

TREATISE ON INVERTEBRATE PALEONTOLOGY

Part H

BRACHIOPODA

Revised

Volume 2:

Linguliformea, Craniiformea, and Rhynchonelliformea (part)

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INFORMATION ON TREATISE VOLUMES

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

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- Part A. INTRODUCTION, xxiii + 569 p., 371 fig., 1979.
- Part C. PROTISTA 2 (Sarcodina, Chiefly "Thecamoebians" and Foraminiferida), Volumes 1 and 2, xxxi + 900 p., 653 fig., 1964.
- Part D. PROTISTA 3 (Protozoa: Chiefly Radiolaria, Tintinnina), xii + 195 p., 92 fig., 1954.
- Part E. ARCHAEOCYATHA, PORIFERA, xviii + 122 p., 89 fig., 1955.
- Part E, Revised. ARCHAEOCYATHA, Volume 1, xxx + 158 p., 107 fig., 1972.
- Part F. COELENTERATA, xvii + 498 p., 358 fig., 1956.
- Part F. COELENTERATA, Supplement 1 (Rugosa and Tabulata), xl + 762 p., 462 fig., 1981.
- Part G. BRYOZOA, xii + 253 p., 175 fig., 1953.
- Part G, Revised. BRYOZOA, Volume 1 (Introduction, Order Cystoporata, Order Cryptostomata), xxvi + 626 p., 295 fig., 1983.
- Part H. BRACHIOPODA, xxxii + 927 p., 746 fig., 1965.
- Part H, Revised. BRACHIOPODA, Volume 1 (Introduction), xx + 539 p., 417 fig., 40 tables, 1997.
- Part I. MOLLUSCA 1 (Mollusca General Features, Scaphopoda, Amphineura, Monoplacophora, Gastropoda General Features, Archaeogastropoda, Mainly Paleozoic Caenogastropoda and Opisthobranchia), xxiii + 351 p., 216 fig., 1960.
- Part K. MOLLUSCA 3 (Cephalopoda General Features, Endoceratoidea, Actinoceratoidea, Nautiloidea, Bactritoidea), xxviii + 519 p., 361 fig., 1964.
- Part L. MOLLUSCA 4 (Ammonoidea), xxii + 490 p., 558 fig., 1957.
- Part L, Revised. MOLLUSCA 4, Volume 4 (Cretaceous Ammonoidea), xx + 362 p., 216 fig., 1996.
- Part N. MOLLUSCA 6 (Bivalvia), Volumes 1 and 2 (of 3), xxxvii + 952 p., 613 fig., 1969; Volume 3, iv + 272 p., 153 fig., 1971.
- Part O. ARTHROPODA 1 (Arthropoda General Features, Protarthropoda, Euarthropoda General Features, Trilobitomorpha), xix + 560 p., 415 fig., 1959.
- Part O, Revised. ARTHROPODA 1 (Trilobita: Introduction, Order Agnostida, Order Redlichiida), xxiv + 530 p., 309 fig., 1997.
- Part P. ARTHROPODA 2 (Chelicerata, Pycnogonida, Palaeoisopus), xvii + 181 p., 123 fig., 1955 [1956].
- Part Q. ARTHROPODA 3 (Crustacea, Ostracoda), xxiii + 442 p., 334 fig., 1961.
- Part R. ARTHROPODA 4, Volumes 1 and 2 (Crustacea Exclusive of Ostracoda, Myriapoda, Hexapoda), xxxvi + 651 p., 397 fig., 1969.
- Part R. ARTHROPODA 4, Volumes 3 and 4 (Hexapoda), xxii + 655 p., 265 fig., 1992.
- Part S. ECHINODERMATA 1 (Echinodermata General Features, Homalozoa, Crinozoa, exclusive of Crinoidea), Volumes 1 and 2, xxx + 650 p., 400 fig., 1967 [1968].
- Part T. ECHINODERMATA 2 (Crinoidea), Volumes 1–3, xxxviii + 1,027 p., 619 fig., 1978.
- Part U. ECHINODERMATA 3 (Asterozoans, Echinozoans), xxx + 695 p., 534 fig., 1966.
- Part V. GRAPTOLITHINA, xvii + 101 p., 72 fig., 1955.

Part V, Revised. GRAPTOLITHINA, xxxii + 163 p., 109 fig., 1970.

Part W. MISCELLANEA (Conodonts, Conoidal Shells of Uncertain Affinities, Worms, Trace Fossils, Problematica), xxv + 259 p., 153 fig., 1962.

Part W, Revised. MISCELLANEA, Supplement 1 (Trace Fossils and Problematica), xxi + 269 p., 110 fig., 1975.

Part W, Revised. MISCELLANEA, Supplement 2 (Conodonta), xxviii + 202 p., frontis., 122 fig., 1981.

THIS VOLUME

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

VOLUMES IN PREPARATION

Part B. PROTISTA 1 (Chryomonadida, Coccolithophorida, Charophyta, Diatomacea, etc.).

Part E, Revised. PORIFERA (additional volumes).

Part F, Revised. CNIDARIA (Scleractinia).

Part G, Revised. BRYOZOA (additional volumes).

Part H, Revised. BRACHIOPODA (additional volumes).

Part K, Revised. MOLLUSCA 3 (Nautiloidea).

Part L, Revised. MOLLUSCA 4 (Ammonoidea) (additional volumes).

Part M. MOLLUSCA 5 (Coleoidea).

Part O, Revised. ARTHROPODA 1 (Trilobita) (additional volumes).

Part Q, Revised. ARTHROPODA 3 (Ostracoda).

Part R, Revised. ARTHROPODA 4 (Crustacea Exclusive of Ostracoda).

Part T, Revised. ECHINODERMATA 2 (Crinoidea).

Part V, Revised. GRAPTOLITHINA.

Part W, Revised. TRACE FOSSILS.

EDITORIAL PREFACE

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. These volumes, Part H, Revised, Brachiopoda, Volumes 2 and 3, have 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 these volumes 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 1985 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. Its publication came too late to allow incorporation in these volumes. In any event the revised *Code* is specified as taking effect at the start of 2000. 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 these volumes. 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 propose 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, p. 73), 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 volumes, 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 13a), or (4) for genus-group names, were unaccompanied by definite fixation of a type species by original designation or indication (*Code*, Article 13b). *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 lit-

erature. 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.

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 often to be made 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* specifies the endings only for subfamily (-inae) and family (-idae) names, but all family-group taxa are defined as coordinate (*Code*, Article 36, p. 77): "A name established for a taxon at any rank in the family group is deemed to be simultaneously

established with the same author and date for taxa based upon the same name-bearing type (type genus) at other ranks in the family group, with appropriate mandatory change of suffix [Art. 34a]." Such changes of rank and concomitant changes of endings as elevation of a tribe to subfamily rank or of a subfamily to family rank, if introduced subsequent to designation of a subfamily or family 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.

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*. 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.

Superfamily AGNOSTOIDEA M'Coy, 1849

[*nom. transl.* SHERGOLD, LAURIE, & SUN, 1990, p. 32, ex Agnostinae M'COY, 1849, p. 402]

Family-Group Names: Use of *nomen correctum*

Valid name changes classed as *nomina correctata* 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* Palaescorpionidae LEHMANN, 1944, p. 177]

Family-Group Names: Replacements

Family-group names are formed by adding combinations of letters, which are prescribed for family and subfamily, 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, p. 79), in which case “. . . it must be replaced either by the next oldest available name from among its synonyms, including those of its subordinate taxa, or, if there is no such name, by a new replacement 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* (p. 81), however, specifies that for subsequent application of the rule of priority, the family-group name “. . . should be cited with its own author and date, followed by the date of the replaced name in paren-

theses.” 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 11f). 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 phylum) 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 MUIRWOOD, 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 33a and Glossary, p. 254) 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 repeat-

ing 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 also is given, 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, 1964, 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 automatically becomes 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 action of the International Com-

mission 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 13b). 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 of the existence of a junior homonym generally is made.

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 separately published, 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 Scutellidae (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.

Mackenziophyllum PEDDER, 1971, p. 48 [**M. insolitum*; OD] [=*Zonastrea* TSYGANKO in SPASSKIY, KRAVTSOV, & TSYGANKO, 1971, p. 85, *nom. nud.*; *Zonastrea* 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.

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, might also be spelled 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 THESE VOLUMES

Some languages, in these volumes 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 Příklad. 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 diacriti-

cal 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, accuracy, and information retrieval.

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 these volumes, we have taken special pains to acknowledge authorship of small subsections. Any reader citing the volumes is 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 these volumes 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 and Jean Burgess with general support. Jill Krebs,

the remaining member of the Paleontological Institute 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
January 1, 2000

STRATIGRAPHIC DIVISIONS

The major divisions of the geological time scale are reasonably well established throughout the world, but minor divisions (*e.g.*, substages, stages, and subseries) 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.

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]

These complementary volumes 2 and 3 and those that follow describe about 5,000 brachiopod taxa belonging to all ranks of the classificatory hierarchy down to subgenera. The full text is intended to diagnose all taxa known in 1995 and nearly all those subsequently erected up to the year of publication of the last volume, where they will be assembled as a concluding supplement. The descriptions have been written by the thirty-four authors listed in the outline of suprafamilial classification (p. 22). Two contributors, Richard E. Grant and Jess G. Johnson, died before their assignments had been completed. But they had already prepared and submitted substantial parts of their assignments, and it has been a collaborative act of remembrance to complete their revisions as homage to two outstanding brachiopodologists.

Responsibilities for the revision and integration of the classificatory descriptions of the Brachiopoda were clearly defined at the outset of the project. Senior authors and their collaborators were responsible for the taxonomic revision of their allotted groups from subgenera to orders inclusive. They have also provided a brief introduction to any group, normally of ordinal rank, warranting an illustrated guide to the basic diagnostic features of its morphology. The introductions have further afforded authors opportunity to air their own views on the classification and phylogeny of the groups being revised.

Throughout the period of preparation, day-to-day advice on procedures, data retrieval, relocation of taxa within the hierarchy, nomenclature, and so on was given by the coordinating author and deputies. As assignments were completed but before final versions had been delivered to the editorial office in Kansas, drafts were submitted to the coordinating author for scientific appraisal. A detailed scrutiny was also made of intro-

ductions and the description of a representative superfamily and all its constituent taxa to ensure that diagnoses were consistently presented and were broadly comparable throughout all contributions, in the weighting and sequential description of relevant characters.

In this way, new descriptions of twenty-five groups of taxa, each with an introduction, were assembled. Their integration within a supraordinal classification then became the responsibility of the coordinating author and deputies. A classification intended for this purpose had already been published (WILLIAMS & others, 1996). Its erection had been made possible by access to documents and advice, freely given by all contributors to this *Treatise*, who have generally accepted the classification as an appropriate framework for the taxonomic revision of the phylum (reservations on a few ordinal groupings are noted in relevant introductions). The classification is described in the opening chapter of this volume. Its adoption has entailed the preparation of new or amended diagnoses for the phylum, three subphyla, and eight classes, with comments on their synapomorphies, on affinities with other groups of equal rank, and on relationships among their constituent taxa.

The mode of presentation of so much information has been determined by the practicalities of publication and the observance of geological and taxonomic conventions. Volumes exceeding 600 pages in length are unwieldy as sources of reference and even more so as bench-top tools. Taxonomic descriptions of groups with long geological records are traditionally arranged according to the chronological order of appearance of their high-ranking taxa. The brachiopod fossil record is unexcelled among metazoans with skeletons, and the preponderance of extinct groups is strikingly evident in that all but three of the 26 orders

comprising the phylum first appeared in Cambro-Ordovician times, while only five survive today. Even so, it seemed at first that the classification of this skewed record could be presented, with proper regard for geological and taxonomic protocol, without having to split the description of any of the many orders between consecutive volumes.

This aim has been frustrated by the inevitable mismatch between the size and geological distribution of supraordinal taxa. Six of the eight classes, including all four restricted to the Early Paleozoic, contain less than 10 percent of described genera compared with more than 20 percent and 60 percent (mainly of post-Ordovician age) respectively assigned to the strophomenates and higher rhynchonellates. Indeed, preliminary estimates of format showed that the Linguliformea and Craniiformea could be described in a text of well under 200 pages, less than one-tenth of that required for the Rhynchonelliformea. Accordingly a volume was planned to hold descriptions not only of all linguliforms and craniiforms but also of some early rhynchonelliforms. The inclusion of such groups in one book of standard size, however, would split the strophomenate text between two, ostensibly self-contained volumes. Even so, it was decided to publish two such volumes numbered consecutively but issued simultaneously, like overweight twins after a long gestation, whose seniority is merely a matter of delivery. This ploy would enable the account of the rhynchonelliform subphylum to be interrupted at a significant node in its genealogy. The most obvious apportionment was to close Volume 3 with the description of the rhynchonelliform orthides and to open Volume 4 with a chapter on the pentamerides, the stem group of the rhynchonellides and all later rhynchonellates.

Finally, a small number of typographic, transpositional and taxonomic errors, and terminological ambiguities have been found in Volume 1 (KAESLER, 1997). The only one requiring immediate correction is the mislabelling of shell folding in Figure 289 (1997, p. 328), which has been correctly

relabelled on p. xxvi of this volume. The other errors should not cause difficulty even for the general reader and, as errors could well occur in this and succeeding volumes, it has been decided to issue a full list of errata in the supplement to Volume 5.

ACKNOWLEDGMENTS

The acknowledgments cited in Volume 1 of Part H(R) (KAESLER, 1997, p. 5–6) were intended to express heartfelt appreciation for the help received by all authors during preparation of their contributions to the entire revision. Assistance of every kind continues to flow, however, from new sources, even in answer to editorial queries, and merits special mention in this foreword.

For the last two years, there has been virtually unceasing communication between Kansas and Glasgow and the coordinating author and his collaborators by telephone, fax, and electronic and surface mail in the form of circular and individual documents as well as scripts in hard copy and on disk. Pivotal to the smooth running of this global exchange has been Sheila Harvey of Glasgow University. Her quick-witted initiative and blithe efficiency continue to keep everyone well supplied with accurate data, expeditiously dispatched; we are all indebted to her.

On the scientific side, many of us are also indebted to the late Vladimír Havlíček, formerly of the Czechoslovakian Geological Survey, for the unconditional use of his superb private collection of fossils and photographs, and to him and G. Arthur Cooper, formerly of the United States National Museum, for invaluable advice on many problems relating to brachiopod taxonomy. Sarah Long of the Natural History Museum, London has been widely consulted about obscure literature and has unstintingly arranged loans of, and access to, brachiopod specimens as have J. Thomas Dutro, Jr., and Jann Thompson of the Smithsonian Institution, Washington D.C.; we are pleased to thank them for their services. The taxonomic descriptions of most contributors have greatly benefitted not only from personal communi-

cations but also from individual loans of specimens and photographs from paleontologists and a host of institutions including those listed below. The sources of those that have been used for illustration are acknowledged in the appropriate figure captions in the text.

Finally some contributors have received previously unreported grants in support of their *Treatise* work and wish to thank the funding bodies. The grants include those

from the Royal Society of London and the Chinese Academy of Science to Rong Jia-yu for travel to, and study in, London; the National Natural Science Fund of China (grant 480070) to Jin Yu-gan, Rong Jia-yu, and Hou Hong-fei for research in *Treatise* themes; the Natural Environment Research Council (grant GR3/09604) to A. Williams for research on shell structure; and the Royal Society of London (grant RSRG16604) to A. Williams for upgrading computer facilities.

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
DNGM: Servicio Nacional Minero Geológico, Buenos Aires, Argentina
DP, DPO: Oviedo University, Spain
DPO: see DP
DPUCM: Departamento de Paleontología, Universidad Complutense, Madrid, Spain
ENSM, FSI, FSL, SSL, TA: Université Claude Bernard, Lyon I, Villeurbanne, France
FD: Geological College of Eastern China, Fuzhou, China
FSI: see ENSM
FSL: see ENSM
GB: Xian Institute of Geology and Mineral Resources, Xian, China
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
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
HIGS: Hangzhou Institute for Geological Science, Hangzhou, China
HM: see GLAHM

- HNHMB:** Hungarian Natural History Museum, Budapest, Hungary
- HUB:** see MB
- IGAS:** Institute of Geology, Chinese Academy of Sciences, Beijing, China
- IGiG:** Institute of Geology and Geophysics, Siberian Branch, Academy of Sciences, Akademgorodok, Russia
- 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
- 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
- LGE:** St. Petersburg State University, St. Petersburg, Russia
- 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
- MGRI:** Moscow Geological Prospecting Institute, Moscow, Russia
- MGU:** Moscow State University, Russia
- 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
- MONZ:** see NMNZ
- MNHN:** Muséum National d'Histoire Naturelle, Paris, France
- Muz IG:** Geological Museum of the Geological Institute, Warsaw, Poland
- MV:** see NMVP
- NIGP:** Nanjing Institute of Geology and Palaeontology, Academia Sinica, Nanjing, China
- NM:** National Museum, Prague, Czech Republic
- NMNZ:** Te Papa, Museum of New Zealand, Wellington, New Zealand
- NMVP:** Victoria Museum, Melbourne, Victoria, Australia
- NMW:** National Museum of Wales, Cardiff, United Kingdom
- 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
- 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
- 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
- SSL:** see ESNM
- SUI:** University of Iowa, Department of Geology, Iowa City, USA
- SUP:** University of Sydney, New South Wales, Australia
- TA:** see ESNM
- 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
- UCF:** The University, Calgary, Canada
- UCM:** University of Canterbury, Christchurch, New Zealand
- UD:** University of Dijon, Dijon, France
- UHR:** Hokkaido University, Sapporo, Japan
- 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
- XIGMR:** Xi'an Institute of Geology and Mineral Resources, Shaanxi, China
- 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

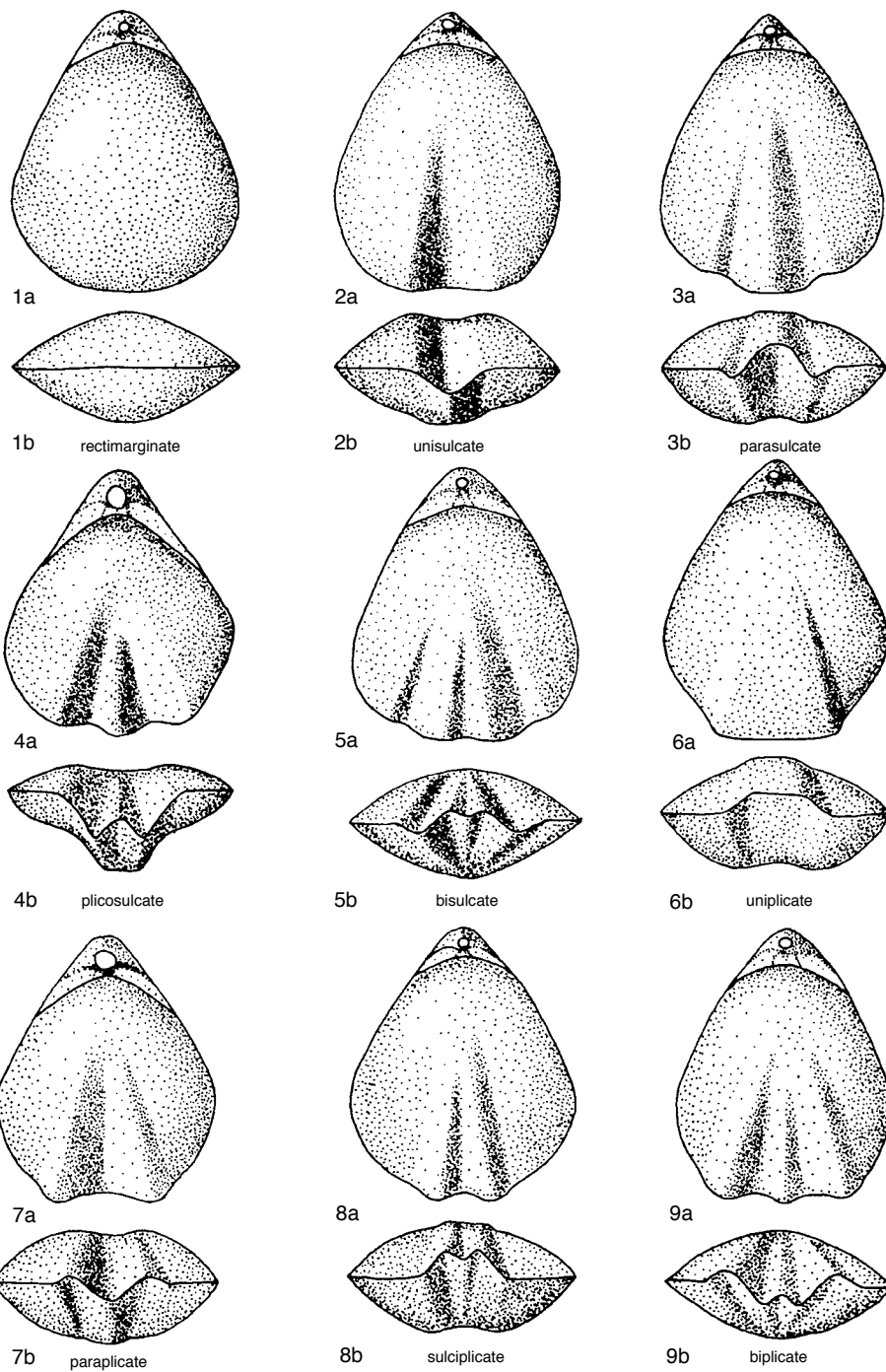


FIG. 289. Types of alternate folding; 1, rectimarginate; 2–5, forms of folding that are basically sulcate; 6–9, forms of folding that are basically plicate (adapted from Williams & Rowell, 1965b).
 [Note: this figure was corrected from the version in Volume 1, 1997, p. 328.]