

## The Living world

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- \* Living organisms are of various types which inhabit in different places right from cold mountains to hot springs. These organisms of a place belonging to same and different species cooperate and conflict among themselves.

### Features of Living organisms

- \* Living organisms show growth, reproduction, metabolism, sensing the surroundings, Interactions, excretion etc.
- \* **Growth** is defined as increase in number and mass of individuals. Unicellular organisms grow in size before they divide. Increase in number of cells in unicellular forms is both growth and reproduction which can be noticed by counting the number of cells under microscope as in case of bacteria.
- \* Multicellular organisms grow by cell division. Plant growth is continuous as long as it lives. Animals show growth only upto certain stage. But cell divisions occur to replace the lost cells.
- \* In living organisms growth is inside. Growth of non-living organisms is not interior but it is exterior due to deposition of materials on the surface of existing material. Hence growth is the feature of both living and non-living beings.
- \* **Reproduction** is formation of new individuals from the existing individuals. It is exclusive feature of living organisms.
- \* Worker Bees, Mules and infertile humans are incapable to reproduce.
- \* Reproduction may be **vegetative, asexual** and **sexual**.
- \* Vegetative reproduction is production new individuals without the formation of seeds and spores. In this parental cell wall becomes a part of daughter cells. It is common among plants. It takes place by fragmentation in filamentous algae and fungi, hydrophytes like Hydrilla and protonema of Mosses. It occurs as budding in lower animals like Hydra and fungi like yeasts. Fragmentation is breakage of vegetative structure into small segments and development of each segment as complete organism upon repeated division. Budding is pinching off of smaller individuals from the parental individuals. Grafting, cutting, vegetative apomixis, layering, division and tissue culture are other types of vegetative reproductions.
- \* Asexual reproduction is production of new individuals from a single parent usually spore formation. It is also called as **Agamogenesis**. In this usually the parental cell wall is not involved only the protoplast is involved. Usually unicellular organisms and sometimes multicellular organisms reproduce by this method. Zoospores, Aplanospores, Conidia, Chlamydo spores, and Akinetes are various types of asexual spores. Fungi and most of the algae reproduce by spore formation.
- \* Sexual reproduction is production of offspring due to union of cells or gametes.
- \* In unicellular organisms like Bacteria, Chlamydomonas like algae and animals like Amoeba reproduction is synonymous to growth. In them there is increase in the number of cells.
- \* **Metabolism** is sum of biochemical reactions occurring in an organism or living cell. During this, chemicals of various sizes, shapes, composition are formed and converted to other biomolecules.
- \* All living organisms show metabolism except Viruses.

- \* The metabolic reactions carried out in a test tube but not in a cell or tissue is a living reaction but not a living thing.
- \* Cellular organization is essential for metabolism.
- \* **Irritability** is response of an organism to stimuli. Living organisms sense the environment.
- \* Animals sense the environment with their sense organs.
- \* Plants respond to factors like light, temperature, water, pollutants and other organisms.
- \* Light influences reproduction in seasonal plant and animal breeders.
- \* Consciousness is awareness of organisms to surroundings. It is the property of living organisms. Humans are self-conscious.
- \* **Phenomena** in living organisms are due to **Interactions**.
- \* The properties of tissue are due to interactions among the cells of the tissue. Properties of cell are due to interactions between its cell organelles. Similarly the cell organelle properties are due to interactions between its biomolecules. Molecular interactions occur in macromolecules such as Proteins, Starch, DNA, RNA, Enzymes etc. These interactions at lower levels gradually result in properties at higher levels of organization. This phenomenon is reflected in the hierarchy of organizational complexity at various levels.
- \* All living organisms are linked to each other by sharing DNA as common type of genetic material.

### Diversity in the living World

- \* Our planet has about 1.7 to 1.8 million of species of living organisms.
- \* **Biodiversity** is defined as number and type of organisms present on the earth.
- \* Biodiversity varies from region to region and climate to climate. With increase in area biodiversity also increases. Forests have more biodiversity than any other region.
- \* The living organisms may be microscopic or macroscopic, unicellular or multicellular, differentiated or undifferentiated and have various shapes, live in various habitats, show different nutrition and reproduction methods.
- \* **Identification** is confirmation of collected specimen of living organism whether it is identical or related to other organism or entirely new to science.
- \* Plants are identified with the help of herbarium specimens and keys provided in the Flora.
- \* **Nomenclature** is providing a universally acceptable and used name to an identified organism. For this the organism must be correctly described and identified.
- \* Nomenclature of Plants must be done according the rules provided in International Code for Botanical Nomenclature (ICBN). According to ICBN
  1. Each plant should have only one scientific name. It should be given in Latin or latinised from of other language.
  2. There should not be two different plant species with similar names.
  3. By describing the plant, all around the world should arrive at the same name.
  4. Binomial nomenclatural system given by Linnaeus must be followed for naming the living organisms.
  5. Naming the plant by using two words is called as Binomial nomenclature. A binomial has two components or epithets. The first word denotes the generic name and the second one species name. While writing, the two epithets of binomial must be underlined separately or printed in italics. Underlining or printing in Italics indicates its Latin origin. The generic name must be started with capital letter and species name with small letter.Ex:

*Mangifera indica* is the scientific name of *Mango* plant. In this *Mangifera* is the generic name and *indica* is species name.

6. After the binomial the author's name who named it must be written in abbreviated form.

Ex: *Mangifera indica* Linn. It should not be underlined or printed in italics.

- \* **Classification** is grouping of organisms into various categories based on easily observable characters. Ex: grouping of organisms as dogs, plants, animals shrubs etc.
- \* Each category is technically called as **Taxon**. Taxa include different levels of categories. Plants, Grasses, wheat, monocots are different taxa.
- \* Classification of organisms into different taxa is called as Taxonomy. The components of taxonomy are Characterization, Identification, Classification and Nomenclature.
- \* Early man classified plants based on types of uses of plants to man such as food, clothing and shelter.
- \* **Systematics** is the study of diversity and relationships among different organisms by considering the evolutionary relationships.
- \* Using the word systematics, Linnaeus wrote a book entitled **Systema Naturae**.

### Taxonomic Categories

- \* Classification has a hierarchy (series) of steps in which each step represents a rank or taxonomic category.
- \* All taxonomic categories together form taxonomic hierarchy.
- \* Each category or rank is a unit of classification and called as **Taxon**.
- \* The various common categories are Kingdom, Division or Phylum, Class, Order, Family, Genus and Species. Kingdom is the highest category and species is the lowest category.
- \* **Species** is a group of organisms with fundamental similarities and can interbreed freely. One species can be distinguishable from other related species based on morphological differences. Ex: *indica* in *Mangifera indica*, *tuberosum* in *Solanum tuberosum*, *tabacum* in *Nicotiana tabacum* are species.
- \* **Genus** is a group related species. A genus has either one or more than one species. Species of a genus have several similarities and few differences among them. Ex: Brinjal (*Solanum melongena*) and Potato (*Solanum tuberosum*) belonging to different species of the same genus.
- \* **Family** is a group of related genera with relatively more differences than similarities when compared to species and genus. Both vegetative and reproductive characters are considered for the characterization of Family. Ex: The genera *Solanum*, *Datura*, *Nicotiana* belong to the family Solanaceae.
- \* **Order** is group of related families which have relatively less similarities among them compared to Genera of a family. Ex: Order Polemoniales has families like Convolvulaceae and Solanaceae.
- \* **Class** is a group of related orders. Ex: Polemoniales, Malvales and Rosales are orders of class Dicotyledonae.
- \* **Division** is a group of related classes. Ex: Division Spermatophyta has classes Dicotyledonae and Monocotyledonae of sub division Angiospermae. In case animals the related classes are included in Phylum.
- \* **Kingdom** is a group of related divisions. Ex: Plant Kingdom has divisions Thallophyta, Bryophyta, Pteridophyta and Spermatophyta. Kingdom is the highest category in classification.

- \* In representing the classification of an organism, the various categories are shown in ascending order from Species to Kingdom. From species to kingdom there is gradual decrease in similarities and increase in differences. Lower is the taxon, more are the similarities among the individuals and higher is the taxon more are the differences in determining the relationships to other taxa of the same level and the problem of classification becomes more complex.

Organisms with their Taxonomic Categories						
Common name	Biological Name	Genus	Family	Order	Class	Phylum/ Division
Man	<i>Homo sapiens</i>	<i>Homo</i>	Hominidae	Priamta	Mammalia	Chordata
House Fly	<i>Muscadomestica</i>	<i>Musca</i>	Muscidae	Diptera	Insecta	Arthropoda
Mango	<i>Mangifera indica</i>	<i>Mangifera</i>	Anacardiaceae	Sapindales	Dicotyledonae	Angiospermae
Wheat	<i>Triticum vulgare</i>	<i>Triticum</i>	Poaceae	Poales	Monocotyledonae	Angiospermae

### Taxonomic Aids

- \* Taxonomy is useful in knowing our bio-resources and their diversity. Its studies are useful in Agriculture, Forestry and Industry.
- \* Taxonomic studies require correct identification and classification of organisms.
- \* Identification requires intensive laboratory and field studies.
- \* Collection of actual specimens of living organisms is essential for identification and taxonomic studies.
- \* There are certain procedures and techniques used to store and preserve the information as well as specimens
- \* **Herbarium** is the store house of pressed, dried plant specimens mounted on a sheet for preservation. These sheets are arranged according to a universally acceptable classification. Herbarium sheet also carries a label with the information about date and place of collection, collectors name, English name, local name and botanical name, family name etc. Herbaria serve as quick referral system in taxonomic studies. Royal Botanical Gardens at Kew, England has largest herbarium and it is international center for plant identification. In our country herbaria are maintained in national institutes such as Botanical Survey of India, Howrah and National Botanical Research Institute at Lucknow.
- \* In **Digital herbaria**, the digital images of the herbarium specimens with related information is published on internet for wider use. It provides analogous online facility for identification of plants.
- \* **Botanical garden** is a place with a collection of living plant specimens for reference. Plants are grown in these gardens for identification. Each plant is tagged with label carrying information about its scientific name and family name. The famous botanical gardens are Royal Botanical gardens of Kew, England, Indian Botanical Gardens of Botanical survey of India at Howrah and National Botanical Gardens of National Botanical Research Institute at Lucknow.
- \* Museum is collection of preserved plant and animal specimens for study and reference. These are maintained in Schools and Colleges. Specimens are preserved in containers with preservative

solutions like Formaldehyde, Alcohol and Acetic acid in different proportions. Dry specimens of plant and animals are also maintained in museum.

- \* **Keys** are used for identification of plants and animals based on similarities and differences. These are analytical in nature and separate keys are made for each taxon such as family, genus and species. Key usually has contrasting characters in pairs known as **Couplet**. Each statement in couplet is called as **Lead**. In a Couplet, a choice is made between the two statements. In this one statement is selected for identification and another one is rejected.
- \* Recording descriptions for identification of organisms are also given in another means such as **Flora, Manuals, Monographs** and **Catalogues**.
- \* **Flora** is a book contains information about habitat and distribution of plants of an area. It has index of plants of an area.
- \* **Manuals** provide information about identification of names of species found in an area.
- \* **Monographs** have information about only one taxon.

### Science of Plants

- \* The biophysical and biochemical techniques such as Chromatography, Centrifugation, Electrophoresis and Spectroscopy helped for rapid progress of Biology in the last three decades.
- \* The term Botany is obtained from the Greek word Bouskein which means Cattle feed.

### Development of Botany

- \* Information of Crop plants and Fruit trees was given in the form of Hieroglyphics was given by Egyptians and Assyrians in 4000 B.C.
- \* Chinese learnt the art of Agriculture in 2500 B.C.
- \* Atharvaveda was written in 2000 B.C. by which has information about medicinal plants.
- \* In 1300 B.C. Parasara wrote two books entitled KrishiParasaram and Vrikshayurveda. KrishiParasaram has information about art of Agriculture and weeds and Vrikshayurveda has information about medicinal plants and their uses, 14 different types of forests and external and internal characters of plants.
- \* Botany has emerged as science with the contributions of Greek philosophers Aristotle, Socrates, and Plato.
- \* Theophrastus is regarded as Father of Botany. He wrote a book entitled '*de HistoriaPlantarum*' which has information about 500 different plants.
- \* 16<sup>th</sup> and 17<sup>th</sup> centuries are the renaissance period of Botany. It is the period of Herbalists who wrote the books entitled Herbals.
- \* Bauhin published the description and identification of 6000 plants. He introduced Binomial nomenclature.
- \* Botany has emerged as a specific science during 17<sup>th</sup> century with the discovery of the cell by Robert Hooke. He wrote the book entitled Micrographia.
- \* Anton Van Leeuwenhoek discovered Bacterial cell in living condition.
- \* Nehemiah Grew and Marcello Malpighi laid foundations for Plant Anatomy.
- \* Sexual reproduction in Plants was discovered by Camerarius.
- \* 18<sup>th</sup> century witnessed the progress in Plant Systematics and Plant Physiology.

- \* Carolus Von Linnaeus popularized Binomial Nomenclature and proposed Sexual system of Classification.
- \* Stephen Hales observed the transport of water through xylem and existence of Root Pressure in Plants.
- \* Joseph Priestly discovered the absorption of toxic gases and release of pure gas by green plants.
- \* In 19<sup>th</sup> century considerable progress was achieved in all branches of Botany.
- \* Gregor Johann Mendel carried out hybridization experiments in Pea plant and proposed laws of inheritance. He is regarded as Father of Genetics.
- \* Haeckel carried ecological studies.
- \* De Candolle, Endlicher, Bentham and Hooker proposed different classification systems of Plants.
- \* Charles Darwin gave the theory of Evolution.
- \* Buchner discovered the enzyme Zymase in yeast cells.
- \* During 20<sup>th</sup> century though several branches progressed, much progress was made in Cell biology and Plant Physiology.
- \* Hugo de Vries discovered mutations in plants.
- \* Sutton and Boveri proposed chromosome theory of inheritance.
- \* Watson and Crick gave the double helical structure of DNA.
- \* Genetic nature of RNA was discovered in TMV by Frankel Conrat.
- \* Khorana artificially synthesized gene.
- \* Hanning, Shimakura, Skoog, White, Nitsch and Maheswari made noteworthy contributions in Plant tissue culture.
- \* Electron Microscope was invented by Knoll and Ruska.
- \* Went identified Auxins.
- \* Krebs discovered Citric acid cycle or Tricarboxylic acid cycle.
- \* Sumner crystallised the enzyme Urease.
- \* Robert Hill, Ruben, Arnon, Emerson and others contributed for the understanding of light reaction of photosynthesis.
- \* Melvin Calvin, Benson and Basham discovered C<sub>3</sub> path way of photosynthesis.
- \* Hatch and Slack contribute for tracing the reactions of C<sub>4</sub> pathway of photosynthesis.
- \* Prot. Ramdas and his students contributed for the understanding of C<sub>4</sub> Photosynthesis.
- \* Wodehouse, P.K.K. Nair, C.G.K.Ramanujam developed the science of pollen grains known as Palynology.
- \* Phylogenetic systems of classifications were given by Bessey, Rendle, Hutchinson, Takntajan and Cronquist.

### **Scope of Botany**

- \* With the beginning of human civilization, man domesticated plants.
- \* The demand for food by the ever growing population can be solved through green revolution and by using the techniques of Biotechnology to develop disease and pest resistant crops.
- \* Hybridisation and Genetic engineering techniques can be applied for the progress in Agriculture, Forestry, Horticulture and Floriculture.
- \* Techniques of Plant Breeding are useful to develop hybrid varieties in crops like Rice, wheat, maize, sugar cane etc.

- \* Knowledge obtained about mineral nutrition of plants is useful in using chemical fertilizers in required quantities and controlling mineral deficiencies to improve agriculture productivity.
- \* The knowledge gained about Phytohormones used to control weeds, breaking seed dormancy, enhancing shelf life of leafy vegetables like Spinach, artificial ripening of fruits like Banana, Apple and Watermelon and vegetative propagation of plants through stem cuttings.
- \* The knowledge obtained in Plant Pathology is applied in preventing and eradicating several plant diseases.
- \* Tissue culture studies helped in large scale production of useful plants in the laboratory in limited period and space.
- \* Botany helped to establish Textile, Paper, Pharmaceutical and Sugar industries.
- \* Medicinal plants like Arnica, Cinchona, Neem, Datura, Digitalis, Rauwolfia, Withania, Ocimum, Belladonna, Aloe etc. are exploited for human health care.
- \* By thorough study of plants it has become possible to produce antibiotics like Penicillin, Bio-insecticides and Single cell Proteins like *Spirulina* and *Chlorella*.
- \* Fuels like Coal, Coke, Gasoline, Petrol are past formed products of plants.
- \* Of recent Biodiesel is produced from plants like *Jatropha* and *Pongamia*.
- \* Studies in Botany helped to solve environmental issues like Global warming and Soil pollution by mass tree plantation and Bioremediation, usage of bio-fertilizers like *Azolla*, *Nostoc*, *Anabaena* and *Rhizobium* to minimize soil pollution, preventing soil erosion by growing soil binders.
- \* Algae like *Chlorella* are used as food in space travels. Iodine and Agar-Agar are obtained from Sea weeds.

### Branches of Botany

- \* Due to application of Chemistry and Physics for the study of living organisms new branches such as Bio-Physics, Bio-Chemistry and Molecular Biology have evolved.
- \* The rapid development of Botany in 19<sup>th</sup> and 20<sup>th</sup> centuries resulted in division of Botany into several branches for easy study.
- \* **Morphology** is study and description of various parts of plants. It is fundamental requirement for Plant Taxonomy. It is external and Internal Morphology.
- \* In **External Morphology**, description of external characters of various organs of plants such as roots, stem and leaves are studied.
- \* In **Internal Morphology**, the internal structure of various plant organs is studied. It has two sub-branches Histology and Anatomy.
- \* **Histology** is study of tissues of plant.
- \* **Anatomy** is study of gross internal structure of various organs of plants such as root, stem and root.
- \* **Cytology** is study of structure of cell and cell organelles and their functions.
- \* **Embryology** is the study of development of male and female gametophytes, formation of gametes, fertilization process, and development of embryo, endosperm and seed.
- \* **Palynology** is study of structure and development of pollen grains.
- \* **Plant Taxonomy** or **Systematic Botany** is study of identification, nomenclature and classification of plants into related groups.
- \* **Plant Physiology** is the study of various vital activities of plants like absorption of mineral water, photosynthesis, respiration, nitrogen metabolism, growth etc.

- \* **Plant Ecology** is the study of plants in relation to environment.
- \* **Palaeobotany** is study of fossilized plants. It helps in understanding evolution.
- \* **Genetics** is study of structure, synthesis, role in inheritance and mutations of genes.
- \* **Phytogeography** is distribution of plants on the earth in past and present.
- \* **Plant Pathology** is the study of causes, symptoms of Plant diseases and their control.
- \* **Phycology** is study of chlorophyllous, autotrophic thallophytes.
- \* **Mycology** is the study of achlorophyllous heterotrophic thallophytes.
- \* **Lichenology** is study of lichens or organisms formed by symbiotic association of Algae and Fungi.
- \* **Bryology** is study of Bryophytes or Amphibians of Plant Kingdom.
- \* **Pteridology** is the study of pteridophytes or Vascular Cryptogams.

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