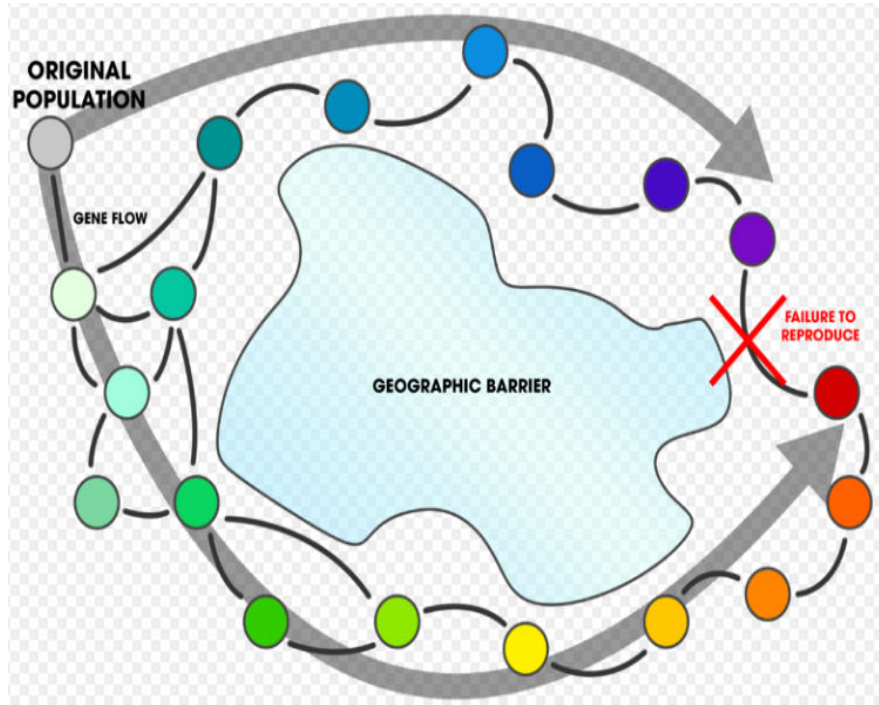


Principles of Systematics

Parapatric Speciation

Parapatric Speciation



[https://en.wikipedia.org/wiki/Parapatric_speciation#/media/File:Ring_Species_\(gene_flow_around_a_barrier\).png](https://en.wikipedia.org/wiki/Parapatric_speciation#/media/File:Ring_Species_(gene_flow_around_a_barrier).png)

Parapatric speciation

- It occurs when populations are separated not by a geographical barrier, such as a body of water, but by an extreme change in habitat.
- Populations in these area may interbreed.
- Charles Darwin was the first to propose this mode of speciation.

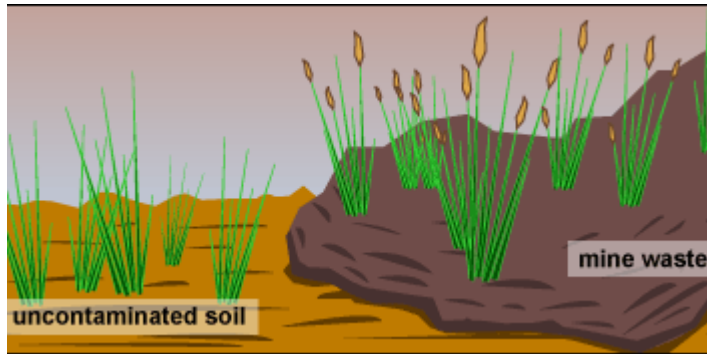
Parapatric Speciation

Parapatric speciation

- Although interbreed but reduced gene flow.
- They often develop distinct characteristics and lifestyles.
- Reproductive isolation is rather temporal or behavioral.
- It is extremely rare.

Parapatric Speciation

Example



<https://images.app.goo.gl/iMY6DE1PcER2Dx1k7>

- Population of grass plant is present near mining area
- Soil near mining area is infused with metals due to which plants grow slowly than those that grows away from mines.
- As a result, two populations of grasses arise having different flowering time.

Parapatric Speciation



<https://www.google.com/search?q=cave+snails&tbm>

Example

- A study of tropical cave snails (*Georissa saulae*) found that cave-dwelling population descended from the above-ground population, likely speciating in parapatry

Principles of Systematics

Module# 19

Principles of Systematics

Paripatric Speciation

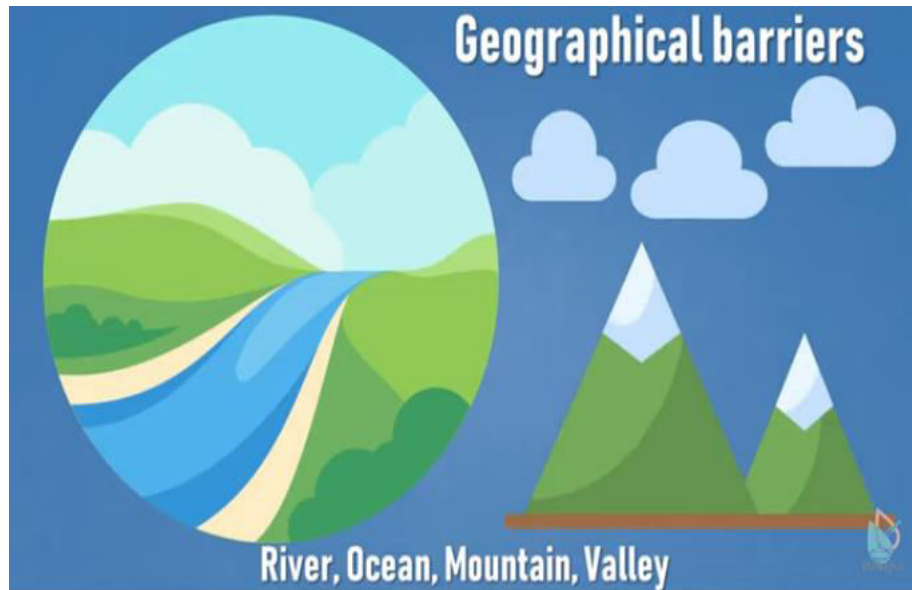
Paripatric Speciation

Paripatric speciation

- Peripatric speciation is a mode of speciation in which a new species is formed from an isolated peripheral population.
- Resemble allopatric speciation/barriers
- Isolating population is small

https://en.wikipedia.org/wiki/Peripatric_speciation#/media/File:Peripatric_Speciation_Schematic.svg

Paripatric Speciation



<https://www.youtube.com/watch?v=7TNN-WGYWks>

Paripatric speciation

- Peripatric speciation is a mode of speciation in which a new species is formed from an isolated peripheral population.
- Resemble allopatric speciation/barriers
- Isolating population is small

Paripatric Speciation



<https://www.google.com/search?q=london+underground+mosquito&hl>

Example

- An **example** of this is the London Underground mosquito, a variant of the mosquito *Culex pipiens*, which entered in the London Underground in 19th century.
- It is found in the London Underground railway system

Paripatric Speciation

Example

- Evidence for its **speciation** includes genetic divergence, behavioral differences, and difficulty in mating.

END

Principles of Systematics

Module# 20

Principles of Systematics

Typological Species Concept

Typological Species Concept

- Species is the basic unit of classification according to the International Commission of Zoological Nomenclature.
- Survey of taxonomic literature shows that there are more than 20 species concepts.

Typological Species Concept

Typological species concept

- This concept was proposed by Aristotle and Plato

According to this concept

“A certain pattern of features is found in each species of organisms and all members of species show maximum equality in this format”

Example: certain pattern in dogs

Typological Species Concept

Typological species concept

- Monotypic species
- Polytypic species

Typological Species Concept

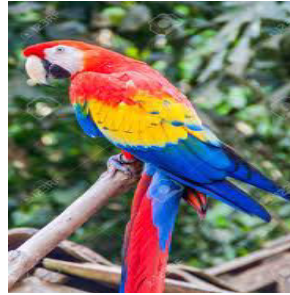
Postulates of Typological species concept

- Species consist of similar individuals sharing the same essence.
- Each species is separated from all others by sharp discontinuity.
- Each species is completely constant through time.
- There are strict possible limits to variations within any one species.

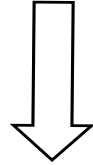
Typological Species Concept



Ara ararauna



Ara macao



sterile hybrid
Catalina macaw

Example

- Two macaw species, blue-and-yellow macaw *Ara ararauna* and the scarlet macaw *Ara macao* are considered different species due to different coloration.
- In nature, their habitats overlap but they not produce hybrids except in captivity.

Typological Species Concept



Anchura substriata

<https://www.google.com/search?q=macaw&tbm=isch&ved=2ahUKEwiQyL>

Strengths

- Applicable to living or extinct species.
- Doesn't depend on complex genetic analysis.
- Morphology can be readily observed, without harming the organisms.

Typological Species Concept

Problems with Typological species concept

- Polymorphism within populations.
- Sibling or cryptic species.
- Geographical variations among populations

END

Principles of Systematics

Module# 21

Principles of Systematics

Biological Species Concept

Biological Species Concept

- According to Biological species concept:
- Species are groups of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups.” Ernst Mayr(1942,1963)

Biological Species Concept

- Can successfully interbreed and produce fertile offspring.
- A species' integrity is maintained by interbreeding within a species.

Biological Species Concept

Why members of species resemble

- This concept explains why members of species resemble and differ from other species.
- When organisms breed they shuffle their gene pool which gives the species its identity.
- Genes are not shared with other species so they look different.

Biological Species Concept

Biological species concept

Members of species constitute:

- Ecological unit
- Reproductive unit
- Genetic unit

END

Principles of Systematics

Module# 22

Principles of Systematics

Biological Species Concept

Biological Species Concept

Biological species concept

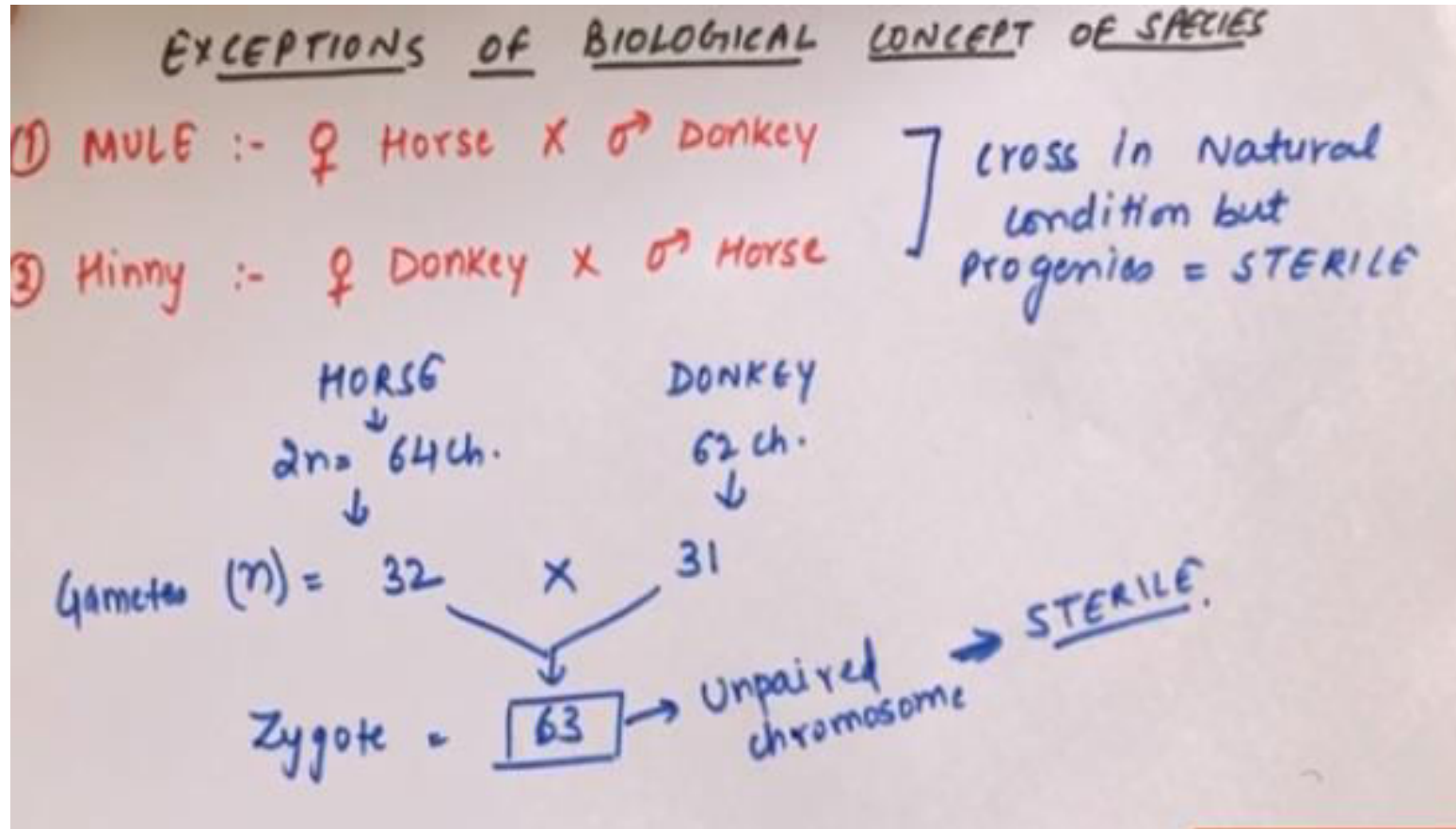
- Ecological unit
- Reproductive unit
- Genetic unit
- .” Ernst Mayr (1942, Darwin of 20th century)

Biological Species Concept

Biological species concept

- Most widely accepted species concept.
- Dobzhansky (1951) and Hanson (1981) accepted the definition of biological Species concept because of two reasons:
 - Gene pool
 - Reproductive isolation

Biological Species Concept

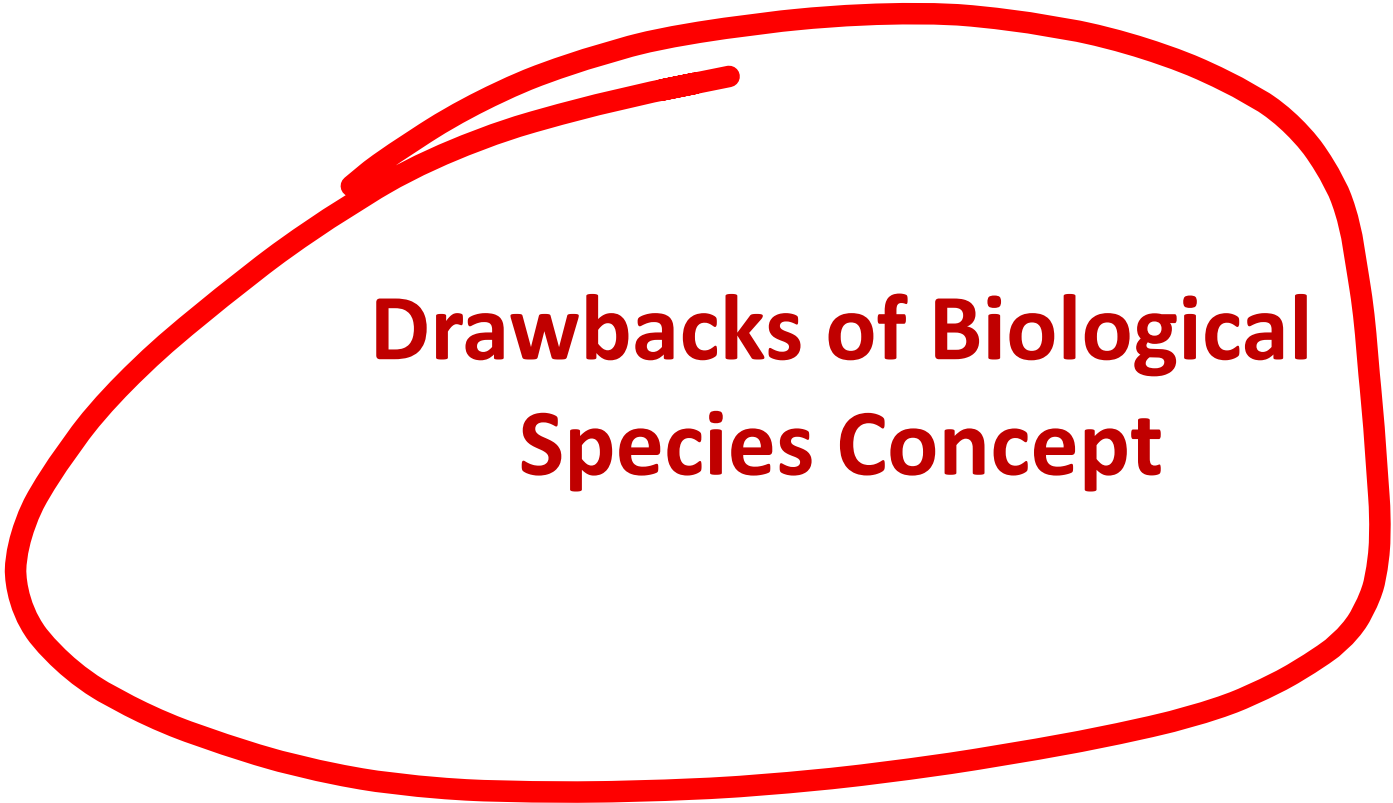


<https://www.youtube.com/watch?v=3Chz-XJHvNE>

Principles of Systematics

Module# 23

Principles of Systematics



**Drawbacks of Biological
Species Concept**

Drawbacks of Biological Species Concept

Drawbacks

- Asexual reproducing organisms.
- Fossils
- Sibling or cryptic species
- Distinguishing between species on the basis of reproductive separation is problematic because reproductive isolation is often incomplete .

Drawbacks of Biological Species Concept

Asexual reproduction/Uniparental reproduction

- Not applicable on apomictic species
- Do not fulfill interbreeding criterion **(Most important in BSC)**
- Apomictic groups
(parthenogenesis, apomixis, budding etc)

Drawbacks of Biological Species Concept

Asexual reproduction/Uniparental reproduction

- Uniparental reproduction is Common in lower invertebrates and lower vertebrate
- Decedents are called agamospecies, binoms or paraspecies
- According to Mayr (1988a) these are not species

Drawbacks of Biological Species Concept

Sibling species/Cryptic species

- As they are morphological similar but reproductively isolated

Incompleteness of Speciation/fossil record

- Evolution is gradual and continuous process. However, fossil record is not complete

END

Principles of Systematics

Module# 24

Principles of Systematics

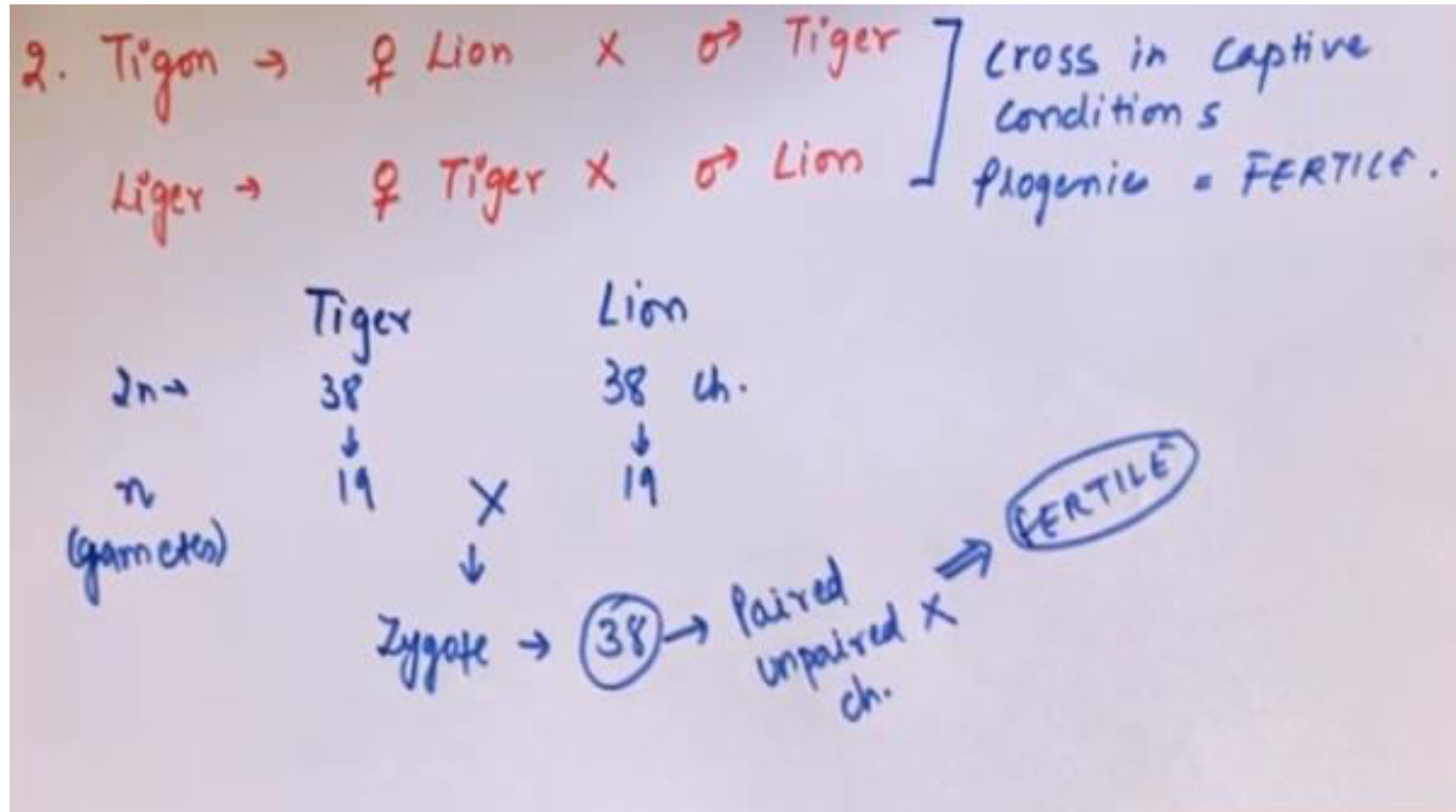
Drawbacks of Biological Species Concept

Drawbacks of Biological Species Concept

Interbreeding between two different species

- According to BSC two different species can not breed and produce fertile offsprings
- However, there are exceptions

Drawbacks of Biological Species Concept



Principles of Systematics

Module# 25

Principles of Systematics

Evolutionary Species Concept

Evolutionary Species Concept

Evolutionary species concept

- Simpson (1940s)
- An **evolutionary species** “is a single lineage of ancestor-descendant populations of organisms which maintains its:
- Identity from other such lineages [in space and time]
- Own **evolutionary** tendencies
- historical fate” (Wiley, 1981)

Evolutionary Species Concept

Evolutionary species concept

- Initially developed to define fossil species.
- Applicable to both sexually and asexually reproducing species and emphasizes common descent.

Evolutionary Species Concept

Drawbacks

- Arbitrary: how to define independent roles and tendencies.
- Does not provide mechanism.

END

Principles of Systematics

Module# 26

Principles of Systematics

Taxonomic Characters

Taxonomic Characters

Character

- It is any attribute of member of taxon by which it may differ from member of other taxon.
- A heritable trait possessed by an organism
- Characters are usually described in terms of **character states**.

Taxonomic Characters

Character state

- One of the variant conditions of a trait.
- **Binary states:** For example: "hair present" vs. "hair absent," where "hair" is the **character**, and "present" and "absent" are its **states**
- **Multistate characters:** Yellow, white or pink flowers or AGCT for nucleotide sequence data.

Taxonomic Characters

Qualities of key characters

- Apply to all member of taxon
- Fairly stable and durable
- Qualitative and absolute
- Detectable without special equipment's, dissection or histological preparations

Taxonomic Characters

Taxonomic Characters are illustrated as:

- Morphological character
- Physiological character
- Behavioral character
- Ecological character
- Geographic character
- Molecular and biochemistry character
- Ontogenetic character

END

Principles of Systematics

Module# 27

Principles of Systematics

**Morphological
Characters**

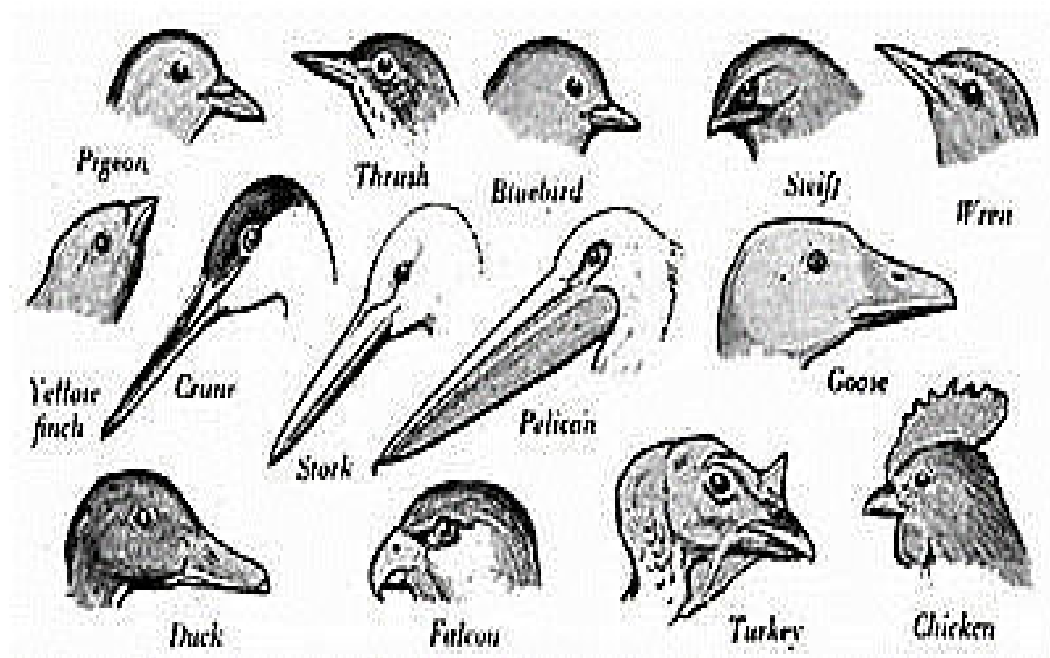
Morphological Characters

Morphological Characters

Morphology describe the structural features. Morphological characters include:

- External morphology
- Genetelic structure
- Internal morphology
- Embryology
- Karyology and other cytological differences

Morphological Characters



General external morphology

The apparent features are easy to detect and observe.

e.g. Plumage of birds, scales of fish and reptiles, pelage of mammals, phylogenetically significant sutures and sclerites of arthropod body etc.

https://tse2.mm.bing.net/th?id=OIP.k_dPDFg2fl7OVNpR7Y72-gHaDa&pid=Api&P=0&w=

Morphological Characters



https://www.researchgate.net/profile/Aidas_Saldaitis/publication/321343778/figure/fig2/AS:568147356336130@1512468293710/Male-genitalia-and-leg-structures-of-the-C-katsumii-holotype_Q320.jpg

Genetalic structures

- The genital structure of each specie are different to depict the reproductive isolation.
- Used to delimit species
- Key and Lock model
- Highly effective insects
- Genetalic structures appear to be among the first to change in the course of speciation.

Morphological Characters

Coloration

- Color pattern and other aspects of coloration are convenient characters in certain group of animals.
- Bird and coloration except few genera with sibling species.
- Same is true or certain reef fishes and butterflies
- Many subspecies are indentified on the basis of colour

END

Principles of Systematics

Module# 28

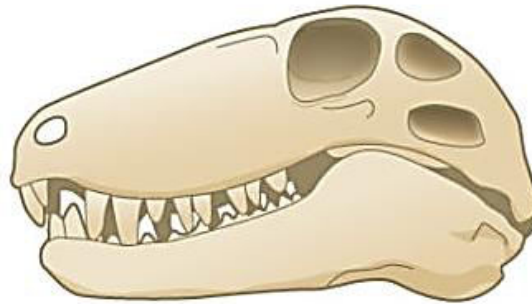
Principles of Systematics

**Morphological
Characters**

Morphological Characters



Anapsid skull (Turtles)



Diapsid skull (Reptiles including birds)



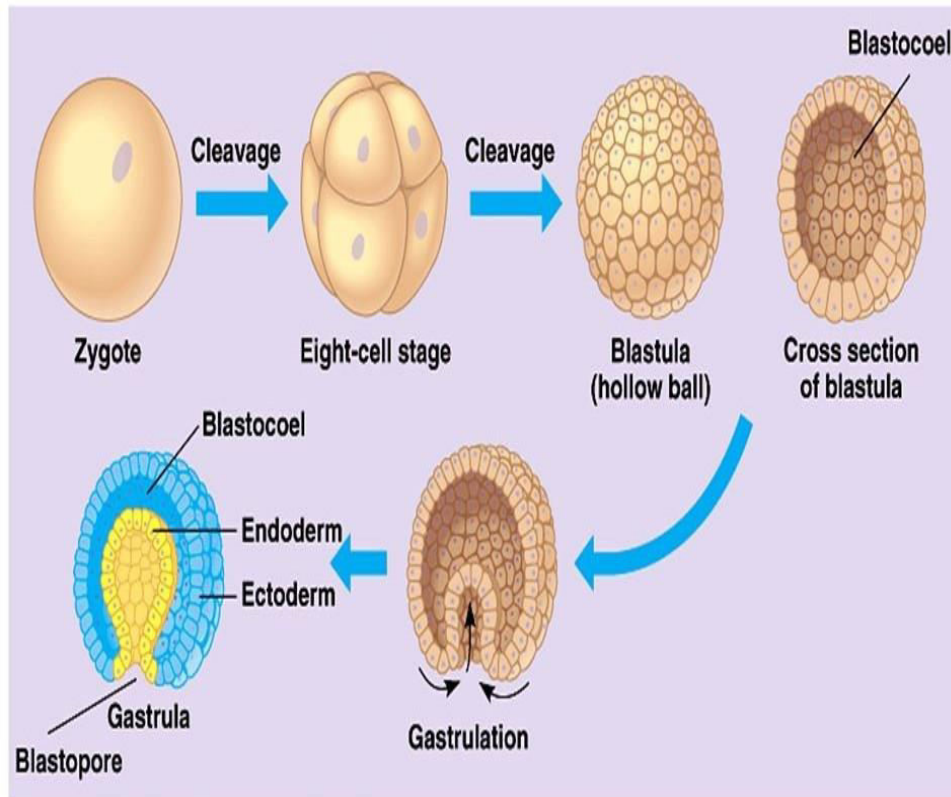
Synapsid skull (Mammals)

<https://www.google.com/search?q=evolution+in+skulls+of+vertebrates>

Internal morphology

- Internal anatomy provides Taxonomic Characters for all groups of higher animals.
- The extent to use vary from group to group.
- The skull is routinely used in classification of higher mammals.
- Teeth and bones of fossils and other hard parts.

Morphological Characters



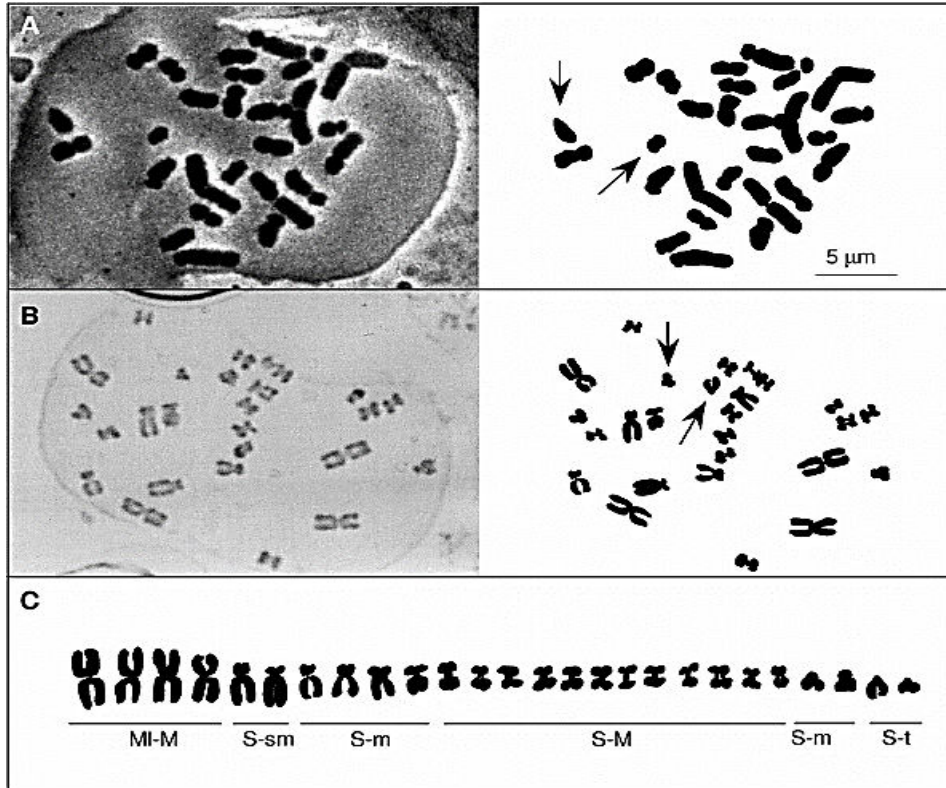
<https://i1.wp.com/orbitbiotech.com/wp-content/uploads/2018/04/embryonic-development-Orbit-Biotech-Training.jpg?ssl=1>

Embryology

Various larval stages, embryology and even eggs may provide taxonomic information.

- Sibling species of *Anopheles maculipennis*-----Egg structure
- Identification of white flies are based on pupae
- Comparative embryological stages like cleavage, blastulation, gastrulation etc are helpful

Morphological Characters



<https://www.liberaldictionary.com/wp-content/uploads/2019/02/karyology-4570.jpg>

Karyology and other cytological factors

- Karyology is description of size, shape and number of chromosomes
- The simplest cytological character is chromosomal number (species specific)
- Comparison of closely related species (sibling species)
- Establishing phyletic lineage

Principles of Systematics

Module# 29

Principles of Systematics

**Physiological
Characters**

Physiological Characters

Physiological Characters

Physiological characters are low weight characters and are variable:

- All structures are product of physiological process and are thus physiological characters.
- This character can not be studied in preserved animals.

Physiological Characters

Physiological Characters

- Metabolic activities
- Body secretion
- Serological protein and other biochemical differences
- Genic sterility factor

Physiological Characters

Metabolic Factors

- Metabolic factors/enzymes help to find the relations in the closely related species

e.g. Gram +ive and Gram –ive bacteria

Physiological Characters



<https://thecotyledon.files.wordpress.com/2010/10/scale-honey.jpg>

Body secretion

Body secretions also have the consistent pattern

- Links can be created by finding the number
- Size and
- Structure of the glands

e.g. waxy secretion of scale insects

Principles of Systematics

Module# 30

Principles of Systematics

**Physiological
Characters**

Physiological Characters

Serological protein and other biochemical differences

- Serology is concerned with the nature and interaction of antigens and antibodies.
- Antigens are the substances capable for inducing the formation of antibodies when introduced into the blood stream of animals.

Physiological Characters

- According to antibodies produced in response to the introduction of foreign antigen

Bovden (1943)

- Protein antigens are conservative hereditary trait.
- Proteins of one organism react more strongly with the antibodies of closely related organism than more distantly related.

Physiological Characters

- Good precipitin technique are reveal the relative degree of biochemical similarity of protein antigens among organisms.

Physiological Characters

Genic sterility factors

- Reproductively incompatible species cannot reproduce new young one
- Only closely related species can hybridize successfully.
- As a result give genetically sterile species.
- Cross fertility in Dobkey and Hourse- Mule
- Cross fertility in ducts (species and genera)

END

Principles of Systematics

Module# 31

Principles of Systematics

Behavioral Characters

Behavioral Characters

Behavioral characters

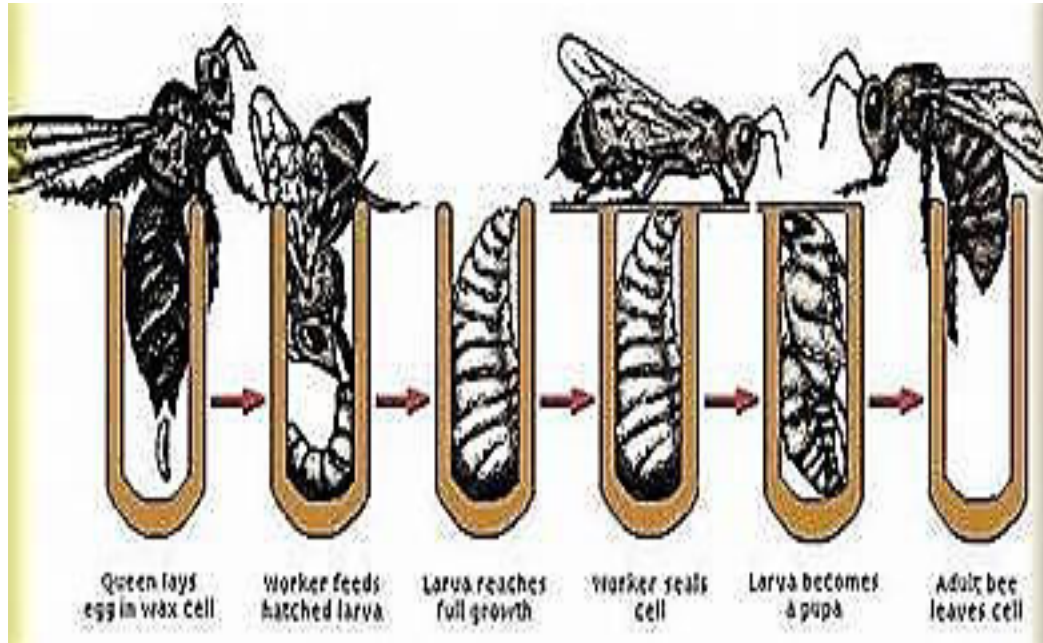
- Behaviour is one of the most important source of Taxonomic Characters.
- They are more superior than morphological characters in the study of closely related species.
- Especially in sibling species
- Mating behaviour, egg laying, nesting behaviour, drinking habit of birds etc.

Behavioral Characters

Behavioral characters

- Mating calls of frogs, toads and crickets are used in species delimitation.
- Webs pattern in spiders can be at various level in classification.

Behavioral Characters



Reproduction

Mating and reproduction behavior of species help in taxonomic classification and also help in determining reproductive isolation and speciation.

E.g. slugs

<https://tse3.mm.bing.net/th?id=OIP.eubyf9OPir29CdF7wsFukQHaDO&pid=Api&P=0&w=392&h=171>

Behavioral Characters



<https://media.buzzle.com/media/images-en/photos/birds/peacocks/1200-77866817-peacock-drinking-water.jpg>

Other behavior pattern

The living, eating and nesting behavior of the animals also depicts the taxonomic character

e.g. drinking habit of pigeon and sand grouse, use of mud in nest building

Behavioral Characters

Drawbacks

- Can not be studied in preserved material
- It is intermittent even in living animal.
- Some behaviours are seasonal
- Change within 24 hours

Principles of Systematics

Module# 32

Principles of Systematics

Ecological Character

Ecological Character

Ecological characters

- Each species has specific niche
- Types of niches
- Habitats and hosts environment
- Food sources
- Seasonal variation
- Parasite and host interaction reaction

Ecological Character

Habitats and host environment

- Habitat of the organisms is not same
- Species cannot coexist at same place or in same environment or partitioned their resource to avoid competition.

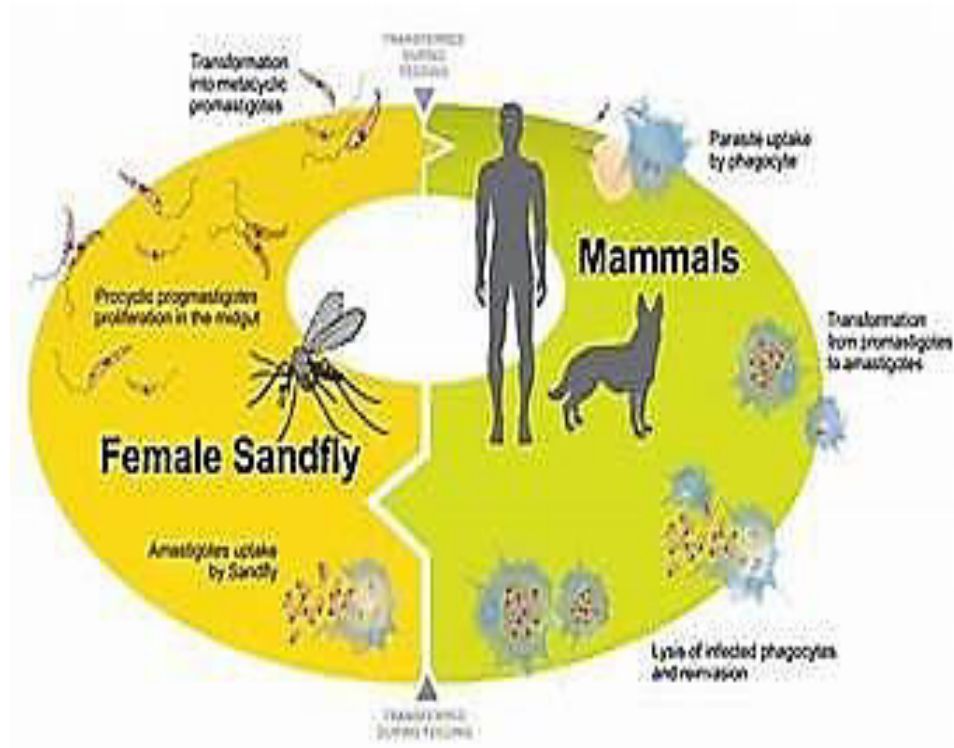
Ecological Character

Food and seasonal variation

- Food sources also varies like in parasites and many others.
- Characteristics of organism also vary depending on season

e.g. plumage of birds and breeding coloration

Ecological Character



Parasite and host interaction reaction

- Structural changes can occur in host after parasitic attack
- Various responses of body like distortion, swelling etc.

<https://tse4.mm.bing.net/th?id=OIP.CDWG77aR8le8a2HGocriegHaEV&pid=Api&P=0&w=341&h=201>

Principles of Systematics

Module# 33

Principles of Systematics

Ecological Character

Ecological Character

Ecological Character

- Every species has its own ecological niche in nature differing from its close relatives in (spider example)
- Food preference
- Breeding season
- Tolerance to physical factors
- Resistance to predators
- Competitors and pathogens

Ecological Character

Ecological Character

- Larvae of both *Drosophila mulleri* and *Drosophila aldriachi* live simultaneously in decaying pulp of the fruits of cactus *Opuntia lindheimeri*.
- Both species are specialized in using certain types of yeast and bacteria.

Ecological Character

Ecological Character

- Similarly tapeworms of man and rodents and *Ascaris* of man and pigs are host specific.
- Each species of Galapagos finch is also specialized according its habitat/ environments

END

Principles of Systematics

Module# 34

Principles of Systematics

**Geographical
Characters**

Geographical Character

Geographical Character

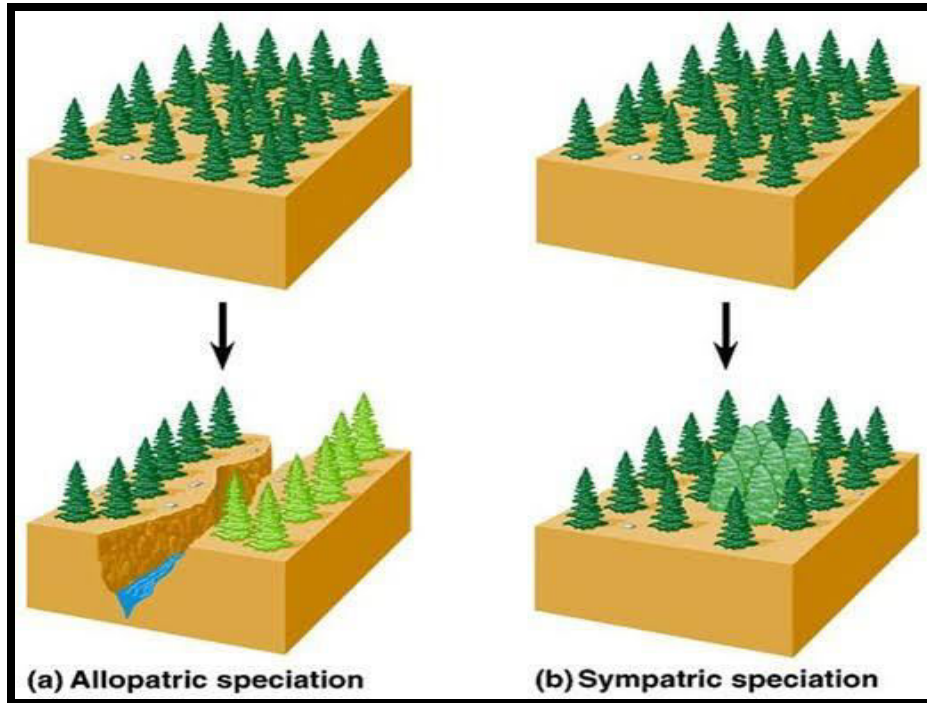
- Each taxon has a geographical range
- Range changes as the taxon evolve
- Distribution of taxa provide past history
- Geographic characters are important at two levels
- Microtaxonomy
- Macrotaxonomy

Geographical Character

Geographical Character

- Taxonomists are important in two types of geographical characters:
- General biogeographical patterns, which are especially useful in arrangement of higher taxa
- Allopatric-sympatric relationship, which is helpful in determining whether or not two species are conspecific.

Geographical Character



Sympatric-allopatric relationship of population

These isolation pattern that occur in the population also determine the links in population

<https://s-media-cache-ak0.pinimg.com/736x/18/49/1c/18491ced4bf91ceac2f85a3fdee59a5f.jpg>

Principles of Systematics

Module# 35

Principles of Systematics

**Molecular and
biochemistry character**

Molecular and Biochemistry Character

Molecular and biochemistry character

This character as taxonomic character is also an approach for the evolutionary links and relations determines if classical taxonomy is defined.

Molecular and Biochemistry Character

Molecular and biochemistry character

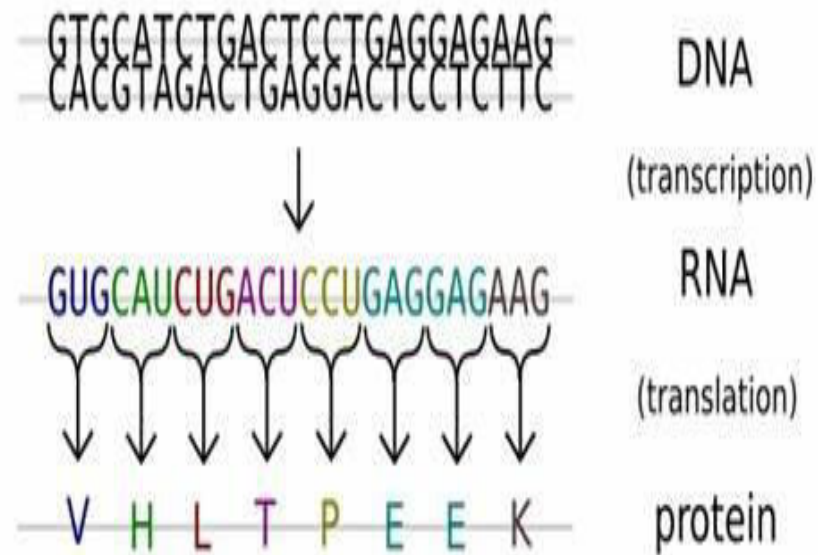
- Immunological distances
- Electrophoretic differences
- Amino acid sequence of protein
- DNA hybridization
- DNA and RNA sequence

Molecular and Biochemistry Character

Amino acid sequences

- Amino acid sequences help to determine the links.
- This approach as a taxonomic character is more absolute.

Molecular and Biochemistry Character



DNA and RNA sequences

- These sequences help to determine the direct links on the basis of sequences
- But these sequences can also undergo some changes under the evolutionary pressure

<https://tse2.mm.bing.net/th?id=OIP.Uo3B4dsPEz-PEzHf3uJ4OwHaCz&pid=Api&P=0&w=517&h=197>

Molecular and Biochemistry Character

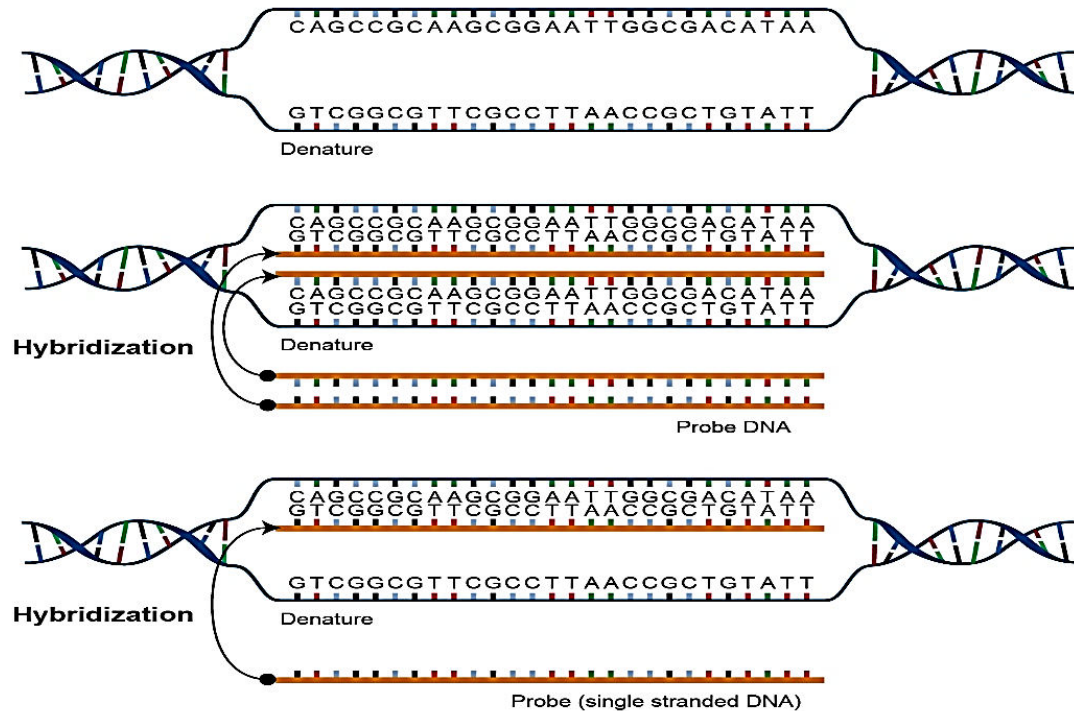
Electrophoretic differences

- This method determine the difference in the isozyme and allozyme.
- Can help to determine share character among taxa.

Molecular and Biochemistry Character

DNA hybridization

- This method is used to determine the genetic distance between two organisms
- Mainly measure the genetic similarity



<https://www.genome.gov/sites/default/files/tg/en/illustration/hybridization.jpg>

Principles of Systematics

Module# 36

Principles of Systematics

Weighing of Characters

Weighing of Characters

- Any attribute by which member of a taxon differ
- Raw material of classification
- Amount of phyletic information **contents** in a given character
- More phyletic information----
high weigh
- Low phyletic information---low
weight

Weighing of Characters

- Animal character may of high weight ----mostly used by taxonomist
- Low weight---rarely used
- Also characters of intermediate weight
- Challenge for taxonomists which discordant character should be trusted?

Weighing of Characters

- Process to determine that which character is more reliable is called *weighting*.

Weighing of Characters

1. Priori (before/without phyletic information)

- Proposed by Aristototele

2. Posteriori

- Proposed by Adenson (after phyletic information collection)
- All classification is based on this model.

END

Principles of Systematics

Module# 37

Principles of Systematics

Correlated Characters

Correlated Characters

- Characters which are functionally correlated have very low weight
- They have low phylogenetic content
- Do not deserve to be treated as separate character
- Analogues organs birds wings, bats and insects (analogus)/convergent evolution
- Redundant

Correlated Characters

- Phyletic correlation
- High weight
- Higher genetic contents
- Diagnostic characters of
Deuterostomes and Chordates
(concordance)----phyletic
correlation—evolutionary related

END

Principles of Systematics

Module# 38

Principles of Systematics

High Weight Characters

High Weight Characters

High weight characters

- Complexity
- Constancy
- Consistency
- Not affected by ecological shift
- Apomorphy
- Not a specific adaptation
- e.g. Morphological and behavioral character

High Weight Characters

Complexity

- Complexity-Genitalia
- Deep genetic character
- Higher complexity-higher weight age

Constancy

- Character which is constant in a large group of species than variable character (Darwin 1859)
- According to Farris (1969) Low phenotypic variability be given high weight

High Weight Characters

Consistency

- A character which is consistently present in one group and consistently absent in related groups should have high weight

High Weight Characters

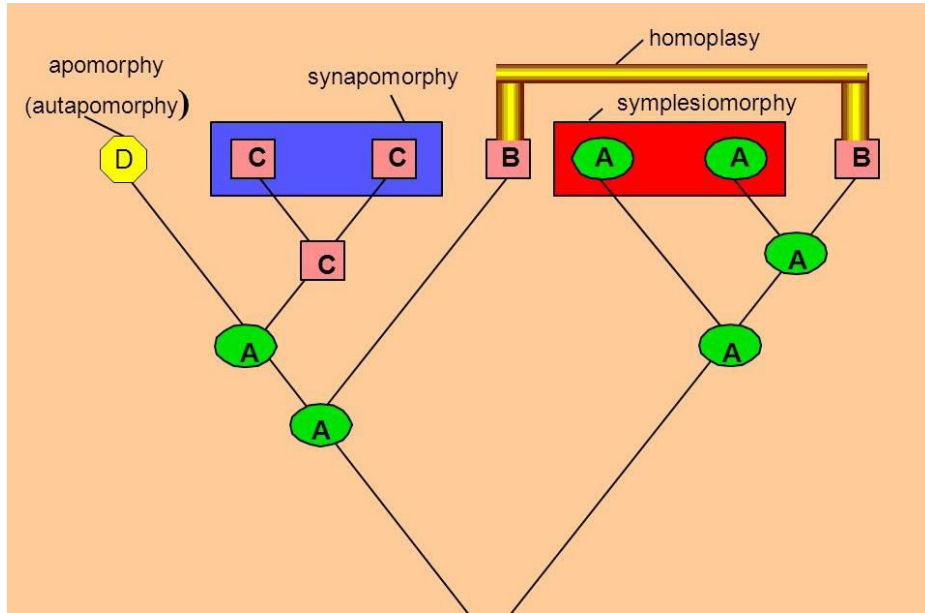


https://www.google.com/search?q=mergansers&sxsrf=ALeKk03jlyrLE0TelgIBxO6mWo9hBiogvg:1603685582863&source=lnms&tbm=isch&sa=X&ved=2ahUKEwjdtv2rstHsAhXvDmMBHZtJB0cQ_AUoAXoECCYQAw&biw=1360&bih=657

Not affected by ecological shift

- A character that no change with ecology
- A bird feeding on fish in one habitat continue to feed on fish in another habitat
- An example is adaptation of mergansers (Mergus) for fish eating

High Weight Characters



https://www.google.com/search?q=apomorphy&sxsrf=ALeKk03Y_tzp73qJK0Em_Bfingu_YHOxiw:1603614144234&source=lnms&tbm=isch&sa=X&ved=2ahUKEwjbjLGbqM_sAhWzShUIHdkiB1oQ_AUoAXoECCAQAw&biw=1360&bih=600#imgrc=GcYTyU7VcBY0LM

Apomorphy

- A novel evolutionary trait that is unique to a particular species and all its descendants and which can be used as a defining character for a species or group in phylogenetic terms.
- Hence, the possession of feathers is unique to birds and defines all members of the class Aves.

Principles of Systematics

Module# 39

Principles of Systematics

Low Weight Characters

Low Weight Characters

- Characters having less taxonomic importance
- Less phylogenetic content
- Not reliable
- Poor indicators of relationships

Low Weight Characters

- Highly variable Characters (hairs, branching pattern of arteries)
- Monogenic and oligogenic characters (albinism) varies independently of other characters

Low Weight Characters

- Regressive characters (loss of eyes, loss of wings, wing veins in insects, loss of teeth in mammals, loss of segments in segmented animals are unnatural.
- Loss may be due to environmental conditions (eye loss in cave, loss of digestive systems in parasitic tapeworms)
- Narrow specialization
e.g. Physiological character

Low Weight Characters

- Not constant
- Not consistent
- Change with ecology
- Less complex
e.g. Physiological character

END

Principles of Systematics

Module# 40

Principles of Systematics

Non-Genetic Variations

Non-Genetic Variations

Types of Non-Genetic variations

- Individual variations in Time
- Social Variations
- Ecological Variations
- Traumatic variation
- Post-mortem variations

Non-Genetic Variations

Individual variations in Time

- Age variations
- Seasonal variations of individuals
- Seasonal variations of generations

Non-Genetic Variations



https://www.google.com/search?q=eel&sxsrf=ALeKk02QiXShlrI7phddXt7HPFtE0QOvmA:1603309550565&source=lnms&tbm=isch&sa=X&ved=2ahUKEwihuefBucbsAhWPTN8KHUuJCQsQ_AUoAXoECDUQAaw&biw=1360&bih=600#imgsrc=eWSxWZoTy-WYyM

Age Variations

- Animals pass through large numbers of juvenile or larvae which are quite different from adult.
- Immature stage of eel (*Anguilla anguilla*) were originally described as *Leptocephalus brevirosteris* in 1856
- Larval stages different from adult (Caterpillar and butterfly)