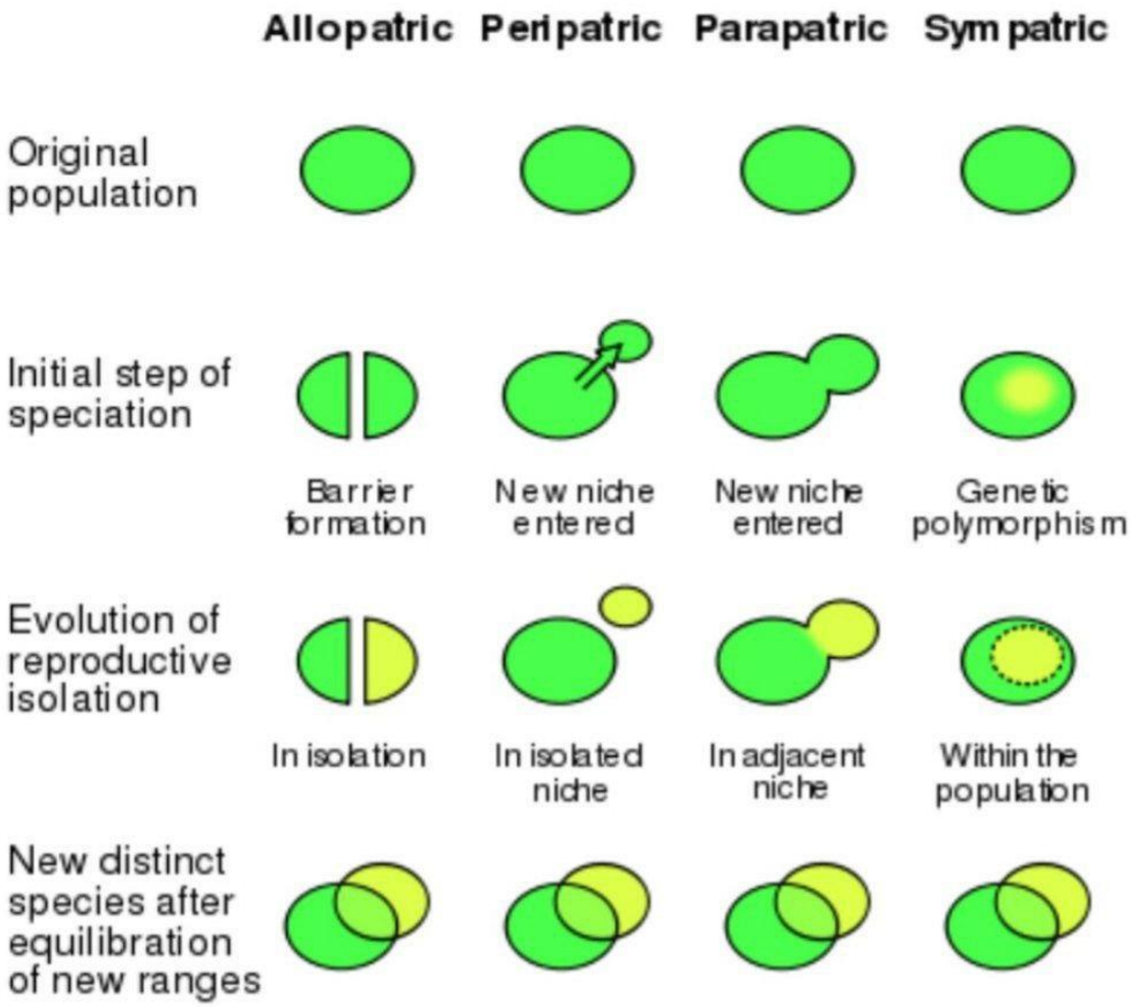
Dimensions of Speciation

- ➢ Speciation is a process within evolution that leads to the formation of new distinct **species** that are reproductively isolated from one another
- ➢ **Anagenesis or phyletic evolution** occurs when evolution acts to create new species ,which are distinct from their ancestors ,along a single lineage ,through gradual changes in physical or genetic traits
- ➢ In this instance,there is no split in the **phylogenetic tree**.converesly **'speciation'** or cladogenesis arises from a splitting event ,where a parent species is split into two distinct species ,often as the result of geographic isolation or another driving force involving the separation of populations
- ➢ The reproductive isolation that is integral to the process of speciation occurs due to reproductive barriers ,which are formed as a consequence of genetic ,behavioural or physical differences arising between the new species
- ➢ These are either **pre-zygotic (pre-mating**)mechanisms, for example ,differences in courtship rituals ,non-compatiable genitalia or gametes,which are unable to fertilize between species
- ➢ Alternatively they are post-zygotic (post -mating),for example **zygote** mortality or the production of sterile off spring
- ➢ Reproductive isolation leads to reinforcement of the distinction between species through **natural selection** and sexual selection .



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❖ **Types of speciation**

➢ **1.Allopatric speciation**

➢ During allopatric speciation,a population splits into two geographically isolated populations (e.g ,habitat fragmentation due to geographical change such as mountain formation)

➢ The isolated populations then undergo **genotypic or phenotypic** divergence as:

➢ (a)they become subjected to dissimilar selective pressures;

➢ (b) they independently undergo genetic drift (variation in the relative frequency of different genotypes in a small population

,owing to the chance disappearance of particular genes as individuals die or do not reproduce);

- (c)different mutations arise in the two populations
- When the populations come back into contact ,they have evolved such that they are reproductively isolated and are no longer capable of exchanging genes
- Allopatric speciation occurs when members of a population become geographically isolated from one another to the extent that genetic exchange ,through mating ,is prevented or interfered with
- This may be a result of geographical changes ,such as the formation of a mountain by a volcano ,island formation ,habitat separation by glaciers and rivers or habitat fragmentation caused by human activity
- Alternatively species members may emigrate,resulting in population separation by dispersal :this is commonly known as vicariance
- The separated population then undergo divergence in genotypic or phenotypic traits as a result of different selective pressures acting upon populations
- This leads natural selection to cause genetic drift as mutations arise within populations
- Over time ,the separate populations may develop morphologically distinct features due to adaptation to their new environment
- The features may become so distinctively different that reproductive isolation occurs ,preventing the inbreeding of populations and thus forming new species
- If the populations become sufficiently different that they are classified as new species ,but not distinct enough for reproductive

isolation to occur the species may come back into contact and mate ,producing hybrids

- The extent of the effect that geographic barriers may have on a population often depends on the dispersal ability of the organism ;for example ,the new formation of a river in a landscape would create an impassable barrier for small terrestrial mammals ,insects and reptiles
- However ,birds and larger mammals would likely disperse across the river with ease
- An elegant example of allopatric speciation ,which first inspired charles darwin to develop the theory of evolution and natural selection ,is the divergent populations of finches inhabiting the galapagos islands and known as **Darwins finches**
- Darwin noticed that each of the galapagos hosted a population of finches which although relatively similar in morphology (compared with other bird species),exhibited slight differences in features such as body size,color and beak length or shape
- He noted that the there were different food sources available for the birds on each of the different islands,and came to the conclusion that the differences in beak shape were an adaptation toward acquiring the particular food source
- **2.Sympatric speciation**
- **Sympatric speciation** is the evolutionary process whereby species are formed from a single ancestral species while inhabiting the same geographic area
- In contrast to allopatric speciation ,the distribution ranges of species which evolve through sympatry may be identical or they may only overlap

- Rather than geographic distance prompting a reduction of **gene flow** between populations ,sympatry occurs when members of one population make use of new **niche**
- This could occur forexample ,if a herbivorous insect begins to feed on a new or novel **plant** source with which it was not ancestrally associated ,or if a new species of plant is introduced to the species geographic range
- As insects generally reproduce or lay eggs within the type of fruit that they were born in ,over time the individuals would specialize in feeding and mating on particular fruits .consequently ,**gene** flow between populations that specialize in different fruits will be reduced ,leading to reproductive isolation of the populations
- It is possible that the populations will also develop morphological differences as they adapt to most effectively exploit the new niche
- Although sympatric speciation does sometime occur,it is uncommon ,especially within large **multicellular** organisms
- **3.Parapatric speciation**
- **Parapatric speciation** is an extremely rare case of speciation that occurs when a population is continuously distributed within a geographic area without any specific barriers to gene flow
- The population does not mate randomly within the population ,but rather individuals mate more commonly with their closet geographic neighbours,resulting in uneven gene flow .
- Non random mating may increase the rate of **dimorphism** within populations,in which varied morphological forms of the same species are displayed
- The result of parapatric speciation is one or more distinct **sub populations** which have small,continous overlaps in their **biogeographic range** and are genotypically dimorphic

- **3.peripatric speciation**
- Peripatric speciation is a form of allopatric speciation that occurs when populations that have become isolated have very few individuals
- Through this process ,the population goes through a genetic bottleneck
- Within the small sub-population ,organisms which are able to survive within the new environment may carry genes that were rare within the main population but that cause a slight variation to behaviour or morphology
- Though repeated matings,the frequency of these,once rare ,genes becomes fixed within the population,leading to an isolated species that is evolutionary distinct from the main population
- **4.Artificial speciation**
- Artificial speciation is the form of speciation that can be achieved by the input of human influence
- By separating populations,and thereby preventing breeding or by intentionally breeding individuals with desired morphological or genotypic traits,humans can create new ,distinct species
- This is also known as **artificial selection ,**most modern domesticated animals and plants have undergone artifical selection
- Although evolution of our modern crops and livestocks has taken thousands of years ,it is possible to visualize the process of artificial selection in species that have short life cycles
- Artificial selection has been demonstrated most effectively in species of fruit fly
- Experiments in which flies are placed into environments which contain different resources or habitats show the changes that occur when the flies adapt to each environment

- After several generations,the flies are removed from the experimental zone and are allowed to cohabitate ,although the populations are unable to mate due to the reproductive isolation process that occurred while in isolation

❖ Species Concept

  - The biological species concept defines a species taxon as a group of organisms that can successfully interbreed and produce fertile offspring
  - According to that concept,a species integrity is maintained by interbreeding within a species as well as by reproductive barriers between organisms in different species .
  - Species concepts originate in taxonomy ,where the species is the basic rank of classification according to the international commission of zoological nomenclature
  - Under the currently accepted biological species concept **(BSC)**,species exist only in sexually reproducing organisms as a consequence of the mechanisms of genetic shuffling and recombination during meiosis and in zygote formation
  - Species do not exist in asexually reproducing organisms except as an artificial classificatory convenience
  - The **BSC** is usually defined as :groups of actually or potentially interbreeding populations in nature which are reproductively isolated from other such groups
  - By reproductive isolation,evolutionists mean that no gene flow exists between different species,not necessarily that members of different species cannot interbreed and produce hybrids
  - Evolutionists actually use the criterion of lack of gene flow between different species ,rather than lack of reproduction

- The distinction between these two definitions is clarified in the classification of intrinsic isolating mechanisms as follows :
- 1.**mechanisms that prevent interspecific crosses** (premating mechanisms)
- (a)potential mates do not meet (seasonal and habitat isolation)
- (b)potential mates meet but do not mate (ethological isolation)
- © copulation attempted but not transfer of sperm takes place(mechanical isolation)
- 2.**Mechanisms that reduce full success of interspecific crosses**(postmating mechanisms)
- (a) sperm transfer takes place but egg is not fertilized (gametic mortality)
- (b) egg is fertilized but zygote dies (zygote mortality)
- (c) zygote produces an F1 hybrid of reduced viability (hybrid inviability)
- (d) F1 hybrid zygote is fully viable but partially or completely sterile,or produces deficient F2 (hybrid sterility)
- All of these intrinsic isolating mechanisms serve to prevent exchange of genetic materials between members of different species taxa and achieve genetic isolation
- Species posses three individual sets of properties that separate them from one another :
- **1.Genetic coherence** :the members of a species form a genetic community which is genetically isolated from other species

- Genetic material from reproduction thus will flow between members of a single species ,but not from one species to another under natural conditions
- **Genetic isolation** is maintained by the possession of intrinsic genetic isolating mechanisms .
- **2.Reproductive coherence**:the members of a species form a breeding community which is reproductively isolated from other species
- Members of one species do not interbreed or attempt to interbreed with members of another species under natural conditions,regardless of the barriers to gene flow between them
- Interbreeding between members of different species would be prevented by particular intrinsic reproductive isolating mechanisms
- **3.Ecological coherence:**
- The members of a species have similar ecological requirements that differ from those of other species
- Competition between sympatric members of different species is thus greatly reduced and separated
- In fully evolved species ,all three sets of properties are developed such that the species are completely genetically isolated ,completely reproductively isolated and largely ecologically separated from other sympatric species .

1.Typological species concept

- Typological species concept defines as species that **"a group of individuals"** that **"a group of individuals that differ from other groups by possessing constant diagnostic characters"**

- Nearly all of the older definitions of the species ,including those of buffon ,lanmark and cuvier refer to the morphological similarities of individuals of the same species
- Typological species concept is also called as **essentialist ,morphological ,phenetic species concept**
- Typology is based on morphology/phenotype
- Still applied in museum research where a single specimen (type specimen)is the basis for defining the species
- In paleontology all you have is morphology :typology is practised and species are defined as morphospecies (eg :snail shells in fosill beds)
- In this concept ,there is a finite number of varieties of living organisms that exist on earth
- These types do not exhibit any relationship with each other
- Such varieties are termed as species
- This inequality is regarded as an unimportant and irrelevant phenomenon
- Aristotle and plato stated this concept in their philosophies
- In the year of 1954 and 1956 ,cain regarded the typological species concept as the morphospecies concept
- As the members of the species or a taxon can be identified by their essential characteristics ,a group of scientists refer to this as essentialist species concept
- Morophospecies concept states that the species can be differentiated from other species by their physical features and can be identified by their morphological attributes .This is called the morphological species concept .

2.Nominalistic species concept

- The nominalistic species concept is the concept of occam and his followers ,of the belief that nature only produces individuals
- Species are the creation of man
- In nature they lack definite existence
- These concept do not have any scientific basis
- It believes that the species have been invented to be referred to big numbers of individuals jointly
- During the 18th century in france ,this concept was in demand and even now is used by some botanists

3.Biological species concept

- In the middle of the 18th century ,a fresh concept called the biological species concept appeared
- This concept was acknowledged in the later half of the nineteenth-centuary once Darwin's **"origin of species "** was published (in 1859)
- This is also known as **newer species concept**
- K .jordan was the first to formulate this concept in 1905
- Later in 1940 ,mayr supported this concept
- As per this concept ,**"a species is a group of interbreeding natural population that is reproductively isolated from such groups "**
- Mayr described that the members of a species exhibit these attributes :
- **1.Reproductive community** :For the purpose of reproduction the individuals of a species recognize one another as potential mates

- **2.Ecological unit** : The species members differ from each other due to many attributes ,but all the members cooperatively form a unit
- They interact with other species as a unit in any environment
- **3.Genetical unit** :species comprises a large ,inter-communicating gene pool,although the individual is simply a non -permanent vessel comprising a small part of the contents of the gene pool for a shorter duration
- **4.Evolutionary species concept**
- The flaws of the biological species concept had led the palaeontologists to formulate the evolutionary species concept
- 1.Simpson (in 1961)had defined it as “an evolutionary species is a lineage (an ancestral -descendant sequence of populations) evolving separately from others and with its own unitary evolutionary role and tendencies
- 2.wiley (in 1978)had provided a revise definition of the evolutionary species concept .He stated that “an evolutionary species are a single lineage of ancestral -descendant population which draws its identity from other such lineages and has its own evolutionary tendencies and historical fate “
- 3.mayr has criticized the evolutionary species definition saying that it is the definition of a phyletic lineage ,but not of the species
- The evolutionary species concept ignores the core of the species problem and thus ,mayr did not accept the evolutionary species concept ignores the core of the species problem and thus,mayr did not accept the evolutionary species concept and he strongly advocated for the biological

species concept in spite of certain difficulties in its application

Subspecies and other infra-specific categories

Subspecies :

- Subspecies is actually a category below species
- Linnaeus used the term “subspecies” when he classified subgroups of man
- He recognised four subgroups such as
- **(i)the american indians (homo sapiens americanus**
- **(ii)the europeans (homo sapiens americanus**
- ,**(iii)the orientals (homo sapiens asiaticus)and the african negroes (homo sapiens afers)**
- Early taxonomists applied the term **“variety”** indiscriminately for any variation in the population of a species
- In the 19th century the term subspecies replaced **“variety”**and the term **“variety”** is obsolete today
- When a population of a species splits up by natural barriers such as mountains,islands ,climate ,etc
- Each isolated group may evolve different characteristic features so as to become recognizable as a separate geographical race or subspecies
- The scientific name of the race (sub species) of indian lion is panthera leo persica ,and the name of the african lion(race) is panthera leo leo
- The distinguishing features of india race are-
- (i)scantier mane than that of the african race
- (ii) a longer tassel of hair at the tip of the tail than that of the african race

- (iii)a well -pronounced tuft of hairs on the elbow joints and (iv)the abdomen bears a fuller fringe of hairs
- Two subspecies (races)of the same species can interbreed if they meet and professional taxonomists can only recognise the differentiating features of the subspecies of a species
- If species which contain two or more than two subspecies,are called polytypic species and the species which is without subspecies is called **monotypic species**
- With the establishment of polytypic concept it is well accepted that some species are distributed in different geographical areas and form different local populations
- It is widely accepted that genotypic variation within allopatric species occurs
- It is widely accepted that these populations become different from each other in morphology ,biochemical or genotypic variations that help to mark a taxonomic level sufficient to designate them as subspecies

Types of species

i.Allopatric species :

- The two or more related species that have separate geographical ranges are called allopatric species
- Examples of such species are **indian lion (panthera leo persica) and african lion(panthera leo leo)**

ii.sympatric species :

- Two or more species are said to be sympatric when their geographical distributions overlap,though they may segregate into different ecological niche
- Examples of this type are the **fig frog (rana grylio)and the gopher frog (R.aerolata)**

- ➢ The former is extremely aquatic ,while the latter species is restricted to the margins of swampy areas

iii.parapatric species

- ➢ These are te species which have the geographical ranges with a very narrow region of overlap
- ➢ Example of this lap

iv.sibling species :

- ➢ Two or more than two closely related species which are morphologically alike but behaviourally or reproductively isolated from each other
- ➢ **Examples are Drosophila persimilis and D .pseudoobscura**
- ➢ The sibling species can interbreed and are incapable of producing fertile hybrids

(v)cryptic species

- ➢ The species which are alike on the basis of observed features but are genetically and sexually they are different are cryptic species
- ➢ There is a confusion between the terms sibling species and cryptic species
- ➢ The cryptic species are incapable of interbreeding

(vi)Monotypic species

- ➢ When a genus includes a single species but does not include any subspecies example vampyroteuthis ,a vampire squid which is a single monotypic genus and also contains a single species ,V.infernalis(monotypic species)

(vii)polytypic species

- ➢ When a species contains two or more subspecies ,it is called polytypic species

- **Examples are tiger,panthera tigris which has several subspecies such as**
- **(i) indian tiger ,panthera tigris tigris**
- **(ii)the chinese tiger,P .t amoyensis,**
- **(iii)the siberian tiger, P.t altaica**
- **(iv) the javan tiger ,P.t sondaica ,etc**

(viii)Endemic species :

- The species which are found in a particular region called endemic species
- Usually the species of oceanic islands which are found in a limited geographic area are called endemic species
- The darwinian finches are the endemic species of galapagos islands

(ix)Agamo species

- Species are those which consist of uniparental organisms
- They may produce gametes but fertilization does not take place
- They reproduce by obligatory parthenogenesis
- In case of bees,wasps,rotifers the haploid eggs develop into haploid individuals and the haploid eggs are not fertilized by sperms

The species category

- During this process of sexual reproduction recombination of genetic materials takes place between parental individuals which leads to new combinations of genes in the progeny
- However there are many examples which do not come under the biological species category such as hermaphroditism,parthenogenesis ,gynogenesis and vegetative reproduction which show uniparental reproduction

- ➢ There are numerous examples of such uniparental reproduction in invertebrates and vertebrates
- ➢ Mayr has given a new terminology to such uniparental lineages
- ➢ Most workers have assumed that the species category is the same as the species concept ,and hence that the **biological species concept (BSC)**is the species category
- ➢ This assumption is invalid because the species category must apply to all organisms ,including asexual ones,and the biological species concept applies only to sexually reproducing organisms
- ➢ A broder definition of the species category is needed ,concordant with the BSC
- ➢ Defining the species category for all organisms is awkward ,but can be summarized as:the fundamental level in the linnaean hierarchy for describing the diversity of biological organisms that is based on the biological species concept for sexually reproducing organisms or on the equivalent of the ecological unit of biological species for groups of asexual organisms
- ➢ Survey of taxonomic literature shows that there are a large number of species categories which have been suggested by naturalists,taxonomists and evolutionary biologists from time to time
- ➢ **Agamo species :** Agamo species are those which consist of uniparental organisms.
- ➢ They may produce gametes but fertilization does not take place
- ➢ They reproduce by obligatory parthenogenesis

- In case of bees ,wasps,rotifers the haploid eggs develop into haploid individuals
- **Cladistic species :**in the cladistic species concept , a species is a lineage of populations between two phylogenetic branch points(between speciation and extinction events)
- The cladistic concept recognizes species by branch point ,independently of how much change occurs between them
- Because of this ,the two patterns in the figure are cladistically identical :in both there are three species and species 1 gives birth to two new species at the branch point
- On the non temporal species concepts,such as the biological ,recognition and ecological species concepts .
- (a) the ancestral species does not change phonetically (or reproductively or ecologically) after a daughter species evolves .
- Species 1 and 2 are phenetically identical but cladistically different.
- (b) The ancestral species changes after the evolution of the new species; species 1 and 2 are both phenetically and cladistically different.
- (c) Phenetic change in one lineage with no speciation.
- **Cohesion Species:** According to the cohesion species concept (Templeton 1989) a species is the largest delimited population that has internal mechanism, and maintains mutual phenotype cohesion among its members.
- Phenotype cohesion of a population occurs when mutual similarity observed among the members of the population even when the average appearance of individuals in the population changes in time

➢ **Composite Species**: All organisms belonging to an internodon and their descendants until a subsequent internodon (internodon is a set of organisms whose parent-child relations are not split).

➢ E.g. the composite species concept defines a species is a lineage between two temporal occurrence of new characters.

➢ **Ecological Species:** A lineage which occupies an adaptive zone, minimally different from that of any other lineage in its range and which evolves separately from all lineages outside its range

➢ **Evolutionary Species**: A lineage (ancestraldescendent sequence of populations) evolving separately from others and with its own unitary evolutionary role and tendencies.

➢ Geological concordance (similarity): Population subdivisions concordantly identified by multiple independent genetic units constitute the population units worthy of recognition as phylogenetic taxa.

➢ **Genetic Species:**

➢ Group of organisms that may inherit characters from each other, common gene pool, reproductive community that forms a genetic unit.

➢ **Genotypic cluster definition:** Clusters of monotypic or polytypic biological entities, identified using morphology or genetics that have few or no intermediates when in contact.

➢ **Hennigian species:** A tokogenetic community that arises when a stem species is dissolved into two new species and ends when it goes extinct or speciates.

➢ **Morphological species**: Similar to typological species concept of Linnaeus; species are the smallest groups that are consistently and persistently distinct and distinguishable by ordinary means.

- **Nominalistic species**: Only individuals exist and nothing more. Species have no actual existence in nature.
- **Nothospecies**: Species formed from the hybridization of two distinct parental species.
- **Phenetic species**: A class of organisms that share most of a set of characters. A family resemblance concept is possession of most characters which required for inclusion in a species but not all.
- **Phylogenetic species**: A species is the smallest diagnosable cluster of individual organisms within which there is a parental pattern of ancestry and descent.
- The concept of a species as an irreducible group whose members are descended from a common ancestor and who all possess a combination of certain defining, or derived, traits.
- Recognition species: The recognition species concept is a concept of species, according to which a species is a set of organisms that recognize one another as potential mates: they have a shared mate recognition system (behavioural, physiological or morphological).
- **Biological Species**: Population of sexually reproducing organisms, interbreeding natural populations isolated from other such groups, depending upon reproductive isolating mechanisms

Biological classification

- Biological Classification: Biological classification is a critical component of the taxonomic process. Biological classification uses taxonomic ranks, in order from most inclusive to least inclusive: Domain, Kingdom, Phylum, Class, Order, Family, Genus, and Species.

- **History of Classification: The Greeks and Romans**
- **Aristotle (384–322 BC)**: In Western scientific taxonomy, the Greek philosopher Aristotle was the first to classify all living things, and some of his groups are still used today, like the vertebrates and invertebrates, which he called animals with blood and without blood. He further divided the animals with blood into egg-bearing and live-bearing, and formed groups within the animals without blood that we recognize today, such as insects, crustacea and testacea (molluscs).
- **Theophrastus (370–285 BC)**: Theophrastus was a student of Aristotle and Plato. He wrote a classification of all known plants, De Historia Plantarum, which contained 480 species. His classification was based on growth form. Carolus Linnaeus accepted many of his generic names. There are two surviving botanical works by Theophrastus – The Enquiry into Plants and On the Causes of Plant Phenomena. In his Causes Theophrastus looks at plant physiology and considers different methods of cultivation. In the Enquiry Theophrastus turns his attention in a more taxonomical direction. In this work he was one of the first authors to attempt to classify plants into different types, dividing them into 'trees', 'shrubs', 'undershrubs' and 'plants'. These two books give Theophrastus a good claim to the title of 'the grandfather of botany'.
- **Dioscorides (40–90 AD)**: Dioscorides was a Greek physician and a medic in Roman Army, who travelled widely in the Roman and Greek world to gather knowledge about medicinal plants and wrote De Materia Medica, which

contained around 600 species. De Materia Medica was used in medicine until the 16th century, and was copied several times. One famous copy from the 6th century is kept in Vienna. The classification in his work is based on the medicinal properties of the species.

- **Plinius (23–79 AD)**: Plinius was involved in the Roman army and wrote many books, but the only one that has survived is his 'Naturalis Historia', a work of 160 volumes, in which he described several plants and gave them Latin names. Many of these names we still recognize, like Populus alba and Populus nigra, and since Latin was later kept for botanical science, we may call him the Father of Botanical Latin.
- Early taxonomists Until the end of the 16th century, the taxonomic works of ancient Greeks were not replaced. One of the reasons for this was the development of optic lenses, which made it possible to study details in the different species. Collection of specimens became part of the growing sciences, and the emphasis turned from medical aspects to taxonomic aspects.
- **Caesalpino (1519–1603)**: Caesalpino in Italy, who is sometimes called "the first taxonomist". In 1583 he wrote De Plantis, a work that contained 1500 species. His classification was based on growth habit together with fruit and seed form, as was that of Theophrastus.
- **Bauhin (1541–1631) and Bauhin (1560–1624)** Two Swiss brothers (Bauhin) wrote the work 'Pinax Theatri Botanici' in 1623. The work is a listing of 6000 species. The Bauhin brothers included synonymes, which was a great necessity of the time. The Bauhin brothers recognized genera and species

as major taxonomic levels. Linnaeus honored the Bauhin brothers Gaspard and Jean in the genus name Bauhinia.

- **John Ray (1627–1705):**John Ray, the English naturalist wrote several important works through his life. His most important contribution was the establishment of species as the ultimate unit of taxonomy. In 1682 he published **'Methodus Plantarum Nova'**, which contained around 18000 plant species, a result of a relatively narrow species concept.
- He published important works on botany, zoology, and natural theology. His classification of plants in his Historia Plantarum, was an important step towards modern taxonomy. Ray rejected the system of dichotomous division by which species were classified according to a pre-conceived, either/or type system, and instead classified plants according to similarities and differences that emerged from observation. He was the first to give a biological definition of the term species.
- In his 1686 History of Plants: "No surer criterion for determining species has occurred to me than the distinguishing features that perpetuate themselves in propagation from seed. Thus, no matter what variations occur in the individuals or the species, if they spring from the seed of one and the same plant, they are accidental variations and not such as to distinguish a species. Animals likewise that differ specifically preserve their distinct species permanently; one species never springs from the seed of another nor vice versa".
- **Joseph Pitton de Tournefort (1656–1708)**: Joseph Pitton de Tournefort from France constructed a botanical classification

that came to rule in botanical taxonomy until the time of Carolus Linnaeus. In 1700, he published Institutiones Rei Herbariae, in which around 9000 species were listed in 698 genera. He put primary emphasis on the classification of genera, and many genera were accepted by Linnaeus and still in use today. Tournefort's plant classification was exclusively based on floral characters.

- **Linnaean era Starting point of modern taxonomy**
- For nomenclatural reasons two works of Carolus Linnaeus (1707–1778) are regarded as the starting points of modern botanical and zoological taxonomy: the global flora ‘Species Plantarum’ , published in 1753 and the tenth edition of ‘Systema Naturae’ in 1758 including global fauna. Linnaeus introduced a binary form of species names called "trivial names" for both plants and animals in these books. The trivial names were intended for fieldwork and education, and not to replace the earlier phrase names.
- Linnaeus counted 8,530 species of flowering plants in 1753. The simplicity of Linnaeus' trivial names revolutionized nomenclature, and soon binary nomenclature.
- Linnaeus published several books that would transform botany and zoology into sciences of their own. Until then, these two disciplines had merely been a fringe of practical medicine. With the works of Linnaeus, botany and zoology transformed into a Scientia, a science surrounded by philosophy, order and systems.
- **Post-Linnaean taxonomy Natural system emerging in France**

- One of the few countries in which the Linnaean systematics did not make success was France. Four French scientists emerged that made an impact on future biological sciences.
- **Georges-Luise Leclerc de Buffon (1707– 1788)** was a strong critic to Linnaeus work, and he found it wrong to impose an artificial order on the disorderly natural world. His approach was for an evolutionary theory.
- **Michel Adanson (1727–1806)** wrote Familles des Plantes already in 1763. He launched the idea 13 that in classification one should not put greater emphasis on some characters than on others. He critized Linnaeus' works, and considered Tournefort's classification far superior
- **Antoine Laurent de Jussieu (1748–1836)** changed the system of plants with his Genera Plantarum in 1789, in which he launched a natural system based on many characters that came to be a foundation of modern classification. He divided the plants into acotyledons and monocotyledons.
- **Jean-Baptiste de Lamarck (1744–1829)** launched an evolutionary theory including inheritance of acquired characters, named the **"Lamarckism".**
- The French scientific work, the development of anatomy and physiology and improved optical instruments made way for a new era of taxonomy, which was trying to cope with an increasing number of species in a rapidly expanding flora and fauna of the world.
- **Theories of biological classification: hierarchy of categories.**
- Biological classification is defined as a process of giving hierarchy of categories by scientific procedure based on

features of organisms and arranging them into different 14 groups.

- The very purpose is to establish the relationship among different organisms and to know about their evolution.
- Further, to study and include each organism along with its identification and habitat.
- **Artificial Classification**
- Artificial Classification uses form, shape as prominent features for grouping organisms.
- Animals were also classified on basis of red blood cells, habitat such as land, water or air.
- They were also classified on their basis to fly or not to fly. This system is relatively easy to follow.
- Artificial System of Classification has many disadvantages. It relies just on form and shape of organisms and does not take into account other features.
- So it is difficult to understand the evolution of organism. It leads to misunderstanding of any relationship among organisms.
- The different types of organisms are arranged in same groups like birds, insects, bats they fly and they are grouped in same criteria. The form and shape of organism is not permanent and it changes with time.
- **Natural System of Classification**
- It takes into account multiple features such as anatomy, physiology, pathology, biochemistry, reproduction and cytology to compare the 15 organisms and establish a relationship between them.

- It overshadows all the disadvantages of artificial system of classification. It helps to understand the evolution of organism by knowing the relationship between them.
- The features undertaken in this classification are constant. In this bird, reptiles and mammals are placed in the different groups based on the multiple features.
- For example humans have 4 chambered hearts, warm blooded nature and denucleated erythrocytes. Fishes have 2 chambered hearts, cold blooded and respire through gills.
- **Phylogenetic System of Classification**
- It is defined as a relationship based on the evolutionary aspect of organisms. It is based on Darwin’s Concept of Natural Selection. It tells us about the original relationship among organisms. The foremost phylogenetic system of classification was given by Engler and Prantl. They divide the plants into primitive and modern types.
- **Hierarchy Categories**
- Taxonomic Hierarchy Categories were also introduced by Linnaeus. They are also known as **Linnaean hierarchy**. It is defined as sequence of categories in a decreasing or increasing order from kingdom to species and vice versa. Kingdom is the 16 highest rank followed by phylum, class, order, family, genus and species. Species is the lowest rank in the Hierarchy.
- The hierarchy has two categories which are obligate and intermediate. Obligate means they are followed strictly and range from kingdom to species as said above. Intermediate are not followed strictly and they are added in obligate list

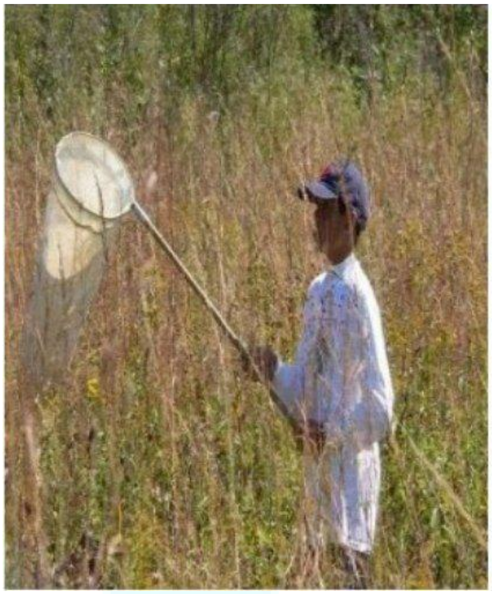
such as subdivision, super family, super class, suborder, subspecies etc.

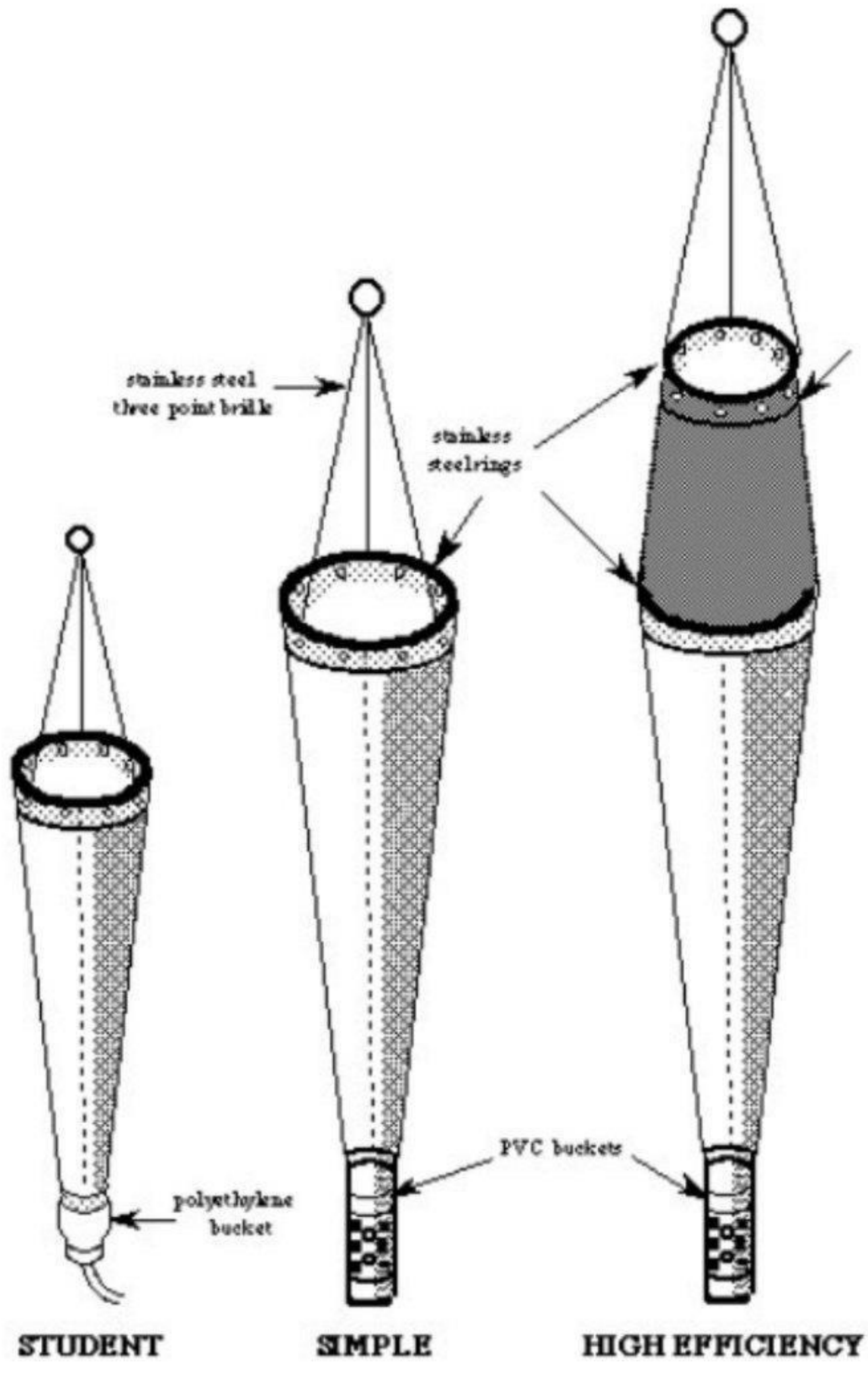
- **Species**: Group of population which is similar in form, shape and reproductive features so that fertile sibling can be produced. Some siblings can be sterile when a hybrid is produced. A hybrid can be product of female horse & male donkey (Mule). Or male tiger & female lion known as Tigon. Sexual reproduction is present in eukaryotes. Species is followed by subspecies, varieties and races. These categories are inferior as compared to species.
- **Genus**: It is defined as group of similar species. But it is not mandatory to have many species. Some genera have only one species known as **Monotypic.** If there are more than one species it is known as **polytypic.** For example lion, tiger are 17 quite similar species placed under the genus Panthera.
- **Family:** It is defined as collection of similar genera. For example, cats and leopard are included in the family Felidae.
- **Order**: One or more than one similar families constitute order. Family felidae are included in the order Carnivora.
- **Class**: One or more than one order makes a class. Class Mammalia includes all mammals which are bats, rodents, kangaroos, whales, apes and man.
- **Phylum**: It is a term used for animals while its synonym **'Division'** is used for plants. It is a collection of similar classes. Phylum Chordata of animals has class Mammalia along with birds, reptiles and amphibians.
- **Kingdom**: The top most taxonomic category. Example all animals are included in Kingdom animalia.

Taxonomic procedures:

- Biological collections are typically preserved plant or animal specimens along with specimen documentation such as labels and notations.
- Types of collection Most biological collections are either dry collections or wet collections.
- They also may include collections preserved at low temperatures or microscopy collections.
- **Dry collections:**
- Dry collections consist of those specimens that are preserved in a dry state.
- Two factors influence decisions about preserving specimens this way: Rigidity - Some specimens can be preserved naturally (starfish) or artificially with sufficient rigidity to accommodate normal handling. Such specimens often are suitable for dry preservation.
- **Specific characteristics -**
- Drying may provide the best available means to preserve natural colours (for example, butterflies) or distinguishing features (such as skeletal parts or surface details). Such specimens in a dry state may have great potential for interpretation and research.
- **Wet collections :**
- Wet collections are specimens kept in a liquid preservative to prevent their deterioration.
- Certain biological specimens are preserved in a wet form due to: Convenience - an intent to preserve body form and soft parts for a variety of uses.

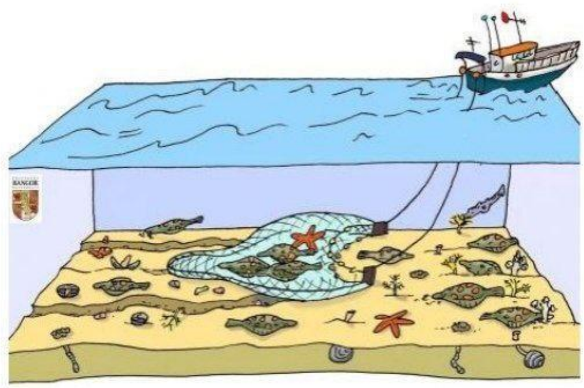
- When colour preservation is not critical and dry preservation sacrifices qualities needed for other intended uses, fluid preservation is beneficial.
- **Biological low-temperature collections**
- Specimens are maintained at low temperatures to preserve:
- soft parts for various biochemical analyses
- Some algae, Protozoa (especially parasitic strains), Viruses, Bacteria, Bacteriophages, Plasmids
- Animal tissues (dissected organs, muscles),Cell lines
- Blood and blood components (serum, plasma etc)
- Semen, Venom
- Other samples (isolated proteins and nucleic acids, cell suspensions)
- **Biological microscopy collections:**
- Scientists preserve certain specimens as microscope preparations to preserve whole or partial organisms for:
- various kinds of microscopic examination
- Biochemical analyses, extraction of DNA.
- Histology
- Karyology
- Scales
- hair
- **Value of biological collections**
- Most biological collections are highly valuable for the following reasons. Museums are only place where extinct species are preserved.
- specimens of special historical value.
- specimens rarely found in any collections.

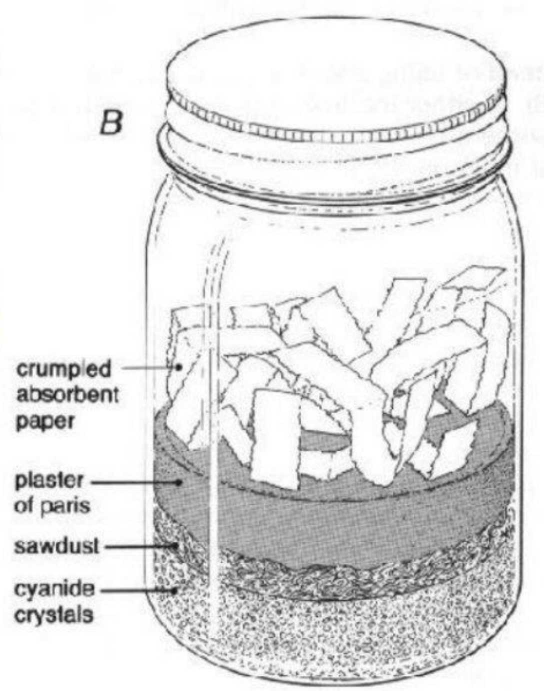
- Many areas in world are geographically inaccessible. Material from such area are invaluable & are preserved at all costs.
- 
- **Methods of collections:**
- Mist net collection
- Collection of insects light trap.
- Sweeping net.
- Aquatic insects and other arthropods are collected by using dip-nets & plankton nets.


stainless steel
three point bridle
stainless
steel rings
PVC buckets
polyethylene
bucket
STUDENT
SIMPLE
HIGH EFFICIENCY

➢

➢ **Killing Jar**:





➢

➢ **Spreading tray**:

➢ **Carcasses or remnants:** Carcasses or remnants of dead animals, scat and other biological material found in the wild may be very useful for obtaining data about wild populations.

➢ It can no longer be regarded as ethical to kill threatened wild animals for obtaining skins for collections; carcasses of animals found or confiscated from poachers may serve as a better source of material for reference collections.

➢ Skeletal material, skulls, owl pellets may be an interesting source of bones, hair samples; reference hair collection of sympatric species,Fur and hair After removing the skin from the animal, as much flesh as possible should be removed, but without damaging the skin with hair roots.

- Then 55 the skin can be dried in the sun, or if necessary, high over a fire, either hung on a line or stretched between pegs.
- Salting the skin will speed the drying process and temporarily preserve the skin.
- Areas that still have flesh or fat should be salted thoroughly. Powdered borax can be put on the skin to further preserve it.
- When the skin is nearly dry, it should be folded with the hairy sides together.
- 
- **Preservatives and Fixatives Formalin**:
- Its use will not harm the specimen, and is a better preservative than alcohol.
- It penetrates more rapidly and internal organs remain in better condition.

- Commercial formalin (40%) should be diluted with ten volumes of water to a 4% solution.
- 2% formalin with seawater is an excellent quick preservative for small marine specimens.
- **Alcohol:**
- It is used in zoology, generally 95% ethyl alcohol (white spirits) which may be diluted with distilled water to strengths of 70% and 80%.
- At least 70% is required for safe storage of material.
- Alcohol is a valuable preservative for **crustacea, polychaeta and echinoderms** with bristles or hardparts.
- A teaspoonful of glycerine mixed with alcohol helps to preserve natural colours and to keep integuments flexible.
- Alcohol in jars containing preserved specimens should be changed at intervals once or twice a year and evaporation should be guarded against.
- One of the most important fixatives for the general collector of invertebrates is Bouin's fluid, which is excellent for general structural and histological work, and for preservation of animals for dissection
- Fixation time is at least 12 hours for a specimen of l cc. bulk, correspondingly longer for larger material.
- There is not much danger of over-fixing. Afterwards specimens should be washed in 70% alcohol, to remove excess picric acid, and stored in 70-80% alcohol.
- Formula for Bouin's: 75 parts saturated aqueous picric acid; 25 parts 40% formalin; 5 parts glacial acetic acid.
- **Preservation by cooling or freezing:**

- Removal of the skin with insulating fur before cooling or freezing may help to cool the carcass down more quickly. Freezing is not recommended if histological examination is planned.
- **Storage of the Collection**
- As the collection grows, the greatest need will be for an orderly storage system, with facilities for 57 quick reference to any container, to field notes and any other information.
- It may be desired to have the collection visible for permanent display, and with dried material a set of flat cabinet drawers is best for storage
- . Most invertebrates will be kept in bottles, and sets of tubes or jars can be kept together in a small space by placing them in deep cardboard boxes, conspicuously labeled with serial box numbers.
- **Containers**
- Uniform sizes of tubes and jars will be preferred.
- Jars should be wide-mouthed, and of clear glass, thick enough to withstand knocks.
- Non Corrodible tops are preferable to metal caps.
- Alternatively, wide-mouthed bottles may be stoppered with firm, good quality corks.
- Preserving jars with rubber washer lids are ideal for larger specimens. Specimens as a rule may be put straight into the container.
- **Labelling**
- The bulk of the information about a specimen should be entered on the record sheet.

- Labels attached to the container should include the habitat, locality and date, and the collector's initial.
- Alternatively specimen labels can be placed in the preservative within the container.
- They should then be written on a stiff, non-absorbent white card, either in pencil or in indian ink.
- Ink labels should be allowed to dry, then steeped for a few minutes in a 3% solution of acetic acid, which effectively sets the ink and prevents “running” when placed in preservative.
- **Recording of data**
- Geographic locality
- Date
- Stage (adult male, female or immature form)
- Altitude or depth.
- Host
- Name of collector and other relevant information
- **Identification**:
- Identification of collections may be carried out based on published references and museum specimens.
- ## Curating of Collections
- Every taxonomist has to take the responsibility of curating collections. This requires a great deal of expertise, knowledge and clear understanding of the function of different collections
- **Preparation of Material**
- There are certain materials which are ready for study as soon as collected from the field e.g., bird and mammal skins.

- There are certain insects which should never be placed in alcohol or any other liquid preservative, whereas others are useless when dried.
- Most insects are pinned, and the wings are spread if they are taxonomically important as in butterflies, moths and some grasshoppers.
- Certain invertebrates are to be preserved in alcohol or formalin before their study.
- **Housing**
- Research collections should be housed in fireproof and dustproof buildings.
- Most museums keep their collections in air conditioned buildings.
- Rapid changes in temperature and humidity are harmful to museum cases and specimens.
- Storage cases should be built to be insect proof. Photographs and films should be stored in air-conditioned rooms.
- Improperly preserved or inadequately labeled specimens should be eliminated by the curator. The most efficient method for the elimination of useless material is to ask specialists to pull out such specimens while scrutinizing the material during a revision.
- **Exchange of Material**
- The selecting of material for exchanges and keeping its record is time consuming, so the exchanges are not as popular as they used to be.
- o A specialist doing a monograph on a certain genus or family can always borrow material from other institutions and return it after completing his work. Exchanges are

sometimes necessary to build up complete identification collections.

- **Taxonomic keys, different types of keys, their merits and demerits**
- A key is a device, which is constructed properly and used to the identification of unknown species.
- It is a series of contrasting statements required to make comparison and identification.
- The key consists of a series of choices, based on observed features of the specimen.
- It provides a choice between two contradictory statements resulting in the acceptance of one and the rejection of the other
- At each point in the decision process, multiple alternatives are offered, each leading to a result or a further choice.
- The alternatives are commonly called "leads", the set of leads at a given point a **"couplet"**. If the entire key consists of exactly two choices at each branching point, the key is called dichotomous, otherwise it is described as **polytomous or poly clave.**
- **Constructive features of taxonomic keys:**
- 1) Constant characteristics rather than variable ones should be used.
- 2) Proper measurements rather than terms like **"large"** and **"small"** should be used.
- 3) Characteristics that are generally available to the user of the key rather than seasonal characteristics or those seen only in the field should be used.

- 4) A positive choice should be made. The term “is” instead of “is not” should be used
- 5) If possible one should start both choices of a pair with the same word.
- 6) If possible, different pairs of choices should be started with different words.
- 7) The descriptive terms should be preceded with the name of the part to which they apply.
- **Types of Taxonomic Keys**
- There are basically two types of keys:
- A) Dichotomous and B) Poly clave (Multiple Access or Synoptic).
- **A) Dichotomous Keys:**
- This is one of the most frequent keys, which are the most common, probably first published by Jean Baptiste-Lamarck in 1778.
- Keys in which the choices allow only two alternative couplets are known as dichotomous keys.
- In constructing a key, contrasting characters are chosen that divide the full set of possible species into smaller and smaller groups i.e. the statements typically begin with broad characteristics and become narrower as more choices are required.
- Each time a choice is made, a number of species are eliminated from consideration and the range of possible species to which the unknown specimen may belong is narrowed.

- Eventually, after sufficient choices have been made, their range reduces to a single species and the identity of the unknown species is revealed.
- Couplets can be organized in several forms. The couplets can be presented using numbers (numeric) or using letters (alphabetical). The couplets can be presented together or grouped by relationships
- **Types of Dichotomous Keys:**
- There are two types of dichotomous keys.
- They differ in the method by which the couplets are organized and how the user is directed to successive choices.
- **i) Indented Keys** (also called yoked): In indented keys, the choices (leads) of the couplet possess an equal distance from the left margin.
- **ii) 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.
- This key has exactly the same choices as the first example. The choices are separated, but it is easy to see the relationships. While this key might be more difficult to construct, it gives more information to the user.
- **Advantages of dichotomous keys**:
- a. Similar specimens are grouped together;
- b. It is harder to get lost your place;
- c. They are faster to use;
- d. It is easier to retrace your steps if you make a "wrong turn".
- **Disadvantages of dichotomous keys**:

- A key may be difficult to use at times because:
- The key may not include all potential variations in the species
- The key may rely on features not present in that season;
- The key may not include "all" species of interest;
- One may misinterpret a feature or make a mistake.
- **B. Poly clave keys**:
- Poly clave keys are tools used to help identify unknown objects or species. The keys are generated using interactive computer programs. Polyclave keys use a process of elimination.
- The user is presented with a series of choices that describe features of the species they wish to identify. The user then checks off a list of character states present in the organism they wish to study.
- The program looks to match those character states with all the species they can possibly match. If a species does not have that character state it is eliminated from the list. The more character states listed the more species that are eliminated.
- This allows the rapid elimination of large numbers of species that the specimen cannot be. The process continues until only one species remains.
- **Advantages of Poly clave keys**
- 1) They are easy to use.
- 2) They allow multi-entry i.e. the user can start anywhere. This is a significant advantage because the user can rely on

characters that are most easy to observe, rather than having to deal with characters that may not be present in the specimen or are poorly developed.

- 3) They are order-free i.e. the user can work in any direction with any character.
- 4) They are faster.
- 5) They are easily computerized. In fact, these keys are most commonly used in this form. Paper versions are typically large and unwieldy because each character needs to list all possible taxa.
- **Disadvantages**:
- It is based on specimens and their availability.
- They have generally been written only for a limited number of taxonomic groups.
- **Polyclave Key**:
- Example - Pollination Type Pollination is the process of transferring pollen from one flower to another. Since plants can't move, they utilize vectors such as wind, water and animals to accomplish this process for them.
- Flowers are specialized by shape, color, odor, nectar reward in order to maximize the chance that a certain vector will accomplish pollination.
- These 69 flower adaptations are collectively known as pollination syndromes. Plants differ in the degree of their specialization for a particular pollination system.
- For example, many orchids are pollinated by only a single type of bee. Other flowers are not as specialized and may be pollinated by a variety of bees or perhaps beetles.

- In other cases, insects may visit flowers without actually transferring pollen. These factors make it difficult to determine with absolute certainty the pollination system by the polyclave key.
- **International code of Zoological Nomenclature (ICZN): Operative principles, interpretation and application of important rules: Formation of Scientific names of various Taxa**
- One of the primary responsibilities of systematic biology is the development of our biological nomenclature and classifications
- Nomenclature is not an end to systematics and taxonomy but is a necessity in organizing information about biodiversity.
- Nomenclature functions to provide labels (names) for all taxa at all levels in the hierarchy of life.
- Biological nomenclature derives from the binomial nomenclature that was originally codified in the works of Linnaeus, Species Plantarum (1753) and Systema Naturae, 10th Edition (1758).
- These publications are the decided starting points for the modern biological nomenclature in most groups of plants and animals.
- Taxa at the level of species are named with binomials, consisting of generic and specific names that together equal the species name.
- Taxa above the level of species are Supraspecific Taxa and are Uninominals
- Taxa below the level of species are **Subspecies** or **Trinominals.**

- **History of Nomenclature Codes**:
- 1758 Linnaeus' 10th Edition of Systema Naturae
- 1840 Strickland Code of British Association for the Advancement of Science
- 1867 Set of "laws" at Paris International Botanical Congress
- 1881 French Code developed
- 1887 U. S. Code developed
- 1889 International Zoological Congress adopted Blanchard Code 1894 German Code developed
- 1901 Regles International Nomenclature of Zoology adopted by 5th Congress, published under the 6th Congress in 1905
- 1904 International Commission on Zoological Nomenclature (ICZN) formed
- 1913 Plenary powers granted to ICZN
- 1952 International Code of Botanical Nomenclature
- 1953 Publication of Copenhagen Decisions and the Follett Summary (1955)
- 1958 Rewritten as international code and updated since that time
- 1976 International Code of Nomenclature of Bacteria
- 1985 Publication of International Code of Zoological Nomenclature
- 1994 Most recent Code of Botanical Nomenclature
- 1999 Most recent Code of Zoological Nomenclature
- **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 (grouped in 18 Chapters) 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.
- The English and French texts of the Code are published on behalf of the Commission by the International Trust for Zoological Nomenclature.
- **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.
- **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 gastropod shell) is Ficus. The scientific name of fig tree is Ficus carica or F. indica, F. religiosa, F. bengalensis etc., but the scientific name of the fig shell is Ficus ficus or Ficus gracilis, etc.

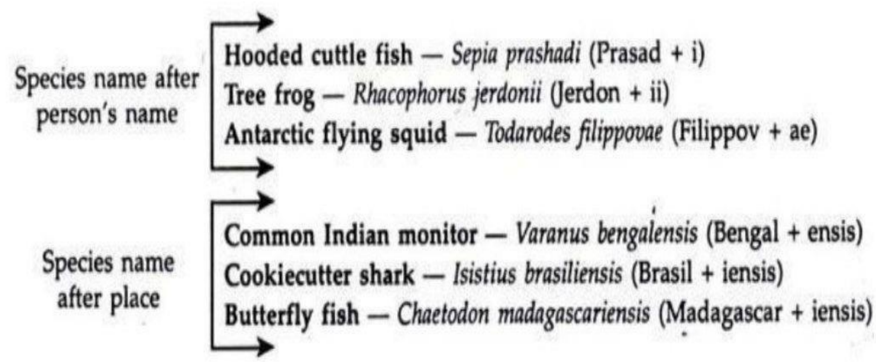
- 2. The scientific name of a species is to be binomial (Art. 5.1) and a subspecies to be trinomial (Art. 5.2). e.g., the scientific name of Indian bull frog is Rana tigerina. It is binomial. The scientific name of Indian lion is Panthera leo persica. It is trinomial. Such a system of naming by three Latin or Latinized words is known as trinomial nomenclature.
- 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.:
  The specific name 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,

Ending in species name	Ending in genus name	Full name of the species
Masculine ending (–i)	(–i/–us/–es)	Common mongoose (*Herpestes edwardsi*) River lapwing (*Vanellus duvaucelli*)
Feminine ending (–a/–e)	(–a/–e)	Golden cuttle fish (*Sepia esculenta*) Humpnosed viper (*Hypnale hypnale*)
Neuter ending (–um/–us, etc.)	(–um/–us, etc.)	Tusk shell (*Dentalium elephantinum*) Common crane (*Grus grus*) Lesser black-backed gull (*Larus fuscus*)

the endings of the species are 'ensis', 'iensis', e.g.:

➢ 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

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.

Name	Genus	Subgenus	Species	Subspecies
Fan shell (Bivalvia)	*Atrina*	*(Servatrina)*	*pectinata*	*pectinata*
Dussumieri's half beak (Osteichthyes)	*Hemirhampus*	*(Reporhampus)*	*dussumieri*	

➢ 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

➢ 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 hypen (-) 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., Mülleri 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:**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 Latinized or so constructed that they can be treated as a Latin word.
- 12. The scientific names must be either in Latin or Latinized or so constructed that they can be treated as a Latin word
- 13. The scientific names must be italicized in printed form, or underlined in hand written or in typed forms, e.g.Indian leopard- Panthera pardus fusca (Meyer)
- 14. All taxa from subgenera level and above must be uninominal (Art. 4.1, 4.2) and are plural nouns for names above genus, and

singular nouns for genus and subgenus. Taxon 'species' may be used as singular or plural.

- 15. In case of animals some rules and practices are applied on the basis of zoological codes (Art. 29.2) for the formation of supra generic taxa from superfamily to tribe, e.g.
- 16. A family name should be based on the basis of type-genus, e.g., Chitonidae—Chiton (type genus)+ idae = Chitonidae.

Taxon level	Endings of the name	Examples
Superfamily	—oidea (for vertebrates) or —acea (for invertebrates)	Hominoidea Genus *Homo* (Latin) = man Genitive *Hominis* Root *Homin*—of *Homo*
Family	—idae	Hominidae [Homin + idae]
Subfamily	—inae	Homininae [Homin + inae]
Tribe	—ini	
Subtribe	—ina	

- 17. Two species under a same genus should not have the same name.
- 18. Nomenclature of a hybrid/hybrids cannot be considered because the hybrids are normally individuals but not population. Thus such names have no status in nomenclature. Hybrids are typically sterile and become synaptic failure during meiosis. They are prevented from back crossing with either parental species.
- 19. A name published without satisfying the conditions of availability (nomen nudum = naked name) has no standing in zoological nomenclature and is best never recorded, even in synonymy.
- 20. A scientific valid name which is not used about 50 years in literature, then as per zoological code's provision the unused senior valid scientific name is treated as obliterated name and junior name

which is used continuously in literature (at least by 10 authors in 25 publications) becomes the accepted official name

- 21. As per the zoological code's provision, the species and subspecies parts of a name may be same spelling and even the second or the third component of the name repeats the generic name (tautonomy), e.g.: Scandinavian red fox- Vulpes vulpes vulpes
- 22. Synonyms are the different names for a same animal or a taxon (species or genus). If the several scientific names are given to a single animal by different scientists, the senior-most name is selected by law of priority. The senior-most or earliest name is called senior synonym (Art. 10.6) and is considered as valid species and the rest of the names are called junior synonyms and are treated as invalid species. The leopard cat was named Felis bengalensis by Kerr and the same animal was named by Gray, Felis chinensis. Again this animal was named as Prionailurus bengalensis by Kerr. So the first name is senior synonym and valid and the rest names are junior synonyms and are invalidThe whale shark was named Rhiniodon typus by Smith in 1828 and the same was named Rhinodon typicus by Muller and Henle in 1839, Micristodus punctatus by Gill in 1865 and Rhinodon pentalineatus by Kishinouye in 1891. Here the first name is considered as senior synonym (Rhiniodon typus) and valid, the rest are junior synonyms and are invalid.
- 23. Homonyms mean when identical names are given to two or more different taxa. According to the zoological code (Art. 52.2) when two or more homonyms are found, the senior most (oldest) homonym (Art. 52.2) is used and the junior-most homonyms are replaced with new names, e.g., Cuvier proposed the genus Echidna in 1797 for the spiny anteater. Forster already proposed the genu

Echidna in 1777 for morey eels. According to Law of Priority, Forsters genus claimed senior homonym and Cuvier’s genus considered as junior homonym. Illiger replaced the Cuvier’s name as Tachyglossus for spiny anteater in 1811.