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Biosystematics

التصنيف الحياتي

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Plant taxonomy or systematic botany

A study of the grouping of plant together and study their diversity and identification, description, classification and naming. (IDCN)

-**The classification** : is arrangement of the plants into hierarchy having common characteristics .

-**Nomenclature (naming)**

Is the study of the naming of taxa, its first formed by Linnaeus in his book (Species Plantarum) in 1753, it requires that scientific names are in Latin form a and they are subject to the rules of as grammar and written in Latin. For example the scientific name of species consisted of at least two words **.** The first word is name of the genus. The second word is name of the species in addition to the author name *Eruca sativa* L.

Hierarchy

Each level of hierarchy is called a rank or category e.g. family, genus, species. And a taxonomic element or classificatory unit of any level or rank may be species, genus , family.

The basic rank of the hierarchy is the species, which is define as group of plant which can interbreed together and form fertile offspring.

Species are grouped into genera singular genus. Genus are grouped into families such as cruciferae and Asteraceae. Family are grouped into orders. Ordar are grouped into classes. Classes are grouped into division. There are other categories below each rank , these can be a group using the prefix sub , as in sub division , sub class, sub family ,sub genus , and also between the family and the genus is the tribe , and between the genus and the

species is the section , below the species is the subspecies , variety and form.

Endings of the names of taxa above the rank of genus should be in the manner noted below:

Rank	Ending	Example
Kingdome	-ae	Plantae
Division	-Phyta or -a	Pterophyta Eudicota
Subdivision	-Phytina	Pterophytina
Class	-opsida or sida	Pteropsida Rosids
Order	-ales	Rosales
Suborder	-ineae	Rosineae
Family	-aceae	Rosaceae
Subfamily	-oideae	Rosoideae
Tribe	-eae	Rosaeae
Genus	-us ʿa ʿ um ʿes ʿon ʿect.	*Rosa, poterium, Plantanus*

The important ranks of the taxonomic hierarchy:

Division

Class

Order

Family

→ Tribe

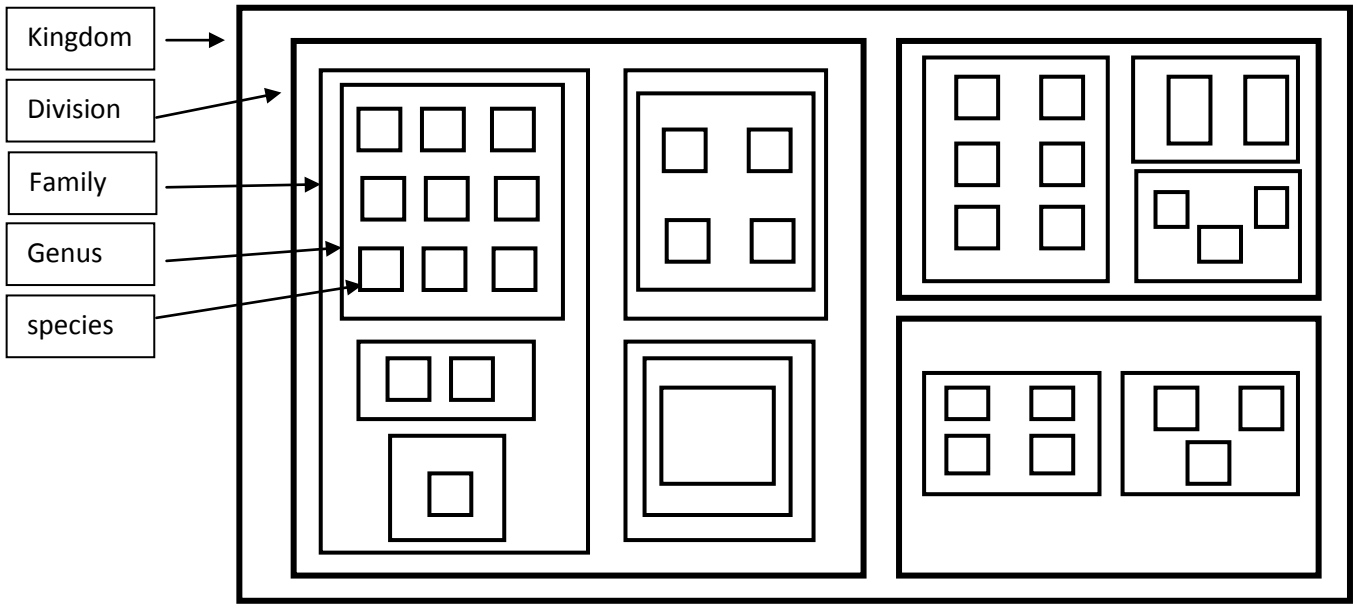
Genus

→ Section

Species

→ Subspecies

Variety



Biosystematics

Is the broad field concerned with morphological, anatomical, ecology, cytological, molecular biology, phylogentical, embryological and genetic investigation, etc. and experimental science studies of living population in the field experimental

garden, laboratory and green house , so that this science to gave the taxonomic more evidence for the classification by using these characters to study phylogenic relationship .

Numerical taxonomy

Is the treatment of various of taxonomic data by computerized methods.

Sources of evidences

Or the relationship between systematic and other sciences such as:

- Morphological evidence.
- Anatomical evidences.
- Chemical evidences.
- Cytological evidences.
- Genetical evidences.
- Palynological evidences.
- Embryological evidences.
- Phylogentic evidences.
- Ecological evidences.
- Geographical evidences.
- Paleobotanical evidences.
- Physiological evidences.
- Molecular Biology evidences.

1. Morphological characters

The study of each vegetative and floral parts, the feature of floral morphology are considered as the most important characters in the classification of following plants.

The morphological characters with some taxa are of little taxonomic value, but in other taxa they can be of major taxonomic feature. But the difficulties of morphological characters the determination which one is primitive and which one is advanced.

The morphological feature considered as an importamt features as a result of:

1- These features are easily observed.
2- And are practical for use in keys and descriptions .
3- Morphological currently provides most of the characters used in constructing taxonomic systems.

2. Anatomical characters

The application of anatomical data to the solution of taxonomic problems. For ex:

1- The similar leaves of *Acer* and *Plantanus* have different anatomical features.

2- the absence of conducting tissues in water plants and the presence of bicollateral vascular bundle in climbing plants.

3-valuable taxonomic evidences has been attained from the study of wood structure, leaves epidermis and stomata etc.

4- Also other example some taxa have similar anatomical feature as in *Euphorbia* genus which has many species characterized by the present of latex-vessels, whether the plant be cactus-like , thorny, shrubs or leafy herbs.

3-Cytological characters

Is the study of chromosomal information which is known as **cytotaxonomy.** Which Is the integration of cytology and taxonomy in the effort better to understand and to resolve problems of plant relationships and cytogenetic is the combining of cytological and genetical techniques in the effort ti arrive at solution of a problem .

And its consist of three major lines:

1-Chromosome number .

2-Chromosome structure .

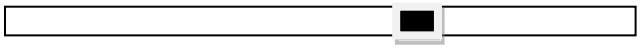
3-Chromosome behavior .

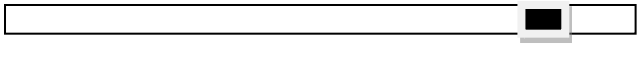
1- chromosomes number in each cell of all individuals of a single species is constant with some exception of that number, species more related, are to have the same chromosome number, and the more distantly related these species they are to have a different number. For example : in the genus of *Festuca* are the species of it with 2n=14 ;28;42;56 and 70 such species known as diploids, tetraploieds, hexaploids ,octaploids and respectively these numbers are based upon 7. All species of this genus to have the same basic number.

2-Chromosome structure The most commonly utilized aspect of chromosome structure is the position of centromeres so that the arm lenth ratio of each chromosome in the genome, sometime it is sufficient only to recognize the distinction between position of centromeres of the chromosome in the middle or near the one end.

According to the position it is called centric, metacentric and telocentric respectively .

Centric position 

Metacentric 

Telocentric 

3. **Chromosome behavior** : The pairing behavior and the subsequent separation of chromosomes at meiosis.

4-**Palynology**

Is the study of pollen and spore morphologically and anatomically in addition to its relation with taxonomy.

Pollen morphology

Is highly significant for the taxonomist . The taxonomt characters provided by pollen grain included :

1-Pollen shape
2- pollen aperture (number, kind, position)
3- pollen wall sculpture. Is studies by using LM (Light microscope and SEM (Scanning electron microscope)
3- pollen type, etc.

Pollen anatomy is the study of Pollen wall structure by using TEM (Transmission electron microscope). Which is done by Studies of thin sections of pollen grain wall that can yield reliable taxonomic information of certain groups.

5-**Paleobotany**

The best source of evidence is actual data from the fossil record .Paleobotanists attempt:

1- To elucidate the composition and the evolution of floras of the past.
2- To trace these evolutionary development through stratigraphic sequences .
3- To determine past ecological condition.

paleobotany could provide little evidence on the origin and diversification of the flowering plant and the origin of these plants are from one source or different source. If one source is termed Monophyletic origin or from more than one source it is called Polyphyletic origin.

6-**Chemical compounds (Chemosystematics)**

Plant chemosystematics

Is the application of chemical data to systematic problem . This filed concerned with using chemical constituents for explaining relationships between plants and inferring phylogeny.

Chemosystematics divided these compounds into two major groups **according to molecule size.**

- Compound of relatively low molecular weight that plant produce many types of natural products such as alkaloids, amino acids, glucosinolates, flavonoides pigments and other phenolic compounds. fatty acids and terpenoids are termed micromolecules.
- Compound of high molecular weight, such as proteins .DNA, RNA, cytochrome C, ferrodoxin, and complex polysaccharides, are referred to as macromolecular .

In general there are three very broad groups of compounds can be recognized :

1- Primary metabolites. such as citric acid , Aconite acid etc.
2- Secondary matabolites. such as alkaloids, phenolics, terpinoides, glucosinolate etc.
3- Semantids. are the information carrying molecules DNA is primary semantids and proteins is tertiary semantids.

Taxonomy types:

1- Classical Taxonomy:

It is taxonomy 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)

2- New Systematics or Modern Taxonomy:

The term new systematics was coined by Julian Huxley (1940). New systematics is systematic study which takes into consideration all types of characters including those from classification morphology, anatomy, cytology, physiology, biochemistry, ecology, genetics, development (embryology), behavior, etc. of the whole population instead of a few typo-logical specimens.

In contrast classical systematics is based on the study of mainly morphological traits of one or a few specimens with supporting evidences from other fields. New systematics is also called population systematics and biosystematics. It is found to bring out evolutionary relationships amongst organisms.

Differences between Classical Taxonomy and Modern Taxonomy	
Classical taxonomy	Modern Taxonomy
1- It deals with morphospecies. 2- it has a typological concept 3-Species is considered to be static. 4- It does not study evolution and inter-relationships of species.	1- it deals with biological species. 2- it has a population or biosystematic concept. 3- Specis is considered to by dynamic. 4- It studies primitiveness, advancement and inter-relationships of species.

"Variation and Evolution"

Variation, definition and sources

Variation, in biology, any difference between cells, individual organisms, or groups of organisms of any species caused by different causes:

1- phenotypic variation :

The characters of the phenotype are a reflection of the interaction of the internal genetic factors of the plant with the environment. Phenotypes of any two plants are different in a distinct range, each individual in a sexually reproducing population has a distinct genetic information that produces different phenotypes, Asexually reproducing plants produce offspring with the same genetic constitution as the parent plant. However in these cases because the environment is differ from site to site, the plants differ morphologically also.

So morphologically variation are caused by genetic variation or Land ecological and geographical variation (Environment)

I- Genetic Variation

- Caused by nuclear genes
  - May give well-defined classes of types, or discontinuous variation
  - May give continuous range of variation
- Caused by cytoplasmic genes--usually inherited maternally
- In general genetic variation can occur in different levels of life cycle of an organisms. The greatest source of genetic variation in natural populations comes from the introduction of genes from neighboring populations in the form of seed or pollen (gene flow, recombination) during sexual reproduction. And Another source of variation is mutation which is happened generally on either genes or chromosome.

1- Gene variation (mutation)

A gene mutation occurs when the nucleotide sequence of the DNA is altered and a new sequence is passed on to the offspring. The change may be either a substitution of one or a few nucleotides for others or an insertion or deletion of one or a few pairs of nucleotides.

2-Chromosomal variation (mutations)

Chromosomes, which carry the hereditary material, or DNA, are contained in the nucleus of each cell. Chromosomes come in pairs, with one member of each pair inherited from each parent. The two members of a pair are called homologous chromosomes. Each cell of an organism and all individuals of the same species have, as a rule, the same number of chromosomes. The reproductive cells (gametes) are an exception; they have only half as many chromosomes as the body (somatic) cells. But the number, size, and organization of chromosomes varies between species. Even closely related organisms may vary considerably in the number of chromosomes.

Changes in the number, size, or organization of chromosomes within a species are termed chromosomal mutations.

II - Environmental Causes

- Caused by geographical differences which is correlated with latitude, longitude and other factors.
- Caused by physical environment (light, temperature, moisture, minerals, exposure, etc.)
- Caused by biological factors (parasites or any other species that interact with the species under study).

For example, plant height is correlated with 1- latitude so, northern plants are shorter than southern ones; and 2- longitude: so, plants growing west are larger than plants growing east.

A classic example of a type of water-controlled variation known as heterophylly may be found among some species of aquatic water buttercup (*Rannunculus aquatilis*) has dissected submerged leaves but on the same stem will have lobed emergent leaves

2- Physiological variation

Its considered about basic functions such as respiration, activity of an enzyme and photosynthesis, these studies clearly show that plants vary probably as much in their physiological characteristics as they do in their morphological attributes.

3- Individual (Developmental) Variation

- Difference between juvenile stage and mature stages
- Variation within single plant
- Mistakes in development

Development, the process whereby a fertilized egg is converted into a mature organism, often in juvenile stages, the individuals appear different from the mature form. A good example is seen in the red huckleberry (*Vaccinium parvifolium*). The juvenile leaves of this plant are dark green, toothed, thick, and evergreen. In contrast, the adult foliage is lighter green, smooth, and toothless, and is shed each year.

Another good example of developmental variation is the variation of leaf shape within a single plant of pepperweed (*Lepidium perfoliatum*). On large plants the lower leaves are compound, finely divided into narrow leaflets. The upper leaves are simple, smooth, and heart-shaped, and they surround the stem where they are attached.

Because development is under such fine control, mistakes can occur. These may occur simply by chance, or they can be

triggered by some environmental agent. So Mistakes occur in plant development. One example is the familiar four-leaf clover which is in natural have three-leaf (compound trifoliate).

These kinds of development mistakes can happen spontaneously. A good example of this is the occurrence of three cotyledons in plant seeds. Flowering plants are divided into two major groups: the *monocts* have one leaf on the seedling, and the *dicots* have two. For un known reasons, very few flowering plants normally have more than two.

Evolution : the changes that occur in organisms over many generation and long periods of time.

So, in order for change to occur there must be at some time a **source of new genes**, and these sources are:

1- Mutation

2- Introduction of genes from neighboring population in the form of seeds or pollen (gene flow , and recombination)

Furthermore in order to have change there must be a **force producing and controlling these changes**:

1- Natural selection

2- Genetic drift

1- Mutation: that is certain changes in the structure of the DNA, that result in a modified protein or enzyme and consequently in some modifications in the phenotype are the ultimate source of variation in the population.

The mutation can be harmless, useful, or can cause death depending on where they occur in the chromosomes. In general they occur rarely but this rate can be speeded up by **mutagens** which is : a factor that causes mutation ex: X-ray, gamma ray, or certain chemicles. So mutation result in variation and this variation leads to evolution.

Some biosystematist considered the mutation not always the sources of the variation. Why?

1. Most of the mutation are deleterious not advantage.
2. Recurrent mutation usually occur with a frequency of $1/10000 = 10^{-4}$ to $1/ 100000000= 10^{-8}$ in rates of mutation which is very low.

3. Most the mutation are recessive so that the appearance of production mutation after many generation and superiority for the appearance of their effect.

   So that the gene flow and recombination considered as the most effective sources of variation than the mutation.

2- Gene flow: is introduction of new genes in to a population from outside sources. So it can be defined as the transfer of alleles or gametes from one population to another as a result of the introduction of foreign seeds or pollen.

3- recombination : It can be defined as, The recombining of genetic material through crossing over and random assortment at meiosis and fusion of genetically different gamete.

So, the genetic effect of normal sexual reproduction is to create new diversity in the diploid stage at each generation, there are two forces controlling the process of recombination in plant:

First- Crossing over

Crossing over is a process of exchange of genetic materials or segments between non-sister chromatids of homologous chromosomes.

Second – Independent assortment

The principle of independent assortment described how different genes independently separate from one another when reproductive cells developed, so its defined as "Is the separation of allelic pairs, or the genes received from parents, and their distribution to different cells (gametes)."

Types of recombination system

1- Closed recombination system

its mean that is no recombination process and it's found in apomixes plant as a result of flowers lacking or sterility as in *Musa spp.* or *Allium stiva*

2- Restricted recombination system

In this system there are some limited genetic variation comparing with opened system as a result of inbreeding of autogamy plant as in cleistogamy flowers ex: *Ficus* spp.

3- Opened recombination system

Opened system characterized by a large amount of genetic variation as a results of outbreeding in allogamy plant as in diaeciasm plants ex:*Phoenix dactylifera* or dichogamy plant or in plant characterized by self incompatibility flowers.

Natural selection : is the steering mechanism of the evolution, and it is the process that accounts for the contribution of varying numbers of offspring to the next generation by the members of the parental generation. The number of offspring an organism contributes to the next generation depend on their **fitness** which is defined as ability of the particular genetic makeup of the zygote to interact with the environment in order

to produce a phenotype that is capable of growing and reproducing(the ability to produce fertile offspring that survive to reproductive age). **The fitness can be increased by:**

1. Formation individuals more adaptation for the environmental condition.
2. By production or formation higher numbers of offspring.

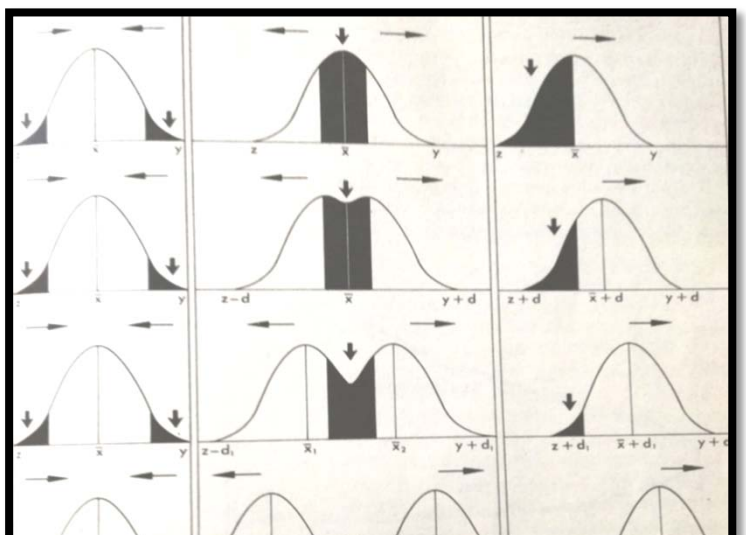
Types of selection

There are three main forms that natural selection represent the ways which the population remains adjusted to an environment which may be either:

1- Stabilizing selection, it is consider a very common type of selection, which is leading to constant and stable population.

2- Disruptive selection, which is becoming more variable and breaking up the population into different sub-environments, this selection is one that favors the extremes over the center on account of an environment that is breaking up into two or more types.

3- Directional (progressive) selection, which is changing the population constantly in a single direction. This is the type of selection where one extreme phenotypic expression of a character is favored



Genetic drift: it can be defined as a small population invase a new area and become a base of new evolutionary line resulting in a lose (zero) or fixation of the genes (gene frequency=1)

Speciation and isolation

Speciation is the process by which new species are formed from other, ancestral ones. There are two major modes by which new species can originate.

1- the process by transformation in time of one species in to another, and this called as phyletic speciation.

2- the process by which one ancestral species gives rise to one or more species without necessarily losing its identity, and this called as multiplication of species or true speciation.

The steps of speciation process:

1- separation of the original gene pool in to two

2- independent evolution of the two gene pools.

3- secondary merger

4- competition between the new gene pools.

Isolation

Isolating mechanisms are phenomena that prevent interbreeding of closely related taxa. And these mechanism included in two type as:

1- prezygotic mechanism : which prevent fertilization and have several type of isolation mechanism as:

- biotic isolation, as genetic factors (gametic isolation), and reproductive factors.(the more important and sharp factors)
- Geographical isolation: such as two species are separated geographically.
- ecological isolation mechanism, which is represented by for example aquatic or terrestrial ecosystem of the species.
- temporal factors, which is consider about blooming time of each species.
- Ethological factors which is include for example the pollinators kind of each species.

2- Postzygotic mechanisms.

"Breeding system"

The breeding system is the manner of reproduction of a particular species and it can be consider as a apart of genetic system,

The main types of breeding system

Basically, the breeding system can be either exclusively outbreeding (crossing always with another plant) or self pollinating in various degrees. Generally cross- fertilization is beneficial and self- fertilization injurious, So in many cases the pollen in outbreeding plant is incapable of germinating on the style of flowers of the plant that produced it or otherwise is incapable of fertilizing the egg, a condition referred to as physiological or genetic self- incompatibility. The converse condition, when the pollen can germinate on the style of flowers of the same plant and fertilize the egg, is called self-compatibility. Pollen of a self compatible plant may habitually fertilize the flower in which it was produced (self pollinated) or it may habitually be prevented mechanically or otherwise from doing.

Comparing between out-breeding and in-breeding plants:

Out-breeding (allogamy)	In-breeding (autogamy)
1- self incompatibility 2- high recombination 3- flowers many 4- flowers colorful 5- corolla rotate 6- nectar guides present 7- Pollen grains many 8- Stigmatic area well defined 9- Anther and stigma in different level 10- Dichogamy 11- Many ovules per flower	1- Self-compatible 2- low recombination 3- Flowers few 4- Flowers not color 5- Corolla funelform, cylinderic, or closed 6- Nectar guides absent 7- Pollen grain fewer 8- Stigmatic area poorly defined 9- Anther and stigma in a same level 10- Homogamy 11- Fewer ovules per flower

Types of breeding system

self pollination: moving of pollens from the anther to the stigma in the same individual plant.

Cross pollinating: moving of pollen from the anther to stigma in different plant but the same species.

Cleistogamy: self fertilization with in closed flower or of a flower which never open and self pollination.

Protogyny: maturing of styles before the anther which usually impedes self fertilization.

Protandry: maturing of the anther before the styles which usually impedes cross fertilization.

Perfect flower: (Bisexual flower) **or** hermaphroditic flower. Its having both sexes (Stamen and pistil ,carpel) are present in the same flower or it is called bisexual flower such as *Vicia* , *Petunia* .The symbols for male flower ♂ and female flower ♀ or in the same flower its symbols

-**Imperfect flower** (Unisexual flower)

Having reproductive organs of one sex only, stamens or pistil .

Including:

1-**Staminate** or male flower .the flower is bearing male organs only (stamens without pistil).

2-**Pistillate** or (female flower) Carpellate : It having pistil and without stamens or no functional stamens.

3-**Sterile** or Neutral flower: Lacking functional sex organs or is bearing male or female organs but inactive . Such as in some species of **Typhaceae** and **Asteraceae** families.

4-**Complete flower** :The flower is bearing Calyx , Corolla, Stamens and Pistil as in *Solanum melongene* .

5-**Incomplete flower** :The flower is lacking one organ. If the flower is without sepals it is called **Asepalous** such as

Euphorbia , and it is called **Apetalous** flower when it is without petals (Corolla) such as in *Morus* , and it is called **Naked** flower if the calyx and corolla (perianth) are absent such as in **Populus** from the family **Salicaceae .**

The plants described as a :

1-Monoecious plant : The plant with staminate and pistillate flower on the same plant as in *Zea mays, Typha , Ricinus.*

2-Diocious plant : If the staminate and pistillate flowers on different plants as in *Morus ,Salix , Phoenix dactylifera* .

3-Polygamous : The plant is bearing unisexual (imperfect flower) and perfect flower (bisexual flower) on the same plant.

Lecture 6

Biological systematics or **Biosystematics** is the science through which life forms are discovered, identified, described, named, classified and catalogued, with their diversity, life histories, living habits, roles in an ecosystem, and spatial and geographical distributions recorded. In essence, it is biosystematics, the science that provides indispensable information to support many fields of research and beneficial applied programs. Biosystematics permits basic identification, makes information available, assembles information from a comparative perspective and allows synthesis and generates and stimulates ideas and hypothesis applicable to other fields.

In recent years a taxonomist is not only to describe, identify and arrange organisms in convenient categories but also to understand their evolutionary histories and mechanisms.

Classifications: the grouping of information or objects based on similarities.

Taxonomy: is the science of grouping and naming organisms. Taxonomy, like classification, has also been used to designate the end products of the taxonomic process.

- **Taxonomy** The science which deals with **describing**, **classifying**, and **naming** organisms.

For the identification of an insect for example , any of the six ways may be adopted

1- to get specimen identified by a professional
2- by comparing it with labeled specimens in a collection.
3- by comparing it with images and illustrations.
4- by comparing it with descriptions.
5- by the use of an identification key.
6- by a combination of two or more of these procedures.

Of these, first two methods may not always be available. Similarly, illustrations, etc. may not be included with description of an organism, and the best procedure is to use the suitable key.

The systematics/ taxonomic studies involves a series of characters which can be grouped as:

1- Morphological characters, general external morphology, special structures (e.g. genitalia) internal morphology, embryology, karyology (and other cytological differences).
2- Physiology characters, metabolic factors, serological, protein and other biological differences, body secretions, gene sterility factors.
3- Ecological characters, habitats and hosts.
4- Food, seasonal variations, parasites, host reactions.
5- Ethological characters, courtship and other ethological isolation, other behaviors patterns.
6- Molecular genetic characters, isozymes, nucleic acid sequences, gene expression and regulation.

The information gathered on these aspects provide better basis for understanding an organism and relationship with the environment as well as other organisms.

The Level of Taxonomy are:

α-taxonomy: description of species – 'descriptive taxonomy'

β-taxonomy: classification

γ-taxonomy: study of intraspecific variation

The seven types of activities definition of **taxonomy** consists of:

1. Recognition, description and naming of taxa (species, genera, families etc., also revision of older descriptions) (≈ α-taxonomy).
2. Comparison of taxa, including studies of relationship (phylogeny) (≈ part of β- taxonomy).
3. Classification of taxa (preferably based on phylogenetic analyses) (≈ part of β- taxonomy).
4. Study of (genetic) variation within species (≈ γ-taxonomy)
5. Construction of tools for identification (keys, DNA barcodes).
6. Identification of specimens (referring them to taxa, using the tools).
7. list record of taxa in specific areas or ecosystems (using the tools for identification)

The biological classification may belong to any of the types:

1) **Phenatic classification**: The taxa are classified either on the basis of few characters or overall characteristics, without direct reference to phylogeny.

2) **Natural classification**: The classification is based on the natural characters of taxa. In this system of classification, the organisms are placed into as many as groups and sub groups as are in similarities and dissimilarities.

3) **Cladistic** or **Phylogenetic Classification**: Cladistic classification is exclusively based on phylogenetic branching. It includes an attempt to map the sequence of phyletic branching through a determination of characters that are shared primitive (**plesiomorphic**) and that are shared-derived (**apomorphic**).

4) **Envolutionary classification**: It is based on the evolutionary relationship of organisms, not just their phylogeny. This classification provides foundations of all comparative studies in biology through the degree of genetic similarity existing between organisms and the phylogenetic sequence of events in their history.

Carolus Linnaeus, (1707-1778)

Swedish botanist, developed and published the first comprehensive and consistent classification system for both plants and animals:

Plants**: Species Plantarum 1753**

(described and classified all plants known in his time = 7300 species)

Animals**: Systema Naturae 1758**

The tenth edition of Systema Naturae in 1758 including global fauna. The reason for this is that Linnaeus introduced in this book he developed a method of a two word naming system called **Binomial Nomenclature.**

Binomial Nomenclature (scientific names):

Rules:

1. One binomial name for each species
2. Capitalized Genus, lowercase species.
   Ex: ***Homo sapiens***, ***Tyrannosaurus rex***
3. Constructed according to rules of Latin or Greek grammar
4. Discoverer of species gets naming rights
5. Typed in *italics*, underlined when written

Taxonomic Linnaean Hierarchy

The Linnaean system of classification consists of a hierarchy of graded taxonomic (named) ranks that are called as **taxa**. Any given **taxon** (singular) may contain several lower taxa, which can be usually distinguished based on certain common characteristics. Such lower ranks may in turn be divided into a succession of progressively smaller ranks. The lower the rank of a group, the more similar are the organisms grouped in it. If any two given organisms can be grouped under the same lower rank or taxon, it implies that the two organisms are structurally, functionally, embryologically similar and that they have had a comparable evolutionary history.

Within the living world as a whole, the biggest taxonomic rank is **Kingdom**. Today, many biologists consider Domains to be a classification above Kingdoms. The next higher rank within a kingdom is the **Phylum** or **Division** (in plant). It is customary to use the term phylum for major groups in the animal kingdom and the term division for major groups in the plant kingdom. The phylum or division is a broad grouping of more or less closely related organisms, sharing certain common characteristics.

Each phylum or division has the next taxon called **Class**. The members of each class exhibit certain distinguishing characters that are unique only to them.

In the same way, using comparable criteria of similarities and relationships, each class can be divided into **orders**, each order into **families**, each family into **genera** and each genus into **species**. Species is normally the basic or fundamental unit of classification. A species is therefore the narrowest taxonomic category and kingdom is the broadest category in the Linnaean hierarchy.

Kingdom,
Phylum,
Subphylum,
Class,
Subclass,
Cohort,
Superorder,
Order,
Suborder,
Infraorder,
Superfamily,
Family,
Subfamily,
Tribe,
Genus,
Subgenus,
Species,
Subspecies.

Below is an example of a hierarchial system for the group of animals that includes humans.

Phylum: Chordata (vertebrates + animals with notocords)

Subphylum: Vertebrata (mammals + fish, amphibians, reptiles, Aves)

Class – Mammalia (primates + rodents, ruminants, carnivores)

Order – Primates (great apes + monkeys)

Family –Hominidae

Genus – ***Homo***

Species – ***Homo sapiens***

Lecture 7

What is a Species?

Species is generally the lowest taxonomic rank representing organisms that are very much closely related to one another. A species is defined as a group of closely related, structurally and functionally similar organisms which can breed among themselves, producing fertile offspring and which are reproductively isolated from such other groups. The members of a species could be spread over a wide geographical area in which considerable, constant environmental variations occur. Hence, a species is considered to be made up of different populations from different geographical areas and it is such local populations that often become the units of study rather than the entire species.

Definitions of species :

Biological Species Concept: a group of organisms capable of interbreeding and producing fertile offspring.

Typological species concept: A species is a group of organisms conforming to a common morphological plan.

Phylogenetic (Cladistic) species concept: A species is a set of organisms (an evolutionary lineage) between two branch points or between one branch point and an extinction happening or a modern population

Ecological species concept: A species is a set of organisms exploiting (or adapted to) a single niche.

Speciation: The evolutionary process of the origin of a new species.

Sibling Species: (cryptic species) :

Any of two or more related species that are morphologically nearly identical but are incapable of producing fertile hybrids. Sibling species can only be identified by genetic, biochemical, behavioral, or ecological factors, and are thought to have become divergent very recently.

Sympatric species:

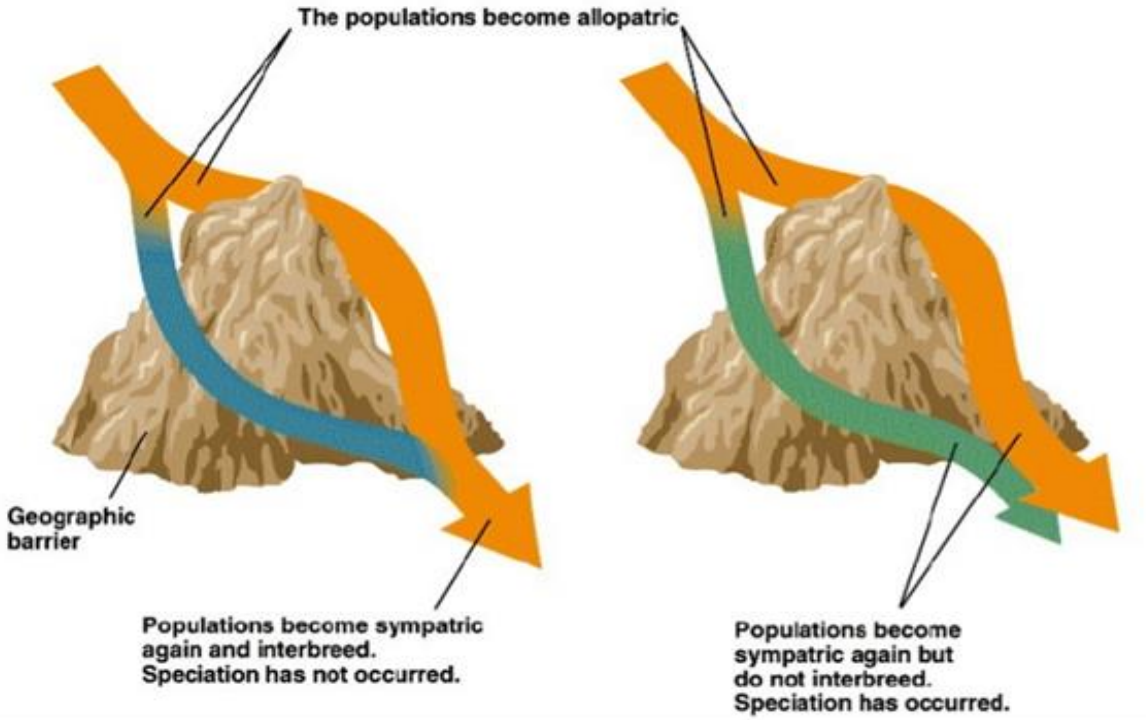
Occupying the same or overlapping geographic areas without interbreeding. Although they share the same geographic range, sympatric populations of related organisms become isolated from each other reproductively. This can happen by the development of subpopulations that become dependent on distinct food sources or that evolve distinct seasonal mating behavior.

sympatric speciation The development of new species as a result of the reproductive isolation of populations that share the same geographic range

allopatric species:

Occurring in separate, nonoverlapping geographic areas. Allopatric populations of related organisms are unable to interbreed because of geographic separation.

allopatric speciation The development of new species as a result of the geographic separation of populations



Reproductive isolation

The inability of a species to breed successfully with related species due to geographical, behavioral, physiological, or genetic barriers.

Or any property of two species that stops them from interbreeding

What are five reproductive barriers?

Five reproductive barriers are **habitat isolation, temporal isolation, gametic isolation, hybrid breakdown, and reduced hybrid fertility.**

1- Prezygotic reproductive barriers:

Habitat isolation, temporal isolation and **gametic isolation** are examples of prezygotic reproductive barriers, meaning that they impede mating or hinder fertilization if mating does occur.

a- Habitat isolation: Even if two species live in the same area, if they live in different habitats (ex: land vs. water), then they may rarely meet each other and thus not be able to reproduce together.

b- Temporal isolation: If a species breeds at different times (different days, seasons, years, etc), then they will not be able to mix their gametes.

c- Gametic isolation: Gametic isolation occurs when the one species' sperm cannot fertilize another species' eggs. This isolation can be produced in a variety of ways such as the sperm's inability to survive the reproductive tract in the other species' females and biochemical mechanisms that prevent the sperm from penetrating the other species' eggs.

2- Postzygotic reproductive barriers:

1Hybrid breakdown and reduced hybrid fertility are examples of postzygotic barriers since they prevent a hybrid zygote from developing into a viable, fertile adult.

a- hybrid breakdown, the first-generation of hybrids are fertile. However, when they reproduce (either by mating with one another or with one of their parent species), the next generation's offspring are feeble (weak) and sterile.

b- reduced hybrid fertility: the hybrids are sterile such as that of a cross between a donkey and a horse-a mule. This can happen if the two parent species have chromosomes with different structures because meiosis will fail to produce normal gametes in the hybrids. As a result, when the hybrids mate with either of their parental species, they cannot produce offspring. Thus, genes cannot freely flow between the species as the hybrids are infertile and cannot reproduce.

Lecture 8

Types in zoology

In zoological nomenclature, the type of a species (or subspecies) is a specimen (or series of specimens), the type of a genus (or subgenus) is a species, and the type of a suprageneric taxon (e.g., family, etc.) is a genus. Names higher than superfamily rank do not have types. A "name-bearing type" "provides the objective standard of reference whereby the application of the name of a nominal taxon can be determined."

Type species*:*

Each genus must have a designated type species. The description of a genus is usually based primarily on its type species, modified and expanded by the features of other included species. The generic name is permanently associated with the name-bearing type of its type species.

Type genus

A type genus is that genus from which the name of a family or subfamily is formed. As with type species, the type genus is not necessarily the most representative, but is usually the earliest described, largest or best known genus. It is not uncommon for the name of a family to be based upon the name of a type genus that has passed into synonymy; the family name does not need to be changed in such a situation.

Kinds of Types: Holotype, Allotype, Paratype, Syntype and Lectotype

Primary Type: A specimen upon which the description of a new species-group name is based. Including:

Secondary Type (**supplementary type**) Specimen used by an author to supplement to correct knowledge of a previously defined species, including **plesiotype**, **neotype**

Primary Type are:

1- **Holotype** The single type specimen that is the sole representative of a named species-group taxon. Usually designated as such **or** A single specimen designated or indicated as the 'the type" by the original author at the time of the publication of the original description.

2- Allotype: The type specimen of the opposite sex of the holotype.

3- **Paratype:** All specimens other than the holotype upon which a species-group name is based and so designated.

4- **Syntype:** Any specimen upon which the author based the description of a new species-group name without designating a holotype, including specimens at hand.

5- **Lectotype** The after designated type specimen of a species that was originally based on more than one specimen and the author did not designate one of those specimens as a holotype.

Secondary Type are:

1- **Plesiotype:** A specimen used by an author for a redescription, supplementary description, or illustration published subsequent to the original description.

2- **Neotype:** The designated type specimen of a species whose type (holotype, lectotype, neotype) or type series (syntypes) has been shown to be lost or destroyed.

Taxonomic keys or Dichotomous keys

A key is a device, tool or mechanism, which properly constructed and used, enables a user to identify an organism.

Indented Keys: indents the choices (leads) of the couplet un equal distance from the left margin. The two choices of the couplet are usually labeled 1 and 1' or 1a and 1b. It is not necessary that the choices are numbered

Bracketed keys: provides both choices side-by-side. The choices of the couplet must be numbered (or lettered). It is very helpful if the previous couplet is given.

The following examples provide the keys for identification four species of frogs namely

Rana hexadactyla* ; *R. cyanophlictis; R. tigrina* and *R. limnochoris.

The Bracketed key (Genus : Rana)

(1a) Large size, snout - vent 100 – 200 mm …….....3
(1b) Small size, snout - vent less than 100 mm 2
(2a) Pointed snout .....*R. limnochori*
(2b) rarely pointed snout .....*R. hexadactyla*
(3a) tongue longer than others .....*R. tigrina*
(3b) tongue not longer ..... *R. cyanophlictis*.

The Indented key (Genus : Rana)

1a. Large sized body
2a. skin smooth ..... *R.hexadactyla*
2b. skin with folds ..... *R. tigrina*
1b. Small size
3a. blunt snout ..... *R. cyanophlictis*
3b. pointed or round snout ..... *R. limnochoris*

Variation in Taxonomic and Systematic Characters:

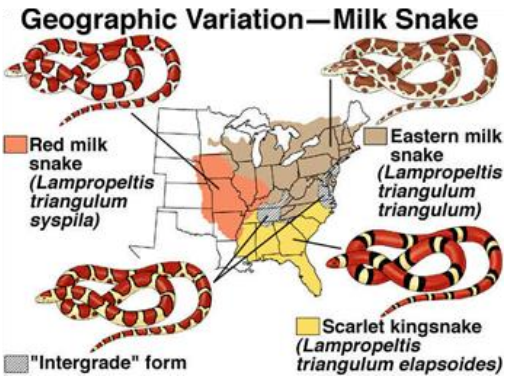
Lecture 9

There are three major types of character variation within and between species that is typically observed in systematic and taxonomic studies. These include:

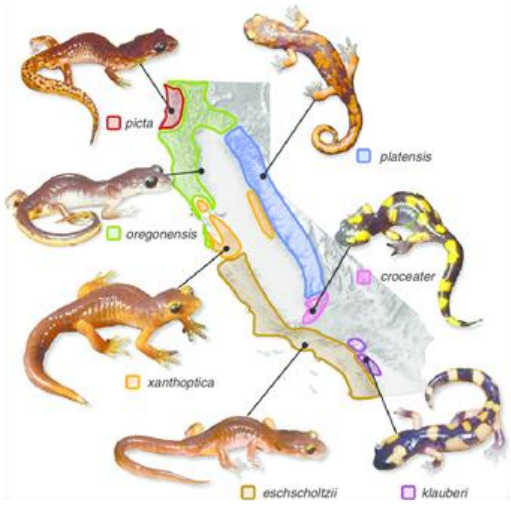
Geographic Variation	Variation in one or more characteristics over space.
Sexual Variation	Variation in one or more traits between or within a sex.
Individual Variation	Variation in one or more characteristics within the lifetime of an individual organism.

1. Geographic Variation

As implied by the name this type of variation occurs over geographic space. This includes, latitudinal, longitudinal, and altitudinal variation of characters.



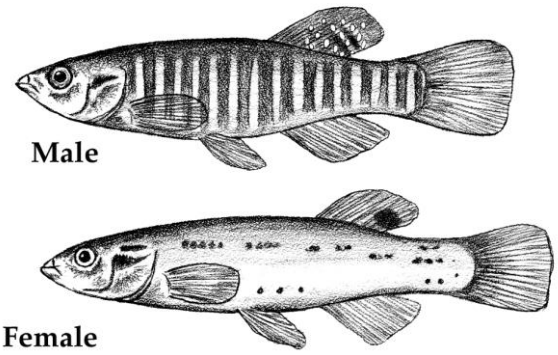
Geographic variation between the variants (subspecies) of buttermilk snake *Lampropeltis triangulum*



Geographic variation among races in the lizard *Ensatina eschscholtzii* ring species in California

2. Sexual Variation

As implied by the name of this type of variation males and females frequently vary from one another for characteristics.

Coloration in Fishes	

3. Individual Variation (Morphological Variation)

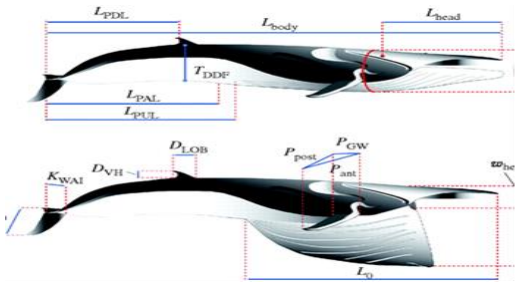
I. Age variations

Common in many groups of organisms to have different looking juveniles or larvae from adults. Many synonyms have resulted from this phenomenon.

For example, Linnaeus described the immature stages of many insects as a different species from adults.

a) Allometric Variation

This type of variation is typically thought of as being under genetic control. **Allometric** growth or variation results when the size of some particular structure or number of structures is unequal relative to other structures or the rest of the body.

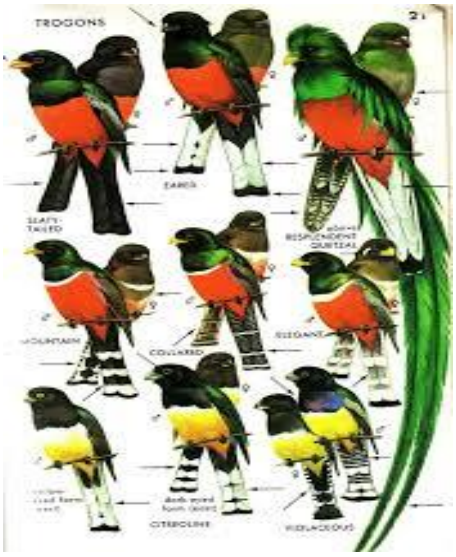


Allometric growth in Skull and buccal cavity of the Rorqual whales

b) Seasonal Variation in

Individuals

In species that survive for more than one year or more than one reproductive season, characteristics may vary depending upon the season. For example, the plumage of birds, antlers of some mammals, and general breeding coloration.



II. Social Variation

In some social insects (bees and wasps, termites) certain castes are developed (reproductive, workers, soldiers). The individuals may be males, females or both.

III. Ecological Variation

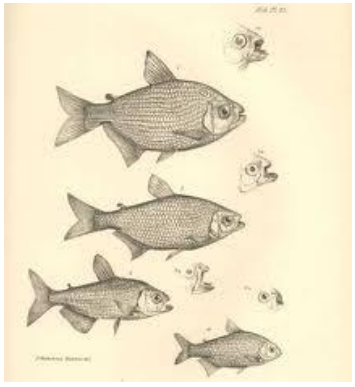
a) Habitat Variation

Populations of a single species may occur in different habitats in the same region and are often visibly different depending upon the habitat that they are found in.

Such as mollusks (snails and mussels). In these species those in the upper parts of rivers where there is cooler water and more flow have different forms from those in lower reaches with higher temperatures and lower flow.

b) Temporary Climatic Conditions

Some species have tremendous phenotypic plasticity and for some traits a different phenotype is produced in years of extreme conditions (drought, cold, warm weather) relative to those from other year classes under normal conditions. Fishes are commonly dwarfed in bad years.



c) Host-Determined Variation

Parasitic species may display different traits dependent upon the host on which they feed. **Cocoons** can vary in color depending upon wasp host. Some wasps may be winged or wingless, depending upon host.

Some hosts may display different characters when parasitized. Color patterns may vary with **fishes** sometimes if they are parasitized (usually this is obvious).

d) Density-Dependent Variation

Crowding can influence morphological variations. This can be a result of reduced food supply or not. Under crowded conditions the phenotypes may vary from those reared under less crowded conditions: This phenomenon is particularly common with locusts.

e) **Neurogenic or Neurohumoral Variation**

Color change in individuals due to regions in environment. Accomplished through the concentration or dispersal of color bearing bodies known as chromatophores. This has been observed in chameleons, some lower vertebrates, crustaceans, cephalopods, and flat fishes.

IV. Traumatic Variation

This type of variation occurs with varying frequency depending on the group. It is usually clear, but in some cases may be indirect and misleading.

a) **Parasite individual variation**

Typical patterns discovered in a host individual will include swelling, distortion, and perhaps mechanical injury.

- With insects parasites can alter head size, wing venation, and other structural features.

- Parasitized fishes may appear pale and soft, have darks spots on the body, have weak fin rays.

b) **Teratological or accidental**

Alterations in development. Usually these are externally induced but can be developmental and may be from hormonal control.

c) **Post-mortem Changes**

Common in some museum specimens that have been fixed or preserved or pinned. Colors are often lost or fade.

Genetic Variation

Lecture 10

In addition to this non-inherited variation, there is much interpopulational variation which is primarily due to differences in genetic constitution. This variation can be more or less arbitrarily divided into two such classes:

I) Sex-Associated Variation

Among the genetically determined variants within a population, there may be some that are sexually associated. They may be sex-linked (expressed in one sex only) or be otherwise associated with one or the other sex.

a) **Primary sex differences -** Those that involve primary sex organs used in reproduction (gonads, genitalia). Where the sexes are otherwise quite similar, these will rarely be a source of taxonomic confusion.

b) **Secondary sex differences -** Many groups display pronounced sexual dimorphism. These differences can be quite prominent. Different sexes have frequently been described as different species until more work has been done on a group.

c) **Alteration of Generations -** In some groups there may be an agamic stage that looks quite different from a reproducing stage. In aphids the parthenogenetic females are wingless whereas the sexual females have wings.

d) **Gynandromorphs and Intersexes-**

Gynandromorphs display male characters on one part of the body and female on the other. Due to unequal somatic distribution of sex chromosomes. Spiders and butterfly.

Intersexes - exhibit a blending of male and female traits. Thought to result from upset in balance of male tendency and female tendency genes.

II. Non-Sex Associated Individual Variation

a) **Continuous Variation -** Most common type of variation due to slight genetic differences which exist between individuals. No two individuals are exactly alike in a population genetically or morphologically.

b) ***Discontinuous Variation*** **-** Differences between individuals in a population are, in general, slight and intergrading. In some species, however, can be grouped into different classes determined by some characters.

e.x. many **bird species** have been proposed to demonstrate this type of polymorphic variation within populations for morphological characteristics.

e.x. some **butterflies** which mimic poisonous species may have more than one morphotype in a population.