MODULE 2- CLASSIFICATION

Biological classification is the scientific procedure that involves the arrangement of the organisms in a hierarchical series of groups and sub-groups on the basis of their similarities and dissimilarities. The classification of organisms is as old as man. However, the credit of defining the biological classification goes to Ernst Mayr, according to whom, the arrangement of entities (taxa) in a hierarchical series of 'nested' classes in which similar or related classes at one hierarchical level are combined comprehensively into more classes at the next higher level can be designated as biological classification.

Biological classification is required to identify the differences among organisms and group similar organisms exhibiting common features and showing relationships. The systematic classification of species based on genetics and evolutionary relationships is termed as taxonomy. There are over 1.6 million species of biological organisms which have been collected, identified and characterized. Biological classification is based on the shared descent from a common ancestor, and has similar traits which can be either homologous (i.e. of similar origin and function), or analogous (i.e. of similar functions, but not necessarily of similar origin). The main objectives of biological classification include uniqueness (each name must be unique), universality (single language for naming the species) and stability (frequent modifications avoided and standard nomenclature accepted by all)

Plants and animals differ in structure, function, shape, colour, life processes and other characteristics. Biology is a natural science that deals with the study of life and living organisms. The study of biology helps us to answer all the questions. It also increases the power of observation. Biology has several branches for the convenience of study. Botany deals with the study of plants, while zoology deals with the study of animals. Microbiology is the study of microorganisms. Cytology is the study of cells, whereas histology is the study of tissues. Physiology deals with the processes and the functions of living organisms. Biotechnology deals with the application of technology in the field of biology, for the benefit of mankind.

Organisms differ from each other in their size, shape, colour, mode of eating, habitat etc. The method of grouping organisms according to their similarities and differences is called as classification. Taxonomy is the branch of biology which deals with the classification of organisms. Classification is important for following main purposes viz. (i) for convenience- easy to study, identify and remember, (ii) to show relationships among various groups of organisms, (iii) to show the evolution of organisms from simple to complex forms of life.

Binominal Nomenclature

Binominal nomenclature is the scientific method of naming the living organisms. Common names of plants and animals often differ from one part of a country to another. Scientific naming helps to sort out the language barrier. Every scientific name has two words. The first word refers to the name of the genus and the second the name of the species. The scientific names are in Latin and Greek. The first letter of the first name, the genus always begins with a capital letter and that of the second i.e. species is a small letter. For eg. The scientific name of mango is '*Mangifera indica'*. *Mangifera* means sweet fruit and *indica* means its origin in India.

Morphological Classification

Morphology is a branch of biology dealing with the study of the form and structure of organisms and their specific structural features. This includes aspects of the outward appearance (shape, structure, colour, pattern, size), i.e. external morphology (or eidonomy), as well as the form and structure of the internal parts like bones and organs, i.e. internal morphology (or anatomy). This is in contrast to physiology, which deals primarily with function. Morphology is a branch of life science dealing with the study of gross structure of an organism or taxon and its component parts.

Biochemical Classification

Biochemistry, is the study of chemical processes within and relating to living organisms. A sub-discipline of both biology and chemistry, biochemistry can be divided in three fields; molecular genetics, protein science and metabolism. Biochemistry focuses on understanding how biological molecules give rise to the processes that occur within living cells and between cells, which in turn relates greatly to the study and understanding of tissues, organs, and organism structure and function. Much of biochemistry deals with the structures, functions and interactions of biological macromolecules, such as proteins, nucleic acids, carbohydrates and lipids, which provide the structure of cells and perform many of the functions associated with life.

Ecological Classification

Ecology is the branch of biology which studies the interactions among organisms and their environment. Objects of study include interactions of organisms with each other and with abiotic components of their environment. Topics of interest include the biodiversity, distribution, biomass, and populations of organisms, as well as cooperation and competition within and between species. Ecosystems are dynamically interacting systems of organisms, the communities they make up, and the non-living components of their environment

Classification based on Cellularity

Unicellular

A unicellular organism, also known as a single-celled organism, is an organism that consists of only one cell, unlike a multicellular organism that consists of more than one cell. Unicellular organisms fall into two general categories: prokaryotic organisms and eukaryotic organisms. Prokaryotes include bacteria and archaea. Many eukaryotes are multicellular, but the group includes the protozoa, unicellular algae, and unicellular fungi. Unicellular organisms are thought to be the oldest form of life, with early protocells possibly emerging 3.8–4 billion years ago.

Multicellular

Multicellular organisms are organisms that consist of more than one cell, in contrast to unicellular organisms. All species of animals, land plants and most fungi are multicellular, as are many algae, whereas a few organisms are partially uni- and partially multicellular. Multicellular organisms arise in various ways, for example by cell division or by aggregation of many single cells. Colonial organisms are the result of many identical individuals joining

together to form a colony. However, it can often be hard to separate colonial protists from true multicellular organisms, because the two concepts are not distinct; colonial protists have been dubbed "pluricellular" rather than "multicellular".

Classification based on Ultrastructure

Prokaryotes

A prokaryote is usually a unicellular organism, sometimes a multi-cellular organism, that lacks a membrane-bound nucleus, mitochondria, or any other membrane-bound organelle The word prokaryote comes from the Greek (pro) "before" and (karyon) "nut or kernel". Prokaryotes are divided into two domains, Archaea and Bacteria. In contrast, species with nuclei and organelles are placed in the third domain, Eukaryota. Prokaryotes reproduce without fusion of gametes. The first living organisms are thought to have been prokaryotes. In the prokaryotes, all the intracellular water-soluble components (proteins, DNA and metabolites) are located together in the cytoplasm enclosed by the cell membrane, rather than in separate cellular compartments. Bacteria, however, do possess protein-based bacterial micro compartments, which are thought to act as primitive organelles enclosed in protein shells.

Eukaryotes

Eukaryotes are organisms whose cells have a nucleus enclosed within membranes, unlike prokaryotes (Bacteria and Archaea). Eukaryotes belong to the domain Eukaryota or Eukarya. Their name comes from the Greek (eu, "well" or "true") and (karyon, "nut" or "kernel"). Eukaryotic cells also contain other membrane-bound organelles such as mitochondria and the Golgi apparatus, and in addition, some cells of plants and algae contain chloroplasts. Unlike unicellular archaea and bacteria, eukaryotes may also be multicellular and include organisms consisting of many cell types forming different kinds of tissue. Animals and plants are the most familiar eukaryotes. Eukaryotes can reproduce both asexually through mitosis and sexually through meiosis and gamete fusion. In mitosis, one cell divides to produce two genetically identical cells. In meiosis, DNA replication is followed by two rounds of cell division to produce four haploid daughter cells. These act as sex cells (gametes). Each gamete has just one set of chromosomes, each a unique mix of the corresponding pair of parental chromosomes resulting from genetic recombination during meiosis.

Classification based on Energy and Carbon Utilization

Autotrophs

An autotroph or producer, is an organism that produces complex organic compounds (such as carbohydrates, fats, and proteins) from simple substances present in its surroundings, generally using energy from light (photosynthesis) or inorganic chemical reactions (chemosynthesis). They are the producers in a food chain, such as plants on land or algae in water (in contrast to heterotrophs as consumers of autotrophs). They do not need a living source of energy or organic carbon. Autotrophs can reduce carbon dioxide to make organic compounds for biosynthesis and also create a store of chemical energy. Most autotrophs use water as the reducing agent, but some can use other hydrogen compounds such as hydrogen sulfide. Some autotrophs, such as green plants and algae, are phototrophs, meaning that they

convert electromagnetic energy from sunlight into chemical energy in the form of reduced carbon.

Heterotrophs

A heterotroph (Ancient Greek héteros = "other" plus trophe = "nutrition") is an organism that cannot produce its own food, relying instead on the intake of nutrition from other sources of organic carbon, mainly plant or animal matter. In the food chain, heterotrophs are primary, secondary and tertiary consumers, but not producers. Ninety-five percent or more of all types of living organisms are heterotrophic, including all animals and fungi and some bacteria and protists. The term heterotroph arose in microbiology in 1946 as part of a classification of microorganisms based on their type of nutrition. The term is now used in many fields, such as ecology in describing the food chain. Heterotrophs may be subdivided according to their energy source. If the heterotroph uses chemical energy, it is a chemoheterotroph (e.g., humans and mushrooms). If it uses light for energy, then it is a photoheterotroph (e.g., green non-sulfur bacteria).

Lithotropes

Lithotrophs are a diverse group of organisms using inorganic substrate (usually of mineral origin) to obtain reducing equivalents for use in biosynthesis (e.g., carbon dioxide fixation) or energy conservation (i.e., ATP production) via aerobic or anaerobic respiration. Known chemolithotrophs are exclusively microorganisms; no known macrofauna possesses the ability to use inorganic compounds as energy sources. Macrofauna and lithotrophs can form symbiotic relationships, in which case the lithotrophs are called "prokaryotic symbionts". An example of this is chemolithotrophic bacteria in giant tube worms or plastids, which are organelles within plant cells that may have evolved from photolithotrophic cyanobacteria-like organisms. Lithotrophs belong to either the domain Bacteria or the domain Archaea. The term "lithotroph" was created from the Greek terms 'lithos' (rock) and 'troph' (consumer), meaning "eaters of rock".

Classification based on Nitrogenous Excretion

Digestion of food and catabolism of protein result in the production of wastes, including various nitrogen-containing products, particularly ammonia, urea, and uric acid. Prolonged dehydration leads to accumulation of nitrogen waste, which causes death if not removed or diluted. The nitrogen compounds through which excess nitrogen is eliminated from organisms are called nitrogenous wastes or nitrogen wastes. They are ammonia, urea, uric acid, and creatinine. All of these substances are produced from protein metabolism. In many animals, the urine is the main route of excretion for such wastes; in some, the faeces is.

Ammonotelic

Ammonotelism is the excretion of ammonia and ammonium ions. Ammonia (NH_3) forms with the oxidation of amino groups. ($-NH_2$), which are removed from the proteins when they convert into carbohydrates. It is a very toxic substance to tissues and extremely soluble in water. Only one nitrogen atom is removed with it. A lot of water is needed for the excretion of ammonia, about 0.5 L of water is needed per 1 g of nitrogen to maintain ammonia levels in the excretory fluid below the level in body fluids to prevent toxicity. Thus, the marine organisms excrete ammonia directly into the water and are called ammonotelic. Ammonotelic animals

include protozoans, crustaceans, platyhelminths, cnidarians, poriferans, echinoderms, and other aquatic invertebrates.

Ureotelic

The excretion of urea is called ureotelism. Land animals, mainly amphibians and mammals, convert ammonia into urea, a process which occurs in the liver and kidney. These animals are called ureotelic. Urea is a less toxic compound than ammonia; two nitrogen atoms are eliminated through it and less water is needed for its excretion. It requires 0.05 L of water to excrete 1 g of nitrogen, approximately only 10% of that required in ammonotelic organisms.

Uricotelic

Uricotelism is the ridding of excess nitrogen using uric acid. This method is used by birds and diapsids, insects, lizards, and snakes, and these animals are uricotelic. Uric acid is less toxic than ammonia or urea. It contains four nitrogen atoms and only a small amount of water (about 0.001 L per 1 g of nitrogen) is needed for its excretion. Uric acid is the least soluble in water and can be stored in cells and body tissues without toxic effects. A single molecule of uric acid can remove four atoms of nitrogen making uricotelism more efficient than ammonotelism or ureotelism. Uricotelic organisms typically have white pasty excreta. Some mammals including humans excrete uric acid as a component of their urine but it is only a small amount.

Classification based on Habitata

Aquatic

An aquatic ecosystem is an ecosystem in a body of water. Communities of organisms that are dependent on each other and on their environment live in aquatic ecosystems. The two main types of aquatic ecosystems are marine ecosystems and freshwater ecosystems.

Marine ecosystems are among the largest of Earth's aquatic ecosystems and are distinguished by waters that have a high salt content. These systems contrast with freshwater ecosystems, which have a lower salt content. Marine waters cover more than 70% of the surface of the Earth and account for more than 97% of Earth's water supply and 90% of habitable space on Earth. Marine ecosystems include near shore systems, such as the salt marshes, mudflats, sea grass meadows, mangroves, rocky intertidal systems and coral reefs. They also extend outwards from the coast to include offshore systems, such as the surface ocean, pelagic ocean waters, the deep sea, oceanic hydrothermal vents, and the sea floor. Marine ecosystems are characterized by their associated biological community of interacting organisms and their physical environment.

Freshwater ecosystems are a subset of Earth's aquatic ecosystems. They include lakes and ponds, rivers, streams, springs, Bogs, and wetlands. They can be contrasted with marine ecosystems, which have a larger salt content. Freshwater habitats can be classified by different factors, including temperature, light penetration, nutrients, and vegetation. Freshwater ecosystems can be divided into lentic ecosystems (still water) and lotic ecosystems (flowing water) Limnology (and its branch freshwater biology) is a study about freshwater ecosystems. It is a part of hydrobiology. Original attempts to understand and monitor freshwater ecosystems were spurred on by threats to human health (ex. Cholera

outbreaks due to sewage contamination). Early monitoring focused on chemical indicators, then bacteria, and finally algae, fungi and protozoa.

Terrestrial

A terrestrial ecosystem is a type of ecosystem found only on biomes. Seven primary terrestrial ecosystems exist: Tundra, Taiga, temperate deciduous forest, tropical rain forest, grassland , deserts. A community of organisms and their environment that occurs on the land masses of continents and islands. Terrestrial ecosystems are distinguished from aquatic ecosystems by the lower availability of water and the consequent importance of water as a limiting factor. Terrestrial ecosystems are characterized by greater temperature fluctuations on both a diurnal and seasonal basis than occur in aquatic ecosystems in similar climates. The availability of light is greater in terrestrial ecosystems than in aquatic ecosystems because the atmosphere is more transparent in land than in water. Gases are more available in terrestrial ecosystems than in aquatic ecosystems. Those gases include carbon dioxide that serves as a substrate for photosynthesis, oxygen that serves as a substrate in aerobic respiration, and nitrogen that serves as a substrate for nitrogen fixation. Terrestrial environments are segmented into a subterranean portion from which most water and ions are obtained, and an atmospheric portion from which gases are obtained and where the physical energy of light is transformed into the organic energy of carbon-carbon bonds through the process of photosynthesis.

Classification based on Molecular Taxonomy

Molecular Taxonomy is the classification of organisms on the basis of the distribution and composition of chemical substances in them. Molecular techniques in the field of biology have helped to establish genetic relationship between the members of different taxonomic categories DNA and protein sequencing, immunological methods, DNA-DNA or DNA-RNA hybridization methods are more informative in the study of different species. The data obtained from such studies are used to construct phylogenetic trees. Fitch and Margoliash, in 1967, made first phylogenetic tree based on molecular data. This tree was so close to the already established phylogenetic trees of the vertebrates that the taxonomists realized significance of molecular data and this made them understand that other traditional methods are although important but molecular evidences could be final or confirmatory evidences.

Model Organisms

A model organism is a species that has been widely studied, usually because it is easy to maintain and breed in a laboratory setting and has particular experimental advantages. Model organisms are non-human species that are used in the laboratory to help scientists understand biological processes. They are usually organisms that are easy to maintain and breed in a laboratory setting. For example, they may have particularly robust embryos that are easily studied and manipulated in the lab, this is useful for scientists studying development, or they may occupy a pivotal position in the evolutionary tree, this is useful for scientists studying evolution.

In researching human disease, model organisms allow for better understanding the disease process without the added risk of harming an actual human. The species chosen will usually meet a determined taxonomic equivalency to humans, so as to react to disease or its treatment in a way that resembles human physiology as needed. Although biological activity

in a model organism does not ensure an effect in humans, many drugs, treatments and cures for human diseases are developed in part with the guidance of animal models.

Many model organisms can breed in large numbers. Some have a very short generation time, which is the time between being born and being able to reproduce, so several generations can be followed at once. Mutants allow scientists to study certain characteristics or diseases. These are model organisms that have undergone a change or mutation in their DNA that may result in a change in a certain characteristic. Some model organisms have similar genes or similar-sized genomes to humans. Model organisms can be used to create highly detailed genetic maps: Genetic maps are a visual representation of the location of different genes on a chromosome, a bit like a real map but one where the key landmarks are areas of interest in the genome. For example, areas of DNA that differ between individuals in the same species (SNPs) or genes. Therefore, model organisms are useful in genetic research.

Escherichia coli

E. coli is the first choice for researchers to investigate numerous basic biological processes which are essential for life and is the most extensively used organism in molecular genetics. The reason of widespread use of E. coli for study purpose is the ease of its maintenance and breeding in a laboratory environment plus its meticulous experimental advantages. As compared to other living organisms more is known about E. coli because of its simple nutritional requirements, rapid growth rate and most important it's well established genetics. Rate of cell division of E. coli is average of once in every 30 min, thus enabling quick environmental adaptation. This fast division rate of E. coli has helped in evolutionary experiments which are conducted in the laboratories.

Saccharomyces cerevisiae

Saccharomyces cerevisiae is a species of yeast. It is one of the most intensively studied eukaryotic model organisms in molecular and cell biology. It is the microorganism behind the most common type of fermentation. *S. cerevisiae* has developed as a model organism because it scores favourably on a number of these criteria. *S. cerevisiae* has been highly studied as a model organism to better understand aging for more than five decades and has contributed to the identification of more mammalian genes affecting aging than any other model organism. Some of the topics studied using yeast are calorie restriction, as well as in genes and cellular pathways involved in senescence.

Drosophila melanogaster

Drosophila melanogaster is a species of fly (the taxonomic order Diptera) in the family Drosophilidae. The species is known generally as the common fruit fly (though inaccurately) or vinegar fly. *D. melanogaster* is typically used in research because it can be readily reared in the laboratory, has only four pairs of chromosomes, breeds quickly, and lays many eggs. Its geographic range includes all continents, including islands. *D. melanogaster* is a common pest in homes, restaurants, and other places where food is served. *D. melanogaster* remains one of the most studied organisms in biological research, particularly in genetics and developmental biology. *D. melanogaster* was among the first organisms used for genetic analysis, and today it is one of the most widely used and genetically best-known of all eukaryotic organisms. All organisms use common genetic systems; therefore,

comprehending processes such as transcription and replication in fruit flies helps in understanding these processes in other eukaryotes, including humans. A study by National Human Genome Research Institute comparing the fruit fly and human genome estimated that about 60% of genes are conserved between the two species. About 75% of known human disease genes have a recognizable match in the genome of fruit flies, and 50% of fly protein sequences have mammalian homologs. An online database called Homophila is available to search for human disease gene homologues in flies and vice versa. *Drosophila* is being used as a genetic model for several human diseases including the neurodegenerative disorders Parkinson's, Huntington's, spin cerebellar ataxia and Alzheimer's disease.[41] The fly is also being used to study mechanisms underlying aging and oxidative stress, immunity, diabetes, and cancer, as well as drug abuse.

Caenorhabditis elegans

Caenorhabditis elegans is a free-living, transparent nematode, about 1 mm in length, that lives in temperate soil environments. It is the type species of its genus. The name is a blend of the Greek *caeno-* (recent), *rhabditis* (rod-like) and Latin *elegans* (elegant). *C. elegans* is an unsegmented pseudo coelomate and lacks respiratory or circulatory systems. *C. elegans* is used as a model organism for the investigation primarily of neural development in animals. It is one of the simplest organisms with a nervous system. *C. elegans* has been a model organism for research into ageing; for example, the inhibition of an insulin-like growth factor signaling pathway has been shown to increase adult lifespan threefold; while glucose feeding promotes oxidative stress and reduce adult lifespan by a half. *C. elegans* has been instrumental to identify the functions of genes implicated in Alzheimer's disease, such as presenilin.

Arabidopsis thaliana

Botanists and biologists began to research *A. thaliana* in the early 1900s, and the first systematic description of mutants was done around 1945. *A. thaliana* is now widely used for studying plant sciences, including genetics, evolution, population genetics, and plant development. Although *A. thaliana* has little direct significance for agriculture, it has several traits that make it a useful model for understanding the genetic, cellular, and molecular biology of flowering plants.

Mus musculus

Mus musculus) is a small mammal of the order Rodentia, characteristically having a pointed snout, large rounded ears, and a long and hairy tail. It is one of the most abundant species of the genus *Mus*. Although a wild animal, the house mouse has benefited significantly from associating with human habitation to the point that truly wild populations are significantly less common than the semi-tame populations near human activity. The house mouse has been domesticated as the pet or fancy mouse, and as the laboratory mouse, which is one of the most important model organisms in biology and medicine. Mice are the most commonly used mammalian laboratory animal, due to their relatively close relationship, and associated high homology, with humans, their ease in maintenance and handling, and their high rate of reproduction. Laboratory mice typically belong to standardized inbred strains selected for the stability or clarity of specific harmful mutations. This allows research with laboratory mice to

easily restrict genetic and biological variables, making them very useful model organisms in genetic and medicinal research.

Tutorial

1. Write a note on the importance of classification in biology.
2. Explain the term binominal nomenclature.
3. List various criteria for classification of organisms.
4. Explain in detail the classification based on nitrogenous excretion.
5. Write a note on the concept of model organism in biology.
6. Why is E. coli the most extensively used model organism in molecular genetics? Explain in brief.

***