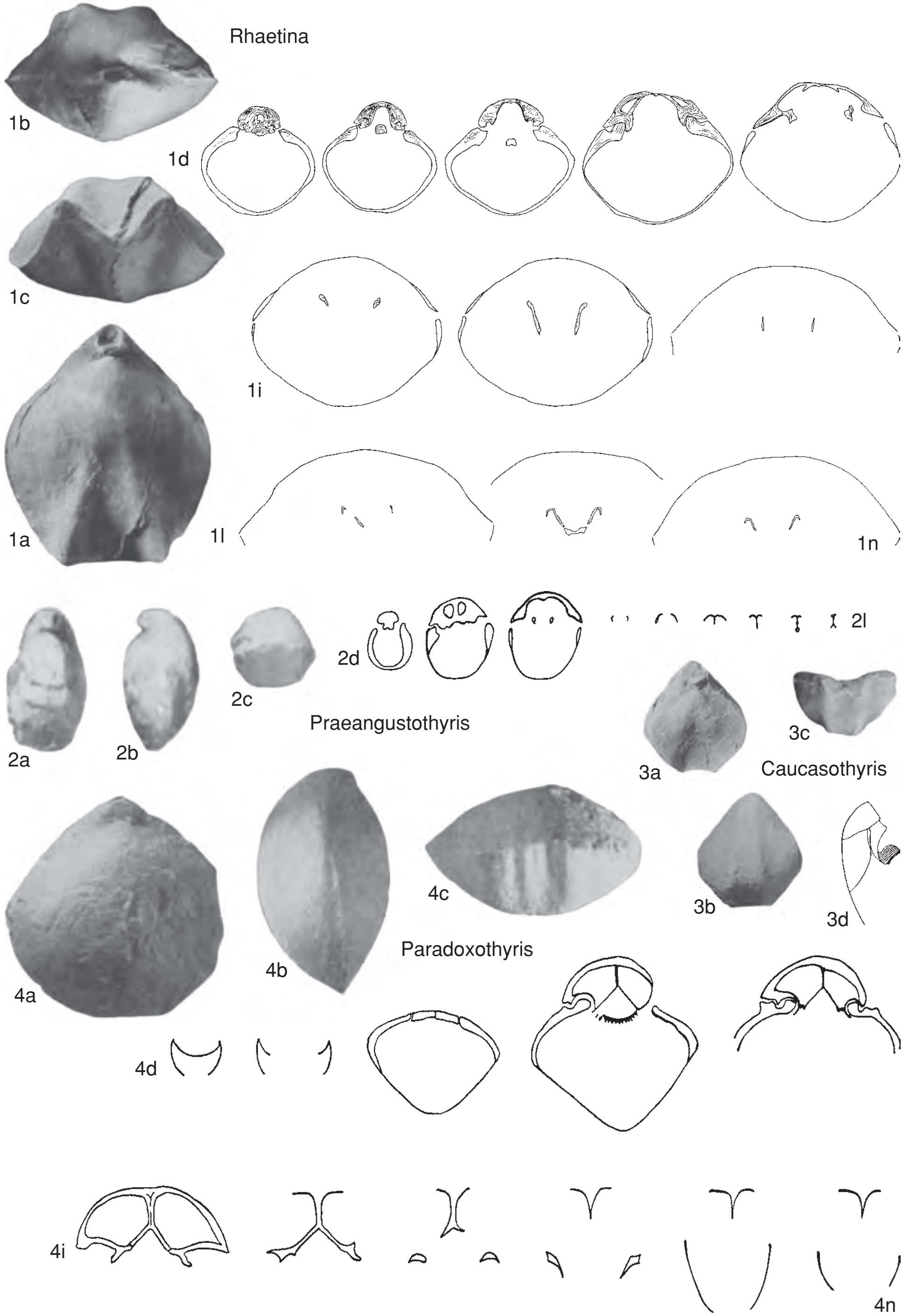

FIG. 1355. Angustothyrididae (p. 2047–2050).

1354,*2a–d.* **C. elegans,* northwestern Caucasus; *a–c,* dorsal, lateral, and anterior views, ×1 (Dagys, 1959a); *d,* reconstructed loop, ×2 (Dagys, 1974).

Cystothyris Sun Dong-Li, 1981, p. 223 [**C. zigaensis;* OD]. Large, oval, biconvex, beak short, erect, projecting over dorsal beak; beak ridges rounded, anterior commissure rectimarginate; foramen large, epithyrid, delthyridium concealed; pedicle collar short, dental plates retrograde, very short, resembling cystiform sacs in beak ridges; teeth thin; cardinal process arched with comblike surface; outer hinge plates very short, fused with inner socket ridges and crural plates, oblique and attached to valve floor or septum; inner socket ridges high, crural bases carinate, close to inner socket ridges and projecting ventrally; crura of *Rhaetina* type; loop short. Differs from *Rhaetina* in possession of cystiform sacs. *Upper Triassic:* China (Tibet).——Fig. 1354,*4a–u.* **C. zigaensis; a–c,* dorsal, lateral, and anterior views, ×1; *d–u,* serial transverse sections 0.7, 2.8, 3.4, 3.9, 4.0, 4.1, 4.3, 4.4, 4.7, 5.6, 6.5, 7.0, 7.3, 8.0, 9.3, 10.0, 10.7, 11.0 mm from ventral umbo, ×1 (Sun Dong-Li, 1981).

Paradoxothyris Xu, 1978, p. 302 [**P. cyclis;* OD] [=*Arcosarina* Jin, Sun, & Ye in Jin & others, 1979, p. 185 (type, *A. foliacea,* OD)]. Medium to large, circular, oval or subpentagonal in outline, biconvex; anterior commissure rectimarginate, uniplicate or sulciplicate; smooth, or with short plicae anteriorly; beak short, erect, beak ridges subangular, foramen mesothyrid or permesothyrid; delthyrium covered with deltidial plates or symphytium; pedicle collar present, cardinal process high and arched, or globular with comblike surface; hinge plates narrow, divided; inner socket ridges high, crural plates long, converging on septum; septalium wide and deep, septum about 0.5 dorsal valve length; crural bases trigonal, attaching ventrally to inner ends of outer hinge plates; crura short, crural processes high; loop short, narrowly trigonal, about 0.3 valve length; transverse band high and roundly arched. *Upper Triassic:* China (Tibet, Guizhou).——Fig. 1355,*4a–n.* **P. cyclis; a–c,* dorsal, lateral, and anterior views, ×1; *d–n,* serial transverse sections 0.0, 0.6, 0.8, 1.8, 2.0, 2.2, 2.6, 3.0, 4.1, 4.4, 4.6 mm from initial section, ×1 (Xu, 1978).

Praeangustothyris Koczyrkevicz, 1984, p. 18 [**P. faticana* Koczyrkevicz, 1984, p. 19; OD]. Small, elongate, anterior commissure rectimarginate or unisulcate; foramen mesothyrid; rudimentary dental plates present; hinge plates supported by septum, forming shallow, short septalium; loop acuminate, about 0.5 length of dorsal valve length. *Permian (Capitanian):* Russia (Primorya).——Fig. 1355,*2a–l.* **P. faticana; a–c,* dorsal, lateral, and anterior views, ×3 (Koczyrkevicz, 1984); *d–l,* serial transverse sections 0.0, 0.9, 1.25, 1.4, 1.85, 2.0, 2.3, 2.5, 2.65 mm from initial section, ×1 (adapted from Koczyrkevicz, 1984).

Praecubanothyris Dagys, 1974, p. 187 [**P. obtusus;* OD]. Small, biconvex, thick shelled; anterior commissure uniplicate; beak prominent, ridges rounded; foramen permesothyrid; pedicle collar present, outer hinge plates narrow, septalium deep, septum low, long; crural processes short; loop long (up to 0.6 dorsal valve length), with high, arched transverse band. *Middle Triassic (Anisian):* Alps, northwestern Caucasus, Pamir.——Fig. 1354,*3a–d.* **P. obtusus,* northwestern Caucasus; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* reconstructed loop, ×2 (Dagys, 1974).

Rhaetina Waagen, 1882, p. 334 [**Terebratula gregaria* Suess, 1854, p. 42; OD] [=*Rhaetinopsis* Yang & Xu, 1966, p. 80 (type, *R. ovata*); *Sanqiaothyris* Yang & Yu, 1966, p. 83 (type, *S. elliptica*)]. Medium to large in size, smooth to biplicate, anterior commissure rectimarginate to sulciplicate; beak short, suberect, beak ridges rounded; foramen permesothyrid; cardinal process low; outer hinge plates inclined, crural plates usually connected to floor of dorsal valve without forming septalium; septum low or absent; loop short, arched (about 0.3 dorsal valve length), with moderately arched transverse band. *?Lower Triassic, Upper Triassic, ?Lower Jurassic:* North America (Idaho), *?Lower Triassic;* Alps, Balkans, Carpathians, Crimea, northwestern Caucasus, Iran, Afghanistan, Vietnam, China, USA (Nevada), *Upper Triassic;* northern Alps, *?Lower Jurassic.*——Fig. 1355,*1a–n.* **R. gregaria* (Suess), Rhaetian, eastern Alps; *a–c,* dorsal, anterior, and posterior views, ×1; *d–n,* serial transverse sections 3.35, 3.5, 3.8, 4.9, 5.5, 6.5, 6.9, 8.1, 8.9, 9.3, 9.5 mm from ventral umbo, ×2 (Pearson, 1977).

Family ANTEZEILLERIDAE Xu & Liu, 1983

[Antezeilleridae Xu & Liu, 1983b, p. 104]

Smooth, biconvex, anterior commissure rectimarginate, dental plates diverging laterally, no septum, loop short. *Triassic.*

Antezeilleria Xu & Liu, 1983b, p. 104 [**A. subrotata;* OD]. Medium; subcircular, foramen small, mesothyrid; hinge plates narrow, discrete; inner socket ridges high, crural plates reaching valve floor, septum absent, loop short, with flanges. *Lower Triassic:* China (Qinghai).——Fig. 1356,*3a–s.* **A. subrotata; a–c,* dorsal, lateral, and anterior views, ×1; *d–s,* serial transverse sections 0.2, 0.4, 0.8, 0.9, 1.1, 1.3, 1.5, 1.6, 1.75, 1.9, 2.2, 2.3, 2.5, 2.7, 2.8, 3.0 mm from ventral umbo, ×1 (Xu & Liu, 1983b).

Emeithyris Xu, 1978, p. 301 [**E. longmendongensis;* OD]. Medium, elongate oval, beak short, suberect; foramen epithyrid, delthyrium open; pedicle collar strongly developed; outer hinge plates very short, merging with inner socket ridges; crural plates subparallel, reaching valve floor; septum absent, crura thin; crural processes moderately high; descending branches of loop slender, transverse band unknown. [Serial transverse sections incomplete.]

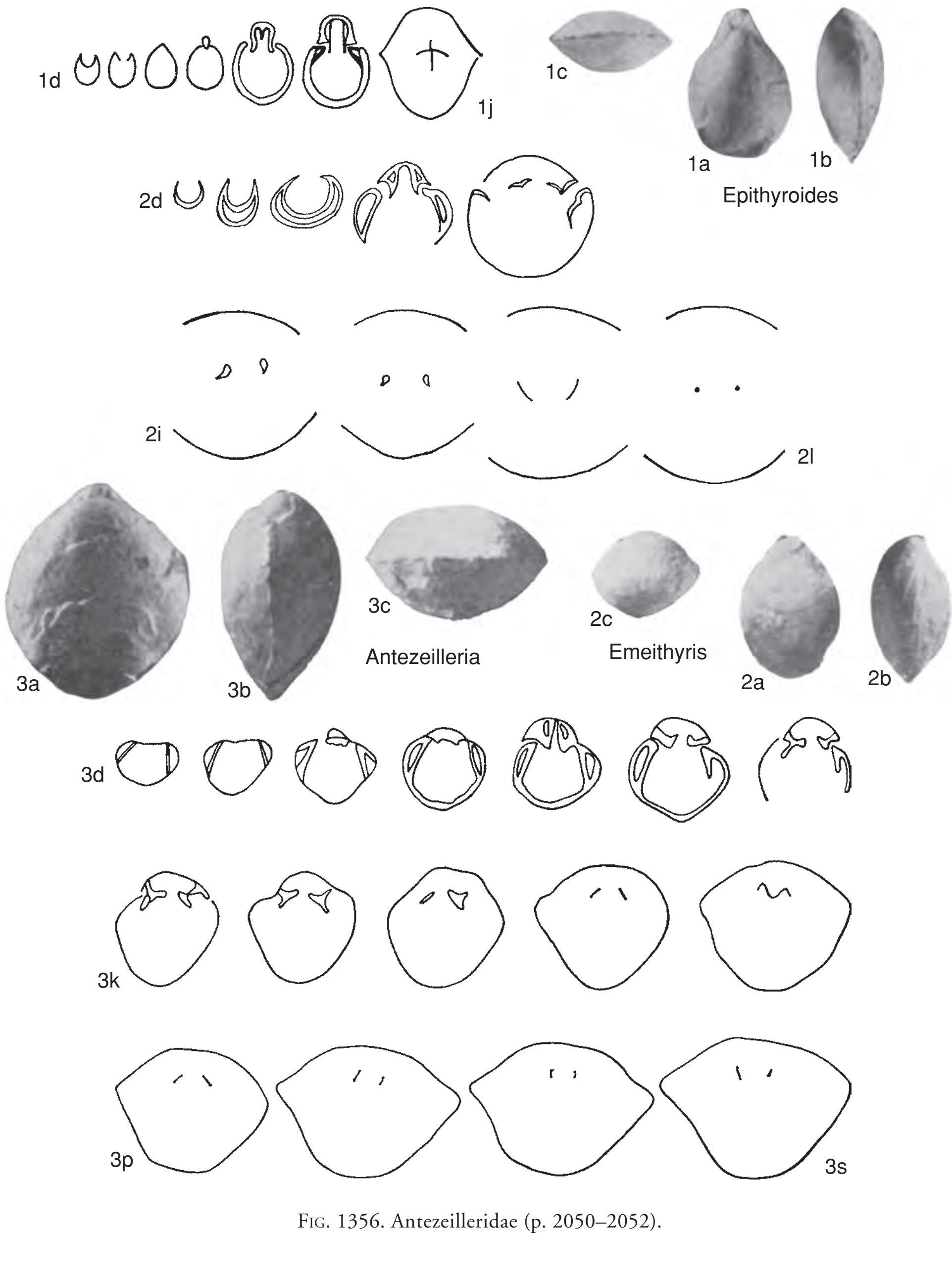

FIG. 1356. Antezeilleridae (p. 2050–2052).

Middle Triassic: China (Sichuan).——FIG. 1356,*2a–l.* **E. longmendongensis; a–c,* dorsal, lateral, and anterior views, ×1; *d–l,* serial transverse sections 0.0, 0.3, 0.8, 1.9, 3.2, 4.05, 4.3, 4.45, 6.05 mm from initial section, ×1 (Xu, 1978).

?**Epithyroides** XU Qing-Jie, 1978, p. 306 [**E. zhonghuaensis;* OD]. Small, elongate oval; beak strongly incurved, beak ridges rounded; foramen elliptical, epithyrid; pedicle collar long; dental plates possibly retrograde, very short, divergent, beak cavities small, narrow; no cardinal process, hinge plates obscure, fused with high, inner socket ridges, and short crural plates extending vertically to valve floor; loop possibly acuminate (centronelliform), with high vertical plate, 0.3 valve length; dorsal median ridge short, low. Differs from *Cubanothyris,* which lacks dental plates and has a wide, deep septalium. [The status of this genus is uncertain, as serial transverse sections are incomplete.] *Upper Triassic:* China (Tibet).——FIG. 1356,*1a–j.* **E. zhonghuaensis; a–c,* dorsal, lateral, and anterior views, ×1; *d–j,* serial transverse sections 0.0, 0.2, 0.7, 1.3, 1.45, 1.6, 5.2 mm from initial section, ×1 (Xu Qing-jie, 1978).

Family ZUGMAYERIIDAE Dagys, 1963

[*nom. correct.* PEARSON, 1977, p. 35, *pro* Zugmayeridae DAGYS, 1963, p. 71]

Shell small, elongate, biconvex, dental plates present; no septum or septalium; crural plates rudimentary or absent; loop short, with low transverse band. *Lower Triassic–Upper Triassic (Rhaetian).*

Zugmayeria WAAGEN, 1882, p. 334 [**Terebratula rhaetica* ZUGMAYER, 1880, p. 13; OD]. Anterior commissure rectimarginate or incipiently uniplicate, beak tapering, suberect, beak ridges obscure; dental plates subparallel; loop short, about 0.3 dorsal valve length, descending lamellae slightly diverging, transverse band almost flat. *Upper Triassic (Rhaetian):* eastern Alps.——FIG. 1348,*2a–e.* **Z. rhaetica* (ZUGMAYER); *a–c,* dorsal, lateral, and anterior views, ×2; *d,* loop, ×2; *e,* transverse section, ×2 (Muir-Wood, 1965a).

Adygelloides DAGYS, 1959a, p. 28 [**A. labensis;* OD]. Anterior commissure uniplicate; beak short, incurved, beak ridges rounded, foramen small, oval, permesothyrid; dental plates long, parallel, pedicle collar lacking; cardinal process low, crural bases distinct; crura falcifer, supported by dorsally directed plates, not reaching valve floor; loop short, with subparallel descending lamellae, transverse band slightly arched. *Upper Triassic (Rhaetian):* northwestern Caucasus.——FIG. 1348,*5a–w.* **A. labensis; a–c,* dorsal, lateral, and anterior views, ×1; *d–w,* serial transverse sections 0.0, 0.9, 1.2, 1.5, 1.6, 1.7, 1.9, 2.0, 2.1, 2.5, 2.7, 2.8, 2.9, 3.1, 3.3, 3.5, 3.8, 4.3, 4.4, 4.9 mm from first section, ×1 (Muir-Wood, 1965a).

Portneufia HOOVER, 1979, p. 7 [**P. episulcata;* OD]. Small, elongate oval, smooth, anterior commissure episulcate to sulciplicate; foramen mesothyrid to permesothyrid, delthyrium closed by small, short, disjunct deltidial plates; pedicle collar present, dental plates short; inner hinge plates present, variable; crura falcifer, deep crural bases may be supported by crural plates; loop with long, slender, descending and ascending lamellae, anterior part of loop unknown. *Lower Triassic:* USA (Idaho).——FIG. 1348,*4a–d.* **P. episulcata; a–b,* dorsal and anterior view of holotype, USNM 242051, ×1; *c–d,* interior views of ventral and dorsal valves, ×1 (Hoover, 1979).

Family JUVAVELLIDAE Bittner, 1896

[*nom. transl.* LEE & others, herein, *pro* Juvavellinae MUIR-WOOD, 1965a, p. 770, *nom. correct. ex* Juvavellinen BITTNER, 1896, p. 132]

Small, smooth, biconvex; no dental plates or septum; loop acuminate (centronelliform) in adult. *Upper Triassic (Norian)–Lower Jurassic.*

Juvavella BITTNER, 1888, p. 127 [**J. suessi;* OD] [=*Juvavellina* BITTNER, 1896, p. 132 (type, *J. kittli*)]. Subtrigonal, with shallow ventral sulcus, anterior commissure rectimarginate or incipiently uniplicate; loop short, about 0.25 dorsal valve length, with small vertical plate directed ventrally. *Upper Triassic (Norian):* eastern Alps.——FIG. 1357,*1a–e.* **J. suessi; a–d,* dorsal, ventral, lateral, and anterior views, ×1; *e,* loop reconstruction, ×1 (Muir-Wood, 1965a).

Slavinithyris TCHORSZHEVSKY, 1986, p. 115 [**S. kamyshani;* OD]. Subpentagonal, anterior commissure rectimarginate; beak high, loop short (about 0.25 dorsal valve length), acuminate. Differs from *Wittenburgella* in absence of outer hinge plates and rectimarginate commissure, and from *Juvavella* in absence of ventral sulcus, and in strongly developed vertical plate and spinous loop. *Lower Jurassic:* Carpathian Mountains.——FIG. 1357,*4a–y.* **S. kamyshani; a–c,* dorsal, lateral, and anterior views of holotype, KhGU 10/9131, ×4; *d–y,* serial transverse sections 0.0, 0.1, 0.25, 0.45, 0.6, 0.7, 0.8, 0.9, 1.05, 1.3, 1.45, 1.65, 1.85, 2.05, 2.35, 2.55, 2.75, 2.95, 3.25, 3.45, 3.7, 3.9 mm from first section, ×8 (Tchorszhevsky, 1986).

Wittenburgella DAGYS, 1959a, p. 30 [**W. minuta;* OD]. Subpentagonal, anterior commissure slightly unisulcate; beak short, incurved; foramen mesothyrid; hinge plates divided, concave ventrally, becoming U-shaped; loop acuminate, 0.5 dorsal valve length, with high median plate extending dorsoventrally. *Upper Triassic (Norian):* northwestern Caucasus.——FIG. 1357,*3a–d.* **W. minuta; a–c,* dorsal, lateral, and anterior views of holotype, ×2 (Muir-Wood, 1965a); *d,* reconstruction of loop, ×2 (Dagys, 1974).

Family UNCERTAIN

Pseudoharttina LIKHAREV, 1934, p. 212 [**P. ovalis;* OD]. Small to medium size, anterior commissure rectimarginate; valves variably convex; hinge plates obsolete; crura arising from socket ridges; dorsal median septum present; all internal structures except loop much thickened; dental plates present but ankylosed to valve wall. *Permian:* Asia, North America (Alaska), Spitzbergen.——FIG. 1357,*2a–b.* **P. ovalis;* dorsal and ventral views, ×1 (Stehli, 1962).——FIG. 1357,*2c–g. P. plica* (KROTOV), Spitzbergen; *c–d,* exterior and interior of dorsal valve, ×1; *e–g,* exterior and interior views of dorsal valves, USNM 134721, ×1 (new).

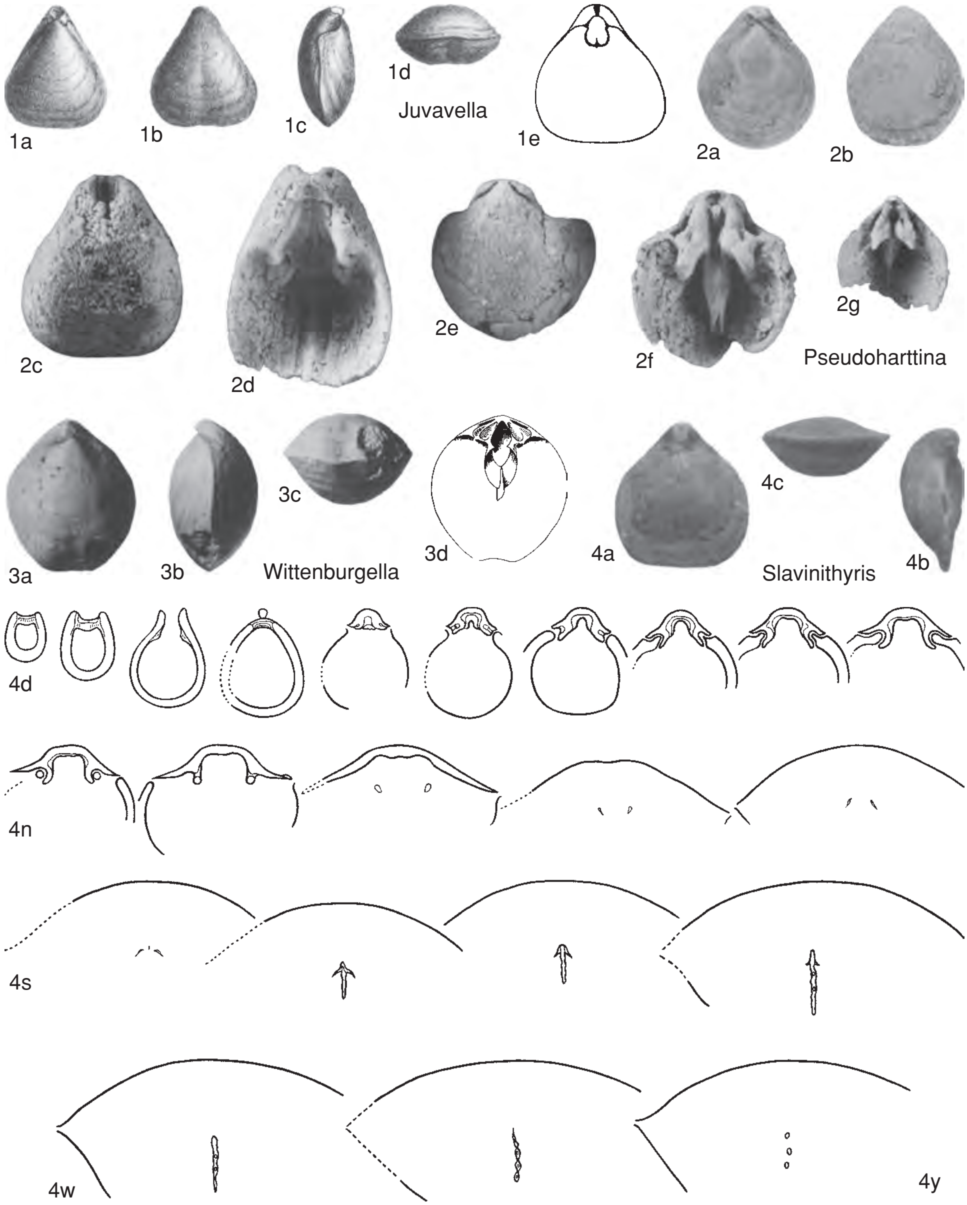

FIG. 1357. Juvavellidae and Uncertain (p. 2052).

TEREBRATULOIDEA

D. E. Lee and T. N. Smirnova

[University of Otago; and Moscow State University]

Superfamily TEREBRATULOIDEA Gray, 1840

[*nom. transl.* Schuchert & LeVene, 1929a, p. 22, *ex* Terebratulidae Gray, 1840, p. 143] [*non* Waagen, 1883, as suborder]

Small to very large, outline rounded, subpentagonal, trigonal or elongate-oval, usually biconvex, anterior commissure rectimarginate, uniplicate, paraplicate, or bisulcate, rarely unisulcate; foramen variable, usually medium to large; modified by deltidial plates, deltidium, or symphytium. No dental plates. No dorsal medium septum. Cardinal process commonly present, variable in size. Loop deltiform, loop development simple (loop growing from crura that meet in transverse band) loop short (varying from 0.2 to 0.4 dorsal valve length); loop generally attached to socket ridges by outer hinge plates, variable in length and width, occasionally absent; inner hinge plates rare; crural bases narrow or broad, attached to socket ridges directly or to dorsal or ventral edge of outer hinge plates. Crural processes vary from bluntly angular to needle sharp, forming focal point in loop; length of descending lamellae variable; transverse band variably arched, horizontal, or posteroventrally directed, narrow or broad. Lophophore plectolophe or modified plectolophe. Spicules present in Holocene species. *?Upper Jurassic, Lower Cretaceous (Berriasian)–Holocene.*

Family TEREBRATULIDAE Gray, 1840

[Terebratulidae Gray, 1840, p. 143]

Small to very large, commonly ventribiconvex; commonly rectimarginate, uniplicate, or sulciplicate; rarely unisulcate; commonly smooth, rarely faintly capillate, rarely peripherally costate or plicate; deltidial plates commonly conjunct, forming symphytium that may be visible or partly concealed; pedicle collar commonly short, excavate; teeth small; cardinal process usually small, transverse; loop variable, usually short (0.25 to 0.35 dorsal valve length), subtriangular; crural processes variable in position, inner hinge plates rarely developed, outer hinge plates usually concave, more rarely flat or absent, variably attached, most commonly to dorsal edge of crural base; transverse band variable; spicules commonly present in Holocene species; lophophore plectolophous. *Paleogene (Paleocene)–Holocene.*

Subfamily TEREBRATULINAE Gray, 1840

[*nom. transl.* Waagen, 1882, p. 330, *ex* Terebratulidae Gray, 1840, p. 143] [=Apletosiinae Cooper, 1983, p. 37]

Anterior commissure rectimarginate, uniplicate or sulciplicate; loop triangular, short to moderately long, crural processes usually anterior of midloop, may be very long, transverse band narrow to broad, anterolateral extremities of loop usually subangular, inner hinge plates rarely developed. *Paleogene (Paleocene)–Holocene.*

Terebratula Müller, 1776, p. 249 [**Anomia terebratula* Linnaeus, 1758, p. 703; SD Lamarck, 1799, p. 89; ICZN plenary powers, 2000, p. 187, Opinion 1,959]. Medium to very large, subpentagonal to broadly oval; smooth; anterior commissure rectimarginate to uniplicate or sulciplicate; beak short, erect; foramen large, mesothyrid to permesothyrid; symphytium partly visible; pedicle collar short; cardinal process variable from a flat semiellipse to a thickened, raised plate or boss; outer hinge plates very narrow or absent, separated from socket ridges by deep trough; no inner hinge plates; loop short, broadly triangular; transverse band narrow, forming a low arch. *Neogene (Miocene–Pleistocene):* Malta, Spain, Poland, Hungary, *Miocene;* Italy, Sicily, Malta, Spain, Algeria, *Pliocene;* Italy, *Pleistocene.*——Fig. 1358,*4a–c.* **T. terebratula* (Linnaeus), Pliocene, Italy; dorsal, lateral, and anterior views of neotype, NHM BG152, ×1 (Lee, Brunton, & others, 2001).——Fig. 1358,*4d–g. T. ampulla* Brocchi, Pliocene, Italy;

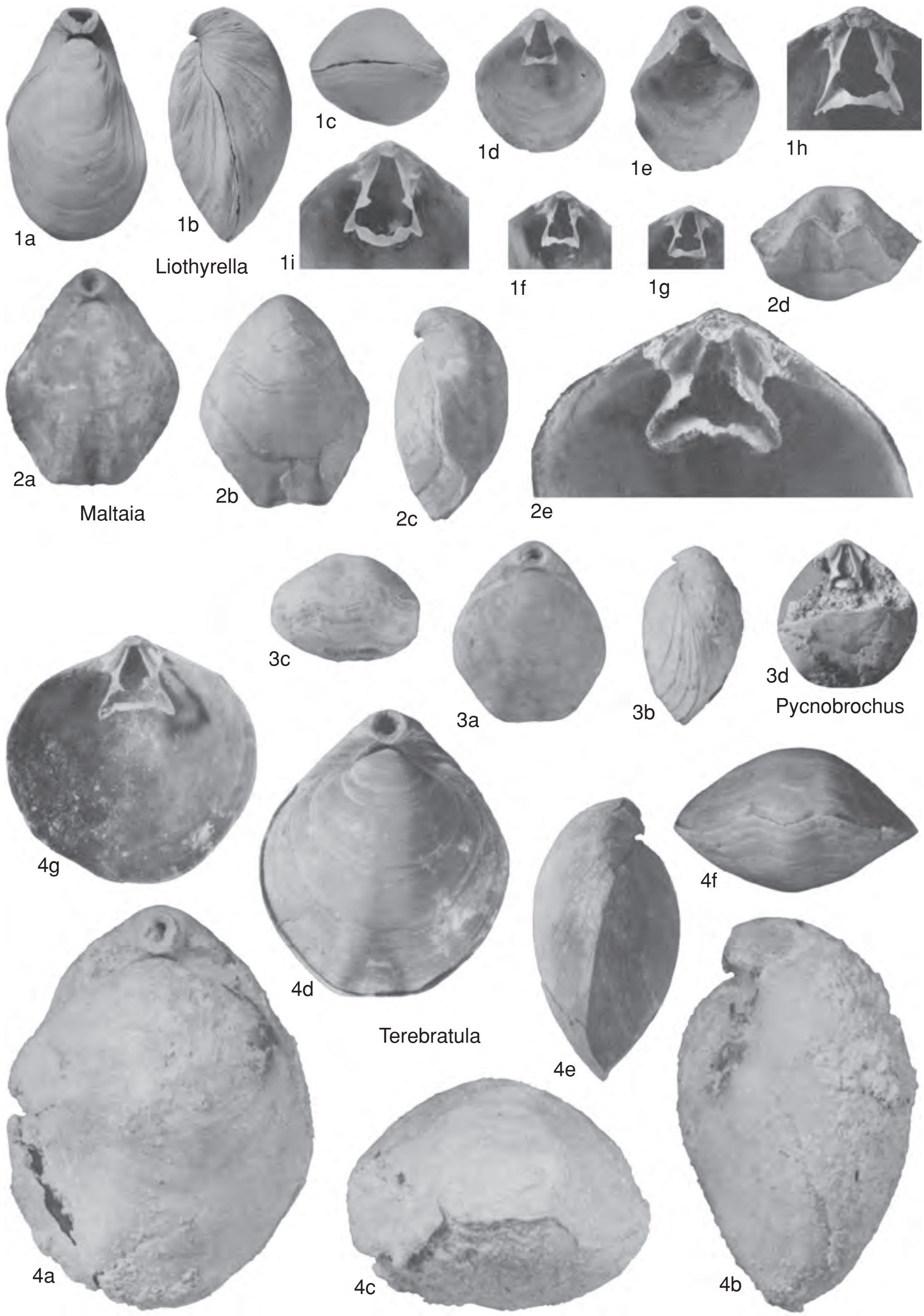

FIG. 1358. Terebratulidae (p. 2054–2057).

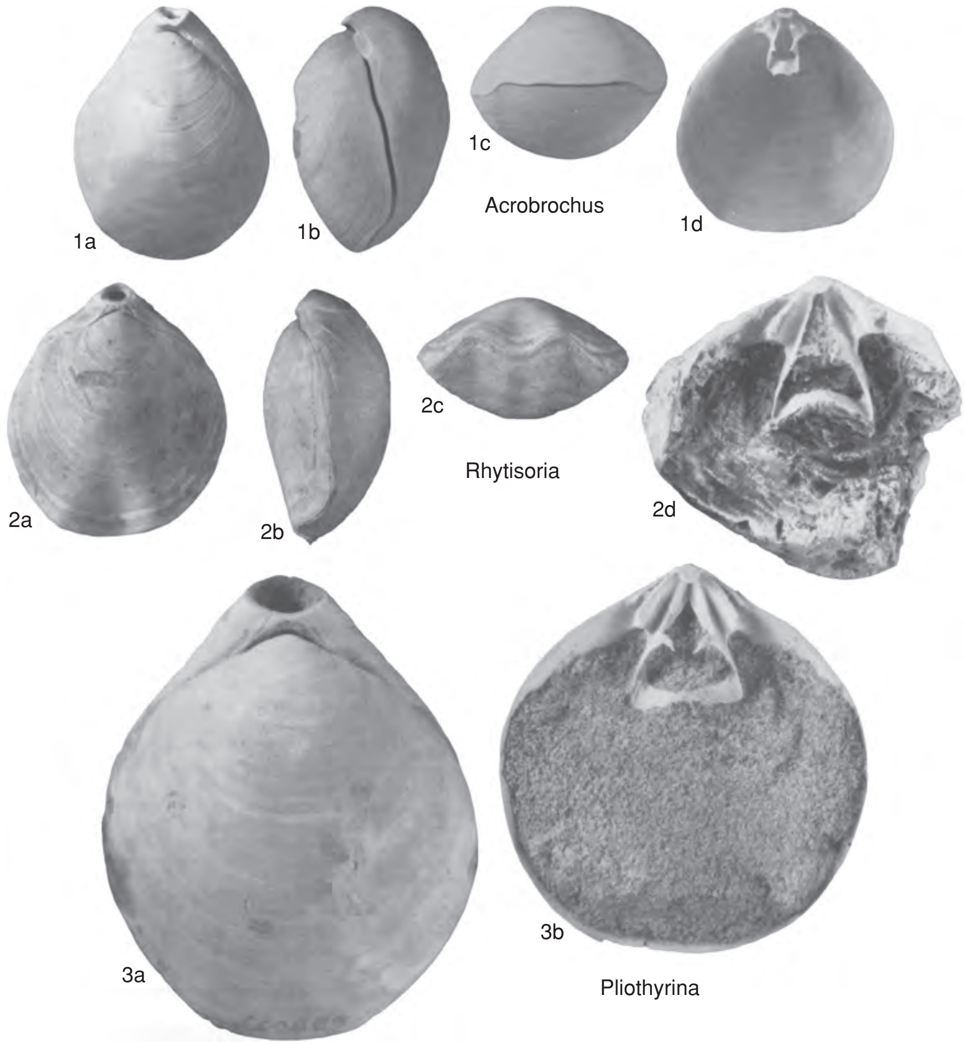

FIG. 1359. Terebratulidae (p. 2056–2057).

d–f, dorsal, lateral, and anterior views, ×1; *g,* dorsal valve interior, ×1 (Cooper, 1983).

Acrobrochus COOPER, 1983, p. 248 [**Liothyrella? vema* COOPER, 1973b, p. 17; OD]. Medium to large, oval to subpentagonal; anterior commissure rectimarginate to uniplicate, smooth; beak suberect, short, labiate; foramen moderately large, permesothyrid; symphytium partly visible; pedicle collar short, excavate; cardinal process is a transverse semiellipse; outer hinge plates taper onto posteroventral edges of crural processes; loop narrow with broad, transverse band. *Paleogene (Eocene)–Holocene:* Australia, *Eocene–Miocene;* New Zealand, *Oligocene–Miocene;* eastern Pacific Ocean off South America, Antarctic Ocean, *Holocene.*——FIG. 1359,*1a–d.* **A. vema* (COOPER), Holocene, off southern Argentina; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* interior of dorsal valve of holotype, USNM 550480a, ×1 (Cooper, 1983).

Liothyrella THOMSON, 1916a, p. 44 [**Terebratula uva* BRODERIP, 1833a, p. 124; OD] [=*Dolichosina* COOPER, 1983, p. 228 (type, *Terebratula oamarutica* BOEHM, 1904, p. 149); *Mimorina* COOPER, 1983, p. 232 (type, *M. ziczac,* OD, =*Liothyrella skinneri* ALLAN, 1932a, p. 8). Large to very large, elongate oval to subcircular; ventribiconvex, anterior commissure usually rectimarginate, occasionally broadly uniplicate; smooth or with faint, radial or zigzag capillae; beak usually short, suberect; foramen usually large, submesothyrid, labiate; symphytium wholly or partly visible; pedicle collar short, teeth triangular, narrow; low myophragm may be present;

cardinal process transverse semiellipse; outer hinge plates variable in width and length; attached near dorsal edge of crural bases; loop variable; usually widely triangular, crural processes located near socket openings, transverse band relatively narrow, variable; spicules abundant. *Paleogene (Eocene)–Holocene:* Australia, *Eocene–lower Miocene, Holocene;* New Zealand, *Eocene–Holocene;* Antarctic Peninsula, *Eocene–Miocene;* eastern Pacific Ocean off Central and South America, Falkland Islands, southern Indian Ocean, sub-Antarctic Ocean, *Holocene.*——FIG. 1358,*1a–e.* **L. uva* (BRODERIP), Holocene; *a–c,* dorsal, lateral, and anterior views of holotype, off Mexico, BMNH ZB1352, ×1.2; *d,* dorsal valve interior with loop, Falkland Islands; *e,* ventral valve interior, Falkland Islands, ×1.2 (Muir-Wood, 1965a).——FIG. 1358,*1f–i. L. neozelanica* THOMSON, Holocene, New Zealand; variation in loops of 4 specimens from single locality, ×1 (Cooper, 1983).

Maltaia COOPER, 1983, p. 231 [**M. maltensis;* OD]. Similar to *Terebratula,* but subpentagonal in outline with strongly sulciplicate anterior commissure; loop wide with protuberant tranverse band. *Neogene (Miocene):* Malta.——FIG. 1358,*2a–e.* **M. maltensis; a–d,* dorsal, ventral, lateral, and anterior views, ×1; *e,* interior of dorsal valve of holotype, USNM 551164c, ×2 (Cooper, 1983).

Pliothyrina ROY, 1980, p. 2 [**Terebratula sowerbyana* NYST, 1845, p. 335; OD] [=*Apletosia* COOPER, 1983, p. 226 (type, *Terebratula maxima* CHARLESWORTH, 1837, p. 92)]. Large to very large, subpentagonal to oval, anterior commissure rectimarginate, becoming moderately sulciplicate in adults; smooth; beak suberect, truncated, labiate; foramen large, mesothyrid to submesothyrid; symphytium short; pedicle collar short, excavate; cardinal process large, subcircular, depressed medially; outer hinge plates very narrow or absent; inner hinge plates small to prominent, disjunct or coalescing; crural bases separated from socket ridges by a marked trough; loop widely triangular; crural processes very long, slender, curved anteromedially; transverse band strongly folded, narrow medially. *Paleogene (Oligocene)–Neogene (Pliocene):* Belgium, England, Germany.——FIG. 1359,*3a–b.* **P. sowerbyana* (NYST), Miocene, Belgium; *a,* dorsal view; *b,* interior of dorsal valve, ×1 (Cooper, 1983).

Pycnobrochus COOPER, 1983, p. 238 [**Liothyrella pulchra* THOMSON, 1918c, p. 118; OD]. Differs from *Liothyrella* in sulciplicate anterior commissure and stout, compact loop. *Paleogene (Eocene):* New Zealand.——FIG. 1358,*3a–d.* **P. pulchra* (THOMSON); *a–c,* dorsal, lateral, and anterior views, ×1; *d,* interior view of dorsal valve, ×1 (Cooper, 1983).

Rhytisoria COOPER, 1983, p. 239 [**R. alabamensis;* OD]. Large, subcircular, smooth; anterior commissure sulciplicate; foramen submesothyrid, symphytium visible; crural bases broad, elevated, forming ridge along inner edge of narrow, outer hinge plates, and deep trough adjacent to socket ridges; loop triangular, wide posteriorly with broadly arched, narrow transverse band. Differs from *Oleneothyris* in position of crural processes, shorter terminal points, and angular transverse band. *Paleogene (Paleocene):* USA (Alabama).——FIG. 1359,*2a–d.* **R. alabamensis; a–c,* dorsal, lateral, and anterior views of holotype, USNM 549392a; *d,* interior of dorsal valve, ×1 (Cooper, 1983).

Subfamily GRYPHINAE Sahni, 1929

[Gryphinae SAHNI, 1929, p. 8]

Medium to large, smooth, rectimarginate to broadly uniplicate; loop short, transverse band broad, crura narrow, outer hinge plate flattish, attached ventrally, crural processes anterior of midloop. *Paleogene (Eocene)–Holocene.*

Gryphus MEGERLE VON MÜHLFELDT, 1811, p. 64, *non Gryphus* BRISSON, 1760, *nom. null.* (see DALL, 1920, p. 310) [**Anomia vitrea* BORN, 1778, p. 104; M] [=*Liothyrina* OEHLERT, 1887b, p. 1,316, obj. (see THOMSON, 1927, p. 193), *nom. nov. pro Liothyris* DOUVILLÉ, 1879, p. 265, *non* CONRAD, 1875]. Elongate oval in outline; ventribiconvex; foramen small to medium, epithyrid; symphytium partially visible; pedicle collar short; cardinal process small, slightly concave, variable; outer hinge plates slightly concave, narrowly triangular; crural bases narrow and flush with inner margin of outer hinge plates; crural processes scooplike in side view; loop short, about 0.25 valve length, variable; descending branches slightly diverging; transverse band broad, gently arched. *Paleogene (Eocene)–Holocene:* Caribbean; Mediterranean, eastern Atlantic, *Miocene–Holocene.*——Fig. 1360,*3a–e.* **G. vitreus* (BORN), Holocene, Mediterranean; *a–c,* dorsal, lateral, and anterior views, ×1 (Muir-Wood, 1965a); *d–e,* interiors of ventral and dorsal valves respectively, ×1 (Logan, 1979).

Subfamily PLICATORIINAE Cooper, 1983

[Plicatoriinae COOPER, 1983, p. 38]

Large, elongate oval, rectimarginate, uniplicate or sulciplicate; smooth or peripherally costate; symphytium visible; pedicle collar short; loop long, with long, outer hinge plates attached dorsally to crural bases; inner hinge plates may be developed; crural processes anterior of midloop, transverse band broad. *Paleogene (Eocene).*

Plicatoria COOPER, 1983, p. 236 [**Terebratula wilmingtonensis* LYELL & SOWERBY in LYELL, 1845, p. 431; OD] [=*Embolosia* COOPER, 1983, p. 229 (type, *E. sphenoidea*)]. Biconvex; ornament and folding highly variable; anterior commissure rectimarginate

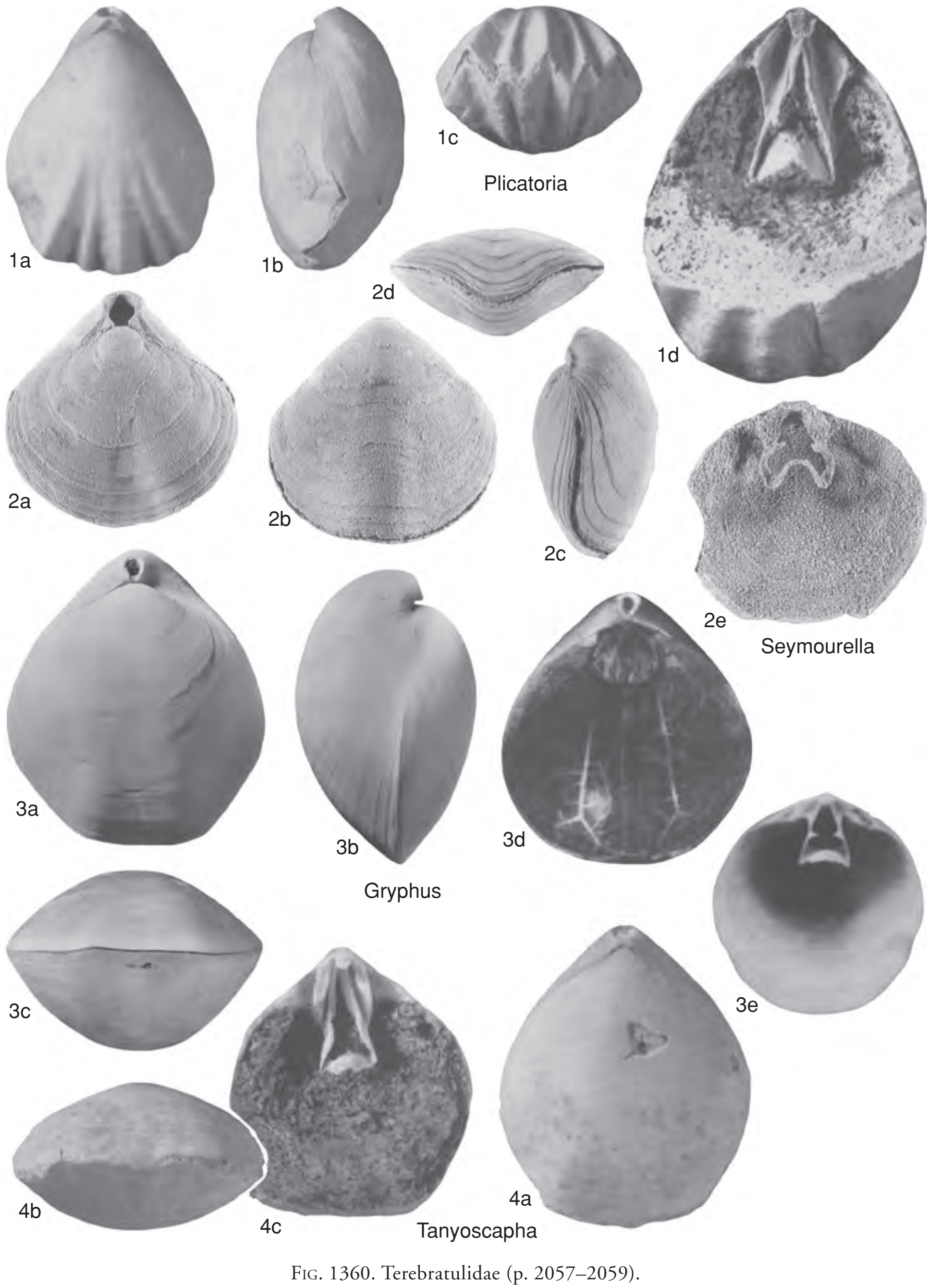

FIG. 1360. Terebratulidae (p. 2057–2059).

to strongly uniplicate; posterior of shell smooth; anterior third to half of shell variably costate to sulciplicate; beak suberect; foramen large, epithyrid to submesothyrid; teeth long, slender; dorsal valve with faint myophragm; cardinal process small, ellipsoidal; outer hinge plates wide, very long; inner hinge plates variable; loop long, triangular; crural processes overhanging broad transverse band. *Paleogene (Eocene):* USA (North Carolina).——FIG. 1360,*1a–d.* **P. wilmingtonensis* (LYELL & SOWERBY);

a–c, dorsal, lateral, and anterior views, ×1; *d,* interior of dorsal valve, ×2 (Cooper, 1983).

Tanyoscapha Cooper, 1983, p. 241 [**T. sigmanae;* OD]. Ventribiconvex, smooth; uniplicate; beak suberect, foramen large, submesothyrid; teeth narrow; cardinal process small, outer hinge plates wide, very long; crural processes short, located close to broad, horizontal transverse band; loop as for *Plicatoria. Paleogene (Eocene):* USA (North Carolina).——Fig. 1360,*4a–c.* **T. sigmanae; a–b,* dorsal and anterior views of holotype, USNM 550911a; *c,* dorsal valve interior, ×1 (Cooper, 1983).

Subfamily SEYMOURELLINAE Bitner, 1996

[*nom. correct.* Lee & Smirnova, herein, *pro* Seymourinae Bitner, 1996, p. 78]

Medium size, smooth, unisulcate, deltidial plates disjunct, loop short, wide anteriorly, with strongly arched transverse band. *Paleogene (Eocene–Oligocene).*

Seymourella Bitner, 1996, p. 78 [**S. oweni;* OD]. Subpentagonal, ventribiconvex, beak large, suberect, foramen large, submesothyrid to mesothyrid; deltidial plates small, triangular, disjunct; pedicle collar very short, cardinal process a transverse depression along posterior margin; outer hinge plates triangular, wide; no inner hinge plates; crural processes long, needlelike, directed ventrally; loop short (0.3 dorsal valve length), very wide anteriorly, with thin, strongly arched transverse band. *Paleogene (Eocene–Oligocene):* Antarctic Peninsula (Seymour Island).——Fig. 1360,*2a–e.* **S. oweni; a–d,* dorsal, ventral, lateral, and anterior views of holotype, ZPAL Bp.XXXVII/140; *e,* interior of dorsal valve, ×1 (Bitner, 1997).

Subfamily TICHOSININAE Cooper, 1983

[Tichosininae Cooper, 1983, p. 37]

Small to large, smooth, ventribiconvex; anterior commissure rectimarginate to uniplicate; beak labiate; outer hinge plates attached to crural bases dorsally; crural processes anterior to midloop; crural props rare; no inner hinge plates; loop short with nearly parallel sides; transverse band usually broad, nearly horizontal to slightly arched medially; anterolateral extremities of loop rounded to angular. *Paleogene (Oligocene)–Holocene.*

Tichosina Cooper, 1977, p. 61 [**T. floridensis* Cooper, 1977, p. 73; OD] [=*Eurysina* Cooper, 1983, p. 259 (type, *Tichosina ovata* Cooper, 1977, p. 79)]. Small to large, subtriangular to ovate in outline; anterior commissure rectimarginate to widely uniplicate; beak suberect, foramen small to large, mesothyrid to permesothyrid; symphytium partially visible; pedicle collar short, teeth narrow; cardinal process elliptical; outer hinge plates variable, concave, with broad, flattish crural bases extending to apex and walling off outer hinge plates, which are attached to dorsal edge of crural base distally; loop small, narrow; crural processes blunt, generally overhanging posterior of broad, medially folded transverse band. *Paleogene (Oligocene)–Holocene:* Caribbean Sea, Gulf of Mexico.——Fig. 1361,*2a–d.* **T. floridensis,* Holocene, off Florida, Gulf of Mexico; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* interior of dorsal valve, ×2 (Cooper, 1983).

Arctosia Cooper, 1983, p. 250 [**Terebratula arctica* Friele, 1878, p. 221; OD]. Small, rectimarginate, foramen small, permesothyrid; pedicle collar long, excavate, tubular; outer hinge plates long, narrow, deeply concave; loop short, wide, with subparallel sides; transverse band narrow, nearly horizontal. *Holocene:* off Greenland.——Fig. 1361,*1a–d.* **A. arctica* (Friele); *a–c,* dorsal, lateral, and anterior views, ×1; *d,* dorsal valve interior, ×3 (Cooper, 1983).

Dolichozygus Cooper, 1983, p. 253 [**Terebratula stearnsi* Dall & Pilsbry, 1891, p. 165; OD]. Large, elongate subtriangular, uniplicate; beak narrow, long, suberect; foramen large, submesothyrid; symphytium visible; pedicle collar long, excavate; outer hinge plates long, loop short, with subparallel sides; transverse band folded, very broad. *Neogene (Pliocene)–Holocene:* Japan.——Fig. 1361,*5a–d.* **D. stearnsi* (Dall & Pilsbry), Holocene, Sagami Bay; *a–c,* dorsal, lateral, and anterior views; *d,* dorsal valve interior, ×1 (Cooper, 1983).

Dysedrosia Cooper, 1983, p. 256 [**Gryphus borneoensis* Dall, 1920, p. 314; OD]. Large, oval; anterior commissure broadly uniplicate; beak truncated; foramen medium, mesothyrid; pedicle collar short, teeth small; cardinal process small, shelflike; outer hinge plates wide, concave; crural bases broad; loop parallel sided, transverse band broad. *Holocene:* off Borneo.——Fig. 1361,*4a–d.* **D. borneoensis* (Dall); *a–c,* dorsal, lateral, and anterior views of holotype, USNM 229297a; *d,* interior of dorsal valve of holotype, ×1 (Cooper, 1983).

Erymnia Cooper, 1977, p. 92 [**E. muralifera;* OD]. Medium size, rounded oval; anterior commissure rectimarginate to uniplicate; beak suberect, truncated; foramen small, submesothyrid, symphytium partially visible; pedicle collar short, excavate; cardinal process small, semicircular; outer hinge plates short, gently concave, attached to top of broad crural bases; crural bases attached to valve floor by two nearly vertical plates; loop small, narrow. *Holocene:* Caribbean Sea.——Fig. 1361,*3a–e.* **E. muralifera; a–c,* dorsal, lateral, and anterior views of holotype, USNM 550520; *d,* interior of dorsal valve, ×1; *e,* closeup, oblique view of loop of holotype, ×2 (Cooper, 1977).

Zygonaria Cooper, 1983, p. 275 [**Gryphus joloensis* Dall, 1920, p. 313; OD]. Small to medium, rounded oval; rectimarginate; beak short, erect; foramen medium, mesothyrid; pedicle collar well

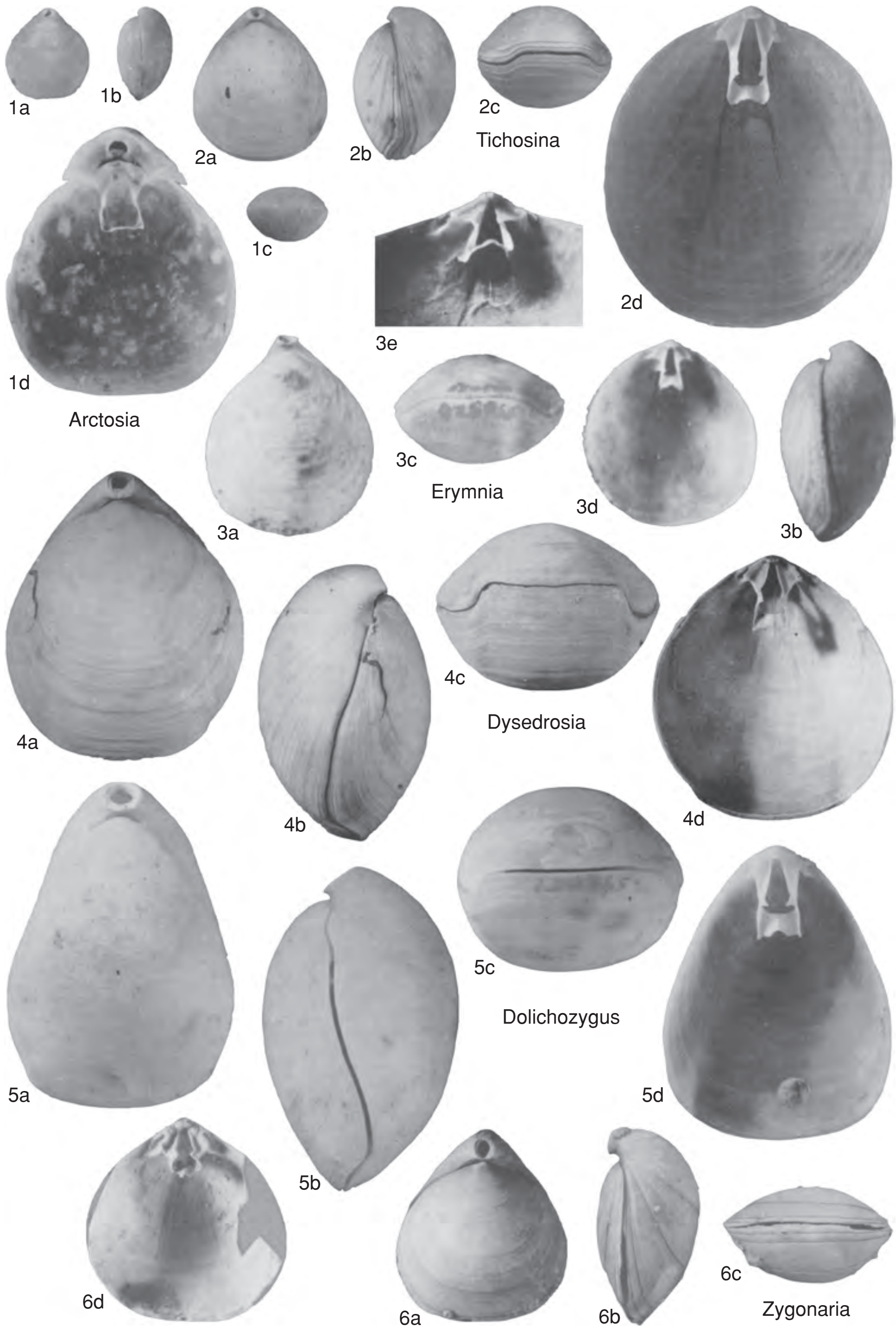

FIG. 1361. Terebratulidae (p. 2059–2061).

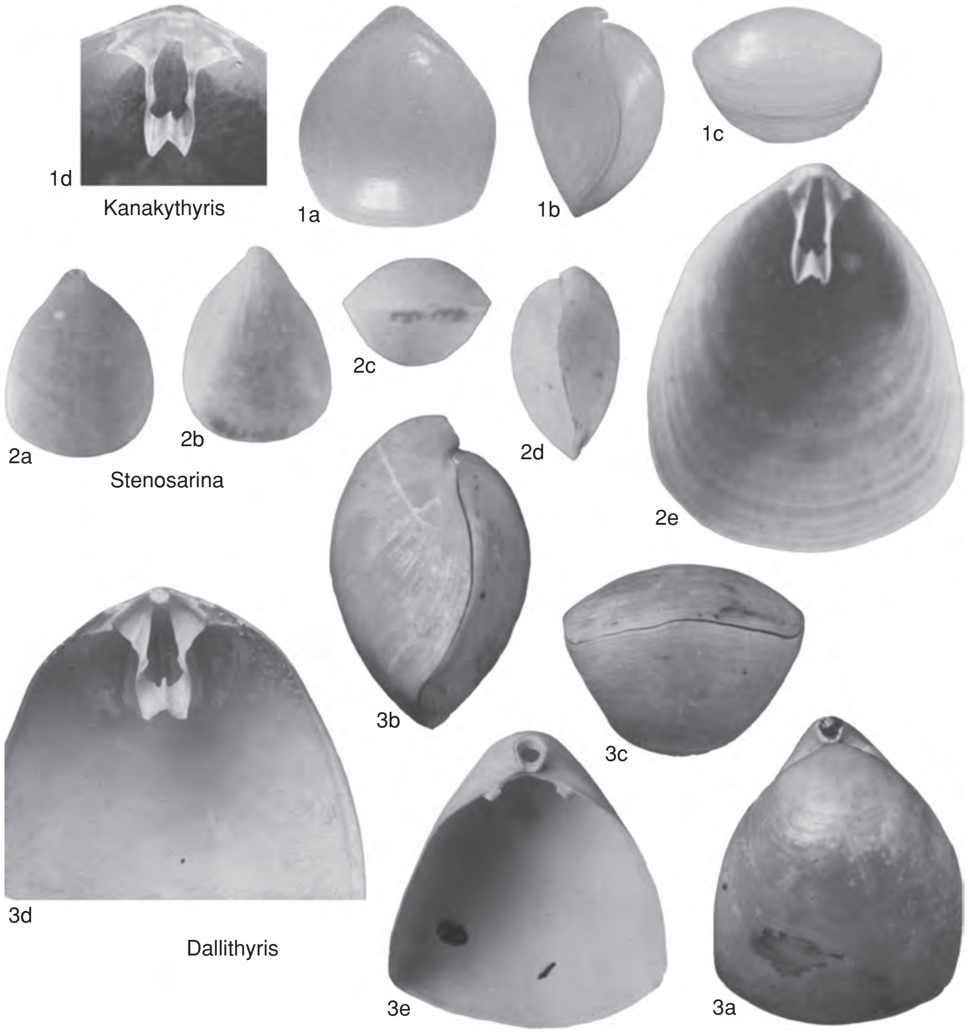

FIG. 1362. Terebratulidae (p. 2061–2062).

developed, teeth large; cardinal process large, semicircular; loop anteriorly rounded and narrowed. *Holocene:* Philippines, Japan.——FIG. 1361,*6a–d*. **Z. joloensis* (DALL), Philippines; *a–c,* dorsal, lateral, and anterior views, ×2; *d,* interior of dorsal valve of holotype, USNM 111062a, ×2 (Cooper, 1983).

Subfamily DALLITHYRIDINAE Katz & Popov, 1974

[Dallithyridinae KATZ & POPOV, 1974a, p. 29; *emend.,* LEE & SMIRNOVA, herein]

Medium to large, smooth, strongly biconvex or ventribiconvex; symphytium partially visible; pedicle collar short, teeth very small; crural bases broad, blunt; loop small, narrow; transverse band broad, with strong median fold. *Paleogene (?Eocene); Neogene (Pliocene)–Holocene.*

Dallithyris MUIR-WOOD, 1959, p. 302 [**D. murrayi;* OD] [=*Epacrosina* COOPER, 1983, p. 256 (type, *Liothyrina fulva* BLOCHMANN, 1906, p. 698)]. Medium to large, subtrigonal to subpentagonal; ventribiconvex, anterior commissure rectimarginate to broadly uniplicate; beak suberect, short, labiate; foramen large, submesothyrid; symphytium short; cardinal process small semiellipse; outer hinge plates broadly triangular, crural bases poorly defined; loop narrow, variable. *Paleogene (?Eocene); Neogene*

(Pliocene)–Holocene: Pacific (Eua, Fiji), *?Eocene, Pliocene–Pleistocene;* Indian Ocean, Pacific Ocean, off South Australia and Tasmania, *Holocene.*——FIG. 1362,*3a–e.* **D. murrayi,* Maldive Islands, Indian Ocean, Holocene; *a–c,* dorsal, lateral, and anterior views of holotype, BMNH ZB1570, ×1; *d,* interior of dorsal valve, ×2; *e,* interior of ventral valve, ×1 (Muir-Wood, 1965a).

Kanakythyris LAURIN, 1997, p. 441 [**K. pachyrhynchos;* OD]. Medium size, strongly biconvex, subcircular to subpentagonal in outline, anterior commissure unisulcate; beak incurved, foramen very small. *Holocene:* southwestern Pacific (New Caledonia).——FIG. 1362,*1a–d.* **K. pachyrhynchos; a–c,* dorsal, lateral, and anterior views of holotype, ×1; *d,* closeup of loop of juvenile specimen, ×2 (Laurin, 1997).

Stenosarina COOPER, 1977, p. 95 [**S. angustata;* OD] [=*Stenobrochus* COOPER, 1983, p. 269 (type, *S. crosnieri*)]. Medium size; elongate triangular in outline; ventribiconvex; anterior commissure rectimarginate; beak suberect, labiate; foramen small, mesothyrid to permesothyrid; pedicle collar short, excavate; teeth small, narrow; cardinal process small, ellipsoidal; outer hinge plates narrow, long, tapering; crural bases elevated along inner margins of outer hinge plates. *Pliocene–Holocene:* Sicily, *Pliocene;* Gulf of Mexico, Caribbean, eastern Atlantic, southwestern Pacific (New Caledonia), Indian Ocean (Madagascar), *Holocene.*——FIG. 1362,*2a–e.* **S. angustata,* Holocene, Gulf of Mexico; *a–d,* dorsal, ventral, lateral, and anterior views of holotype, USNM 550594, ×1; *e,* interior of dorsal valve of holotype, ×2 (Cooper, 1977).

Family SELLITHYRIDIDAE Muir-Wood, 1965

[*nom. transl.* LEE & SMIRNOVA, herein, *ex* Sellithyridinae MUIR-WOOD, 1965a, p. 793]

Small to large, subpentagonal, oval or subcircular in outline; smooth or finely capillate, rarely costate; biconvex or ventribiconvex, cardinal process commonly small, anterior commissure highly variable, rectimarginate, unisulcate, uniplicate, sulciplicate, or bisulcate; outer hinge plates dorsally attached to crural bases; inner hinge plates may be present; loop short; crural processes near or anterior to midloop, transverse band narrow to moderately broad. *?Upper Jurassic, Lower Cretaceous (Berriasian)–Paleogene (Eocene).*

Subfamily SELLITHYRIDINAE Muir-Wood, 1965

[Sellithyridinae MUIR-WOOD, 1965a, p. 793]

Medium to small, commonly smooth, subpentagonal to oval in outline, rarely faintly capillate or costate, beak generally short, foramen mesothyrid or permesothyrid; no inner hinge plates; outer hinge plates narrow, concave in section; loop triangular, transverse band narrow, with high arch. *Lower Cretaceous (Berriasian)–Upper Cretaceous (Turonian).*

Sellithyris MIDDLEMISS, 1959, p. 113 [**Terebratula sella* J. DE C. SOWERBY, 1823 in 1823–1825, p. 53; OD]. Small to medium, subpentagonal in outline, anterior commissure strongly sulciplicate, shell may be faintly capillate; beak short, erect, foramen large, marginate, mesothyrid to permesothyrid; cardinal process semiellipse; outer hinge plates wide, concave, forming deep, U-shaped troughs between socket ridges and crural bases; no inner hinge plates; loop wide, triangular; transverse band narrow, strongly arched and protuberant. *Cretaceous (Berriasian–Turonian):* Ukraine, Kazakstan, Caucasus, Georgia, *Berriasian–Hauterivian;* Mexico, *Hauterivian;* England, France, Belgium, Germany, Spain, Switzerland, Sardinia, Egypt, Turkmenia, Tibet, *Aptian–Turonian.*——FIG. 1363,*1a–t.* **S. sella* (J. DE C. SOWERBY), Aptian, Isle of Wight, England; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* dorsal valve interior, ×1 (Cooper, 1983); *e–t,* serial transverse sections 3.6, 3.8, 4.2, 4.6, 5.0, 5.2, 5.4, 5.5, 5.6, 6.0, 6.8, 7.4, 8.0, 9.2, 9.8, 10.0 mm from ventral umbo, ×1 (Middlemiss, 1959).

Boubeithyris COX & MIDDLEMISS, 1978, p. 419 [**Terebratula boubei* D'ARCHIAC, 1847, p. 320; OD]. Oval pentagonal in outline, biconvex, foramen large, circular, mesothyrid, anterior commissure rectimarginate to sulciplicate to bisulcate; hinge plates thin, concave, transverse band highly arched. *Cretaceous (?Hauterivian; Barremian–Cenomanian):* England, Belgium, France, Germany, Poland, Morocco.——FIG. 1364,*3a–d.* **B. boubei* (D'ARCHIAC), Cenomanian, Belgium; *a–c,* dorsal, lateral, and anterior views of neotype, IRScNB M.T.C.10154, ×1 (Cox & Middlemiss, 1978); *d,* dorsal valve interior, ×1 (Cooper, 1983).

Glosseudesia LOBATSCHEVA, 1974, p. 146 [**Terebratula semistriata* DEFRANCE, 1828b, p. 156; OD; *non Glosseudesia semistriata* LOBATSCHEVA, 1974; =*Luppovithyris ovalis* LOBATSCHEVA, 1990] [=*Costithyris* MIDDLEMISS, 1981, p. 702, obj.]. Subcircular to oval, costate; rectimarginate to bisulcate; beak suberect, foramen mesothyrid; hinge plates concave, becoming cuneate, not strongly differentiated from inner socket ridges; loop lamellae narrow and thin, transverse band high arched and slightly trapezoidal. [LOBATSCHEVA (1974) described a new genus, *Glosseudesia,* based upon a Neocomian, long-looped brachiopod from Turkmenia. Unfortunately, she designated the short-looped species, *Terebratula semistriata* DEFRANCE, 1828b, as type species of this new genus. In 1990, LOBATSCHEVA redescribed the long-looped Turkmenian species as *Luppovithyris ovalis.* "The

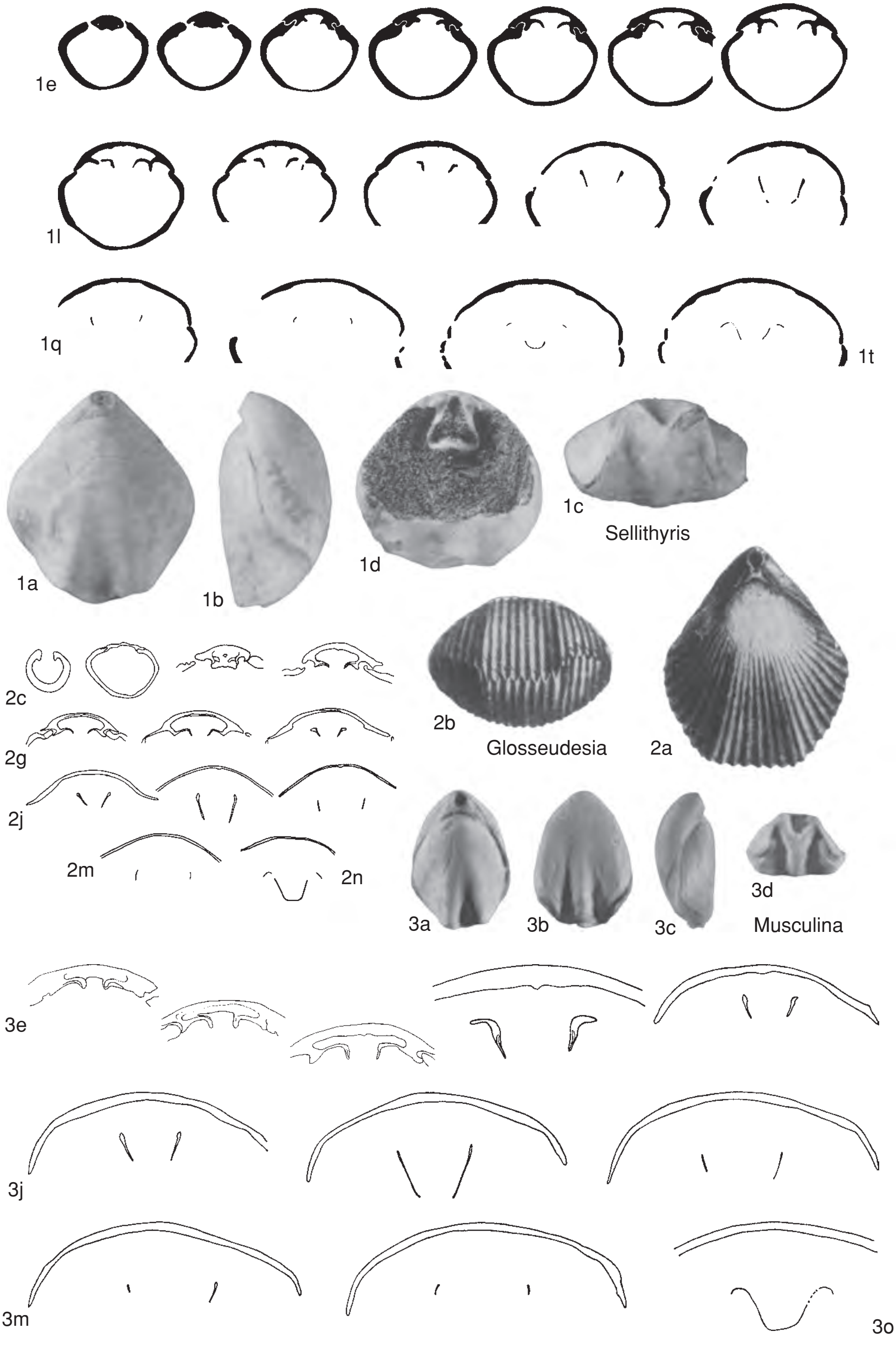

FIG. 1363. Sellithyrididae (p. 2062–2065).

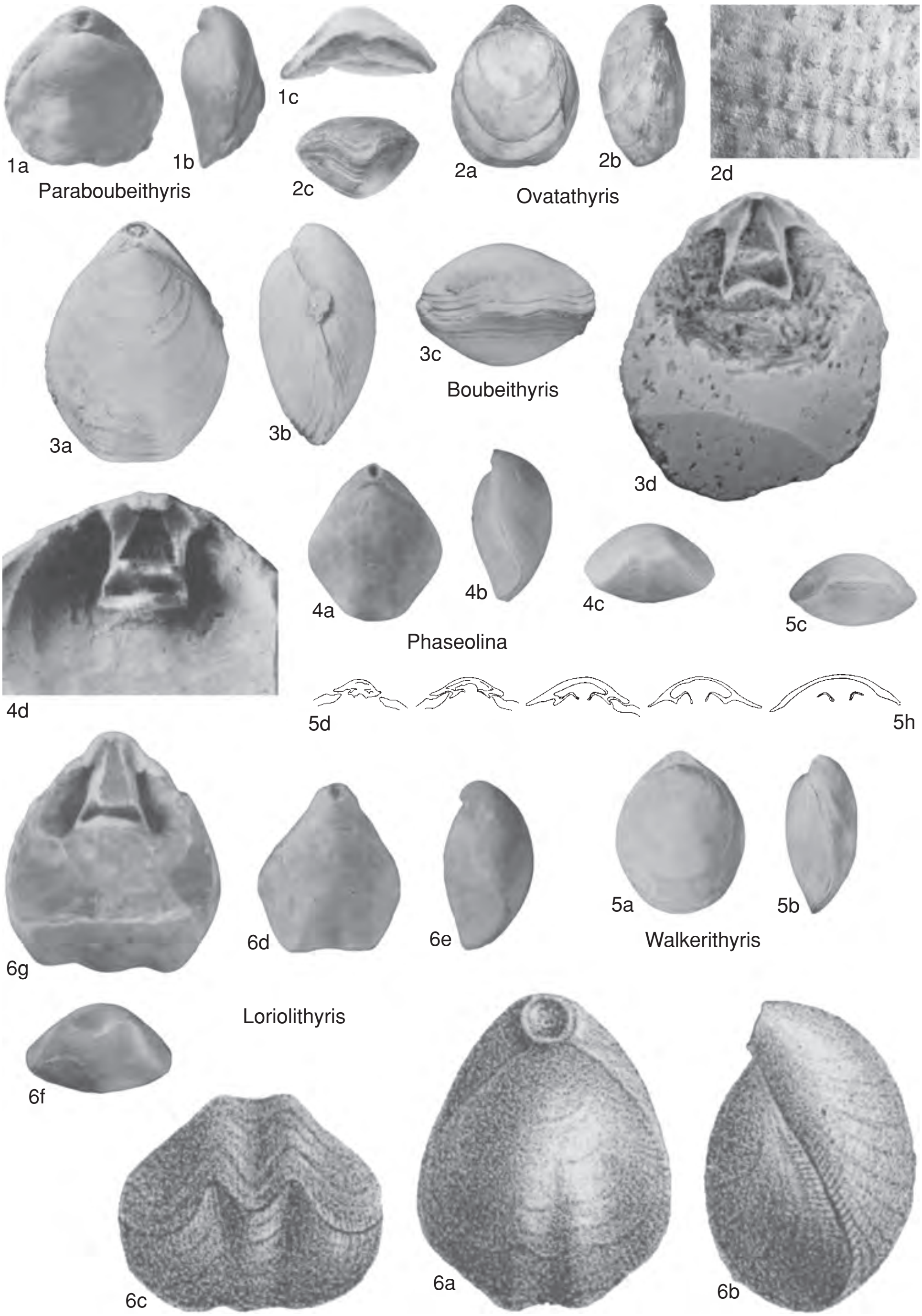

FIG. 1364. Sellithyrididae (p. 2062–2065).

diagnosis, description, and figures accompanying the erection of the new generic name [*Glosseudesia*] are not applicable to *T[erebratula] semistriata* DEFRANCE. . . . Nevertheless, since LOBACHEVA designated *T. semistriata* DEFRANCE, 1828b, as type species of *Glosseudesia,* the latter must stand as the valid generic name for DEFRANCE's species, irrespective of the inappropriate text and figures that accompany it. *Costithyris* MIDDLEMISS, 1981, is therefore a junior objective synonym of *Glosseudesia* LOBACHEVA, 1974" (see MIDDLEMISS, 1983, p. 689). The description and serial sections figured herein are from MIDDLEMISS, 1981.] *Lower Cretaceous (Valanginian–Barremian):* Switzerland, France, Turkmenia.——FIG. 1363,*2a–n.* **G. semistriata* (DEFRANCE), Switzerland; *a–b,* dorsal and anterior views, ×1 (Pictet, 1872); *c–n,* serial transverse sections 0.8, 2.4, 2.8, 3.2, 4.0, 4.4, 4.8, 5.2, 6.0, 6.4, 7.2, 8.0 mm from ventral umbo, ×1 (adapted from Middlemiss, 1981).

Loriolithyris MIDDLEMISS, 1968, p. 176 [**Terebratula russillensis* DE LORIOL, 1868, p. 88; OD]. Similar to *Sellithyris,* but less strongly folded; cardinal process bilobed; outer hinge plates narrow, loop short, thin, transverse band narrow, rarely preserved. *Lower Cretaceous:* Europe, Morocco, northwestern Caucasus, Kazakstan, Turkmenia.——FIG. 1364,*6a–c.* **L. russillensis* (DE LORIOL), Barremian, Switzerland; dorsal, lateral, and anterior views of lectotype, CB 1520, ×1 (de Loriol, 1868).——FIG. 1364,*6d–g. L. valdensis* DE LORIOL, Valanginian, Switzerland; *d–f,* dorsal, lateral, and anterior views, ×1; *g,* interior of dorsal valve, ×2 (Cooper, 1983).

Musculina SCHUCHERT & LEVENE, 1929b, p. 120, *nom. nov. pro Musculus* QUENSTEDT, 1868 in 1868–1871, p. 27, *non* BOLTEN, 1798, *nec* RAFINESQUE, 1818 [**Terebratula biplicata acuta* VON BUCH, 1835, p. 108; SD S. BUCKMAN, 1907a, p. 530; *non Terebratula acuta* J. SOWERBY, 1816, p. 115; =*Terebratula sanctaecrucis* CATZIGRAS, 1948, p. 391]. Medium size, elongate, dorsal valve strongly convex posteriorly, flattening anteriorly; anterior commissure sulciplicate, plication developed at an early growth stage; beak straight to suberect, symphytium bordered by ridges; foramen small, mesothyrid to permesothyrid; cardinal process small, wide, bilobed; hinge plates strongly concave, crural bases high, not clearly differentiated from hinge plates, clubbed; crural processes thickened at bases, incurved at tips, loop narrow, thin; transverse band thin, high arched. *Lower Cretaceous:* Germany, Switzerland, Russia, Spain, Sardinia, Caucasus, Turkmenia, Georgia.——FIG. 1363,*3a–o.* **M. sanctaecrucis* (CATZIGRAS), Hauterivian, Switzerland; *a–d,* dorsal, ventral, lateral, and anterior views, ×1; *e–g,* serial transverse sections 3.6, 4.0, 4.4 from ventral umbo, ×2; *h–o,* serial transverse sections 4.8, 5.2, 5.6, 6.4, 6.8, 7.2, 7.6, 8.6 mm from ventral umbo, ×2 (Dieni, Middlemiss, & Owen, 1975).

Ovatathyris OWEN, 1988, p. 106 [**Terebratula ovata* J. SOWERBY, 1812 in 1812–1815, p. 46; OD]. Oval, shell ornament of short, radiating spinules, anterior commissure unisulcate to paraplicate; foramen large, mesothyrid; cardinal process low, flat. Differs internally from *Boubeithyris* in longer, more acutely concave outer hinge plates. *Upper Cretaceous (Cenomanian):* England.——FIG. 1364,*2a–d.* **O. ovata* (J. SOWERBY); *a–c,* dorsal, lateral, and anterior views, ×1; *d,* enlargement of spinules on dorsal valve exterior, ×10 (Owen, 1988).

Paraboubeithyris MIDDLEMISS, 1980, p. 533 [**P. plicae;* OD]. Rounded pentagonal in outline, smooth, beak erect, anterior commissure strongly uniplicate or sulciplicate with very small, asymmetric median sinus; dorsal valve with strong median fold extending from umbonal region to anterior commissure; foramen mesothyrid; hinge plates concave, thin, sharply differentiated from inner socket ridges, piped to strongly corniced; transverse band with high arch. *Lower Cretaceous (Hauterivian–Barremian):* Morocco.——FIG. 1364,*1a–c.* **P. plicae,* Barremian; dorsal, lateral, and anterior views of holotype, S.548/1/3, ×1 (Middlemiss, 1980).

Phaseolina GASPARD, 1988, p. 163 [**Terebratula phaseolina* LAMARCK, 1819, p. 252; OD; =*Aphragmus sohli* COOPER, 1983, p. 172] [=*Aphragmus* COOPER, 1983, p. 171, *nom. imperf.* (type, *A. sohli,* OD)]. Medium size, subpentagonal to subcircular in outline; biconvex, smooth with fine lateral capillae, anterior commissure sulciplicate; foramen large, mesothyrid to permesothyrid; cardinal process small, bilobed; loop similar to that of *Sellithyris,* but narrow anteriorly; outer hinge plates long, narrow, concave, tapering anteriorly into crural processes. *Upper Cretaceous (Cenomanian):* France, Spain, Czech Republic, Slovakia.——FIG. 1364,*4a–d.* **P. phaseolina* (LAMARCK), France; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* closeup of loop, ×1 (Cooper, 1983).

?Walkerithyris COX & MIDDLEMISS, 1978, p. 424 [**W. mendax* COX & MIDDLEMISS, 1978, p. 425; OD; =*Terebratula moutoniana* WALKER in LAMPLUGH & WALKER, 1903, p. 251, *non T. moutoniana* D'ORBIGNY, 1849]. Subpentagonal, smooth, dorsibiconvex, anterior commissure uniplicate; beak short, wide, foramen circular, mesothyrid; hinge plates wide, thin, deeply concave, piped. [Subfamily placing is uncertain, as loop is not known.] *Lower Cretaceous (Albian):* England.——FIG. 1364,*5a–h.* **W. mendax*; *a–c,* dorsal, lateral, and anterior views, ×1; *d–h,* serial transverse sections 3.2, 3.6, 4.0, 4.2, 4.8 mm from ventral umbo, ×1.5 (Cox & Middlemiss, 1978).

Subfamily NERTHEBROCHINAE Cooper, 1983

[Nerthebrochinae COOPER, 1983, p. 38]

Medium size, planoconvex to ventribiconvex, smooth; foramen large, mesothyrid or submesothyrid, loop short, with broad, transverse band; outer hinge plates attached at or near dorsal edge of crural base; inner hinge plates may be present. *Lower Cretaceous (Valanginian)–Paleogene (lower Eocene).*

Nerthebrochus Cooper, 1983, p. 206 [**Terebratula robertoni* d'Archiac, 1847, p. 315; OD]. Planoconvex, anterior commissure rectimarginate to slightly uniplicate; foramen submesothyrid; symphytium exposed; cardinal process wide, semiellipse, outer hinge plates wide, triangular, concave, attached along dorsal edge of crural bases; loop short, triangular. *Upper Cretaceous (Cenomanian):* Belgium.——Fig. 1365,*1a–d. *N. robertoni* (d'Archiac), Belgium; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* dorsal valve interior, ×1 (Cooper, 1983).

Dilophosina Cooper, 1983, p. 187 [**D. paraplicata;* OD]. Oval, ventribiconvex, anterior commissure paraplicate; foramen large, mesothyrid; no inner hinge plates, outer hinge plates attached to dorsal part of crural bases; loop short, squarish, transverse band narrow, nearly horizontal. Similar to *Boubeithyris,* but paraplicate rather than sulciplicate. *Upper Cretaceous (Cenomanian):* France, Spain.——Fig. 1365,*3a–d. *D. paraplicata,* France; *a–c,* dorsal, ventral, and anterior views of holotype, USNM 550932a, ×1; *d,* dorsal valve interior, ×1 (Cooper, 1983).

Hadrosia Cooper, 1983, p. 195 [**H. convexa;* OD]. Externally similar to *Sellithyris,* but more strongly convex and beak more incurved; loop anteriorly rounded with stout, broad, transverse band. *Lower Cretaceous (Valanginian):* France.——Fig. 1365,*4a–d. *H. convexa; a–c,* dorsal, lateral, and ventral views of holotype, USNM 550930a; *d,* dorsal valve interior, ×1 (Cooper, 1983).

Harmatosia Cooper, 1983, p. 196 [**Terebratula crassa* d'Archiac, 1847, p. 318; OD]. Similar to *Dilophosina,* but with well-developed inner hinge plates. *Upper Cretaceous (Cenomanian):* Belgium, Germany.——Fig. 1365,*2a–d. *H. crassa* (d'Archiac), Germany; *a–c,* dorsal, lateral, and anterior views; *d,* dorsal valve interior, ×1 (Cooper, 1983).

Leymerithyris Calzada Badia in Calzada Badia, Seguier, & Tambareau, 1988, p. 40 [**Terebratula montolearensis* Leymerie, 1846, p. 362; OD]. Oval, biconvex, uniplicate or biplicate; outer hinge plates corniced or fasciculate; inner hinge plates concave; crural processes at midloop. *Paleogene (lower Eocene):* Spain, France.——Fig. 1365,*5a–h. *L. montolearensis* (Leymerie); *a–c,* dorsal, lateral, and anterior views, ×1; *d–g,* serial transverse sections 2.9, 6.1, 6.9, 8.8 mm from ventral umbo, approximately ×1; *h,* loop reconstruction, ×2 (Calzada Badia, Seguier, & Tambareau, 1988).

Subfamily RECTITHYRIDINAE Muir-Wood, 1965

[Rectithyridinae Muir-Wood, 1965a, p. 795]

Large, smooth, biconvex, beak generally elongate, exposing large, convex symphytium, foramen large, permesothyrid to mesothyrid; inner hinge plates rare; loop widely triangular, transverse band broad. *?Upper Jurassic, Lower Cretaceous (Berriasian)–Upper Cretaceous (Maastrichtian).*

Rectithyris Sahni, 1929, p. 9 [**Terebratula depressa* Valenciennes in Lamarck, 1819, p. 249; OD; =*T. nerviensis* d'Archiac, 1847, p. 313] [=*Cyranoia* Cooper, 1983, p. 185 (type, *Terebratula depressa vissae* Hadding, 1919, p. 20, OD)]. Ventribiconvex, elongate oval, anterior commissure rectimarginate, uniplicate or sulciplicate; beak long, erect; foramen large, mesothyrid; symphytium large, convex; cardinal process transverse semiellipse; inner hinge plates variably developed in some adult specimens; thick, inclined socket ridges, crural bases and outer hinge plates forming U-shaped troughs (virgate keeled outer hinge plates), transverse band of loop medianly horizontal. *Cretaceous (Albian–Coniacian):* Spain, Crimea, *Albian;* Belgium, England, Germany, Poland, Russia, Tibet, India, *Cenomanian;* Antarctic Peninsula, *Albian–Coniacian.*——Fig. 1366,*1a–i. *R. depressa* (Valenciennes), Cenomanian, Belgium; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* closeup of loop, ×2 (Cooper, 1983); *e–i,* serial transverse sections 6.0, 6.5, 8.0, 9.0, 11.5 mm from ventral umbo, ×2 (Cox & Middlemiss, 1978).

Collinithyris Middlemiss, 1981, p. 722 [**Terebratula collinaria* d'Orbigny, 1849 in 1849–1852, p. 81; OD]. Subcircular or subpentagonal, anterior commissure uniplicate to gently sulciplicate; beak suberect, symphytium exposed; hinge plates initially horizontal, becoming gently concave; cuneate, not clearly differentiated from socket ridges; loop lamellae thin; transverse band low arched. *Lower Cretaceous (Valanginian–Aptian):* Europe.——Fig. 1366,*3a–d. *C. collinaria* (d'Orbigny), Neocomian, France; dorsal, ventral, lateral, and anterior views, ×1 (Smirnova, 1990a).

Cyrtothyris Middlemiss, 1959, p. 123 [**Terebratula depressa* var. *cyrta* Walker, 1868, p. 404; OD]. Oval to subpentagonal, biconvex, anterior commissure uniplicate; beak short, foramen large, mesothyrid; symphytium narrow, exposed; cardinal process small; loop wide, hinge plates ventrally concave, slightly clubbed, keeled. *Cretaceous (Valanginian–Campanian):* Mexico, *Valanginian;* Europe, Greenland, *Aptian;* Madagascar, *?Albian;* South Africa (Zululand), *Aptian–Campanian.*——Fig. 1366,*2a–b. *C. cyrta* (Walker), Aptian, England; dorsal view, dorsal valve interior, ×1 (Cooper, 1983).——Fig. 1366,*2c–e. C. uniplicata* Walker, Aptian, England; dorsal, lateral, and anterior views of holotype, BMNH 67843, ×1 (Muir-Wood, 1965a).

Moutonithyris Middlemiss, 1976, p. 63 [**Terebratula moutoniana* d'Orbigny, 1849 in 1849–1852, p. 89; OD] [=*Atactosia* Cooper, 1983, p. 173 (type, *Terebratula obtusa* J. de C. Sowerby, 1823 in 1823–1825, p. 53)*; Biplicatoria* Cooper, 1983, p. 174

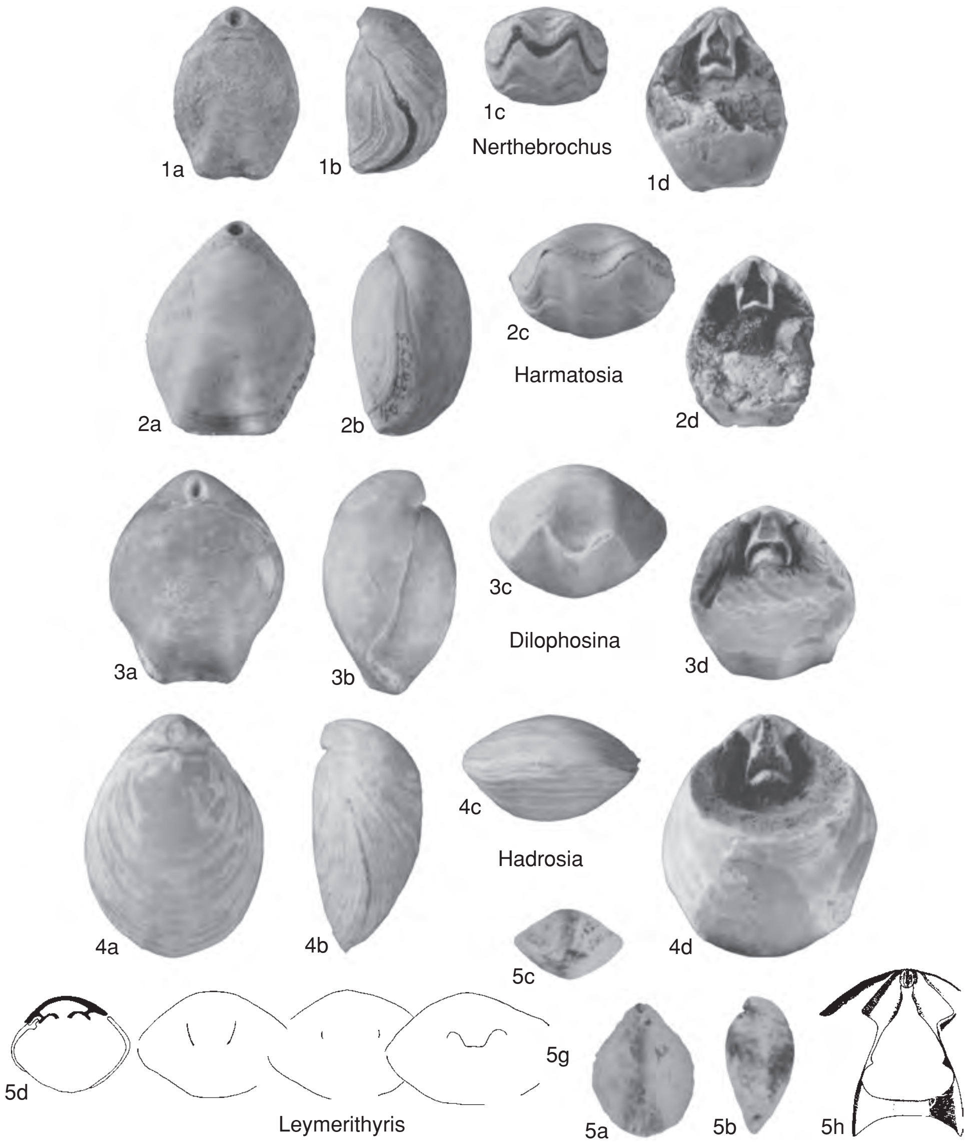

FIG. 1365. Sellithyrididae (p. 2066).

(type, *B. ferruginea* COOPER, 1983, p. 175; =*Terebratula biplicata dutempleana* DAVIDSON, 1853, pl. 6,*1, non T. dutempleana* D'ORBIGNY, 1847]. Oval to subcircular, anterior commissure rectimarginate to bisulcate; beak erect, foramen circular, permesothyrid; deltidium generally concealed; hinge plates horizontal or slightly convex, cuneate, keeled; crural flanges and keels may be present; loop narrow, transverse band low arched. *Cretaceous (Berriasian–Cenomanian):* France, Czech Republic, Slovakia, Germany, Hungary, Switzerland, Portugal, Spain, Sardinia, Ukraine.——FIG. 1367,*1a–p.* **M. moutoniana* (D'ORBIGNY), Aptian, France; *a–c,* dorsal, lateral, and anterior views of lectotype, MNHN 5529, ×1; *d–p,* serial transverse sections 1.5, 3.1, 3.9, 4.3, 4.7, 5.1, 5.5, 6.3, 6.7, 7.1, 7.9, 8.7, 9.1, 9.5 mm from ventral umbo, ×1 (Middlemiss, 1976).

Neoliothyrina SAHNI, 1925, p. 375 [**Terebratula obesa* DAVIDSON, 1852a, p. 53; OD; *non* J. DE C. SOWERBY, 1823, p. 54; =*N. obesa* SAHNI, 1925, p. 375]. Elongate oval, biconvex, anterior commissure

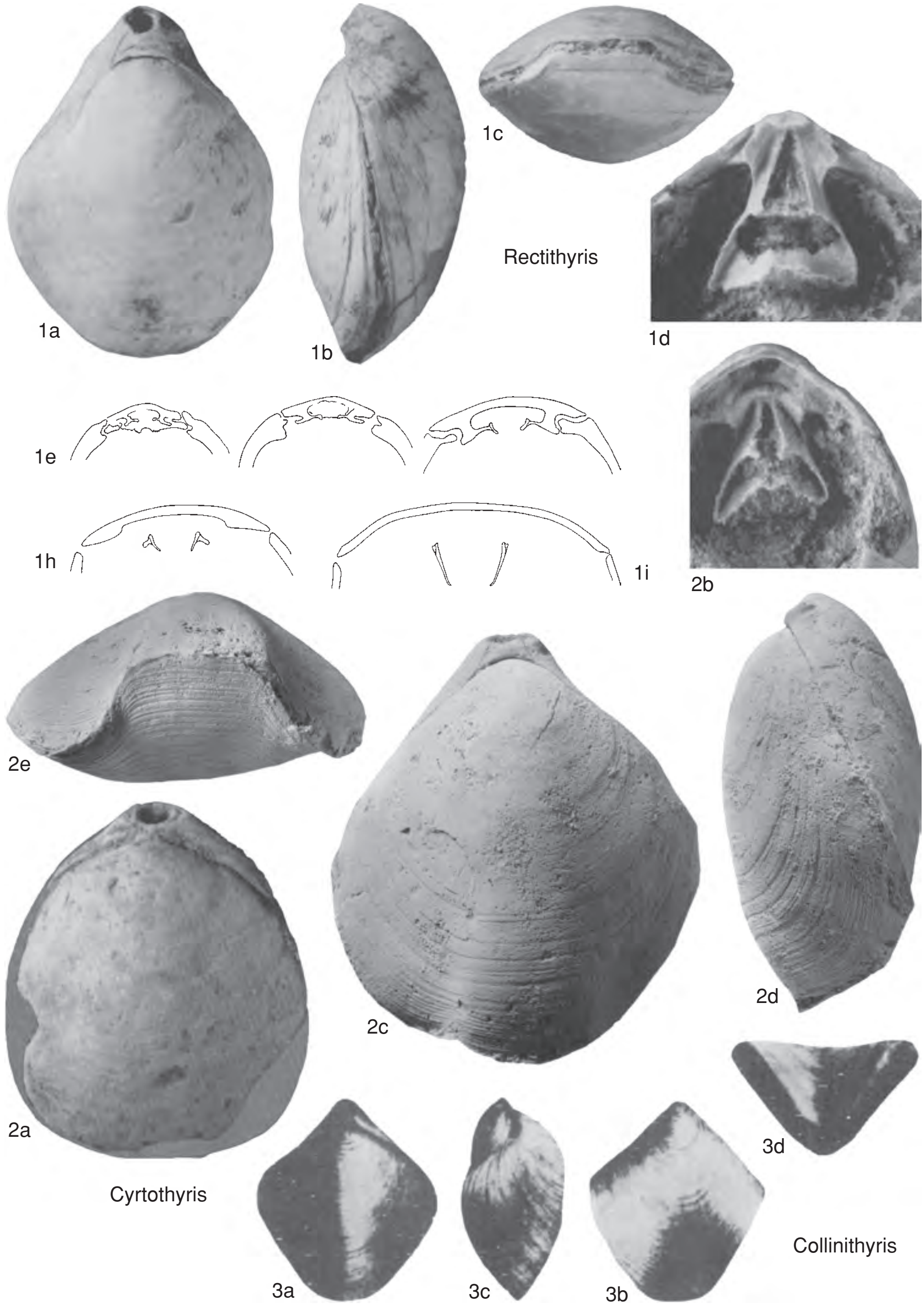

FIG. 1366. Sellithyrididae (p. 2066).

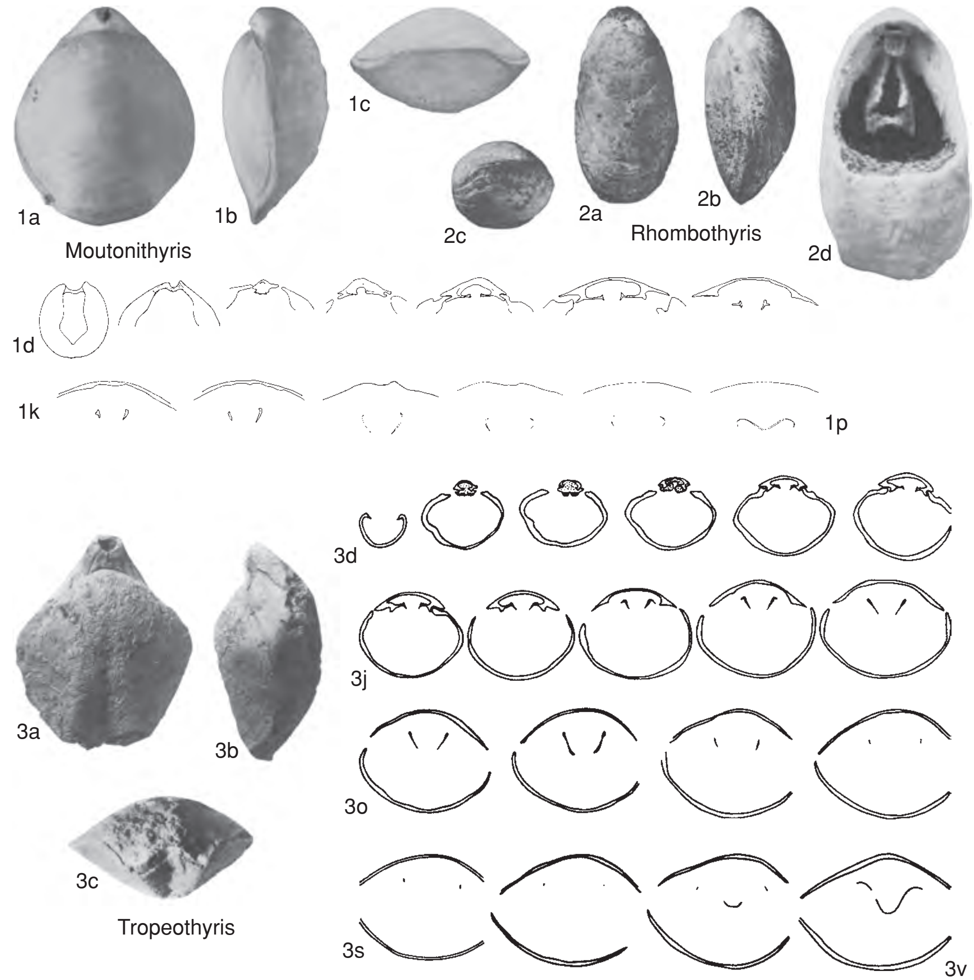

FIG. 1367. Sellithyrididae (p. 2066–2070).

rectimarginate to sulciplicate; foramen large, permesothyrid; cardinal process small semiellipse; outer hinge plates narrow, concave; socket ridges, outer hinge plates, and crural bases forming narrow, U-shaped troughs; inner hinge plates well developed, may coalesce; transverse band broad, high arched. *Upper Cretaceous (Coniacian–Maastrichtian):* Europe.——FIG. 1368,*2a–d.* **N. obesa* (DAVIDSON), Senonian, England; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* loop, ×2 (Muir-Wood, 1965a).

Praelongithyris MIDDLEMISS, 1959, p. 134 [**P. praelongiforma;* OD; =*Terebratula praelonga* J. DE C. SOWERBY in FITTON, 1836, p. 339, auctt., *partim*]. Elongate oval, anterior commissure rectimarginate, becoming sulciplicate; beak long, suberect, foramen large, circular, permesothyrid; hinge plates in section ventrally concave, becoming V-shaped, clubbed, and anteriorly keeled; loop long, high arched. *Cretaceous (Hauterivian–Cenomanian):* Europe, Greenland, Asia; South Africa (Zululand), ?Madagascar, Iran, *Albian.*——FIG. 1368,*1a–d.* **P. praelongiforma,* Aptian, England; *a–c,* dorsal, lateral, and anterior views of holotype, BMNH BM67590, ×1 (Middlemiss, 1959); *d,* interior of dorsal valve, ×1 (Cooper, 1983).

Rhombothyris MIDDLEMISS, 1959, p. 99 [**Terebratula extensa* MEYER, 1864, p. 252; OD]. Elongate oval, ventribiconvex, anterior commissure rectimarginate, unisulcate or sulciplicate; beak short, nearly straight, foramen large, mesothyrid, attrite; symphytium very short, exposed; loop short, high

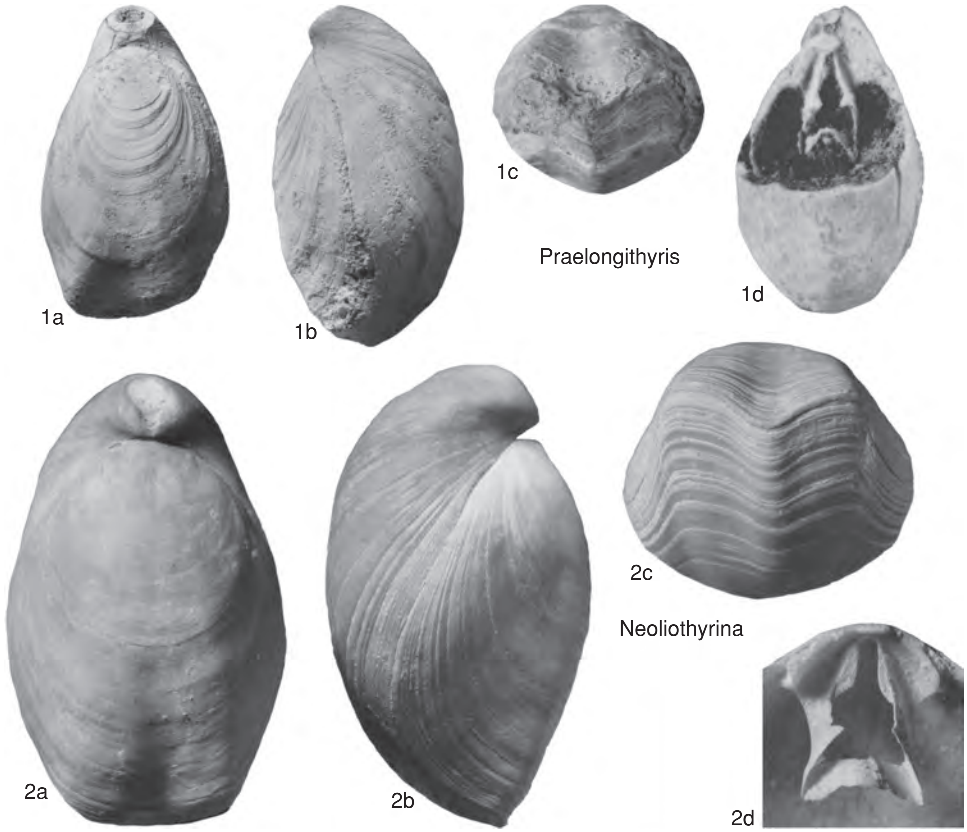

FIG. 1368. Sellithyrididae (p. 2071).

arched, with narrow transverse band. *Lower Cretaceous (Aptian):* England.——FIG. 1367,*2a–c.* **R. extensa* (MEYER); dorsal, lateral, and anterior views of lectotype, BMNH BB.16739, ×1 (Middlemiss, 1959).——FIG. 1367,*2d. R. microtrema* WALKER; interior of dorsal valve, ×1 (Cooper, 1983).

Tropeothyris SMIRNOVA, 1972, p. 69 [**T. kugusemi;* OD]. Oval or rounded pentagonal, anterior commissure parasulcate, beak long, massive, suberect to incurved, beak ridges weak, symphytium high, exposed; pedicle collar present; cardinal process small, transverse; hinge plates horizontal or concave in section, may be keeled; loop wide, short, transverse band strongly arched. *?Upper Jurassic; Cretaceous (Berriasian–Cenomanian):* Western Europe; Turkmenia, *Lower Cretaceous.*——FIG. 1367,*3a–v.* **T. kugusemi,* Hauterivian, Mangyschlak; *a–c,* dorsal, lateral, and anterior views of holotype, MGU No.16 060/89, ×1; *d–v,* serial transverse sections 0.00, 2.65, 2.85, 3.05, 3.75, 3.85, 4.25, 4.65, 5.15, 5.55, 6.15, 6.5, 6.85, 7.35, 7.95, 8.25, 8.8, 9.6, 9.75 mm from first section, ×1 (new).

Family CAPILLITHYRIDIDAE Cooper, 1983

[*nom. transl.* LEE & SMIRNOVA, herein, *ex* Capillithyridinae COOPER, 1983, p. 42]

Small to large, biconvex or ventribiconvex, rectimarginate, uniplicate, unisulcate, rarely sulciplicate; capillate, smooth, or faintly capillate on shell flanks; foramen generally medium to large, mesothyrid or permesothyrid; loop short (0.25 to 0.3 dorsal valve length), wide, outer hinge plates broad, tranverse band generally broad; crural props may be present. *Lower Cretaceous–Upper Cretaceous.*

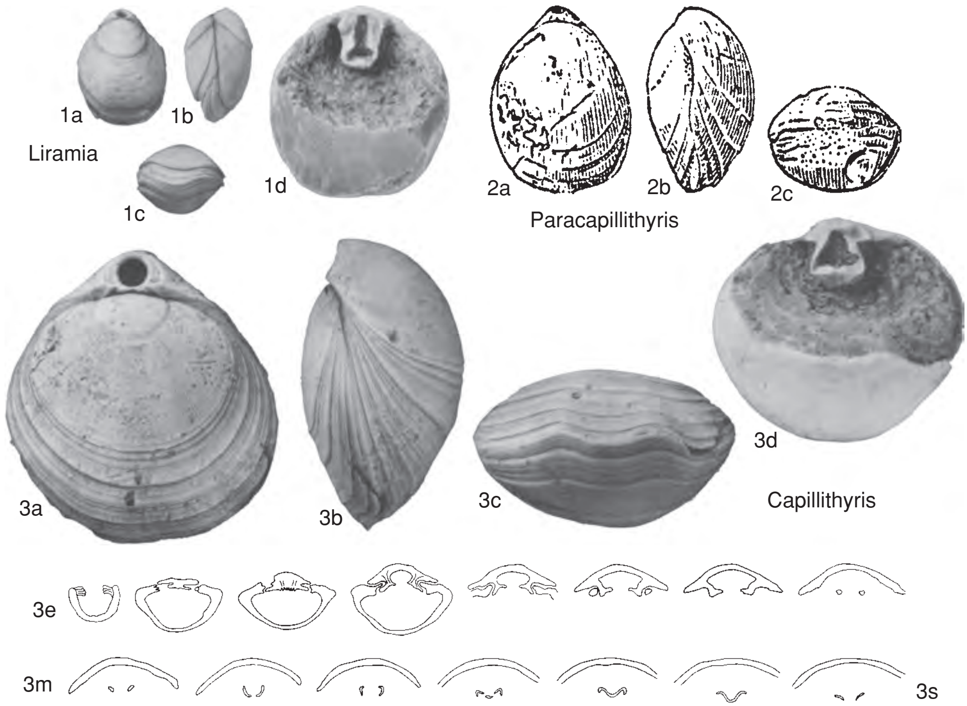

FIG. 1369. Capillithyrididae (p. 2070–2071).

Subfamily CAPILLITHYRIDINAE Cooper, 1983

[Capillithyridinae COOPER, 1983, p. 42]

Finely capillate over entire shell, foramen large, mesothyrid. *Lower Cretaceous (Albian)–Upper Cretaceous (Turonian).*

Capillithyris KATZ, 1974, p. 258 [**Terebratula capillata* D'ARCHIAC, 1847, p. 323; OD] [=*Capillarina* COOPER, 1983, p. 177 (type, *Platythyris diversa* COX & MIDDLEMISS, 1978, p. 434)]. Large, subcircular to subpentagonal, anterior commissure rectimarginate, uniplicate or sulciplicate; beak short, symphytium short, partly exposed; cardinal process small; hinge plates parallel to valve floor, becoming slightly concave anteriorly; loop variable, short (0.25 to 0.3 dorsal valve length), subtriangular, with broad, transverse band. Spicules may be preserved. *Cretaceous (Albian–Cenomanian):* Russia, Belgium, England, France, Poland, Germany, Spain, ?Antarctic Peninsula.——FIG. 1369,*3a–s.* **C. capillata* (D'ARCHIAC), Cenomanian, Belgium; *a–c,* dorsal, lateral, and anterior views; *d,* dorsal valve interior, ×1 (Cooper, 1983); *e–s,* serial transverse sections 0.6, 2.2, 2.6, 3.0, 3.5, 3.9, 4.1, 4.5, 4.9, 5.3, 6.0, 6.6, 7.0, 7.3, 7.8 mm from ventral umbo, ×1 (Bilinkevich & Popiel-Barczyk, 1979).

Liramia COOPER, 1983, p. 199 [**Terebratula disparilis* D'ORBIGNY, 1849 in 1849–1852, p. 100; OD]. Small, elongate oval, anterior commissure slightly unisulcate; loop stout, narrow. [May be a synonym of *Paracapillithyris.*] *Cretaceous (Turonian):* France, England.——FIG. 1369,*1a–d.* **L. disparilis* (D'ORBIGNY); *a–c,* dorsal, lateral, and anterior views, ×1; *d,* dorsal valve interior, ×2 (Cooper, 1983).

?Paracapillithyris KATZ & POPOV, 1974a, p. 26 [**P. alexeevi;* OD]. Medium size, elongate oval, rectimarginate; beak narrow, incurved, foramen apical; hinge plates broad, low; crura wide with dorsal and lateral carinae. [The description does not provide details of the loop, and no illustrations of the interior are available for this genus.] *Upper Cretaceous (Cenomanian):* Russia, Ukraine, Caucasus, Crimea.——FIG. 1369,*2a–c.* **P. alexeevi,* ?Ukraine; dorsal, lateral, and anterior views, ×1 (Katz & Popov, 1974a).

Subfamily ANIABROCHINAE Manceñido, 1993

[Aniabrochinae MANCEÑIDO, 1993, p. 203, *nom. nov. pro* Platythyridinae DIENI, MIDDLEMISS, & OWEN, 1975, p. 195, based on invalid junior homonym]

Small to medium size, smooth or very faintly capillate. *Lower Cretaceous*

(Berriasian)–Upper Cretaceous (Maastrichtian).

Aniabrochus COOPER, 1983, p. 170, *nom. nov. pro Platythyris* MIDDLEMISS, 1959, p. 109, *non Platythyris* GROTE & ROBINSON, 1866, p. 361 [**Platythyris comptonensis* MIDDLEMISS, 1959, p. 109; OD]. Medium size, elongate oval to subpentagonal, biconvex, smooth to faintly capillate on flanks, anterior commissure rectimarginate, uniplicate, sulciplicate, or unisulcate; beak short, truncated; foramen large, mesothyrid to permesothyrid, symphytium very short; cardinal process small; hinge plates in section horizontal to very slightly concave, tapering, or with rounded inner margins, becoming cuneate and keeled in gerontic stage; crural processes incurved; loop short (0.3 dorsal valve length), transverse band broad, low arched. *Cretaceous (Barremian–Turonian):* England, Belgium, France, Italy, Poland, Sardinia, Spain, Crimea, Georgia, Tibet, ?Sarawak.——FIG. 1370,*5a–r.* **A. comptonensis* (MIDDLEMISS), Aptian, England; *a–c,* dorsal, lateral, and anterior views; *d,* closeup of loop, ×1 (Cooper, 1983); *e–r,* serial tranverse sections 2.4, 2.5, 3.6, 3.8, 4.1, 4.6, 4.9, 5.4, 6.2, 8.3, 9.2, 9.6, 10.0, 10.8 mm from ventral umbo, ×1 (Middlemiss, 1959).

Bolgarithyris TITOVA, 1986, p. 118 [**B. boncevi;* OD]. Small to medium size, strongly biconvex, anterior commissure rectimarginate or unisulcate; oval to subtriangular in outline; may be faintly capillate; cardinal process lamellar; hinge plates horizontal or dorsally deflected, often straight; crural bases prolongations of hinge plates; loop short, transverse band low arched. [Subfamily placing is uncertain.] *Upper Cretaceous (Maastrichtian):* Turkmenia.——FIG. 1370,*1a–n.* **B. boncevi; a–c,* dorsal, lateral, and anterior view of holotype, TsNIGR Museum No. 203/10445, ×1; *d–n,* serial transverse sections 1.4, 3.15, 3.35, 3.8, 4.2, 4.55, 4.95, 5.25, 5.85, 6.25, 6.6 mm from ventral umbo, ×2 (Titova, 1986).

Dyscritothyris COOPER, 1979, p. 15 [**D. cubensis;* OD]. Small, subcircular to subpentagonal, smooth or may be faintly capillate, biconvex, anterior commissure uniplicate; beak small, foramen submesothyrid, deltidial plates disjunct; outer hinge plates nearly flat, horizontally tapering; loop short, about 0.3 dorsal valve length, imperfectly known. [Subfamily placing is uncertain.] *Upper Cretaceous:* Cuba.——FIG. 1371,*1a–m.* **D. cubensis; a–c,* dorsal, lateral, and anterior views of holotype, USNM 550460a, ×2 (Cooper, 1983); *d–m,* serial transverse sections 0.7, 0.8, 1.0, 1.4, 1.5, 1.7, 1.9, 2.3, 2.3, 2.5 mm from ventral umbo, ×5 (Sandy & others, 1997).

Iberithyris KVAKHADZE, 1972, p. 75 [**I. rionensis* KVAKHADZE, 1972, p. 76; OD]. Small, elongate to rounded pentagonal, smooth, rectimarginate, unisulcate or uniplicate; beak incurved; foramen small, mesothyrid; pedicle collar weakly developed; cardinal process small, platelike; outer hinge plates broad, thin, horizontal throughout their length, often ventrally convex; loop short, narrow, rounded, with gently convex, broad, transverse ribbon supported by dorsal crural props attaching crural bases to valve floor. [Subfamily placing is uncertain.] *Lower Cretaceous (Hauterivian–Barremian):* Georgia, Spain.——FIG. 1370,*3a–o.* **I. rionensis,* Hauterivian, Georgia; *a–c,* dorsal, lateral, and anterior views of holotype, ×1; *d–n,* serial transverse sections 0.5, 1.6, 2.2, 2.8, 3.3, 3.9, 4.6, 5.1, 5.3, 5.7, 6.5 mm from ventral umbo, ×2; *o,* drawing of loop, ×1 (Kvakhadze, 1972).

Lunpolaia CHING & YE in YE & YANG, 1979, p. 67 [**L. cymbaliformis;* OD]. Smooth or with faint capillae, subcircular, ventribiconvex, uniplicate, beak erect, foramen large; pedicle collar short; cardinal process small; hinge plates horizontal, tapering, and with low, rounded margins anteriorly; outer hinge plates narrowly concave; loop short, wide, transverse band gently convex. [Subfamily placing is uncertain.] *Cretaceous (Aptian–Cenomanian):* China.——FIG. 1370,*4a–d.* **L. cymbaliformis; a–c,* dorsal, lateral, and anterior views, ×1; *d,* closeup view of loop, ×3 (Ye & Yang, 1979).

Middlemissithyris SMIRNOVA, 2001, p. 598 [**M. rarus;* OD]. Medium size, smooth, ventribiconvex, subpentagonal to subtriangular, anterior commissure slightly uniplicate; beak incurved, foramen mesothyrid, pedicle collar present; cardinal process small, hinge plates wide, horizontal, crural bases high; loop very short, anteriorly rounded. *Lower Cretaceous:* Crimea, Ukraine.——FIG. 1371,*3a–q.* **M. rarus; a–c,* dorsal, lateral, and anterior views, ×1; *d–p,* serial transverse sections 0.9, 1.4, 1.7, 1.9, 2.0, 2.1, 2.2, 2.4, 2.9, 3.4, 3.9, 4.2, 4.6 mm from ventral umbo, ×1; *q,* drawing of loop, ×4 (Smirnova, 2001).

Paraplatythyris SUN, 1987, p. 77 [**P. xizangensis;* OD]. Small, oval, smooth, biconvex, anterior commissure uniplicate; beak short, erect; foramen mesothyrid to permesothyrid, pedicle collar short; no cardinal process, hinge plates tapering and slightly concave; loop short, widely triangular, tranverse band narrow, low arched. *Lower Cretaceous (Berriasian):* Tibet.——FIG. 1371,*2a–l.* **P. xizangensis; a,* dorsal view, ×3; *b–l,* serial transverse sections 0.1, 1.0, 1.2, 1.6, 1.9, 2.1, 2.2, 2.5, 2.9, 3.6, 3.7 mm from ventral umbo, ×2.65 (Sun, 1987).

Sardope DIENI, MIDDLEMISS, & OWEN, 1975, p. 196 [**S. sardoa* DIENI, MIDDLEMISS, & OWEN, 1975, p. 198; OD]. Similar to *Aniabrochus,* but smooth with straight beak; posterior part of shell bulbous. *Lower Cretaceous (Aptian–Albian):* Sardinia, *Aptian;* France, *Albian.*——FIG. 1370,*2a–j.* **S. sardoa,* Sardinia; *a–c,* dorsal, lateral, and anterior views of holotype, IGPSB 31, ×1; *d–j,* serial transverse sections 1.6, 2.0, 2.4, 2.8, 3.2, 3.6, 4.4 mm from ventral umbo, ×1 (Dieni, Middlemiss, & Owen, 1975).

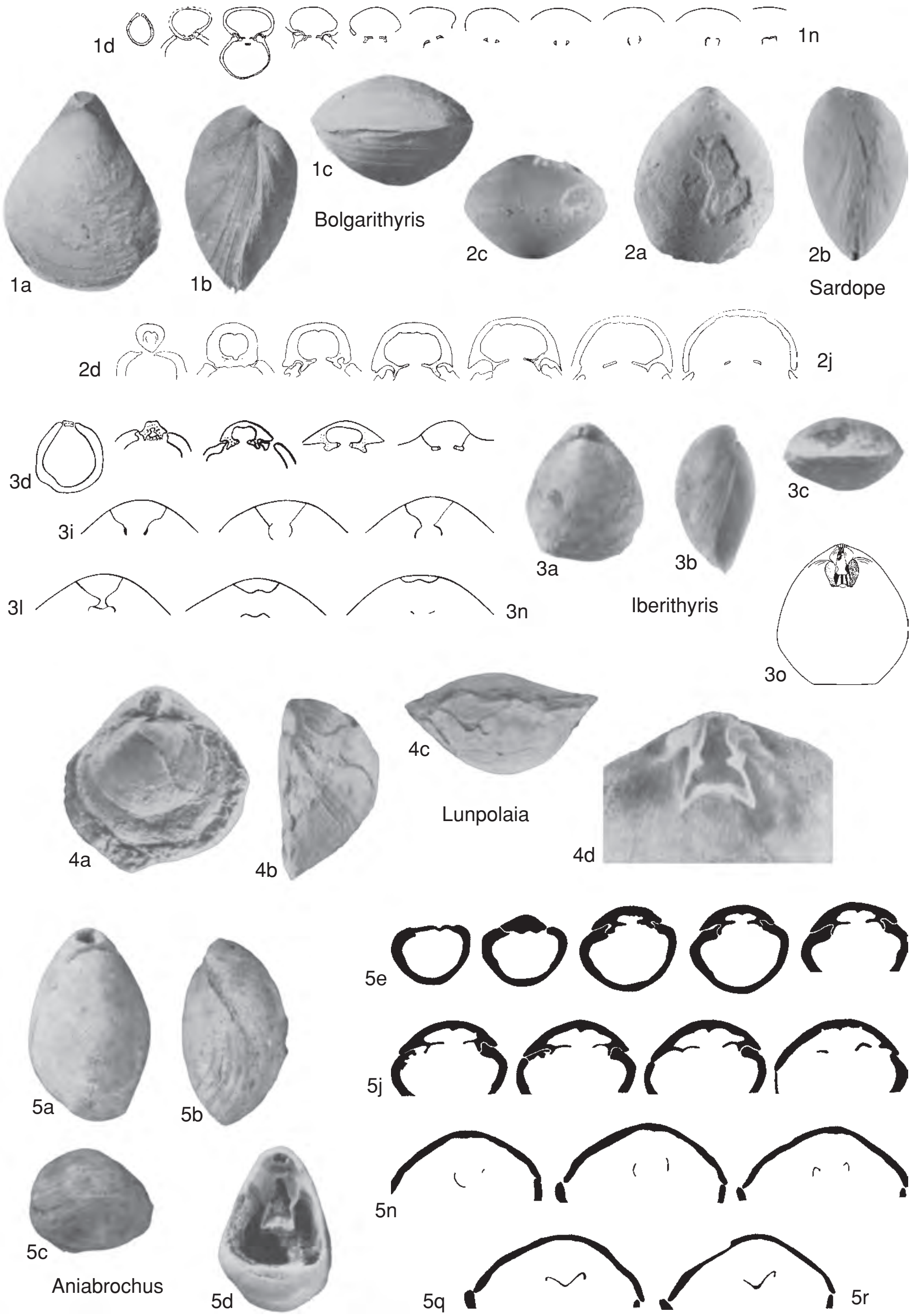

FIG. 1370. Capillithyrididae (p. 2072).

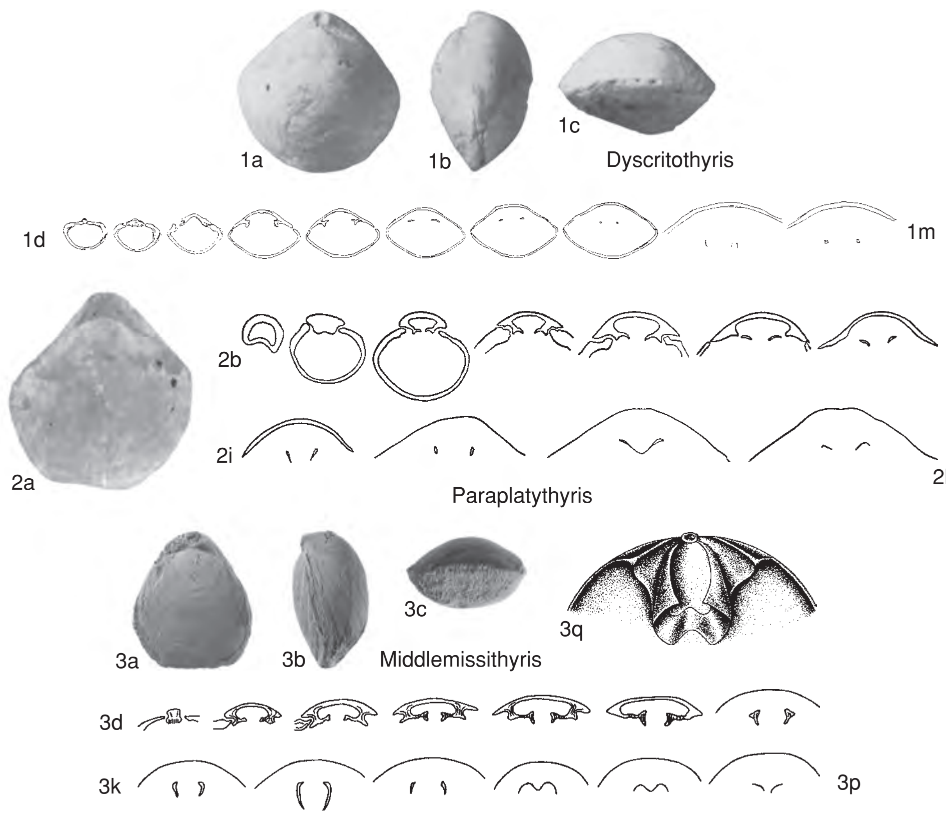

FIG. 1371. Capillithyrididae (p. 2072).

Family WEBERITHYRIDIDAE Smirnova, 1990

[Weberithyrididae SMIRNOVA, 1990a, p. 66]

Smooth, anterior commissure unisulcate, rarely bisulcate; no inner hinge plates; early loop stages with secondary loop structures. *Upper Jurassic–Lower Cretaceous.*

Weberithyris SMIRNOVA, 1969b, p. 144 [**Rectithyris moisseevi* WEBER, 1949, p. 116; OD]. Elongate, beak high, erect, symphytium high, grooved; no pedicle collar; cardinal process small, concave, bilobed; hinge plates horizontal or slightly concave with obtuse margins; loop with thin branches, transverse band thin, rectimarginate, strongly arched. *Upper Jurassic–Lower Cretaceous:* Crimea, Caucasus; Western Europe, *Upper Jurassic.*——FIG. 1372*a–x*. **W. moisseevi* (WEBER), Lower Cretaceous, Crimea; *a–c,* dorsal, lateral, and anterior views, ×1; *d–w,* serial transverse sections 0.0, 0.4, 0.5, 0.7, 0.8, 1.0, 1.7, 1.9, 2.1, 2.3, 2.8, 3.3, 4.0, 4.3, 4.8, 5.8, 6.3, 6.4, 6.7, 7.2 mm from first section, approximately ×0.85; *x,* reconstruction of loop, ×1 (Smirnova, 1969).

Family GIBBITHYRIDIDAE Muir-Wood, 1965

[*nom. correct.* KATZ & POPOV, 1974a, p. 24, *pro* Gibbithyridae DAGYS,1968, p. 26, *nom. transl. ex* Gibbithyridinae MUIR-WOOD, 1965a, p. 797]

Medium to large, biconvex or ventribiconvex, rectimarginate, uniplicate or sulciplicate, beak often incurved, foramen permesothyrid to epithyrid, very small to large; cardinal process variable, small to massive; loop short, crural bases broad, outer hinge plates attached at or near ventral edge of crural bases; crural processes anterior of midloop, transverse band usually broad, variably arched. *Cretaceous–Paleogene (Paleocene).*

Subfamily GIBBITHYRIDINAE Muir-Wood, 1965

[Gibbithyridinae MUIR-WOOD, 1965a, p. 797]

Smooth or with prominent growth lamellae or rugae, with small cardinal process. *Cretaceous–Paleogene (Paleocene).*

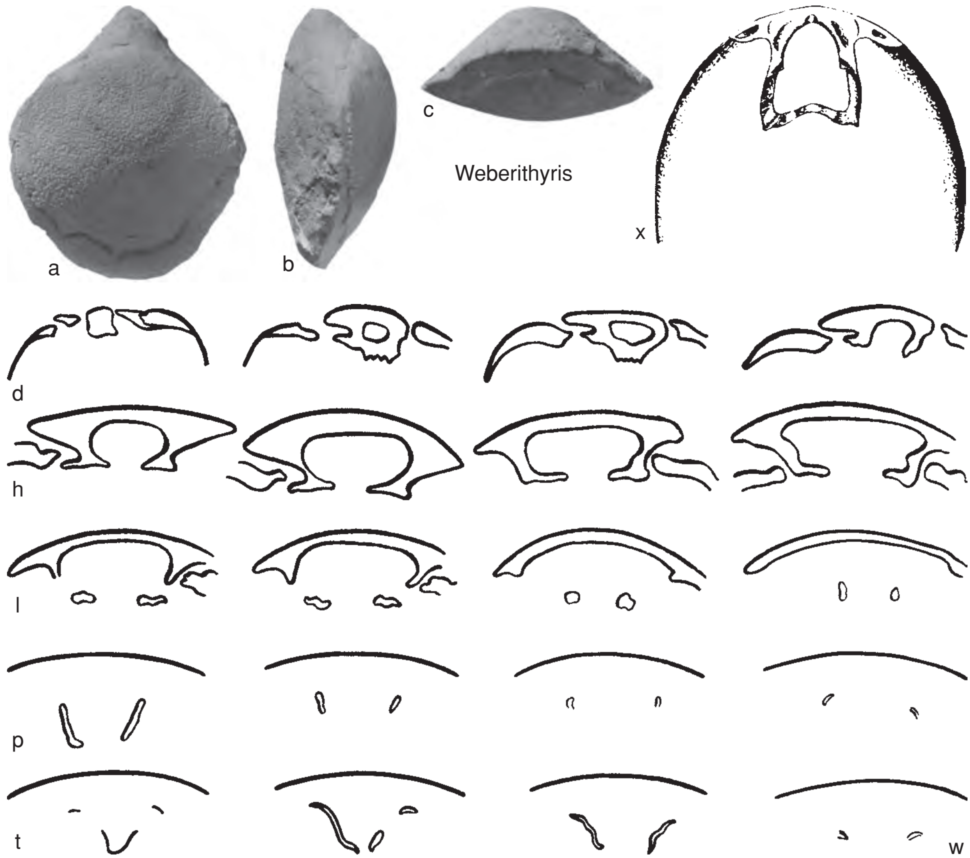

FIG. 1372. Weberithyrididae (p. 2074).

Gibbithyris SAHNI, 1925, p. 372 [**G. gibba;* OD] [=*Kestonithyris* SAHNI, 1925, p. 363 (type, *K. inflata*); *Piarothyris* SAHNI, 1925, p. 370 (type, *P. rotunda*)]. Medium size, strongly biconvex, anterior commissure rectimarginate to sulciplicate, beak short, suberect to erect, incurved, symphytium usually concealed, foramen minute, epithyrid to permesothyrid, beak ridges strong; cardinal process small, transverse, crural bases broad, dorsally directed; outer hinge plates in section usually convex or horizontal, with pendant, dorsally directed crural bases; loop short, 0.3 dorsal valve length, triangular, transverse band gently arched. [No satisfactory illustrations of the type are available.] *Upper Cretaceous (Cenomanian–Santonian):* England, France, Sweden, Russia.——FIG. 1373,*1a–d. G. semiglobosa* J. SOWERBY, Cenomanian, England; *a–c,* dorsal, lateral, and anterior views of holotype, BMNH B.49833, ×0.9; *d,* close up view of loop, ×1.8 (Muir-Wood, 1965a).——FIG. 1373,*1e–q. G. subrotunda* J. SOWERBY, Turonian, England; serial transverse sections 0.8, 1.2, 1.6, 2.0, 2.4, 3.2, 3.6, 4.4, 4.8, 5.6, 6.0, 6.4, 7.2 mm from ventral umbo, ×1 (Middlemiss, 1991).

Concinnithyris SAHNI, 1929, p. 11 [**Terebratula obesa* J. DE C. SOWERBY, 1823 in 1823–1825, p. 54; OD]. Medium to large, elongate oval to subcircular in outline, ventribiconvex, anterior commissure rectimarginate to uniplicate or sulciplicate; beak slightly incurved to erect, truncated; foramen small to large, circular, permesothyrid to epithyrid, rarely labiate; symphytium concealed, beak ridges indistinct; cardinal process low, flat, poorly developed; outer hinge plates horizontal to gently convex, may be keeled, attached to ventral edge of broad, flat crural bases; crural processes high, tapering, inwardly curving; thin, descending branches of short, narrow loop with low, arched transverse band, may have small depression or sulcus posteriorly. *Cretaceous (Albian–Turonian):* England, France, Poland.——FIG. 1373,*2a–n.* **C. obesa* (J. DE C. SOWERBY), Cenomanian, Lower Chalk, Wiltshire, England; *a–c,* dorsal, lateral, and anterior views of holotype, BMNH B.49832, ×1; *d–n,* serial transverse sections 4.1, 5.7, 6.5, 6.8, 7.2, 7.8, 8.2, 8.6, 9.0, 9.3, 9.9 mm from ventral umbo, ×1 (Owen, 1988).——FIG. 1373,*2o. C. rouenensis* COOPER, Cenomanian, France; close up view of loop, ×2 (Cooper, 1983).

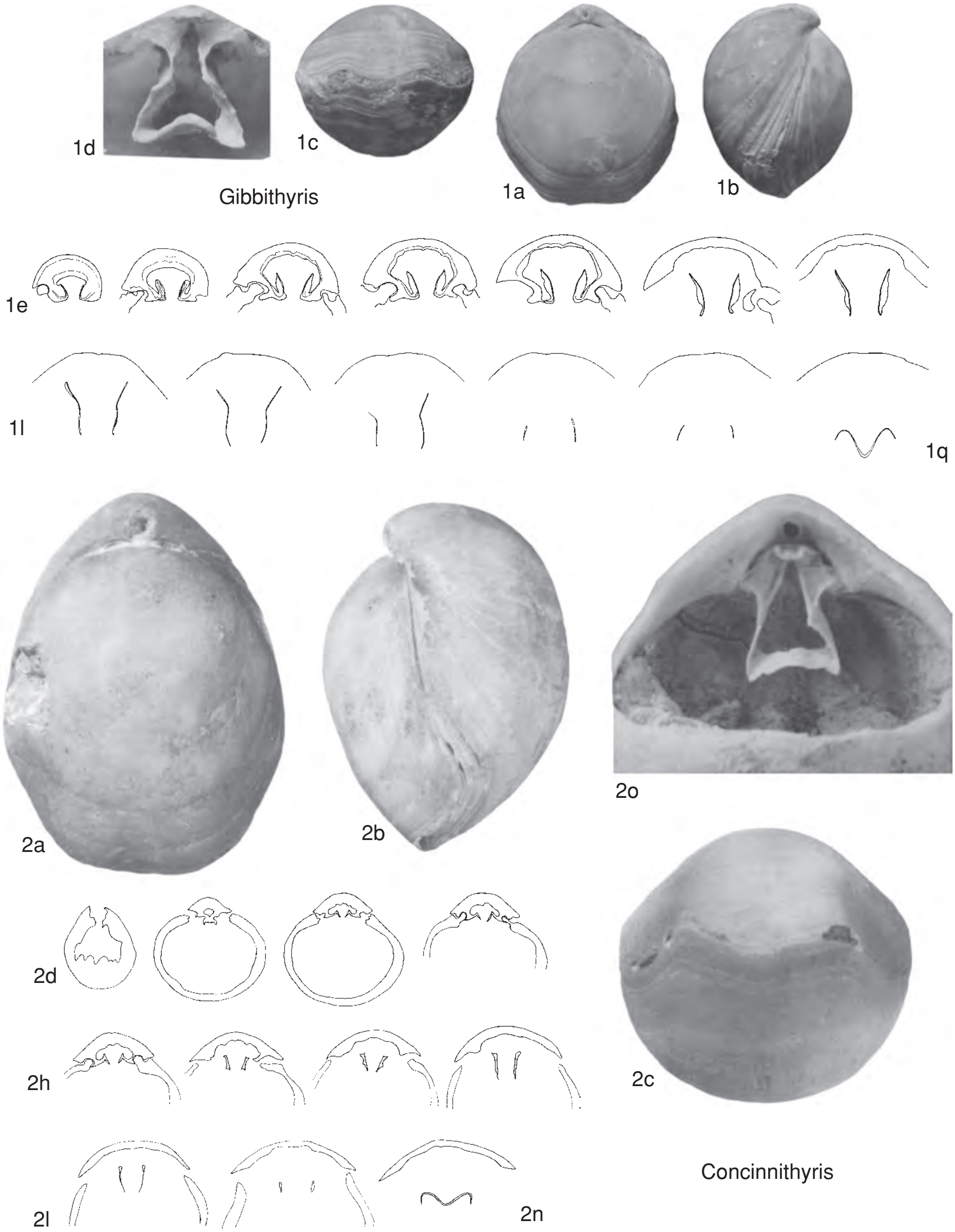

FIG. 1373. Gibbithyrididae (p. 2075).

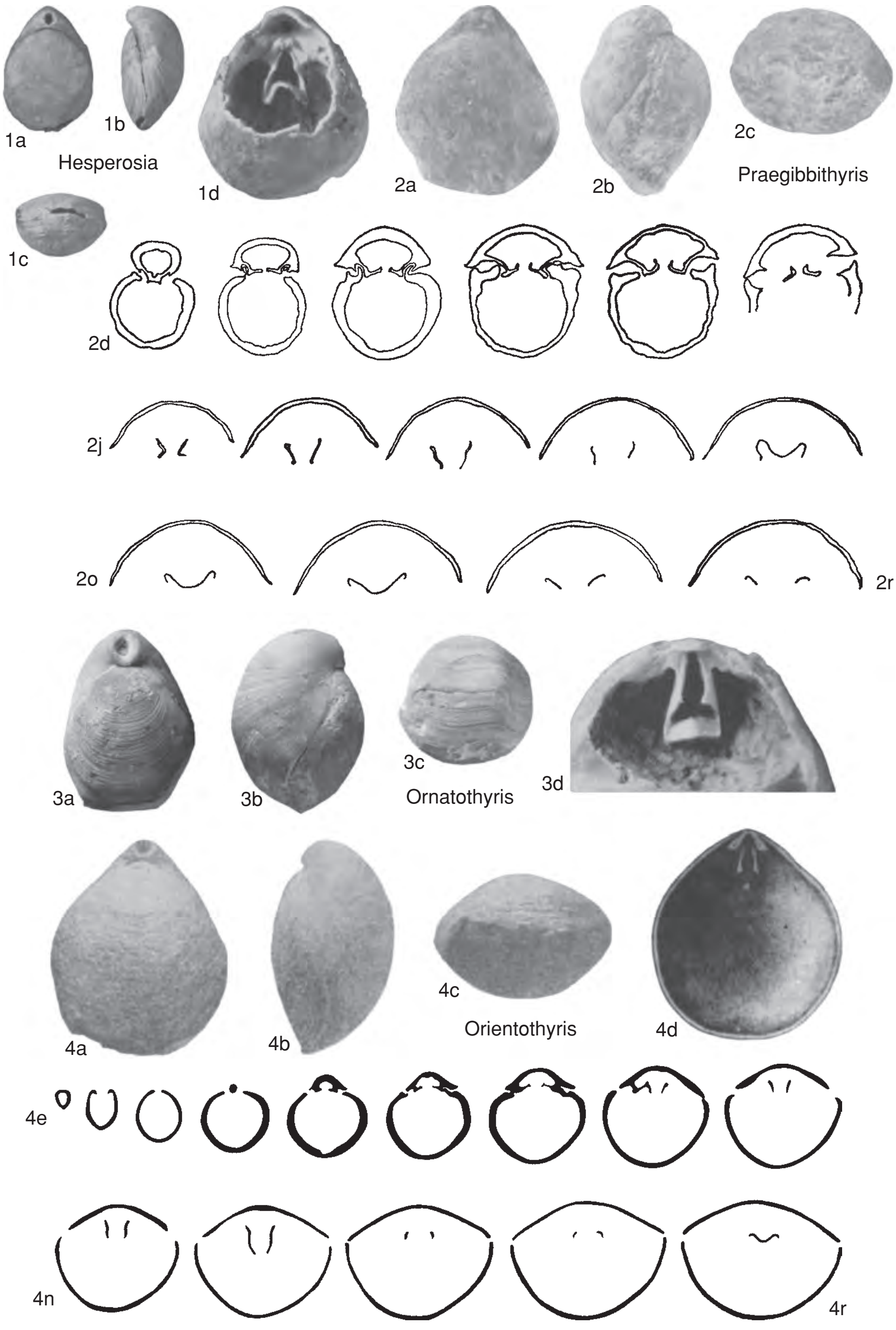

FIG. 1374. Gibbithyrididae (p. 2078).

Hesperosia Cooper, 1983, p. 197 [**Rectithyris vespertina* Cooper, 1955b, p. 4; OD]. Medium size, oval, ventribiconvex, rectimarginate, smooth, beak large, protuberant, erect; foramen large, permesothyrid; cardinal process small semiellipse; loop similar to that of *Concinnithyris* but with narrow crural bases and wider loop angle. *Cretaceous:* USA (Arizona), Mexico.——Fig. 1374,*1a–d.* **H. vespertina* (Cooper), Arizona; *a–c,* dorsal, lateral, and anterior views of holotype, USNM 124194b, ×1; *d,* interior of dorsal valve, ×2 (Cooper, 1983).

Orientothyris Katz & Popov, 1974a, p. 28 [**Gryphus orientalis* Vantschurov & Kalugin, 1966, p. 119; OD]. Medium size, elongate oval; anterior commissure uniplicate, faint lateral capillae may be present; beak massive, foramen large, epithyrid; crural bases attached to wide hinge plates that hang low into dorsal apical cavity, almost uniting with floor of valve; crural bases with high ventral keels. Differs from *Concinnithyris* in wide hinge plates and type of crura. [Subfamily placing is uncertain.] *Upper Cretaceous* (*Maastrichtian)–Paleogene (Paleocene):* Crimea, Caucasus, Kazakstan, Turkmenia.——Fig. 1374,*4a–r.* **O. orientalis* (Vantschurov), ?Maastrichtian, ?Crimea; *a–c,* dorsal, lateral, and anterior views of holotype, ×1; *d,* interior of dorsal valve, ×0.5; *e–r,* serial transverse sections 0.4, 1.0, 1.6, 2.6, 3.2, 3.6, 4.0, 4.6, 5.1, 5.5, 6.4, 7.1, 7.7, 8.5 mm from ventral umbo, ×1 (Vantschurov & Kalugin, 1966).

Ornatothyris Sahni, 1929, p. 45 [**Terebratula sulcifera* Morris in Morris & Davidson, 1847, p. 254; OD]. Large, ovate to subpentagonal, ventribiconvex, anterior commissure gently uniplicate to sulciplicate; ornament of strong, concentric lamellae; beak massive, short, foramen permesothyrid, large, labiate, symphytium visible or hidden; pedicle collar well developed; cardinal process narrow semiellipse; crural bases broad, extending under short, narrow, horizontal outer hinge plates to produce a keeled hinge plate in section, loop narrow but variable, transverse band broad. *Cretaceous (Cenomanian):* England, France, Poland, Switzerland, Russia, ?Sarawak, China.——Fig. 1374,*3a–d.* **O. sulcifera* (Morris), England; *a–c,* dorsal, lateral, and anterior views of holotype, BMNH Davidson Collection, 50822, ×0.6 (Muir-Wood, 1965a); *d,* interior of dorsal valve, ×2 (Cooper, 1983).

Praegibbithyris Sun, 1987, p. 82 [100] [**P. langshanensis;* OD]. Medium size, oval, strongly biconvex, anterior commissure sulciplicate; smooth; beak short, nearly straight; foramen large, permesothyrid to epithyrid; beak ridges rounded, delthyrium covered by symphytium; pedicle collar present, cardinal process low, transversely oval, bilobate myophore directed posteroventrally; hinge plates separate, ventrally convex with dorsally directed crural bases; inner socket ridges fused with narrow, outer hinge plates; loop short, triangular, wide, transverse band trapezoidal. *Lower Cretaceous (Aptian):* Tibet.——Fig. 1374,*2a–r.* **P. langshanensis; a–c,* dorsal, lateral, and anterior views of holotype, ×1; *d–r,* serial transverse sections 3.1, 3.6, 3.8, 4.0, 4.3, 4.5, 5.3, 6.2, 6.7, 7.3, 7.9, 8.3, 8.9, 9.2, 9.5 mm from ventral umbo, ×1 (Sun, 1987).

Pseudogibbithyris Owen, 1995, p. 275 [**P. arabica;* OD]. Medium size, elongate oval to subcircular, biconvex, uniplicate, beak short, suberect, foramen small, permesothyrid, cardinal process flat, bifid, hinge trough deep, hinge plates short, triangular. *Upper Cretaceous (Maastrichtian):* United Arab Emirates (Jebel Huwayyah), Oman.——Fig. 1375,*1a–m.* **P. arabica; a–c,* dorsal, lateral, and anterior views of holotype, BMNH BF47, ×1; *d–m,* serial tranverse sections 1.3, 1.5, 1.9, 2.0, 2.2, 2.4, 2.6, 3.3, 3.7, 4.0 mm from first section, ×1 (Owen, 1995).

Sahnithyris Radulović & Ramamoorthy, 1995, p. 187 [**Concinnithyris andurensis* Sahni, 1960, p. 10; OD]. Very large, elongate oval, ventribiconvex, beak short, massive, concealing symphytium; foramen mesothyrid; anteriorly commissure broadly sulciplicate; pedicle collar present; cardinal process wide, concave with well-defined myophore; loop thin, transverse band broad, strongly arched. *Upper Cretaceous (Campanian):* southern India, ?Bulgaria.——Fig. 1375,*2a–p.* **S. andurensis* (Sahni), southern India; *a–c,* dorsal, lateral, and anterior views of lectotype, GSI 1553, ×1 (Sahni, 1960); *d–p,* serial transverse sections 2.1, 6.4, 7.2, 9.3, 10.3, 12.5, 13.5, 14.0, 15.2, 18.7, 19.1, 19.5, 20.7 mm from ventral umbo, ×0.5 (Radulović & Ramamoorthy, 1995).

Subfamily CARNEITHYRIDINAE Muir-Wood, 1965

[Carneithyridinae Muir-Wood, 1965a, p. 799]

Medium to large, smooth, subcircular to oval to subpentagonal in outline, rectimarginate to uniplicate, rarely unisulcate, smooth; beak incurved, foramen small to minute; loop short, variable in shape, cardinal process large to massive; outer hinge plates often swollen, no inner hinge plates; crural processes anterior to midloop; transverse band usually narrow, moderately arched. *Upper Cretaceous (Coniacian)–Paleogene (upper Paleocene).*

Carneithyris Sahni, 1925, p. 364 [**C. subpentagonalis;* OD] [=*Chatwinothyris* Sahni, 1925, p. 368 (type, *C. subcardinalis,* OD); *Ellipsothyris* Sahni, 1925, p. 371 (type, *E. similis,* OD); *Magnithyris* Sahni, 1925, p. 367 (type, *M. magna,* OD); *Ornithothyris* Sahni, 1925, p. 374 (type, *O. carinata,* OD); *Pulchrithyris* Sahni, 1925, p. 361 (type, *P. gracilis,* OD); *Ogmusia* Cooper, 1983, p. 207 (type, *Terebratula incissa* von Buch, 1835, p. 95)]. Medium to large, oval to subcircular, ventribiconvex, anterior commissure rectimarginate to uniplicate or unisulcate; foramen small to minute, beak ridges angular, mesothyrid to permesothyrid; symphytium hidden; cardinal process large to massive, bulbous,

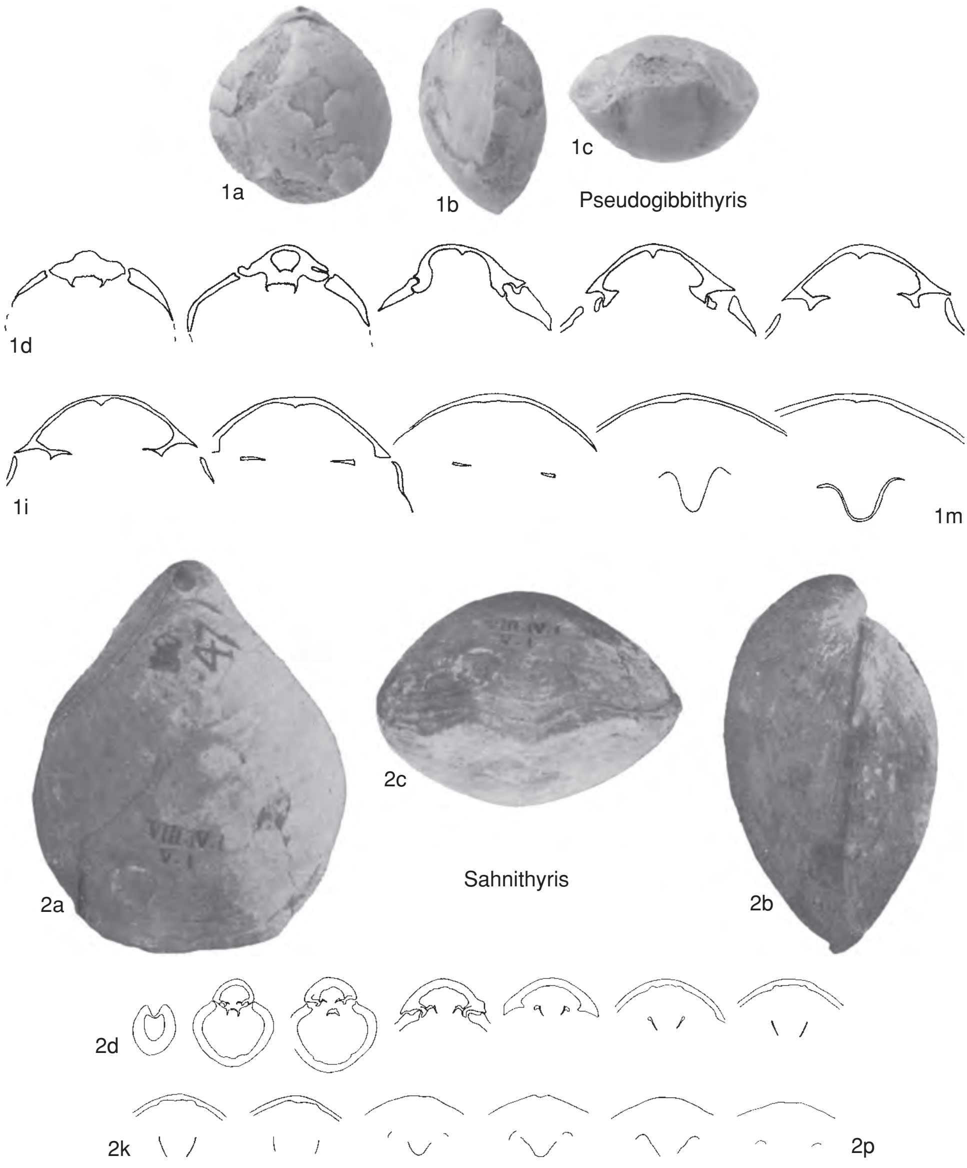

FIG. 1375. Gibbithyrididae (p. 2078).

highly variable; myophore forming bilobed pit with elevated sides and median ridge; socket ridges and hinge plates thickened, fused, and forming prominent, broad ridge; loop subtriangular to subrectangular. [Synonyms listed above are considered to be variants of *Carneithyris* and not distinct genera.] *Upper Cretaceous (Coniacian)–Paleogene (Danian):* England, Belgium, Denmark, France, Germany, Poland, Russia, Sweden.——FIG. 1376,*2a–d.* **C. subpentagonalis,* Senonian, England; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* closeup view of cardinalia, ×3 (Cooper, 1983).——FIG. 1376,*2e. C. rotunda* SAHNI, Senonian, England; interior of dorsal valve, ×1 (Cooper, 1983).

Giraliathyris CRAIG, 2000, p. 117 [**G. mcnamarai;* OD]. Medium size, biconvex, subcircular to subpentagonal, anterior commissure rectimarginate to slightly unisulcate; beak short, foramen small, mesothyrid to permesothyrid; symphytium narrow, concave, mostly concealed, deltidial plates conjunct; with median ridge, cardinal process a protuberant cup; loop short, 0.35 dorsal valve length.

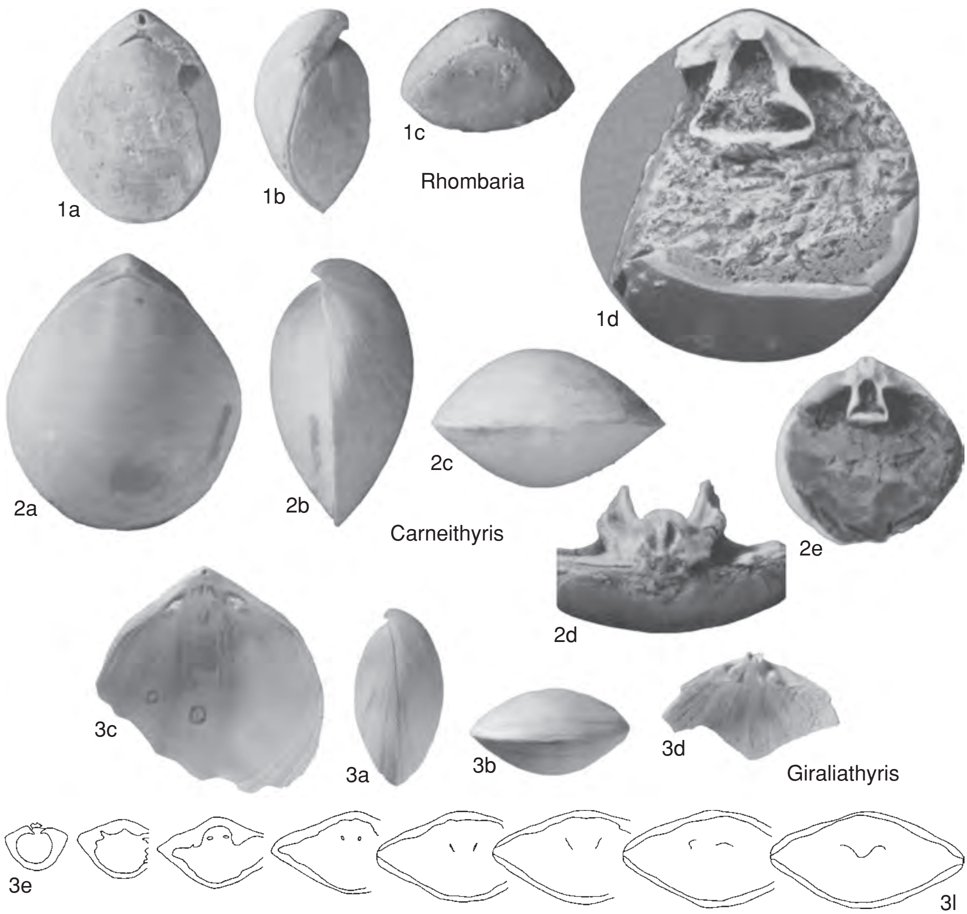

FIG. 1376. Gibbithyrididae (p. 2078–2080).

Paleogene (upper Paleocene): Western Australia (Carnarvon basin).——FIG. 1376,*3a–l.* **G. mcnamarai; a–b,* lateral and anterior views of holotype, WAM 96.826, ×1; *c,* interior of ventral valve, ×1; *d,* interior of dorsal valve, ×1; *e–l,* serial transverse sections 4.8, 6.0, 7.2, 8.2, 10.5, 11.3, 11.5, 11.7 mm from ventral umbo, ×0.5 (Craig, 2000).

Subfamily RHOMBARIINAE Cooper, 1983

[Rhombariinae COOPER, 1983, p. 41]

Smooth, foramen small, anterior commissure uniplicate; loop wide, outer hinge plates narrow, ventrally attached to crural bases, crural processes anterior to midloop, transverse band thin, medially protuberant. *Upper Cretaceous (Coniacian–Maastrichtian).*

Rhombaria COOPER, 1983, p. 215 [**Terebratula rhomboidalis* NILSSON, 1827, p. 34; OD]. Medium size, elongate oval, strongly ventribiconvex; beak long, narrow, erect, beak ridges rounded, foramen small, symphytium exposed, permesothyrid; cardinal process large, shelflike, outer hinge plates very narrow, attached ventrally, tapering anteriorly to crural processes; crural bases, outer hinge plates and socket ridges forming V-shaped troughs; loop triangular, as wide as long. *Upper Cretaceous (Coniacian–Maastrichtian):* Sweden.——FIG. 1376,*1a–d.* **R. rhomboidalis* (NILSSON), Senonian; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* interior of dorsal valve, ×2 (Cooper, 1983).

Family UNCERTAIN

Heligothyris MIDDLEMISS, 1991, p. 230 [**H. schmidi;* OD]. Small, rounded triangular, smooth, biconvex, anterior commissure unisulcate; dorsal valve

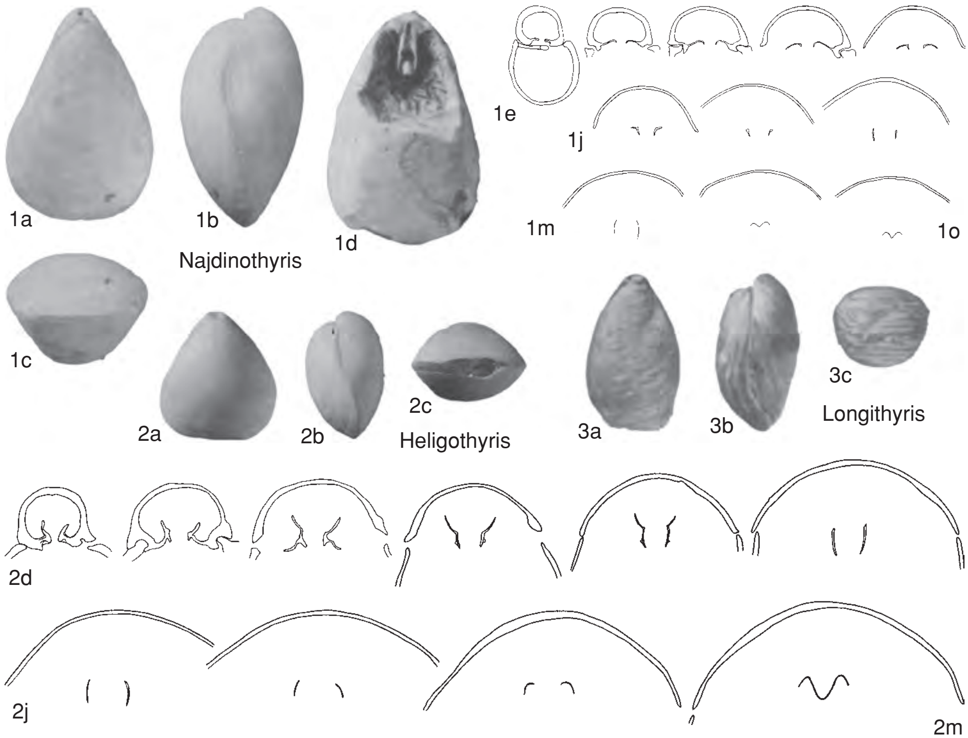

FIG. 1377. Uncertain (p. 2080–2081).

strongly inflated posteriorly; umbo suberect, foramen circular, mesothyrid, deltidium hidden in gerontic forms; cardinal process small; hinge plates initially horizontal, becoming convex; cuneate; attached crural bases given off dorsally and ventrally; free crural bases extended dorsally as thin, curved plates; loop narrow, transverse band low arched. *Upper Cretaceous (Turonian):* North Sea (Helgoland), ?Ireland.——FIG. 1377,*2a–m.* **H. schmidi,* Helgoland; *a–c,* dorsal, lateral, and anterior views of holotype, HG1700a, ×1; *d–f,* serial transverse sections 2.0, 2.4, 2.8 mm from ventral umbo, ×2; *g–m,* serial transverse sections 3.2, 3.6, 4.4, 5.2, 5.6, 6.4, 6.8 mm from ventral umbo, ×2 (Middlemiss, 1991).

Ilyinella JASSJUKEVITCH, 1973, p. 104 [**I. mangyschlakensis;* OD]. Small, elongate oval, possibly finely capillate; anterior commissure rectimarginate; pedicle collar short; cardinal process trilobed; loop exceptionally short and narrow (loop reported to measure 1 mm by 1 mm in 12-mm-long dorsal valve). [This genus is poorly known; there are no illustrations of internal structures available.] *Paleogene (lower Eocene):* Mangyschlak, Kazakstan.

?Longithyris KATZ & POPOV, 1974a, p. 30 [**Najdinothyris? longa* KATZ, 1974, p. 260; OD]. Small, elongate oval, biconvex, anterior commissure uniplicate; smooth or with lateral capillae; beak incurved, foramen large, epithyrid; crural bases attached to broad, thin, outer hinge plates that are suspended in dorsal umbonal cavity, almost reaching valve floor; loop short, 0.25 dorsal valve length, narrow, with wide transverse band. [The status of this genus is questionable, as no serial sections or illustrations of the shell interior are available.] *Upper Cretaceous (Cenomanian):* Ukraine.——FIG. 1377,*3a–c.* **L. longa* (KATZ); dorsal, lateral, and anterior views of holotype, ×1 (Katz, 1974).

Najdinothyris KATZ, 1974, p. 260 (MAKRIDIN & KATZ in MAKRIDIN, 1964, p. 35, *nom. nud.*) [**Terebratula becksii* ROEMER, 1841, p. 44; OD]. Medium size, elongate, smooth, ventribiconvex, anterior commissure unisulcate; dorsal valve strongly inflated posteriorly, beak suberect, foramen large, circular, permesothyrid; cardinal process small; inner socket ridges well differentiated from hinge plates; hinge plates initially concave, cuneate, becoming wide, thin, horizontal; crura given off ventrally; hinge plates attached to free crural bases; loop narrow, transverse band low arched. *Upper Cretaceous:* Germany, Poland, Russia.——FIG. 1377,*1a–o.* **N. becksii* (ROEMER), Turonian, Germany; *a–c,* dorsal, lateral, and anterior views; *d,* dorsal valve interior, ×1 (Cooper, 1983); *e–o,* serial transverse sections 2.0, 2.4, 2.8, 3.2, 3.6, 4.0, 4.8, 5.6, 6.0, 7.2, 7.6 mm from ventral umbo, ×1 (Middlemiss, 1991).

LOBOIDOTHYRIDOIDEA

D. E. LEE,[1] T. N. SMIRNOVA,[2] and A. S. DAGYS[3]

[[1]University of Otago; [2]Moscow State University; and [3]deceased, formerly of Lithuanian Academy of Sciences]

Superfamily LOBOIDOTHYRIDOIDEA Makridin, 1964

[*nom. correct.* LEE, SMIRNOVA, & DAGYS, herein, *pro* Loboidothyracea DAGYS, 1968, p. 88, *nom. transl. ex* Loboidothyrinae MAKRIDIN, 1964, p. 213]

Shell of adult small to very large, commonly smooth, rarely costate anteriorly, or capillate; commonly ventribiconvex, rarely planoconvex; outline commonly subpentagonal to elongate oval; anterior commissure commonly rectimarginate to biplicate or sulciplicate; foramen commonly large; permesothyrid; dental plates absent; no median septum, cardinal process commonly well developed; outer hinge plates well developed; inner hinge plates rare; loop deltiform, commonly long flanged; commonly 0.4 to 0.6 dorsal valve length; transverse band commonly strongly arched; loop ontogeny may be complex; developmental stages unknown for most genera. *Triassic–Lower Cretaceous.*

Family LOBOIDOTHYRIDIDAE Makridin, 1964

[*nom. correct.* KATZ & POPOV, 1974a, p. 22, *pro* Loboidothyridae DAGYS, 1968, p. 194, *nom. transl. ex* Loboidothyrinae MAKRIDIN, 1964, p. 213]

Small to large, rectimarginate to sulciplicate, commonly smooth, rarely capillate or anteriorly costellate; outer hinge plates dorsally attached to crural bases; terminal points moderately short or weakly developed. *Lower Jurassic (Toarcian)–Lower Cretaceous (Valanginian).*

Subfamily LOBOIDOTHYRIDINAE Makridin, 1964

[*nom. correct.* COOPER, 1983, p. 44, *pro* Loboidothyrinae MAKRIDIN, 1964, p. 213]

Smooth or rarely finely capillate, planoconvex to ventribiconvex, foramen commonly large, permesothyrid, crural bases close to or anterior of midloop. *Lower Jurassic (Toarcian)–Lower Cretaceous (Valanginian).*

Loboidothyris BUCKMAN, 1918, p. 112 (BUCKMAN, 1914, p. 2, *nom. nud.*) [**L. latovalis;* OD] [=*Dundrythyris* ALMÉRAS, 1971, p. 188 (type, *Terebratula perovalis* J. DE C. SOWERBY, 1825 in 1823–1825, p. 51)]. Medium to very large, subcircular to elongate oval, smooth, ventribiconvex, anterior commissure rectimarginate to uniplicate to sulciplicate; beak large, short, foramen large, circular, commonly labiate, permesothyrid; symphytium usually hidden; pedicle collar short; cardinal process low, lobate; outer hinge plates short, narrowly triangular, dorsally attached to crural bases; crural processes anterior of midloop; loop triangular, 0.35 to 0.45 dorsal valve length; transverse band with low arch, flattened medially; terminal points fairly short. *Lower Jurassic (Toarcian)–Middle Jurassic (Bajocian):* Europe, Asia, South America.——FIG. 1378,*4a–c.* **L. latovalis,* Aalenian, Dorset, England; dorsal, lateral, and anterior views of holotype, BGS GSM 31976, ×1 (Muir-Wood, 1965a).——FIG. 1378,*4d. L. perovalis* (J. DE C. SOWERBY), Bajocian, England; interior of dorsal valve, ×1 (Cooper, 1983).

Avonothyris BUCKMAN, 1918, p. 102 [**A. plicatina;* OD]. Small to medium size; subtriangular to subpentagonal, smooth, with radial capillae where exfoliated; ventribiconvex, anterior commissure sulciplicate; beak short, suberect, foramen large, permesothyrid, symphytium partly visible; cardinal process small, semielliptical; outer hinge plates very narrow, close to valve floor; loop 0.4 to 0.45 dorsal valve length, widely triangular, transverse band with low arch. *Middle Jurassic (Bathonian–Callovian):* England, France, Egypt, ?Tunisia, Tibet.——FIG. 1378,*1a–d.* **A. plicatina,* Bathonian, England; *a–b,* dorsal and lateral views of holotype; *c,* anterior view of holotype, BGS 51326, ×1 (Muir-Wood, 1965a); *d,* interior of dorsal valve, ×1 (Cooper, 1983).

Arabatia COOPER, 1989, p. 70 [**A. concava;* OD] [=*Arabicella* COOPER, 1989, p. 70 (type, *A. subpentagonalis,* OD); *Arapsopleurum* COOPER, 1989, p. 73 (type, *A. arabicum,* OD); *Arapsothyris* COOPER, 1989, p. 74 (type, *A. magna,* OD)]. Medium to large, subpentagonal to elongate oval, smooth, planoconvex to ventribiconvex, anterior commissure sulciplicate; broad costae may form peripherally; beak erect to incurved; foramen small to medium, mesothyrid to permesothyrid; symphytium usually hidden; cardinal process small, loop 0.4 to 0.5 dorsal valve length. *Middle Jurassic (Bathonian–Callovian):* Saudi Arabia.——FIG. 1378,*2a–d.* **A. concava,* Callovian; *a–c,* dorsal, lateral, and anterior

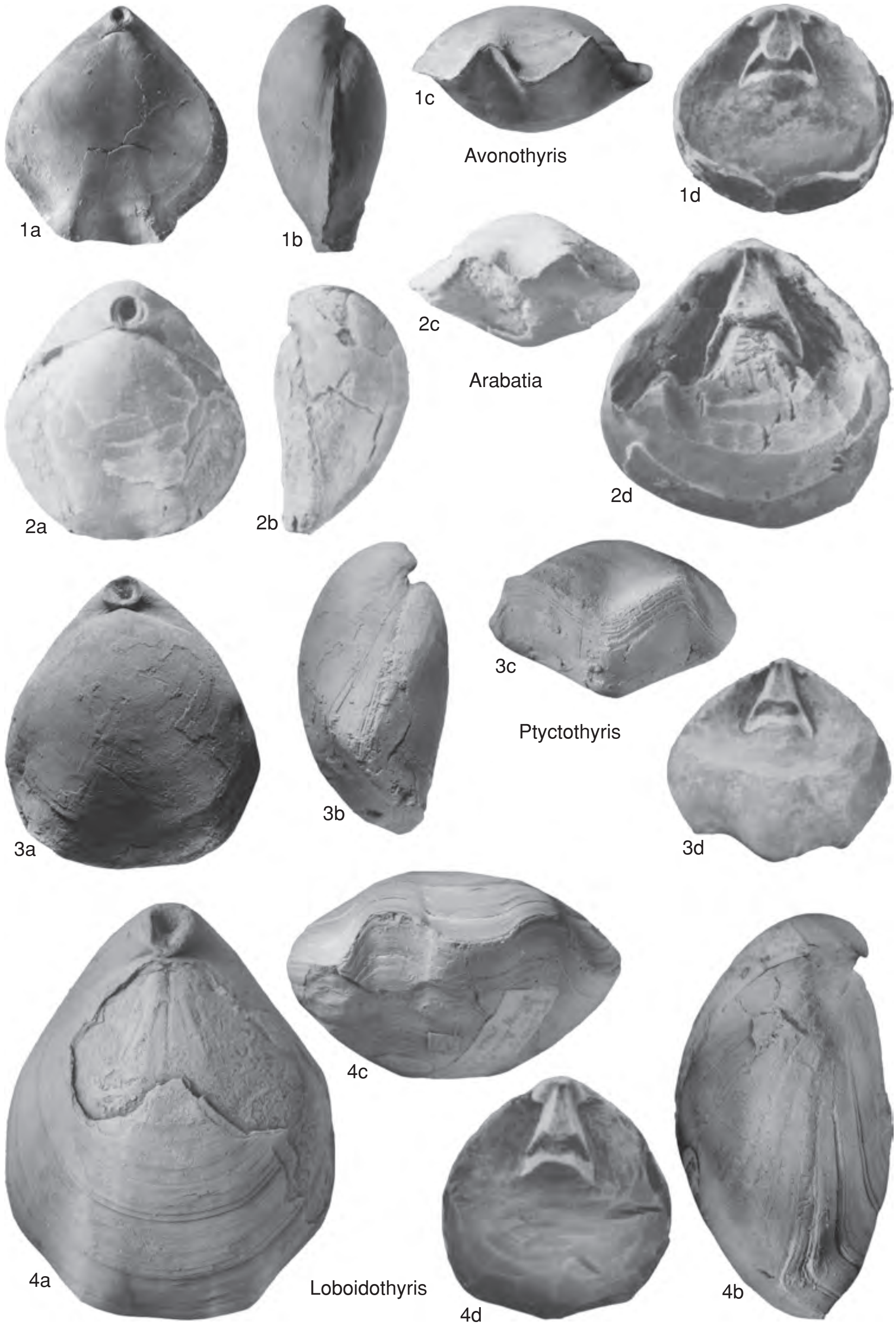

FIG. 1378. Loboidothyrididae (p. 2082–2084).

views of holotype, USNM 380462a; *d,* interior of dorsal valve, ×1 (Cooper, 1989).

Bihenithyris MUIR-WOOD, 1935, p. 110 [**B. barringtoni;* OD]. Medium size, subpentagonal, smooth, ventribiconvex, anterior commissure sulciplicate to bisulcate, beak massive, suberect to incurved, symphytium hidden, foramen large, permesothyrid; pedicle collar present; cardinal process short, broad, medianly depressed; hinge plates wide, tapering, forming deep U-shape with socket ridge; loop 0.45 dorsal valve length; transverse band almost horizontal, terminal points moderately long. *Middle Jurassic (Callovian):* Somalia, Egypt, Saudi Arabia, Israel.——FIG. 1379,*3a–d.* **B. barringtoni; a–c,* dorsal, lateral, and anterior views of holotype, BMNH B 85648, Somalia, ×1 (Muir-Wood, 1965a); *d,* interior of dorsal valve of specimen, Israel, ×1 (Cooper, 1983).

Charltonithyris BUCKMAN, 1918, p. 106 (BUCKMAN, 1915, p. 78, *nom. nud.*) [**Terebratula uptoni* BUCKMAN, 1895, p. 455; OD]. Large, subpentagonal, smooth, planoconvex to ventribiconvex, anterior commissure rectimarginate to uniplicate; beak short, foramen large, permesothyrid, symphytium exposed, beak ridges strong; cardinal process small; hinge plates short, triangular, concave, forming V-shaped troughs; loop widely triangular, 0.4 dorsal valve length; transverse band broad, with high, medially horizontal arch. *Middle Jurassic (Bajocian):* England.——FIG. 1379,*6a–d.* **C. uptoni* (BUCKMAN); *a–c,* dorsal, lateral, anterior views of paratype, ×1 (Muir-Wood, 1965a); *d,* interior of dorsal valve of specimen with slightly damaged loop, ×1 (Cooper, 1983).

Colosia COOPER, 1983, p. 67 [**Terebratula zieteni* LORIOL, 1876–1878, p. 168; OD]. Medium to large, elongate-oval, smooth, ventribiconvex, anterior commissure uniplicate in juveniles to sulciplicate in adults, beak erect, foramen large, mesothyrid, symphytium partly exposed; pedicle collar short; hinge plates wide, short; loop 0.25 to 0.45 dorsal valve length, highly variable in juvenile specimens, transverse band broad. *Upper Jurassic (Kimmeridgian):* Switzerland, Germany.——FIG. 1379,*1a–d.* **C. zieteni* (LORIOL), Switzerland; *a–c,* dorsal, lateral, anterior views ×1; *d,* closeup of loop, ×1 (Cooper, 1983).

Dolichobrochus COOPER, 1983, p. 73 [**Terebratula excavata* DESLONGCHAMPS, 1856b, p. 97; OD]. Small, subpentagonal, smooth, ventribiconvex, anterior commissure sulciplicate; foramen small, permesothyrid; crura long, broad; loop long, narrow, 0.45 dorsal valve length. *Middle Jurassic (Callovian):* France, ?Saudi Arabia.——FIG. 1379,*2a–d.* **D. excavata* (DESLONGCHAMPS), France; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* interior of dorsal valve, ×1 (Cooper, 1983).

Ectyphoria COOPER, 1989, p. 79 [**E. inflata;* OD]. Medium size, subpentagonal, smooth, strongly biconvex, anterior commissure biplicate; foramen small, permesothyrid, ventral umbo carinate, dorsal umbo sulcate, cardinal process bilobed, loop long, transverse band not seen. *Middle Jurassic (Bathonian–Callovian):* Saudi Arabia.——FIG. 1379,*4a–c.* **E. inflata;* dorsal, lateral, and anterior views of holotype, USNM 380413, ×1 (Cooper, 1989).

Pinaxiothyris DAGYS, 1968, p. 86 [**P. campestris;* OD]. Medium size, oval, gently biconvex, smooth, anterior commissure rectimarginate, beak short, foramen large, permesothyrid; symphytium low, partly hidden; pedicle collar short; cardinal process large, outer hinge plate horizontal in section, loop 0.35 dorsal valve length, widely triangular, transverse band arched. *Upper Jurassic (Kimmeridgian)–Lower Cretaceous (Valanginian):* Asia (Northern Urals, northern Siberia).——FIG. 1379,*5a–d.* **P. campestris,* Tithonian, northern Siberia; *a–c,* dorsal, lateral, anterior views, ×1; *d,* reconstruction of loop, approximately ×1 (Cooper, 1983).

Pseudoglossothyris BUCKMAN, 1901, p. 234 [240] [**Terebratula curvifrons* DAVIDSON, 1878a, p. 153; SD MUIR-WOOD, 1965a, p. 786; *non* OPPEL, 1858, p. 423, =*Aulacothyris leckhamptonensis* ROLLIER, 1919, p. 347]. Medium to large, subpentagonal, smooth, planoconvex to ventribiconvex, anterior commissure unisulcate; beak short, foramen large, permesothyrid, symphytium exposed, beak ridges strong; cardinal process large, lobate; loop widely triangular, 0.4 dorsal valve length; transverse band broad, with high, narrow arch. *Middle Jurassic (Bajocian):* England, France.——FIG. 1380,*5a–d.* **P. leckhamptonensis* (ROLLIER), England; *a–c,* dorsal, lateral, and anterior views, ×1 (Muir-Wood, 1965a); *d,* interior of dorsal valve, ×1 (Cooper, 1983).

Ptyctothyris BUCKMAN, 1918, p. 101 (BUCKMAN, 1914, p. 2, *nom. nud.*) [**Terebratula stephani* DAVIDSON, 1877, p. 75; OD] [=*Systenothyris* COOPER, 1983, p. 156 (type, *S. triangulata,* OD)]. Large, subtriangular, smooth, ventribiconvex, with prominent ventral fold, anterior commissure rectimarginate to sulciplicate; beak large, incurved, foramen large, permesothyrid, symphytium partly visible; cardinal process small, hinge plates short, close to valve floor, loop 0.3 to 0.4 dorsal valve length, triangular, transverse band wide, with flattened arch. *Middle Jurassic (Bajocian–Bathonian, ?Callovian):* England, France, Egypt.——FIG. 1378,*3a–d.* **P. stephani* (DAVIDSON), Bajocian, England; *a–c,* dorsal, lateral, and anterior views, ×1 (Muir-Wood, 1965a); *d,* interior of dorsal valve, ×1 (Cooper, 1983).

Sphaeroidothyris BUCKMAN, 1918, p. 115 (BUCKMAN, 1914, p. 2, *nom. nud.*) [**S. globisphaeroidalis;* OD] [=*Pachythyris* BOULLIER, 1976, p. 154 (type, *Terebratula arduennensis* DOUVILLÉ, 1886, p. 65), *non* FELDER, 1874, Lepidoptera; *Pionopleurum* COOPER, 1989, p. 83 (type, *P. obesum*)]. Small to medium size, subcircular, planoconvex to ventribiconvex to globose; smooth, anterior commissure rectimarginate to slightly uniplicate; beak short, incurved, foramen large, permesothyrid, symphytium hidden;

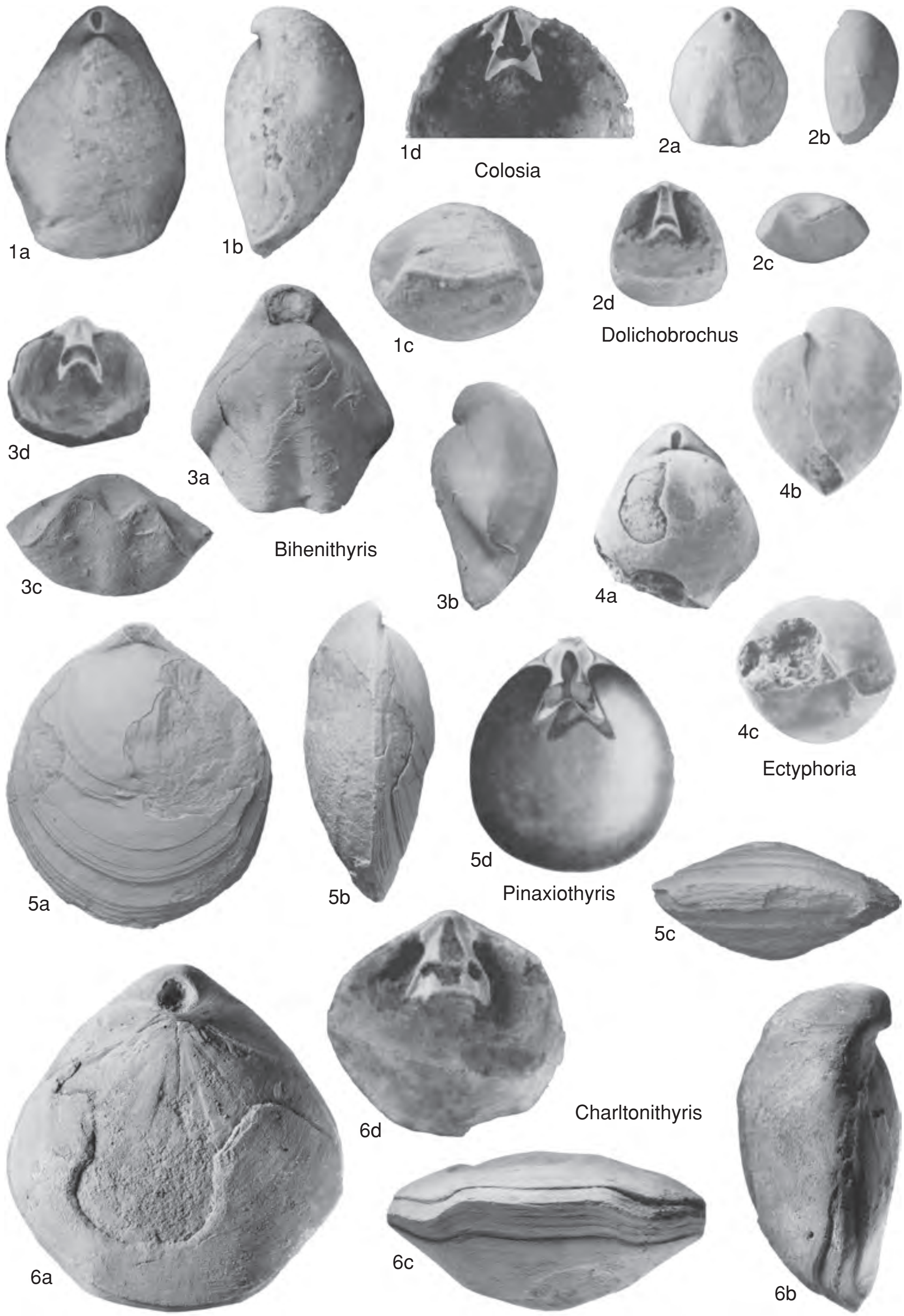

FIG. 1379. Loboidothyrididae (p. 2084).

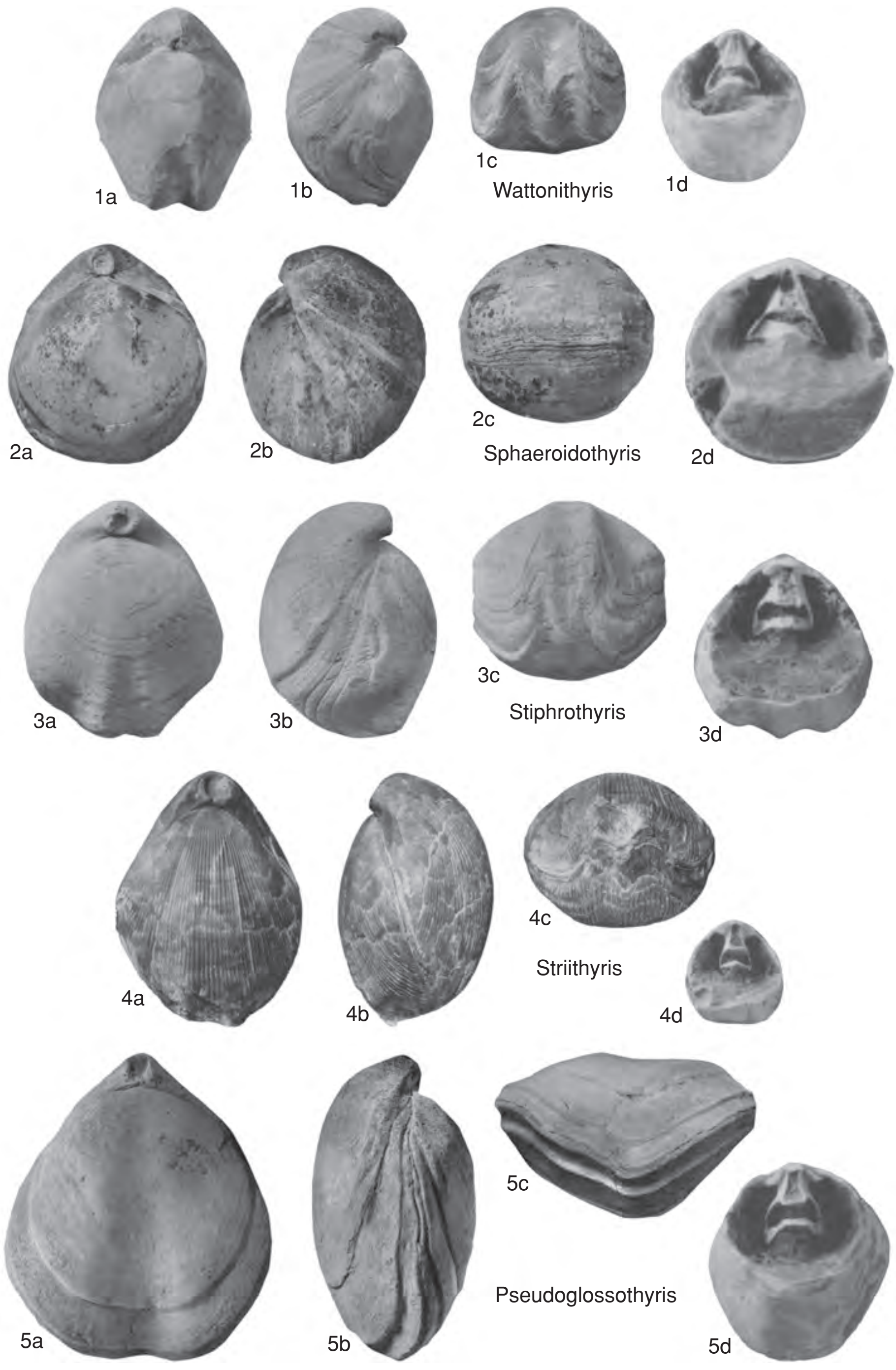

FIG. 1380. Loboidothyrididae (p. 2084–2087).

cardinal process prominent, lobate, medianly depressed; hinge plates short, triangular, thin, close to valve floor; loop 0.3 to 0.4 dorsal valve length, widely triangular, transverse band with angular arch. *Middle Jurassic (Bajocian–Bathonian):* England, France, Germany, Saudi Arabia, Tibet.——FIG. 1380,*2a–d.* *S. globisphaeroidalis,* Bajocian, England; *a–c,* dorsal, lateral, and anterior views, ×1 (Muir–Wood, 1965a); *d,* interior of dorsal valve, ×1 (Cooper, 1983).

Stiphrothyris BUCKMAN, 1918, p. 109 (BUCKMAN, 1915, p. 78, *nom. nud.*) [*Terebratula globata* var. *tumida* DAVIDSON, 1878a, p. 149; OD]. Medium size, concavoconvex, becoming strongly ventribiconvex; smooth, anterior commissure sulciplicate, beak short, incurved in older specimens, symphytium usually visible, foramen large, permesothyrid; cardinal process narrow, bilobed, protuberant, outer hinge plates short, narrowly triangular, forming narrow, U-shaped troughs with crural bases; loop 0.4 to 0.5 dorsal valve length, widely triangular; transverse band with high arch. *Middle Jurassic (Bajocian–Bathonian):* England; Saudi Arabia, *?Bajocian.*——FIG. 1380,*3a–d.* *S. tumida* (DAVIDSON), Bajocian, England; *a–c,* dorsal, lateral, and anterior views, ×1 (Muir-Wood, 1965a); *d,* interior of dorsal valve, ×1 (Cooper, 1983).

Striithyris MUIR-WOOD, 1935, p. 129 [*S. somaliensis;* OD]. Medium size, elongate-oval, ventribiconvex, finely costellate, anterior commissure uniplicate to sulciplicate, beak short, massive, foramen large, permesothyrid, symphytium partly visible; cardinal process low, medianly depressed; hinge plates short, narrow, tapering, forming broad, U-shaped troughs with crural bases; loop 0.4 to 0.5 dorsal valve length, transverse band with low arch. *Middle Jurassic (Callovian)–Upper Jurassic (Oxfordian):* Somalia, Saudi Arabia, Israel.——FIG. 1380,*4a–d.* *S. somaliensis,* Oxfordian; *a–c,* dorsal, lateral, and anterior views, Somalia, ×1 (Muir-Wood, 1965a); *d,* interior of dorsal valve of specimen, Saudi Arabia, ×1 (Cooper, 1983).

Wattonithyris MUIR-WOOD, 1936, p. 91 [*W. wattonensis;* OD] [=*Pseudowattonithyris* ALMÉRAS, 1971, p. 393 (type, *Terebratula circumdata* DESLONGCHAMPS, 1885 in 1862–1885, p. 131)]. Small to medium size, oval to subpentagonal, smooth, ventribiconvex, anterior commissure sulciplicate to bisulcate; beak suberect to incurved, foramen small, permesothyrid; pedicle collar present; cardinal process small, with shallow median sulcus; hinge plates ventrally concave, clubbed; loop 0.4 to 0.5 dorsal valve length, widely triangular, with nearly straight sides, transverse band with broad arch. *Middle Jurassic (?Bajocian, Bathonian):* England, France, Bulgaria, Poland, Russia, Morocco, ?Saudi Arabia, Tibet.——FIG. 1380,*1a–c.* *W. wattonensis,* Bathonian, England; dorsal, lateral, and anterior views, ×1 (Muir–Wood, 1965a).——FIG. 1380,*1d.* *W. fullonica* MUIR-WOOD, Bathonian, England; interior of dorsal valve, ×1 (Cooper, 1983).

Subfamily BOTHROTHYRIDINAE Cooper, 1983

[Bothrothyridinae COOPER, 1983, p. 45]

Large, rhomboidal, smooth, concavoconvex, anterior commissure unisulcate; crural processes anterior of midloop. *Middle Jurassic (Callovian).*

Bothrothyris COOPER, 1983, p. 61 [*B. curiosa;* OD]. Beak short, incurved, foramen small, mesothyrid; cardinal process thick, shafted, bilobed; crural bases round, solid; outer hinge plates narrow; crura long, narrow, descending lamellae long, thin; loop triangular, 0.4 dorsal valve length; transverse band strongly arched. *Middle Jurassic (Callovian):* Egypt.——FIG. 1381,*1.* *B. curiosa;* ventral view of dorsal valve of interior of holotype, USNM 551007, ×1 (Cooper, 1983).

Subfamily CERERITHYRIDINAE Cooper, 1983

[Cererithyridinae COOPER, 1983, p. 45]

Smooth or anteriorly costate; loops with shorter terminal points than Loboidothyridinae and crural processes close to or posterior of midloop. *Middle Jurassic (Bajocian)–Upper Jurassic (Oxfordian).*

Cererithyris BUCKMAN, 1918, p. 109 (BUCKMAN, 1914, p. 2, *nom. nud.*) [*Terebratula intermedia* J. SOWERBY, 1813 in 1812–1815, p. 48; OD]. Medium to large, ventribiconvex, smooth, anterior commissure rectimarginate to uniplicate or sulciplicate, beak short, foramen large, permesothyrid, symphytium partly visible; cardinal process small, hinge plates short, narrowly triangular, forming short, V- or U-shaped troughs with socket ridges; loop 0.5 dorsal valve length, widely triangular, transverse band with high arch. *Middle Jurassic (Bathonian):* England, France, Bulgaria, Tibet.——FIG. 1381,*5a–d.* *C. intermedia* (J. SOWERBY), England; *a–c,* dorsal, lateral, and anterior views of lectotype, ×1 (Muir–Wood, 1965a); *d,* interior of dorsal valve, ×1 (Cooper, 1983).

Animonithyris COOPER, 1983, p. 52 [*Terebratula dorenbergi* FELIX, 1891, p. 176; OD]. Medium size, subcircular, smooth, ventribiconvex, anterior commissure rectimarginate to sulciplicate; beak short, erect, foramen large, meso- to submesothyrid, deltidial plates small, conjunct, pedicle collar short, excavate; cardinal process broad, semielliptical; crural processes at midloop; loop widely triangular, about 0.4 dorsal valve length. *Upper Jurassic (Oxfordian):* Mexico.——FIG. 1381,*2a–d.* *A. dorenbergi* (FELIX); *a–c,* dorsal, lateral, and anterior views, ×1; *d,* interior of dorsal valve, ×1 (Cooper, 1983).

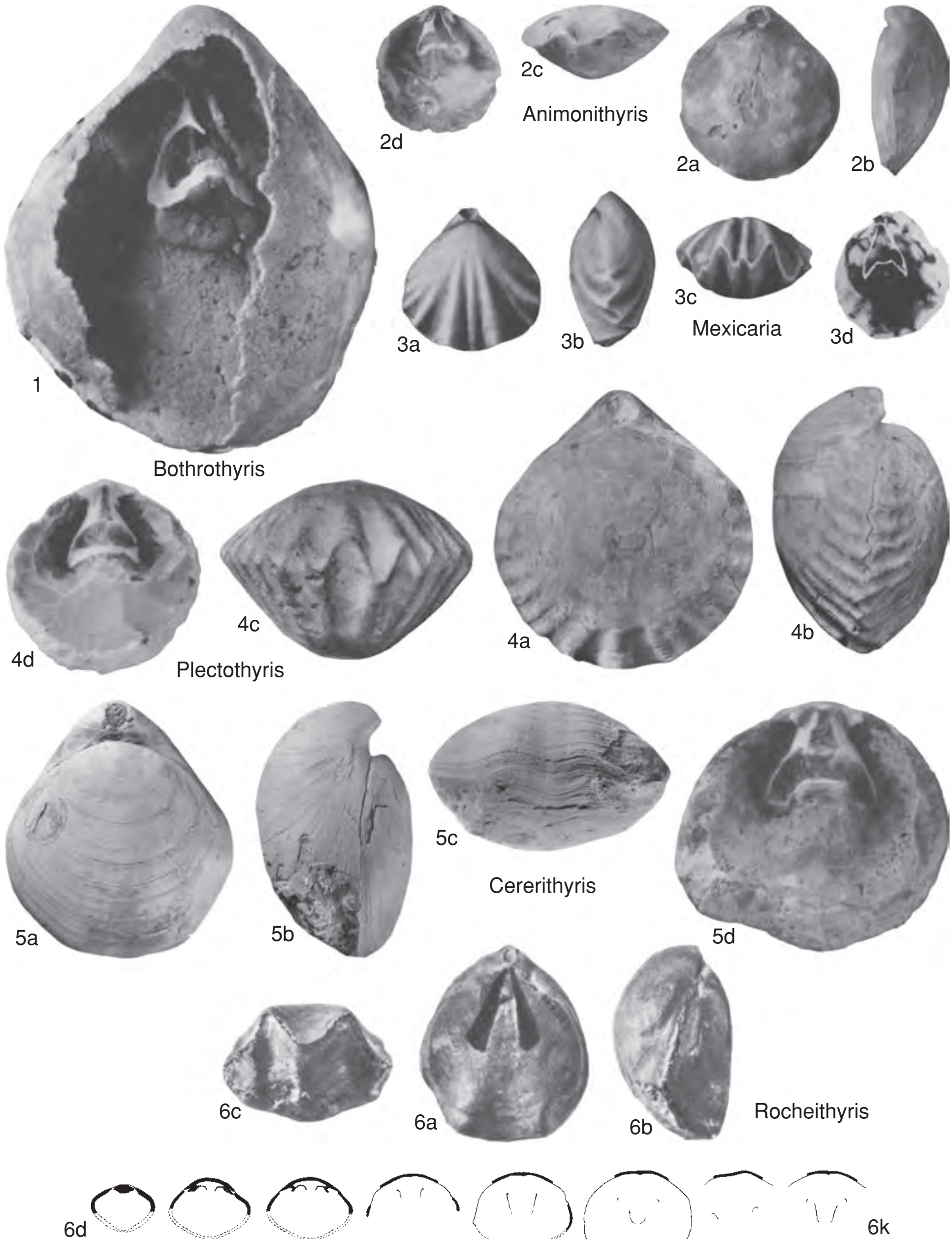

FIG. 1381. Loboidothyrididae (p. 2087–2089).

Mexicaria COOPER, 1983, p. 114 [**Parathyridina mexicana* OCHOTERENA, 1960, p. 24; OD]. Small, subpentagonal, ventribiconvex, anteriorly strongly but variably costate; anterior commissure sulciplicate, but with 2 or 3 costae on fold; beak short, suberect, foramen large, mesothyrid, loop similar to that of *Animonithyris. Upper Jurassic (Oxfordian):* Mexico.——FIG. 1381,*3a–d.* **M. mexicana* (OCHOTERENA); *a–c,* dorsal, lateral, and anterior views, ×1; *d,* interior of silicified dorsal valve, ×1 (Cooper, 1983).

Plectothyris Buckman, 1918, p. 121, *non* Rollier, 1918, p. 252 (Buckman, 1914, p. 2, *nom. nud.*) [**Terebratula fimbria* J. Sowerby, 1822 in 1821–1822, p. 27; OD]. Medium to large, subcircular, plano- to ventribiconvex, anterior third to half of adult shell strongly costate; anterior commissure rectimarginate; beak short, foramen large, permesothyrid; cardinal process small, bilobed; loop broadly triangular. *Middle Jurassic (Bajocian):* England, France, ?Saudi Arabia.——Fig. 1381,*4a–d. P. fimbria* (J. Sowerby), England; *a–c,* dorsal, lateral, and anterior views, ×1 (Muir-Wood, 1965a); *d,* interior of dorsal valve, ×1 (Cooper, 1983).

Rocheithyris Alméras, 1971, p. 345 [**R. curvata;* OD]. Medium size, subpentagonal, smooth, biconvex, anterior commissure sulciplicate; beak short, foramen small, permesothyrid to mesothyrid, symphytium not exposed, pedicle collar present; cardinal process planoconvex, hinge plates in section club shaped, loop 0.5 dorsal valve length. *Middle Jurassic (Bajocian–Bathonian):* France.——Fig. 1381,*6a–k.* **R. curvata; a–c,* dorsal, lateral, and anterior views of holotype, FSL 47917, ×1; *d–k,* serial transverse sections, 3.8, 5.5, 5.9, 7.5, 8.5, 11.5, 11.8, 13.9 mm from ventral umbo, ×1 (Alméras, 1971).

Family PLECTOCONCHIDAE Dagys, 1974

[*nom. transl.* Lee, Smirnova, & Dagys, herein, *ex* Plectoconchinae Dagys, 1974, p. 197; *emend.,* Cooper, 1983, p. 38]

Medium size, semicostate to costate, beak labiate, anterior commissure rectimarginate to uniplicate, outer hinge plates dorsally attached to crural bases, loop short, wide. *Upper Triassic–Lower Jurassic.*

Plectoconcha Cooper, 1942, p. 233 [**Rhynchonella aequiplicata* Gabb, 1864, p. 35; OD]. Subrounded, strongly ventribiconvex, anterior commissure uniplicate, beak erect, foramen large, permesothyrid, labiate; pedicle collar strong; cardinal process broadly elliptical; outer hinge plates narrow, tapering anteriorly; crural processes close to anterior end of hinge plates; loop wide, transverse band thin, broadly arched. *Upper Triassic:* USA (Nevada).——Fig. 1382,*2a–f.* **P. aequiplicata* (Gabb); *a–d,* dorsal, ventral, lateral, and anterior views, ×1 (Sandy & Stanley, 1993); *e–f,* dorsal and lateral views of imperfect loop, ×2 (Cooper, 1983).

Merophricus Cooper, 1983, p. 113 [**M. dubari;* OD; =*Terebratula* cf. *semiarata* Dubar, 1942, p. 63]. Subcircular, ventribiconvex, anterior commissure rectimarginate to uniplicate, beak short, suberect, foramen large, incomplete; outer hinge plates broad, flatly concave, crura not developed, loop short (0.3 dorsal valve length), wide, transverse band thin. *Lower Jurassic:* Morocco, Greece.——Fig. 1382,*1a–d.* **M. dubari; a–c,* dorsal, lateral, and anterior views, ×1; *d,* dorsal view of imperfect loop, ×3 (Cooper, 1983).

Family TRIADITHYRIDIDAE Pearson, 1977

[*nom. transl.* Lee, Smirnova, & Dagys, herein, *ex* Triadithyridinae Pearson, 1977, p. 42]

Medium to large, smooth, biconvex, anterior commissure rectimarginate to biplicate, cardinal process distinct, outer hinge plates narrow, with ventrally directed crural bases; loop about 0.4 to 0.6 dorsal valve length, transverse band high arched, formed of secondary elements that evolved in ontogeny on ventral part of vertical plate; flanges usually long. *Triassic–Upper Jurassic (Tithonian).*

Triadithyris Dagys, 1963, p. 187 [**Terebratula gregariaeformis* Zugmayer, 1880, p. 13; OD]. Medium size, subpentagonal, ventribiconvex, anterior commissure sulciplicate, beak short, suberect, foramen permesothyrid; pedicle collar present; cardinal process large, bilobed, outer hinge plates narrow, horizontal in section, crural bases indistinct; loop about 0.5 dorsal valve length, with diverging, descending lamellae. *Upper Triassic (Norian–Rhaetian):* Alps, Balkans, Carpathians, Crimea, Caucasus, Pamir.——Fig. 1383,*4a–s.* **T. gregariaeformis* (Zugmayer); *a–c,* dorsal, lateral, and anterior views, ×1.7; *d–r,* serial transverse sections 0.8, 1.6, 2.4, 2.5, 2.7, 3.0, 3.3, 3.6, 3.75, 4.05, 4.5, 5.25, 6.45, 6.6, 6.75 mm from ventral umbo, ×1; *s,* loop reconstruction, ×1 (Pearson, 1977).

Inversithyris Dagys, 1968, p. 92 [**I. rhomboidalis* Dagys, 1968, p. 93; OD]. Medium size, biconvex, anterior commissure inicipiently unisulcate, beak short, foramen mesothyrid; pedicle collar present; cardinal process large, undivided, outer hinge plates horizontal or sloping; crural bases perpendicular to hinge plates, directed ventrally and dorsally; loop about 0.5 dorsal valve length, with flanges. *Middle Jurassic:* northeastern Siberia.——Fig. 1383,*1a–q.* **I. rhomboidalis; a–c,* dorsal, lateral, and anterior views, ×1; *d–q,* serial transverse sections 0.0, 2.2, 2.6, 2.8, 3.9, 4.4, 4.7, 5.2, 5.8, 6.9, 8.8, 9.7, 10.2, 11.2 mm from first section, ×1 (Dagys, 1968).

Laevithyris Dagys, 1974, p. 198 [**Lobothyris rossochae* Dagys, 1965, p. 143; OD]. Medium size, elongate-oval, anterior commissure slightly uniplicate; beak short, permesothyrid; pedicle collar short; cardinal process low, undivided, outer hinge plates narrow, horizontal, crural bases high, directed ventrally, loop 0.4 dorsal valve length, with short flanges. *Triassic:* northeastern Siberia, Primorye.——Fig. 1383,*2a–c.* **L. rossochae* (Dagys), Norian, Siberia; dorsal, lateral, and anterior views, ×1 (Dagys, 1968).

Lenothyris Dagys, 1968, p. 100 [**L. perflexus;* OD]. Large, subrounded, juveniles thin, with flattened dorsal valve; adults strongly biconvex, geniculate; anterior commissure rectimarginate; beak short, foramen permesothyrid; pedicle collar short; cardinal process thickened, undivided; outer hinge plate

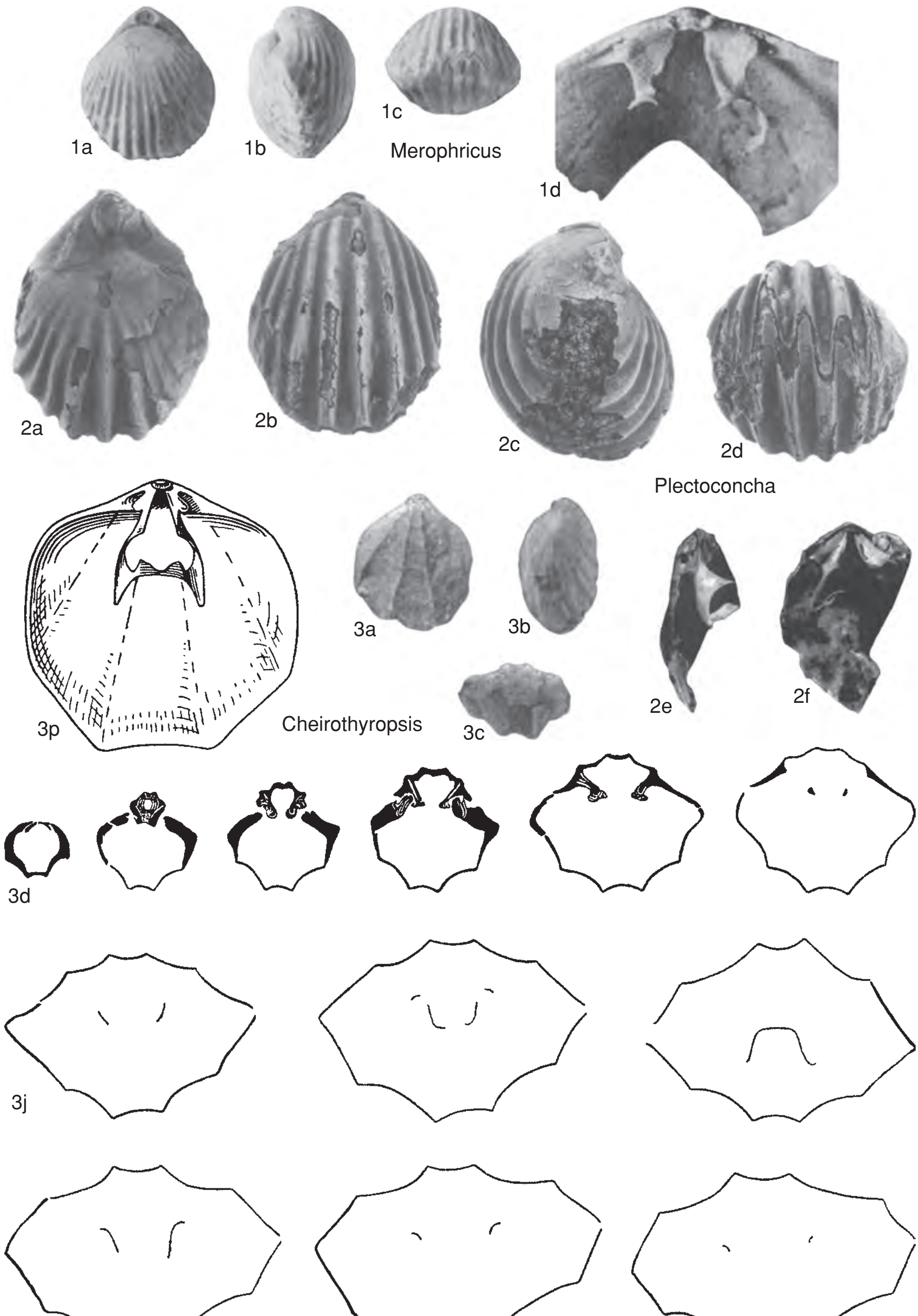

FIG. 1382. Plectoconchidae and Cheirothyropsidae (p. 2089–2096).

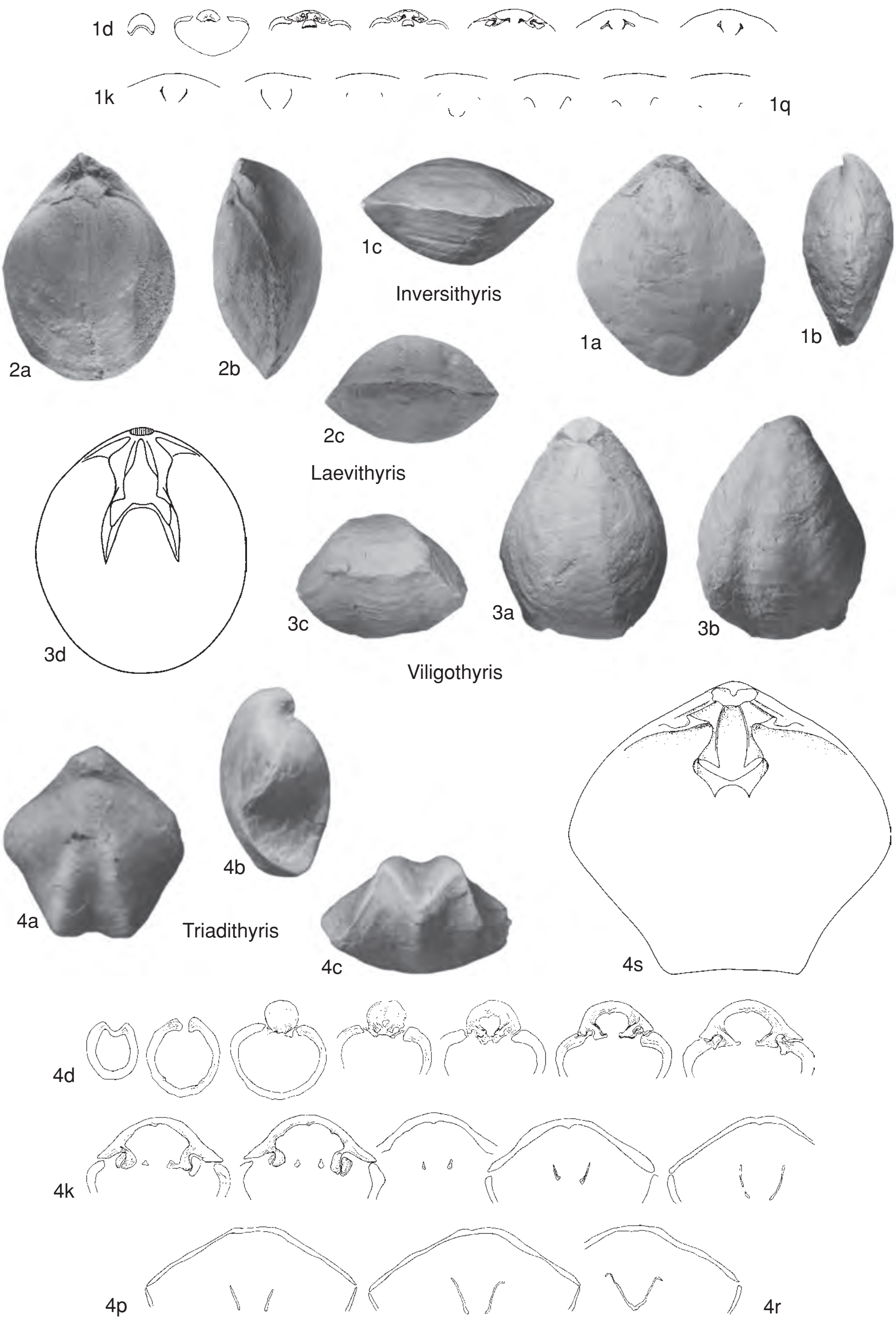

FIG. 1383. Triadithyrididae (p. 2089–2092).

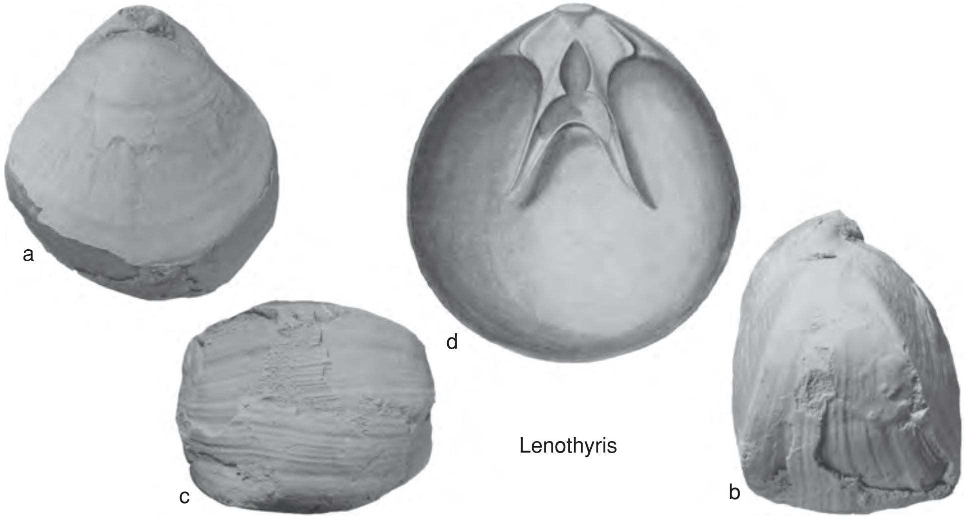

FIG. 1384. Triadithyrididae (p. 2089–2092).

subhorizontal in section, crural bases distinct; loop about 0.5 dorsal valve length, with long flanges. *Upper Jurassic (Tithonian):* Northern Siberia.——FIG. 1384*a–d.* **L. perflexus,* Volgian; *a–c,* dorsal, lateral, and anterior views, ×1 (Dagys, 1968); *d,* reconstruction of loop, ×1 (Cooper, 1983).

Viligothyris DAGYS, 1968, p. 89 [**V. orientalis;* OD]. Medium size, biconvex, elongate-oval, anterior commissure uniplicate to paraplicate; beak short, foramen permesothyrid; pedicle collar distinct; cardinal process low, undivided, outer hinge plates narrow, subhorizontal in section; crural bases low, directed ventrally; narrow, inner hinge plates present; loop about 0.6 dorsal valve length, with long, anterior flanges. *Lower Jurassic (Pliensbachian):* northeastern Siberia.——FIG. 1383,*3a–d.* **V. orientalis; a–c,* dorsal, ventral, and anterior views, ×2 (Dagys, 1968); *d,* loop reconstruction, ×1 (Cooper, 1983).

Family BOREIOTHYRIDIDAE Dagys, 1968

[*nom. correct.* SMIRNOVA, 1990a, p. 98, *pro* Boreiothyridae DAGYS, 1968, p. 110]

Large to very large, smooth, rectimarginate to unisulcate; beak short, foramen large, permesothyrid; crural process distinct, crural plates connected with valve floor or enveloping low septum, forming broad septalium; loop about 0.5 dorsal valve length, high arched, with long flanges; transverse band formed from secondary elements that evolve on ventral part of vertical plate during ontogeny. *Lower Jurassic–Lower Cretaceous (Hauterivian).*

Boreiothyris DAGYS, 1968, p. 110 [**B. bojarkensis;* OD]. Very large, subtrigonal to elongate-oval, ventribiconvex, anterior commissure rectimarginate; pedicle collar thick; cardinal process massive, undivided, outer hinge plates narrow, crural plates long, inclined to valve floor, enveloping low septum forming septalium. *Middle Jurassic (Callovian)–Upper Jurassic (Kimmeridgian):* northeastern Siberia.——FIG. 1385*a–p.* **B. bojarkensis,* Kimmeridgian; *a–c,* dorsal, lateral, and anterior views, ×1; *d–p,* serial transverse sections 3.6, 4.4, 5.1, 5.5, 5.9, 7.1, 9.1, 10.6, 12.1, 15.1, 17.1, 18.6, 24.6 mm from ventral umbo, ×1 (Dagys, 1968).

Omolonothyris DAGYS, 1968, p. 132 [**O. inopinatus;* OD]. Large, oval, biconvex, anterior commissure rectimarginate; pedicle collar present; cardinal process low, undivided; outer hinge plates broad, subhorizontal in section, crural plates very short, perpendicular to hinge plates, connected with valve floor some distance from low septum. *Lower Jurassic (Toarcian):* northeastern Siberia.——FIG. 1386,*1a–c.* **O. inopinatus;* dorsal, lateral, and anterior views, ×1 (Dagys, 1968).

Pamirothyropsis OVTSHARENKO, 1979, p. 126, *nom. nov. pro Pamirothyris* OVTSHARENKO, 1975, p. 116, *non* DAGYS, 1974, p. 195 [**Pamirothyris vialovi* OVTSHARENKO, 1975, p. 117; OD]. Large, concavo-convex, anterior commissure broadly unisulcate, beak short, hinge teeth massive; cardinal process short, bilobate; hinge plates slightly inclined dorsally, crural plates derived from dorsal ends of crural bases almost perpendicular to valve floor; resting on short septal lamellae; ventral ends of crural processes strongly curved laterally. *Middle Jurassic*

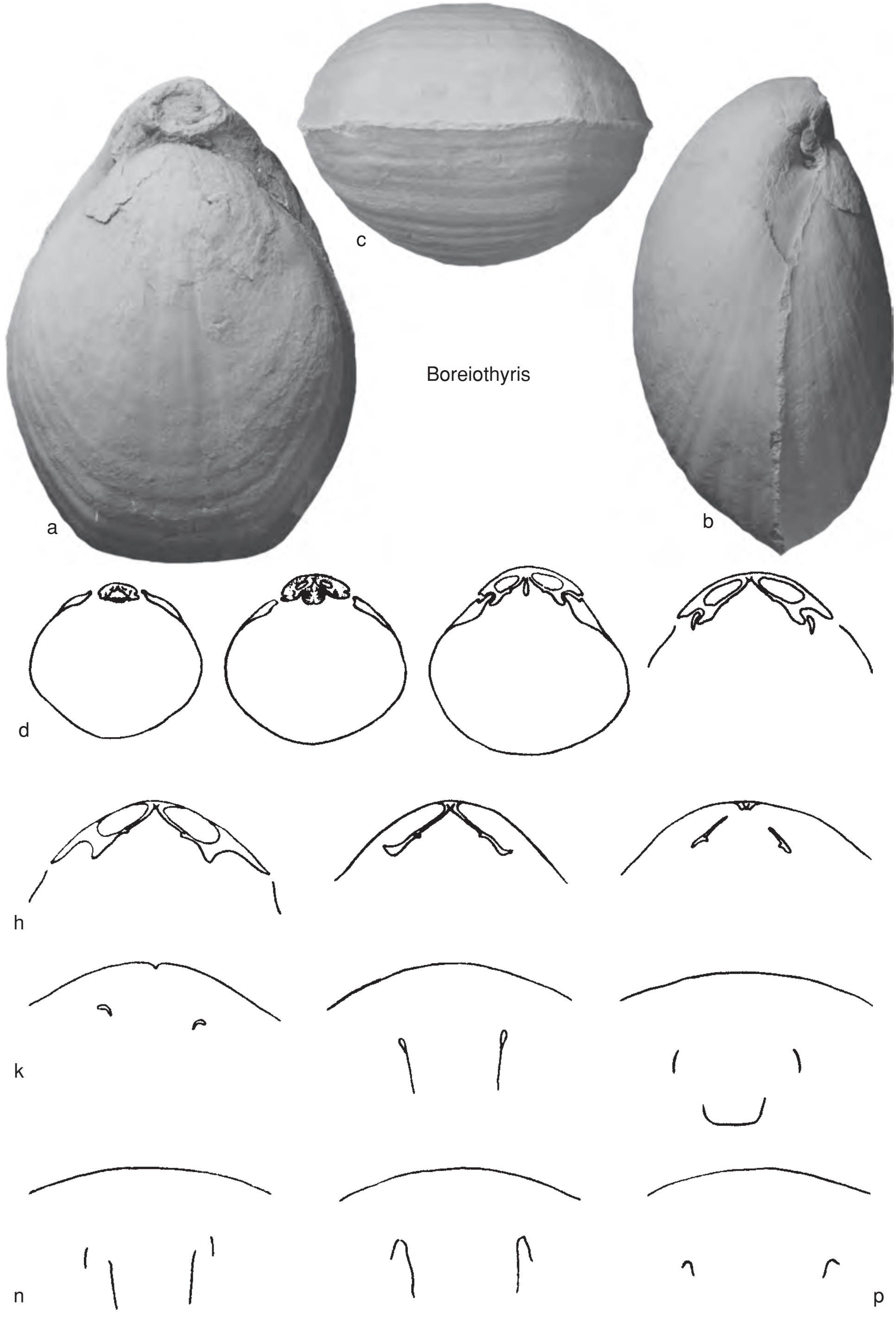

FIG. 1385. Boreiothyrididae (p. 2092).

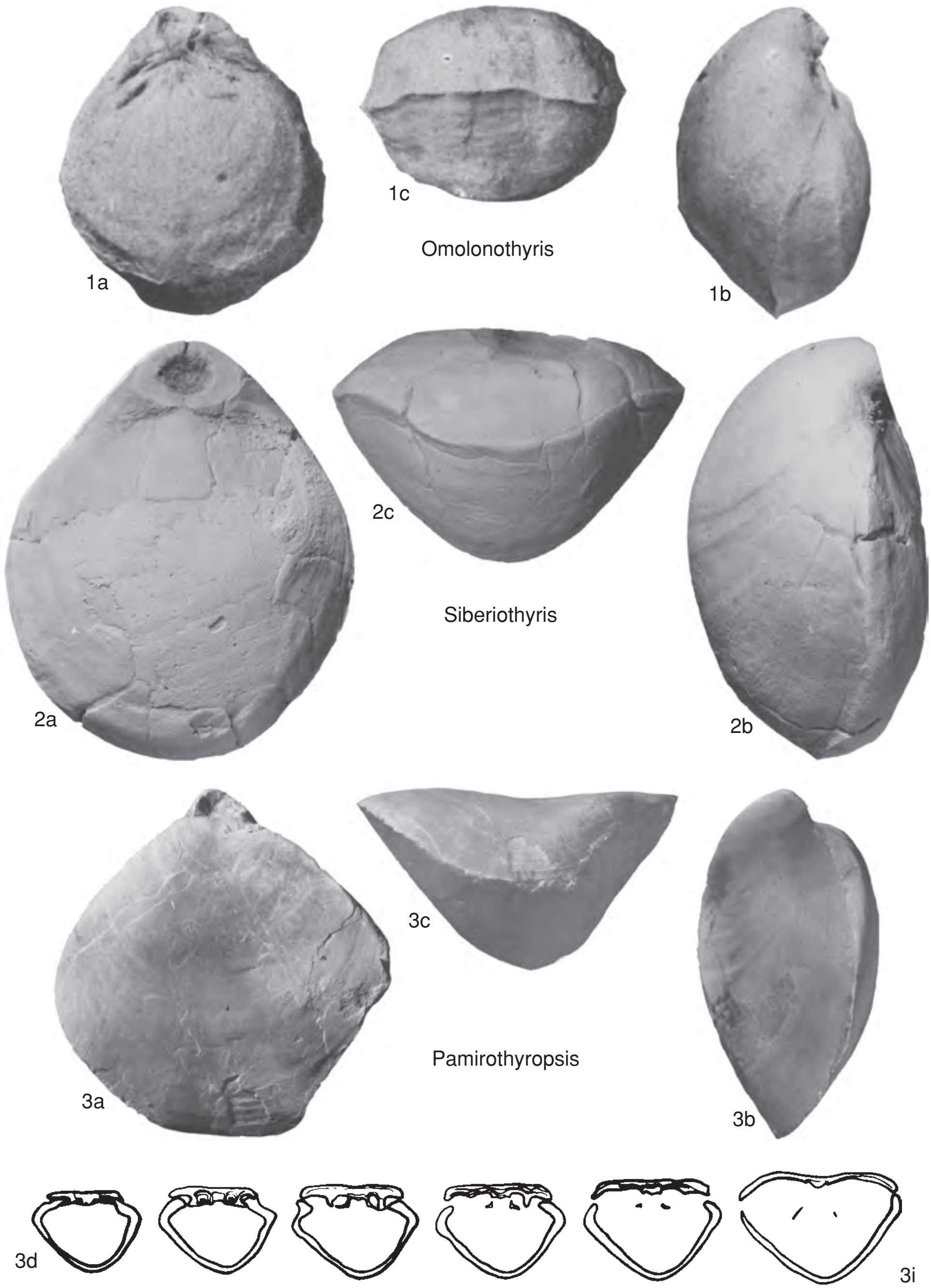

FIG. 1386. Boreiothyrididae (p. 2092–2095).

(Callovian): Tadzhikistan, Pamirs.——FIG. 1386,*3a–i.* **P. vialovi* (OVTSHARENKO), Pamirs; *a–c,* dorsal, lateral, and anterior views; *d–i,* serial transverse sections 2.4, 3.6, 4.1, 4.5, 5.2, 7.1 mm from ventral umbo, ×1 (new).

Siberiothyris DAGYS, 1968, p. 128 [**S. crassus;* OD]. Very large, planoconvex, anterior commissure broadly unisulcate, beak thick, short, suberect; pedicle collar massive; cardinal process low, undivided, crural plates weakly diverging, connected

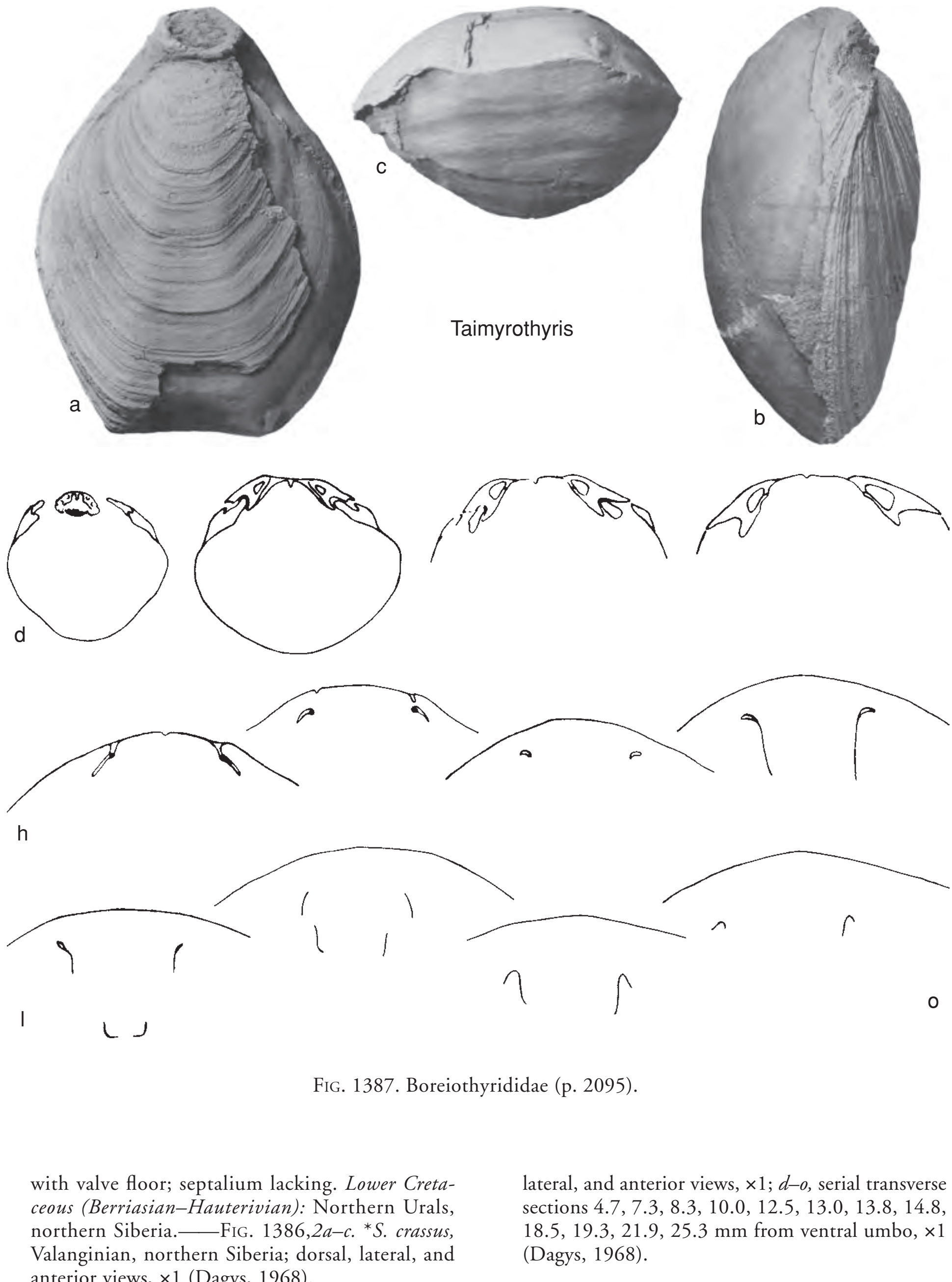

FIG. 1387. Boreiothyrididae (p. 2095).

with valve floor; septalium lacking. *Lower Cretaceous (Berriasian–Hauterivian):* Northern Urals, northern Siberia.——FIG. 1386,*2a–c.* **S. crassus,* Valanginian, northern Siberia; dorsal, lateral, and anterior views, ×1 (Dagys, 1968).

Taimyrothyris DAGYS, 1968, p. 118 [**T. bisulcatus;* OD]. Large, biconvex, may have sulcus on both valves; anterior commissure rectimarginate; pedicle collar distinct; cardinal process low, undivided, outer hinge plates narrow, crural plates diverging, attached to valve floor some distance from low median septum. *Upper Jurassic–Lower Cretaceous (Tithonian–Valanginian):* Northern Siberia.——FIG. 1387*a–o.* **T. bisulcatus,* Tithonian; *a–c,* dorsal, lateral, and anterior views, ×1; *d–o,* serial transverse sections 4.7, 7.3, 8.3, 10.0, 12.5, 13.0, 13.8, 14.8, 18.5, 19.3, 21.9, 25.3 mm from ventral umbo, ×1 (Dagys, 1968).

Family CHEIROTHYROPSIDAE Cooper, 1983

[Cheirothyropsidae COOPER, 1983, p. 45]

Medium size, subpentagonal; both valves with four opposite, ridgelike plications, anterior commissure rectimarginate. *Middle Jurassic (Callovian).*

Cheirothyropsis MAKRIDIN, 1964, p. 267 [**Terebratula pseudotrigonella* TRAUTSCHOLD, 1877, p. 102; OD]. Biconvex, ornament reticulate, four radial carinae on each valve; beak short, slightly incurved, foramen large, circular, mesothyrid; symphytium exposed; pedicle collar small; cardinal process bi- or trilobed; hinge plates divided, loop about 0.5 dorsal valve length, with long flanges; transverse band strongly arched. [Homeomorph of the zeilleriid *Cheirothyris.*] *Middle Jurassic (Callovian):* Russian Platform, Crimea, ?Western Europe.——FIG. 1382,*3a–p.* **C. pseudotrigonella* (TRAUTSCHOLD), Russia; *a–c,* dorsal, lateral, and anterior views, ×1; *d–o,* serial transverse sections 2.0, 3.0, 3.3, 3.7, 4.5, 4.9, 6.5, 9.0, 9.1, 9.4, 10.2, 10.8 mm from ventral umbo, ×1; *p,* loop reconstruction, ×2 (Makridin, 1964).

Family CHENIOTHYRIDIDAE Muir-Wood, 1965

[Cheniothyrididae MUIR-WOOD, 1965a, p. 800]

Small, subpentagonal to elongate; ornament of steplike, squamose lamellae with numerous papillae, loop short. *Middle Jurassic (Bajocian).*

Cheniothyris BUCKMAN, 1918, p. 128 (BUCKMAN, 1915, p. 79, *nom. nud.*) [**Terebratula morierei* EUDES-DESLONGCHAMPS in DAVIDSON, 1852b, p. 256; OD]. Moderately biconvex, each valve with median depression forming gently bilobate anterior margin; shell folding ligate, anterior commissure rectimarginate, foramen large, permesothyrid, symphytium high; cardinal process low, short, hinge plates in section thick, somewhat trigonal, ventrally directed and concave; loop about 0.3 valve length, with strongly arched transverse band, not fully known. *Middle Jurassic (Bajocian):* England, France.——FIG. 1388,*1a–l.* **C. morierei* (EUDES-DESLONGCHAMPS); *a–c,* dorsal, lateral, and anterior views, ×2; *d–l,* serial transverse sections, distances between sections unknown, ×1.4 (Muir-Wood, 1965a).

Family DICTYOTHYRIDIDAE Makridin, 1964

[*nom. correct. et transl.* MUIR-WOOD, 1965a, p. 801, *ex* Dictyothyrinae MAKRIDIN, 1964, p. 260]

Small to medium size, subpentagonal, shell ornament reticulate, anterior commissure plicosulcate. *Middle Jurassic–Lower Cretaceous (Hauterivian).*

Dictyothyris DOUVILLÉ, 1879, p. 267 [**Terebratulites coarctatus* PARKINSON, 1811, p. 229; OD]. Ventribiconvex; folding ligate, anterior commissure strongly plicosulcate; ornament reticulate with low nodes or spines at point of intersection; beak long, erect; foramen large, mesothyrid, symphytium may be exposed; cardinal process large, bilobed, medianly flattened, with posterior umbonal cavity; outer hinge plates small, triangular, thick and flattened, attached ventrally to crural bases; crura short, crural processes long, slender, ventrally directed, anterior of midloop; loop 0.4 dorsal valve length, very wide; transverse band strongly arched, medially flattened, protuberant, with short flanges. *Middle Jurassic (Bathonian)–Lower Cretaceous (Hauterivian):* England, France, Russia, Crimea.——FIG. 1388,*3a–d.* **D. coarctata* (PARKINSON), Bathonian, England, France; *a–c,* dorsal, lateral, and anterior views, ×1.8 (Muir-Wood, 1965a); *d,* interior of dorsal valve of specimen, France, ×2 (Cooper, 1983).

Family DIENOPIDAE Cooper, 1983

[Dienopidae COOPER, 1983, p. 42]

Medium size, elongate-pentagonal, ornament reticulate, anterior commissure parasulcate, loop very long. *Middle Jurassic (Callovian).*

Dienope COOPER, 1983, p. 72 [**Terebratula trigeri* DESLONGCHAMPS, 1856b, p. 97; OD]. Ventribiconvex, ornament of fine, radial capillae crossed by fine, concentric threads, beak suberect, foramen large, mesothyrid; cardinal process bilobed, protuberant; outer hinge plates welded to socket ridges, moderately convex toward ventral valve; crural processes wide, sharply pointed, loop extremely long, about 0.7 dorsal valve length, descending lamellae narrow, slender, transverse band moderately broad. *Middle Jurassic (Callovian):* France.——FIG. 1388,*2a–e.* **D. trigeri* (DESLONGCHAMPS); *a–b,* dorsal and anterior views, ×1; *c–d,* ventral and lateral views of loop of another specimen, ×1; *e,* somewhat idealized loop reconstruction, ×1 (Cooper, 1983).

Family HESPERITHYRIDIDAE Cooper, 1983

[Hesperithyrididae COOPER, 1983, p. 42]

Smooth, strongly plicate, outer hinge plates narrow, ventrally attached to crural bases. *Lower Jurassic.*

Hesperithyris DUBAR, 1942, p. 78 [**Terebratula renierii* CATULLO, 1827, p. 167, var. *sinuosa* DUBAR, 1942, p. 83; OD]. Small to large, strongly ventribiconvex, anterior commissure uniplicate, ornament of broad, subangular plicae, alternating on opposite valves, normally 2 on fold, 1 in sulcus, and 2 bounding sulcus; beak long, protuberant, foramen large, symphytium exposed; cardinal process large, wide, bilobed; outer hinge plates small, fused with crural bases; loop short, not fully known. *Lower Jurassic:* Morocco, Portugal, Alps, Timor.——FIG. 1388,

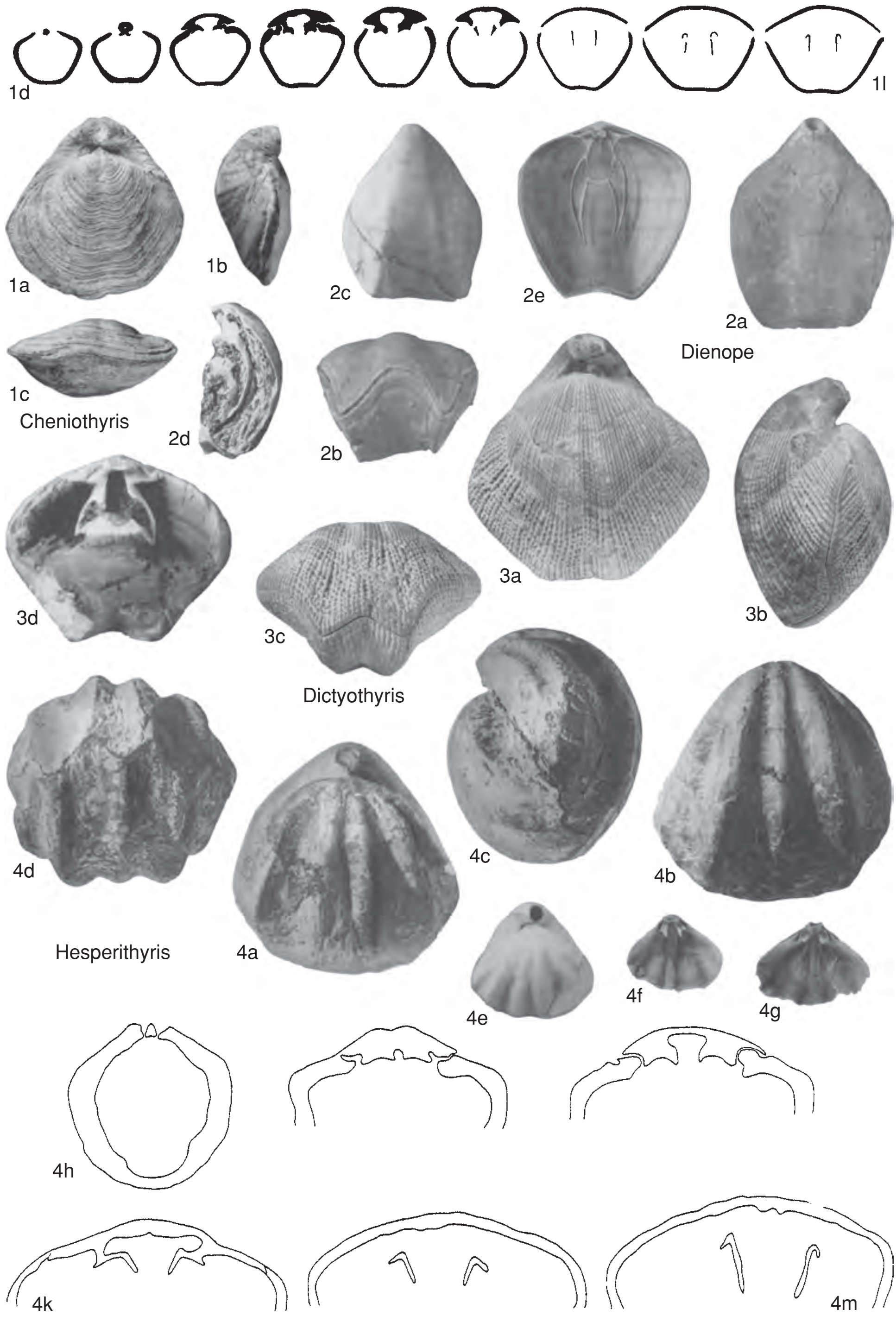

FIG. 1388. Cheniothyrididae, Dictyothyrididae, Dienopidae, and Hesperithyrididae (p. 2096–2098).

4a–g. **H. sinuosa* (DUBAR), Morocco; *a–d,* dorsal, ventral, lateral, and anterior views, ×1 (Muir-Wood, 1965a); *e–g,* dorsal and interior views, ×1 (Cooper, 1983).——FIG. 1388,*4h–m. H. ribeiroi* (CHOFFAT), Sinemurian, Portugal; serial transverse sections 4.7, 5.5, 5.9, 6.9, 7.8, 8.6 mm from first sections, ×2 (Ager & Walley, 1977).

Family LISSAJOUSITHYRIDIDAE Cooper, 1983

[*nom. transl.* LEE, SMIRNOVA, & DAGYS, herein, *ex* Lissajousithyridinae COOPER, 1983, p. 43]

Small to large, smooth, commonly ventribiconvex, commonly rectimarginate, uniplicate or sulciplicate, loop long, variable in width, outer hinge plates dorsally attached to crural bases, crural processes posterior of midloop, terminal points may be very long. *Lower Jurassic (Toarcian)–Upper Jurassic.*

Subfamily LISSAJOUSITHYRIDINAE Cooper, 1983

[Lissajousithyridinae COOPER, 1983, p. 43]

Transverse band without deep reentrant on posterior side. *Lower Jurassic (Toarcian)–Upper Jurassic.*

Lissajousithyris ALMÉRAS, 1971, p. 164 [**Terebratula matisconensis* LISSAJOUS in ARCELIN & ROCHE, 1936, p. 80; OD]. Medium size, elongate-oval; anterior commissure uniplicate to sulciplicate, sulcus broad; beak short, foramen mesothyrid, symphytium wide, exposed; pedicle collar short; teeth massive; cardinal process small, outer hinge plates short, triangular, loop very long, 0.4 to 0.6 dorsal valve length, terminal points very long, webbed, transverse band high, narrow arch, flattened medially. *Middle Jurassic (Bajocian):* France.——FIG. 1389,*1a–d.* **L. matisconensis* (LISSAJOUS); *a–c,* dorsal, lateral, and anterior views, ×1 (Alméras, 1971); *d,* interior of dorsal valve, ×1 (Cooper, 1983).

Apatecosia COOPER, 1983, p. 53 [**Cererithyris nutiensis* BAGUE, 1955, p. 219; OD] [=*Gyrosina* COOPER, 1983, p. 86 (type, *G. rotunda,* OD)]. Medium size, oval, anterior commissure sulciplicate; beak narrow, labiate, foramen mesothyrid, symphytium partly visible; cardinal process small, outer hinge plates short, narrow; loop 0.45 dorsal valve length, transverse band narrowly arched. *Middle Jurassic (Callovian):* France, Saudi Arabia, Tibet.——FIG. 1389,*3a–d.* **A. nutiensis* (BAGUE), France; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* dorsal valve interior, ×1 (Cooper, 1983).

Arcelinithyris ALMÉRAS, 1971, p. 173 [**Terebratula arcelini* LISSAJOUS in ARCELIN & ROCHE, 1936, p. 83; OD]. Medium size, elongate oval; anterior commissure rectimarginate; beak suberect, labiate, foramen large, permesothyrid, symphytium exposed; pedicle collar short, teeth narrow, elongate; cardinal process small, outer hinge plates wide, triangular, flat, loop elongate triangular, 0.5 dorsal valve length. *Middle Jurassic (Bajocian):* France.——FIG. 1389,*2a–d.* **A. arcelini* (LISSAJOUS); *a–c,* dorsal, lateral, and anterior views, ×1; *d,* loop, ×2 (Cooper, 1983).

Dorsoplicathyris ALMÉRAS, 1971, p. 437 [**Terebratula dorsoplicata* SUESS, 1855, in DESLONGCHAMPS, 1856b, p. 97; OD] [=*Pentithyris* COOPER, 1983, p. 127 (type, *Terebratula pelagica* ROLLIER, 1918, p. 233); *Stenorina* COOPER, 1989, p. 91 (type, *S. parallela*); *Tanyothyris* COOPER, 1989, p. 94 (type, *T. angustata*)]. Large, elongate oval, anterior commissure uniplicate to sulciplicate; beak short, labiate, foramen large, permesothyrid; cardinal process small; outer hinge plates long, close to valve floor; crural processes at midloop; loop long, triangular, flanges long, narrow. *Middle Jurassic (Bathonian)–Upper Jurassic (Oxfordian):* France, Switzerland, Germany, Turkmenia, Crimea, Saudi Arabia, Nepal, Tibet.——FIG. 1390,*2a–d.* **D. dorsoplicata* (SUESS), Callovian, France; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* dorsal valve interior, ×2 (Cooper, 1983).

Eristenosia COOPER, 1983, p. 78 [**E. circularis;* OD]. Small, nearly circular, anterior commissure rectimarginate, beak short, erect, foramen small, permesothyrid; cardinal process very small, outer hinge plates short, narrow, deeply concave; loop 0.4 dorsal valve length, very narrow, terminal points long, webbed, transverse band very narrow, forming an angular arch. *Upper Jurassic (Kimmeridgian):* France.——FIG. 1390,*1a–d.* **E. circularis; a–c,* dorsal, lateral, and anterior views, ×1; *d,* dorsal valve interior, ×2 (Cooper, 1983).

Monsardithyris ALMÉRAS, 1971, p. 198 [**Terebratula ventricosa* ZIETEN, 1830 in 1830–1833, p. 52; OD]. Large, elongate oval; anterior commissure rectimarginate to broadly uniplicate to sulciplicate; beak short, suberect, labiate, foramen large, permesothyrid; pedicle collar short, excavated, teeth long, narrow; cardinal process small, outer hinge plates short, narrow, triangular, concave, often notched anteriorly, loop long, triangular, 0.5 dorsal valve length, terminal points very long, webbed, transverse band and loop variable. *Lower Jurassic (Toarcian)–Middle Jurassic (Bajocian):* France, England, Germany, Algeria, Morocco, Arabia, Tibet.——FIG. 1390,*5a–d.* **M. ventricosa* (ZIETEN), Bajocian; *a–c,* dorsal, lateral, and anterior views, Germany, ×1 (Alméras & Moulan, 1988); *d,* interior of dorsal valve, France, ×1 (Cooper, 1983).

Rouillieria MAKRIDIN in LICHAREW, MAKRIDIN, & RZHONSNITSKAYA, 1960, p. 295 [**Terebratula michalkowii* FAHRENKOHL, 1856, p. 228; OD]. Large to very large, subcircular to elongate-oval, anterior commissure uniplicate to sulciplicate, beak very short, foramen large, mesothyrid; pedicle collar present, hinge teeth long, narrow; cardinal process broad, thin dorsal septum reaching 0.5 valve length; outer hinge plates broad, crural bases

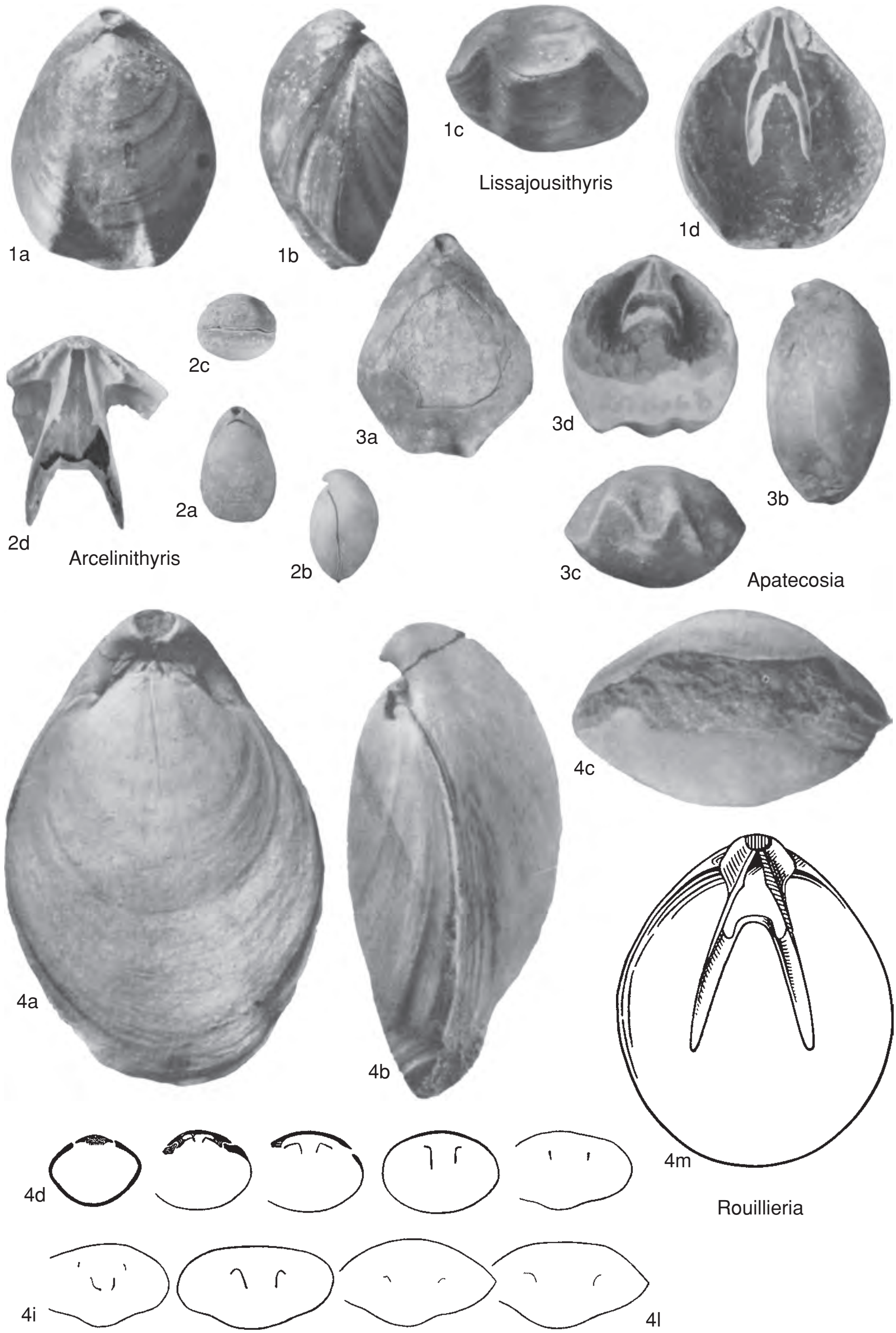

FIG. 1389. Lissajousithyrididae (p. 2098–2101).

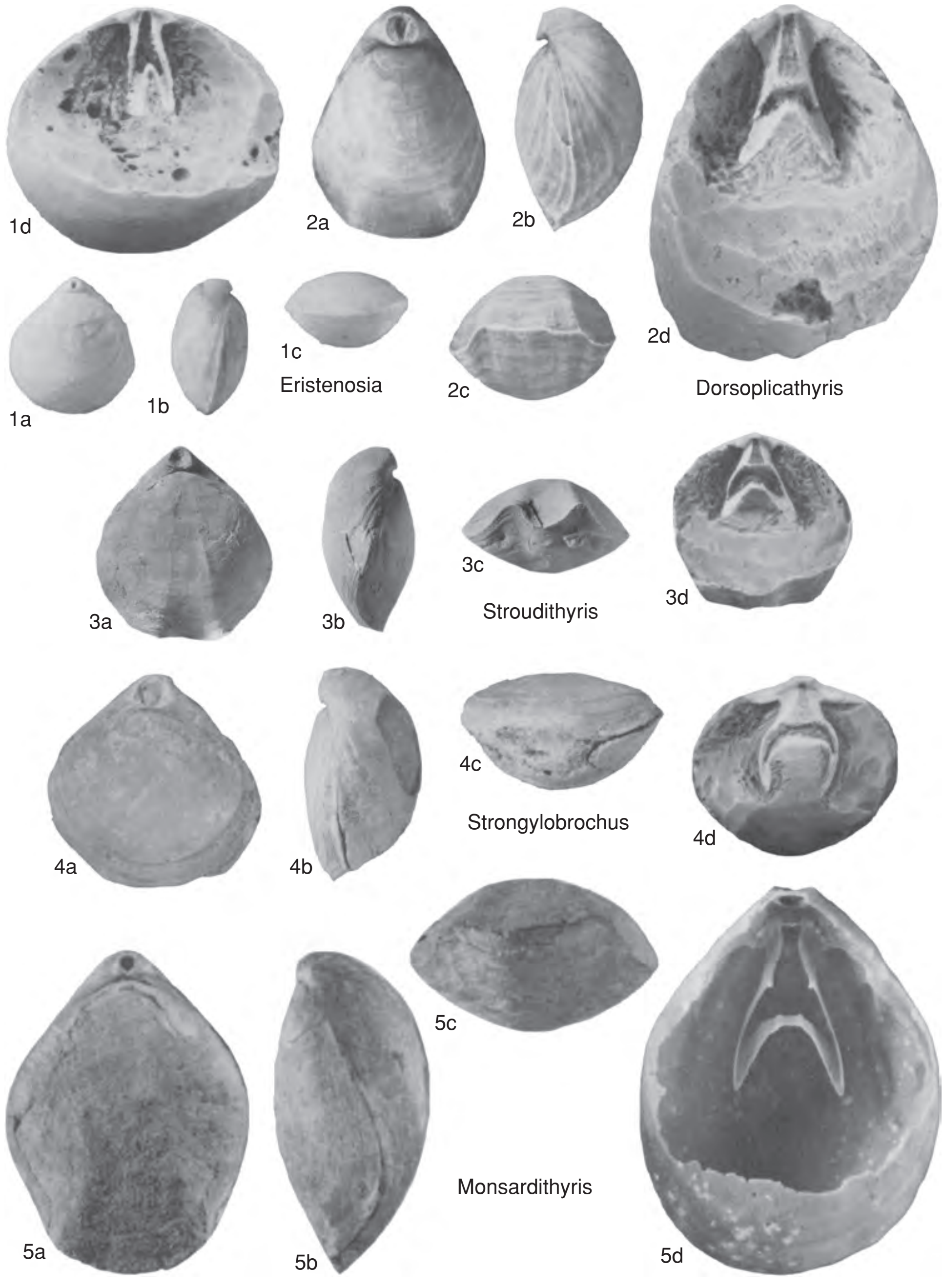

FIG. 1390. Lissajousithyrididae (p. 2098–2101).

forming lateral umbonal cavities reaching valve floor; loop slender, very long, 0.6 to 0.7 dorsal valve length, terminal points very long, webbed; transverse band narrow. *Upper Jurassic:* Russian Platform, Urals, Poland, England.——FIG. 1389,*4a–m.* **R. michalkowii* (FAHRENKOHL), Russia; *a–c,* dorsal, lateral, and anterior views, ×1; *d–l,* serial transverse sections 6.8, 8.7, 10.1, 12.6, 16.2, 18.0, 21.0, 29.6, 32.3 mm from ventral umbo, ×1; *m,* reconstruction of loop, ×1 (Makridin, 1964).

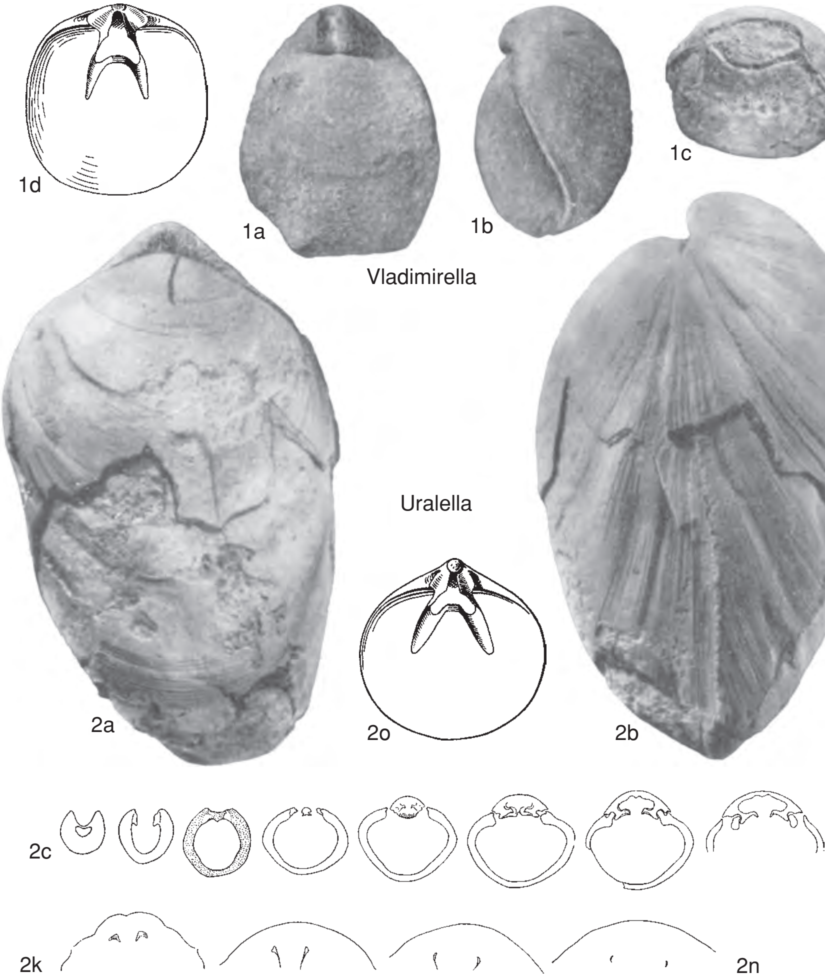

FIG. 1391. Lissajousithyrididae (p. 2101–2102).

Strongylobrochus COOPER, 1983, p. 155 [**Terebratula omalogastyr* ZIETEN, 1830 in 1830–1833, p. 54; OD]. Large, subpentagonal to broadly ovate, planoconvex, anterior commissure rectimarginate to gently uniplicate, beak large, protuberant, foramen large, permesothyrid, symphytium visible; cardinal process thin, narrow, outer hinge plates narrow, close to valve floor; loop 0.6 dorsal valve length, descending branches thin, widely bowed; terminal points long, webbed, bowed inwardly; transverse band broad, flattened arch. *Middle Jurassic (Bajocian):* Germany.——FIG. 1390,*4a–d*. **S. omalogastyr* (ZIETEN); *a–c,* dorsal, lateral, and anterior views, ×1; *d,* dorsal valve interior, ×1 (Cooper, 1983).

Stroudithyris BUCKMAN, 1918, p. 111 (BUCKMAN, 1915, p. 78, *nom. nud.*) [**Terebratula pisolithica* BUCKMAN, 1886, p. 41; OD] [=*Saucrobrochus* COOPER, 1983, p. 145 (type, *Terebratula whaddonensis* BUCKMAN, 1910, p. 101)]. Medium size, subpentagonal, anterior commissure sulciplicate, beak short, suberect, labiate, foramen large, mesothyrid, symphytium mainly concealed; cardinal process small, no umbonal cavity, outer hinge plates narrow, deeply concave, loop 0.5 dorsal valve length, terminal points long, webbed, transverse band high. *Lower Jurassic (Toarcian)–Middle Jurassic (Bajocian):* England, France, Switzerland, Italy, Spain, Portugal, North Africa (Algeria).——FIG. 1390,*3a–d*. **S. pisolithica* (BUCKMAN), Bajocian, England; *a–c,* dorsal, lateral, and anterior views, ×1 (Muir-Wood, 1965a); *d,* interior of dorsal valve, ×1 (Cooper, 1983).

Uralella MAKRIDIN in LICHAREW, MAKRIDIN, & RZHONSNITSKAYA, 1960, p. 295 [**Terebratula strogonofii* D'ORBIGNY, 1845b, p. 483; OD]. Very large, elongate-oval, anterior commissure rectimarginate, beak large, foramen circular,

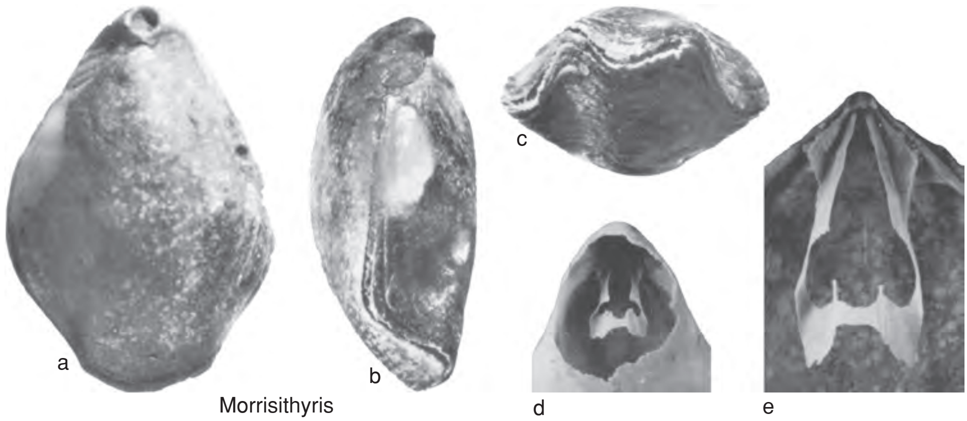

FIG. 1392. Lissajousithyrididae (p. 2102).

permesothyrid; pedicle collar well developed; cardinal process large, almost quadrate in section; crural bases thick, may touch valve floor, forming lateral cavities; median septum well developed, especially in juveniles; loop poorly known, apparently long, widely triangular, with long terminal points. *Upper Jurassic (Tithonian):* Northern Urals, northern Siberia, ?England.——FIG. 1391,*2a–n.* **U. strogonofii* (D'ORBIGNY), Urals; *a–b,* dorsal and lateral views ×0.6 (Makridin, 1964); *c–n,* serial transverse sections, ×1 (Dagys, 1968).——FIG. 1391,*2o. U. gigantea* MAKRIDIN; reconstruction of loop, ×1 (Makridin, 1964).

Vladimirella POPOV, 1994, p. 106, *nom. nov. pro Nalivkinella* POPOV in KATZ & POPOV, 1974a, p. 23, *non* SOSHKINA, 1939 [**Terebratula retrocarinata* NALIVKIN, 1910, p. 19; OD; *non* ROTHPLETZ, 1886, p. 101; =*Nalivkinella nalivkini* POPOV in KATZ & POPOV, 1974a, p. 23]. Large, elongate to subpentagonal, anterior commissure slightly unisulcate or bisulcate, beak incurved, foramen large, epithyrid; cardinal process small, outer hinge plates delicate, directed laterally; loop 0.5 dorsal valve length, loop flanges long. *Upper Jurassic:* Russian Platform, Crimea, Caucasus, central Asia, Western Europe. ——FIG. 1391,*1a–d.* **V. nalivkini* (POPOV), Russia; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* reconstruction of loop, ×0.5 (Makridin, 1964).

Subfamily MORRISITHYRIDINAE Cooper, 1983

[Morrisithyridinae COOPER, 1983, p. 44]

Transverse band with deep reentrant on posterior side. *Middle Jurassic (Bajocian–Callovian).*

Morrisithyris ALMÉRAS, 1971, p. 131 [**Terebratula phillipsi* MORRIS in MORRIS & DAVIDSON, 1847, p. 255; OD]. Large, elongate-pentagonal, anterior commissure strongly sulciplicate; beak long, narrow, labiate, foramen large, permesothyrid; pedicle collar short, excavated, teeth long, narrow; cardinal process small, outer hinge plates long, narrow, triangular, concave, loop triangular, 0.3 to 0.4 dorsal valve length, terminal points long, webbed; loop, transverse band, and terminal points variable. *Middle Jurassic (Bajocian–Callovian):* Europe, Russia, Caucasus, Crimea, Turkmenistan, ?South America.——FIG. 1392*a–e.* **M. phillipsi* (MORRIS), Bajocian, France; *a–c,* dorsal, lateral, and anterior views, ×1 (Alméras, 1971); *d,* loop of young specimen, ×1; *e,* loop of adult specimen, ×2 (Cooper, 1983).

Family LOBOTHYRIDIDAE Makridin, 1964

[*nom. transl.* LEE, SMIRNOVA, & DAGYS, herein, *ex* Lobothyridinae COOPER, 1983, p. 44, *nom. correct. pro* Lobothyrinae MAKRIDIN, 1964, p. 204]

Small to very large, smooth, crural processes posterior or anterior of midloop, loop 0.3 to 0.6 dorsal valve length; terminal points long to very long, may be webbed. *Lower Jurassic–Upper Jurassic (Kimmeridgian).*

Subfamily LOBOTHYRIDINAE Makridin, 1964

[*nom. correct.* COOPER, 1983, p. 44, *pro* Lobothyrinae MAKRIDIN, 1964, p. 204]

Medium to very large; rectimarginate to uniplicate or unisulcate, crural processes posterior of midloop, loop 0.4 to 0.6 dorsal valve length, terminal points moderately long to very long, may be webbed. *Lower Jurassic–Middle Jurassic (Bajocian).*

Lobothyris Buckman, 1918, p. 107 (Buckman, 1914, p. 2, *nom. nud.*) [**Terebratula punctata* J. Sowerby, 1813 in 1812–1815, p. 46; OD] [=*Loboidothyropsis* Sučić-Protić, 1971, p. 16 (type, *L. typica,* OD); *Mirisquamea* Sučić-Protić, 1971, p. 38 (type, *Lobothyris punctata clevelandensis* Ager, 1956, p. 2, OD); *Pirotothyris* Sučić-Protić, 1971, p. 31 (type, *P. fortis,* OD); *Squamiplana* Sučić-Protić, 1971, p. 8 (type, *S. piroidea,* OD)]. Large to very large, moderately biconvex, rectimarginate, beak suberect to incurved, foramen epithyrid to permesothyrid, symphytium short; pedicle collar present; cardinal process broad, flat, comblike; hinge plates and inner socket ridges in section slightly concave ventrally, clubbed, gently inclined dorsally; crural processes posterior of midloop, loop about 0.4 dorsal valve length, with moderately long terminal points. *Lower Jurassic (Sinemurian)–Middle Jurassic (Bajocian):* England, Scotland, France, Germany, Spain, Portugal, Sicily, Bulgaria, Romania, Yugoslavia, China, Thailand, Canada (British Columbia), USA (Nevada), Argentina, New Zealand.——Fig. 1393,*6a–v.* **L. punctata* (J. Sowerby), Pliensbachian, England; *a–c,* dorsal, lateral, and anterior views of lectotype, BMNH B61522, ×1 (Ager, 1990); *d,* interior of dorsal valve of calcite-encrusted specimen, ×1 (Cooper, 1983); *e–v,* serial transverse sections 0.6, 1.0, 1.2, 2.2, 3.6, 4.0, 4.4, 4.8, 5.0, 5.6, 5.8, 6.2, 7.0, 7.4, 7.6, 7.8, 8.2, 10.0 mm from ventral umbo, ×1 (Ager, 1990).——Fig. 1393,*6w. L. subpunctata* Dubar, Lower Jurassic, France; dorsal valve interior, ×1 (Cooper, 1983).

Cuersithyris Alméras & Moulan, 1982, p. 32 [**C. cuersensis;* OD]. Medium size, thick shelled; elongate oval, strongly ventribiconvex to globose, anterior commissure rectimarginate to slightly unisulcate; pedicle collar short, beak incurved, foramen permesothyrid; loop 0.45 to 0.6 dorsal valve length. *Lower Jurassic (Pliensbachian–Toarcian):* France, ?England, Spain, Hungary, Yugoslavia, Argentina.——Fig. 1393,*1a–l.* **C. cuersensis,* Pliensbachian, France; *a–c,* dorsal, lateral, and anterior views of holotype, FSL305094, ×1; *d–l,* serial transverse sections 1.8, 3.3, 4.6, 5.4, 6.5, 8.2, 10.3, 11.6, 14.4 mm from ventral umbo, ×1 (Alméras & Moulan, 1982).

Exceptothyris Sučić-Protić, 1971, p. 37 [**E. expressa;* OD]. Externally similar to *Lobothyris,* but with crural processes close to hinge plates; loop long (resembling that of *Rouillieria*), 0.6 dorsal valve length, terminal points very long, webbed; transverse band very narrow. *Lower Jurassic:* France, Italy, Yugoslavia.——Fig. 1393,*2.* **E. expressa,* Yugoslavia; reconstruction of loop, ×1 (Cooper, 1983).

Inaequalis Sučić-Protić, 1971, p. 12 [**I. dubari;* OD] [=*Pyraeneica* Sučić-Protić, 1971, p. 23 (type, *P. numerosa,* OD); *Senokosica* Sučić-Protić, 1971, p. 28 (type, *S. matura,* OD); *Serbiothyris* Sučić-Protić, 1971, p. 25 (type, *S. medioliassica,* OD)]. Externally similar to *Lobothyris,* but with narrow transverse band and longer terminal points. *Lower Jurassic:* France, Germany, Yugoslavia, England.——Fig. 1393,*7a–c.* **I. dubari,* Yugoslavia; *a–b,* dorsal and anterior views, ×1 (Sučić-Protić, 1971); *c,* reconstruction of loop, ×1 (Cooper, 1983).

Notosia Cooper, 1983, p. 122 [**N. chiliensis;* OD]. Medium size, oval, ventribiconvex; anterior commissure rectimarginate to slightly uniplicate, foramen permesothyrid; loop widely and roundly triangular, with long terminal points. *Lower Jurassic:* Chile.——Fig. 1393,*4a–d.* **N. chiliensis; a–c,* dorsal, lateral, and anterior views of holotype, USNM 551049a, ×1; *d,* close-up of loop, ×1 (Cooper, 1983).

Rhapidothyris Tuluweit, 1965, p. 72 [**R. arciferens;* OD]. Similar to *Lobothyris,* but medium size, subcircular, biconvex; anterior commissure rectimarginate to unisulcate. *Lower Jurassic (Pliensbachian):* Germany, England.——Fig. 1393,*5a–c.* **R. arciferens,* Germany; dorsal, lateral, and anterior views of holotype, IMGPT Br 1244/13, ×1 (Tuluweit, 1965).

Telothyris Alméras & Moulan, 1982, p. 136 [**Terebratula jauberti pyrenaica* Dubar, 1931, p. 51; OD]. Similar to *Cuersithyris,* but subcircular in outline, biconvex, rectimarginate to slightly sulciplicate; shorter loop, 0.39–0.49 dorsal valve length. *Lower Jurassic:* France, Spain, Romania, Morocco, Algeria, Argentina.——Fig. 1393,*3a–c.* **T. pyrenaica* (Dubar), Toarcian, France; dorsal, lateral, and anterior views, ×1 (Alméras & Moulan, 1982).

Subfamily LOPHROTHYRIDINAE Cooper, 1983

[Lophrothyridinae Cooper, 1983, p. 44]

Small to medium size, uniplicate to sulciplicate or biplicate; outer hinge plates dorsally attached to crural bases; crural processes anterior of midloop; terminal points of intermediate length. *Middle Jurassic (Bajocian)–Upper Jurassic (Kimmeridgian).*

Lophrothyris Buckman, 1918, p. 114 (Buckman, 1914, p. 2, *nom. nud.*) [**L. lophus;* OD]. Small to medium size, subcircular to subpentagonal, ventribiconvex, anterior commissure strongly uniplicate, rarely sulciplicate; beak short, foramen epithyrid, symphytium narrow; cardinal process small; outer hinge plates short, narrow, dorsally attached; loop broadly triangular, about 0.4 to 0.5 dorsal valve length, with moderately long terminal points; transverse band broad. *Middle Jurassic (Bajocian):* England, France, China.——Fig. 1394,*1a–d.* **L. lophus,* England; *a–c,* dorsal, lateral, and anterior views of holotype, BGS GSM 31990, ×1 (Muir-Wood, 1965a); *d,* interior of dorsal valve, ×2 (Cooper, 1983).

Argovithyris Rollet, 1972b, p. 95 [**Terebratula birmensdorfensis* Moesch, 1867, p. 312; OD]. Small, biconvex, anterior commissure rectimarginate to uniplicate or weakly sulciplicate; beak strongly incurved, may touch dorsal umbo, foramen small, epithyrid, often labiate; pedicle collar

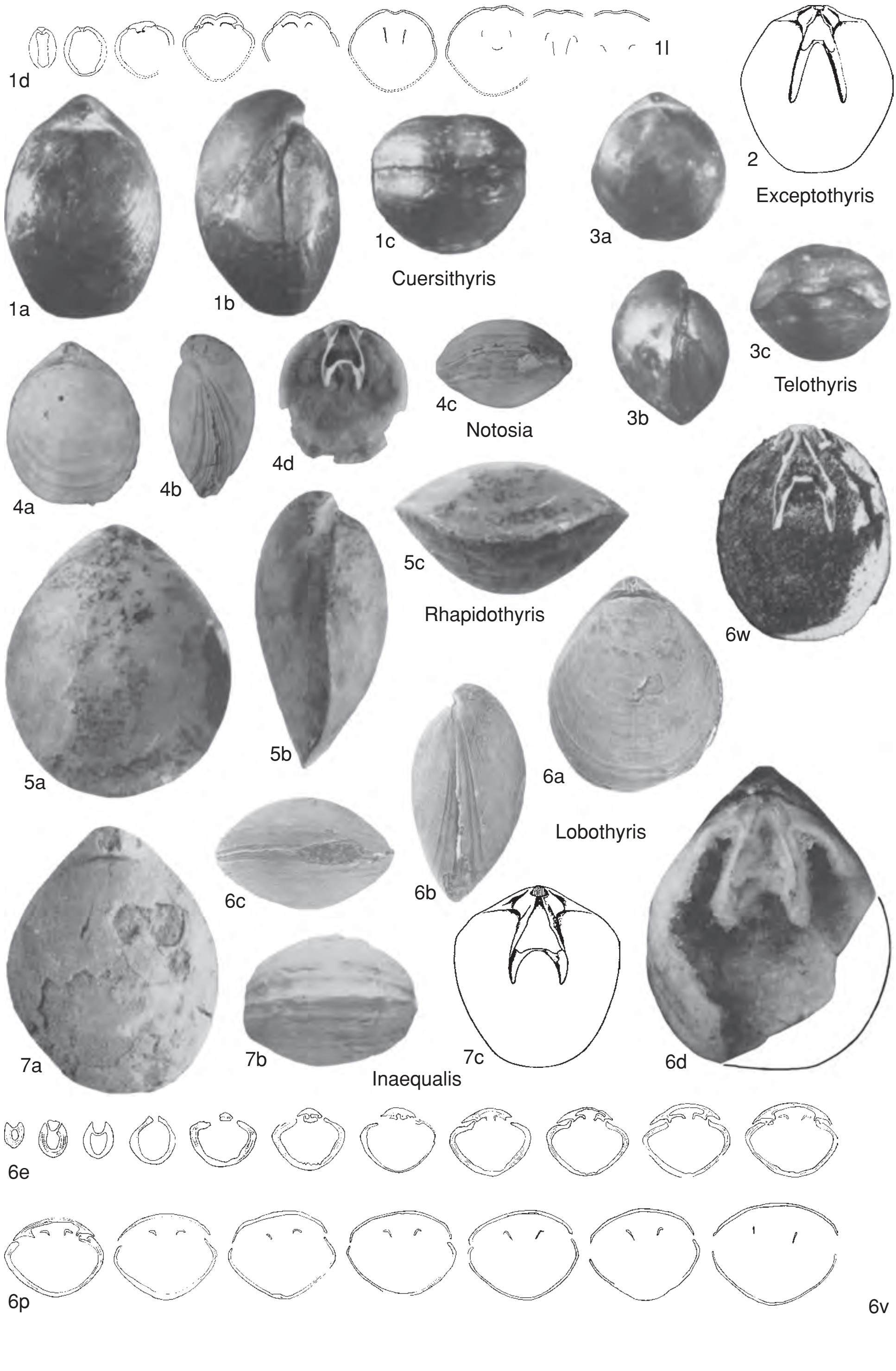

FIG. 1393. Lobothyrididae (p. 2103).

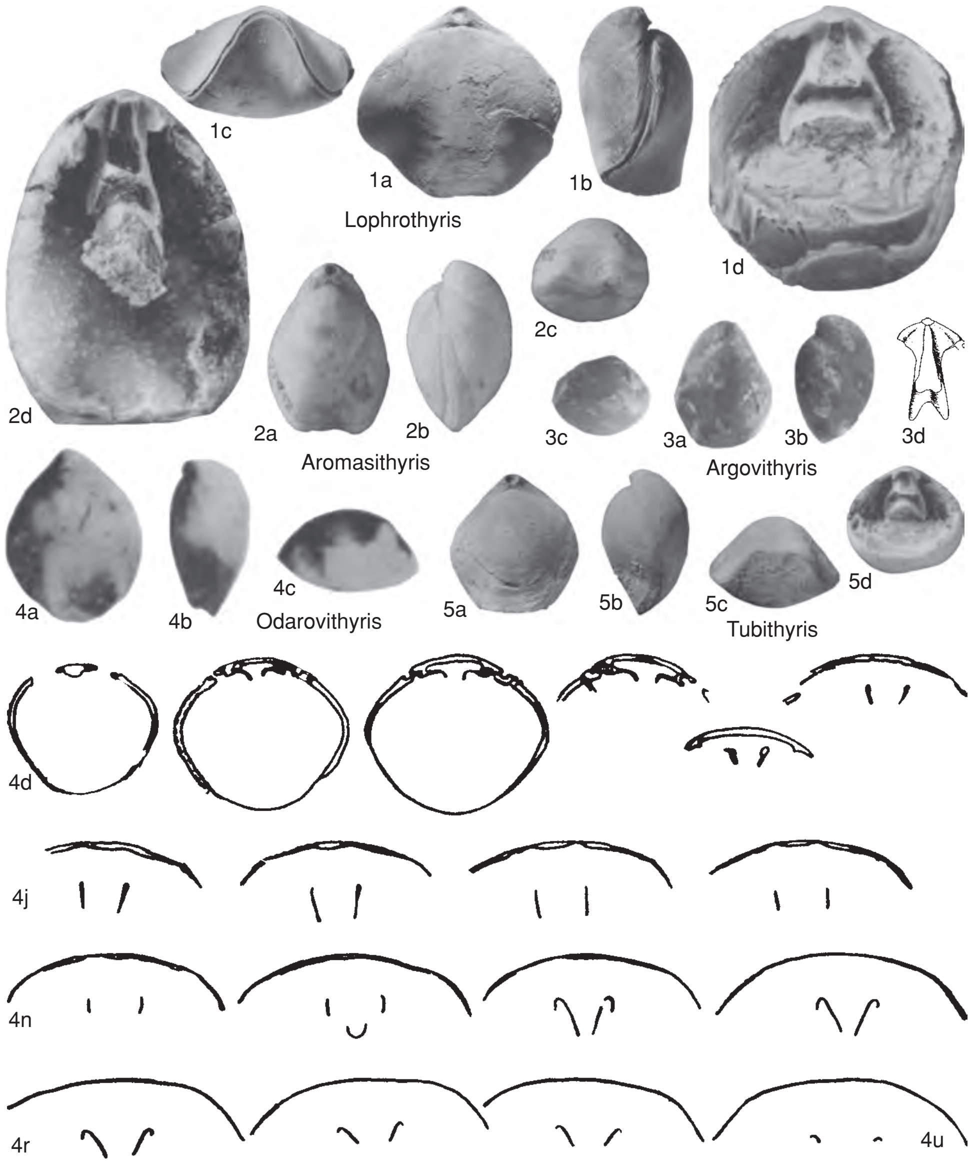

FIG. 1394. Lobothyrididae (p. 2103–2106).

present; cardinal process small, hinge plates thin and flat; loop with subparallel sides, 0.3 to 0.4 dorsal valve length, transverse band broad. *Upper Jurassic (Oxfordian–Kimmeridgian):* France, Germany, Switzerland, Poland.——FIG. 1394,*3a–d.* **A. birmensdorfensis* (MOESCH), Oxfordian, Switzerland; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* reconstruction of loop, ×2 (Boullier, 1976).

Aromasithyris ALMÉRAS, 1971, p. 544 [**Terebratula balinensis* SZAJNOCHA, 1879, p. 203; OD]. Medium size, pentagonal, biconvex, anterior commissure uniplicate to weakly sulciplicate or paraplicate; beak incurved; pedicle collar present; cardinal process small; hinge plates flat and thin, loop 0.3 to 0.4 dorsal valve length, transverse band very strongly arched. *Middle Jurassic (Callovian):* Poland, France, Germany, Portugal, Russia.——FIG. 1394,*2a–d.* **A. balinensis* (SZAJNOCHA), Poland; *a–c,* dorsal, lateral, anterior views, ×1; *d,* interior of dorsal valve, ×2 (Cooper, 1983).

Odarovithyris TCHORSZHEVSKY, 1971a, p. 62 [**O. odarovi;* OD]. Medium size, smooth, ventribiconvex, anterior commissure biplicate; beak short, incurved; foramen small, permesothyrid; cardinal process low, outer hinge plates wide, thin; loop 0.5 dorsal valve length, transverse band strongly folded, loop flanges long. *Middle Jurassic (Bajocian):* Transcarpathians.——FIG. 1394,*4a–u.* **O. odarovi; a–c,* dorsal, lateral, anterior views, ×1; *d–u,* serial transverse sections 0.25, 1.4, 2.05, 2.35, 2.85, 4.1, 4.3, 5.1, 5.6, 5.9, 6.55, 6.85, 7.05, 7.2, 8.1, 8.5, 9.2, 9.5 mm from first section, ×1 (Tchorszhevsky, 1971a).

Tubithyris BUCKMAN, 1918, p. 115 (BUCKMAN, 1915, p. 78, *nom. nud.*) [**Terebratula wrighti* DAVIDSON, 1855, p. 20; OD] [=*Pseudotubithyris* ALMÉRAS, 1971, p. 361 (type, *Terebratula globata* J. DE C. SOWERBY, 1823–1825, p. 51)]. Small to medium, subcircular, biconvex to spheroidal, anterior commissure uniplicate to sulciplicate, beak short, incurved, foramen tubular, permesothyrid; symphytium narrow, visible; cardinal process bilobed, prominent; hinge plates narrow, triangular, deeply concave; loop 0.5 dorsal valve length, very wide, transverse band moderately arched. *Middle Jurassic (Bajocian–Bathonian):* England, France, Switzerland, Italy, Morocco, Egypt, Kenya, Saudi Arabia, Turkmenia.——FIG. 1394,*5a–d.* **T. wrighti* (DAVIDSON), Bajocian, England; *a–c,* dorsal, lateral, and anterior views, ×1 (Muir-Wood, 1965a); *d,* interior of dorsal valve, ×1 (Cooper, 1983).

Family MUIRWOODELLIDAE Tchorszhevsky, 1974

[Muirwoodellidae TCHORSZHEVSKY, 1974, p. 51]

Smooth, outer hinge plates well developed; loop long flanged, 0.3 to 0.5 dorsal valve length; transverse band formed from ring arising from ventral margin of vertical plate of acuminate (centronelliform) loop. *Middle Jurassic–Lower Cretaceous (Berriasian).*

Subfamily MUIRWOODELLINAE Tchorszhevsky, 1974

[Muirwoodellinae TCHORSZHEVSKY, 1974, p. 51]

Outer hinge plates not supported by crural plates. *Middle Jurassic.*

Muirwoodella TCHORSZHEVSKY, 1974, p. 52 [**M. muirwoodae;* OD]. Medium size, anterior commissure unisulcate or slightly bisulcate; beak incurved; foramen mesothyrid or permesothyrid; cardinal process small, oval; outer hinge plates slightly inclined dorsally; crural processes slightly curved. *Middle Jurassic (Bajocian):* Carpathians, Transcarpathia, Russia.——FIG. 1395,*2a–q.* **M. muirwoodae,* Carpathians; *a–c,* dorsal, lateral, and anterior views, ×0.6; *d–q,* serial transverse sections 0.3, 0.7, 1.9, 2.7, 2.9, 3.7, 4.2, 5.95, 6.7, 7.7, 8.3, 11.4, 13.4, 14.7 mm from first section, ×1 (Tchorszhevsky, 1974).

Goniothyropsis OVTSHARENKO, 1983b, p. 155 [**G. indigena;* OD]. Rounded to subpentagonal, ventribiconvex; anterior commissure biplicate; beak incurved, foramen large; deltidial plates conjunct; cardinal process short, flattened; crural bases joined dorsally to outer hinge plates, forming small, ventral keels, descending branches and flanges short, loop about 0.3 dorsal valve length. *Middle Jurassic:* Tadzhikistan, Pamirs.——FIG. 1395,*1a–k.* **G. indigena; a–c,* dorsal, lateral, and anterior views, ×1; *d–k,* serial transverse sections 2.6, 3.5, 4.3, 4.6, 5.0, 6.3, 6.9, 8.2 mm from first section, ×1 (Ovtsharenko, 1983b).

Subfamily KARADAGITHYRIDINAE Tchorszhevsky, 1974

[Karadagithyridinae TCHORSZHEVSKY, 1974, p. 56]

Outer hinge plates may be supported by crural plates. *Middle Jurassic–Upper Jurassic.*

Karadagithyris TCHORSZHEVSKY, 1974, p. 55 [**K. babanovae;* OD]. Medium to small, foramen small, mesothyrid, symphytium short, narrow; cardinal process oval, high, undivided; outer hinge plates broad, thin, curved in an arc dorsally; at point of attachment to crura, narrow, ventrally directed, and semicircular in cross section; crura and crural processes thick, broad, slightly convergent ventrally; outer hinge plate processes are well developed, reaching level of transverse band of loop, but resting on valve floor only apically. *Middle Jurassic–Upper Jurassic:* Crimea, Poland, Hungary, Yugoslavia.——FIG. 1396,*2a–v.* **K. babanovae,* Bajocian, Crimea; *a–c,* dorsal, lateral, and anterior views, ×1; *d–v,* serial transverse sections 3.1, 3.2, 3.45, 3.85, 4.35, 4.65, 5.05, 5.25, 6.05, 6.65, 7.3, 8.1, 9.85, 10.25, 10.85, 11.85, 12.75, 13.75, 14.65 mm from ventral umbo, ×1 (Tchorszhevsky, 1974).

Karadagella BABANOVA, 1965, p. 95 [144] [**K. moisseievi;* OD]. Large, oval, strongly ventribiconvex, foramen mesothyrid, crural plates attached to outer hinge plates by ventral ends; in early ontogeny resting on dorsal valve floor, becoming free in later stages; loop with long flanges. *Middle Jurassic (Bajocian):* Crimea.——FIG. 1396,*1a–d.* **K. moisseievi; a–c,* dorsal, lateral, and anterior views, ×1; *d,* reconstruction of loop, ×1 (Babanova, 1965).

Subfamily UNCERTAIN

Dzharithyris OVTSHARENKO, 1989, p. 96 [**Inaequalis dzharensis* OVTSHARENKO, 1983b, p. 130; OD]. Medium, rounded to subpentagonal, ventribiconvex, strongly uniplicate, outer hinge plates broad, fused with inner socket ridges; loop about 0.5 dorsal valve length; flanges about 0.3 loop length. *Middle Jurassic:* Tadzhikistan, Pamirs.——

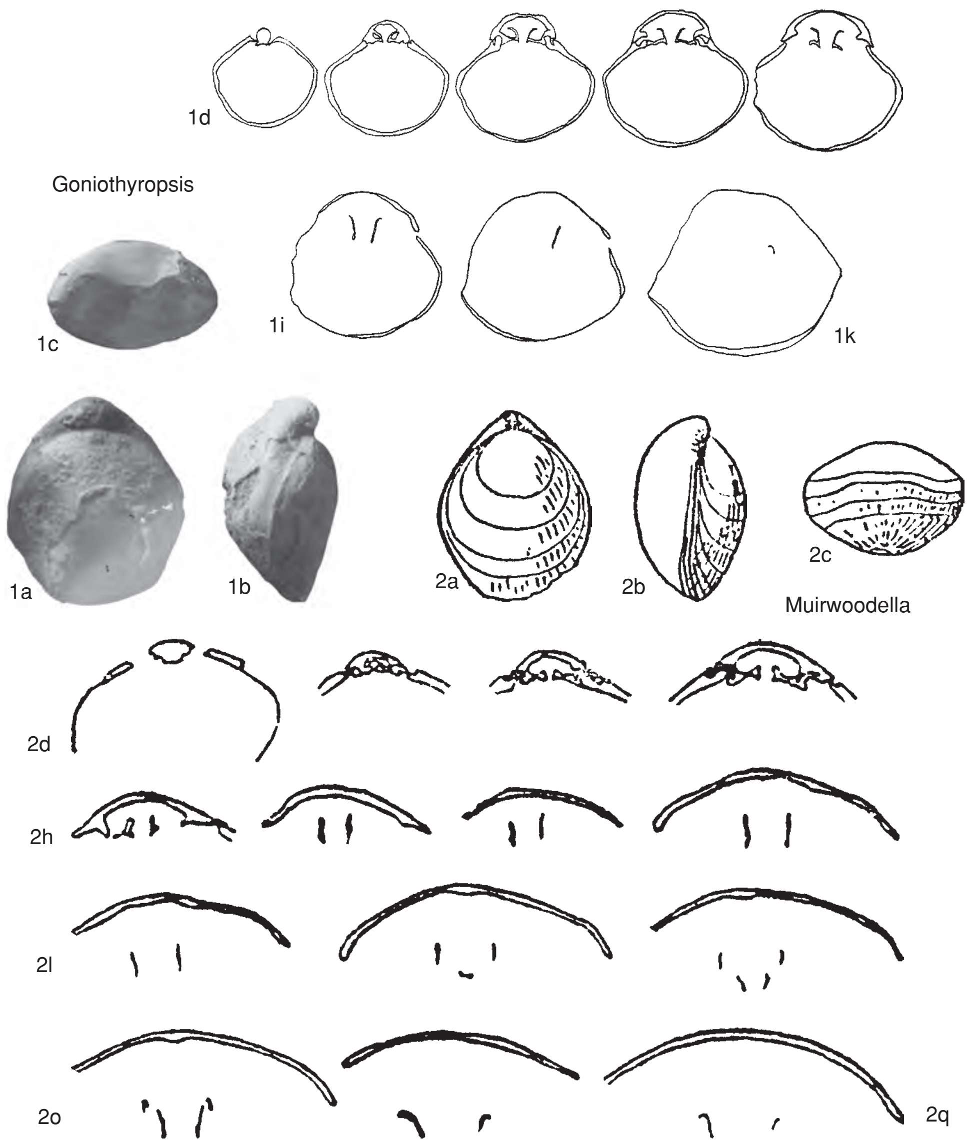

FIG. 1395. Muirwoodellidae (p. 2106).

FIG. 1397,*3a–q*. **D. dzharensis* (OVTSHARENKO); *a–c,* dorsal, lateral, and anterior views, ×1; *d–q,* serial transverse sections 0.2, 1.8, 2.6, 2.8, 3.4, 4.9, 5.1, 5.9, 6.9, 7.3, 8.4, 9.2, 9.6, 10.4 mm from first section, ×1 (Ovtsharenko, 1983b).

Negramithyris PROSOROVSKAJA, 1985, p. 114 [**N. negramensis;* OD]. Small to medium size, elongate oval, planoconvex; anterior commissure rectimarginate or slightly uniplicate; beak massive, short, suberect, foramen large, mesothyrid; cardinal process large; outer hinge plates very thin, curved acutely toward dorsal valve, hinge plate processes resting on floor of dorsal valve; loop short (about 0.3 dorsal valve length), transverse band of loop high, narrow; flanges well developed. *Middle Jurassic (Bajocian):* Armenia (Transcaucasus).——FIG. 1397,*2a–k*. **N. negramensis; a–c,* dorsal, lateral, and anterior views of holotype, ×1; *d–k,* serial transverse sections 5.2, 5.3, 5.7, 6.1, 6.7, 8.4, 8.6, 9.0 mm from ventral umbo, ×1 (Prosorovskaja, 1985).

?Praegoniothyris OVTSHARENKO, 1983b, p. 142 (OVTSHARENKO, 1977, p. 38, *nom. nud.*)

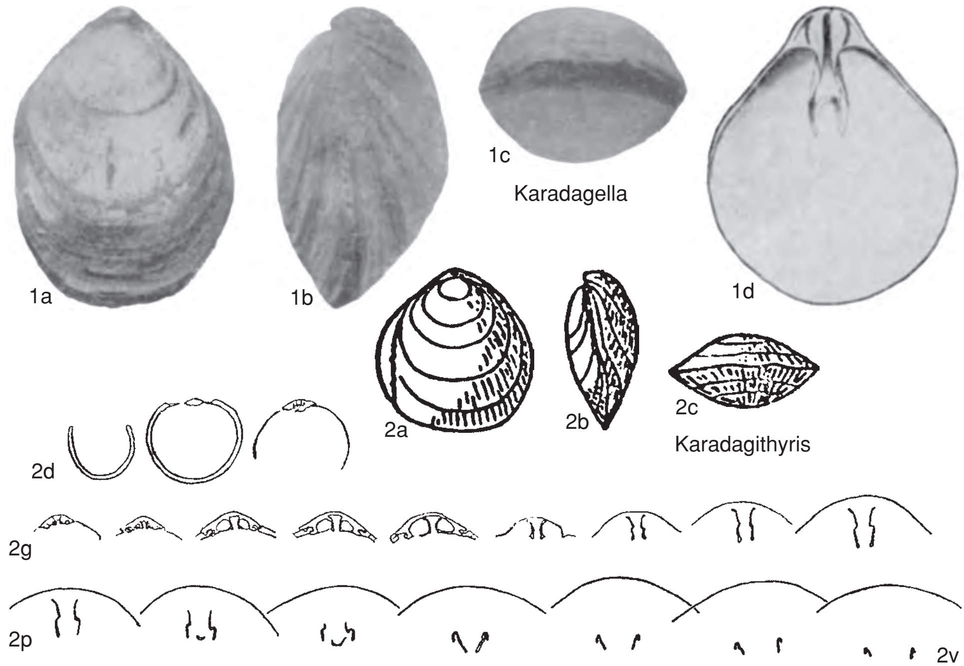

FIG. 1396. Muirwoodellidae (p. 2106).

[**P. salangurensis;* OD]. Medium size, oval, ventribiconvex, beak short, rounded, strongly incurved; cardinal process short, no umbonal cavity; outer hinge plates ventrally convex, dorsally inclined with small processes, crural bases on dorsal side of hinge plates; crura short, low, almost parallel, loop less than 0.5 dorsal valve length; low dorsal septum present posteriorly. [Internal structures not fully known.] *Lower Jurassic:* Tadzhikistan, Pamirs.——FIG. 1397,*1a–l.* **P. salangurensis; a–c,* dorsal, lateral, and anterior views, ×1; *d–l,* incomplete serial transverse sections 1.0, 1.3, 1.8, 2.2, 2.6, 2.8, 2.9, 3.7, 4.1 mm from first section, ×1 (Ovtsharenko, 1983b).

Svaljavithyris TCHORSZHEVSKY, 1989a, p. 75 (TCHORSZHEVSKY, 1974, p. 54, *nom. nud.*) [**Terebratula carpathica* ZITTEL, 1870, p. 77; OD]. Small, oval to subtrigonal, beak incurved, foramen small, mesothyrid, umbonal cavity infilled with callus; beak short, symphytium low, planoconvex, cardinal process small, with myophore; outer hinge plates wide, thin, short, or slightly concave dorsally, thin crural plates resting on dorsal valve floor as far as transverse band of loop; loop about 0.5 dorsal valve length, with long flanges. *Upper Jurassic (Tithonian)–Lower Cretaceous (Berriasian):* Carpathians, Italy.——FIG. 1398*a–t.* **S. carpathica* (ZITTEL), Tithonian, Ukraine; *a–c,* dorsal, lateral, and anterior views, ×1; *d–t,* serial transverse sections, distances between sections not given, ×2 (Tchorszhevsky, 1989a).

Family POSTEPITHYRIDIDAE Tchorszhevsky, 1974

[Postepithyrididae TCHORSZHEVSKY, 1974, p. 50]

Rectimarginate to strongly biplicate, commonly smooth, rarely capillate or peripherally costate, loop long (0.4 to 0.6 dorsal valve length), outer hinge plates attached dorsally to crural bases, crural processes at or posterior of midloop, flanges of moderate length. *Lower Jurassic (Toarcian)–Lower Cretaceous.*

Postepithyris MAKRIDIN in LICHAREW, MAKRIDIN, & RZHONSNITSKAYA, 1960, p. 294 [**Terebratula cincta* COTTEAU, 1857, p. 137; OD]. Medium size, subcircular, smooth, anterior commissure weakly sulciplicate; beak long, erect, foramen large, permesothyrid, symphytium partly visible; pedicle collar short; cardinal process semielliptical, outer hinge plates triangular, short, flatly concave, attached to dorsal part of crural base; loop an elongate triangle, about 0.5 dorsal valve length, terminal points very long, webbed, transverse band highly arched, with flattened bridge. *Upper Jurassic (Oxfordian–Kimmeridgian):* Europe, Crimea, Caucasus, Russia.——FIG. 1399,*4a–s.* **P. cincta* (COTTEAU), France; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* interior of dorsal valve, ×1 (Cooper, 1983); *e–s,* serial transverse sections 3.4, 4.0, 4.3,

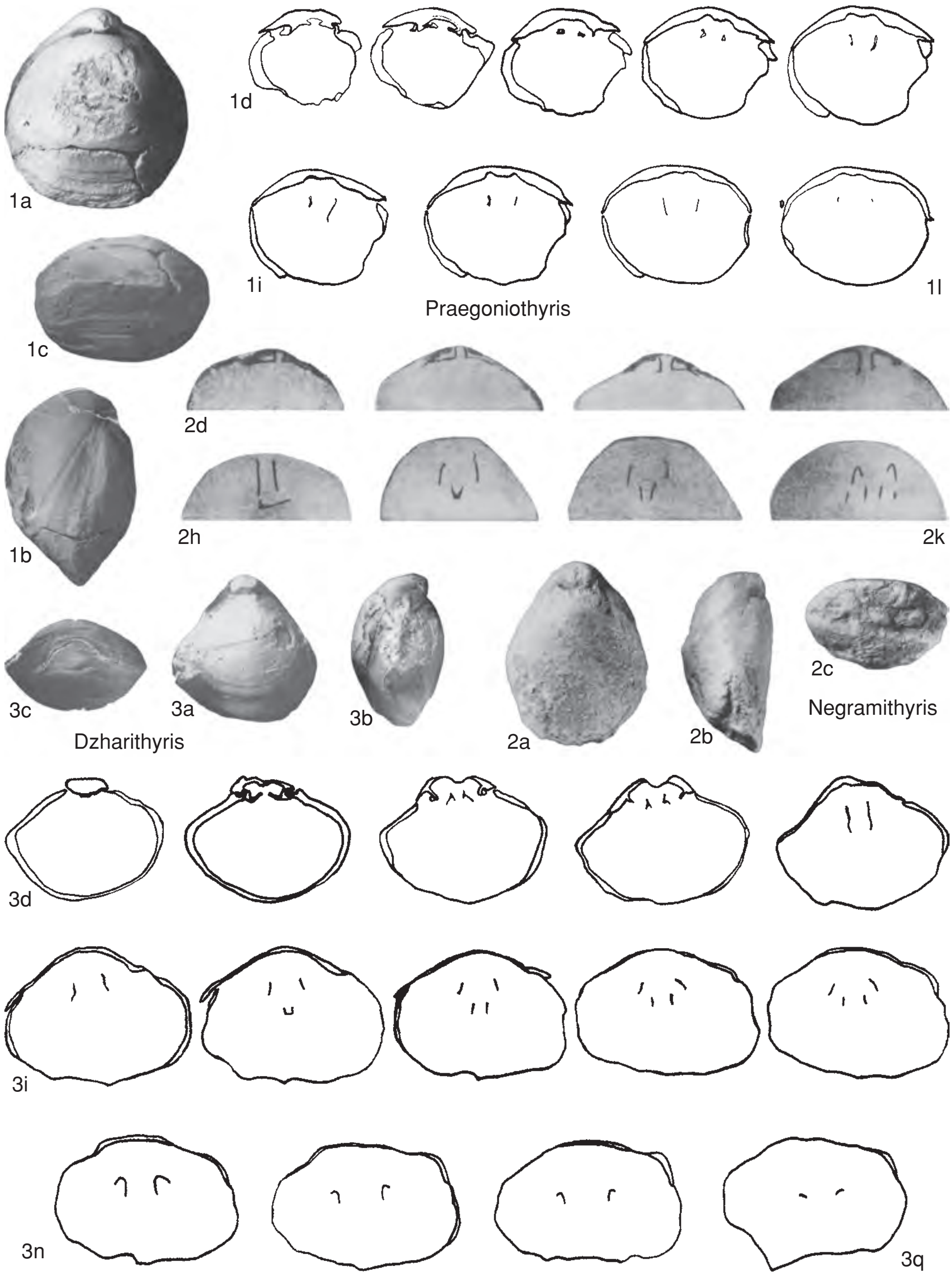

FIG. 1397. Muirwoodellidae (p. 2106–2108).

5.2, 5.6, 7.5, 8.5, 9.1, 10.7, 11.9, 12.9, 13.4, 15.6, 16.5, 18.8 mm from ventral umbo, ×1 (Makridin, 1964).

Arceythyris ROLLET, 1964, p. 38 [**Terebratula diptycha* OPPEL, 1856, p. 496; OD]. Medium size, biconvex, anterior commissure uniplicate in juveniles, becoming bisulcate; beak short, slightly recurved, foramen permesothyrid, symphytium hidden; pedicle collar present; cardinal process prominent, may be grooved, hinge plates club shaped, poorly differentiated from socket ridges, loop 0.4 to 0.5 dorsal valve length, transverse band horizontal. *Middle*

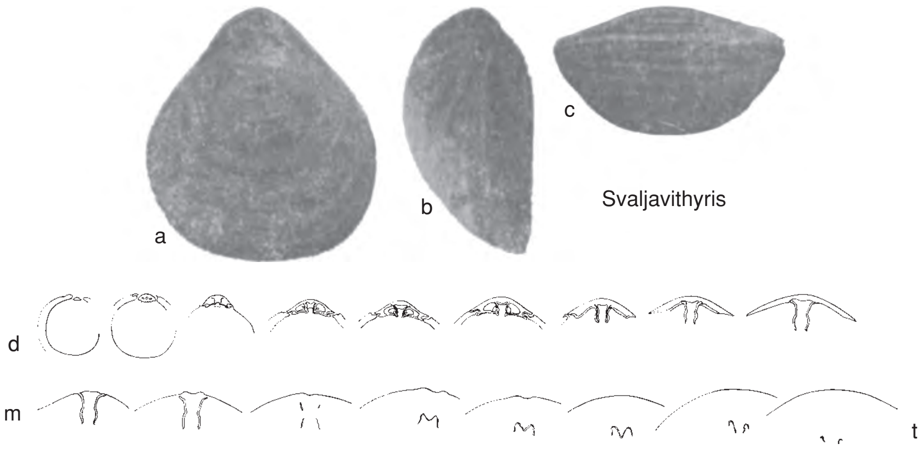

Fig. 1398. Muirwoodellidae (p. 2108).

Jurassic (Bajocian–Callovian): France, Germany, Switzerland.——Fig. 1399,*3a–d.* **A. diptycha* (Oppel), Bathonian, France; *a–c,* dorsal, lateral, and anterior views, ×1 (Alméras & Moulan, 1988); *d,* loop reconstruction, ×1 (Contini & Rollet, 1970).

Caryona Cooper, 1983, p. 62 [**Terebratula saemani* Oppel, 1857, p. 272; OD]. Small, smooth, pentagonal, anterior commissure uniplicate; beak short, foramen large, permesothyrid; symphytium partially to wholly visible; cardinal process small, wide; outer hinge plates short, deeply concave, attached to dorsal edge of crural bases; crural processes short, blunt; loop triangular, 0.4 to 0.5 dorsal valve length. *Middle Jurassic (Callovian):* France.——Fig. 1399,*5a–d.* **C. saemani* (Oppel); *a–c,* dorsal, lateral, and anterior views; *d,* dorsal valve interior, ×1 (Cooper, 1983).

Conarothyris Cooper, 1983, p. 69 [**C. opima* Cooper, 1983, p. 71; OD] [=*Pionothyris* Cooper, 1983, p. 130 (type, *Terebratula eudesiana* Buckman in Davidson, 1884, p. 255, OD); *Toxonelasma* Cooper, 1989, p. 95 (type *T. arabicum,* OD)]. Medium size, smooth, roundly oval to subpentagonal, strongly biconvex, anterior commissure sulciplicate; beak erect, foramen permesothyrid, symphytium concealed; pedicle collar long; outer hinge plates broad, short, tapering; crural processes short, pointed; loop wide, 0.4 to 0.5 dorsal valve length, descending lamellae nearly straight, transverse band strongly arched. *Middle Jurassic (Aalenian–Bajocian):* England, France, Saudi Arabia.——Fig. 1399,*2a–d.* **C. opima,* Bajocian, England; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* dorsal valve interior, ×2 (Cooper, 1983).

Epithyris Phillips, 1841, p. 55, *non* King, 1850, p. 146 [**Terebratula maxillata* J. de C. Sowerby, 1823 in 1823–1825, p. 52; SD Buckman, 1906b, p. 321] [=*Dielasma* King, 1859, p. 256 (type, *Terebratulites elongatus* Schlotheim, 1816, p. 27)]. Large, subpentagonal, smooth, biconvex, anterior commissure uniplicate to sulciplicate, beak short, foramen large, mesothyrid, symphytium partly concealed; pedicle collar present; cardinal process small, bilobed; outer hinge plates triangular, short, thick, concave (may be so thickened as to appear flat); crural processes at midloop, acutely pointed, loop widely triangular, about 0.4 dorsal valve length, transverse band wide, strongly arched, with flattened, protuberant median bridge, terminal points long, webbed. *Middle Jurassic (Bathonian):* England, France.——Fig. 1399,*1a–c.* **E. maxillata* (J. de C. Sowerby), England; dorsal, lateral, and anterior views of holotype, BMNH B.61550, ×1 (Muir-Wood, 1965a).——Fig. 1399,*1d. E. oxonica* Arkell, England; interior of dorsal valve, ×1 (Cooper, 1983).

Euidothyris Buckman, 1918, p. 101 (Buckman, 1915, p. 78, *nom. nud.*) [**Terebratula euides* (broad form) Buckman, 1886, p. 218; OD; =*E. extensa* Buckman, 1918, p. 101]. Large, smooth, broadly subpentagonal, biconvex, anterior commissure sulciplicate, foramen large, permesothyrid; cardinal process trilobed, outer hinge plates short, concave, attached to dorsal margin of crural bases, crural processes narrow, acute, transverse band strongly arched, loop wide, about 0.5 dorsal valve length. *Middle Jurassic (Bajocian):* England, France.——Fig. 1400,*1a–d.* **E. extensa* Buckman, England; *a–c,* dorsal, lateral, and anterior views of holotype, ×1 (Muir-Wood, 1965a); *d,* interior of dorsal valve, ×1 (Cooper, 1983).

Ferrythyris Alméras, 1971, p. 218 [**Terebratula ferryi* Deslongchamps in Ferry, 1861, p. 27; OD]. Medium size, smooth, rounded triangular to subpentagonal, globose, anterior commissure strongly paraplicate; beak large, foramen large, circular, permesothyrid to epithyrid; symphytium concealed; pedicle collar long; cardinal process long, elevated, grooved; loop similar to that of *Conarothyris,* 0.5 to 0.6 dorsal valve length. *Lower Jurassic (Toarcian)–*

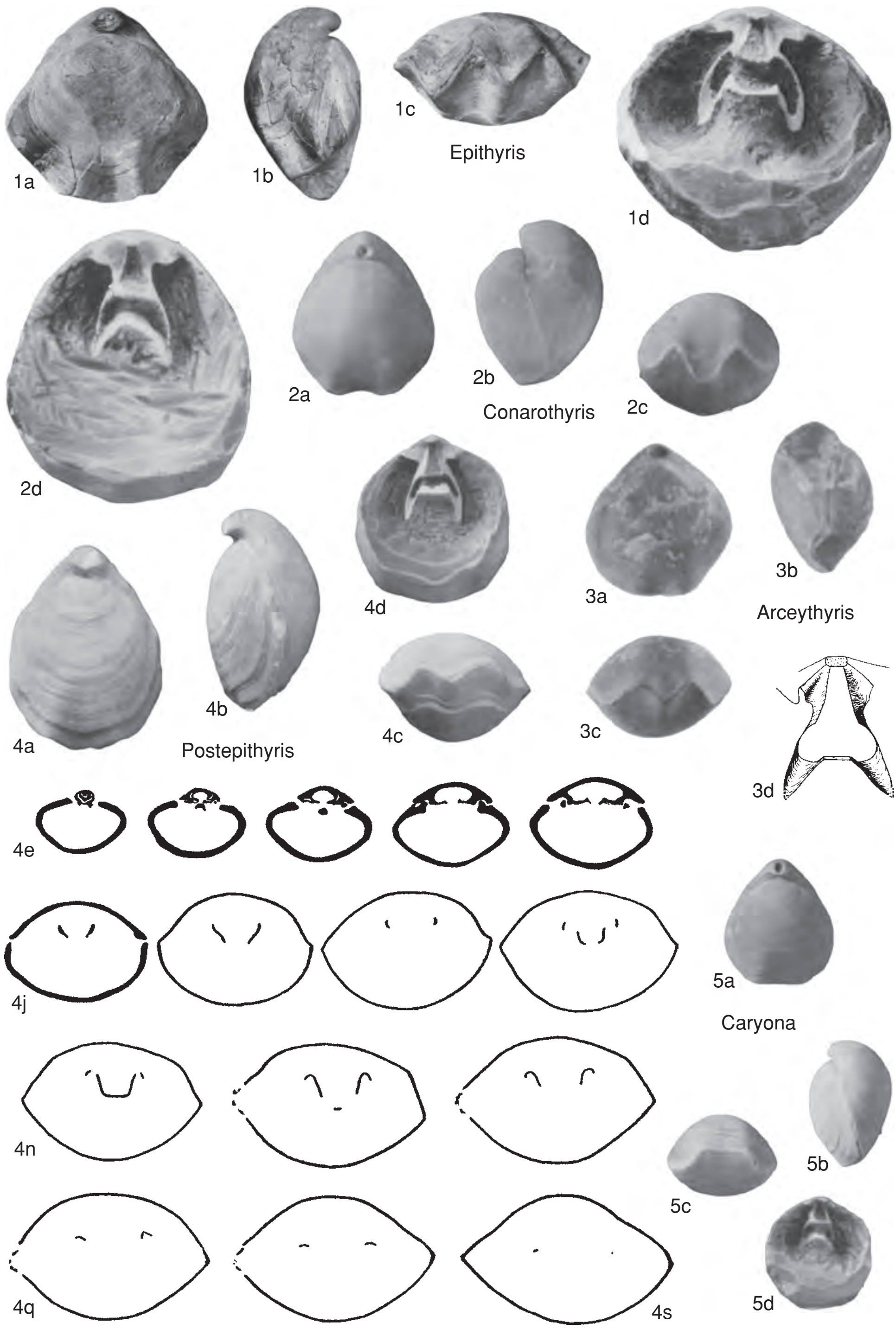

FIG. 1399. Postepithyrididae (p. 2108–2110).

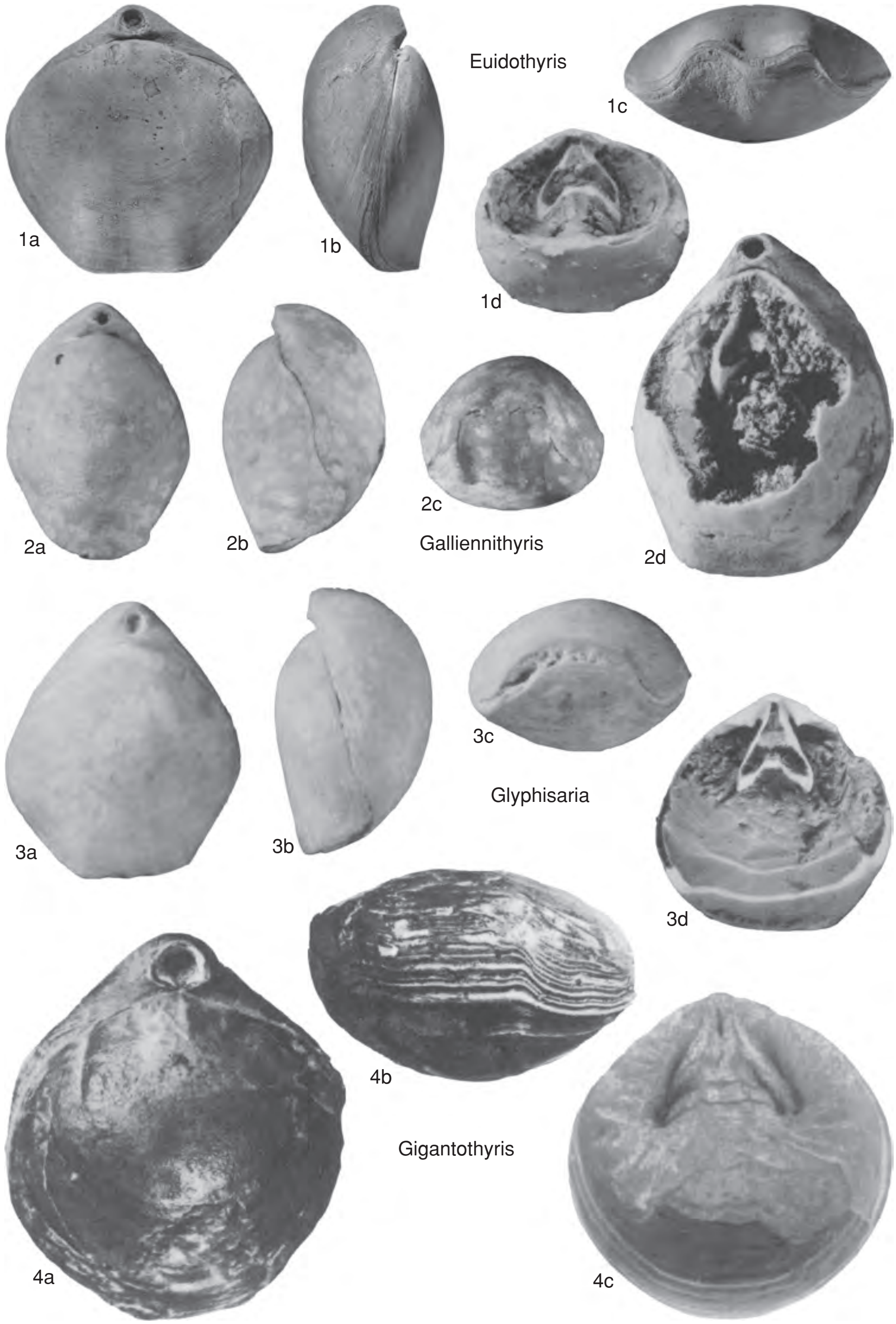

FIG. 1400. Postepithyrididae (p. 2110–2113).

Middle Jurassic (Bathonian): France, England, Germany, Switzerland, Yugoslavia.——Fig. 1401,*1a–c.* **F. ferryi* (Deslongchamps), Bajocian, France; dorsal, lateral, and anterior views, ×1 (Alméras, 1971).

Galliennithyris Rollet, 1966, p. 304 [**Terebratula galliennei* d'Orbigny, 1850 in 1847–1851, p. 377; OD]. Large, elongate oval, ventribiconvex, anterior commissure rectimarginate to sulciplicate, beak short, foramen small, permesothyrid, symphytium visible; pedicle collar present; cardinal process thin, narrow, semiellipse, medially indented with concave myophore; outer hinge plates flatly concave, narrowly triangular, attached to dorsal edge of crural bases; loop with long terminal points, transverse band narrow, high arched. *Middle Jurassic (Callovian)–Upper Jurassic (Oxfordian):* Switzerland, France.——Fig. 1400,*2a–d.* **G. galliennei* (d'Orbigny), Oxfordian, Switzerland; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* dorsal valve interior with incomplete loop, ×2 (Cooper, 1983).

Gigantothyris Seifert, 1963, p. 180 [**G. gigantea;* OD]. Very large, rounded pentagonal, planoconvex to ventribiconvex; anterior commissure uniplicate to sulciplicate, beak erect, foramen large, permesothyrid; symphytium concealed; outer hinge plates short, loop wide, triangular; about 0.4 dorsal valve length, transverse band broad, moderately arched and medially flattened. *Middle Jurassic (Bajocian):* Germany.——Fig. 1400,*4a–c.* **G. gigantea; a–b,* dorsal and anterior views of holotype, IMGPT Br 3/49/101, ×1; *c,* interior of dorsal valve, ×1 (Seifert, 1963).

Glyphisaria Cooper, 1983, p. 83 [**G. uniplicata;* OD]. Large, subpentagonal, ventribiconvex, anterior commissure uniplicate, beak erect, foramen permesothyrid, symphytium exposed; cardinal process small, elliptical with concave myophore; outer hinge plates very narrow as socket ridges and crural bases unite dorsally to form V-shaped troughs, notched at junction with crural bases; loop widely triangular, about 0.4 dorsal valve length. *Middle Jurassic–Upper Jurassic:* France, Saudi Arabia.——Fig. 1400,*3a–d.* **G. uniplicata,* Oxfordian, France; *a–c,* dorsal, lateral, and anterior views of holotype, USNM 551085, ×1; *d,* dorsal valve interior, ×1 (Cooper, 1983).

Habrobrochus Cooper, 1983, p. 87 [**Terebratula subsella* Leymerie, 1846, pl. 10,*5;* OD]. Externally similar to *Xestosina,* but with a more delicate loop, thinner, flatter transverse band, and shorter terminal points. *Upper Jurassic (Kimmeridgian):* Germany, France, Saudi Arabia, ?Mexico.——Fig. 1401,*6a–d.* **H. subsella* (Leymerie), Germany; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* dorsal valve interior, ×1 (Cooper, 1983).

Heimia Haas, 1890, p. 87 [**Terebratula mayeri* Choffat in Haas, 1883, p. 254; OD]. Medium size, subtriangular, planoconvex, smooth, anterior commissure unisulcate to paraplicate, beak short, foramen permesothyrid, symphytium concealed; cardinal process short, prominent, outer hinge plates short, crural processes wide angled; loop not fully known, 0.4 dorsal valve length, transverse band strongly arched, with broad, flattened bridge. *Middle Jurassic (Bajocian):* England, France, Switzerland.——Fig. 1401,*2a–g.* **H. mayeri* (Choffat), Switzerland; *a–c,* dorsal, lateral, and anterior views, ×1 (Muir-Wood, 1965a); *d–g,* incomplete serial transverse sections approximately 1.5, 1.7, 3.0, 4.3 mm from ventral umbo, ×1 (Singeisen-Schneider, 1976).

Holcothyris Buckman, 1918, p. 125 (Buckman, 1915, p. 78, *nom. nud.*) [**H. angulata;* OD]. Medium size, smooth, finely capillate where exfoliated, subpentagonal, biconvex, anterior commissure unisulcate to paraplicate, beak suberect, foramen possibly permesothyrid, symphytium usually concealed; pedicle collar moderately long; cardinal process bilobate, medianly depressed; hinge plates concave ventrally, club shaped posteriorly; loop 0.5 dorsal valve length. *Middle Jurassic (Bathonian):* Burma, China, India, Europe, New Zealand.——Fig. 1401,*7a–m.* **H. angulata,* Burma; *a–c,* dorsal, lateral, and anterior views of holotype, ×1 (Muir-Wood, 1965a); *d–m,* serial transverse sections of specimen, France, 2.1, 3.1, 3.5, 4.0, 5.2, 5.8, 7.6, 10.0, 10.5, 10.9 mm from ventral umbo, ×1 (Alméras, 1971).

Juralina Kyansep, 1961, p. 29 [**J. procerus;* OD]. Large, elongate oval, smooth, planoconvex or biconvex, anterior commissure rectimarginate to gently uniplicate; beak elongate, straight to suberect; foramen large, permesothyrid; symphytium high, exposed (externally homeomorphic with *Rectithyris*); pedicle collar present; cardinal process prominent, medianly depressed; crural bases ventrally directed from hinge plates; loop triangular, strongly arched, with flattened bridge, 0.4 dorsal valve length. *Upper Jurassic (Oxfordian–Kimmeridgian):* Germany, France, Switzerland, Russia, Caucasus, Crimea, Malaysia, ?Morocco.——Fig. 1401,*4a–b.* **J. procerus,* Kimmeridgian, Crimea; dorsal and lateral views of holotype, ×1 (Muir-Wood, 1965a).——Fig. 1401,*4c–d. J. cervicula* Rollier, Upper Jurassic, Germany; *c,* dorsal view; *d,* ventral view of dorsal valve interior, ×1 (Cooper, 1983).

Karakulithyris Ovtsharenko, 1991, p. 63 [**Terebratula bobkovi* Moisseev, 1938, p. 225–226; OD] [=*Klunnikovithyris* Ovtsharenko, 1991, p. 91 (type, *Terebratula klunnikovi* Moisseev, 1938, p. 235, OD)]. Medium to large, oval to subpentagonal; beak short, foramen large, mesothyrid; cardinal process small; loop triangular, 0.35 to 0.5 dorsal valve length, transverse band strongly arched. *Upper Jurassic:* India (Pamirs).——Fig. 1401,*3a–c.* **K. bobkovi* (Moisseev); *a–b,* dorsal and lateral views, ×1; *c,* reconstruction of loop, ×1 (Ovtsharenko, 1991).

Kutchithyris Buckman, 1918, p. 113 (Buckman, 1915, p. 78, *nom. nud.*) [**Terebratula acutiplicata* Kitchin, 1897, p. 9; OD] [=*Eurypthyris* Ovtsharenko, 1983b, p. 117 (type, *Terebratula euryptycha* Kitchin, 1900, p. 25, OD)]. Medium size,

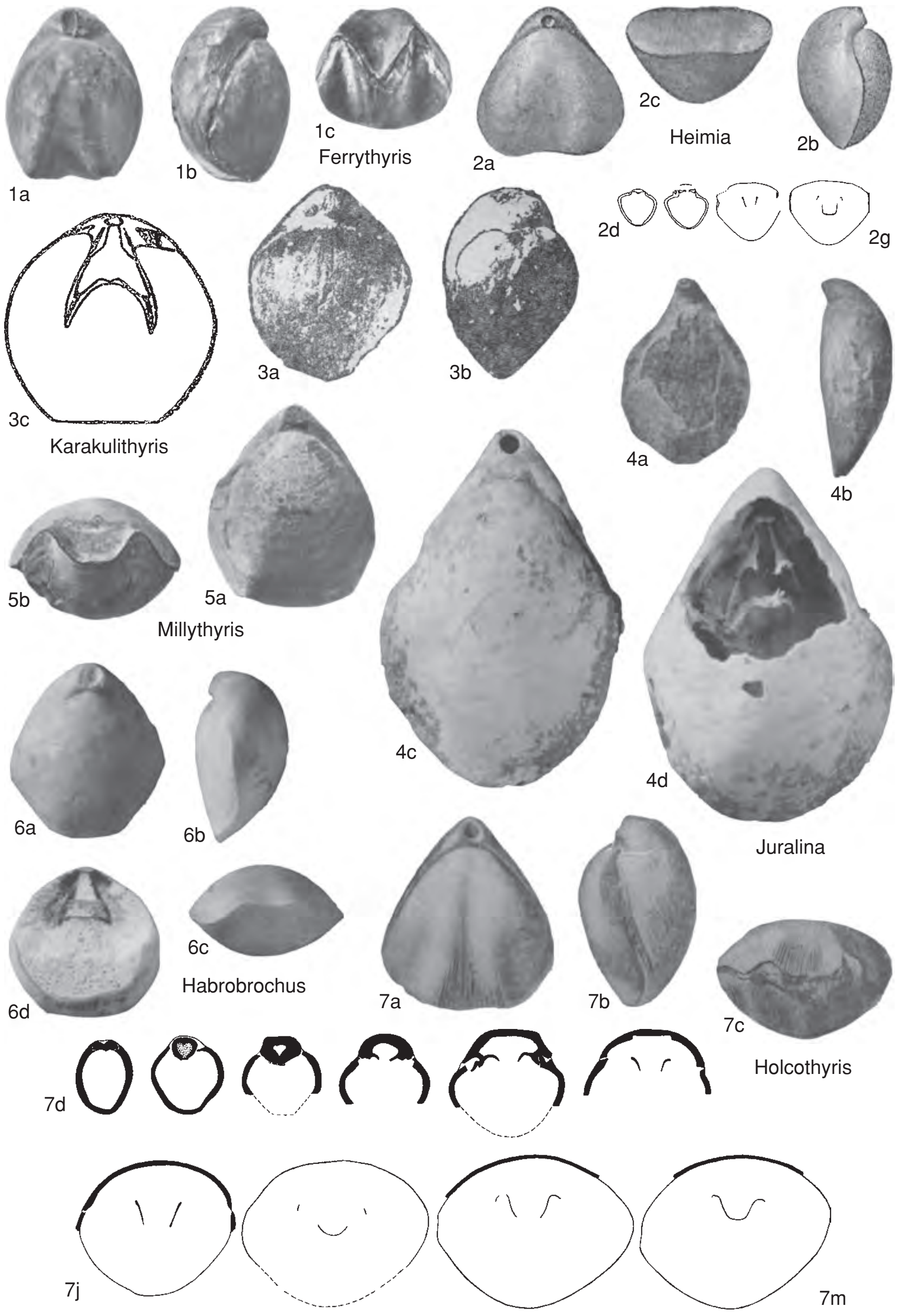

FIG. 1401. Postepithyrididae (p. 2110–2115).

subpentagonal; strongly ventribiconvex, smooth, or rarely finely capillate, with two broad plicae developing anteriorly; anterior commissure uniplicate to sulciplicate, beak short, incurved, attrite; foramen large, mesothyrid to epithyrid; symphytium hidden; cardinal process prominent, grooved; hinge plates wide, concave, flattening anteriorly, not well demarcated from inner socket ridges; crural bases low where attached to hinge plates, passing into high, thin, slightly flanged crural processes; hinge plates and crural processes clubbed; descending lamellae thin; loop not fully known; transverse band high arched, loop 0.4 to 0.5 dorsal valve length, with long terminal points. *Middle Jurassic–Upper Jurassic:* Burma, India, Pakistan, China, Tajikistan, Russia, Europe, North Africa, New Zealand.——FIG. 1402,*1a–o*. **K. acutiplicata* (KITCHIN), Upper Jurassic, Kutch, India; *a–d,* dorsal, ventral, lateral, anterior views of lectotype, GSI Type no. 6601, ×1; *e–o,* serial transverse sections 3.4, 4.9, 5.45, 7.05, 8.9, 10.2, 11.85, 13.2, 13.75, 14.25, 14.55 mm from ventral umbo, ×1 (Mukherjee & others, 2003).

Maritimithyris SMIRNOVA in SMIRNOVA & KONOVALOV, 1986, p. 76 [**M. lautus* SMIRNOVA in SMIRNOVA & KONOVALOV, 1986, p. 77; OD]. Large, pyriform or rounded, biconvex, ventral sulcus broad, commissures curved, beak massive, strongly incurved, foramen large; hinge teeth directed vertically in dental sockets, cardinal process broad, hinge plates inclined strongly to valve floor; crural bases broad with sharp angle inclined to hinge plates; crural processes broad, loop long, transverse band strongly curved, flanges long. *Lower Cretaceous:* Russia (Far East).——FIG. 1402,*2a–u*. **M. lautus; a–c,* dorsal, lateral, and anterior views of slightly crushed holotype, ×1; *d–u,* serial transverse sections 0.0, 1.1, 1.3, 1.5, 2.1, 4.0, 4.5, 5.0, 6.9, 7.4, 8.5, 8.7, 9.4, 9.6, 10.8, 11.0, 11.8, 12.5 mm from first section, ×1 (new).

Millythyris ALMÉRAS, 1971, p. 245 [**M. millythyris;* OD]. Medium size, oval to rounded pentagonal, biconvex, anterior commissure paraplicate; beak straight, symphytium low, narrow; foramen circular, permesothyrid; pedicle collar long. Interior features as for *Conarothyris. Middle Jurassic (Toarcian)–Upper Jurassic (Bathonian):* France, England, Germany.——FIG. 1401,*5a–b*. **M. millythyris,* Bajocian, France; dorsal and anterior views, ×1 (Alméras, 1971).

Moeschia BOULLIER, 1976, p. 333 [**Terebratula alata* ROLLET, 1972a, p. 24; OD]. Large, subpentagonal, planoconvex to ventribiconvex, smooth, anterior commissure broadly uniplicate to weakly sulciplicate, beak short, incurved; foramen permesothyrid; pedicle collar present; cardinal process prominent, hinge plates wide, flat to concave, thin; loop 0.3 to 0.4 dorsal valve length, transverse band moderately arched, narrow; terminal points well developed. *Upper Jurassic:* France, Switzerland, Poland, Romania, Russia, Iran.——FIG. 1403,*2a–d*. **M. alata* (ROLLET), Oxfordian, Jura, France; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* loop reconstruction, ×1 (Boullier, 1976).

Moisseevia MAKRIDIN, 1964, p. 243 [**M. sokolovi;* OD]. Large, elongate oval, smooth, beak strongly curved, foramen small; pedicle collar well developed; cardinal process short; low, short dorsal septum (possibly myophragm), loop more than 0.3 dorsal valve length, with long flanges. [No loop illustrations are available, therefore placement in family is uncertain.] *Upper Jurassic:* Europe, Russian Platform, Caucasus, Crimea.——FIG. 1403,*3a–c*. **M. sokolovi,* Oxfordian, Russia; dorsal, lateral, and anterior views, ×1 (Makridin, 1964).

Peculneithyris SMIRNOVA in SMIRNOVA & TEREKHOVA, 1972, p. 76 [**P. longiusculus;* OD]. Elongate oval, lateral margins flattened, anterior margin uniplicate, valves moderately convex, equally convex along whole surface; beak low, foramen small, permesothyrid; pedicle collar massive, funnel-like, cardinal process small, not lobate, with distinct, longitudinal crenulation; hinge plates thin, inclined to symmetry plane; crural bases distinct, broad, prominent dorsally, oriented with sharp angle to hinge plates, parallel to symmetry plane; inner socket ridges high, distinguishable from hinge plates; dorsal septum short, crural processes broad; loop slender, about half length of dorsal valve, transverse band broad, trapeziform flanges long. *Lower Cretaceous:* Russia (northeastern Siberia, Kamchatka, Khabarovsk region).——FIG. 1403,*1a–x*. **P. longiusculus; a–c,* dorsal, lateral, and anterior views, ×1; *d–x,* serial transverse sections 2.0, 2.3, 2.6, 2.8, 3.1, 3.4, 3.7, 4.0, 4.7, 5.2, 6.2, 7.0, 7.4, 9.0, 9.3, 10.3, 10.8, 12.8, 13.1, 14.8, 17.6 mm from first section, ×0.3 (Smirnova & Terekhova, 1972).

Perrierithyris ALMÉRAS, 1971, p. 423 [**Terebratula dorsoplicata* var. *perrieri* DESLONGCHAMPS,1859, p. 22; OD]. Large, subtriangular, strongly biconvex, beak short, anterior commissure paraplicate, foramen large, circular, symphytium exposed; pedicle collar present; cardinal process short, trilobed; hinge plates forming a deep V; loop 0.5 to 0.6 dorsal valve length, transverse band subhorizontal. *Middle Jurassic (Callovian)–Upper Jurassic (Oxfordian):* France, Switzerland, Germany, Portugal.——FIG. 1404,*1a–k*. **P. dorsoplicata perrieri* (DESLONGCHAMPS), France; *a–c,* dorsal, lateral, and anterior views of neotype, FSL47667, ×1; *d–k,* serial transverse sections 2.8, 3.7, 4.1, 5.2, 8.4, 11.4, 12.4, 15.8 mm from ventral umbo, ×1 (Alméras, 1971).

Petalothyris COOPER, 1983, p. 128 [**Terebratula simplex* J. BUCKMAN, 1845, pl. 7,*5;* OD]. Large, planoconvex, externally like *Gigantothyris;* loop large, triangular, 0.5 dorsal valve length, transverse band wide, steeply arched, with flat bridge. *Middle Jurassic (Bajocian):* England.——FIG. 1404,*3a–d*. **P. simplex* (J. BUCKMAN); *a–c,* dorsal, lateral, and anterior views, ×1; *d,* dorsal valve interior, ×1 (Cooper, 1983).

Plectoidothyris BUCKMAN, 1918, p. 122 (BUCKMAN, 1914, p. 2, *nom. nud.*) [**Terebratula polyplecta* BUCKMAN, 1901, p. 242; OD] [=*Oligorhytisia* COOPER, 1983, p. 125 (type, *O. magnifica,* OD);

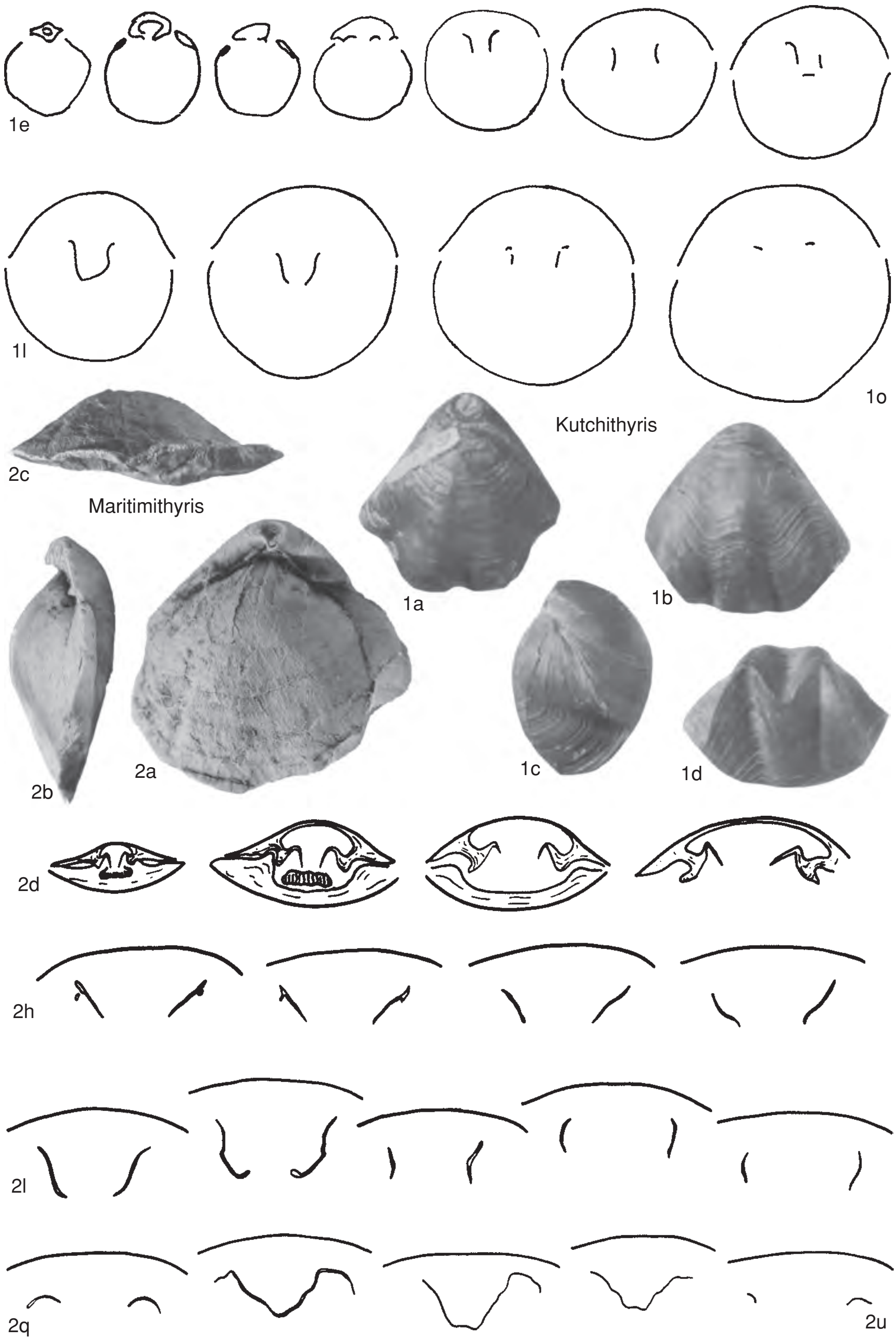

FIG. 1402. Postepithyrididae (p. 2113–2115).

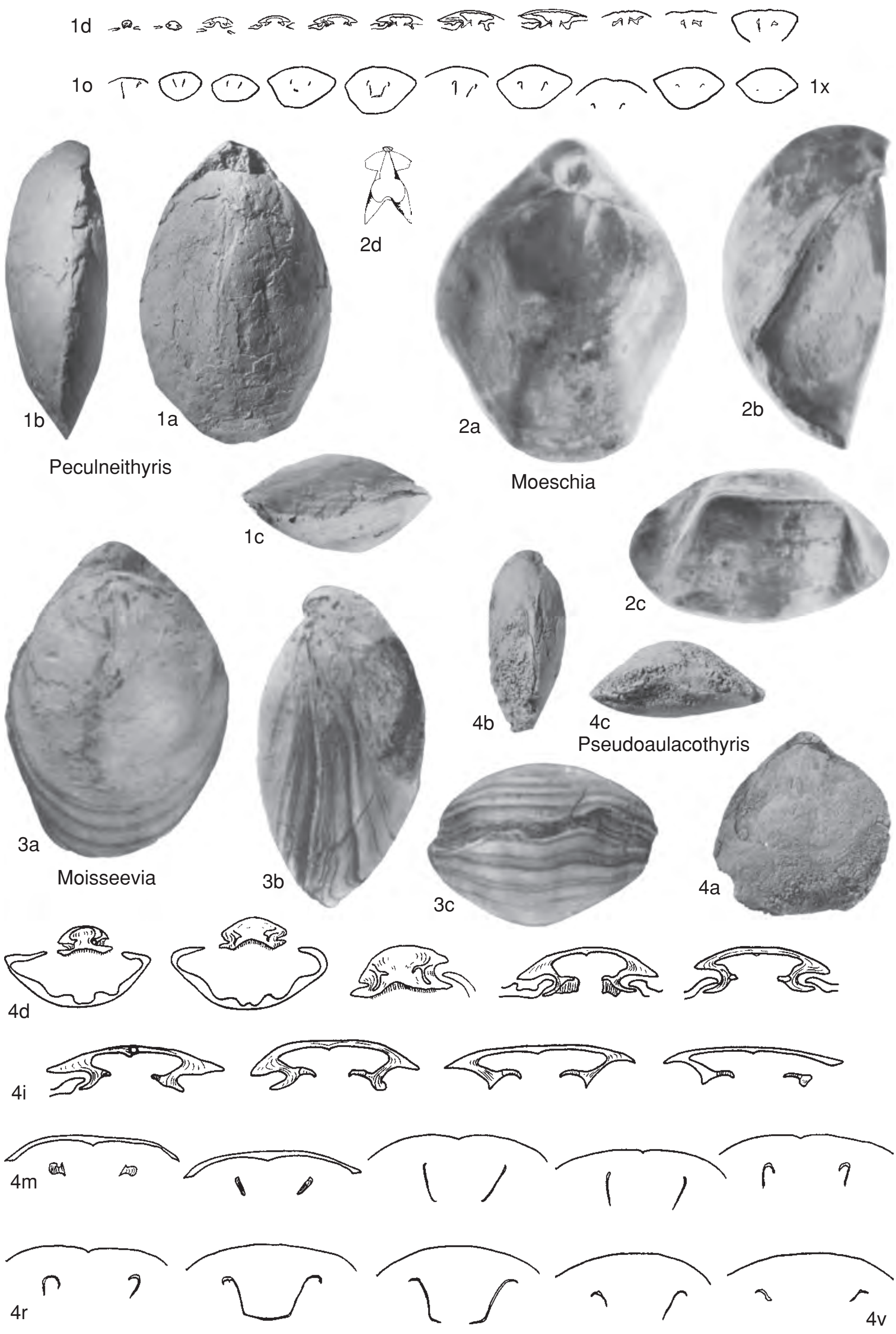

FIG. 1403. Postepithyrididae (p. 2115–2119).

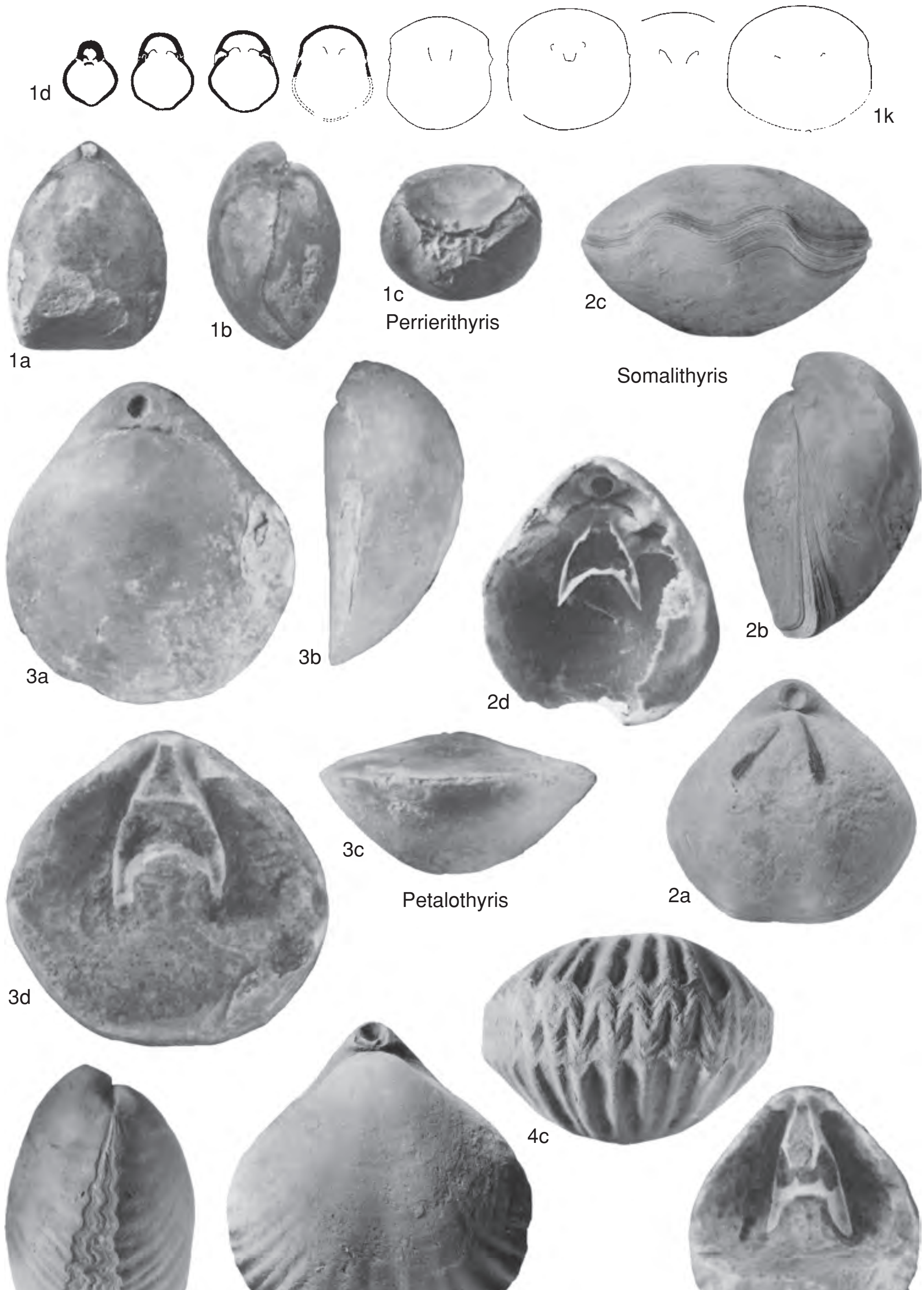

FIG. 1404. Postepithyrididae (p. 2115–2119).

Pleuraloma COOPER, 1989, p. 84 (type, *P. labiatum,* OD); *Dissoria* COOPER, 1989, p. 97 (type, *D. costata,* OD)]. Large, ventribiconvex, subpentagonal to elongate oval, smooth in juveniles, irregular, rounded costae developing anteriorly; anterior commissure rectimarginate to uniplicate, becoming multiplicate, beak short, foramen permesothyrid, symphytium partly visible; pedicle collar present; cardinal process small, thin, bilobed; outer hinge plates short, narrow, deeply concave; loop 0.5 to 0.6 dorsal valve length, with strongly webbed, long terminal points; transverse band narrow, strongly arched. *Middle Jurassic (Bajocian–Callovian):* England, France, Saudi Arabia.——FIG. 1404,*4a–d.* **P. polyplecta* (BUCKMAN), Bajocian, England; *a–c,* dorsal, lateral, and anterior views of holotype, ×1 (Muir-Wood, 1965a); *d,* dorsal valve interior, ×1 (Cooper, 1983).

Pseudoaulacothyris SMIRNOVA, 1990a, p. 93 [**P. pandus;* OD]. Medium size, subcircular, slightly biconvex, smooth, with sulcus on dorsal valve, ventral valve carinate; anterior commissure unisulcate, beak low, broad; foramen small, epithyrid; pedicle collar thin; cardinal process concave, bilobate; hinge plates slightly concave, not differentiated from inner socket ridges; loop about 0.5 dorsal valve length; flanges of moderate length. *Lower Cretaceous:* Russia (northeastern Siberia, Kamchatka). ——FIG. 1403,*4a–v.* **P. pandus; a–c,* dorsal, lateral, and anterior views of holotype, ×1; *d–v,* serial transverse sections 0.6, 0.7, 0.9, 1.1, 1.9, 2.1, 3.0, 3.2, 3.9, 4.2, 5.1, 5.3, 6.1, 6.3, 7.0, 7.3, 8.6, 9.4, 11.2 mm from first section, ×1 (new).

Somalithyris MUIR-WOOD, 1935, p. 124 [**S. macfadyeni;* OD]. Medium size, subpentagonal to subcircular; ventribiconvex; anterior commissure uniplicate to sulciplicate; beak short, suberect, symphytium hidden; foramen large, permesothyrid; cardinal process bilobed; loop 0.4 dorsal valve length. *Upper Jurassic (Oxfordian–Kimmeridgian):* Somalia, Saudi Arabia.——FIG. 1404,*2a–c.* **S. macfadyeni,* Oxfordian, Somalia; dorsal, lateral, and anterior views of holotype, BMNH B 85655, ×1 (Muir-Wood, 1965a).——FIG. 1404,*2d. S. ovata,* Kimmeridgian, Saudi Arabia; interior of dorsal valve, ×1 (Cooper, 1989).

Xestosina COOPER, 1983, p. 166 [**X. arguta;* OD]. Externally similar to *Sellithyris,* but with widely triangular loop, 0.5 dorsal valve length, with moderately long terminal points. *Upper Jurassic (Kimmeridgian):* France.——FIG. 1405*a–d.* **X. arguta; a–c,* dorsal, lateral, and anterior views, ×1; *d,* interior of dorsal valve, ×1 (Cooper, 1983).

Family TCHEGEMITHYRIDIDAE Tchorszhevsky, 1972

[Tchegemithyrididae TCHORSZHEVSKY, 1972, p. 36]

Small to large, smooth, rectimarginate to uniplicate to sulciplicate, crural processes anterior of midloop, outer hinge plates attached dorsally to crural bases; loop long, with long flanges; transverse band with narrow bridge; loop development may be complex. *Middle Jurassic (Callovian)–Upper Jurassic.*

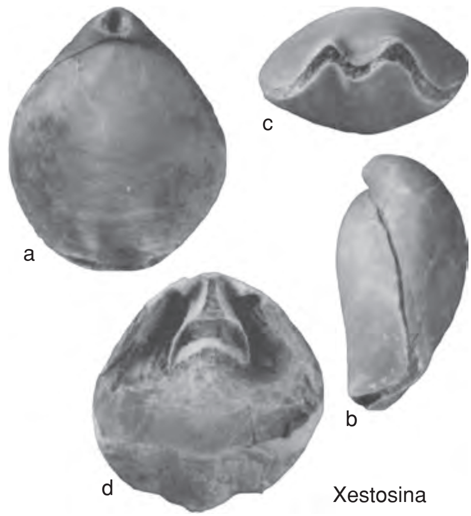

FIG. 1405. Postepithyrididae (p. 2119).

Subfamily TCHEGEMITHYRIDINAE Tchorszhevsky, 1972

[Tchegemithyridinae TCHORSZHEVSKY, 1972, p. 36]

Loop about 0.6 dorsal valve length. *Middle Jurassic (Callovian)–Upper Jurassic (Oxfordian).*

Tchegemithyris TCHORSZHEVSKY, 1972, p. 36 [**Terebratula tchegemensis* MOISSEEV, 1934, p. 97; OD]. Small to medium size, subcircular to subpentagonal; strongly biconvex or globose, anterior commissure uniplicate; beak strongly incurved, symphytium short; foramen mesothyrid or epithyrid, pedicle collar weakly developed; outer hinge plates thick, crural processes derived from anterior margin of hinge plates. *Middle Jurassic (Callovian)–Upper Jurassic (Oxfordian):* Turkmenia, Caucasus, Lebanon, Syria.——FIG. 1406,*1a–v.* **T. tchegemensis* (MOISSEEV), Oxfordian, Caucasus; *a–c,* dorsal, lateral, and anterior views, ×1 (Moisseev, 1934); *d–u,* serial transverse sections 1.0, 3.5, 4.25, 5.3, 6.2, 6.8, 7.3, 8.15, 9.0, 9.85, 10.1, 10.5, 11.35, 12.65, 13.25, 14.3, 16.45, 16.75 mm from first section, ×1 (Tchorszhevsky, 1972); *v,* reconstruction of loop, ×3.5 (Cooper, 1983).

Subfamily TURKMENITHYRIDINAE Tchorszhevsky, 1974

[Turkmenithyridinae TCHORSZHEVSKY, 1974, p. 50]

Loop about 0.3 dorsal valve length. *Upper Jurassic.*

Turkmenithyris PROSOROVOSKAJA, 1962, p. 109 [**T. krimholzi;* OD] [=*Bejrutella* TCHORSZHEVSKY, 1972, p. 40 (type, *B. bejrutica,* OD)]. Medium to large, subpentagonal, ventribiconvex, strongly uniplicate to sulciplicate; beak incurved, concealing symphytium, foramen large, mesothyrid; pedicle collar present; cardinal process large, bilobed; hinge plates short, slightly concave, posteriorly U-shaped, becoming V-shaped anteriorly; crural processes high, their ventral ends deflected laterally, loop short (about 0.3 dorsal valve length), widely triangular, transverse band thin, strongly arched, loop flanges very long. *Upper Jurassic:* Turkmenia, Crimea, Lebanon, Syria.——FIG. 1406,*2a–v.* **T. krimholzi,* Turkmenia; *a–c,* dorsal, lateral, and anterior views of holotype, ×1; *d–u,* serial transverse sections 2.2, 6.6, 6.8, 8.0, 8.1, 9.2, 9.6, 10.0, 10.5, 10.6, 10.9, 11.4, 12.0, 13.2, 14.0, 15.4, 16.0, 18.2 mm from ventral umbo, ×1; *v,* reconstruction of loop, ×1 (Prosorovoskaja, 1962).

Family TEGULITHYRIDIDAE Muir-Wood, 1965

[Tegulithyrididae MUIR-WOOD, 1965a, p. 801]

Smooth or rarely capillate, anterior commissure biplicate or parasulate. *Lower Jurassic (Toarcian)–Middle Jurassic (Callovian).*

Tegulithyris BUCKMAN, 1918, p. 123 (BUCKMAN, 1915, p. 78, *nom. nud.*) [**Terebratula bentleyi* DAVIDSON, 1851, p. 58; OD]. Medium size, subpentagonal, ventribiconvex; anterior commissure strongly biplicate; dorsal sulcus becoming median fold, and angular folds separating deep ventral sulcus from concave flanks; smooth or rarely capillate; beak long, erect; foramen large, permesothyrid, symphytium exposed; cardinal process small, bilobed; outer hinge plates short, narrow, concave, may be thickened, attached dorsally to crural bases; crura short, loop long, 0.5 dorsal valve length, transverse band strongly arched, medially flattened, protuberant, with short flanges. *Middle Jurassic (Bathonian–Callovian):* England, France, Germany, Russia.——FIG. 1407,*1a–e.* **T. bentleyi* (DAVIDSON), Callovian, England; *a–d,* dorsal, ventral, lateral, and anterior views, ×1; *e,* dorsal valve interior, ×2 (Cooper, 1983).

Prototegulithyris ALMÉRAS, ELMI, & BENSHILI, 1988, p. 67 [**P. khadijae;* OD]. Description as for *Tegulithyris,* but smooth, rounded pentagonal in outline, and anterior commissure gently parasulcate. *Lower Jurassic (Toarcian)–Middle Jurassic (Aalenian):* Morocco, Sicily, Italy, Bavaria.——FIG. 1407,*3a–q.* **P. khadijae,* Toarcian, Morocco; *a–c,* dorsal, lateral, and anterior views of holotype, FSL 306466, ×1; *d–q,* serial transverse sections 1.2, 4.4, 5.1, 5.6, 7.6, 8.2, 8.4, 8.6, 9.8, 10.8, 11.0, 11.2, 12.0, 12.7 mm from ventral umbo, ×1 (Alméras, Elmi, & Benshili, 1988).

Family ALABUSHEVOTHYRIDIDAE Smirnova, 1994

[Alabushevothyrididae SMIRNOVA, 1994, p. 40]

Biconvex, smooth, rectimarginate, dental plates massive, diverging; cardinal process trilobate, loop anteriorly spinose. *Lower Cretaceous.*

Alabushevothyris SMIRNOVA, 1994, p. 41 [**A. angusta;* OD]. Medium size, elongate oval; beak erect, interarea high; beak cavities fused with callus; cardinal process trilobed, strongly grooved; loop about 0.5 length of dorsal valve. *Lower Cretaceous:* Russia (Kamchatka).——FIG. 1407,*2a–v.* **A. angusta; a–c,* dorsal, lateral, and anterior views of holotype, MGU138/350, ×1; *d–v,* serial transverse sections 0.0, 0.2, 0.6, 1.5, 2.0, 4.0, 4.8, 5.8, 6.8, 7.6, 8.6, 9.0, 9.3, 9.8, 10.8, 12.0, 13.0, 14.4, 16.4 mm from first section, ×1 (new).

Family CLATHRITHYRIDIDAE Smirnova, 1974

[Clathrithyrididae SMIRNOVA, 1974, p. 47]

Smooth or with reticulate ornament, unisulcate; dental plates present; inner hinge plates may be present; adult loop deltiform; loop ontogeny may involve septal pillar in early stages. *Lower Cretaceous.*

Clathrithyris SMIRNOVA, 1974, p. 48 [**C. clathriensis;* OD]. Medium size, dorsibiconvex with deep dorsal sulcus and prominent, ventral median fold; growth lamellae squamose and overlapping, radial costae thin, low, flattened, ornament reticulate; beak erect; foramen small, epithyrid, deltidial plates conjunct; beak cavity infilled with callus; dental plates broad, pedicle collar present; no cardinal process, hinge plates broad, inclined; deep septalium consisting of high median septum and wide, inner hinge plates; septalium infilled with callus in adult shells; crural bases massive, fused with inner hinge plates; crural processes broad; adult loop about 0.5 length of valve, anteriorly spinose, transverse band broad, flattened. *Lower Cretaceous:* Russia (Kamchatka).——FIG. 1408,*3a–w.* **C. clathriensis; a–c,* dorsal, lateral, and anterior views of holotype, MGU 138/331, ×1; *d,* closeup of ornament, ×5; *e–v,* serial transverse sections 0.8, 1.0, 1.8, 2.2, 2.7, 2.8, 3.1, 3.3, 3.8, 4.4, 5.1, 5.8, 6.2, 6.9, 7.7, 8.1, 8.9, 10.8

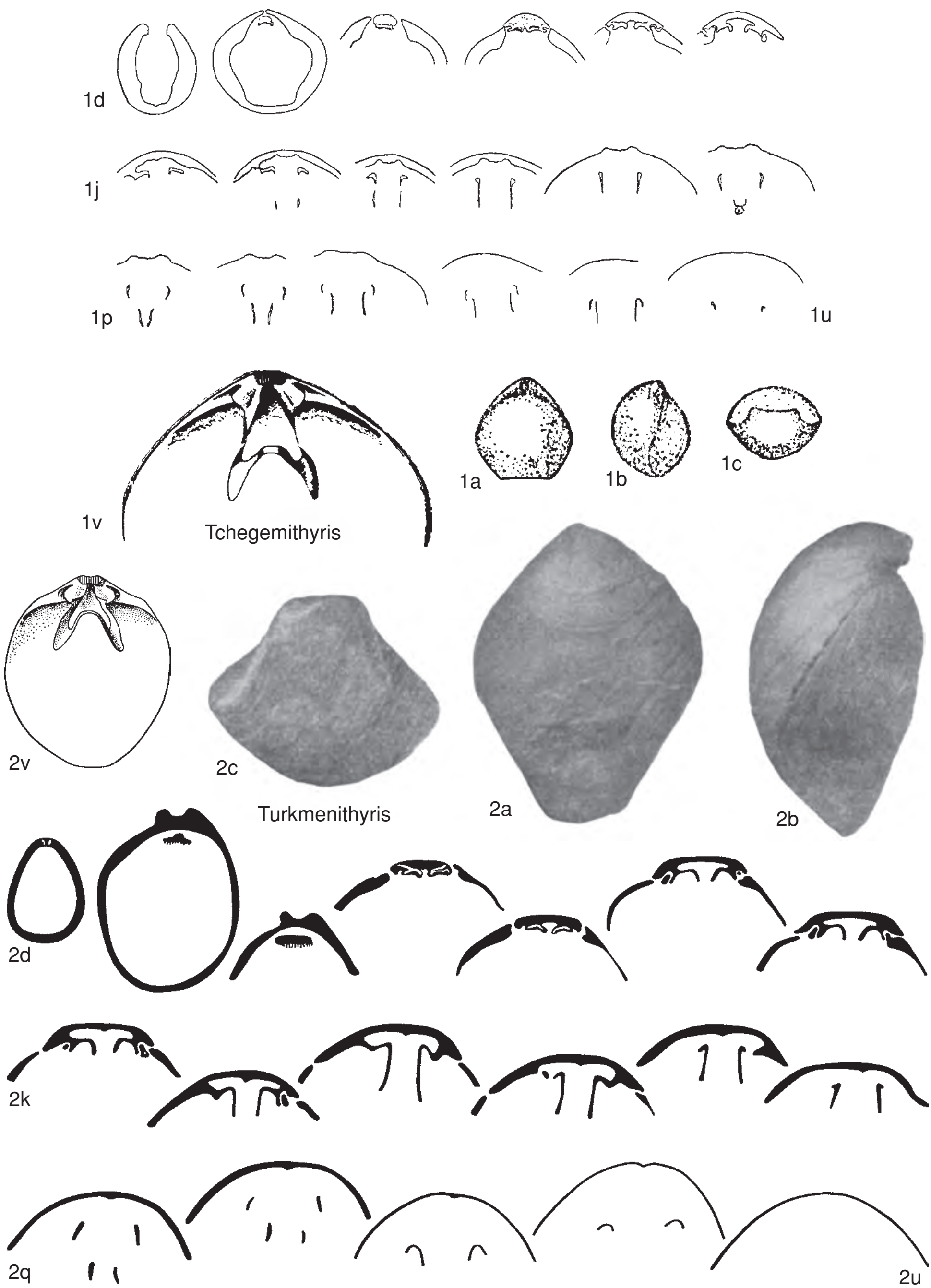

FIG. 1406. Tchegemithyrididae (p. 2119–2120).

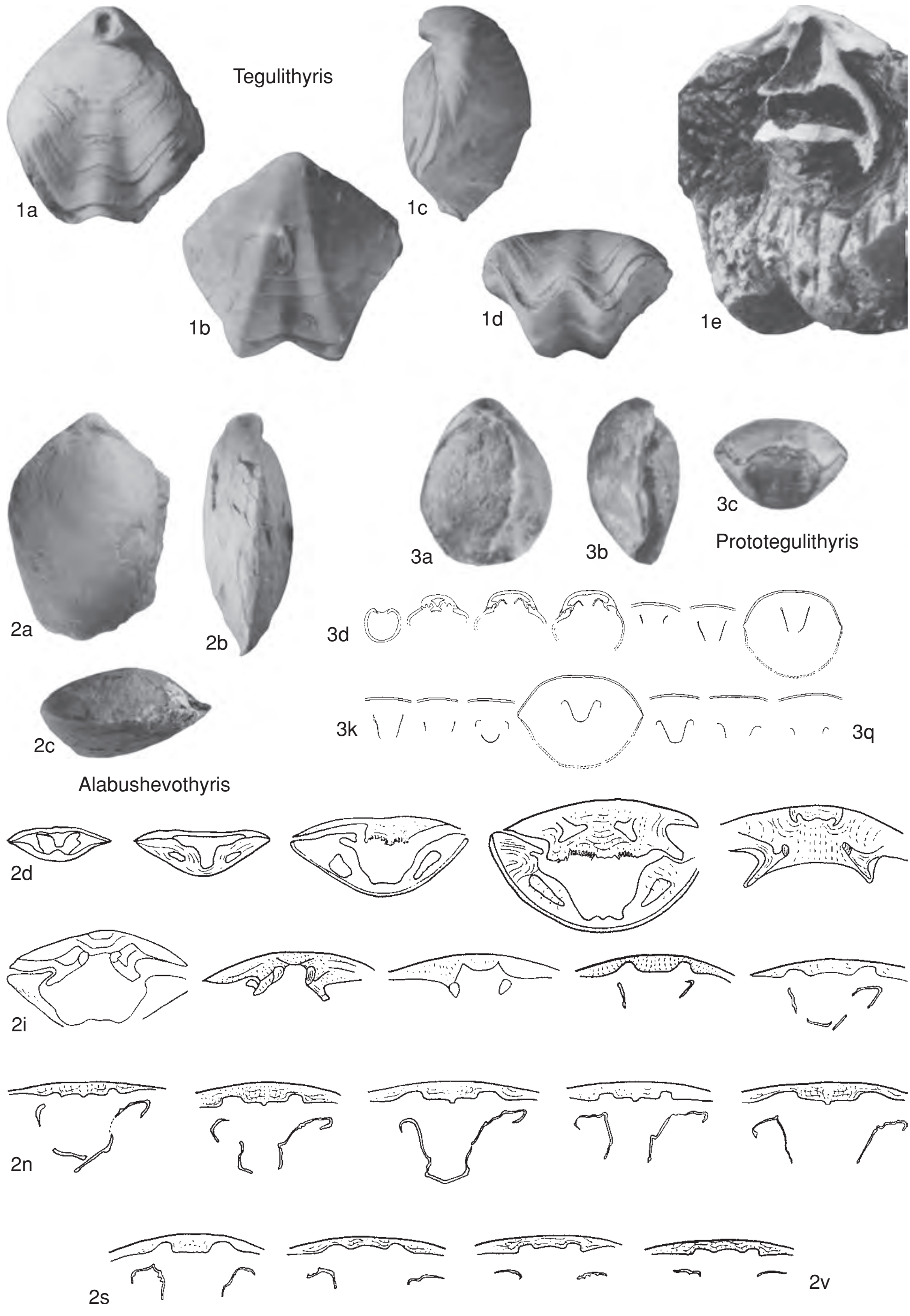

FIG. 1407. Tegulithyrididae and Alabushevothyrididae (p. 2120).

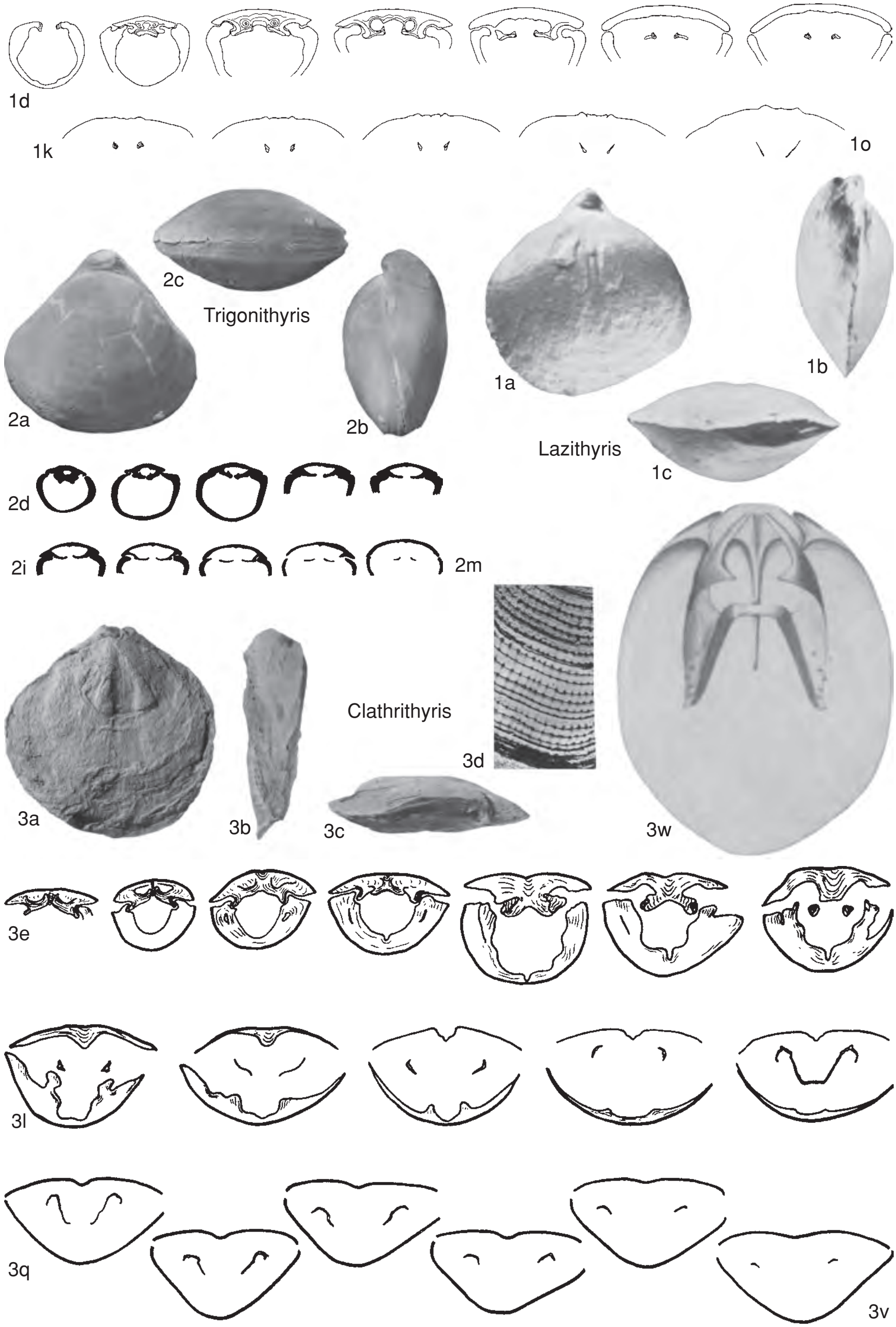

FIG. 1408. Clathrithyrididae and Trigonithyrididae (p. 2120–2129).

mm from first section, ×1; *w,* reconstructed loop, ×2.5 (Smirnova, 1974).

Family HARPOTOTHYRIDIDAE Smirnova, 1990

[Harpotothyrididae Smirnova, 1990b, p. 53]

Medium to large, smooth; biconvex, pedicle collar present; cardinal process small, crural bases broad, concave, inclined almost perpendicularly to hinge plates; loop with long flanges. *Lower Cretaceous.*

Harpotothyris Smirnova, 1990b, p. 53 [**H. karakhabdaensis;* OD]. Elongate oval to rounded trigonal; anterior commissure rectimarginate to uniplicate; beak high, strongly incurved; cardinal process small, concave, often medially convex; crural bases high, crescent shaped in section, inclined almost perpendicularly to narrow, flattened hinge plates; short median ridge present; transverse band of loop thin, flanges long, slender. *Lower Cretaceous:* Kazakhstan.——Fig. 1409,*5a–w.* **H. karakhabdaensis; a–c,* dorsal, lateral, and anterior views of holotype, MGU 139/700, ×1; *d–w,* serial transverse sections 0.0, 0.3, 3.0, 3.2, 4.0, 4.3, 5.0, 5.6, 6.2, 6.8, 7.9, 8.0, 9.5, 9.8, 11.9, 12.4, 13.4, 14.6, 15.9, 17.9 mm from first section, approximately ×1 (new).

Atelithyris Smirnova, 1975c, p. 77 [**A. crestensis;* OD]. Elongate oval, slightly uniplicate; beak long, foramen large, epithyrid, beak ridges rounded; cardinal process low, hinge plates slightly inclined, flattened; inner socket ridges indistinct, crural processes high; loop about 0.5 dorsal valve length, transverse band slender, strongly arched, flanges long. *Lower Cretaceous (Hauterivian):* Russia (Russian Platform).——Fig. 1409,*2a–d.* **A. crestensis; a–c,* dorsal, lateral, and anterior views of holotype, MGU 138/477, ×1; *d,* reconstruction of loop, ×1 (Smirnova, 1975c).

Convexothyris Smirnova, 1994, p. 37 [**C. tylokrilica;* OD]. Large, elongate oval, anterior commissure rectimarginate to slightly uniplicate, beak massive, incurved; cardinal process small; hinge plates broad, ventrally convex, crural bases concave with pointed dorsal ends; dorsal septal platform may be developed, loop with long flanges, transverse band trapeziform in section. *Lower Cretaceous:* Russia (Kamchatka).——Fig. 1409,*4a–c.* **C. tylokrilica;* dorsal, lateral, and anterior views of holotype, MGU138/518, ×1 (Smirnova, 1994).

Lissothyris Smirnova, 1987, p. 35 [**L. piriformis* Smirnova, 1987, p. 37; OD]. Large, subpentagonal, anterior commissure uniplicate to biplicate; beak high, foramen large; pedicle collar not seen; cardinal process low, broad; hinge plates broad, parallel to valve floor, slightly demarcated from inner socket ridges; crural bases with strongly concave inner surface and high, sharp, ventral ends; short dorsal ends of crural bases almost fused with hinge plates; transverse band strongly curved, rectimarginate in section; loop slender with long flanges; cardinal structures may be fused with callus. *Lower Cretaceous:* Russia (Russian Platform). ——Fig. 1409,*3a–c.* **L. piriformis;* dorsal, lateral, and anterior view of holotype, MGU139/547, ×1 (Smirnova, 1987).

Okathyris Smirnova, 1975c, p. 71 [**O. chevkinensis;* OD]. Medium size, subcircular, slightly unisulate or bisulcate; foramen epithyrid, beak ridges obscure; cardinal process low, slightly concave; hinge plates narrow, steeply inclined to plane of symmetry; inner socket ridges high, crural bases inclined to hinge plates; crural processes long; loop about 0.5 dorsal valve length, transverse band broadly arched. *Lower Cretaceous (Berriasian):* Russia (Russian Platform), England.——Fig. 1409,*1a–d.* **O. chevkinensis; a–c,* dorsal, lateral, and anterior views of holotype, MGU 139/91, ×1 (Smirnova, 1975c); *d,* loop reconstruction, ×1 (Cooper, 1983).

Family MAMETOTHYRIDIDAE new family

[Mametothyrididae Smirnova & Lee, herein] [type genus, *Mametothyris* Smirnova in Smirnova & Pergament, 1969, p. 34]

Large, smooth, anterior commissure rectimarginate, foramen small, no pedicle collar, crural bases fused with hinge plates, loop long with long flanges. *Lower Cretaceous (Albian).*

Mametothyris Smirnova in Smirnova & Pergament, 1969, p. 34 [**M. mametica;* OD]. Rounded trigonal, beak short, incurved, cardinal process low, concave, hinge plates ventrally concave; loop slender, long, 0.5 dorsal valve length; transverse band high, rounded. *Lower Cretaceous (Albian):* Russia (Kamchatka).——Fig. 1410*a–x.* **M. mametica; a–c,* dorsal, lateral, and anterior views of holotype, MGU138/64, ×1; *d–x,* serial transverse sections 0.3, 0.5, 0.8, 1.4, 2.1, 2.3, 2.8, 3.3, 3.6, 3.8, 5.2, 5.4, 6.9, 7.2, 7.6, 8.1, 8.6, 9.9, 11.1, 11.7, 12.9 mm from first section, ×2 (Smirnova & Pergament, 1969).

Penzhinothyris Smirnova in Smirnova & Pergament, 1969, p. 36 [**P. plana;* OD]. Subcircular, thick shelled, slightly biconvex or dorsibiconvex, beak slightly incurved, beak ridges sharp; interarea high, smooth; cardinalia massive, cardinal process trilobed, hinge plates inclined to symmetry plane, demarcated from inner socket ridges by a groove; loop long, more than 0.5 dorsal valve length; transverse band broad, high, trapeziform in section; loop flanges long; septal platform massive, consisting of three ridges. *Lower Cretaceous (Albian):* Russia (Kamchatka).——Fig. 1411*a–r.* **P. plana; a–c,* dorsal, lateral, and anterior views of holotype, MGU138/63, ×1; *d–r,* serial transverse sections 0.2, 2.1, 4.1, 5.4, 6.3, 6.9, 8.0, 8.1, 9.2, 9.4, 10.6, 11.4, 13.2, 14.6, 16.1 mm from first section, ×1.5 (Smirnova & Pergament, 1969).

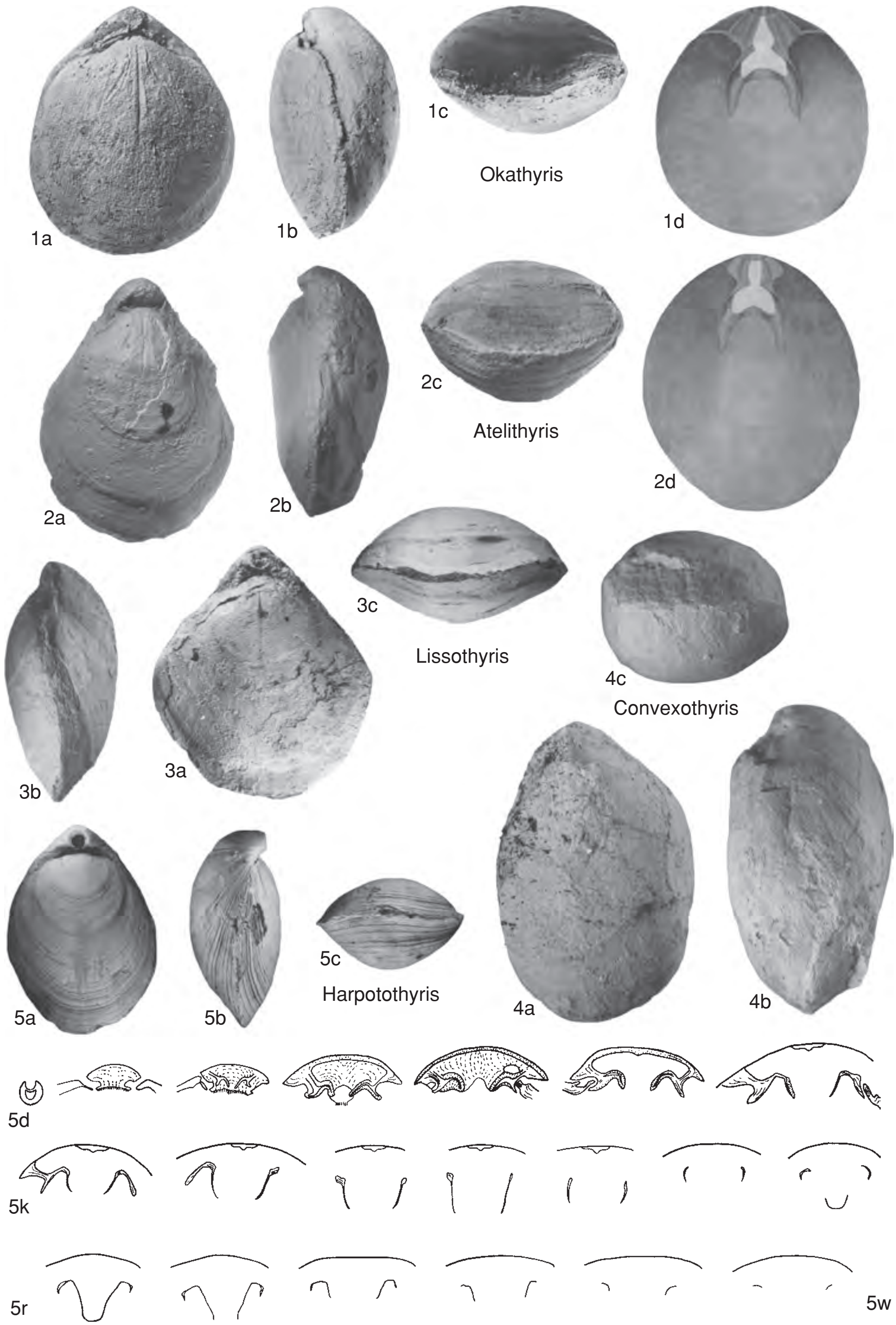

FIG. 1409. Harpotothyrididae (p. 2124).

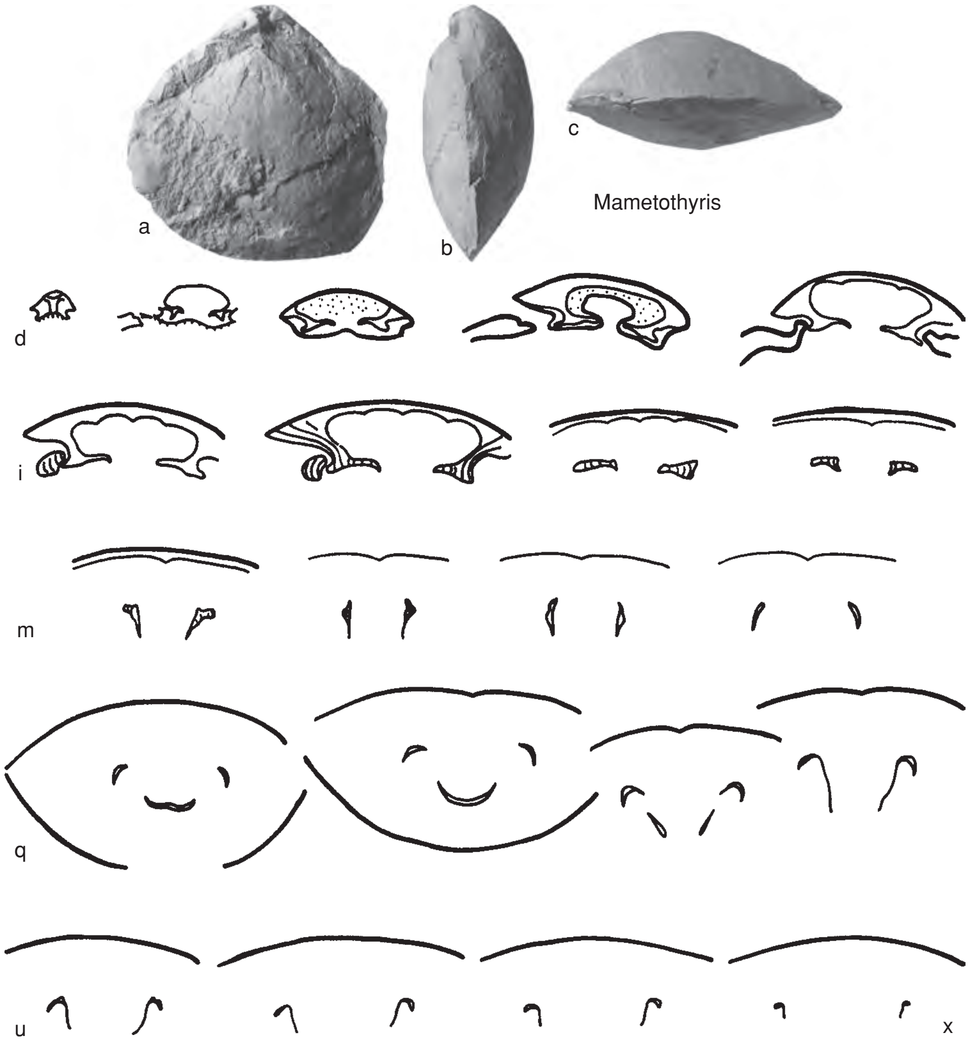

FIG. 1410. Mametothyrididae (p. 2124).

Family SPASSKOTHYRIDIDAE Smirnova, 1977

[*nom. transl.* SMIRNOVA 1990a, p. 104, *ex* Spasskothyridinae SMIRNOVA, 1977, p. 74]

Medium to large, smooth, pedicle collar may be present; crural bases with well-developed ventral and dorsal ends, inner hinge plates may be present; loop narrow with long flanges. *Lower Cretaceous.*

Spasskothyris SMIRNOVA, 1975c, p. 74 [**S. rjasanensis;* OD]. Large, elongate oval; slightly bisulcate; beak long; foramen large, epithyrid; pedicle collar rounded; cardinal process low; crural bases with long ventral and dorsal extremities separating inner and outer hinge plates, and in contact with floor of dorsal valve, much reduced anteriorly; ventral extremities of crural bases forming ridgelike projections adjacent to hinge plates, passing into inner hinge plates; outer hinge plates broad, concave; crural bases and crural processes concave; loop narrow, 0.5 to 0.6 length of dorsal valve; flanges very long. *Lower Cretaceous (Berriasian):* Russia (Russian Platform).——FIG. 1412*a–cc*. **S. rjasanensis; a–c,* dorsal, lateral, and anterior views of holotype, MGU 139/65; *d,* reconstruction of loop, ×1 ; *e–cc,* serial

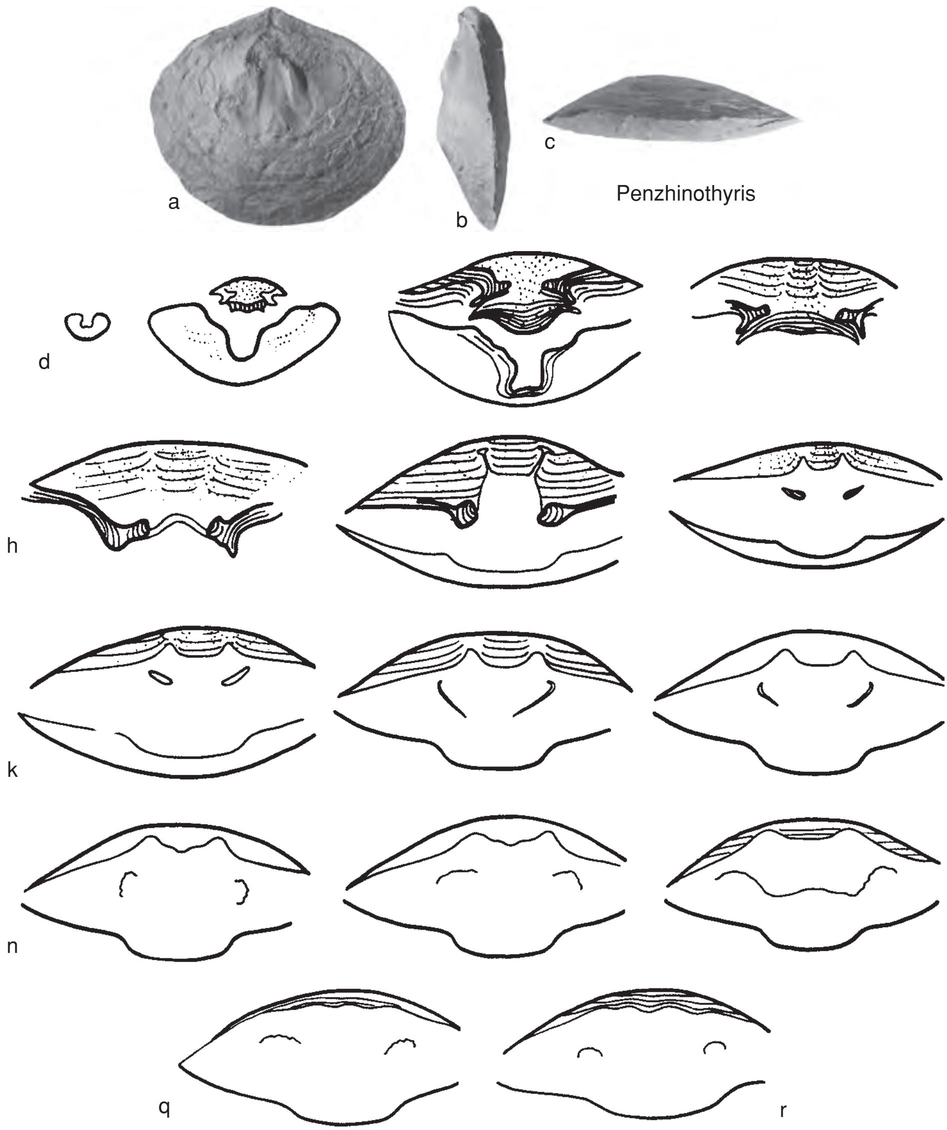

FIG. 1411. Mametothyrididae (p. 2124).

transverse sections 0.0, 0.2, 6.2, 6.7, 7.2, 7.7, 8.0, 8.5, 9.0, 10.2, 10.7, 11.3, 11.7, 13.0, 13.7, 14.7, 16.2, 17.9, 18.7, 19.1, 20.3, 21.5, 23.6, 26.3, 29.3 mm from first section, ×1 (Smirnova, 1975c).

Volgathyris SMIRNOVA, 1987, p. 38 [**V. sublatus;* OD]. Rounded-pentagonal, biconvex, uniplicate; beak massive, foramen large; no pedicle collar; hinge teeth large, wedge shaped with distinct denticulum; cardinal process narrow, denticulated; hinge plates dorsally inclined to midvalve, planar, gradually transformed into broad socket ridges at right angles to crural bases; crural bases broad with long ventral and shorter dorsal ends, inclined to symmetry plane with sharp angle; crural processes broad; loop narrow with thin branches, transverse band highly trapeziform, flanges long. *Lower Cretaceous:* Russia (Russian Platform).——FIG. 1413*a–u*. **V. sublatus; a–c,* dorsal, lateral, and anterior views of holotype, MGU139/509, ×1; *d–u,* serial transverse sections 1.1, 1.6, 2.0, 2.4, 2.6, 2.8, 3.2, 3.5, 4.0, 4.6, 5.0, 7.8, 9.1, 11.9, 12.5, 14.4, 15.4, 16.4 mm from first section, ×1 (Smirnova, 1987).

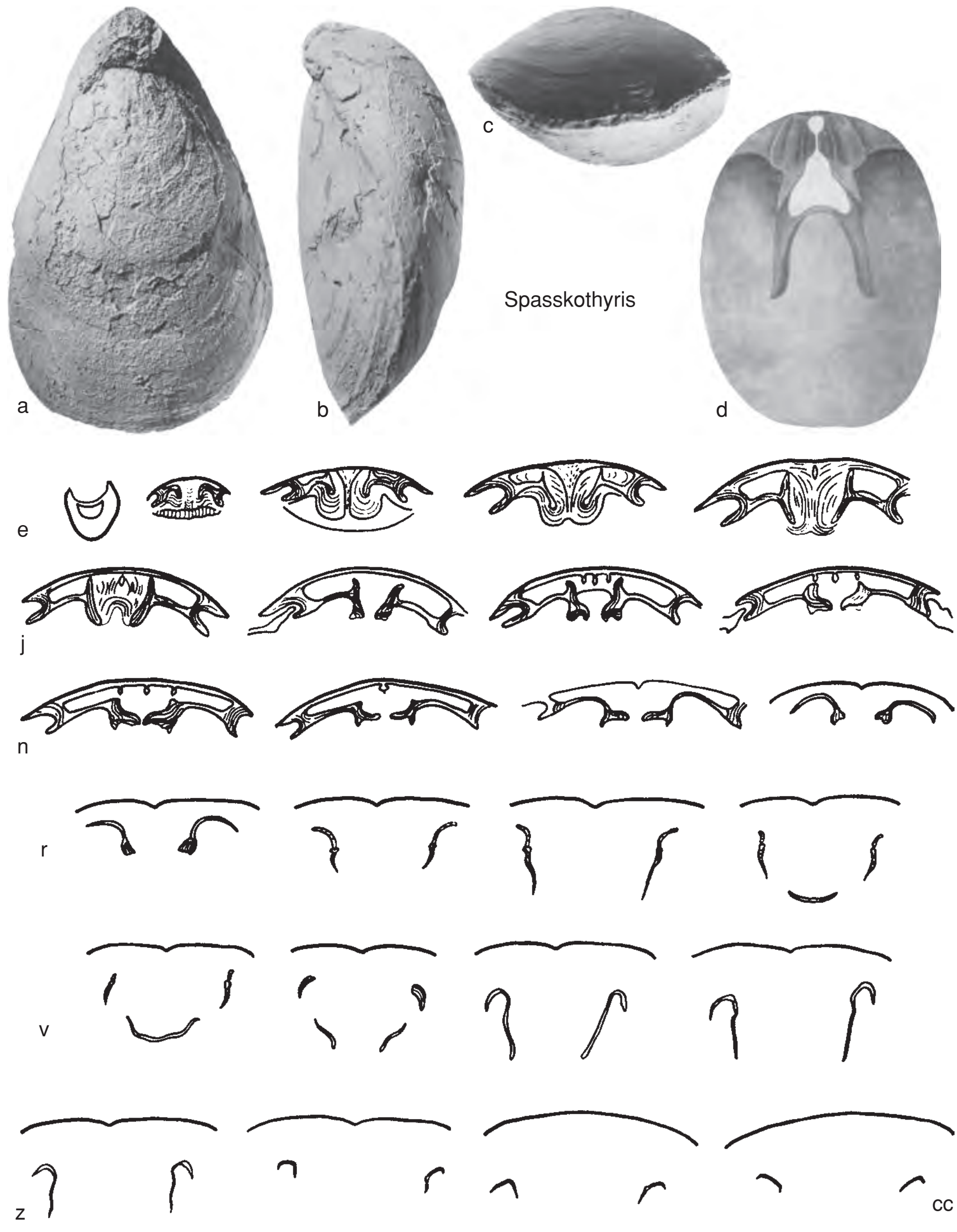

FIG. 1412. Spasskothyrididae (p. 2126–2127).

Family TRIGONITHYRIDIDAE Radulović, 1986

[Trigonithyrididae RADULOVIĆ, 1986, p. 44]

Medium to large, smooth, biconvex, anterior commissure rectimarginate to slightly unisulcate, foramen large, no pedicle collar; outer hinge plates broad, subhorizontal to dorsally inclined; crura long and narrow, loop narrow, thin, about 0.4 to 0.5 dorsal valve length. *Middle Jurassic (Bajocian)–Upper Jurassic (Oxfordian).*

Trigonithyris MUIR-WOOD, 1935, p. 131 [**T. eruduwensis;* OD]. Medium size, trigonal, anterior commissure rectimarginate; beak short, foramen

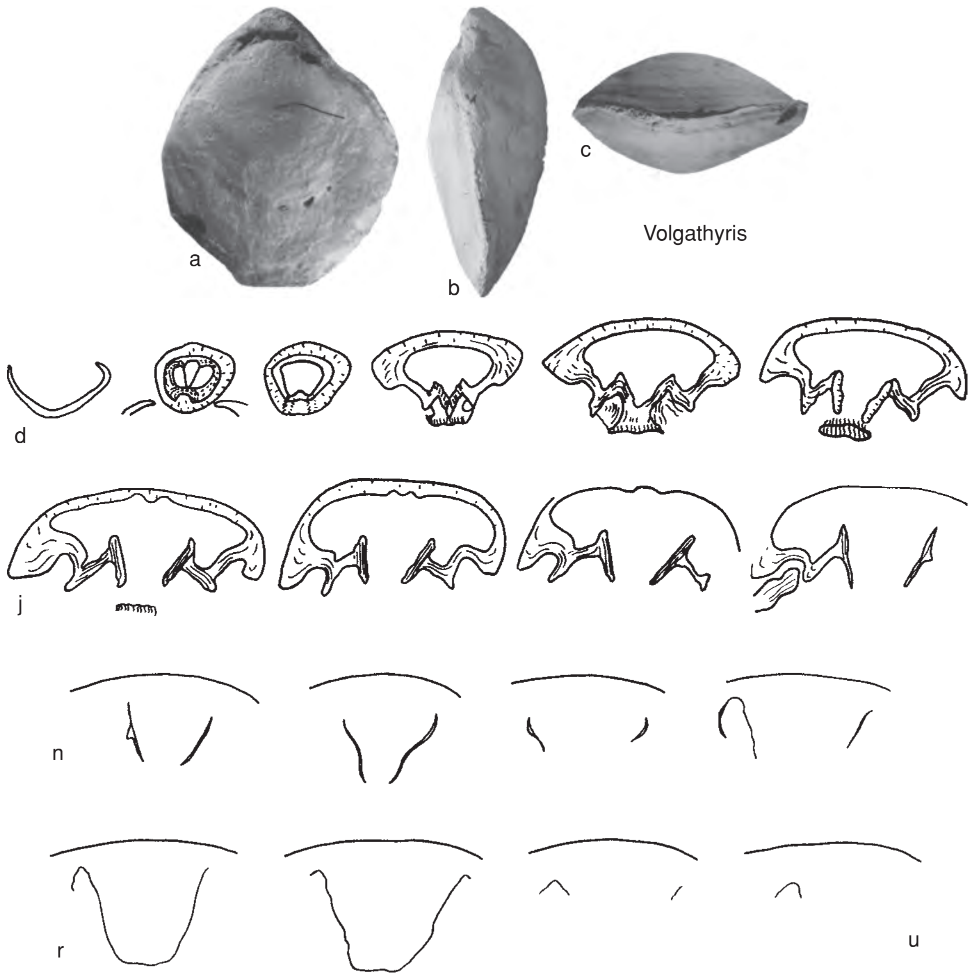

FIG. 1413. Spasskothyrididae (p. 2127).

epithyrid, symphytium visible; cardinal process broad, medianly depressed, with posterior umbonal cavity; outer hinge plates well developed, horizontal or becoming slightly convex ventrally; crura long and narrow, crural processes well anterior of outer hinge plates; loop about 0.5 dorsal valve length, not known fully. *Upper Jurassic (Oxfordian):* Somalia. ——FIG. 1408,*2a–m.* **T. eruduwensis; a–c,* dorsal, lateral, and anterior views, ×1; *d–m,* serial transverse sections, no measurements available, ×1 (Muir-Wood, 1965a).

Lazithyris RADULOVIĆ, 1986, p. 45 [**L. andjelkovici;* OD]. Medium to large, circular to elongate oval, anterior commissure rectimarginate to slightly unisulcate; beak short, narrow, erect, foramen hypothyrid; symphytium short; deltidial plates weakly developed, disjunct; cardinal process bilobate; loop about 0.4 dorsal valve length, not known fully. *Middle Jurassic (Bajocian–Bathonian):* Yugoslavia (Carpathians, Balkanides).——FIG. 1408,*1a–o.* **L. andjelkovici; a–c,* dorsal, lateral, and anterior views of holotype, ×1; *d–o,* serial transverse sections 2.5, 3.5, 4.1, 4.7, 4.9, 5.5, 5.7, 5.9, 6.1, 6.3, 6.7, 7.5 mm from ventral umbo, ×1.6 (Radulović, 1986).

Family UNCERTAIN
Subfamily GONIOTHYRIDINAE Tchorszhevsky, 1971

[Goniothyridinae TCHORSZHEVSKY, 1971b, p. 45]

Medium to large, beak short, strongly truncated, dorsal valve strongly convex; loop long, outer hinge plates convex ventrally. *Middle Jurassic (Aalenian–Bajocian).*

Goniothyris BUCKMAN, 1918, p. 117 (BUCKMAN, 1914, p. 2, *nom. nud.*) [**Terebratula gravida* SZAJNOCHA, 1881, p. 74; OD]. Trigonal to subpentagonal, strongly dorsibiconvex, ventral valve convex to carinate, anterior commissure rectimarginate; foramen epithyrid to permesothyrid, symphytium narrow; pedicle collar very short; cardinal process very small, hinge plates in section convex ventrally and deflected dorsally, keeled; loop of type species unknown; loop of *G. poleymiensis* moderately long, narrow, with broad transverse band, crural processes near midloop, terminal points. Moderately long. *Middle Jurassic (Aalenian–Bajocian):* England, France, Czech Republic, Slovakia, Austria, Hungary, Transcarpathia.——FIG. 1414,*1a–d*. **G. gravida* (SZAJNOCHA), Carpathians; holotype, dorsal, ventral, lateral, and anterior views, ×1 (Szajnocha, 1881).

Subfamily HETEROBROCHINAE Cooper, 1983

[Heterobrochinae COOPER, 1983, p. 42]

Medium size, subpentagonal, anterior commissure sulciplicate, loop wide angled, crural processes posterior of midloop, outer hinge plates ventrally attached to crural bases, transverse band broad, medially protuberant. *Upper Jurassic (Kimmeridgian).*

Heterobrochus COOPER, 1983, p. 89 [**H. incultus* COOPER, 1983, p. 90; OD]. Large, subpentagonal, smooth, beak short, erect; foramen large, permesothyrid; cardinal process small, bilobed; outer hinge plates small, flattened to concave, attached to ventral edge of crural bases; loop very wide. *Upper Jurassic (Kimmeridgian):* Germany. ——FIG. 1414,*3a–d*. **H. incultus; a–c,* dorsal, lateral, and anterior views, ×1; *d,* closeup of loop, ×2 (Cooper, 1983).

Subfamily PSEBAJITHYRIDINAE Tchorszhevsky, 1974

[Psebajithyridinae TCHORSZHEVSKY, 1974, p. 47]

Medium to large, uniplicate to weakly sulciplicate, loop short, narrow, about 0.3 dorsal valve length, outer hinge plates attached to ventral edges of crura, transverse band broad, nearly horizontal; transverse band developing from vertical plate of acuminate (centronelliform) loop. *Upper Jurassic.*

Psebajithyris TCHORSZHEVSKY, 1974, p. 48 [**P. rostovtsevi;* OD]. Large, oval to subpentagonal, anterior commissure uniplicate, beak thick, strongly curved, foramen large, oval, beak ridges rounded; pedicle collar short; cardinal process very small, delicate, oval; outer hinge plates delicate, rather long, hooklike, dorsally curved. *Upper Jurassic (Oxfordian):* northwestern Caucasus, Russia.——FIG. 1414,*5a–s*. **P. rostovtsevi,* Crimea; *a–c,* dorsal, lateral, and anterior views, ×1; *d–s,* serial transverse sections 3.6, 3.7, 3.9, 4.1, 4.4, 5.2, 5.7, 5.8, 6.5, 6.8, 7.0, 7.45, 7.75, 8.3, 8.55, 8.75 mm from first section, ×1 (adapted from Tchorszhevsky, 1974).

Placothyris WESTPHAL, 1970, p. 38 [**Terebratula rollieri* HAAS, 1893, p. 124; OD]. Medium to large, elongate subpentagonal, ventribiconvex; anterior commissure uniplicate to sulciplicate, beak labiate; pedicle collar present, hinge plates pendant; loop 0.3 valve length, with broad transverse band and blunt crural processes. *Upper Jurassic:* Germany, Switzerland, France.——FIG. 1414,*4a–n*. **P. rollieri* (HAAS), Oxfordian, Switzerland; *a–c,* dorsal, lateral, and anterior views, ×1; *d–m,* serial transverse sections 0.5, 1.1, 1.9, 2.7, 3.3, 3.9, 4.9, 5.3, 5.5, 5.7 mm from ventral umbo, ×1 (Boullier, 1976); *n,* oblique view of silicified loop, ×2 (Cooper, 1983).

Unkurithyris OVTSHARENKO, 1991, p. 75 [**U. unkurensis;* OD]. Small to large, subcircular, strongly biconvex or planoconvex, uniplicate, cardinal process small, flat; outer hinge plates planar, loop short, with short flanges. *Upper Jurassic:* Pamirs.——FIG. 1414,*2a–n*. **U. unkurensis; a–c,* dorsal, lateral, and anterior views, ×1; *d–m,* serial transverse sections 0.5, 1.2, 1.7, 2.5, 3.3, 3.6, 4.2, 4.9, 5.0, 5.2 mm from first section, ×1; *n,* reconstruction of loop, ×1 (Ovtsharenko, 1991).

Family and Subfamily UNCERTAIN

Gibbithyrella OVTSHARENKO, 1989, p. 87 [**G. kurtensis;* OD]. Medium size, strongly biconvex, anterior commissure bisulcate, beak ridges rounded, foramen small, oval, mesothyrid; hinge plates broad; crural bases dorsally curved; loop about 0.3 dorsal valve length, loop flanges short. *Middle Jurassic:* Tadzhikistan (Pamirs).——FIG. 1415,*2a–i*. **G. kurtensis; a–c,* dorsal, lateral, and anterior views, ×1; *d–i,* serial transverse sections 0.1, 1.2, 3.0, 3.5, 4.7, 5.2 mm from first section, ×1 (Ovtsharenko, 1989).

Jaisalmeria SAHNI & BHATNAGAR, 1958, p. 421 [**J. taylori;* OD]. Small to medium size, biconvex, finely capillate; anterior commissure rectimarginate to uniplicate to biplicate; beak ridges angular; foramen small, submesothyrid; deltidial plates disjunct; loop unknown. *Upper Jurassic:* India, Pakistan.——FIG. 1415,*3a–d*. **J. taylori,* India; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* dorsal valve showing capillae, ×1 (Muir-Wood, 1965a).

Kendzhilgithyris OVTSHARENKO, 1983b, p. 82 [**K. kendzhilgensis;* OD]. Medium size, subrounded, beak short, anterior commissure rectimarginate; pedicle collar present; cardinal process small, outer hinge plates broad, horizontal or slightly curved, loop narrow, with long, diverging flanges. *Lower Jurassic:* Tadzhikistan, Pamirs.——FIG. 1415,*7a–m*. **K. kendzhilgensis,* Tadzhikistan; *a–c,* dorsal, lateral, and anterior views, ×1; *d–m,* serial transverse sections 2.4, 2.8, 3.1, 4.0, 4.8, 5.0, 6.0, 7.6, 8.3, 8.7 mm from ventral umbo, ×1 (new).

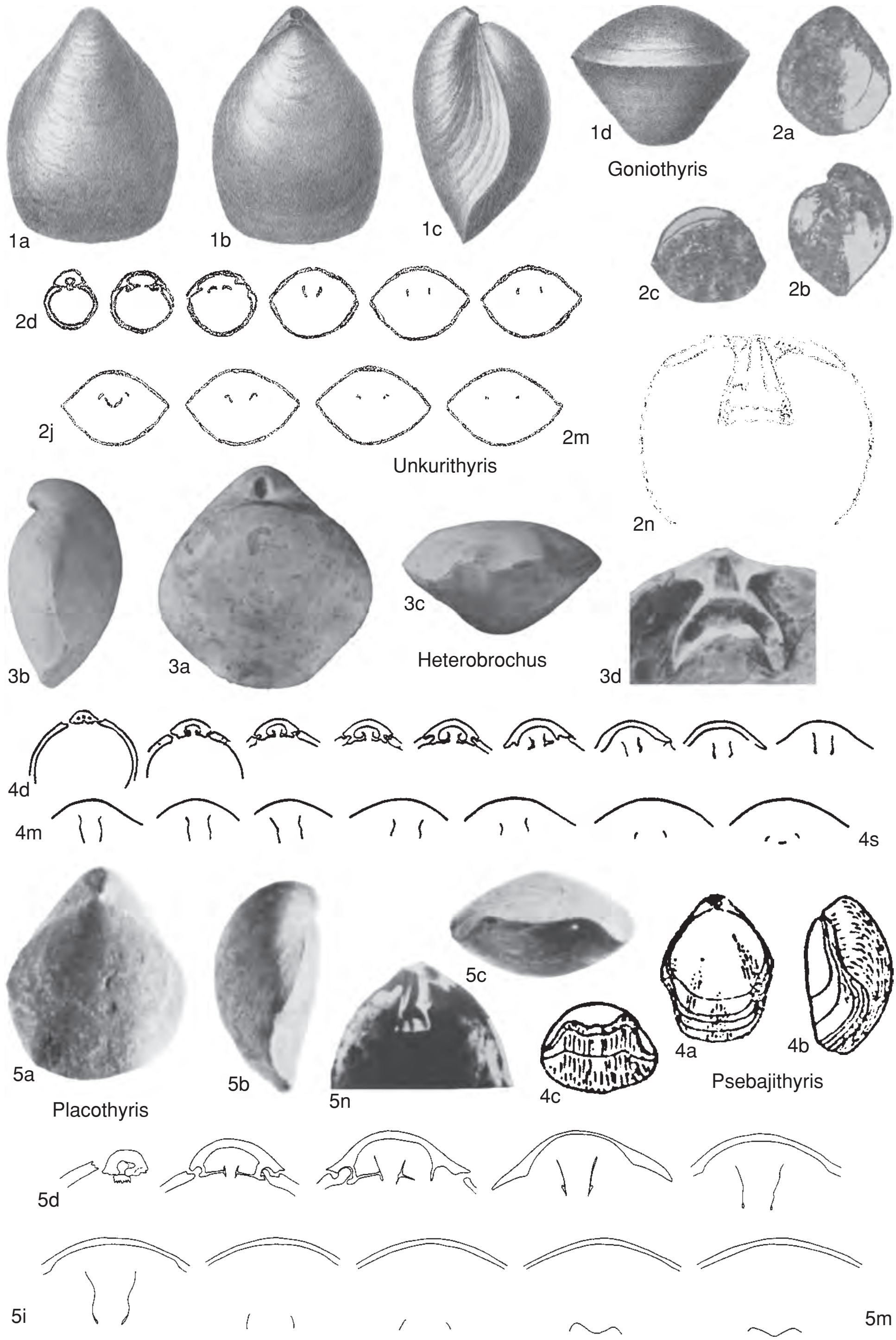

FIG. 1414. Uncertain (p. 2130).

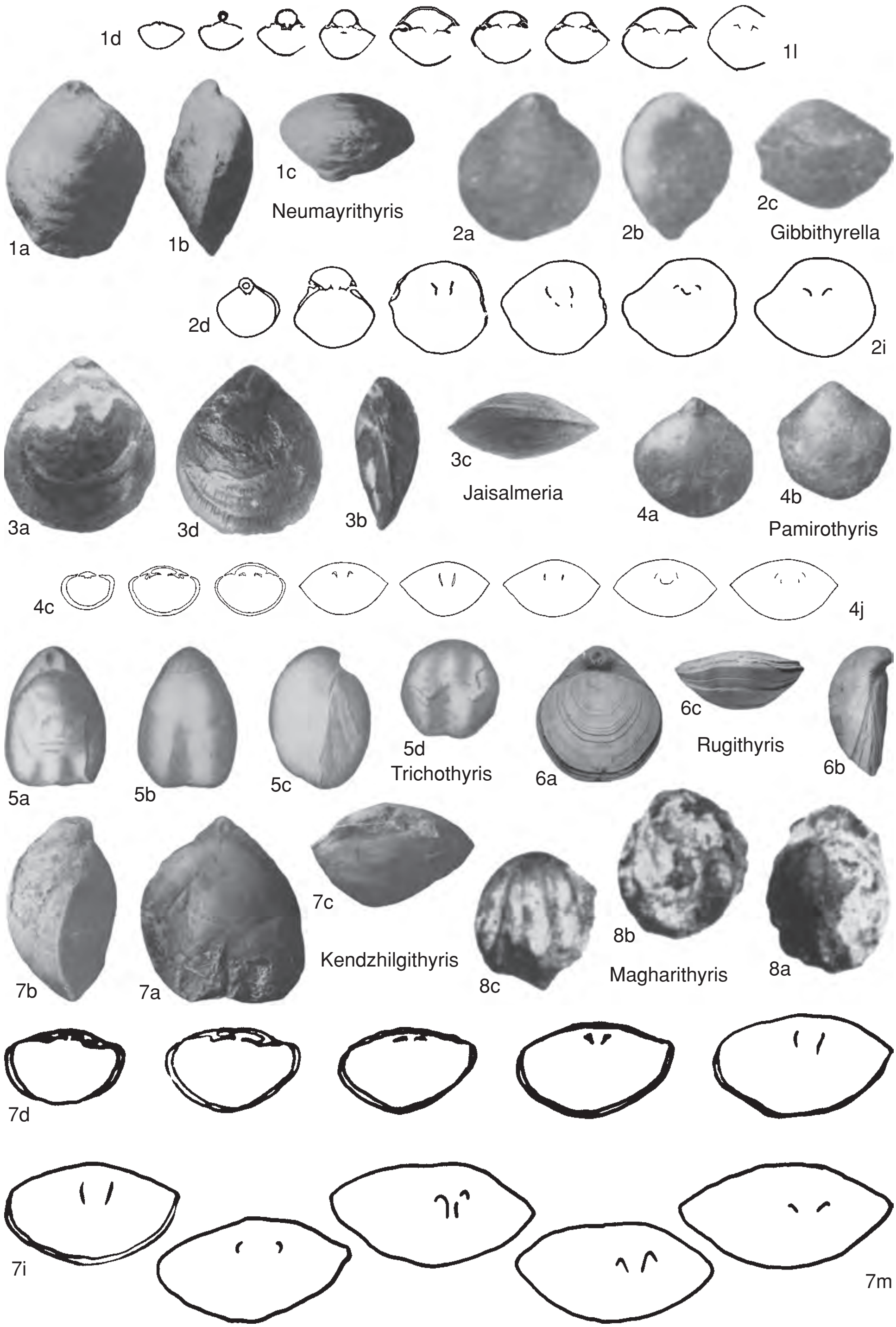

FIG. 1415. Uncertain (p. 2130–2133).

?Lobothyroides Xu, 1978, p. 307 [**L. striata;* OD]. Medium to small, subpentagonal in outline; capillate; rectimarginate; interior details uncertain. *Upper Triassic:* China (Sichuan).——Fig. 1416,*1a–d.* **L. striata; a–c,* dorsal, lateral, and anterior views, ×1; *d,* closeup of shell ornament, ×2 (Xu, 1978).

?Magharithyris Farag & Gatinaud, 1962, p. 77 [**M. triplicata;* OD]. Medium size, globose, said to be closely related to *Parathyridina,* but shell more elongate, folding uniplicate, triplicate, or multiplicate. [Genus based on one imperfectly preserved specimen; internal characters unknown.] *Middle Jurassic (Bathonian):* Egypt, ?Saudi Arabia.——Fig. 1415,*8a–c.* **M. triplicata;* dorsal, lateral, and anterior views, ×1 (Farag & Gatinaud, 1962).

Naradanithyris Tokuyama, 1958a, p. 2 [**N. kuratai;* OD]. Small to medium size, oval to pentagonal, shell rarely capillate; biconvex, anterior commissure angularly biplicate, beak short, incurved, foramen large, possibly mesothyrid or permesothyrid; symphytium short, usually concealed; beak ridges obscure; no pedicle collar; cardinal process short, wide, hinge plates in section inclined dorsally, separated from inner socket ridges by shallow sulcus; loop less than 0.5 dorsal valve length; internal characters poorly known. *Middle Jurassic (Bajocian)–Upper Jurassic:* Japan, ?Pamirs, *Bajocian–Bathonian;* Asia, *Upper Jurassic.*——Fig. 1416,*2a–c.* **N. kuratai,* Japan; dorsal, lateral, and anterior views of holotype, ×1 (Tokuyama, 1958a).

Neumayrithyris Tokuyama, 1958b, p. 120 [**N. torinosuensis;* OD]. Medium size, smooth, biconvex, anterior commissure uniplicate, beak short, suberect to incurved, beak ridges rounded, foramen permesothyrid; cardinal process short, medianly depressed, commonly with posterior umbonal cavity; hinge plates in section almost horizontal, merging into socket ridges; crural bases given off ventrally at angle to hinge plates. *Middle Jurassic–Upper Jurassic:* Europe, *Middle Jurassic;* Crimea, Japan, Sarawak, *Upper Jurassic.*——Fig. 1415,*1a–l.* **N. torinosuensis,* Upper Jurassic, Japan; *a–c,* dorsal, lateral, and anterior views of holotype, ×1; *d–l,* serial transverse sections 0.5, 1.05, 1.55, 1.95, 2.05, 2.2, 2.65, 2.75, 3.05 mm from first section, ×1 (Tokuyama, 1958b).

Pamirothyris Dagys, 1974, p. 195 [**Lobothyris kushlini* Dagys, 1963, p. 184; OD]. Small, smooth, biconvex, anterior commissure rectimarginate, beak incurved; foramen mesothyrid to permesothyrid; pedicle collar short, cardinal process low; hinge plates wide, lying in plane of valves, crural bases developed poorly, crura narrow, loop short (0.3 dorsal valve length), extremities rounded. *Triassic (Norian–Rhaetian):* Pamir.——Fig. 1415,*4a–j.* **P. kushlini* (Dagys); *a–b,* dorsal and lateral views of holotype, IGIG 200/62, ×1; *c–j,* serial transverse sections 0.0, 2.1, 3.4, 3.8, 4.4, 5.0, 6.1, 6.5 mm from first section, ×1 (Dagys, 1963).

Rarithyris Tchorszhevsky, 1989a, p. 79 [**R. rarus;* OD]. Small, strongly biconvex, smooth, anterior commissure unisulcate, beak short, incurved; foramen small, epithyrid, deltidial plates conjunct; cardinal process small, pedicle collar thin; outer hinge plates broad, horizontal or inclined dorsally, crura slender, arc shaped, loop short (about 0.25 dorsal valve length), rounded, transverse band low, wide. *Upper Jurassic (Tithonian):* Carpathians.——Fig. 1416,*3a–k.* **R. rarus; a–c,* dorsal, lateral, and anterior views of holotype, Kharkov University 10/5056, ×1; *d–k,* serial transverse sections 0.6, 1.3, 1.7, 4.0, 4.2, 4.4, 4.7, 4.8 mm from first section, ×2 (Tchorszhevsky, 1989a).

Rugithyris Buckman, 1918, p. 127 (Buckman, 1915, p. 79, *nom. nud.*) [**Terebratula subomalogaster* Buckman, 1901, p. 259; OD]. Medium size, planoconvex, surface ornament of squamose growth lamellae; anterior commissure rectimarginate to uniplicate or sulciplicate; beak incurved, foramen permesothyrid; cardinal process short, lobate; hinge plates narrow, slightly concave; loop not fully known. *Middle Jurassic (Bajocian):* England, ?Russia.——Fig. 1415,*6a–c.* **R. subomalogaster* (Buckman), England; dorsal, lateral, and anterior views, ×1 (Muir-Wood, 1965a).

Taurothyris Kyansep, 1961, p. 27 [**T. avundaensis;* OD]. Large, biconvex, elongate oval, smooth but decorticated shell capillate; anterior commissure rectimarginate to uniplicate; beak very small, suberect, tapering; symphytium exposed; cardinal process massive, bilobate; hinge plates and inner socket ridges in section slightly deflected ventrally and slightly concave; crural bases given off ventrally; loop possibly short, triangular, not fully known. *Upper Jurassic (Oxfordian):* Crimea, Russia.——Fig. 1416,*4a–k.* **T. avundaensis; a–c,* dorsal, ventral, and lateral views, ×1 (Kyansep, 1961); *d–k,* serial transverse sections 0.0, 0.2, 0.9, 1.4, 1.5, 1.8, 1.9, 2.1 mm from first section, ×1 (Muir-Wood, 1965a).

Trichothyris Buckman, 1918, p. 125 (Buckman, 1915, p. 78, *nom. nud.*) [**Dictyothyris compressa* Kitchin, 1897, p. 28; OD]. Small, biconvex, finely capillate, anterior commissure uniplicate to parasulcate; beak short, foramen large, epithyrid, with discrete deltidial plates. Internal features unknown. *Middle Jurassic (Callovian):* Pakistan.——Fig. 1415,*5a–d.* **T. compressa* (Kitchin); dorsal, ventral, lateral, and anterior views, ×1 (Muir-Wood, 1965a).

Tshemsarythyris Ovtsharenko, 1983a, p. 38 [**T. tshemsarensis;* OD]. Small, subtrigonal, biconvex, anterior commissure slightly bisulcate, beak short, foramen mesothyrid; pedicle collar small; outer hinge plates broad, loop about 0.3 dorsal valve length, loop narrow, with long flanges. *Upper Jurassic:* Tadzhikistan, Pamirs.——Fig. 1417,*2a–m.* **T. tshemsarensis,* Tadzhikistan; *a–c,* dorsal, lateral, and anterior views; *d–m,* serial transverse sections 2.8, 3.4, 3.9, 4.3, 4.5, 5.3, 5.6, 6.0, 6.35, 6.9 mm from ventral umbo, ×1 (new).

Viallithyris Vörös, 1978, p. 62 [**Terebratula gozzanensis* Parona, 1880, p. 196; OD]. Medium to large, subpentagonal to subcircular, ventribiconvex, capillate; anterior commissure broadly

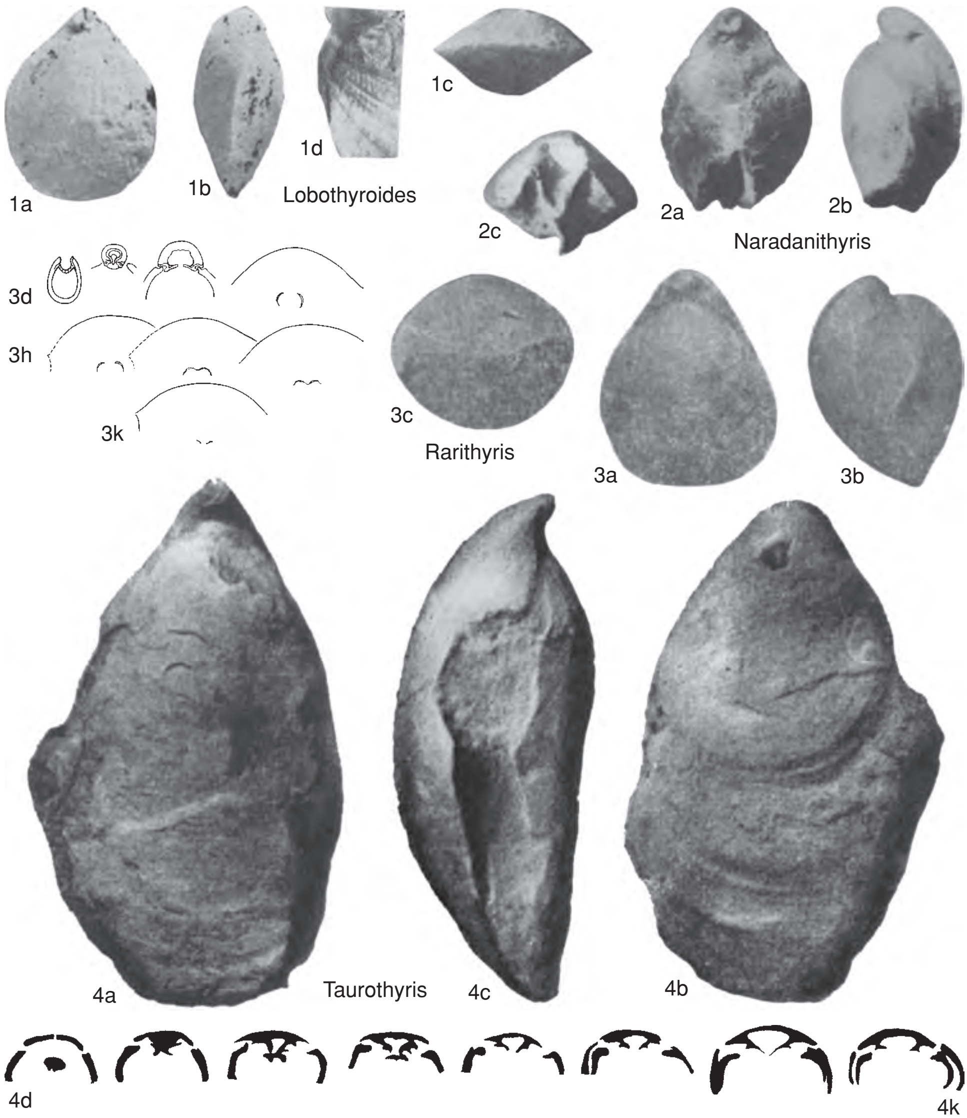

FIG. 1416. Uncertain (p. 2133).

unisulcate; foramen large, mesothyrid to permesothyrid; pedicle collar long; outer hinge plates thin, horizontal in section; crural bases given off dorsally; crural processes small, poorly defined; loop short (0.25 dorsal valve length), narrow, with fairly long terminal points; loop supported by variable narrow plates resting on valve floor. *Lower Jurassic (Pliensbachian):* Italy, Hungary.——FIG. 1417,*1a–p.* **V. gozzanensis* (PARONA); *a–c,* dorsal, lateral, and anterior views, ×1; *d–p,* serial transverse sections 1.30, 1.65, 2.0, 2.2, 2.3, 2.5, 3.4, 3.9, 4.5, 4.7, 5.0, 5.3, 5.9 mm from ventral umbo, ×1 (Vörös, 1978).

Weldonithyris MUIR-WOOD, 1952, p. 130 [**W. weldonensis;* OD]. Small to medium size, biconvex,

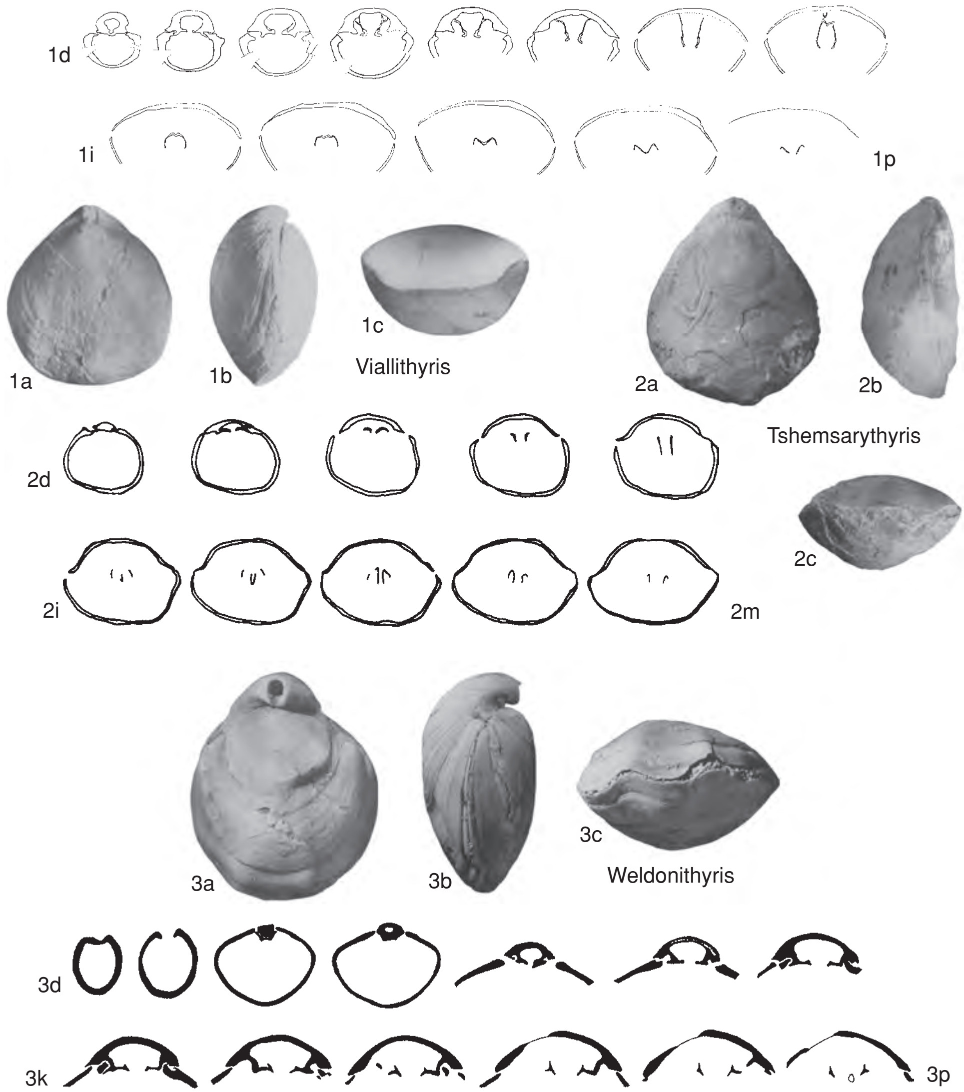

FIG. 1417. Uncertain (p. 2133–2135).

smooth, anterior commissure uniplicate to sulciplicate, beak incurved in adult, foramen large, epithyrid, labiate, concealing symphytium; cardinal process low, medianly depressed; hinge plates and inner socket ridges in section slightly deflected dorsally, gently concave, keeled; loop approximately 0.3 dorsal valve length, high arched, with medianly horizontal transverse band. *Middle Jurassic (Bajocian):* England.——FIG. 1417,*3a–p.* **W. weldonensis; a–c,* dorsal, lateral, and anterior views of holotype, SM J,34,866, ×1; *d–p,* incomplete serial transverse sections of posterior region of shell, no distances given, ×1 (Muir-Wood, 1952).

DYSCOLIOIDEA

D. E. Lee

[University of Otago]

Superfamily DYSCOLIOIDEA Fischer & Oehlert, 1891

[*nom. correct.* Lee, herein, *pro* Discoliacea Manceñido, 1993, p. 203, *nom. transl. ex* Dyscoliidae Fischer & Oehlert, 1891, p. 23]

Adult shells small to very large; commonly biconvex, rarely planoconvex; may be subtriangular to subrounded in outline; commonly smooth but may be finely capillate; foramen commonly mesothyrid or permesothyrid; anterior commissure rectimarginate, unisulcate, or with dorsal median sulcus and ventral fold posteriorly, sometimes developing as two lateral lobes in young and fusing in adult to enclose median perforation; no median septum or dental plates; cardinal process commonly small; hinge plates often poorly defined; loop deltiform, very short, commonly wide and rounded anteriorly, with inconspicuous crural processes commonly anterior of midloop; living species may be strongly spiculate. *Lower Jurassic–Holocene.*

Family DYSCOLIIDAE Fischer & Oehlert, 1891

[Dyscoliidae Fischer & Oehlert, 1891, p. 23]

Small to very large, smooth or capillate, capillae often in zigzag pattern; loop short, variable, commonly with thin, narrow transverse band that is horizontal or directed anteriorly; outer hinge plates often poorly defined; crural bases indistinct posteriorly; crural processes anterior of midloop. *Lower Cretaceous–Holocene.*

Subfamily DYSCOLIINAE Fischer & Oehlert, 1891

[*nom. correct.* Thomson, 1927, p. 172, *pro* Discoliinae Beecher, 1893, p. 377, *nom. transl. ex* Dyscoliidae Fischer & Oehlert, 1891, p. 23]

Medium to very large, exterior smooth or with fine, zigzag capillae; anterior commissure rectimarginate; beak commonly truncated, labiate; loop short, scooplike, outer hinge plates poorly defined; crura narrow, crural bases indistinct posteriorly; crural processes anterior of midloop; transverse band nearly horizontal or directed anteriorly, anterolateral extremities of loop rounded or subangular; living species strongly spiculate. *Upper Cretaceous (Cenomanian)–Holocene.*

Dyscolia Fischer & Oehlert, 1890, p. 70 [**Terebratulina wyvilli* Davidson, 1878b, p. 436; OD; *emend.,* Fischer & Oehlert, 1891, p. 70]. Medium to very large, subtrigonal to elongate oval; ventribiconvex; surface smooth or with fine, zigzag capillae; beak short, suberect, often truncated or labiate; foramen large, epithyrid to submesothyrid; symphytium almost concealed; pedicle collar long, anteriorly excavated; cardinal process not developed, diductor muscles attached to apical pit; outer hinge plates very weakly developed; crural processes weak, blunt; loop small (less than 0.3 dorsal valve length), thin, with rounded, anterolateral extremities; lophophore small, modified schizolophe; spicules very abundant; four main mantle canals in each valve, branching pattern pinnate. *Neogene (Pliocene)–Holocene:* Mediterranean (Sicily, Italy), *Pliocene–Pleistocene;* Indian Ocean, East Atlantic Ocean (off Africa, France, Spain), Caribbean, Pacific Ocean (New Caledonia), ?Antarctic Ocean, *Holocene.*——Fig. 1418,*3a–e.* **D. wyvillei* (Davidson), Holocene; *a–c,* dorsal, lateral, and anterior views of holotype, Caribbean, ZB1356, ×1; *d,* valves separated showing mantle canals and imperfect loop, Caribbean, ×1 (Muir-Wood, 1965a); *e,* interior of dorsal valve, off northwestern Africa, ×1 (Cooper, 1983).

Goniobrochus Cooper, 1983, p. 260 [**Dyscolia ewingi* Cooper, 1973b, p. 19; OD]. Large, subcircular; surface ornament of radial, zigzag capillae; beak truncated, suberect, labiate; foramen large, mesothyrid to submesothyrid; pedicle collar short; cardinal process not developed, diductor muscles attached to apical pit; sockets wide; crural bases narrow troughs between weakly developed, narrow hinge plates and stout socket ridges; crura short, narrow; loop wide, almost square in outline. *Holocene:* off Argentina.——Fig. 1419*a–d.* **G. ewingi* (Cooper); *a–c,* dorsal, lateral, and anterior views of holotype, USNM 550461a, ×1; *d,* interior of dorsal valve of holotype, ×1 (Cooper, 1973b).

Moraviaturia Sahni, 1960, p. 19 [**Terebratula diphimorpha* Stoliczka, 1872, p. 25; OD]. Large, subtrigonal, ventribiconvex; anterior margin geniculate; surface capillate with steplike growth lamellae; beak massive, slightly incurved, symphytium narrow; foramen large, beak ridges obscure; internal characters unknown, probably dyscoliid. *Upper*

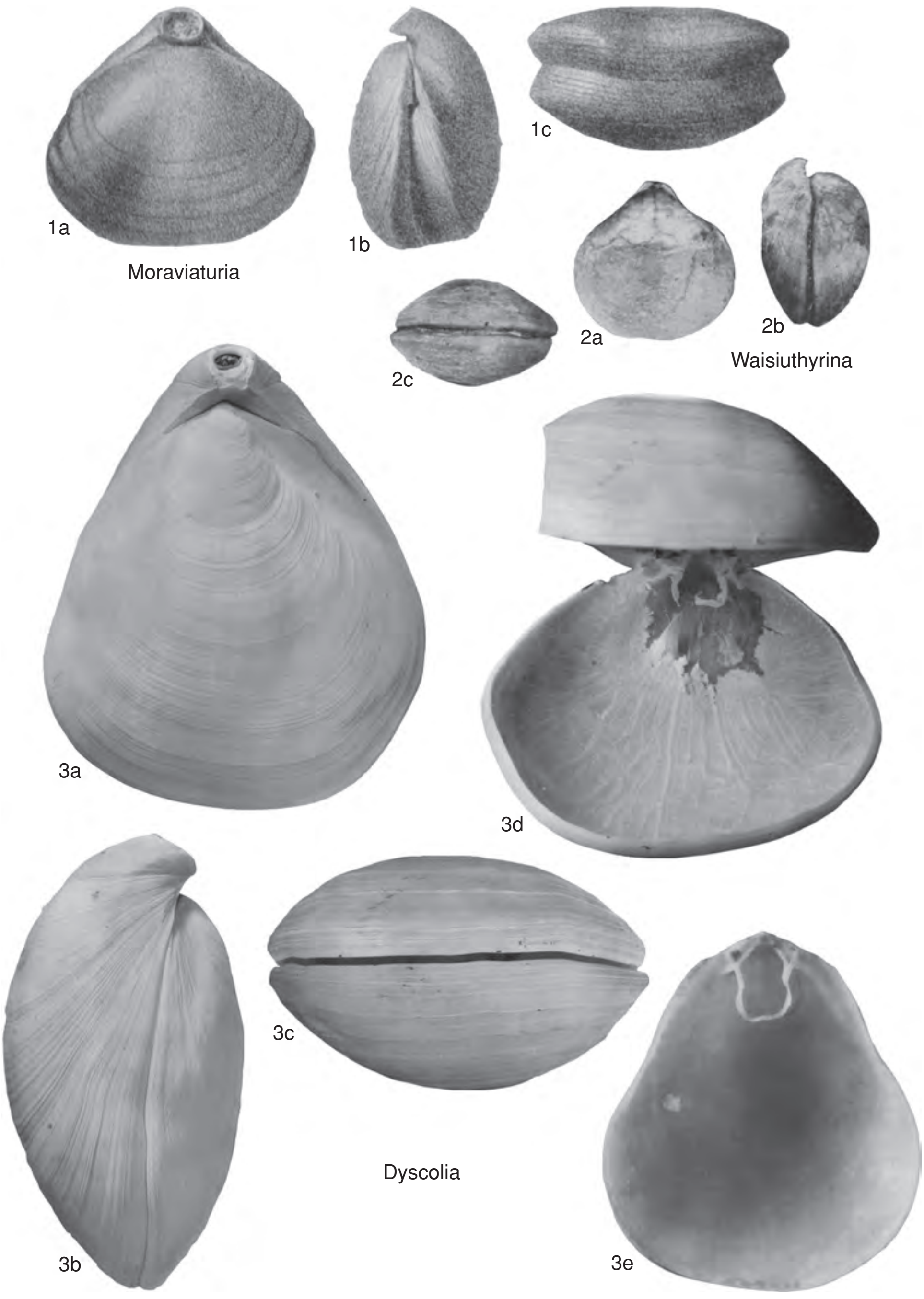

FIG. 1418. Dyscoliidae (p. 2136–2138).

Cretaceous (Cenomanian): southern India.——FIG. 1418,*1a–c.* **M. diphimorpha* (STOLICZKA); dorsal, lateral, and anterior views of holotype, ×1 (Muir-Wood, 1965a).

Waisiuthyrina BEETS, 1943, p. 341 [**W. margineplicata;* OD]. Large, subcircular, dorsibiconvex; smooth; beak truncated, labiate; foramen large, mesothyrid or epithyrid; symphytium narrow;

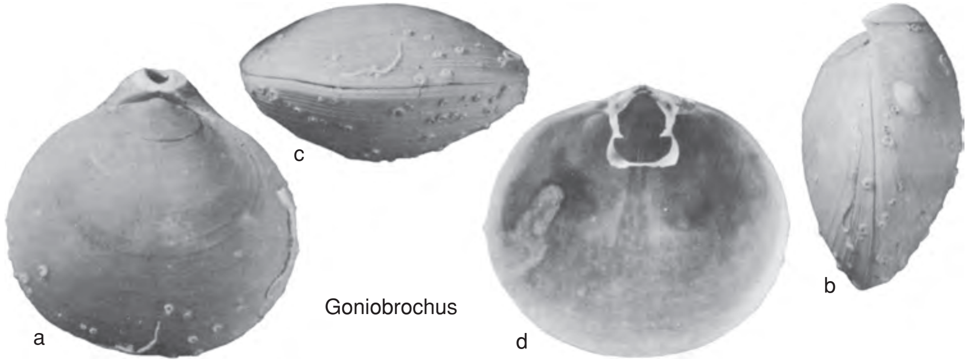

FIG. 1419. Dyscoliidae (p. 2136).

pedicle collar absent, hinge teeth small, grooved; cardinal process small, transverse, bilobed; loop unknown, probably dyscoliid. *Neogene (Pliocene):* southeastern Asia (Sulawesi).——FIG. 1418,*2a–c*. **W. margineplicata;* dorsal, lateral, and anterior views of holotype, ×0.5 (Muir-Wood, 1965a).

Subfamily AENIGMATHYRIDINAE Cooper, 1983

[Aenigmathyridinae COOPER, 1983, p. 40]

Small to medium size, rectimarginate to strongly unisulcate, smooth or may be lamellose or faintly capillate; foramen commonly permesothyrid; loop short, outer hinge plates poorly defined, crura commonly narrow, crural processes near or anterior to midloop; transverse band commonly convex anteriorly with narrow median fold. *Paleogene (Danian)–Holocene.*

Aenigmathyris COOPER, 1971, p. 3 [**A. stearnsi;* OD]. Shell medium, widely ovate, ventribiconvex, anterior commissure rectimarginate to unisulcate; ornament of faint capillae; beak short, labiate, foramen permesothyrid, symphytium concave; pedicle collar narrow, elevated; cardinal process small, transverse; loop variable, but narrower and more strongly folded than in *Dyscolia. Paleogene (Eocene):* Eua, Tonga.——FIG. 1420,*2a–d*. **A. stearnsi,* Eua; *a–c,* dorsal, lateral, and anterior views of holotype, USNM 550447a, ×1; *d,* closeup view of loop, ×3 (Cooper, 1983).

Abyssothyris THOMSON, 1927, p. 190; *emend.,* MUIR-WOOD, 1960, p. 521 [**Terebratula wyvilli* DAVIDSON, 1878b, p. 436; OD; *emend.,* THOMSON, 1927, p. 190]. Small to medium, oval to subpentagonal in outline, ventribiconvex, smooth, thin shelled; anterior commissure unisulcate; beak small, suberect; foramen large, permesothyrid; symphytium partly visible; pedicle collar short, teeth small; cardinal process small, semielliptical, outer hinge plates narrowly triangular, tapering anteriorly to bluntly pointed crural processes located at midloop; crural bases narrow; transverse band broad, gently folded medially, anterior part of loop variable, anterolateral extremities rounded to subangular; lophophore plectolophous with small median coil. [THOMSON (1927) confused the terebratulid genus *Abyssothyris* with the rhynchonellid genus *Neorhynchia* in his original diagnosis. Subsequently, MUIR-WOOD (1960) redefined the genus *Abyssothyris* and disentangled the two homeomorphs.] *Neogene (Miocene)–Holocene:* Fiji, *Miocene;* Pacific Ocean (Alaska, Galapagos Islands, Chile, New Guinea, New Caledonia, South Australia, New Zealand, Antarctica), South Atlantic Ocean at abyssal depths (825 m to >5,000 m), *Holocene.*——FIG. 1420,*4a–d*. **A. wyvillei* (DAVIDSON), Holocene, off South Australia; *a–c,* dorsal, lateral, and anterior views of lectotype, NHM B12501, ×2 (Muir-Wood, 1965a); *d,* Holocene, off California; closeup of loop, ×2 (Cooper, 1983).

Acrobelesia COOPER, 1983, p. 247 [**Gryphus cooperi* D'HONDT, 1976, p. 6; OD]. Small to medium, subcircular, ventribiconvex, lamellose with faint radial capillae; foramen large, submesothyrid; deltidial plates disjunct; pedicle collar short, anteriorly excavate; cardinal process small, bilobed myophore; crura short, thin, ribbonlike; crural processes anterior to midloop; loop very short (0.2 dorsal valve length); transverse band of loop convex anteriorly. *Holocene:* Atlantic Ocean, France (Gulf of Gascogne), Canary Islands.——FIG. 1420,*3a–d*. **A. cooperi* (D'HONDT); *a–c,* dorsal, lateral, and anterior views, ×2; *d,* dorsal valve interior, ×4 (Cooper, 1983).

Ceramisia COOPER, 1983, p. 227 [**Terebratula meneghiniana* SEGUENZA, 1865, p. 29; OD]. Small to medium, subcircular, biconvex; unisulcate; lamellose without radial capillae; foramen large, mesothyrid, deltidial plates conjunct or disjunct; pedicle collar short, excavate; cardinal process small, transverse; hinge plates not developed; transverse band of loop convex anteriorly. *Neogene (Pliocene):* Sicily.——FIG. 1420,*1a–d*. **C. meneghiniana*

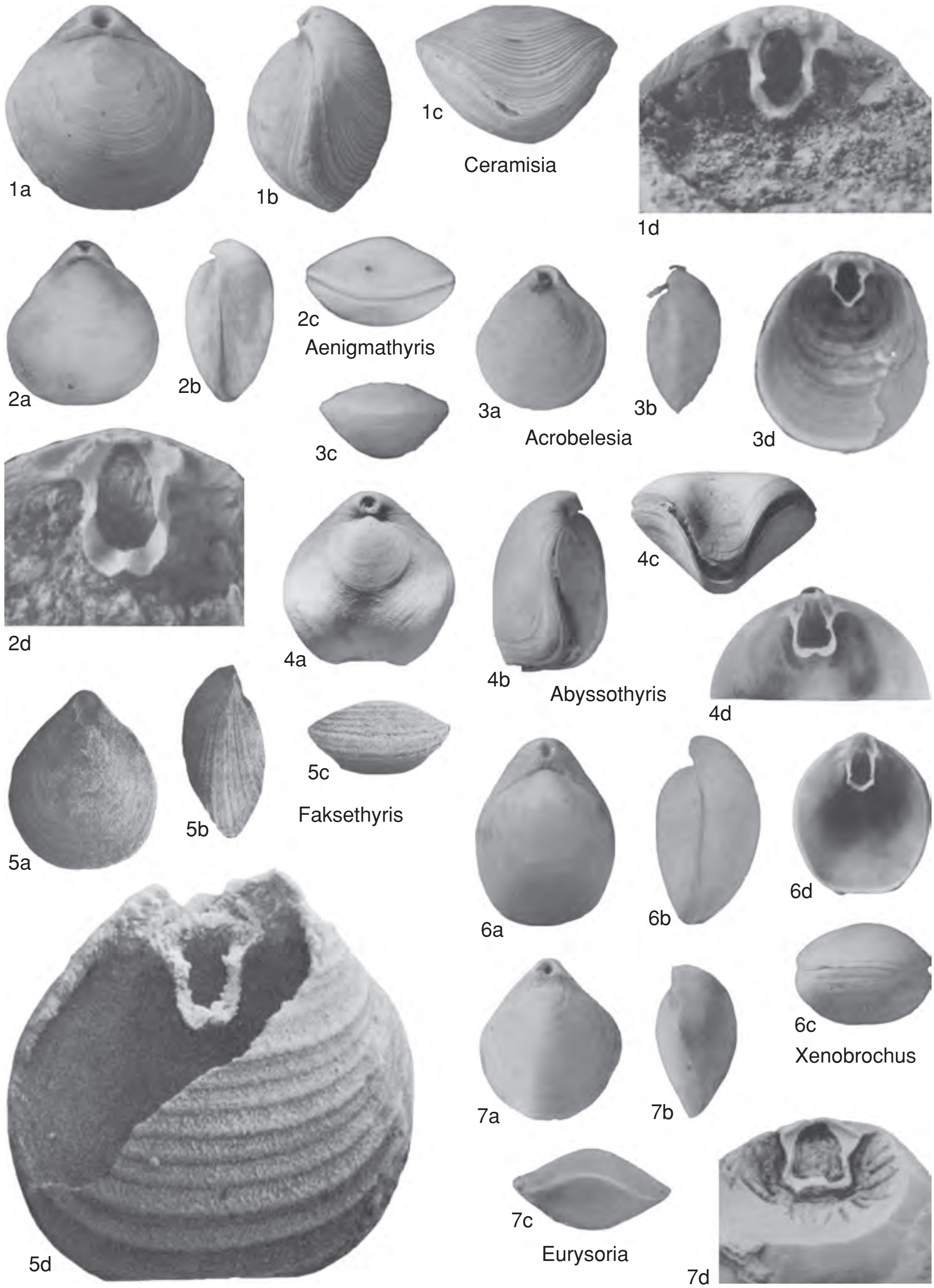

FIG. 1420. Dyscoliidae (p. 2138–2140).

(SEGUENZA); *a–c,* dorsal, lateral, and anterior views, ×2; *d,* closeup of loop, ×5 (Cooper, 1983).

Faksethyris ASGAARD, 1971, p. 385 [**F. nielseni* ASGAARD, 1971, p. 386; OD; =*Terebratula cincta* NIELSEN, 1911, p. 609, *non* COTTEAU, 1857]. Small, ovate, biconvex, lamellose; anterior margin rectimarginate; beak straight, foramen submesothyrid, large, attrite; deltidial plates conjunct;

pedicle collar long; cardinal process weak, transverse; hinge plates not developed; crural processes posterior to midloop, loop narrow, rounded anteriorly. *Paleogene (Danian):* Denmark.——FIG. 1420,*5a–d.* **F. nielseni; a–c,* dorsal, lateral, and anterior views of lectotype, MMH 574, ×10; *d,* interior of dorsal valve, ×25 (Asgaard, 1971).

Xenobrochus COOPER, 1981, p. 19 [**Gryphus africanus* COOPER, 1973a, p. 8; OD]. Small to medium, oval, ventribiconvex, smooth; anterior commissure rectimarginate; beak long, erect, labiate, foramen large, permesothyrid, symphytium visible; pedicle collar short, teeth large; cardinal process broad, semielliptical; hinge plates narrow, poorly defined; loop narrow, rounded, transverse band convex anteriorly. *Holocene:* Indian Ocean, western Pacific, off Philippines and New Caledonia, ?Atlantic, ?Mediterranean.——FIG. 1420,*6a–d.* **X. africanus* (COOPER), Durban Bay, Indian Ocean; *a–c,* dorsal, lateral, and anterior views of holotype, USNM 550375a, ×4; *d,* interior of dorsal valve, ×4 (Cooper, 1983).

Subfamily EURYSORIINAE Cooper, 1983

[Eurysoriinae COOPER, 1983, p. 40]

Small to medium, subpentagonal, smooth or faintly capillate; anterior commissure uniplicate; crural processes obtuse, anterior to midloop; outer hinge plates and crural bases poorly defined; loop short. *Lower Cretaceous.*

Eurysoria COOPER, 1983, p. 189 [**E. texana;* OD]. Ventribiconvex; beak ridges strong; foramen mesothyrid, deltidium partially resorbed; cardinal process small; outer hinge plates wide, attached to narrow crural bases; loop short, wide, almost square in outline, transverse band broad, convex posteriorly. *Lower Cretaceous:* USA (Texas).——FIG. 1420,*7a–d.* **E. texana; a–c,* dorsal, lateral, and anterior views of holotype, USNM 550572a, ×1; *d,* closeup of loop, ×2 (Cooper, 1983).

Family PYGOPIDAE Muir-Wood, 1965

[Pygopidae MUIR-WOOD, 1965a, p. 801; *emend.,* DIENI, MIDDLEMISS, & OWEN, 1975, p. 192]

Shell medium to large, smooth, commonly subtriangular to subrounded in outline; rectimarginate to strongly unisulcate; shell may develop two lateral lobes that curve toward each other and may fuse in adult stage, enclosing median perforation; hinge plates horizontal to slightly convex in serial section, tapering, or with rounded inner edges, which pass forward as horizontal structures to join crura; loop very short, with low-arched transverse band. *Lower Jurassic (Pliensbachian)–Lower Cretaceous (Barremian).*

Subfamily PYGOPINAE Muir-Wood, 1965

[*nom. transl.* DIENI, MIDDLEMISS, & OWEN, 1975, p. 192, *ex* Pygopidae MUIR-WOOD, 1965a, p. 801]

Pygopidae in which shell may develop two lateral lobes, which may curve toward each other and fuse in adult stage, enclosing a median perforation. *Upper Jurassic (Kimmeridgian)–Lower Cretaceous (Barremian).*

Pygope LINK, 1830, p. 451 [**Terebratula antinomia* CATULLO, 1827, p. 169 (pl. 5,*r*); SD BUCKMAN, 1906a, p. 445; =*T. deltoidea* VALENCIENNES in LAMARCK, 1819, p. 250; *T. diphya* VON BUCH, 1835, p. 88] [=*Antinomia* CATULLO, 1851, p. 74 (type, *Terebratula dilatata* CATULLO, 1851, p. 75); *Pugites* BRONN, 1838, p. 653, obj.]. Shell medium to large, subtriangular to subrounded in outline, umbo erect to incurved; foramen oval, permesothyrid; beak ridges rounded; anterior commmissure rectimarginate to uniplicate; shell strongly sulcate in juvenile, developing two lateral lobes that come into contact and fuse in adult stage, enclosing median perforation; perforation central or posterior of center. [Few authors (with the exception of BUCKMAN, 1906 and MUIR-WOOD, 1965) have used any name but *Terebratula diphya* VON BUCH, 1835, for the type species of *Pygope.* The ICZN has not further considered the positions of the names *Terebratula deltoidea* VALENCIENNES, 1819 and *T. diphya* VON BUCH, 1835 (ICZN, 1988).] *Upper Jurassic (Kimmeridgian)–Lower Cretaceous (Barremian):* Europe, North Africa, Greenland.——FIG. 1421,*2a–m.* **P. diphya* (VON BUCH), Tithonian, Italy; *a–d,* dorsal, ventral, lateral, and anterior views, ×1; *e–m,* serial transverse sections 1.2, 4.0, 5.2, 5.6, 6.0, 6.8, 7.6, 8.0, 8.4 mm from ventral umbo, ×2 (Dieni & Middlemiss, 1981).

Pygites BUCKMAN, 1906a, p. 449 [**Terebratula diphyoides* D'ORBIGNY, 1849 in 1849–1852, p. 87; OD]. Similar to *Pygope* but ventral valve with sulcus in median fold posterior to perforation, dorsal sulcus with similar median fold; large central perforation in adult; cardinal process low; posterior umbonal cavity developed; hinge plates in section dorsally deflected, slightly concave ventrally, tapering, not well demarcated from long inner socket ridges. *Upper Jurassic (Tithonian)–Lower Cretaceous (Barremian):* Europe, North Africa, Arctic.——FIG. 1421,*1a–e.* **P. diphyoides* (D'ORBIGNY), Berriasian; *a–d,* dorsal, ventral, lateral, and anterior views, France, ×1 (Muir-Wood, 1965a); *e,* close up of loop, Czech Republic, Slovakia, ×2 (Cooper, 1983).

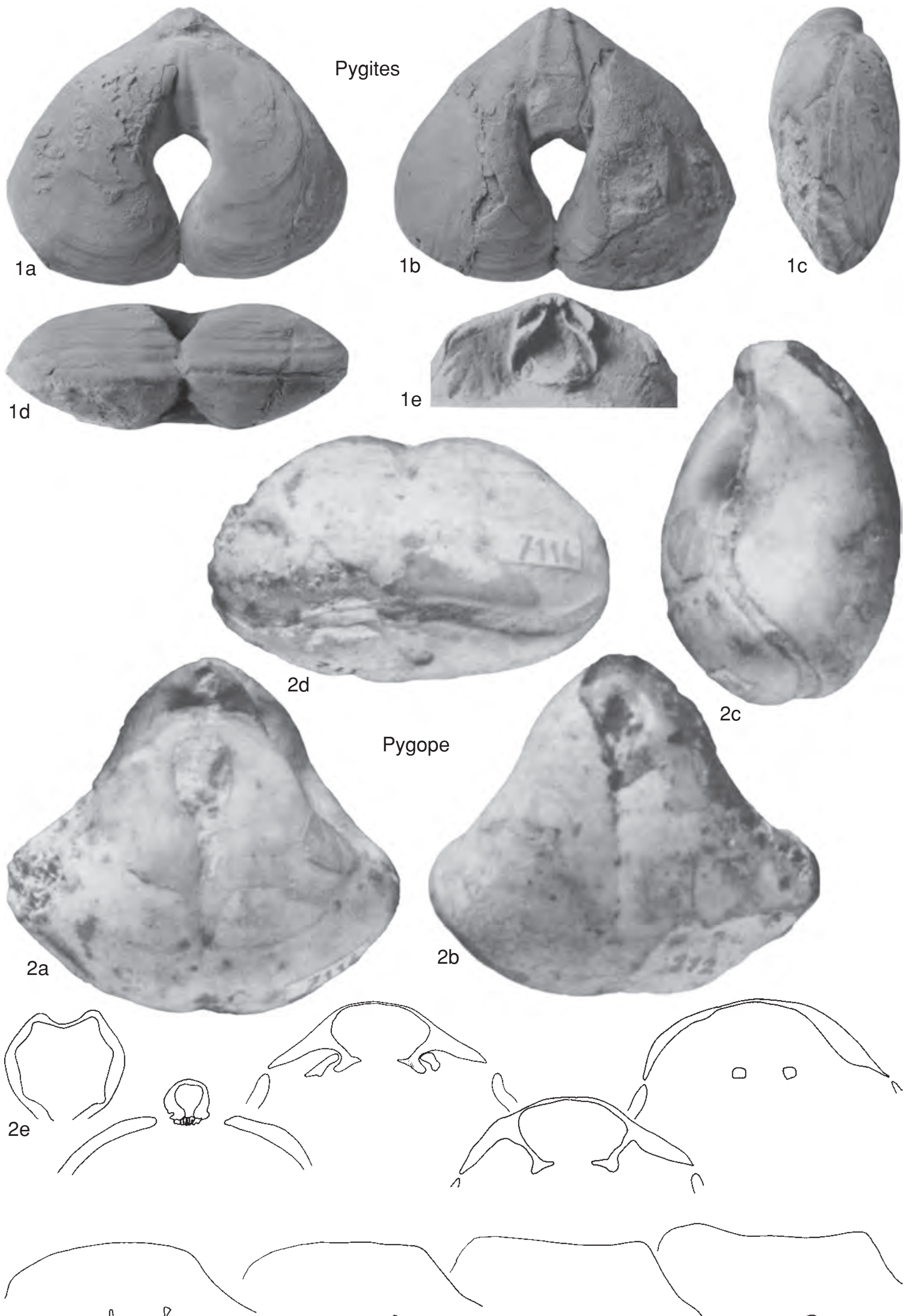

FIG. 1421. Pygopidae (p. 2140).

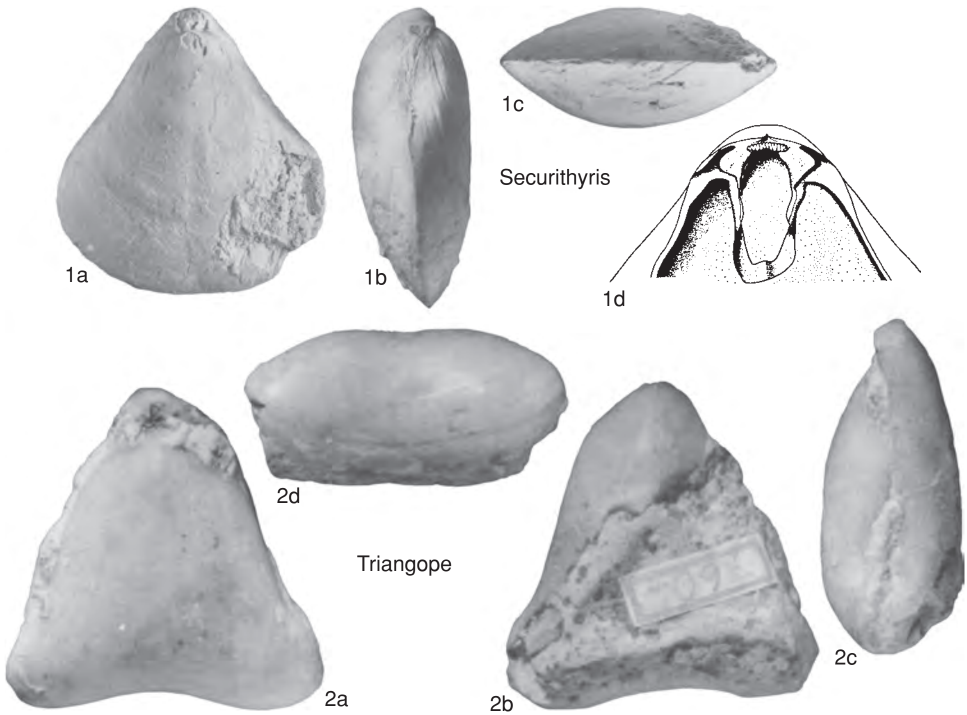

FIG. 1422. Pygopidae (p. 2142).

Subfamily TRIANGOPINAE Manceñido, 1993

[Triangopinae MANCEÑIDO, 1993, p. 203]

Similar to Pygopinae but imperforate. *Lower Jurassic (Pliensbachian)–Lower Cretaceous (Barremian).*

Triangope DIENI & MIDDLEMISS, 1981, p. 39 [**Terebratula triangulus* VALENCIENNES in LAMARCK, 1819, p. 250; OD]. Shell triangular, beak suberect to incurved; foramen oval, permesothyrid; hinge plates slightly convex, crural bases given off dorsally from anterior ends of hinge plates. *Upper Jurasssic (Kimmeridgian)–Lower Cretaceous (Barremian):* Europe, North Africa.——FIG. 1422,*2a–d.* **T. triangulus* (VALENCIENNES), Tithonian, Italy; dorsal, ventral, lateral, and anterior views, ×1 (Dieni & Middlemiss, 1981).

Securithyris VÖRÖS, 1983, p. 13 [**Terebratula adnethensis* SUESS, 1855b, p. 31; OD]. Medium to large, subtriangular, slightly to strongly biconvex, anterior commissure wide, rectimarginate, ligate or unisulcate; pedicle collar well developed; cardinal process wide, crenulated; hinge plates reduced or absent; crura given off from inner socket ridges; loop short, narrow. *Lower Jurassic (Pliensbachian):* Mediterranean, Sicily, Italy, Hungary, Greece, Spain, Morocco.——FIG. 1422,*1a–d.* **S. adnethensis* (SUESS), Bakony Mountains, Hungary; *a–c,* dorsal, lateral, and ventral views, ×1; *d,* reconstruction of loop, ×2 (Vörös, 1983).

Family NUCLEATIDAE Schuchert, 1929

[*nom. transl.* COOPER, 1983, p. 39, *ex* Nucleatinae SCHUCHERT in SCHUCHERT & LEVENE, 1929a, p. 24]

Small to medium size, smooth, moderately to strongly unisulcate; loop short, crural bases indistinct, crural processes blunt, anterior to midloop; outer hinge plates poorly defined; transverse band anteriorly rounded. *Lower Jurassic–Upper Cretaceous (Cenomanian).*

Nucleata QUENSTEDT, 1868 in 1868–1871, p. 25 [**N. collina;* OD; =*Terebratulites nucleatus* VON SCHLOTHEIM, 1820, p. 281] [=*Glossothyris* DOUVILLÉ, 1879, p. 267, obj.; *Vjalovithyris* TCHORSZHEVSKY, 1989b, p. 33 (type, *V. pinguis* TCHORSZHEVSKY, 1989b, p. 34, OD)]. Small to medium, subrounded to subpentagonal in outline;

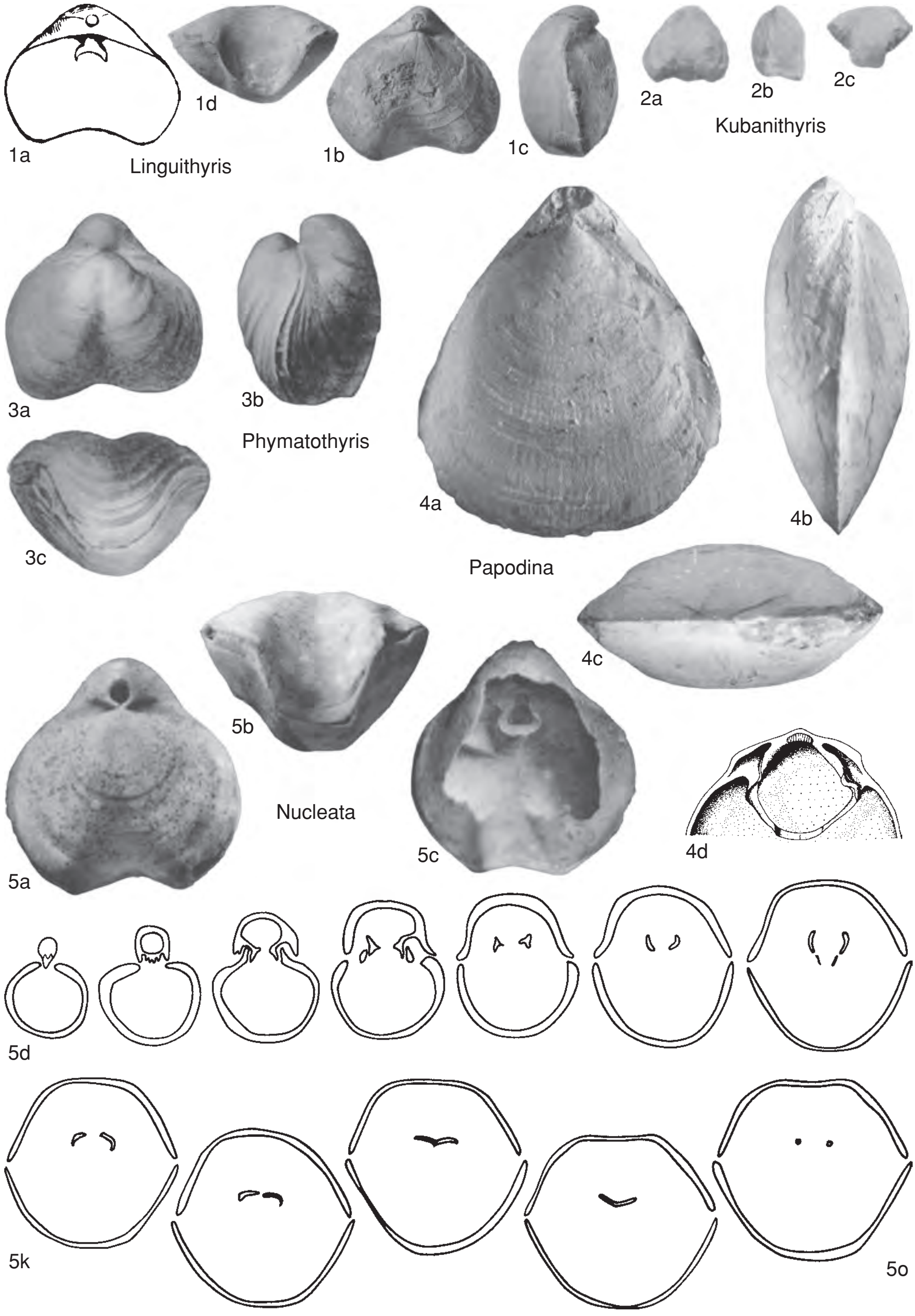

FIG. 1423. Nucleatidae and Uncertain (p. 2142–2144).

ventribiconvex or planoconvex, anterior commissure unisulcate; beak short, truncated by small to medium foramen, beak ridges obscure, no symphytium; cardinal process small; short crural bases expanding directly into crural processes and curving into wide transverse band of very short, wide, rounded loop. *?Middle Jurassic (Bathonian), Upper Jurassic (Oxfordian)–Upper Cretaceous (Cenomanian):* Europe, Crimea, Caucasus, North Africa, Greenland; *Upper Jurassic:* Indonesia (Sula Islands).——FIG. 1423,*5a–o*. **N. nucleata* (SCHLOTHEIM), White Jura, Bavaria, Germany; *a–b,* dorsal and anterior views of silicified specimen, ×2; *c,* ventral valve with loop exposed, ×2 (Cooper, 1983); *d–o,* serial transverse sections, 1.2, 1.7, 2.2, 2.5, 2.9, 3.5, 4.1, 4.4, 4.7, 4.9, 5.3, 5.7 mm from first section, ×1 (Barczyk, 1969).

Kubanithyris TCHORSZHEVSKY, 1989b, p. 29 [**K. parvus;* OD]. Small, planoconvex; anterior commissure unisulcate; beak ridges sharp; foramen small, mesothyrid; cardinal process small, bilobate; outer hinge plates narrow, dorsally inclined; no crural bases; loop short. *Middle Jurassic:* Caucasus, ?England.——FIG. 1423,*2a–c*. **K. parvus,* Caucasus; dorsal, lateral, and anterior views, ×1 (Tchorszhevsky, 1989b).

Linguithyris BUCKMAN, 1918, p. 99 (BUCKMAN, 1914, p. 2, *nom. nud.*) [**Terebratula bifida* ROTHPLETZ, 1886, p. 114; OD]. Small to medium, biconvex, anterior commissure strongly unisulcate, beak incurved, beak ridges angular, epithyrid, symphytium narrow; cardinal process low, short, lobate; hinge plates in transverse section short, slightly concave ventrally, tapering, well demarcated from inner socket ridges; loop about 0.25 of valve length, transverse band slightly arched, rounded. *Lower Jurassic–Middle Jurassic:* Europe, North Africa; New Zealand, *Lower Jurassic.*——FIG. 1423,*1a*. **L. bifida* (ROTHPLETZ), Middle Inferior Oolite, Dorset, England; reconstruction of loop, ×1 (Muir-Wood, 1965a).——FIG. 1423,*1b–d*. *L. umbonata* BUCKMAN, Middle Inferior Oolite, England; dorsal, lateral, and anterior views, ×1 (Muir-Wood, 1965a).

Phymatothyris COOPER & MUIR-WOOD, 1951, p. 195, *nom. nov. pro Pallasiella* RENZ, 1932, p. 40, *non* SARS, 1895 [**Pallasiella kerkyraea* RENZ, 1932, p. 41; OD]. Small to medium, smooth, planoconvex, anterior commissure unisulcate; umbones swollen, strongly incurved; foramen concealed by swollen beak of ventral valve; loop presumably short; muscle scars similar to those of nucleatids. *Lower Jurassic (Hettangian–Toarcian):* Italy, Albania, Hungary, Greece, Alps.——FIG. 1423,*3a–c*. **P. kerkyraea* (RENZ), Greece; dorsal, lateral, and anterior views, ×1 (Muir-Wood, 1965a).

Family UNCERTAIN

Papodina VÖRÖS, 1983, p. 15 [**Terebratula bittneri* GEYER, 1889, p. 11; OD]. Medium to large, subtrigonal, biconvex, finely capillate; anterior commissure rectimarginate to ligate; beak high, suberect; foramen mesothyrid; pedicle collar well developed; cardinal process small, low, crenulated; no hinge plates; loop wide, short, dorsally arched transverse band. *Lower Jurassic (Sinemurian–Pliensbachian):* Hungary.——FIG. 1423,*4a–d*. **P. bittneri* (GEYER), Pliensbachian; *a–c,* dorsal, lateral, and anterior views ×2; *d,* reconstruction of loop, ×2 (Vörös, 1983).

CANCELLOTHYRIDOIDEA

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Superfamily CANCELLOTHYRIDOIDEA Thomson, 1926

[*nom. correct.* LEE, herein, *pro* Cancellothyridacea COOPER, 1973c, p. 373, *nom. transl. pro* Cancellothyrididae MUIR-WOOD, 1965a, p. 807, *nom. correct. pro* Cancellothyridae MUIR-WOOD, 1955, p. 93, *nom. transl. ex* Cancellothyrinae THOMSON, 1926, p. 525]

Adult shells small to medium in size; outline elongate-oval, subcircular, or subtriangular; capillate, costate, or costellate; anterior commissure commonly rectimarginate, rarely unisulcate, uniplicate, or sulciplicate; foramen small to large, commonly margined by narrow deltidial plates. Dental plates commonly absent, median septum rarely present, outer hinge plates commonly absent, inner hinge plates absent, socket ridges strong, elevated, crural bases attached to socket ridges; loop short (0.3 of dorsal valve length); crural processes may be disjunct or united to form a ringlike loop or tube; dorsal pedicle muscles attached to floor of dorsal valve between adductors; lophophore spirolophous or plectolophous. Mantle and body wall usually strongly spiculate. *Lower Jurassic (Pliensbachian)–Holocene.*

Family CANCELLOTHYRIDIDAE Thomson, 1926

[*nom. correct.* MUIR-WOOD, 1965a, p. 807, *pro* Cancellothyridae MUIR-WOOD, 1955, p. 93, *nom. transl. ex* Cancellothyrinae THOMSON, 1926, p. 525]

Valves capillate or costellate; crural processes of loop united to form a ring with transverse band; lophophore usually plectolophous. *Lower Jurassic (Pliensbachian)–Holocene.*

Subfamily CANCELLOTHYRIDINAE Thomson, 1926

[*nom. correct.* MUIR-WOOD, 1965a, p. 807, *pro* Cancellothyrinae THOMSON, 1926, p. 525] [=Terebratulinae DALL, 1870, p. 99, *partim*]

Valves rostrate, ovate with narrow hinge; crural processes fused in adult forming complete ringlike loop. *Upper Jurassic–Holocene.*

Cancellothyris THOMSON, 1926, p. 525 [**Terebratula cancellata* KOCH in KÜSTER, 1844, p. 35; OD; *non* EICHWALD, 1829, p. 276; =*Terebratulina hedleyi* FINLAY, 1927 (March), p. 533; *Cancellothyris australis* THOMSON, 1927, p. 188)]. Small to medium sized, ovate to subpentagonal, valves biconvex; anterior commissure uniplicate to sulciplicate; surface finely capillate; umbo short, massive, suberect; foramen large, epithyrid, labiate; deltidial plates conjunct. Pedicle collar developed; cardinal process low, bilobed; loop wide, transverse band broad, slightly arched ventrally, lophophore plectolophous. *Neogene (Miocene)–Holocene:* New Zealand, *Miocene;* South Africa, *Pliocene–Pleistocene;* South Australia, Tasmania, off southwestern New Zealand (6–366 m), *Holocene.*——FIG. 1424,*1a–d.* **C. hedleyi* (FINLAY), Holocene, South Australia; *a–c,* dorsal, lateral, and anterior views, ×1.2; *d,* dorsal valve interior with loop, ×1.2 (Muir-Wood, 1965a).

Murravia THOMSON, 1916a, p. 45 [**Terebratulina davidsoni* ETHERIDGE, 1876, p. 16; OD; *non* BOLL, 1856, p. 37; =*Terebratulina catinuliformis* TATE in TATE & DENNANT, 1896, p. 130 (footnote)]. Small, thick shelled, thick, ovate, planoconvex, with wide hinge line, anterior commissure rectimarginate or unisulcate; surface costellate; foramen hypothyrid, deltidial plates disjunct. Pedicle collar present, myophragm may be present; cardinal process prominent, swollen anteriorly; socket ridges strong; internal margin of both valves crenulate. *Paleogene (Oligocene)–Holocene:* Australia; New Zealand, *Oligocene.*——FIG. 1424,*4a–c.* **M. catinuliformis* (TATE), Miocene, Victoria, Australia; dorsal view, interior views of ventral and dorsal valves, ×3 (Muir-Wood, 1965a).——FIG. 1424,*4d–e. M. exarata* VERCO, Holocene, South Australia; holotype, dorsal and lateral views, ×6 (Muir-Wood, 1965a).

Ortholina CALZADA BADIA, 1984b, p. 5 [**Terebratella decorata* VIDAL, 1921, p. 56; OD]. Small to medium size, subcircular in outline, planoconvex, hinge line wide, almost straight; anterior commissure rectimarginate; surface finely costellate; foramen small, submesothyrid, deltidial plates disjunct. Cardinal process small, bilobed, loop wide, myophragm present. *Upper Cretaceous:* Spain.——FIG. 1424,*5a–c.* **O. decorata* (VIDAL), Maastrichtian; dorsal, ventral, and lateral views, ×1.5 (Calzada Badia, 1984b).——FIG. 1424,*5d. O. lujana* VIDAL, Maastrichtian; interior of dorsal valve, ×3 (Calzada Badia, 1984b).

Rhynchonellopsis VINCENT, 1893, p. 51, *non* BÖSE, 1894, *nec* DE GREGORIO, 1930 [**Terebratulina nysti* BOSQUET, 1862, p. 349; OD]. Small, thick shelled, rounded, convexoplane; anterior commissure

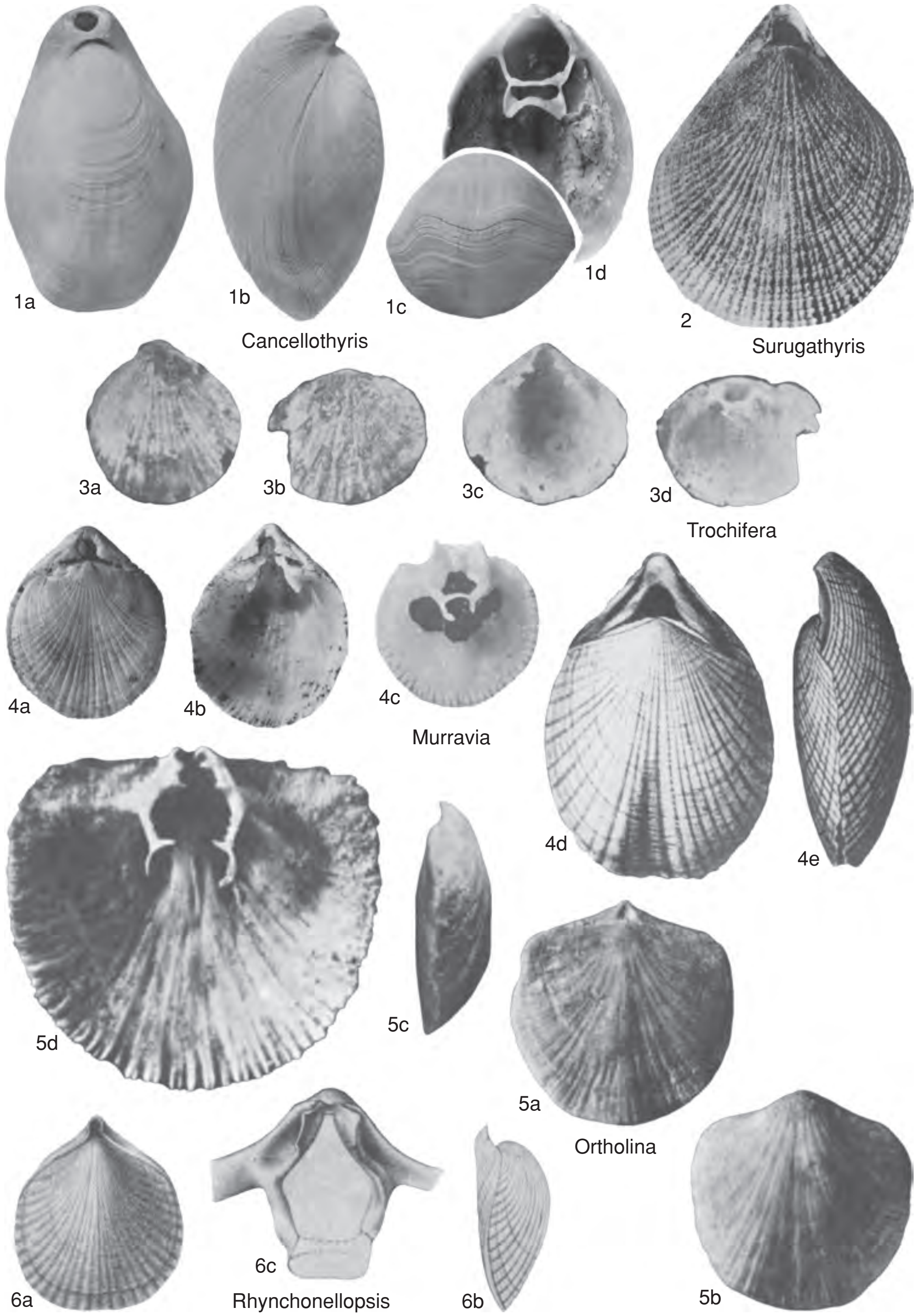

FIG. 1424. Cancellothyrididae (p. 2145–2147).

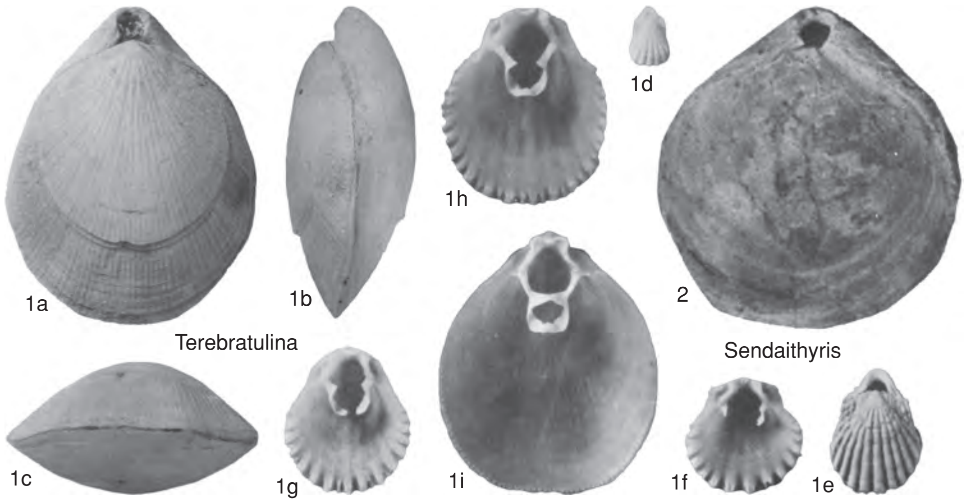

FIG. 1425. Cancellothyrididae (p. 2147).

rectimarginate to gently uniplicate; surface capillate; umbo small, short, suberect, beak ridges obscure; foramen small, deltidial plates disjunct. Hinge plates absent, socket ridges prominent and united with crural bases, crura converging, loop probably terebratulinid; inner shell margin crenulated. *Paleogene (Oligocene):* Belgium, The Netherlands, Germany, Russia.——FIG. 1424,*6a–c*. **R. nysti* (BOSQUET), Belgium; *a–b,* dorsal and lateral views, ×3; *c,* dorsal valve interior with loop, restored, ×9 (Muir-Wood, 1965a).

Sendaithyris HATAI, 1940, p. 253 [**S. otutumiensis;* OD]. Medium size, circular, biconvex, anterior commissure rectimarginate; surface indistinctly costellate. Interior imperfectly known; cardinalia and loop said to be as in *Terebratulina,* but with short, bifurcated septum in dorsal valve. *Neogene (Miocene):* Japan.——FIG. 1425,*2*. **S. otutumiensis,* Rikuzen; dorsal valve view, ×1 (Muir-Wood, 1965a).

?Surugathyris YABE & HATAI, 1934, p. 587 [**S. (Terebratulina) suragaensis;* OD]. Imperfectly known, may be immature form of some species of *Terebratulina. Holocene:* Japan.——FIG. 1424,*2*. **S. suragaensis;* dorsal valve view, ×2.4 (Muir-Wood, 1965a).

Terebratulina D'ORBIGNY, 1847 in 1847–1851, p. 249 [**Anomia retusa* LINNAEUS, 1758, p. 701; OD; =*A. caputserpentis* LINNAEUS, 1767, p. 1,153, *non* LINNAEUS, 1758, p. 703]. Small to large, ovate to subpentagonal, slightly auriculate, valves biconvex; anterior commissure rectimarginate to uniplicate; surface costellate, costellae may be enlarged or granular, with prominent nodules in young; umbo suberect, foramen incomplete, mesothyrid to permesothyrid, deltidial plates disjunct. Pedicle collar present, median septum and hinge plates absent; cardinal process small; socket ridges and crural bases fused, forming prominent ridge, hinge teeth without swollen bases, but with sulcus on inner face; crura converging, crural processes united to form ringlike loop, transverse band ventrally arched. *Upper Jurassic–Holocene:* Europe, *Upper Jurassic–Cretaceous;* cosmopolitan, *Paleogene–Holocene.*——FIG. 1425,*1a–i*. **T. retusa* (LINNÉ), Holocene; *a–c,* dorsal, lateral, and anterior views, off Norway, ×2 (Muir-Wood, 1965a); *d–e,* dorsal valve views, Gulf of Gascogne, France, ×5; *f–h,* dorsal valve interiors showing loop ontogeny, Gulf of Gascogne, France, ×5; *i,* dorsal valve interior showing adult loop, Gulf of Gascogne, France, ×2 (Cooper, 1981).

Trochifera JIN & YE in JIN & others, 1979, p. 68 [**T. bangonica;* OD]. Small, elliptical to roundly pentagonal, ventribiconvex; anterior commissure rectimarginate or incipiently uniplicate; costellae low, rounded and bifurcate; beak straight; beak ridges angular; interarea narrow and flattened; foramen large, subcircular, submesothyrid to hypothyrid; deltidial plates disjunct. Pedicle collar short or absent; ventral muscle scar obscure and petal-like; myophragm narrow. Cardinal process low, bilobate; socket ridges raised above posterior margin and buttressed by small, curved plates; crural bases attached to ends of inner socket ridges; crura converging; crural processes united to form ring; loop very short; transverse band gently arched ventrally; dorsal median ridge low and bifurcating anteriorly. *Cretaceous (Albian):* northern Tibet (Bangon).——FIG. 1424,*3a–d*. **T. bangonica; a–b,* holotype, dorsal, and ventral views, ×3; *c–d,* interior of ventral and dorsal valves, ×3 (Jin & others, 1979).

Subfamily CRICOSIINAE Cooper, 1973

[Cricosiinae COOPER, 1973c, p. 383] [=Cruralininae SMIRNOVA, 1990a, p. 53]

Small, costellate or capillate, subcircular, with nearly tubular loop. *Upper Jurassic–Paleogene (Danian).*

Cricosia COOPER, 1973c, p. 384 [**Terebratulina filosa* CONRAD, 1866, p. 77; OD]. Small, subcircular to oval, finely costellate; anterior commissure nearly rectimarginate; foramen small, oval, hypothyrid; deltidial plates small, disjunct, extended adjacent to dorsal valve margin and obliquely raised; pedicle collar narrow. Thin, elevated socket ridges join with thickened posterior area that serves as cardinal process; crura stout, narrow; crural processes united to form narrow, tubelike loop. *Upper Cretaceous:* southwestern USA (Texas).——FIG. 1426,*1a–f.* **C. filosa* (CONRAD); *a–d,* dorsal, ventral, lateral, and anterior views, ×2; *e–f,* ventral and posterior views of reconstructed loop, ×4 (Cooper, 1973c).

Bisulcina TITOVA, 1977, p. 81 [**Terebratulina tunicata* VANTSCHUROV in VANTSCHUROV & KALUGIN, 1966, p. 121; OD]. Small to medium size, rounded to oval, slightly biconvex; beak blunt, foramen large, deltidial plates disjunct; shell capillate (up to 100 ribs present), small tubercles prominent in posterior and lateral parts of shell. Pedicle collar present, hinge teeth narrow with denticulum; inner socket ridges more prominent than outer. *Upper Cretaceous–Paleogene (Danian):* western Turkmenia; Western Europe, *Upper Cretaceous.*——FIG. 1426,*2a–u.* **B. tunicata* (VANTSCHUROV), Danian, western Turkmenia; *a–d,* dorsal, ventral, lateral, and anterior views, ×5; *e–u,* serial transverse sections 0.10, 0.25, 0.45, 0.55, 0.65, 0.75, 0.90, 1.05, 1.35, 1.80, 2.00, 2.15, 2.30, 2.55, 2.70, 3.05, 3.25 mm from ventral umbo, ×3 (Titova, 1977).

Cruralina SMIRNOVA, 1966, p. 32 [**C. cruralinica* SMIRNOVA, 1966, p. 33; OD]. Small, rounded to pentagonal, anterior margin rectimarginate to uniplicate; costellate; beak suberect or slightly incurved, beak ridges sharp, with false interarea; foramen large, pedicle collar present. Cardinal process small, inner margins of hinge plates forming projections on valve floor that connect with crural bases; crural bases close together, separated by depressions from inner socket ridges that are low, parallel to, and almost united with valve floor; crura short, crural processes join to form single cross piece that is strongly curved ventrally; transverse band bent ventrally medianly at acute angle. *Lower Cretaceous–Upper Cretaceous:* Crimea, Europe, *Lower Cretaceous;* USA (Texas), Cuba, *Upper Cretaceous.* ——FIG. 1427,*2a–jj.* **C. cruralinica,* Lower Cretaceous, Crimea; *a–d,* holotype, dorsal, ventral, lateral, and anterior views, ×1; *e–f,* ventral and lateral views of reconstructed loop, ×2 (Smirnova, 1966); *g–jj,* serial transverse sections 0.0, 0.3, 0.5, 0.9, 1.2, 1.3, 1.32, 1.35, 1.37, 1.40, 1.45, 1.50, 1.55, 1.60, 1.63, 1.68, 1.71, 1.81, 1.91, 2.01, 2.11, 2.21, 2.31, 2.41, 2.51, 2.61, 2.71, 2.81, 2.91, 3.01 mm from ventral umbo, ×2 (Smirnova, 1990a).

Gyrosoria COOPER, 1973c, p. 386 [**Terebratulites gracilis* SCHLOTHEIM, 1813, p. 112, pl. 3,*3;* OD]. Small, outline elongate-oval in juveniles, subcircular in adults; planoconvex; costellae strong, often granulose or beaded; beak short, incurved; foramen small, deltidial plates disjunct, extended adjacent to dorsal valve margin; pedicle collar absent, teeth strong. Cardinalia narrow, socket ridges stout, cardinal process small, supported by short ridge; crura thick, oblique, supporting a narrow, tubelike loop. *Upper Cretaceous (Campanian–Maastrichtian):* Denmark, England.——FIG. 1428*a–k.* **G. gracilis* (SCHLOTHEIM), Trimingham, Norfolk, England; *a–d,* dorsal, ventral, lateral, and anterior views, ×3; *e,* dorsal valve interior, ×4; *f–g,* interiors of dorsal and ventral valves, ×4 (Cooper, 1973c); *h–k,* growth stages, 1.4 mm, 2.1 mm, 4.8 mm, 10.7 mm (Surlyk, 1972).

Symphythyris SMIRNOVA, 1966, p. 37 [**Terebratulina arguinensis* MOISSEEV in WEBER, 1949, p. 117; OD]. Small to medium size, rounded trigonal, gently biconvex; anterior commissure rectimarginate to uniplicate; surface finely costellate; beak very elongated, suberect or gently incurved; foramen large, circular, mesothyrid or submesothyrid, symphytium long, convex. No pedicle collar; cardinal process small, outer hinge plates fused with high, massive socket ridges that project deeply into beak cavity, socket ridges buttressed by small, curved plates that reach valve floor on either side of low median septum; crural processes forming broad transverse band, slightly convex ventrally; loop almost tubular. *Upper Jurassic–Lower Cretaceous:* Crimea, Caucasus, Switzerland, Czech Republic.——FIG. 1427,*1a–b.* **S. arguinensis* (MOISSEEV), Valanginian, Crimea; dorsal and lateral views, ×1 (Smirnova, 1990a). ——FIG. 1427,*1c–h. S. neocomiensis* D'ORBIGNY, Neocomian, Switzerland; *c–f,* dorsal, ventral, lateral, and anterior views, ×2 (Cooper, 1973c); *g–h,* reconstructions of loop, ×2 (Smirnova, 1972).

Subfamily ALITHYRIDINAE Sun, 1981

[Alithyridinae SUN, 1981, p. 242]

Small, subcircular, with dental plates. *Upper Cretaceous.*

Alithyris SUN, 1981, p. 242 [**A. shiquanheensis;* OD]. Small, subcircular, biconvex, anterior commissure rectimarginate; beak short, slightly incurved; delthyrium open; surface with subangular plicae

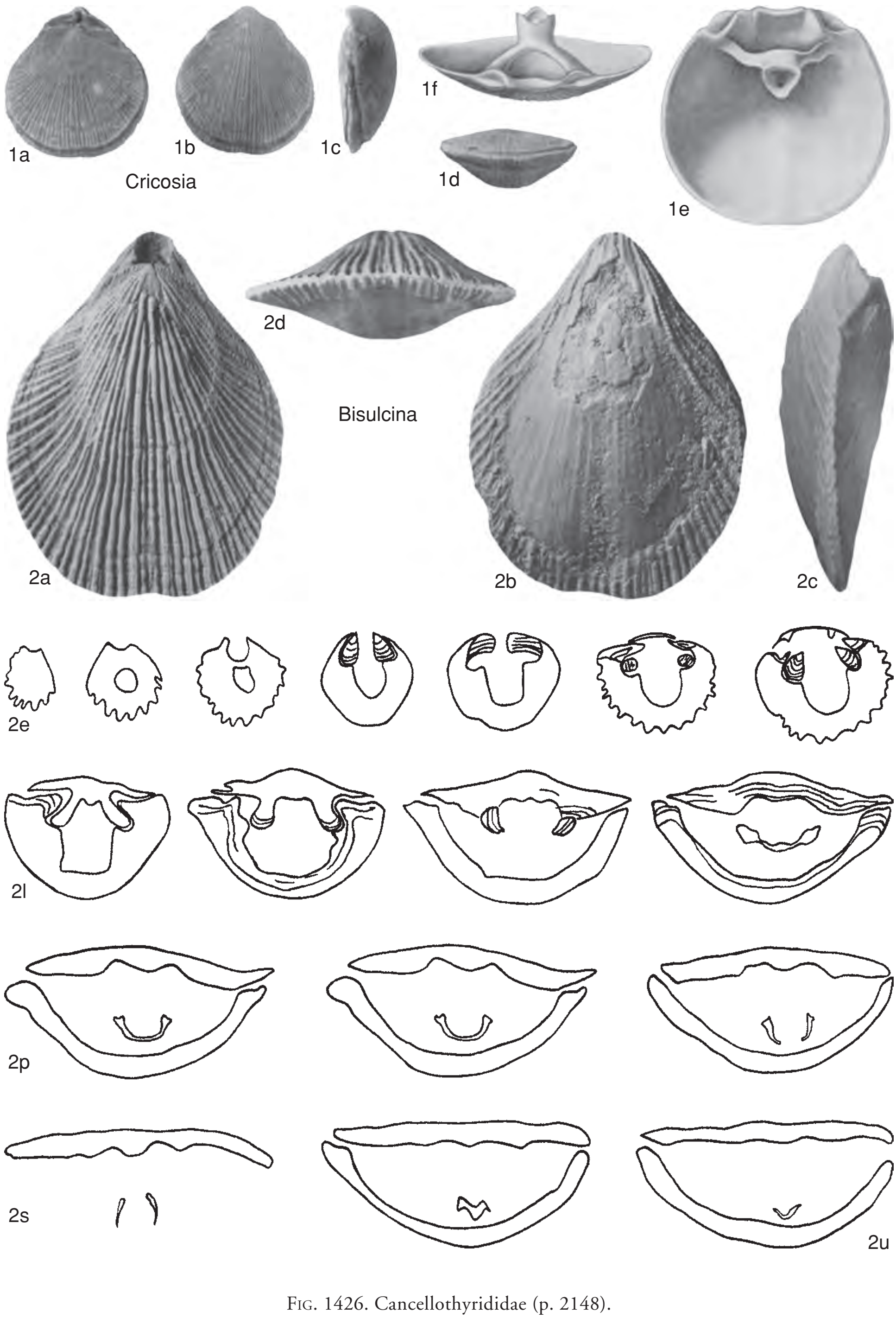

FIG. 1426. Cancellothyrididae (p. 2148).

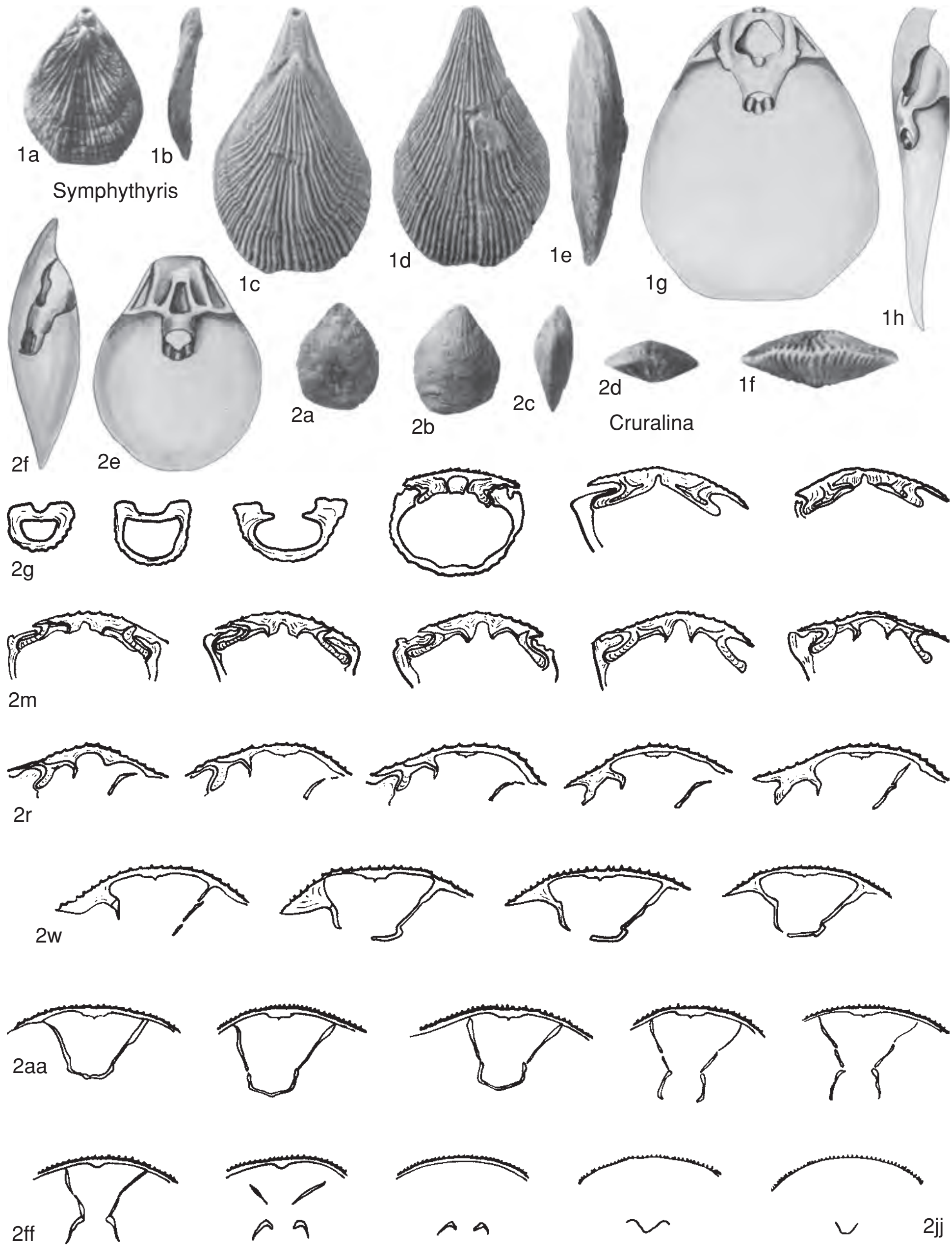

FIG. 1427. Cancellothyrididae (p. 2148).

and weak capillae; foramen obscure. Dental plates recessive and slightly diverging; umbonal cavities narrow, teeth small and obtusely circular; cardinal process a low, short platform, bilobate; inner socket ridges high, projecting over cardinal margin and fused with outer hinge plates; crura falcifer; crural processes uniting to form ringlike loop; descending branches short; transverse band incurved ventrally with low arch. *Upper Cretaceous:* Tibet.——FIG. 1429*a–t*. **A. shiqanheensis; a–d,* dorsal, ventral, lateral, and anterior views, ×3; *e–t,* serial transverse sections 0.5, 0.7, 7.0, 7.2, 7.3, 7.4, 7.5, 7.7, 8.0, 8.1, 8.15, 8.25, 8.3, 8.4, 8.45, 8.5 mm from ventral umbo, ×6 (Sun, 1981).

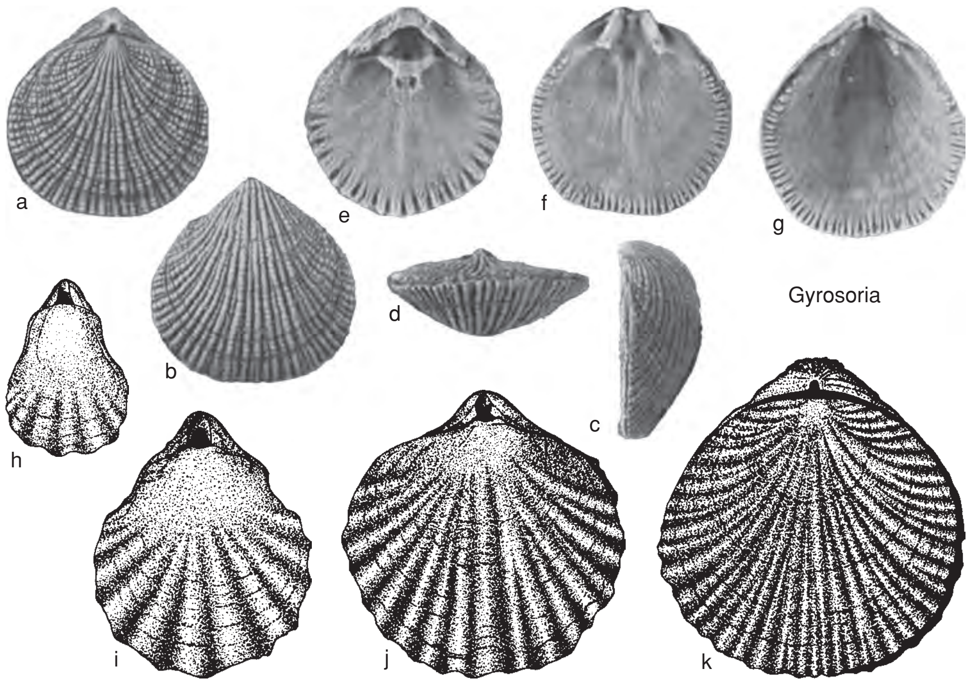

FIG. 1428. Cancellothyridiae (p. 2148).

Subfamily UNCERTAIN

Cooperithyris TCHORSZHEVSKY, 1988, p. 31 [**C. tenuicostata;* OD]. Small, biconvex, anterior commissure rectimarginate; capillate with fine, sharp ribbing; beak small, foramen small, deltidial plates conjunct. Pedicle collar narrow, adminicula well developed in ventral valve. Cardinal process small; septal ridge extending for 0.3 dorsal valve length; crural bases strong, crural processes high, arcuate, uniting to form high half ring; transverse band low, narrow; loop tapering anteriorly. *Lower Jurassic (Pliensbachian–Toarcian):* Transcaucasus.——FIG. 1430*a–y.* **C. tenuicostata,* Pliensbachian; *a–c,* dorsal, ventral, and anterior views, ×3; *d–y,* serial transverse sections, 0.2, 0.5, 0.8, 0.9, 1.1, 1.2, 1.4, 1.6, 1.8, 2.2, 2.4, 2.6, 2.8, 3.0, 3.1, 3.2, 3.4, 3.6, 3.9, 4.1, 4.4, 4.45 mm from first section, ×4 (Tchorszhevsky, 1988).

Family CHLIDONOPHORIDAE Muir-Wood, 1959

[*nom. transl.* COOPER, 1973c, p. 386, *ex* Chlidonophorinae MUIR-WOOD, 1959, p. 295]

With characteristic cardinalia of superfamily but with crural processes of loop never united to form ring. *Lower Jurassic (Pliensbachian)–Holocene.*

Subfamily CHLIDONOPHORINAE Muir-Wood, 1959

[Chlidonophorinae MUIR-WOOD, 1959, p. 295]

Transverse band of loop directed anteroventrally; lophophore subplectolophous. *Lower Jurassic (Pliensbachian)–Holocene.*

Chlidonophora DALL, 1903, p. 1,538 [**Terebratulina? incerta* DAVIDSON, 1878b, p. 438; OD]. Small, semicircular, valves moderately biconvex, anterior commissure rectimarginate to gently uniplicate; hinge line wide, straight, interarea short; beak short, foramen incomplete; deltidial plates narrow, disjunct, pedicle collar developed. Socket ridges broad, projecting above hinge line and uniting with transverse cardinal process; crura short, crural processes concave inwardly and sharply pointed; anterior part of loop flat and ribbonlike, directed anteriorly; pedicle variable but characteristically frayed into numerous strands; lophophore subplectolophous. *?Upper Cretaceous, Holocene:* Spain, *?Upper Cretaceous;* Atlantic, Caribbean, Gulf of Mexico

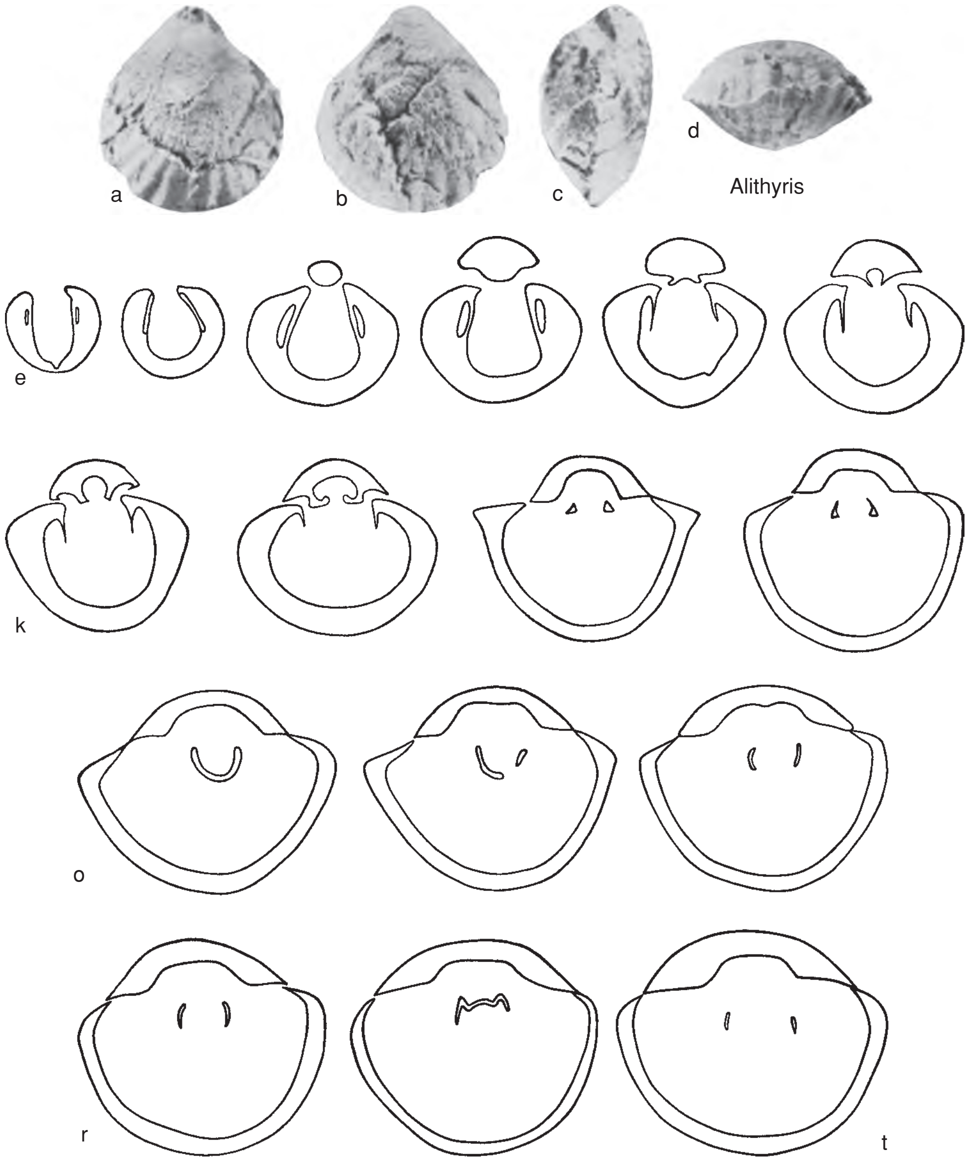

FIG. 1429. Cancellothyrididae (p. 2148–2150).

(534–3,384 m), Indian Ocean (680–1,660 m), ?Pacific, *Holocene.*——FIG. 1431,*1a–f.* **C. incerta* (DAVIDSON), Holocene, North Atlantic Ocean; *a–c,* holotype, dorsal, lateral, and anterior views, ×2.5 (Muir-Wood, 1965a); *d–e,* laterally tilted and ventral view of dorsal valve interior with loop, ×4 (Cooper, 1973b); *f,* ventral valve interior showing teeth and mantle canals, ×3 (Muir-Wood, 1965a).——FIG. 1431,*1g–h. C. chuni* BLOCHMANN, Holocene, Maldive Islands, Indian Ocean; *g,* dorsal valve view with long, divided pedicle attached to *Globigerina,* ×2; *h,* subplectolophous lophophore, ×10 (Muir-Wood, 1965a).

Deslongchampsithyris LEE & TCHORSZHEVSKY, herein, p. 2,255, *nom. nov. pro Deslongchampsia* TCHORSZHEVSKY, 1988, p. 33, *non* MORRIS & LYCETT, 1851, *nec* ROCHÉ, 1939 [**Deslongchampsia moiseevi* TCHORSZHEVSKY, 1988, p. 33; OD; =*Terebratella*

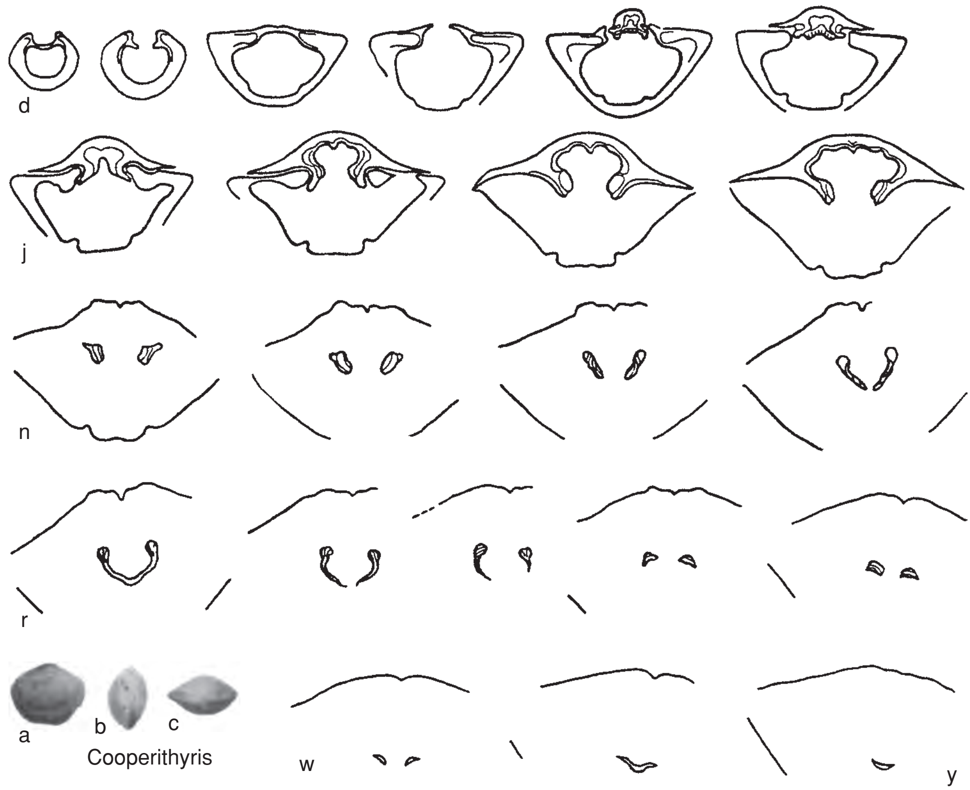

FIG. 1430. Cancellothyrididae (p. 2151).

liasina MOISSEEV, 1934, p. 156, *non* DESLONGCHAMPS, 1863, *nec* RAU, 1902]. Small, subcircular, biconvex; beak small, triangular; anterior commissure uniplicate; costellae low, narrow; foramen small, subapical, deltidial plates conjunct. Cardinal process small, flat, with distinct myophore; crural bases heavy, oval in cross section, arcuate; loop narrow. *Lower Jurassic (Pliensbachian):* Crimea, Transcaucasus, England, Germany.——FIG. 1432,*3a–t.* **D. moiseevi* (TCHORSZHEVSKY), Crimea; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* dorsal valve, ×3; *e–t,* serial transverse sections, 0.0, 0.1, 0.5, 0.9, 1.15, 1.35, 1.5, 1.80, 2.15, 2.35, 2.65, 2.85, 3.05, 3.15, 3.35, 3.55 mm from first section, ×4 (Tchorszhevsky, 1988).

Disculina DESLONGCHAMPS, 1884a, p. 147 [**Terebratula hemisphaerica* J. SOWERBY, 1826 in 1826–1829, p. 69; OD]. Small, subcircular, valves concavo- to planoconvex, anterior commissure rectimarginate to incipiently unisulcate; valves finely capillate and nodose; umbo incurved, foramen large, incomplete, mesothyrid; deltidial plates disjunct, small interarea in ventral valve. Pedicle collar present; cardinal process small; socket ridges broad and long; crura oblique with disjunct crural processes and anteriorly ventrally protuberant transverse band. *Middle Jurassic (Bathonian)–Upper Jurassic (upper Oxfordian):* England, France.——FIG. 1431,*4a–d.* **D. hemisphaerica* (J. de C. SOWERBY), Bathonian, France; *a–c,* dorsal, ventral, and lateral views, ×4, *d,* dorsal view of loop, ×5 (Cooper, 1973c).

Gisilina STEINICH, 1963, p. 735 [**Terebratula gisii* ROEMER, 1841, p. 40; OD]. Small, rounded, auriculate, valves biconvex, with narrow interarea; anterior commissure rectimarginate or incipiently uniplicate; capillae simple, prominent, smooth or enlarged at intersection with growth lines; umbo short, suberect or erect; foramen ovoid, mesothyrid; deltidial plates disjunct. Pedicle collar present; hinge teeth with swollen bases; loop ventrally directed, crural processes converging, lophophore from spicule arrangement probably plectolophous. *Upper Cretaceous–Paleogene (Danian, ?Eocene):* Denmark, Germany, Romania, England, *Upper Cretaceous;* Ukraine, *Danian, ?Eocene;* Australia, *Santonian–Campanian.*——FIG. 1432,*1a–i.* **G. gisii* (ROEMER), Rugen; *a–b,* dorsal and lateral views, ×3; *c–f,* dorsal, lateral, anterior, and ventral valve interior views, ×4 (Muir-Wood, 1965a); *g,* dorsal

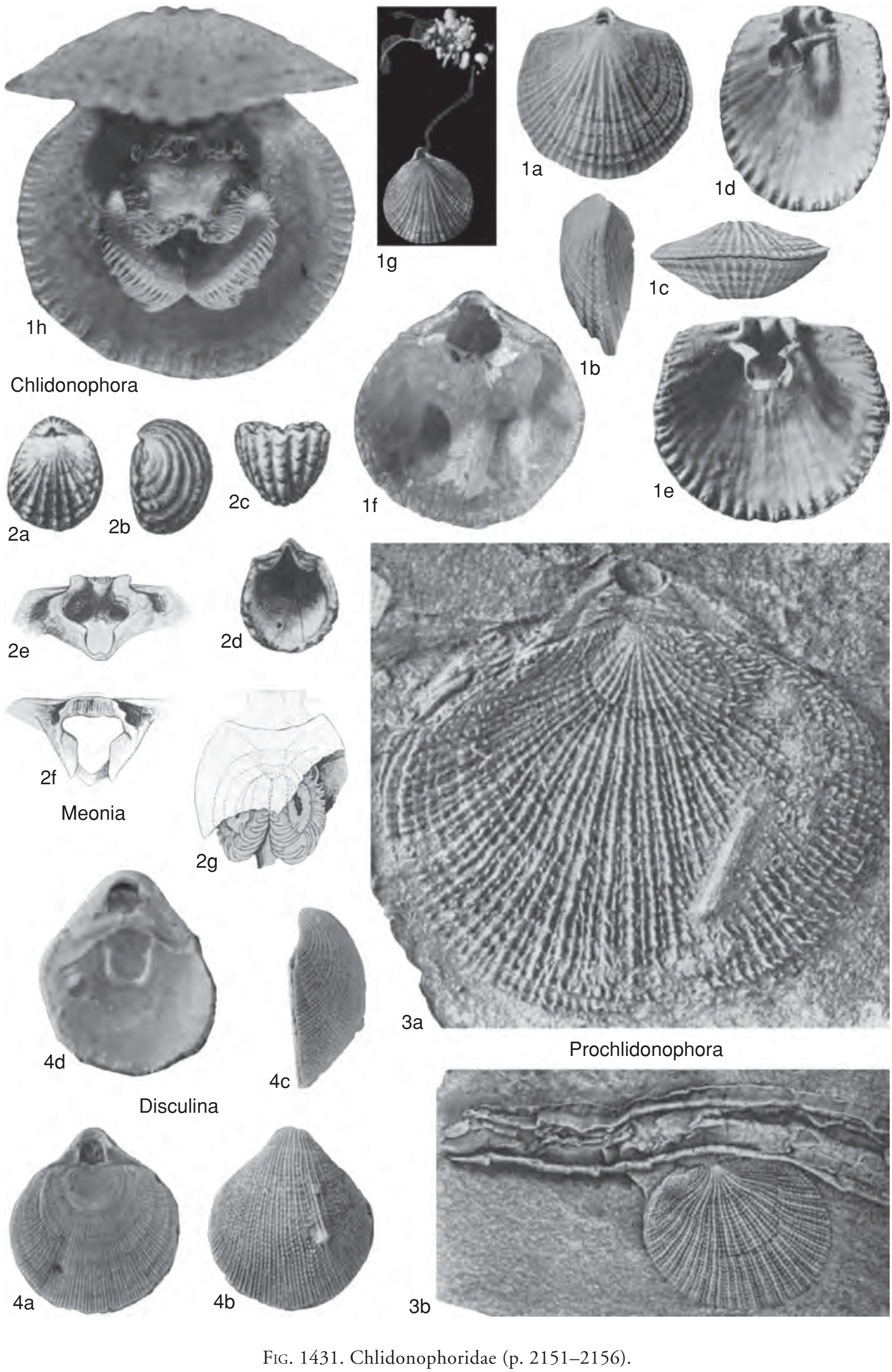

FIG. 1431. Chlidonophoridae (p. 2151–2156).

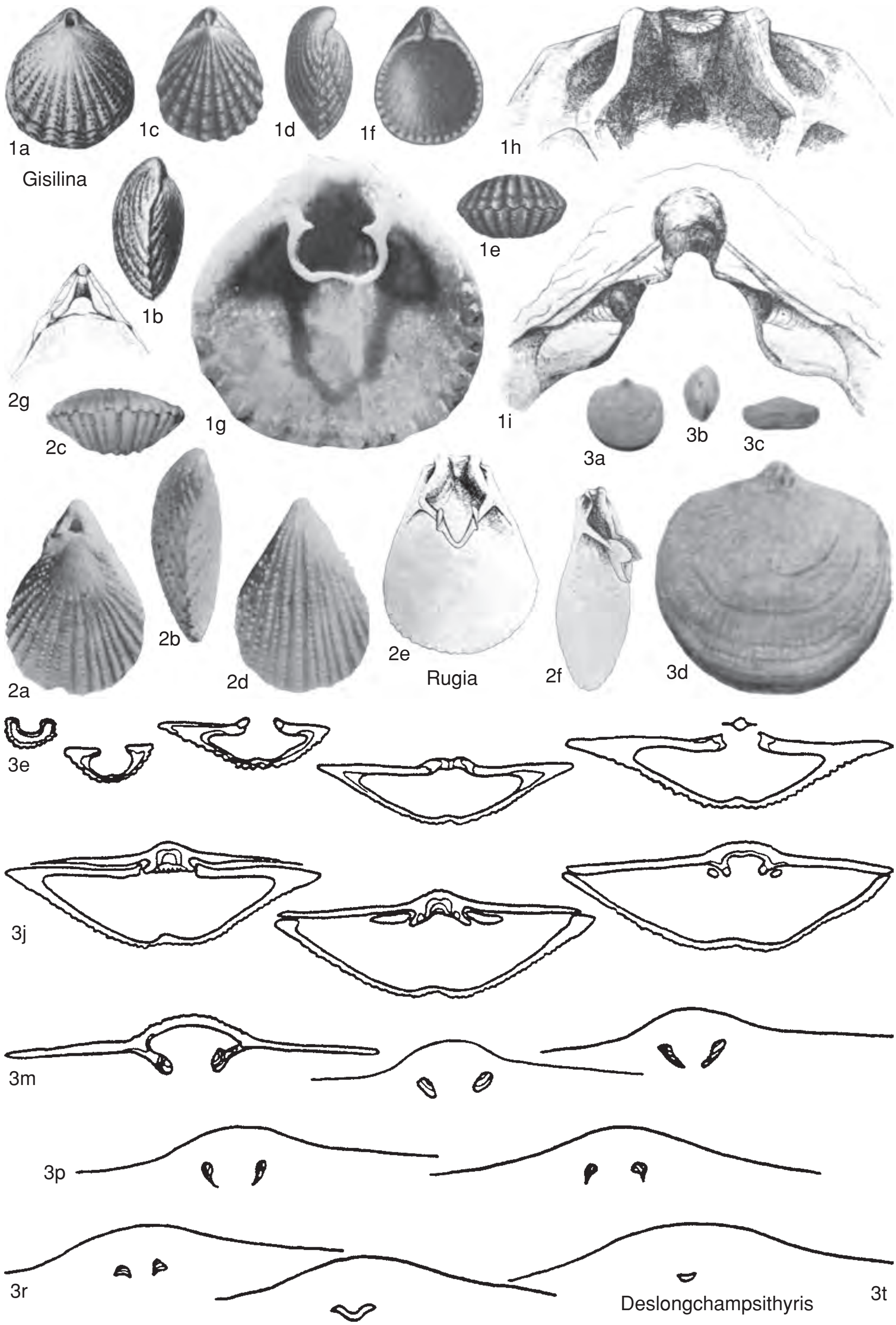

FIG. 1432. Chlidonophoridae (p. 2152–2156).

valve interior with loop, ×10; *h–i,* dorsal valve interior, ventral valve interior, ×11 (Steinich, 1963).

Meonia STEINICH, 1963, p. 732 [**Terebratula semiglobularis* POSSELT, 1894, p. 35; OD]. Small, rounded shells with straight hinge line and narrow interarea, strongly planoconvex; anterior commissure rectimarginate or slightly sulcate; umbo short, foramen small, mesothyrid; capillae simple, granular. Cardinal process crenulated; hinge teeth with deep sockets on inner face; loop short, ventrally projecting; crural processes scarcely developed, narrow transverse band uniting broader converging crura; lophophore probably spirolophous, with spirals set at angle to plane of symmetry. *Upper Cretaceous, Paleogene (?Danian, ?Eocene):* Denmark, Sardinia, Spain, ?Gulf of Gascogne, *Upper Cretaceous;* Denmark, *?Danian;* Ukraine, *?Eocene.*——FIG. 1431,*2a–g.* **M. semiglobularis* (POSSELT); *a–d,* dorsal valve, lateral, anterior, ventral valve interior, ×3 (Muir-Wood, 1965a); *e–f,* dorsal valve interior showing loop, same, more posterior view; *g,* dorsal valve interior with brachial spirals silicified and part of interior restored, ×10 (Steinich, 1963).

Prochlidonophora THOMSON & OWEN, 1979, p. 28 [**P. muirwoodae;* OD]. Small, subcircular, costellate with spinules, planoconvex to incipiently biconvex; beak short, erect; foramen large, circular, mesothyrid; hinge line slightly extended, interarea long, beak ridges distinct; delthyrium well exposed, deltidial plates conjunct. Cardinalia and loop unknown. *Lower Cretaceous:* Antarctica (Alexander Island).——FIG. 1431,*3a–b.* **P. muirwoodae; a,* holotype, silicone rubber cast from external mold, ×5; *b,* latex cast from external mold of ventral valve, ×2 (Thomson & Owen, 1979).

Rugia STEINICH, 1963, p. 735 [**R. tenuicostata;* OD]. Minute, resembles *Terebratulina* in hinge characters and probable plectolophous lophophore, but differs in small size of adult shells, rectimarginate commissure, more elongate umbo, long tapering deltidial plates and long pedicle collar, hypothyrid foramen, and more granular shell surface. *Upper Cretaceous:* Denmark, Germany, Poland, England, Sweden, Spain.——FIG. 1432,*2a–g.* **R. tenuicostata; a–d,* dorsal, ventral, lateral, and anterior views; *e–f,* dorsal valve interior showing loop and crural processes in ventral and lateral views; *g,* ventral valve umbo showing deltidial plates, ×10 (Steinich, 1963).

Subfamily EUCALATHINAE Muir-Wood, 1965

[Eucalathinae MUIR-WOOD, 1965a, p. 811]

Transverse band of loop medially directed toward dorsal valve; lophophore spirolophous. *Paleogene (Eocene)–Holocene.*

Eucalathis FISCHER & OEHLERT, 1890, p. 72 [**Terebratulina? murrayi* DAVIDSON, 1878b, p. 437; OD]. Small, subtrigonal, auriculate, ventribiconvex, anterior commissure rectimarginate or incipiently uniplicate, hinge straight; surface capillate with rare intercalations or granular; umbo short, obliquely truncate; deltidial plates short, triangular, disjunct. Pedicle collar present, loop chlidonophorid but transverse band dorsally directed, socket ridges as narrow plates uniting with cardinal process, and anteriorly with crural bases; lophophore with 2 single whorl spirals set at angle to plane of symmetry, filaments long. *Paleogene (Eocene)–Holocene:* USA, *Eocene;* Italy, *Miocene;* cosmopolitan (185–3,870 m), *Holocene.*——FIG. 1433,*2a–e.* **E. murrayi* (DAVIDSON), Holocene, off Fiji Islands, Pacific Ocean; *a,* dorsal view, ×16; *b–c,* lateral and anterior views, ×9; *d–e,* dorsal valve interior showing lophophore, with loop, ×20 (Muir-Wood, 1965a).——FIG. 1433,*2f–j. E. ergastica* FISCHER & OEHLERT, Holocene, North Atlantic Ocean; *f–h,* dorsal, lateral, anterior views; *i,* ventral valve interior; *j,* dorsal valve interior with loop, ×4 (Muir-Wood, 1965a).

Bathynanus FOSTER, 1974, p. 79 [**B. tenuicostatus* FOSTER, 1974, p. 80; OD]. Very small, faintly capillate, subpentagonal in outline; foramen small, hypothyrid; deltidial plates disjunct. Cardinal process indistinct, socket ridges fusing with crural bases; crural plates extending anteriorly as low, narrow ridges on valve floor, crura short, flat, converging slightly; loop incomplete, lophophore zygolophous. *Holocene:* Pacific, Indian, Atlantic Oceans (3,843–5,160 m).——FIG. 1433,*1a–f.* **B. tenuicostatus,* southeastern Pacific Ocean; *a,* holotype, dorsal valve view, USNM 550282A; *b–c,* interior views of ventral and dorsal valves; *d,* dorsal valve interior, ×5; *e–f,* drawing of dorsal valve and dorsal valve interior, ×12.5 (Foster, 1974).

Nanacalathis ZEZINA, 1981a, p. 162 [**N. minuta;* OD]. Minute, biconvex, costate; beak suberect, foramen mesothyrid, deltidial plates conjunct. Cardinal process small, socket ridges fusing with crural bases; crura short, converging slightly; loop incomplete. *Holocene:* Indian Ocean, Atlantic Ocean (289–3,731 m).——FIG. 1434,*1a.* **N. minuta,* Indian Ocean; dorsal view, ×23 (Zezina, 1981c).——FIG. 1434,*1b–e. N.* sp, Atlantic Ocean; *b–c,* exterior and interior of dorsal valve, ×10; *d–e,* exterior and interior of ventral valve, ×10 (Cooper, 1973b).

Notozyga COOPER, 1977, p. 105 [**N. lowenstami;* OD]. Small, subpentagonal in outline, biconvex, hinge wide, costellae beaded. Differs from *Eucalathis* in having thick, wide crural bases, thick, angular crural processes, and a broad, rounded transverse band that does not extend anteriorly to crural processes. *Holocene:* Caribbean, Indian Ocean, Pacific Ocean.——FIG. 1434,*2a–e.* **N. lowenstami,* Caribbean; *a–d,* holotype, dorsal,

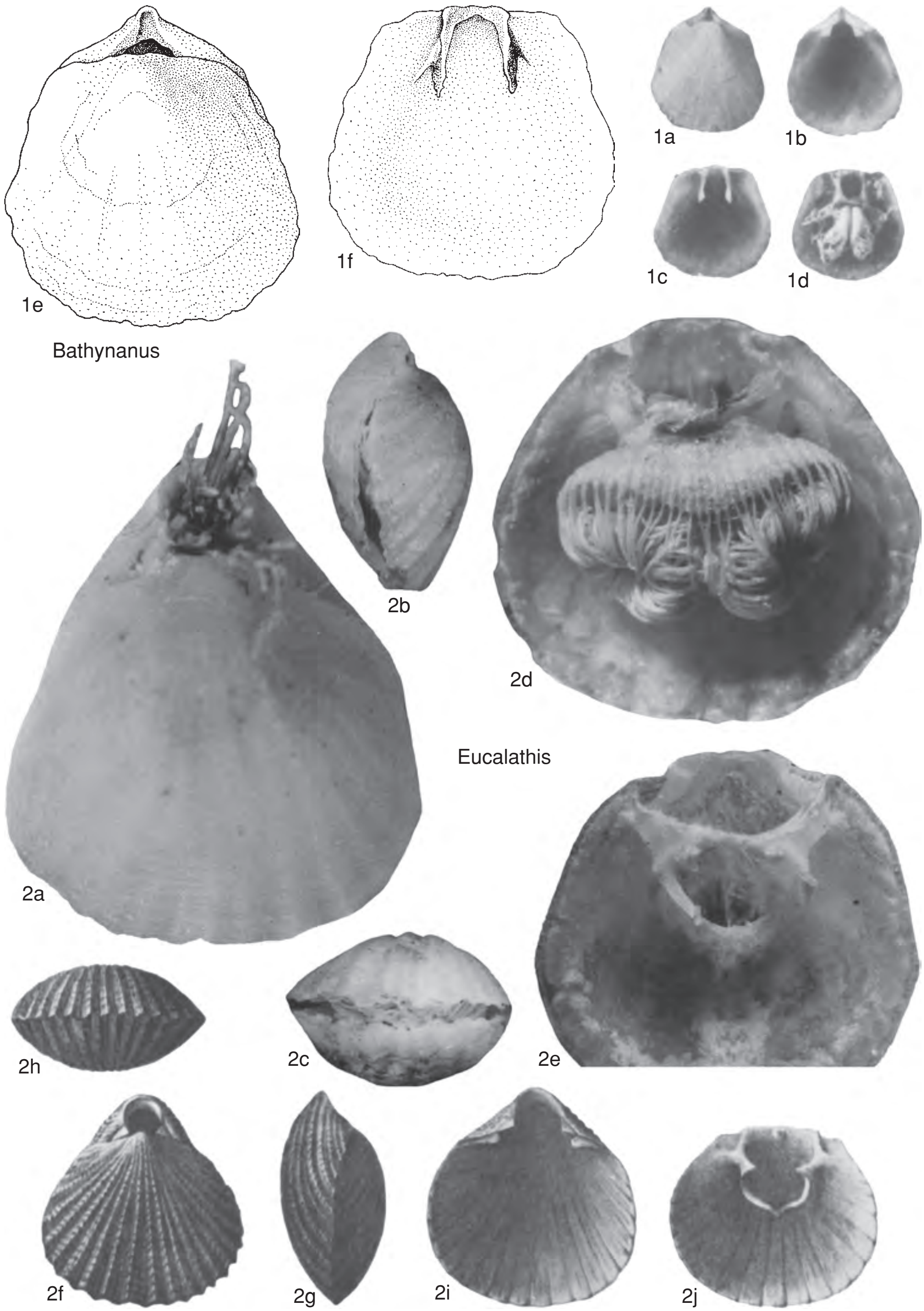

FIG. 1433. Chlidonophoridae (p. 2156).

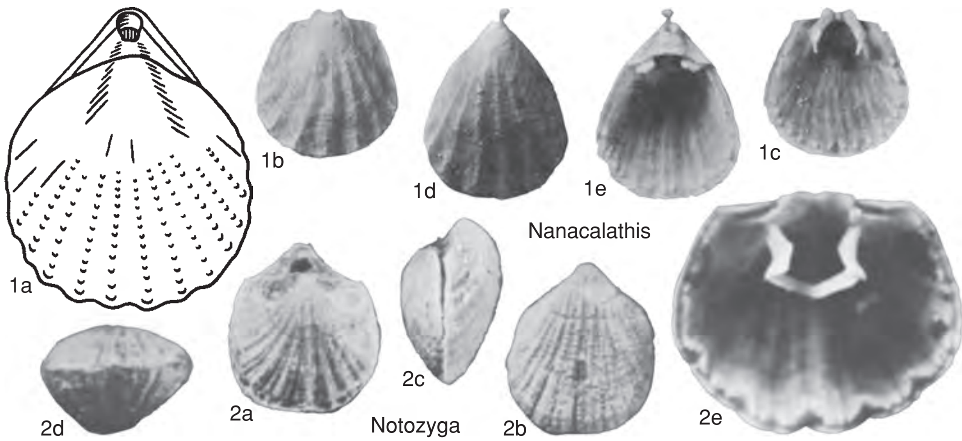

FIG. 1434. Chlidonophoridae (p. 2156–2158).

ventral, lateral, and anterior views, USNM 550591a, ×10; *e,* interior of dorsal valve, ×15 (Cooper, 1977).

Subfamily AGULHASIINAE Muir-Wood, 1965

[Agulhasiinae MUIR-WOOD, 1965a, p. 812]

With greatly elongated ventral beak and long pedicle collar. *Neogene (lower Miocene)–Holocene.*

Agulhasia KING, 1871, p. 109 [**A. davidsoni;* OD]. Small, rounded trigonal; rostrate, with greatly elongated ventral beak one-third of valve length; biconvex, with faint, ventral median sulcus, anterior commissure rectimarginate to unisulcate; deltidial plates disjunct, separated by long, narrow, sunken apical plate forming elongated pedicle collar; foramen anterior, hypothyrid. Hinge teeth longitudinally grooved and articulating with socket ridges, cardinal process large, knoblike; loop rather long, narrow, and anteriorly rounded; internal shell margin strongly crenulated. *Neogene (lower Miocene)–Holocene:* South Africa, *lower Miocene;* South Atlantic and southern Indian Ocean (off South Africa, 78–800 m), *Holocene.*——FIG. 1435,*1a–g.* **A. davidsoni,* Holocene, Agulhas Bank; *a–d,* dorsal, ventral, lateral, and anterior views, ×6; *e–f,* interior of ventral and dorsal valve, ×6; *g,* dorsal valve interior showing loop, ×12 (Cooper, 1973b).

Subfamily DRACIINAE Steinich, 1967

[Draciinae STEINICH, 1967, p. 1,145]

Small, dorsal valve smooth, ventral valve ribbed; foramen amphithyrid, transverse band strongly arched posteroventrally. *Upper Cretaceous (Campanian–Maastrichtian).*

Dracius STEINICH, 1967, p. 1,146 [**D. carnifex;* OD]. Small, planoconvex to concavoconvex, anterior commissure rectimarginate; beak short; foramen amphithyrid; dorsal valve nearly smooth, ventral valve ribbed; deltidial plates disjunct. Socket ridges high, projecting above hinge line, cardinal process absent; crura flattened, with short, ventrally directed crural processes; transverse band strongly arched toward posterior margin; lophophore subplectolophous. *Upper Cretaceous (Campanian–Maastrichtian):* Germany, Denmark, England.——FIG. 1435,*3a–f.* **D. carnifex,* lower Maastrichtian, Rugen; *a–d,* holotype, dorsal valve, ventral valve, lateral, and anterior views, ×9; *e–f,* dorsal valve interiors, ×15 (Steinich, 1967).

Subfamily ORTHOTHYRIDINAE Muir-Wood, 1965

[Orthothyridinae MUIR-WOOD, 1965a, p. 813]

Small, costate, concavoconvex chlidonophorids. *Upper Cretaceous.*

Orthothyris COOPER, 1955a, p. 64 [**O. radiata;* OD]. Small, subcircular in outline with wide, straight hinge, slightly biconvex, becoming concavoconvex; anterior commissure broadly sulcate; ornament of coarse costae medianly and anteriorly, and posteriorly mediolaterally directed costellae; delthyrium margined by elevated deltidial plates, interarea well developed, beak ridges strong, foramen small. Sockets deep, with erect socket ridges; crura short, stout, crural processes large, expanded; loop a thin ribbon, projecting ventrally, attached to socket ridges; interior margin scalloped anteriorly. *Upper Cretaceous:*

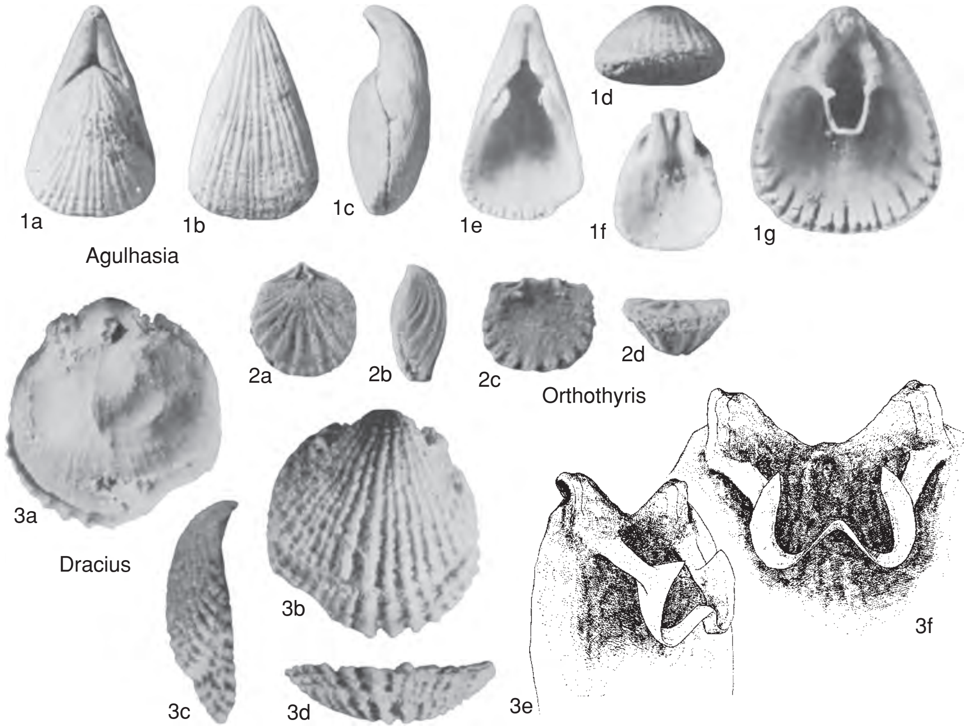

FIG. 1435. Chlidonophoridae (p. 2158–2159).

Caribbean, India.——FIG. 1435,*2a–d.* **O. radiata,* Habana Province, Cuba; *a–c,* holotype, dorsal, lateral, and anterior views, USNM 108687; *d,* dorsal interior view, ×8 (Cooper, 1973c).

Family CNISMATOCENTRIDAE Cooper, 1973

[Cnismatocentridae COOPER, 1973c, p. 389]

Small to large, smooth or capillate with ornament of radial striae; deltidial plates conjunct; cardinalia with strong, elevated socket ridges, no definable outer hinge plates; crural processes anterior, loop very wide and slightly arched, narrow transverse band; musculature like that of *Terebratulina* with dorsal adjustors on dorsal valve floor. *Upper Cretaceous–Holocene.*

Subfamily CNISMATOCENTRINAE Cooper, 1983

[Cnismatocentrinae COOPER, 1983, p. 45]

Large, capillate, uniplicate; foramen large. *Holocene.*

Cnismatocentrum DALL, 1920, p. 321 [**Terebratula (Liothyris) sakhalinensis* DALL, 1908, p. 28; OD]. Large, stout, biconvex, anterior commissure uniplicate, surface smooth or anteriorly capillate; umbo stout; foramen large, deltidial plates conjunct, symphytium exposed. Pedicle collar with short septum; cardinal process small, prominent; low median ridge in dorsal valve; socket ridges attached to valve wall and prolonged anteriorly over flat crura at their bases; crural processes short; loop very wide, slender, almost flattened, transverse band narrow and medially folded; lophophore

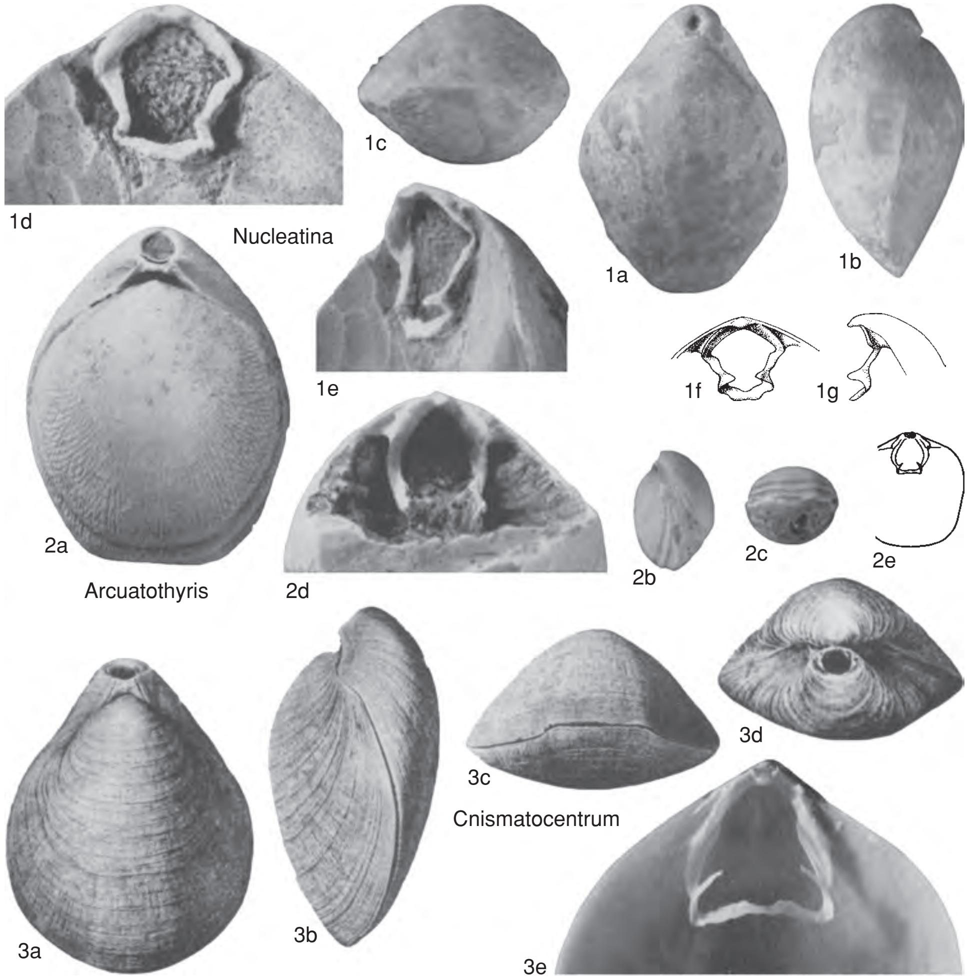

FIG. 1436. Cnismatocentridae (p. 2159–2161).

plectolophous. *Holocene:* Sakhalin Island, Okhotsk Sea, Japan, USA (Alaska).——FIG. 1436,*3a–e.* **C. sakhalinensis* (DALL); *a–d,* holotype, dorsal valve, lateral, anterior, and posterior views, off Sakhalin, USNM 110786A, ×1; *e,* interior of dorsal valve, Chignik Bay, Alaska, ×2 (Cooper, 1983).

Subfamily ARCUATOTHYRIDINAE Katz, 1974

[*nom. transl. et correct.* COOPER, 1983, p. 221, *ex* Arquatothyrididae KATZ, 1974, p. 267]

Small to medium, smooth or with ornament of radial striae, rectimarginate to slightly uniplicate or unisulcate, loop short, crural processes small and anterior. *Upper Cretaceous.*

Arcuatothyris POPIEL-BARCZYK, 1972, p. 136 [**Terebratula arcuata* ROEMER, 1841, p. 44; OD]. Shell medium size, biconvex, oval to pentagonal in outline, anterior commissure rectimarginate or unisulcate, shell ornament of irregular, radial striae; beak large, suberect, foramen large, permesothyrid, symphytium distinct. Cardinal process small with distinct myophore; socket ridges stout, long, high; crural bases narrow, small, triangular; thin plate separating socket ridge and fulcral plate; loop short, straight, transverse band narrow, nearly horizontal ribbon attached just beyond anterior end of crural processes. *Upper Cretaceous (Cenomanian):* Germany, England, France, Poland, Russia.——FIG.

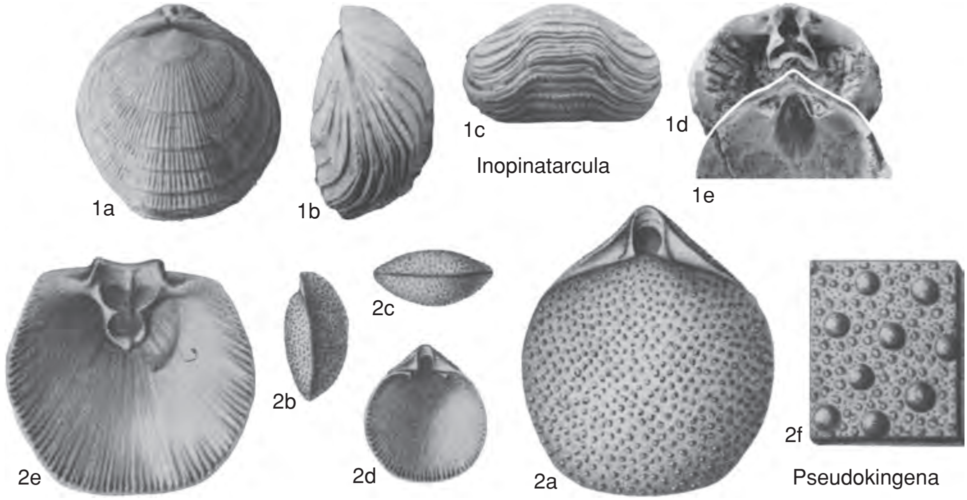

FIG. 1437. Inopinatarculidae and Uncertain (p. 2161–2162).

1436,*2a–e*. **A. arcuata* (ROEMER), Rouen, France; *a,* dorsal view, ×3; *b–c,* ventral and anterior views, ×1; *d,* dorsal valve with cardinalia exposed, ×3; *e,* drawing of ventral view of loop, ×1 (Cooper, 1983).

Nucleatina KATZ, 1962, p. 135 [**Terebratula nanclasi* COQUAND, 1862, p. 237; OD]. Medium to large, subcircular to elongate pentagonal, biconvex, anterior commissure uniplicate; smooth or with faint radial ornament; beak short, suberect; foramen large, permesothyrid, symphytium hidden. Cardinal process small, narrow, semielliptical; inner socket ridges well developed, incurved laterally; crural bases developing directly from lateral valve sides in front of socket ridges; loop short, wide posteriorly, narrow and truncated anteriorly. *Upper Cretaceous:* France, Russia, Spain, central Asia, southern India, northern Africa, southern Europe.——FIG. 1436,*1a–g*. **N. nanclasi* (COQUAND), Santonian, Rouen, France; *a–c,* dorsal, lateral, and anterior views, ×1; *d–e,* dorsal valves showing loops; *f–g,* drawings of loops, ×1 (Cooper, 1983).

Family INOPINATARCULIDAE Muir-Wood, 1965

[*nom. transl.* COOPER, 1983, p. 45, *ex* Inopinatarculinae MUIR-WOOD, 1965a, p. 800]

Small, costellate, foramen small, anterior commissure uniplicate; crural processes large, transverse band fairly broad longitudinally, moderately arched. *Lower Cretaceous (Albian)–Upper Cretaceous (Campanian).*

Inopinatarcula ELLIOTT, 1952, p. 2 [**Trigonosemus acanthodes* ETHERIDGE, 1913, p. 15; OD]. Small, subcircular in outline, biconvex, anterior commissure uniplicate; surface finely costellate, costellae with short spines; beak short, suberect; foramen minute, permesothyrid, symphytium triangular, transversely rugose. Cardinal process small, trilobed; socket ridges erect, massive; fulcral plates thick, massive, no outer hinge plates; crural bases concealed beneath thickened socket ridges; crura short, crural processes short; transverse band broad, medially arched. *Lower Cretaceous (Albian)–Upper Cretaceous (Campanian):* Australia, *Santonian–Campanian;* New Zealand, *Albian.*——FIG. 1437,*1a–e*. **I. acanthodes* (ETHERIDGE), Senonian, Australia; *a–c,* dorsal, lateral, and anterior views, ×2; *d–e,* dorsal valve, ventral valve interiors, ×2 (Cooper, 1983).

Family UNCERTAIN

Pseudokingena BOESE & SCHLOSSER, 1900, p. 177 [**Terebratulina deslongchampsi* DAVIDSON, 1850c, p. 450; OD]. Small, rounded or quadrate, ventribiconvex; dorsal valve may have shallow sulcus; anterior commissure rectimarginate or slightly folded; shell surface granular, with 2 sizes of tubercles; beak short, palintrope well defined; beak ridges well defined; foramen hypothyrid; deltidial plates narrow, disjunct. Pedicle collar present; dental plates absent; inner shell surface around margins capillate. Cardinalia like those of *Terebratulina;* loop short (about 0.3 dorsal valve length), similar to that of *Eucalathis. Lower Jurassic:* England, France,

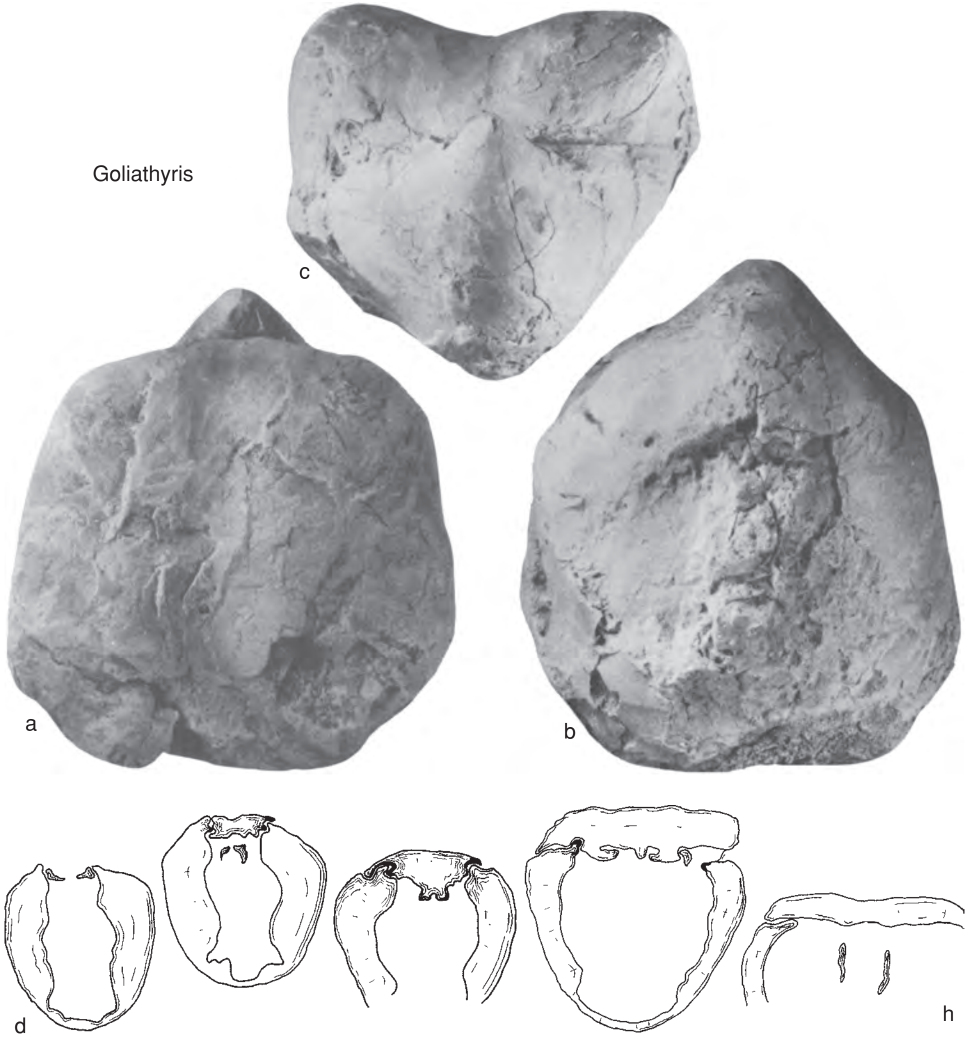

FIG. 1438. Uncertain (p. 2162).

Italy.——FIG. 1437,*2a–f.* **P. deslongchampsi* (DAVIDSON), France; *a,* dorsal view, ×4; *b–c,* lateral and anterior views, ×2; *d,* interior of ventral valve, ×2; *e,* interior of dorsal valve, ×4; *f,* ornament, enlarged (Muir-Wood, 1965a).

Superfamily UNCERTAIN

Goliathyris FELDMAN & OWEN, 1988, p. 4 [**G. lewyi;* OD]. Very large, thick shelled, smooth, subpentagonal in outline, concavoconvex or planoconvex, ventral valve almost carinate; strongly unisulcate, foramen small, permesothyrid; beak incurved; cardinal process massive, bilobate; hinge plates weakly differentiated from inner socket ridges, horizontal, becoming concave toward floor of dorsal valve; loop unknown. *Middle Jurassic (Callovian):* Sinai.——FIG. 1438*a–h.* **G. lewyi; a–c,* dorsal, lateral, and posterior views of holotype, GSI M7261a, ×1; *d–h,* serial transverse sections, ×0.5 (Feldman & Owen, 1988).

INVALID GENERIC NAME ASCRIBED TO BRACHIOPODA

Eudesites RIOULT, 1966, p. 74 [**E. deslongchampsia;* OD]. Parageneric name applied to brachiopod spicules.

TEREBRATELLIDINA

D. I. MacKinnon,[1] D. E. Lee,[2] P. G. Baker,[3] T. N. Smirnova,[4]
A. S. Dagys,[5] and Sun Dong-li[6]

[[1]University of Canterbury; [2]University of Otago; [3]University of Derby; [4]Moscow State University; [5]deceased, formerly of Lithuanian Academy of Sciences; and [6]Nanjing Institute of Geology and Paleontology]

Suborder TEREBRATELLIDINA Muir-Wood, 1955

[*nom. correct.* Muir-Wood & Stehli, 1965, p. 730, *pro* suborder Terebratelloidea Muir-Wood, 1955, p. 79]

All long-looped terebratulides in which the loop develops by a complex ontogeny that always involves either a septal pillar or median septum. *Upper Triassic–Holocene.*

ZEILLERIOIDEA

Peter G. Baker

[University of Derby]

Superfamily ZEILLERIOIDEA Allan, 1940

[*nom. transl.* Kyansep, 1961, p. 80, *ex* Zeilleriidae Allan, 1940a, p. 269]

Small to large, outline variable, biconvex, less commonly ventribiconvex or globose, rarely dorsiconvex or planoconvex, anterior commissure variable, shell smooth, less commonly costate, or exceptionally with rugae, umbo normally small to moderate size, rarely massive, typically short, suberect to strongly incurved, with well-defined, curved beak ridges, deltidial plates conjunct, or exceptionally disjunct or forming symphytium, pedicle foramen small to large, mesothyrid to permesothyrid; pedicle collar present or absent, shell without callus, or apical only, thick umbonal callus rarely developed; teeth moderate, rarely large, dental plates present, slender to thick, unenveloped, partially enveloped, or completely enveloped in callus, variably disposed, cardinal process rarely developed (except in one family), inner socket ridges occasionally deflected dorsally or ventrally, outer hinge plates normally not demarcated from inner socket ridges, ventrally concave or convex, crural bases and loop given off dorsally or ventrally, or mesially exceptionally, hinge plates fused, inner hinge plates or crural plates present, septalium present or absent, adult loop teloform, moderate to long, slender, with no adult connection with median septum, with or without spines, descending branches, ascending branches, and transverse band typically narrow, transverse band typically posterior, loop development associated with septal pillar very early in ontogeny (except in one family), dorsal adductor scars variable; shell attached throughout life by pedicle emerging through apically resorbed delthyrium. *Lower Triassic (Induan)–Holocene.*

Family ZEILLERIIDAE Allan, 1940

[*nom. correct.* Allan, 1940a, p. 269, *pro* Zeilléridés Rollier, 1915, p. 14]

Small to medium size, rarely larger, shell smooth, exceptionally with costae developed anteriorly or rugate or capillate; umbo normally moderate size, with angular beak ridges, deltidial plates normally conjunct, pedicle foramen typically small, commonly telate; pedicle collar commonly developed, thick umbonal callus developed exceptionally; teeth large exceptionally, dental plates typically short, straight, ventrally divergent; outer hinge plates demarcated exceptionally, commonly convex ventrally, crural plates typically forming shallow, broadly V-shaped septalium, supported by a low, bladelike, short to moderate median septum, transverse band of loop typically posterior, loop rarely smooth, spines normally numerous on descending branches, rarely forming anterior fringe, rarely occurring on both descending and ascending branches, loop development associated with septal pillar very early in ontogeny (in some genera). [Authorship and date of this family would be ROLLIER, 1915, if generally accepted by paleontologists (ICZN, 1999, *Code,* Art. II, c, iii) but ALLAN, 1940a has come to be recognized instead.] *Lower Triassic (Induan)–Holocene.*

Subfamily ZEILLERIINAE Allan, 1940

[*nom. transl.* BAKER, herein, *ex* Zeilleriidae ALLAN, 1940a, p. 269]

Large exceptionally, outline commonly subpentagonal or variant, valves commonly lobate, bilobate, or quadrilobate, biconvex, less commonly ventribiconvex or globose, anterior commissure typically rectimarginate, commonly unisulcate, umbo long exceptionally, typically with persistent beak ridges, extended exceptionally, deltidial plates, exceptionally disjunct or forming symphytium, pedicle foramen typically oval, commonly telate; dental plates unenveloped, or enveloped exceptionally, relatively strong, commonly long; cardinal process absent, or exceptionally represented by callus lobe, crural bases given off dorsally, septalium occasionally U- or W-shaped, occasionally deep, median septum commonly triangular, rarely acutely triangular, rarely long, transverse band of loop occasionally broad, with posterior projections. *Lower Triassic (Induan)–Upper Jurassic (Kimmeridgian), Lower Cretaceous (?Berriasian–?Hauterivian).*

Zeilleria BAYLE, 1878, expl. pl. 9 (no page number) [**Terebratula cornuta* J. de C. SOWERBY, 1824 in 1823–1825, p. 66; SD DOUVILLÉ, 1879, p. 275] [=*Columellithyris* TCHORSZHEVSKY & RADULOVIĆ, 1984, p. 164 (type, *C. novoselica* TCHORSZHEVSKY & RADULOVIĆ, 1984, p. 165, OD); *Sinusella* SUČIĆ-PROTIĆ, 1985, p. 26 (type, *S. laskarevi,* OD)]. Small to large, subpentagonal, bilobate or quadrilobate outline, biconvex, becoming anteriorly lobate with no posterior dorsal sulcation, umbo suberect to much incurved, beak ridges clearly delimiting palintropes, foramen permesothyrid, commonly telate; pedicle collar absent, dental plates strong, slightly inwardly concave, ventrally divergent; cardinal process exceptionally represented by callus lobe, hinge plates ventrally deflected and convex ventrally in section, septalium broadly U-shaped, commonly with anterior median groove, median septum triangular in cross section, extending about 0.3 valve length, loop almost reaching anterior, with spinose, descending branches, connection between anterior of loop and septal pillar early in ontogeny; dorsal adductor scars subcircular. [Distinction of *Columellithyris,* based on the absence of inner hinge plates and the unresorbed remnant of a septal pillar, cannot be sustained, as a septalium is clearly present and a septal pillar remnant is present in the ontogeny of *Zeilleria.* Distinction based on three specimens and resting solely on the presence of a shallow sulcus in the anterior half of the ventral valve is not valid; *Sinusella* is therefore regarded as a synonym of *Zeilleria.*] ?*Upper Triassic, Lower Jurassic–Middle Jurassic:* Europe (or cosmopolitan), *Lower Jurassic.*——FIG. 1439,*1a–d.* **Z. cornuta* (J. de C. SOWERBY), middle Lias, Somerset, England; *a–c,* dorsal, lateral, anterior views; *d,* internal mold showing adductor scars, ×1.3 (Muir-Wood, 1965b).——FIG. 1439,*1e. Z. quadrifida* (VALENCIENNES in LAMARCK), middle Lias, France; dorsal view showing quadrilobation, ×0.7 (Muir-Wood, 1965b).——FIG. 1439,*1f–uu. Z. leckenbyi* (DAVIDSON *ex* WALKER MS), lower Aalenian, Gloucestershire, England; *f,* dorsal valve interior, reconstruction, ×1.3 (Baker, 1972); *g–aa,* serial transverse sections, early juvenile shell, 0.15, 0.36, 0.45, 0.54, 0.69, 0.75, 0.87, 0.99, 1.20, 1.29, 1.59, 1.74, 1.80, 1.86, 1.92, 2.04, 2.07, 2.10, 2.46, 2.79, 3.12 mm from umbo, ×4; *bb–uu,* serial transverse sections, adult shell 1.4, 2.8, 3.5, 4.2, 4.9, 5.6, 7.0, 7.7, 9.1, 9.8, 11.2, 11.9, 12.6, 15.4, 16.1, 16.8, 19.6, 20.3, 21.0, 21.7 mm from umbo, ×0.65 (adapted from Baker, 1972).

Ajukuzella OVTSHARENKO, 1983b, p. 165–166 [**A. ajukuzensis* OVTSHARENKO, 1983b, p. 166; OD]. Rounded-square or rounded-pentagonal in outline, strongly ventribiconvex, anterior commissure rectimarginate or incipiently uniplicate, umbo small, suberect, with short, subangular beak ridges, foramen permesothyrid; poorly developed pedicle collar occasionally present; outer hinge plates very narrow, deflected ventrally, septalium broadly U-shaped with crural plates curved ventrally to form low, median ridge, median septum triangular in cross section, extending about 0.3 valve length, crural processes long, arched, loop relatively short, barely extending 0.4 valve length. *Middle Jurassic:* Tadzhikistan, Pamirs.——FIG. 1440,*4a–c.* **A. ajukuzensis,* Tadzhikistan; dorsal, lateral, anterior views, ×1 (new).

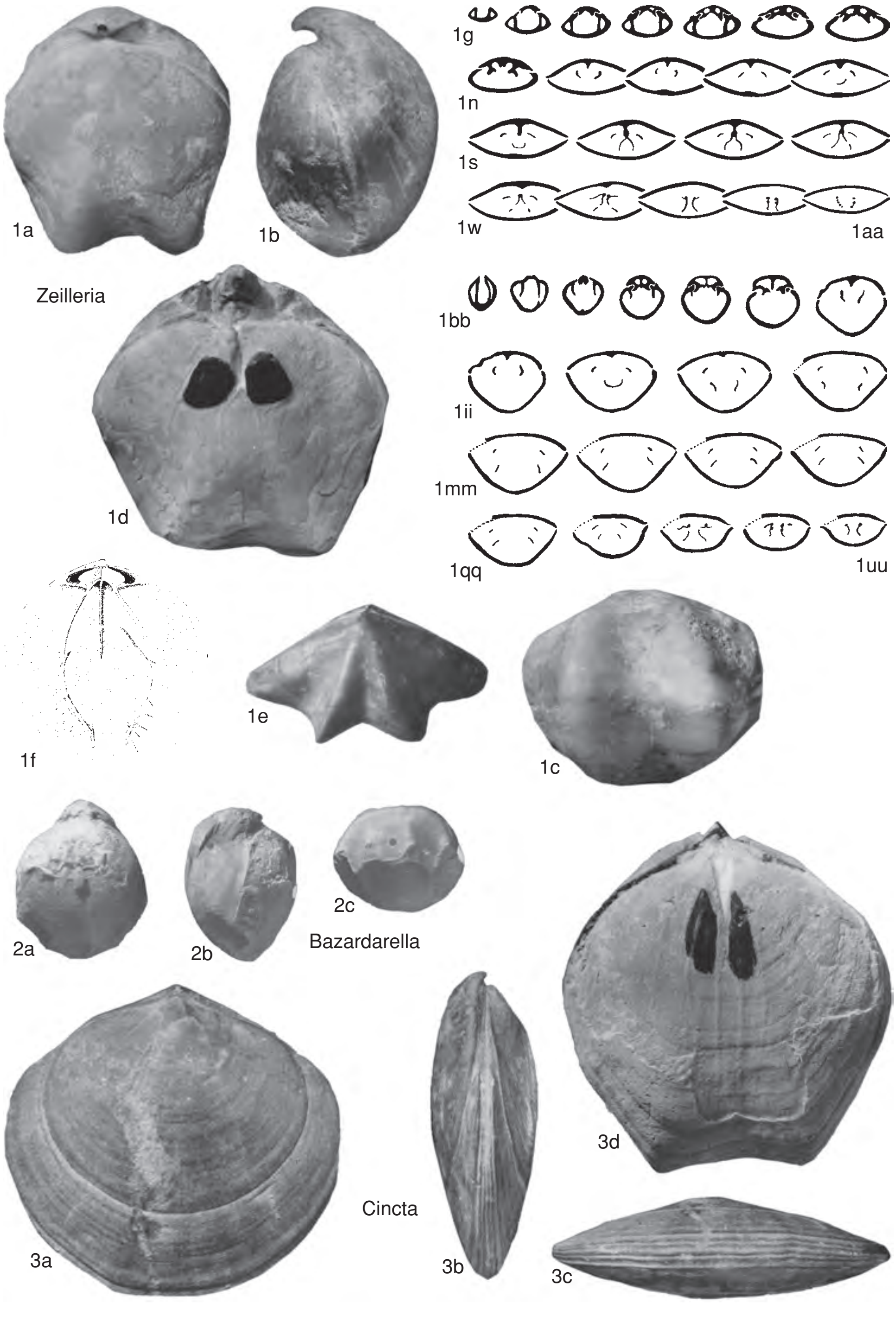

FIG. 1439. Zeilleriidae (p. 2164–2169).

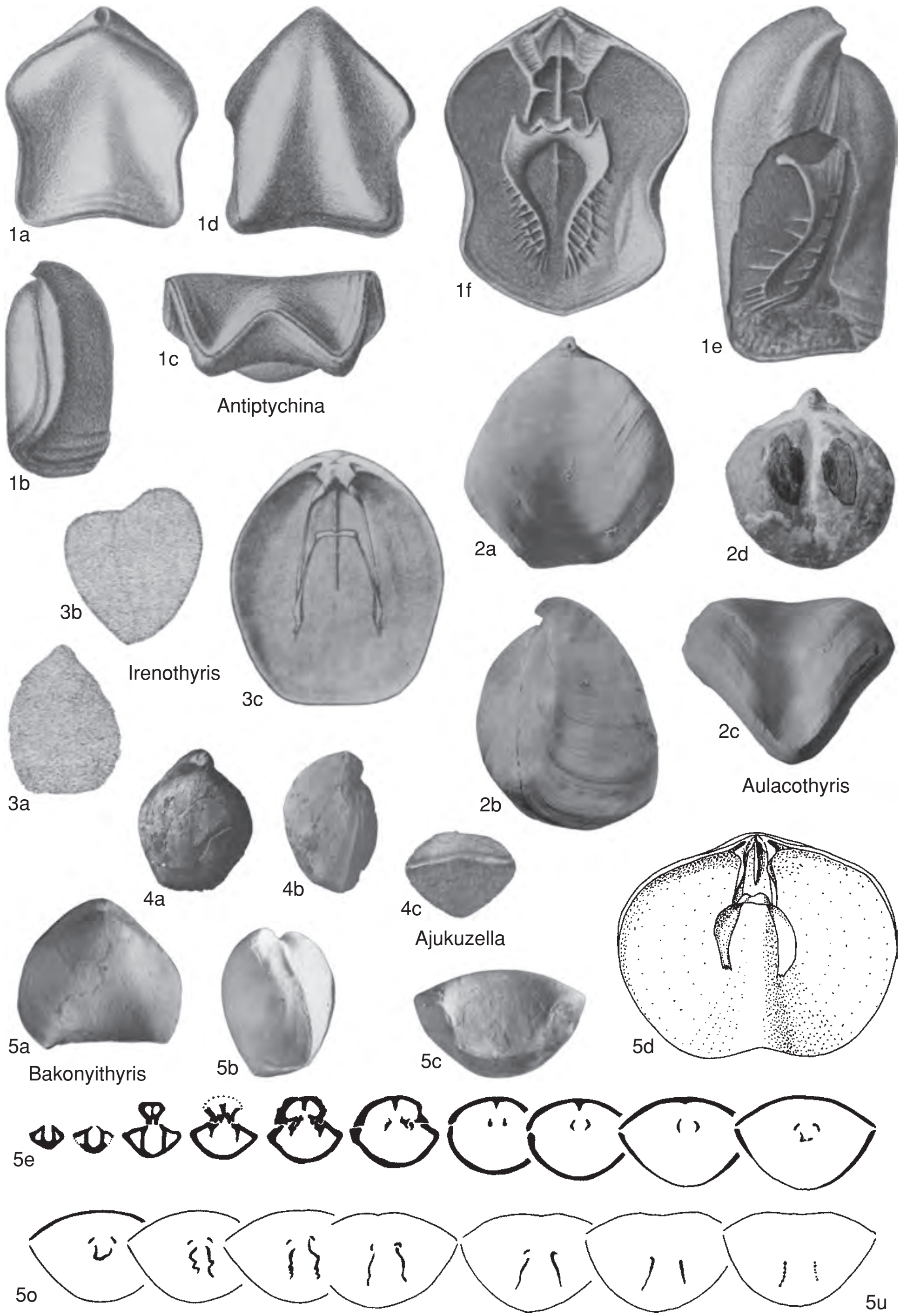

FIG. 1440. Zeilleriidae (p. 2164–2169).

Antiptychina Zittel, 1880, p. 704 [**Terebratula bivallata* Deslongchamps, 1860, p. 20 (p. 7 of separate); SD Eudes-Deslongchamps, 1884, p. 268]. Small, oblong-pentagonal to quadrilobate in outline, flatly biconvex, ventral valve carinate with median sulcus, dorsal valve sulcate with median fold, anterior commissure biplicate, umbo fine tapering, suberect with long, angular beak ridges extending to anterolateral margin, foramen elliptical, possibly epithyrid; cardinal process represented by small callus knob, septalium possibly broadly U-shaped, median septum long, bladelike or acutely triangular in cross section, extending for almost 0.75 valve length, loop with long spines on both ascending and descending branches, broad transverse band with two lateral, posteriorly projecting carinae separated from median lobe by deep concavity. [Cretaceous record relates to unnamed terebratulid homeomorph.] *Middle Jurassic (Bajocian)–Upper Jurassic (Oxfordian):* France, Germany, Czech Republic, Slovakia, Austria, *Bajocian.*——Fig. 1440,*1a–f.* **A. bivallata* (Deslongchamps), upper Bajocian, France; *a–d,* dorsal, lateral, anterior, ventral views, ×2; *e,* breached shell showing lateral view of loop, ×3; *f,* dorsal valve interior, ×2.5 (Muir-Wood, 1965b).

Aulacothyris Douvillé, 1879, p. 277 [**Terebratula resupinata* J. Sowerby, 1816 in 1815–1818, p. 116; OD]. Subpentagonal in outline, strongly ventribiconvex or concavocarinate to planoconvex, anterior commissure normally unisulcate, umbo small, flattened, incurved with palintrope strongly demarcated, pedicle foramen permesothyrid, commonly telate, interior of shell commonly with much callus thickening; pedicle collar not observed, dental plates angled, subparallel to ventrally convergent; hinge plates convex ventrally, not clearly demarcated from inner socket ridges, septalium rounded V-shaped, median septum moderately high, triangular in cross section, about 0.5 valve length, connection between anterior of loop and septal pillar early in ontogeny, dorsal adductor scars elongate-oval, anterior scars about half size of posterior scars. *?Triassic, Lower Jurassic (lower Pliensbachian)–Middle Jurassic (Aalenian), ?Upper Jurassic:* Europe, ?cosmopolitan.——Fig. 1440,*2a–d.* **A. resupinata* (J. Sowerby), Pliensbachian, Somerset, England; dorsal, lateral, anterior views, dorsal valve interior mold showing adductor scars, ×1.3 (Muir-Wood, 1965b).

Bakonyithyris Vörös, 1983, p. 22 [**Waldheimia pedemontana* Parona, 1893, p. 49; OD]. Small, subpentagonal to rounded outline, anterior commissure unisulcate, umbo small, incurved, pedicle foramen very small, mesothyrid, deltidial plates disjunct, dental plates long, parallel; crural processes incurved, septalium deep, V-shaped, median septum acutely triangular in cross section, extending barely 0.25 valve length, loop moderate, descending branches slender, ascending branches expanded, uniting with transverse band to form hoodlike structure, anterior of loop with fringe of short spines. *Lower Jurassic (Sinemurian–Pliensbachian):* Sicily, Apennines, southern Alps, West Carpathians, Hungary, Crimea, *Sinemurian.*——Fig. 1440,*5a–u.* **B. pedemontana* (Parona), Pliensbachian, Ibex Zone, Bakony Mountains, Kericser, Hungary; *a–c,* dorsal, lateral, anterior views, ×2 (Vörös, 1983); *d,* dorsal valve interior reconstruction, ×3.5; *e–u,* serial transverse sections, 0.3, 0.5, 0.7, 0.85, 1.0, 1.2, 1.5, 1.7, 2.1, 2.5, 2.7, 2.8, 3.0, 3.3, 3.7, 4.3, 4.6 mm from umbo, ×2.5 (adapted from Vörös, 1983).

Bazardarella Ovtsharenko, 1983b, p. 159–160 [**B. bazardarensis* Ovtsharenko, 1983b, p. 160; OD]. Medium size, rounded or oval, biconvex, unevenly bisulcate with folds distinctively developed anteriorly, umbo small, incurved to strongly incurved with short, subangular beak ridges; hinge teeth simple with small denticulum, dental plates inwardly concave, becoming ventrally convergent; outer hinge plates broad, ventrally convex, dorsally deflected, crural plates ventrally convex, combined effect producing septalium replaced by median ridge for most of length and whole structure with flattened, W-shaped section, lateral umbonal cavities with apical callus, crural processes short, divergent, median septum extending almost 0.5 valve length, excavated, as in *Rugitela,* to leave narrow cardinal shelf; dorsal adductor scars rather broad, parallel or slightly diverging. *Middle Jurassic:* Tadzhikistan, Pamirs.——Fig. 1439,*2a–c.* **B. bazardarensis,* Tadzhikistan; dorsal, lateral, anterior views, ×1 (new).

Calpella Owen & Rose, 1997, p. 508 [**Zeilleria aretusa* Di Stefano, 1887, p. 93; OD]. Small, subpentagonal in outline with maximum width in anterior third, equally biconvex, anterior commissure rectimarginate, anterior half of shell costate with 10 to 12 costae originating from midvalve area and radiating anteriorly, umbo short, suberect, with subangular beak ridges clearly delimiting palintropes, pedicle foramen permesothyrid, comparatively large; median septum prominent, extending slightly more than 0.5 valve length, other internal characters unknown. *Lower Jurassic (?upper Sinemurian):* Gibraltar, Sicily, Morocco.——Fig. 1441,*2a–c.* **C. aretusa* (Di Stefano), lower Lias, Gibraltar; dorsal, lateral, anterior views, ×1.5 (Owen & Rose, 1997).

Cincta Quenstedt, 1868 in 1868–1871, p. 25 [**Terebratula numismalis* Valenciennes in Lamarck, 1819, p. 249; SD Dall, 1877a, p. 20] [=*Cinctopsis* Sučić-Protić, 1985, p. 45 (type, *C. luka,* OD)]. Subcircular to pentagonal in outline, growth lines prominent, weakly biconvex, anteriorly lobate, umbo acute, suberect, beak ridges short, foramen minute mesothyrid; dental plates angled, ventrally convergent, commonly embedded in callus; hinge plates slightly ventrally inclined, septalium rounded V-shaped becoming deep U-shaped, median septum triangular in cross section, extending about 0.3 valve length, dorsal adductor scars elongate-oval, tapering posteriorly. [The characters cited for

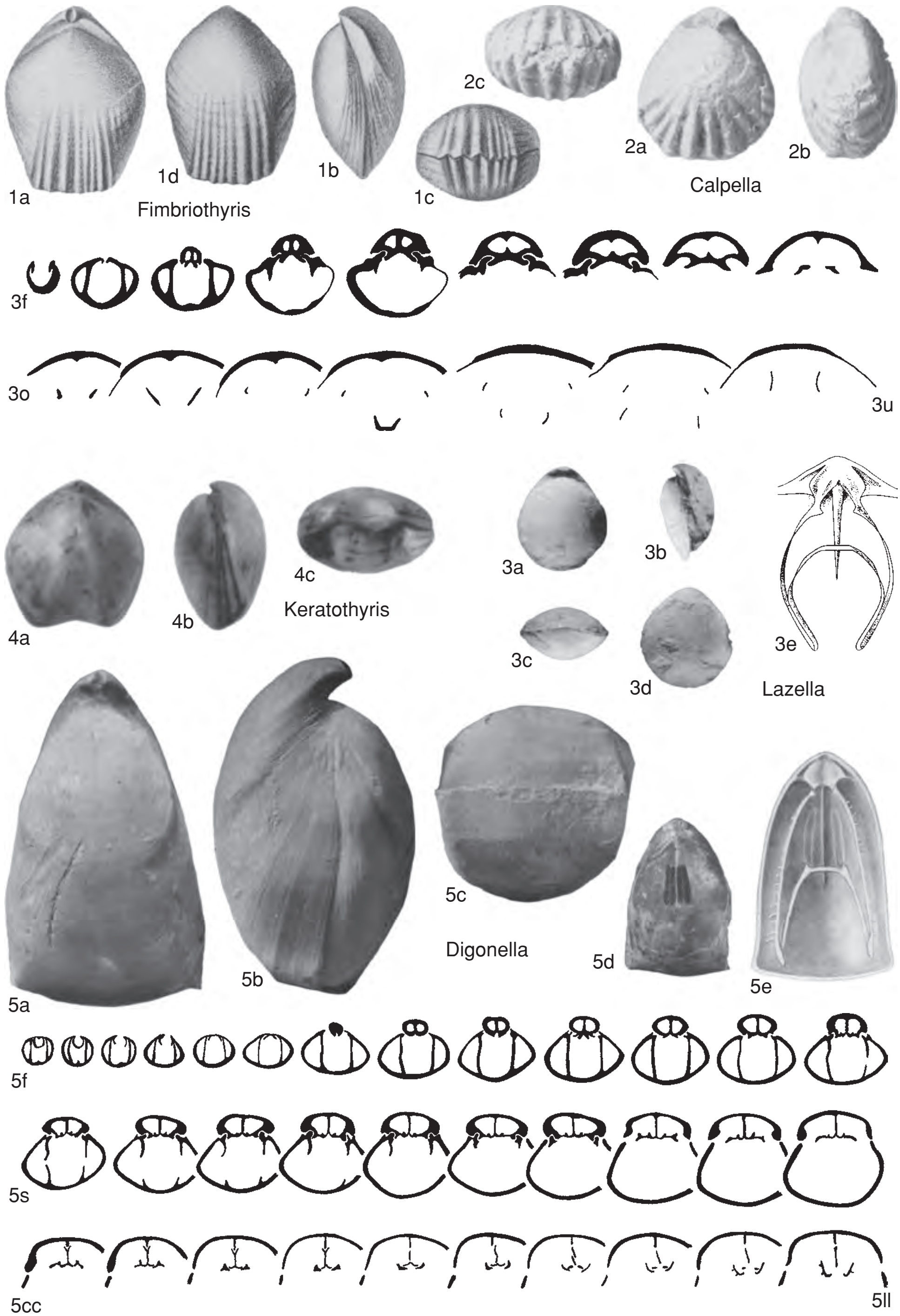

FIG. 1441. Zeilleriidae (p. 2167–2170).

distinction of *Cinctopsis* are trivial and fall well within the range of characters exhibited by other *Cincta* species. *Cinctopsis* is therefore regarded as a synonym.] *Lower Jurassic (Hettangian)–Middle Jurassic (lower Bajocian):* Europe (?cosmopolitan). ——FIG. 1439, *3a–c.* **C. numismalis* (VALENCIENNES), Pliensbachian, France; dorsal, lateral, anterior views, ×1.3 (Muir-Wood, 1965b).——FIG. 1439,*3d. C. pernumismalis* BUCKMAN, England; internal mold showing dorsal adductor scars and vascular trunks, ×1 (Muir-Wood, 1965b).

Digonella MUIR-WOOD, 1934, p. 550 [**Terebratula digona* J. SOWERBY, 1815 in 1812–1815, p. 217; OD]. Elongate to sac shaped in outline, greatest width anteriorly with development of angular carinae, concavocarinate posteriorly, becoming biconvex, umbo flattened, suberect with short beak ridges, foramen mesothyrid or permesothyrid, telate; pedicle collar with septum, dental plates slender, subparallel; hinge plates demarcated from inner socket ridges, slightly concave ventrally, septalium open V-shape, becoming almost flat with median groove anteriorly, median septum bladelike, slightly more than 0.5 valve length, loop with numerous long spines, transverse band with posteriorly projecting carinae; dorsal adductor scars linear, adjacent to septum. *Middle Jurassic (Bathonian):* England, France.——FIG. 1441,*5a–ll.* **D. digona* (J. SOWERBY), Great Oolite Series, southern England; *a–c,* dorsal, lateral, anterior views, ×2; *d,* dorsal valve interior mold showing adductor scars, ×1 (Muir-Wood, 1965b); *e,* dorsal valve interior, reconstruction, ×1.5 (Muir-Wood, 1934); *f–ll,* serial transverse sections, 1.0, 1.2, 1.3, 1.4, 1.6, 1.9. 2.9, 3.3, 3.7, 3.8, 3.9, 4.0, 4.2, 4.3, 4.5, 4.6, 4.7, 4.8, 5.0, 5.1, 5.3, 5.4, 5.5, 6.1, 6.3, 6.5, 6.7, 6.8, 6.9, 7.3, 7.5, 7.7, 7.9 mm from umbo, ×1.25 (adapted from Muir-Wood, 1934).

Eoantiptychia XU & LIU, 1983b, p. 97 [**Antiptychia pentagona* YANG & YIN in YANG & others, 1962, p. 122; OD]. Small, pentagonal in outline, unequally biconvex, anterior commissure unisulcate initially, becoming biplicate, umbo erect or slightly incurved, palintropes small, foramen mesothyrid; pedicle collar present; inner socket ridges well developed, hinge plates narrow, crural processes high, crural plates convex distally, giving septalium open V-shape posteriorly, becoming deep, truncated V-shape anteriorly, median septum broadly triangular in cross section, approximately 0.3 valve length, loop descending branches slender, ascending elements unknown. *Middle Triassic:* China (Qinghai Province, Junzihe Formation).——FIG. 1442,*1a–e.* **E. pentagona* (YANG & YIN), South Dajialian Member, southern Qilian Mountains; dorsal, lateral, anterior, ventral, posterior views, ×1 (Xu & Liu, 1983b).

Fimbriothyris EUDES-DESLONGCHAMPS, 1884, p. 273 [**Terebratula guerangeri* DESLONGCHAMPS, 1856a, p. 304; OD]. Subpentagonal in outline and laterally compressed, equally biconvex, without median fold or sulcus, umbo suberect, with long, subangular beak ridges delimiting narrow palintropes, foramen permesothyrid, telate, symphytium narrow, anterior half of shell costate medianly, costae simple, subparallel, rare on lateral slopes; dental plates long, slender, subparallel; inner socket ridges and hinge plates convex ventrally, septalium deep posteriorly, becoming broad, shallow, U-shaped, septalial plates incompletely fused, leaving small cavity below septalium, median septum bladelike, becoming acutely triangular in cross section anteriorly, extending only about 0.3 of valve length. *Lower Jurassic (upper Pliensbachian):* Europe, ?Morocco.——FIG. 1441,*1a–d.* **F. guerangeri* (DESLONGCHAMPS), Sarthe, France; dorsal, lateral, anterior, ventral views, ×1 (Muir-Wood, 1965b).

Irenothyris POJARISKAJA, 1966, p. 27 [**Zeilleria guldaraensis* MOISSEEV, 1944, p. 60; OD]. Medium size, subpentagonal, subtrigonal or rounded in outline, globose, becoming anteriorly lobate or metacarinate, anterior commissure rectimarginate, umbo acute, strongly incurved, beak ridges rounded, foramen mesothyrid to epithyrid; pedicle collar present, hinge teeth short, thick, with weakly developed denticulum; dental plates slender; outer hinge plates ventrally concave in juveniles, forming troughlike structure but in adults almost planar due to secondary thickening combined with ventrally convex crural plates to form T-shaped septalium unsupported anteriorly as in *Rugitela,* median septum thin, high, extending about 0.5 valve length, loop long, ascending elements relatively wide, dorsal adductor scars elongate, pyriform, close to septum; mantle canals parallel. *Upper Jurassic:* Russia, western Europe.——FIG. 1440,*3a–c.* **I. guldaraensis* (MOISSEEV), Gusapski region, River Guldara, Russia; *a–b,* dorsal, lateral views, ×1 (Moisseev, 1944); *c,* dorsal valve interior, reconstruction, ×1.5 (Pojariskaja, 1966).

Keratothyris TULUWEIT, 1965, p. 76 [**Terebratula cor* LAMARCK, 1819, p. 249; OD] [=*Spinulothyris* ANTOSTSCHENKO, 1973, p. 112 (type, *S. patilensis* ANTOSTSCHENKO, 1973, p. 113, OD)]. Small, subpentagonal to incipiently bilobate in outline, biconvex to slightly globose, anterior commissure paraplicate to rectimarginate or weakly unisulcate, lobate, umbo broad, erect to incurved, with clearly delimited palintropes, foramen mesothyrid, commonly telate; inner socket ridges dorsally deflected, septalium open V-shaped, becoming U-shaped anteriorly, median septum moderately high, lateral umbonal cavities with thick apical callus, connection between anterior of loop and septal pillar early in ontogeny. [External and internal similarity of *Spinulothyris* to *Keratothyris,* together with coincident distribution and loss of all comparative material of *Spinulothyris,* renders *Spinulothyris* inseparable from *Keratothyris.*] *Lower Jurassic (Sinemurian–Toarcian):* France, Switzerland, *Sinemurian;* Crimea, Caucasus, Yugoslav Carpatho-Balkan arch, western Europe, *Pliensbachian;* Germany, France, *Toarcian.*——FIG. 1441,*4a–c.* **K. cor* (LAMARCK), Pliensbachian, Echte, northwestern Germany; dorsal, lateral, anterior views, ×1 (Tuluweit, 1965).

Kolymithyris DAGYS, 1965, p. 148 [**Zeilleria kolymensis* MOISSEEV, 1937, p. 3; OD]. Medium size, oval in outline, umbo short, incurved, pedicle foramen minute, mesothyrid; pedicle collar absent, dental plates angled, slightly ventrally divergent, enveloped in thick umbonal callus; cardinal process massive callus structure, undivided, projecting into delthyrial cavity, anteriorly fused with inner socket ridges, outer hinge plates, and crural plates, internal structures much obscured by umbonal callus but in section, inner socket ridges deflected ventrally, septalium V-shaped, median septum low, triangular, extending about 0.25 valve length, loop long, without spines, transverse band with laterally projecting carinae. *Upper Triassic (Carnian–Norian):* northeastern Siberia; ?New Zealand, *Norian.*——FIG. 1443,*1a–bb.* **K. kolymensis* (MOISSEEV), Norian, Kolyma River Basin, northeastern Siberia; *a–c,* dorsal, anterior, ventral views, ×1 (Dagys, 1965); *d–bb,* serial transverse sections, 0.2, 0.7, 1.0, 1.3, 1.7, 2.0, 2.3, 2.6, 2.8, 3.0, 3.2, 3.4, 3.6, 3.8, 4.1, 4.8, 5.3, 6.1, 7.0, 7.8, 9.0, 9.4, 10.3, 12.2, 17.0 mm from umbo, ×1.25 (adapted from Dagys, 1965).

Kuntella OVTSHARENKO, 1991, p. 112 [**K. kuntensis;* OD]. Small to medium size, subpentagonal to elongate pentagonal in outline, anterior commissure rectimarginate to incipiently uniplicate, umbo small, suberect with short, rounded-angular beak ridges, pedicle foramen small, apparently round, apparently permesothyrid; pedicle collar not observed, dental plates very short, subparallel to slightly ventrally convergent; inner socket ridges deflected dorsally, outer hinge plates flat, septalium open U-shape initially, becoming flat anteriorly, wholly supported by median septum except for narrow, anterior cardinal shelf, median septum thin, moderately high, extending more than 0.5 valve length, loop about 0.75 valve length, transverse band moderately broad with posterior projections. *Middle Jurassic–Upper Jurassic:* Pamir.——Fig. 1443,*3a–c.* **K. kuntensis,* Middle Jurassic; dorsal, lateral, and anterior views, ×1.5 (Ovtsharenko, 1991).

Lazella RADULOVIĆ, 1991, p. 29 [**L. nana* RADULOVIĆ, 1991, p. 30; OD]. Small, oval, anterior commissure rectimarginate to incipiently uniplicate, umbo relatively long, erect, beak ridges clearly delimiting palintropes, pedicle foramen round, mesothyrid, deltidial plates disjunct, incurved; poorly developed pedicle collar occasionally present, hinge teeth massive, dental plates slender, inner socket ridges slightly deflected dorsally, outer hinge plates demarcated from inner socket ridges, septalium very shallow, broadly U-shaped, median septum triangular in cross section, extending about 0.5 valve length, excavated, as in *Plesiothyris,* to leave narrow, cardinal shelf. *Middle Jurassic (upper Bajocian–Bathonian):* Yugoslav Carpatho-Balkan arch.——FIG. 1441,*3a–u.* **L. nana,* upper Bajocian, Laz, Yugoslavia; *a–d,* dorsal, lateral, anterior, ventral views, ×1; *e,* dorsal valve interior, reconstruction, ×5 (Radulović, 1991); *f–u,* serial transverse sections, 0.3, 1.3, 1.7, 2.0, 2.3, 2.6, 2.7, 2.9, 3.4, 4.0, 4.5, 5.0, 6.4, 6.9, 8.2, 9.6 mm from umbo, ×2 (adapted from Radulović, 1991).

Mycerosia COOPER, 1989, p. 117 [**M. amygdaliformis;* OD]. Small, pentagonal in outline, maximum width in posterior third, ventribiconvex, anterior commissure rectimarginate with slight tendency to uniplication, umbo small, erect, with rounded-angular beak ridges, foramen medium size, mesothyrid, slightly telate; short pedicle collar, dental plates short; septalium flattish, with or without low median elevation, median septum thin, high, bladelike, slightly less than 0.5 valve length, crural bases given off possibly dorsally, loop extending for about four fifths of valve length, descending and ascending branches spinose, transverse band narrow laterally, wide ventrodorsally with short projections extending dorsally from junction with ascending lamellae. *Middle Jurassic (?Bathonian, Callovian)–Upper Jurassic (Kimmeridgian):* ?Egypt, *?Bathonian;* Saudi Arabia, *Callovian.*——FIG. 1444,*1a–d.* **M. amygdaliformis,* Kimmeridgian, Hanifa Formation, Jebel Tuwaiq, Saudi Arabia; *a–c,* dorsal, lateral, anterior views, ×3; *d,* dorsal valve interior, showing spinose loop, ×2 (Cooper, 1989).

Obovothyris BUCKMAN, 1927, p. 32 [**O. magnobovata;* OD]. Subpentagonal in outline with angular, anterolateral carinae, sulcocarinate posteriorly, becoming biconvex, umbo suberect to incurved, with short, subangular beak ridges, pedicle foramen permesothyrid; pedicle collar with stout septum; septalium very shallow, flatly undulating, median septum bladelike, slightly more than 0.5 valve length; dorsal adductor scars elongate-oval, tapering posteriorly. *Middle Jurassic (Bathonian):* England, France.——FIG. 1445,*1a–e.* **O. magnobovata,* Lower Cornbrash, England; *a–c,* dorsal, lateral, anterior views; *d,* interior mold showing dorsal adductor scars, ×1.3 (Muir-Wood, 1965b); *e,* dorsal valve interior, reconstruction, ×1 (Muir-Wood, 1934).

Parathyridina SCHUCHERT & LEVENE, 1929b, p. 121, *nom. nov. pro Parathyris* DOUVILLÉ, 1916, p. 35, *non* HÜBNER, 1816 [**Parathyris plicatoides* DOUVILLÉ, 1916, p. 36; OD]. Small to medium size, shell equally biconvex to globose without prominent fold or sulcus, anterior commissure uniplicate with superimposed, alternating costation, costae few, broad, near anterior margin only; umbo short, suberect, with obscure beak ridges, foramen possibly permesothyrid, symphytium narrow, median septum prominent, clearly visible on partially worn shells, other internal characters unknown. [The presence of a strong median septum is regarded as strong evidence that *Parathyridina* is a zeilleriid resembling the Liassic *Fimbriothyris.*] *Middle Jurassic (Bajocian):* Egypt, Sinai Peninsula.——FIG. 1443,*2a–b.* **P. plicatoides* (DOUVILLÉ), Egypt; dorsal, anterior views, ×1 (Muir-Wood, 1965a).

Periallus HOOVER, 1979, p. 17 [**P. woodsidensis;* OD]. Small, pyriform in outline, unequally biconvex, anterior commissure rectimarginate to uniplicate or paraplicate, umbo broad, suberect with prominent beak ridges, pedicle foramen large, mesothyrid, deltidial plates disjunct; pedicle collar clearly devel-

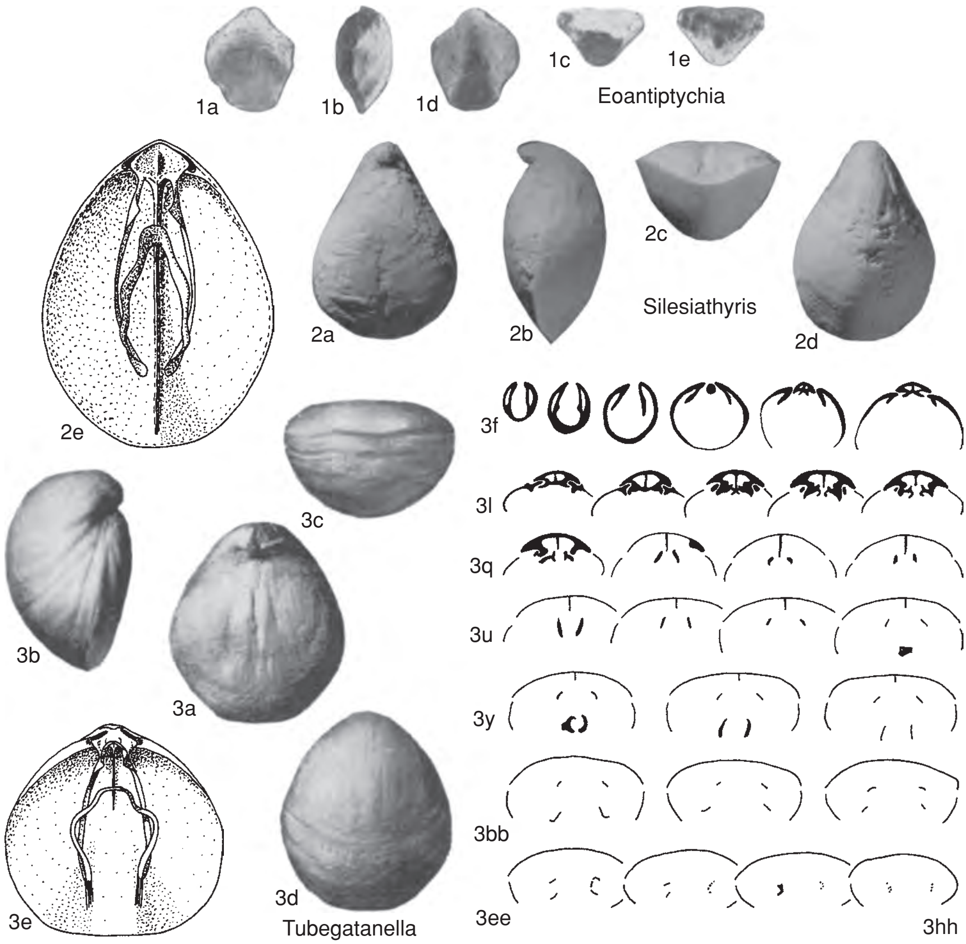

FIG. 1442. Zeilleriidae (p. 2169–2176).

oped, dental plates subparallel, hinge teeth well developed, ventral muscle scars elongate-triangular; hinge plates narrow, flat, arising at about midheight of inner socket ridges, crural bases possibly given off mesially in some specimens, crural plates variably disposed from vertical, joining valve floor, to dorsomesially directed, forming small acute septalium, median septum bladelike, approximately 0.5 valve length, loop moderate, commonly 0.6 valve length, dorsal surface of descending branches, profusely spinose, no trace of septal pillar involvement in loop development in specimens only 2.00 mm long. *Lower Triassic (Induan–Olenekian):* USA (southeastern Idaho).——FIG. 1443,*6a–g*. **P. woodsidensis,* Woodside Formation, Bear Lake; *a–c,* dorsal, lateral, anterior views, ×3; *d,* fragment of articulated valves showing pedicle collar, strong dental plates, and median septum, ×8; *e,* dorsal valve, anteroventral view showing individual in which septalial plates do not contact median septum; *f,* dorsal valve interior showing form of septalium developed; *g,* dorsal valve interior showing spinose descending branch of loop and portion of ascending branch, ×6 (Hoover, 1979).

Pirotella SUČIĆ-PROTIĆ, 1985, p. 22 [**P. petkovici;* OD]. Large, elongate oval to subpentagonal in outline, anterior commissure commonly undulating, umbo slightly incurved, with short, rounded, angular beak ridges, pedicle foramen round, small to moderate, permesothyrid; dental plates slightly inwardly concave, slightly ventrally divergent; median septum triangular in cross section, extending about 0.3 valve length, loop transverse band narrow to moderate. *Lower Jurassic (upper Pliensbachian):* Yugoslav Carpatho-Balkanids.——FIG. 1445,*2a–e*. **P. petkovici,* Stara Planina, Senokos, Serbia; *a–d,* dorsal, lateral, anterior, ventral views, ×1; *e,* dorsal valve interior, reconstruction, ×1.2 (Sučić-Protić, 1985).

Plesiothyris DOUVILLÉ, 1879, p. 275 [**Terebratula (Waldheimia) verneuili* EUDES-DESLONGCHAMPS, 1864, p. 268; OD] [=*Rhomboidella* SUČIĆ-PROTIĆ,

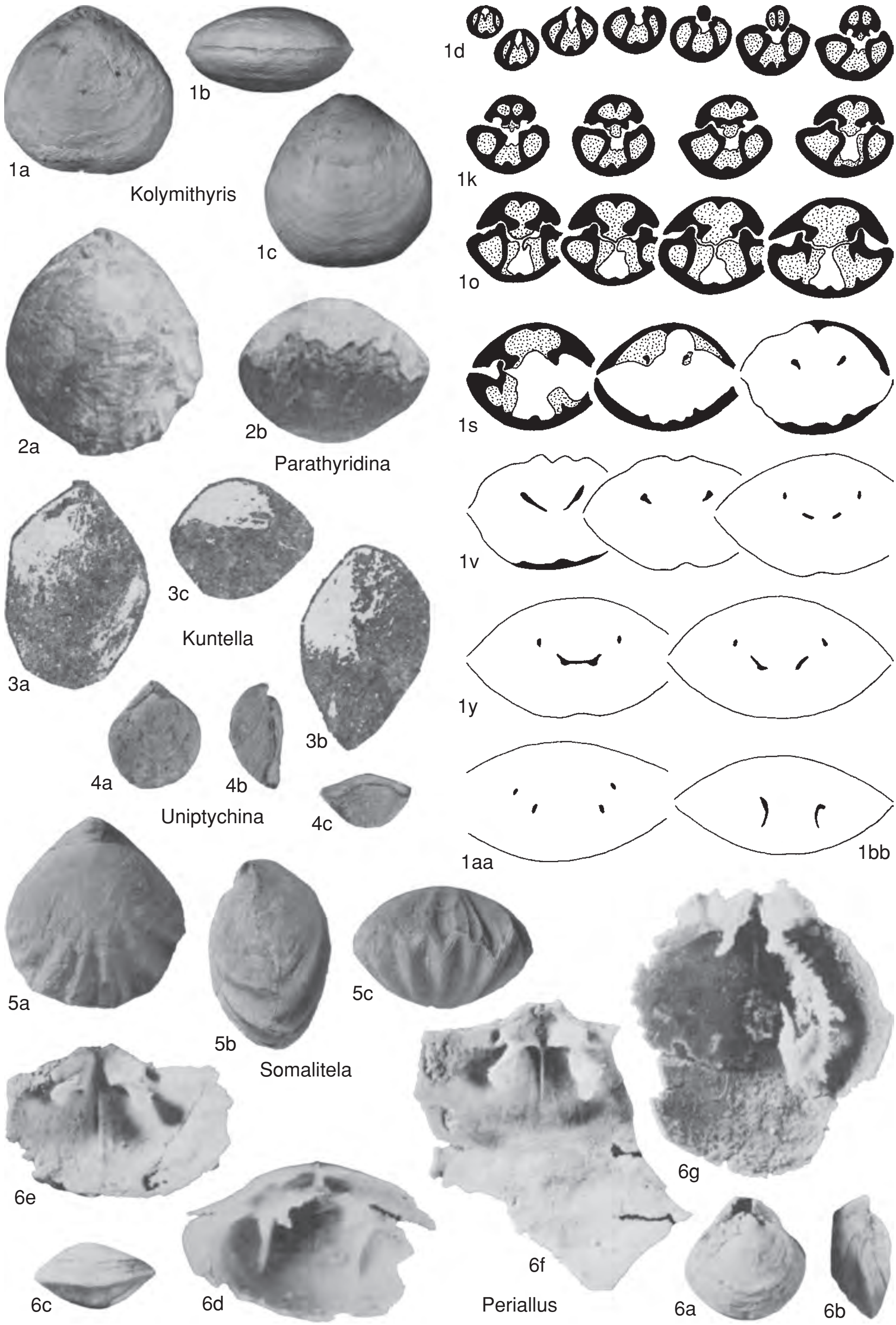

FIG. 1443. Zeilleriidae (p. 2170–2176).

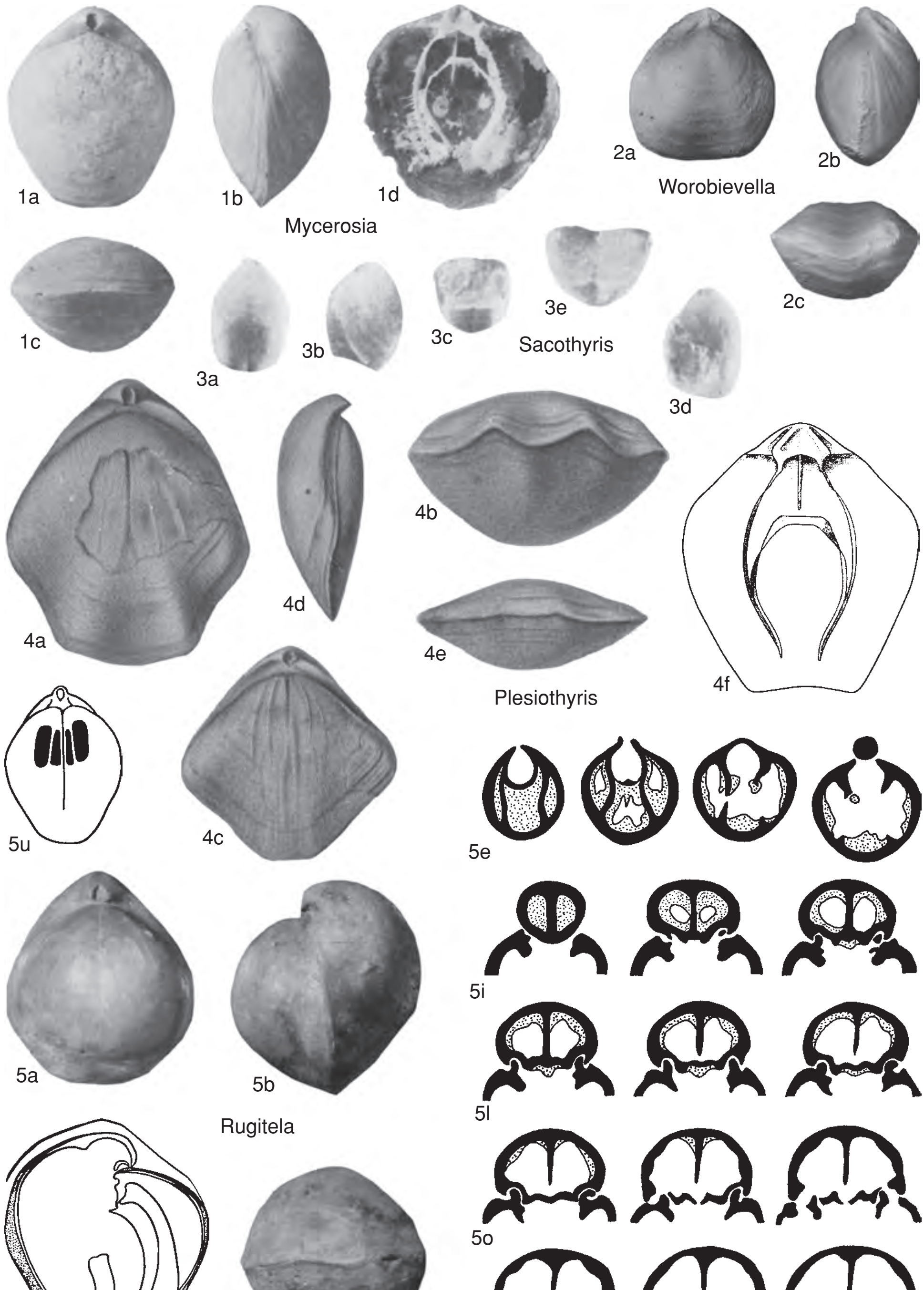

FIG. 1444. Zeilleriidae (p. 2170–2176).

1985, p. 30 (type, *R. rhombica,* OD)]. Medium size, pentagonal in outline, moderately biconvex, anteriorly bilobate or quadrilobate, anterior commissure rectimarginate or sulciplicate, umbo suberect to incurved, beak ridges long, sharply demarcating palintropes, pedicle foramen commonly telate, permesothyrid, symphytium short; dental plates long, subparallel; hinge plates flat in section, septalium V-shaped, becoming broad, open, U-shape anteriorly, median septum acutely triangular in cross section, extending about 0.3 valve length, excavated beneath anterior of septalium to leave narrow cardinal shelf, loop almost reaching anterior; dorsal adductor scars linear, apparently similar to *Digonella.* [Distinction of *Rhomboidella* is based on only four specimens; its small size and close approximation to the morphology of a juvenile *Plesiothyris,* together with the form of the median septum and similarity of the septalium to the early-formed septalium and immature loop of *Plesiothyris* is considered to render *Rhomboidella* synonymous.] *Lower Jurassic:* Spain, France, Yugoslavia.——FIG. 1444,*4a–e.* **P. verneuili* (EUDES-DESLONGCHAMPS), upper Pliensbachian; *a,* dorsal view, Spain; *b,* anterior view, adult specimen, Spain; *c–d,* dorsal, lateral view, Spain; *e,* anterior view, immature specimen, Spain, ×1 (Muir-Wood, 1965b).——FIG. 1444,*4f. P. beli* SUČIĆ-PROTIĆ, Senokos, Serbia; dorsal valve interior, reconstruction, ×1.5 (Sučić-Protić, 1985).

Rugitela MUIR-WOOD, 1936, p. 121 [**Terebratula bullata* J. de. C. SOWERBY, 1823 in 1823–1825, p. 49; OD] [=*Russiella* MAKRIDIN, 1964, p. 288 (type, *Terebratula royeriana* D'ORBIGNY, 1845a, p. 484)]. Medium size, elongate-oval to bilobate in outline, sulcocarinate in early stages, becoming biconvex, commonly globose, anterior commissure rectimarginate, lobate, umbo suberect to incurved, with short, subangular beak ridges, pedicle foramen mesothyrid or permesothyrid, telate, shell surface with concentric rugae; pedicle collar rarely observed, dental plates angled, thickened by callus; septalium replaced by callus ridge anteriorly, inner socket ridges, hinge plates, and median callosity forming W-shaped structure, median septum long, high, bladelike or acutely triangular in cross section, extending 0.7 valve length, supporting posterior half of crural plates only, structures thickened by umbonal callus, loop possibly without spines; dorsal adductor scars elongate-oval. [The characters cited for distinction of *Russiella* are trivial and fall well within the range of characters exhibited by other *Rugitela* species. Separation based essentially on the form of the median septum is not acceptable. *Russiella* is therefore regarded as a synonym.] *Lower Jurassic (Toarcian)–Middle Jurassic (Bathonian), Lower Cretaceous (?Berriasian–?Hauterivian):* England, France; Saudi Ababia, *Toarcian.*——FIG. 1444,*5a–t.* **R. bullata* (J. de C. SOWERBY), Bathonian, Fullers Earth Rock, Frome, southern England; *a–c,* dorsal, lateral, anterior views; *d,* longitudinal section showing loop, ×1.3 (Muir-Wood, 1965b); *e–t,* serial transverse sections, 0.4, 2.5, 2.7, 2.9, 3.9, 4.2, 4.3, 4.5, 4.9, 5.1, 5.2, 5.3, 5.6, 5.8, 6.1, 6.5 mm from umbo, ×1.2 (adapted from Muir-Wood, 1936).——FIG. 1444,*5u. R. cadomensis* (EUDES-DESLONGCHAMPS), Fullers Earth Rock, Bath, southern England; dorsal valve interior mold, showing median septum and adductor muscle scars, ×0.7 (Muir-Wood, 1965b).

Sacothyris CHING, SUN, & YE, 1979, p. 214 [**Aulacothyropsis sinosa* JIN & FANG, 1977, p. 64; OD]. Rounded oblong in outline, ventribiconvex, sulcocarinate, broadening anteriorly, anterior commissure unisulcate or plicosulcate, umbo incurved, beak ridges rounded, pedicle foramen mesothyrid, symphytium present; pedicle collar present, dental plates slender; septalium moderately deep, median septum very long, extending almost to anterior margin, crural processes high, loop ascending branches vertical, platelike, transverse band thin or wide, arched belt. *Upper Triassic:* Tibet, China (Qinghai, Sichuan, Yunnan Provinces).——FIG. 1444,*3a–e.* **S. sinosa* (JIN & FANG), Benzilan, Yunnan Province; dorsal, lateral, anterior, ventral, anterior views of plicosulcate specimen, ×1 (Ching, Sun, & Ye, 1979).

Securina VÖRÖS, 1983, p. 23 [**Waldheimia securiformis* GEMMELLARO, 1874, p. 66; OD]. Medium size, trigonal in outline, umbo strong, incurved, beak ridges angular in both valves, extended, reaching anterolateral extremities of shell, demarcating well-developed, concave planareas, pedicle foramen mesothyrid; inner socket ridges deflected dorsally, crura of falcifer type, septalium V-shaped, median septum slender, loop almost reaching anterior, descending branches straight, divergent, ascending branches wide, uniting with wide, arched transverse band, loop apparently without spines. *Lower Jurassic (Sinemurian–Pliensbachian):* Betic Cordilleras, Saharan Atlas, Sicily, Apennines, southern Alps, northern Limestone Alps, West Carpathians, Hungary, *Sinemurian.*——FIG. 1445,*3a–r.* **S. securiformis* (GEMMELLARO), Sinemurian, Bakony Mountains, Urkut, Hungary; *a–c,* dorsal, lateral, anterior views, ×2 (Vörös, 1983); *d,* dorsal valve interior, reconstruction, ×2.5; *e–r,* serial transverse sections, 1.8, 2.2, 2.6, 3.5, 4.3, 5.6, 6.1, 6.3, 6.9, 7.4, 9.0, 10.5, 12.0, 13.0 mm from umbo, ×1.5 (adapted from Vörös, 1983).

Silesiathyris BRÜGGE, 1977, p. 664 [**Terebratulites angustus* VON SCHLOTHEIM, 1820, p. 285; OD]. Small, pyriform to subpentagonal in outline, ventribiconvex or concavocarinate, dorsal valve with persistent sulcus, widening anteriorly, anterior commissure unisulcate, umbo long, erect, with short, rounded-angular beak ridges, pedicle foramen elongate-oval, moderate, epithyrid; dental plates slender, very short, inwardly concave, subparallel, concealed by callus in apical region; hinge plates flat, septalium wide, posterior concavity soon replaced by median ridge, giving open W-shape anteriorly, median septum rounded-triangular in cross section, extending almost to anterior, loop ascending branches wider, transverse band broad, acutely arched posteriorly, loop apparently without spines. *lower Middle Triassic:* Poland.——FIG. 1442,*2a–e.*

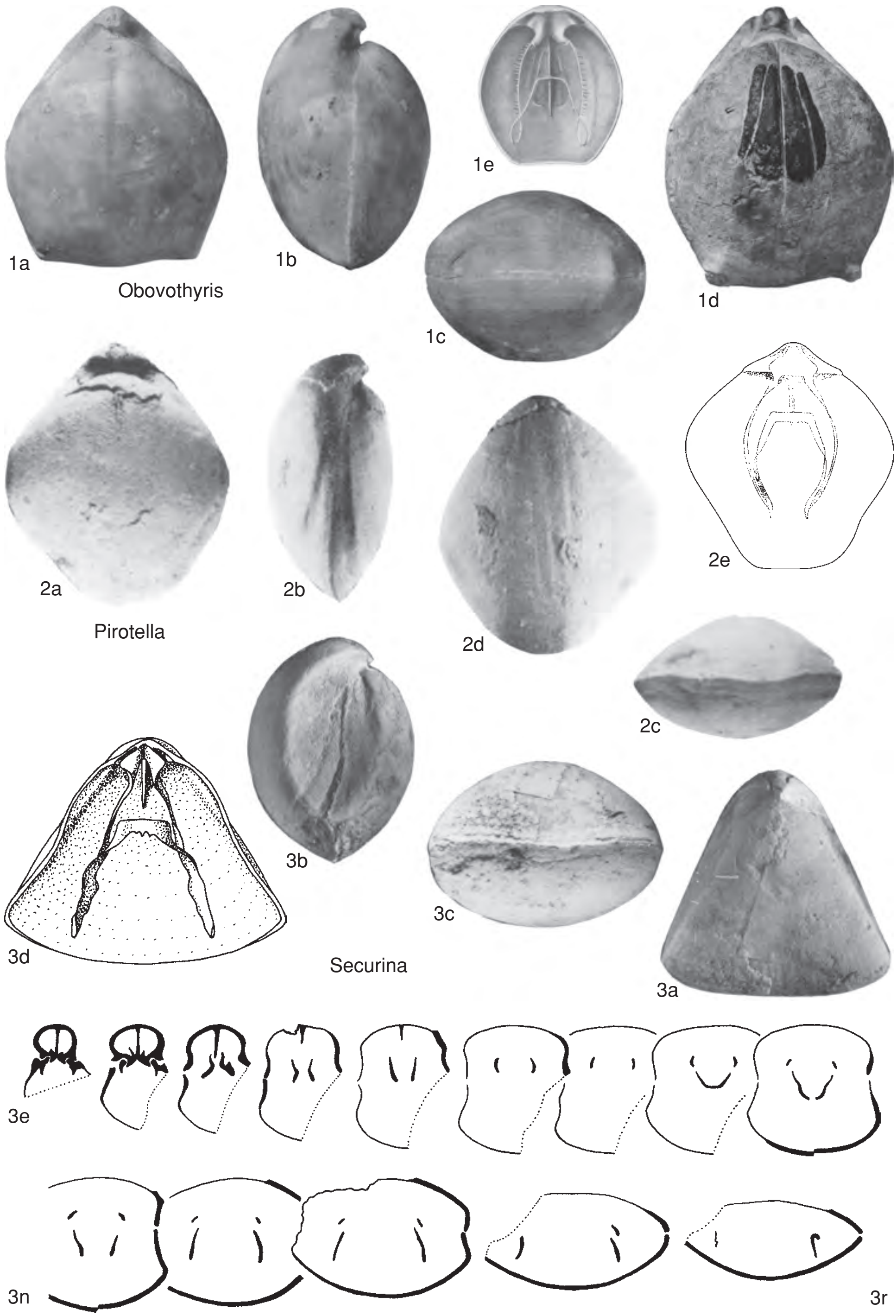

FIG. 1445. Zeilleriidae (p. 2170–2174).

S. angusta (VON SCHLOTHEIM), Anisian, Tarnowiec, Gorny Slask; *a–d,* dorsal, lateral, anterior, ventral views, ×2.5 (Brügge, 1977); *e,* dorsal valve interior, reconstruction, ×4.25 (adapted from Brügge, 1977).

Somalitela MUIR-WOOD, 1935, p. 140 [**S. ambalensis;* OD]. Small, elongate-oval in outline, anterior commissure incipiently uniplicate, umbo flattened, suberect with short, rounded-angular beak ridges, pedicle foramen relatively large, permesothyrid, telate, anterior half of shell prominently costate; dental plates slightly inwardly concave, subparallel; inner hinge plates slighty concave ventrally, septalium shallow, replaced by median ridge for most of length and whole structure with flattened, W-shaped section, median septum acutely triangular in cross section, about 0.5 length of valve, supporting hinge plates posteriorly. *Upper Jurassic (?Kimmeridgian):* Somaliland.——FIG. 1443,*5a–c.* **S. ambalensis;* dorsal, lateral, anterior views, ×2 (Muir-Wood, 1965b).

Tubegatanella PROSOROVSKAJA, 1968, p. 244 [**T. repmanae* PROSOROVSKAJA, 1968, p. 245; OD]. Medium size, subpentagonal in outline, strongly ventribiconvex, anterior commissure usually rectimarginate, umbo massive, strongly incurved, with short, rounded-angular beak ridges, pedicle foramen very small, permesothyrid; dental plates slender; crural bases short, septalium flattening to become convex anteriorly, anterior edge of crural plates curved acutely in dorsoventral direction, median septum high, thin, approximately 0.3 valve length, loop spinose anteriorly. *Upper Jurassic (upper Oxfordian):* Tadzhikskaya.——FIG. 1442,*3a–hh.* **T. repmanae,* Gissar, Tian Shan; *a–d,* dorsal, lateral, anterior, ventral views, ×1 (Prosorovskaja, 1968); *e,* dorsal valve interior, reconstruction, ×1.2; *f–hh,* serial transverse sections, 0.6, 0.8, 1.0, 3.5, 3.9, 4.4, 4.8, 4.9, 5.0, 5.1, 5.3, 5.5, 5.8, 6.4, 6.8, 7.2, 7.8, 8.4, 9.5, 9.7, 10.3, 10.8, 11.8, 12.7, 14.0, 16.7, 17.4, 17.5, 17.8 mm from umbo, ×0.75 (adapted from Prosorovskaja, 1968).

Uniptychina ALMÉRAS & ELMI, 1998, p. 96 [**Waldheimia böhmi* PARONA, 1895, p. 31; OD]. Small, subpentagonal, becoming rounded elongate with age, strongly ventribiconvex, anterior commissure essentially parasulcate with median fold flattened and sulci widely separated with complementary folds in ventral valve masked by convexity of valve, umbo small, suberect, beak ridges sharp, demarcating well-developed symphytium, foramen small, circular, mesothyrid; median septum extending approximately 0.5 valve length, other internal characters unknown. *Middle Jurassic (lower Bathonian):* France, England, Italy.——FIG. 1443,*4a–c.* **U. boehmi* (PARONA), Montchaud à Saint Brés, France; dorsal, lateral, anterior views, ×1 (Alméras & Elmi, 1998).

Worobievella DAGYS, 1959a, p. 33 [**W. caucasica;* OD] [=*Woroboviella* MUIR-WOOD, 1965b, p. 828, *nom. null.*]. Small, elongate-oval in outline, with shallow, dorsal median sulcus, anterior commissure weakly unisulcate, umbo small, incurved, pedicle foramen minute, mesothyrid; dental plates slender, inwardly concave, slightly ventrally divergent; inner socket ridges and hinge plates dorsally inclined, septalium rounded V-shaped, median septum thin, about 0.3 valve length, loop smooth, with broad, ascending branches, transverse band convex, only slightly posterior. *Upper Triassic (Norian):* northwestern Caucasus.——FIG. 1444,*2a–c.* **W. caucasica;* dorsal, lateral, anterior views, ×1.5 (Dagys, 1959a).

Subfamily VECTELLINAE new subfamily

[Vectellinae BAKER, herein]
[type genus, *Vectella* OWEN, 1965, p. 51]

Small to medium size, rarely medium size to large, biconvex, or exceptionally ventribiconvex, dorsiconvex or planoconvex, anterior commissure commonly folded, umbo commonly suberect, beak ridges typically short, exceptionally extended, deltidial plates exceptionally disjunct, pedicle foramen typically round, mesothyrid; dental plates normally slender, rarely long; cardinal process commonly represented by callus lobe, inner socket ridges commonly deflected ventrally or exceptionally dorsally, crural bases given off ventrally, septalium rarely flat or U-shaped, occasionally deep or exceptionally very deep, median septum commonly triangular, less commonly acutely triangular, or long, transverse band of loop exceptionally located anteriorly. *Middle Triassic–Lower Cretaceous (Albian).*

Vectella OWEN, 1965, p. 51 [**Waldheimia celtica* MORRIS, 1854, p. 158; OD]. Elongate-oval in outline, sulcocarinate to biconvex, anterior commissure rectimarginate to uniplicate or unisulcate, umbo moderate, suberect; dental plates short, ventrally convergent, embedded in callus; cardinal process represented by apical callus, crural bases triangular, septalium deep, V-shaped, median septum thick, acutely triangular in cross section. *Lower Cretaceous (upper Aptian):* southern England.——FIG. 1446,*1a–p.* **V. celtica* (MORRIS), Shanklin, Isle of Wight; *a–c,* dorsal, lateral, anterior views, ×1 (Owen, 1965); *d–p,* serial transverse sections. 0.8, 1.4, 1.6, 1.9, 2.4, 2.7, 3.2, 3.5, 3.7, 4.0, 4.2, 4.9, 5.2 mm from umbo, ×1 (adapted from Owen, 1965).

Advenina SANDY, 1986a, p. 187 [**A. oweni;* OD]. Small, oval, subpentagonal or subtriangular in outline, anterior commissure rectimarginate to uniplicate, occasionally multiplicate, umbo erect, beak ridges well defined, foramen medium size; septalium V-shaped posteriorly, becoming open U-shaped to subhorizontal anteriorly, crura stout, extending rapidly into high crural processes, median septum high, bladelike, extending 0.5 or more of

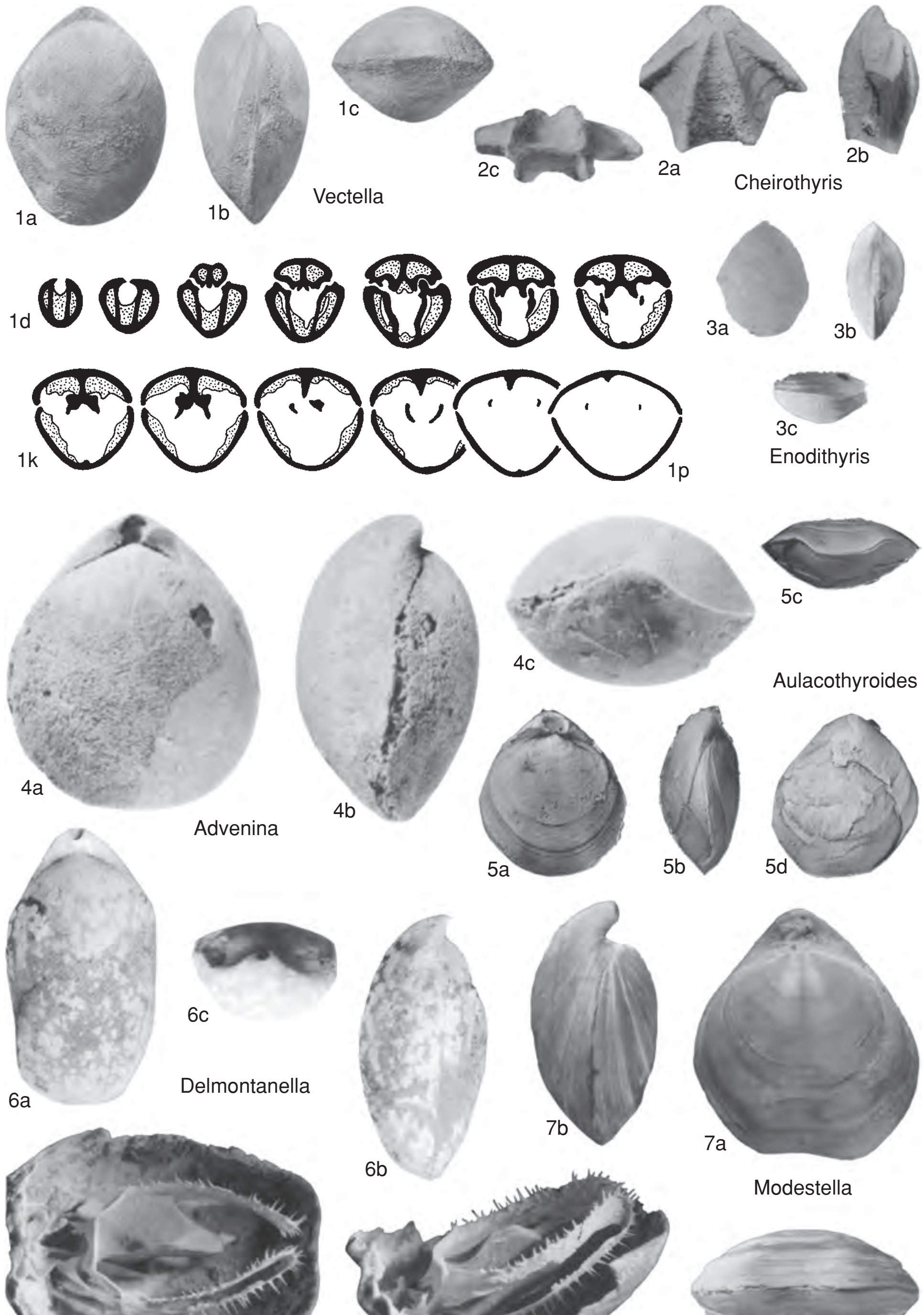

FIG. 1446. Zeilleriidae (p. 2176–2180).

valve length. *Lower Cretaceous (?Berriasian, Valanginian–Aptian):* France, Switzerland, Sardinia, *?Berriasian, Valanginian;* Crimea, Caucasus, Georgia, Kazakhstan, *Valanginian–Aptian.*——FIG. 1446,*4a–c.* **A. oweni,* lower Valanginian, Alpes de Haute Provence, France; holotype, dorsal, lateral, anterior views, BMNH BB86852, ×3 (Sandy, 1986a).

Aulacothyroides DAGYS, 1965, p. 155 [**A. bulkutensis;* OD]. Small, suboval in outline, ventribiconvex, anterior commissure unisulcate to plicosulcate, umbo moderate size, short, erect, beak ridges rounded, foramen large, round, permesothyrid; pedicle collar present, dental plates short, straight, ventrally divergent; low cardinal process probably represented by apical callus development, outer hinge plates not demarcated from inner socket ridges, septalium shallow, open, V-shaped trough filled with callus medially, minor development of apical umbonal callus, median septum low, bladelike, extending about 0.6 valve length, enveloped for much of its length by extension of crural plates, loop long, descending and ascending branches spinose anteriorly. *Upper Triassic (Carnian–Norian):* Svalbard, northern Siberia, Sikhote-Alin.——FIG. 1446,*5a–d.* **A. bulkutensis,* Carnian, Rossokh River Basin, Bulkut River, northern Siberia; dorsal, lateral, anterior, ventral views, ×1.5 (Dagys, 1974).

Carpatothyris SMIRNOVA, 1975a, p. 135 [**Terebratella repanda* ZEUSCHNER, 1857, p. 48–49; OD]. Large, pyriform in outline, ventribiconvex, anterior commissure strongly unisulcate, both valves flattened medianly, umbo elongate, suberect with long, angular beak ridges extending to posterolateral margin, symphytium high; dental plates long, subparallel, lateral umbonal cavities small; crural plates subhorizontal, septalium poorly developed, rudimentary, median septum united with hinge plates in umbonal region only, acutely triangular in cross section, extending about 0.8 valve length, loop long, almost reaching anterior margin, with wide, ascending lamellae and broad, transverse band. *Upper Jurassic (Tithonian):* Poland (Carpathians), Czech Republic.——FIG. 1447,*3a–c.* **C. repanda* (ZEUSCHNER), upper Tithonian, Carpathians, Poland; dorsal, lateral, ventral views, ×1 (Smirnova, 1975a).

Cheirothyris ROLLIER, 1919, p. 338 [**Terebratula fleuriausa* D'ORBIGNY, 1850 in 1849–1852, p. 25; OD] [=*Neotrigonella* COSSMANN, 1910 in 1895–1921, p. 74, obj., *nom. nov. pro Trigonella* QUENSTEDT, 1868 in 1868–1871, p. 25, obj., *non* DA COSTA, 1778, *nec* CONRAD, 1837, *nec* HEHL, 1842]. Pentangular in outline with four prominent carinae, flatly biconvex, anterior commissure rectimarginate, umbo suberect, broad with long beak ridges extending to lateral margin, pedicle foramen large, incomplete, deltidial plates disjunct; dental plates relatively thick, subparallel to slightly ventrally divergent; inner socket ridges convex ventrally, septalium broad, with posterior median ridge giving low W-shape, median septum triangular in cross section, extending about 0.5 valve length, loop with low-arched, transverse band. [Homeomorph with short loop, no septum or dental plates, as well as two terebratelloid homeomorphs (*Ismenia* and *Trigonellina*) exist in Upper Jurassic.] *Upper Jurassic (middle Kimmeridgian–upper Kimmeridgian):* France, Switzerland, Germany.——FIG. 1446,*2a–c.* **C. fleuriausa* (D'ORBIGNY), Germany; dorsal, lateral, anterior views, ×2 (Muir-Wood, 1965b).

Delmontanella SULSER, 1995, p. 725, *nom. transl.* BAKER, herein, *ex Ornithella (Delmontanella)* SULSER, 1995, p. 725 [**Terebratula (Waldheimia) delmontana* OPPEL, 1857, p. 607; OD]. Large, elongate oval or elongate pentagonal in outline, anterior commissure rectimarginate, commonly carinate, umbo small to moderate, suberect, palintropes slightly flattened, foramen permesothyrid; dental lamellae robust; septalium initially shallowly concave, later flattened, retaining residual concavity with some undulation anteriorly with unsupported, anterior shelf, median septum acutely triangular, extending slightly more than 0.5 valve length, loop descending and ascending branches spinose, ascending elements relatively wide, transverse band saddle shaped with paired, posterior projections; connection between anterior of loop and median septum in ontogeny. [The similarity between *Delmontanella* and *Ornithella* as indicated by external morphology is not confirmed internally. Important differences in the dental lamellae, septalium, and brachidium lead to the conclusion that *Delmontanella* should be regarded as a separate genus.] *Upper Jurassic (lower Oxfordian–middle Oxfordian):* Switzerland (northwestern Jura).——FIG. 1446,*6a–e.* **D. delmontana* (OPPEL), lower middle Oxfordian, Liesberg Formation, Montfaucon; *a–c,* dorsal, lateral, posterior views, ×1; *d,* dorsal valve interior, prepared specimen; *e,* dorsal valve interior, tilted lateral view, prepared specimen, ×1.8 (Sulser, 1995).

Enodithyris SMIRNOVA in SMIRNOVA & KONOVALOV, 1986, p. 79 [**E. fluens;* OD]. Small, elongate-oval or elongate-rhomboidal in outline, anterior commissure rectimarginate to incipiently unisulcate, umbo suberect, with angular beak ridges; dental plates slightly ventrally divergent; septalium V-shaped posteriorly, acutely V-shaped anteriorly, crural bases short, inclined, crural processes widely diverging, median septum acutely triangular to triangular in cross section, extending about 0.3 valve length, loop spinose. *Lower Cretaceous:* Russia (Far East).——FIG. 1446,*3a–c.* **E. fluens;* holotype, ventral, lateral, anterior views, MGU 245/230, ×1 (Smirnova, 1990a).

Epicyrta EUDES-DESLONGCHAMPS, 1884, p. 275 [**Terebratula eugenii* VON BUCH in DAVIDSON, 1850a, p. 72; OD]. Medium size, elongate-subpentagonal in outline, dorsiconvex, ventral valve depressed-convex with deep, median sulcus, anterior commissure dorsally arched, umbo suberect, flattened, beak ridges persistent in both valves, ventral beak ridges delimiting flattened

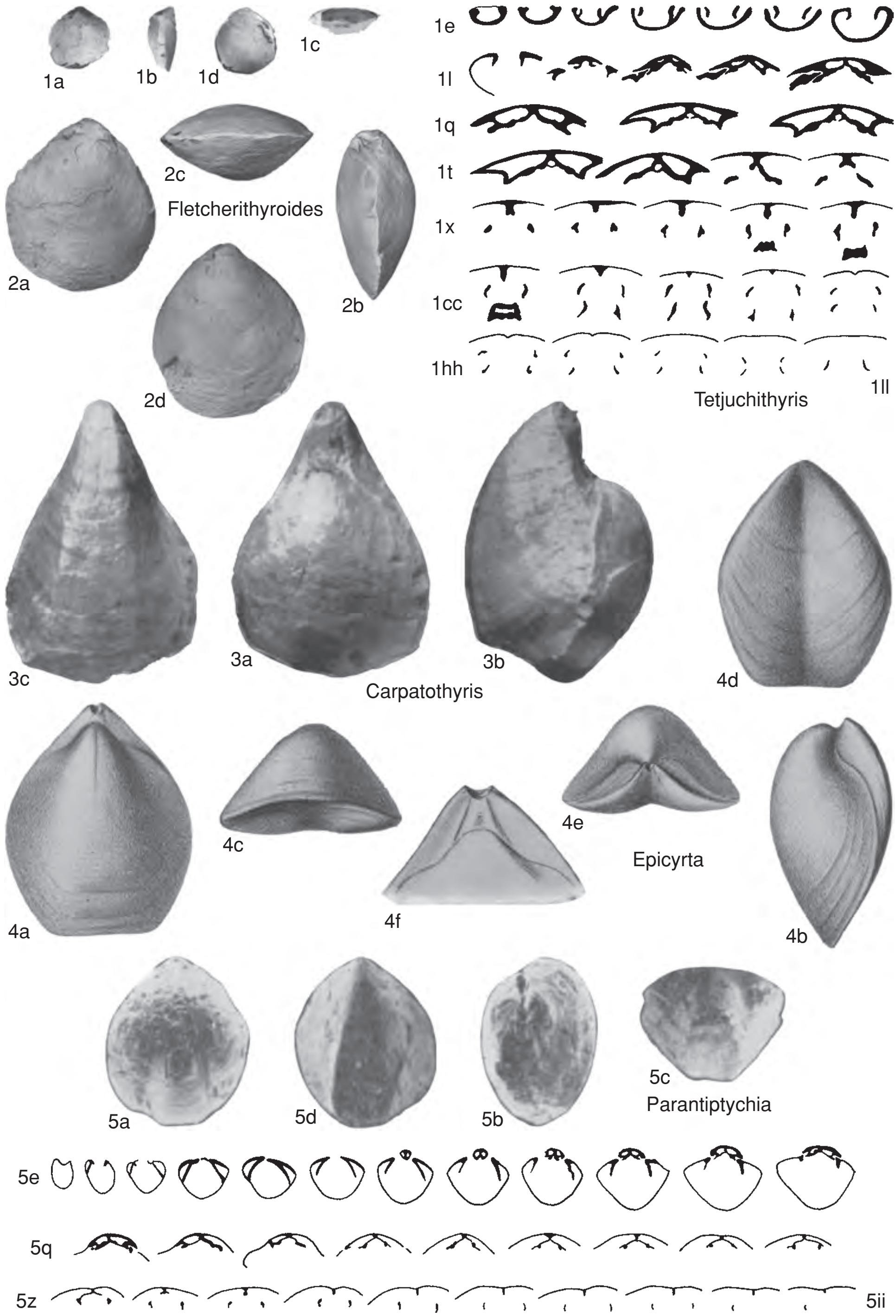

FIG. 1447. Zeilleriidae (p. 2178–2183).

palintropes, extending almost to anterolateral margin, dorsal beak ridges more rounded, pedicle foramen apical, telate, shell with rarely preserved, fine capillation; dental plates subparallel, becoming ventrally convergent; inner socket ridges ventrally deflected at high angle, hinge plates keeled, septalium deep, angular, U-shaped, median septum bladelike, high posteriorly, low anteriorly, less than 0.5 valve length, loop spines not observed. *Lower Jurassic:* Europe.——FIG. 1447,*4a–f.* **E. eugenii* (VON BUCH), middle Lias, France; *a–e,* dorsal, lateral, anterior, ventral, posterior views, ×1; *f,* umbo enlarged, ×2 (Muir-Wood, 1965b).

Fletcherithyroides DAGYS, 1977, p. 14 [**F. gregarius* DAGYS, 1977, p. 15; OD]. Medium size, oval in outline, anterior commissure rectimarginate to incipiently uniplicate, umbo small, short, suberect, beak ridges rounded, foramen small; pedicle collar unsupported, dental plates straight, becoming slightly inwardly concave anteriorly, ventrally divergent; cardinal process low, undivided, possibly callus lobe, inner socket ridges deflected ventrally, demarcated from outer hinge plates, septalium moderately deep, broad V-shaped, median septum low, bladelike, extending about 0.4 valve length, loop long, spinose anteriorly. *Middle Triassic:* northeastern Siberia.——FIG. 1447,*2a–d.* **F. gregarius,* Ladinian; dorsal, lateral, anterior, ventral views, ×1 (Dagys, 1977).

Gemerithyris SIBLÍK, 1977, p. 203 [**Waldheimia (Aulacothyris) supina* var. *hungarica* BALOGH, 1940, p. 26; OD]. Medium size, subpentagonal to elongate-oblong in outline, ventribiconvex, ventral valve sometimes carinate, strongly convex with median sulcus, dorsal valve flatter, sulcate with median fold, anterior commissure plicosulcate, umbo relatively small, erect, with rounded beak ridges, pedicle collar present; outer hinge plates separated from crural plates by massive crural bases, septalium deep, V-shaped or broadly U-shaped with anterior median groove, median septum high, almost reaching anterior margin, loop with wider, ascending branches, transverse band convex ventrally, descending branches rarely with a few short spines. *?Middle Triassic, Upper Triassic:* Czech Republic, Slovakia, Austria, Romania.——FIG. 1448,*2a–d.* **G. hungarica hungarica* (BALOGH), Carnian, Silicka Brezova, Czech Republic, Slovakia; *a–c,* dorsal, lateral, anterior views, ×2.5; *d,* younger specimen, dorsal view, ×3 (Siblík, 1977).

Karpatiella SUČIĆ-PROTIĆ, 1985, p. 27 [**K. valeriae* SUČIĆ-PROTIĆ, 1985, p. 28; OD]. Medium size to large, elongate-oval to subpentagonal in outline, anterior commissure weakly uniplicate to weakly sulciplicate, umbo large, broad, erect with rounded-angular beak ridges, pedicle foramen moderate, dental plates long, straight to slightly inwardly concave, slightly ventrally divergent; cardinal process represented by callus knob, inner socket ridges slightly dorsally deflected, outer hinge plates demarcated, slightly concave ventrally, septalium long, slightly undulating, median septum extending about 0.25 valve length. *Lower Jurassic (upper Pliensbachian):* England, France, Czech Republic, Slovakia, Yugoslav Carpatho-Balkan arch.——FIG. 1449,*2a–e.* **K. valeriae,* Stara Planina, Senokos, Serbia; *a–d,* dorsal, lateral, anterior, ventral views; *e,* dorsal valve interior reconstruction, ×1 (Sučić-Protić, 1985).

Kedrovothyris SMIRNOVA, 1990a, p. 119 [**K. kedrovaensis;* OD]. Medium size, rounded-pentagonal in outline, anterior commissure rectimarginate, umbo small, erect; dental plates thick, probably partially enveloped in umbonal callus; cardinal process probably represented by callus lobe, crural plates slender, median septum obtusely triangular in cross section, extending less than 0.5 valve length, loop transverse band with posterior projections. *Lower Cretaceous:* Kamchatka.——FIG. 1449,*3a–d.* **K. kedrovaensis; a–c,* dorsal, lateral, anterior views; *d,* holotype, ventral view, internal mold of conjoined valves, MGU 138/401, ×1.5 (Smirnova, 1990a).

Modestella OWEN in CASEY, 1961, p. 573 [**M. modesta;* OD]. Small, rounded subpentagonal in outline, shallow median sulcus between faint ridges in each valve, lobate anteriorly, anterior commissure rectimarginate, emarginated, umbo suberect, pedicle foramen large, deltidial plates concave; hinge teeth wedge shaped, dental plates thick, ventrally convergent; cardinal process commonly represented by callus lobe, hinge plates convex ventrally, septalium very deep, acutely V-shaped, median septum triangular in cross section, extending 0.5 valve length, structures commonly thickened by callus apically. *Lower Cretaceous (Albian):* England.——FIG. 1446,*7a–c.* **M. modesta,* lower Albian, Bedfordshire, southern England; dorsal, lateral, anterior views, ×3 (Casey, 1961).

Ornithella EUDES-DESLONGCHAMPS, 1884, p. 273 [**Terebratula ornithocephala* J. SOWERBY, 1815 in 1812–1815, p. 227; OD] [=*Microthyridina* SCHUCHERT & LEVENE, 1929b, p. 120 (type, *Terebratulites lagenalis* VON SCHLOTHEIM, 1820, p. 284), *nom. nov. pro Microthyris* EUDES-DESLONGCHAMPS, 1884, p. 274, *non* LEDERER, 1863]. Elongate-oval to pentagonal in outline, lobate anteriorly, anterior commissure rectimarginate, umbo suberect to incurved with rounded beak ridges, pedicle foramen permesothyrid; pedicle collar rarely observed, dental plates inwardly concave to angled, converging ventrally, embedded in callus in adult; hinge plates slightly deflected ventrally, becoming gently undulating, septalium flattening anteriorly to become convex median ridge, median septum acutely triangular in cross section, less than 0.5 valve length, umbonal cavities commonly filled with callus, connection between anterior of loop and septal pillar early in ontogeny; dorsal adductor scars elongate, set at slight angle to septum. *Middle Jurassic (Bajocian)–Upper Jurassic (Callovian), ?Cretaceous:* Europe, *Bajocian.*——FIG. 1448,*3a–d.* **O. ornithocephala* (J. SOWERBY), Bathonian, lower Cornbrash, ?Somerset, England; *a–c,* dorsal, lateral, anterior views, ×1.3 (Muir-Wood, 1965b); *d,* dorsal valve interior, reconstruction, ×1.5 (Muir-Wood,

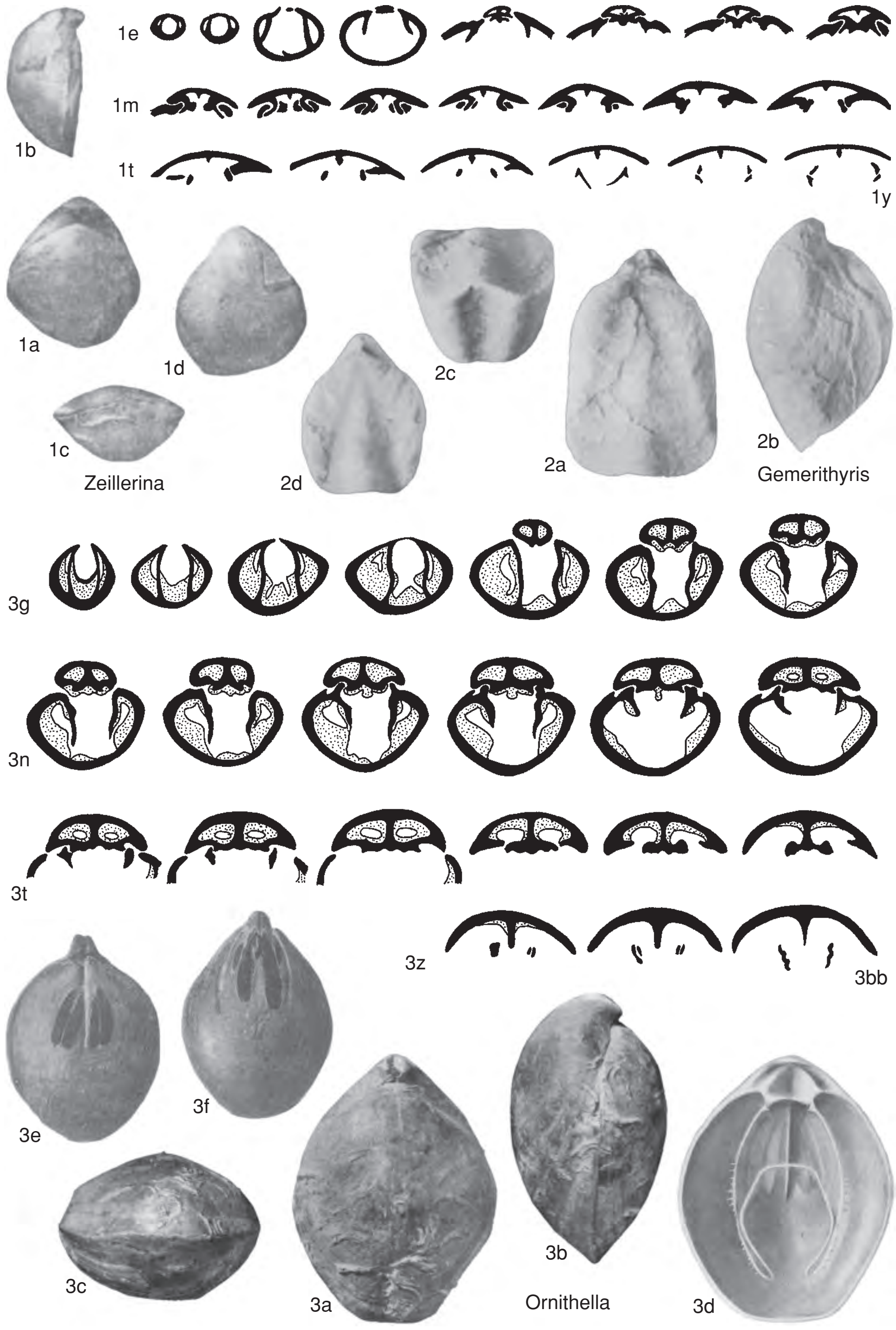

FIG. 1448. Zeilleriidae (p. 2180–2183).

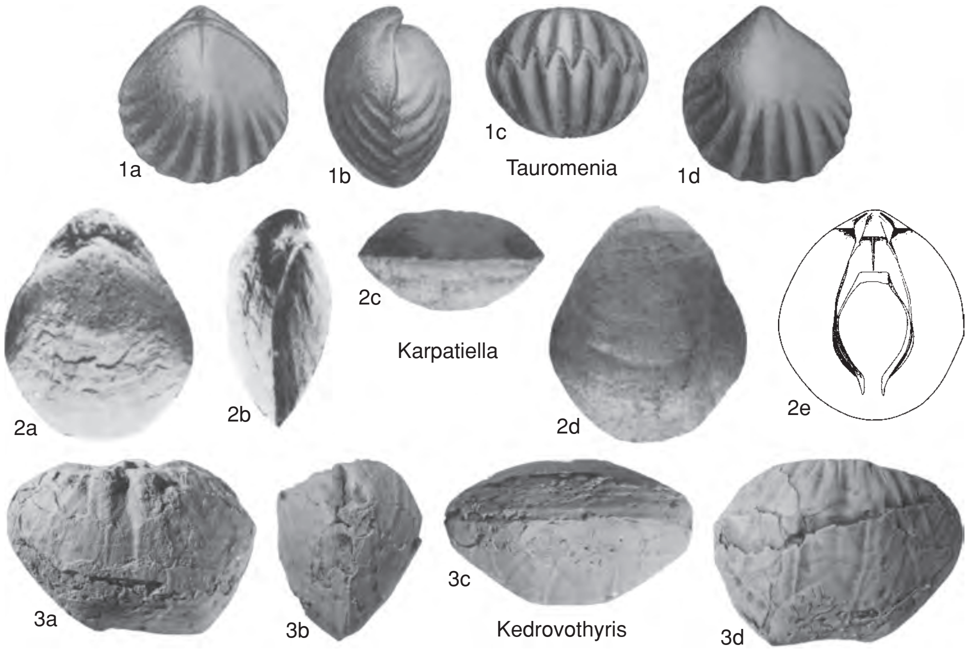

FIG. 1449. Zeilleriidae (p. 2180–2182).

1934).——FIG. 1448,*3e–bb. O. bathonica,* middle Bathonian, Fullers Earth Rock, Wiltshire, England; *e–f,* dorsal, ventral adductor scars, ×1 (Muir-Wood, 1934); *g–bb,* serial transverse sections, 1.1, 1.8, 2.4, 2.6, 3.7, 3.9, 4.0, 4.3, 4.4, 4.7, 4.9, 5.5, 5.8, 6.1, 6.3, 6.7, 6.8, 7.1, 7.2, 7.4, 7.5, 7.6 mm from umbo, ×1.25 (adapted from Muir-Wood, 1934).

Parantiptychia XU & LIU, 1983b, p. 99 (XU & LIU, 1980, p. 36, *nom. nud.*) [**Antiptychina robusta* YANG & YIN in YANG & others, 1962, p. 124; OD]. Medium to large size, broadly oval to subpentagonal in outline, anterior commissure rectimarginate early, becoming unisulcate or plicosulcate, umbo incurved with short beak ridges, pedicle foramen moderately large, possibly permesothyrid; pedicle collar present; inner socket ridges slightly deflected ventrally, hinge plates long and narrow, crural plates thin, persistent, extended as in *Aulacothyroides,* septalium commonly with anterior median ridge, septalium extending almost 0.3 valve length, median septum triangular in cross section, extending more than 0.5 valve length, loop ascending elements unknown. *Middle Triassic:* China (Qinghai Province).——FIG. 1447,*5a–d.* **P. robusta* (YANG & YIN), Junzihe Formation, southern Qilian Mountains; dorsal, lateral, anterior, ventral views, ×1 (Xu & Liu, 1983b).——FIG. 1447,*5e–ii. P. sulcata* XU & LIU, Zunzihe Formation, southern Qilian Mountains; transverse serial sections, 1.0, 1.5, 1.8, 2.5, 3.0, 3.5, 3.6, 3.7, 3.9, 4.3, 4.6, 4.9, 5.2, 5.6, 5.9, 6.1, 6.3, 6.9, 7.2, 7.6, 8.0, 8.5, 8.9, 9.1, 9.3, 9.8, 10.2, 10.7, 11.1, 11.6, 11.9 mm from umbo, ×0.6 (adapted from Xu & Liu, 1983b).

Tauromenia SEGUENZA, 1885, p. 253, footnote, *non* FUCINI, 1931 [**T. polymorpha;* OD]. Small, rounded to elongate-oval or rounded-pentagonal in outline, anterior commissure rectimarginate, umbo small, erect, pedicle foramen permesothyrid, anterior half of shell prominently costate; dental plates short, other characters unknown; hinge plates slightly convex ventrally, septalium shallow, median septum less than 0.5 valve length, loop characters unknown. *Upper Triassic (?Rhaetian), Lower Jurassic (Hettangian–Sinemurian):* Italy, *?Rhaetian;* Italy, Portugal, Spain, northern Africa, *Hettangian–Sinemurian.*——FIG. 1449,*1a–d.* **T. polymorpha,* Hettangian, Sicily; dorsal, lateral, anterior, ventral views, ×1 (Muir-Wood, 1965b).

Tetjuchithyris SMIRNOVA in SMIRNOVA & KONOVALOV, 1986, p. 81 [**T. flexibilis;* OD]. Small, subcircular to subtriangular in outline, anterior commissure uniplicate, umbo acute, erect; dental plates angled, widely spaced, recessive; septalium long, wide, septalial plates with outgrowth overarching septalial trough anteriorly, median septum long, thick posteriorly, becoming bladelike to acutely triangular anteriorly, extending about 0.75 valve length, loop long, almost reaching anterior margin, ascending branches widening posteriorly, uniting with broad, posteriorly arched transverse band. *Lower Cretaceous (Berriasian–Valanginian):* Russia (Far East).——FIG. 1447,*1a–ll.* **T. flexibilis; a–d,* dorsal, lateral, anterior, ventral views, ×1 (Smirnova & Konovalov, 1986); *e–ll,* serial transverse sections, 0.2, 0.4, 0.6, 0.7, 1.0, 1.2, 1.6, 1.9, 2.3, 2.5, 2.6, 2.7, 2.8, 2.85, 2.9, 3.0, 3.1, 3.25, 3.45, 3.65, 4.05, 4.15, 4.45, 4.65, 4.75, 4.95, 5.05, 5.15, 6.15, 6.45, 6.55, 8.35, 8.75 mm from umbo [there is no record of the distance of the final section], ×1.5 (adapted from Smirnova & Konovalov, 1986).

Zeillerina Kyansep, 1959, p. 119 [**Zeilleria belbekensis* Moisseev, 1934, p. 149; OD; *emend.,* Kyansep, 1961, p. 80]. Small, young specimens oval-pentagonal, adult specimens commonly strongly pentagonal in outline, ventribiconvex to planoconvex, anterior commissure incipiently uniplicate, umbo erect to slightly incurved, with subangular beak ridges; pedicle collar developed, teeth massive; cardinal process small, commonly weakly developed or absent, hinge plates slightly ventrally convex to flat, septalium poorly developed, rudimentary, median septum united with hinge plates in umbonal region only, triangular in cross section, 0.5 to 0.75 valve length, loop with short, ascending branches, sometimes with wedge-shaped spines. [The emended diagnosis of *Zeillerina belbekensis* Kyansep, 1961, p. 80, does not materially affect the diagnosis of *Zeillerina* included herein.] *Upper Jurassic (Oxfordian–Kimmeridgian):* Mediterranean region, Crimea, Poland.——Fig. 1448,*1a–y.* **Z. belbekensis* (Moisseev), Kimmeridgian, southwestern Crimea; *a–d,* dorsal, lateral, anterior, ventral views, ×1 (Kyansep, 1959); *e–y,* serial transverse sections, 1.0, 1.1, 1.5, 1.9, 3.6, 4.4, 4.8, 5.3, 6.3, 6.5, 6.6, 6.9, 7.1, 7.2, 7.5, 7.6, 7.8, 8.1, 8.8, 9.5, 10.1 mm from umbo, ×1 (adapted from Kyansep, 1959).

Subfamily MACANDREVIINAE Cooper, 1973

[*nom. transl.* Baker, herein, *ex* Macandreviidae Cooper, 1973b, p. 23]

Small to medium size, biconvex, anterior commissure rectimarginate or weakly unisulcate, umbo short, broad, with beak ridges ill defined, deltidial plates disjunct, pedicle foramen moderate, round; pedicle collar well developed, sessile, impunctate, minor development of umbonal callus, dental plates slender; cardinal process absent, crural bases given off mesially, septalium absent, median septum absent, adult loop teloform, connected to septal pillar early in ontogeny. *Paleogene (Eocene)–Holocene.*

Macandrevia King, 1859, p. 261 [**Terebratula cranium* Müller, 1776, p. 249; OD] [=*Macandrewia* Bronn, 1862, p. 305, obj., improper emendation; *Frenula* Dall, 1871, p. 55 (type, *F. jeffreysi,* OD); *Waldheimiathyris* Helmcke, 1939, p. 331, obj.; *Notorygmia* Cooper, 1972, p. 13 (type, *N. abyssa,* OD)]. Subpentagonal in outline, smooth or with fine radial sculpture, umbo suberect to erect, deltidial plates rudimentary, pedicle foramen possibly permesothyrid, attrite; teeth moderate to large, dental plates short, straight, ventrally divergent, united by callus deposit closely applied to floor of valve; crural bases fused with inner socket ridges, crural plates steeply inclined to floor of valve, extended anteriorly, forming long, V-shaped trough extending about 0.5 valve length, low median ridge present early in ontogeny, but median septum absent in adult, loop extending about 0.75 valve length, smooth except for anterior fringe of short spines, ascending branches and transverse band moderately broad with short, posterior projections at union; diductor muscle scars attached to small, transverse impression over dorsal umbo; endopunctae minute, rather widely separated. [Preservation of detail in figured type material is poor. Generic characters are more clearly illustrated in the species figured herein.] *Paleogene (Eocene)–Holocene:* Antarctic Peninsula, *Eocene;* Japan, *Miocene;* Italy, *Pliocene;* Norway, Sweden, Italy, *Pleistocene;* Atlantic (10–2,900 m), Pacific (240–4,400 m), Antarctic (400–2,800 m), *Holocene.*——Fig. 1450,*2a–e. M. americana* Dall, Holocene, west entrance to Strait of Magellan, 470–562 m, Pacific, off Chile; *a–c,* dorsal, lateral, anterior views, ×1; *d,* dorsal valve interior; *e,* dorsal valve oblique interior view, ×1 (Cooper, 1973b).

Subfamily UNCERTAIN

Polyplectella Feldman, Owen, & Hirsch, 2001, p. 654 [**P. debriani;* OD]. Medium size, oval to subpentagonal, almost equally biconvex but with ventral valve more inflated anteriorly, anterior commissure uniplicate, shell mostly smooth but with polyplication developed marginally, umbo erect with distinct, mesothyrid beak ridges; median septum thin, extending about 0.6 of valve length. [Distinction is based on only two specimens and details of the loop remain unknown; inclusion in the Zeilleriidae is resting on the presence of dental lamellae.] *Middle Jurassic (Callovian):* southern Israel (Negev).——Fig. 1450,*1a–f.* **P. debriani,* upper Callovian, Hamakhtesh Hagadol; *a–c,* holotype, dorsal, lateral, anterior views, NHM 1038; *d–f,* paratype, dorsal, lateral, anterior views, NHM 1037, ×1 (Feldman, Owen, & Hirsch, 2001).

Family GUSARELLIDAE Ovtsharenko, 1976

[Gusarellidae Ovtsharenko, 1976, p. 20]

Small to medium size, outline commonly oval to elongate, biconvex, shell smooth, umbo normally small, incurved, with short beak ridges; teeth moderate, dental plates not enveloped in callus, short, strong; cardinal process absent, inner socket ridges occasionally deflected ventrally, outer hinge

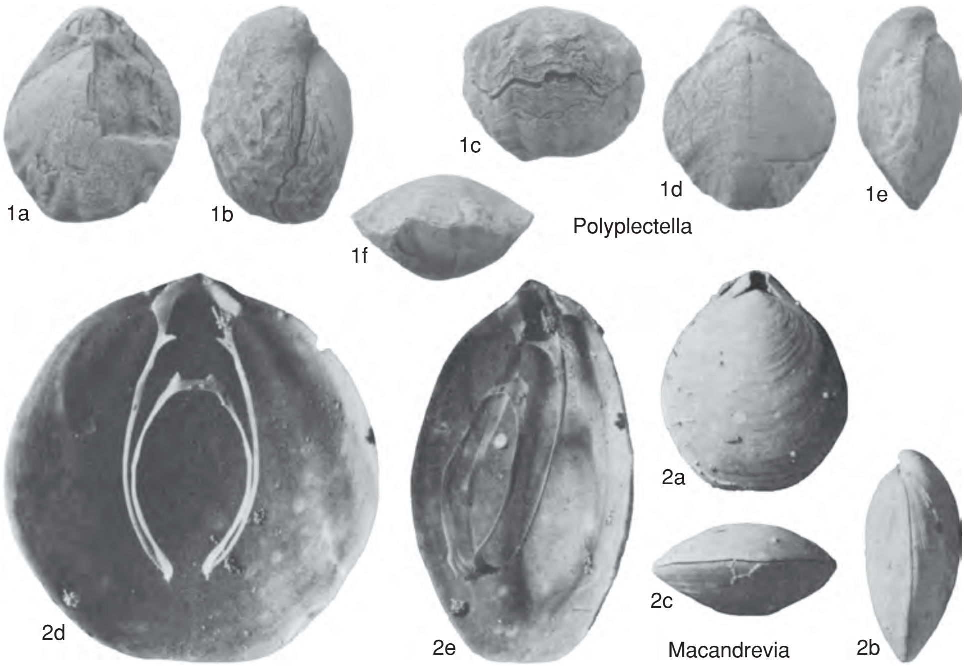

FIG. 1450. Zeilleriidae (p. 2183).

plates slightly concave ventrally, rarely undulating, crural bases given off dorsally, inner hinge plates slightly concave, ventrally forming typically U-shaped cardinal plate, minor development of apical umbonal callus, septalium absent, median septum absent, except possibly rudimentary in very early growth stages, loop smooth, rarely with few spines at union between descending and ascending branches, development of septal pillar in ontogeny not observed. *Lower Triassic (Induan)–Upper Jurassic.*

Gusarella PROSOROVSKAJA, 1962, p. 111 [**Zeilleria gusarensis* MOISSEEV, 1944, p. 58; OD] [=*Montanella* OVTSHARENKO, 1976, p. 21 (type, *Gusarella longa* PROSOROVSKAJA in PROSOROVSKAJA & POJARISSKAJA, 1968, p. 30); *Micella* OVTSHARENKO, 1976, p. 24 (type, *Gusarella makridini* POJARISSKAJA in PROSOROVSKAJA & POJARISSKAJA, 1968, p. 32); *Eousella* OVTSHARENKO, 1976, p. 26 (type, *Gusarella moisseievi* POJARISSKAJA in PROSOROVSKAJA & POJARISSKAJA, 1968, p. 35)]. Medium size, elongate-oval to elongate-pentagonal in outline, anterior commissure weakly uniplicate with tendency toward sulciplication, umbo small, broad, with rounded-angular beak ridges, pedicle foramen circular, pedicle collar absent; dental plates straight, diverging ventrally; hinge plates united to form broadly U-shaped cardinal plate becoming W-shaped anteriorly, cavity may be present between crural bases and inner hinge plates, median septum absent, or rudiment present only in earliest development stages, loop almost reaching anterior margin, commonly spinose at point of union of descending and ascending branches, delicate transverse band rather posterior, dorsal adductor scars large, oval. *Middle Jurassic–Upper Jurassic:* Crimea, Caucasus, Turkoman, *Middle Jurassic.*——FIG. 1451,*3a–jj.* **G. gusarensis* (MOISSEEV), Callovian, near Caspian Sea, western Turkoman; *a–d,* dorsal, lateral, anterior, ventral views, ×0.75 (new); *e,* dorsal valve interior reconstruction, ×0.75 (Prosorovskaja, 1962); *f–jj,* serial transverse sections, 1.9, 2.3, 3.8, 4.1, 4.7, 5.0, 5.2, 5.3, 5.5, 6.5, 6.6, 7.4, 7.9, 8.5, 8.6, 8.7, 9.6, 10.2, 10.7, 11.4, 11.9, 13.4, 14.7, 15.1, 15.8, 19.6, 21.9, 25.4, 27.8, 28.5, 29.6 mm from umbo, ×1 (adapted from Prosorovskaja, 1962).

Paragusarella SHI, 1992, p. 158 (SHI, 1990, p. 315, *nom. nud.*) [**P. uniplicata* SHI, 1992, p. 159; OD]. Elongate-oval in outline, strongly biconvex, anterior commissure uniplicate, umbo relatively small, erect to slightly incurved with angular beak ridges, pedicle foramen possibly permesothyrid; pedicle collar present, dental plates inwardly concave, diverging ventrally; cardinal process present, inner socket ridges deflected ventrally, hinge plates united to form shallow, U-shaped, entire cardinal plate,

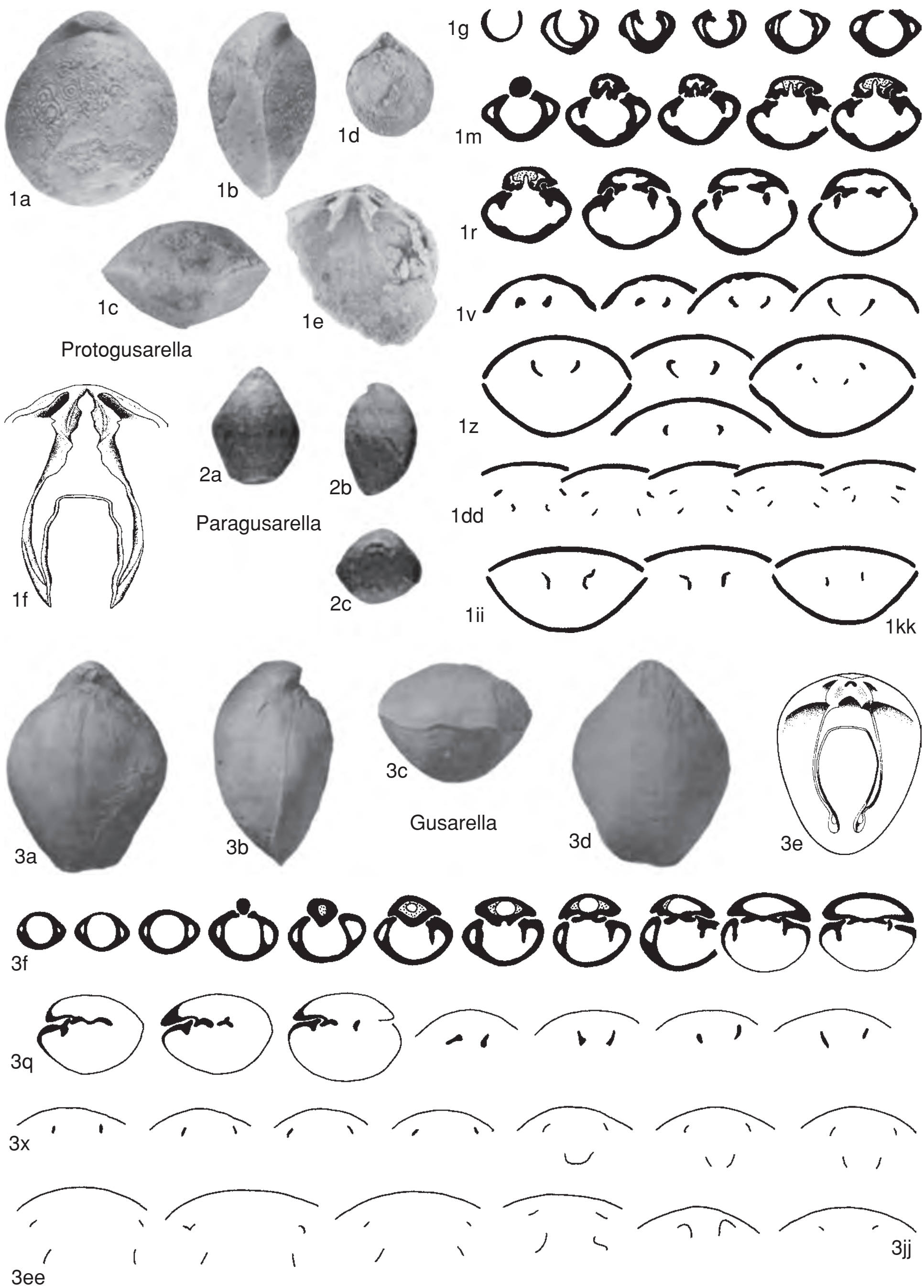

FIG. 1451. Gusarellidae (p. 2184–2186).

median septum not developed but trace of low, median ridge in early development stage, loop descending branches slender, nature of ascending elements unknown, dorsal adductor scars elongate on either side of low, indistinct myophragm. *Middle Jurassic (Callovian):* southern Tibet.——FIG. 1451,*2a–c*. **P. uniplicata,* Burang; dorsal, lateral, anterior views, P31011, ×1 (Shi, 1992).

Protogusarella PERRY & CHATTERTON, 1979, p. 315 [**P. smithi;* OD]. Elongate-suboval in outline, anterior commissure weakly unisulcate to rectimarginate, umbo moderately incurved with rounded-angular beak ridges, foramen moderately large, permesothyrid; well-developed pedicle collar, dental plates inwardly concave, subparallel; hinge plates W-shaped, crural bases strong, given off possibly dorsally, inner hinge plates converging medianly but not meeting, forming perforate, apical cardinal plate, loop delicate, ribbonlike, at least 0.75 valve length, apparently not spinose, dorsal adductor scars elongate on either side of low, indistinct myophragm. *Lower Triassic (Induan–Olenekian):* USA (Idaho, Wyoming, Utah).——FIG. 1451,*1a–kk*. **P. smithi,* Thaynes Formation, Preuss Range, southeastern Idaho; *a–c,* dorsal, lateral, anterior views; *d,* juvenile shell, dorsal view; *e,* dorsal valve interior, ×2.6; *f,* loop reconstruction, ×5 (Perry & Chatterton, 1979); *g–kk,* serial transverse sections, 0.8, 0.9, 1.0, 1.1, 1.2, 1.4, 1.5, 1.6, 1.7, 1.9, 2.0, 2.1, 2.2, 2.4, 2.6, 2.8, 3.0, 3.2, 3.6, 3.8, 4.0, 4.6, 4.8, 5.2, 5.6, 6.2, 6.6, 7.0, 7.4, 7.6, 7.8 mm from umbo, ×2.6 (adapted from Perry & Chatterton, 1979).

Family EUDESIIDAE Muir-Wood, 1965

[Eudesiidae MUIR-WOOD, 1965b, p. 829]

Small to large size, outline commonly oval to elongate-oval, biconvex or ventribiconvex, anterior commissure rectimarginate to uniplicate and multiplicate, shell costate, rarely costellate, umbo normally massive, typically with short, obscure to rounded beak ridges, pedicle foramen large, round, mesothyrid, rarely without pedicle collar, shell with apical or thick umbonal callus; teeth moderate, dental plates short, commonly enveloped in callus, typically straight, subparallel; cardinal process present, bilobed, trilobed, or elaborated, or exceptionally represented by callus lobe only, inner socket ridges occasionally deflected dorsally, outer hinge plates demarcated exceptionally, crural bases given off dorsally, inner hinge plates developed, typically united to form cardinal plate with anterior median ridge, giving open W-shape in cross section, septalium absent, median septum typically low and triangular in cross section, supporting cardinal plate at apex only, loop apparently smooth, transverse band variable, commonly with posterior projections. *Lower Jurassic (Toarcian)–Upper Jurassic (Kimmeridgian).*

Eudesia KING, 1850, p. 144 [**Terebratula orbicularis* J. de C. SOWERBY, 1826 in 1826–1829, p. 68; OD; =*T. cardium* VALENCIENNES in LAMARCK, 1819, p. 255]. Small to medium size, elongate-oval in outline, umbo suberect to incurved, concealing deltidial plates; dental plates commonly enveloped in callus ventrally; hinge plates slightly convex ventrally, cardinal plate keeled, median septum high posteriorly, acutely triangular in cross section, extending about 0.5 valve length, loop transverse band with posteriorly directed carinae. *Middle Jurassic (?upper Bajocian, Bathonian):* Serbia, *?upper Bajocian;* Europe, Asia, Africa, *Bathonian.*——FIG. 1452,*3a–u*. **E. cardium* (VALENCIENNES), Bathonian, Ranville, France; *a–e,* dorsal, lateral, anterior, ventral, posterior views, ×1 (Cooper, 1989); *f–u,* serial transverse sections, distances unknown, ×1.2 (adapted from Muir-Wood, 1965b).

Apothyris COOPER, 1989, p. 101 [**A. aberrans;* OD]. Small, costellate, elongate-oval to subcircular in outline, ventribiconvex, anterior commissure commonly incipiently uniplicate, umbo broad, suberect to erect, with flattened palintropes demarcated by strong beak ridges, deltidial plates commonly excavated remnantal, costellae irregular, narrow, separated by spaces as wide as or wider than costellae, intercalation in two or three generations; pedicle collar not developed, dental plates very short, usually enveloped by callus; cardinal process small, possibly bilobed, inner socket ridges dorsally deflected, hinge plates concave ventrally, cardinal plate possibly perforate posteriorly, median septum very short, less than 0.2 valve length, supporting cardinal plate at apex, crural processes blunt, loop almost reaching anterior, ascending branches about half loop length, transverse band flattened. *Lower Jurassic (Toarcian)–Middle Jurassic (Callovian):* Saudi Arabia.——FIG. 1453,*1a–e*. **A. aberrans,* Callovian, Jebel Tuwaiq; dorsal, lateral, anterior, ventral, posterior views, ×2 (Cooper, 1989).

Flabellothyris EUDES-DESLONGCHAMPS, 1884, p. 262 [**Terebratula flabellum* DEFRANCE, 1828a, p. 160; OD]. Small, subtrigonal to flabellate in outline, weakly biconvex, commissure commonly incipiently uniplicate, dorsal fold, if formed, occupying about 0.3 of valve width, commonly formed by three costae, umbo suberect with rounded-angular beak ridges, deltidial plates disjunct to conjunct, commonly flaring, commonly concealed; hinge plates demarcated from inner socket ridges, ventrally directed, slightly concave, median septum short, dorsal valve structures concealed by callus apically. [Specimens from the Lower Jurassic and Upper Cretaceous are homeomorphs.] *Middle Jurassic (Bathonian):* England, France, Saudi Arabia. ——FIG. 1453,*2a–c*. **F. flabella* (DEFRANCE); dorsal, lateral, anterior views, lower Bathonian, middle Dhruma Formation, Djebel Tuwaiq, Saudi Arabia, ×2 (Cooper, 1989).

Praeudesia HEGAB & TKHORZHEVSKY, 1991, p. 3 [**P. makridini* HEGAB & TKHORZHEVSKY, 1991, p. 4; OD]. Small to medium size, rounded oval to subtrigonal in outline, maximum width anterior to

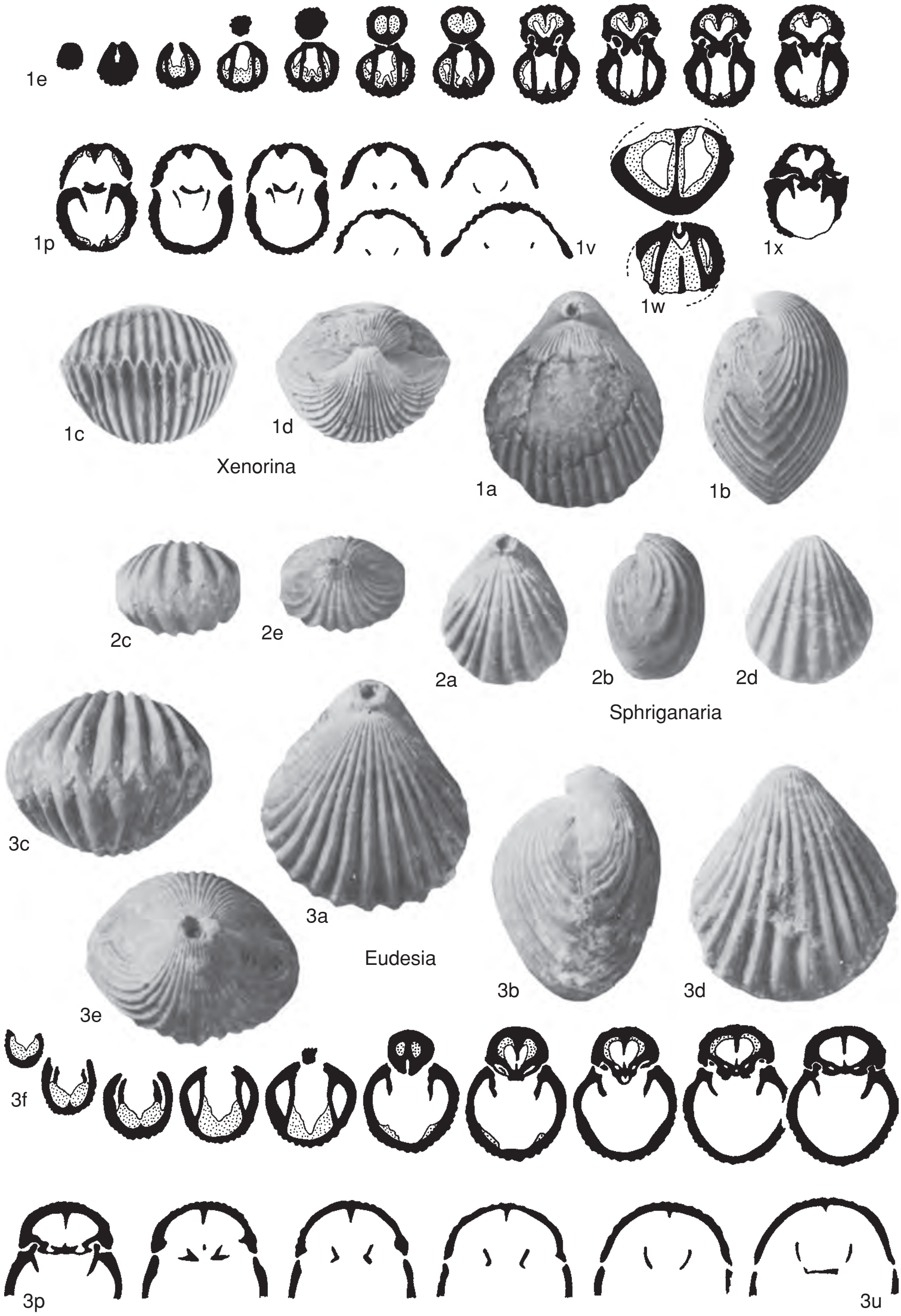

FIG. 1452. Eudesiidae (p. 2186–2188).

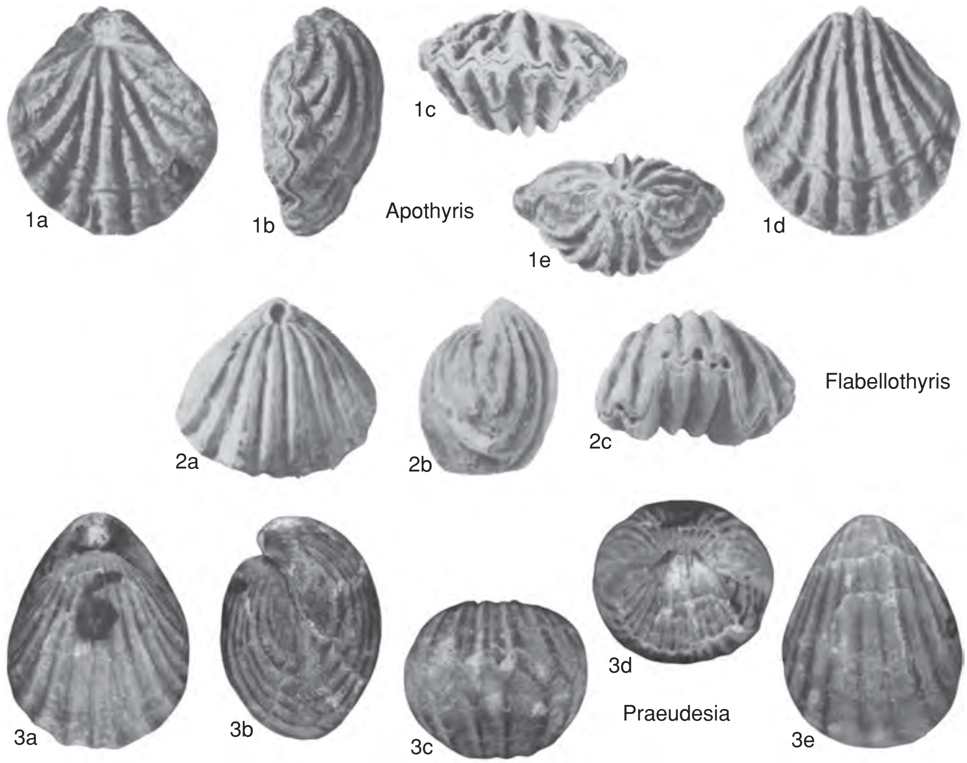

FIG. 1453. Eudesiidae (p. 2186–2188).

midvalve, shell costellate laterally, biconvex, umbo suberect to incurved, concealing short, thin symphytium, with rounded beak ridges; pedicle collar not developed, dental plates thick, partially enveloped in callus, subparallel or slightly ventrally convergent; cardinal process absent, outer hinge plates weakly developed on ventral margin of inner socket ridges, deflected dorsally, median septum very low, about 0.25 valve length, appearing anteriorly as a euseptoidum, structures much thickened and obscured by umbonal callus, loop transverse band narrow. *Middle Jurassic (upper Bathonian, ?Callovian):* Sinai.——FIG. 1453,*3a–e*. **P. makridini,* Kehailia Member, Masajid Formation, Gebel Maghara, northern Sinai; dorsal, lateral, anterior, posterior, ventral views, ×1.5 (Hegab & Tkhorzhevsky, 1991).

Sphriganaria COOPER, 1989, p. 102 [**S. modesta* COOPER, 1989, p. 111; OD]. Small to medium size, costellate, oval to subtrigonal in outline, maximum width ranging from midvalve to anterior, usually slightly ventribiconvex, anterior commissure with tendency toward weak uniplication in some species, umbo straight to erect, with rounded beak ridges, pedicle foramen usually mesothyrid; pedicle collar sessile, dental plates slender, slightly inwardly concave; cardinal process absent, inner socket ridges dorsally deflected, hinge plates flat, median septum very low, about 0.5 valve length. *Middle Jurassic (Bajocian)–Upper Jurassic (Kimmeridgian):* Saudi Arabia, Sinai, Egypt.——FIG. 1452,*2a–e*. **S. modesta,* Callovian, upper Dhruma Formation, Jebel Tuwaiq, Saudi Arabia; *a–e,* dorsal, lateral, anterior, ventral, posterior views, ×1 (Cooper, 1989).

Xenorina BAKER, *nom. nov.* herein (COOPER, 1989, p. 115, *nom. nud.*) [**X. ovata;* OD]. Large, oval in outline, with rounded sides and narrowly rounded anterior, ventribiconvex, umbo erect to strongly incurved, pedicle foramen ranging from moderately large to very small; dental plates fairly long, parallel, thickened by callus in adult; cardinal process bilobed, protruberant, hinge plates short, thick, convex ventrally, cardinal plate scarcely supported by short, thick, rounded triangular median septum, structures much thickened by callus in old specimens, loop with broad transverse band. *Middle Jurassic (Bathonian–Callovian):* Saudi Arabia.——FIG. 1452,*1a–x*. **X. ovata,* Callovian, upper Dhruma Formation, Jebel Tuwaiq; *a–d,* dorsal, lateral, anterior, posterior views, ×1 (Cooper, 1989); *e–v,* serial transverse sections, 0.4, 1.3, 1.7, 2.3, 2.7, 3.1, 3.2, 3.6, 4.0, 4.4, 4.6, 5.1, 5.4, 5.5, 5.7, 6.5, 7.2, 7.6 mm from umbo, ×1; *w,* transverse, oblique section showing pedicle collar, ×1.5; *x,* transverse section showing well-developed cardinal process, ×1 (adapted from Cooper, 1989).

KINGENOIDEA

D. I. MacKinnon,[1] T. N. Smirnova,[2] and D. E. Lee[3]

[[1]University of Canterbury; [2]Moscow State University; and [3]University of Otago]

Superfamily KINGENOIDEA Elliott, 1948

[*nom. transl.* MacKinnon, Smirnova, & Lee, herein, *ex* Kingeninae Elliott, 1948b, p. 311]

Adult shells small to large, subcircular to subtriangular or subpentagonal, exterior smooth to granular, anterior commissure rectimarginate, unisulcate or intraplicate, foramen small to medium, deltidial plates conjunct or disjunct. Pedicle collar broad and sessile. Dental plates well developed; cardinal process a small, transversely oval myophore; outer hinge plates commonly well developed; inner hinge plates uniting to form septalium; crural bases weakly differentiated. Adult loop commonly mediovertical, may be diploform or bilacunar. Septal pillar retained throughout ontogeny, commonly developing as long, thin median septum. Septal pillar bifurcating early in ontogeny. Septal flanges not developed. Lophophore plectolophous. Mantle may be spiculate. *Middle Triassic–Holocene.*

Family KINGENIDAE Elliott, 1948

[*nom. transl.* Owen, 1970, p. 49, *ex* Kingeninae Elliott, 1948b, p. 311]

Adult loop bilacunar or mediovertical. *Upper Jurassic–Holocene.*

Subfamily KINGENINAE Elliott, 1948

[Kingeninae Elliott, 1948b, p. 311]

Adult loop bilacunar with both lateral and mediovertical connecting bands. *Upper Jurassic–Neogene (lower Miocene).*

Kingena Davidson, 1852a, p. 40 [**Terebratula lima* Defrance, 1828b, p. 156; OD] [=*Kingia* Schloenbach, 1866, p. 296, *nom. null., non* Theobald, 1910, *nec* Malloch, 1921]. Small to large, biconvex, elongate-oval to pentagonal, rectimarginate to faintly uniplicate to ligate; shell ornament granular, beak short, suberect, foramen subcircular, permesothyrid, deltidial plates disjunct. Pedicle collar sessile. Cardinal process small, transversely oval myophore; septalium broad, shallow, supported by long, thin, moderately high median septum; loop bilacunar, may be thickened. *Lower Cretaceous–Upper Cretaceous:* Europe, Australasia, India.——Fig. 1454,*3a–c*. **K. lima* (Defrance), Upper Cretaceous, England; dorsal, anterior, and lateral views of exterior of neotype, NHM B79709, ×2 (Owen, 1970).——Fig. 1454,*3d–e*. *K. mesembrina* (Etheridge), Upper Cretaceous, Western Australia; ventral and anterior views of partially complete loop showing strong, mediovertical connecting bands, ×9 (new).

Aldingia Thomson, 1916b, p. 501 [**Terebratella furculifera* Tate, 1880, p. 161; OD]. Small to medium, smooth, elongate-oval, anterior commissure rectimarginate to unisulcate; deltidial plates commonly disjunct but conjunct in some adults; foramen submesothyrid to mesothyrid; beak short, erect. Pedicle collar sessile, hinge teeth supported by swollen bases derived from thickened dental plates. Cardinal process a sessile, transverse myophore; cardinalia thick with socket ridges flanking a solid hinge trough with large, strongly impressed adjustor scars; fused anteriorly with median septum; loop bilacunar. *Paleogene (Eocene):* Australia.——Fig. 1454,*2a–d*. **A. furculifera* (Tate); *a–b,* dorsal and lateral views of exterior of lectotype, SAM.P T895H, ×1.5; *c–d,* ventral and anterior view of dorsal valve interior, ×3 (Richardson, 1973).

Dictyothyropsis Barczyk, 1969, p. 66 [**Terebratulites loricatus* Schlotheim, 1820, p. 270; OD]. Small, biconvex, pentagonal in outline; costellae fine, dichotomous; anterior commissure parasulcate; beak short, massive, erect; deltidial plates disjunct to conjunct. Pedicle foramen large, round, mesothyrid; pedicle collar present; cardinal area wide and flat; teeth and dental plates long, massive, smooth. Cardinal process small, poorly developed, fused with hinge plates and median septum; loop bilacunar with mediovertical connecting band and broad hood. *Upper Jurassic:* Europe.——Fig. 1455,*2a–e*. **D. loricata* (Schlotheim), Poland; *a–d,* dorsal, ventral, lateral, and anterior views of exterior, ×2.5; *e,* detail of umbonal region, ×6 (Barczyk, 1969).——Fig. 1455,*2f–dd*. *D. roemeri* (Rollier), Poland; serial transverse sections 0.0, 1.4, 1.6, 2.0, 2.2, 2.5, 2.8, 3.2, 3.4, 3.6, 4.1, 4.4, 4.9, 5.1, 5.3, 5.5, 5.7, 6.0, 6.2, 6.4, 6.7, 7.1, 7.7, 8.0, 8.9 mm from first section, ×1 (adapted from Barczyk, 1969).

Laquethiris Bitner, 1996, p. 86 [**L. curiosa;* OD]. Small to medium, smooth, elongate-oval to subpentagonal, anterior commissure rectimarginate to mildly unisulcate; deltidial plates small, disjunct; foramen large, oval to subcircular, submesothyrid to mesothyrid; beak short, suberect. Pedicle collar

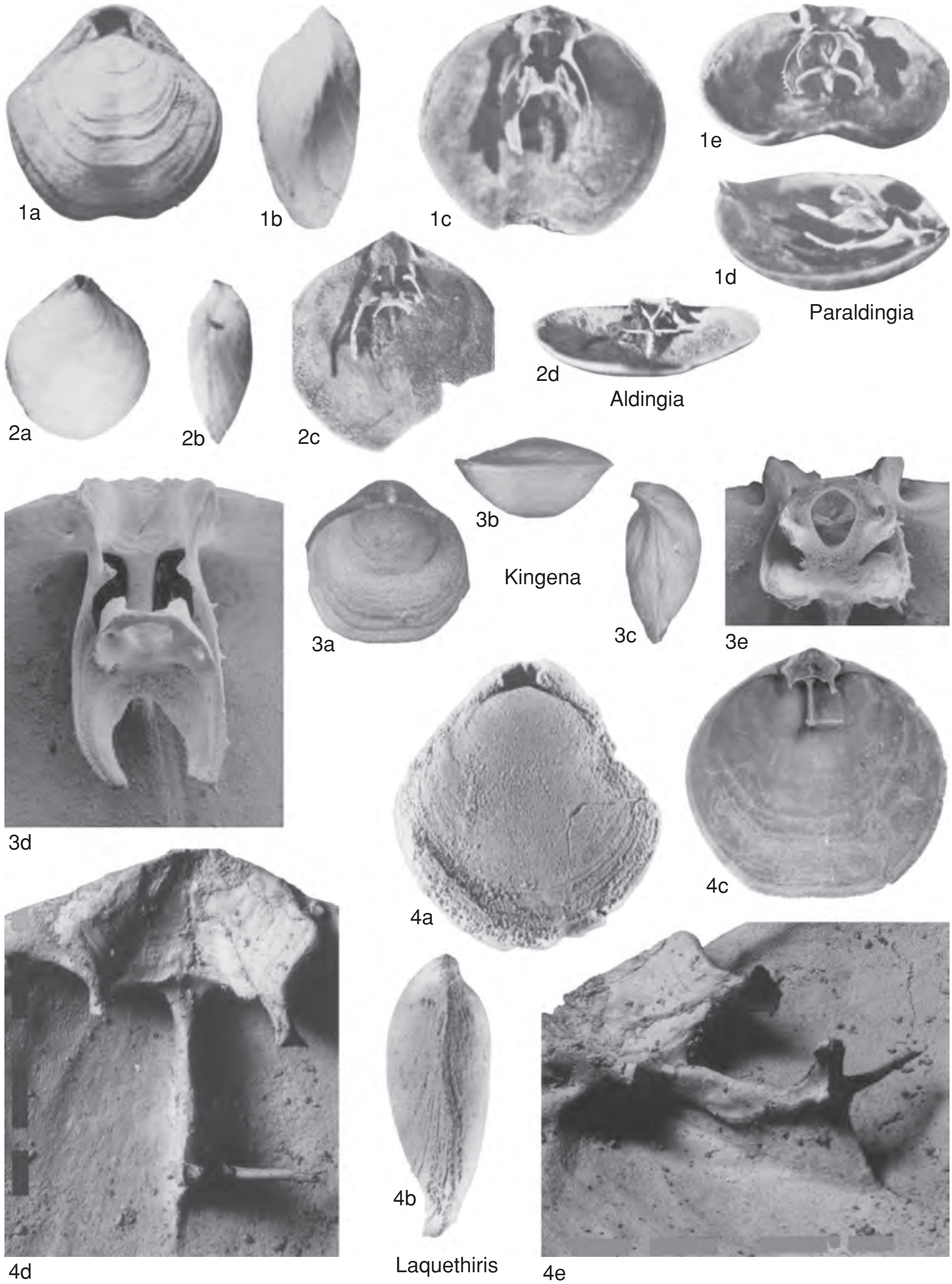

FIG. 1454. Kingenidae (p. 2189–2192).

sessile, hinge teeth small, supported by dental plates. Cardinalia lamellar, with well-developed inner and outer hinge plates separated by prominent crural bases; inner hinge plates uniting with median septum to form septalium; cardinal process an indistinct, sessile, transverse myophore; loop bilacunar, mediovertical and lateral connecting bands slender. *Paleogene (Eocene):* Antarctica, ?Australia.——FIG. 1454,*4a–e*. **L. curiosa,* Antarctica; *a–b,* dorsal and lateral views of exterior of holotype,

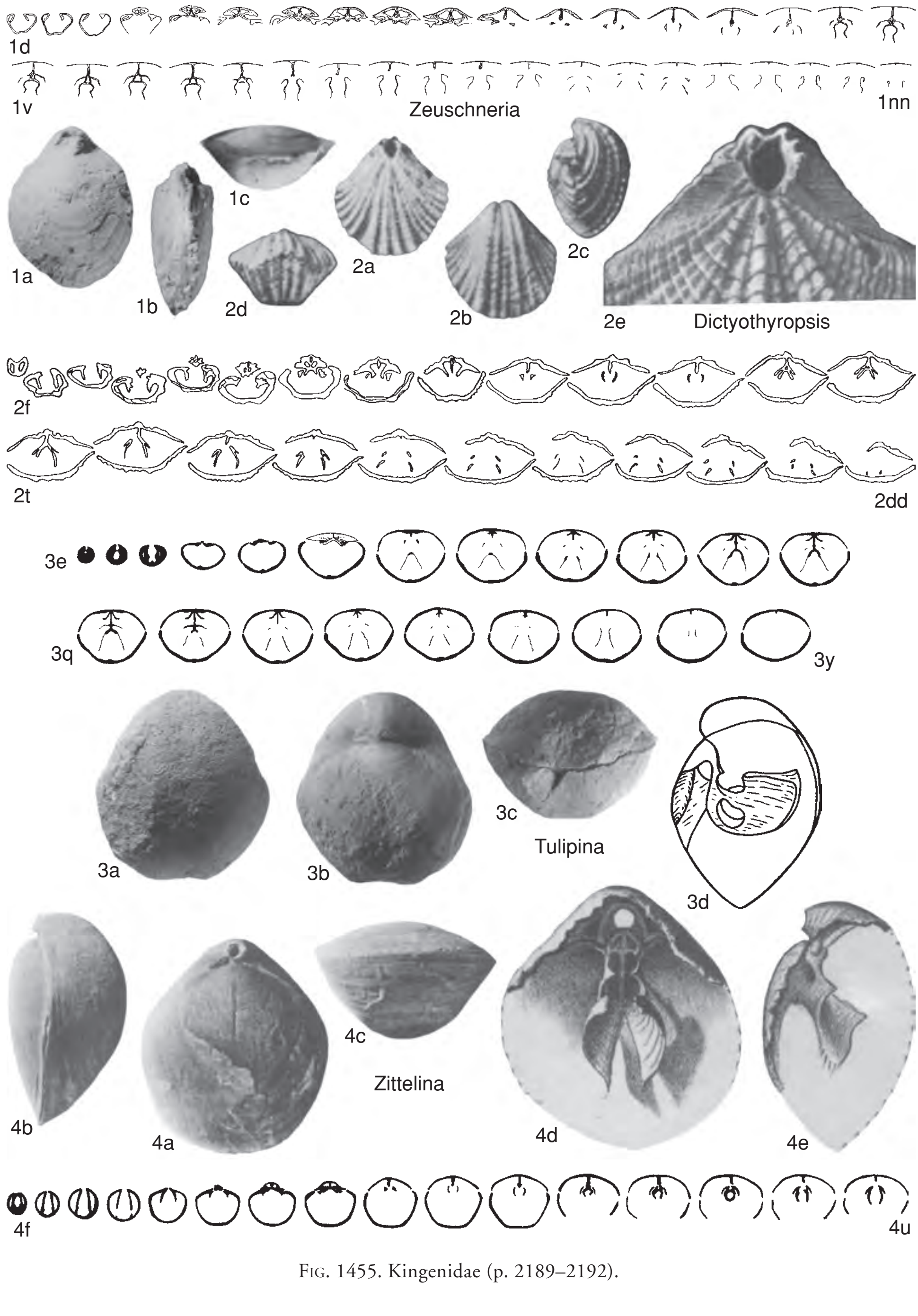

FIG. 1455. Kingenidae (p. 2189–2192).

ZPAL Bp. XXXVII/565, ×2 (Bitner, 1996); *c,* dorsal interior, ×1.5 (new); *d–e,* ventral and anterior oblique view of dorsal interior showing cardinalia and mediovertical and lateral connecting bands of loop, ×4.5, ×5 (new).

Paraldingia RICHARDSON, 1973, p. 122 [**Terebratella(?) woodsii* TATE, 1880, p. 161]. Differs from *Aldingia* in possession of discrete dental plates, unisulcation, excavate inner hinge plates, and bilacunar loop with broad and moderately thick, mediovertical and lateral connecting bands. *Paleogene (lower Eocene)–Neogene (lower Miocene):* Chatham Islands, New Zealand, *lower Eocene;* Australia, *upper Eocene–lower Miocene.*——FIG. 1454,*1a–e.* **P. woodsii* (TATE), lower Miocene, Australia; *a–b,* dorsal and lateral views of exterior of lectotype, SAM.P T901A, ×2.5; *c–e,* ventral, lateral oblique, and anterior views of dorsal valve interior, ×3 (Richardson, 1973).

Tulipina SMIRNOVA, 1962, p. 102 [**Zeilleria koutaisensis* DE LORIOL, 1896, p. 145; OD]. Small, smooth, subpentagonal, globose, anterior commissure unisulcate, beak low, strongly incurved; pedicle foramen small, mesothyrid. Dental plates short and thick; lateral umbonal cavities vestigial. Cardinal process not differentiated, crural bases massive, septalium deep and cuplike; median septum short, high, bladelike with pair of obliquely inclined flanges (possibly for dorsal adductor muscle attachment) extending from base; loop bilacunar with prominent, mediovertical connecting band; hood strongly flared, with posteromedian lacuna and broad, dorsally convex transverse band. *Lower Cretaceous:* Georgia.——FIG. 1455,*3a–y.* **T. koutaisensis* (DE LORIOL); *a–c,* ventral, dorsal, and anterior views, ×3 (Smirnova, 1990a); *d,* lateral view with loop reconstruction, ×3 (Muir-Wood, 1965a); *e–y,* serial transverse sections 0.0, 0.7, 0.8, 1.6, 2.2, 2.6, 3.2, 3.6, 3.8, 4.1, 4.2, 4.3, 4.6, 4.8, 5.2, 5.35, 5.6, 6.0, 6.4, 6.8, 7.6 mm from ventral umbo, ×1 (adapted from Smirnova, 1962).

Zeuschneria SMIRNOVA, 1975a, p. 137 [**Z. imitabilis;* OD] Small, smooth, elongate oval, anterior commissure rectimarginate, beak erect, foramen mesothyrid. Dental plates short, steeply inclined, bounding small, lateral umbonal cavities. Septalium broad with gently inclined hinge plates. Loop bilacunar with broad hood and well-developed mediovertical connecting band, spinose anteriorly. *Upper Jurassic:* Poland.——FIG. 1455,*1a–nn.* **Z. imitabilis; a–c,* dorsal, lateral, and anterior views, ×3 (Smirnova, 1975a); *d–nn,* serial transverse sections 0.0, 0.3, 0.7, 1.2, 1.4, 1.7, 1.9, 2.2, 2.4, 2.6, 2.9, 3.1, 3.5, 3.7, 4.2, 4.5, 5.1, 5.3, 5.5, 5.9, 6.2, 6.4, 6.5, 6.7, 7.0, 7.1, 7.7, 7.9, 8.7, 9.2, 9.4, 9.6, 10.4, 10.5, 10.7, 11.5, 11.6 mm from ventral umbo, ×1 (adapted from Smirnova, 1975a).

Zittelina ROLLIER, 1919, p. 368 [**Terebratula orbis* QUENSTEDT, 1858, p. 639; OD]. Small, smooth, subpentagonal to subquadrate; anterior commissure rectimarginate to incipiently unisulcate; beak suberect to slightly incurved, beak ridges indistinct; foramen small, circular, permesothyrid. Pedicle collar present. Cardinalia with small, central, concave hinge platform, septum thin, loop diploform, with short descending branches fringed with long spines, and large hood with annular flutings, laterally angled and anteriorly produced into gracefully curved projections. *Upper Jurassic, ?Lower Cretaceous:* Europe, Western Asia, *Upper Jurassic;* Europe, *?Lower Cretaceous.*——FIG. 1455,*4a–u.* **Z. orbis* (QUENSTEDT), Upper Jurassic, Germany; *a–c,* dorsal, lateral, and anterior views of exterior, ×2 (Owen, 1970); *d–e,* ventral and lateral views of loop, ×4 (adapted from Zittel, 1870); *f–u,* serial transverse sections 0.0, 0.3, 0.7, 0.9, 1.1, 1.4, 1.7, 2.0, 2.2, 2.6, 2.8, 3.1, 3.3, 3.8, 4.0 mm from first section, ×1 (Owen, 1970).

Subfamily ECNOMIOSINAE Cooper, 1977

[*nom. transl.* MACKINNON, herein, *ex* Ecnomiosidae COOPER, 1977, p. 128]

Adult loop mediovertical. *Lower Cretaceous–Holocene.*

Ecnomiosa COOPER, 1977, p. 129 [**E. gerda* COOPER, 1977, p. 131; OD]. Medium to large, subrounded to subpentagonal, smooth, rectimarginate, beak short, suberect, attrite; foramen large, mesothyrid, deltidial plates narrow, disjunct. Teeth strong, dental plates short. Cardinal process an indistinct, sessile, transverse myophore; cardinalia having inner hinge plates attached to short median septum; adult loop mediovertical; descending branches of loop attached to median septum in early adult stages of development (bilacunar). *Holocene:* Caribbean, Japan, Indian Ocean.——FIG. 1456,*1a–f.* **E. gerda,* Caribbean; *a–d,* dorsal, lateral, posterior, and anterior views of exterior of holotype, USNM 550510a, ×1; *e–f,* ventral and lateral oblique views of dorsal interior of holotype showing mediovertical loop, ×1 (Cooper, 1977).

Belothyris SMIRNOVA, 1960, p. 117 [**B. plana* SMIRNOVA, 1960, p. 118; OD]. Medium, subpentagonal to elongate-oval, smooth, biconvex, ligate; anterior margin rectimarginate, beak low, incurved, deltidial plates conjunct. Dental plates gently diverging, curved, teeth massive with distinct denticulum. Hinge plates almost fused with inner socket ridges, septalium deep, broadly cup shaped, flattened anteriorly; loop mediovertical. [Possible junior synonym of *Dzirulina* NUTSUBIDZE, 1945.] *Lower Cretaceous:* Georgia (Crimea, Caucasus, Daghestan), Western Europe.——FIG. 1456,*3a–s.* **B. plana; a–c,* dorsal, lateral, and anterior views of exterior of holotype, MGU 784/19, ×1 (Smirnova, 1990a); *d–r,* serial transverse sections 0.25, 0.40, 1.4, 1.5, 2.4, 2.7, 3.3, 4.3, 4.7, 5.0, 5.1, 5.45, 5.8, 6.5, 8.3 mm from ventral umbo, ×1 (adapted from Smirnova, 1990a); *s,* loop reconstruction, ×1.3 (adapted from Smirnova, 1960).

Dzirulina NUTSUBIDZE, 1945, p. 188 [**Terebratula dzirulensis* ANTHULA, 1899, p. 70; OD]. Small to medium, subpentagonal, biconvex, smooth, or capillate near shell margin; anterior commissure rectimarginate; beak incurved, concealing symphytium, beak ridges short, angular, foramen circular, permesothyrid. Loop mediovertical. *Lower Cretaceous (Aptian–Albian):* Georgia (Caucasus), USA (California).——FIG. 1456,*4a–bb.* **D. dzirulensis* (ANTHULA), Albian; *a–c,* dorsal, lateral, and anterior views of exterior, ×1 (Muir-Wood, 1965a); *d,* loop reconstruction, ×1.5; *e–bb,* serial transverse sections 0.0, 0.5, 1.3, 1.9, 2.4, 2.6, 2.8, 3.3, 3.9, 4.8, 5.5, 5.6, 5.8, 5.85, 5.9, 6.0, 6.15, 6.4,

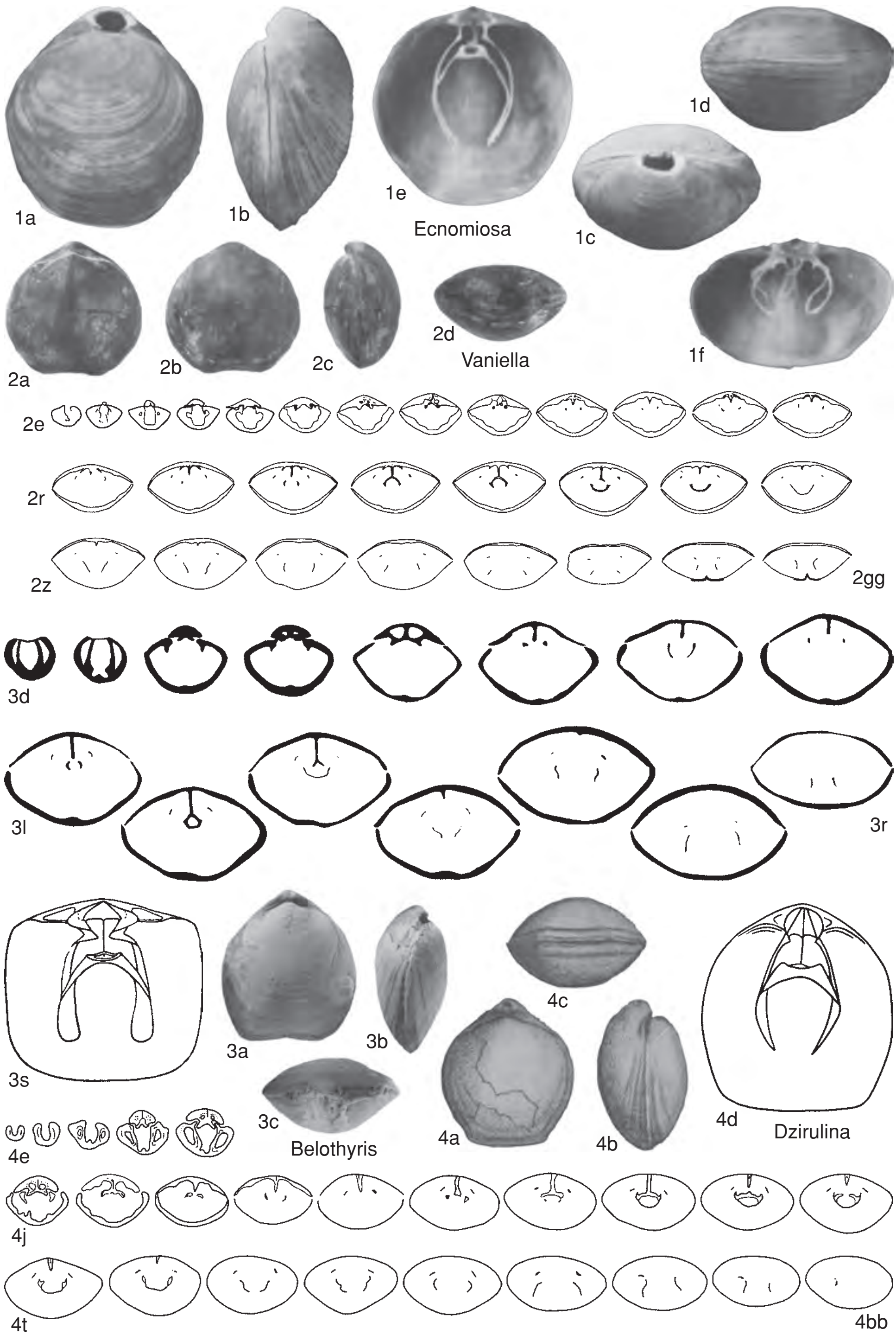

FIG. 1456. Kingenidae (p. 2192–2194).

6.7, 7.2, 8.2, 9.8, 10.9, 11.5 mm from ventral umbo, ×1 (adapted from Kvakhadze, 1972).

Vaniella KVAKHADZE, 1974, p. 493 [**V. sinuata* KVAKHADZE, 1974, p. 495; OD]. Subpentagonal, ventribiconvex, ligate; anterior commissure weakly unisulcate; beak short, incurved, foramen submesothyrid. Dental plates thickened, lateral beak cavities small. Cardinal process indistinct; inner socket ridges high; septalium deep, rather broad; loop mediovertical; lateral margins of muscle scars projecting above valve floor as obliquely inclined flanges. *Lower Cretaceous (Aptian):* Georgia.——FIG. 1456,*2a–gg. *V. sinuata; a–d,* dorsal, ventral, lateral, and anterior views of holotype, GMG 329/1, ×1; *e–gg,* serial transverse sections 0.9, 1.1, 1.4, 1.7, 2.1, 2.4, 2.7, 3.0, 3.2, 3.8, 4.0, 4.2, 4.5, 5.1, 5.7, 5.9, 6.1, 6.2, 6.3, 6.5, 6.9, 7.0, 7.2, 8.0, 8.4, 9.8, 11.4, 12.0, 12.3 mm from ventral umbo, ×1 (adapted from Kvakhadze, 1972).

Family AULACOTHYROPSIDAE Dagys, 1972

[Aulacothyropsidae DAGYS, 1972b, p. 53]

Smooth, biconvex, rectimarginate to unisulcate or ligate; dental plates present; adult loop generally haptoid to diploform, less commonly teloform. *Middle Triassic–Holocene.*

Subfamily AULACOTHYROPSINAE Dagys, 1972

[*nom. transl.* MACKINNON, SMIRNOVA, & LEE, herein, *ex* Aulacothyropsidae DAGYS, 1972b, p. 53]

Adult loop generally haptoid to diploform, with tendency for late detachment from septum. *Middle Triassic–Holocene.*

Aulacothyropsis DAGYS, 1959b, p. 99 [**Waldheimia (Aulacothyris) reflexa* BITTNER, 1890, p. 258; OD]. Small, elongate-oval, planoconvex to ventribiconvex, mildly unisulcate; beak short, erect, with distinct beak ridges; foramen minute, mesothyrid. Dental plates parallel; pedicle collar fused laterally to dental plates. Cardinal process not differentiated; septalial trough shallow, with outer hinge plates and crural bases lying in commissural plane; median septum long and thin; adult loop diploform with incipient detachment from septum; crural processes, dorsal and anterior edges of loop spinose. *Middle Triassic–Upper Triassic:* Alps, Balkans, Carpathians, Crimea, northwestern Caucasus, Pamirs, China.——FIG. 1457,*1a–ff. *A. reflexa* (BITTNER), Norian, northwestern Caucasus; *a–c,* dorsal, lateral, anterior views, ×1.5 (Dagys, 1963); *d–dd,* serial transverse sections 0.1, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.5, 1.6, 1.8, 2.0, 2.4, 2.8, 3.1, 3.3, 3.7, 3.8, 3.9, 4.0, 4.2, 4.5, 5.1, 5.8, 7.2, 7.9, 8.0 mm from ventral umbo, ×1; *ee–ff,* loop reconstructions, ×2 (Dagys, 1974).

Camerothyris BITTNER, 1890, p. 318 [**Terebratula subangusta* MÜNSTER, 1841, p. 64; SD DIENER, 1920, p. 98]. Small, smooth, planoconvex to biconvex, rectimarginate to unisulcate; beak short, erect; foramen small, mesothyrid. Dental plates uniting with ventral median septum to form Y-shaped, spondylium-like structure. Cardinal process not differentiated; well-developed septalium supported by bladelike median septum; adult loop diploform but possibly detached (through resorption) from septum. *Middle Triassic–Upper Triassic:* Alps, Carpathians, northwestern Caucasus.——FIG. 1458*a–c. *C. subangusta* (MÜNSTER), Upper Triassic, Dolomites, Italy; dorsal, ventral, anterior views, ×2 (Dagys, 1974).——FIG. 1458*d–z. C. minor* DAGYS, Upper Triassic, northwestern Caucasus; *d–x,* serial transverse sections 0.2, 0.3, 0.4, 0.5, 0.7, 0.9, 0.85, 0.9, 1.0, 1.1, 1.2, 1.4, 1.5, 1.7, 1.9, 2.0, 2.2, 2.3, 2.4, 2.6, 2.8 mm from ventral umbo, ×6 (adapted from Dagys, 1974); *y–z,* loop reconstructions, ×6 (Dagys, 1974).

Coriothyris OVTSHARENKO, 1983b, p. 168 [**C. corumensis* OVTSHARENKO, 1983b, p. 169; OD]. Small, oval or rounded-pentagonal, ventribiconvex, mildly unisulcate; beak short, erect to incurved with distinct beak ridges; formen minute, mesothyrid. Dental plates short, bladelike, ventrally divergent. Cardinal process not differentiated; outer hinge plates short, dorsally inclined, inner hinge plates ventrally curved, uniting early in ontogeny with high median septum to form septalium; crural processes short, parallel; adult loop teloform, extending about half length of dorsal valve, descending and ascending loop branches broad. *Middle Jurassic–Upper Jurassic:* Tadzhikistan, Pamirs.——Fig. 1457,*2a–ii. *C. corumensis,* Tadzhikistan; *a–c,* dorsal, ventral, and anterior views, ×1 (Ovtsharenko, 1983b); *d–ii,* serial transverse sections 0.2, 0.5, 0.7, 1.0, 1.3, 1.5, 1.7, 2.1, 2.2, 2.8, 2.9, 3.5, 4.0, 4.1, 4.2, 4.3, 4.5, 4.7, 5.0, 5.3, 5.8, 6.2, 6.8, 7.5, 8.5, 8.7, 9.3, 9.7, 10.0, 10.1, 10.7, 10.9 mm from ventral umbo, ×1.8 (adapted from Ovtsharenko, 1983b).

Oppeliella TCHORSZHEVSKY, 1989a, p. 81 [**Waldheimia pinguicula* ZITTEL, 1870, p. 139; OD]. Small, rounded-rhomboidal or transverse-oval, anterior commissure uniplicate, beak thick, short, moderately incurved, foramen small, mesothyrid, beak ridges short, sharp; deltidial plates conjunct; dental plates thick, short, slightly convergent ventrally; inner hinge plates fused posteromedianly, forming gently convex platform in section, median septum short, adult loop diploform. *Upper Jurassic (Tithonian):* Ukraine (Carpathians).——FIG. 1459,*4a–cc. *O. pinguicula* (ZITTEL); *a–d,* dorsal,

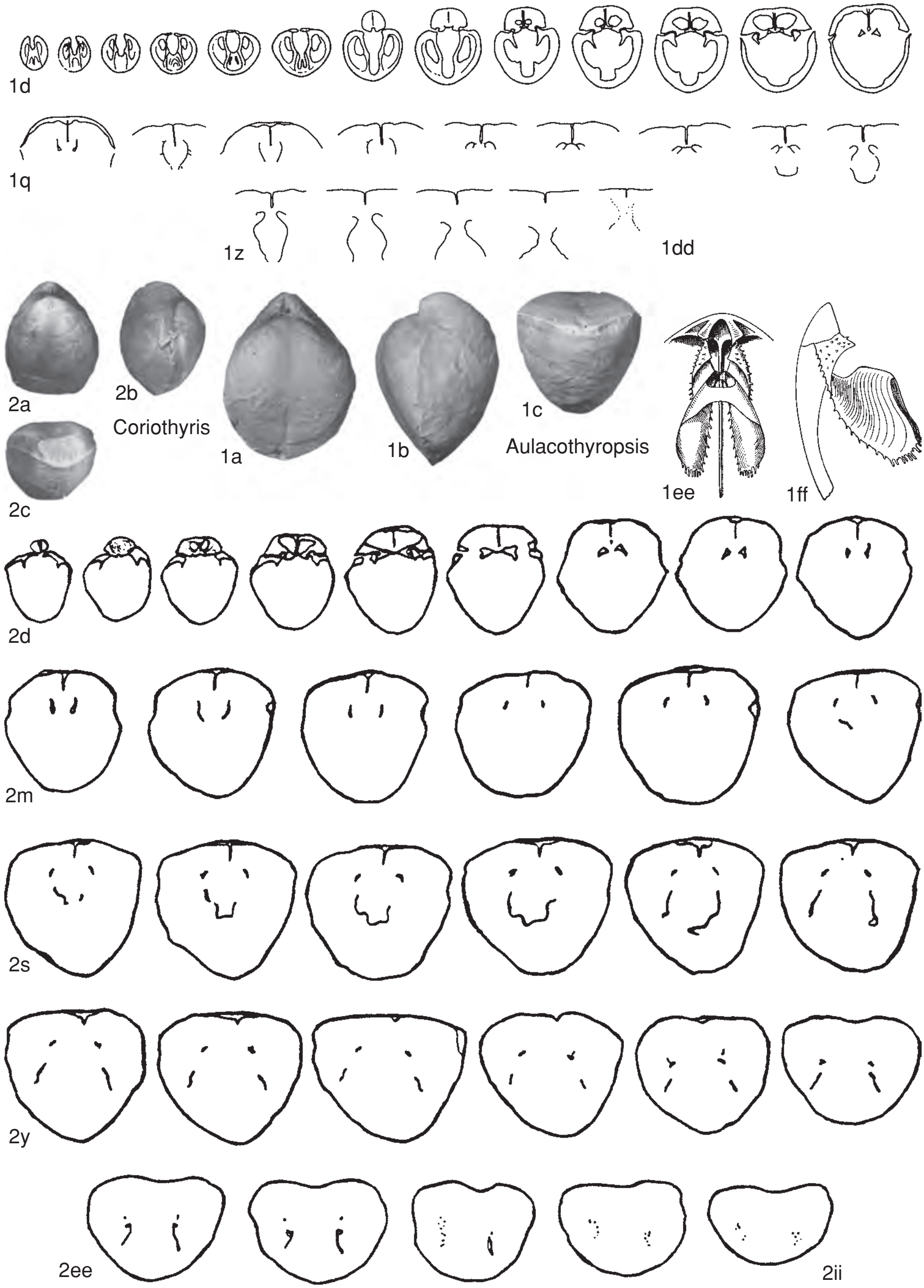

FIG. 1457. Aulacothyropsidae (p. 2194).

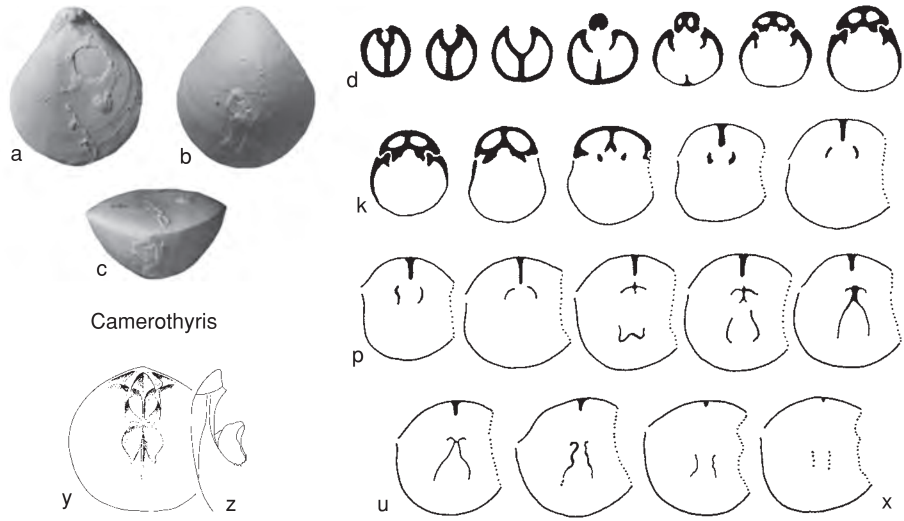

FIG. 1458. Aulacothyropsidae (p. 2194).

ventral, lateral, and anterior views of exterior, ×1 (Zittel, 1870); *e–cc,* serial transverse sections 0.0, 0.3, 0.5, 0.7, 0.85, 1.1, 1.3, 1.45, 1.65, 2.05, 2.45, 2.8, 3.15, 3.35, 3.55, 3.85, 4.15, 4.45, 4.65, 5.05, 5.25, 5.45, 6.45, 7.25, 8.45 mm from ventral umbo, ×2 (adapted from Tchorszhevsky, 1989a).

Ornatothyrella DAGYS, 1974, p. 210 [**O. ornata;* OD]. Very small, equibiconvex, ovoid outline, surface ornament of concentric rugae, anterior commissure rectimarginate, umbo short, erect, beak ridges distinct, foramen minute, mesothyrid; dental plates parallel, ventrally converging, pedicle collar absent; high dorsal median septum extending about 0.3 valve length, septalium Y-shaped. Adult loop resembling that of *Aulacothyropsis,* but less spinose and descending branches not medially united (i.e., adult loop of general diploform character but essentially teloform). *Upper Triassic (Norian):* northwestern Caucasus.——FIG. 1459,*1a–y.* **O. ornata; a–d,* dorsal, ventral, lateral, and anterior views, ×2 (Dagys, 1974); *e–y,* serial transverse sections 0.0, 0.1, 0.2, 0.25, 0.35, 0.45, 0.55, 0.65, 0.75, 0.85, 1.05, 1.15, 1.25, 1.35, 1.45, 1.55, 1.65, 1.75, 1.85, 2.05, 2.65 mm from ventral umbo, approximately ×2 (adapted from Dagys, 1974).

Pseudorugitela DAGYS, 1959b, p. 100 [**Waldheimia (Aulacothyris) pulchella* BITTNER, 1890, p. 200; OD]. Small, biconvex, rounded subpentagonal in outline, surface ornament of concentric rugae, anterior commissure rectimarginate, tending to anterior ligation; umbo short, erect, beak ridges distinct, foramen minute, mesothyrid; dental plates thin, parallel, and united to pedicle collar; dorsal septalium Y-shaped, loop similar to that of *Aulacothyropsis* but spinose only anteriorly. *Upper Triassic (Carnian, Norian):* Alps, Carpathians, northwestern Caucasus, Pamirs, China.——FIG. 1459,*2a–dd.* **P. pulchella* (BITTNER), Norian, Kuma River, northwestern Caucasus; *a–d,* dorsal, ventral, lateral, and anterior views, ×2 (Dagys, 1963); *e–cc,* serial transverse sections 0.0, 0.3, 0.6, 0.9, 1.3, 1.6, 1.8, 2.1, 2.3, 2.6, 3.0, 3.2, 3.5, 3.9, 4.2, 4.4, 5.0, 5.5, 5.7, 6.1, 6.5, 7.6, 8.9, 9.4, 10.3 mm from first section, ×2 (adapted from Dagys, 1959b); *dd,* loop reconstruction, ×4 (Dagys, 1974).

Smirnovina CALZADA BADIA, 1985, p. 88 [**S. smirnovae;* OD]. Small, smooth, subpentagonal, globose, anterior commissure unisulcate to plicosulcate, beak low, incurved, pedicle foramen small. Dental plates slender, subparallel; pedicle collar short, sessile. Cardinalia lamellar; inner hinge plates gently inclined and fused medianly to septum to form short septalium; median septum short, high, bladelike; loop diploform, strongly flared, with posteromedian lacuna and broad, dorsally convex, transverse band. *Lower Cretaceous:* Spain.——FIG. 1459,*3a–x.* **S. smirnovae; a–d,* dorsal, ventral, lateral, and anterior views of exterior of holotype, MGSB 32.690.1, ×2 (Smirnova, 1990a); *e–x,* serial transverse sections 0.6, 1.0, 1.4, 2.3, 2.5, 2.7, 3.0, 3.4, 3.8, 4.0, 5.4, 5.9, 6.1, 6.3, 6.5, 6.7, 6.9, 8.0, 8.7, 9.3 mm from ventral umbo, ×1 (adapted from Calzada Badia, 1985).

Subfamily BABUKELLINAE new subfamily

[Babukellinae MacKinnon, Smirnova, & Lee, herein] [type genus, *Babukella* Dagys, 1974, p. 208]

Loop of adult generally haptoid to diploform, with retention of strong, mediovertical connection to septum. *Upper Triassic–Holocene.*

Babukella Dagys, 1974, p. 208 [**B. loculus;* OD]. Small, subpentagonal, ventribiconvex, strangulate, anterior commissure rectimarginate to unisulcate; beak short, attrite, with rounded beak ridges, foramen small, mesothyrid. Dental plates short. Cardinal process not differentiated; septalium distinct, dorsal median septum high, about 0.6 valve length. Loop diploform, with spinose anterior edges. *Upper Triassic:* northwestern Caucasus, Pamirs.——Fig. 1460,*5a–ff.* **B. loculus,* Carnian, northwestern Caucasus; *a–d,* dorsal, ventral, lateral, and anterior views, ×2; *e–dd,* serial transverse sections 0.0, 0.1, 0.2, 0.3, 0.5, 0.7, 0.9, 1.0, 1.1, 1.2, 1.4, 1.5, 1.7, 1.9, 2.0, 2.2, 2.5, 2.7, 2.8, 2.9, 3.1, 3.3, 3.6, 3.8, 4.2, 4.5 mm from ventral umbo, ×2; *ee–ff,* loop reconstructions, ×4 (Dagys, 1974).

Fallax Atkins, 1960a, p. 72 [**F. dalliniformis;* OD]. Medium, biconvex, smooth, elongate ovate to subpentagonal, anterior commissure rectimarginate to parasulcate; beak low, erect; beak ridges rounded; deltidial plates conjunct in adults; foramen small, round, permesothyrid. Dental plates lamellar, straight; pedicle collar broad, sessile, impunctate. Cardinalia lamellar with short, well-developed septalium; inner and outer hinge plates well developed, crural bases not differentiated; cardinal process not differentiated; median septum extending anteriorly about three-quarters valve length; crura short, subparallel, crural processes short; loop diploform; lophophore and mantle finely spiculate. *Holocene:* eastern Atlantic, western and southwestern Pacific.——Fig. 1460,*4a–e.* **F. dalliniformis; a–c,* dorsal, lateral, and anterior views of holotype, NHM ZB2988, ×1 (Atkins, 1960a); *d,* dorsal interior showing diploform loop; *e,* oblique view of ventral valve interior showing dental plates and muscle scars, ×2 (new).

Hynniphoria Suess, 1859 in 1858–1859, p. 44 [**H. globularis;* OD]. Small, globose, smooth, broadly uniplicate; beak low, erect to incurved, beak ridges indistinct, deltidial structures small and obscure, foramen very small. Ventral interior with dental plates and stout, apparently composite, median septal structure that projects free anteriorly as curved and thickening, blade- or scimitar-like structure, extending dorsally into shell cavity. Dorsal interior bearing stout inner socket ridges; median septum short, low, diminishing rapidly anteriorly; loop possibly diploform. [Loop and other internal features imperfectly known.] *Upper Jurassic:* central Europe.——Fig. 1460,*3a–e.* **H. globularis; a–c,* dorsal, lateral, and anterior views, ×2; *d,* lateral view of shell interior, reconstruction; *e,* oblique view of loop, reconstruction, approximately ×10 (Suess, 1858 in 1858–1859).

Katchathyris Smirnova, 1975b, p. 120 [**K. privus;* OD]. Small, moderately biconvex, subcircular in outline, capillate, anterior commissure rectimarginate, beak low, slightly incurved, foramen permesothyrid; dorsal interior with broad, V-shaped septalium, septum extending for 0.3 valve length, crural processes short, loop diploform, extending about 0.75 valve length. *Lower Cretaceous:* Crimea, Ukraine.——Fig. 1461,*2a–ww.* **K. privus,* Crimea; *a–d,* ventral, dorsal, lateral, and anterior views of holotype, MGU 136/440, ×2.5 (Smirnova, 1975b); *e–uu,* serial transverse sections 0.0, 0.05, 0.1, 0.15, 0.25, 0.35, 0.55, 0.75, 0.85, 0.95, 1.0, 1.05, 1.1, 1.15, 1.2, 1.3, 1.35, 1.45, 1.5, 1.55, 1.75, 1.85, 1.9, 2.1, 2.2, 2.3, 2.4, 2.45, 2.5, 2.6, 2.7, 2.75, 2.8, 2.85, 2.9, 2.95, 3.0, 3.1, 3.15, 3.2, 3.3, 3.4, 3.5 mm from ventral umbo, ×2.5 (adapted from Smirnova, 1975b); *vv–ww,* loop reconstructions, ×3 (Smirnova, 1975b).

Makridinithyris Tchorszhevsky, 1989a, p. 82 [**Terebratula wahlenbergi* Zeuschner, 1846, p. 83; OD]. Small, strongly biconvex, subtrigonal or subpentagonal in outline, beak small, trigonal, erect to moderately incurved, foramen small, mesothyrid, beak ridges short, sharp; dental plates thin, ventrally convergent, trigonal septalium; crura prefalcifer, loop slender, relatively short, diploform. *Upper Jurassic (Tithonian)–Lower Cretaceous (Berriasian):* Ukraine (Carpathians).——Fig. 1460,*1a–t.* **M. wahlenbergi* (Zeuschner), Tithonian; *a–d,* dorsal, ventral, lateral, and anterior views of possible lectotype, ×1 (Zittel, 1870); *e–t,* serial transverse sections 0.0, 0.8, 1.1, 1.3, 1.5, 2.0, 2.4, 2.6, 3.1, 3.3, 3.5, 4.3, 4.6, 5.1, 5.5, 6.5 mm from ventral umbo, ×1 (adapted from Barczyk, 1971).

Septicollarina Zezina, 1981c, p. 16 [**S. hemiechinata;* OD]. Small, thin shelled, transversely oval, biconvex, anterior commissure slightly unisulcate; dorsal valve smooth; ventral valve carrying small low spines; beak straight, short, foramen permesothyrid, deltidial plates narrow, disjunct; dental plates straight, well developed; short septum in ventral valve dividing cavity beneath wide pedicle collar into two chambers; no cardinal process; inner hinge plates attached to long median septum; spicules not present; loop diploform, anteriorly spinose. *Holocene:* western Pacific (Sea of Japan).——Fig. 1460,*2a–c.* **S. hemiechinata; a–b,* exterior and interior views of ventral valve, ×4; *c,* line drawing of dorsal valve interior, ×4 (Zezina, 1981c).

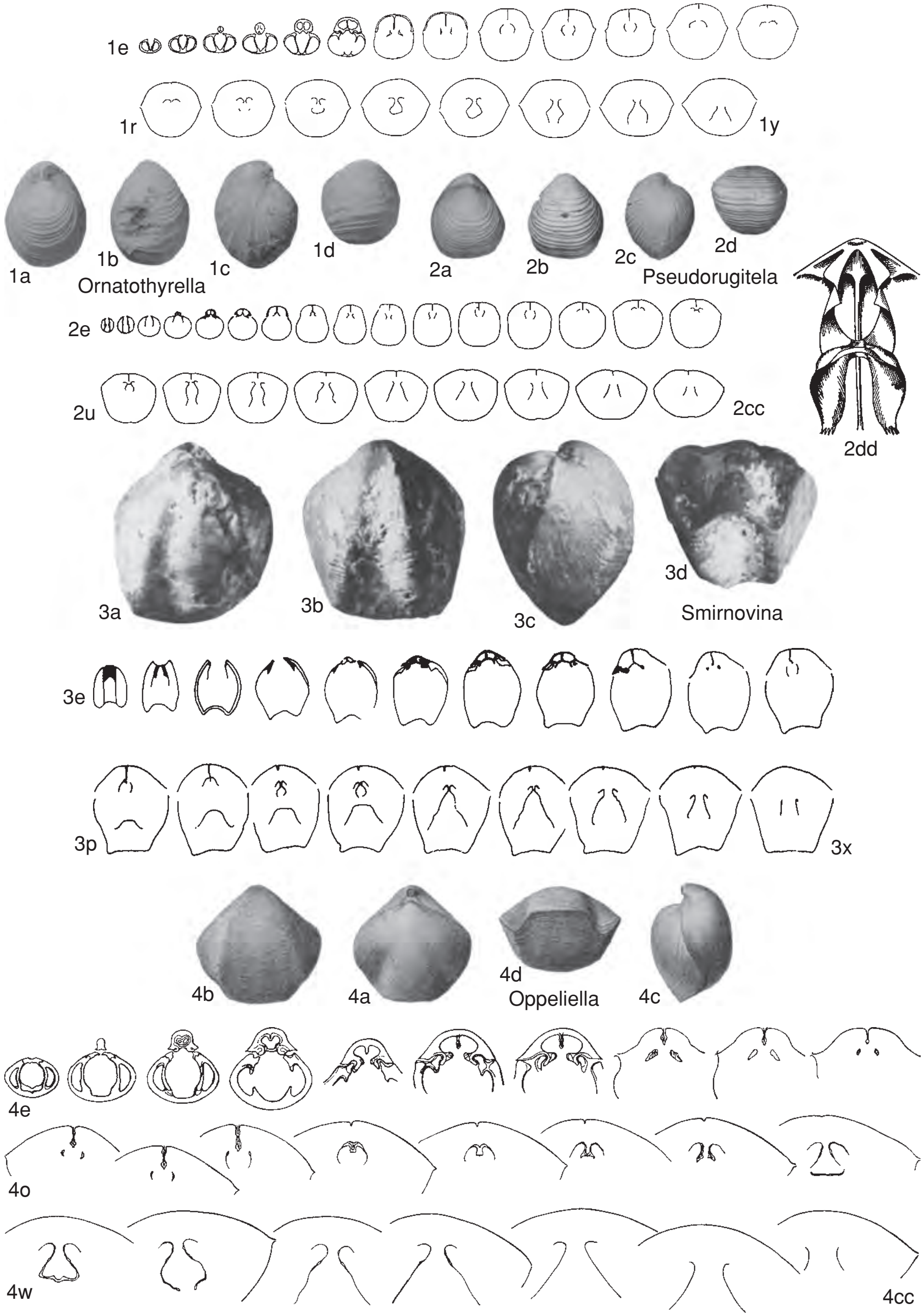

FIG. 1459. Aulacothyropsidae (p. 2194–2196).

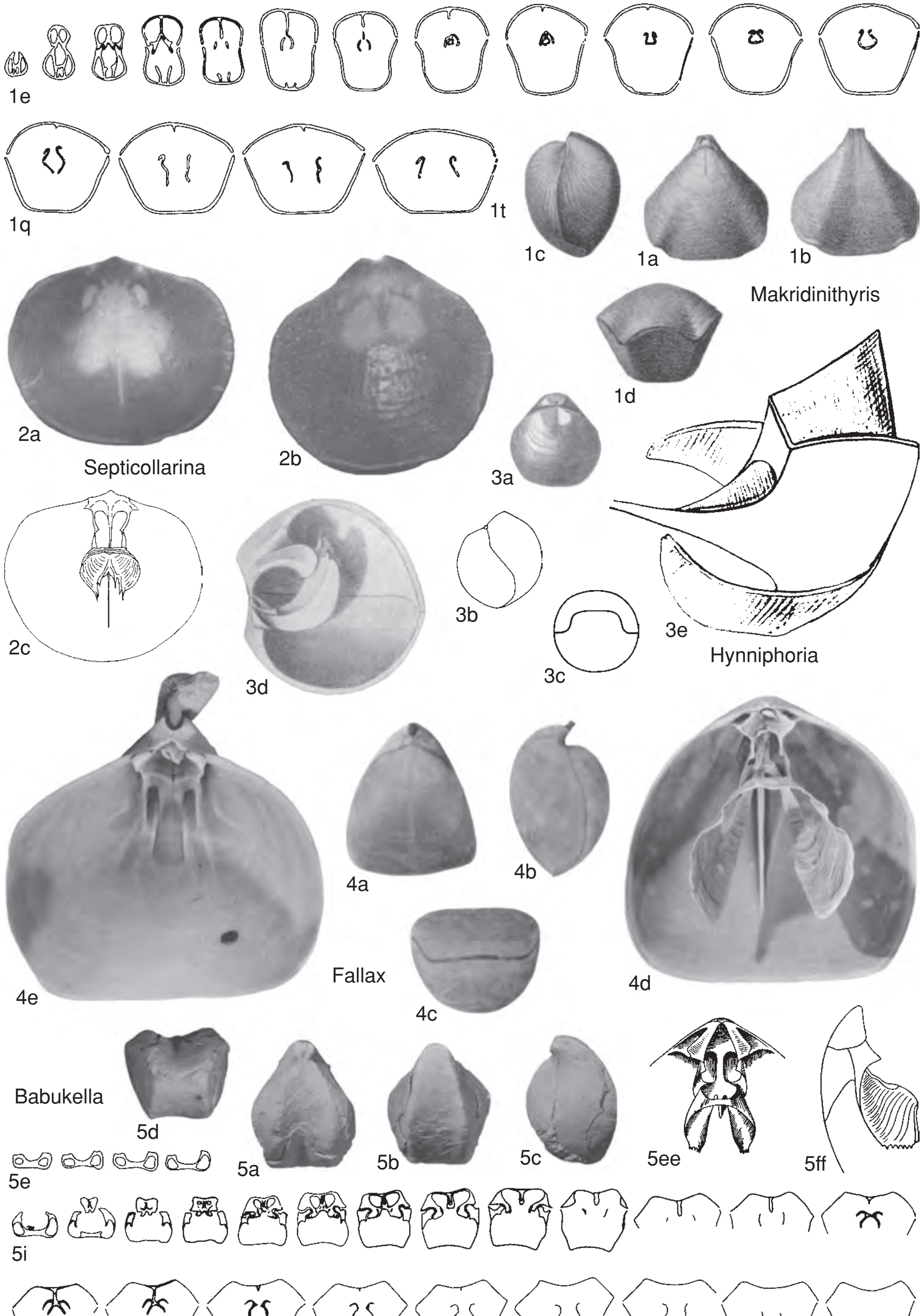

FIG. 1460. Aulacothyropsidae (p. 2197).

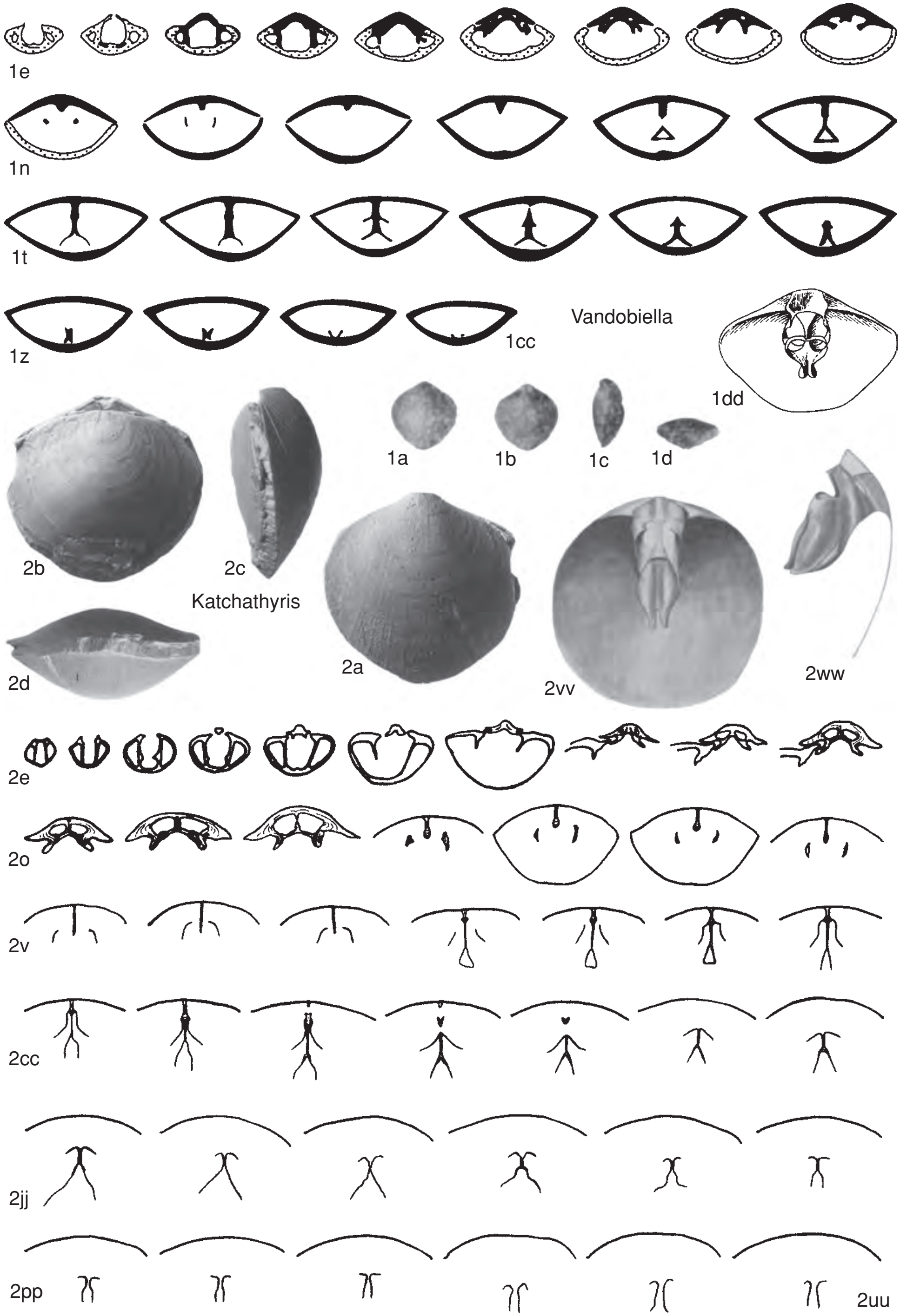

FIG. 1461. Aulacothyropsidae (p. 2197–2201).

Vandobiella POJARISKAJA, 1966, p. 22 [**V. perpusilla;* OD]. Small, planoconvex or slightly biconvex, subcircular to subrhomboidal in outline, umbo broad, erect, beak ridges sharp, foramen large, oval, submesothyrid to mesothyrid, deltidial plates disjunct. Teeth elongate, wedge shaped; dental plates short, thick; inner hinge plates converging on valve floor to form V-shaped trough; cardinal process weakly developed; well-developed median septum associated with diploform loop. *Middle Jurassic (Bathonian):* Tadzhikistan (Gissar Range).——FIG. 1461,*1a–dd.* **V. perpusilla; a–d,* ventral, dorsal, lateral, and anterior views of holotype, MGRI Museum No. VI-152/9, ×1 (Pojariskaja, 1966); *e–cc,* serial transverse sections, ×2 (adapted from Pojariskaja, 1966); *dd,* loop reconstruction, ×3 (Pojariskaja, 1966).

LAQUEOIDEA

D. I. MACKINNON and D. E. LEE

[University of Canterbury; and University of Otago]

Superfamily LAQUEOIDEA Thomson, 1927

[*nom. transl.* MACKINNON & LEE, herein, *ex* Laqueinae THOMSON, 1927, p. 256]

Adult shells small to large, subcircular to transverse or elongate oval, commonly smooth, some multicostate, anterior commissure rectimarginate to unisulcate, foramen small to large, with deltidial plates conjunct, disjunct, or forming symphytium. Pedicle collar broad and sessile. Dental plates well developed; cardinal process with transversely oval myophore, which may be sessile or elevated; dorsal septal pillar or median septum present; outer hinge plates commonly well developed; inner hinge plates absent, disjunct, or united to form septalium; crural bases differentiated when septalium present. Adult loop axial, annular, haptoid, trabecular, bilacunar, bilateral, or laterovertical. Septal flanges present on septal pillar during axial, cucullate, and annular phases of loop ontogeny. Lophophore plectolophous. *Upper Triassic–Holocene.*

Family LAQUEIDAE Thomson, 1927

[*nom. transl.* COOPER, 1973a, p. 21, *ex* Laqueinae THOMSON, 1927, p. 256]

Well-developed inner and outer hinge plates separated by crural bases; septalium well developed; cardinal process weakly differentiated; adult loop axial, haptoid, or bilateral. *Upper Triassic–Holocene.*

Subfamily LAQUEINAE Thomson, 1927

[Laqueinae THOMSON, 1927, p. 256; *non* HATAI, 1965c, p. 845]

Adult loop bilateral. *Neogene (Miocene)–Holocene.*

Laqueus DALL, 1870, p. 123 [**Terebratula californiana* KÜSTER, 1844, pl. 2b,*21–23;* OD; =*Laqueus erythraeus* DALL, 1920, p. 350, SD MACKINNON & LONG, 2000, p. 89; =*L. californicus* DALL, 1870, p. 123)]. Medium to large, variably ovate, subpentagonal to ligate, biconvex, smooth; anterior commissure rectimarginate; beak low, erect, with distinct beak ridges, foramen medium, mesothyrid to permesothyrid; either symphytium or conjunct deltidial plates. Hinge teeth with ventrally recessive dental plates; pedicle collar sessile. Cardinalia with inner and outer hinge plates separated by crural

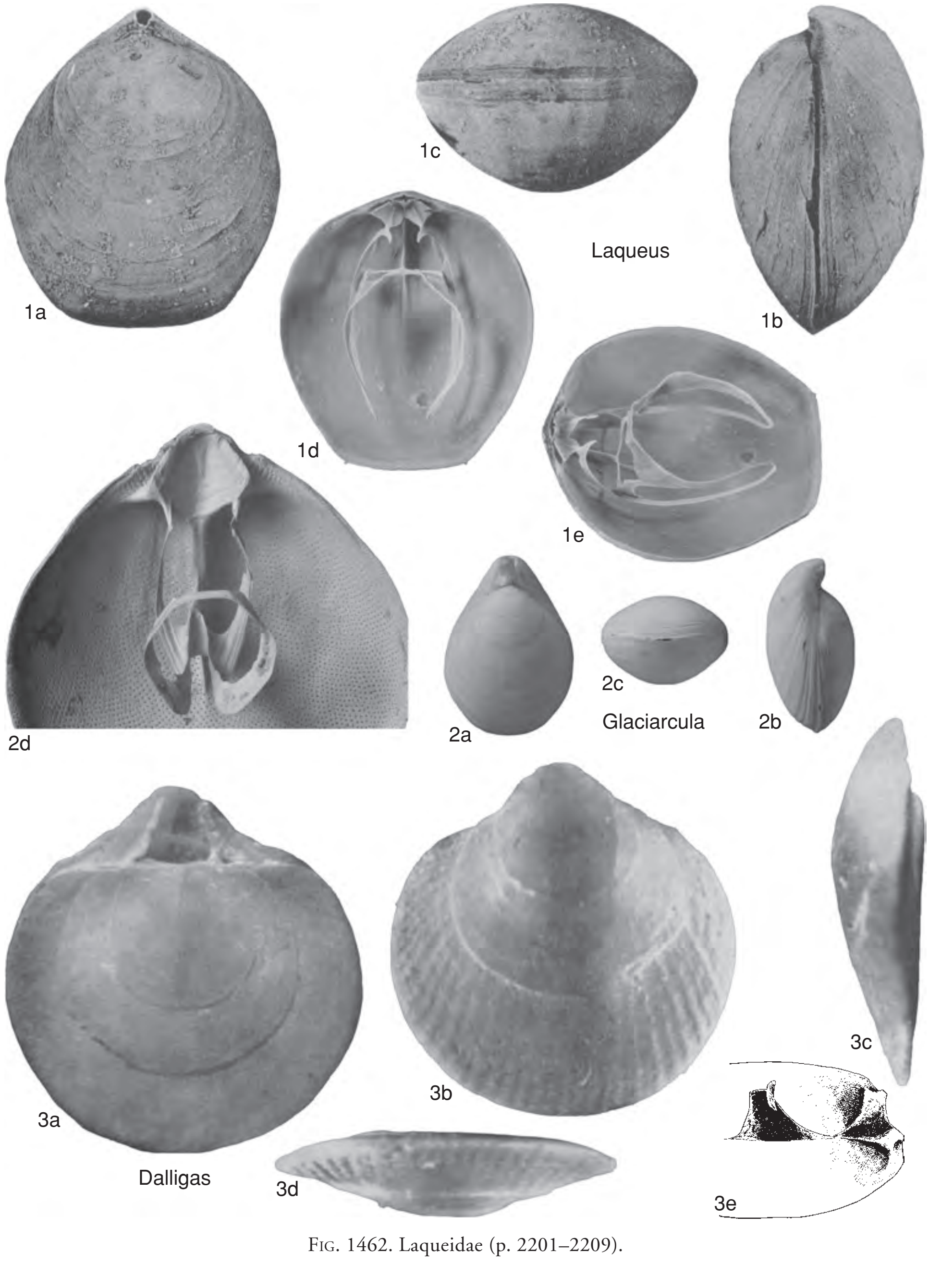

FIG. 1462. Laqueidae (p. 2201–2209).

bases; inner hinge plates uniting with median septum to form septalium; cardinal process a very short, transverse myophore; mantle canals spiculate; adult loop bilateral. [Type species now fixed (under Article 70.3 of the *Code,* ICZN, 1999) as *Laqueus erythraeus* DALL, 1920, misidentified as *Terebratula californiana* KÜSTER, 1844, in the original designation by DALL (1870).] *Neogene (Miocene)–Holocene:* circum-north Pacific Ocean from California to Japan.——FIG. 1462,*1a–e.* **L. erythraeus,* Holocene, California, USA; *a–c,* dorsal, lateral, and anterior views of holotype, USNM 19395, ×1 (Hertlein &

Grant, 1944); *d–e,* normal and lateral oblique view of dorsal interior showing loop, ×1 (new).

Subfamily PARAKINGENINAE Sun, 1981

[Parakingeninae SUN, 1981, p. 249]

Adult loop bilateral, with relatively robust lateral and vertical connecting bands forming a broad, hoodlike ring. *Lower Cretaceous–Upper Cretaceous.*

Parakingena SUN, 1981, p. 250 [**P. xizangensis;* OD]. Medium, roundly pentagonal, ventribiconvex; anterior commissure rectimarginate; beak short, erect; beak ridges angular; foramen large, subcircular, permesothyrid; deltidial plates narrow, disjunct; exterior finely pustulate with low plicae near anterior margin. Dental plates long, divergent. Cardinal process low, bilobate, inner hinge plates subhorizontal, uniting medianly and supported by bladelike median septum; loop bilacunar. [The figured specimen (possibly the holotype) and the specimen serially sectioned by SUN possess the same registration number; therefore it would appear that the holotype has been serially sectioned]. *Lower Cretaceous–Upper Cretaceous:* Tibet.——FIG. 1463,*1a–dd.* **P. xizangensis,* Lower Cretaceous; *a–c,* dorsal, lateral, and anterior views, ×1 (Sun, 1981); *d–dd,* serial transverse sections 0.2, 0.9, 1.8, 2.2, 2.6, 3.0, 3.3, 3.6, 4.0, 4.4, 5.2, 5.7, 6.8, 7.0, 7.1, 7.4, 7.8, 8.1, 8.5, 9.0, 9.7, 11.0, 11.3, 12.0, 15.3, 15.5, 15.8 mm from ventral umbo, ×1 (adapted from Sun, 1981).

Colinella OWEN, 1981, p. 306 [**Antiptychina? müllerriedi* IMLAY, 1937, p. 568; OD] [=*Nekvasilovela* CALZADA BADIA, 1987, p. 321 (type, *N. magransi* CALZADA BADIA, 1987, p. 322)]. Subpentagonal to broadly oval, smooth, biconvex, plicosulcate; beak low, erect to incurved, attrite; beak ridges sharp; foramen medium, permesothyrid. Dental plates short, thickened, slightly convergent. Cardinal process not differentiated, septalium well developed, adult loop bilateral. *Lower Cretaceous (Valanginian–Hauterivian):* Mexico, Morocco.——FIG. 1463,*2a–hh.* **C. muellerriedi* (IMLAY), Mexico; *a–d,* dorsal, ventral, lateral, and anterior views of holotype, U.M. 18752, ×1 (Imlay, 1937); *e–hh,* serial transverse sections 0.6, 1.0, 1.3, 1.6, 1.8, 2.0, 2.4, 2.7, 2.9, 3.1, 3.3, 3.5, 3.7, 3.9, 4.2, 4.4, 4.6, 4.8, 5.0, 5.3, 5.5, 5.7, 5.9, 6.1, 6.3, 6.5, 6.7, 6.9, 7.2, 7.5 mm from ventral umbo, ×2 (adapted from Owen, 1981).

Langshanthyris SUN, 1987, p. 89 [100] [**L. xizangensis;* OD]. Small, transversely rhomboidal to roundly pentagonal, ventribiconvex, anterior commissure rectimarginate to parasulcate; shell smooth, occasionally with low and short plicae near anterior commissure. Beak low, erect; beak ridges subangular; foramen large, permesothyrid; deltidial plates disjunct. Dental plates long, stout; pedicle collar excavate, resting on low, bladelike, ventral median septum. Cardinal process low and lobate; loop bilateral. *Lower Cretaceous:* Tibet.——FIG. 1464,*1a–ee.* **L. xizangensis; a–c,* dorsal, lateral, and anterior views of holotype, NIGP 79212, ×2 (Sun, 1987); *d–ee,* serial transverse sections 0.2, 0.6, 0.9, 1.2, 1.6, 1.9, 2.3, 2.7, 2.8, 2.9, 3.2, 3.5, 3.7, 4.0, 4.1, 4.3, 4.4, 4.8, 5.3, 5.4, 5.7, 5.9, 6.4, 6.8, 7.3, 8.9, 9.3, 9.9 mm from ventral umbo, ×1 (adapted from Sun, 1987).

Rossithyris OWEN, 1980, p. 138 [**R. humpensis;* OD]. Small, oval, biconvex, rectimarginate; shell smooth; beak low, erect; foramen small, permesothyrid. Dental plates short, subparallel, supporting inwardly directed, peglike hinge teeth. Septalium Y-shaped, consisting of steeply inclined inner hinge plates fused to high, bladelike median septum; loop bilateral. *Upper Cretaceous (Campanian):* Antarctica (James Ross Island).——FIG. 1463,*3a–p.* **R. humpensis; a,* dorsal view of holotype, NHM BB 76773, ×1.5 (Owen, 1980); *b–p,* serial transverse sections 1.2, 1.4, 1.6, 2.0, 2.2, 2.5, 2.7, 2.9, 3.1, 3.3, 3.5, 3.8, 4.0, 4.2, 4.5 mm from ventral umbo, ×2 (adapted from Owen, 1980).

Waconella OWEN, 1970, p. 74 [**Terebratula wacoensis* ROEMER, 1852, p. 81; OD]. Medium, smooth, biconvex, oval-pentagonal to elongate-oval; anterior commissure rectimarginate; beak erect, beak ridges sharp; foramen small, permesothyrid; deltidial plates conjunct. Cardinal process not differentiated; septalium well developed; median septum extending about half valve length; adult loop bilateral. *Cretaceous (Albian–Cenomanian):* USA (Texas), Mexico.——FIG. 1464,*2a–y.* **W. wacoensis* (ROEMER), Texas, USA; *a–c,* dorsal, lateral, and anterior views, ×2 (Owen, 1970); *d–y,* serial transverse sections 0.4, 1.4, 1.7, 2.1, 2.6, 3.0, 3.6, 4.0, 4.4, 4.7, 5.1, 5.6, 6.9, 6.3, 6.6, 7.1, 7.5, 7.9, 8.2, 8.6, 8.9, 9.3 mm from ventral umbo, ×2 (adapted from Owen, 1970).

Subfamily TEREBRATALIOPSINAE Smirnova, 1990

[Terebrataliopsinae SMIRNOVA, 1990a, p. 108]

Shells smooth, usually unisulcate; cardinal process indistinct. *Upper Triassic–Upper Cretaceous.*

Terebrataliopsis SMIRNOVA, 1962, p. 98 [**T. quadrata;* OD]. Small, ventribiconvex, subpentagonal in outline, ventral valve roundly carinate, commissure rectimarginate to unisulcate; beak erect, foramen small, circular, beak ridges sharp. Hinge teeth broad, denticulum present, dental plates short, ventrally divergent, pedicle collar present. Hinge plates united medially and supported by median septum that extends for 0.6 valve length, loop trabecular, spinose. *Upper Jurassic–Lower Cretaceous:* Poland, Czech Republic, *Upper Jurassic;* Crimea, Caucasus, Mangyshlak, *Lower Cretaceous.*——FIG. 1465,*3a–mm.* **T. quadrata,* Lower Cretaceous,

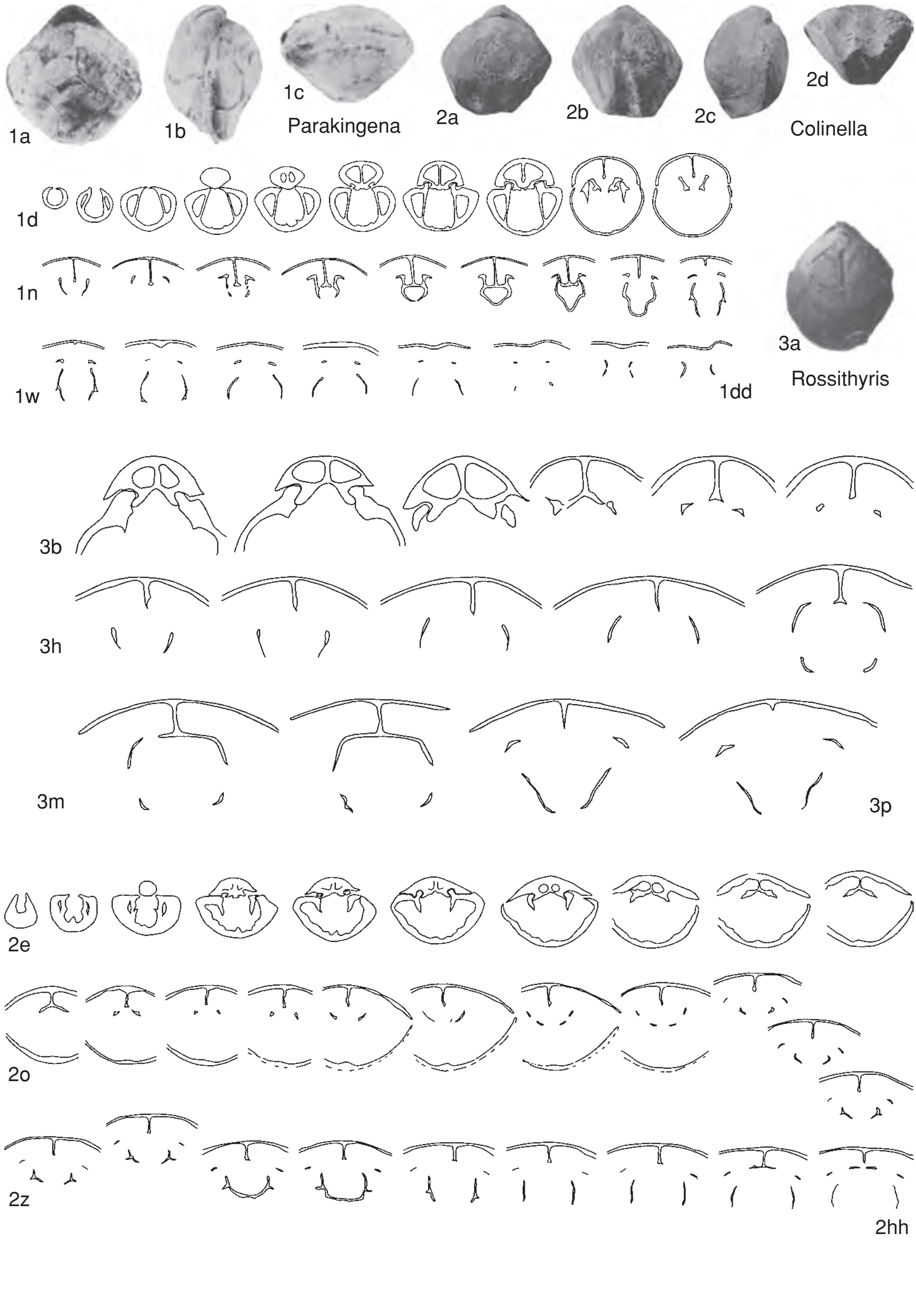

FIG. 1463. Laqueidae (p. 2203).

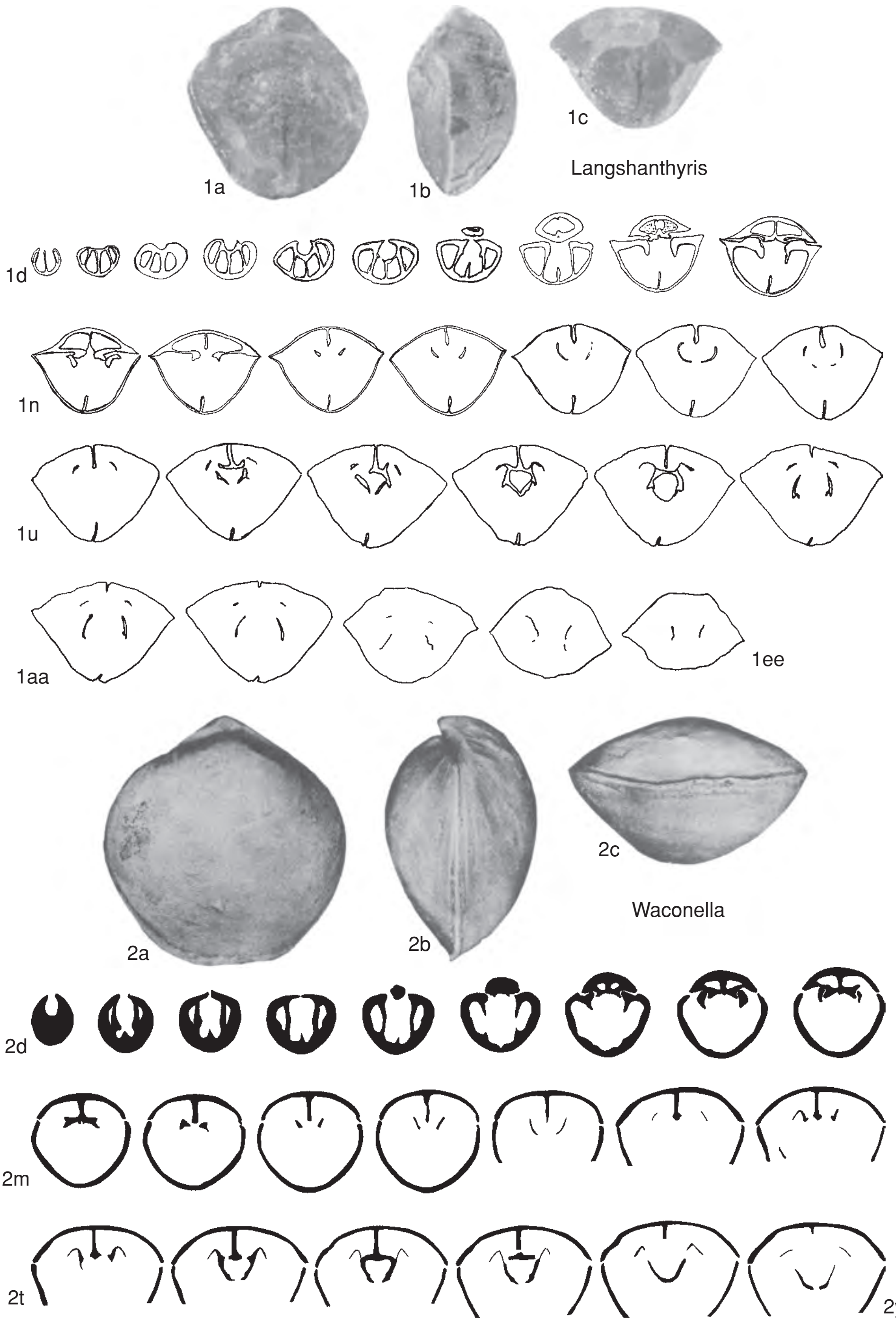

FIG. 1464. Laqueidae (p. 2203).

Crimea; *a–c,* dorsal, lateral, and anterior views, ×3 (new); *d–kk,* serial transverse sections 0.0, 0.75, 1.4, 1.9, 2.15, 2.25, 2.5, 2.65, 2.75, 2.85, 3.0, 3.25, 3.55, 3.95, 4.45, 4.65, 4.95, 5.45, 5.9, 6.1, 6.45, 6.7, 7.05, 7.35, 7.6, 7.75, 8.1, 8.7, 9.1, 9.6, 9.8, 10.5, 10.8, 11.1 mm from first section, ×1.5 (adapted from Smirnova, 1962); *ll–mm,* loop reconstructions, ×3 (Muir-Wood, 1965a).

Eodallina Elliott, 1959, p. 146 [**E. peruviana;* OD]. Small, smooth, biconvex; anterior commissure beak erect, foramen hypothyrid, apparently lacking deltidial plates. Ventral interior with short, strong dental plates; low median ridge bisecting ventral muscle scars, extending to about midvalve. Septalium well developed, dorsal median septum extending anteriorly beyond midlength; loop diploform with spinose leading edges, crural processes short, transverse band of hood narrow. *Upper Triassic:* Peru.——Fig. 1465,*1a–c.* **E. peruviana; a–b,* dorsal and lateral views, ×4 ; *c,* dorsal interior, reconstruction, ×4 (Stehli, 1956c).

Hamptonina Rollier, 1919, p. 360 [**Terebratella buckmani* Moore, 1860, p. 441; OD]. Small, subpentagonal, biconvex, rectimarginate; beak short, suberect, attrite, foramen circular; deltidial plates small, disjunct. Dorsal interior with inner socket ridges enclosing concave hinge plate, cardinal process small, transverse; dorsal median septum low posteriorly, rising steeply anteriorly, loop haptoid to diploform with spinose edges, moderately long crural processes. *Middle Jurassic:* England.——Fig. 1465,*2a–d.* **H. buckmani* (Moore); *a–c,* dorsal, lateral, and anterior views, ×3 (new); *d,* dorsal valve interior showing loop, reconstruction, ×4 (Elliott, 1965a).

Kafirnigania Katz, 1962, p. 138 [**K. pentangulata;* OD]. Small, elongate-subpentagonal in outline, smooth, biconvex; anterior commissure weakly uniplicate, less commonly rectimarginate; beak erect, beak ridges sharp; foramen submesothyrid; deltidial plates disjunct. Dental plates slightly convex, diverging from beak; lateral umbonal cavities deep. Well-developed, Y-shaped septalium. Loop (possibly incipiently) trabecular; haptoid and diploform juvenile loop stages also known. *Upper Cretaceous (Turonian):* Tadzhikistan Republic.——Fig. 1466,*2a–hh.* **K. pentangulata; a–c,* holotype, dorsal, lateral, and anterior views, No. 4-770/1, author's collection, Kharkov State University, ×1; *d–gg,* transverse serial sections 0.3, 0.4, 0.5, 0.7, 1.0, 1.2, 1.5, 1.8, 2.0, 2.1, 2.4, 2.6, 2.7, 2.8, 3.1, 3.7, 3.9, 4.1, 4.3, 4.5, 4.7, 4.9, 5.0, 5.3, 5.7, 6.2, 6.8, 7.4, 8.0, 8.2 mm from ventral umbo, ×1 (Katz, 1962); *hh,* loop reconstruction, ×2 (adapted from Katz, 1962).

Psilothyris Cooper, 1955b, p. 10 [**P. occidentalis;* OD] [=*Tamarella* Owen, 1965, p. 57 (type, *Terebratula tamarindus* J. de C. Sowerby in Fitton, 1836, p. 338)]. Small to medium size, smooth, biconvex, ovate to subpentagonal, rectimarginate to uniplicate, umbo erect, foramen small to large, round, mesothyrid, deltidial plates disjunct to conjunct; dental plates bladelike; cardinal process small, hinge plates fused, medianly concave; median septum short, slender, extending about 0.3 valve length, hinge plates fused with septum posteriorly to form septalium but may be free of hinge plates anteriorly; loop teloform, with short crura and long crural processes. *Lower Cretaceous–Upper Cretaceous:* North America; Europe, *Lower Cretaceous.*——Fig. 1466,*1a–e.* **P. occidentalis,* Lower Cretaceous, Arizona, USA; *a–d,* dorsal, lateral, anterior, and posterior views of holotype, USNM 124191, ×2 (Cooper, 1955b); *e,* posterior part of interior of conjoined valves showing dental plates, medianly fused inner hinge plates with upturned edges, crura, and partially descending loop branches, ×4 (Cooper, 1955b).

Subfamily GLACIARCULINAE new subfamily

[Glaciarculinae MacKinnon & Lee, herein] [type genus, *Glaciarcula* Elliott, 1956, p. 285]

Adult loop haptoid. *Pleistocene–Holocene.*

Glaciarcula Elliott, 1956, p. 285 [**Terebratella spitzbergensis* Davidson, 1852c, p. 78; OD]. Small, elongate-pyriform, biconvex, smooth, thin shelled, rectimarginate; ventral beak elongate, moderately incurved, suberect, attrite; foramen mesothyrid; deltidial plates long, narrow, disjunct. Hinge teeth supported by vertical, lamellar dental plates; pedicle collar long, sessile. Cardinalia with well-developed inner and outer hinge plates; inner hinge plates steeply inclined, uniting with low median septum to form septalium; cardinal process a very short, transverse myophore; septal flanges developed on juvenile septal pillar; adult loop haptoid to incipiently trabecular. *Pleistocene–Holocene:* Scandanavia, *Pleistocene;* North Atlantic, Arctic, North Pacific, *Holocene.*——Fig. 1462,*2a–d.* **G. spitzbergensis* (Davidson), Holocene, North Atlantic; *a–c,* dorsal, lateral, and anterior views of holotype, ZB1518, ×3; *d,* dorsal interior showing loop and cardinalia, ×6 (new).

Subfamily DALLIGADINAE new subfamily

[Dalligadinae MacKinnon & Lee, herein] [type genus, *Dalligas* Steinich, 1968b, p. 336]

Shells minute to small; adult loop axial with septal flanges. *Upper Cretaceous (Maastrichtian).*

Dalligas Steinich, 1968b, p. 336 [**D. nobilis;* OD]. Minute to small, thin shelled, elongate-oval to subcircular, weakly capillate, hinge line straight, anterior commissure rectimarginate; beak erect, foramen large, hypothyrid. Cardinal process not differentiated; cardinalia consisting of sessile septalium, crura absent; loop axial with laterally directed septal flanges on posteroventral edge of

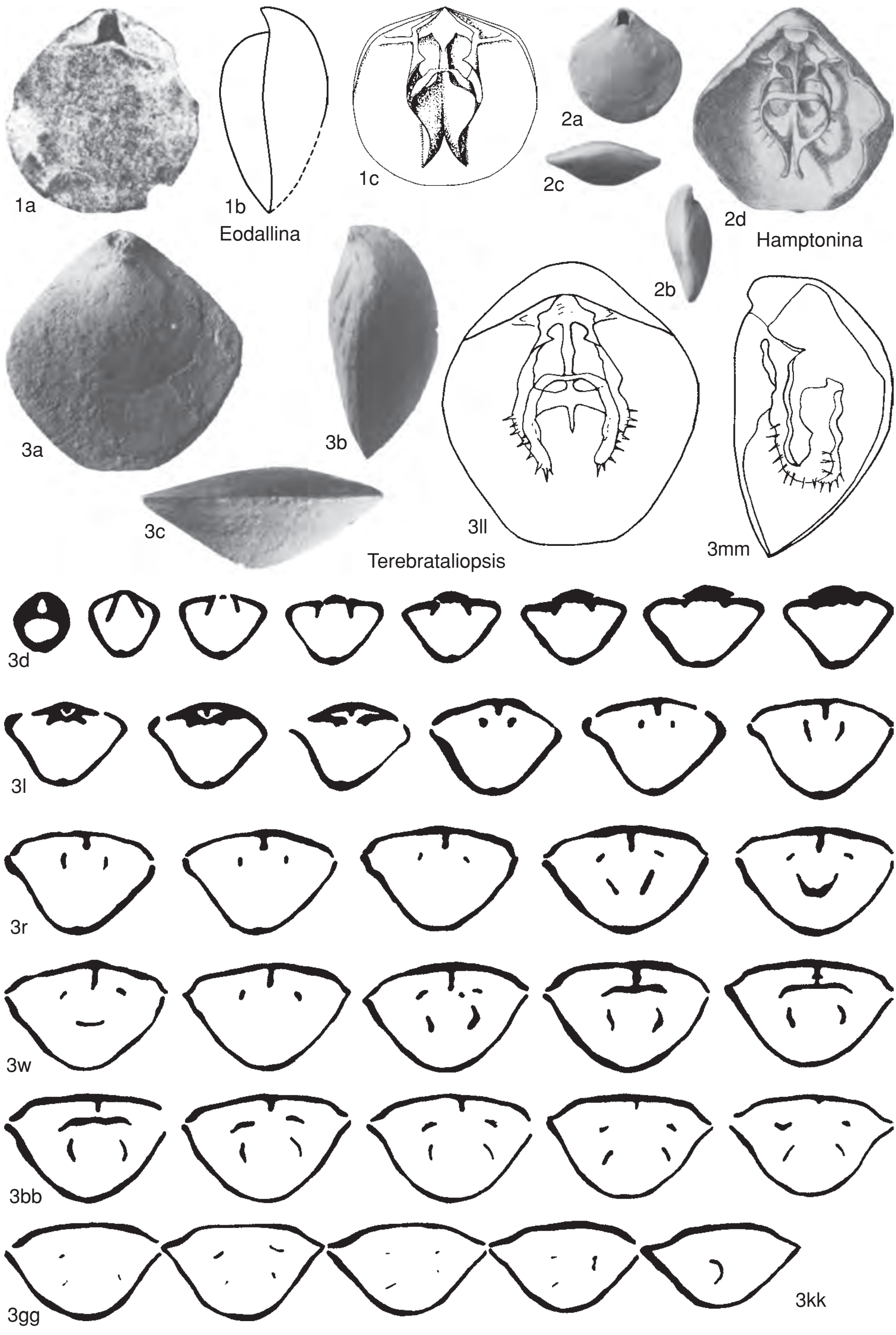

FIG. 1465. Laqueidae (p. 2203–2206).

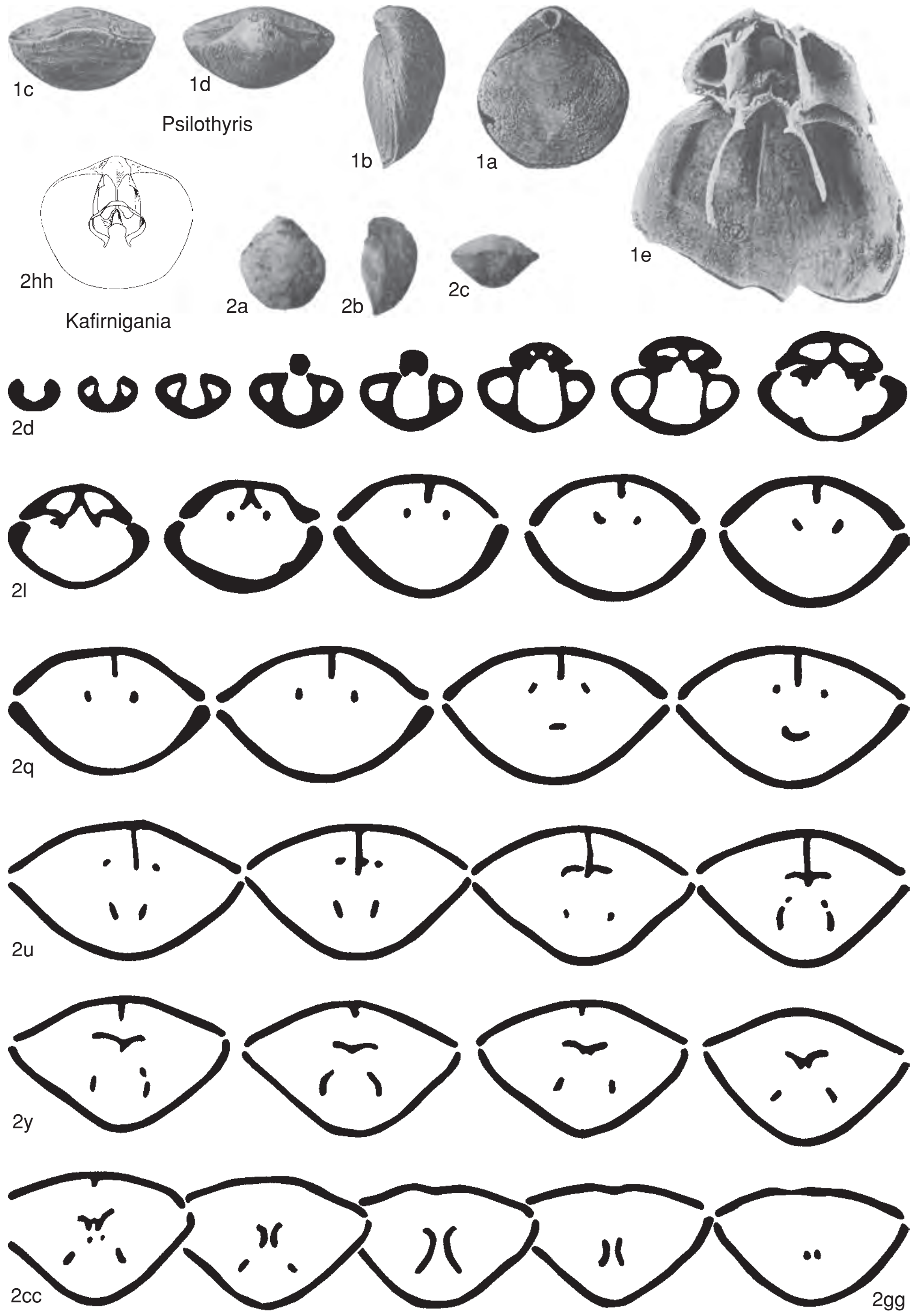

FIG. 1466. Laqueidae (p. 2206).

high septal pillar. Lophophore spiculate. *Upper Cretaceous (Maastrichtian):* Western Europe.——FIG. 1462,*3a–e*. **D. nobilis,* Germany; *a–d,* dorsal, ventral, lateral, and anterior views, ×10 (Steinich, 1968); *e,* lateral oblique view of dorsal interior, ×10 (Steinich, 1968b).

Family FRENULINIDAE Hatai, 1938

[*nom. transl.* MACKINNON & LEE, herein, *ex* Frenulininae HATAI, 1938, p. 109]

Outer hinge plates and crural bases well developed; inner hinge plates not differentiated or rudimentary; septalium not developed; cardinal process moderately to strongly developed; adult loop annular, bilacunar, bilateral, or laterovertical; septal pillar nonbifurcate. *Neogene (Miocene)–Holocene.*

Subfamily FRENULININAE Hatai, 1938

[Frenulininae HATAI, 1938, p. 109]

Inner hinge plates rudimentary; adult loop bilacunar or bilateral. *Neogene (Miocene)–Holocene.*

Frenulina DALL, 1895, p. 724 [**Anomia sanguinolenta* GMELIN, 1792, p. 3,347; OD]. Small, biconvex, smooth, commonly reddish-orange with white mottling, unisulcate, beak suberect, foramen submesothyrid; deltidial plates commonly disjunct, occasionally conjunct. Hinge teeth with ventrally recessive dental plates; pedicle collar sessile. Cardinalia divergent from apex with inner socket ridges rather strong, united on their inner sides to crural bases; inner hinge plates rudimentary and not united medianly; cardinal process small, striated myophore; loop bilacunar to incipiently bilateral. *Neogene (Pliocene)–Holocene:* Okinawa, Ryukyu Islands, *Pliocene–Pleistocene;* Pacific, Indian Oceans, *Holocene.*——FIG. 1467,*1a–d*. **F. sanguinolenta* (GMELIN), Holocene; *a–c,* dorsal, lateral, and anterior views, Hawaiian Islands, ×3 (new); *d,* dorsal interior showing loop, Philippines, ×5 (new).

Jolonica DALL, 1920, p. 366 [**Campages (Jolonica) hedleyi* DALL, 1920, p. 366; OD] [=*Compsoria* COOPER, 1973a, p. 23 (type, *C. suffusa,* OD); *Kamoica* HATAI, 1936, p. 313 (type, *Jolonica (Kamoica) iduensis* HATAI, 1936, p. 313, OD)]. Medium, smooth, ovate to subpentagonal, rectimarginate to weakly unisulcate; beak low, suberect, attrite; foramen mesothyrid to permesothyrid, deltidial plates conjunct. Dental plates recessive with narrow, lateral umbonal cavities; pedicle collar long, sessile. Cardinalia very similar to *Frenulina* but with prominent, upstanding cardinal process; strong inner socket ridges, flattened ventrally, fused to stout crural bases; inner hinge plates and septalium absent; median septum prominent, diminishing posteriorly. Loop bilacunar with median lacuna of hood occupied by calcareous plate. *Neogene (Miocene)–Holocene:* Japan (Okinawa, Ryukyu Islands), *Miocene–Pleistocene;* western Pacific (South Japan, Philippines to 640 m), western Indian Ocean (off Mozambique to 132 m), *Holocene.*——FIG. 1467,*2a–g*. **J. hedleyi,* Holocene, off Jolo, Philippines; *a–d,* dorsal, anterior, lateral, and posterior views of holotype, USNM 111059, ×1; *e–f,* ventral and lateral views of dorsal interior of holotype showing loop, ×2; *g,* tilted view of ventral interior of holotype showing dental plates, ×2 (Cooper, 1957b).

Subfamily PICTOTHYRIDINAE Yabe & Hatai, 1941

[*nom. correct.* HATAI, 1965c, p. 846, *pro* Pictothyrinae YABE & HATAI, 1941, p. 494]

No inner hinge plates; adult loop laterovertical. *Neogene (Pliocene)–Holocene.*

Pictothyris THOMSON, 1927, p. 260 [**Anomia picta* DILLWYN, 1817, p. 295; OD]. Medium, ovate, biconvex, rectimarginate to faintly unisulcate, smooth; shell commonly reddish and variegated; beak suberect; foramen medium size, mesothyrid, attrite; deltidial plates conjunct. Hinge teeth strong, dental plates short, recessive; pedicle collar broad, sessile. Cardinal process prominent, upstanding, with distal, impressed, bilobed myophore; median septum low, thick; adult loop laterovertical. *Neogene (Pliocene)–Holocene:* Japan (Formosa, Ryukyu Islands, 40–160 m).——FIG. 1467,*3a–e*. **P. picta* (DILLWYN), Holocene, Japan; *a–c,* dorsal, lateral, and anterior views, ×1; *d–e,* dorsal and ventral interiors, ×2 (Cooper, 1957b).

Kikaithyris YABE & HATAI, 1941, p. 495 [**Pictothyris hanzawai* YABE, 1932, p. 196; OD]. Medium, ovate to subpentagonal, biconvex; beak low, erect; beak ridges strong; deltidial plates conjunct; foramen small to minute, mesothyrid. Hinge teeth strong, dental plates thickened and almost obscured; diductor scars elongate, narrow. Cardinalia resembling *Pictothyris* but more robust; inner socket ridges swollen, cardinal process upstanding with distal, bilobed myophore; dorsal median septum low and thick. Adult loop laterovertical. *Neogene (Pliocene)–Pleistocene:* Japan (Ryukyu Islands), Taiwan.——FIG. 1467,*4a–e*. **K. hanzawai* (YABE), Ryukyu Islands; *a–c,* dorsal, lateral, and anterior views, ×1; *d–e,* dorsal and ventral interiors, ×2 (Cooper, 1957b).

Subfamily SHIMODAIINAE new subfamily

[Shimodaiinae MACKINNON & LEE, herein] [type genus, *Shimodaia* MACKINNON, SAITO, & ENDO, 1997, p. 226]

Shells small, adult loop annular. *Holocene.*

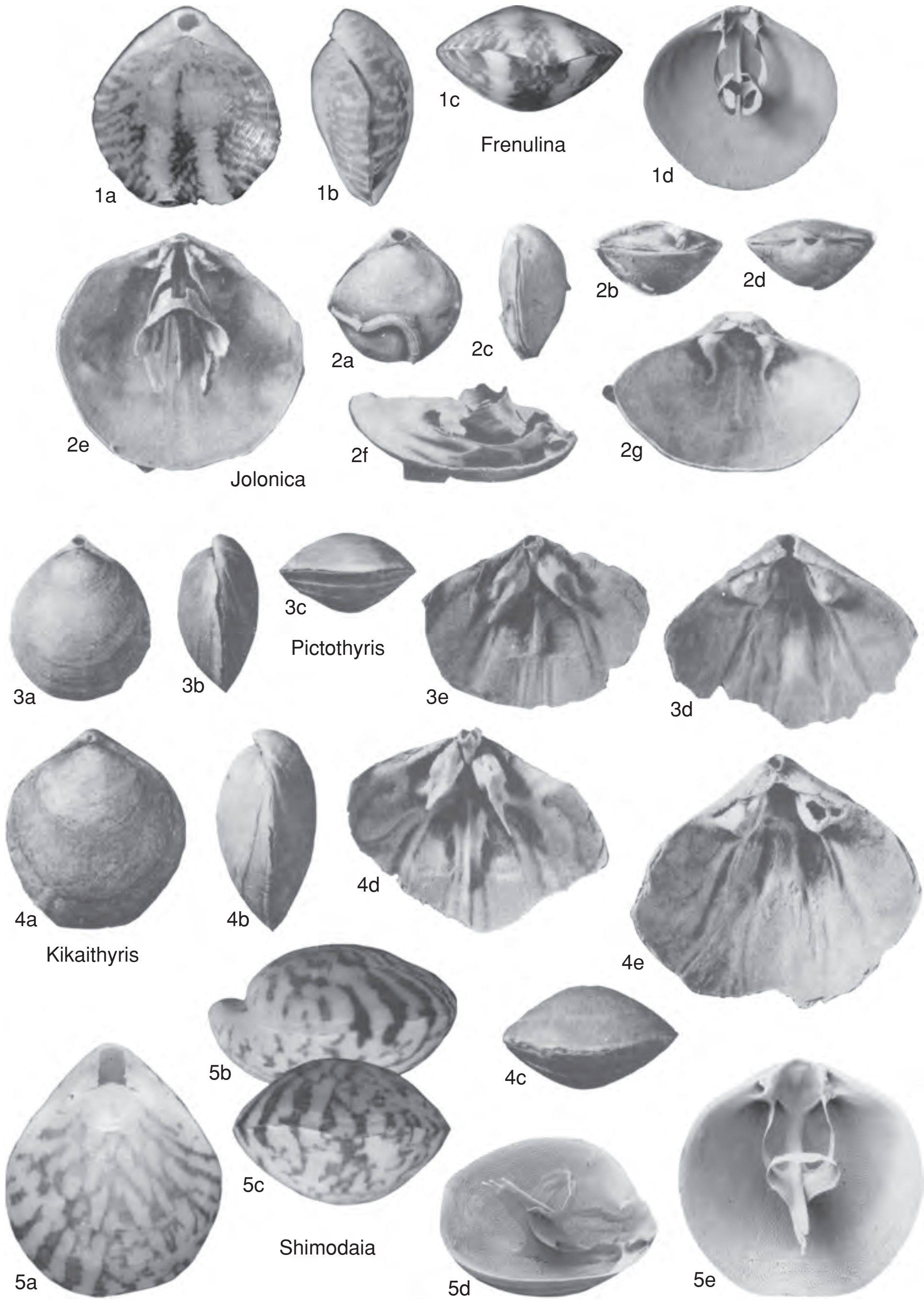

FIG. 1467. Frenulinidae (p. 2209–2211).

Shimodaia MacKinnon, Saito, & Endo, 1997, p. 226 [**S. pterygiota;* OD]. Small, red to white color markings, ovate, commissure rectimarginate; beak erect, attrite; foramen submesothyrid; deltidial plates disjunct. Dental plates recessive, pedicle collar long, sessile. Cardinal process inconspicuous; septal pillar arising (in adults) about midvalve, very long and narrow, strongly inclined anteroventrally, sometimes spinose distally, extending posteriorly as low ridge; hinge trough with incipient inner hinge plates; adult loop annular with descending branches attached to septal pillar and ascending branches commonly incomplete; juvenile axial loop phase with well-developed septal flanges. *Holocene:* Japan, South China Sea.——Fig. 1467,*5a–e.* **S. pterygiota; a–c,* dorsal, lateral, and anterior views of holotype, UMUT RB27390, ×5; *d–e,* two views of dorsal interior, ×5 (MacKinnon, Saito, & Endo, 1997).

Family TEREBRATALIIDAE Richardson, 1975

[*nom. transl.* Zezina, 1985, p. 171, *ex* Terebrataliinae Richardson, 1975b, p. 310]

Inner hinge plates or septalium absent or rudimentary; adult loop diploform, trabecular, rarely teloform. *Upper Jurassic–Holocene.*

Subfamily TEREBRATALIINAE Richardson, 1975

[Terbrataliinae Richardson, 1975b, p. 310]

Shells smooth to multicostate, small to large, commonly transversely oval, foramen large, beak short, strongly attrite. Adult loop commonly trabecular. *Upper Cretaceous (Maastrichtian)–Holocene.*

Terebratalia Beecher, 1893, p. 377 [**Terebratula transversa* G. B. Sowerby, 1846, p. 94; OD; =*Magasella radiata* Dall, 1877b, p. 49] [=*Pacifithyris* Hatai, 1938, p. 98 (type, *Terebratalia xanthica* Dall, 1920, p. 346, OD)]. Medium to large, outline extremely variable from subcircular to transversely oval, mildly unisulcate, ornamentation highly variable from smooth to costate; beak short, suberect, strongly attrite, beak ridges sharp, foramen large, mesothyrid, deltidial plates disjunct. Pedicle collar short, dental plates ventrally recessive, lateral umbonal cavities narrow and tending to infill with secondary shell. Cardinal process transverse-oval myophore; cardinalia strong with some median shell thickening, dorsal adjustor scars impressed on thickened inner socket ridges, crura fairly long, slender, roughly circular in cross section; loop trabecular with very slender, lateral connecting bands extending from low median septum. *Paleogene (Eocene)–Holocene:* Mexico (Baja California), *Eocene;* western North America, ?Japan, *Oligocene;* western North America, Japan, *Miocene–Pleistocene;* North Pacific (10–1,750 m), *Holocene.*——Fig. 1468,*1a–d.* **T. transversa* (Sowerby), Holocene, Vancouver Island, Canada; *a–c,* dorsal, lateral, and anterior views; *d,* dorsal interior, loop missing, ×1 (new).

Coptothyris Jackson, 1918a, p. 479 [**Terebratula grayi* Davidson, 1852c, p. 76; OD; =*Magasella adamsi* Davidson, 1871, p. 307] [=*Pereudesia* Dall, 1920, p. 360, obj., *nom. nov. pro Thomsonia* Jackson, 1916, p. 22, *non* Signoret, 1879, *nec* Konow, 1884; =*Cacata* Strand, 1928, p. 38, obj., *nom. nov. pro Thomsonia* Jackson, 1916, p. 22, *non* Signoret, 1879, *nec* Konow, 1884]. Medium to large, biconvex, subquadrate to transversely oval, rectimarginate to mildly uniplicate, multicostate; beak suberect, attrite, foramen large, mesothyrid to permesothyrid; deltidial plates conjunct in adults. Pedicle collar short, hinge teeth strong, dental plates ventrally recessive with very reduced, lateral umbonal cavities. Cardinalia as in *Terebratalia,* median septum very low, loop teloform. *Neogene (Miocene)–Holocene:* Japan, Korea.——Fig. 1468,*4a–d.* **C. grayi* (Davidson), Holocene, Korea Strait; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* dorsal interior showing cardinalia, teloform loop missing, ×2 (new).

Dallinella Thomson, 1915c, p. 75 [**Terebratalia obsoleta* Beecher, 1893, p. 382, 392; OD; =*Terebratella occidentalis obsoleta* Dall, 1891b, p. 186]. Medium to large, biconvex, subquadrate to transversely oval, multiplicate with wide, subdued, median uniplication; beak erect, attrite, foramen large, mesothyrid to permesothyrid; deltidial plates conjunct in adults. Pedicle collar short, hinge teeth strong, dental plates ventrally recessive with very reduced, lateral umbonal cavities. Cardinalia as in *Terebratalia,* crural processes attenuated, anteriorly projecting. Loop trabecular. *Neogene (Miocene)–Holocene:* northeastern Pacific (100–220 m).——Fig. 1468,*5a–d.* **D. obsoleta* (Dall), Holocene; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* dorsal interior showing cardinalia, trabecular loop missing, ×2 (new).

Diestothyris Thomson, 1916b, p. 504 [**Terebratula frontalis* Middendorff, 1849, p. 518; OD] [=*Diestothyris (Tisimania)* Hatai, 1938, p. 203 (type, *Diestothyris tisimana* Nomura & Hatai, 1936, p. 131)]. Small to medium, smooth; anterior commissure rectimarginate to weakly unisulcate; beak short, suberect, strongly attrite; foramen large, submesothyrid; deltidial plates very narrow. Pedicle collar well developed, thin, ventrally recessive dental plates, with small, deep, lateral umbonal cavities. Cardinal process subtriangular myophore; cardinalia strong, socket ridges strong, disjunct inner hinge plates with deeply impressed dorsal adjustor scars, fused posteriorly to cardinal process;

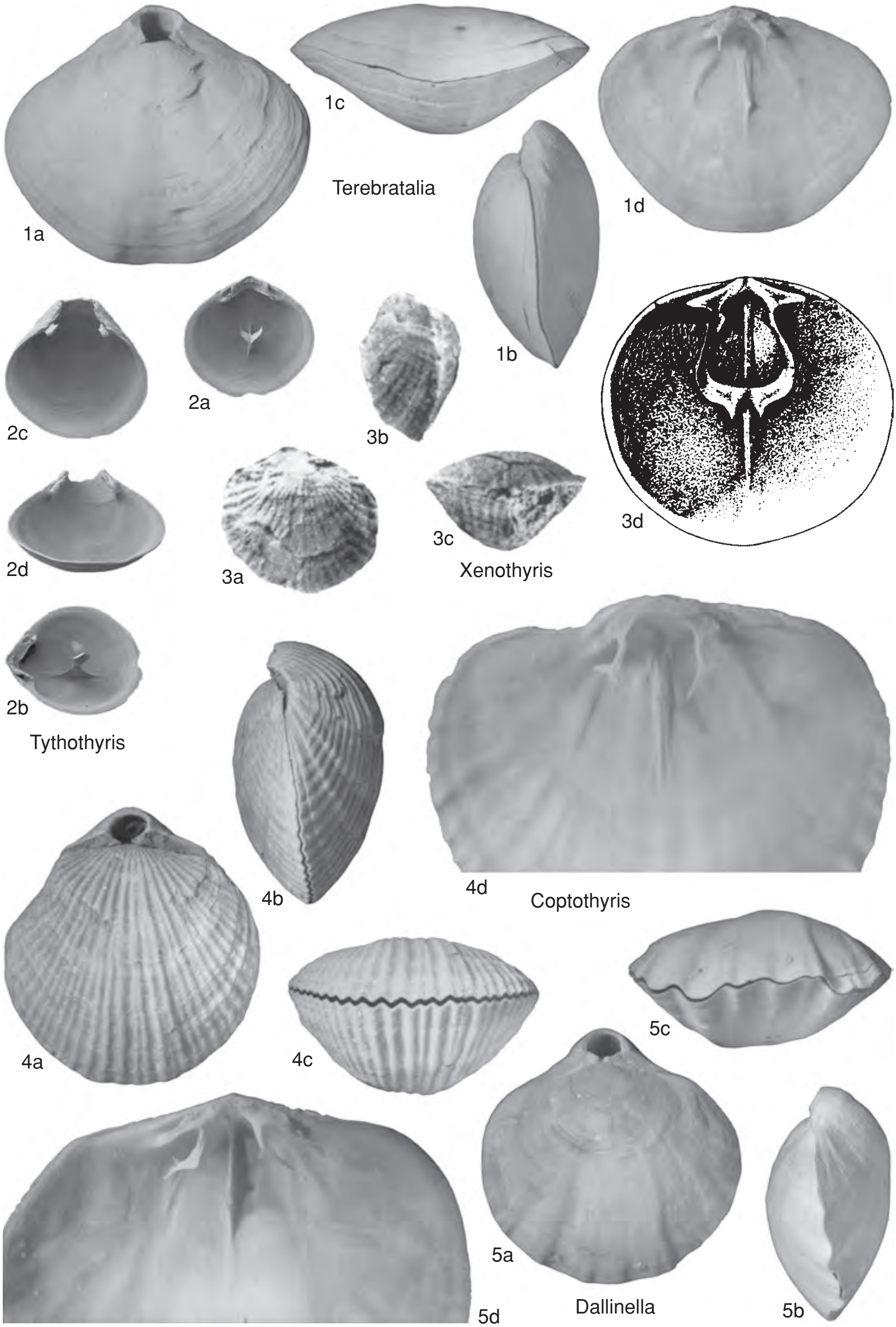

FIG. 1468. Terebrataliidae (p. 2211–2213).

septal pillar located anterior of midvalve; loop trabecular, slender. [*Tisimania* was erected as a subgenus of *Diestothyris* by HATAI (1938)]. *Neogene (Miocene)–Holocene:* North America, *Miocene–Pleistocene;* Kamchatka, Japan, *Pliocene;* North Pacific (Okhotsk Sea, Japan Sea), *Holocene.*——FIG. 1469*a–d.* **D. frontalis* (MIDDENDORFF), Holocene, North Pacific; *a,* dorsal view, ×1.5; *b–c,* lateral and anterior views, ×2 (new); *d,* dorsal interior showing loop, reconstruction, ×3 (Davidson, 1887).

Tythothyris ZEZINA, 1979, p. 223 [**T. rosimarginata;* OD]. Small, smooth, biconvex, rectimarginate to weakly sulcate; similar to juvenile *Diestothyris* but crura and descending loop branches not developed; septal pillar with ventrally curved, ascending lamellae that do not unite, with small, posteriorly directed flanges at apices of ascending lamellae. *Holocene:* Okhotsk Sea, Kurile Islands.——FIG. 1468,*2a–d.* **T. rosimarginata; a–b,* ventral and lateral oblique views of dorsal interior; *c–d,* dorsal and anterior oblique views of ventral interior, ×5 (new).

Xenothyris CHING, RONG, & SUN, 1976, p. 337 [**X. tuilaensis;* OD]. Small, subcircular; hinge line straight, ventribiconvex, multiplicate; anterior commissure rectimarginate to uniplicate; beak short, suberect; foramen semicircular, without deltidial plates. No ventral septum; dental plates short, highly divergent. Cardinal process low, flattened; narrow outer hinge plates present between divergent inner socket ridges, and crural bases as in *Terebratalia;* loop imperfectly known, possibly trabecular; dorsal median septum long, low posteriorly, high at midvalve, and forming a low ridge anteriorly. *Upper Cretaceous (Maastrichtian):* Tibet.——FIG. 1468,*3a–d.* **X. tuilaensis; a–c,* dorsal, lateral, and anterior views, ×1; *d,* reconstruction of dorsal interior showing possibly incomplete loop, ×4 (Ching, Rong, & Sun, 1976).

Subfamily GEMMARCULINAE Elliott, 1947

[Gemmarculinae ELLIOTT, 1947, p. 145]

Costate, cardinal process large, fused with cardinalia; accessory structures present on all stages of trabecular loop. *Upper Jurassic–Upper Cretaceous.*

Gemmarcula ELLIOTT, 1947, p. 145 [**G. aurea;* OD; =*Terebratula truncata* J. DE C. SOWERBY, 1826 in 1826–1829, p. 21, *non Anomia truncata* LINNAEUS, 1767, p. 1,152] [=*Trifidarcula* ELLIOTT, 1959, p. 147 (type, *Terebratella trifida* MEYER, 1864, p. 167, OD)]. Small to medium, biconvex, strophic, ovate to subquadrate, costate, rectimarginate to parasulcate, umbo short, suberect, attrite; foramen large, submesothyrid; symphytium present. Dental plates short, ventrally divergent; pedicle collar present. Cardinalia strong, buttressed by median septum, cardinal process transverse and countersunk in shallow hinge trough; adult loop trabecular, with small flanges extending laterally from transverse band, loop ontogeny similar to *Terebratalia. Lower Cretaceous–Upper Cretaceous:* Europe; North America, *Upper Cretaceous.*——FIG. 1470,*1a–d.* **G. aurea,* Lower Cretaceous, England; *a–c,* dorsal, lateral, anterior views of holotype, BMNH BB 9251, ×2 (new); *d,* dorsal valve interior, ×6.5 (Muir-Wood, 1965a).

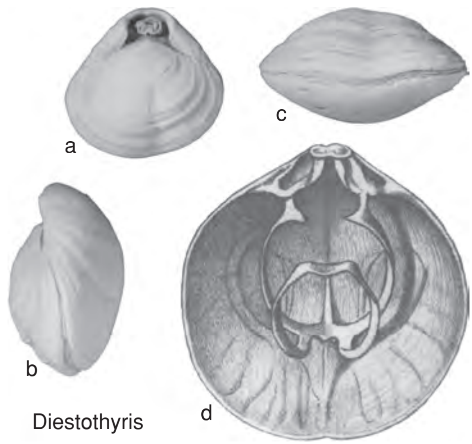

FIG. 1469. Terebrataliidae (p. 2211–2213).

Arenaciarcula ELLIOTT, 1959, p. 147 [**Terebratella fittoni* MEYER, 1864, p. 250; OD]. Small, ovate, costate, commissure uniplicate to parasulcate; beak erect, beak ridges sharp; foramen mesothyrid, deltidial plates conjunct. Dental plates fused to side of valve. Septalium with raised inner socket ridges, crural bases, and median septal ridge; cardinal process consisting of medianly bifid myophore. Adult loop possibly trabecular. *Cretaceous (Aptian–Cenomanian):* England, France, Belgium, Poland, Denmark, Germany, Austria, Russia, Turkmenistan.——FIG. 1470,*5a–m.* **A. fittoni* (MEYER), Aptian, England; *a–c,* dorsal, lateral, and anterior views of exterior, ×2; *d–m,* serial transverse sections 1.1, 1.4, 1.9, 2.2, 2.6, 2.9, 3.2, 3.6, 3.9, 4.3 mm from ventral umbo, ×2 (Owen, 1977).——FIG. 1470,*5n. A. beaumonti* (D'ARCHIAC), Cenomanian, Belgium; dorsal interior, ×2 (Owen, 1977).

Choristothyris COOPER, 1942, p. 233 [**Terebratula plicata* SAY, 1820, p. 43; OD]. Small, subcircular, multicostate to plicate, sulcate, shell thick, beak suberect to erect, foramen large, submesothyrid, deltidial plates small, disjunct. Hinge teeth large, with deep fossettes in supporting callus, ventral muscle area large, flabellate, divided by low, stout median ridge. Cardinalia strong, inner socket ridges strong and high; hinge plate small, concave, cardinal process massive, trilobed; median septum high, thin, reaching to center of valve, crural processes long, slender, loop trabecular. *Upper Cretaceous:* North America.——FIG. 1470,*2a–c.* **C. plicata* (SAY), New Jersey, USA; *a,* dorsal exterior, ×1; *b–c,* dorsal valve interior, interior showing calcite-encrusted loop, ×2 (Muir-Wood, 1965a).

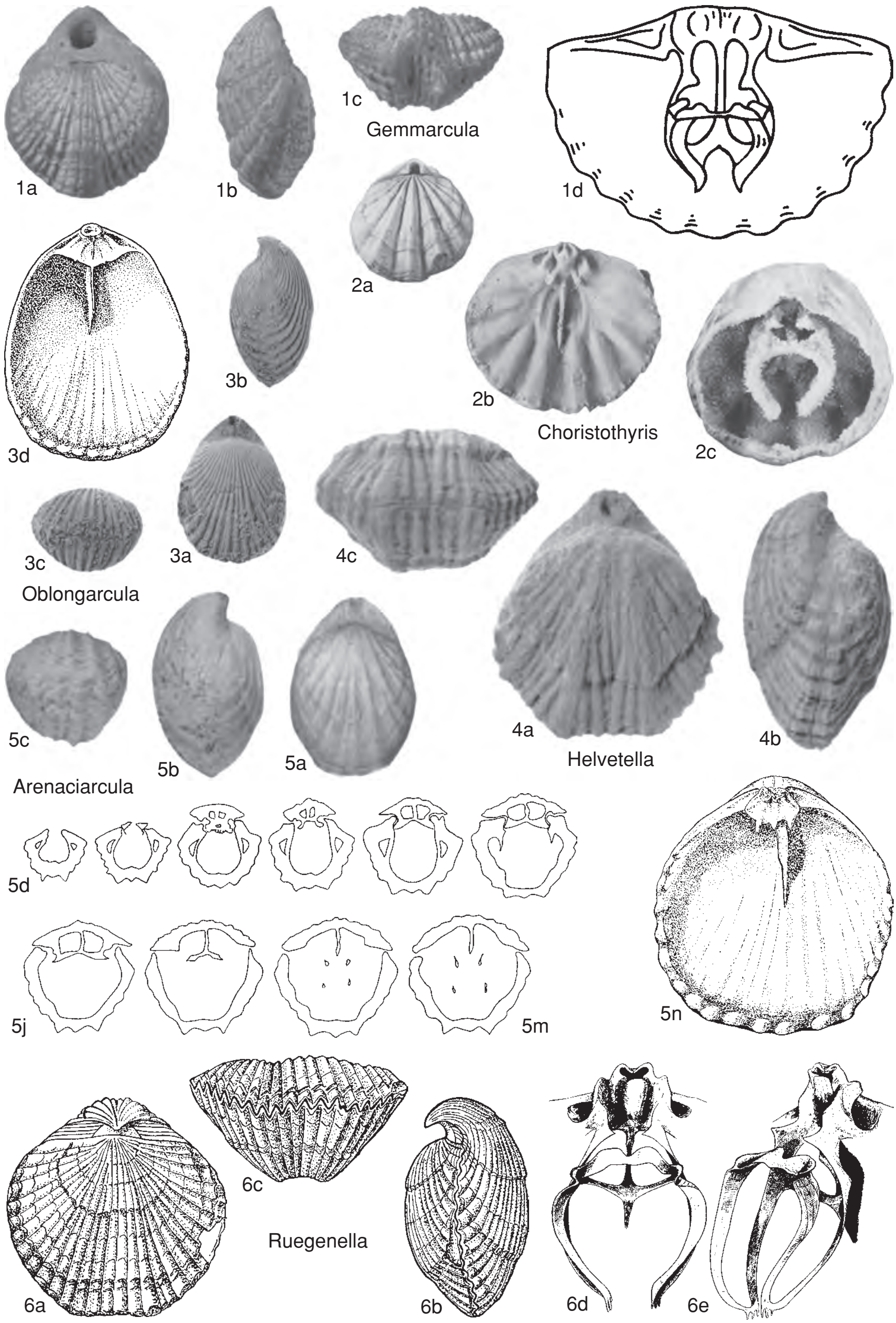

FIG. 1470. Terebrataliidae (p. 2213–2215).

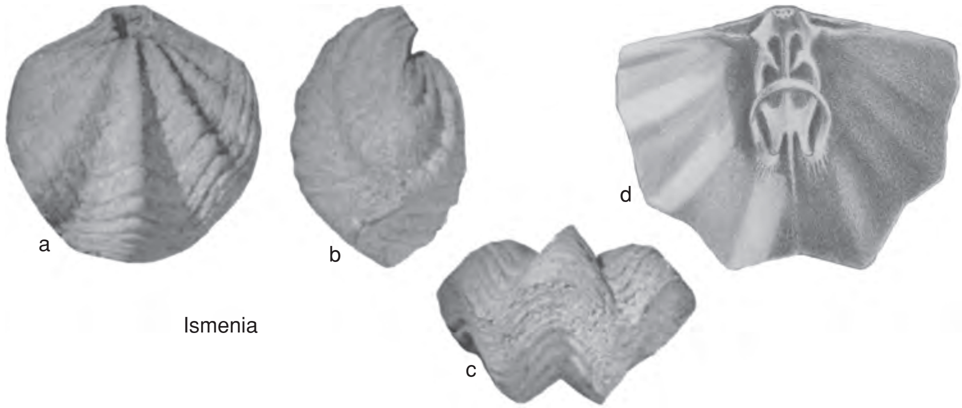

FIG. 1471. Terebrataliidae (p. 2215).

Helvetella OWEN, 1977, p. 221 [**Terebratula (Terebratella) arzierensis* DE LORIOL, 1864, p. 441; OD]. Medium, biconvex, pentagonal, costae strong, rounded; uniplicate to parasulcate; umbo massive, beak suberect; foramen large, circular, mesothyrid; symphytium short, broad; cardinal area extensive, slightly concave, beak ridges distinct. Cardinal process not developed, hinge plates short, triangular, ventrally deflected; loop trabecular. *Lower Cretaceous (Valanginian):* Switzerland, Spain.——FIG. 1470,*4a–c*. **H. arzierensis* (DE LORIEL), Arzier, Vaud, Switzerland; dorsal, lateral, and anterior views, ×2 (Owen, 1977).

Ismenia KING, 1850, p. 142 [**Terebratulites pectunculoides* VON SCHLOTHEIM, 1820, p. 271; OD]. Small, transverse, biconvex, with about 5 prominent plicae on each valve, beak low, suberect, attrite, foramen large, rounded, deltidial plates small; hinge line nearly strophic. Inner socket ridges prominent, inner hinge plates buttressed by median septum to form small septalium, cardinal process transverse, loop trabecular, anteriorly spinose. *Upper Jurassic–Lower Cretaceous:* Europe, Russia.——FIG. 1471*a–d*. **I. pectunculoides* (VON SCHLOTHEIM), Germany; *a–c,* dorsal, lateral, and anterior views, ×2 (Owen, 1977); *d,* dorsal interior showing loop, reconstructed, ×3 (Muir-Wood, 1965a).

Oblongarcula ELLIOTT, 1959, p. 147 [**Terebratula oblonga* J. DE C. SOWERBY, 1829 in 1826–1829, p. 68; OD]. Medium, elongate oval to subpentagonal, biconvex, costate to costellate, anterior commissure rectimarginate to incipiently unisulcate, shell thin; beak suberect, foramen mesothyrid, deltidial plates conjunct, beak ridges well defined, pedicle collar well developed. Teeth strong, dental plates thin with narrow, lateral umbonal cavities. Cardinalia thin, platelike; cardinal process a raised, transverse myophore; sockets narrow, inner socket ridges enclosing septalium; median septum thin, supporting septalium beneath and extending anteriorly to half of valve length; crura delicate. Adult loop possibly teloform. *Lower Cretaceous (Hauterivian–Aptian):* England, Germany, France.——FIG. 1470,*3a–d*. **O. oblonga* (J. DE C. SOWERBY), Aptian, Berkshire, England; *a–c,* dorsal, lateral, and anterior views, ×1; *d,* dorsal valve interior, ×2 (Owen, 1977).

Ruegenella OWEN, 1977, p. 224 [**Terebratula humboldti* HAGENOW, 1842, p. 539; OD]. Small to medium size, subquadrate to oval, costae rounded; anterior commissure rectimarginate to parasulcate; beak acuminate, incurved; foramen small, circular, mesothyrid; symphytium well exposed; beak ridges sharp, interarea extensive. Cardinal process massive, bilobed; hinge plates thickened, fused; median septum low. Adult loop trabecular. *Upper Cretaceous (Maastrichtian):* Belgium, Germany.——FIG. 1470,*6a–e*. * *R. humboldti* (HAGENOW), Rügen, Germany; *a–c,* dorsal, lateral, and anterior views, ×2 (Owen, 1977); *d–e,* views of dorsal valve interior showing trabecular loop, ×4 (Steinich, 1965).

Subfamily TRIGONOSEMINAE Elliott, 1965

[Trigonoseminae ELLIOTT, 1965b, p. 851]

Shell costellate, sulcate; cardinal process robust, loop trabecular to teloform. *Cretaceous.*

Trigonosemus KÖNIG, 1825, p. 3 [**T. elegans;* OD] [=*Delthyridea* M'COY, 1844, p. 150 (type, *Delthyridaea McCoy* KING, 1850, p. 141, OD); *Fissirostra* D'ORBIGNY, 1847 in 1847–1851, p. 269 (type, *Terebratula recurva* DEFRANCE, 1828b, p. 133); *Fissurirostra* D'ORBIGNY, 1850 in 1849–1852, p. 132, *nom. null., errore pro Fissirostra*]. Medium to large, unequally biconvex to planoconvex; strophic, beak high, incurved, acutely pointed; unisulcate, shell thick, costate, interarea high, smooth, concave; foramen small, circular, permesothyrid; symphytium high and narrow. Ventral valve posteriorly thickened, teeth heavy, dental plates thick, lateral umbonal cavities vestigial. Cardinalia dominated by massive cardinal process with swollen base; dorsal diductor muscle scars deeply sunken;

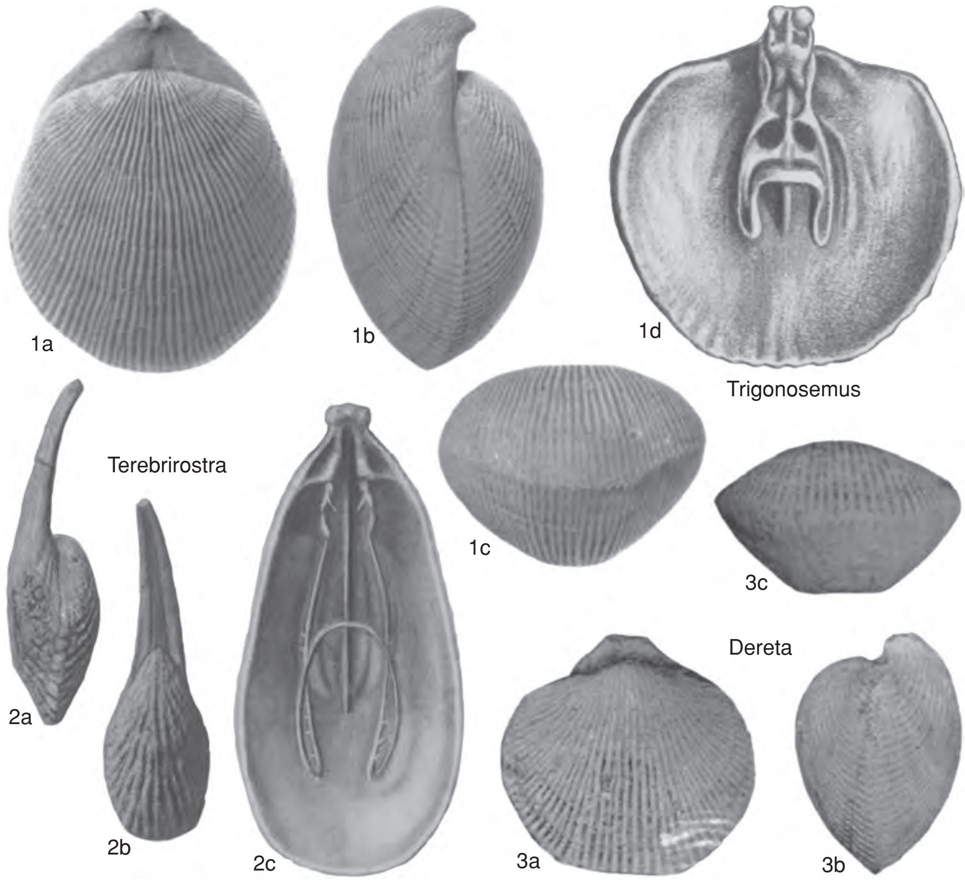

FIG. 1472. Terebrataliidae (p. 2215–2216).

median septum thick, extending anteriorly to just over half valve length; loop narrow, rather small, trabecular. *Upper Cretaceous:* France, Belgium, Holland, England, Turkmenia.——FIG. 1472,*1a–d.* **T. elegans,* Maastrichtian, Ciply, Belgium; *a–c,* dorsal, lateral, and anterior views, ×2 (Owen, 1977); *d,* dorsal valve interior, ×4 (Muir-Wood, 1965a).

Dereta ELLIOTT, 1959, p. 147 [**Terebratula pectita* J. SOWERBY, 1816 in 1815–1818, p. 83; OD]. Medium to large, subcircular, strongly biconvex, costate, anterior commissure unisulcate; foramen round to oval, mesothyrid; beak suberect, beak ridges angular; lateral areas smooth, bordering symphytium. Pedicle collar present; median ridge in ventral umbonal area; dental lamellae strong. Cardinal platform small, thick; cardinal process high, narrow, pillarlike; hinge plates fused anteriorly and supported by high median septum; adult loop possibly trabecular. *Cretaceous (Albian–Cenomanian):* Europe.——FIG. 1472,*3a–c.* **D. pectita* (SOWERBY), England; dorsal valve, lateral, and anterior views, ×2 (Owen, 1977).

Terebrirostra D'ORBIGNY, 1847 in 1847–1851, p. 269 [**Terebratula lyra* J. SOWERBY, 1816 in 1815–1818, p. 83; OD] [=*Lyra* CUMBERLAND in J. SOWERBY, 1816 in 1815–1818, p. 84, *nom. nud.*]. Medium, biconvex, ornament of wavy radial costellae, dorsal valve elongate-oval to subtrigonal in outline, ventral valve very elongate, suberect beak; anterior commissure rectimarginate or slightly unisulcate; beak ridges angular, deltidial plates conjunct. Dental plates extending whole length of umbo, anteriorly curved and uniting with lateral margin. Cardinalia with large, triangular sockets; central hinge trough deep; cardinal process large, trilobed; median septum long, thin, extending anteriorly from cardinalia; adult loop teloform, long, thin. *Cretaceous:* Western Europe.——FIG. 1472,*2a–b.* **T. lyra* (SOWERBY), England; lateral and dorsal views of exterior, ×1.5 (adapted from Muir-Wood, 1934).——FIG. 1472,*2c. T. incurvirostrum* LAMPLUGH & WALKER, England; dorsal valve interior, ×2.5 (adapted from Muir-Wood, 1934).

MEGATHYRIDOIDEA

D. E. Lee,[1] D. I. MacKinnon,[2] and T. N. Smirnova[3]

[[1]University of Otago; [2]University of Canterbury; and [3]Moscow State University]

Superfamily MEGATHYRIDOIDEA Dall, 1870

[*nom. transl.* MacKinnon & Smirnova, 1995, p. 671, *ex* Megathyrididae Hatai & Elliott, 1965, p. 830, *nom. correct. pro* Megathyridae Allan, 1940a, p. 269, *nom. transl. ex* Megathyrinae Dall, 1870, p. 100]

Adult shells commonly small in size, outline subquadrate, commonly multiplicate with wide hinge line and well-developed interareas; beak attrite, foramen large. Pedicle collar long, wide, elevated; short, low, ventral median septum commonly present; dental plates rarely present. Cardinal process or myophore inconspicuous; high, narrow dorsal median septum commonly present, rarely bifurcate distally; outer hinge plates absent; conjunct inner hinge plates forming low septalium may be present; loop axial, consisting of a pair of laterally arcuate, ribbonlike descending branches derived solely from short crura and commonly fused to valve floor; distal extremities of loop converging on high, triangular median septum; no ascending loop elements; lophophore schizolophous or ptycholophous; one species reportedly weakly spiculate. *Lower Cretaceous–Holocene.*

Family MEGATHYRIDIDAE Dall, 1870

[*nom. correct.* Hatai & Elliott, 1965, p. 830, *pro* Megathyridae Allan, 1940a, p. 269, *nom. transl. ex* Megathyrinae Dall, 1870, p. 100]

Loop axial, composed of descending branches only; lophophore trocholophous to ptycholophous; posterior margin strophic or nearly so; dental plates absent. *Upper Cretaceous (Campanian)–Holocene.*

Megathiris d'Orbigny, 1847, p. 269, *nom. nov. pro Argiope* Deslongchamps, 1842, p. ix, *non* Audouin in Savigny, 1827 [**Anomia detruncata* Gmelin, 1790, p. 3,347; OD] [=*Megathyris* Bronn, 1848, p. 244, *nom. van.; Argyope* Davidson, 1850a, p. 65, obj., *non* Savigny, 1826]. Small, broadly transverse, hinge line straight; ventribiconvex, multiplicate, anterior commissure rectimarginate to slightly uniplicate; beak short, attrite; foramen hypothyrid, deltidial plates disjunct. Hinge teeth small, elongate; pedicle collar supported by long, narrow median septum and 2 subdued lateral septa extending almost to anterior margin. Cardinal process small, transverse, grooved; cardinalia with low hinge platform uniting 2 prominent socket ridges; crura short, widely separated, crural processes prominent, horizontal, pointed; median septum very long, narrow, high; flanked in anterior part of shell by 2 lateral septa reaching to near middle of dorsal valve; loop of 2 slender, arcuate descending branches free only near crura, attached to base of crura, valve floor, and anterior extremities of lateral septa and median septum; lophophore attached to dorsal mantle, ptycholophous; rarely weakly spiculate. *Upper Cretaceous (Campanian)–Holocene:* England, France, Belgium, *Campanian–Maastrichtian;* Italy, *Eocene;* Germany, *Oligocene;* Italy, Poland, *Miocene;* Europe, *Pliocene;* Mediterranean, Channel Islands, Portugal, Madeira, Algeria, France, Italy, Greece, Israel, Ghana (3–260 m), *Holocene.*——Fig. 1473,*3a–e.* **M. detruncata* (Gmelin), Holocene, Mediterranean; *a–b,* dorsal and ventral valve views; *c,* interior of dorsal valve, ×5.4 (Muir-Wood, 1965a); *d–e,* interior of dorsal and ventral valves, ×12 (Logan, 1979).

Argyrotheca Dall, 1900, p. 44 [**Terebratula cuneata* Risso, 1826, p. 388; OD] [=*Cistella* Gray, 1853, p. 114, obj., *non* Gistl, 1848; *Cistellarcula* Elliott, 1954, p. 726 (type, *C. wrigleyi,* OD)]. Small, commonly transversely ovate with wide hinge line but outline variable; ventribiconvex, smooth to more commonly multiplicate; beak short, subtruncate; foramen large, commonly hypothyrid; deltidial plates narrow. Pedicle collar well developed, supported by long, narrow, median septum. Cardinal process short, transversely elongate, buttressed by long, high, thick median septum; crura widely separate, short, prominent, pointed; loop long, formed of 2 slender, arcuate descending branches attached to base of crura, valve floor, and anterior end of median septum; short septal flanges present in adult stages; lophophore large, schizolophous, spicules not observed. [*Argyrotheca* may include species that should be assigned to several different genera.] *Upper Cretaceous (Maastrichtian)–Holocene:* Belgium, *Maastrichtian;* cosmopolitan, *Eocene–Miocene;* England, Italy, *Pliocene;* Atlantic (60–1,280 m), Caribbean, Pacific (160 m), Mediterranean (3–400 m), *Holocene.*——Fig. 1473,*2a–e.* **A. cuneata* (Risso), Holocene, Mediterranean; *a,* dorsal valve view, ×15; *b,* ventral valve view, ×13; *c,* dorsal valve interior of juvenile, ×20; *d–e,* dorsal and ventral valve interiors, ×20 (Logan, 1979).

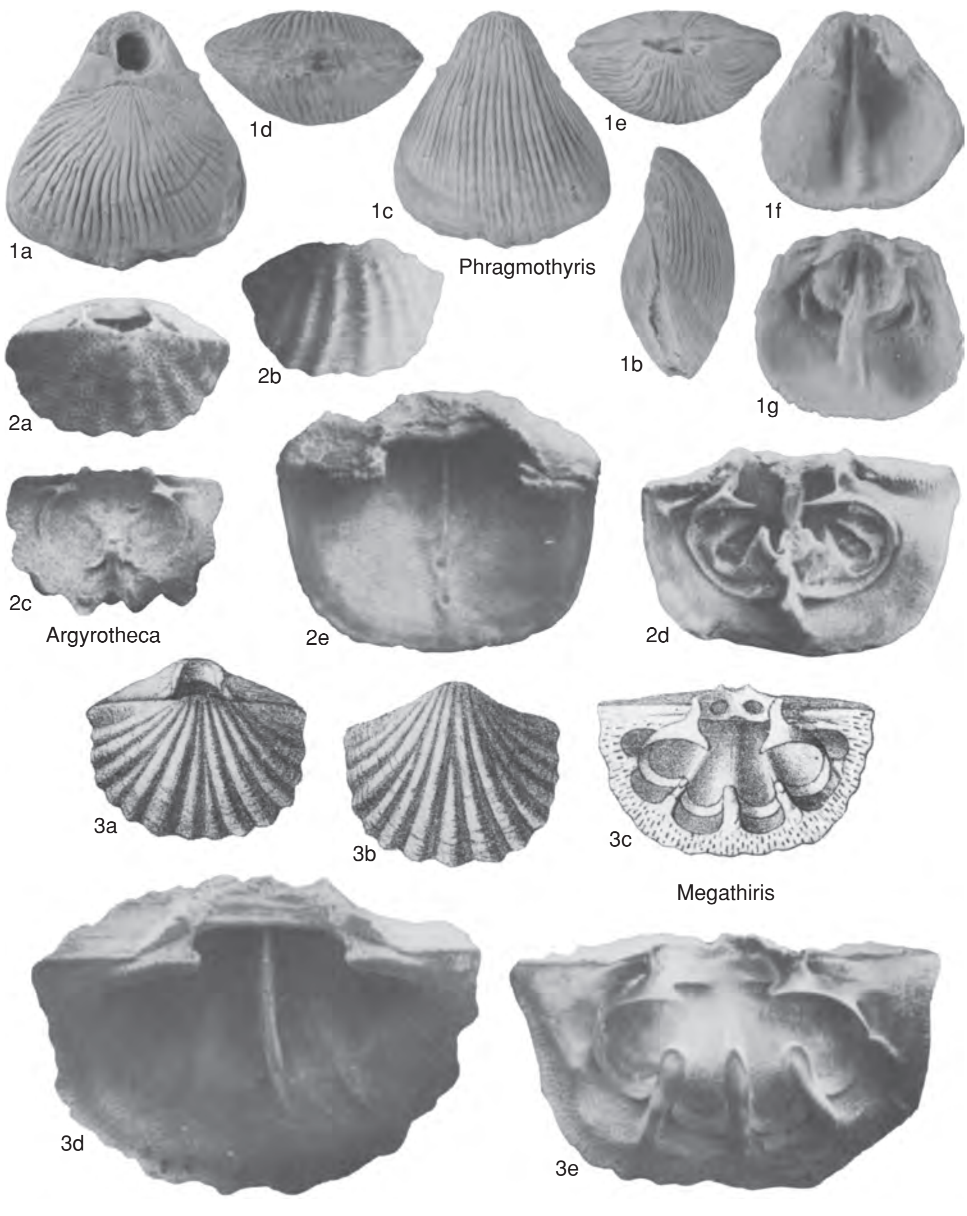

FIG. 1473. Megathyrididae (p. 2217–2221).

Bronnothyris POPIEL-BARCZYK & SMIRNOVA, 1978, p. 134 [**Terebratula bronnii* ROEMER, 1841, p. 41; OD]. Small, semicircular to subpentagonal in outline; wider than long; biconvex to planoconvex; plicate, with 6 to 10 broad, low costae; beak erect, foramen large, trigonal, deltidial plates narrow, disjunct. Pedicle collar well developed, ventral septum thin, short. Cardinal process low, broad; hinge plates broad, circular, concave; dorsal septum high, long, reaching from cardinalia to anterior margin; short septal flanges extending ventrally from dorsal septum. *Upper Cretaceous (upper Campanian)–Paleogene (lower Danian):* Germany, Denmark, Poland, England, The Netherlands, *upper Campanian–Maastrichtian;* Denmark, *lower Danian.*——FIG. 1474*a–o.* **B. bronnii* (ROEMER), lower Maastrichtian, Kronsmoor, northwestern Germany; *a,* dorsal valve view, ×10; *b,* dorsal valve

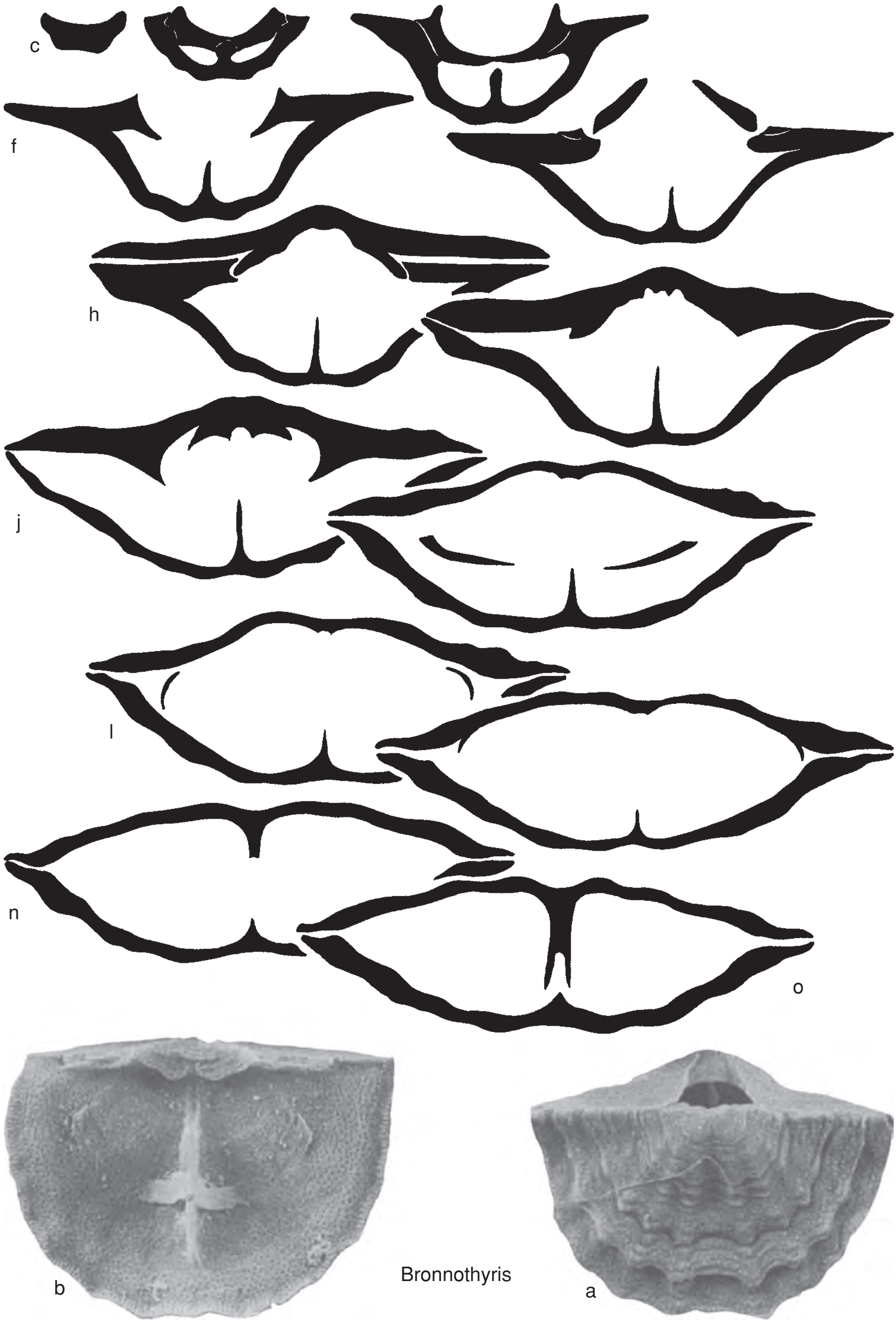

FIG. 1474. Megathyrididae (p. 2218–2220).

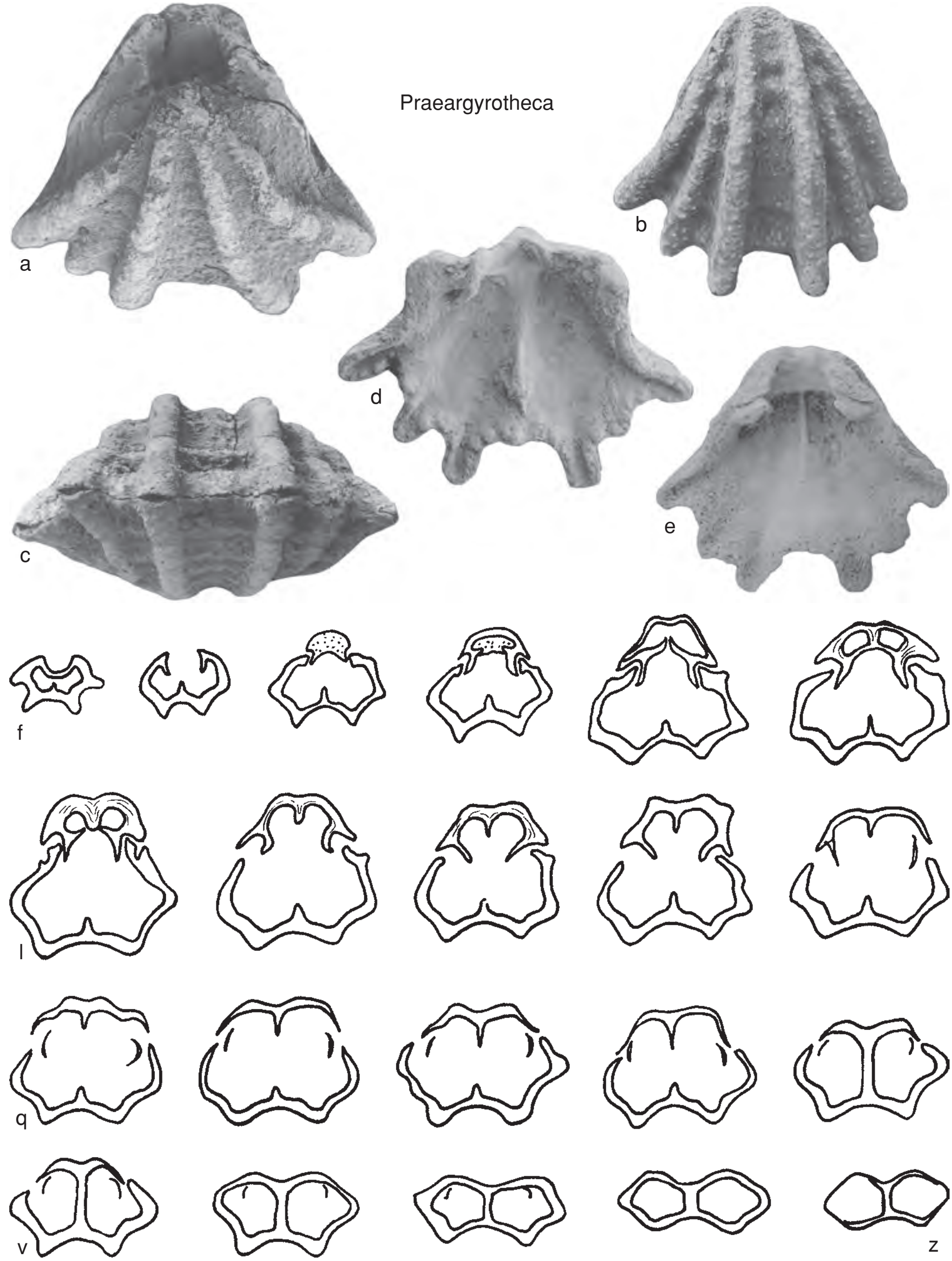

FIG. 1475. Praeargyrothecidae (p. 2221–2222).

interior, ×15 (Johansen & Surlyk, 1990); *c–o,* serial transverse sections 0.1, 0.3, 0.5, 0.7, 0.8, 0.85, 0.9, 1.1, 1.2, 1.35, 1.5, 1.75, 1.8 mm from ventral umbo, ×18 (Steinich, 1966).

Phragmothyris COOPER, 1955a, p. 65 [**P. cubensis;* OD]. Small to medium size; ventribiconvex, commissure rectimarginate to sulcate, multicostellate; foramen large, submegathyrid, symphytium rarely complete. Hinge teeth large, median ridge extending from beak nearly to anterior margin. Dorsal valve with wide, deep sockets bounded by elevated socket ridges; adductor scars on elevated platform

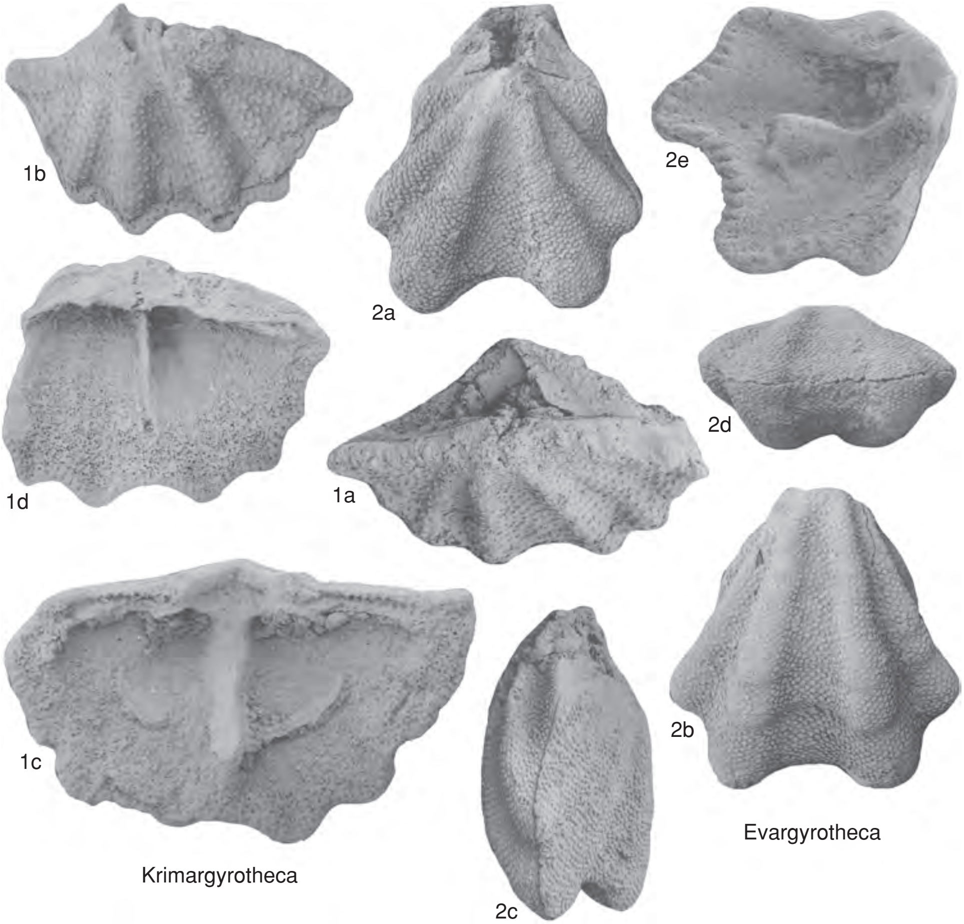

FIG. 1476. Praeargyrothecidae (p. 2222).

with median septum rising above it; loop consisting of broad ribbon extending around muscle platform, and uniting with valve floor beneath it. *Paleogene (Eocene)–Oligocene:* Cuba.——FIG. 1473,*1a–g*. **P. cubensis;* Eocene, Camaguey Province; *a,* holotype, dorsal valve, ×3; *b–e,* lateral, ventral valve, anterior, posterior views, ×3; *f–g,* ventral valve interior, dorsal valve interior, ×3 (Muir-Wood, 1965a).

Family PRAEARGYROTHECIDAE MacKinnon & Smirnova, 1995

[Praeargyrothecidae MACKINNON & SMIRNOVA, 1995, p. 671]

Small to minute, generally strongly plicate, with conspicuous granular microornament; ventral medium septum well developed; dental plates present in young stages, obscured by later shell thickening in adult forms; inner hinge plates and low median septum united to form low dorsal septalium; loop axial, consisting of only two gently curved, descending lamellae that unite anteriorly on high, triangular median septum. *Lower Cretaceous.*

Praeargyrotheca SMIRNOVA in SMIRNOVA, ZEZINA, & POPIEL-BARCZYK, 1983, p. 52 [**Argyrotheca hexaplicata* SMIRNOVA, 1972, p. 108; OD] [=*Smirnovaena* NEKVASILOVÁ, 1985, p. 101 (type, *S. quadricostata,* OD)]. Shell small, biconvex, with 4 to 10 prominent, dorsoventrally opposed high, keeled plicae in each valve; with commonly flat-topped, granular microornament not coincident with endopunctae; anterior commissure rectimarginate; foramen large, hypothyrid to submesothyrid; deltidial plates disjunct; interior margin of both valves crenulated. Dental plates and lateral umbonal cavities visible in early growth stages, commonly obscured by secondary shell thickening

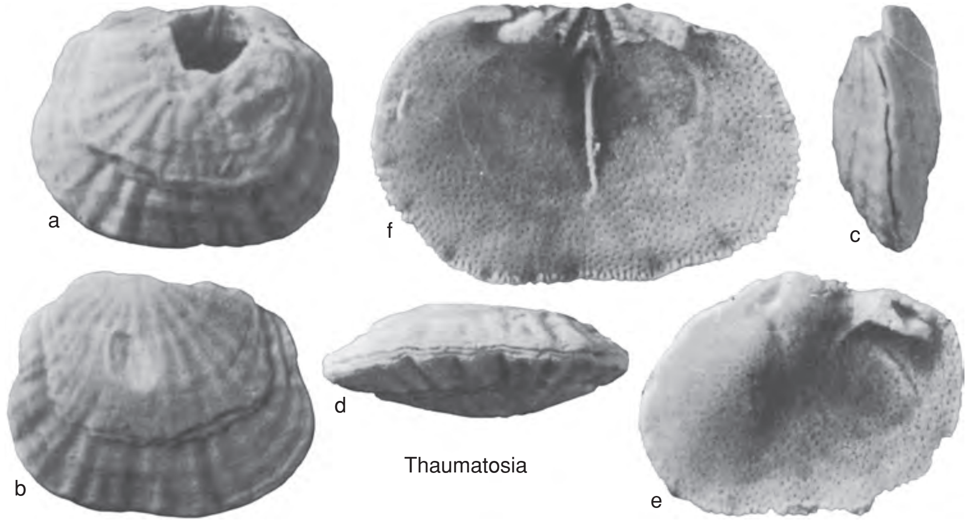

FIG. 1477. Thaumatosiidae (p. 2222).

in adults. Cardinal process not differentiated but small, transverse myophore may be visible; prominent trapezoidal median septum extending about 0.8 distance to anterior margin, tapering posteriorly to unite with a pair of inclined, partially excavate inner hinge plates to form septalium; septalium well demarcated from high inner socket ridges; descending branches of loop consisting of pair of arcuate ribbons that unite with dorsal valve floor and median septum just anterior of midvalve. *Lower Cretaceous:* Ukraine (Crimea).——FIG. 1475*a–z*. **P. hexaplicata* (SMIRNOVA), Berriasian; *a,* posterodorsal valve view; *b,* ventral valve view; *c,* anterior view; *d,* dorsal valve interior; *e,* ventral valve interior, ×20 (MacKinnon & Smirnova, 1995); *f–z,* serial transverse sections 0.0, 0.1, 0.2, 0.3, 0.4, 0.6, 0.7, 0.8, 0.9, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.1, 2.3, 2.4 mm from ventral umbo, ×5 (adapted from Smirnova, 1972).

Evargyrotheca MACKINNON & SMIRNOVA, 1995, p. 676 [**Argyrotheca alta* SMIRNOVA, 1972, p. 110; OD]. Minute, subpentagonal, hinge line narrow; ventribiconvex; commonly with 4 dorsoventrally opposed, rounded plicae; anterior commissure rectimarginate; microornament of triangular granules coincident with endopunctae; beak high, apsacline; foramen large, mesothyrid, deltidial plates disjunct. Interior as for *Praeargyrotheca. Lower Cretaceous:* Ukraine (Crimea).——FIG. 1476,*2a–e*. **E. alta* (SMIRNOVA), Berriasian; *a,* dorsal view; *b,* ventral view; *c,* dorsolateral view; *d,* anterior view; *e,* oblique view of dorsal valve interior, ×20 (MacKinnon & Smirnova, 1995).

Krimargyrotheca MACKINNON & SMIRNOVA, 1995, p. 676 [**Argyrotheca concinna* SMIRNOVA, 1972, p. 107; OD]. Minute, hinge line wide; ventribiconvex; commonly with 6 to 9 dorsoventrally opposed, rounded plicae; microornament of rounded granular mounds in granular groundmass; beak high, apsacline; foramen large, deltidial plates disjunct. Interior as for *Praeargyrotheca. Lower Cretaceous (Berriasian):* Crimea.——FIG. 1476,*1a–d*. **K. concinna* (SMIRNOVA); *a,* posterodorsal view; *b,* ventral valve view; *c,* dorsal valve interior; *d,* ventral valve interior, ×20 (MacKinnon & Smirnova, 1995).

Family THAUMATOSIIDAE Cooper, 1973

[Thaumatosiidae COOPER, 1973a, p. 15]

Minute, foramen amphithyrid; without loop, septum, or other calcareous supports; lophophore schizolophous. *Holocene.*

Thaumatosia COOPER, 1973a, p. 15 [**T. anomala;* OD]. Minute, quadrate to subcircular in outline with wide hinge line; costellate; anterior commissure rectimarginate to unisulcate; foramen large, amphithyrid. Teeth small, unsupported, with pedicle groove at apex; ventral median septum narrow, long. Dorsal valve sockets broad, deep; socket ridges erect, short, thick; no loop or other brachial support. *Holocene:* Andaman Sea, off Thailand (40–77 m).——FIG. 1477*a–f*. **T. anomala; a–d,* holotype, dorsal, ventral, lateral, and anterior views, USNM 550347c, ×10; *e–f,* dorsal and ventral valve interiors, ×20 (Cooper, 1973b).

BOUCHARDIOIDEA

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Superfamily BOUCHARDIOIDEA Allan, 1940

[*nom. transl.* MacKinnon & Lee, herein, *ex* Bouchardiinae Allan, 1940a, p. 270]

Adult shells small to medium size, smooth, ovate to elongate-oval with pronounced ventral carina, anterior commissure unisulcate; beak commonly straight; hinge teeth strong, with swollen bases grooved for reception of socket ridges; cardinal process and inner socket ridges commonly fused to form a solid hinge platform that may bear a prominent, inverted, V-shaped scar reflecting deep impression of posterodorsal extremities of diductor muscles; crura vestigial to absent; septal pillar high, with truncated distal extremity touching ventral valve; brachidial supports, when present, arising solely from septal pillar, consisting of either a pair of septal flanges or more elaborate, posteroventrally directed lamellae with medially directed extremities that do not unite to form complete ring; lophophore plectolophous; not spiculate. *Lower Cretaceous–Holocene.*

Family BOUCHARDIIDAE Allan, 1940

[*nom. transl.* MacKinnon & Lee, herein, *ex* Bouchardiinae Allan, 1940a, p. 270]

Diagnosis as for superfamily. *Lower Cretaceous–Holocene.*

Bouchardia Davidson, 1850a, p. 62 [**Anomia rosea* Mawe, 1823, p. 65; OD] [=*Pachyrhynchus* King, 1850, p. 70, obj., *non* Wagler, 1822, *nec* Germar, 1824]. Small to medium size, very thick shelled posteriorly; beak nearly straight, foramen permesothyrid; symphytium slightly concave. Ventral valve with low septal ridge. High inner socket ridges enclosing massive hinge platform with inverted, V-shaped, diductor muscle grooves; crura absent; paired brachidial lamellae curving posteroventrally from high septal pillar, but not uniting distally. *Upper Cretaceous (?Maastrichtian), Paleogene (Paleocene)–Holocene:* South America (0–150 m); *upper Eocene–Oligocene,* Antarctica (Seymour Island).——Fig. 1478,*1a–f.* **B. rosea* (Mawe), Holocene, Brazil; *a–d,* dorsal, ventral, lateral, and anterior views, ×2; *e,* ventral valve interior; *f,* dorsal valve interior, ×4 (Brunton, 1996).

Australiarcula Elliott, 1960b, p. 26 [**A. artesiana;* OD]. Small, ovate; beak straight, foramen medium, permesothyrid, attrite; symphytium slightly concave, beak ridges sharp. Cardinal process small, bilobed myophore, posteriorly inserted on cardinal platform; septal pillar high anteriorly, with curved, posteriorly directed, brachidial lamellae situated close to elevated margins of deeply inserted adductor muscle scars on valve floor; crura reduced to a pair of minute, inwardly curving projections located high in anterior wall of cardinal platform. [There is no evidence to support the loop reconstruction of Elliott, 1960b.] *Lower Cretaceous:* South Australia.——Fig. 1478,*4a–c.* **A. artesiana; a–b,* dorsal and anterior views, ×2 (Muir-Wood, 1965a); *c,* dorsal valve interior, reconstructed, ×2 (adapted from Elliott, 1960b).

Bouchardiella Doello-Jurado, 1922, p. 200 [**Bouchardia patagonica* Ihering, 1903a, p. 210; OD]. Small, ventribiconvex, elongate-oval, thick shelled; beak short, straight, foramen permesothyrid, attrite; symphytium flat to concave. Ventral valve greatly thickened, bearing prominent grooves to accommodate inner socket ridges. Cardinal process small, bilobed myophore, posteriorly inserted on cardinal platform, socket ridges prominent; septal pillar high anteriorly and bearing 2 short, posteriorly inclined flanges. *Upper Cretaceous–Paleogene:* Australia, South America.——Fig. 1478,*2a.* **B. patagonica* (Ihering), Paleogene, Argentina; dorsal view of holotype, ×2 (Ihering, 1903a).——Fig. 1478,*2b–e. B. cretacea* (Etheridge), Western Australia; *b,* dorsal view, ×6; *c,* dorsal valve interior, ×7; *d,* ventral valve interior, ×6; *e,* oblique anterior view of conjoined valves showing septal pillar and septal flange abutting ventral valve, ×10 (new).

Malleia Thomson, 1927, p. 283 [**Terebratella portlandica* Chapman, 1913, p. 187; OD]. Small, planoconvex; beak short, foramen hypothyrid, deltidial plates narrow, disjunct. Hinge teeth strong, transversely striated, with deeply grooved, swollen bases. Massive inner socket ridges united posteromedianly, bearing deep, inverted, V- or Y-shaped diductor muscle pits and enclosing a prominent posteromedian trough that probably served as a dorsal adjustor muscle attachment site; crura absent; elongate adductor muscle scars enclosing septal pillar; septal pillar high with incomplete ascending and rudimentary descending lamellae. *Paleogene (Oligocene)–Neogene (Pliocene):* Australia.——Fig. 1478,*3a–d.* **M. portlandica* (Chapman), Oligocene–Miocene; *a–b,* holotype, dorsal and anterior views, NMVP 12460, ×4 (Richardson, 1973); *c,*

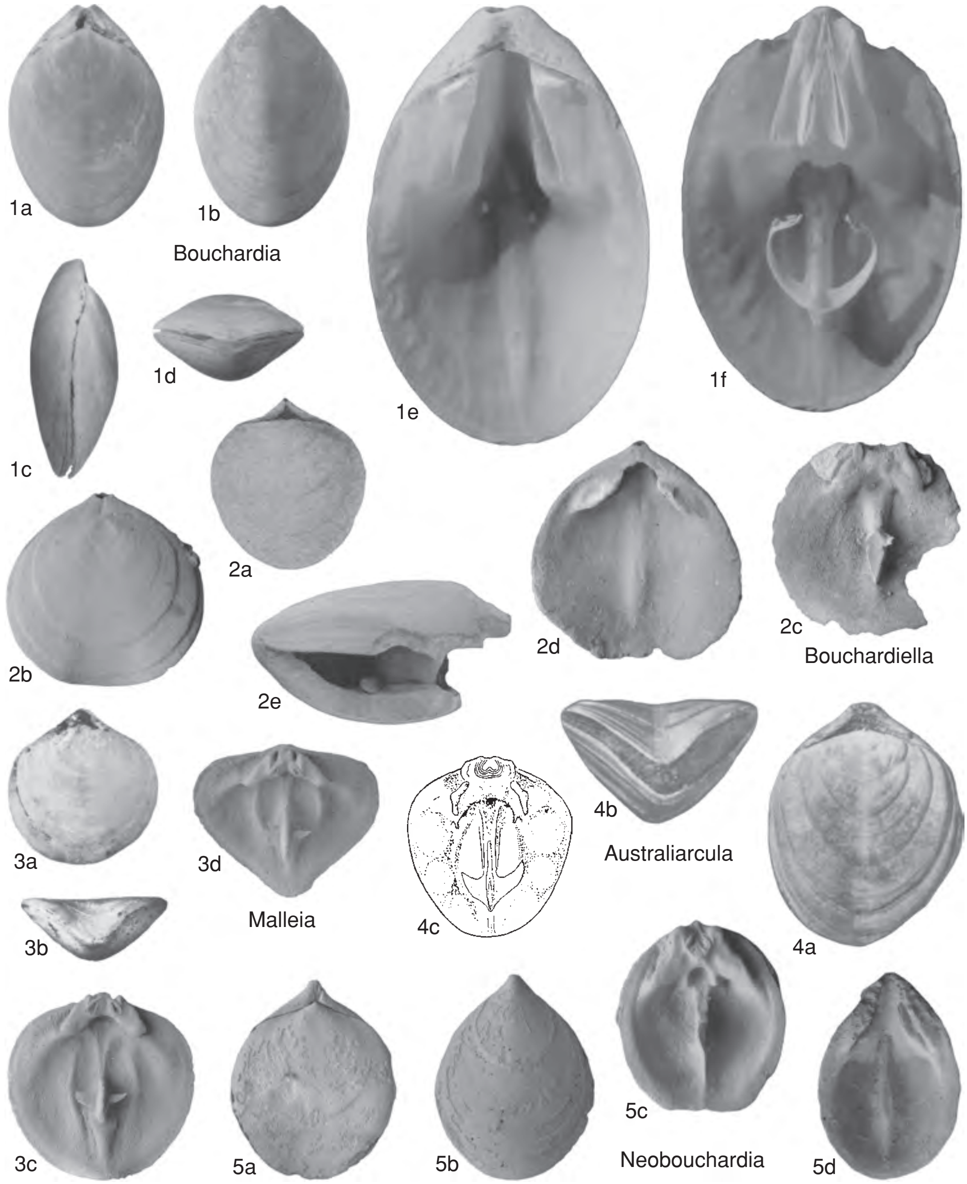

FIG. 1478. Bouchardiidae (p. 2223–2224).

dorsal valve interior showing septal lamellae, ×5; *d,* posterior oblique view of dorsal valve interior, ×5 (new).

Neobouchardia THOMSON, 1927, p. 270 [**Bouchardia minima* THOMSON, 1918b, p. 260; OD]. Small, thick shelled; beak straight to suberect; foramen minute, permesothyrid, beak ridges sharp; symphytium slightly concave. Ventral valve greatly thickened, bearing prominent grooves to accommodate inner socket ridges. Cardinalia greatly thickened, inner socket ridges fused medially, supporting posteriorly a variably swollen, bosslike cardinal process bearing paired, inverted, Y-shaped diductor scars; crura vestigial; septal pillar very high, brachidial lamellae absent. *Paleogene (Oligocene)–Neogene (Pliocene):* New Zealand; Australia, *Oligocene–Miocene.*——FIG. 1478,*5a–d.* **N. minima* (THOMSON), Miocene, New Zealand; *a–b,* dorsal and ventral views; *c,* dorsal valve interior; *d,* ventral valve interior with damaged beak, ×6 (new).

PLATIDIOIDEA

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Superfamily PLATIDIOIDEA Thomson, 1927

[*nom. transl.* MacKinnon & Lee, herein, *ex* Platidiinae Thomson, 1927, p. 215]

Adult shell small, planoconvex, convexoplane or slightly biconvex; outline subcircular or ovate, smooth, capillate or spinose; anterior commissure rectimarginate; foramen relatively large, amphithyrid or hypothyrid. Dental plates weak or absent; pedicle collar short, sessile. Cardinal process weak or absent; hinge plates not developed, septal pillar may be present; crura, when present, long and slender, extending directly from inner socket ridges; descending branches or high triangular septal pillar may be developed; posterolaterally directed septal flanges may project from distal end of pillar; lophophore and mantle strongly spiculate; adult lophophore schizolophous or zygolophous. *Upper Cretaceous–Holocene.*

Family PLATIDIIDAE Thomson, 1927

[*nom. transl.* Allan, 1940a, p. 269, *ex* Platidiinae Thomson, 1927, p. 215]

Diagnosis as for superfamily. *Upper Cretaceous–Holocene.*

Subfamily PLATIDIINAE Thomson, 1927

[Platidiinae Thomson, 1927, p. 215]

Generally planoconvex shells, foramen amphithyrid; septal pillar, when present, high and triangular (axial loop phase); septal flanges at apex; crura and descending branches not always developed; mantle, body wall, lophophore, and tentacles strongly spiculate; lophophore schizolophous or zygolophous. Setae very long. *Upper Cretaceous–Holocene.*

Platidia Costa, 1852 (Jan.), p. 47 [**Orthis anomioides* Scacchi & Philippi, 1844, p. 69; OD] [=*Morrisia* Davidson, 1852d (May), p. 371, obj.]. Small, subcircular to subquadrate in outline, planoconvex, thin shelled, semitransparent; smooth, or with radiating lines or spinules on ventral valve; hinge line wide, foramen large, amphithyrid; deltidial plates very narrow, disjunct. Pedicle collar short, sessile; hinge teeth with narrow dental plates and grooved, swollen bases; short ventral myophragm. Cardinal process absent; inner socket ridges strong; outer socket ridges narrow; no hinge plates; septal pillar located directly anterior to large amphithyrid pedicle embayment, bladelike and leaning anteriorly proximally but posteriorly deflected distally and terminating in a pair of posteriorly directed, U-shaped septal flanges; crura long and slender with short processes, descending branches strongly arcuate, uniting medianly with lateral flanks of U-shaped septal flanges. Lophophore zygolophous. *Paleogene (Danian)–Holocene:* Denmark, *Danian;* North America, *Eocene;* Germany, Italy, *Oligocene;* Italy, Poland, *Miocene;* Italy, *Pliocene;* North America, *Pleistocene;* cosmopolitan: Mediterranean (180–400 m), eastern Atlantic (50–1,340 m), western Atlantic, Caribbean (170–1,290 m), eastern Pacific (100–400 m), western Pacific (130 m), Indian Ocean (90–1,500 m), *Holocene.*——Fig. 1479,*3a–i.* **P. anomioides* (Scacchi & Philippi), Holocene, Caribbean; *a–c,* dorsal, ventral, and lateral views, ×5; *d,* interior of ventral valve, ×10; *e–h,* ventral, anterior, and 2 laterally tilted views of dorsal valve interior, ×10; *i,* bilobed lophophore, ×10 (Cooper, 1977).

Aemula Steinich, 1968a, p. 193 [**A. inusitata;* OD]. Shell small (up to 8 mm in length), thin, oval to irregular subcircular, may be wider than long, planoconvex; dorsal valve smooth, ventral valve may carry fine spines; beak short, suberect, foramen large, amphithyrid, irregular in outline, deltidial plates narrow. Pedicle collar short, teeth small, dental plates slender. Hinge plates weakly developed, crura absent, septal pillar triangular with small, divergent septal flanges on apex; lophophore schizolophous to zygolophous. Differs from *Platidia* in lacking both crura and descending branches. *Upper Cretaceous (Santonian)–Paleogene (Danian):* northwestern Germany, *Santonian–Maastrichtian;* England, *Campanian;* Denmark, Germany, Poland, *Maastrichtian–lower Danian.* ——Fig. 1479,*1a–c.* **A. inusitata,* Maastrichtian, Hvidskud, Mon, Denmark; *a–b,* dorsal and ventral views, ×10 (Surlyk, 1974); *c,* dorsal valve interior, ×10 (Steinich, 1968a).

Amphithyris Thomson, 1918a, p. 20 [**A. buckmani;* OD]. Small (up to 5 mm wide), broadly suborbicular, planoconvex, smooth or with faint capillae on ventral valve, hinge line nearly straight; beak apicate, foramen amphithyrid. Hinge teeth without

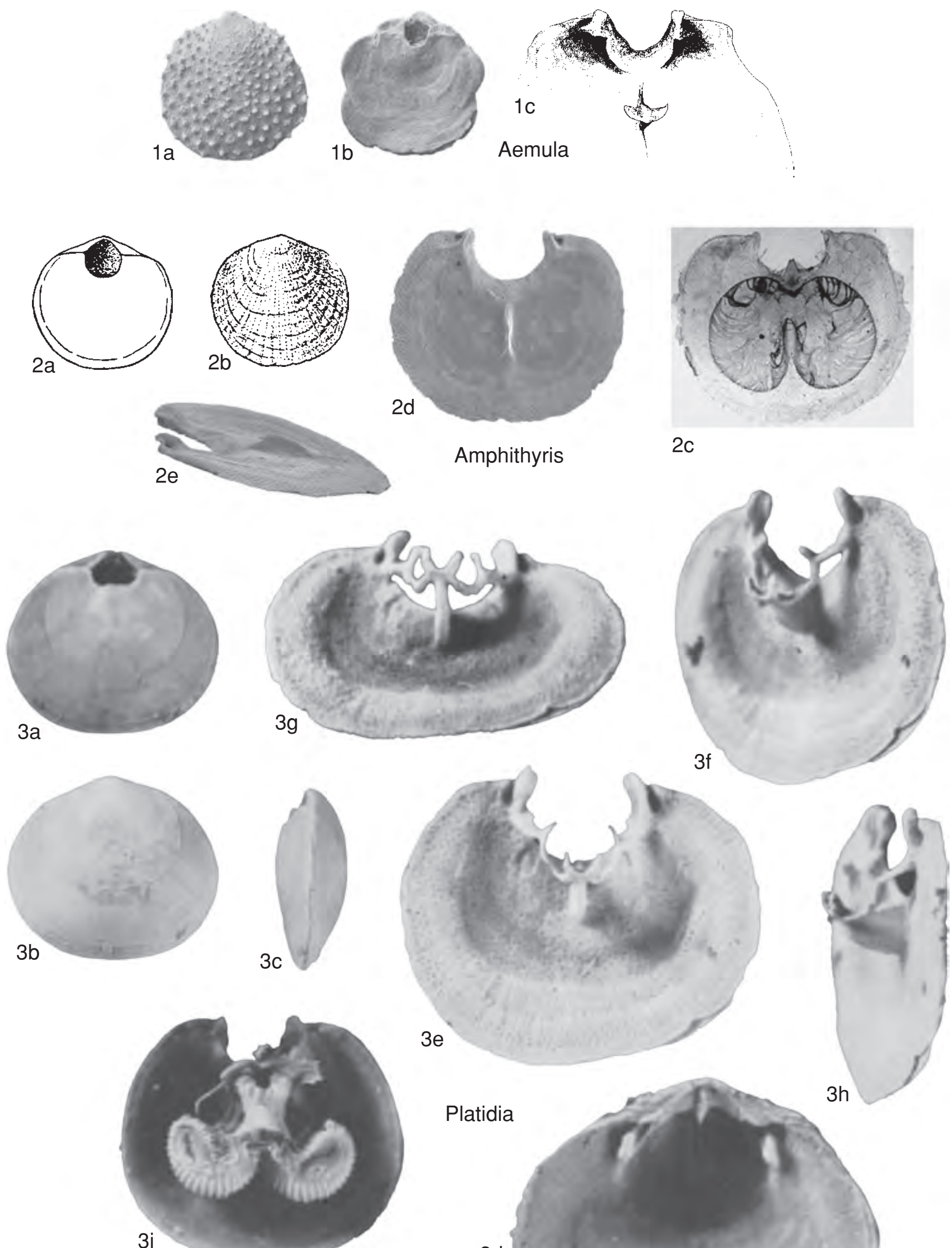

FIG. 1479. Platidiidae (p. 2225–2226).

dental plates or swollen bases. Cardinalia consisting of socket ridges only; dorsal median septum low, triangular in lateral view; lophophore schizolophous, supported by spicules. *Holocene:* New Zealand, Ross Sea, South Orkney Islands (74–641 m).——FIG. 1479,*2a–e*. **A. buckmani,* holotype, NMNZ Br 80; *a–b,* line drawings of ventral and dorsal valve exteriors, ×6 (Thomson, 1927); *c,* schizolophous lophophore; *d–e,* dorsal and oblique views of dorsal valve interior with lophophore removed, ×6 (new).

Annuloplatidia ZEZINA, 1981b, p. 144 [**A. indopacifica;* OD]. Small (up to 4.7 mm wide), smooth, planoconvex to concavoconvex; foramen amphi-

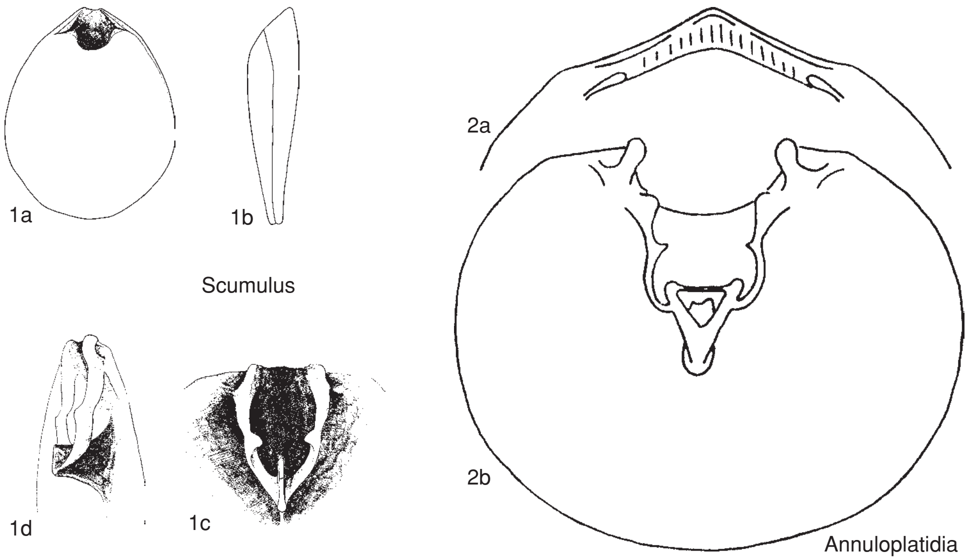

FIG. 1480. Platidiidae (p. 2226–2227).

thyrid; pedicle collar sessile; deltidial plates rudimentary. Crura projecting anteriorly from inner socket ridges; transverse band connecting distal extremities of divergent septal flanges on apex of septal pillar to form a triangular ring; descending branches as in *Platidia;* lophophore zygolophous. Differs from *Platidia* in presence of transverse band in brachidium. *Neogene (Pliocene)–Holocene:* USA (California), *Pliocene;* Indian Ocean, central Pacific, North Atlantic (370–5,240 m), *Holocene.*——FIG. 1480,*2a–b.* **A. indopacifica,* Holocene, Pacific; *a,* beak of ventral valve; *b,* dorsal valve interior, ×18 (Zezina, 1981b).

Scumulus STEINICH, 1968a, p. 199 [**S. inopinatus;* OD]. Small, smooth, thin shelled, outline subtriangular to elongate-oval; flattened biconvex, short, straight beak; foramen large, amphithyrid in juveniles to hypothyrid in adults. Pedicle collar distinct. Brachidium represented by descending branches that extend between crura and narrow, high, subtriangular septal pillar with truncated apex; lophophore strongly spiculate. *Upper Cretaceous:* England, *upper Campanian;* Denmark, *Maastrichtian.*——FIG. 1480,*1a–d.* **S. inopinatus,* Maastrichtian, Denmark; *a–b,* dorsal and lateral view of small specimen; *c,* dorsal valve interior; *d,* lateral view of brachidium, ×20 (Steinich, 1968a).

Subfamily PHANEROPORINAE Zezina, 1981

[*nom. transl.* MACKINNON & LEE, herein, *pro* Phaneroporidae ZEZINA, 1981c, p. 17]

Shell small, slightly biconvex, foramen hypothyrid; dental plates recessive. Inner socket ridges strong; crura long, slender, and flattened distally; descending branches when present uniting with high, triangular septal pillar (axial loop phase); adult lophophore zygolophous and heavily spiculate. *Holocene.*

Phaneropora ZEZINA, 1981c, p. 18 [**P. galatheae;* OD]. Small, subcircular, smooth, gently biconvex, anterior commissure rectimarginate; beak ridges slightly tuberculate; foramen large, hypothyrid, deltidial plates very narrow, disjunct, pedicle collar short; hinge teeth with small recessive dental plates. No cardinal process; high inner socket ridges with long crura that are anteromedially convergent; septal pillar platelike at its base with high, narrow distal extremity (axial loop phase), descending branches absent; lophophore zygolophous and heavily spiculate. *Holocene*: Great Australian Bight, Southwestern Pacific, Indonesia (Arafura Sea), 390–755 m. ——FIG. 1481,*2a–f.* **P. galatheae; a–b,* holotype, dorsal and lateral views, Great Australian Bight, 1,320–1,340 m, ZMUC-BRA-1, ×8 (Zezina, 1981c); *c–d,* ventral and lateral views of dorsal interior, ×20; *e,* ventral valve interior, ×20; *f,* detail of beak region, off Tasmania, 755 m, ×40 (new).

Leptothyrella MUIR-WOOD 1965c, p. 855, *nom. nov. pro Leptothyris* MUIR-WOOD, 1959, *non* CONRAD in KERR, 1875, p. 20 [**Leptothyris ignota* MUIR-WOOD, 1959, p. 308; OD]. Very similar to *Phaneropora* but lacking beak ridge tubercles and with narrow descending loop branches extending between crura and distal extension of high, septal pillar; lophophore zygolophous. *Holocene*: Indian Ocean (off Zanzibar), Gulf of Aden, North Atlantic (2,000–

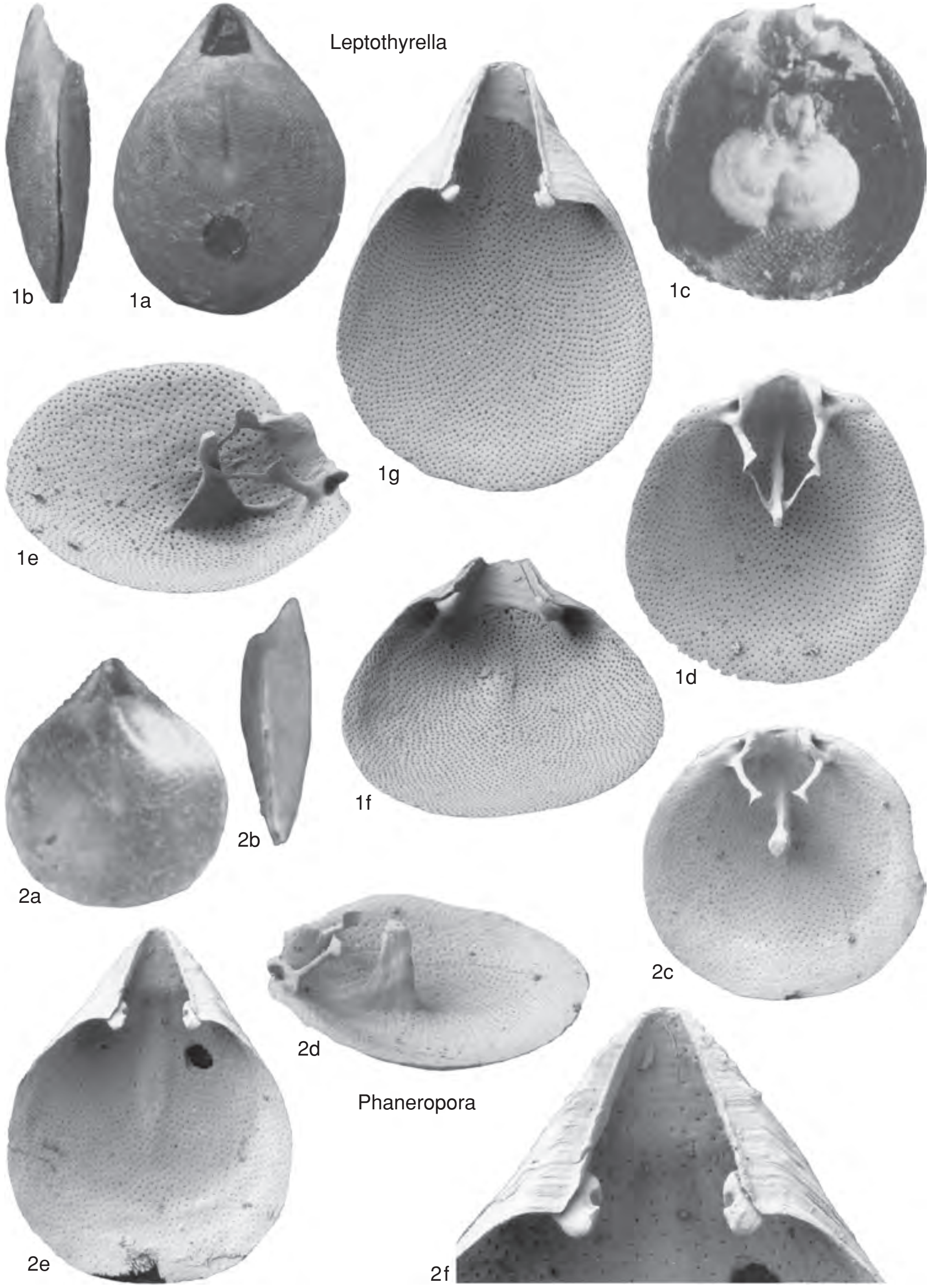

FIG. 1481. Platidiidae (p. 2227–2228).

4,737 m).——FIG. 1481,*1a–c.* *L. ignota; a–b,* dorsal and lateral views, Gulf of Aden, ×7; *c,* dorsal interior, holotype NHM ZB 1555, off Zanzibar, ×12 (Muir-Wood, 1965c).——FIG. 1481, *1d–g. L. incerta* (DAVIDSON), Gulf of Gascoigne, Atlantic; *d–e,* ventral and lateral views of dorsal interior, ×20; *f–g,* dorsal and anterior oblique views of ventral interior, ×20 (new).

TERREBRATELLOIDEA

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Superfamily TEREBRATELLOIDEA King, 1850

[*nom. transl.* Allan, 1940a, p. 269, *ex* Terebratellidae King, 1850, p. 245]

Adult shells small to large, generally biconvex, subcircular to elongate oval, commonly smooth, some multicostate; anterior commissure rectimarginate to unisulcate, rarely biplicate; ventral umbo commonly attrite, foramen small to large, mesothyrid to permesothyrid, with delthyrium restricted by deltidial plates (either disjunct or conjunct), or by a symphytium. Dental plates absent; pedicle collar short, sessile. Cardinalia lamellar or variably thickened. Cardinal process with transversely oval myophore that may have swollen, anterior boss; septal pillar retained throughout ontogeny, commonly developing as a median septum; hinge plates commonly uniting with septum to form septalium. Anteroventral edge of septal pillar bladelike and nonbifurcate throughout ontogeny; septal flanges not developed. Adult loop commonly teloform, but may be annular, haptoid, diploform, or trabecular; nonspiculate. *Paleogene–Holocene.*

Family TEREBRATELLIDAE King, 1850

[Terebratellidae King, 1850, p. 245]

Loop passing through some or all of axial, cucullate, annular, haptoid, trabecular, and teloform phases; inner hinge plates uniting with median septum to form septalium; posterior shell thickening developed in some taxa. *Paleogene–Holocene.*

Subfamily TEREBRATELLINAE King, 1850

[*nom. transl.* Davidson, 1886, p. 4, *ex* Terebratellidae King, 1850, p. 245]

Smooth or multicostate; deltidial plates disjunct or conjunct in adults. Cardinalia commonly lamellar with excavate, inner hinge plates meeting on medium septum to form septalium; posterior shell thickening extensive in adult growth stages of some genera; adult loop commonly trabecular but also may be annular, haptoid, or teloform. *Paleogene–Holocene.*

Terebratella d'Orbigny, 1847, p. 269 [**Terebratula chilensis* Broderip, 1833b, p. 141; OD; =*Anomia dorsata* Gmelin, 1792, p. 3,348; *Terebratula flexuosa* P. P. King, 1835, p. 337; *Terebratula patagonica* Gould, 1850, p. 347] [=*Waltonia* Davidson, 1850d, p. 474 (type, *W. valenciennesii*); *Magasella* Dall, 1870, p. 134 (type, *Terebratella evansii* Davidson, 1852c, p. 77). Medium to large, transversely ovate, unisulcate, costate to strongly multicostate; beak erect to suberect, attrite, foramen medium to large, submesothyrid to mesothyrid, deltidial plates commonly conjunct. Cardinalia weakly to moderately thickened, hinge plates excavate, moderately to steeply inclined, meeting on low median septum to form septalium; adult loop trabecular, lophophore plectolophous. *Paleogene (Oligocene)–Holocene:* South America, New Zealand.——Fig. 1482,*1a–f.* **T. dorsata* (Gmelin), Holocene, Strait of Magellan; *a–d,* dorsal, ventral, anterior, and lateral views, ×1; *e,* ventral interior, ×1; *f,* dorsal interior showing brachidium, ×1 (Fischer & Oehlert, 1892).

Aerothyris Allan, 1939, p. 245 [**Magellania macquariensis* Thomson, 1918a, p. 30; OD]. Medium size, variably ovate, weakly to moderately unisulcate, smooth; beak suberect, attrite, foramen medium to large, mesothyrid, deltidial plates commonly disjunct, rarely conjunct in some adults. Cardinalia moderately thickened; outer hinge plates prominent and gently inclined; inner hinge plates more steeply inclined, uniting medianly to form septalium; cardinal process prominent, consisting of striated transverse myophore; crura with prominent crural processes; median septum bladelike; adult loop teloform. *Holocene:* Macquarie Island, Antipodes Island.——Fig. 1483,*1a–e.* **A. macquariensis* (Thomson), Macquarie Island; *a–d,* dorsal, lateral, anterior, and posterior views, ×1; *e,* interior of dorsal valve, ×1 (Foster, 1974).

Aneboconcha Cooper, 1973b, p. 28 [**A. obscura;* OD]. Small, smooth, elongate oval, gently unisulcate, beak suberect, foramen large, submesothyrid; deltidial plates disjunct. Cardinal process consisting of transversely oval myophore; socket ridges and outer hinge plates narrow, crural bases narrow, inner hinge plates well developed, uniting with bladelike median septum to form

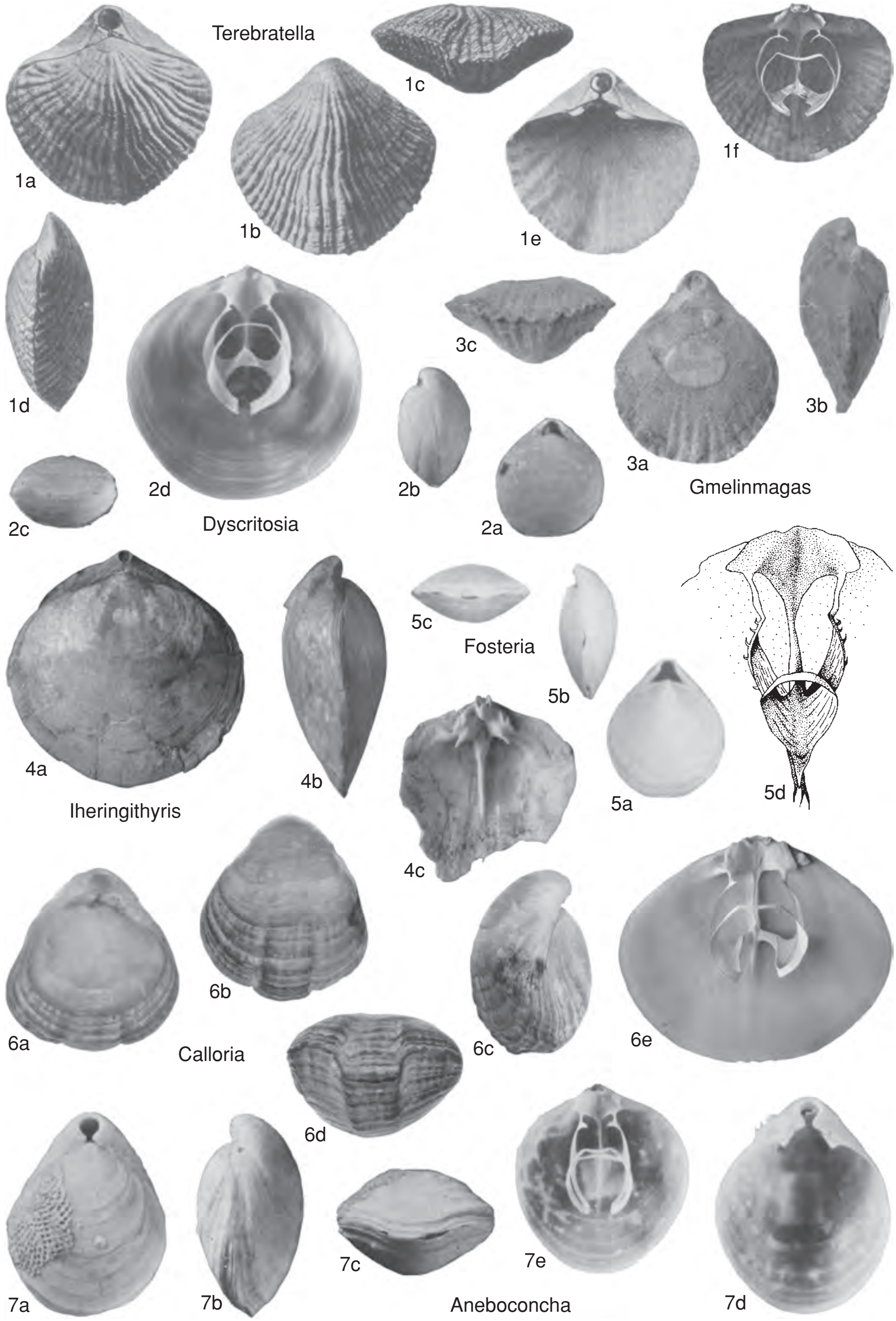

FIG. 1482. Terebratellidae (p. 2229–2231).

septalium; loop trabecular. *Holocene:* South Atlantic.——FIG. 1482,*7a–e.* **A. obscura,* South Shetland Islands; *a–c,* dorsal, lateral, and anterior views; *d–e,* interior of ventral and dorsal valves, ×2 (Cooper, 1973b).

Calloria COOPER & LEE, 1993, p. 267 [**Terebratula inconspicua* G. B. SOWERBY, 1846, p. 92; OD; =*Terebratula rubicunda* G. B. SOWERBY, 1846, p. 93]. Shell red, small to medium, smooth, or secondarily anteriorly costate, moderately to strongly unisulcate, beak short, attrite, foramen large, submesothyrid; deltidial plates commonly disjunct but sporadically conjunct in gerontic specimens. Cardinal process a transverse myophore lacking any anterior swelling; inner hinge plates meeting low median septum to form septalium, loop trabecular. *Neogene (Pliocene)–Holocene:* New Zealand.——FIG. 1482,*6a–e.* **C. inconspicua* (G. B. SOWERBY), Holocene; *a–d,* lectotype, dorsal, ventral, lateral, and anterior views, ZB 595, ×1 (Cooper & Lee, 1993); *e,* dorsal interior, ×4 (new).

Dyscritosia COOPER, 1982, p. 22 [**D. secreta;* OD]. Small to medium, smooth, subcircular, biconvex, rectimarginate; beak low, attrite, erect; foramen medium, submesothyrid; deltidial plates narrow, disjunct. Cardinalia similar to *Aneboconcha.* Adult loop trabecular. *Holocene:* USA (southern Georgia).——FIG. 1482,*2a–d.* **D. secreta; a–c,* holotype, dorsal, lateral, and anterior views, USNM 551169a, ×1; *d,* dorsal interior, ×2 (Cooper, 1982).

Fosteria ZEZINA, 1980, p. 26 [**Magellania? spinosa* FOSTER, 1974, p. 142; OD]. Small, smooth, rectimarginate to unisulcate, foramen large, submesothyrid; beak suberect, attrite; deltidial plates very narrow, disjunct. Cardinalia lamellar, lacking clearly defined cardinal process; inner hinge plates broad, steeply inclined, uniting with low posterior trail of median septum to form septalium; septal pillar high, spinose anteriorly; loop annular, descending branches with several curved spines. *Holocene:* Antarctic and South Atlantic (311–1,226 m).——FIG. 1482,*5a–d.* **F. spinosa* (FOSTER), Ross Sea; *a–c,* holotype, dorsal, lateral, and anterior views, USNM 550269A, ×4; *d,* line drawing of dorsal valve interior, ×12 (Foster, 1974).

Gmelinmagas DE MARIÑELARENA, 1964, p. 267 [**G. plicata;* OD; =*Terebratella dorsata* ORTMANN, 1902, p. 74, *non Anomia dorsata* GMELIN, 1792, p. 3,348]. Medium, ventribiconvex, subpentagonal, unisulcate, coarsely costate anteriorly but smooth posteriorly; beak suberect, attrite, foramen relatively large, mesothyrid, deltidial plates conjunct. Cardinal process high, transverse, hinge plates excavate, moderately inclined, meeting on low septum to form septalium; loop trabecular. *Paleogene–Neogene:* Patagonia.——FIG. 1482,*3a–c.* **G. plicata,* Miocene; dorsal, lateral, and anterior views, ×1 (new).

Gyrothyris THOMSON, 1918a, p. 23 [**G. mawsoni;* OD]. Medium, transversely ovate to elongate oval; finely multicostate, anterior commissure weakly unisulcate; beak suberect to erect, foramen small, mesothyrid, attrite; deltidial plates usually conjunct, concave, almost hidden. Cardinalia thickened; cardinal process transversely oval myophore, median septum uniting posteriorly with narrow septalium; adult loop typically trabecular but occasionally teloform. *Holocene:* off southern New Zealand and Macquarie Islands.——FIG. 1483,*2a–e.* **G. mawsoni,* Macquarie Island; *a–c,* dorsal, lateral, and anterior views, ×1; *d–e,* ventral and dorsal valve interiors, ×1 (Foster, 1974).

Iheringithyris LEVY, 1961, p. 84 [**Magellania ameghinoi* IHERING, 1903b, p. 326; OD]. Medium to large, smooth, biconvex, circular, rectimarginate; beak low, suberect, foramen small, mesothyrid, deltidial plates conjunct, beak ridges sharp. Cardinalia thickened; crural bases swollen, diverging at about 45° from median plane and enclosing narrow, partially infilled septalium; cardinal process well differentiated, consisting of posterior, rather sunken myophore with upturned lateral margins and anterior bosslike swelling; inner socket ridges with submarginal thickening; median septum relatively low and bladelike, extending about 0.6 valve length; loop teloform. *Neogene (Miocene):* Patagonia.——FIG. 1482,*4a–c.* **I. ameghinoi* (IHERING); *a–b,* dorsal and lateral views, ×1; *c,* interior of dorsal valve, ×1 (new).

Magadina THOMSON, 1915a, p. 399 [**M. browni;* OD]. Small, smooth, biconvex to planoconvex, ventrally carinate, unisulcate. Beak suberect, foramen permesothyrid, deltidial plates conjunct. Hinge teeth strong with grooved, swollen bases. Cardinal process a transverse myophore, lacking anterior swelling; swollen inner socket ridges tending to fuse anteriorly to enclose a short, deep hinge trough; septal pillar high; incomplete annular loop. *Paleogene (Oligocene)–Neogene (Miocene):* New Zealand; Australia, *Miocene.*——FIG. 1483,*3a–f.* **M. browni,* Miocene, New Zealand; *a–d,* holotype, dorsal, lateral, anterior, and posterior views, NMNZ Br46, ×2; *e–f,* dorsal and oblique views of dorsal valve interior, ×4 (new).

Magella THOMSON, 1915a, p. 396 [**M. carinata;* OD; =*Terebratella kakanuiensis* THOMSON, 1908, p. 102, *non* HUTTON, 1905, p. 479]. Small, smooth, unisulcate; beak suberect, foramen submesothyrid, deltidial plates disjunct. Cardinalia strongly resembling those of *Calloria,* but adult loop phase haptoid to incipiently trabecular. *Paleogene (Eocene–Oligocene):* New Zealand.——FIG. 1483,*4a–e.* **M. carinata,* Oligocene; *a,* dorsal view, ×2; *b–c,* lateral and anterior views, ×1; *d,* dorsal valve interior, ×2; *e,* oblique view of loop, ×3 (new).

Neothyris DOUVILLÉ, 1879, p. 274 [**Terebratula lenticularis* DESHAYES, 1839, p. 359; OD]. Large, smooth, weakly unisulcate, beak erect to incurved, foramen small, mesothyrid, attrite; deltidial plates conjunct. Strong posterior shell thickening in adults. Cardinalia thickened, crural bases fused with socket ridges; median septum short, high, bifurcating posteriorly to form wide hinge trough, almost filled by large, swollen boss of cardinal process; crura rather short, crural processes prominent; adult

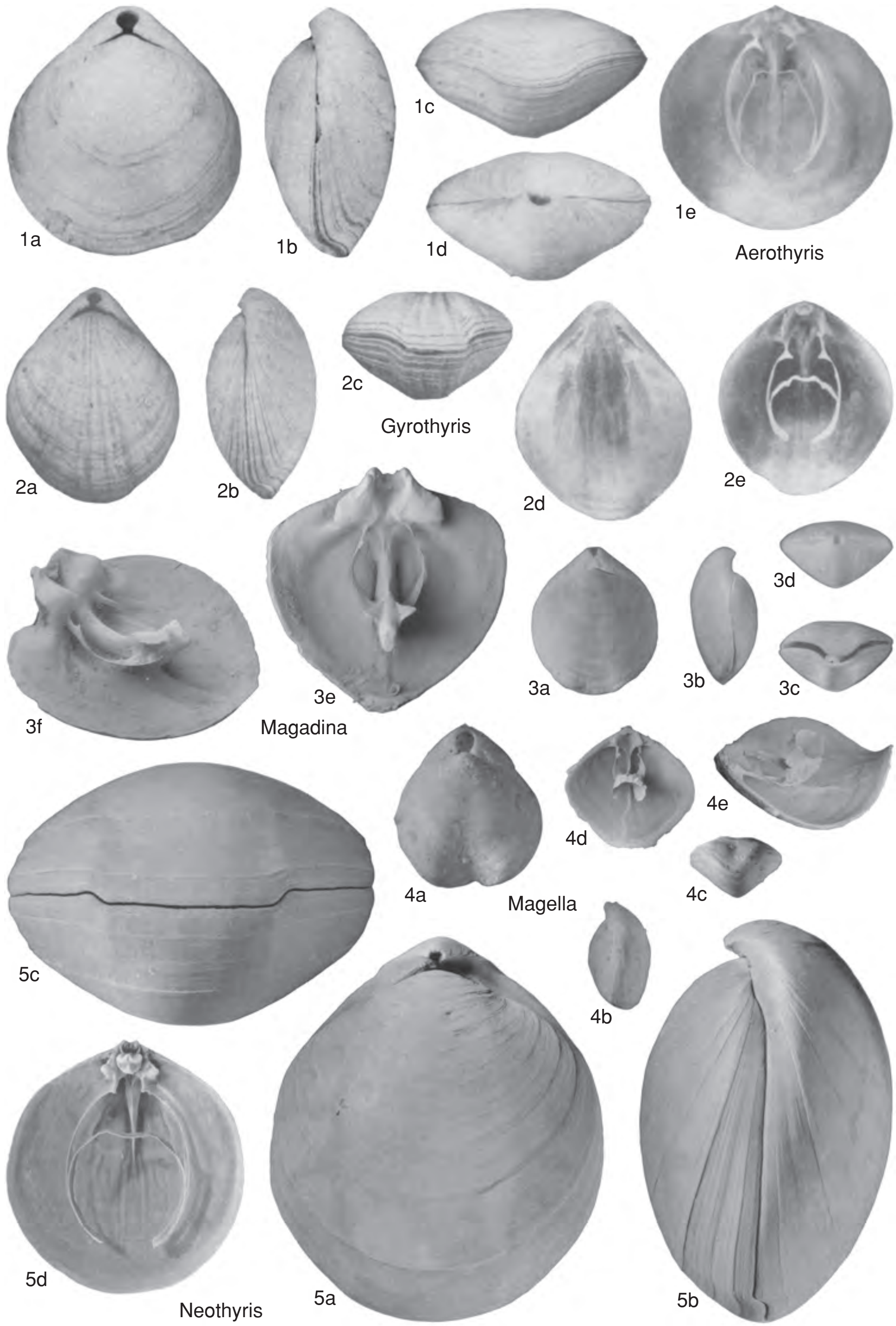

FIG. 1483. Terebratellidae (p. 2229–2233).

loop teloform, lophophore plectolophous. *Neogene (Miocene)–Holocene:* New Zealand.——FIG. 1483,*5a–d.* **N. lenticularis* (DESHAYES), Holocene; *a–c,* dorsal, lateral, and anterior views; *d,* dorsal interior showing loop, ×1 (new).

Pachymagas IHERING, 1903b, p. 332 [**Terebratella (Pachymagas) tehuelcha* IHERING, 1903b, p. 332; OD]. Medium to large, smooth, unisulcate, beak suberect to erect; foramen large, mesothyrid, attrite; deltidial plates conjunct; posterior shell thickening moderately to very strongly developed. Hinge teeth strong. Cardinalia thickened; median septum bifurcating posteriorly to form wide hinge trough, almost completely filled by very swollen boss of cardinal process; loop trabecular. *Paleogene (Oligocene)–Neogene (Pliocene):* South America; New Zealand, *Oligocene–Miocene.*——FIG. 1484,*4a–c.* **P. tehuelcha,* Pliocene, Patagonia; *a–b,* lectotype, dorsal and lateral views of exterior, MACN 4990, ×1; *c,* dorsal interior, loop not preserved, ×1 (new).

Praemagadina MACKINNON in MACKINNON, BEUS, & LEE, 1993, p. 338 [**P. campbelli;* OD]. Small, smooth, unisulcate, beak suberect, foramen submesothyrid, deltidial plates disjunct; both valves thickened posteriorly. Hinge teeth strong with grooved swollen bases; inner socket ridges robust, enclosing sessile hinge trough bearing large pedicle adjustor muscle scars; septal pillar high, anteriorly inclined; adult loop incomplete haptoid. *Paleogene (Oligocene):* New Zealand.——FIG. 1484,*3a–e.* **P. campbelli; a–c,* holotype, dorsal, lateral, and anterior views, OU 40741, ×3; *d–e,* dorsal valve interior, normal and oblique views, ×6 (MacKinnon, Beus, & Lee, 1993).

Syntomaria COOPER, 1982, p. 20 [**S. curiosa;* OD]. Small, smooth but with prominent growth lines, elongate oval, narrowly biconvex, rectimarginate; beak suberect, attrite, foramen wide, deltidial plates narrow, disjunct. Cardinal process a well-developed transverse myophore; inner hinge plates excavate, uniting on valve floor; septal pillar high, anteriorly inclined, and narrow. Loop annular to incipiently haptoid; descending branches occasionally incomplete. *Holocene:* South Sandwich Islands, South Atlantic.——FIG. 1484,*1a–d.* **S. curiosa; a–c,* holotype, dorsal, lateral, and anterior views, USNM 551173a, ×5; *d,* dorsal valve interior, ×7 (Cooper, 1982).

Waiparia THOMSON, 1920, p. 380 [**Pachymagas abnormis* THOMSON, 1917, p. 412; OD]. Medium to large, smooth, unisulcate; beak erect, attrite, foramen submesothyrid to mesothyrid, deltidial plates conjunct. Cardinal process with transversely oval myophore and small, pyramidal anterior boss; cardinalia thickened, inner hinge plates well developed, uniting on short median septum to form septalium; loop trabecular. *Paleogene (Oligocene)–Neogene (Miocene):* New Zealand.——FIG. 1484,*2a–d.* **W. abnormis* (THOMSON), Miocene; *a–c,* holotype, dorsal, lateral, and anterior views, NMNZ Br113, ×1.5; *d,* dorsal interior, loop not preserved, ×3.5 (new).

Subfamily ADNATIDINAE new subfamily

[Adnatidinae MACKINNON & LEE, herein] [type genus, *Adnatida* RICHARDSON, 1991, p. 38]

Small, smooth, unisulcate, crura vestigial, loop incomplete annular to incomplete haptoid. *Paleogene (Eocene).*

Adnatida RICHARDSON, 1991, p. 38 [**Magasella deformis* TATE, 1880, p. 165; OD]. Small, smooth, strongly unisulcate, ventrally carinate, beak erect to slightly incurved, foramen small, mesothyrid to submesothyrid; deltidial plates conjunct and downwardly convergent along median line; beak ridges well developed. Cardinalia massively thickened; cardinal process small, sessile, transversely oval myophore; small pedicle adjustor muscle pits inserted just anteriorly of cardinal process, tending to become infilled by secondary shell in gerontic specimens; massive median swelling between very strong inner socket ridges; septal pillar very high; loop annular to haptoid. *Paleogene (Eocene):* Australia.——FIG. 1485,*3a–f.* **A. deformis* (TATE); *a–c,* dorsal, lateral, and anterior views, ×3.5 (Richardson, 1991); *d,* ventral interior; *e–f,* normal and lateral views of dorsal interior, ×4 (new).

Subfamily ANAKINETICINAE Richardson, 1991

[Anakineticinae RICHARDSON, 1991, p. 30]

Small to medium, smooth, unisulcate, ventrally carinate; high septal pillar almost touching ventral valve floor; hinge trough may become completely infilled with secondary shell, forming prominent cardinal platform with posterior pits for dorsal adjustor muscle attachment; loop annular to trabecular. *Paleogene (Oligocene)–Holocene.*

Anakinetica RICHARDSON, 1987, p. 38 [**Terebratella(?) cumingii* DAVIDSON, 1852d, p. 368; OD]. Small to medium, ovate, biconvex; beak large, suberect to straight; symphytium wide, flat; cardinal margin straight or nearly straight. Substantial posterior shell thickening in both valves; pedicle canal long and narrow; crura short; loop annular to trabecular. *Paleogene (Oligocene)–Holocene:* Australia.——FIG. 1485,*2a–e.* **A. cumingii* (DAVIDSON); *a–d,* dorsal, lateral, posterior, and anterior views, ×2; *e,* dorsal interior, ×3 (Richardson, 1987).

Parakinetica RICHARDSON, 1987, p. 39 [**P. stewarti;* OD]. Small, planoconvex; beak small, straight; deltidial plates disjunct; loop annular. *Holocene:* Australia.——FIG. 1485,*1a–f.* **P. stewarti,* Bass Strait; *a–d,* dorsal, lateral, posterior, and anterior views; *e–f,* dorsal and ventral interiors, ×5 (Richardson, 1987).

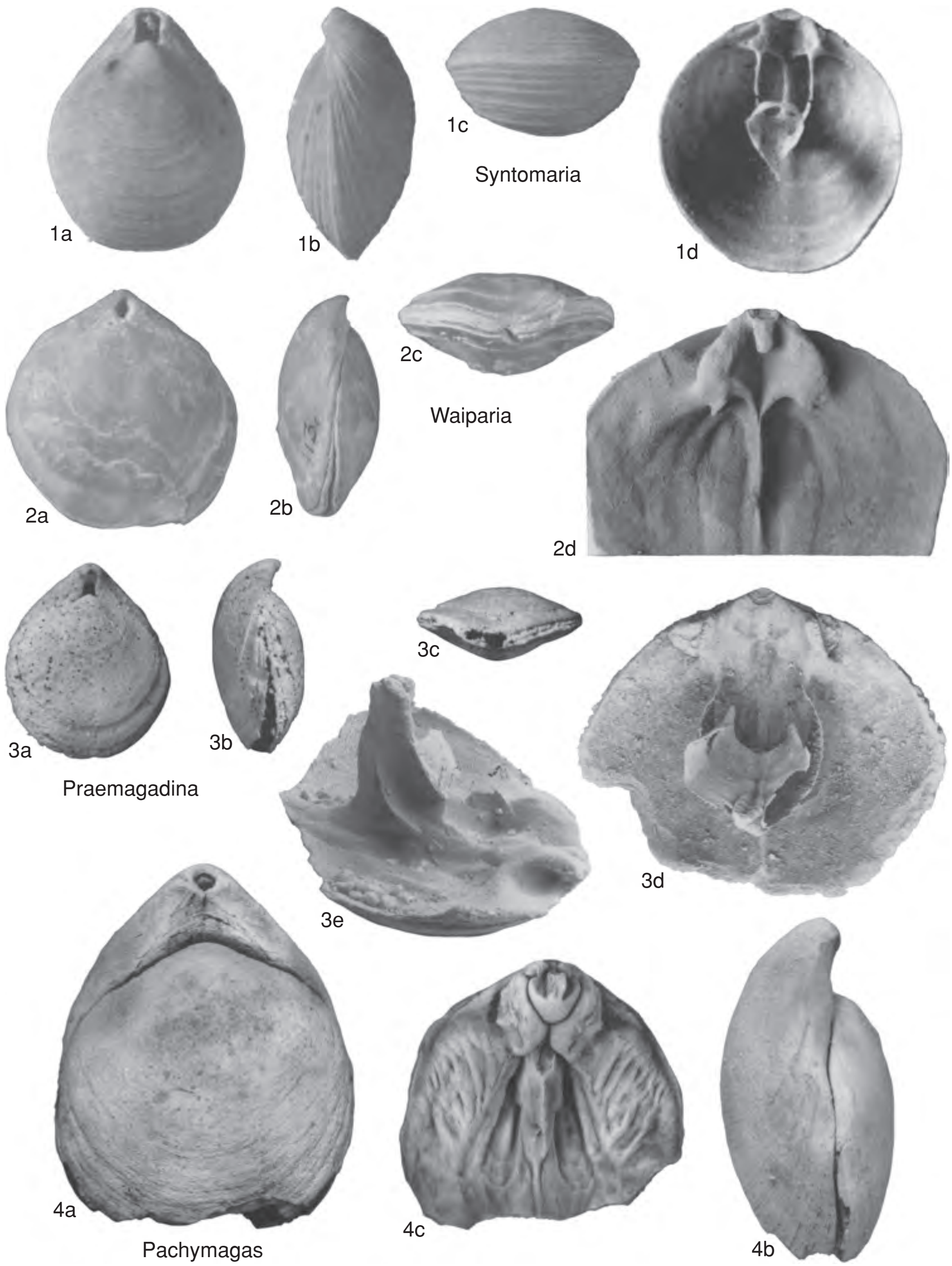

FIG. 1484. Terebratellidae (p. 2233).

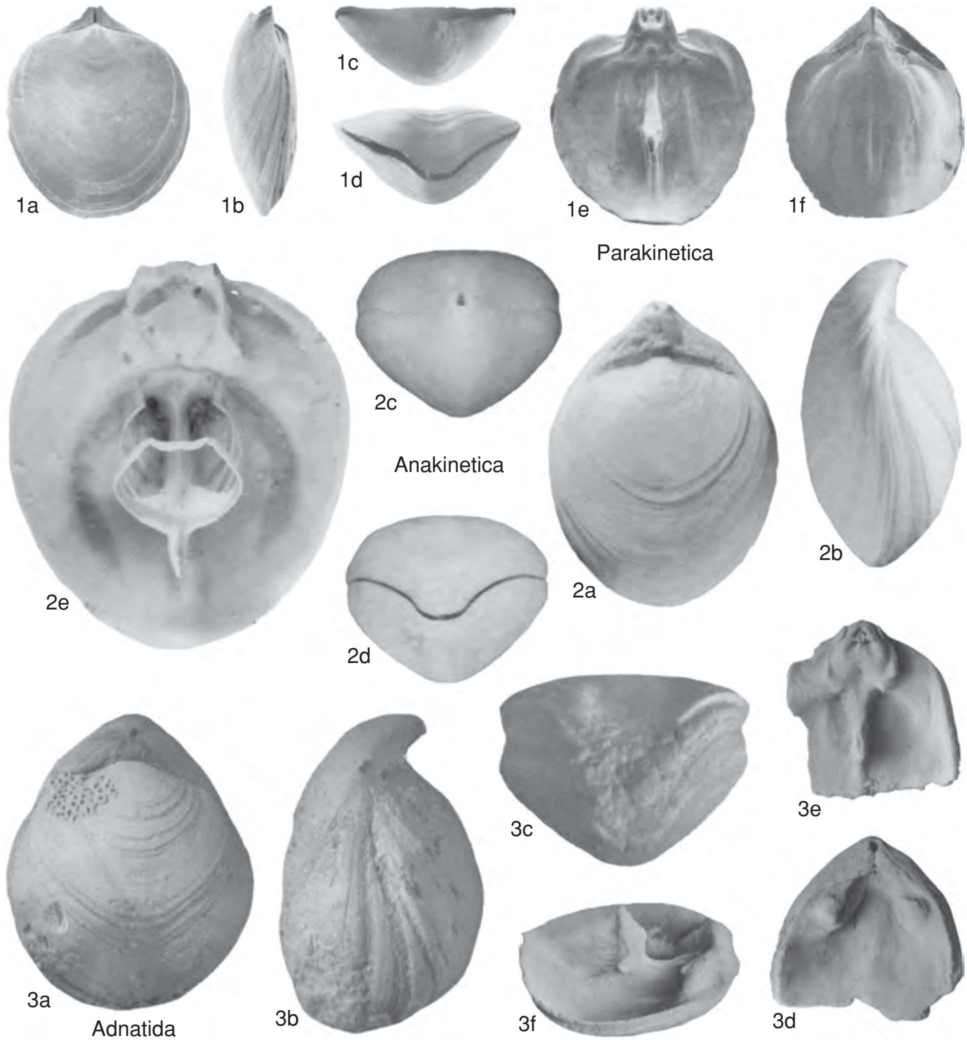

FIG. 1485. Terebratellidae (p. 2233).

Subfamily MAGELLANIINAE Beecher, 1893

[Magellaniinae BEECHER, 1893, p. 391]

Small to large, smooth to multiplicate, biconvex, with suberect to incurved beak, mesothyrid to permesothyrid foramen; symphytium well developed; cardinalia commonly lamellar with excavate inner hinge plates meeting on medium septum to form septalium; posterior shell thickening extensive in adult growth stages of some genera. Adult loop commonly teloform. *Paleogene (Eocene)–Holocene.*

Magellania BAYLE, 1880, p. 240, ***nom. nov. pro*** *Waldheimia* KING, 1850, p. 81, *non* BRULLÉ, 1846 [**Terebratula australis* QUOY & GAIMARD, 1834, p. 551; OD; =*Terebratula flavescens* LAMARCK, 1819, p.

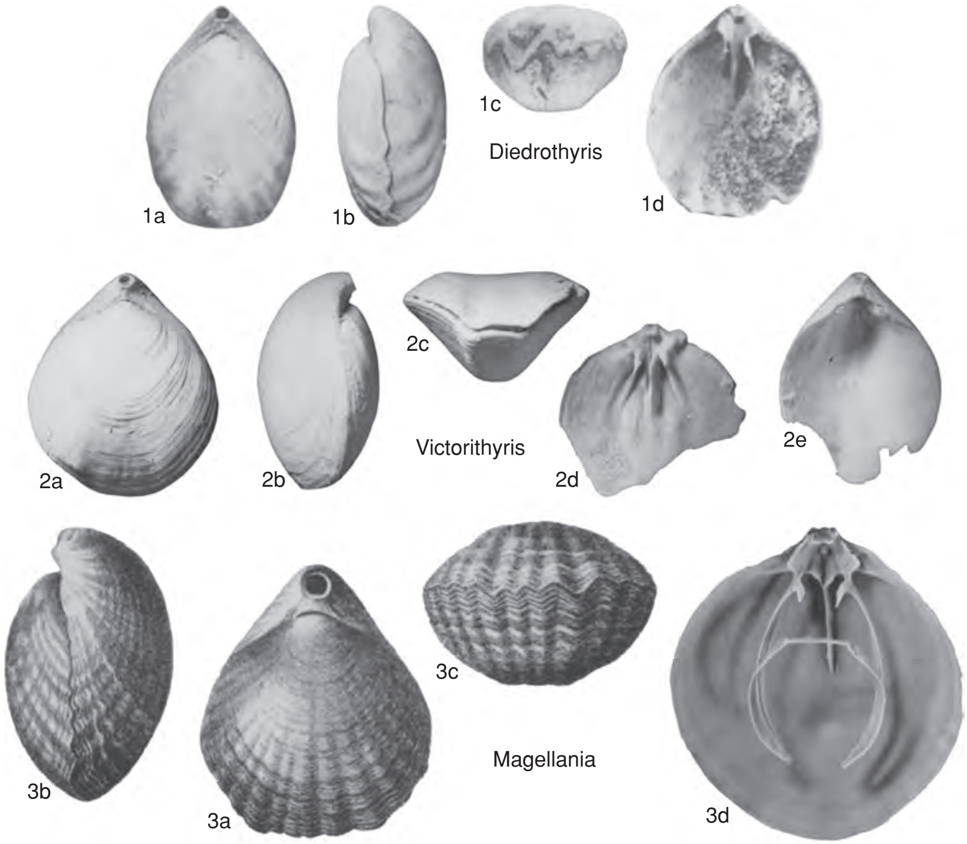

FIG. 1486. Terebratellidae (p. 2235–2236).

246]. Medium to large, ovate, smooth as juvenile, becoming costate, unisulcate; beak suberect to erect; foramen large, mesothyrid, attrite; symphytium moderately high. Cardinalia lamellar with wide inner hinge plates and narrow outer hinge plates divided by narrow crural bases, hinge plates excavate, meeting on medium septum to form septalium; cardinal process a transverse myophore; crura short, crural processes prominent; loop teloform, lophophore plectolophous. *Neogene (?Miocene), Holocene:* Australia, Antarctica, South America.——FIG. 1486,*3a–d.* **M. flavescens* (LAMARCK), Holocene, Australia; *a–c,* dorsal, lateral, and anterior views, ×1 (Davidson, 1886); *d,* dorsal valve interior, ×1.5 (new).

Diedrothyris RICHARDSON, 1980, p. 48 [**Waldheimia (?) johnstoniana* TATE, 1880, p. 151; OD]. Medium, smooth, becoming multiplicate in adult, rectimarginate to unisulcate to intraplicate; beak suberect, foramen medium in size, mesothyrid. Cardinalia with crural bases separating excavate inner and outer hinge plates; inner hinge plates moderately inclined, uniting with bladelike median septum to form septalium; cardinal process consisting of upwardly projecting subquadrate myophore; loop teloform. *Paleogene (Eocene)–Neogene (Miocene):* Australia.——FIG. 1486,*1a–d.* **D. johnstoniana* (TATE), upper Eocene, Aldinga, South Australia; *a–c,* dorsal, lateral, and anterior views, ×1.6; *d,* interior of dorsal valve, ×2 (Richardson, 1980).

Victorithyris ALLAN, 1940b, p. 289 [**V. peterboroughensis;* OD]. Medium to large, smooth to variably costate, unisulcate to intraplicate, beak suberect to erect, foramen small, mesothyrid; symphytium convex with median ridge. Cardinalia thickened, with fused socket ridges and stout crural bases; thickened inner hinge plates meeting on short, thick median septum to form septalium; loop teloform. *Paleogene (Eocene)–Neogene (Miocene):* Australia.——FIG. 1486,*2a–e.* **V. peterboroughensis,* Miocene, Victoria; *a–c,* dorsal, lateral, and anterior views; *d–e,* dorsal and ventral interiors, ×1 (new).

Subfamily STETHOTHYRIDINAE MacKinnon, 1993

[Stethothyridinae MACKINNON in MACKINNON, BEUS, & LEE, 1993, p. 342]

Smooth to marginally plicate, commonly unisulcate but may be intraplicate or paraplicate; biconvex with suberect to incurved beak, mesothyrid to permesothyrid foramen, symphytium present; inner socket ridge, outer hinge plate area wide to very wide and commonly swollen; crura originating close to median plane and diverging at acute angle from just anterior of cardinal process; dorsal median septum bladelike, merging posteriorly with very narrow, commonly parallel-sided septalium that is often obscured in adults by secondary infilling of cavities or extreme thickening of crural bases; loop teloform. *Paleogene (Eocene)–Neogene (Miocene).*

Stethothyris THOMSON, 1918a, p. 23 [**S. uttleyi;* OD]. Small to medium, subcircular to elongate-oval, smooth, biconvex, unisulcate; beak suberect; foramen small, mesothyrid; symphytium wide with superficial grooves and ridges. Pedicle cavity reduced by posterior valve thickening; hinge teeth small, strong, with swollen bases grooved to accommodate socket ridges. Cardinal process with swollen anterior lobe, and posterior myophore with lateral, upturned flanges that project beyond umbo; cardinalia swollen; extremely narrow, largely infilled septalium uniting posteromedianly with crural bases; pedicle adjustor attachment sites restricted and posteriorly located, forming prominent excavations leading to isolation of cardinal process from remainder of thickened inner socket ridge, hinge plate, crural base complex; loop teloform. *Paleogene (Eocene–Oligocene):* New Zealand.——FIG. 1487,*3a–e.* **S. uttleyi,* Eocene: *a–c,* holotype, dorsal, lateral, and anterior views, NMNZ Br1270, ×1; *d–e,* detail of ventral and dorsal valve interiors, ×4 (new).

Aliquantula RICHARDSON, 1991, p. 42 [**Waldheimia(?) insolita* TATE, 1880, p. 151; OD]. Medium, subcircular to elongate oval, smooth, biconvex, rectimarginate; beak suberect to slightly incurved, foramen very small, mesothyrid; beak ridges sharp, symphytium wide with superficial grooves and ridges. Pedicle cavity restricted by posterior shell thickening; teeth large, swollen bases grooved to accommodate socket ridges. Cardinal process small with small anterior lobe and upturned lateral margins; inner socket ridges and crural bases greatly swollen, restricting septalial trough; loop teloform. *Paleogene (Eocene–Oligocene):* Australia.——FIG. 1488,*4a–d.* **A. insolita* (TATE), Eocene, South Australia; *a–b,* dorsal and lateral views, ×1.5; *c,* detail of pedicle foramen; *d,* closeup of cardinalia, ×5 (new).

Austrothyris ALLAN, 1939, p. 238 [**Waldheimia gambierensis* ETHERIDGE, 1876, p. 19; OD; =*W. grandis* TENISON-WOODS, 1865, p. 2]. Large, elongate subpentagonal, smooth, or marginally multiplicate, with intraplicate anterior commissure; beak prominent, suberect, truncated obliquely by a large, mesothyrid, attrite foramen; beak ridges rounded; symphytium high with median ridge. Cardinalia rather slender; cardinal process upwardly projecting, consisting of subquadrate myophore with mildly swollen anterior boss; low, bladelike median septum extending to midvalve; crura long and slender; crural bases low and well differentiated from stout, steeply inclined inner socket ridges; inner hinge plates fused to crural bases, steeply inclined and meeting low on sides of median septum; inner hinge plates extremely narrow anteriorly and broadening posteriorly; loop teloform. *Paleogene (Oligocene)–Neogene (Miocene):* Australia.——FIG. 1487,*2a–e.* **A. grandis* (TENISON-WOODS); *a–c,* dorsal, lateral, and anterior views; *d,* dorsal interior, ×1; *e,* detail of cardinalia, ×2 (new).

Cudmorella ALLAN, 1939, p. 242 [**C. tatei;* OD]. Shell medium to large, smooth, biconvex, intraplicate, beak erect, foramen mesothyrid and moderately large, symphytium low, with median ridge. Hinge teeth strong, with swollen bases. Cardinalia moderately thickened; inner socket ridges and stout crural bases separated by deep groove, crura short, thick; cardinal process small, subtriangular with prominent anterior boss; median septum thick, bifurcating posteriorly to form V-shaped hinge trough; adductor scars deeply impressed on either side of septum; loop teloform. *Neogene (Miocene):* Australia.——FIG. 1488,*1a–d.* **C. tatei; a–c,* dorsal, lateral, and anterior views, ×0.5; *d,* dorsal interior, ×1 (new).

Elderra RICHARDSON, 1991, p. 38 [**E. toorlooensis;* OD]. Medium, ovate, smooth, biconvex, unisulcate, beak suberect, beak ridges sharp; symphytium with median ridge. Cardinal process with small, transverse myophore and slight median swelling; small, earlike projections adjacent to myophore; crural bases and inner socket ridges thickened and swollen but not uniting medianly; loop teloform. *Neogene (Miocene):* Australia.——FIG. 1488,*2a–d.* **E. toorlooensis,* Victoria; *a–c,* dorsal, lateral, and anterior views, ×1.5; *d,* dorsal interior, ×3.5 (new).

Epacrothyris HILLER & MACKINNON, 2000, p. 68 [**Waldheimia pectoralis* TATE, 1880, p. 157; OD]. Large, smooth, strongly biconvex, elongate oval to subpentagonal, unisulcate to intraplicate; beak narrow, erect to incurved; foramen small, mesothyrid to permesothyrid; beak ridges moderately developed, symphytium flat to concave. Inner socket ridges, outer hinge plates, and crural bases well developed and fused; cardinal process large, cuplike; median septum high, uniting posteriorly with very

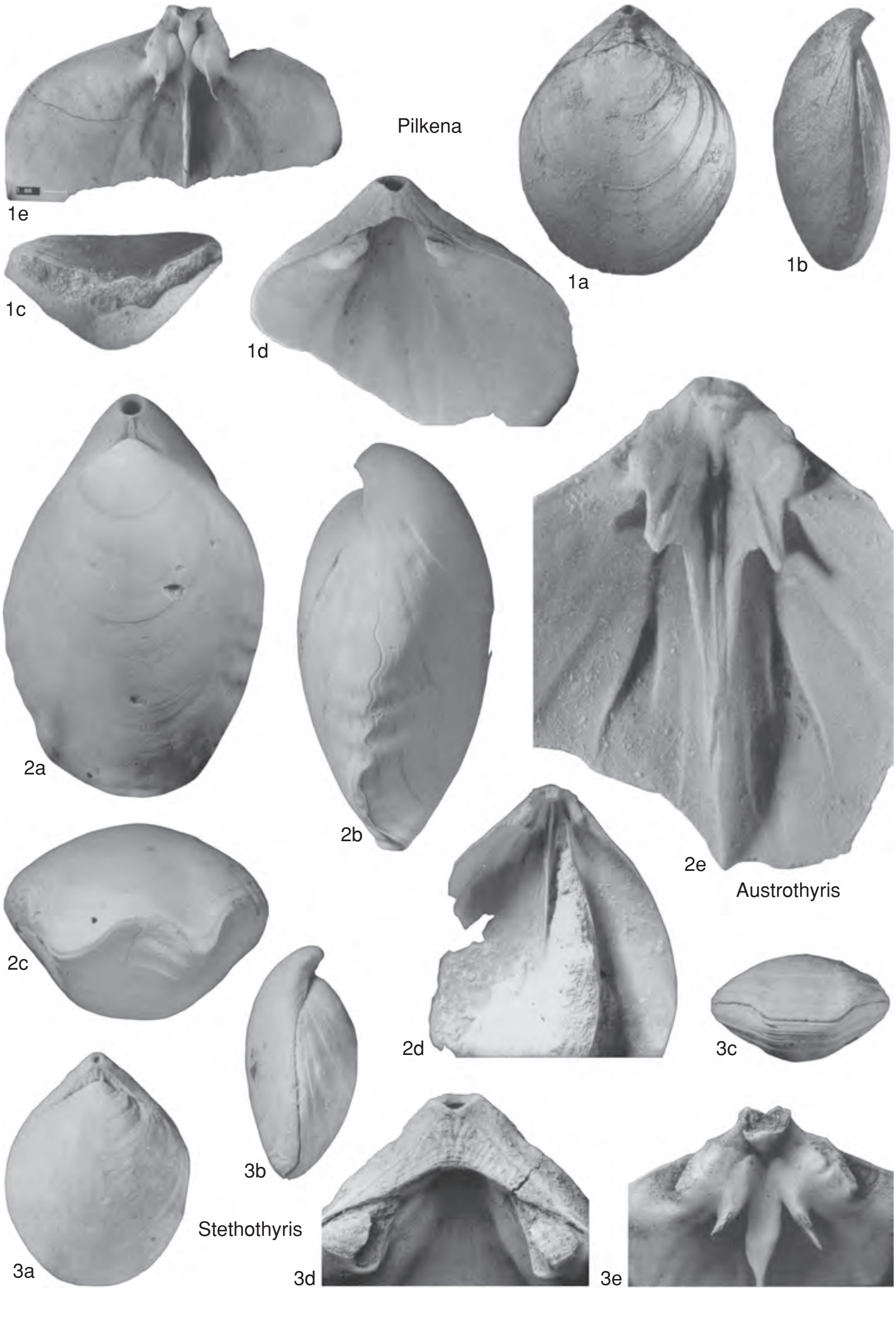

FIG. 1487. Terebratellidae (p. 2237–2240).

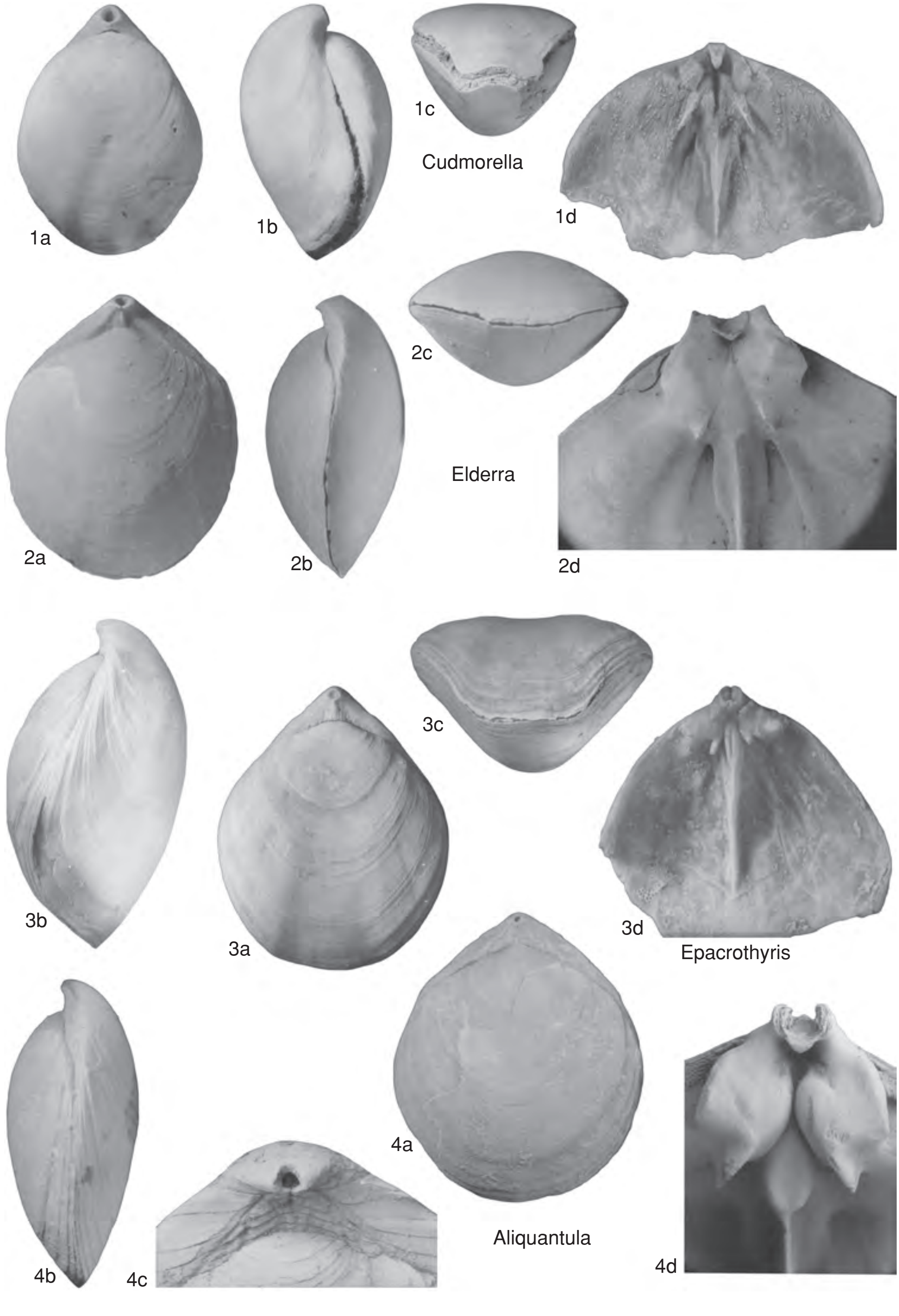

FIG. 1488. Terebratellidae (p. 2237–2240).

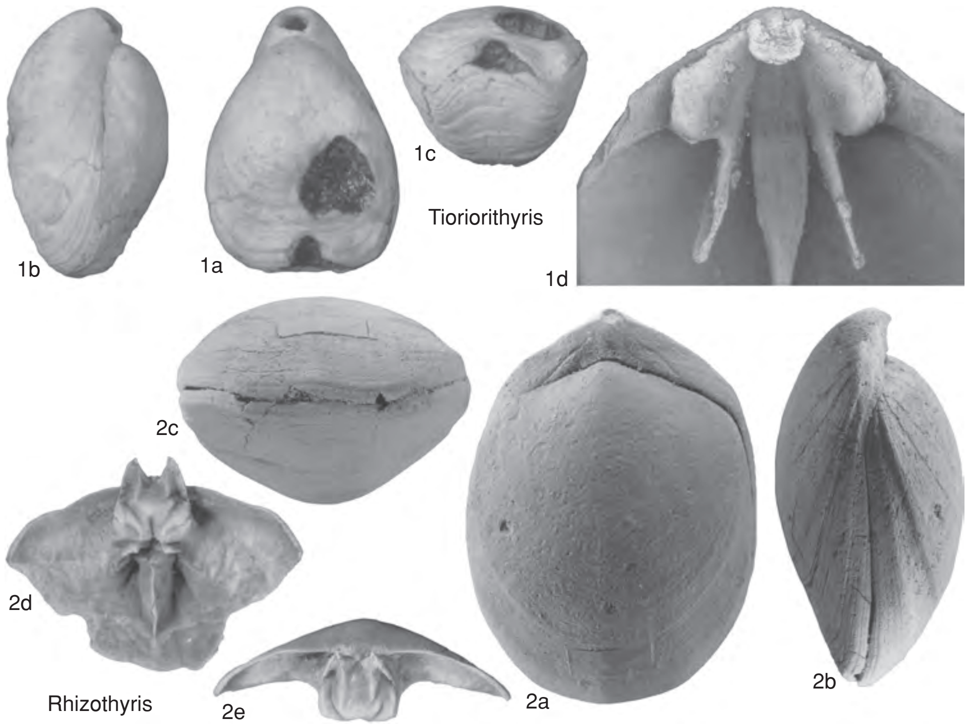

FIG. 1489. Terebratellidae (p. 2240).

narrow septalium; loop teloform. *Paleogene (Eocene)–Neogene (Miocene):* Australia; New Zealand, *Eocene–Oligocene.*——FIG. 1488,*3a–d.* **E. pectoralis* (TATE); *a–c,* dorsal, lateral, and anterior views, ×1; *d,* dorsal interior, loop not preserved, ×2 (new).

Pilkena RICHARDSON, 1991, p. 42 [**P. compressa;* OD]. Smooth, medium, ovate, unisulcate, beak suberect, beak ridges sharp, ventral valve carinate; symphytium with low median ridge. Cardinal process consisting of transverse myophore with prominent anterior swelling that may occupy entire hinge trough; crural bases swollen; median septum short, thick, with bladelike ventral edge; loop teloform. *Paleogene (Oligocene):* Australia.——FIG. 1487,*1a–e.* **P. compressa,* Victoria; *a–c,* dorsal, lateral, and anterior views, ×1.5 (Richardson, 1991); *d–e,* ventral and dorsal interior, ×3 (new).

Rhizothyris THOMSON, 1915a, p. 399 [**Bouchardia rhizoida* HUTTON, 1905, p. 480; OD]. Medium to large, biconvex, rectimarginate to unisulcate, elongate-oval, smooth; beak suberect; foramen small to medium, permesothyrid; symphytium wide, often with median ridge. Hinge teeth strong, pedicle cavity restricted by posterior shell thickening. Cardinalia very swollen and fused to form a massive hinge platform; distinctive cardinal process bearing two earlike, posterior projections, each bearing a deep, dorsal, pedicle, adjustor muscle pit; posterior bifurcation of median septum forming very narrow septalium commonly obscured by shell thickening; loop teloform. *Paleogene (Oligocene)–Neogene (Miocene):* New Zealand.——FIG. 1489,*2a–c.* **R. rhizoida* (HUTTON), Miocene; dorsal, lateral, and anterior views, ×1 (Bowen & Campbell, 1973).——FIG. 1489,*2d–e. R. labiata* ALLAN; normal and posterior views of dorsal interiors, ×1 (new).

Tioriorithyris HILLER & MACKINNON, 2000, p. 74 [**Campages chathamensis* ALLAN, 1932b, p. 14; OD]. Small to medium, subtriangular to subpentagonal, smooth, biconvex, parasulcate; beak suberect, attrite; foramen large, mesothyrid; symphytium low, gently convex; beak ridges not developed. Crural bases prominent, diverging from immediately anterior of linguiform, elevated cardinal process, and enclosing a narrow, elongate, nearly flat septalium; loop teloform. *Paleogene (Paleocene–Eocene):* New Zealand (Chatham Islands).——FIG. 1489,*1a–d.* **T. chathamensis* (ALLAN); *a–c,* holotype, dorsal, lateral, and anterior views, UCM 1436, ×2; *d,* detail of dorsal interior, ×5 (Hiller & MacKinnon, 2000).

Subfamily UNCERTAIN

Chathamithyris ALLAN, 1932b, p. 15 [**C. traversi;* OD]. Small, smooth, elongate oval, strongly biconvex, rectimarginate to gently unisulcate, beak

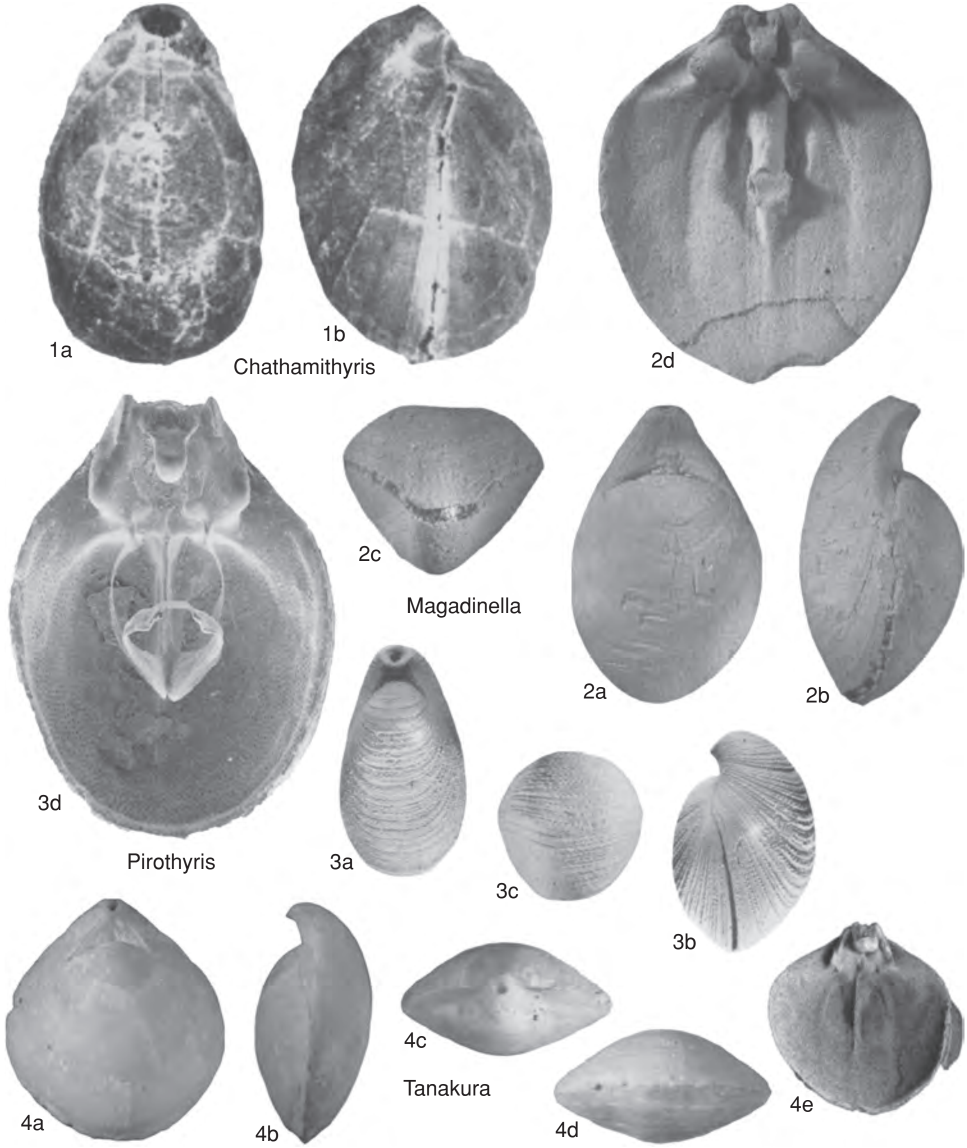

FIG. 1490. Terebratellidae (p. 2240–2242).

suberect, foramen large, mesothyrid, symphytium low. Cardinalia lamellar, septalium with gently inclined, equidimensional, inner and outer hinge plates separated by indistinct crural bases; cardinal process with ovate myophore, crura short; loop teloform. *Paleogene (Paleocene):* New Zealand (Chatham Islands).——FIG. 1490,*1a–b.* **C. traversi;* holotype, dorsal and lateral views, UCM 1439, ×4.6 (Muir-Wood, 1965a).

Magadinella THOMSON, 1915a, p. 400 [**Magasella woodsiana* TATE, 1880, p. 163; OD]. Medium, smooth, pyriform to ovate, unisulcate; beak erect to nearly straight; symphytium wide. Strong posterior shell thickening; cardinalia strongly developed with anterior parts of outer hinge plates massively swollen; cardinal process with swollen anterior boss; dorsal pedicle adjustor muscle attachment sites forming restricted hinge trough, deeply impressed adjacent to cardinal process; loop haptoid to teloform. *Paleogene (Oligocene)–Holocene:* Australia.——FIG. 1490,*2a–d.* **M. woodsiana* (TATE), Oligocene–Miocene; *a–c,* dorsal, lateral, and anterior views, ×2; *d,* dorsal interior, ×3 (Richardson, 1991).

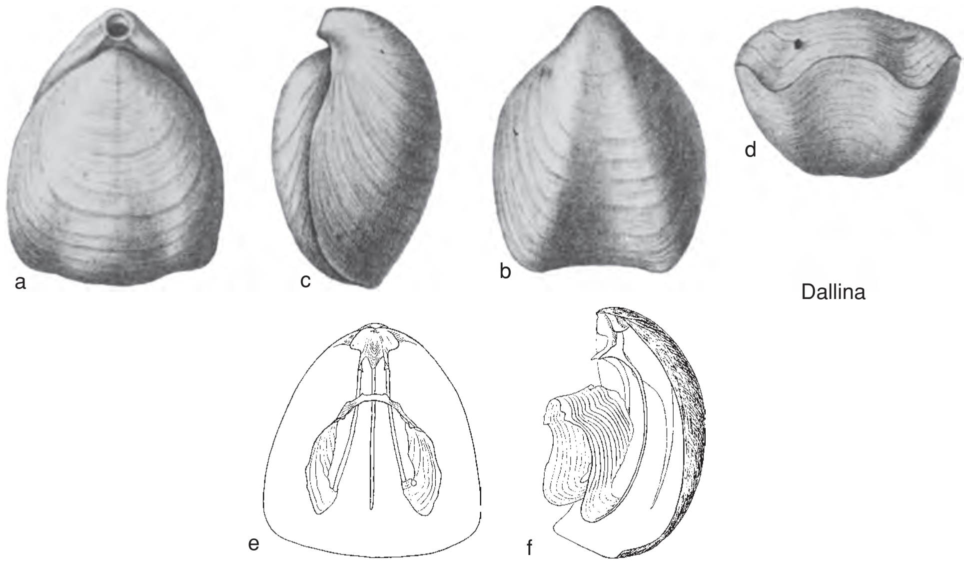

FIG. 1491. Dallinidae (p. 2242–2243).

Pirothyris THOMSON, 1927, p. 280 [**Magasella vercoi* BLOCHMANN, 1910, p. 91; OD]. Small, smooth, elongate oval, strongly biconvex, rectimarginate to slightly parasulcate, beak suberect, symphytium present. Cardinalia thickened, inner socket ridges massive; cardinal process with ovate myophore and prominent anterior boss occupying about half of hinge trough, crura short; loop haptoid. *Holocene:* Australia.——FIG. 1490,*3a–d*. **P. vercoi* (BLOCHMANN); *a–c,* dorsal, lateral, and anterior views of exterior, ×4; *d,* dorsal interior, ×10 (Richardson, 1987).

Tanakura HATAI, 1936, p. 322 [**Magasella fibula* HAYASAKA, 1921, p. 1; OD; *non* REEVE, 1861, p. 180; =*Tanakura tanakura* HATAI, 1936, p. 322]. Small to medium, smooth, subovate, rectimarginate; beak high, suberect; foramen small, permesothyrid to almost epithyrid; symphytium wide and concave with prominent median groove. Hinge teeth strong, bases swollen and grooved for reception of socket ridges; ventral muscle scars elongate and deeply impressed. Cardinalia with strong shell thickening; cardinal process a transverse myophore with massive, anterior, boss filling and dorsally fused to hinge trough; median septum bladelike, thickened posteriorly and extending anteriorly to about midvalve. Loop probably teloform. *Neogene (Miocene):* Japan.——FIG. 1490,*4a–e*. **T. tanakura* (HATAI); *a–d,* dorsal, lateral, posterior, and anterior views, ×2; *e,* dorsal valve interior, ×2 (new).

Family DALLINIDAE Beecher, 1893

[*nom. transl.* ALLAN, 1940a, p. 270, *ex* Dallininae BEECHER, 1893, p. 391]

Small to large, biconvex, smooth, rectimarginate, unisulcate, or intraplicate; beak attrite, foramen mesothyrid, symphytium generally present; adult loop commonly diploform, but occasionally trabecular, bilateral, or teloform. [Examination of early growth stages of *Dallina septigera* (LOVÉN), the type species of the nominate genus, confirms that dental plates are absent in juvenile as well as adult stages of that species. Taxa bearing dental plates previously assigned to the superfamily Dallinoidea are now assigned to the superfamilies Kingenoidea or Laqueoidea as defined herein.] *Paleogene (Oligocene)–Holocene.*

Subfamily DALLININAE Beecher, 1893

[Dallininae BEECHER, 1893, p. 391]

Adult loop teloform. *Neogene (Miocene)–Holocene.*

Dallina BEECHER, 1893, p. 382 [**Terebratula septigera* LOVÉN, 1846, p. 29; OD]. Small to large, triangular to subquadrangular in outline; rectimarginate to paraplicate; beak erect, without beak ridges; foramen small to large, mesothyrid, attrite, symphytium concave. Hinge teeth small, weak; pedicle collar very short. Cardinalia lamellar with excavate inner and outer hinge plates separated by narrow crural bases; inner hinge plates converging on median septum to form V-shaped septalium; cardinal process not differentiated; median septum low anteriorly, extending beyond midvalve; adult

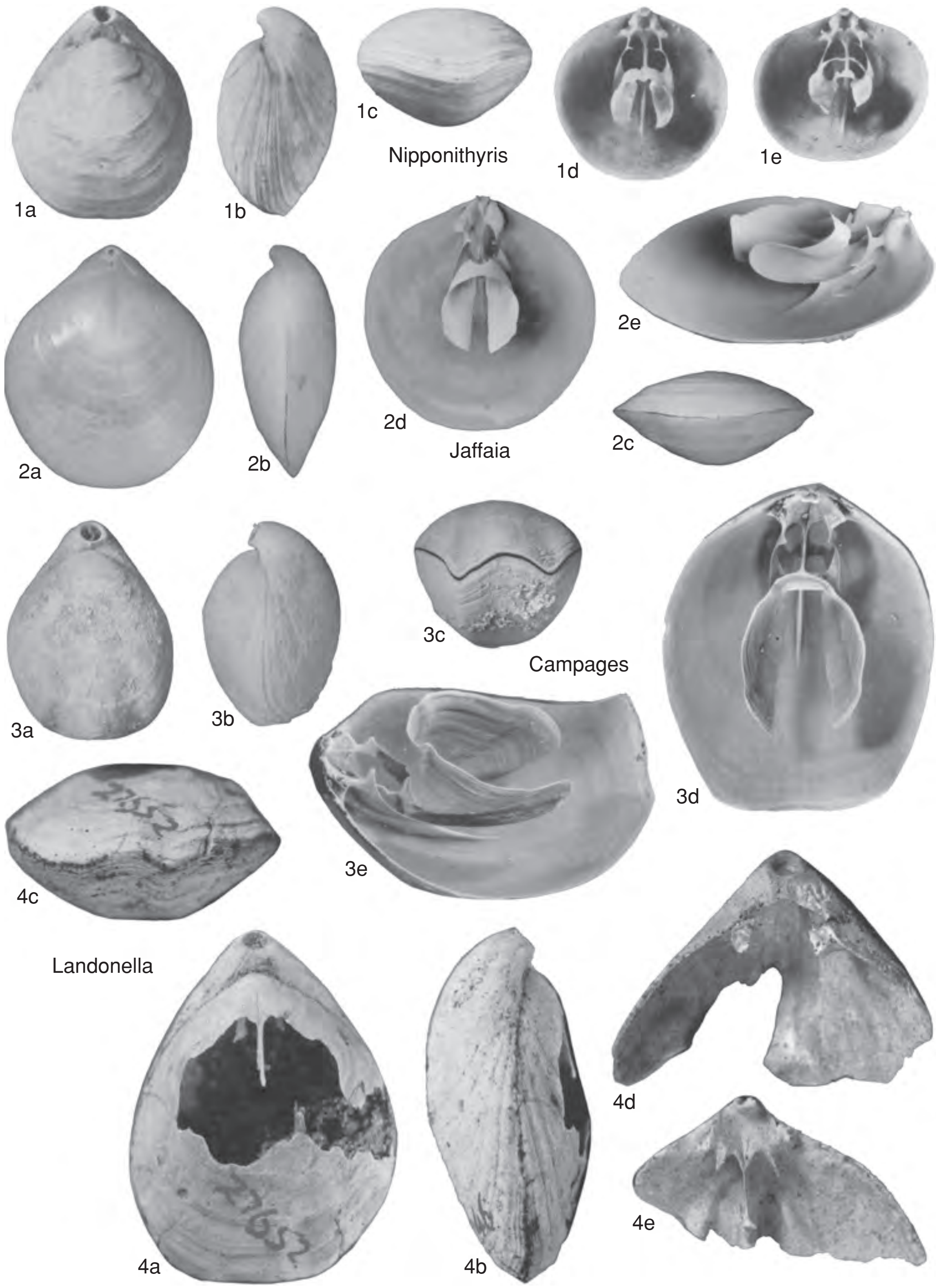

FIG. 1492. Dallinidae (p. 2244).

loop teloform. *Neogene (Miocene)–Holocene:* Italy, Japan, *Miocene–Pliocene;* Italy, Japan, Norway, *Pleistocene;* Atlantic Ocean (40–2,338 m), Pacific Ocean (23–402 m), Pacific-Antarctic Ridge (915–1,153 m), *Holocene.*——FIG. 1491*a–f.* **D. septigera* (LOVÉN), Holocene, North Atlantic; *a–d,* dorsal, ventral, lateral, and anterior views, ×1 (Muir-Wood, 1965a); *e–f,* ventral and oblique lateral views of dorsal interior showing loop, ×1 (Atkins, 1960b).

Subfamily NIPPONITHYRIDINAE Hatai, 1938

[*nom. correct.* HATAI, 1965b, p. 842, *pro* Nipponithyrinae HATAI, 1938, p. 110]

Adult loop commonly diploform, rarely bilateral or trabecular. *Paleogene (Oligocene)–Holocene.*

Nipponithyris YABE & HATAI, 1934, p. 588 [**N. nipponensis;* OD] [=*Miyakothyris* HATAI, 1938, p. 237 (type, *Nipponithyris subovata* HATAI, 1936, p. 321, OD); *Isumithyris* HATAI, 1948, p. 498 (type, *I. kazusaensis,* OD); *Dicrosia* COOPER, 1978, p. 12 (type, *Abyssothyris fijiensis* ELLIOTT, 1960a, p. 526, OD)]. Small to medium, rounded pentagonal, rectimarginate to strongly unisulcate, beak erect to suberect, foramen small, mesothyrid, deltidial plates conjunct, both valves thickened posteriorly. Hinge teeth stout, ventral muscle scars deeply impressed, partly lodged in narrow delthyrial cavity. Cardinal process small, semielliptical to triangular, confined to apex; inner socket ridges strong, sockets deep; inner hinge plates forming a V-shaped trough, median septum extending anteriorly as low ridge well past midvalve; loop diploform to trabecular. *Neogene (Miocene)–Holocene:* Japan, Pacific Ocean, Indian Ocean.——FIG. 1492,*1a–e.* **N. nipponensis,* Holocene, Japan; *a–c,* dorsal, lateral, and anterior views, ×2; *d–e,* ventral and anterior oblique views of dorsal interior, ×2 (Cooper, 1973a).

Campages HEDLEY, 1905, p. 43 [**C. furcifera;* OD] [=*Japanithyris* THOMSON, 1927, p. 251 (type, *Terebratella mariae* ADAMS, 1860, p. 412)]. Small to medium, subtriangular in outline; rectimarginate to intraplicate, beak short, suberect to erect; foramen large, mesothyrid, symphytium narrow, beak ridges not developed. Hinge teeth small, weak, pedicle collar very short. Lamellar inner hinge plates fused to median septum to form septalium, crural bases and outer hinge plates well developed; cardinal process spoon shaped, roughened, myophore facing posteriorly; adult loop diploform to trabecular. *Neogene (Miocene)–Holocene:* Japan; off eastern Australia, western Pacific (140–1,400 m), Indian Ocean, *Holocene.*——FIG. 1492,*3a–e.* **C. furcifera,* Holocene, Moreton Bay, Australia; *a–c,* dorsal, lateral, and anterior views, ×1; *d–e,* ventral and lateral oblique views of dorsal interior, ×2 (new).

Jaffaia THOMSON, 1927, p. 254 [**Magasella jaffaensis* BLOCHMANN, 1910, p. 92; OD]. Small to medium; subcircular, biconvex, weakly unisulcate, beak suberect, foramen small, mesothyrid, deltidial plates conjunct but resembling symphytium, beak ridges present. Hinge teeth strong, grooved; pedicle cavity partially restricted by shell thickening. Cardinalia moderately thickened, crural bases and socket ridges united; cardinal process a transverse myophore with small, triangular, anterior boss; hinge plates uniting to form septalium supported on median septum; crura and crural processes short; loop diploform. *Holocene:* Australia.——FIG. 1492,*2a–e.* **J. jaffaensis* (BLOCHMANN); *a–c,* dorsal, lateral, and anterior views, ×2; *d–e,* normal and oblique views of dorsal valve interior, ×3 (new).

Landonella MACKINNON in MACKINNON, BEUS, & LEE, 1993, p. 337 [**L. laqueiformis;* OD]. Medium, ovate to subpentagonal, rectimarginate to intraplicate; beak suberect, attrite; foramen medium to large, mesothyrid; symphytium convex with median ridge. Hinge teeth small; cardinal process prominent; broad, excavate hinge plates fused to high, bladelike median septum; adult loop bilateral, ascending lamellae and transverse band broad, laterovertical connecting band slender. *Paleogene (Oligocene):* New Zealand.——FIG. 1492,*4a–e.* **L. laqueiformis; a–c,* holotype, dorsal, lateral, and anterior views, UCM RSA27652; *d,* ventral interior; *e,* oblique view of cardinalia, ×2 (new).

KRAUSSINOIDEA

D. E. Lee and D. I. MacKinnon

[University of Otago; and University of Canterbury]

Superfamily KRAUSSINOIDEA Dall, 1870

[*nom. transl.* Lee & MacKinnon, herein, *ex* Kraussininae Dall, 1870, p. 137]

Adult shells small to medium size; commonly biconvex, may be planoconvex; commonly costate; anterior commissure rectimarginate or unisulcate; beak strongly attrite; foramen usually large, deltidial plates disjunct. Pedicle collar short, sessile; dental plates absent; ventral and dorsal valve interior commonly tuberculate. Cardinal process small, inconspicuous; inner socket ridges prominent and widely divergent; with or without undifferentiated hinge plates; crura and descending lamellae present or absent; septal flanges expanding greatly during ontogeny to form strongly bifurcate septal pillar with or without slender distal extensions that may or may not unite to form a ring; lophophore zygolophous or plectolophous; mantle moderately to strongly spiculate. *Neogene (Miocene)–Holocene.*

Family KRAUSSINIDAE Dall, 1870

[*nom. transl.* Allan, 1940a, p. 269, *ex* Kraussininae Dall, 1870, p. 137] [=Mühlfeldtiinae Oehlert, 1887b, p. 1,314]

Diagnosis as for superfamily. *Neogene (Miocene)–Holocene.*

Kraussina Davidson in Suess, 1859, p. 210, *nom. nov. pro Kraussia* Davidson, 1852d, p. 369, *non* Dana, 1852 [**Anomia rubra* Pallas, 1776, p. 182; SD Davidson, 1853, p. 69]. Small to medium size, transversely oval in outline; ventribiconvex; anterior commissure rectimarginate to unisulcate; multicostate or rarely smooth; hinge line broad, nearly straight; beak strongly attrite. Cardinal process low, short, wide; socket ridges widely divergent, enclosing a pair of large, thickened, dorsal pedicle adjustor scars; crura and descending lamellae not developed; adult brachidium consisting of bifurcate septal pillar from distal tips of which may extend slender, curved, ventromedially directed processes; spicules very small. *Neogene (Pliocene)–Holocene:* South Africa (Namaqualand), *Pliocene–Pleistocene;* Indian Ocean (off southern Africa, 20–300 m), *Holocene.*——Fig. 1493,*1a–h*. * *K. rubra* (Pallas), Holocene, off southern Africa; *a–e,* dorsal, ventral, lateral, posterior, and anterior views, ×1; *f–h,* posterior, ventral, and anterior views of dorsal valve interior, ×1 (Cooper, 1973b).

Megerlia King, 1850, p. 145 [**Anomia truncata* Linnaeus, 1767, p. 1,152; OD; not preoccupied by *Megerlea* Robineau-Desvoidy, 1830] [=*Mühlfeldtia* Bayle, 1880, p. 240, obj.; *Pantellaria* Dall, 1919, p. 251 (type, *Terebratula monstruosa* Scacchi, 1836, p. 8)]. Medium size, usually wider than long, biconvex to concavoconvex; anterior commissure unisulcate; capillate, striae slightly nodulose; foramen large, submesothyrid to amphithyrid; beak suberect, subtruncate, usually abraded; deltidial plates disjunct. Valve interiors radially tuberculate; ventral valve with small median septum extending under but not supporting pedicle collar. No cardinal process; crural bases attached to inner sides of widely divergent socket ridges that are excavate below; loop bifurcate with distal extensions forming complete ring, descending branches extending from cardinalia to ring; lophophore plectolophous; spicules common in mantle and arms. *Neogene (Miocene)–Holocene:* Italy, France, *Miocene–Pliocene;* Gibraltar, Algeria, *Pliocene–Holocene;* Mediterranean, eastern Atlantic, including Ivory Coast (12–1,430 m), off South Africa, Australia (New South Wales), Barbados, Florida Straits, Venezuela, *Holocene.*——Fig. 1493,*2a–g*. **M. truncata* (Linnaeus), Holocene, Marseille, Mediterranean; *a–e,* dorsal, ventral, lateral, posterior, and anterior views, ×1; *f,* interior of dorsal valve; *g,* interior of ventral valve, ×1.2 (Logan, 1979).

Megerlina Eudes-Deslongchamps, 1884, p. 243 [**Kraussia lamarckiana* Davidson, 1852c, p. 80; OD]. Small, subpentagonal in outline, ventribiconvex; anterior commissure unisulcate, finely costellate; beak suberect, attrite; foramen submesothyrid, deltidial plates disjunct; valve interiors radially tuberculate. Pedicle collar anteriorly excavate. Cardinal process weak, acutely triangular; inner socket ridges defining deep sockets and enclosing a pair of prominent, nonexcavate, pedicle adjustor scars; crura not developed, descending lamellae extending posteriorly as curved flanges from lateral flanks of bifurcate septal pillar but not reaching cardinalia; septal pillar tapers posteriorly as low, thick median septum; spicules stouter than in *Kraussina. Neogene–Holocene:* Tasmania, *Neogene;* Australia (New South Wales), South Africa (40–90 m), *Holocene.*——Fig. 1493,*3a–f*. **M. lamarckiana* (Davidson), Holocene, South Australia; *a–c,* dorsal, lateral, and anterior views, ×5, *d,* interior of ventral

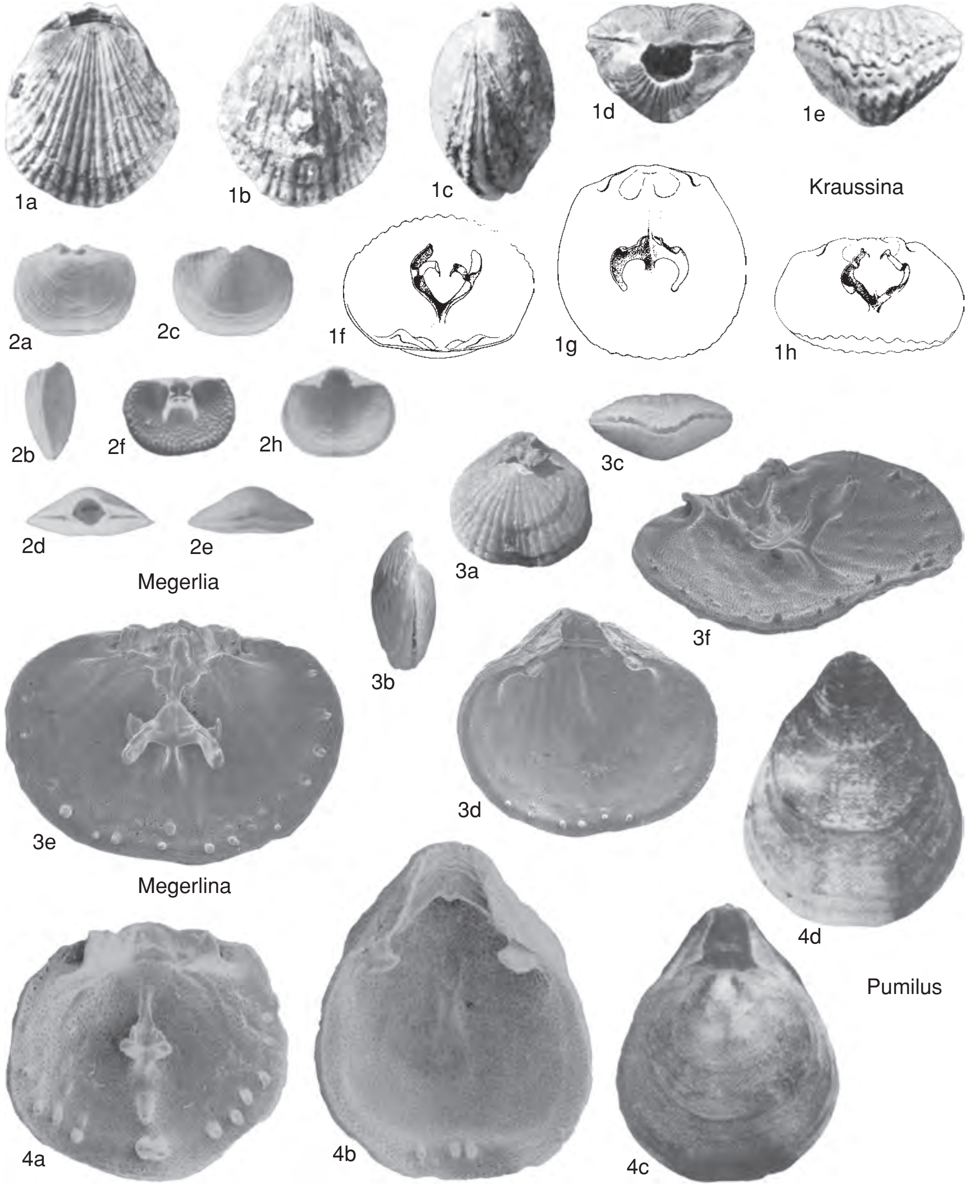

FIG. 1493. Kraussinidae (p. 2245–2246).

valve, ×6; *e,* interior of dorsal valve; *f,* oblique view of dorsal valve interior, ×6 (new).

Pumilus ATKINS, 1958, p. 560 [**P. antiquatus;* OD]. Small, subpentagonal to oval in outline; smooth, anterior commissure unisulcate; beak suberect, attrite; foramen hypothyrid, deltidial plates narrow, disjunct. Pedicle collar well developed, excavate anteriorly. Dorsal diductor attachment a low, narrow, posteromedian strip; crura and descending lamellae not developed; adult brachidium consisting of bifurcate septal pillar from distal tips of which may extend slender, curved, pointed, ventromedially directed processes. Submarginal rim of dorsal valve prominently tuberculate, ventral valve less so; spicules present, adult lophophore schizolophous. *Holocene:* New Zealand.——FIG. 1493,*4a–d.* **P. antiquatus; a–b,* dorsal and ventral valve interiors, ×13 (new); *c–d,* dorsal and ventral views of exterior, ×9 (Atkins, 1958).

UNCERTAIN

D. I. MacKinnon

[University of Canterbury]

Suborder UNCERTAIN
Superfamily GWYNIOIDEA new superfamily

[Gwynioidea MacKinnon, herein] [type genus, *Gwynia* King, 1859, p. 258]

Shell smooth, minute, subcircular to subquadrate, mildly strophic, plano- to biconvex, rectimarginate, foramen large, amphithyrid, dorsal umbo larger than ventral. Teeth peglike; dental plates absent; pedicle collar weakly developed. Dental sockets strong, with well-developed inner and outer socket ridges. Trocholophous or schizolophous lophophore supported by a pair of symmetrically disposed, bladelike, arcuate, submarginal ridges fused to valve floor. *Middle Jurassic–Holocene.*

Gwynia King, 1859, p. 258 [**Terebratula capsula* Jeffreys, 1859, p. 43; OD]. Biconvex, notothyrium triangular, wider and larger than delthyrium. Ventral interarea narrow, triangular, apsacline; delthyrium bounded by 2 small, oval teeth. Dorsal valve interior with a pair of well-developed, arcuate, submarginal ridges extending from stout inner socket ridges; dorsal interarea anacline; cardinal process not differentiated. *Pleistocene–Holocene:* Norway, *Pleistocene (postglacial);* eastern Atlantic, Adriatic (Croatia), *Holocene.*——Fig. 1494,*1a–f.* **G. capsula* (Jeffreys), Holocene, United Kingdom; *a–d,* ventral, dorsal, posterior, and lateral views, ×50; *e–f,* ventral and dorsal interiors, ×55 (Logan, MacKinnon, & Phorson, 1997).

Zellania Moore, 1855, p. 111 [**Z. davidsoni;* OD]. Adult shells shield shaped in outline; juveniles biconvex, adults more planoconvex with convexity retained in ventral valve. Probable schizolophous lophophore supported by a pair of well-developed, arcuate submarginal ridges and a hollow median septum. Ventral valve interior with ancillary median septum and ancillary lateral ridges. *Middle Jurassic:* United Kingdom.——Fig. 1494,*2a–f.* **Z. davidsoni; a–d,* dorsal, lateral, anterior, and posterior views, ×30 (Baker, 1970b); *e–f,* sketches of dorsal and ventral interiors, approximately ×40 (adapted from Baker, 1970b).

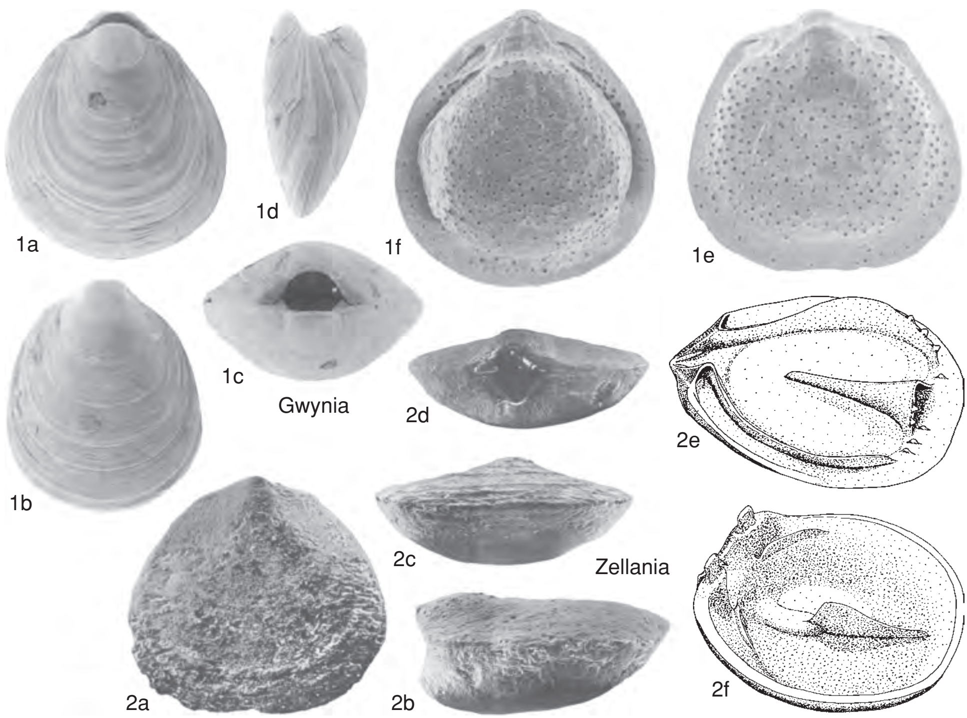

Fig. 1494. Uncertain (p. 2247).

UNCERTAIN

JIN YU-GAN and D. E. LEE

[Nanjing Institute of Geology and Palaeontology; and University of Otago]

Superfamily UNCERTAIN
Family OBOLORUGIDAE Zhang, 1983

[Obolorugidae ZHANG in ZHANG, FU, & DING, 1983, p. 425]

Punctate; small, elongate oval to circular, ventribiconvex, apical foramen, ornament of concentric wrinkles, dorsal hinge plate with posterior foramen; thin short dental lamellae; simple short loop. *Middle Devonian (Givetian).*

Obolorugia ZHANG in ZHANG, FU, & DING, 1983, p. 425 [**O. lixianensis;* OD]. Beak acutely elongated with apical foramen; rectimarginate; loop extending to midlength of dorsal valve. *Middle Devonian (Givetian):* China (southern Gansu).——FIG. 1495*a–l.* **O. lixianensis; a–d,* dorsal, ventral, lateral, and anterior views of holotype; *e–l,* transverse serial sections, ×3 (Zhang, Fu, & Ding, 1983).

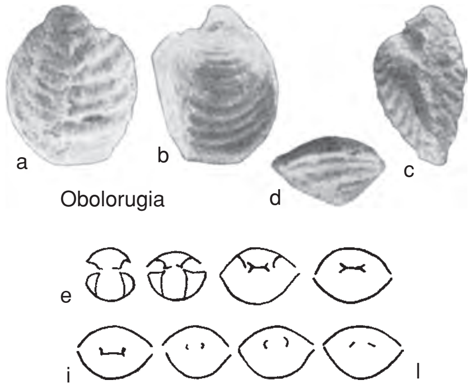

FIG. 1495. Obolorugidae (p. 2248).

UNCERTAIN

P. G. Baker

[University of Derby]

Superfamily and Family UNCERTAIN

Parasulcatinella Xu & Liu, 1983b, p. 96 (Xu & Liu, 1980, p. 37, *nom. nud.*) [**P. obesus;* OD]. Small, rounded rhomboidal in outline, unequally biconvex, ventral valve strongly convex, bow shaped with sides steeply sloping, fold extending from beak to anterior margin, dorsal valve weakly convex with wide, shallow sulcus appearing posteriorly with small plication at anterior margin, anterior commissure plicosulcate, beak sharp, incurved, beak ridges angular, delimiting well-developed palintrope, delthyrium narrow, without deltidial plates; pedicle collar absent, dental plates thin, straight, ventrally divergent; cardinal process absent, hinge plates not demarcated from well-developed, inner socket ridges, septalium broadly V-shaped, median septum low, thick, very short, crural plates divergent on floor of valve anteriorly, loop short with wide, ascending lamellae. [This genus is probably dielasmatoid, similar to *Sulcatinella.*] *Middle Triassic:* China (Qilian Province, Junzihe Formation).——Fig. 1496,*1a–m.* **P. obesus,* southern Qilian Mountains, Qingai; *a–d,* dorsal, lateral, anterior, ventral views, ×1 (Xu & Liu, 1983b); *e–m,* serial transverse sections, 0.5, 0.7, 0.9, 1.0, 1.4, 1.9, 2.3, 2.5, 2.7 mm from umbo, ×1.25 (adapted from Xu & Liu, 1983b).

Triseptothyris Xu, 1978, p. 314 [**T. yanjinensis;* OD]. Small, semioval to elliptical in outline, biconvex, smooth, anterior commissure rectimarginate, umbo erect, beak ridges subangular, clearly delimiting palintrope, foramen moderate, oval, permesothyrid; pedicle collar present, dental plates slender, short, straight, ventrally divergent; cardinal process absent, inner socket ridges deflected dorsally, demarcated from outer hinge plates, crural bases given off possibly ventrally, septalium wide, open U-shape, moderately deep, supported by low, thick, bladelike median septum and two lateral septa, length of median septum and form of loop unknown. [The cardinalia of this genus is vaguely zeilleriid but unusual supporting structure for septalium and lack of knowledge of loop preclude assignment to suprageneric taxon.] *Middle Triassic:* southwestern China (Liekoupo Formation, Yunnan Province).——Fig. 1496,*2a–h.* **T. yanjinensis,* Yanjin County; *a–d,* dorsal, lateral, anterior, ventral views, ×1.5 (Xu, 1978); *e–h,* serial transverse sections, 0.2, 0.6, 0.8, 1.5 mm from umbo, ×2 (adapted from Xu, 1978).

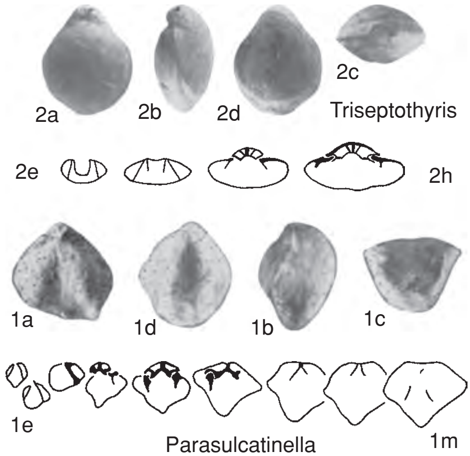

Fig. 1496. Uncertain (p. 2249).

UNCERTAIN

JIN YU-GAN

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Superfamily UNCERTAIN

Rugosothyris ZHANG, 1987a, p. 151 [**R. dangduoensis;* OD]. Small, pentagonal, ventribiconvex, ventral beak elongate with apical foramen, curved and overhanging dorsal beak; bisulcate; few coarse, low plicae, generally only two; ornament of 8–10 evenly spaced, concentric wrinkles; thin, short dental plates; posteriorly foramenate hinge plate; punctate; simple short loop. *Middle Devonian (Givetian):* China (southern Gansu).——FIG. 1497*a–i*. **R. dangduoensis; a–d,* holotype, ventral, dorsal, lateral, and anterior views, XI-B337, ×2; *e–i,* serial transverse sections 0.4, 0.8, 1.2, 1.8, 2.5 mm from ventral umbo, ×2 (Zhang, 1987a).

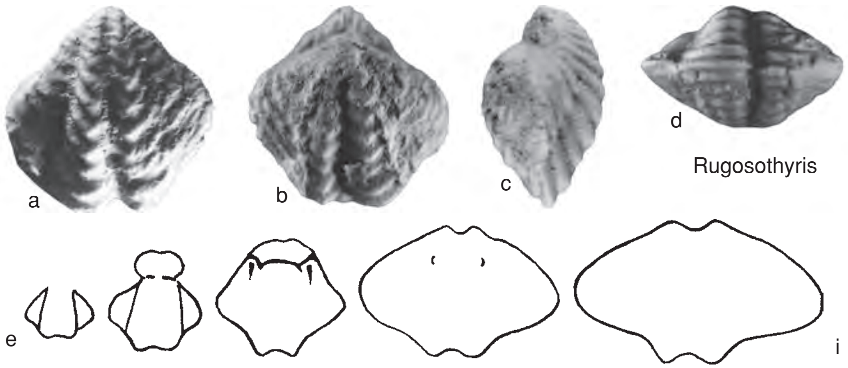

FIG. 1497. Uncertain (p. 2250).

UNCERTAIN

D. I. MacKinnon

[University of Canterbury]

Order UNCERTAIN
Superfamily CADOMELLOIDEA Schuchert, 1893

[*nom. correct.* Harper & others, 1993, p. 450, *pro* Cadomellacea Muir-Wood, 1955, p. 90, *nom. transl. ex* Cadomellinae Schuchert, 1893, p. 153, *non* Munier-Chalmas ms]

Micromorphic, subquadrate, very mildly concavoconvex shells, with very narrow mantle cavity. Pedicle foramen hypothyrid, with very narrow, subtriangular deltidial plates. Beak ridges and hinge line well developed, ventral interareas very low and wide. Prominent adductor muscle scars flanked by a pair of rodlike crura; brachidium (if any) unknown; tuberculate submarginal rim well developed on valve interiors. [The superfamily Cadomelloidea, as currently constituted, is a monospecific taxon. The only other species up to now attributed to the genus *Cadomella, C. davidsoni* (Eudes-Deslongchamps), is reassigned herein to the genus *Koninckodonta* Bittner (MacKinnon, 2002, p. 1604). The apparent absence of a spiral brachidium precludes placement into the Koninckinidina. The shell ultrastructure of *Cadomella* precludes placement into the Strophomenida.] *Lower Jurassic (Pliensbachian–Toarcian).*

Cadomella Oehlert, 1887b, p. 1,285, *non* Munier-Chalmas ms [**Leptaena moorei* Davidson in Davidson & Morris, 1847, p. 251; OD]. Very small, subquadrate, with wide hinge line and low interareas; ornamentation of subdued capillae and impersistent growth lamellae. Teeth strong, extending subparallel to hinge line; umbonal region almost completely infilled with secondary callus with surface opposing cardinal process forming bilobed platform; thickened submarginal rim of ventral valve bearing numerous depressions that appear to accommodate corresponding tuberculation in the dorsal valve. Cardinal process prominent, bilobed, flanked by pair of transverse hinge sockets; short, pronglike, anteroventrally directed crura defining posterolateral margins of adductor muscle scars; dorsal adductor muscle scars large and very prominent, bounded by raised margins that meet medianly to form hollow, triangular median ridge; dorsal valve submarginal ridge strongly tuberculate. *Lower Jurassic (Pliensbachian–Toarcian):* France, England.——Fig. 1498*a–d.* **C. moorei* (Davidson), Ilminster, England; *a–b,* dorsal, ventral exterior, ×8; *c,* dorsal interior, ×18, *d,* ventral interior, ×13.5 (new).

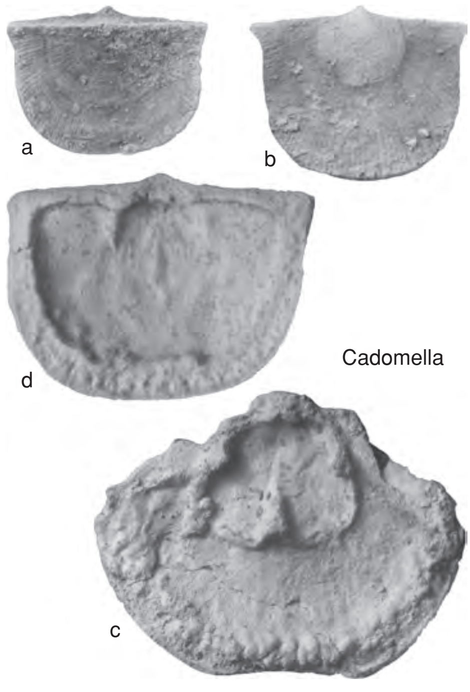

Fig. 1498. Uncertain (p. 2251).

UNCERTAIN

JIN YU-GAN and D. E. LEE

[Nanjing Institute of Geology and Palaeontology; and University of Otago]

Order UNCERTAIN
Family MONGOLELLIDAE Alekseeva, 1976

[Mongolellidae ALEKSEEVA, 1976, p. 346]

Small, costate, ventribiconvex with ventral beak incurved over dorsal beak; cardinal process massive, elongate; ventral spondylium-like structure supported by massive median septumlike structure, both features covered with thick secondary material, dental lamellae probably absent so that massive hinge teeth and associated secondary material probably form the walls of spondylium. *Lower Devonian.*

Mongolella ALEKSEEVA, 1976, p. 347 [**M. altaica;* OD]. Description as for family. *Lower Devonian:* Mongolia.——FIG. 1499,*1a–g. *M. altaica; a–d,* dorsal, ventral, lateral, and anterior views of holotype, PIN 3406/50, ×3; *e,* lateral view, ×5; *f,* posterior part of shell interior, ×3; *g,* line drawing of cardinalia, ×5 (Alekseeva, Mendbayar, & Erlanger, 1981).

Order UNCERTAIN
Family UNCERTAIN

Microbilobata JIN & CHATTERTON, 1996, p. 47 [**M. avalanchensis;* OD]. Very small; possibly punctate; subtriangular to subpentagonal in outline; slightly ventribiconvex, smooth posteriorly, bisulcate anteriorly with median plica in ventral sulcus and two plicae in dorsal sulcus, delthyrium narrow, with no deltidial plates; interarea not developed; long, acuminate loop; other internal features unknown. *middle Silurian:* Canada.——FIG. 1499,*2a–e. *M. avalanchensis; a–c,* dorsal, lateral, and anterior views of holotype, UA10897, ×20; *d,* silicified shell with ventral valve removed to show acuminate loop, ×20; *e,* drawing to show possible crural and loop structures in *d,* ×20 (Jin & Chatterton, 1996).

NOMINA DUBIA

Phyllonia SU, 1980, p. 327 [**Etymothyris? dichopleura* SU, 1976, p. 227; OD]. As illustrated this taxon appears to be more like a bivalve than a brachiopod.

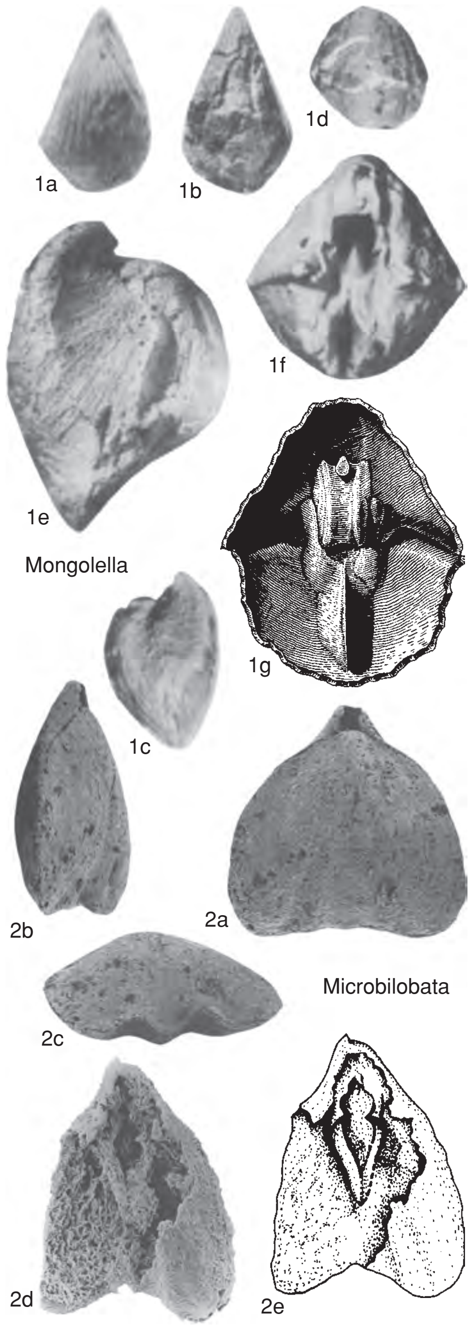

FIG. 1499. Mongolellidae and Uncertain (p. 2252).

UNCERTAIN

ALWYN WILLIAMS and C. HOWARD C. BRUNTON

[deceased, formerly of The University of Glasgow; and formerly of The Natural History Museum, London]

?Class STROPHOMENATA
Order UNCERTAIN
Family LIOSOMENIIDAE Liang, 1990

[Liosomeniidae LIANG, 1990, p. 110]

Large, smooth, convexoconcave, ovate with flattened posterolateral margins and very short hinge line; ventral interarea small, orthocline, with convex pseudodeltidium, dorsal interarea obsolete; ventral interior without dental plates or myophragm, muscle scar flabellate; dorsal interior with bladelike cardinal process; pseudopunctate. *Permian (Capitanian).*

Liosomena LIANG, 1990, p. 110 [457] [**L. obscura;* OD]. Characters as for family. [This species has been described as a pseudopunctate orthotetoid; but the smooth surface of the shell and the bladelike cardinal process immediately preclude its assignment to the Orthotetidina. More and better-preserved specimens of the species will have to be collected and described before even its general affinities can be determined.] *Permian (Capitanian):* China (Zhejiang).

NOMENCLATORIAL NOTE

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PETRIATHYRIS, NEW NAME FOR THE GENUS *PETRIA* MENDES, 1961 (BRACHIOPODA, TEREBRATULIDA) PREOCCUPIED BY *PETRIA* SEMENOV, 1894 (ARTHROPODA, COLEOPTERA)

During preparation of the manuscript for volume 5 of the revised brachiopod *Treatise on Invertebrate Paleontology,* it was realized that the cryptonelloid brachiopod genus name *Petria* MENDES, 1961, p. 21, is preoccupied by a coleopteran genus published by SEMENOV, 1894, p. 363 (see p. 2,025 herein). According to Article 60 of ICZN rules (1999) we here propose the name *Petriathyris* as replacement name for *Petria* MENDES, 1961. The type species for *Petriathyris* is *Waldheimia coutinhoana* DERBY, 1874, p. 3.

ACKNOWLEDGMENTS

We would like to thank Jill Hardesty for her advice on this matter.

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NOMENCLATORIAL NOTE

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DESLONGCHAMPSITHYRIS, NEW NAME FOR THE GENUS *DESLONGCHAMPSIA* TCHORSZHEVSKY, 1988 (BRACHIOPODA, TEREBRATULIDA) PREOCCUPIED BY *DESLONGCHAMPSIA* MORRIS & LYCETT, 1851 (MOLLUSCA, ARCHAEOGASTROPODA)

During preparation of the manuscript for volume 5 of the revised brachiopod *Treatise on Invertebrate Paleontology*, it was realized that the cancellothyridoid brachiopod genus name *Deslongchampsia* TCHORSZHEVSKY, 1988, p. 33, is preoccupied by a molluscan genus published by MORRIS and LYCETT, 1851, p. 94 (see p. 2,152 herein; KNIGHT & others, 1960, p. 233). According to Article 60 of the code of the ICZN (1999), we here propose the name *Deslongchampsithyris* as replacement name for *Deslongchampsia* TCHORSZHEVSKY, 1988, not *Deslongchampsia* MORRIS & LYCETT 1851, nor *Deslongchampsia* ROCHÉ, 1939 (Mollusca: Ammonoidea; ARKELL, KUMMEL, & WRIGHT, 1957, p. 290). The type species for *Deslongchampsithyris* is *Deslongchampsia moiseevi* TCHORSZHEVSKY, 1988, p. 33, =*Terebratella liaisina* MOISSEEV, 1934, p. 156, *non* DESLONGCHAMPS, 1863, *nec* RAU, 1902.

ACKNOWLEDGMENTS

We would like to thank Jill Hardesty for her advice on this matter.

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INDEX