

BIOL 215 (TAXONOMY AND BIOLOGICAL NOMENCLATURE) NOTES

Ahmadu Bello University, Zaria

Taxonomy versus Systematics

Henderson's Dictionary of Biological Terms/Henderson's Dictionary of Biology defines **Taxonomy** as follows:
"The analysis of an organism's characteristics for the purpose of classification", and,

Systematics as: "Study of the identification, taxonomy and nomenclature of organisms including the classification of living things, with regard to their natural relationships and the study of variation and the evolution of taxa." ^{unit of} _{hierarchy}

OTHER:

Taxonomy: "The science of classifying and naming organisms"

Biosystematics: "The science of determining evolutionary relationships among organisms."
(It goes on to say that most Biosystematists are taxonomists).

The definitions of taxonomy and systematics overlap and more often than not, the terms are used interchangeably.

TAXONOMY AS SCIENCE

TERMINOLOGY

1. Science

- Systematic and formulated knowledge
- Aims to describe and understand the world
- Accumulated by scientific method
- Evidence gathered by observation and experiment
- Scientific statements (hypotheses) must be falsifiable (but are tested in bundles)

2. **Taxonomy** (Greek, *taxis* = arrangement; *nomos* = law.) The practice of identifying, describing and naming organisms based on the rules of zoological nomenclature.

- Making and maintaining collections
- Differentiating species
- Identification (keys) and diagnosis of species and genera
- Naming and describing species and genera

Aroja - no legs

Aroja - no tails

Clairier - tamwada

Caro, salmon

3. **Systematics** (Greek, *systema* = a whole made up of several parts.)

- Develops the classification of organisms
- Species comparison and grouping into higher categories
- Organisms are arranged in definite, hierarchical order
- The order of the system is based on hypotheses of common descent

4. Classification

- Arrangement of organisms into taxonomic groups.
- Membership in groups can be based on any heritable attribute, such as structural features (anatomy), biological characteristics, behavioural attributes or molecular and biochemical features.

A Natural classifications

Natural classifications use natural relationships between organisms. Internal as well as external features of organisms are used. Similarities of embryology, physiology, biochemistry, cell structure and behavior are all used. Classifications that are used today are mostly natural and phylogenetic; here, organisms which have a common ancestor are believed to be grouped together.

- Natural classifications are objective.

1. Regarded as monophyletic (Greek, *monos* = one; *phyle* = tribe) - a group of organisms consisting of all and only descendants of a common ancestor.
2. Classifications which include members of unrelated lineages are regarded as polyphyletic (Greek, *polys* = many; *phyle* = tribe).

B. Artificial classifications

These are based on only a few easily observable characteristics for convenience and simplicity. The ancient Chinese system of classification for example organized the animal kingdom into groups such as stray dogs, those that resembled flies at a distance, those that broke a flower pot, etc. Linnaeus included all worm-like organisms in the group he called Vermes. This group included organisms such as nematodes, earthworms, maggots and snakes! This classification was artificial since it did not take into account the vertebral column in the snake and the lack of it in the others. The snake has more features in common with other vertebrates than with the worms and maggot. Another example of artificial classification is the grouping of fish with respect to their environment – freshwater, brackish water and marine. This is convenient for the purpose of investigating their mechanisms of osmoregulation. Microscopically small organisms are referred to as microorganisms for convenience.

- Artificial classifications are subjective, e.g.

1. Black butterflies versus peppered butterflies (as in the industrial melanism of the peppered moth).
2. Early 19th Century classifications classified snakes, worms and maggots together, based on shape.

C. Phenetic Classification

This is classification based purely on similarities in phenotypic characters, not necessarily relationships by evolutionary descent. In an attempt to avoid the problem of establishing evolutionary relationships, phenetic classification is used. Problem: there is little or no fossil record in many instances, leading to difficulties and controversies. Phenetic is derived from the Greek word *phainomenon* (that which is seen). This type of classification is therefore based on observable characteristics and the characters used are considered to be equally important. All the features of an organism are used for its distinction and do not necessarily have to be of evolutionary significance. A huge amount of data is collected and the degrees of similarity and difference between organisms are calculated usually using a computer, due to the complexity of the calculations. This is also called numerical taxonomy. Phenetic classifications produce very similar outcomes as phylogenetic classifications.

TAXONOMIC STATEMENTS ARE HYPOTHESES

- Taxonomic Statements

1. Sample specimen/s A belongs to taxon x. Taxon x may be new or already described.
2. Hypothesis - Proposition made as a basis for further testing. Not assumed to be true.
3. Taxonomic Hypotheses

e.g. *You* Genus nov. articulates three separate hypotheses:

- 1) *You* has not been described before (objective)
- 2) *You* is different from genus *Him* which has been described (subjective)
- 3) *You* consists of all and only the descendants of a common ancestor (history)

1) and 2) are internal to taxonomy, making sure that one unique scientific name is applied to a particular taxon. If hypothesis 1 or 2 is incorrect, we have two names for the same biological entity (*You* and *Him*). This happens quite often-7% to 80% of species have more than one name in insects.

3) is external to taxonomy, and ensures that species are a common currency for use in biological theories. If 3 is incorrect, then it makes our theories hard to test. We can't distinguish whether (a) the theory is incorrect or if (b) the genus/era involved in the test doesn't live up to our definition.

TESTING TAXONOMIC HYPOTHESES

Every new specimen collected and every new character observed tests the current classification as a hypothesis of ancestry and descent.

Hypothesis at the species-level falsified when entity found to be already described-synonymy Systematists often draw conclusions from the degree of morphological difference between populations on the probable degree of reproductive isolation between the populations.

Assumes that morphological traits being examined are heritable (e.g. ecomorphs in Collembola), and that any marked differences are not due to sampling error (e.g. two ends of a cline).

RULES OF ZOOLOGICAL NOMENCLATURE

- Biological nomenclature has been devised to promote stability and universality in applying names to organisms
- Classification is the process of identifying systematic groups
- Nomenclature aims to provide a unique scientific name for each systematic group
- A name is a convenient and conventional symbol used as a means of reference in communication
- Nomenclature provides rules and recommendations to help solve problems in assigning a unique name to a taxon
- These rules must not infringe on taxonomic judgement. It is the only area of science that is governed by rules
- names should be informative, convenient, memorable, unambiguous, assignable (but need not necessarily be true)
- Scientific names also give information on the rank of the group in the taxonomic hierarchy

NAMES AND NOMENCLATURE

Taxonomic names have a dual role

A) taxonomic categories as indexing terms for biological literature

B) taxonomic categories as scientific hypotheses

It is best if indexing terms do not change

Hypotheses are subject to change in light of evidence (new/old)

This duality sometimes causes tension in the application of taxonomic names.

1. Common Names versus Scientific Names

A. Common names subjective: Mudfish in Nigeria may be very different from Mudfish in Asia; Catfish may be one of up to 100 genera etc.

B. Scientific Names are objective and based on rules. There can be only one *Polypterus endlicheri*, one *Clarias anguillaris* etc.

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2. International Code of Zoological Nomenclature.

- A. Sets out the guidelines for providing names and interpreting their application.
- B. First guidelines for nomenclature adopted by committee of Strickland (1842) Committee members included Richard Owen and Charles Darwin.
- C. Guidelines were discussed for many years and Rules were first established in 1905, amended periodically, latest 2000.

3. International Commission on Zoological Nomenclature (ICZN).

- A. Composed of several taxonomists throughout the world (Australia, U.S, England, Russia)
- B. Quasi-legal Recourse for resolving problems with scientific names.
- C. Taxonomists with problems submit Petitions to Commission for suppression or recognition.
- D. Has the power to make rules and alter or interpret old ones.

Rules of Zoological Nomenclature

- Names of organisms are binomial - composed of a genus and a species name. *eg. Bugex vinia (a plant)*
- Zoological, Botanical and Bacteriological Nomenclature are independent. In other words a name given to a plant may also be given to an animal (though the practice is not recommended).
- The International Code of Zoological Nomenclature (ICZN) has mandatory Rules and non-mandatory Recommendations on correct procedure. The rules are presented as 88 articles in the current edition of the ICZN.
- The general term adopted for taxonomic units is taxa (sing. taxon). Taxa exist at various levels in the taxonomic hierarchy (species-genus-tribe-subfamily-family-on up to kingdom).
- For the purposes of the code there are three groups of taxa:
 - 1) **species-group** species and subspecies
 - 2) **genus-group** *genera and subgenera*
 - 3) **family-group** tribes, subfamilies, families and superfamilies

Categories below subspecies (e.g. "varieties" and "forms") and those above superfamily (Orders, Classes) are not part of formal taxonomic nomenclature. Names of the same "group" are co-ordinate in nomenclature and similar rules apply. If a name is first proposed as a new subfamily, it also takes date and authorship from that act as a family, and as a tribe.

The four guiding principles of the ICZN are as follows:

1. **Availability**

- Each name must comply with a set of criteria to become available under taxonomic nomenclature.
- All available names acquire nomenclatural status and must be taken into account.
- All available names for a taxon "compete" for validity.

2. **Validity**

- There is only one valid name (of all the available names) for any taxon
- Two different names for the same taxon are termed synonyms
- Two names exactly the same but applied to two different taxa are homonyms
- All names for a taxon other than the valid name are rejected

3. **Priority**

- The valid name is the earliest available name
- Applies even if the earliest description is inadequate
- The date of publication becomes critical in some cases

*Gymnase - named anus
fish*

- The Commission can use its Plenary Powers to waive priority if it would cause instability. Overlooked names are termed suppressed.

4. Typification

- Names are allocated to taxa by means of nomenclatural types
- Typification is the process of designating a type
- A type is a nomenclatural concept, and has no bearing on classification.

CRITERIA OF AVAILABILITY *next*

General

1. Names must be published after 1757. In general, the 10th edition of Linnaeus's *Systema Naturae* (1758) is taken as the start of Zoological Nomenclature. Published here means issued publicly for the permanent scientific record, freely obtainable when first issued, and it must be produced in numerous, simultaneous, identical copies. The code recommends that authors do not use photocopies, but they are allowed. Handwriting (even printed), microfilm, computer printouts, acoustic recordings, mention at a meeting, or deposition of a Thesis in a Library, do not constitute publication.
2. Names of all taxa must be Latin, Latinized or constructed so it can be treated as a Latin word. Many names are ancient Greek converted into Latin, Greek in terms of the code means ancient Greek only.
3. The author must have consistently applied the principles of binomial nomenclature in the work in which the name is published.
4. The name must be accompanied by a statement that purports to give characters differentiating the taxon (applies to names published after 1930, and not to replacement names). A nomen nudum is a name published without description or indication.
5. The name must not be published anonymously (after 1950).
6. The name must not be proposed conditionally (after 1960).
 - A name takes authorship and date from the publication in which it became available. The author and date of publication of the name of a species or genus should be given at least the first time it is mentioned in a scientific work. This is to facilitate index searching and to avoid confusion. The authors name is not separated by a comma from the taxon name, but the date is e.g. *Musca domestica* Linnaeus, 1758; *Musca* Linnaeus, 1758
 - If the species is later transferred to another genus then the name of the author and • date of publication of the specific name is placed in parentheses. Such rearrangements are known as *new combinations*. Nowadays it is common for the authors name but not the date of publication to be appended to the taxon name.

Species-group names

Must be:

1. A non-hyphenated word of more than one letter
2. Written with a small/lower case initial letter
3. Published in combination with a particular generic name
4. The name can be an adjective, a nominative noun (e.g. *Felis leo* -leo = lion in Latin), or a noun denoting a place or a person (a genitive noun). If the name is an adjective, it must be of the same gender as the generic name.
5. Must not include a sign that cannot be Latinised, e.g. ?-album
6. Designated sp. nov. or similar
7. Incorrect original spellings are automatically changed, e.g. deletion of apostrophe, hyphen, dieresis:
aken'ovai/aken'ovae become *akenovai* (masculine) *akenovae* (feminine), note the removal of the apostrophe and the masculine, and feminine endings -ai and -ae; *stáli* becomes *stali*; *novae-hollandiae* becomes *novae-hollandi*.

Urocyon

Name Gender

Latin words have gender in grammar and these affect the ending of the word. For instance *domesticus* is the Latin word for a house, it is masculine (you can tell by the -us ending). To convert this into feminine or neuter forms it is written as follows: *domestica* (feminine), or *domesticum* (neuter).

If a species has an adjectival name and is moved to a genus of different gender, the gender (ending) of the specific name automatically changes. In practice most species names are adjectives. For instance, *Musca* is feminine, so the correct name for the house fly is *Musca domestica*, not *M. domesticus*. If the species was moved to the genus *Tabanus*, the species epithet would automatically change to *domesticus*.

Names that are nouns do not change. In practice, most families have genera of the same gender.

About 50 pages of the current Code is devoted to Latin and Greek grammar. This includes the stem, declension, gender of words, correct ways of joining words, etc.

Some Common name terminations:

- a) -us (masculine); -a (feminine); -um (neuter). Examples: *auritus*; *aurita*; *auritum*. – Long-eared.
- b) -is (masculine); -is (feminine); -e (neuter). Examples: *agilis*; *agilis*; *agile*. – Nimble.
- c) -er (masculine); -era (feminine); -erum (neuter). Examples: *pulcher*; *pulchera*; *pulcherum*. – Beautiful.

Generally, Latin genitives are formed from personal names by adding i to a man's name, if it ends in a vowel, or er (the vowel itself often changed to i), ii if it ends in a consonant. Plural forms are given the terminations -orum (masculine) or -arum (feminine).

NB – Genitive: special form of a noun in certain languages indicating possession or close connection; special form of a noun, pronoun or adjective used to indicate possession or close connection.

Genus-group names

Must be:

1. A single word, not hyphenated.
 2. Always capitalised (initial letter)
 3. A type species must be designated (after 1930).
 4. Must be followed by "gen. nov." or similar.
- Generic names are always a Latin noun in the nominative singular, or if not Latin are treated as such. They may be masculine, feminine or neuter.
 - Subgenera are coordinate with genera and are subject to the same rules as genera.
 - When a subgenus is in a name, it is placed in brackets between the genus and species name.

SYNONYMS

- Two different names for the same taxon
- **The senior** (first published) synonym is the available name having priority
- **Junior synonyms** are all the remaining available names other than the valid one
- **Objective synonyms** are based on the same type (specimen, species or genus)
- **Subjective synonyms** are based on different types
- Junior synonyms are **rejected** but remain available

HOMONYMS

- Names of exactly the same spelling applied to different taxa

- Homonymy only applies to names of the same group, i.e. a genus and an order can have the same name.
- Not recommended, however.
- In the species-group homonymy only applies to names within the same genus
- The **senior homonym** is the available name having priority
- The **junior homonyms** are the remaining available names other than the valid one
- Junior homonyms are spoken of as preoccupied by the senior
- **Primary homonymy** has existed since the publication of the junior homonym
- A **replacement name** must be coined for the junior homonym
- **Secondary homonymy** may arise when species are transferred from genus to genus
- A **primary junior homonym** is permanently rejected (in species- and genus-group)
- A **secondary junior homonym** may become valid again whenever the two genus-groups in question are considered distinct.

Homonymy is a significant problem at the generic level because many 10,000's of names have been used.

RULES FOR THE USE OF ZOOLOGICAL NAMES

1. Superfamily - suffix oidea. **Recommendation only.**
2. Family - suffix "-idae" (Apidae - bees; Pompilidae - spider wasps). **Rule.**
(Note: in the Botanical Code it is -aceae e.g. Proteaceae)
3. Subfamily - name suffix "inae" (Apinae - a subfamily of bees; Pompilinae - a subfamily of spider wasps). **Rule.**
4. Tribe - name suffix "-ini" (Apini - a tribe of bees; Pompilini - a tribe of spider wasps) applied consistently in Entomology and Acarology. **Recommendation.**
5. Generic-level Names
 - A. Uninomial, single word, always capitalized initial letter, *italicized or underlined*.
6. Species names are more elaborately defined.
 - A. Species name is composed of 2 parts, collectively called a binomen: *Heterobrachus bidorsalis*.
 - i. Generic name: *Heterobrachus* always has capitalised initial letter.
 - ii. Specific epithet: *bidorsalis* is never capitalized – all lower case.
 - iii. Sometimes, the generic name is abbreviated, but the specific epithet **must** always be spelled out completely (*H. bidorsalis*, **never** *Heterobrachus bidor.*)
 - B. Species names are underlined or *italicised*.
 - C. A species cannot be referred to by its specific name only, i.e. *bidorsalis*

THE TYPE-CONCEPT IN TAXONOMY

- Types are of 2 different kinds: specimens and taxa.
- Names, not taxa, have types.
- The type is a purely nomenclatural concept and has no significance for classification
- Not meant to be typical in the sense of variation.

Type specimens

- Type specimens are actual animals which are designated types of species and subspecies.
- There is no rule that holotype must be designated for a species name to be available (unlike genus-group names).

There are only four such kinds of **name-bearing** type specimens in taxonomic nomenclature:

- A. A single specimen designated or indicated as the type specimen by the original author at the time of publication is termed the **holotype**. A holotype is collected from the **type locality**.
- B. A **syntype** is one of a number of specimens (syntype series) of equal nomenclatural rank which formed all or part of the material used by the original author in describing the species when he/she did not designate a holotype.
- C. A **lectotype** is a single specimen, selected from a series of **syntypes** subsequent to the establishment of the species name. Has the nomenclatural value of a holotype. Remaining members of syntype series automatically become **paralectotypes**.
- D. A **neotype** (used only from 1953) is a single specimen chosen to replace a holotype or lectotype that has been lost or destroyed. It should be from the type locality. The name remains a **nomen dubium** until a neotype is established.

In addition to these four basic types there are others that are commonly used:

- E. A specimen or specimens supplementary to the holotype and used by the original author in writing the description are designated as **paratypes** - widely used and distributed in museums.
- F. A specimen in type-series of sex opposite to holotype called **allotype**. If holotype is female, then allotype must be male.
- G. A specimen from the type-locality of the species is termed a **topotype**, frequently used in adjectival form - **topotypic** material.

Type taxa

- Taxonomic groups of animals which are designated types of higher taxa. E.g. each genus and subgenus has a type species. Each tribe, subfamily and family has a type genus.
- The type of a genus is known as the type-species. Since 1930 it has been necessary to designate a type species for a genus in order to make a genus name available.
- For genera established before 1931, the type may be:
 - a) the species stated by the author at the time of publication as the type
 - b) type by monotypy-only one included species
 - c) species named *typicus* or *typus* at that time
 - d) absolute tautonymy, e.g. *Mola mola*
 - e) a species can subsequently be selected as type as long as it was before the original describer.
- The type of a family is a type genus.
- It does not have to be the earliest described genus of the family
- It is the genus first selected as type.
- The valid family-group name is the earliest published name, based on a genus, that clearly represented a suprageneric taxon (at rank above the genus), usually, that genus bearing the name on which the family is based: *Musca*/Muscidae.
- If the genus on which the family name is based is found to be a junior synonym, no change is made to the name of the family-group (after 1960).

ICBN (International Code of Botanical Nomenclature)

After the recognition of **five kingdoms** of living things (Prokaryotae, Protista/Protoctista, Fungi, Plantae and Animalia) as opposed to the traditional **two kingdoms** (Plantae and Animalia i.e. plants and animals) the **International Code of Botanical Nomenclature (ICBN)** was re-named **The International Code of Nomenclature for algae, fungi, and plants (ICN)**, which is the set of rules and recommendations dealing with the formal names that are given to plants, fungi and a few other groups of organisms, all those "traditionally treated as algae, fungi, or plants". The name was changed at the International Botanical Congress in Melbourne, Australia in July 2011 as part of the Melbourne Code, which replaces the Vienna Code of 2005. As with previous codes, it took effect as soon as it was ratified by the congress (**on Saturday 23 July 2011**), but the documentation of the code in its final form was not finished until sometime after the congressional meeting. Preliminary wording of some of the articles with the most significant changes has been published in **September 2011**.

The name of the Code is partly capitalized and partly not. The lower-case for "algae, fungi, and plants" indicates that these terms are not formal names of clades, but indicate groups of organisms that were historically known by these names and traditionally studied by phycologists, mycologists, and botanists. This includes blue-green algae (Cyanobacteria); fungi, including chytrids, oomycetes, and slime moulds; photosynthetic protists and taxonomically related non-photosynthetic groups. There are special provisions in the ICN for some of these groups, as there are for fossils.

The ICN can only be changed by an International Botanical Congress (IBC), with the International Association for Plant Taxonomy providing the supporting infrastructure. Each new edition supersedes the earlier editions and is retroactive back to 1753, except where different starting dates are specified.

For the naming of cultivated plants there is a separate code, the International Code of Nomenclature for Cultivated Plants, which gives rules and recommendations that supplement the ICN.

Some important versions are listed below:

Year adopted	Informal name
1867	Laws of botanical nomenclature
1905	Vienna Rules (2nd ed., 1912)
1935	Cambridge Rules
1952	Stockholm Code
1969	Seattle Code
1975	Leningrad Code
1981	Sydney Code
1987	Berlin Code
1993	Tokyo Code
1999	St Louis Code, The Black Code
2005	Vienna Code
2011	Melbourne Code (current, yellow cover)

☐ Sources of Information:

- ☞ Personal Lecture Notes
- ☞ Dr. David Walter's Lectures (Qld. Uni.)
- ☞ Henderson's Dictionary of Biological Terms
- ☞ Henderson's Dictionary of Biology
- ☞ Biological Science
- ☞ Wikipedia

Professor T. O. I. Aghan'Ova

Department of Zoology,
Ahmadu Bello University,
Zaria.
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