

TREATISE ON INVERTEBRATE PALEONTOLOGY

*Prepared under the Guidance of the
Joint Committee on Invertebrate Paleontology*

*Paleontological
Society*

*Society of Economic
Paleontologists and
Mineralogists*

*Palaeontographical
Society*

Directed and Edited by

RAYMOND C. MOORE
Assisted by CHARLES W. PITRAT

Part I

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MOLLUSCA—GENERAL FEATURES

SCAPHOPODA

AMPHINEURA

MONOPLACOPHORA

GASTROPODA—GENERAL FEATURES

ARCHAEOGASTROPODA AND SOME (MAINLY PALEOZOIC)

CAENO GASTROPODA AND OPISTHOBRANCHIA

J. BROOKES KNIGHT, L. R. COX, A. MYRA KEEN, A. G. SMITH, R. L. BATTEN,
E. L. YOCHELSON, N. H. LUDBROOK, ROBERT ROBERTSON, C. M. YONGE, and
R. C. MOORE

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The list of contributing authors is subject to change.

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ADDENDA (index).

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EDITORIAL PREFACE

The aim of the *Treatise on Invertebrate Paleontology*, as originally conceived and consistently pursued, is to present the most comprehensive and authoritative, yet compact statement of knowledge concerning invertebrate fossil groups that can be formulated by collaboration of competent specialists in seeking to organize what has been learned of this subject up to the mid-point of the present century. Such work has value in providing a most useful summary of the collective results of multitudinous investigations and thus should constitute an indispensable text and reference book for all persons who wish to know about remains of invertebrate organisms preserved in rocks of the earth's crust. This applies to neozoologists as well as paleozoologists and to beginners in study of fossils as well as to thoroughly trained, long-experienced professional workers, including teachers, stratigraphical geologists, and individuals engaged in research on fossil invertebrates. The making of a reasonably complete inventory of present knowledge of invertebrate paleontology may be expected to yield needed foundation for future research and it is hoped that the *Treatise* will serve this end.

The *Treatise* is divided into parts which bear index letters, each except the initial and concluding ones being defined to include designated groups of invertebrates. The chief purpose of this arrangement is to provide for independence of the several parts as regards date of publication, because it is judged desirable to print and distribute each segment as soon as possible after it is ready for press. Pages in each part will bear the assigned index letter joined with numbers beginning with 1 and running consecutively to the end of the part. When the parts ultimately are assembled into volumes, no renumbering of pages and figures is required.

The outline of subjects to be treated in connection with each large group of invertebrates includes (1) description of morphological features, with special reference to hard parts, (2) ontogeny, (3) classification, (4) geological distribution, (5) evolutionary trends and phylogeny, and (6) systematic description of genera, subgenera,

and higher taxonomic units. In general, paleoecological aspects of study are omitted or little emphasized because comprehensive treatment of this subject is being undertaken in a separate work, prepared under auspices of a committee of the United States National Research Council. A selected list of references is furnished in each part of the *Treatise*.

Features of style in the taxonomic portions of this work have been fixed by the Editor with aid furnished by advice from the Joint Committee on Invertebrate Paleontology representing the societies which have undertaken to sponsor the *Treatise*. It is the Editor's responsibility to consult with authors and co-ordinate their work, seeing that manuscript properly incorporates features of adopted style. Especially he has been called on to formulate policies in respect to many questions of nomenclature and procedure. The subject of family and subfamily names is reviewed briefly in a following section of this preface, and features of *Treatise* style in generic descriptions are explained.

A generous grant of \$35,000 has been made by the Geological Society of America for the purpose of preparing *Treatise* illustrations. Administration of expenditures has been in charge of the Editor and most of the work by photographers and artists has been done under his direction at the University of Kansas, but sizable parts of this program have also been carried forward in Washington and London.

FORM OF ZOOLOGICAL NAMES

Many questions arise in connection with the form of zoological names. These include such matters as adherence to stipulations concerning Latin or Latinized nature of words accepted as zoological names, gender of generic and subgeneric names, nominative or adjectival form of specific names, required endings for some family-group names, and numerous others. Regulation extends to capitalization, treatment of particles belonging to modern patronyms, use of neo-Latin letters, and approved methods for converting diacritical marks. The magnitude and complexities of nomenclature problems surely are enough to warrant the

complaint of those who hold that zoology is the study of animals rather than of names applied to them.

CLASSIFICATION OF ZOOLOGICAL NAMES

In accordance with the "Copenhagen Decisions on Zoological Nomenclature" (London, 135 p., 1953), zoological names may be classified usefully in various ways. The subject is summarized here with introduction of designations for some categories which the *Treatise* proposes to distinguish in systematic parts of the text for the purpose of giving readers comprehension of the nature of various names together with authorship and dates attributed to them.

CO-ORDINATE NAMES OF TAXA GROUPS

Five groups of different-rank taxonomic units (termed *taxa*, sing., *taxon*) are discriminated, within each of which names are treated as co-ordinate, being transferrable from one category to another without change of authorship or date. These are: (1) Species Group (subspecies, species); (2) Genus Group (subgenus, genus); (3) Family Group (tribe, subfamily, family, superfamily); (4) Order/Class Group (suborder, order, subclass, class); and (5) Phylum Group (subphylum, phylum). In the first 3 of these groups, but not others, the author of the first-published valid name for any taxon is held to be the author of all other taxa in the group which are based on the same nominate type and the date of publication for purposes of priority is that of the first-published name. Thus, if author A in 1800 introduces the family name X-idae to include 3 genera, one of which is X-us; and if author B in 1850 divides the 20 genera then included in X-idae into subfamilies called X-inae and Y-inae; and if author C in 1950 combines X-idae with other later-formed families to make a superfamily X-acea (or X-oidea, X-icae, etc.); the author of X-inae, X-idae and X-acea is A, 1800, under the Rules. Because taxonomic concepts introduced by authors B and C along with appropriate names surely are not attributable to author A, some means of recording responsibility of B and C are needed. This is discussed later in explaining proposed use of "*nom. transl.*"

The co-ordinate status of zoological names belonging to the species group is stipulated in Art. 11 of the present Rules; genus group in Art. 6 of the present Rules; family group in paragraph 46 of the Copenhagen Decisions; order/class group and phylum group in paragraphs 65 and 66 of the Copenhagen Decisions.

ORIGINAL AND SUBSEQUENT FORMS OF NAMES

Zoological names may be classified according to form (spelling) given in original publication and employed by subsequent authors. In one group are names which are entirely identical in original and subsequent usage. Another group comprises names which include with the original subsequently published variants of one sort or another. In this second group, it is important to distinguish names which are inadvertent changes from those constituting intentional emendations, for they have quite different status in nomenclature. Also, among intentional emendations, some are acceptable and some quite unacceptable under the Rules.

VALID AND INVALID NAMES

Valid names. A valid zoological name is one that conforms to all mandatory provisions of the Rules (Copenhagen Decisions, p. 43-57) but names of this group are divisible into subgroups as follows: (1) "*inviolate names,*" which as originally published not only meet all mandatory requirements of the Rules but are not subject to any sort of alteration (most generic and subgeneric names); (2) "*perfect names,*" which as they appear in original publication (with or without precise duplication by subsequent authors) meet all mandatory requirements and need no correction of any kind but which nevertheless are legally alterable under present Rules (as in changing the form of ending of a published class/order-group name); (3) "*imperfect names,*" which as originally published and with or without subsequent duplication meet mandatory requirements but contain defects such as incorrect gender of an adjectival specific name (for example, *Spironema recta* instead of *Spironema rectum*) or incorrect stem or form of ending of a family-group name (for example, Spironemidae instead

of Spironematidae); (4) “*transferred names*,” which are derived by valid emendation from either of the 2nd or 3rd subgroups or from a pre-existing transferred name (as illustrated by change of a family-group name from -inae to -idae or making of a superfamily name); (5) “*improved names*,” which include necessary as well as somewhat arbitrarily made emendations allowable under the Rules for taxonomic categories not now covered by regulations as to name form and alterations that are distinct from changes that distinguish the 4th subgroup (including names derived from the 2nd and 3rd subgroups and possibly some alterations of 4th subgroup names). In addition, some zoological names included among those recognized as valid are classifiable in special categories, while at the same time belonging to one or more of the above-listed subgroups. These chiefly include (7) “*substitute names*,” introduced to replace invalid names such as junior homonyms; and (8) “*conserved names*,” which are names that would have to be rejected by application of the Rules except for saving them in their original or an altered spelling by action of the International Commission on Zoological Nomenclature in exercising its plenary powers to this end. Whenever a name requires replacement, any individual may publish a “new name” for it and the first one so introduced has priority over any others; since newness is temporary and relative, the replacement designation is better called substitute name rather than new name. Whenever it is considered desirable to save for usage an otherwise necessarily rejectable name, an individual cannot by himself accomplish the preservation, except by unchallenged action taken in accordance with certain provisions of the Copenhagen Decisions; otherwise he must seek validation through ICZN.

It is useful for convenience and brevity of distinction in recording these subgroups of valid zoological names to introduce Latin designations, following the pattern of *nomen nudum*, *nomen novum*, etc. Accordingly, the subgroups are (1) *nomina inviolata* (sing., *nomen inviolatum*, abbr., *nom. inviol.*); (2) *nomina perfecta* (sing., *nomen perfectum*, abbr., *nom. perf.*); (3) *nomina imperfecta* (sing., *nomen imperfectum*,

abbr., *nom. imperf.*); (4) *nomina translata* (sing., *nomen translatum*, abbr., *nom. transl.*); (5) *nomina correctata* (sing., *nomen correctum*, abbr., *nom. correct.*); (6) *nomina substituta* (sing., *nomen substitutum*, abbr., *nom. subst.*); (7) *nomina conservata* (sing., *nomen conservatum*, abbr., *nom. conserv.*).

Invalid names. Invalid zoological names consisting of originally published names that fail to comply with mandatory provisions of the Rules and consisting of inadvertent changes in spelling of names have no status in nomenclature. They are not available as replacement names and they do not preoccupy for purposes of the Law of Homonymy. In addition to *nomen nudum*, invalid names may be distinguished as follows: (1) “*denied names*,” which consist of originally published names (with or without subsequent duplication) that do not meet mandatory requirements of the Rules; (2) “*null names*,” which comprise unintentional alterations of names; and (3) “*vain or void names*,” which consist of invalid emendations of previously published valid or invalid names. Void names do have status in nomenclature, being classified as junior synonyms of valid names.

Proposed Latin designations for the indicated kinds of invalid names are as follows: (1) *nomina negata* (sing., *nomen negatum*, abbr., *nom. neg.*); (2) *nomina nulla* (sing., *nomen nullum*, abbr., *nom. null.*); (3) *nomina vana* (sing., *nomen vanum*, abbr., *nom. van.*). It is desirable in the *Treatise* to identify invalid names, particularly in view of the fact that many of these names (*nom. neg.*, *nom. null.*) have been considered incorrectly to be junior objective synonyms (like *nom. van.*), which have status in nomenclature.

SUMMARY OF NAME CLASSES

Partly because only in such publications as the *Treatise* is special attention to classes of zoological names called for and partly because new designations are now introduced as means of recording distinctions explicitly as well as compactly, a summary may be useful. In the following tabulation valid classes of names are indicated in bold-face type, whereas invalid ones are printed in italics.

Definitions of Name Classes

- nomen conservatum (nom. conserv.).** Name otherwise unacceptable under application of the Rules which is made valid, either with original or altered spelling, through procedures specified by the Copenhagen Decisions or by action of ICZN exercising its plenary powers.
- nomen correctum (nom. correct.).** Name with intentionally altered spelling of sort required or allowable under the Rules but not dependent on transfer from one taxonomic category to another ("improved name"). (See Copenhagen Decisions, paragraphs 50, 71-2-a-i, 74, 75, 79, 80, 87, 101; in addition, change of endings for categories not now fixed by Rules.)
- nomen imperfectum (nom. imperf.).** Name that as originally published (with or without subsequent identical spelling) meets all mandatory requirements of the Rules but contains defect needing correction ("imperfect name"). (See Copenhagen Decisions, paragraphs 50-1-b, 71-1-b-i, 71-1-b-ii, 79, 80, 87, 101.)
- nomen inviolatum (nom. inviol.).** Name that as originally published meets all mandatory requirements of the Rules and also is uncorrectable or alterable in any way ("inviolate name"). (See Copenhagen Decisions, paragraphs 152, 153, 155-157.)
- nomen negatum (nom. neg.).** Name that as originally published (with or without subsequent identical spelling) constitutes invalid original spelling and although possibly meeting all other mandatory requirements of the Rules, is not correctable to establish original authorship and date ("denied name"). (See Copenhagen Decisions, paragraph 71-1-b-iii.)
- nomen nudum (nom. nud.).** Name that as originally published (with or without subsequent identical spelling) fails to meet mandatory requirements of the Rules and having no status in nomenclature, is not correctable to establish original authorship and date ("naked name"). (See Copenhagen Decisions, paragraph 122.)
- nomen nullum (nom. null.).** Name consisting of an unintentional alteration in form (spelling) of a previously published name (either valid name, as *nom. inviol.*, *nom. perf.*, *nom. imperf.*, *nom. transl.*; or invalid name, as *nom. neg.*, *nom. nud.*, *nom. van.*, or another *nom. null.*) ("null name"). (See Copenhagen Decisions, paragraphs 71-2-b, 73-4.)
- nomen perfectum (nom. perf.).** Name that as originally published meets all mandatory requirements of the Rules and needs no correction of any kind but which nevertheless is validly alterable ("perfect name").
- nomen substitutum (nom. subst.).** Replacement name published as substitute for an invalid name, such as a junior homonym (equivalent to "new name").
- nomen translatum (nom. transl.).** Name that is derived by valid emendation of a previously

published name as result of transfer from one taxonomic category to another within the group to which it belongs ("transferred name").

nomen vanum (nom. van.). Name consisting of an invalid intentional change in form (spelling) from a previously published name, such invalid emendations having status in nomenclature as junior objective synonyms ("vain or void name"). (See Copenhagen Decisions, paragraphs 71-2-a-ii, 73-3.)

Except as specified otherwise, zoological names accepted in the *Treatise* may be understood to be classifiable either as *nomina inviolata* or *nomina perfecta* (omitting from notice *nomina correctata* among specific names) and these are not discriminated. Names which are not accepted for one reason or another include junior homonyms, a few senior synonyms classifiable as *nomina negata* or *nomina nuda*, and numerous junior synonyms which include both objective (*nomina vana*) and subjective (all classes of valid names) types; effort to classify the invalid names as completely as possible is intended.

NAME CHANGES IN RELATION TO GROUP CATEGORIES

SPECIFIC AND SUBSPECIFIC NAMES

Detailed consideration of valid emendation of specific and subspecific names is unnecessary here because it is well understood and relatively inconsequential. When the form of adjectival specific names is changed to obtain agreement with the gender of a generic name in transferring a species from one genus to another, it is never needful to label the changed name as a *nom. transl.* Likewise, transliteration of a letter accompanied by a diacritical mark in manner now called for by the Rules (as in changing originally published *bröggeri* to *broeggeri*) or elimination of a hyphen (as in changing originally published *cornuoryx* to *cornuoryx* does not require "*nom. correct.*" with it. Revised provisions for emending specific and subspecific names are stated in the report on Copenhagen Decisions (p. 43-46, 51-57).

GENERIC AND SUBGENERIC NAMES

So rare are conditions warranting change of the originally published valid form of generic and subgeneric names that lengthy discussion may be omitted. Only elimi-

nation of diacritical marks of some names in this category seems to furnish basis for valid emendation. It is true that many changes of generic and subgeneric names have been published, but virtually all of these are either *nomina vana* or *nomina nulla*. Various names which formerly were classed as homonyms are not now, for two names that differ only by a single letter (or in original publication by presence or absence of a diacritical mark) are construed to be entirely distinct. Revised provisions for emendation of generic and subgeneric names also are given in the report on Copenhagen Decisions (p. 43-47).

Examples in use of classificatory designations for generic names as previously given are the following, which also illustrate designation of type species, as explained later.

Kurnatiophyllum THOMSON, 1875 [**K. concentricum*; SD GREGORY, 1917] [=*Kumatiophyllum* THOMSON, 1876 (*nom. null.*); *Cymatiophyllum* THOMSON, 1901 (*nom. van.*); *Cymatiophyllum* LANG, SMITH & THOMAS, 1940 (*nom. van.*)].

Stichophyma POMEL, 1872 [**Manon turbinatum* RÖMER, 1841; SD RAUFF, 1893] [=*Stychophyma* VOSMAER, 1885 (*nom. null.*); *Sticophyma* MORET, 1924 (*nom. null.*)].

Stratophyllum SMYTH, 1933 [**S. tenue*] [=*Ethmoplax* SMYTH, 1939 (*nom. van. pro Stratophyllum*); *Stratophyllum* LANG, SMITH & THOMAS, 1940 (*nom. van. pro Stratophyllum* SMYTH) (*non Stratophyllum* SCHEFFEN, 1933)].

Placotelia OPPLIGER, 1907 [**Porostoma marconi* FROMENTEL, 1859; SD DELAUBENFELS, herein] [=*Plakotelia* OPPLIGER, 1907 (*nom. neg.*)].

Walcottella DELAUB., *nom. subst.*, 1955 [*pro Rhopalicus* SCHRAMM., 1936 (*non FÖRSTER*, 1856)].

Cyrtograptus CARRUTHERS, 1867 [*nom. correct.* LAPWORTH, 1873 (*pro Cyrtograpsus* CARRUTHERS, 1867), *nom. conserv.* proposed BULMAN, 1955 (ICZN pend.)]

FAMILY-GROUP NAMES; USE OF "NOM.
TRANSL."

The Rules now specify the form of endings only for subfamily (-inae) and family (-idae) but decisions of the Copenhagen Congress direct classification of all family-group assemblages (taxa) as co-ordinate, signifying that for purposes of priority a name published for a unit in any category and based on a particular type genus shall date from its original publication for a unit in any category, retaining this priority (and

authorship) when the unit is treated as belonging to a lower or higher category. By exclusion of -inae and -idae, respectively reserved for subfamily and family, the endings of names used for tribes and superfamilies must be unspecified different letter combinations. These, if introduced subsequent to designation of a subfamily or family based on the same nominate genus, are *nomina translata*, as is also a subfamily that is elevated to family rank or a family reduced to subfamily rank. In the *Treatise* it is desirable to distinguish the valid emendation comprised in the changed ending of each transferred family group name by the abbreviation "*nom. transl.*" and record of the author and date belonging to this emendation. This is particularly important in the case of superfamilies, for it is the author who introduced this taxon that one wishes to know about rather than the author of the superfamily as defined by the Rules, for the latter is merely the individual who first defined some lower-rank family-group taxon that contains the nominate genus of the superfamily. The publication of the author containing introduction of the superfamily *nomen translatum* is likely to furnish the information on taxonomic considerations that support definition of the unit.

Examples of the use of "*nom. transl.*" are the following.

Subfamily STYLININAE d'Orbigny, 1851

[*nom. transl.* EDWARDS & HAIME, 1857 (*ex Stylinidae* d'ORBIGNY, 1851)]

Superfamily ARCHAEOCTONOIDEA
Petrunkevitch, 1949

[*nom. transl.* PETRUNKEVITCH, herein (*ex Archaeoctonidae* PETRUNKEVITCH, 1949)]

Superfamily CRIOCERATITACEAE Hyatt, 1900

[*nom. transl.* WRIGHT, 1952 (*ex Crioceratitidae* HYATT, 1900)]

FAMILY-GROUP NAMES; USE OF "NOM.
CORRECT."

Valid emendations classed as *nomina correctae* do not depend on transfer from one category of family-group units to another but most commonly involve correction of the stem of the nominate genus; in addition, they include somewhat arbitrarily chosen modification of ending for names of tribe

or superfamily. Examples of the use of “*nom. correct.*” are the following.

Family STREPTELASMATIDAE Nicholson, 1889

[*nom. correct.* WEDEKIND, 1927 (*ex* Streptelasmidae NICHOLSON, 1889, *nom. imperf.*)]

Family PALAEOSCORPIIDAE Lehmann, 1944

[*nom. correct.* PETRUNKEVITCH, *herein* (*ex* Palaescorpioidae LEHMANN, 1944, *nom. imperf.*)]

Family AGLASPIDIDAE Miller, 1877

[*nom. correct.* STØRMER, *herein* (*ex* Aglaspidae MILLER, 1877, *nom. imperf.*)]

Superfamily AGARICICAE Gray, 1847

[*nom. correct.* WELLS, *herein* (*ex* Agaricioideae VAUGHAN & WELLS, 1943, *nom. transl. ex* Agaricidae GRAY, 1847)]

FAMILY-GROUP NAMES; USE OF “*NOM. CONSERV.*”

It may happen that long-used family-group names are invalid under strict application of the Rules. In order to retain the otherwise invalid name, appeal to ICZN is needful. Examples of use of *nom. conserv.* in this connection, as cited in the *Treatise*, are the following.

Family ARIETITIDAE Hyatt, 1874

[*nom. correct.* HAUG, 1885 (*pro* Arietidae HYATT, 1875), *nom. conserv.* proposed ARKELL, 1955 (ICZN pend.)]

**Family STEPHANOCERATIDAE
Neumayr, 1875**

[*nom. correct.* FISCHER, 1882 (*pro* Stephanoceratinen NEUMAYR, 1875, invalid vernacular name), *nom. conserv.* proposed ARKELL, 1955 (ICZN pend.)]

FAMILY-GROUP NAMES; REPLACEMENTS

Family-group names are formed by adding letter combinations (prescribed for family and subfamily but not now for others) to the stem of the name belonging to genus (nominate genus) first chosen as type of the assemblage. The type genus need not be the oldest in terms of receiving its name and definition, but it must be the first-published as name-giver to a family-group taxon among all those included. Once fixed, the family-group name remains tied to the nominate genus even if its name is changed by reason of status as a junior homonym or junior synonym, either objective or subjective. According to the Copenhagen Decisions, the family-group name requires replacement only in the event that the nominate genus is found to be a junior

homonym, and then a substitute family-group name is accepted if it is formed from the oldest available substitute name for the nominate genus. Authorship and date attributed to the replacement family-group name are determined by first publication of the changed family-group name.

The aim of family-group nomenclature is greatest possible stability and uniformity, just as in case of other zoological names. Experience indicates the wisdom of sustaining family-group names based on junior subjective synonyms if they have priority of publication, for opinions of different workers as to the synonymy of generic names founded on different type species may not agree and opinions of the same worker may alter from time to time. The retention similarly of first-published family-group names which are found to be based on junior objective synonyms 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 much-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. Conversely, a long-used family-group name founded on a junior objective synonym and having priority of publication is better continued in nomenclature than a replacement name based on the senior objective synonym. The Copenhagen Decisions (paragraph 45) take account of these considerations by providing a relatively simple procedure for fixing the desired choice in stabilizing family-group names. In conformance with this, the *Treatise* assigns to contributing authors responsibility for adopting provisions of the Copenhagen Decisions.

Replacement of a family-group name may be needed if the former nominate genus is transferred to another family-group. Then the first-published name-giver of a family-group assemblage in the remnant taxon is to be recognized in forming a replacement name.

**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 for 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 differentiated subfamilies must have a nominate (*sensu stricto*) subfamily, which is based on the same type genus as that for the family, and the author and date set down for the nominate subfamily invariably are identical with those of the family, without reference to whether the author of the family or some subsequent author introduced subdivisions.

Changes in the form of family-group names of the sort constituting *nomina correctae*, as previously discussed, do not affect authorship and date of the taxon concerned, but in publications such as the *Treatise* it is desirable to record the authorship and date of the correction.

ORDER/CLASS-GROUP NAMES; USE OF "NOM. CORRECT."

Because no stipulation concerning the form of order/class-group names is given yet by the Rules, emendation of all such names actually consists of arbitrarily devised changes in the form of endings. Nothing precludes substitution of a new name for an old one, but a change of this sort is not considered to be an emendation. Examples of the use of "*nom. correct.*" as applied to order/class-group names are the following.

Order DISPARIDA Moore & Laudon, 1943

[*nom. correct.* MOORE, 1952 (*ex* Disparata MOORE & LAUDON, 1943)]

Suborder FAVIINA Vaughan & Wells, 1943

[*nom. correct.* WELLS, *herein* (*ex* Faviida VAUGHAN & WELLS, 1943)]

Suborder FUNGIINA Verrill, 1865

[*nom. correct.* WELLS, *herein* (*ex* Fungiida DUNCAN, 1884, *ex* Fungacea VERRILL, 1865)]

TAXONOMIC EMENDATION

Emendation has two measurably distinct aspects as regards zoological nomenclature. These embrace (1) alteration of a name itself in various ways for various reasons, as has been reviewed, and (2) alteration of

taxonomic scope or concept in application of a given zoological name, whatever its hierarchical rank. The latter type of emendation primarily concerns classification and inherently is not associated with change of name, whereas the other type introduces change of name without necessary expansion, restriction, or other modification in applying the name. Little attention generally has been paid to this distinction in spite of its significance.

Most zoologists, including paleozoologists, who have signified emendation of 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 may accompany the name, with statement of the author and date of the emendation. On the other hand, a multitude of workers concerned with systematic zoology think that publication of "*emend.*" with a zoological name is valueless because more or less alteration of taxonomic sort is introduced whenever a subspecies, species, genus, or other assemblage of animals is incorporated under or removed from the coverage of a given zoological name. 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 worth while, both as aid to subsequent workers in taking account of the altered nomenclatural usage and as indication that not-to-be-overlooked discussion may be found at a particular place in the literature. Authors of contributions to the *Treatise* are encouraged to include records of all specially noteworthy emendations of this nature, using the abbreviation "*emend.*" with the name to which it refers and citing the author and date of the emendation.

In Part G (Bryozoa) and Part D (Protista 3) of the *Treatise*, the abbreviation "*emend.*" is employed to record various sorts of name emendations, thus conflicting with usage of "*emend.*" for change in taxonomic application of a name without

alteration of the name itself. This is objectionable. In Part E (Archaeocyatha, Porifera) and later-issued divisions of the *Treatise*, use of "emend." is restricted to its customary sense, that is, significant alteration in taxonomic scope of a name such as calls for noteworthy modifications of a diagnosis. Other means of designating emendations that relate to form of a name are introduced.

STYLE IN GENERIC DESCRIPTIONS

DEFINITION OF NAMES

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 2 or more distinct taxonomic units, however, it is necessary to differentiate such homonyms, and 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, *Callopora* HALL, 1851, introduced for Paleozoic trepostome bryozoans, is invalid because GRAY in 1848 published the same name for Cretaceous-to-Recent cheilostome bryozoans, and BASSLER in 1911 introduced the new name *Hallopora* to replace HALL's homonym. The *Treatise* style of entry is:

Hallopora BASSLER, 1911 [*pro Callopora* HALL, 1851 (*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 avoided). The requirement that an exact bibliographic reference must be given for the replaced name commonly can be met in the *Treatise* by citing a publication recorded in the list of references, using its assigned index number, as shown in the following example.

Mysterium DELAUBENFELS, *nom. subst.* [*pro Mysterium* SCHRAMMEN, 1936 (ref. 40, p. 60) (*non* ROGER, 1862)] [**Mysterium porosum* SCHRAMMEN, 1936].

For some replaced homonyms, a footnote reference to the literature is necessary. A senior homonym is valid, and in so far as

the *Treatise* is concerned, such names are handled according to whether the junior homonym belongs to the same major taxonomic division (class or phylum) as the senior homonym or to some other; in the former instance, the author and date of the junior homonym are cited as:

Diplophyllum HALL, 1851 [*non* SOSHKINA, 1939] [**D. caespitosum*].

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

CITATION OF TYPE SPECIES

The name of the type species of each genus and subgenus is given next following the generic name with its accompanying author and date, or after entries needed for definition of the name if it is involved in homonymy. The originally published combination of generic and trivial names for 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 which it serves as type; in such case, the initial letter of the generic name followed by the trivial name is given without repeating the name of the author and date, for this saves needed space. Examples of these 2 sorts of citations are as follows:

Diplotrypa NICHOLSON, 1879 [**Favosites petropoli-tanus* PANDER, 1830].

Chainodictyon FOERSTE, 1887 [**C. laxum*].

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

Accervularia SCHWEIGGER, 1819 [**A. baltica* (= **Madrepora ananas* LINNÉ, 1758)].

It is judged desirable to record the manner of establishing the type species, whether by original designation or by subsequent designation, but various modes of original designation are not distinguished.

Original designation of type species. The Rules provide that the type species of a genus or subgenus may be recognized as an original designation if only a single species was assigned to the genus at the time of first publication (monotypy), if the author of a generic name employed this same name for one of the included species (tautonymy), if

one of the species was named “*typus*,” “*typicus*,” or the like, if the original author explicitly indicated the species chosen as the type, or if some other stipulations were met. According to convention adopted in the *Treatise*, the absence of any indication as to manner of fixing the type species is to be understood as signifying that it is established by original designation, the particular mode of original designation not being specified.

Subsequent designation of type species; use of “SD” and “SM.” 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, and 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 and 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 and in the *Treatise* this subsequent monotypy is indicated by the letters “SM.” Of course, the first publication containing assignment of species to the genus which originally lacked any included species is the one concerned in fixation of the type species, and if this named 2 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” and “SM” are employed in the *Treatise* follow.

Hexagonaria GÜRICH, 1896 [**Cyathophyllum hexagonum* GOLDFUSS, 1826; SD LANG, SMITH & THOMAS, 1940].

Muriceides STUDER, 1887 [**M. fragilis* WRIGHT & STUDER, 1889; SM WRIGHT & STUDER, 1889].

SYNONYMS

Citation of synonyms is given next following record of the type species and if 2

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. Examples showing *Treatise* style in listing synonyms follow.

Calapocia BILLINGS, 1865 [**C. anticostiensis*; SD LINDSTRÖM, 1833] [= *Columnopora* NICHOLSON, 1874; *Houghtonia* ROMINGER, 1876].

Staurocyclia HAECKEL, 1882 [**S. cruciata* HAECKEL, 1887] [= *Coccostaurus* HAECKEL, 1882 (obj.); *Phacostaurus* HAECKEL, 1887 (obj.)].

A synonym which also constitutes a homonym is recorded as follows:

Lyopora NICHOLSON & ETHERIDGE, 1878 [**Palaeopora? favosa* M’COY, 1850] [= *Liopora* LANG, SMITH & THOMAS, 1940 (*non* GIRTY, 1915)].

Some junior synonyms of either objective or subjective sort may take precedence desirably over senior synonyms wherever uniformity and continuity of nomenclature are served by retaining a widely used but technically rejectable name for a generic assemblage. This requires action of ICZN using its plenary powers to set aside the unwanted name and validate the wanted one, with placement of the concerned names on appropriate official lists. In the *Treatise* citation of such a conserved generic name is given in the manner shown by the following example.

Tetragraptus SALTER, 1863 [*nom. correct.* HALL, 1865 (*pro Tetragrapsus* SALTER, 1863), *nom. conserv.* proposed BULMAN, 1955, ICZN pend.] [**Fucoides serra* BRONGNIART, 1828 (= *Graptolithus bryonoides* HALL, 1858)].

ABBREVIATIONS

A few author’s names and most stratigraphic and geographic names are abbreviated in order to save space. General principles for guidance in determining what names should be abbreviated are frequency of repetition, length of name, and avoidance of ambiguity. Abbreviations used in this division of the *Treatise* are explained in the following alphabetically arranged list.

Abbreviations

Aalen. , Aalenian	cour. , courant	K. , Kaiserlich
Abhandl. , Abhandlungen	Cret. , Cretaceous	Kais. , Kaiserlich
Abt. , Abteilung, -en	Czech. , Czechoslovakia	Kan. , Kansas
Acad. , Academia, Académie, Academy	Dan. , Danian	Kimm. , Kimmeridgian
Afr. , Africa, -an	Denkschr. , Denkschriften	Kgl. , Königlich
Agric. , Agriculture, -al	Denm. , Denmark	Komm. , Kommissionen
Akad. , Akademie	Dept. , Department, -s	kön. , königlich
Ala. , Alabama	deutsch. , deutschen	Kunigl. , Kongliga
Alb. , Albanian	Dev. , Devonian	Ky. , Kentucky
Alba. , Alberta	Dict. , Dictionnaire	L. , Lower, Land
Am. , America, -n	E. , East	Ladin. , Ladinian
Anat. , Anatomic	ed. , edition, editor	Landesanst. , Landesanstalt
Anis. , Anisian	e.g. , <i>exempli gratia</i> (for example)	lat. , lateral
Ann. , Annal, -s, Annual	Eng. , England	Lias. , Liassic
Antarct. , Antarctic	Eoc. , Eocene	Lief. , Lieferung, -en
App. , Appendix	Ergebn. , Ergebnisse	Linn. , Linnean, Linnéene
Apt. , Aptian	Est. , Estonia	livr. , livre, -s
Arch. , Archipelago, Archiv	etc. , et cetera	Ls. , Limestone
Arct. , Arctic	Eu. , Europe	M. , Middle
Arenig. , Arenigian	expériment. , expérimentale	Maastricht. , Maastrichtian
Arg. , Argentina	Explor. , Exploration	Mag. , Magazine
Argov. , Argovian	f., för, für	Malac. , Malacological
Ariz. , Arizona	F. , Formation	Malacol. , Malacology
Ark. , Arkansas	Fac. , Facultad, Faculté, Faculty	malak. , malakologisch
Årssk. , Årsskrift	fasc. , fascicle	Man. , Manitoba, Manual
Art. , Article	fig. , figure, -s	Mass. , Massachusetts
Assoc. , Association	Fla. , Florida	Md. , Maryland
Atl. , Atlantic	Förhandl. , Förhandlingar, -er	Med. , Medicine, Medizin
Auctt. , Auctores	Fortschr. , Fortschritte	Meddel. , Meddelelser
Aus. , Austria	Fr. , France, Française, -e, French	Medit. , Mediterranean
Austral. , Australia	Fysiogr. , Fysiografiska	Mem. , Memoir, -s, Memoria
Baj. , Bajocian	G.Brit. , Great Britain	Mém. , Mémoire, -s
Barrem. , Barremian	Geogr. , Geographic, -al	Mex. , Mexico
Bathon. , Bathonian	Geol. , Geologiá, Geological, Geo- logico, Geologie, Geologisch, Geologiska, Geology	Micr. , Microscopical
B.C. , British Columbia	Géol. , Géologie, Géologique	Mineral. , Mineralogical, Min- rale, Mineralogisch, -e
Belg. , Belgique, Belgium	Ger. , Germany	Minn. , Minnesota
Biol. , Biological, Biology	Gesell. , Gesellschaft	Mio. , Miocene
Blackriv. , Blackriveran	Gotl. , Gotland	Misc. , Miscellaneous
Bol. , Boletín, Bolivia	Gr. , Group	Miss. , Mississippi, Mississippian
Brit. , Britain, British	Greenl. , Greenland	Mittel. , Mitteilungen
Bull. , Bulletin	Handb. , Handbuch	mm. , millimeter
Bur. , Bureau	Handl. , Handlingar	Mo. , Missouri
Burdigal. , Burdigalian	Havunders. , Havundersøgelser	Mon. , Monograph
C. , Central	Hemi. , Hemisphere	Morphol. , Morphology, -ic
ca. , circa	Hist. , Histoire, -ia; Historia, History	MS. , Manuscript
Cab. , Cabinet	Hofmus. , Hofmuseums	Mus. , Musée, Museo, Museum
Calif. , California	Hung. , Hungarica, Hungary	n. , new
Callov. , Callovian	I. (Is.) , Island, -s	N. , North
Cam. , Cambrian	ICZN , International Commission on Zoological Nomenclature	N.Am. , North America
Campan. , Campanian	i.e. , id est (that is)	Nat. , Natural; Naturale, -s; Nat- urali; Naturelle, -s
Can. , Canada	Ill. , Illinois	Natl. , National
Carb. , Carboniferous	illus. , illustration, -s	naturforsch. , naturforschende
Carib. , Caribbean	in. , inches	Naturhist. , Naturhistorie, -ischen
Carn. , Carnian	Ind. , Indiana	Naturwiss. , Naturwissenschaft, -liche
Cenom. , Cenomanian	Inst. , Institut, Institute, Institutet, Institution, Instituto, Instituut	NC. , North Central
c.f. , confero (compare)	intermed. , intermediate	N.Car. , North Carolina
chirur. , chirurgisch	Ire. , Ireland	NE. , Northeast
Coll. , Collection, -s; College	Jahrb. , Jahrbuch	Neb. , Nebraska
Colo. , Colorado	Jahrg. , Jahrgang	Neocom. , Neocomian
Comp. , Comparative	Jour. , Journal	Neog. , Neogene
Conch. , Conchology	Jur. , Jurassic	Nev. , Nevada
Conchyl. , Conchylologie		Newf. , Newfoundland
Coniac. , Coniacian		
Contr. , Contribution, -s		
cosmop. , cosmopolitan		

no., number, -s; **numéro**, -s;
 número, -s
nom. correct., nomen correctum
nom. nov., nomen novum
nom. null., nomen nullum
nom. subst., nomen substitum
nom. transl., nomen translatum
Nor., Norway
N.S.W., New South Wales
NW., Northwest
N.Y., New York
N.Z., New Zealand
obj., objective
Okla., Oklahoma
Oligo., Oligocene
Ont., Ontario
Ord., Ordovician
Oxford., Oxfordian
p., page, -s
Pa., Pennsylvania
Pac., Pacific
Paläont., Paläontologie, Paläontol-
 ogisch
Palaeont., Palaeontologia
Palaeontogr., Palaeontographia,
 Palaeontographica, Palaeon-
 tographical
Paleoc., Paleocene
Paléont., Paléontologie
pend., pending
Penn., Pennsylvanian
Perm., Permian
philomat., philomathique
Philos., Philosophical
Phys., Physique, Physikalische
pl., plates, -s
Pleist., Pleistocene
Plio., Pliocene
Portland., Portlandian
Preuss., Preussische
Proc., Proceedings
pt., part, -s
Pub., Publication

Pubbl., Pubblicazioni
Publ., Publication
Quart., Quarterly
Que., Quebec
Queensl., Queensland
Raurac., Rauracian
Rec., Recent
reconstr., reconstructed, -ion
ref., reference
Reichsanst., Reichsanstalt
Rept., Report, -s
Rhaet., Rhaetian
Roy., Royal, -e
Russ., Russia
S., South; Sea
S.Am., South America
Sarmat., Sarmatian
SC., South Central
Sci., Sciences, Scientifique
Scot., Scotland
SD, subsequent designation
SE., Southeast
sec., seciton, -s
Selsk., Selskabs
Senon., Senonian
ser., series, serial
sér., série
Sib., Siberia
Sil., Silurian
Sitzungsber., Sitzungsberichte
Skr., Skrifter
Smithson., Smithsonian
Soc., Sociedad, Società, Société,
 Society
Sp., Spain
sp., species
spp., species (plural)
Spec., Special
s.s., sensu stricto
SSSR, Soiuз Sovetskikh Sotsiali-
 sticheskikh Respublik
Staz., Stazione

subtrop., subtropical
Suppl., Supplement
SW., Southwest
Swed., Sweden, Swedish
Switz., Switzerland
Tasm., Tasmania
tech., technical
Tenn., Tennessee
Tert., Tertiary
Tex., Texas
Tithon., Tithonian
Tournais., Tournaisian
Trans., Transactions
transv., transverse
Trias., Triassic
trop., tropical
Turon., Turonian
u., und
U., Upper
Univ., Universidad, Università,
 Université, Universitets, Uni-
 versity
U.S., United States
USA, United States (America)
USSR, Union of Soviet Socialist
 Republics
v., volume, -s
Va., Virginia
Ver., Verein
Verhandl., Verhandlung, -en
Vetenskapsak., Vetenskapsakade-
 miens
Videnskab., Videnskabernes
Vt., Vermont
W., West
Wis., Wisconsin
Wiss., Wissenschaften
Wyo., Wyoming
z., zone
Zeitschr., Zeitschrift
Zool., Zoologi, Zoologia, Zoo-
 logical, Zoologie, Zoologisch,
 Zoologiska

REFERENCES TO LITERATURE

Each part of the *Treatise* is accompanied by a selected list of references to paleontological literature consisting primarily of recent and comprehensive monographs available but also including some older works recognized as outstanding in importance. The purpose of giving these references is to aid users of the *Treatise* in finding detailed descriptions and illustrations of morphological features of fossil groups, discussions of classifications and distribution, and especially citations of more or less voluminous literature. Generally speaking, publications listed in the *Treatise* are not original sources of inform-

ation concerning taxonomic units of various rank but they tell the student where he may find them; otherwise it is necessary to turn to such aids as the *Zoological Record* or NEAVE'S *Nomenclator Zoologicus*. References given in the *Treatise* are arranged alphabetically by authors and accompanied by index numbers which serve the purpose of permitting citation most concisely in various parts of the text; these citations of listed papers are inclosed invariably in parentheses and are distinguishable from dates because the index numbers comprise no more than 3 digits. Ordinarily, index numbers for literature references are given at the end of generic or family diagnoses.

SOURCES OF ILLUSTRATIONS

At the end of figure captions an index number is given to supply record of the author of illustrations used in the *Treatise*, reference being made to an alphabetically arranged list of authors' names which follows. The names of authors, but generally not individual publications, are cited. Illustrations consisting of exact copies of previously published figures (except for possible

change of scale) are distinguished by the use of an asterisk (*) with the index number, and previously unpublished illustrations are marked by the letter "n" (signifying "new") with the index number; all other indications of the sources of illustrations are construed to mean "after" the cited author or authors, that is, embodying some degree of change. Addition of the abbreviation "mod." denotes appreciable alteration of the source figure.

STRATIGRAPHIC DIVISIONS

Classification of rocks forming the geologic column as commonly cited in the *Treatise* in terms of units defined by concepts of time is reasonably uniform and firm throughout most of the world as regards major divisions (e.g., series, systems, and rocks representing eras) but it is variable and unfirm as regards smaller divisions (e.g., substages, stages, and subseries),

which are provincial in application. Users of the *Treatise* have suggested the desirability of publishing reference lists showing the stratigraphic arrangement of at least the most commonly cited divisions. Accordingly, a tabulation of European and North American units, which broadly is applicable also to other continents, is given here.

Generally Recognized Divisions of Geologic Column

EUROPE ROCKS OF CENOZOIC ERA

NEOGENE SYSTEM¹

Pleistocene Series (including Recent)
Pliocene Series
Miocene Series

PALEOGENE SYSTEM

Oligocene Series
Eocene Series
Paleocene Series

ROCKS OF MESOZOIC ERA

CRETACEOUS SYSTEM

Upper Cretaceous Series

Maastrichtian Stage²
Campanian Stage³
Santonian Stage²
Coniacian Stage²
Turonian Stage
Cenomanian Stage

Lower Cretaceous Series

Albian Stage
Aptian Stage

NORTH AMERICA ROCKS OF CENOZOIC ERA

NEOGENE SYSTEM¹

Pleistocene Series (including Recent)
Pliocene Series
Miocene Series

PALEOGENE SYSTEM

Oligocene Series
Eocene Series
Paleocene Series

ROCKS OF MESOZOIC ERA

CRETACEOUS SYSTEM

Gulfian Series (Upper Cretaceous)

Navarroan Stage
Tayloran Stage
Austinian Stage

Woodbinian (Tuscaloosan) Stage
Comanchean Series (Lower
Cretaceous)
Washitan Stage

Fredericksburgian Stage
Trinitian Stage

Coahuilan Series (Lower Cretaceous)

Barremian Stage³
Hauterivian Stage³
Valanginian Stage³
Berriasian Stage³

JURASSIC SYSTEM

Upper Jurassic Series
Portlandian Stage⁴
Kimmeridgian Stage
Oxfordian Stage

Middle Jurassic Series

Callovian Stage
Bathonian Stage
Bajocian Stage

Lower Jurassic Series (Liassic)

Toarcian Stage
Pliensbachian Stage
Sinemurian Stage
Hettangian Stage

TRIASSIC SYSTEM

Upper Triassic Series

Rhaetian Stage⁵
Norian Stage
Carnian Stage

Middle Triassic Series

Ladinian Stage
Anisian Stage (Virgilorian)

Lower Triassic Series

Scythian Series (Werfenian)

ROCKS OF PALEOZOIC ERA

PERMIAN SYSTEM

Upper Permian Series

Tartarian Stage⁶

Middle Permian Series

Kazanian Stage⁷
Kungurian Stage
Artinskian Stage⁸

Lower Permian Series

Sakmarian Stage

CARBONIFEROUS SYSTEM

Upper Carboniferous Series

Stephanian Stage

Westphalian Stage

Namurian Stage

Nuevoleonian Stage

Durangoan Stage

JURASSIC SYSTEM

Upper Jurassic Series
Portlandian Stage
Kimmeridgian Stage
Oxfordian Stage

Middle Jurassic Series

Callovian Stage
Bathonian Stage
Bajocian Stage

Lower Jurassic Series (Liassic)

Toarcian Stage
Pliensbachian Stage
Sinemurian Stage
Hettangian Stage

TRIASSIC SYSTEM

Upper Triassic Series

(Not recognized)
Norian Stage
Carnian Stage

Middle Triassic Series

Ladinian Stage
Anisian Stage

Lower Triassic Series

Scythian Stage

ROCKS OF PALEOZOIC ERA

PERMIAN SYSTEM

Upper Permian Series

Ochoan Stage

Middle Permian Series

Guadalupian Stage

Leonardian Stage

Lower Permian Series

Wolfcampian Stage

PENNSYLVANIAN SYSTEM

Kawvian Series (Upper Pennsylvanian)

Virgilian Stage
Missourian Stage

Oklan Series (Middle Pennsylvanian)

Desmoinesian Stage
Bendian Stage

Ardian Series (Lower Pennsylvanian)

Morrowan Stage

MISSISSIPPIAN SYSTEM

Tennessean Series (Upper Mississippian)

Lower Carboniferous Series	Chesteran Stage
Viséan Stage	Meramecian Stage
	Waverlyan Series (Lower
	Mississippian)
Tournaisian Stage	Osagian Stage
Strunian Stage	Kinderhookian Stage
DEVONIAN SYSTEM	DEVONIAN SYSTEM
Upper Devonian Series	Chautauquan Series (Upper
Famennian Stage	Devonian)
	Conewangoan Stage
Frasnian Stage	Cassadagan Stage
	Senecan Series (Upper Devonian)
	Chemungian Stage
	Fingerlakesian Stage
Middle Devonian Series	Erian Series (Middle Devonian)
Givetian Stage	Taghanican Stage
	Tioughniogan Stage
Couvinian Stage	Cazenovian Stage
Lower Devonian Series	Ulsterian Series (Lower Devonian)
Coblentzian Stage	Onesquethawan Stage
	Deerparkian Stage
Gedinnian Stage	Helderbergian Stage
SILURIAN SYSTEM	SILURIAN SYSTEM
Upper Silurian Series	Cayugan Series (Upper Silurian)
Ludlovian Stage	Keyseran Stage
	Tonolowayan Stage
	Salinan Stage
Middle Silurian Series	Niagaran Series (Middle Silurian)
Wenlockian Stage	Lockportian Stage
	Cliftonian Stage
Llandoveryan Stage (upper part)	Clintonian Stage
Lower Silurian Series	Medinan Series (Lower Silurian)
Llandoveryan Stage (lower part)	Alexandrian Stage
ORDOVICIAN SYSTEM	ORDOVICIAN SYSTEM
Upper Ordovician Series	Cincinnatian Series (Upper
Ashgillian Stage	Ordovician)
Caradocian Stage (upper part)	Richmondian Stage
	Maysvillian Stage
	Edenian Stage
Middle Ordovician	Champlainian Series (Middle
Caradocian Stage (lower part)	Ordovician)
	Mohawkian Stage
Llandeillian Stage	Trentonian Substage
Llanvirnian Stage	Blackriveran Substage
Lower Ordovician Series	Chazyan Stage
Arenigian Stage	Canadian Series (Lower Ordovician)
Tremadocian Stage ^o	
CAMBRIAN SYSTEM	CAMBRIAN SYSTEM
Upper Cambrian Series	Croixian Series (Upper Cambrian)
	Trempealeauan Stage
	Franconian Stage

Middle Cambrian Series
Lower Cambrian Series

EOCAMBRIAN SYSTEM
ROCKS OF PRECAMBRIAN AGE

Dresbachian Stage
Albertan Series (Middle Cambrian)
Waucoban Series (Lower Cambrian)

EOCAMBRIAN SYSTEM
ROCKS OF PRECAMBRIAN AGE

¹ Considered by some to exclude post-Pliocene deposits.

² Classed as division of Senonian Subseries.

³ Classed as division of Neocomian Subseries.

⁴ Includes Purbeckian deposits.

⁵ Interpreted as lowermost Jurassic in some areas.

⁶ Includes some Lower Triassic and equivalent to upper Thuringian (Zechstein) deposits.

⁷ Equivalent to lower Thuringian (Zechstein) deposits.

⁸ Equivalent to upper Autunian and part of Rotliegend deposits.

⁹ Classed as uppermost Cambrian by some geologists.

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