**Definition, basic concept and importance of Systematics and Taxonomy**

**Taxonomy**

Variation is the rule of nature. The most impressive aspect of the world of life is its diversity and the uniqueness of its components. No two sexually reproducing populations are the same, nor are any two populations, species or higher taxa. About more than one million species of animals and half a million of plants have already been described and estimates on the number of still undescribed living species ranges from three to ten millions. Furthermore each species may exist in numerous different forms like sexes, age, seasonal forms, morphs etc. It would be impossible to deal with this enormous diversity if it were not ordered and classified. Systematic Zoology endeavors to order this diversity of the animal world and to develop methods and principles to make this task possible.

**Definition of taxonomy**

Taxonomy is the theory and practice of identifying plants and animals. In fact, taxonomy deals with the principles involved in the study of classification of organisms. It is the functional science which deals with identification, nomenclature and classification of different kinds of organisms all over the world. The word ‘taxonomy’ is derived from the Greek words *taxis* (=arrangement) and *nomos* (=law). The term ‘taxonomy’ was coined by A.P. de Candolle in 1813. Different workers have tried to define taxonomy from their view point. Some of the accepted definitions of taxonomy are as follows:

- According to Mason (1950) taxonomy is the synthesis of all the facts about the organisms into a concept and expression of the interrelationship of organisms.
Harrison (1959) defined taxonomy as the study of principles and practices of classification, in particular in methods, the principles and even in part, the result of biological classification.

Simpson (1961) defines taxonomy as the theoretical study of classification, including its bases, principles, procedures, and rules.

Heywoods (1967) defined taxonomy as the way of arranging and interpreting information’s.

Blackwelder (1967) explains it as the day to day practice of handling different kinds of organisms. It includes collection and identification of specimens, the publication of data, the study of literature and the analysis of variations shown by the specimens.

According to Johnson (1979), taxonomy is the science of placing biological form in order.

Christoffersen (1995) defines taxonomy as the practice of recognizing, naming and ordering taxa into a system of words consistent with any kind of relationships among taxa that the investigator has discovered in nature.

**Systematics**

Systematics is the study of diversification and relationships of life forms of extinct extant.

The word systematics is derived from the Latinized Greek word ‘systema’ applied to the system of classification developed by Linnaeus in the 4th edition of his historical book *Systema Nature* in 1735. Today’s systematics generally makes extensive use of molecular biology and computer Programs to study organisms.

**Definition of systematic**

According to Blackwelder and Boyden (1952), “systematic is the entire field dealing with the kind of animals, their distinctions, classification, and evolution.

Simpson (1961) defines systematic as “The scientific study which deals with kinds and diversity of organisms and any or all relationships among them’

According to Blackwelder (1967), systematics is that science which includes both taxonomy and classification, and all other aspects of dealing with kinds of organisms and the data accumulated about them.
Christofferson (1995) defined systematic as the theory, principles and practice of identifying (discovering) systems, i.e., of ordering the diversity of organism (parts) into more general systems of taxa (wholes) according to the most general causal processes.

According to Padian (1999), systematic can be seen as the philosophy of organization nature, taxonomy as the use of sets of organic data guided by systematic principles, and classification as the tabular or hierarchical end result of this activity.

**Relationship of taxonomy to the systematics**

Kapoor (1998) considered that the relationship of taxonomy to systematics is somewhat like that of theoretical physics to the whole field of physics. Taxonomy includes classification and nomenclature but systematics includes both taxonomy and evolution. In simple terms, actually there are two parts of systematic. The first part, taxonomy, is concerned with describing and naming the different kinds of organisms, whether exist or extinct. This science is supported by institutions holding collection of organisms which are curated with relevant data. The second part of systematics, evolution, is concerned with understanding just how all these kinds of animals arose in the first place and what processes are at work today to maintain or change them. Systematics uses taxonomy as a means to understand organisms. Systematics elucidate the new methods and theories that can be used to classify species based on similarities of traits and possible mechanisms of evolution, a change in gene pool of a population over time. According to Wagele (2005), although theoretically the term taxonomy and systematic could be synonyms, in practice, however, differences in uses are obvious and a systematist and a taxonomist can conduct different analyses.

The major differences between taxonomy and systematic can be summarized as follows:

1. Taxonomy is the most important branch of systematic and thus systematics is a broader area than taxonomy.
2. Taxonomy is concerned with nomenclature, description, classification and identification of a species, but systematics is important to provide layout for all those taxonomic functions.

3. Evolutionary history of a species is studied under systematics but not in taxonomy.

4. The environmental factors are directly related with systematics but in taxonomy it is indirectly related.

5. Taxonomy is subjected to change in course of time, but systematics is not changed if it was properly done.

Stages in taxonomy

There are several stages of taxonomy such as:-

1. **Alpha taxonomy:** In this stage species are identified and characterized on the basis of gross morphological features.

2. **Beta taxonomy:** In this stage species are arranged from lower to higher categories, i.e., hierarchic system of classification.

3. **Gamma taxonomy:** In this stage intraspecific differences and evolutionary history are studied.

Classical Taxonomy and Modern Taxonomy:

Classical Taxonomy:

The classical taxonomy is based on observable morphological characters with normal individuals considered to be expression of the same while their variations are believed to be imperfect expressions. Classical taxonomy originated with Plato followed by Aristotle (Father of Zoology), Theophrastus (Father of Botany) up to Linnaeus (Father of Taxonomy) and his contemporaries.

1. Species are delimited on the basis of morphological characteristics.

2. Only a few characters are employed for classification.

3. A few individuals or their preserved specimens are used for study. It is called typological concept.

4. Species are believed to be static.
5. Species is the centre stage of study. Its subunits are not important.

**Modern Taxonomy (New Systematics):**

The term new systematic was coined by Julian Huxley (1940). New systematic is systematic study which takes into consideration all types of characters. Besides classical morphology, it includes anatomy, cytology, physiology, biochemistry, ecology, genetics, embryology, behavior etc. of the whole population instead of a few typological specimens. In contrast classical systemetics is based on the study of mainly morphological traits of one or a few specimens with supporting evidences from other fields. New systematics ia also called population systematics and biosystematics. It strives to bring out evolutionary relationship amongst organisms.

1. New systematic is based on the all types of variation in the species.
2. Along with morphological variations, other investigations are also carried out to know the variety of traits.
3. Delimitation of species is carried out on the basis of all types of biological traits. It is also called biological delimitation.
4. Traits indicating primitiveness and advancement are found out.
5. Inter-relationships are brought out.
6. Species are considered as dynamic unit.

**Aims and tasks of taxonomist:-**

The various aims and tasks of a taxonomist are-

1. To catalogue and preserve the biodiversity collected from different sources.
2. To differentiate the variations among organisms and arranged them on the basis of their relationships or associations.
3. To provide scientific name to the taxa, so that one can recorded, stoe and retrieved when needed.
4. To establish a set of rules to choice characters for arranging species into hierarchic classification.
5. To study the genetic and phylogenetic relationships among life forms.
6. To make extensive use of computer to analyze and differentiate the intra and interspecific relationships among organisms.

**The contribution of systematic to biology:**

Systematics is the key to understand fascinating biodiversity around us. Systematics benefits the human beings by providing the fundamental knowledge about the sustainable resource management, environmental protection, and landscape preservation to food security. Systematic biology provides the skill to make policies for successful implementation of preservation and management of our biodiversity, which is critical to have long term quality of life for us as well as to our nature.

The contribution of systematic to biology can be studied into two heads:-

A. **Theoretical biology and**

B. **Applied biology.**

A. **Theoretical biology:**

   Systematics has played some important role in the field of theoretical biology, such as:-

1. It is responsible in making conceptual contribution like population thinking.
2. It is responsible in solving the problems of multiplication of species. It illustrates the structure of species and evolutionary processes.
3. Mimicry and other evolutionary areas also have been a clearly understood through taxonomy.
4. It has also played important role in the development of behavioural science.
5. Taxonomy is the key to the study of ecology, as no ecological survey can be undertaken unless all the species of ecological importance are identified.

B. **Applied biology:**

Systematics provides basic understanding about the components of biodiversity which is necessary for effective decision making about conservation and sustainable use. The most important are:-
1). **Agriculture and forestry:** - Presently we are faced with the acute problem of saving our crops and trees from the attack of various kinds of pests. So, it is necessary to know the correct names of such pests; before their proper control, and eradication. Taxonomists can give correct identification of pest species, which is vital for its effective control. Similarly, many of the plant diseases are caused by certain vectors. The correct identification of a particular vector is vital for bringing the vector under control by killing its transmitters.

2). **Biological control:** - Natural enemies of pests can be introduced for biological control of pests. The biological control is much more economical than the chemical control. In 1940s a parasite *Arachytus incertus* was introduced from Uruguay and Argentina into the U.S.A. to control armyworms. The systematists are presently greatly involved in designing and implementing the biological control programmes of pests and diseases most effectively.

3). **Public health:** - Taxonomy plays an important role in public health program also. There are number of diseases, which are spread by many Arthropods. So, our controlled measures should be planned to attack the target species. As for example, All *Anopheles maculipennis* are not responsible for transmitting malaria. This species consists of several sibling species, of which a few were responsible for transmitting malaria. An expert taxonomist can identify this particular sibling species. A correct identification ensures a maximum of effective control at minimum cost.

4). **Quarantine:** - Many new pests and diseases of plants, animals and human beings can spread from one country to another through transportation. Respective Governments have established quarantine laboratories at aerodromes, ports etc. to check such transmissions. Taxonomists play a vital role here in prompt identification of these pests and diseases.

5). **Wild life management:** - Presently great attention is being paid to conserve and propagate wild life. The indiscriminate killing and felling of trees have already resulted in great disturbance in the natural environment. Taxonomists can help all environmental
protectors by identifying the economically and ecologically important wild life. The task is important for the preservation and protection of our biodiversity.

6). **Mineral prospecting:** -The identification of fauna and flora in sedimentary rocks gives a clear picture of the sequence of geological events, which helps in search for fuels and mineral deposits. The paleontologists play a major role in the identification of such fossil specimens of the sedimentary rocks and thus give us a clear picture of the correct sequence of geological events. Such works have been great success in the industrialization in America.

7). **National defense:** - Information concerning disease vectors and parasites is an obvious application of systematics to national defense. The use of biological means in the war is economical and requires fewer efforts in their operation. During World War II, Japanese paper balloons carrying paper balloons created havoc in the forest of north east America. Eventually a balloons was recovered with sand contained a large number of shells of micro-organisms. The taxonomists of America observed the shells of micro-organisms and confirmed that this type of sand represent mainland island of Japan. Subsequent bombing of this beach area destroyed the balloon launching site. Moreover, the identification of potential disease vectors is vital to the health of both military and civilian populations all over the world.

8). **Environmental problem:** - Taxonomists have played an important role in detecting some of the environmental problems. Certain pesticides are entered in the food chain of ecosystem and biomagnification of pesticide takes place at certain trophic level. Here a taxonomist can play important role in detecting such problem and can take effective measures to control it. Presently water pollution is considered as a major environmental problem. Certain planktons are reliable indicator of the degree of water pollution. The identification of such organism by taxonomists give rapid information for detecting pollution.

9). **Soil fertility:** - Some organisms play important role in increasing the fertility of soil. So, it is necessary to know such animals for their proper management in agriculture.
10. **In commerce:** Many animals and animal’s products are used commercially by human beings such as, honey, silk, lac, dyes etc. Systematics play important role in increasing and improving the qualities of these products by manipulating the useful species.

Systematists and taxonomists are presently employed by universities, research institute, museum, central and state govt. agencies, industries, and zoos. A well trained taxonomist is well qualified teacher to teach course of zoology or biology as he has a great background in morphology, physiology, genetics and ecology.

**Importance of Biosystematics:**
The importance of biosystematics in biology can be briefed as under –
1. Biosystematics gives us a vivid picture of the existing organic biodiversity of our earth.
2. It provides much of the information permitting a reconstruction of the phylogeny of the life.
3. It reveals numerous evolutionary phenomena and thus makes them available for casual study by the other branches of biology.
4. It supplies, almost exclusively, the information needed for entire branches of biology.
5. It is indispensable in the study of ecologically and medically important organisms.

It supplies classifications which are of great heuristic and explanatory value in most branches of biology like evolutionary biology, biochemistry, immunology, ecology, ethology and historic
HISTORY OF NOMENCLATURE

Nomenclature
- The term nomenclature comes from the Latin words nomen (name) and clature (to call).
- So it means to call by name.
- It is the role of nomenclature to provide labels for taxa at all levels in order to facilitate, communication among biologists.

- The word nomenclature is derived from two Latin words i.e.
- “nomen” which means name
- “clature” means to call
- so it means to call by name. it can be defined as “the system which is responsible for giving name to an organism is called nomenclature”. 
History

- As common names are not authentic and can not be used for scientific purposes b/c these names changed from language to language.
- Carl Linnaeus proposed the system of naming to each organism which is called binomial nomenclature in 1758.
- In this system organism are named and their name consist of two parts,
- The first part indicate genus and 2nd species from which the organism belong.

- The need for a code to give a scientific name to every species was first realised by British Association for the Advancement of Science in 1842, when a set of rules were framed by it.
- This was also felt by American Association for the Advancement of Science in 1877.
- Then similar learned bodies in different countries like France, Germany and Soviet Union developed codes for their respective countries.
- In 1889, at the International Congress of Zoology in Paris, discussions were made to find out some common code of nomenclature.
• First version of the code was adopted in the V\textsuperscript{th} International Congress of Zoology in Berlin in 1901.

• In the XV\textsuperscript{th} session held in London in 1958, the codes were rewritten and published on 6\textsuperscript{th} November, 1961 and the updated version of the code (1961) was made available in 1964 (2nd edition).

• This code is concerned only up to naming of superfamily and did not satisfy the zoologists.

• The latest edition (4\textsuperscript{th} edition) of the code was published in 1999 and its effective use has started from 2000.

• The International Zoological Congress elects a judicial body, called International Commission of Zoological Nomenclature which interprets or recommends the provisions of the code for classification or nomenclatural problems of the animals.

• Again the International Code of Zoological Nomenclature (ICZN) formed by the International Commission of Zoological Nomenclature to see the rules and principles of nomenclature and the application of these rules for both living and fossil animals.
ZOOLOGICAL NOMENCLATURE

- Zoological nomenclature is the system of scientific names applied to taxonomic units of animals (taxa, taxon), known to occur in nature, whether living or extinct.
- The term nomenclature comes from Latin words:
  - Nomen ------------ Names
  - Calare ----------- to call
  - And means literally to call by name

Important requisite of taxa names

- Three important requisites should be kept in mind before giving any name to a taxon.
  - Uniqueness - name should be unique
  - Universality - name should be name all over the world
  - Stability - name should not be changed
The international code of zoological nomenclature

- A set of rules for naming of animals and for resolution of nomenclatural problems is called the international code of zoological nomenclature.
- After 1800 all the authors adapted Linnaean system—change existing names if they had not been correctly formed—result in nomenclatural confusion
- A need for definite rules or code arose
- The first set of rules were presented in the first international congress of zoology in 1889.

Nomenclature- Binomial, Trinomial, Homonymy and Synonymy

BINOMIAL NOMENCLATURE

- Bi means two
- Nomen means name
- A **binomial nomenclature** is a classification system using two names to identify an organism
Principle of binominal nomenclature

- This is the principle that the scientific name of a species, and not of a taxon at any other rank, is a combination of two names; the use of a trinomen for the name of a subspecies and of uninional names for taxa above the species group is in accord with this principle.
- Example house mouse

House mouse

Kingdom-----Animalia
Phylum------Chordata
Class--------Mammalia
Order--------Rodentia
Family-------Muridae
Genus--------Mus
Species -----M. musculus  Linnaeus, 1758
Subspecies

- *Mus musculus bactrianus*
- *Mus musculus castaneus*
- *Mus musculus domesticus*
- *Mus musculus gentilulus*
- *Mus musculus musculus*

Definitions

- **Synonym:** A taxonomic name which has the same application as another, especially one which has been superseded and is no longer valid.

  In nomenclature, each of the two or more different names for the same taxon is called synonym.

  X

  Species A ....... synonyms

  Y
Antilocapra antilopina

Pronghorn

synonyms
Antilocapra americana --- 1815

Antilocapra americana  Ord, 1815
Homonym: a Latin name which is identical to that of a different organism, the newer of the two names being invalid.

In nomenclature, one or two or more identical but independently proposed names for the same or different taxa are called homonym.

X ------- 1818
Species A ---- ----- homonym
X ------- 1915
Species A ---- X ------- 1779
------ homonym
Species B ---- X ------- 1907

Moray eel --- Echidna ---1777
(Johan Reinhold forster)
Spiny anteater --- Echidna --- 1797
(George cuvier)
Another name for spiny anteater is Tachyglossa
Trinomial Nomenclature:

- Sometimes it becomes imperative to recognise subspecies within a species and is given a third specific name. Such system of naming is known as Trinomial nomenclature.
- The scientific name of the lion is *Panthera leo* (Linn.).
- The same species of the specimen collected in different countries shows minor differences from the original form.
- So a third sub-specific name becomes necessary in many cases.
• The scientific name of the Indian lion is designated as *Panthera leo persica* (Linn.).

• A trinomen is used to recognise a subspecies. International Rules of Zoological Nomenclature recognised the trinomial nomenclature.

• The adoption of Latinised names for the organisms and the scheme of classification according to hierarchy are the two main themes of the classificatory secret of Linnaeus.

• The selection of Latin as the language of nomenclature is quite reasonable because it remains unchanged through generations and is not subjected to grammatical changes as it happens in other vernacular languages.
Brief History of International Code of Zoological Nomenclature:

The need for a code to give a scientific name to every species was first realized by British Association for the Advancement of Science in 1842, when a set of rules were framed by it. This was also felt by American Association for the Advancement of Science in 1877. Then similar learned bodies in different countries like France, Germany and Soviet Union developed codes for their respective countries.

In 1889, at the International Congress of Zoology in Paris, discussions were made to find out some common code of nomenclature. First version of the code was adopted in the Vth International Congress of Zoology in Berlin in 1901. In the XVth session held in London in 1958, the codes were rewritten and published on 6th November, 1961 and the updated version of the code (1961) was made available in 1964 (2nd edition).
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Again the International Code of Zoological Nomenclature (ICZN) formed by the International Commission of Zoological Nomenclature to see the rules and principles of nomenclature and the application of these rules for both living and fossil animals.

**Parts of International Code of Zoological Nomenclature:**

The International Code of Zoological Nomenclature contains three main parts:

(i) The Code proper,

(ii) The Appendices and

(iii) The Official glossary.

The code proper includes a preamble followed by 90 articles which cover mandatory rules without any explanation.

There are three Appendices, of which the first two cover the status of recommendations and the third part of the Appendices is the constitution of the commission. The glossary contains the terms used in the codes with detailed definition.
Rules of Zoological Nomenclature:

At present the naming of the animal is governed by the International Code of Zoological Nomenclature. There are many rules (Articles) concerning the Zoological Nomenclature.

Of these rules, some important ones are cited below:

1. Zoological nomenclature is independent of other system of nomenclature. The scientific name of animals and plants must be different, and the generic name of a plant and an animal may be same, but this system is to be avoided. e.g., the generic name of banyan or fig tree is Ficus and the fig shell (a kind of gastropod shell) is Ficus. The scientific name of fig tree is Ficus carica or F. indica, etc., but the scientific name of the fig shell is Ficus ficus or Ficus gracilis, etc.

2. The scientific name of a species is to be binomial (Art. 5.1) and a subspecies to be trinomial (Art. 5.2).

   e.g., the scientific name of Indian bull frog is Rana tigerina. It is binomial. The scientific name of Indian lion is Panthera leo persica. It is trinomial. Such a system of naming by three Latin or Latinised words is known as trinomial nomenclature. Sometimes it becomes imperative to recognise subspecies within a species and is given a third specific name.

3. The first part of a scientific name is generic (L. Genus = race) and is a single word and the first alphabet or letter must be written in Capital letter. The genus must be a noun in the nominative singular. The generic part assigns a Latin noun, a Latinized Greek or a Latinized vernacular word.

4. The second part of a name is species (L. species = particular kind) name and may be a single word or a group of words. The first alphabet or letter of the species name
must be written in small letter. The species name must be adjective form in nominative singular agreeing in gender with genus name which is in noun form; e.g.:

<table>
<thead>
<tr>
<th>Ending in species name</th>
<th>Ending in genus name</th>
<th>Full name of the species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Masculine ending (-i)</td>
<td>(-i/-us/-es)</td>
<td>Common mongoose (Herpestes edwardsi)</td>
</tr>
<tr>
<td>Feminine ending (-a/-e)</td>
<td>(-a/-e)</td>
<td>River lapwing (Vanellus duvaucelli)</td>
</tr>
<tr>
<td>Neuter ending</td>
<td>(-um/-us, etc.)</td>
<td>Golden cuttle fish (Sepia esculenta)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Humprosed viper (Hypnale hypnale)</td>
</tr>
</tbody>
</table>

The specific name (species part) indicates distinctness while generic part shows relationship.

5. If the species names are framed after any person’s name, the endings of the species are i, ii and ae, or if the species name are framed after geographical place, the endings of the species are ‘ensis’, ‘iensis’, e.g.:

- **Hooded cuttle fish** — *Sepia prashadi* (Prasad + i)
- **Tree frog** — *Rhacophorus jerdonii* (Jerdon + ii)
- **Antarctic flying squid** — *Todarodes filippovae* (Filiippo + ae)
- **Common Indian monitor** — *Varanus bengaliensis* (Bengal + ensis)
- **Cookiecutter shark** — *Isistius brasiensiis* (Brasil + iensis)
- **Butterfly fish** — *Chaetodon madagascariensis* (Madagascar + iensis)

6. First part of a compound species-group name is a Latin letter and denotes a character of the taxon, connected to the remaining part of the name by a hyphen (-), e.g., Sole (a kind of flat fish)—Aseraggodes sinus-arabici. L. Sinus = recess China-rose (a kind of coloured rose)—Hibiscus rosa-sinensis. L. rosa = rose
7. If a subgenus taxon is used, it is included within parenthesis in between genus and species part and is not included in binomial and trinominal nomenclature, e.g.:

<table>
<thead>
<tr>
<th>Name</th>
<th>Genus</th>
<th>Subgenus</th>
<th>Species</th>
<th>Subspecies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fan shell (Bivalvia)</td>
<td>Atrina</td>
<td>(Servatrina)</td>
<td>pectinata</td>
<td>pectinata</td>
</tr>
<tr>
<td>Dussumier’s half beak (Osteichthyes)</td>
<td>Hemirhampus</td>
<td>(Repohampus)</td>
<td>dussumieri</td>
<td></td>
</tr>
</tbody>
</table>

8. The person who first publishes the scientific name of an animal, is the original author of a name, may be written after the species name along with the year of publication. The author’s name may be in its abbreviated form.

Lion—Felis leo Linnaeus, 1758 Lion—Felis leo Linn., 1758 or Felis leo L., 1758

9. Comma is only used between author’s name and the year of publication (Art. 22. A. 2.1), e.g., the scientific name of Common octopus is Octopus vulgaris Cuvier, 1797. No punctuation marks are considered one to other ends of the name, e.g., “Octopus vulgaris Cuvier, 1797” (Not considered). No diacritic mark, apostrophe (i’) and hyphen (-) are used in names. In German word the umlaut sign is removed from a vowel and the letter ‘e’ is inserted after the vowel, e.g., mulleri becomes muelleri.

10. If the original generic name given by the first author who also reported the species name, transfers the species part from one genus to the other, the name of the original author is put within parenthesis, e.g.,

**Tiger:**
Felis tigris Linnaeus, 1758. At first almost all the members of the cat family were placed under the genus-Felis.

**Later the genus Felis was divided into two genera, the genus of the larger cats (tiger, lion, leopard, etc.) is Panthera and**
smaller cats such as jungle cat, fishing cat, golden cat, etc. are placed under the genus Felis, e.g.:

Lion—Felis leo Linnaeus, 1758 – Lion—Panthera leo (Linnaeus, 1758)

Jungle cat—Felis chaus

11. The names are not acceptable before the publication of Linnaean treatise, Systema Naturae (10th edition) which was published on 1st January, 1758 except the Nomenclature of spiders which starts in 1757. The book Aranei suecici was published by C. Clerck in 1757.

12. The scientific names must be either in Latin or Latinised or so constructed that they can be treated as a Latin word.

13. The scientific names must be italicised in printed form, or underlined in hand written or in typed forms, e.g.

Indian leopard—Panthera pardus fusca (Meyer)

Principle of priority:

Of all the rules of zoological nomenclature, it is the most controversial part to choose the correct name when two or more names of a single taxon are discovered. Arbitrariness in nomenclature prevails since the period from 1780-1850. The taxonomists of different countries specially in Europe were unable to consult the names of different taxa during the period of French revolution and Napoleonic wars.

A large number of synonyms appeared on these days. The continuous change of names of different taxa could be prevented when priority was adopted as a basic principle of nomenclature.
Reasons for the Changes of Name:

1. Changes dictated by scientific progress:
   (i) Change of the generic part of binomial (binominal).

   (ii) Change of specific name.

   (iii) Synonymising of currently accepted species names.

   (iv) Analysis of species complex.

2. Changes dictated by rules of nomenclature:
   (i) Discovery of an earlier (senior) synonym.

   (ii) Discovery of an earlier (senior) homonym.

   (iii) Discovery of an earlier genotype fixation.

   (iv) Discovery of inapplicable type-specimen.

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**International Code of Zoological Nomenclature (ICZN)**

- By the end of the 19th century it became apparent that more and more problems have been created instead of amicable settlement.
- As a result it becomes essential to have an International Code for International Zoology.
- On the 11th January in 1961 finally a draft was prepared and submitted to the International Congress of Zoological Nomenclature (formed 1910).
- It was then approved by the commission and finally accepted by voting as “International Code for Zoological Nomenclature” and published by International Trust of Zoological Nomenclature in 1961.
This code consists of three parts:
1) The Code proper
2) Appendices
3) Glossary

1. The Code proper

- It includes ‘preambles’ followed by 87 consecutive numbered Articles which grouped in 18 chapters.
- The Articles are composed of mandatory rules to which in some cases are attached the Recommendations.
- The use of recommendations is not mandatory but lays down the best procedure for cases not strictly covered by the application of rules.
- These are designated by the number of the article with which they are associated, followed by appropriate capital letter, e.g., Recommendations 10A, 72B, 74D etc.

2. Appendices

- Appendices are like recommendations not to be followed strictly like Article. These are five in numbers and all are designated from A-E. The particular paragraph of the appendices is written as A7, D21c etc.

3. Glossary

- The terms are used in the text are clearly defined in the glossary.
Requisites for Scientific Nomenclature

Three important requisites for scientific nomenclature:
1. Uniqueness
2. Universality
3. Stability

1. Uniqueness
- A classification is a filling system, an information retrieval system.
- Every name has to be unique because it is the key to entire literature relating to this species or higher taxon.
- If several names have been given to the same taxon, there must be a clear cut method of determining which of them has validity.
- In case Zoological nomenclature, priority usually decides in case of conflict.

2. Universality
- Scientific communication would be very difficult if there were only vernacular names for animals.
- In that case specialists would have to learn the names of taxa in innumerable languages in order to communicate each other.
- To avoid this, a single set of names for animals to be used worldwide.

3. Stability
- As recognition symbols the names of object would lose much of their usefulness if they are changed frequently and arbitrarily.
- It would certainly create confusion if we were to call an object a spoon today but an apple next week.
The Three domains of life

1. Define phylogeny.
2. Name the 3 Domains of the 3 Domain system of classification and recognize a description of each.
3. Name the four kingdoms of the Domain Eukarya and recognize a description of each.
4. Define horizontal gene transfer.

The Earth is 4.6 billion years old and microbial life is thought to have first appeared between 3.8 and 3.9 billion years ago; in fact, 80% of Earth's history was exclusively microbial life. Microbial life is still the dominant life form on Earth. It has been estimated that the total number of microbial cells on Earth on the order of $2.5 \times 10^{30}$ cells, making it the major fraction of biomass on the planet.

Phylogeny refers to the evolutionary relationships between organisms. The Three Domain System, proposed by Woese and others, is an evolutionary model of phylogeny based on differences in the sequences of nucleotides in the cell's ribosomal RNAs (rRNA), as well as the cell's membrane lipid structure and its sensitivity to antibiotics. Comparing rRNA structure is especially useful. Because rRNA molecules throughout nature carry out the same function, their structure changes very little over time. Therefore similarities and dissimilarities in rRNA nucleotide sequences are a good indication of how related or unrelated different cells and organisms are.
There are various hypotheses as to the origin of prokaryotic and eukaryotic cells. Because all cells are similar in nature, it is generally thought that all cells came from a common ancestor cell termed the **last universal common ancestor (LUCA)**. These LUCAs eventually evolved into three different cell types, each representing a domain. The three domains are the *Archaea*, the *Bacteria*, and the *Eukarya*. 

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**Approaches to Classifying Organisms**

- **A two-kingdom system—Linnaeus**
  - Plantae
  - Animalia

- **A five-kingdom system—Whittaker**
  - Monera
  - Protista
  - Fungi
  - Plantae
  - Animalia

- **A six-kingdom system—Woese**
  - Eubacteria
  - Archaeabacteria
  - Protista
  - Fungi
  - Plantae
  - Animalia

- **A three-domain system—Woese**
  - Bacteria
  - Archaea
  - Eukarya
More recently various fusion hypotheses have begun to dominate the literature. One proposes that the diploid or 2N nature of the eukaryotic genome occurred after the fusion of two haploid or 1N prokaryotic cells. Others propose that the domains Archaea and Eukarya emerged from a common archaeal-eukaryotic ancestor that itself emerged from a member of the domain Bacteria. Some of the evidence behind this hypothesis is based on a "superphylum" of bacteria called PVC, members of which share some characteristics with both archaea and eukaryotes. There is growing evidence that eukaryotes may have originated within a subset of archaea. In any event, it is accepted today that there are three distinct domains of organisms in nature: Bacteria, Archaea, and Eukarya. A description of the three domains follows.
There is a "superphylum" of bacteria called PVC, referring to the three members of that superphylum: the Planctomycetes, the Verrucomicrobia, and the Chlamydiae. Members of the PVC, while belonging to the domain *Bacteria*, show some features of the domains *Archaea* and *Eukarya*.

Some of these bacteria show cell compartmentalization wherein membranes surround portions of the cell interior, such as groups of ribosomes or DNA, similar to eukaryotic cells. Some divide by budding or contain sterols in their membranes, again similar to eukaryotes. Some lack peptidoglycan, similar to eukaryotes and archaia. It has been surmised that these bacteria might be an intermediate step between an ancestor that emerged from a bacterium (domain *Bacteria*) and an archael-eukaryotic ancestor prior to its split into the domains *Archaea* and *Eukarya*.

**The Archaea (archaeabacteria)**

The *Archaea* possess the following characteristics:

a. *Archaea* are prokaryotic cells.

b. Unlike the *Bacteria* and the *Eukarya*, the *Archaea* have membranes composed of branched hydrocarbon chains (many also containing rings within the hydrocarbon chains) attached to glycerol by ether linkages (Figure 1.3.31.3.3).

c. The cell walls of *Archaea* contain no peptidoglycan.

d. *Archaea* are not sensitive to some antibiotics that affect the *Bacteria*, but are sensitive to some antibiotics that affect the *Eukarya*.

e. *Archaea* contain rRNA that is unique to the *Archaea* as indicated by the presence molecular regions distinctly different from the rRNA of *Bacteria* and *Eukarya*. 
Archaea often live in extreme environments and include methanogens, extreme halophiles, and hyperthermophiles. One reason for this is that the ether-containing linkages in the Archaea membranes is more stable than the ester-containing linkages in the Bacteria and Eukarya and are better able to withstand higher temperatures and stronger acid concentrations.

The **Bacteria (eubacteria)**

Bacteria (also known as eubacteria or "true bacteria") are prokaryotic cells that are common in human daily life, encounter many more times than the archaebacteria. Eubacteria can be found almost everywhere and kill thousands upon thousands of people each year, but also serve as antibiotics producers and food digesters in our stomachs. The Bacteria possess the following characteristics:

a. **Bacteria** are prokaryotic cells.
b. Like the *Eukarya*, they have membranes composed of unbranched fatty acid chains attached to glycerol by ester linkages (Figure 1.3.3).

c. The cell walls of *Bacteria*, unlike the *Archaea* and the *Eukarya*, contain peptidoglycan.

d. *Bacteria* are sensitive to traditional antibacterial antibiotics but are resistant to most antibiotics that affect *Eukarya*.

e. *Bacteria* contain rRNA that is unique to the *Bacteria* as indicated by the presence molecular regions distinctly different from the rRNA of *Archaea* and *Eukarya*.

*Bacteria* include mycoplasmas, cyanobacteria, Gram-positive bacteria, and Gram-negative bacteria.

**The *Eukarya* (eukaryotes)**

The *Eukarya* (also spelled *Eucarya*) possess the following characteristics:

a. *Eukarya* have eukaryotic cells.

b. Like the *Bacteria*, they have membranes composed of unbranched fatty acid chains attached to glycerol by ester linkages (Figure 1.3.3).

c. Not all *Eukarya* possess cells with a cell wall, but for those *Eukarya* having a cell wall, that wall contains no peptidoglycan.

d. *Eukarya* are resistant to traditional antibacterial antibiotics but are sensitive to most antibiotics that affect eukaryotic cells.

e. *Eukarya* contain rRNA that is unique to the *Eukarya* as indicated by the presence molecular regions distinctly different from the rRNA of *Archaea* and *Bacteria*. 
The *Eukarya* are subdivided into the following four kingdoms:

1. **Protista Kingdom**: Protista are simple, predominately unicellular eukaryotic organisms. Examples include slime molds, euglenoids, algae, and protozoans.

2. **Fungi Kingdom**: Fungi are unicellular or multicellular organisms with eukaryotic cell types. The cells have cell walls but are not organized into tissues. They do not carry out photosynthesis and obtain nutrients through absorption. Examples include sac fungi, club fungi, yeasts, and molds.

3. **Plantae Kingdom**: Plants are multicellular organisms composed of eukaryotic cells. The cells are organized into tissues and have cell walls. They obtain nutrients by photosynthesis and absorption. Examples include mosses, ferns, conifers, and flowering plants.

4. **Animalia Kingdom**: Animals are multicellular organisms composed of eukaryotic cells. The cells are organized into tissues and lack cell walls. They do not carry out photosynthesis and obtain nutrients primarily by ingestion. Examples include sponges, worms, insects, and vertebrates.

It used to be thought that the changes that allow microorganisms to adapt to new environments or alter their virulence capabilities was a relatively slow process occurring within an organism primarily through mutations, chromosomal rearrangements, gene deletions and gene duplications. Those changes would then be passed on to that microbe's progeny and natural selection would occur. This gene transfer from a parent organism to its offspring is called vertical gene transmission.

It is now known that microbial genes are transferred not only vertically from a parent organism to its progeny, but also horizontally to relatives that are only distantly related, e.g., other species and other genera. This latter process is known as horizontal gene transfer. Through mechanisms such as [transformation], [transduction],
and conjugation, genetic elements such as plasmids, transposons, integrons, and even chromosomal DNA can readily be spread from one microorganism to another. As a result, the old three-branched "tree of life" in regard to microorganisms (Figure 1.3.11.3.1) now appears to be more of a "net of life."

Microbes are known to live in remarkably diverse environments, many of which are extremely harsh. This amazing and rapid adaptability is a result of their ability to quickly modify their repertoire of protein functions by modifying, gaining, or losing their genes. This gene expansion predominantly takes place by horizontal transfer.

**Summary**

1. Phylogeny refers to the evolutionary relationships between organisms.
2. Organisms can be classified into one of three domains based on differences in the sequences of nucleotides in the cell's ribosomal RNAs (rRNA), the cell's membrane lipid structure, and its sensitivity to antibiotics.
3. The three domains are the Archaea, the Bacteria, and the Eukarya.
4. Prokaryotic organisms belong either to the domain Archaea or the domain Bacteria; organisms with eukaryotic cells belong to the domain Eukarya.
5. Microorganism transfer genes to other microorganisms through horizontal gene transfer - the transfer of DNA to an organism that is not its offspring.