

# TREATISE ON INVERTEBRATE PALEONTOLOGY

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## Part R ARTHROPODA 4

Volume 3: Superclass Hexapoda

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# TREATISE ON INVERTEBRATE PALEONTOLOGY

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 are available on orders sent to the Publication Sales Department, The Geological Society of America, 3300 Penrose Place, P.O. Box 9140, Boulder, Colorado 80301.

## VOLUMES ALREADY PUBLISHED

- Part A. INTRODUCTION, xxiii + 569 p., 371 fig., 1979.
- Part C. PROTISTA 2 (Sarcodina, chiefly "Thecamoebians" and Foraminiferida), xxxi + 900 p., 5,311 fig., 1964.
- Part D. PROTISTA 3 (chiefly Radiolaria, Tintinnina), xii + 195 p., 1,050 fig., 1954.
- Part E. ARCHAEOCYATHA, PORIFERA, xviii + 122 p., 728 fig., 1955.
- Part E, Revised. ARCHAEOCYATHA, Volume 1, xxx + 158 p., 871 fig., 1972.
- Part F. COELENTERATA, xvii + 498 p., 2,700 fig., 1956.
- Part F. COELENTERATA, Supplement 1 (Rugosa and Tabulata), xl + 762 p., 3,317 fig., 1981.
- Part G. BRYOZOA, xii + 253 p., 2,000 fig., 1953.
- Part G, Revised. BRYOZOA, Volume 1 (Introduction, Order Cystoporata, Order Cryptostomata), xxvi + 626 p., 1,595 fig., 1983.
- Part H. BRACHIPODA, xxxii + 927 p., 5,198 fig., 1965.
- Part I. MOLLUSCA 1 (Mollusca General Features, Scaphopoda, Amphineura, Monoplacophora, Gastropoda General Features, Archaeogastropoda, mainly Paleozoic Caenogastropoda and Opisthobranchia), xxiii + 351 p., 1,732 fig. 1960.
- Part K. MOLLUSCA 3 (Cephalopoda General Features, Endoceratoidea, Actinoceratoidea, Nautiloidea, Bactritoidea), xxviii + 519 p., 2,382 fig., 1964.
- Part L. MOLLUSCA 4 (Ammonoidea), xxii + 490 p., 3,800 fig., 1957.
- Part N. MOLLUSCA 6 (Bivalvia), Volumes 1 and 2 (of 3), xxxvii + 952 p., 6,198 fig., 1969; Volume 3, iv + 272 p., 742 fig., 1971.
- Part O. ARTHROPODA 1 (Arthropoda General Features, Protarthropoda, Euarthropoda General Features, Trilobitomorpha), xix + 560 p., 2,880 fig., 1959.
- Part P. ARTHROPODA 2 (Chelicerata, Pycnogonida, Palaeoisopus), xvii + 181 p., 565 fig., 1955.
- Part Q. ARTHROPODA 3 (Crustacea, Ostracoda), xxiii + 442 p., 3,476 fig., 1961.
- Part R. ARTHROPODA 4, Volumes 1 and 2 (Crustacea exclusive of Ostracoda, Myriapoda, Hexapoda), xxxvi + 651 p., 1,762 fig., 1969.
- Part S. ECHINODERMATA 1 (Echinodermata General Features, Homalozoa, Crinozoa, exclusive of Crinoidea), xxx + 650 p., 2,868 fig., 1967 [1968].
- Part T. ECHINODERMATA 2 (Crinoidea), Volumes 1-3, xxxviii + 1027 p., 4,833 fig., 1978.
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- Part W. MISCELLANEA (Conodonts, Conoidal Shells of Uncertain Affinities, Worms, Trace Fossils, Problematica), xxv + 259 p., 1,058 fig., 1962.
- Part W, Revised. MISCELLANEA, Supplement 1 (Trace fossils and Problematica), xxi + 269 p., 912 fig., 1975.
- Part W, Revised. MISCELLANEA, Supplement 2 (Conodonta), xxviii + 202 p., frontis., 858 fig., 1981.

## THIS VOLUME

Part R. ARTHROPODA 4, Volumes 3 and 4 (Hexapoda), xxii + 655 p., 1,489 fig., 1992.

## VOLUMES IN PREPARATION

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

Part E, Revised. PORIFERA. Volume 2.

Part G, Revised. BRYOZOA (additional volumes).

Part H, Revised. BRACHIOPODA.

Part I. Introduction to MOLLUSCA (part).

Part J. MOLLUSCA 2 (Caenogastropoda, Streptoneura exclusive of Archaeogastropoda, Euthyneura).

Part L, Revised. MOLLUSCA 4 (Ammonoidea).

Part M. MOLLUSCA 5 (Coleoidea).

Part O, Revised. ARTHROPODA 1 (Trilobita).

Part Q, Revised. ARTHROPODA 3 (Ostracoda).

## 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 single specialist with a synoptic view of the group being monographed. More rarely, two or perhaps three specialists worked together. Recently, however, both new *Treatise* volumes and revisions of existing ones have been undertaken increasingly by teams of specialists led by a coordinating author. Part R, Hexapoda, prepared by Professor Frank M. Carpenter, is certainly the last of the volumes that will be written by a single author rather than by a team of specialists. Few paleontologists have ever had such an all-encompassing command of a major group of fossils as Professor Carpenter's of the fossil insects. We are indeed privileged that he has found both the time and the energy over the years to compile this information and share it with the paleontological and entomological communities.

These volumes on the Hexapoda, the final section of Part R, are not a revision of previous work but are one of four remaining parts of the *Treatise* project that have not yet been covered for the first time. The others remaining to be done are Part B, Protista; Part J, Caenogastropoda; and Part M, Coleoidea, all of which are presently in preparation.

The fourth part of the arthropod *Treatise* has had a long history. Volumes 1 and 2, forming one unit, were published in 1969 and comprise an introduction to Hexapoda and an introduction and systematics sections on Onychophora, Crustacea other than Ostracoda, and Myriapoda. Volumes 3 and 4, originally planned for a single volume, cover the Hexapoda including, of course, the fossil insects, taxonomy of which fills most of the two volumes. The introduction to the insects is brief. The insects and their hexapod relatives are morphologically, physiologically, and ecologically quite complex organisms that abound in the modern world. Numerous excellent introductions are avail-

able. To reintroduce them here would require extensive duplication, and an adequate introductory section would be beyond the scope of the *Treatise on Invertebrate Paleontology*.

## 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, is undertaking a revision of the *Code* that will enhance nomenclatorial stability. Nevertheless, 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, 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 two 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 Linnean, 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 (Article 33). Not all original spellings are correct, just as is true of subsequent spellings.

### 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; and 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 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 a revised *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 altered terminations of adjectival specific names to agree in gender with associated generic names; 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 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 the

author has used only *nomen nudum* (plural *nomina nuda*, naked names). The reader is referred to *Part G Bryozoa (Revised)* of the *Treatise* and to the *Code* (Articles 10 to 20) for further details on availability of names. Here, besides the discussion of *nomina nuda* below, 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 (Articles 12 and 16) 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 substitutum*) of a preexisting available name (Article 13a), or (4) for genus-group names, were unaccompanied by definite fixation of a type species by original designation or indication (Article 13b). *Nomina nuda* have no status in nomenclature and 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 generally the oldest. 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, 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 an adjectival specific name 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*.

### 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: 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 assemblages, 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. Also, every family containing differ-

entiated subfamilies must have a nominotypical subfamily (*sensu stricto*), which is based on the same type genus as the family; and the author and date set down for the nominotypical 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 (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. 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 super-

family 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.

An example of the use of *nomen translatum* is the following.

**Family HEXAGENITIDAE** Lameere, 1917

[*nom. transl.* DEMOULIN, 1954, p. 566, *ex* Hexagenitinae LAMEERE, 1917, p. 74]

**Family-Group Names: Use of  
*nomen correctum***

Valid name changes classed as *nomina correctum* do not depend on transfer from one category of family-group units 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. P73, *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 (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; but, for subsequent application of the rule of priority, the name takes the date of the replaced name (see Recommendation 40A). Many family-group names that have been in use for a long time are *nomina nuda*, since they fail to satisfy criteria of availability (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. 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 unmentioned 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. 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 nomenclatural 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; superfamily Bellerophon-tacea McCoy, 1851; family Bellerophontidae McCoy, 1851). Family-group names are not coordinate with suprafamilial names.

3. The rules of priority and homonymy lack any force of international agreement as applied to suprafamilial names, yet in the interest of nomenclatural 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. O217, *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 an altered name (*nomen correctum*).

**Order DISPARIDA Moore & Laudon, 1943**  
[*nom. correct.* MOORE in MOORE, LALICKER, & FISCHER, 1952, p. 613, *pro* order Disparata MOORE & LAUDEN, 1943, p. 24]

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

**Order HYBOCRINIDA Jackel, 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 nominotypical 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 *et al.*, 1964, p. K128, *ex* order Endoceroidea TEICHERT, 1933, p. 214]

**Order ENDOCERIDA Teichert, 1933**  
[*nom. correct.* TEICHERT in TEICHERT *et al.*, 1964, p. K165, *pro* order Endoceroidea TEICHERT, 1933, p. 214]

**Suborder ENDOCERINA Teichert, 1933**  
[*nom. correct.*, TEICHERT in TEICHERT *et al.*, 1964, p. K165, *ex* Endoceratina SWEET, 1958, p. 33, suborder]

## TAXONOMIC EMENDATION

Emendation has two distinct meanings as regards zoological nomenclature. These are (1) alteration of a name itself in various ways for various reasons, as has been reviewed, and (2) alteration of the taxonomic scope or concept for which a name is used. The *Code*

(Article 33a and Glossary, p. 148) concerns itself only with the first type of emendation, applying the term to either justified or unjustified changes, both intentional, 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 assemblage of animals is incorporated into or removed from the coverage of 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 radical revisions are put forward, generally with published statement of reasons for changing the application of a name. To erect a signpost at such points of most significant change is worthwhile, both as aid to subsequent workers in taking account of the altered nomenclatural 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. H299]

Subfamily ROVEACRININAE Peck, 1943  
[Roveacrininae PECK, 1943, p. 465; *emend.*, PECK in MOORE & TEICHERT, eds. 1978, p. T921]

## STYLE IN GENERIC DESCRIPTIONS

### Citation of Type Species

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 and date of original publication. An exception in this procedure is made, however, 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 philipsi* 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; =*Lonsdalaeia floriformis* (MARTIN), 1809, pl. 43; validated by ICZN Opinion 419]

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 a figure caption.

### 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 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 and 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*, fixation of the type species 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 date of publishing 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 are 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* GÜRICH, 1896, p. 171 [\**Cyathophyl- lum 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 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 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-to-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. subst. pro*  
*Callophora* HALL, 1852, p. 144, *non* GRAY, 1848

In like manner, a needed replacement generic name 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. subst. 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 later-introduced name 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 are nomenclatural homonyms, based on the same type genus; and 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 R. & E. 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.

**Mackenziophyllum** 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* LINNÉ, 1758, p. 795, see SMITH & TREMBERTH, 1929, p. 368] [= *Patropontes* LANG & SMITH, 1927, p. 456 (type, *Madrepora truncata* LINNÉ, 1758, p. 795, OD); *Codonophyllum* LANG, SMITH, & THOMAS, 1940, p. 39, obj.]

Some junior synonyms of either the objective or the subjective sort may take precedence desirably 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 ICZN, which may use its plenary powers to set aside the unwanted name and validate the wanted one, with placement of the concerned names on appropriate official lists.

## MATTERS OF STYLE SPECIFIC TO THESE VOLUMES

### The Fossil Record of Hexapods

In spite of their being the most diverse group of organisms, the insects have a surprisingly poor fossil record. Their dominantly terrestrial mode of life and lack of mineralized skeletons have contributed to extensive taphonomic loss. Thus, whereas such *Treatise* volumes as Part Q, Ostracoda have sought to include all genera in the group whether or not they have a fossil record because of their potential for fossilization, to attempt to do so with the insects would be both beyond the scope of the *Treatise on Invertebrate Paleontology* and doomed to failure. Most of the recent genera of insects are not included

herein. In fact, a recent genus with no fossil record is included only if it is the type genus of a family that contains fossil forms. Moreover, for recent genera that have a fossil record, we do not indicate type species or give diagnoses. Instead, we give only the last name of their author, the date of publication, and the page number. Although full citations of these author-date combinations are not in the bibliography, subsequent references to the literature are included.

### Names of Taxa, Places, and Authors

Several matters relate specifically to the style of generic descriptions. Names of type species have been corrected only by having diacritical marks removed. For example, *Corydaloïdes* has been changed to *Corydaloides*. Throughout the text the author has used the solidus to indicate uncertainty with respect to age. "Oligo./Mio.," for example, indicates that the age of the genus is uncertain but is one of the two ages noted. The question mark is used when the age is still more uncertain.

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 two years have shown how rapidly geography can change, and in all likelihood we have not seen the last of such change. Throughout the text, the author has used the letters RSFSR to refer to the Russian Socialist Federated Soviet Republic with two parts, European and Asian, separated by the Ural Mountains. The RSFSR, of course, no longer exists as a political or geographical entity, but the strata containing fossil insects remain where they were. One expects confusion among readers in the future as they try to decipher such geographical terms as U.S.S.R. or Yugoslavia. Such confusion is unavoidable, as books must be completed



and published at some time. Our libraries would be small indeed if publication were always delayed until the world had settled down.

Chinese scientists have become increasingly active in systematic paleontology in the past two decades. Chinese names cause English-language bibliographers headaches 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, which is the most common family name in the world, 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 the Chinese author 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 to his work. It is entirely possible, therefore, that the publications of a Chinese author may be listed in more than one place in the bibliography.

Second, most but by no means all Chinese list their family name first followed by given names, but people with Chinese names who study in the West often reverse the order, putting the family name last. Thus, for example, Dr. Yi-Maw Chang, now on 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, and his subsequent bibliographic citations are listed as "Chang, Yi-Maw." The *Treatise* staff has adopted the convention of listing family names first, inserting a comma, and following this with given names or initials. We do this even for Chinese authors who have not reversed their names in the Western fashion.

Several specific systems exist for transliterating the Cyrillic alphabet into the Roman alphabet, so that this problem need not occur, for example, with names of Russian authors. We have adopted System II from J. Thomas Shaw's *Transliteration of Modern Russian for English-Language Publications*, which is the same as the Library of Congress system for transliteration of modern Russian with diacritical marks omitted.

### Stratigraphical Range Charts

Readers may notice that stratigraphical range charts in this volume are somewhat different from those in previous volumes. Charts in this volume were prepared using RangeChart, an unpublished computer-software program developed by Kenneth C. Hood and David W. Foster, both now with Exxon, when they were graduate students at The University of Kansas. RangeChart sorts the taxa by their ranges and the degree of certainty of those ranges and uses different weights of lines for different categories. A revised version of the program, RangeChart 2.0, is in preparation.

### Acknowledgments

The *Treatise* volumes on the Hexapoda have had a long history of development, having been the focus of Professor Carpenter's efforts with varying degrees of intensity since the early stages of the *Treatise* project. The staff of the Paleontological Institute has remained remarkably stable during the ensuing decades, but given the length of time quite a number of people have been involved with the volumes. They deserve special mention here, for without their efforts the *Treatise* project as a whole and these volumes specifically would not be what they are today. Not the least of these are the three previous Editors and Directors of the Paleontological Institute: the late Raymond C. Moore as well

as Curt Teichert and Richard A. Robison. The two previous Assistant Editors for Text, Lavon McCormick and Virginia Ashlock, and the previous Assistant Editor for Illustrations, Roger B. Williams, worked closely with Professor Carpenter on the volumes. The present Assistant Editor for Text, Elizabeth Brosius, and the Assistant Editor for Illustrations, Jane Priesner, have faced admirably the formidable task of moving the volumes through the final stages of editing and into and beyond the production phase. In this they have been ably assisted by Jill Hardesty with word processing; Jill Krebs with editorial backup; and Jack Keim with photography, layout, and preparation of range charts. Yi-Maw Chang, the remaining member of the Paleontological Institute staff, is involved with preparation of PaleoBank, the paleon-

tological data base for future *Treatise* volumes, and has not been closely involved with the hexapod *Treatise*. Margery Rowell edited the Russian titles in the bibliography, and Richard A. Leschen and George W. Byers, respectively, drew figures 173 and 204.

This Editorial Preface is an extensive revision of prefaces prepared for previous *Treatise* volumes by former editors, including the late Raymond C. Moore, 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.

Roger L. Kaesler  
Lawrence, Kansas  
May 1, 1992

## AUTHOR'S PREFACE

Nearly thirty years ago Professor Raymond Moore, then editor of the *Treatise on Invertebrate Paleontology*, invited me to prepare the volume on the Hexapoda. Following considerable correspondence with him, I decided to undertake that assignment, although no definite date was set for its completion. My start on the project was slow, mainly because I was shortly asked to serve in several administrative positions at Harvard University, in addition to my regular teaching schedule. Not until 1974, when I became professor *emeritus*, was I able to devote full time to the preparation of the volume. At that time previously submitted manuscript was revised, and the first draft of the manuscript was sent to the editorial office of the *Treatise* in 1982. It was decided to set the end of 1983 as the terminal date for literature citations, since there had been an unusual amount of literature on fossil insects published during the preceding twenty years

(1963 to 1983), and since a large part of that was in Russian and needed to be translated. In this connection I should mention that a bibliography of fossil insects, covering the years 1980 to 1990, is now in preparation by E. A. Jarzembowski and A. J. Ross (Booth Museum, Brighton, U. K.) and will be published in 1992 in *The Fossil Record* (eds., M. J. Benton & M. A. Whyte, Chapman & Hall, London).

I am deeply grateful to the editorial staff of the *Treatise*, especially to Elizabeth Brosius and Jane Priesner, for their indispensable assistance, particularly regarding the bibliography. I am equally indebted to Helen Vaitaitis, who has done all of the translating of the numerous Russian articles for me these many years. Dr. Laurie Burnham assisted me for several years with the preparation of the illustrations for the *Treatise*, and Dr. Curtis Sabrosky has provided helpful advice pertaining to special taxonomic problems. My

wife, Ruth Carpenter, has been very supportive in many ways and especially with the preparation of an index to the genera in the early stages of the manuscript. I acknowledge with gratitude the cooperation of the following museums in the United States and Europe that have placed type material at my disposal at the institutions or have loaned such specimens when needed: the United States National Museum (Washington), the Field Museum (Chicago), the British Museum,

Natural History (London), Museum d'Histoire Naturelle (Paris), and the Paleontological Institute (Moscow). Finally, I am indebted to our National Science Foundation for research grants that made these investigations possible.

Frank M. Carpenter  
Cambridge, Massachusetts  
January, 1992

### SOURCES OF ILLUSTRATIONS

Some illustrations in this volume are new. Where previously published illustrations are used, the author and date of publication are given in parentheses in the figure explanation. Full citation of the publication is provided in the references.

In addition to the citation of the publication, additional credit was requested by those who supplied the following illustrations. Figure 10 is reproduced with permission, from the Annual Review of Entomology, Vol. 26, ©1981 by Annual Reviews Inc. Figure 193,2 is reproduced with permission, from the Museum of Comparative Zoology, Harvard University, ©President and Fellows of Harvard College. The artists responsible for the illustrations reproduced from *The Insects of Australia* are F. Nanninga (Figure 79,2), N. Key (Figure 82,2), B. Rankin (Figure 132), S. Curtis (Figure 134), and T. Binder (Figure 217).

### 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 show the fairly coarse time resolution that is characteristic of the study of fossil hexapods.

#### CENOZOIC ERATHEM

##### Quaternary System

- Holocene Series
- Pleistocene Series

##### Tertiary System

- Pliocene Series
- Miocene Series
- Oligocene Series
- Eocene Series
- Paleocene Series

#### MESOZOIC ERATHEM

##### Cretaceous System

##### Jurassic System

##### Triassic System

#### PALEOZOIC ERATHEM

##### Permian System

##### Carboniferous System

- Upper Carboniferous Subsystem
- Lower Carboniferous Subsystem

##### Devonian System

##### Silurian System

##### Ordovician System

##### Cambrian System

#### PRECAMBRIAN (undifferentiated herein)

PART R  
ARTHROPODA 4

HEXAPODA

VOLUMES 3, 4

By FRANK M. CARPENTER

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