PRINCIPLES OF TAXOMOMY:

- Principles of taxonomy is an interesting tool, need to understand concept and meaning between Taxonomy, Systematic and International code of nomenclature.
- Taxonomy or Systematic, two terms that more or less synonymously used.

WHAT IS TAXONOMY

- It is the science of grouping biodiversity into species, describing the species, and classifying this diversity into higher-level taxa that reflect evolutionary history.
- (1) It introduces the main concepts and goals of taxonomy and systematics.
- (2) It teaches the qualitative and quantitative techniques that are today used to describe/identify species and higher-level taxa based on the analysis of morphological and DNA sequence evidence.
- The aim is to equip environmental as well as other biologists with a thorough understanding of taxonomic/systematic units and the tools needed for evaluating and quantifying diversity in samples of plant and animal specimens.

TAXONOMY & SYSTEMATIC

Hawksworth and Bisby (1988) suggest that…….

- Taxonomy is only a part of systematic.
- **Taxonomy** in this sense includes a range of different areas from description and naming of new taxa (nomenclature), classification and construction of identification system for particular groups of organisms.
- **Systematic** includes traditional taxonomy with the addition of theoretical and practical aspects of evolution, genetics and speciation.
- The study of the evolutionary relationship between organisms is usually referred to as **phylogenetics**.

SYSTEMATIC

- -science of the diversity of organisms
- -broad field concerned with biodiversity, naming, classification according to evolutionary relationships, and identification of animals
- -sometimes used interchangeably with taxonomy

TAXONOMY

- **- theory and practice of classifying organisms**
- **- study of classification, identification, nomenclature, & faunistics**

- Classification- arrangement of animals into groups having common characteristics that express evolutionary relationships

- Identification or Determination- identifying animals by the recognition of certain characters

- Nomenclature- naming of organisms according to the International Code of Zoological Nomenclature (ICZN)

- Faunistics- inventory of the native or naturalized animals of an area; called a fauna

WHY IS A SYSTEM OF CLASSIFICATION NEEDED?

- a. Organize species into groups and discuss them.
- b. Identify new organisms.
- c. Show relationships between organisms.

TAXONOMY

(GREEK, TAXIS = ARRANGED; NOMOS = LAW)

- Making and maintaining collection
- Differentiating species
- Identification (Keys) and diagnosis of species and genera
- Naming and describing species and genera

SYSTEMATICS (GREEK, SYSTEMA = A WHOLE MADE 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
- (" Study of the kinds and diversity of organisms and the relationships between them")

PRIMARY GOALS OF ANIMAL SYSTEMATICS:

1. Identify and describe all animals of world

@55,000 species of vertebrates known. Many more undiscovered. Undiscovered species are much more in case of invertebrates.

2. Develop a uniform, practical, and stable system of naming animals that can be used by both animal taxonomists and others needing to communicate about animals

International Code of Zoological Nomenclature (ICZN) provides rules for naming and classification that is uniform and stable

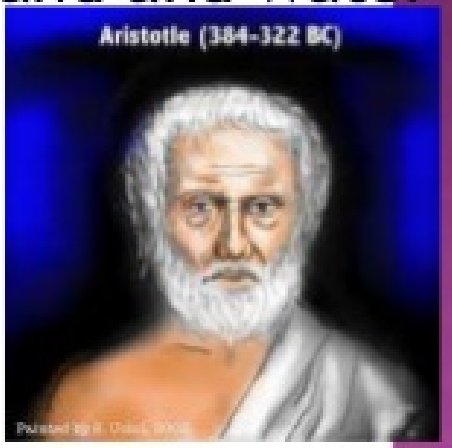
3. Form groups that reflect their evolutionary relationships

IMPORTANCE OF TAXONOMY

- **Biodiversity**: In last two and a half century only one million animals and 0.5 million plants identified. This forms 10% of worlds organisms. Many may extinct before discovered. Status to be studied to conserve.
- Base of research & studies:
- Use in Medicine:
- Agriculture and pest management-
- Identification of pests-
- Identification of natural enemies-
- Fisheries-
- Conservation

EARLY SYSTEMS:

- **Aristotle** (384 BC – 322 BC) classified all living organisms known at that time as either a plant or an animal. Animals also grouped as land and water animals.



- Life |------ Regnum Vegetabile
  |------ Regnum Animalia

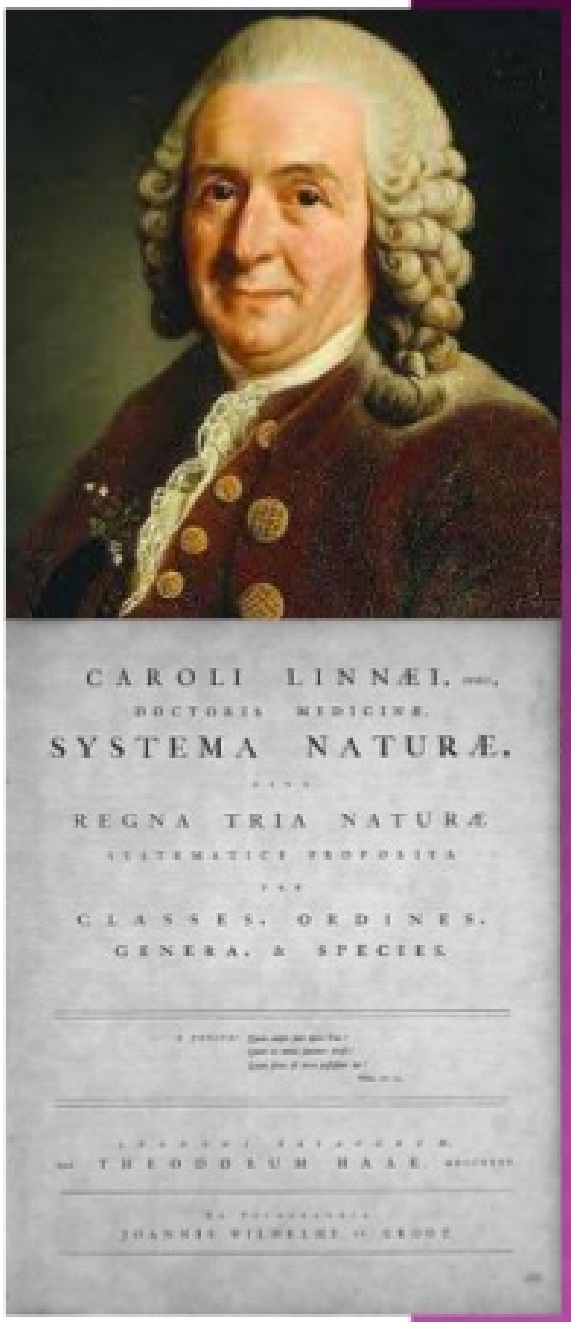
- Conrad von Gesner (1516-1565) next brought to hand descriptions and specimens of many novel forms of animal life of parts of the New World .

CARL LINNAEUS (1707-1778)

Kingdom Animalia

- Classis 1. Mammalia
- Classis 2. Aves
- Classis 3. Amphibia
- Classis 4. Pisces
- Classis 5. Insecta
- Classis 6. Vermes

- Introduced binomial system of nomenclature



The **Binomial system**, also called **binomial nomenclature**, involves each organism being given a two part name using Latin as a standard language.

i. Developed by Carolus Linnaeus (1707-1778).

ii. Provides a uniform means of communication for all people. This avoids the confusion caused by organisms with different common names in different areas.

iii. The format is Genus species or G. species
e.g., Sardinella fimbriata

(1) The **genus** name is capitalized and may be abbreviated by the first initial. The **species** name is not capitalized and cannot be used alone. *e.g., S. fimbriata.*

iv. The 2 part name gives clues about relationships between organisms.

(1) For instance, *Lutjanus johnii*, *L. fulvus*, *L. fulviflamma*, and *L. bohar* are all related.

v. Names were based largely on physical appearances but modern taxonomists use genetic information, molecular biology, and phylogeny (evolutionary relationships) as other criteria for classifying.

(1) The work of Charles Darwin introduced the idea of considering evolutionary history.

The binomial classification system is hierarchical

i. The levels of organization are **kingdom**, **phylum**, **class**, **order**, **family**, **genus**, and **species**. Each of these levels is called a **taxon** (plural, taxa).

ii. Note that the genus and species name are italicized because they are Latin. When handwriting, underline the words. Other levels are capitalized but no special print features are used.

LIFE

Empire Prokaryota

Kingdom Monera

Empire Eukaryota

Kingdom Fungi

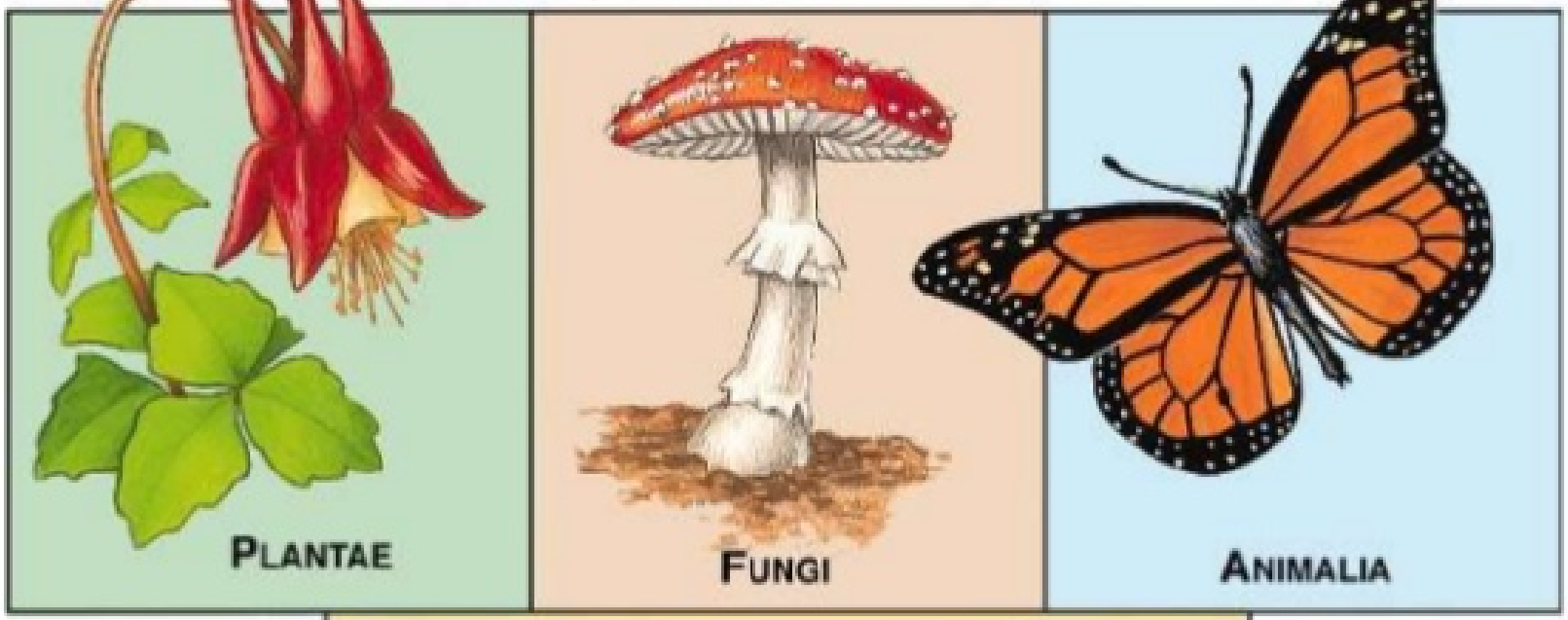
Kingdom Protista

Kingdom Plantae

Kingdom Animalia

Five Kingdoms

Uni or multicellular
Eukaryotic



Eukaryotic
Unicellular

Bacteria
Archaea

Unicellular

Prokaryotic

LIFE

Domain Bacteria

Kingdom Bacteria

Domain Archaea

Kingdom Archaea

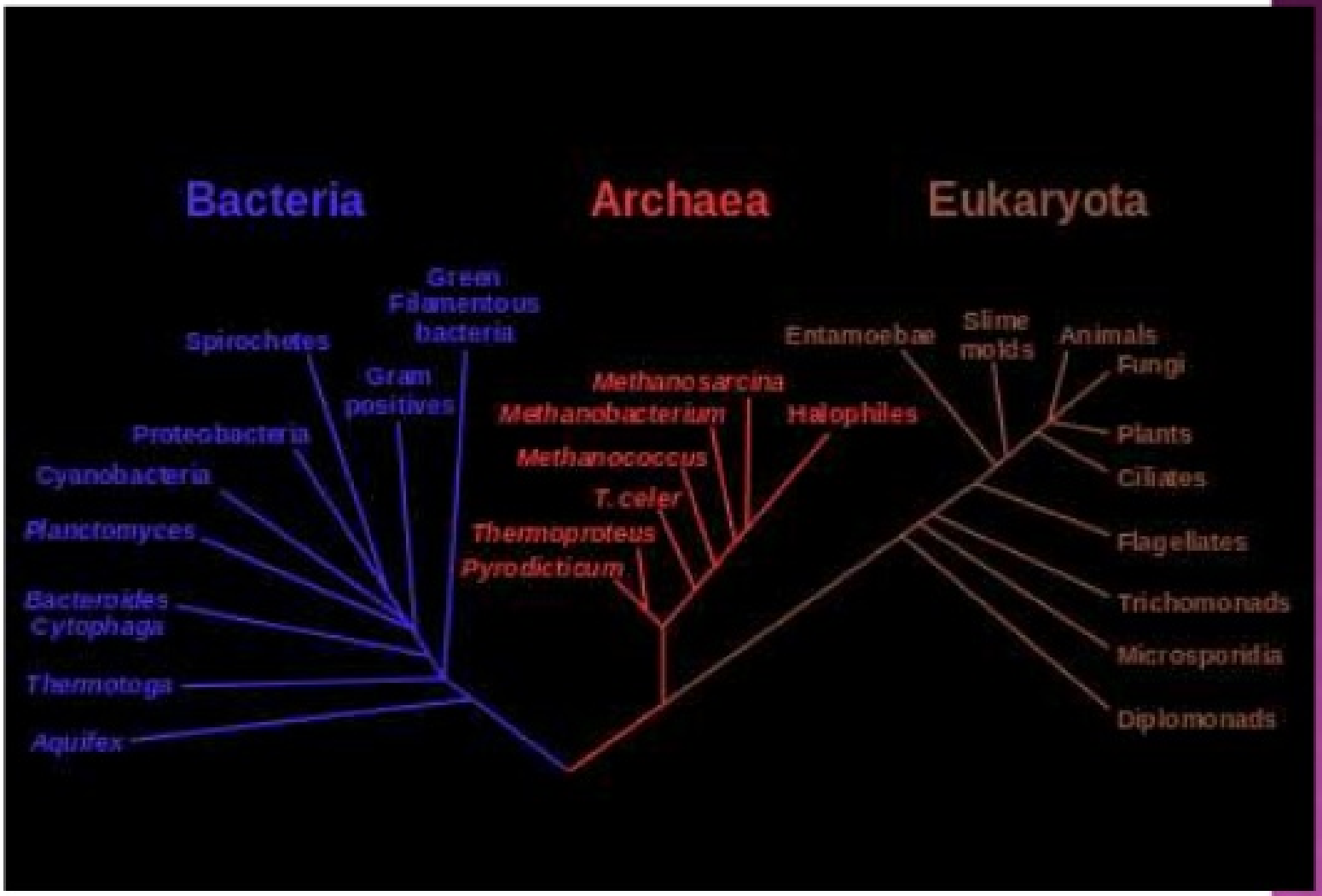
Domain Eukarya

Kingdom Protoctista or Protista

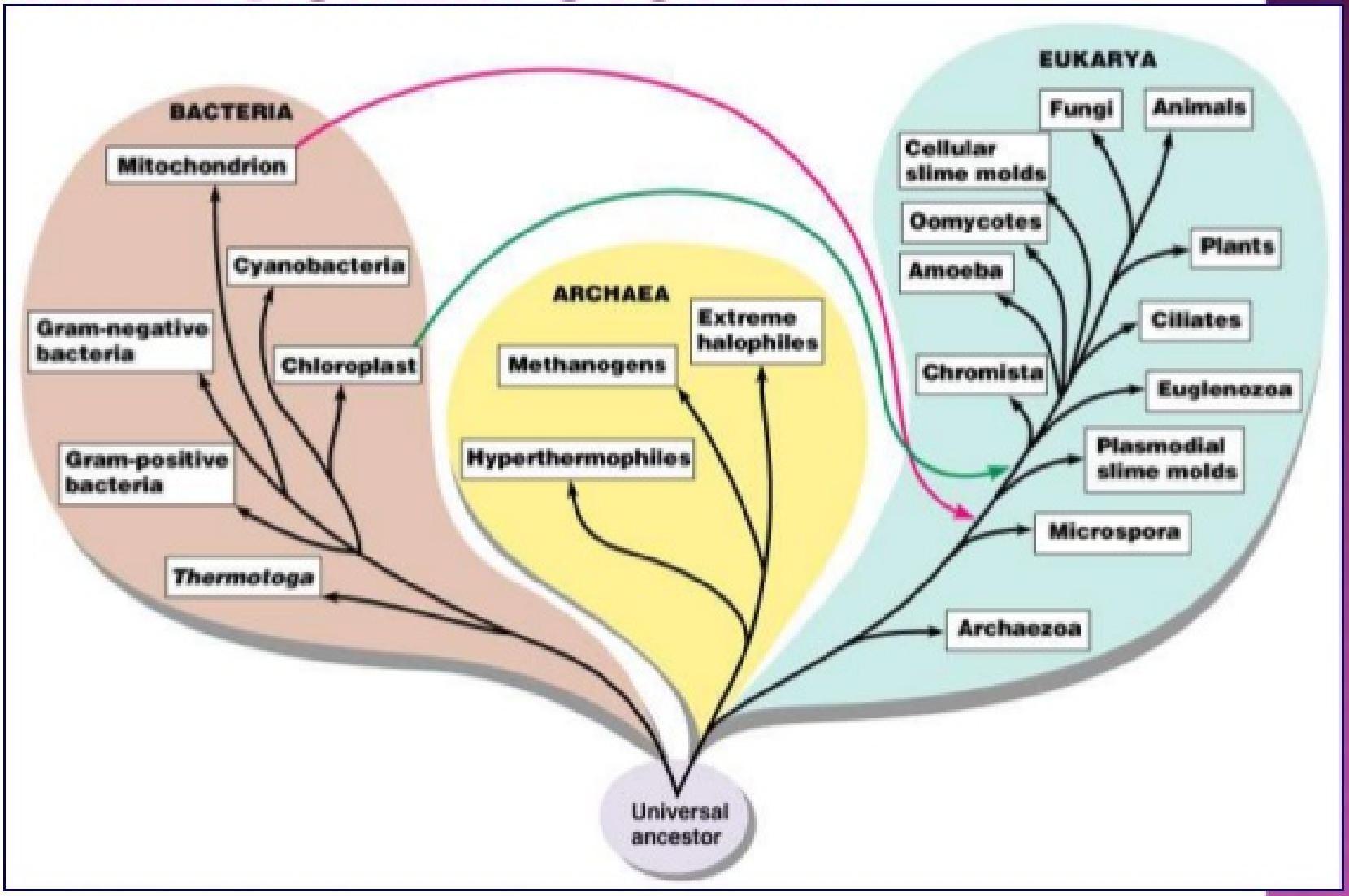
Kingdom Plantae

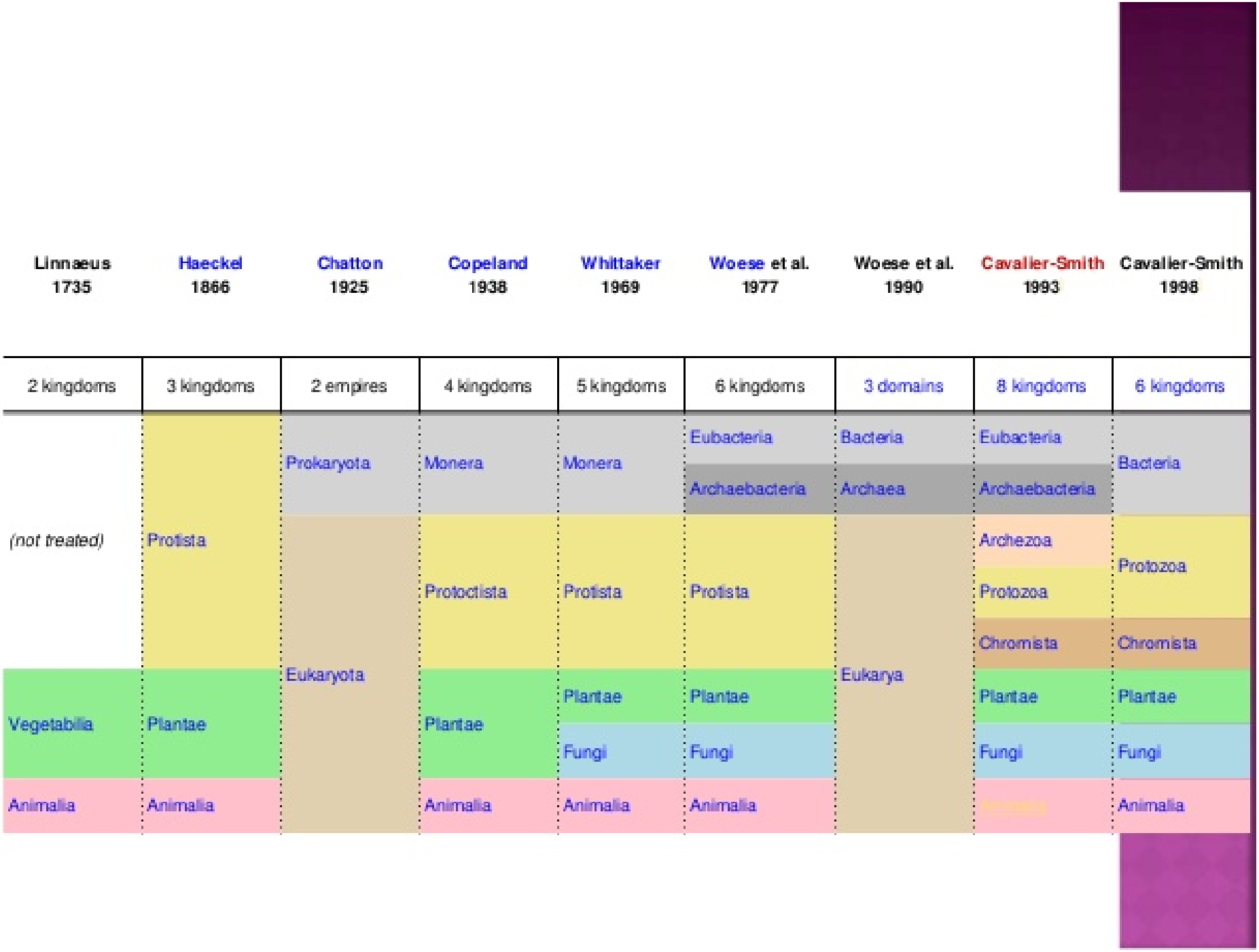
Kingdom Fungi

Kingdom Animalia


Bacteria
Archaea
Eukaryota
Green Filamentous bacteria
Spirochetes
Gram positives
Proteobacteria
Cyanobacteria
Planctomyces
Bacteroides Cytophaga
Thermotoga
Aquifex
Methanosarcina
Methanobacterium
Methanococcus
T. celer
Thermoproteus
Pyrodicticum
Halophiles
Entamoebae
Slime molds
Animals
Fungi
Plants
Ciliates
Flagellates
Trichomonads
Microsporidia
Diplomonads

THREE DOMEIN SYSTEM




Linnaeus 1735
Haeckel 1866
Chatton 1925
Copeland 1938
Whittaker 1969
Woese et al. 1977
Woese et al. 1990
Cavalier-Smith 1993
Cavalier-Smith 1998
2 kingdoms
3 kingdoms
2 empires
4 kingdoms
5 kingdoms
6 kingdoms
3 domains
8 kingdoms
6 kingdoms
(not treated)
Protista
Prokaryota
Eukaryota
Monera
Protoctista
Monera
Protista
Eubacteria
Archaebacteria
Protista
Plantae
Fungi
Bacteria
Archaea
Eukarya
Plantae
Fungi
Eubacteria
Archaebacteria
Archezoa
Protozoa
Chromista
Plantae
Fungi
Bacteria
Protozoa
Chromista
Plantae
Fungi
Vegetabilia
Plantae
Plantae
Animalia
Animalia
Animalia
Animalia
Animalia
Animalia

SCHOOLS IN TAXONOMY

- Taxa are grouped according to two main schools of taxonomists:

1. Traditional taxonomists

   -use Linnaean system of binomial nomenclature and hierarchical ranks to reflect evolutionary history

   -look at overall similarity or phonetics which may recognize

paraphyletic groups like Asclepiadaceae and Reptiles

   -Cronquist System is a widely used traditional classification and uses monophyletic and paraphyletic groups

Monophyletic group-taxon that includes most recent common ancestor and all its descendents

-groups taxonomists try to form

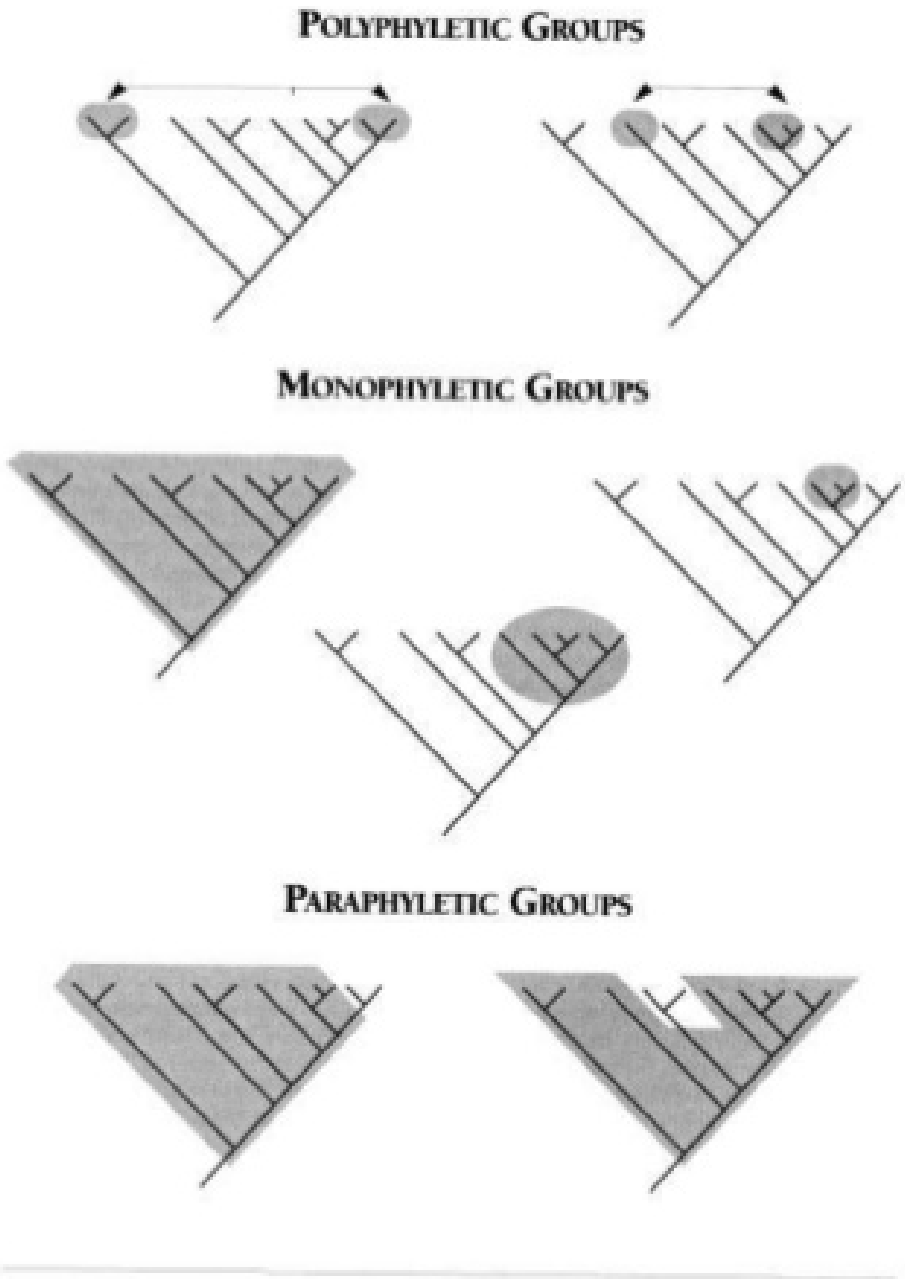
-give information that is critical for breeding programs and search for useful products

Paraphyletic group-taxon that includes common ancestor but not all its descendents

-accepted by traditional taxonomist when group is phenetically
different and can be identified by its morphology.

Polyphyletic group-taxon having species derived from more than one common ancestor

-taxonomist has made a mistake due to convergent evolution where species are not genetically closely related but have adapted to similar environments


POLYPHYLETIC GROUPS
MONOPHYLETIC GROUPS
PARAPHYLETIC GROUPS

2. Cladists or phylogenetic classification

-does not use binomial nomenclature or ranks

-only examines the branching patterns of evolution using phylogenetic trees that reflect monophyletic groups

-only recognizes monophyletic groups, so birds part of Reptilia

-only recognizes cladogram using DNA sequence data

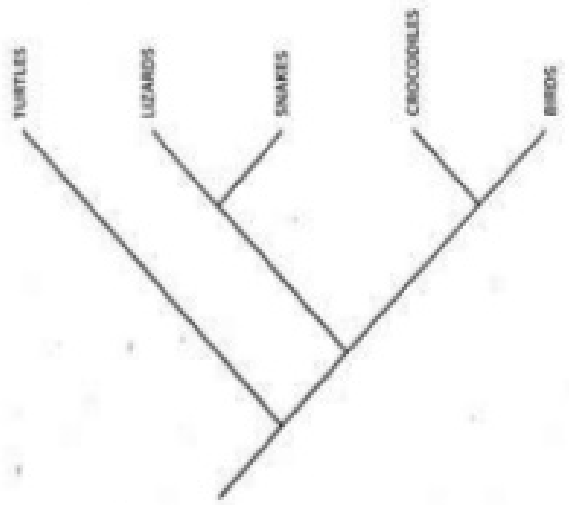


FIG. 38/DENDROGRAM SHOWING RELATIONSHIPS OF SOME VERTEBRATE GROUPS. NOTE THE PARAPHYLETIC NATURE OF THE "REPTILIA."

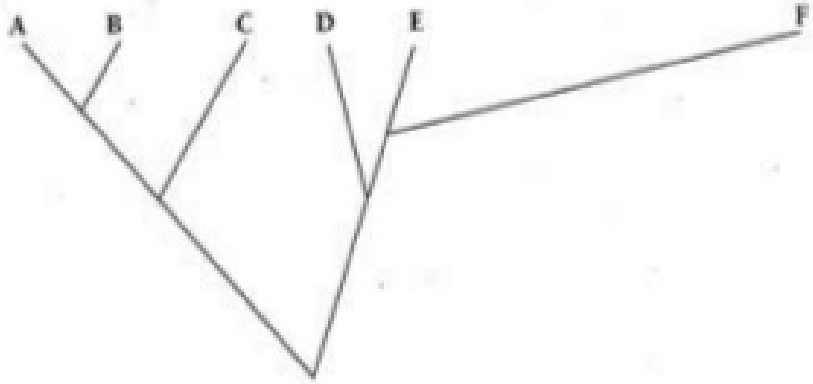
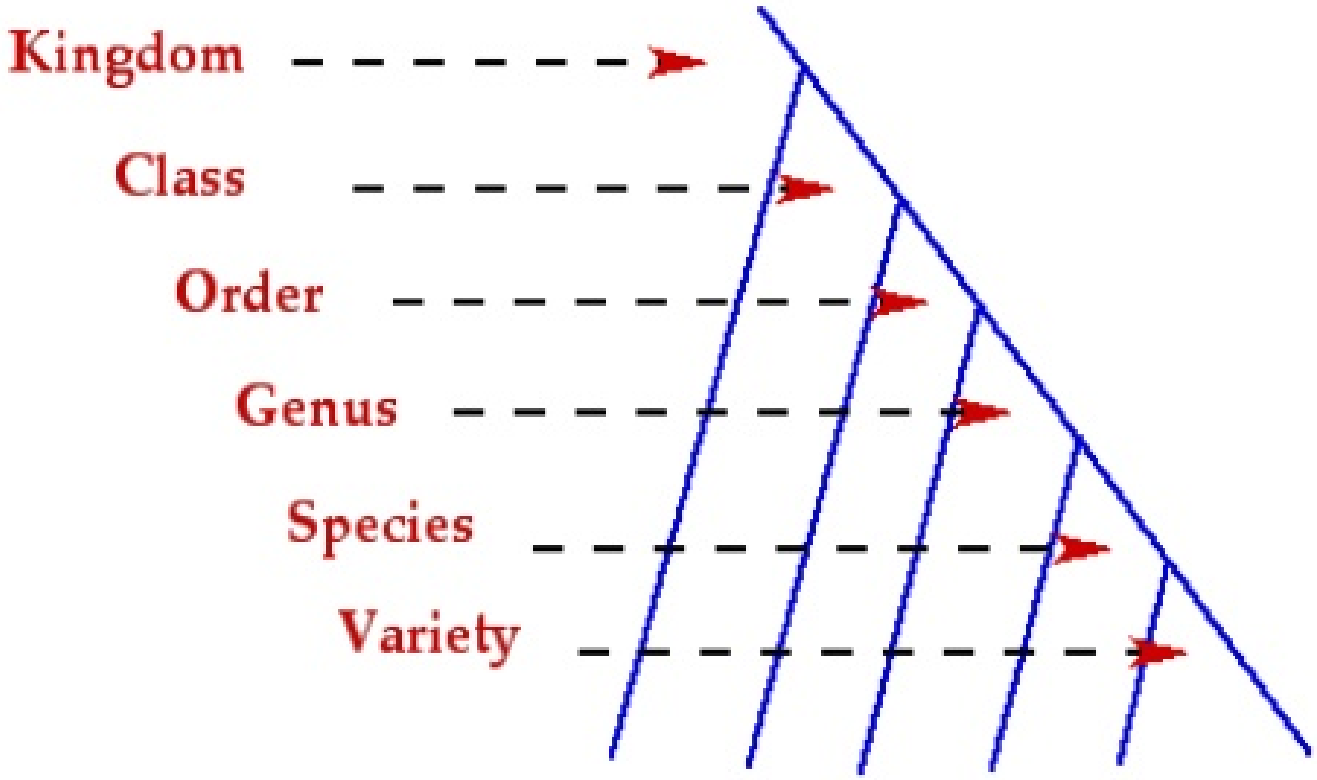
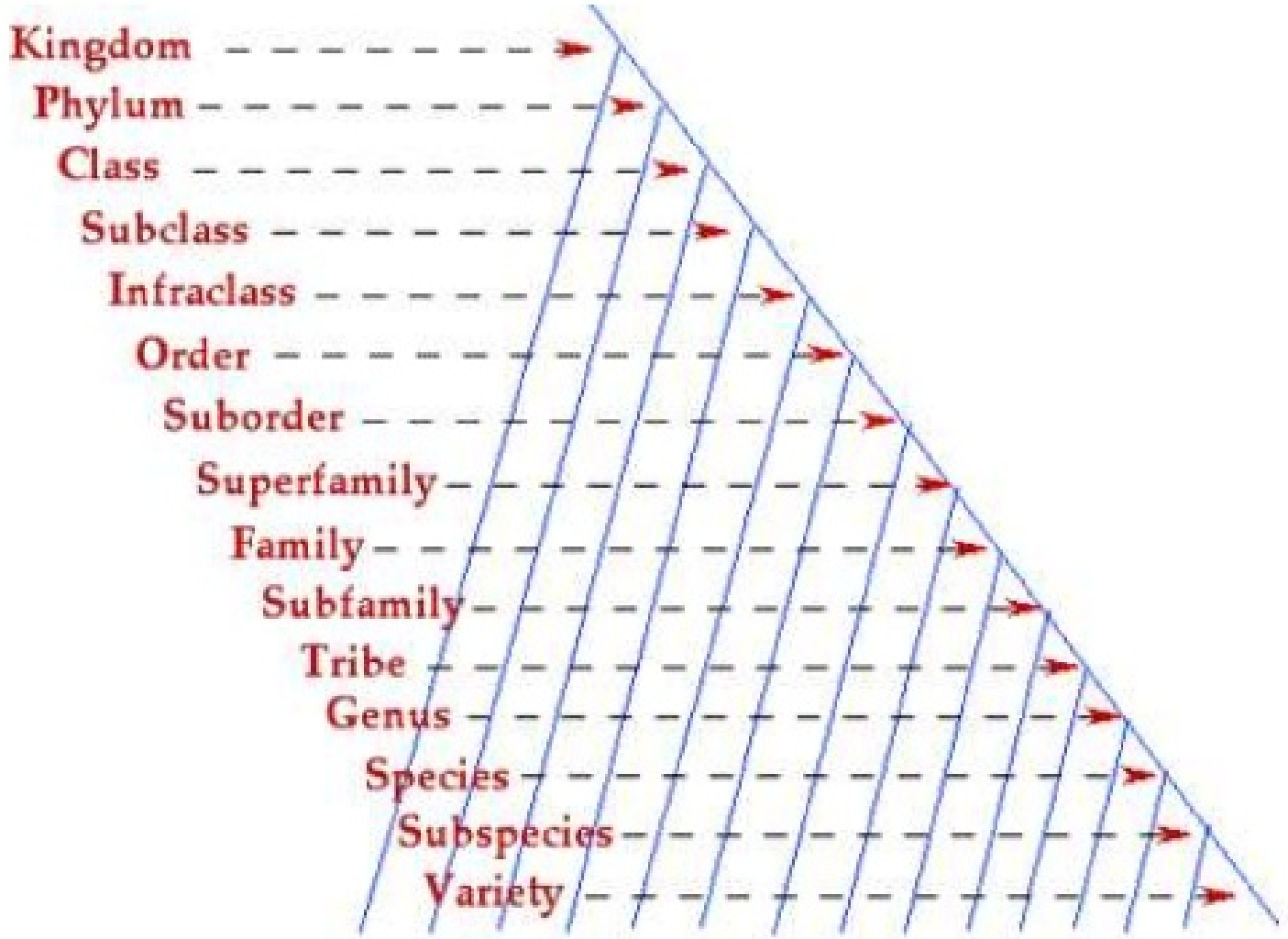


FIG. 39/PHENETIC DISTANCE DIAGRAM. HORIZONTAL DISTANCE BETWEEN SPECIES INDICATES PHENETIC DIFFERENCE. NOTE THAT SPECIES F, WHILE MOST CLOSELY RELATED PHYLOGENETICALLY TO SPECIES E, IS QUITE DIFFERENT IN TERMS OF PHENETICS.

Linnaean Hierarchy in 10th Edition of Systema Naturae (1758)



Categories Used in More Modern Classifications



Common Hierarchical Ranks:

Domain
Kingdom
Phylum
Class
Order
Family
Genus
Species

COLLECTION

- Methods of collection-
- Labeling- Locality: Collector: Date of Collection
- Curation of collection & preservation-
- Cataloging-

IDENTIFICATION

- Study of available literature of the group
- Learn the terms and relevant data used to describe a taxa of the group
- Collection of relevant literature
- Identification using taxonomic keys
- Comparing of identified specimen with previous description available
- Comparing with authenticated identified specimen
- Requesting help of specialists
- Use of internet information

TAXONOMIC KEYS

- **Dichotomous keys-**
- Bracket key
- Serial key
- Indented key
- Branching key
- Circular key
- Box key
- Multi-entry key

NOMENCLATURE

- Linnaeus' system of classification made a major impact on the world in terms of naming diversity and organizing the information.
- There are four different codes of nomenclature today.
- = *International Code of Zoological Nomenclature*. 1999. Fourth Edition. International Trust for Zoological Nomenclature. London. 306 pp.
- = *International Code of Botanical Nomenclature*. 1994. Koeltz Scientific Publishers, Koenigstein, Germany (International Association for Plant Taxonomy)
- = *International Code of Nomenclature of Bacteria*. 1976. American Society of Microbiology, Washington, D. C. 180 pp.
- = *International Code of Nomenclature for Cultivated Plants*. 1980. American Horticultural Society. 32 pp.

General Objectives

Uniqueness - Gives one immediate access to all of the known information. If several names used, valid name should be ascertained.

Universality -Vernacular names for taxa in innumerable languages. A single language (Latin) and a single set of names for biological diversity to be used on a worldwide.

Stability – Not to be changed frequently and arbitrarily

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.**

NOMENCLATURE

- Each species is placed into a genus. 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. *Homo sapiens*
- Both names are set apart from the accompaning text:
  The species is *Homo sapiens*.
  The species is Homo sapiens.
  The species is **Homo sapiens**
- Scientific names do not include diacritial marks but may be hyphenated *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.

  Psallopsis femoralis Reuter

  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.

  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.

  Macrocoleus femoralis Reuter, 1879
  Cyrtocapsus femoralis Reuter, 1892

- 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

  Notropis cardinalis Mayden

- 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

  Luxilus cardinalis (Mayden)

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.

BASIC RULES OF CODES

- Priority: The first name applied to a taxon is the name that will be used. Priority relates to date of publication. The oldest valid name of a taxon (senior name) takes precedence over all other names of a taxon.
- Priority is not intended to upset stability. 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.
- Any works published in 1758 or after are considered published.

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)

PUBLICATION:

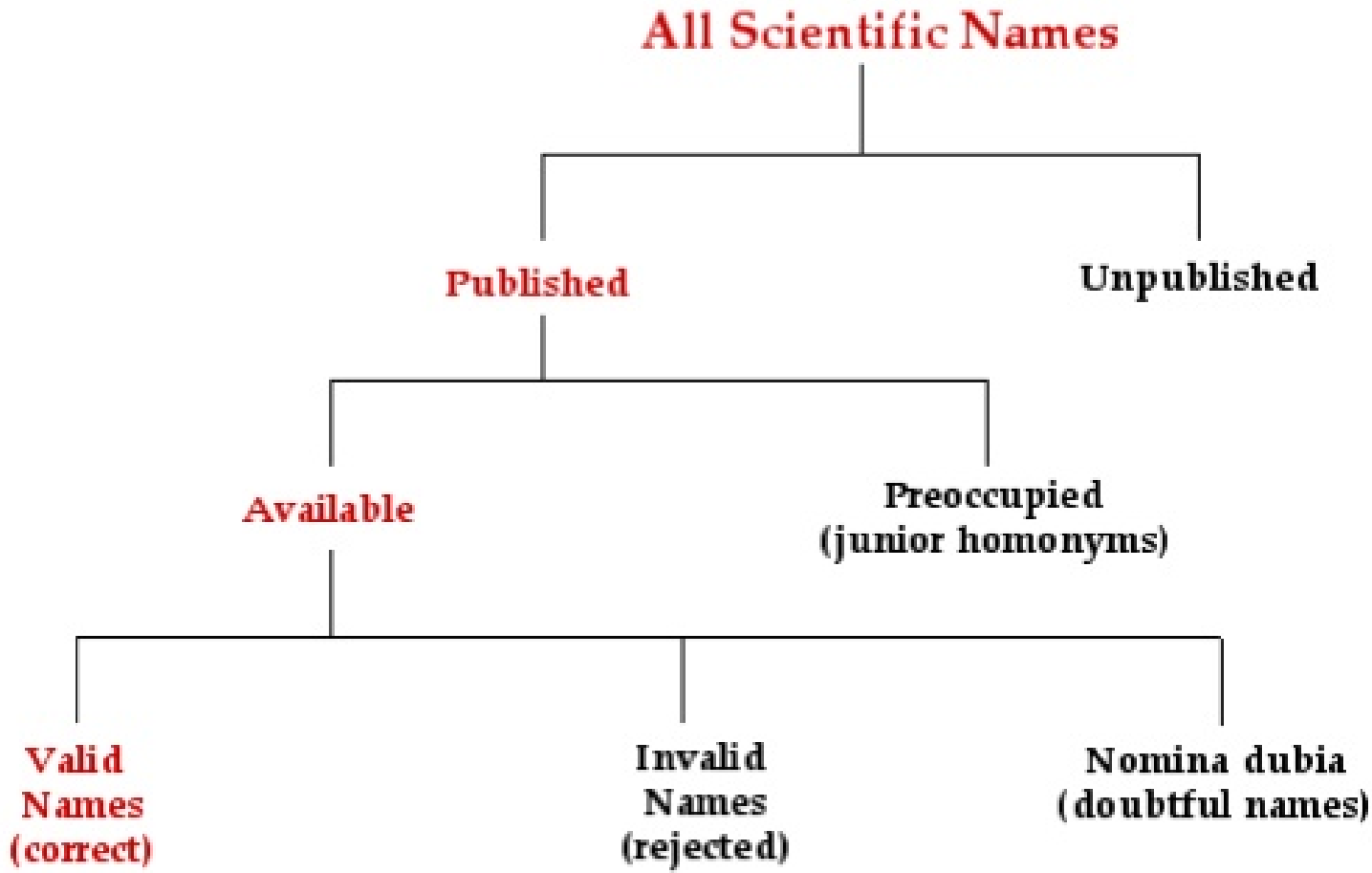
Okay publications –

- 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, and 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).



Categories of Scientific Names (modified from Blackwelder, 1967)

TYPE CONCEPT

- ***Species-group types*** 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.
- **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.

- **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.
- **Topotypes**: specimen(s) collected from the same location as the holotype (perhaps at the same time). These specimens are useful at the time of designating a Neotype.
- **Neotype:** A specimen later designated to replace a holotype (or other primary type) if the latter can be documented as lost or destroyed.

GENUS-GROUP TYPES

- **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*.

HOMONYMY

- **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)
- **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.

SYNONYMY

- The concept of synonymy relates to the application of different names to the same taxon.
- **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.

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 wich 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.

OCCUPATION:

- 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, genus group names the type species must be unambiguously designated. Species group names - a description of the work alone is unacceptable. After 1950, 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.

NAMING OF SPECIES

- Descriptive name: *giganticus; globosa; alba; nigrus; longipinnis; macrocephalus; filamentosus*
- Ecological names: *subterraneus; arboricola; parasitus*
- Geographical names: *keralensis; andhraensis; bengalensis; indicus*
- Patronymic names: *silasi, johni, blochi, horai, dayi*
- Names without meaning: *fantana; kalona; gentana*
- Undesirable names: should be avoided (long names; facetious names causing religious or personal offence).
- Other kinds of names: host organisms- *rosae, lantanae* OR mythological names '*arjunai*'
- Local names: *phasa; phutuni, para, savala*


Thank you