Semester II
Core Course (CC 8) Biosystematics and Evolution

Unit 1: Biosystematics

2. Hierarchy of categories, outline of classification of animals, important criteria used for classification upto classes in each phylum

and

4. International code of Zoological nomenclature (ICZN): operative principles and important rules, Zoological nomenclature and scientific names of various taxa.

Biological Nomenclature

Nomenclature: *nomen* (name) and *calare* (to call) -- to call by name

One of the primary responsibilities of systematic biology is the development of a system of biological nomenclature and classifications. Nomenclature is of utmost importance in systematics and taxonomy and is necessary in organizing information about the vast biodiversity (Nomenclature functions to provide labels (names) for all taxa at all levels in the hierarchy of life.

Carolus Linnaeus was the first to establish a system of organizing the diversity of life in a hierarchical classification and developed a consistent binomial system of naming. He established Latin as the common language for the scientific naming of all organisms as Latin used to be an important language at the time of Linnaeus. Therefore, Latin came to be a critical language for international communication. As will be seen below the various Codes for nomenclature consider Latin to be an essential language.

- Taxa at the level of species are named with **binomials**, consisting of generic and specific epithets or names that together equal the **species name**
- Taxa above the level of species are **Supraspecific Taxa** and are **Uninominals**.
- Taxa below the level of species are **Subspecies** and are **Trinominals**.

The binomial system has been a successful system because it is the only system that has been universally accepted.
Common vs Scientific Names

Common names for species are names the species are famously called (in a specific dialect or local area)

Disadvantages:

They are not useful to people with a different language or dialect

Some species have several common names

Some species share the same common name

Some species may not have a common name

Scientific names are Latin or Latinized names that are standardized by a series of rules and are applicable worldwide.

\[\text{Linnaean Hierarchy}\]

This is a system of categories that connote taxonomic rank. The same thing could be achieved through a system of indentation (see below) or a system of numbers connoting rank in a hierarchy. However, these latter systems are generally more difficult to represent and remember by the user.

With the Linnaean system one only needs to know the general categories and know rank order in the hierarchy!

The original Linnaean system had a limited set of categories that successfully reflected a nested set of groups within groups.

Linnaean Hierarchy in 10th Edition of Systema Naturae (1758)
Later many authors began to incorporate categories above and below these original categories. Some classifications contain well in excess of 10 different categories, as can be see below.

**Categories Used in More Modern Classifications**

<table>
<thead>
<tr>
<th>Taxonomic Category</th>
<th>Singular</th>
<th>Plural</th>
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<tbody>
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<td>Kingdom</td>
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<td>Variety</td>
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**Proper Usage of Taxonomic Categories**

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<tr>
<td>1758</td>
<td>Linnaeus' 10th Edition of <em>Systema Naturae</em></td>
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<tr>
<td>1840</td>
<td>Strickland Code of British Association for the Advancement of Science</td>
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<tr>
<td>1867</td>
<td>Set of &quot;laws&quot; at Paris International Botanical Congress</td>
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<td>1881</td>
<td>French Code developed</td>
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<td>1887</td>
<td>U. S. Code developed</td>
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<td>1889</td>
<td>International Zoological Congress adopted Blanchard Code</td>
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<td>1894</td>
<td>German Code developed</td>
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<tr>
<td>1901</td>
<td>Regles International Nomenclature of Zoology adopted by 5th Congress, published under the 6th Congress in 1905</td>
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<tr>
<td>1904</td>
<td>International Commission on Zoological Nomenclature (ICZN) formed</td>
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<tr>
<td>1913</td>
<td>Plenary powers granted to ICZN</td>
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<tr>
<td>1952</td>
<td>International Code of Botanical Nomenclature</td>
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<tr>
<td>1953</td>
<td>Publication of Copenhagen Decisions and the Follett Summary (1955)</td>
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<tr>
<td>1958</td>
<td>Rewritten as international code and updated since that time</td>
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<tr>
<td>1976</td>
<td>International Code of Nomenclature of Bacteria</td>
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<tr>
<td>1985</td>
<td>Publication of International Code of Zoological Nomenclature</td>
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<td>1994</td>
<td>Most recent Code of Botanical Nomenclature</td>
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<tr>
<td>1999</td>
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Codes of Nomenclature

Linnaeus' system of classification made a major impact on the world in terms of naming diversity and organizing the information. The other systems of classification being developed by other workers have become obsolete today.

There are four different codes of nomenclature today. We will deal primarily with the International Code for Zoological Nomenclature (ICZN).

In Zoology the code consists of a series of "Articles" and "Recommendations."

**Articles & endash;** intended to be followed strictly by those involved in the creation or modifications of scientific names or supraspecific taxon names.

**Recommendations & endash;** intended as guidelines that should be followed if working on creation or modifications of scientific names or supraspecific taxon names.

**Some General Objectives of Scientific Nomenclature and Codes**

**Uniqueness.** The name of a particular organism gives one immediate access to all the known information about the particular taxon. Every name must be unique because it is the key to the entire literature relating to the species or higher taxon in question. If several names have been given to the same taxon, there must be a clear-cut method whereby it can be determined which of the names has validity.

**Universality.** Scientific communication would be made very difficult if we had only vernacular names for taxa in innumerable languages in order to communicate with each other. To avoid this we have adopted an international agreement for a single language (Latin) and a single set of names for biological diversity to be used on a worldwide basis.

**Stability.** As recognition symbols of diversity, names of organisms would lose much of their usefulness if they were changed frequently and arbitrarily.

**Groups of Names Covered by Codes**

The names covered by the various codes fall into the following groups. A name proposed in a given grouping can serve at any level within that grouping.
Superfamilial names

These are names above the family-group level. These names are not regulated in zoology and need not be based on generic names. These names generally do not have standardized endings.

In the botanical literature it is recommended that these names be based on a nomenclatorial type (generic name; to be covered below) and have standardized endings.

Family-Group names

Includes groups from genus-group names up to and including the rank of Superfamily. The most commonly used ranks are tribe, subfamily, family, and superfamily; however, the latter is not used in botany.

Names in this group usually have standardized endings for botany and zoology. Some of the names established by Linnaeus have been considered exceptions to the standardized endings in botany.

Names in this group are based on generic names and types.

Genus-Group names

Applies to generic and subgeneric names. (The same rules apply at all levels)

Species-Group names

Applies to species and subspecies names in zoology and infraspecific names in botany. (The same rules apply at all levels)

Species Names

In the hierarchical system developed by Linnaeus species are referred to by two different "names". Historically, predecessors of Linnaeus referred to species in descriptive phrases, in Latin.

Binominal nomenclature consists of a genus and species name (epithet).
• Each species is placed into a genus.
  o Generic names are Latin nouns.

Names of species are Latin adjectives in agreement with the nouns (Generic epithet) (or are nouns in apposition).

• Generic names (epithets) always begin with a capital letter; species names (epithets) always begin with lower-case letter.
  o Homo sapiens

• Both names are set apart from the accompanying text:
  o The species is Homo sapiens.
  The species is Homo sapiens.

• Scientific names do not include diacritical marks but may be hyphenated
  o Erimystax x-punctata

• Author's names

All generic and specific epithets have authors, the name(s) of the person(s) who first officially described them in a publication. You will often see scientific names with an author's name following it. This is often confusing to non-taxonomists but is really important because it is very useful in tracing the history of applications of names through time. Scientific names with very similar spellings can usually be distinguished from one another when an author's names is included.

  Examples: Rhinacloa pallipes Reuter
  Rhinacloa pallidipes Maldonado

• Dates of authorship

Dates of official descriptions can also be included with scientific names to further clarify situations and locate relevant literature.

  Examples:  Macrocoleus femoralis Reuter, 1879
  Cyrtocapsus femoralis Reuter, 1892
  Psallopsis femoralis Reuter, 1901
• **Author's names in parentheses - typographical errors?**

No. If the species in question in a particular classification is in the genus in which it was described the author's name(s) do not appear in parentheses

  o *Notropis cardinalis* Mayden

However, if the species in a classification is in a genus other than the one in which it was described the author's name(s) appear in parentheses

  o *Luxilus cardinalis* (Mayden)

In the botanical literature the same applies but the author's name(s) in parentheses may be followed by another name of the author who moved the species to its genus of current placement.

  o *Ceratozamia* boliviana Brongn.

    *Zamia boliviana* (Brongn.) A. DC.

• **Different usages of the same name?**

  In some instances in zoology authors may use a scientific name differently than the person (author) who originally described the species. In such a case the scientific name, as listed in catalogs and other writings, is separated from users name by a colon.

*Phytocoris* marmoratus Blanchard

*Phytocoris marmoratus*: Stonedahl.

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**Basic Tenets of the Codes**

While the codes differ in their organization and some rules the basic ideas behind all of the codes are outlined below. Each of these will be discussed in more detail below.

• **Priority**
Priority

This is a simple concept: the first name applied to a taxon is the name that will be used.

Often, taxonomists, systematists, ecologists, behavioral biologists, and others encounter multiple names that appear to relate to the same taxon, say a species. Which name is correct?

While not part of his system, Linnaeus did endorse priority in principle but did not practice it.

Such a dilemma typically is the result of early taxonomic studies where researchers were in different parts of the world or continent and were independently describing taxa without knowledge that another person was describing the same taxon.

It can also result from researchers not fully understanding variation within a species or that the different "looking" things are different stages in a life cycle or different sexes.

Example: parrot fishes, aphids

Priority relates to date of publication or mailing date (public availability). Priority involves only date, not page or line precedence. If the day is not determinable then the accepted date is the 1st day of the smallest time unit (week, month, year) that can be determined. Older valid names have priority over newer valid names; the oldest valid name of a taxon takes precedence over all other names of a taxon. Generally this name is referred to as the senior name.

In zoology priority extends to ranks of the Superfamily and below.
Priority is not intended to upset stability because stability of classification is one of the basic objectives of biological classification. Thus, in instances where a name change would cause much confusion the codes provide provisions that permit the conservation of a younger and well-established name. In zoology the ICZN has the power to suppress an older name and make the younger name the valid name for the taxon.

Priority extends back to particular taxonomic works for each group of organisms. Names applied before these specified works are not considered valid names.

The baseline priority for zoological nomenclature begins with Linnaeus' *Systema Naturae*, 10th edition, considered published 1 January 1758. Any works published in 1758 or after are considered published.

For spiders the baseline priority dates to the work of Clerck (1757).

Baseline priority for botanical names dates to Linnaeus' *Species Plantarum* (1753)

**Simple example of priority:**

**Stoneroller**

*Campostoma anomalum* (Rafinesque)

*Rutilus anomalus* Rafinesque, 1820.

*Exoglossum spinicephalum* Valenciennes, 1844

*Exoglossum dubium* Kirtland, 1845

*Leuciscus prolixus* Storer, 1845

*Chondrostoma pullum* Agassiz, 1854

*Campostoma nasutum* Girard, 1856

*Campostoma formosulum* Girard, 1856

*Dionda plumbea* Girard, 1856
These are all valid and available names for the same taxon (species). Using priority the correct name to be applied to the taxon is *Rutilus anomalus* Rafinesque but when placed in the genus *Campostoma* the specific epithet must agree in gender with the genus. Hence, the name becomes *Campostoma anomalum* (Rafinesque).

**More complex example of priority:**

*Lygaeus salititans* Fallen, 1807

*Chlamydatus* was described by Curtis (1883) and included a new species *marginatus* Curtis.

Fieber (1858) described new genus *Agalliastes* that included *saltitans* (Fallen), along with other species.

The type of *Agalliastes* was fixed as *saltitans* by Kirkaldy in 1906.

Flor synonymized *marginatus* Curtis with *salititans* Fallen.

Thus, *Chlamydatus salititans* (Fallen) is the name that must be used on the basis of priority.

Finally, there is a basic conflict between the objective of stability and the code of priority.

**Availability**

Whereas priority is a comparatively objective criterion, availability is more nebulous. With reference to the different codes, most names would be considered "available" if they meet the following four criteria.

- Appear in a work published after 1753 for plants and 1758 for most animals.
- Meet the criteria for publication designated by the codes.
- Are written in the Latin alphabet (today in English except for plants)
- Are binominal (if referring to species)

The codes also require other things depending upon the code.

**Publication:**
• Must be issued publically for the purpose of providing a permanent scientific record.
• Must be obtainable, when first issued, free of charge or by purchase.
• Must have been produced in an edition containing simultaneously obtainable copies by a method that assures numerous identical copies.

Before 1986, must be via ink on paper, i.e. conventional printing or mimeographing (latter okay in zoology but not botany)

After 1985 can be via photocopying or any other "unconventional" method but must include a statement that nomenclatural content is for permanent, public, adn scientific record therein.

• **Forbidden publications** -
  • Distribution on microfilm, computer printouts, or pre-1986 photocopies
  • A mention of a name at a scientific meeting
  • Labeling specimens deposited in a museum
  • The distribution of proof sheets (zoology)
  • Deposition of document (e.g., thesis) in a collection of documents, a library, or other archive
  • Distribution only to colleagues or students of a note, even if printed, in explanation of an accompanying illustration.

Criteria for "publication" are being evaluated seriously now with the many more options for reproducing multiple copies available to the public for permanent record (dissertations through University Microfilms and WWW).
Typification

The ideas of priority and availability were implicit in studies from the time of Linnaeus. However, the type concept was not.

Early authors considered the most common species to be "typical" of the genus. Species were represented by a series of "typical" specimens. Linnaeus commonly replaced is typical specimens with "better" specimens. This is a big problem for many reasons.

This was problematic. It became difficult for fixing generic limits or determining representatives of different species names.

The type concept and requirement for designation of types partially solved this problem and assisted in the objective of stability; it was a major advance in the evolution of the codes. In zoology it was codified in the Regles (the first code: International Nomenclature of Zoology adopted by 5th Congress, published under the 6th Congress in 1905). Mandatory designation of types in botany did not apply until Jan. 1958.
This procedure ties names to specimens and is important.

**The concept is not typological:**
The type specimen is not meant to be "typical"

Types are not suppose to represent variation in a taxon.

However, there are some biases practiced today.

A "good" specimen

An adult in breeding condition or with additional characters visible.

**Forms of Types:**

There are two forms of types - (1) names or (2) specimens.

**Species-group types.**

These represent a single specimen to which a name is attached. This provides an objective criterion for establishment of usage of that name. Species-group types are recognized in the codes as primary types and include the following possibilities.

**Type locality:** All types of species and subspecies are tied to a spatial location called the *type locality*.

**Holotype:** Single specimen designated by the author(s) of the name at the time of publication of the original description.

**Neotype:** A specimen later designated to replace a holotype (or other primary type) if the latter can be documented as lost or destroyed.

**Syntypes:** A group of specimens thought to represent a species, as designated or indicated by the author(s) of the original description. These specimens may sometimes be referred to as the "type series". Cotypes are sometimes used in the same way. If syntypes exist for a species only from this series can a lectotype be designated. [Many early descriptions of species were based on syntypes because the requirement for a holotype designation or indication did not exist].
Lectotype: One of the syntypes chosen by the original or subsequent author(s) to function as the name bearer.

Primary types are customarily deposited in recognized institutions dedicated to the long-term maintenance of collections.

Other types:

Isotype: a specimen (in botany) collected from the same individual plant as the holotype.

Topotypes: specimen(s) collected from the same location as the holotype (perhaps at the same time).

Paratype: Commonly designated in descriptions of new species as specimens being studied by the author in the description of the new species or subspecies and designated by that person at the time of publication of the original description. These specimens are valuable as reference materials that are deposited at multiple, dedicated museums or institutions, they have no standing in nomenclature (these series can sometimes contain misidentified specimens). Paratypes may, however, serve as useful materials to select a neotype from if needed.

Genus-group types.

These types represent species, comprised of names - not specimens. Traditionally authors did not designate types of genera; modern codes, however, require that for a generic or subgeneric name to become available a type species must be designated by the author describing the new genus or subgenus.

Types for genera published before mandates of types are most commonly fixed &endash; assigned either through monotypy or subsequent designation.

Monotypy: The genus has only one species included in it at the time that they type species is designated and is thus monotypic. If other species are added to the genus before a type is designated then the type can only be the original species that existed in the genus.

Subsequent designation: If more than one species was originally included in a new genus the type can be selected either by the original author or at a later time by another person.
**Indication:** An original indication of a type is one that the author of the name indicates via illustration or other means and is referred to as typus or typicus.

**Tautonymy:** When a new genus and species is described with the same name for the genus and species epithet it becomes the type. An example is Bison bison. This is okay in zoology but not in botany.

**Family-group names.**

Genera form the types in these groups. Family group names are subject to the rules of homonymy (below), in that no two can be spelled identically, even though they may be based on different, although similar, generic names. Just because a generic name on which the oldest family-group name is based is in synonymy (below), this does not invalidate the family group name.

**For example:**

Insect suborder Heteroptera the family Velocipedidae contains a single valid genus *Scotomedes*. The generic name on which the family name is based, *Velocipedes*, is a junior synonym of *Scotomedes*.

Angiosperm genus *Winteria* is a junior synonym of *Drimys* but the genus is in the family Winteraceae.

**Homonymy**

This basic principle refers to the application of the same name to different taxa. Our codes of nomenclature state that NO two names above the species-group level may be the same in zoology or botany, although names may be duplicated between the two fields.

Homonyms are of different types:

**Senior homonyms:** The available name on the basis of priority.

**Junior homonyms:** A preoccupied name (not in use) on the basis of priority or by a ruling by a nomenclatorial body.
**Primary homonyms**: In a species-group (species, subspecies, etc.) these are names that are the same and were proposed in the same genus-group taxon. The junior homonym must always be replaced must always be replaced either by a new name or a junior synonym (if one exists)

Example: *Cottus pygmaeus* &endash; pygmy sculpin. This species was described and later it was discovered that this name was already preoccupied by an old description of a *Cottus* from the Old World. This then is a primary homonym. A new name for the pygmy sculpin is currently being described.

**Secondary homonyms**: These are species that are placed in the same genus subsequent to their publication and they have the same specific epithets. The senior secondary homonym is the older of the two names. An alternative name will have to be provided either through description or junior synonyms for the junior homonym.

Example:

*Cyprinella garmani* (Jordan)

gibbous shiner

*Notropis garmani* Jordan, 1885:813. [Substitute name for preoccupied *rubripinna* Garman, 1881]

*Cyprinella rubripinna* Garman, 1881:91. [Original description; Type locality: Lago del Muerto, near Parras, Coahuila, Mexico.]

**Synonymy**

In taxonomy the concept of synonymy relates to the application of different names to the same taxon. As in the case for homonyms, synonyms can be of several types.

**Senior synonyms**: The oldest of two or more names that are considered valid by nomenclatorial codes. This is usually based on priority, but may also be done on the basis of choice of names by the first revisor (zoology) or by a nomenclatorial governing body.
**Junior synonyms:** The junior names are those that are considered invalid on the basis of priority or because of a choice of the first revisor, or by a governing body of nomenclature. These names, however, can be elevated to senior synonyms if new taxa are identified later and the type(s) of the new taxa are the name bearers of these names.

**Objective synonyms:** Different names that by examination of nomenclatorial literature alone are judged to refer to the same taxon. For example, any two family-group names with the same type genus or any two genera with the same type species are objective synonyms. Two species based on the same specimen are also considered objective synonyms. These synonyms are generally created only by a drug or alcohol-induced stupor that lasts for days or weeks for the author or by an inadvertent error.

**Subjective synonyms:** These are different names that have been applied taxon as determined by a taxonomist or systematist. An example would include two species originally described as distinct but were later determined by a professional in the field that they are the same species. This is the most common type of synonymy and these can be the sources of confusion and great debate.

**Example:**

**Stoneroller**

*Campostoma anomalum* (Rafinesque)

*Rutilus anomalus* Rafinesque, 1820.

*Exoglossum spinicephalum* Valenciennes, 1844

*Exoglossum dubium* Kirtland, 1845

*Leuciscus prolixus* Storer, 1845

*Chondrostoma pullum* Agassiz, 1854

*Campostoma nasutum* Girard, 1856

*Campostoma formosulum* Girard, 1856
Dionda plumbea Girard, 1856

Regarding Stability of Nomenclature

The strict application of the code can be suspended in some instances.

One has the right to appeal to the commission.

There is a statute of limitation for an unused senior synonym in zoology of 50 year = nomen oblitum

Other items on Nomenclature

First revisor principle:

This is the first person to examine a species or group of species under the modern codes. This person has the right to choose which of several equally valid names is to be used. They may also identify a lectotype and designate and restrict type localities. They may choose senior synonyms among names published in the same publication by page or line priority if they wish.

Retroactive? Yes.

Validity and Availability

Name correctly formed and validly and effectively published
Available (zoology)
Legitimate (botany)

However, the only name that can be used is a valid (zoology) or correct (botany) name.

Illegitimate names

Forgotten name = nomen oblitum (after 1960 if not used for 50 years) [ Law of proscription]
Superfluous name = *nomen superfluum*

A name is superfluous if it includes the type of another name which should have been used (i.e., a description error; should never have been described)

Ambiguous name = *nomen ambiguum*

A name that has been used for a long time in different contexts and is thus confused (seriously)

Dubious name = *nomen dubium*

Available name but cannot be assigned to a definite taxon due to the shortcomings in the original description/diagnosis or because of type material problems. These names are in taxonomic limbo and are never allocated until such time that a type fixation is devised. Usually in these cases no type was designated or only an illustration may exist.

Improper publication of a new name without a description

= *nomen nudum*. These are names that may be nomenclaturally published but lack any description or indication; they have no nomenclatural status (i.e., not occupied)

Supressed names = *nomina conservanda.*

These are names that have been suppressed by a nomenclatural governing body.

**Law of type fixation**

Provides for the fixation of a name application, at all levels, by designation of a single type.

**What constitutes an indication?**

- A bibliographic reference to a previously published description, definition, or figure.
- Inclusion of a name in an index to a work
- Substitution of new name for a previously established name
- Citation of one or more available epithets in combination with, or listed under, the new generic name
- Illustration of an included species
• Description of the "work" on an animal (tubes, tracks, feces, nests, galls, etc.)

**Differential diagnosis**

Minimum description is necessary

One should go beyond and compare to nearest relatives

**Names of hybrids**

No! They are not taxa, they are individual organisms. However, there are species of hybrid origin and these are taxa and should be named.

**Date of publication**

This is the mailing date, not the printed date.

**Formation of names**

Latin or latinized

Gender must agree

Use no long, hard to pronounce names (recommendation)

Do not use the same name as a species in a related genus (or subspecies in a related species) because it could become a homonym.

The taxonomist should provide etymology (and gender)

**Patronymics**

Women = -ae; Man = -i; Brothers or Mr and Mrs -orum; Sisters -arum

However, it is preferred by many that the names be descriptive.

**Original Spelling**

The original spelling is retained with exceptions (*lapsus calami* = inadvertant printer's error)
Authorship

No anonymous descriptions after 1950

Use of parentheses

Abbreviations for authors (L. = Linnaeus)

Suspension

Any automatic provision of the code which disturbs the objectives of nomenclature can be suspended for any given case presented by appeal to the ICZN for use of its plenary powers.

Occupation:

For a name to have status in nomenclature it must be occupied. This requires the following.

Properly published

Must be in Latin or Latinized

Must be formed properly

Cannot be based on hypothetical taxa, teratological specimens, hybrids, etc.

Must be accompanied by a description, diagnosis, and indication

(After 1930 must have an actual diagnosis or definition or reference to OR be proposed expressly as a replacement name for an existing name)

In addition:

After 1930 &endash; genus group names the type species must be unambiguously designated. Species group names - a description of the work alone is unacceptable.

After 1950 &endash; name cannot be proposed anonymously

If any of these are violated the name is nonexistent nomenclatorially.
However, species group names can be based on any stage of the life cycle or life history, either sex, or body part.

**Availability**

Again, those names that are occupied, identifiable, and, in addition, would be valid if they were the earliest available name of the taxon (excludes some homonyms, nomina oblita, nomina dubia, names suppressed by the nomenclatorial governing body. A name may be occupied but not available.

**Generic names**

Treated as Latin nouns

Latin nouns have grammatical gender, but this usually has nothing to do with the actual gender; often indicated by ending

- *a* mostly are feminine
- *us* mostly are masculine
- *is* may be either masculine or feminine
- *um* mostly are neuter
- *e* feminine or neuter