TREATISE ON INVERTEBRATE PALEONTOLOGY

Part H

BRACHIOPODA

Revised

Volume 4: Rhynchonelliformea (part)

ALWYN WILLIAMS, C. H. C. BRUNTON, and S. J. CARLSON with

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PART H, Revised

BRACHIOPODA

VOLUME 4:

Rhynchonelliformea (part)

Alwyn Williams, C. H. C. Brunton, S. J. Carlson, Fernando Alvarez, R. B. Blodgett, A. J. Boucot, Paul Copper, A. S. Dagys, R. E. Grant, Jin Yu-Gan, D. I. MacKinnon, M. O. Manceñido, E. F. Owen, Rong Jia-Yu, N. M. Savage, and Sun Dong-Li

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EDITORIAL PREFACE

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[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 4, has been prepared by such a team of specialists whose work was coordinated by Sir Alwyn Williams at The University of Glasgow. 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 Jack Keim with photography and computer graphics, Mike Cormack with his outstanding computer skills, and Jean Burgess with general support. Jill Krebs, the remaining member of the Paleontological Institute editorial staff, is involved with preparation of PaleoBank, the paleontological database for future *Treatise* volumes, and has not been closely involved with the brachiopod *Treatise.*

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, I am pleased to extend once again on behalf of the members of the staff of the Paleontological Institute, both past and present, our most sincere thanks to Sir Alwyn Williams for the unwavering scholarship, dedication to the task, and scrupulous attention to detail that have marked his involvement with this project from the outset and, indeed, his entire career as a specialist on the Brachiopoda.

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Roger L. Kaesler
Lawrence, Kansas
July 1, 2002

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**
  - Přídolí 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

ALWYN WILLIAMS
[University of Glasgow]

The 1,170 or so genera described in volume 4 of *Treatise Part H (Revised, Brachiopoda)* belong to four rhynchonellate orders that make up the ancestral mainstream of all articulated brachiopods living today. Their relative modernity is reflected in two ways. First, although the orders as a whole span the Phanerozoic geological record, their peaks of generic diversity are post-Ordovician, unlike those of linguliforms, craniiforms, and primitive rhychonelliforms (except for the productides), described in volumes 2 and 3. The greatest generic diversities of the Pentamerida and Atrypida were attained during the Silurian (Wenlock) and Middle Devonian, respectively. The geological distribution of athyridide genera is bimodal with a peak in the Middle Devonian and a strong, subsidiary one in the Upper Triassic. The rhynchonellide distribution is polymodal with peaks in the Upper Devonian, Lower Carboniferous, and Upper Jurassic. The extent and separateness of these peaks, especially those of rhynchonellides, may be exaggerated by investigative practices referred to below.

The orders also share many basic morphological and anatomical characters that distinguish living rhychonelliforms. Devices precursory to the crural supports for the lophophore arose within the Pentamerida. The interlocking, cyrtomatodont teeth and sockets and the curved, astrophic hinge line are synapomorphies of the Rhynchonellida, Atrypida, and Athyridida; and, judging from the disposition of muscle scars relative to pedicle collars, the lobation and mantle reversal of living rhynchonelliform larvae were also ontogenetic features of extinct species of all three orders. Yet, despite well-documented geological records and demonstrably close affinities, infraordinal classifications have been difficult to erect and are more subjective in structure than originally anticipated. The resultant compromises are due mainly to the limitations of morphological data in characterizing suprageneric taxa. All four ordinal classifications, however, have also been affected to a varying degree by the way subtle changes in the microscopic features of the shell have been revealed and interpreted.

The complementary intergrowth of cyrtomatodont teeth and their sockets has always caused valves of later rhynchonelliforms to be interlocked and to remain so even after death and autolysis. Consequently, most samples, especially of fossil rhynchonellides and athyridides, include complete shells within which the cardinalia and calcified lophophore supports are commonly perfectly preserved. For most of the last century these features that play so important a role in rhynchonelliform systematics have been studied by preparing serial sections of shells. Unfortunately, much data obtained in this way can be misleading. It is seldom possible to prepare serial sections of shells of different species so that exposed surfaces being compared for taxonomic purposes bear the same relationship to, say, a constant medial vector of growth. Moreover, very few studies have taken into account microstructural evidence of the way features grew. Nothwithstanding these shortcomings, serial sections have been (and still are) used to erect genera based on micromorphological differences in internal skeletal pieces that have been viewed in two dimensions only.

The limitations of such practices were recognized nearly seventy years ago by ST. JOSEPH. In a series of pioneering reconstructions of spiriferides (1935a), pentamerides (1935b, 1941), and rhynchonellides (1937), ST. JOSEPH used camera lucida enlargements of serial sections to build scale models in wax of cardinalia and spiralia. Had this procedure been universally adopted, there would now be less concern about the validity of some genera and a much wider appreciation of how differences in internal features need reflect nothing more than variations in rates of shell secretion. Of course, computer programs are now available to generate digitized, three-dimensional models from sets of serial sections. It is hoped that this volume will inspire computerized reappraisals based on serial sections of those features that have been used for systematic purposes.

Preparing for the *Treatise* systematic descriptions of genera founded on serial sections inevitably raised a conflict of interests with no set battle line. On the one hand, it would have been editorially and scientifically unacceptable to publish copies of every section used to illustrate original generic diagnoses. Apart from excessively high publication costs and the scientific dubiety of some of the data, even specialist readers would have found the full array indigestible. On the other hand, there were options either to publish serial sections separately on compact disk or for *Treatise* authors to undertake a selective cull of up to thirty percent of serial-section sets figured in the original description of genera. All *Treatise* authors were consulted on which procedure should be adopted. The great majority decided that they themselves should select the sections illustrating the diagnoses that they had written. This responsibility fell heaviest on the authors of the chapters on the rhynchonellides and athyridides, and we are indebted to them for having carried out such painstaking culls after they had submitted their contributions.

Another problem facing authors of this volume was the need to standardize terminology for use not only between but even within orders. The terms now adopted to describe pentameride cardinalia have been brought in line with those used for homologous structures (WILLIAMS, BRUNTON, & MACKINNON, 1997, p. 369) in other rhynchonelliform groups. The intention is to signal that the synapomorphies concerned with late rhynchonellate articulation and lophophore support had their origins in the Pentamerida. The change to a new terminology has been accepted with varying reluctance (p. 928 herein) because the early ontogeny of pentamerides is too poorly known to confirm (or refute) the postulated homologies. Terminology has even suffered the effects of the Permian mass extinction! The unprecedented collaboration among authors of the rhynchonellides uncovered terminological and other differences of approach (p. 1027 herein) between brachiopodologists describing Paleozoic species and those restricting their attention to samples from younger stocks.

The four orders described in this volume have been classified in different ways ranging from the intuitive to the cladistic. The orders themselves are clearly defined and probably more or less compatible with the genealogy of their constituent taxa. Infraordinal groupings, however, are much less secure, as they are generally based on relative minor changes in shell morphology that are prone to homoplasy.

This complication determined the way the rhynchonellides were eventually classified. The morphology of the rhynchonellide shell has always been relatively simple. Yet the number of genera has increased threefold since 1965 (p. 1027 herein), many of them founded on subtle changes of internal parts as seen in serial sections. As a result, initial attempts at cladistic analysis of the order were thwarted by repeated convergence that has affected virtually every feature of the rhynchonellide shell in the course of its long geological history. Eventually, the authors had to content themselves with ensuring that the sixty-five families of the order are well-founded morphological units.

The authors describing the other three orders have had the systematic advantage of classifying groups with shorter geological records and generally more elaborate shells, which reduced the potential for obfuscation by repeated homoplasy. The pentameride syntrophiidines, with their well-differentiated internal markings and varied devices serving as muscle bases, have been cladistically analyzed and are shown to be the paraphyletic link between older rhynchonelliforms (Orthida) and the rhynchonellate crown group (Rhynchonellida). In contrast, genera belonging to the other pentameride suborder, the pentameridines, have been assembled hierarchically by classical comparative methods. In fact, however, the absence of internal markings and the relative simplicity of shell apophyses limit the efficacy of cladistic analysis in classifying pentameridines, at least until more is known about the fine structure and growth of spondylia and cardinalia.

The classifications of the Atrypida and Athyridida are most likely to accord, at least broadly, with their genealogies because additional apophyses (spiralia) characterizing both orders underwent elaborate transformations that have been taxonomically exploited to the full. The atrypides have been classified by traditional methods. They are, however, the shortest lived of all rhynchonellate ordinal stocks and have been so comprehensively studied that a phylogeny differing significantly from the classification presented here is difficult to visualize. The same assertion can be made about the athyridide classification, which is based on the cladistic analysis of a group characterized by the most elaborate brachidia ever to have evolved within the phylum. Admittedly the distinction between the atrypides and athyridides is only unambiguous because four families classified as Uncertain (p. 1604 herein) have been excluded from either order as presently defined. This group is noteworthy not only because further study of its genera might cast light on the phylogenetic relationships between the athyridides and atrypides. It was also prepared jointly as a priority by Fernando Alvarez and Paul Copper, the senior and sole authors, respectively, of the athyridides and atrypides. Such collaboration is the hallmark of *Treatise* teamwork, which augurs well for brachiopod research in the twenty-first century.

In summary, the classifications used as frameworks for the systematic descriptions of the later rhynchonellates are more traditional than cladistic in construction. Even so, they are likely to be, at least, broad reflections of the genealogies of the orders described. This assumption can be tested for the rhynchonellides, which, as the most morphologically conservative order with the longest geological history of all other rhynchonellates, would have been most prone to homoplasy. Four rhynchonellide superfamilies, erected exclusively on morphological differences, are represented by living species. Two superfamilies, the Dimerelloidea and Pugnacoidea, date back to the Devonian, the other two (the Norelloidea and Hemithiridoidea) to the Triassic. It is noteworthy that, in a recent molecular study involving living brachiopods (COHEN, 2000), a rhynchonellide clade shows the pugnacoid *Eohemithiris* as a sister group of the hemithiridoid *Notosaria* and the norelloid *Neorhynchia.* The test of concordance between traditional and molecular methods of classifying rhynchonellides, however, will come when living representatives of the fourth superfamily, the Dimerelloidea, are studied genetically. Living dimerelloids, like *Cryptopora* (see HELMCKE, 1940), have one pair of metanephridia as do all other brachiopods and not two pairs as in other extant rhynchonellides. Presumably, the dimerelloids belong to a group that is ancestral to the other three superfamilies as the current classification suggests (Miguel MANCEÑIDO, personal communication, August 2001). Whether this will be confirmed by molecular studies remains to be seen. Meanwhile, for the rhynchonellates at least, the classical paleontological methods of constructing phylogenetic-taxonomic hierarchies by morphological comparison have not yet had their day.

It is saddening to end this Introduction with notices of the deaths of four distinguished scientists who contributed so much to our understanding of the Brachiopoda. Two were authors of the revised *Treatise.* Alan Ansell, who died on 18 July, 1999, was a marine biologist of great versatility. He was a key contributor to the ground-breaking chapter on brachiopod physiology in Volume 1 (PECK & others, 1997) and, up to the time of his death, was actively engaged in preparing materials for the last volume of the revision of *Treatise Part H,* the Supplement. Algirdas Dagys of the Lithuanian Academy of Science died on 7 January, 2000. He was an internationally acclaimed palaeontologist whose perceptive studies of brachiopod cardinalia, loops, and spires have been pivotal to the revisions of the Rhynchonellida, Terebratulida, and Athyridida. His coauthored contributions are published in this volume and will also appear in the Supplement.

Introductions to previous volumes have always acknowledged the indebtedness of many authors for advice and access to private materials, so freely given by two giants of twentieth century Paleontology. Their wise counsels, alas, are no longer available. G. Arthur Cooper, formerly of the United States National Museum, died on 17 October, 2000. His beautifully illustrated monographs on brachiopods from the Appalachians, western Texas, the Caribbean Sea, and Indian Ocean will long continue to serve not only as standard references but also as models for the presentation of meticulously prepared data. Vladimír Havlíček, formerly of the Czechoslovakian Geological Survey, died on 10 September, 1999. His splendid monographs were concerned primarily with Bohemian brachiopods, but he also described southern European and North African assemblages with equal authority. Arthur Cooper and Vladimír Havlíček were truly the James Hall and Joachim Barrande of their day!

ACKNOWLEDGMENTS

This volume could not have been published without the help received by all authors during the preparation of their contributions. Collation of data, of course, has been going on for many years and has entailed the study of collections in institutions throughout the world. These repositories are exhaustively listed below and we all greatly appreciate the range of facilities placed at our disposal whenever our needs were made known. Special mention should be noted of Dr. Sarah Long, Curator at the Natural History Museum, London, who not only made collections immediately available *in situ* or by loan but also retrieved, at short notice, vital information about, or from, the most obscure references. The systematic descriptions of most authors have benefitted from gifts of photographs as well as the loan of specimens. The sources of those that have been used for illustration are acknowledged in the appropriate figure captions in the text.

Finally, some authors have received previously unreported grants in support of their *Treatise* work and wish to thank the funding bodies. The grants include those from The University of Kansas Paleontological Institute and the University of La Plata for M. O. Manceñido; the Natural Science Foundation of China and the Laboratory of Palaeontology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Academia Sinica for Rong Jia-yu; and The University of Kansas Paleontological Institute and the University of Glasgow for secretarial assistance for A. Williams.

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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
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
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
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
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
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

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. Lower 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–Upper Ordovician.
L. E. Holmer & L. E. Popov
Siphonotretoidea. Middle Cambrian–Upper 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. Lower Ordovician–Holocene.
M. G. Bassett

Trimerellida. Lower Ordovician–upper Silurian.
L. E. Popov & L. E. Holmer
Trimerelloidea. Lower Ordovician–upper Silurian.
L. E. Popov & L. E. Holmer
Rhynchonelliformea. Lower Cambrian–Holocene.
Alwyn Williams, S. J. Carlson, & C. H. C. Brunton
Chileata. Lower Cambrian–Upper 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, ?Lower Triassic.
Alwyn Williams, C. H. C. Brunton, & L. R. M. Cocks
Strophomenida. Lower Ordovician–Upper Carboniferous.
L. R. M. Cocks & Rong Jia-yu
Strophomenoidea. Lower Ordovician–Upper Carboniferous.
L. R. M. Cocks & Rong Jia-yu
Plectambonitoidea. Lower Ordovician–Middle 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–Upper Permian, ?Lower Triassic.
P. R. Racheboeuf
Chonetoidea. Upper Ordovician–Upper 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
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. 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–upper Silurian.
A. J. Boucot, Rong Jia-yu, & R. B. Blodgett
Stricklandioidea. Silurian.
A. J. Boucot, Rong Jia-yu, & R. B. Blodgett
Gypiduloidea. lower 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. Middle Triassic–Holocene.
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–Upper Permian.
J. L. Carter, J. G. Johnson, Rémy Gourvennec, & Hou Hong-Fei
Spiriferidina. Upper Ordovician–Upper Permian.
J. L. Carter, J. G. Johnson, Rémy Gourvennec, & Hou Hong-Fei
Cyrtioidea. Upper Ordovician–Lower Devonian.
J. G. Johnson & Hou Hong-Fei
Spinelloidea. upper Silurian–Upper Devonian.
J. G. Johnson
Theodossioidea. Lower Devonian–Lower Carboniferous, ?Upper Carboniferous.
J. G. Johnson, J. L. Carter, & Hou Hong-Fei

Cyrtospiriferoidea. Lower Devonian–Upper Devonian.
J. G. Johnson
Ambocoelioidea. upper Silurian–Permian.
J. G. Johnson, J. L. Carter, & Hou Hong-Fei
Martinioidea. Silurian–Upper Permian.
J. L. Carter & Rémy Gourvennec
Spiriferoidea. Upper Devonian–Upper Permian.
J. L. Carter
Paekelmanelloidea. Upper Devonian–Upper Permian.
J. L. Carter
Brachythyridoidea. Upper Devonian–Upper Permian.
J. L. Carter
Delthyridina. lower Silurian–Upper Permian.
J. G. Johnson, Rémy Gourvennec, J. L. Carter, & Hou Hong-Fei
Delthyridoidea. lower Silurian–Middle Devonian.
J. G. Johnson & Hou Hong-Fei
Reticularioidea. lower Silurian–Upper Permian.
Rémy Gourvennec, J. G. Johnson, & J. L. Carter
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–Lower Carboniferous.
J. G. Johnson
Suessioidea. Lower Carboniferous–Lower Jurassic.
J. L. Carter
Spondylospiroidea. Middle Triassic–Upper Triassic.
J. L. Carter
Syringothyridoidea. Upper Devonian–Upper 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
Thecideidina. 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, A. J. Boucot, T. N. Smirnova, A. S. Dagys, Jin Yu-gan, & Sun Dong-li
Centronellidina. Lower Devonian–Upper Permian.
A. J. Boucot, Jin Yu-gan, & D. E. Lee
Stringocephaloidea. Lower Devonian–Upper Devonian.
A. J. Boucot, Jin Yu-gan, & D. E. Lee
Terebratulidina. Lower Devonian–Holocene.
D. E. Lee, A. J. Boucot, A. S. Dagys, T. N. Smirnova, Sun Dong-li, & Jin Yu-gan
Cryptonelloidea. Lower Devonian–Upper Triassic.
A. J. Boucot, Jin Yu-gan, & D. E. Lee
Dielasmatoidea. Lower Devonian–Lower Jurassic.
D. E. Lee, Jin Yu-gan, A. J. Boucot, Sun Dong-li, & A. S. Dagys

Terebratuloidea. Upper Triassic–Holocene.
D. E. Lee, T. N. Smirnova, Sun Dong-li, & A. S. Dagys
Loboidothyridoidea. Upper 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. 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 & A. S. Dagys
Kingenoidea. Middle Triassic–Holocene.
D. I. MacKinnon, D. E. Lee, T. N. Smirnova, & A. S. Dagys
Laqueoidea. Lower Jurassic–Holocene.
D. I. MacKinnon, T. N. Smirnova, & 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. Paleocene–Holocene.
D. I. MacKinnon & D. E. Lee
Kraussinoidea. Miocene–Holocene.
D. E. Lee & D. I. MacKinnon
Uncertain.
Gwynioidea. Lower Jurassic–Holocene.
D. I. MacKinnon
Uncertain.
Plicanoplitoidea. Upper Silurian-Middle Devonian.
P. R. Racheboeuf
Cadomelloidea. Lower Jurassic.
D. I. Mackinnon