TREATISE ON INVERTEBRATE PALEONTOLOGY

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THE GEOLOGICAL SOCIETY OF AMERICA, INC.
and
THE UNIVERSITY OF KANSAS
BOULDER, COLORADO, and LAWRENCE, KANSAS
1978

Library of Congress Catalogue Card
Number: 53-12913
I.S.B.N. 0-8137-3021-X
TIVPA 1-1027 (1978)

Text Composed by
THE UNIVERSITY OF KANSAS PRINTING SERVICE
Lawrence, Kansas

Illustrations and Offset Lithography
THE MERIDEN GRAVURE COMPANY
Meriden, Connecticut

Binding
TAPLEY-RUTTER COMPANY
Moonachie, New Jersey

Published 1978

Distributed by the Geological Society of America, Inc., 3300 Penrose Place, Boulder, Colo., 80301, to which all communications should be addressed.

The *Treatise on Invertebrate Paleontology* has been made possible by (1) grants of funds from The Geological Society of America through the bequest of Richard Alexander Fullerton Penrose, Jr., for initial preparation of illustrations, and partial defrayment of organizational expenses in 1948-1957, and again since 1971, and from the United States National Science Foundation, awarded annually since 1959, for continuation of the *Treatise* project; (2) contribution of the knowledge and labor of specialists throughout the world, working in cooperation under sponsorship of The Geological Society of America, The Paleontological Society, The Society of Economic Paleontologists and Mineralogists, The Palaeontographical Society, and The Palaeontological Association; and (3) acceptance by The University of Kansas of publication without any financial gain to the University.

TREATISE ON INVERTEBRATE PALEONTOLOGY

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EDITORIAL PREFACE

INTRODUCTION

The history of the volumes constituting Part T of the *Treatise on Invertebrate Paleontology* goes back as far as the beginnings of the *Treatise* project itself, that is, to the years 1948 and 1949. It seems that the earliest section of systematic text to be attacked was treatment of the Articulata, for in the academic year 1950-51 Dr. HERTHA SIEVERTS-DORECK spent several months in Lawrence working with R. C. MOORE on the first draft for the systematic descriptions of that group. Little or no progress seems to have been made on this or any other section of Part T, however, during the one-and-a-half decades following Dr. SIEVERTS-DORECK's visit. No doubt, during this period Dr. MOORE must have worked sporadically on his own assignments, which included the Inadunata and Flexibilia.

In 1965, at MOORE's request, TEICHERT conferred with Dr. SIEVERTS-DORECK in Stuttgart-Möhringen and it was decided to invite Dr. H. WIENBERG RASMUSSEN of Copenhagen to assist in the completion of the description of the Articulata. These arrangements, however, did not come to fruition until about 10 years later when WIENBERG RASMUSSEN finally undertook to complete the text on the Articulata himself.

The systematic chapter on the Flexibilia was completed by R. C. MOORE in 1973. Dr. GEORGES UBAGHS completed the chapter on the Camerata in the same year. MOORE's assignments also included the description of the Inadunata, a task in which he was ably assisted by N. GARY LANE and H. L. STRIMPLE. In spite of grave illness MOORE continued work on text for the Inadunata throughout 1973 and completed the task only a few months before his death in April, 1974.

Until 1972, little thought had been given to the organization of materials for the introductory part, although in 1968, at the invitation of Dr. MOORE, ALBERT BREIMER had delivered a manuscript describing the anatomy, physiology, and ecology of living crinoids.

In the spring of 1972, TEICHERT paid a visit to UBAGHS in Liège, Belgium, and the two of them drew up plans for preparation of materials required for the introductory sections of Part T and an outline of contents was prepared that was very closely adhered to in the cooperative efforts that followed. The editors enlisted the help of GEORGES UBAGHS to shape the chapter on skeletal morphology, of D. B. MACURDA, JR., D. L. MEYER, and MICHEL ROUX the chapter on the crinoid stereom, and of N. GARY LANE, H. WIENBERG RASMUSSEN, ALBERT BREIMER, J. C. BROWER, and H. L. STRIMPLE for a variety of assignments as is apparent from the following text. Most of these manuscripts were completed only after

R. C. MOORE's death in April, 1974, and they were reviewed and edited by CURT TEICHERT and the editorial staff. The cutoff date for addition of information to the systematic descriptions was toward the end of 1976.

It is the purpose of the Introduction of the Editorial Preface to give a brief history of a particular Part of the *Treatise,* to explain the aims of the *Treatise* in general terms, and to make appropriate acknowledgments for support received. The bulk of the Editorial Preface then is devoted to an explanation of nomenclatural practices adopted in the *Treatise.* Although in the present volume much of this text has been copied unchanged from the prefaces of earlier editions, numerous sections have been thoroughly revised by CURT TEICHERT.

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 year of publication of each individual part. Such work has value in providing a most useful summary of the collective results of multitudinous investigations and thus constitutes 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 is yielding needed foundation for future research.

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 was judged desirable to print and distribute each segment as soon as possible after it is ready for press. Pages in each part bear the assigned index letter joined with numbers beginning with 1 and running consecutively to the end of the part. In numerous cases materials for individual parts were so voluminous that these parts had to be published in two or even three volumes. In such cases, pagination is continuous through successive volumes.

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, (6) paleoecology, and (7) systematic description of genera, subgenera, and higher taxonomic units. Selected lists of references only were furnished in earlier parts of the *Treatise,* but since the mid-1960's the tendency has been to make these lists as comprehensive as possible.

Features of style in the taxonomic portions of this work have been fixed by the editors with aid furnished by advice from representatives of the societies which have undertaken to sponsor the *Treatise.* It is the editors' responsibility to consult with authors and coordinate their work, seeing that manuscript properly incorporates features of adopted style. Especially they are called on to formulate policies in respect to many questions of nomenclature and procedure. The subject of genus-group as well as 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 was made in 1948 by the Geological Society of America for initial work in preparing *Treatise* illustrations. Additional grants were made by The Geological Society of America in 1971 ($6,200), 1972 ($6,000), $7,000 each year for 1973 and 1974, and $20,000 each for 1975, 1976, and 1977. Administration of expenditures has been in charge of the editors and most of the work by photographers and artists has been done under their direction at the University of Kansas, but sizable parts of this program have also been carried forward in Washington, London, Ottawa, and many other places.

In December, 1959, the National Science Foundation of the United States, through its Division of Biological and Medical Sciences and the Program Director for Systematic Biology, made a grant in the amount of $210,000 for the purpose of aiding the completion of yet-unpublished volumes of the *Treatise*. Payment of this sum was provided to be made in installments distributed over a five-year period, with administration of disbursements handled by the University of Kansas. An additional grant (No. GB 4544) of $102,800 was made by the National Science Foundation in January, 1966, for the two-year period 1966-67, and this was extended for the calendar year 1968 by payment of $25,700 in October, 1967. This grant was extended further by payments of $57,800 in 1968 for calendar year 1969, and $66,000 each for calendar years 1970-72. For the years 1973-77 grants totaled $197,400. These funds are used primarily to maintain editorial operations at the University of Kansas and to provide assistance to authors needed in preparation of manuscripts and illustrations. Grateful acknowledgment to the Foundation is expressed on behalf of the societies sponsoring the *Treatise,* the University of Kansas, and innumerable individuals benefited by the *Treatise* project.

ZOOLOGICAL NAMES

Many questions arise in connection with zoological names, especially including those that relate to their acceptability and to alterations of some which may be allowed or demanded. Procedure in obtaining answers to these questions is guided and to a large extent governed by regulations published (1961) in the *International Code of Zoological Nomenclature*[1] (hereinafter cited simply as the *Code*). The prime object of the *Code* is to promote stability and universality in the scientific names of animals, ensuring also that each name is distinct and unique while avoiding restrictions on freedom of taxonomic thought or action. Priority is a basic principle, but under specified conditions its application can be modified. This is all well and good, yet nomenclatural tasks confronting the zoological taxonomist are formidable. They warrant the complaint of some that zoology, including paleozoology, is the study of animals rather than of names applied to them.

Several ensuing pages are devoted to aspects of zoological nomenclature that are judged to have chief importance in relation to procedures adopted in the *Treatise*. Terminology is explained, and examples of style employed in the nomenclatural parts of systematic descriptions are given.

TAXA GROUPS

Each taxonomic unit (taxon, pl., taxa) belongs to a rank in the adopted hierarchy of classificatory divisions. In part, this hierarchy is defined by the *Code* to include a species-group of taxa, a genus-group, and a family-group. Units of lower rank than subspecies are excluded from zoological nomenclature and those higher than superfamily of the family-group are not regulated by the *Code*. It is natural and convenient to discuss nomenclatural matters in general terms first and then to consider each of the taxa groups separately. Especially important is the provision that within each taxa group classificatory units are coordinate (equal in rank), whereas units of different taxa groups are not coordinate.

FORMS OF NAMES

All zoological names are divisible into groups based on their form (spelling). The first-published form (or forms) of a name is defined as original spelling (*Code,* Art. 32) and any later-published form (or forms) of the same name is designated as subsequent spelling (Art. 33). Obviously, original and subsequent spellings of a given name may or may not be identical and this affects consideration of their correctness. Further, examination of original spellings of names shows that by no means all can be distinguished as correct. Some are incorrect, and the same is true of subsequent spellings.

Original Spellings

If the first-published form of a name is consistent and unambiguous, the original spelling is defined as correct unless it contravenes some stipulation of the *Code* (Arts.

[1] N. R. Stoll et al. (ed. comm.), *International Code of Zoological Nomenclature, adopted by the XV International Congress of Zoology,* xvii + 176 p. (International Trust for Zoological Nomenclature, London, 1961).

26-31), or 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* (Arts. 26-31).

Incorrect original spellings are any that fail to satisfy requirements of the *Code,* or that represent an inadvertent error, or that 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 diacritic mark, apostrophe, diaeresis, 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 is accompanied by inserting "e" after the vowel.

Subsequent Spellings

If a name classed as a subsequent spelling is identical with an original spelling, it is distinguishable as correct or incorrect on the same criteria that apply to the original spelling. This means that a subsequent spelling identical with a correct original spelling is also correct, and one identical with an incorrect original spelling is also incorrect. In the latter case, both original and subsequent spellings require correction (authorship and date of the original incorrect spelling being retained).

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 (except that such changes as altered terminations of adjectival specific names to obtain agreement in gender with associated generic names, of family-group names to denote assigned taxonomic rank, and corrections for originally used diacritic marks, hyphens, and the like are excluded from spelling changes conceived to produce a different name). In certain cases species-group names having variable spellings are regarded as homonyms as specified in Art. 58 of the *Code.*

Altered subsequent spellings other than the exceptions noted may be either intentional or unintentional. If demonstrably intentional, the change is designated as an emendation. Emendations are divisible into justifiable and unjustifiable ones. 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 that differ in any way from original spellings, other than previously noted exceptions, and that are not classifiable as emendations are defined as incorrect subsequent spellings. They have no status in nomenclature, do not enter into homonymy, and cannot be used as replacement names. It is the purpose of the following chapters to explain in some detail the implications of various kinds of subsequent spellings and how these are dealt with in the *Treatise.*

AVAILABLE AND UNAVAILABLE NAMES

Available Names

An available zoological name is any that conforms to all mandatory provisions of the *Code.* Such names are classifiable in groups which are recognized in the *Treatise,* though not explicitly differentiated in the *Code.* They are as follows:

1) So-called *"inviolate names"* include all available names that are not subject to alteration from their originally published form. They comprise correct original spellings and commonly include correct subsequent spellings, but include no names classed as emendations. Here belong most genus-group names (including those for collective groups), some of which differ in spelling from others by only a single letter.

2) Names may be termed *"perfect names"* if, as originally published they

meet all mandatory requirements, needing no correction of any kind, but nevertheless are legally alterable in such ways as changing the termination (e.g., many species-group names, family-group names). This group does not include emended incorrect original spellings (e.g., *Oepikina,* replacement of *Öpikina*).

3) *"Imperfect names"* are available names that as originally published contain mandatorily emendable defects. Incorrect original spellings are imperfect names. Examples of emended imperfect names are: among species-group names, *guerini* (not *Guérini*), *obrienae* (not *O'Brienae*), *terranovae* (not *terra-novae*), *nunezi* (not *Nuñezi*), *Spironema rectum* (not *Spironema recta,* because generic name is neuter, not feminine); among genus-group names, *Broeggeria* (not *Bröggeria*), *Obrienia* (not *O'Brienia*), *Maccookites* (not *McCookites*); among family-group names, Oepikidae (not Öpikidae), Spironematidae (not Spironemidae, incorrect stem), Athyrididae (not Athyridae, incorrect stem). The use of "variety" for named divisions of fossil species, according to common practice of some paleontologists, gives rise to imperfect names, which generally are emendable (*Code,* Art. 45e) by omitting this term so as to indicate the status of this taxon as a subspecies.

4) *"Vain names"* are available names consisting of unjustified intentional emendations of previously published names. The emendations are unjustified because they are not demonstrable as corrections of incorrect original spellings as defined by the *Code* (Art. 32c). Vain names have status in nomenclature under their own authorship and date. They constitute junior objective synonyms of names in their original form. Examples are: among species-group names, *geneae* (published as replacement of original unexplained masculine, *geni,* which now is not alterable), *ohioae* (invalid change from original *ohioensis*); among genus-group names, *Graphiodactylus* (invalid change from original *Graphiadactyllis*); among family-group names, Graphiodactylidae (based on junior objective synonym having invalid vain name).

5) An important group of available zoological names can be distinguished as *"transferred names."* These comprise authorized sorts of altered names in which the change depends on transfer from one taxonomic rank to another, or possibly on transfers in taxonomic assignment of subgenera, species, or subspecies. Most commonly the transfer calls for a change in termination of the name so as to comply with stipulations of the *Code* on endings of family-group taxa and agreement in gender of specific names with associated generic names. Transferred names may be derived from any of the preceding groups except the first. Examples are: among species-group names, *Spirifer ambiguus* (masc.) to *Composita ambigua* (fem.), *Neochonetes transversalis* to *N. granulifer transversalis* or vice versa; among genus-group names, *Schizoculina* to *Oculina (Schizoculina)* or vice versa; among family-group names, Orthidae to Orthinae or vice versa, or superfamily Orthacea derived from Orthidae or Orthinae; among suprafamilial taxa (not governed by the *Code*), order Orthida to suborder Orthina or vice versa. The authorship and date of transferred names are not affected by the transfers, but the author responsible for the transfer and the date of his action is generally recorded in the *Treatise.*

6) Improved or *"corrected names"* include both mandatory and allowable emendations of imperfect names and of suprafamilial names, which are not subject to regulation as to name form. Examples of corrected imperfect names are given with the discussion of group 3. Change from the originally published ordinal name Endoceroidea (Teichert, 1933) to the presently recognized Endocerida illustrates a "corrected" suprafamilial name. Group 6 names differ from those in group 5 in not being dependent on transfers in taxonomic rank or assignment, but some names are classifiable in both groups.

7) *"Substitute names"* are available names expressly proposed as replacements for invalid zoological names, such as junior homonyms. These may be classifiable also as belonging in groups 1, 2, or 3. The glossary appended to the *Code* refers to these as "new names" *(nomina nova)* but they are better designated as substitute names, since their newness is temporary and relative. The first-published substitute name

that complies with the definition here given takes precedence over any other. An example is *Marieita* Loeblich & Tappan, 1964, as substitute for *Reichelina* Marie, 1955 (*non* Erk, 1942).

8) *"Conserved names"* include a relatively small number of species-group, genus-group, and family-group names which have come to be classed as available and valid by action of the International Commission on Zoological Nomenclature exercising its plenary powers to this end or ruling to conserve a junior synonym in place of a rejected "forgotten" name *(nomen oblitum)* (Art. 23b). Currently, such names are entered on appropriate "Official Lists," which are published from time to time.

It is useful for convenience and brevity of distinction in recording these groups of available zoological names to employ Latin designations in the pattern of *nomen nudum* (abbr., *nom. nud.*) and others. Thus we recognize the preceding numbered groups as follows: 1) *nomina inviolata* (sing., *nomen inviolatum,* abbr., *nom. inviol.*), 2) *nomina perfecta (nomen perfectum, nom. perf.),* 3) *nomina imperfecta (nomen imperfectum, nom. imperf.),* 4) *nomina vana (nomen vanum, nom. van.),* 5) *nomina translata (nomen translatum, nom. transl.),* 6) *nomina correcta (nomen correctum, nom. correct.),* 7) *nomina substituta (nomen substitutum, nom. subst.),* 8) *nomina conservata (nomen conservatum, nom. conserv.).* It should be noted that the *Code* does not differentiate between different kinds of subsequent intentional changes of spelling, all of which are grouped as "emendations" (see below).

Additional to the groups differentiated above, the *Code* (Art. 17) specifies that a zoological name is not prevented from availability a) by becoming a junior synonym, for under various conditions this may be re-employed, b) for a species-group name by finding that original description of the taxon relates to more than a single taxonomic entity or to parts of animals belonging to two or more such entities, c) for species-group names by determining that it first was combined with an invalid or unavailable genus-group name, d) by being based only on part of an animal, sex of a species, ontogenetic stage, or one form of a polymorphic species, e) by being originally proposed for an organism not considered to be an animal but now so regarded, f) by incorrect original spelling which is correctable under the *Code*, g) by anonymous publication before 1951, h) by conditional proposal before 1961, i) by designation as a variety or form before 1961, j) by concluding that a name is inappropriate (Art. 18), or k) for a specific name by observing that it is tautonymous (Art. 18).

Unavailable Names

All zoological names which fail to comply with mandatory provisions of the *Code* are unavailable names and have no status in zoological nomenclature. None can be used under authorship and date of their original publication as a replacement name *(nom. subst.)* and none preoccupies for purposes of the Law of Homonymy. Names identical in spelling with some, but not all, unavailable names can be classed as available if and when they are published in conformance to stipulations of the *Code* and they are then assigned authorship and take date of the accepted publication. Different groups of unavailable names can be discriminated as follows.

9) *"Naked names"* include all those that fail to satisfy provisions stipulated in Article 11 of the *Code,* which states general requirements of availability. In addition they include names, if published before 1931, that were unaccompanied by a description, definition, or indication (Arts. 12, 16), as well as names published after 1930 that lacked accompanying statement of characters purporting to serve for differentiation of the taxon, or definite bibliographic reference to such a statement, or that were not proposed expressly as replacement (nom. subst.) of a pre-existing available name (Art. 13a) or that were unaccompanied by definite fixation of a type species by original designation or indication (Art. 13b). Examples of "naked names" are: among species-group taxa, *Valvulina mixta* Parker & Jones, 1865 (=*Cribrobulimina mixta* Cushman, 1927, available and valid); among genus-group taxa, *Orbitolinopsis* Silvestri, 1932 (=*Orbitolinopsis* Henson, 1948, available but classed as invalid junior synonym of *Orbitolina* d'Orbigny, 1850); among family-group taxa, Aequilateralidae d'Orbigny,

1846 (lacking type-genus), Hélicostègues D'ORBIGNY, 1826 (vernacular not latinized by later authors, Art. 11e(iii)), Poteriocrinidae AUSTIN & AUSTIN, 1843 (=fam. Poteriocrinoidea AUSTIN & AUSTIN, 1842) (neither 1843 or 1842 names complying with Art. 11e, which states that "a family-group name must, when first published, be based on the name then valid for a contained genus," such valid name in the case of this family being *Poteriocrinites* MILLER, 1821).

10) *"Denied names"* include all those that are defined by the *Code* (Art. 32c) as incorrect original spellings. Examples are: Specific names, *nova-zelandica, mülleri, 10-brachiatus;* generic names, *M'Coyia, Størmerella, Römerina, Westgårdia;* family name, Růžičkinidae. Uncorrected "imperfect names" are "denied names" and unavailable, whereas corrected "imperfect names" are available.

11) *"Impermissible names"* include all those employed for alleged genus-group taxa other than genus and subgenus (Art. 42a) (e.g., supraspecific divisions of subgenera), and all those published after 1930 that are unaccompanied by definite fixation of a type species (Art. 13b). Examples of impermissible names are: *Martellispirifer* GATINAUD, 1949, and *Mirtellispirifer* GATINAUD, 1949, indicated respectively as a section and subsection of the subgenus *Cyrtospirifer; Fusarchaias* REICHEL, 1949, without definitely fixed type species (=*Fusarchaias* REICHEL, 1952, with *F. bermudezi* designated as type species).

12) *"Null names"* include all those that are defined by the *Code* (Art. 33b) as incorrect subsequent spellings, which are any changes of original spelling not demonstrably intentional. Such names are found in all ranks of taxa.

13) *"Forgotten names"* are defined (Art. 23b) as senior synonyms that have remained unused in primary zoological literature for more than 50 years. Such names are not to be used unless so directed by ICZN.

Latin designations for the discussed groups of unavailable zoological names are as follows: 9) *nomina nuda* (sing., *nomen nudum,* abbr., *nom. nud.*), 10) *nomina negata (nomen negatum, nom. neg.),* 11) *nomina vetita (nomen vetitum, nom. vet.),* 12) *nomina nulla (nomen nullum, nom. null.),* 13) *nomina oblita (nomen oblitum, nom. oblit.).*

VALID AND INVALID NAMES

Important distinctions relate to valid and available names, on one hand, and to invalid and 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 partly may be 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 name, generally the oldest. Obviously, no valid name can also be an unavailable name, but invalid names may include both available and unavailable names. Any name for a given taxon other than the valid name is an invalid name.

A sort of nomenclatorial no-man's-land is encountered in considering the status of some zoological names, such as *"doubtful names," "names under inquiry,"* and *"forgotten names."* Latin designations of these are *nomina dubia, nomina inquirenda,* and *nomina oblita,* respectively. Each of these groups may include both available and unavailable names, but the latter can well be ignored. Names considered to possess availability conduce to uncertainty and instability, which ordinarily can be removed only by appealed action of ICZN. Because few zoologists care to bother in seeking such remedy, the "wastebasket" names persist.

SUMMARY OF NAME GROUPS

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

DEFINITIONS OF NAME GROUPS

nomen conservatum (nom. conserv.). Name unacceptable under regulations of the *Code* which is made valid, either with original or altered spelling, through procedures specified by the *Code* or by action of ICZN exercising its plenary powers.

nomen correctum (nom. correct.). Name with intentionally altered spelling of sort required or

allowable by the *Code* but not dependent on transfer from one taxonomic rank to another ("improved name"). (*See Code,* Arts. 26b, 27, 29, 30a(i)(3), 31, 32c(i), 33a; in addition change of endings for suprafamilial taxa not regulated by the *Code*.)

nomen imperfectum (nom. imperf.). Name that as originally published meets all mandatory requirements of the *Code* but contains defect needing correction ("imperfect name"). (*See Code,* Arts. 26b, 27, 29, 32c, 33a.)

nomen inviolatum (nom. inviol.). Name that as originally published meets all mandatory requirements of the *Code* and also is not correctable or alterable in any way ("inviolate name").

nomen negatum (nom. neg.). Name that as originally published constitutes invalid original spelling, and although possibly meeting all other mandatory requirements of the *Code,* cannot be used and has no separate status in nomenclature ("denied name"). It is to be corrected wherever found.

nomen nudum (nom. nud.). Name that as originally published fails to meet mandatory requirements of the *Code* and having no status in nomenclature, is not correctable to establish original authorship and date ("naked name").

nomen nullum (nom. null.). Name consisting of an unintentional alteration in form (spelling) of a previously published name (either available name, as *nom. inviol., nom. perf., nom imperf., nom. transl.*; or unavailable name, as *nom. neg., nom. nud., nom. van.,* or another *nom. null.*) ("null name").

nomen oblitum (nom. oblit.). Name of senior synonym unused in primary zoological literature in more than 50 years, not to be used unless so directed by ICZN ("forgotten name").

nomen perfectum (nom. perf.). Name that as originally published meets all mandatory requirements of the *Code* and needs no correction of any kind but which nevertheless is validly alterable by change of ending ("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 rank to another within the group to which it belongs ("transferred name").

nomen vanum (nom. van.)[1]. Name consisting of an invalid intentional change in form (spelling) from a previously published name, such invalid emendation having status in nomenclature as a junior objective synonym ("vain name").

nomen vetitum (nom. vet.). Name of genus-group taxon not authorized by the *Code* or, if first published after 1930, without definitely fixed type species ("impermissible name").

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 correcta* among specific names) and these are not discriminated. Names which are not accepted for one reason or another include junior homonyms, senior synonyms classifiable as *nomina negata* or *nomina nuda,* and numerous junior synonyms which include both objective *(nomina vana)* and subjective types; rejected names are classified as completely as possible.

NAME CHANGES IN RELATION TO TAXA GROUPS

SPECIES-GROUP 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 *Code* (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.

GENUS-GROUP 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 elimination of diacritical marks of some names

[1] Chorn & Whetstone (*Jour. Paleontology,* in press, 1978) have called attention to the fact that the term *nomen vanum* was first proposed by Simpson (*Bull. Am. Museum Nat. History,* v. 85, Oct., 1945, p. 27, 30) for taxa properly proposed but "which cannot be properly defined either on the basis of the original diagnosis or from the available specimens" (Simpson, *ibid.,* v. 91, Art. 1, July, 1948, p. 31). It appears, however, that at the time of Simpson's writings the term *nomen dubium* was already in use for the kind of name Simpson had in mind (R. Richter, *Einfüihrung in die zoologische Nomenklatur durch Erläuterung der Internationalen Regeln,* Senck. Naturf. Gesellsch., Frankfurt/Main, 1943, p. 102; H. M. Smith, *Science,* v. 102, no. 2648, Aug., 1945, p. 186). As early as 1913, the International Commission on Zoological Nomenclature had referred to a genus based on unrecognizable specimens as *genus dubium* (ICZN, Op. 54). The term *nomen dubium* was later used by authors from Schenk & McMasters (*Procedure in Taxonomy,* 2nd edit., Stanford Univ. Press, Stanford, 1948, p. 9) to Lehmann (*Geologisches Wörterbuch,* Ferd. Enke, Stuttgart, 1964, p. 196). We, therefore, regard *nomen vanum sensu* Simpson (1945) as a synonym of *nomen dubium* of authors. The term *nomen vanum* for intentional, unjustified emendations of names was first defined by Moore (Editorial Preface, *Treatise,* Part E, June, 1955, p. xi) and this use was continued in all later *Treatise* volumes. It is here maintained.—Curt Teichert.

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.

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

Paleomeandron PERUZZI, 1881, p. 8 [**P. elegans*; SD HÄNTZSCHEL, 1975, p. *W*91] [=*Palaeomeandron* FUCHS, 1885, p. 395 *(nom. van.)*].

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

Vacuocyathus OKULITCH, 1950, p. 392 [**Coelocyathus kidrjassovensis* VOLOGDIN, 1937, p. 478 *(nom. nud.)*; 1939, p. 237; OD] [=*Coelocyathus* VOLOGDIN, 1934, p. 502 *(nom. nud.)*; 1937, p. 472 *(nom. nud.)*].

Cyrtograptus CARRUTHERS, 1867, p. 540 [*nom. correct.* LAPWORTH, 1873 (*pro Crytograpsus* CARRUTHERS, 1867), ICZN Op. 650, 1963] [**Cyrtograpsus murchisoni*; OD].

It is in many cases difficult to decide whether a change in spelling of a name by a subsequent author was intentional or unintentional, that is, whether it should be classified as *nomen vanum* or *nomen nullum,* and the decision will often have to be arbitrary.

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

The *Code* specifies the endings only for subfamily (-inae) and family (-idae) but all family-group taxa are defined as coordinate, signifying that for purposes of priority a name published for a taxon in any category and based on a particular type genus shall date from its original publication for a taxon in any category, retaining this priority (and authorship) when the taxon 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 alteration 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 alteration. 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 *Code,* 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.* VERRILL, 1864 (*ex* Stylinidae D'ORBIGNY, 1851)]

Superfamily ARCHAEOCTONOIDEA Petrunkevitch, 1949

[*nom. transl.* PETRUNKEVITCH, 1955 (*ex* Archaeoctonidae PETRUNKEVITCH, 1949)]

Superfamily ANCYLOCERATACEAE Meek, 1876

[*nom. transl.* WRIGHT, 1957 (*ex* Ancyloceratidae MEEK, 1876)]

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

Valid name changes classed as *nomina correcta* 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 (*pro* Streptelasmidae NICHOLSON, 1889)]

Family PALAEOSCORPIIDAE Lehmann, 1944

[*nom. correct.* PETRUNKEVITCH, 1955 (*pro* Palaeoscorpionidae LEHMANN, 1944)]

Family AGLASPIDIDAE Miller, 1877

[*nom. correct.* STØRMER, 1959 (*pro* Aglaspidae MILLER, 1877)]

Superfamily AGARICIICAE Gray, 1847

[*nom. correct.* WELLS, 1956 (*pro* Agaricioidae VAUGHAN & WELLS, 1943, *nom. transl.* WELLS, 1956, *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 *Code*. In order to retain the otherwise invalid name, appeal to ICZN is needful. An example of use of *nom. conserv.* in this connection, as cited in *Treatise* style, is the following.

Subfamily OMPHALOTROPIDINAE Thiele, 1927

[*nom. conserv.*, ICZN (pending)] [=Realiinae PFEIFFER, 1858, *nom. correct.*, KOBELT, 1906 (*ex Realiea* PFEIFFER, 1858)]

FAMILY-GROUP NAMES; REPLACEMENTS

Family-group names are formed by adding letter combinations (prescribed for family and subfamily) 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. Seemingly, the *Code* (Art. 39) requires replacement of a family-group name 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, but for purposes of the Law of Priority, they take the date of the replaced name. Numerous long-used family-group names are incorrect in being *nomina nuda,* since they fail to satisfy criteria of availability (Art. 11e). These also demand replacement by valid names.

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.

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 correcta,* as previously discussed, do not affect authorship and date of the taxon concerned, but in the *Treatise* it is desirable to record the authorship and date of the correction.

SUPRAFAMILIAL TAXA

International rules of zoological nomenclature as given in the *Code* (1961) are

limited to stipulations affecting lower-rank categories (infrasubspecies 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*[1] (1953, Arts. 59-69) proposed to adopt rules for naming suborders and higher taxonomic divisions up to and including phylum, with provision for designating a type genus for each, hopefully in such manner as not to interfere with the taxonomic freedom of workers. Procedures for applying the Law of Priority and Law of Homonymy to suprafamilial taxa were outlined and for dealing with the names for such units and their authorship, with assigned dates, when 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 XVth 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 which 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, if a class or order was defined by some author at a given date, using chosen morphologic characters (e.g., gills of bivalves), this should not be allowed to freeze nomenclature, taking precedence over another later-proposed class or order distinguished by different characters (e.g., hinge-teeth of bivalves). Even the fixing of type genera for suprafamilial taxa might have small value, if any, hindering taxonomic work rather than aiding it. At all events, no legal basis for establishing such types and for naming these taxa has yet been provided.

[1] Francis Hemming, ed., *Copenhagen Decisions on Zoological Nomenclature. Additions to, and modifications of, the Règles Internationales de la Nomenclature Zoologique*, xxix + 135 p. (International Trust for Zoological Nomenclature, London, 1953).

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. At least a degree of uniform policy is thought to be needed, especially for the guidance of *Treatise*-contributing 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 which 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, a) with a capital initial letter, b) without diacritical mark, apostrophe, diaeresis, or hyphen, and c) if a component consisting of a numeral, numerical adjective, or adverb is used, this must be written in full (e.g., Stethostomata, Trionychi, Septemchitonina, Scorpiones, Subselliflorae). No uniformity in choice of ending for taxa of a given rank is demanded (e.g., orders named Gorgon*acea,* Millepor*ina,* Rugos*a,* Scleractin*ia,* Stromatopor*oidea,* Phalang*ida*).

2) Names of suprafamilial taxa may be constructed in almost any way, a) intended to indicate morphological attributes (e.g., Lamellibranchiata, Cyclostomata, Toxoglossa), b) based on the stem of an included genus (e.g., Bellerophontina, Nautilida, Fungiina), or c) arbitrary combinations of letters, (e.g., Yuania), but none of these can be allowed to end in -idae or -inae, 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 which 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 Bellerophontacea M'Coy, 1851; family Bellerophontidae M'Coy, 1851). Family-group names and suprafamilial names are not coordinate.

3) The Laws of Priority and Homonymy lack any force of international agreement as applied to suprafamilial names, yet in the interest of nomenclatural stability and the avoidance of confusion these laws 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 change(s) cannot rationally be judged to alter the authorship and date of the taxon as published originally. a) A name revised from its previously published rank is a "transferred name" *(nom. transl.)*, as illustrated in the following.

Order CORYNEXOCHIDA Kobayashi, 1935

[*nom. transl.* MOORE, 1959 (*ex* suborder Corynexochida KOBAYASHI, 1935)]

b) A name revised from its previously published form merely by adoption of a different termination, without changing taxonomic rank, is an "altered name" *(nom. correct.)*. Examples follow.

Order DISPARIDA Moore & Laudon, 1943

[*nom. correct.* MOORE, in MOORE, LALICKER, & FISCHER, 1952 (*pro* order Disparata MOORE & LAUDON, 1943)]

Suborder AGNOSTINA Salter, 1864

[*nom. correct.* HARRINGTON & LEANZA, 1957 (*pro* suborder Agnostini SALTER, 1864)]

c) A suprafamilial name revised from its previously published rank with accompanying change of termination (which may or may not be intended to signalize the change of rank) is recorded as *nom. transl. et correct.*

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]

5) The authorship and date of nominate subordinate and superordinate 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. *K*128 (*ex* superorder Endoceratoidea SHIMANSKIY & ZHURAVLEVA, 1961, *nom. transl.* TEICHERT in TEICHERT *et al.*, 1964, p. *K*128, *ex* order Endoceroidea TEICHERT, 1933)]

Order ENDOCERIDA Teichert, 1933

[*nom. correct.* TEICHERT in TEICHERT *et al.*, 1964, p. *K*165 (*pro* order Endoceroidea TEICHERT, 1933)]

Suborder ENDOCERINA Teichert, 1933

[*nom. correct.*, herein, *ex* Endoceratina SWEET, 1958 (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 taxonomic scope or concept in application of a given zoological name. The *Code* (Art. 33a and Glossary p. 148) concerns itself with only the first type of emendation, applying the term to either justified or unjustified changes, both intentional, of the original spelling of a name. These categories are identified in the *Treatise* as *nomina correcta* and *nomina vana*, respectively. 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 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, many 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 emenda-

tion 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 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.

Examples from *Treatise* volumes are:

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]

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 next 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 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. Examples of these two sorts of citations are as follows:

Diplotrypa Nicholson, 1879 [**Favosites petropolitanus* 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:

Acervularia Schweigger, 1819 [**A. baltica* (=**Madrepora ananas* Linné, 1758); M].

It is desirable to record the manner of establishing the type species, whether by original designation or by subsequent designation.

Fixation of type species originally. 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 specified ways subsequent to the original publication. Fixation of the type species of a genus or subgenus in an original publication is stipulated by the *Code* (Art. 68) in order of precedence as 1) *original designation* (in the *Treatise* indicated as 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 includes 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 type belonging to one of the three preceding categories.

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, 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 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" and "SM" as 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].

Another mode of fixing the type species of a genus is action of the International Commission on 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.

It should be noted that *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,* Art. 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. This provision of the *Code* has not been consistently applied in all earlier *Treatise* volumes, but is rigidly adhered to in the present volume.

Type species of synonyms. In about 1969 a decision was made by the editors to include the names of type species of genera that were placed in subjective synonymy. Such species are simply identified as "type." An example is:

Trachycardium MÖRCH, 1853 [**Cardium isocardia* LINNÉ, 1758; SD VON MARTENS, 1870] [=*Kathocardia* TUCKER & WILSON, 1932 (type, *Cardium (K.) aclinense*; OD)].

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, 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-Holocene 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 [*nom. subst. 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 generally 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, as shown in the following example.

Mysterium DE LAUBENFELS, herein [*nom. subst. pro Mystrium* SCHRAMMEN, 1936 (ref., p. 60) (*non* ROGER, 1862)] [**Mystrium porosum* SCHRAMMEN, 1936].

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 which 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 synonymic homonyms and in the *Treatise* the junior one of these is indicated by the abbreviation "jr. syn. hom."

Identical family-group names not infre-

quently 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 synonymic homonyms are distinguished in the *Treatise* as in dealing with generic names.

SYNONYMS

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

Calapoecia BILLINGS, 1865 [**C. anticostiensis;* SD LINDSTRÖM, 1883] [=*Columnopora* NICHOLSON, 1874; *Houghtonia* ROMINGER, 1876].

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

Graphiocrinus DE KONINCK & LE HON, 1854, p. 115 [**G. encrinoides*; M] [=*Scaphiocrinus* HALL, 1858b, p. 550 (type, *S. simplex*; OD)].

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.

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 some other continents, is given here. No stage subdivisions of the Tertiary series are given here because they are not used in these volumes.

Generally Recognized Divisions of Geologic Column

EUROPE	NORTH AMERICA
CAINOZOIC ERATHEM	**CENOZOIC ERATHEM**
QUATERNARY SYSTEM	**QUATERNARY SYSTEM**
Holocene Series	**Holocene Series**
Pleistocene Series	**Pleistocene Series**
TERTIARY SYSTEM[1]	**TERTIARY SYSTEM**[1]
Pliocene Series	**Pliocene Series**
Miocene Series	**Miocene Series**
Oligocene Series	**Oligocene Series**
Eocene Series	**Eocene Series**
Paleocene Series	**Paleocene Series**
MESOZOIC ERATHEM	**MESOZOIC ERATHEM**
CRETACEOUS SYSTEM	**CRETACEOUS SYSTEM**[2]
Upper Cretaceous Series	**Gulfian Series (Upper Cretaceous)**
Maastrichtian Stage[3]	Navarroan Stage
Campanian Stage[3]	Taylorian Stage
Santonian Stage[3]	Austinian Stage

Coniacian Stage[3]	Eaglefordian Stage
Turonian Stage	Woodbinian (Tuscaloosan) Stage
Cenomanian Stage	
Lower Cretaceous Series	**Comanchean Series**
	(Lower Cretaceous)
Albian Stage (Gault)	Washitan Stage
Aptian Stage	Fredericksburgian Stage
Barremian Stage[4]	Trinitian Stage
Hauterivian Stage[4]	
Valanginian Stage[4]	**Coahuilan Series (Lower Cretaceous)**
Berriasian Stage[4]	Nuevoleonian Stage
	Durangoan Stage
JURASSIC SYSTEM	**JURASSIC SYSTEM**
Upper Jurassic Series	**Upper Jurassic Series**
Tithonian Stage	Portlandian Stage
Kimmeridgian Stage	Kimmeridgian Stage
Oxfordian Stage	Oxfordian Stage
Middle Jurassic Series	**Middle Jurassic Series**
Callovian Stage[5]	Callovian Stage[6]
Bathonian Stage	Bathonian Stage
Bajocian Stage	Bajocian Stage
Lower Jurassic Series (Liassic)	**Lower Jurassic Series (Liassic)**
Toarcian Stage	Toarcian Stage
Pliensbachian Stage	Pliensbachian Stage
Sinemurian Stage	Sinemurian Stage
Hettangian Stage	Hettangian Stage
TRIASSIC SYSTEM	**TRIASSIC SYSTEM**
Upper Triassic Series	**Upper Triassic Series**
Rhaetian Stage	Rhaetian Stage
Norian Stage	Norian Stage
Carnian Stage	Carnian Stage
Middle Triassic Series	**Middle Triassic Series**
Ladinian Stage	Ladinian Stage
Anisian Stage	Anisian Stage
Lower Triassic Series	**Lower Triassic Series**
Scythian Stage	Scythian Stage
PALEOZOIC ERATHEM	**PALEOZOIC ERATHEM**
PERMIAN SYSTEM	**PERMIAN SYSTEM**
Upper Permian Series	**Upper Permian Series**
Tatarian Stage[6]	Ochoan Stage
Kazanian Stage[7]	Guadalupian Stage
Kungurian Stage	
Lower Permian Series	**Lower Permian Series**
Artinskian Stage[8]	Leonardian Stage
Sakmarian Stage	Wolfcampian Stage
Asselian Stage	
CARBONIFEROUS SYSTEM	**PENNSYLVANIAN SYSTEM**
Upper Carboniferous Series	**Upper Pennsylvanian Series**
Stephanian Stage	Virgilian Stage
	Missourian Stage
	Middle Pennsylvanian Series
Westphalian Stage	Desmoinesian Stage
	Atokan Stage
Namurian Stage	**Lower Pennsylvanian Series**
Lower Carboniferous Series	Morrowan Stage
Visean Stage	**MISSISSIPPIAN SYSTEM**
	Upper Mississippian Series
	Chesterian Stage
	Meramecian Stage

Tournaisian Stage	**Lower Mississippian Series**
	Osagian Stage
	Kinderhookian Stage
DEVONIAN SYSTEM	**DEVONIAN SYSTEM**
Upper Devonian Series	**Chautauquan Series (Upper Devonian)**
Famennian Stage	Bradfordian Stage[10]
	Cassadagan Stage[10]
Frasnian Stage	**Senecan Series (Upper Devonian)**
	Chemungian Stage[10]
	Fingerlakesian Stage[10]
Middle Devonian Series	**Erian Series (Middle Devonian)**
Givetian Stage	Taghanican Stage[10]
	Tioughniogan Stage[10]
Couvinian Stage[9]	Cazenovian Stage[10]
Lower Devonian Series	**Ulsterian Series (Lower Devonian)**
Emsian Stage	Onesquethawan Stage[10]
Siegenian Stage	Deerparkian Stage[10]
Gedinnian Stage	Helderbergian Stage[10]
SILURIAN SYSTEM	**SILURIAN SYSTEM**
Pridolian Series	**Cayugan Series[12] (Upper Silurian)**
Ludlovian Series	**Niagaran Series[12] (Middle Silurian)**
Wenlockian Series	**Alexandrian Series[12] (Lower Silurian)**
Llandoverian Series	
ORDOVICIAN SYSTEM	**ORDOVICIAN SYSTEM**
	Cincinnatian Series (Upper Ordovician)
Ashgillian Series	Richmondian Stage
	Maysvillian Stage
	Edenian Stage
	Champlainian Series (Middle Ordovician)
	Mohawkian Stage
	Trentonian Substage
	Blackriveran Substage
	Chazyan Stage
	Whiterockian Stage
Caradocian Series	**Canadian Series (Lower Ordovician)**
Llandeilian Series	
Llanvirnian Series	
Arenigian Series	
Tremadocian Series[11]	
CAMBRIAN SYSTEM	**CAMBRIAN SYSTEM**
Upper Cambrian Series (Merioneth)	**Croixian Series (Upper Cambrian)**
	Trempealeauan Stage
	Franconian Stage
	Dresbachian Stage
Middle Cambrian Series (St. David)	**Albertan Series (Middle Cambrian)**
Lower Cambrian Series (Comley)	**Waucoban Series (Lower Cambrian)**
ROCKS OF PRECAMBRIAN ERAS	**ROCKS OF PRECAMBRIAN ERAS**
PROTEROZOIC ERATHEM	**PROTEROZOIC ERATHEM**
Dalradian, Eocambrian, Vendian, Riphean, and equivalents	Algonkian, Beltian, Hadrynian, Helikian, Aphebian, and equivalents

R. C. Moore and Curt Teichert

[1] For convenience Miocene and Pliocene are often grouped as Neogene, Paleocene, Eocene, and Oligocene as Paleogene subsystems.

[2] Follows essentially Gulf Coast usage.

[3] Classed as division of Senonian Subseries.

[4] Classed as division of Neocomian Subseries.

[5] Included in Upper Jurassic by some authors.

[6] Equivalent to upper Thuringian (Zechstein) deposits.

[7] Equivalent to lower Thuringian (Zechstein) deposits.

[8] Equivalent to upper Autunian and part of Rotliegend deposits.

[9] Also known as Eifelian.

[10] Applies essentially to eastern United States; in western North America European stage terminology is used.

[11] Tremadocian placed in Cambrian by some authors.

[12] Applies essentially to eastern North America only. Berry and Boucot have advocated use of the English standard scale everywhere in North America (Geol. Soc. America, Spec. Paper 102, 1970).

ABBREVIATIONS

Abbreviations used in this division of the *Treatise* are explained in the following alphabetically arranged list.

Abhandl., *Abhandlung(en)*
abstr., abstract
Abt., *Abteilung*
aff., *affinis* (related to)
Afr., Africa,-an
Ala., Alabama
Alb., Albian
Alg., Algeria
Alta., Alberta
A.M., *Artium Magister* (Master of Arts)
Am., America,-n
Anis., Anisian
ant., anterior
append., appendix
Apt., Aptian
Arenig., Arenigian
Arg., Argentina
Ariz., Arizona
Ark., Arkansas
art., article
Artinsk., Artinskian
Atl., Atlantic
auctt., *auctorum* (of authors)
Aug., August
Aus., Austria
Austral., Australian
Avd., *Avdelingen*

Bajoc., Bajocian
Barrem., Barremian
Bathon., Bathonian
B.C., British Columbia
Bd., *Band*
Beil., *Beilage*
Belg., *Belgique*, Belgium
Bend., Bendian
Blackriver., Blackriveran
Boh., Bohemia
Bol., *Boletim, Boletín*, Bolivia
Brit., Britain, British
Bulg., Bulgaria
Bull., Bulletin

C., Centigrade, Central
ca., *circa*
Calif., California
Callov., Callovian
Cam., Cambrian
Campan., Campanian
Can., Canada
Caradoc., Caradocian
Carb., Carboniferous
Carib., Caribbean
Carn., Carnian
cat., catalogue
Cauc., Caucasus
cc., cubic centimeter(s)
Cenoman., Cenomanian
cf., *confer* (compare)
Chazy., Chazyan
Chemung., Chemungian
Chester., Chesterian
Cincinnat., Cincinnati., Cincinnatian
cm., centimeter(s)
Co., Company, County
Coll., Collection(s)
Colo., Colorado
Colom., Colombia
commun., communication
Coniac., Coniacian
correct., *correctum*
cosmop., cosmopolitan
Couvin., Couvinian
Cret., Cretaceous
Czech., Czechoslovakia

Dan., Danian
Dec., decade, December
Denm., Denmark
Desmoines., Desmoinesian
Dev., Devonian
diag., diagram
diagram., diagrammatic, diagrammatical
Doc., Document
Dol., Dolomite

E., East
ed., edited, editor
edit., edition
eds., editors
e.g., *exempli gratia* (for example)
emend., *emendatus(-a)*, emended
Ems., Emsian
Eng., England, English
enl., enlarged
Eoc., Eocene
equiv., equivalent
Erforsch., *Erforschung*
Est., Estonia
et al., *et alii* (and others, persons)
etc., *et cetera* (and others, objects)
Eu., Europe
Ex., Executive
ext., exterior

F., Formation
fam., family
Feb., February
fig., figure(s)
Fla., Florida
Frasn., Frasnian
Ft., Fort

Ga., Georgia
G.Brit., Great Britain
gen., genus
Geol., Geological, *Geologicheskikh, Geologische, Geologiya*, Geology
Géol., *Géologique*
Ger., German, Germany
Givet., Givetian
Gotl., Gotland
Gr., Great, Group
Greenl., Greenland
Guadalup., Guadalupian

Hamilton., Hamiltonian
Handl., *Handling(ar)*
Hauteriv., Hauterivian
Heers., Heersian
Helderberg., Helderbergian
Hettang., Hettangian
Hist., History
Holo., Holocene
Hung., *Hungarica*, Hungary

I., Island, Isles
Ia., Iowa
ICZN, International Commission on Zoological Nomenclature
i.e., *id est* (that is)
Ill., Illinois
illus., illustrated,-ions
incl., inclined, including
incompl., incomplete
Ind., Indiana
indet., *indeterminata*, indeterminate
Ind. O., Indian Ocean
Indon., Indonesia
Inst., *Institut*, Institute, Institution
int., interior
Internatl., International
Ire., Ireland
Is., Island(s)

Jahr., *Jahrgang*
jr., junior
Jur., Jurassic

K., Kongl., *Königlich, Kongelige, Kongliga, Koninklijk*
K.K., *Kaiserlich Königlich*
Kans., Kansas

Kimmeridg., Kimmeridgian
Kinderhook., Kinderhookian
Ky., Kentucky

L., Low., Lower
La., Louisiana
Ladin., Ladinian
Lancash., Lancashire
lat., lateral
Lias., Liassic
Llandeil., Llandeilian
Llandov., Llandoverian
Llanvirn., Llanvirnian
long., longitudinal, longitude
Ls., Limestone
Ludlov., Ludlovian

m., meter(s)
M, monotypy
M., Middle
Maastricht., Maastrichtian
Madag., Madagascar
Mbr., Member
Md., Maryland
Medit., Mediterranean
Meramec., Meramecian
Mesoz., Mesozoic
Mex., Mexico
Mich., Michigan
Minn., Minnesota
Mio., Miocene
Miss., Mississippi, Mississippian
Missour., Missouri., Missourian
mm., millimeter(s)
Mo., Missouri
mod., modified
Mohawk., Mohawkian
Mont., Montana
Morrow., Morrowan
Moscov., Moscovian
MS., manuscript
Mtg., Meeting
Mts., Mtns., Mountains
Mus., Museum

n., n, new
N., North
N. Am., North America(n)
Namur., Namurian
Nat., Natural
Natl., National
NC., north central
N.Car., North Carolina
NE., Northeast
Neb., Nebraska
Neocom., Neocomian
Neth., Netherlands
Nev., Nevada
Newf., Newfoundland
Niag., Niagaran
N.J., New Jersey
no., number
Nom., Nomenclator
nom. conserv., *nomen conservatum* (conserved name)
nom. correct., *nomen correctum* (corrected or intentionally altered name)
nom. imperf., *nomen imperfectum* (imperfect name)
nom. nud., *nomen nudum* (naked name)
nom. null., *nomen nullum* (null, void name)
nom. subst., *nomen substitum* (substitute name)
nom. transl., *nomen translatum* (transferred name)
nom. van., *nomen vanum* (vain, void name)
nom. vet., *nomen vetitum* (impermissible name)
Nomencl., Nomenclature
nov., *novum* (new)
NW., Northwest
N.Y., New York

O., Ocean
obj., objective
Oct., October
OD, original designation
Okla., Oklahoma
Oligo., Oligocene
Ont., Ontario
Op., Opinion
opp., opposite
Ord., Ordovician
Ore., Oregon
orig., original
Osag., Osagian
Oxford., Oxfordian

p., page(s)
Pa., Pennsylvania
Pac., Pacific
Palaeoz., Palaeozoic
Paläont., *Paläontologie*
Paleoc., Paleocene
Paleont., Paleontological, *Paleontologicheskiy*
Paleoz., Paleozoic
part., partial
Penn., Pennsylvanian
Perm., Permian
pers., personal
Ph.D., *Philosophiae Doctor* (Doctor of Philosophy)
Philip., Philippines
pl., plate(s), plural
platf., platform
Pleist., Pleistocene
Pliensbach., Pliensbachian
Plio., Pliocene
Pol., Poland
Port., Portugal
post., posterior
Prag., Pragian
prov., province(s)
prox., proximal
pt., part(s)
publ., *publicacion*, publication(s), published

Quat., Quaternary
Que., Quebec
Queensl., Queensland

Rec., recent, record(s)
reconstr., reconstructed, -ion
ref., reference(s)
reg., region
Rept., Report
Rev., Review, *Revista, Revue*
Richmond., Richmondian
Riksmus., Riksmuseum

S., Sea, South
S.Am., South America
Santon., Santonian
S.Car., South Carolina
Sc.D., *Scientiae Doctor* (Doctor of Science)
Sci., Science, Scientific
Scot., Scotland
SD, subsequent designation
SE., Southeast
sec., *seccion(es)*, section(s)
Sept., September
ser., serial, series, *seriya*
sér., *séries*
sess., session, *sessiya*
Sh., Shale
Sib., Siberia
Siegen., Siegenian
Sil., Silurian
Sinemur., Sinemurian
SM, subsequent monotypy
sp., species (spp., plural)
spec., special, specification, specimen
Ss., Sandstone
Ste., *Sainte*
subj., subjective
subtrop., subtropical
suppl., supplement(s), supplementary
SW., Southwest
Swed., Sweden
Switz., Switzerland
syn., synonym, synonymous

Tasm., Tasmania
tech., technical
temp., temperate
Tenn., Tennessee

Terr., Territory,-ies
Tert., Tertiary
Tithon., Tithonian
Toarc., Toarcian
Tournais., Tournaisian
Trans., Transactions
transl., translation
transv., transverse
Tremadoc., Tremadocian
Trenton., Trentonian
Trias., Triassic
trop., tropical
Turon., Turonian

U., Up., Upper
Univ., *Universidad, Universitá, Universität, Université, Universitet*, University
unpubl., unpublished
Urgon., Urgonian
U.S., United States
U.S.A., United States of America
USSR, Union of Soviet Socialist Republics

v., vol., volume(s)
Va., Virginia
Valangin., Valanginian
var., variety
vert., vertical
Virgil., Virgilian
vyp., *vypusk*

W., West
Wenlock., Wenlockian
Westphal., Westphalian
Wis., Wisconsin
Wolfcamp., Wolfcampian
Word., Wordian
Wyo., Wyoming

Yorks., Yorkshire
Yugo., Yugoslavia

Z., Zone
Zeitschr., *Zeitschrift*
Zool., Zoological, *Zoologicus, Zoologie, Zoologisch*, Zoology

REFERENCES TO LITERATURE

Each part of the *Treatise* is accompanied by a list, or lists, of references to paleontological literature. In *Treatise* parts published in the 1950's and early 1960's these lists were highly selective, consisting primarily of recent and comprehensive monographs, but also including some older works recognized as outstanding in importance. In time, however, *Treatise* authors and readers pressed for more exhaustive documentation, and for volumes published from about 1964 to 1965, this has been as comprehensive as possible. Since that time the aim has been to provide documentation, complete with author, publication year, and page number, for all taxa described anywhere in the text, as well as for all illustrations copied or adapted from preexisting publications. In other words, the lists of references contain the full titles and places of publication of all books, monographs, and serial articles to which reference is made in the text.

The following is a statement of the full names of serial publications which are cited in abbreviated form in the lists of references in the present volume. The information thus provided should be useful in library research work. The list is alphabetized according to the serial titles which were employed at the time of original publication. Those following in brackets are those under which the publication may be found currently in the *Union List of Serials*, the United States Library of Congress listing, and most library card catalogues. The names of serials published in Cyrillic are transliterated; in the reference lists these titles, which may be abbreviated, are accompanied by transliterated authors' names and titles, with English translation of the title. The place of publication is added (if not included in the serial title).

The method of transliterating Cyrillic letters that is adopted as "official" in the *Treatise* is that suggested by the Geographical Society of London and the U.S. Board on Geographic Names. It follows that names of some Russian authors in transliterated form derived in this way differ from other forms, possibly including one used by the author himself. In *Treatise* reference lists the alternative (unaccepted) form is given enclosed by square brackets (e.g., Chernyshev [Tschernyschew], T.N.).

List of Serial Publications

Academia Naturae Curiosorum. Halle. (*See* Deutsche Akademie der Naturforscher.)

Academia Republicii Popülare Române, Buletin Stiintific. Bucuresti.

Académie Impériale des Sciences, St. Pétersbourg, Mémoires; Recueil des actes de la seance publique (Akademiya Nauk SSSR Leningrad).

Académie Malgache, Mémoires. Tananarive, Malagasy Republic.

Académie Royale de Belgique, Class des Sciences, Bulletin; Mémoires. Bruxelles.

Académie des Sciences de Paris, Comptes Rendus; Mémoires. Paris.

Académie des Sciences de l'URSS, Comptes Rendus; Institut Paléontologique, Travaux; Institut Paléozoologique, Travaux [Akademiya Nauk SSSR, Doklady]. Leningrad.

Academy of Natural Sciences of Philadelphia, Journal; Proceedings.
Academy of Science of St. Louis, Bulletin; Memoirs; Transactions.
Accademia Gioenia delle Scienze Naturali di Catantia, Atti; Bollettino.
Acta et Commentationes Universitatis Tartuensis (Dorpatensis). Tartu Riiliku Ülikooli Toimetused, Uchenye Zapiski; Tartu Ülikooli Geologia-Instituudi Toimetused.
Acta Geologica (Academiae Scientiarum Hungaricae). Budapest.
Acta Geologica Polonica. Warszawa.
Acta Helvetica. Basel.
Acta Palaeontologica Polonica [Polska Akademia Nauk, Komitet Geologiczny]. Warszawa.
Acta Palaeontologica Sinica. Peking. (*See* Ku Sheng Wu Hsüeh Pao.)
Acta Zoologica. Stockholm.
[K.] Akademie van Wetenschappen te Amsterdam, Jaarboek; Proceedings; Verslagen en Mededeelingen.
Akademie der Wissenschaften, physikalisch-mathematische Klasse, Abhandlungen; Monatsberichte. Berlin.
Akademie der Wissenschaften zu München, mathematisch-physikalische Klasse, Denkschriften; Sitzungsberichte.
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