SYSTEMATICS & EVOLUTION

NEWER TRENDS IN SYSTEMATICS

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CHEMOTAXONOMY

- **Chemotaxonomy** is the method of biological classification based on similarities in the structure of certain compounds present in the the organisms.
- Chemotaxonomists classify natural products into two: **micromolecules** like aminoacids, alkaloids, terpenoids, fattyacids, flavonoids, etc and macromolecules like proteins, DNA, RNA etc

- Protoplasm: Every living cell, from a bacterium to an elephant, from grasses to the blue whale, has protoplasm. Though the complexity and constituents of the protoplasm increases from lower to higher living organism, the basic compound is always the protoplasm.
- it is clear that all living things have a common origin point or a common ancestor, which in turn had protoplasm. Its complexity increased due to changes in the mode of life and habitat.
- Based on similarity in protoplasmic constituents, classification can be made

- Nucleic Acids: include both DNA and RNA. If the alleles of the strands of any two species are close, then it can be concluded that these two species are more closely related.
- Digestive Enzymes: Enzymes are chemical compounds that help in digestion. Proteins are always digested by pepsin, trypsin, etc. Likewise,carbohydrates are always digested by amylase, and fats by lipase. The complexity in the composition of these enzymes increases from lower to higher organisms but are fundamentally the same.

- Hormones: Hormones are secretions from the endocrine glands like the thyroid, pituitary, adrenal, etc.
- Their chemical nature is the same in all animals. For example, thyroxine is secreted from the thyroid gland, irrespective of what the animal is. It is used to control metabolism in all animals. If a human being is deficient in thyroxine, it is not mandatory that this hormone should be supplemented from another human being. It can be extracted from any mammal andinjected into humans for normal metabolism to take place.
- Likewise, insulin is secreted from the pancreas

- Visual Pigments: In the vertebrates, vision is controlled by two very distinct types of visual pigments, porphyropsin and rhodopsin.
- They are present in the rods of the retina. Fresh water fishes have porphyropsin; marine ones and land vertebrates have rhodopsin.
- In amphibians, a tadpole living in fresh water has porphyropsin, and the adult frog, which lives on land most of the time, has rhodopsin.
- In catadromous fish, which migrate from fresh water to the sea, the porphyropsin is replaced by rhodopsin. In an anadromous fish, which migrates from the sea to freshwater, the rhodopsin is replaced by porphyropsin.
- These examples show the freshwater origin of vertebrates. They then deviated into two lines, one leading to marine life and the other to terrestrial life.

- For example, in classifying plants, crude extract of a plant is separated to individual components i.e. to micromolecules through chromatography, electrophoresis, etc
- Then individual spots (micromolecules separated) are subjected to spectroscopy like uv, infrared, etc so we get informations about its structure also
- Thus classification of plants can be done according to different components present as well as based on its structure
- If macromolecules serve as basis for classification then x-ray crystallography can be employed so that we get information regarding 3D structure. And classification can be done

SEROTAXONOMY

- It is the application of serology in classification
- Serology is the study of Ag- Ab reaction
- This type of classification is mainly used to classify plants
- Proteins extracted from plants are injected to an animal (this protein act as an Ag in the animal), then Ab will be produced.
- Blood sample is collected from the animal, Ab is determined
- Thus different plant proteins can be identified and plants can be classified

CYTOTAXONOMY

- Classification of organisms using comparative studies of chromosomes
- The number, structure, and morphology of chromosomes are used for classification of which chromosome number is the most widely used and quoted character- karyotaxonomy
- No:, shape and banding of chromosomes can be determined by various staining techniques

- Chromosome no:, shape, size, banding, etc are unique to a species. Hence it can be used for classification

CLADISTICS

- System of classification based on phylogenetic relationships and evolutionary history of groups of organisms
- Until the end of 1980s cladistics remained a minority approach to classification, however, in 1990s it became the dominant method of classification
- German entomologist Willi Henning, referred to it as phylogenetic systematics

- Cladistics or phylogenetic systematics or phylogenetic taxonomy is the classification of organisms based on common ancestory
- Cladistics is based on 3 principles:

1) Groups of organisms are descended from a common ancestor
2) At each node, there are two branching lines of descendants
3) Evolution results in modification of characteristics over time

- According to cladistics, classification is based on shared characteristics or synapomorphic characters
- Organisms with same ancestor share characters, so they are classified into taxonomic groups called clade
- Species divergence from common ancestor can be depicted in the form of a diagram in cladistics; cladogram
- Cladogram graphically represents a hypothetical evolutionary process

- In cladistics type of classification only monophyletic groups are considered (species from common ancestor) paraphyletic (classification based on pleisiomorphic character i.e. present in primitive organism, so not present in all of its descendants) and polyphyletic groups (one which is neither monophyletic nor paraphyletic) are rejected

MOLECULAR SYSTEMATICS

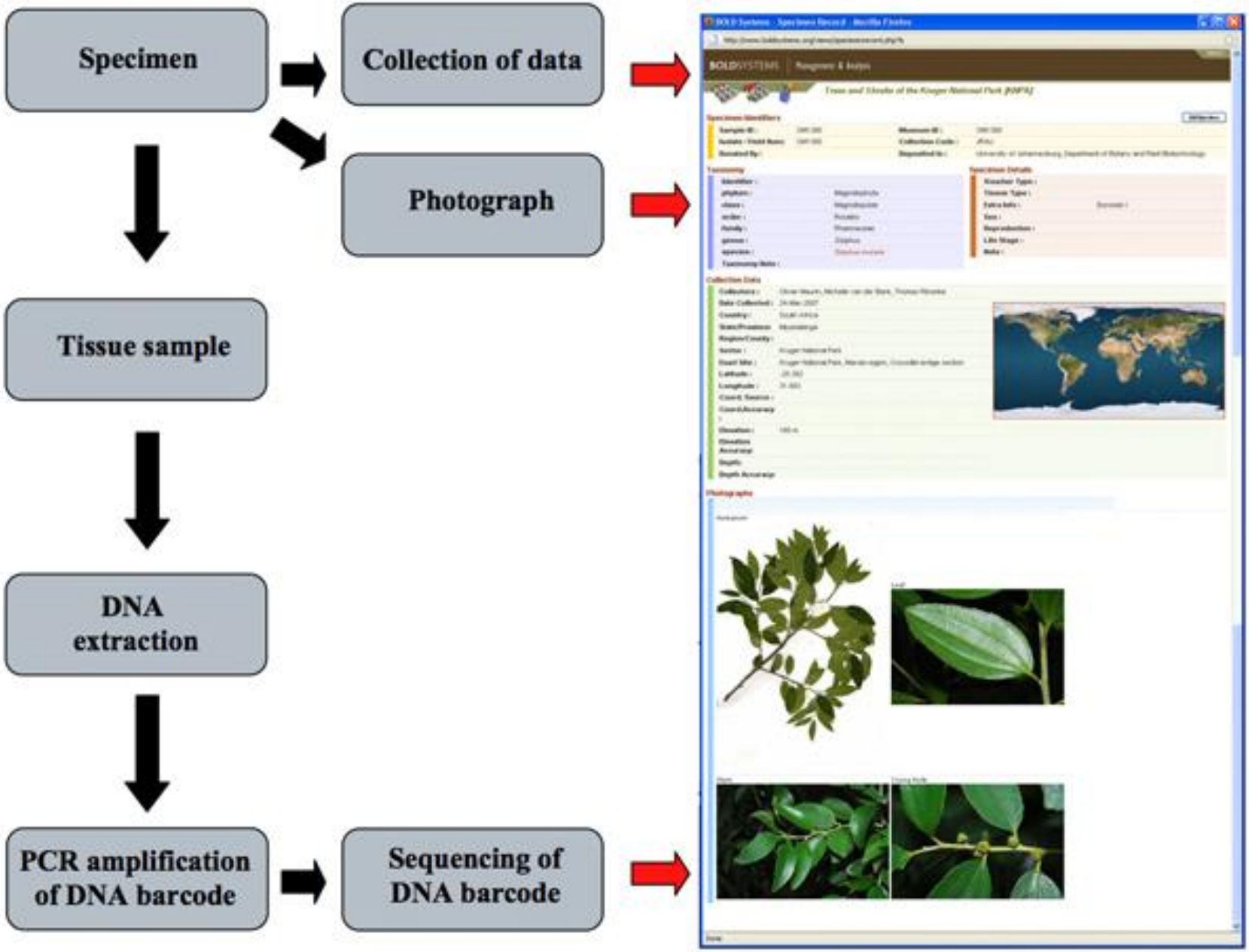
- Also called as molecular phylogenetics
- Theoretical framework that molecular systematics were laid in 1960s by Emile Zuckerlandt, Emanuel Margolish, Linus Pauling and Walter. M. Fitch
- Make use of DNA, RNA and proteins and their molecular structure for classification
- Every living organism contains DNA, RNA, and proteins. Closely related organisms have a high degree of similarity in the molecular structure of these substances, while the molecules of distantly related organisms usually show a pattern of dissimilarity

- In molecular systematics, mainly DNA sequencing is used. The base sequences at a location will be unique to an organism, dissimilar in distantly related organisms. This particular sequence found in a given organism is referred to as haplotype
- Haplotypes are determined in molecular systematics, they are compared and classification is done
- This relationship is used for constructing a ‘relationship tree’ that shows probable evolution of various organisms

DNA BARCODING

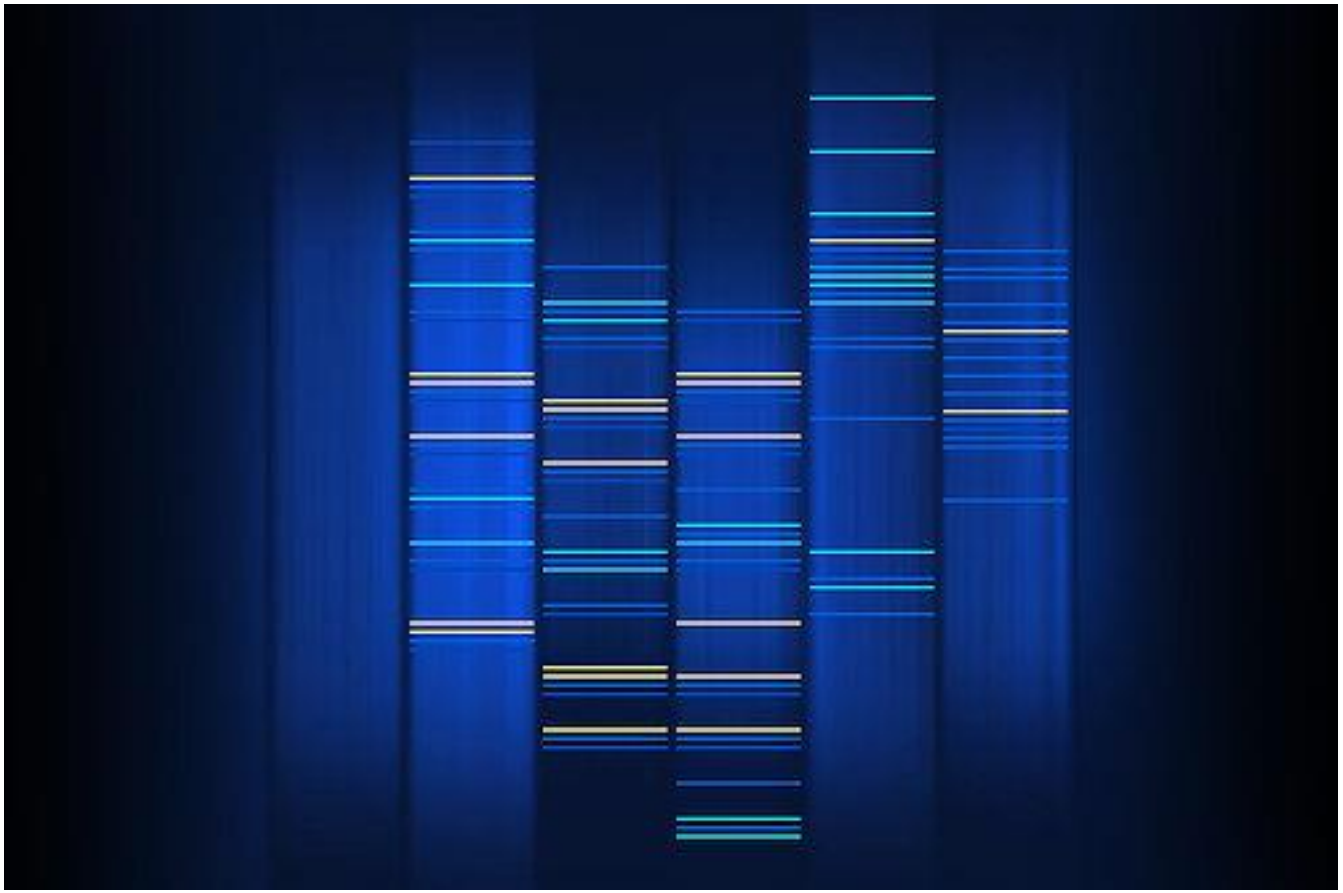
- **DNA barcoding** is a taxonomic method that uses a short genetic marker in an organism's DNA to identify it as belonging to a particular species
- It is different from molecular phylogeny in that it does not determine patterns of relationship but to identify unknown species
- The most commonly used barcode region, for animals, is a segment of approximately 600 base pairs of the mitochondrial gene cytochrome oxidase I (COI).

- A desirable locus for DNA barcoding should be standardized first, then PCR- primers specific to that locus is added, PCR is carried out. It is then subjected to gel electrophoresis, bands are then identified which corresponds to parent specimen. From this relation between species, similarity, dissimilarity etc can be identified, thus helps in species identification


Specimen
Collection of data
Photograph
Tissue sample
DNA extraction
PCR amplification of DNA barcode
Sequencing of DNA barcode

- mt DNA has a relatively fast mutation rate, resulting in the generation of diversity within and between populations over relatively short evolutionary timescales, that is why mt DNA is considered as the basis for DNA barcoding. Eg: mitochondrial cytochrome c oxidase subunit I (COI) gene

DNA SEQUENCING



NUMERICAL TAXONOMY

- It is the **numerical evaluation** of affinity or similarity between taxonomic units and ordering of these units into taxa on the basis of their affinities
- It is also called taximetry
- Here classification is done based on using maximum no: of characters and all are given equal weight

Disadvantages:

- Numerical taxonomy does not take into account convergence, parallelism, special adaptations, etc, so classification is difficult
- Numerical taxonomists use complex mathematical and statistical methods which is difficult for biological taxonomists to follow