

- Life can be defined as unique complex organization of molecules expressing itself through chemical reactions (metabolism) which lead to growth, development, responsiveness, adaptation and reproduction.
- Living things possess certain characteristics, which makes them different from non-living things.

CHARACTERISTICS OF LIVING BEINGS

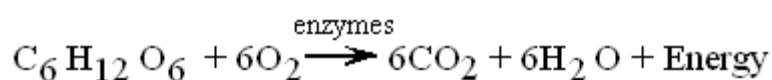
Characteristics of living beings are as follows

I) METABOLISM

- Metabolism is a process by which all living things assimilate energy and use it for various purposes like growth, movement, development, responsiveness, reproduction, etc
- Chemical reactions are classified into catabolism and anabolism

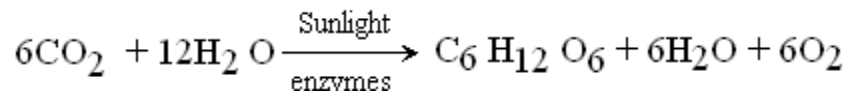
Catabolic activities

- (i) Catabolic activities release energy
- (ii) Energy liberating reactions are termed as 'exergonic'
- (iii) These are some total of breakdown or destructive process.
- (iv) These reactions from simple substances from complex ones



Anabolic activities

- (i) Anabolic reactions store energy.
- (ii) Energy absorbing reactions are termed as 'endergonic'.
- (iii) These are some total of building up or constructive process.
- (iv) These reactions produce complex molecules from the simpler ones.



- However, some of the metabolic reaction can be carried outside living system. Isolated metabolic reactions 'in vitro' are not living things, but are living reactions.

Growth

- All living organisms show growth either by multiplication or by increase in size. It is an irreversible increase in mass of individual.
- For larger organisms, growth is related to the development of new parts either in between or within the older ones. Thus, a sort of internal growth is visible in living beings.
- Two types of cells are produced by cells, i.e. apoplastic and protoplactic. Protoplactic substances are components of living matter like cytoplasm and nucleus. Apoplastic substances are non-living material formed by the cells which becomes components of tissue, e.g. cell wall, fibres of connective tissue, matrix of bone and cartilage. So, we can say growth is common characteristic feature of all living beings.
- Plants grow throughout their life while animals grow for a certain period only. Although some non-living things like mountains, sand mounds and crystal also grow, but their growth is due to the addition of matter from outside. This process is called accretion.

REPRODUCTION

- It is formation of new individuals of similar kind either by asexual (uniparental) or sexual (biparental) mode. This is required for perpetuation of a population/ species and also help in passing on traits from one generation to the next. Although some organisms live for a very long time, no organisms lives forever. Because all organisms dies one

day, ongoing life is impossible without reproduction. Thus the process of reproduction is essential for the continuity of life on the earth.

- Fungi reproduces asexually producing millions of asexual spore, while yeast, Hydra multiply by budding.
- Planaria exhibit true regeneration by fragmentation. In amoeba, growth and reproduction are synchronized. When repeated reproduction is there in life cycle of any organism at regular interval it is called iteroparity.
- Although reproduction and metabolism are most important features of living beings, but when we compare these two the importance of metabolism comes first. It is due to this reason that we do not include viruses in living beings inspite of the fact that viruses have power of reproduction.
- All organisms consists of one or more cells, i.e. complex organized assemblage of molecules in the form of cell organelles enclosed within the biological unit membranes. So cellular structures is a defining property of living beings cells are made of living matter called protoplasm. Cell work together in hierarchical manner to form tissues organ and organ systems.

RESPONSIVENESS

- All organisms respond to external stimuli which can be physical, chemical or biological and this property is called irritability. The stimulus response may be either simple (e.g. movement of an organism towards alight source) or quite complex such as responding to a complicated series of signals in mating ritual.
- Stimuli are perceived by sense organs in animals, but plants can response to external factors like light, water, temperature, pollutants etc. Both plants and animals respond to photo periods which influence their reproduction cycles as well. Actually, all living phenomena are due to underlying interaction.

- The properties of tissues are not present in the constituent cells, however, arise as a result of interactions among component cells. The appearance of new characteristic at a given level of organization is called emergence and these properties are called emergent properties.

NUTRITION

- All living organisms need food. The food is used as a source of energy and materials for the processes of life such as growth. Light and chemical energies are used by all the living organism. Those organisms specialized for using light energy carry out photosynthesis e.g. plants, algae and photosynthetic bacteria. The organisms which use chemical energy, always depend on other living organisms, e.g. humans, animal and non-green plants i.e. fungi.

RESPIRATION

- All life processes require energy and much of it is food obtained by the nutrition which is used as a source of this energy. The energy is released during the breakdown of certain energy rich compounds in the process of respiration.
- The energy is stored in ATP (Adenosine tri phosphate), a compound known to occur in all living cells and is referred to universal energy carrier.

MOVEMENT

- Animals and some unicellular forms have the ability to move from place to place, called as locomotion. This is necessary to obtain their food, shelter and mate. Plants lacks locomotion. Nevertheless, some movements of part of body structure can be seen in plants. E.g. roots move in search of water under the soil or flower closes at night etc.

Excretion

- Excretion is the removal of waste products from the body. Every living cell, whether it exists independent or as part of a multicellular organism, must eliminate waste products otherwise it might poison the body, if stored inside.
- For example, the process of aerobic respiration produces a waste product CO_2 (carbon dioxide) and must be eliminated because it can be harmful in excess. Animals take in food during nutrition, this material breaks down during metabolism and need to be excreted.

HOMEOSTASIS

- It is a property of all living organisms homoiois –alike, stasis – standing. Maintenance of a favorable dynamic constancy of internal environment despite changes in the external environment is called homeostasis.
- It is carried out by regulatory mechanisms which coordinate internal functions such as providing nutrients to cells and transporting substances. Some organisms attain, homeostasis by adapting to change in temperature, salinity and other aspects of environment
- This process occurs at all levels i.e. from cellular level to ecosystem level. The term 'homeostasis' are used by Cannon (1932)
- Most of the known modes of homeostasis occur through
 1. Maintenance of an internal environment
 2. Self –regulatory mechanisms using genetic clock
 3. Feedback system (in which the rate of the product formation is regulated by gathering information about the amount left out at any time). They generally involve switching on and switching off mechanism operating at different levels in all organism.

DEATH

- Ageing is a progressive deterioration of structure and function of cells, tissues and vital organs so, that the ability to repair and resist disease declines. It leads to death. Death is stoppage of life activities in an individual due to degeneration of body parts and increase in entropy.
- In nature, death occurs due to ageing predation, accident or disease.
- Biological death occurs when brain and other body parts begin to degenerate due to non-availability of nutrients and oxygen.
- Clinical death is characterized by stoppage of vital functions like pulse, heart beat and breathing etc. Death is essential for keeping a population under check and recycling of minerals.

DIVERSITY IN THE LIVING WORLD

- The planet earth is full of variety of animals and plants. This refers to biodiversity. Every distinct geographical location has its own set of flora and fauna. Each different kind of plant, animal or organism represent a species.
- The number of species that are known and described range between 1.7 - 1.8 million. The number of known species are increasing day-by-day because of projects like Global Biodiversity information facility and species 2000.
- The estimated number of living organism on earth is now between 5-30 million, most occurring in dense tropical rain forests and under water reefs.

IDENTIFICATION

- It is about finding a correct name and place of an organism with the help of identification keys and comparing similarities and dissimilar comparing similarities with already known organism

CLASSIFICATION

- By observing the fundamental characteristics of organism and their comparison with the organism already known, we include the new organism in special class or group which represent distinct biological entities. John Ray developed the key for identification.

NOMENCLATURE

- It is a science of providing distinct and proper names to organism so that they can easily be recognized and differentiated from others.
- These are the names given to the organisms by biologists based on agreed principles and criteria for their acceptability all over the world. These are

(i) Polynomial system of nomenclature : Prior to 1750, biologists used descriptive names for organisms with each name being made up of several Latin words e.g. 'Caryophyllumsaxnatilis, Folisgramineus, umbellatiscorymbis' (Caryophyllum growing on rocks having grass-like leaves and umbellate corymb flower)

(ii) Trinomial system of nomenclature: Sometimes, binomial nomenclature can also be extended to trinomial system of nomenclature, where the names of sub species or varieties can be incorporated. E.g, Brassica oleracea botrytis.

(iii) Binomial system of nomenclature.

- This system was proposed by C Linnaeus in 1753 in his book species Plantarum. Though the idea of binomial nomenclature was first introduced by Gaspard Bauhin.
- As per this system, name of any organism consists of two parts or epithets i.e. Generic epithet and Specific epithets E.g. Botanical name of Mango is *Mangifera indica* in which *mangifera* is generic epithet, which

represents its genus and *indica* is specific epithet which represents its species.

- The following rules are followed for Binomial Nomenclature as given below
 - (a) Names are in Greek or Latin language.
 - (b) Names are in begins with Capital letters (Mangifera) and is placed before specific name small letters (indica)
 - (c) The scientific name should be either underlined in case of hand written or italicized if printed
 - (d) Name of the authority should be written after specific epithet in an abbreviate form.

TAXONOMY

- It is the branch of study that deals with principles and procedure and classification code for Botanical nomenclature (ICBN) has developed a system for identification and classification of plants. Similarly international code of zoological nomenclature (ICZN) has developed a system for identifying and classifying the animals. The term 'Taxonomy' was given by deCandolle (1813).

BRANCHES OF TAXONOMY

Varous branches of taxonomy are as follows:

- (i) Classical taxonomy or α -taxonomy or old systematic is based on the morphological traits.
- (ii) Artificial taxonomy makes use of habit and habitat of organisms. Pling used this system first time
- (iii) Practical taxonomy is based on the utility of organisms
- (iv) Natural taxonomy is based on natural, similarities amongst organisms

- (v) Phylogeny or evolutionary history of a species.
- (vi) Experimental taxonomy is based on experimental determination of genetic inter-relationship
- (vii) Chemotaxonomy is based on the presence or absence of chemical in cells or tissues.
- (viii) Numerical taxonomy is based on the number of shared characters of various organisms. It is also called phenetic or Adansonian classification
- (ix) Cytotaxonomy is based on cytological studies.
- (x) Karyotaxonomy is based on nuclear and chromosomal studies
- (xi) Morphotaxonomy is based on morphological studies of organisms

Note

- ICBN – International code of Botanical Nomenclature.
- ICZN – International code of zoological Nomenclature.
- ICNB – International code for Nomenclature of Bacteria.
- ICNCP – International code for Nomenclature of cultivated Plants
- ICTV – International Committee on Taxonomy of Viruses

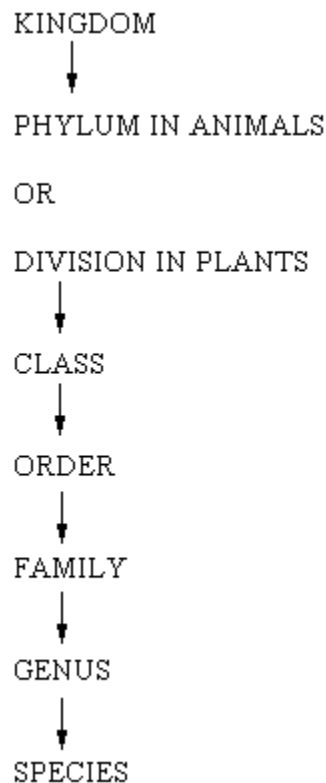
TAXON

- A taxon is a taxonomic group belonging to any rank in a given system of classification. The term 'taxon' was introduced for the first time by ICBN in 1956.
- Mayr(1964) defined taxon to be taxonomic group of any rank that is sufficiently distinct to be worthy of being assigned a definite category.

SYSTEMATIC HIERARCHY

- The systematic is the analytical approach to understand the diversity and relatedness of organisms.

- The system by which various taxonomic categories are arranged in a proper descending order is called taxonomic or systematic hierarchy



- Kingdom is the highest rank and species is the lowest or basic rank.
- Hierarchy of categories is also called Linnaean hierarchy because it was first proposed by Carolus Linnaeus.

SPECIES

- Species is the fundamental or smallest unit of classification. The concept of species was proposed by John Ray. The definition of species is given by Ernst Mayer
- Species is a group of individuals which resemble each other in morphological, physiological, biochemical and behavioral characters. These individuals are capable of inbreeding freely in between themselves under natural conditions, but are incapable of breeding with the membranes of other species is an important boundary between different species.

GENUS

- Genus comprises a group of related species, which have more common characters in comparison to the species of another genera. Hence genera are aggregates of closely related species. For example , potato (*Solanumtuberosum*), tomato (*Solanumlycopersicum*) and brinjal (*Solanumnigrum*) are three different species but all belong to the genus *Solanum*.
- Some genera have only one species and is called monotypic, whereas others have a large number of closely related species and are called polytypic

FAMILY

- Family is a taxonomic category, which contains a group of related genera with still less number of similarities as compared to the genus and species. All genera of a family have some common features and are separated by some important characteristic difference.
- Families are characterized on the basis of both vegetative and reproductive features of plant species. Among plants, for example 3 different genera *Solanum*, *Petunia* and *Datura* are placed in the family- *Solanaceae*.

ORDER

- An order includes a group of related families. Generally, order and other higher taxonomic categories are identified based on the aggregates of characters. Order is an assemblage of families, which exhibit a few similar characters. The similar characters are less in numbers as compared to different genera included in a family.
- Plant families like convolvulaceae, Solanaceae are included in the order. Polymoniales mainly based on the floral characters.

CLASS

- Class is group of related order. For example, order-primata comprising monkey, gorilla and gibbon is placed in class-mammalia alongwith order carnivore that includes animals like tiger, cat and dog.

PHYLUM

- Phylum is group of classes, Phylum Chordata comprises animal like fishes, amphibians, reptiles, birds along with mammals. All these are included in Phylum chordate, based on common features like the presence of notochord and dorsal hollow neural system.
- In case of plants, classes with a few similar characters are assigned to a higher category called division.

KINGDOM

- Kingdom is the highest taxonomic category. All the plants are included in kingdom-plantae, while all animals to kingdom-Animalia

TAXONOMICAL AIDS

- Biologist use herbarium, botanical gardens, museums, zoological park. Flora, fauna and keys in taxonomical studies.

HERBARIUM

- A herbarium is a collection of plants which have been dried, pressed, mounted on herbarium sheets, identified and classified according to any universally accepted system of classification (mostly Bentham and Hooker)
- A herbarium sheet carries label providing information about data and place of collection, English, local and botanical names, family, collector's name etc.

BOTANICAL GARDEN

- A botanical garden is essentially a collection of living plants maintained for both pure and applied studies.
- The botanical gardens play the following roles
 - (i) On site teaching: Collection of plants is often displayed according to the families, genera or habitats and can be used for self-instruction or demonstration purposes
 - (ii) Conservation” Botanical gardens are now gaining more importance for their role in conserving genetic diversity and rare, endangered species.
 - (iii) Aesthetic appeal: Botanical gardens have an aesthetic appeals and attract large number of visitors from the observation of general plant diversity as also the curious plants.
 - (iv) Material for Botanical garden: Botanical gardens generally have a wide range of species growing together and offer ready material for botanical research, which can go a long way in understanding taxonomic affinities.
 - (v) Seed exchange: More than 500 botanical gardens of the world operate an informal seed exchange scheme, offering annual lists of available species and a free exchange of seeds.
- Major Botanical gardens of the world are as follows
 - (a) New York Botanical garden, USA
 - (b) Royal Botanical Garden, Kew, England
 - (c)Pisa Botanical Garden, Italy
 - (e) Berlin Botanical garden and museum, Berlin – Dahlem
 - (f) Cambridge University Botanical Garden USA
- Major Botanical gardens of India are
 - (a) Indian Botanical Garden, Sibpur, Kolkata, was established in 1787. It has an area of 273 acre

(b) National Botanical Garden, Lucknow now known as National Botanical Research Institute

MUSEUMS

- Museums have collection of preserved plants and animal specimens for the study and reference.
- Some important museums are listed below
 - a) Natural History Museum, London (England)
 - b) United states National Museum, Washington (USA)
 - c) Field Museum of Natural, History, Chicago (USA)
 - d) Musee de l'Homme, Paris (France)
 - e) Zoology Museum, Amsterdam
 - f) Prince of Wales museum, Mumbai
 - g) Indian Museum, Kolkata
 - h) National Meseum of Natural History (NMNH) Delhi
 - i) MaharajaSawai Man Singh(II) museum,Jaipur
 - j) Forest Museum, Andaman and Nicobar Islands.

ZOOLOGICAL PARK

- Zoological parks (Zoos) are the places where wild animals are kept in protected environments under human care and which enable us to learn about their food habits and behavior some common zoos of India are listed below
 - (i) Nehru Zoological Park, Hyderabad
 - (ii) Zoological garden, Alipore, Kolkata.
 - (iii) Himalayan zoological Park, Gangtok
 - (iv) National zoological Garden, Delhi
 - (v) Kamala Nehru Zoological Garden, Ahemdabad
 - (vi) Prince of Wales zoological Park, Lucknow

KEYS

- Keys is taxonomical aid used for the identification of plants and animals based on the similarities and dissimilarities. The keys are based on the contrasting characters generally in a pair called couplet.
- It represents the choice made between two opposite options. Each statement in the key is called a lead.

MONOGRAPH

- A monograph is a comprehensive treatment of a taxon in biological taxonomic of any one taxon.
- The first ever monograph of a plant taxon was given in Robert Morison, 1672 *Plantarum Umbelliferum Distribution Nova*.

SYSTEMS OF CLASSIFICATION

These systems can be categorized into three main types

- i) Artificial system of classification
- ii) Natural system of classification
- iii) Phylogenetic system of classification

ARTIFICIAL SYSTEM OF CLASSIFICATION

- The first attempt of classifying plants was made by Theophrastus, the father of Botany. He classified about 450 plants on the basis of form and texture in his book *Historia Plantarum*. He classified them into herbs, under-shrubs, shrubs and trees. He also distinguished between annual, biennial and perennial plants, also noted the difference between

centripetal and centrifugal inflorescences, epigynous, perigynous and hypogynous corolla and monocot and dicot plants

- Carolus Linnaeus is the father of modern Botany. He followed the binomial system of nomenclature describing hundreds of plants from various parts of the world. His important works were *Species Plantarum* and *Flora Lapponica*. He proposed an artificial sexual system of classification in *System Natural* (1735) containing twenty four classes. The system was based on the number, cohesion length and various other characters of the stamens.

NATURAL SYSTEM OF CLASSIFICATION

- A natural system of classification was proposed by the French botanist A.P. de Candolle in his work *Theories elementaire de la Bontanique* (1818). This system provided the base for Bentham and hooker's Classification. He divided the plants into Cellulares (algal to bryophytes) and Vasculares (pteridophytes to angiosperms) which were further divided into classes and orders.
- D.de. Jussieu (1699 -1776) was not satisfied of classification and modified it into a natural one. He divided the flowering plants into groups on the basis of monocots, dicots, ovary positions, presence or absence of petals. His opinions were published by his new nephew A.L. de Jussieu in *Genera Plantarum* (1789). He divided plants into 15 classes based mainly on the number and positions of cotyledons and adhesion of petals.
- George Bentham and J.D. Hooker gave most important system of classification of angiosperms and published it in three volumes of '*Genera Plantarum*'. They described 202 families. In this system description of plants was based on their detailed studies and dissections. It is widely acceptable and all British Commonwealth countries including India widely follow this system for practical purpose and hence it is called practical classification

PHYLOGENETIC SYSTEM OR CLADISTICS

- Biologists are now developing new approaches using taxonomic affinity based on evolutionary as well as genetic relationship amongst organism besides morphology. They ignore the morphological similarity or differences. This system of classification is designated as phylogenetic classification or cladistia.
- This system is based on evolutionary sequence as well as the genetic relationship among the living beings. It reflects the true relationship among the organism.