The Living World

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INTRODUCTION

The branch of science that deals with varied life forms micro organisms as well as macroorganisms is called Biology. On earth, life is present in almost all habitats even in some of the most harsh environments as well like hot sulphur springs and snow-covered areas. To deal with such a vast group of organisms related to their conservation and study there is need of adequate classification system. Another requirement for better understanding of formation of life is to set evolutionary relationship with other extant as well as extinct organisms.

What is living?

Life is a unique, complex organisation of molecules expressing itself through chemical reactions (metabolism) reproduction.

Hence, 'the object by itself exhibiting the growth, reproduction, consciousness, and other life processes, etc. and show independent existence in nature is designated as living being'.

Gray Matter Alert!!!

Ernst Mayr (1904–2004)

Born on 5 July 1904, in Kempten, Germany, Ernst Mayr, the Harvard University evolutionary biologist who has been called 'The Darwin of the 20th century', was one of the greatest scientists of all time. He almost single-handedly made the origin of species diversity, a central question of currently accepted definition of a biological species. Mayr was awarded the three prizes widely regarded as the *triple crown* of biology: the *Balzan Prize* in 1983, the *International Prize for Biology* in 1994, and the *Crafoord Prize* in 1999. Mayr died at the age of 100 in the year 2004.

CHARACTERISTICS OF LIVING BEINGS

All the living beings share certain unique and basic characteristics which set them apart from non-living objects. Some of these characteristics are listed below:

- Growth
- Reproduction
- Metabolism
- Cellular organisation
- Consciousness

Growth

- Growth refers to irreversible increase in mass or overall size of a tissue, an organism, or its parts.
- Growth occurs when anabolism or synthetic processes exceed catabolism.
- Increase in mass of cells and increase in number of cells are twin characters of growth.
- Plants grow continuously and this growth is by cell division. The process of cell division is also observed in certain plant parts only.
- Animal's growth occurs only up to a certain age.
- Unicellular organisms grow by cell division, but being unicellular, as the organism grows, it divides into two new organisms e.g., *Amoeba*. Hence, growth and reproduction are synonymous to each other.
- In majority of higher plants and animals growth and reproduction are mutually exclusive events.

- Non-living objects may also demonstrate growth like increase in body mass (can be taken as a criterion of growth). But non-living objects show only extrinsic growth i.e., increase in the mass of body from outside e.g. sand dunes, mountains, etc.
- Growth is observed in both living and non-living beings hence, cannot be taken as a defining property of living organisms.

  Note: Degrowth or negative growth – It happens when catabolism exceeds anabolism which results in decrease in body mass.

Definition

Living Being: The object by itself exhibiting growth, reproduction, consciousness, and other life processes and show independent existence in nature is designated as living being.

Reproduction

- Reproduction is the biological process that helps in the formation of new individuals from the parent of its own kind.
- Types of reproduction - asexual and sexual. In asexual reproduction, always one parent gives rise to new organisms of its own kind i.e., uniparental reproduction.
- Asexual reproduction can be of either type like fission (binary and multiple), formation of spores, fragmentation, and vegetative propagation or multiplication.
- Fungi multiply by spores produced asexually, budding is common in yeast and *Hydra*, true regeneration in *Planaria* and fragmentation is observed in fungi, filamentous algae, protonema of mosses.
- In single-celled organisms like bacteria, unicellular alga, and *Amoeba*, growth and reproduction run parallel to each other.
- Non-living objects are incapable of reproducing or replicating by themselves.
- There are some living organisms which do not reproduce at all, e.g., worker bees, mules, infertile human couples, etc.
- Hence, reproduction cannot be an all-inclusive defining property of living organisms.

Metabolism

- Metabolism is the sum of all anabolic chemical reactions and catabolic chemical reactions which occur in any living organism.
- Metabolism involves exchange of matter and energy between an organism and its environment and transformation of matter and energy.
- Though all the living organisms differ from each other greatly still metabolic reactions are unusually similar in all of them.
- No non-living object exhibits metabolism.
- Metabolic reactions can be easily demonstrated outside the body in cell-free systems.
- An isolated metabolic reaction(s) in a test tube (in vitro) is neither living nor non-living and are not living things but these living reactions without a doubt.
- Hence, metabolism is a defining feature of all living organisms without an exception.
- So, metabolism is considered as defining feature of organism.

Rack your Brain

Why can we not consider *in vitro* metabolic reactions as living things ?

Cellular Organisation

- Cell is made up of different biomolecules having specific organisation and performing different metabolic reactions this peculiar organisation is known as cellular organisation.
- Body organisation of all living organisms consists of cells, tissues and their biological products.
- Hence, cellular organisation of the body of an organism is the defining feature.

Consciousness

- The most obvious and technically complicated feature of all living organisms is the ability to sense their surroundings or environment and respond to these environmental stimuli which could be physical, chemical, or biological.
- Response of an organism to such external stimuli is known as consciousness.
- A question may arise whether a man lying in coma on the life support system is living or non-living? The answer lies in the quantitative presence of consciousness in the living being in that particular state. In fact, the person in coma has lost the requisite quantity of consciousness to exhibit the features of living being, but still exhibits life. If the requisite consciousness is restored, the person may again start to be as living being or die otherwise.
- Human being is the only organism who is aware of himself, i.e., self-consciousness.
- Consciousness, therefore, becomes the defining property of living organisms.
- All living phenomena are due to underlying interactions. Properties of tissues are not present in the constituent cells but arise because of interactions among the constituent cells. Similarly, properties of cellular organelles are not present in the molecular constituent of the organelle but arise because of interactions among the molecular components comprising the organelle. These interactions result in emergent properties at a higher level of organisation. This phenomenon is true in the hierarchy of organisational complexity at all levels.
- Therefore, we can say that living organisms are self-replicating, evolving, and self-regulating interactive systems capable of responding to external stimuli.
- Biology is the story of life on earth. Biology is the story of evolution of living organisms on earth. All living organisms — present, past, and future, are linked to one another by the sharing of the common genetic material, but to varying degrees.

Question:

Coma patient is-

(a) Living (b) Non-living

(c) Suspended life

(d) cannot be explained.

Sol. (c)

Coma patient is living because is supported by life support-system, only few functions are visible like functioning of the heart and respiration. But other major functions are not performed, hence, is example of suspended life.

Note: Cellular death starts first and after half an hour brain is dead in a dying person. Cellular death continues for 48 hours. Last organ to die is skin.

BIODIVERSITY

- Different types of animal, plant and micro-organisms are present on earth considered as biodiversity of earth.
- Estimated scientifically named and classified species are 1.7 million approximately (about 1.2 million animal species and over 0.5 million species of plants).
- Largest animal group – insects, highly diverse and maximum of these thrive in tropical rain forests and tropical oceans.

Definition

Biodiversity: Different types of animal, plant and microorganisms present on earth are considered as biodiversity of earth.

CLASSIFICATION

The method of placing organisms into groups (category) on the basis of similarities and dissimilarities in a systemic way is called classification.

Need for Classification

- Vast number of plants and animals species are present.
- Diversity in the form, structure and complexity of organisms.
- It is impossible to study all the organisms on individual basis or separately.
- For the ease of studying, ranks or categories are created to place the organisms.
- Few other needs of classification are-
  - To understand the inter-relationship among different groups of organisms.
  - Development of other biological sciences like biogeography needs a base from classification.
  - Exact identification and classification are required in other sub-fields of biology like fisheries.

Major Categories of Classification

Artificial System of Classification

When the classification is done on the basis of one or two morphological characters only. i.e., overall morphology is not considered.

- Aristotle classified plants (tree, shrub and herb).
- Classification proposed by Linnaeus is sexual system of classification.

Carolus Linnaeus classified plant kingdom on the basis of only two floral characters:

- Stamen
- Carpel

On the basis of stamens and carpel, Carolus Linnaeus classified plant kingdom into 24 classes.

Out of these 23 classes of flowering plants and one class of non-flowering plants (Cryptogamian).

Note: In artificial classification, the plants belonging to the same group show only, 1 or 2 similar characters while dissimilarities are more.

- **Natural System of Classification**
  - Complete morphology, anatomy, cytology, embryology and other characters except phylogeny are considered to classify the organisms.
  - Natural classification is believed to be the best classification, because

it represents the natural similarities and dissimilarities of plants i.e., it represents the interrelationship among plants.

- In this classification, the plants belonging to the same group shows many similarities, while in artificial classification, the plants belonging to the same group shows only, 1 or 2 similar characters. They have many dissimilarities.
- One of the best natural classification was given by Bentham and Hooker in the book "Genera *Plantarum*".
- In this system, plants are classified on the basis of numbers of similarities and dissimilarities. This classification is easily carried out by using computers and it is based on all observable characteristics.
- In this classification number and codes are assigned to all the characters and the data are prepared and then processed. Those organisms which have maximum similarities are placed in same group. In this way each character is given equal importance and at the same time hundreds of characters can be considered.

- **Phylogenetic Classification**
  - This classification is based on all the characters of organisms including their evolutionary relationship.
  - Evolutionary relationship of the organisms is known as phylogeny.
  - A.W. Eichler, Hutchinson, Takhtajan, Ostwald Tippo gave phylogenetic classification.

Definition

Natural classification: Classification of plants on the basis of complete morphology, anatomy, cytology, embryology and other characters except phylogeny.

Rack your Brain

Why is Linnaeus's classification termed as artificial system of classification?

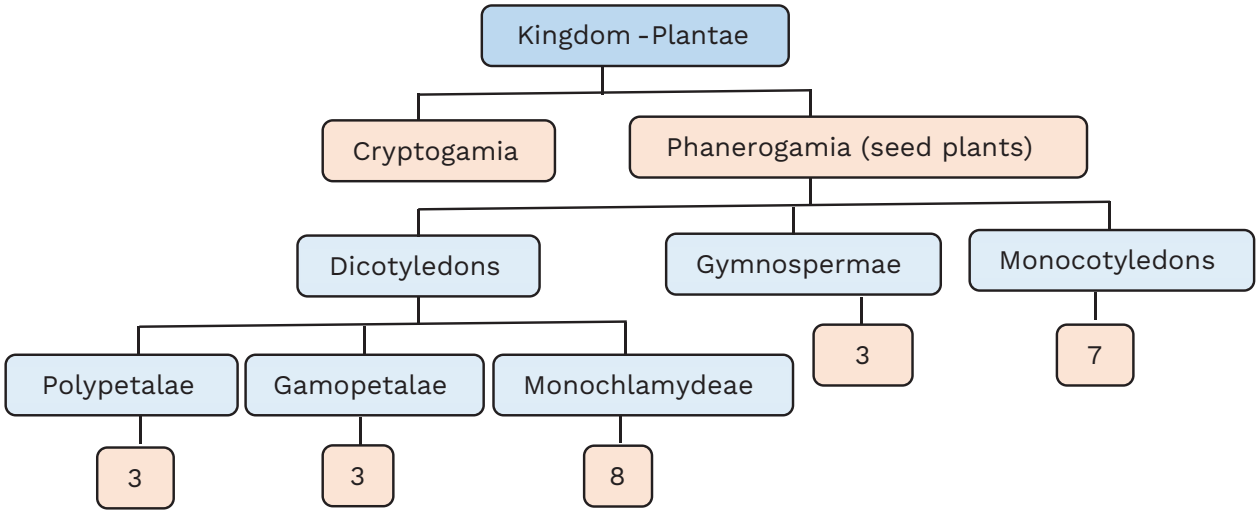
TAXONOMY

The branch of science (Biology) which deals with the study of principles and procedures of classification is called taxonomy. The Greek term 'taxonomy' was coined by A.P. de Candolle.

Linnaeus is considered as 'Father of Taxonomy'.

- **The fundamental elements of taxonomy:**
  - **Characterization and identification:** This includes determination of the similarities of an organism with an already known organism, based upon specific characters.
  - **Nomenclature:** It is the determination of correct name of an organism according to established universal rules.
  - **Classification:** It is grouping of organisms into convenient categories on the basis of easily observable characters.

Note: Classical Taxonomy is based on observable morphological characters



while the modern taxonomy deals with several characters for the classification of organisms like -

- External and internal structure along with the structure of cell.
- Development process.
- Ecological information of organisms.

- **Types of Taxonomy**
  - **Cytotaxonomy:** The use of cytological characters of plants in classification is called cytotaxonomy.
  - Characters used in cytotaxonomy are Chromosome number, Chromosome morphology, chromosome size, total length of chromatin, arm's ratio, primary and secondary constrictions, Chromosome behaviour at meiosis.
  - **Karyotaxonomy:** Based on characters of nucleus and chromosomes. Pattern of chromosomal band (dark bands and light bands) is most specific character.
  - **Chemotaxonomy:** The uses of chemical characters of plants in classification or in solving taxonomic problems are called chemotaxonomy or chemical taxonomy. It is based on the chemical constituents of plants.
  - Alkaloids, carotenoids, tannins, polysaccharide, nucleic acids, fatty acids, amino acids, aromatic compounds are generally considered in chemotaxonomy.

Definition

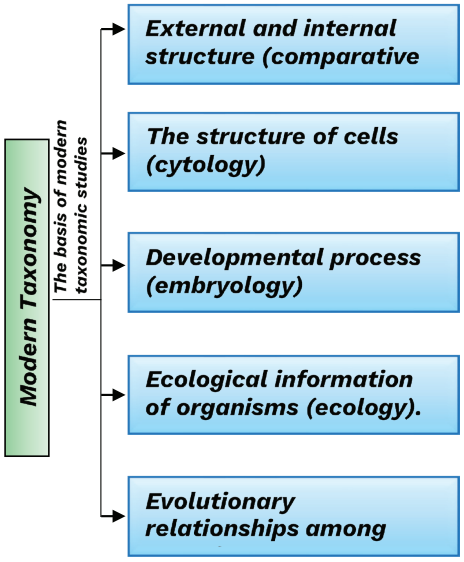
Taxonomy: The branch of Biology that deals with naming, identifying, and classifying an organism.

Rack your Brain

What are the basic processes in taxonomy?

- **Basis of modern taxonomic studies:** In the initial years of taxonomy only the morphological characters were considered. Due to advancements in technology scientists started using structure of cells,

developmental process of the organisms, ecological information of organisms, evolutionary relationship among organisms for classifying the organisms. So, now this is the base of modern taxonomic studies.



SYSTEMATICS

- The word 'systematics' is derived from Latin word '*systema*' which means systematic arrangement of organisms.
- It was first used by Carolus Linnaeus. According to him, "systematics is the discipline of biology which deals with the kind and diversity of all organisms and the existing relationships amongst them."
- New systematics or Biosystematics or Neo Systematics is based upon all characters i.e., morphological, cytological, ecological, biochemical, genetical etc.
- The term 'new systematics' was coined by Julian Huxley.
- Basic unit of classification is population or sub-species for the new systematics.

The main uses of systematics are given below:

- It helps in providing knowledge of great diversity of animals and plants. It provides information regarding evolution that took place among plants and animals by knowing their distinction, relationship, habits and habitat. It thus, gives a vivid picture of entire organic diversity.
- It helps in the identification of fossils which gives useful information about the phylogeny of organisms.

Rack your Brain

What was the sole criterion for classification during the initial period of taxonomy?

Definition

Systematics: The branch of Biology that deals with the study of evolutionary relationships among organisms and this aids taxonomy.

Differences between Classical Taxonomy and Modern Taxonomy

Classical Taxonomy		Modern Taxonomy	
1.	It deals with morphospecies (species that are classified on the basis of morphological characteristics)	1.	It deals with biological species.
2.	It has a typological concept.	2.	It has a population or biosystematics concept.
3.	Species are considered to be static.	3.	Species are considered to be dynamic.
4.	It does not study evolution and inter-relationships among species.	4.	It studies primitiveness, advancement, and inter-relationships among species.

Differences between Classical Taxonomy and Systematics

S.No.	Taxonomy	Systematics
1.	Taxonomy includes following processes. (i) Characterization (ii) Identification (iii) Nomenclature (iv) Classification	Systematics deals with the study of diversity of living being, it includes: (i) Characterization (ii) Identification (iii) Nomenclature (iv) Classification (v) Affinity
2.	Unit of taxonomy is species	Unit of systematics is population
3.	This term was given by A.P. De Candolle	This term was given by Linnaeus
4.	Alpha (a), Beta (b) and Omega (w) taxonomy was given by Turill.	New systematics was given by Julian Huxley (1940)

Note- Newly discovered organisms can be identified through systematics.

NOMENCLATURE

- Giving names to an organism in biology is considered as nomenclature.

- **Polynomial system**
  - Giving many names to the organisms or plants.
  - For e.g., *Caryophyllum* → *Caryophyllum sexatilis folis gramineus umbellatis corumbis*.
- **Trinomial system**
  - Proposed by Huxley and Strickland.
  - According to this system name of any plant or species is composed of three names.
  - Generic name
  - Specific name,
  - Third name is sub-species for animals, or third name is of variety for plants.

When any species has large variations then trinomial system is used. On the basis of dissimilarities, the species is classified into sub species.

e.g., *Brassica oleracea* var. *botrytis* (*Cauliflower*)

Brassica oleracea var. *capitata* (*Cabbage*)

Brassica oleracea var. *caulorapa* (*Knol-Khol*)

Rack your Brain

What are the disciplines where systematics has significant role other than the field of biology?

Binomial System

- Book-Pinax Theatri Botanica written by Gaspard Bauhin has the reference of the Binomial system.
- Linnaeus is the founder of binomial nomenclature system.
- Linnaeus proposed scientific name of 5900 species of plants in his book Species Plantarum. It was published on 1st May 1753.
- Linnaeus proposed scientific name of 4326 species of animals in his book Systema Naturae. (10th edition) was published on 1st August 1758.

Rules of Nomenclature

- **Principle of priority**
  - The name proposed first is termed as valid then the later proposed name stands for species named after 1753.
  - If two names are proposed for any animal after the 1758, the valid name is the name proposed earlier, just after 1 August 1758 on priority basis.
  - It is the most important rule of binomial nomenclature.
- **International Code of Botanical Nomenclature (ICBN)**
  - Collection of rules regarding scientific nomenclature of plants.
  - ICBN was accepted in 1961.
  - In the 12th International congress, Leningrad (Russia), revised ICBN in 1975. After revision, it was republished in 1978.

Note:

- ICZN = International Code of Zoological Nomenclature
- ICNB = International Code of Nomenclature for Bacteria
- ICVN= International Code of Viral Nomenclature
- ICNCP = International Code of Nomenclature for Cultivated Plants

Definition

Binomial Nomenclature: The process of giving two names to an organism as per the set rules of the binomial nomenclature.

- **Main rules of ICBN**
  - According to binomial system, the name of any species consists of two epithets:
  - First letter of generic name must be in capital letter and first letter of specific epithet must be in small letter. e.g., *Mangifera indica*.
  - If specific epithet is based on the name of sonic person, its first letter should be capital letter. e.g., *Chaetomium Subramaniella.*
  - Length of generic name or specific epithet should not be less than 3 letters and not more than 12 letters, e.g., *Mangifera indica.*
  - **Exception:** *Riccia pathankotensis* (specific epithet with more than 12 letters).
  - In plant nomenclature (ICBN) **tautonyms** are not valid i.e., generic name and specific epithet should not be same in plants. e.g., *Mangifera*. But tautonyms are valid in animal nomenclature (ICZN-International Code of Zoological Nomenclature) e.g., *Naja naja* (Indian cobra), *Rattus rattus* (Rat)
  - When scientific name written with free hand or typed, then generic name and specific epithet should be separately underlined. But during printing name should be Italized.
  - Name of scientist (who proposed nomenclature) should be written in short after the specific epithet. e.g., *Mangifera Indica* Linn.
  - Name of scientist should be neither underlined nor written in italics but written in roman letters (simple alphabets).
  - If any scientist has proposed wrong name, then his name should be written in bracket and the name of the scientist who corrected the name should be written after the bracket. e.g., *Tsuga Canadensis* (Linn.) Salisbury
  - Linnaeus named this plant as *Pinus canadensis.*

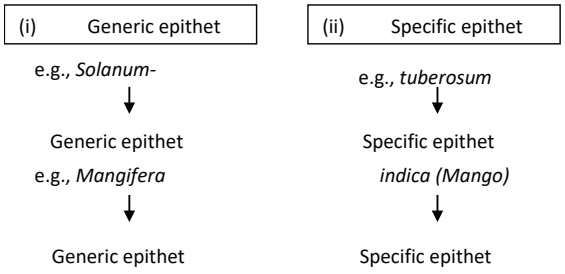
Rack your Brain

Name the Indian organization that exercise control in the exploration of our plant wealth.

Rack your Brain

What does the third name of an animal represent, according to trinomial nomenclature?

  - **Latin or Greek** language is used to
  - derive scientific names as these are dead languages or should be Latinized.



Note: Fossils are known by their scientific names only.

Tautonym: In plant nomenclature (ICBN) **tautonyms** are not valid i.e., generic name and specific epithet should not be same in plants. e.g., *Mangifera*.

But tautonyms are valid in animal nomenclature (ICZN) e.g., *Naja naja* (Indian cobra), Rattus *rattus* (Rat).

Parenthesis

- The name/s of the describing person or scientist is abbreviated along with the scientific name (complete generic name) of the organism with date at least once in the article.
- If any species undergoes taxonomic revision, then parentheses help in giving the credit to the original author as his name along with the new scientific name is abbreviated.
- Full generic name instead of abbreviated one, should be published in the article to avoid confusion with any other scientific name. For example, *Pisum sativum* is more suitable than *P. sativum.*
- For example: *Pisum sativum* Linn., the given name is of pea, given by Linnaeus.

TAXONOMIC HIERARCHY (Also known as Linnaean Hierarchy)

- It involves hierarchy (ascending or descending) of steps.
- Each step represents a rank or category. Where the category is a part of overall taxonomic arrangement.
- Each category is termed as a unit of classification, represented as rank and is commonly called as taxon.
- The taxon is group of similar organisms that belong to a category.
- Taxonomic hierarchy is a series of different ranks placed in ascending or descending order.

Rack your Brain

Organisms of which category are known by their technical names only?

- **Taxonomic categories:**
  - Kingdom
  - Division (for plants) or phylum (for animals)
  - Class
  - Order
  - Family
  - Genus
  - Species
- Higher taxonomic category- The number of organisms in it is more with fewer number of common characters. With few characteristics in common tracing the relationships to other taxa of the same level become tedious.
- Taxonomic categories and hierarchy can be illustrated by few examples.
- All insects possess three pairs of jointed legs and so can be given a common rank or category at some level i.e.class Insecta.
- Mammals represent animals with hair on the skin, external ears, mammary glands etc. so at some level these can be placed in the same category i.e. class Mammalia.
- But Dog, mammals, animals are all taxa but of different categories like species, class and kingdom,respectively.

Taxon (First introduced during 1956 by ICBN)

- Each Biological category is referred to as a unit of classification.
- Each category is also called as Rank and is commonly termed as taxon (Pl. taxa).
- According to Mayr (1964) taxon is a group of any rank that is sufficiently distinguished of being assigned a definite category.
- In simple words, taxon refers to a group of organisms with similarities.

Clade or Monophyletic Taxon

- Clade (Monophyletic taxon)- A taxon that includes a common ancestral species and all the species descended from it.

Species (Term given by John Ray)

- It is lowest and the basic category of classification.
- It is a group individuals with similar morphological, anatomical, biochemical, and cytological characters.
- This unit of classification that has real existence.
- Individual of species naturally interbreed and produce fertile offsprings.

Genus consisting of only one species as a representative

e.g. *Hyacinth macaw* and *Homo sapiens*

} **Monotypic species**

Genus consisting of more than one species.

E.g *Panthera leo*
P. tigris
P. pardus

} **Polytypic species**

Definition

Category: It is an abstract term that is used to represent either a rank or a level of organism's group.

Concept of Species

- Biological concept of species was given by Ernst Mayr.
- Species is the fundamental unit of classification.
- A species is a group of similar organisms (structurally and functionally) which share a common gene pool and can naturally interbreed to produce fertile offsprings in a natural environment.
- This concept of species is based upon reproductive isolation and called biological concept.

Definition

Taxon: It is a group of related organisms placed in any specific taxonomic category.

Exception to Biological Concept of Species

Some important interspecific hybrids

- Sterile Hybrid (under natural conditions).
  Mule = Produced by a cross between male donkey and female horse (Mare).
  Hinny = Produced by a cross between male horse (Stallion) and female donkey.

- Fertile Hybrid (under captive conditions).
  Tigon = Produce by cross between male tiger and female lion
  Liger = Produced by a cross between male lion and female tiger
- Some examples of species:

Pisum sativum	–	Pea
Mangifera indica	–	Mango
Solanum tuberosum	–	Potato
Solanum melongena	–	Brinjal
Panthera leo	–	Lion
Panthera tigris	–	Tiger
Homo sapiens	–	Human being

Here, *sativum, indica, tuberosum, leo, sapiens* represent the specific epithet, while *Pisum, Mangifera*, *Solanum*, *Panthera* and *Homo* represent genera.

Genus (Term given by John Ray)

- Genus is a group of related species.
- Members of genus have comparatively less characters in common in comparison to individual species of that genera.
- e.g., Potato, (*Solanum tuberosum*), Makoi (*Solanum nigrum*) and Brinjal (*Solanum melongena*) belong to genus *Solanum* though all the three are different species.
- Genus *Panthera* include Lion, leopard and tiger with several common features though species are different.

Note:

A plant family name ends with a suffix -aeae and sub-family name ends with -oideae.
While an animal family name has a suffix -idae and sub-family name end with -inae.

Family (Term given by John Ray)

- A group of related genera, with less similarities among the members as compared to genus and species. Family, this taxon is characterised on the basis of both vegetative and reproductive features of plants.
- Suffix 'aceae' is generally used in plant families.
- For example, family Solanaceae includes four related genera *Solanum, Petunia*, Datura and *Atropa*.
- Family Felidae includes Genus *Panthera* and *Felis* (cat).
  Note: Lower taxonomic categories from family to species are identified on a number of similar characters.

Rack your Brain

What does parenthesis mean in biological nomenclature?

Definition

Species: It is a group of organisms that interbreed and produce fertile offsprings. It is also the basic unit in taxonomic hierarchy that has real existence.

- A group of related families which exhibit only few similar characters. The number of similar characters decreases as different genera are included.
- For example, Order Polymoniales has plant families like Convolvulaceae and Solanaceae (mainly based on floral characters).
- Suffix 'ales' is generally used for order of plants.
- In animals, order carnivora includes families like Felidae (cat) and Canidae (dog).

ORDER	FAMILIES
Carnivora	Canidae (dog, wolf, and fox), Felidae (cat, leopard, tiger and lion), Ursidae (bear) and Hyaenidae (hyaena)
Polemoniales	Solanaceae (potato and tomato), Convolvulaceae (sweet potato and morning glory), Polemoniaceae (herbs, shrubs, and small trees) and Hydrophyllaceae (water leaf)
Primates	Lemuridae (lemurs), Cebidae (new world monkeys), Pongidae (apes) and Hominidae (humans).

Class (Used by Linnaeus)

- It is a group of related orders.
- For example, plant orders like Sapindales (mango) and Polemoniales are included in Class 'Dicotyledonae' and plant orders like Asparagales & Poales are included in class-Monocotyledonae.
- In animals, order Primata (man, monkey) and Carnivora (cat, dog) are included in class - Mammalia.

Phylum/Division (Term given by **Ernst Haeckel)**

- A group of related classes.
- The category 'Phylum' is used in Animalia while 'Division' is used in Plantae.
- The phylum Chordata of animals contains the following classes Mammalia (Mammals), Aves (birds), Reptilia (reptiles) Amphibia (amphibians) and Osteichthyes (fishes).
- In case of plants, classes with few similar characters like dicots and monocots constitute division 'Angiospermae'.

Kingdom

- It is highest category in hierarchy with related Phyla or Divisions.
- Kingdom Animalia includes all animals belonging to different Phyla from Porifera to Chordata. Kingdom Plantae includes all plants of various Divisions, i.e., Algae, Bryophyta, Pteridophyta, Gymnosperm & Angiosperm.

Note- In higher taxonomic categories i.e., from order to kingdom, are identified based on the aggregate characters.

OBLIGATE OR COMMON CATEGORIES (Seven in number)

- The taxonomic categories, which are broadly used in hierarchial classification

of organisms are called obligate or common categories.

- From higest to lowest (descending order) these categories are kingdom, phylum or division, class, order, family, genus and species.
- All the members of taxonomic categories possess some similar characters, which are different from those of the others taxonomic categories.
- Members of a species are almost similar with few variations but are potential interbreeders.
- Similarity of characters decreases with the increase in hierarchy. Similarity of characters increases with decrease in hierarchy.

INTERMEDIATE CATEGORIES

- Taxonomists have developed sub-categories in this hierarchy to facilitate more scientific placement of various taxa.
- These sub-categories are sub-species (or varieties), sub-genera, sub-families, sub-orders, sub-classes and sub-phyla.
- Intermediate categories are more in number than obligate categories.

Rack your Brain

Who established the hierarchy of categories for the first time?

Definition

Kingdom: It is the highest taxonomic category that includes phyla

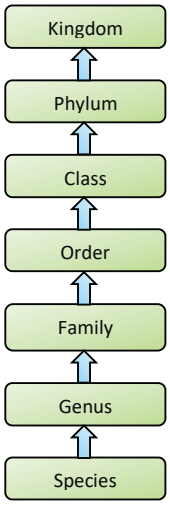


Figure: Taxonomic categories showing hierarchical arrangement in ascending order

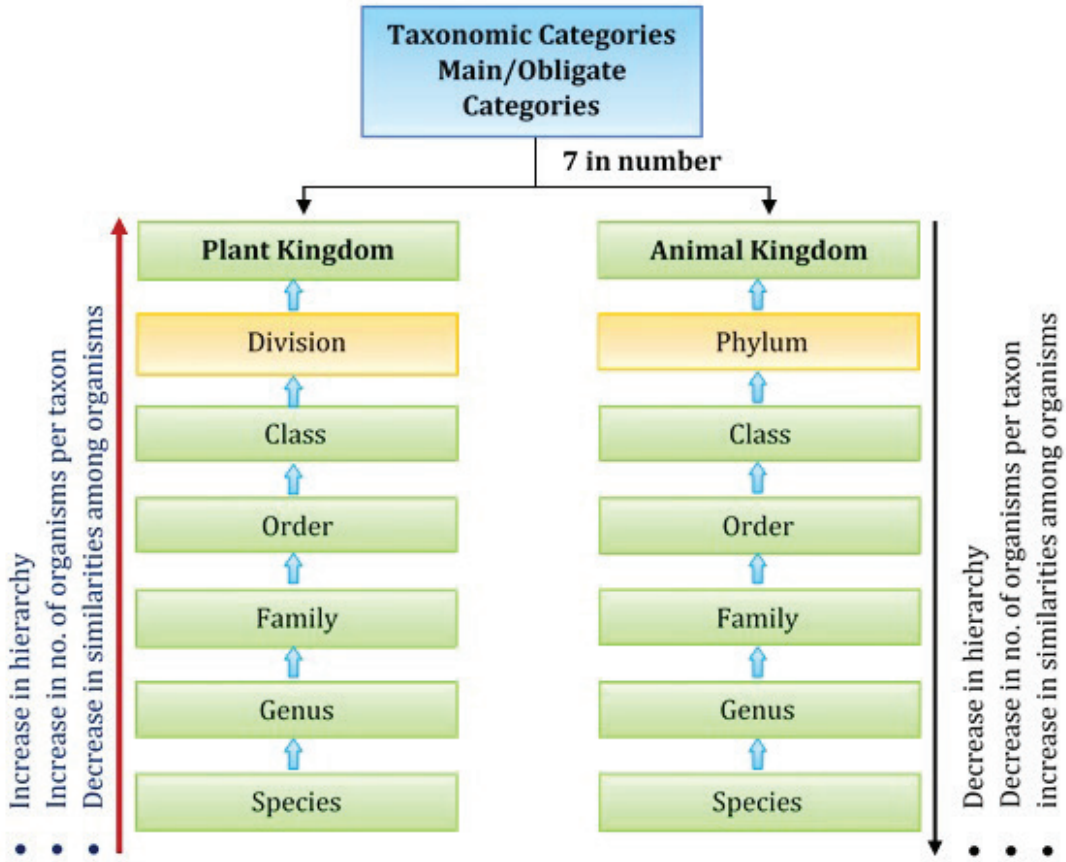
Organisms with their Taxonomic Categories

Common Name	Biological name	Genus	Family	Order	Class	Phylum/ Division
Man	*Homo sapiens*	*Homo*	Hominidae	Primata	Mammalia	Chordata
Housefly	*Musca domestica*	*Musca*	Muscidae	Diptera	Insecta	Arthropoda
Mango	*Mangifera indica*	*Mangifera*	Anacardi-aceae	Sapindales	Dicotyledonae	Angiospermae
Wheat	*Triticum aestivum*	*Triticum*	Poaceae	Poales	Monocoty-ledonae	Angiospermae

Note- Race: When there is morphological diversity in the members of species or sub-species than an informal rank in the taxonomic hierarchy is used called Race. The members of race can interbreed and produce fertile off springs.

TAXONOMICAL AIDS

- Studies of various plant species, animal species and other organisms are of great importance in agriculture, forestry,etc.
- Such aids are helpful in knowing our bio-resources and their diversity.
- For accurate studies we require correct classification and identification of organisms.
- Identification of organisms requires intensive laboratory and field studies by skilled people.
- The collection of actual specimens of plant and animal species is essential and is the prime source of taxonomic studies. These are also fundamental to studies and essential for training in systematics.
- It is used for classification of an organism, and the information gathered is also stored along with the specimens.
- The specimens are even preserved for future studies.
- Some of these Taxonomic aids are:
  - Herbarium
  - Botanical gardens



- Zoological parks
- Museums
- Keys
- Flora, manuals, monographs, and catalogues.

Rack your Brain

Who is authorised to give scientific name to an organism?

- **Herbarium**
  - Etymology: Latin *'herba'* – grass, vegetation.
  - Word 'Herbarium was initially used to refer to a book on medicinal plants. Joseph Pitton de Tournefort (1656-1708) first applied the term 'Herbarium to "a collection of mounted, pressed plant specimens, systematically arranged, providing a record of botanical diversity and the world it inhabits."
  - The store house of collected dead, dried, pressed, and preserved plant specimens on herbarium sheets is known as Herbarium.
  - These sheets are arranged in the sequence of an accepted classification system.
  - These specimens, along with their description on herbarium sheets, become a store house or repository for future use. The herbarium sheet contains a label on the right-hand side at lower corner.
  - Label provides information about date and place of collection, English, local and botanical names, family, collector's name etc.
  - Herbaria also serve as quick referral systems in taxonomical studies.

The herbarium technique involves the following steps:

(a) Collection
(b) Drying
(c) Poisoning
(d) Mounting and stitching
(e) Labelling and Deposition
(f) Storage

Rack your Brain

Can different members of a race interbreed?

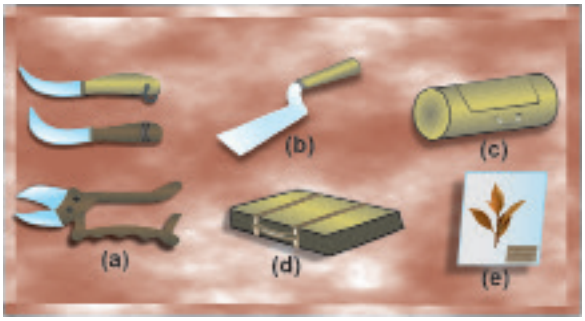
Gray Matter Alert!!!

Human Races: There are seven human races *viz*. Negroid, Caucasoid, Mongoloid, Australoid, Polynesian, Red Indian and Bushmen.

Explanation to prepare herbarium.

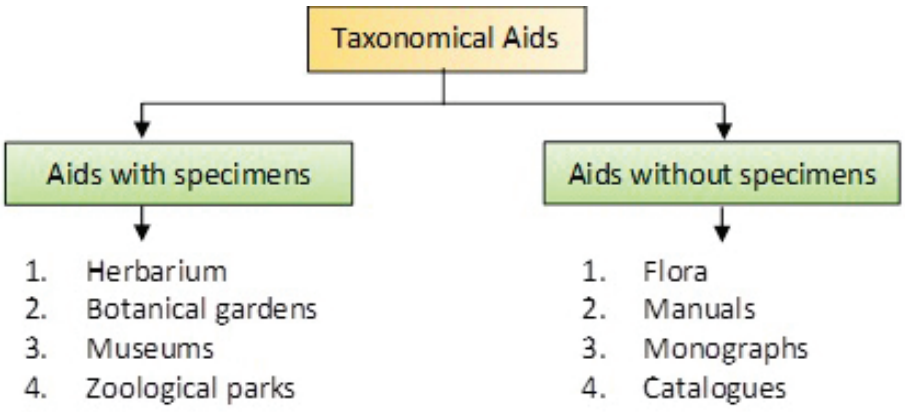
(a) **Field visits and collection of specimens.**

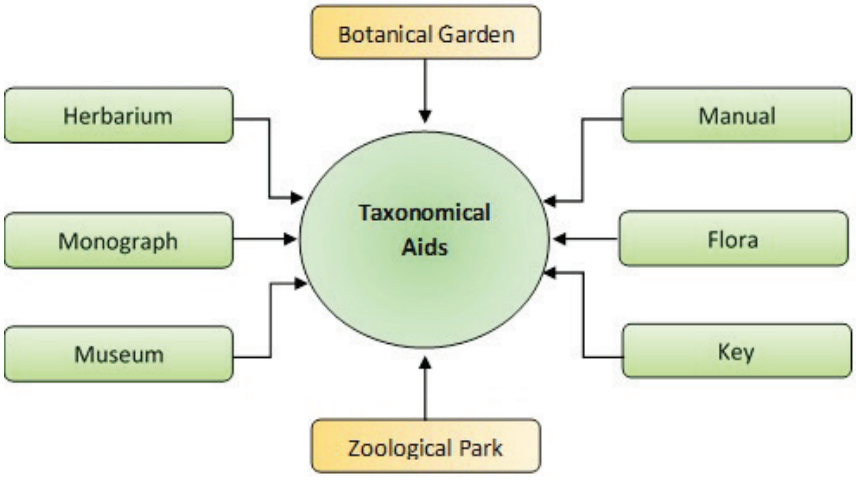
- Field visits should be regular to obtain specimen of a plant species at every stage of its growth and reproduction.
- The entire plant is collected in case of a herbaceous species. Shoots having flowers, leaves and fruits are collected for others.
- Tools required for collection:
- Clippers, diggers (khurpi), plastic and paper bags, small tags, field notebook, a map of the area.



Definition

Sub-species or variety: It is distinct subgroup within the species consisting of one or more populations and can interbreed.
It is inferior in rank to species.





Tools of plants collection

(a) Cutters (b) Digger (khurpi)
(c) Vasculum (d) Plant press
(e) Herbarium sheet

(b) Transport of specimen and drying of specimen.

- Specimens are kept in vasculum specimen box which prevents witting of specimens for transportation purpose.
- Specimens are spaced out between folds of old newspaper or blotting sheets.
- These sheets are kept in plant press and changed after 24 hours for quick drying. The process is repeated for many days.

(c) Mounting on herbarium sheets

- Sheets on general size of 30 × 45 cm are selected and the specimen is stitched to these herbarium sheets.
- The international size of the herbarium sheet is 41 × 29 cm (– × –)
- The field data is entered on label on the right-hand side lower corner of the herbarium sheet.
- Size of label to be placed on the herbarium sheet is commonly 7 × 12 cm.

(d) Poisoning (An important step in preparing herbarium)**.**

- The specimens are poisoned to keep away the microbes. When the specimens are partially dehydrated, they are poisoned by using chemicals like 0.1% of corrosive, sublimate ($HgCl_2$), for preventing fungal infection.
- The specimens so preserved are sprayed with repellents or disinfectants such as DDT powder, copper sulphate solution at intervals of 4 to 6 months.
- Para dichlorobenzene is an insecticide and prevents the dried specimens against action of insects.
- Most common solution for preservation of specimen is formalin. It is a solution of formaldehyde in water (FAA: 10 ml formalin, 5 ml glacial acetic acid, 50 ml of 95% ethyl alcohol and 35 ml of water) is used to store fleshy organs.
- Pesticides like naphthalene and carbon disulphide are also used.

(e) Labelling.

- Labels (7 × 12 cm) are fixed over the right lower corner of the herbarium sheets.
- The label includes the following:
  Scientific Name
  Common Name
  Locality and Habitat
  Description
  Collectors
  Date of collection
  Accession number
  Notes

(f) Storage

- Best conditions for storage include:
- Low temperature
- Low humidity
- Low light
- The sheets are sealed in plastic.

- **Significance of an herbarium.**
  - To confirm the identity of a plant i.e., helpful in taxonomy.
  - Documenting different specimen concepts.
  - Providing locality data of local flora for field trips.

- Checking plant characteristics (genetic and seasonal) and variation (morphology)
- Allowing documentation of flowering and fruiting times and juvenile forms of plants (taxonomy, systematics, ecology, phenology)
- Documenting similar and different habitats of plants i.e., helpful in studying ecology.
- Locating wild varieties of different species.
- Serving as a repository for voucher specimens (ecology, environmental impact studies, etc.)

Note-The herbarium sheets are arranged according to the Bentham and Hooker system of classification.

- **Archive**
  - The practice of making an herbarium is attributed to Luca Ghini (1490-1556), who was an Italian physician and a botanist. The collection of mounted plant specimens was called as a *hortus siccus* (dry garden) or *hortus hiemalis* (winter garden).
  - Carolus Linnaeus (1707-1778) was 1st to keep his specimens unbound in the form of herbarium sheets.
  - Oldest extant herbarium made by Gherardo Cibo (student of Luca Ghini) is dating established around (1532), Bologna, Italy.
  - University of Florida Herbarium – oldest and most comprehensive. Half a million specimens 273,000 vascular plants, 160,000 bryophytes and lichens, 56,500 fungi and 15,300 wood samples. There are specimens from every continent except Antarctica.
  - The Central National Herbarium, Howrah, one of the oldest established in 1795 by Dr. William Roxburgh. At present possesses 2 million \ sheets belonging to nearly 350 families of higher plants.
- **Specimen**
  - When a plant (whole or any of its parts) and animal (whole or skeleton) selected to serve as a reference point for taxonomic studies then it is called a specimen.
- **Types of Specimen**
  - **Holotype:** The single specimen is chosen by the original author at the time the species name and description were published.
  - **Isotype:** A duplicate specimen of the holotype.
  - **Syntype:** Any two or more specimens listed in the original description of a taxon when a holotype was not designated.
  - **Isotype:** A duplicate of a syntype.
  - **Neotype:** A specimen chosen by a later researcher to serve in place of a holotype when the initial collected specimens or holotype has been destroyed.
- **Botanical Gardens**
  - These specialised gardens have collections of diversity of living plants.
  - Plant species are grown for identification purposes and each plant is labelled indicating its botanical or scientific name and its family.
  - Botanical gardens are also used for *ex-situ* conservation of plant species.
  - Plant breeding experiments are also carried out at botanical gardens.

Few Botanical Gardens of Importance

- Lalbagh Botanical Garden, Bangalore (Karnataka)
  - Layout in 1760.
  - It has a central glass house (built in 1890) used for flower shows.
- Acharya Jagadish Chandra Bose, Indian Botanic Garden, Shibpur, Kolkata
  - The Great Banyan (*Ficus benghalensis*), largest tree in the world is the main attraction. It occupies 4 acres of land and is more than 250 years old.
  - Founded in 1787 by Colonel Robert Kyd.
- Government Botanical Garden, Ooty (Tamil Nadu)
  - It's a pioneer in introducing vegetables, spices condiments and aromatic plants in India.
  - *Cinchona* and *Eucalyptus* species are cultivated and taken care of.
  - Situated in Nilgiri Hills at an altitude of 2,200 meters.
- Yellowstone National Park (New York)
  - First National Park In the world
  - Established on March 01, 1872.

The Famous Botanical Gardens in India

Indian Botanical Garden, Shibpur, Kolkata.
NBRI – National Botanical Research Institute is in Lucknow.
FRI – Research Institute is in Dehradun.
Lloyd Botanical Garden – Darjeeling.

- **Zoological Parks**
  - Zoo or Zoological Gardens (parks) are protected areas or enclosed spaces where live wild animals are kept, under human care. This enables us to learn their food habits and behaviour.
  - Objectives are public exhibitions to understand wildlife, recreation, education, ***ex-situ*** conservation and breeding of rare fauna.
  - National Zoological Park (Delhi) is one of the finest Zoos in Asia.

- **Important Zoological Parks of India are:**
  - Alipore Zoological gardens, Kolkata
  - Indira Gandhi Zoological Park, Visakhapatnam, Andhra Pradesh
  - Jawaharlal Nehru Biological park, Bokaro Steel City
  - Jaipur Zoo, Jaipur
  - Mahendra Chaudhary Zoological Park, Chhatbir, Punjab
  - Nandankanan Zoo, Orissa, India
  - National Zoological Park, Delhi
  - Sakkarbaug Zoological Garden, Junagadh, Gujarat
  - Rajiv Gandhi Zoological Park, Pune, Maharashtra.
  - Kaziranga National Park and Manas National Park (Having Highest Indian Rhino density)

Note- Yellowstone National Park is the first national park in the world.

- **Museums**
  - These have collections of preserved plants and animals for study and reference.
  - Specimens are preserved in jars or containers in preservative solution.
  - Dry specimens – Dried plants or plant parts and animal specimens
  - Insect boxes- To keep the insects preserved after **collecting, killing and pinning.**
  - Larger animals are usually stuffed and preserved.

Definition

Specimen: When a plant (whole or any of its parts) and animal (whole or skeleton) selected to serve as a reference point for taxonomic studies then it is called a specimen.

- These often have collections of skeletons of animals too.

- **Some Important Museums:**
  - Natural History Museum, London (England)
  - National Museum of Natural History (NMNH), Delhi
- **Keys**
  - Analytical in nature and are artificial taxonomical aid.
  - It is used for identification of both plants and animals based on the similarities and dissimilarities.
    - In keys, we use couplet (a pair of characters) contrasting characters (dissimilarities).
    - It represents the choice made between two opposite options. This results in acceptance of only one and rejection of the other.
    - Each statement in the key is called a lead.
    - Separate taxonomic keys are required for each taxonomic category such as family, genus and species for identification purposes.

Types of Key:

Indented Key (Yoked Key):
The key contains a sequence of choices between two or more characteristics. By careful selection of character at each subdivision the exact name of the organism can be arrived at.

Bracketed Key:
The key uses contrasting characters but they are not separated by intervening subdividing characters. Here, each character is given a number in brackets.

Definition

Botanical Garden: It is a type of taxonomic aid and can be defined as a place of ***ex situ*** conservation of plants that serves educational purpose and awakes interest in masses for plant wealth.

Gray Matter Alert!!!

Carolus Linnaeus
Described 5900 species of plants in his book 'Species Plantarum' (1753) and 4326 species of animals in 'Systema Naturae' (1758). The world systematics is derived from Latin word '*systema*' which means systematic arrangement of organisms. Linnaeus used 'Systema Naturae' as the title of his book.

Difference between Indented key and Bracketed key.

Indented key	Bracketed Key
Example of an Indented Key on *Rhododendron* **1a.** Flowers in shades of red **2a.** Flowers's blood-red. Leaves oblong-ovate, leathery and thick malty texture..... ***R. sikkimense*** **2b.** Flowers crimson red, leaves broad, oval to elliptic oblong. Shiny green above**.....** ***R. fulgens*** **1b.** Flowers in shades of rose-pink **3a.** Calyx 3-5 mm long. Leaf under surface covered with tufts of brown hair..... ***R. wallichii*** **3b.** Calyx obscure, 1-2 mm long. Leaf under surface covered with continuous indumentum.	**Example of Bracketed Key on *Rhododendron*** **1a.** Flowers in shades of red. ..... go to 2 **1b.** Flowers in shades of rose-pink ..... go to 3 **2a.** flowers blood-red leaves oblong-ovate, leathery and thick matty texture..... ***R. sikkimense*** **2b.** Flowers crimson red, leaves broad, oval to elliptic oblong. Shiny green above. ... ***R. fulgens*** **3a.** Calyx 3-5 mm long. Leaf under surface covered with tufts of brown hair..... ***R. wallichii*** **3b.** Calyx obscure, 1-2 mm long, leaf under surface covered with continuous indumentum... .. to 4

- **Flora, Manuals, Monographs and Catalogues**
  - **Flora:** Specific for a studied area which contains the actual account of habitat and distribution of plants of a given area.
  - The index is provided for the plant species found in a particular area with detailed description.

  Some important floras are given below:
  - Flora of British India by J.D. Hooker.
  - Flora of Delhi by J.K. Maheshwari.
  - **Manuals:** The complete listing and description of the plants growing in a particular area. Manuals are useful in providing information for identification of names of species found in an area.
    e.g., Manual of Cultivated Plants by L.H. Bailey
  - **Monographs:** Contain information on any one taxon.
    e.g., The Genus Pinus by N.T. Mirov.
  - **Catalogues:** This includes the alphabetical arrangements of species describing their features.

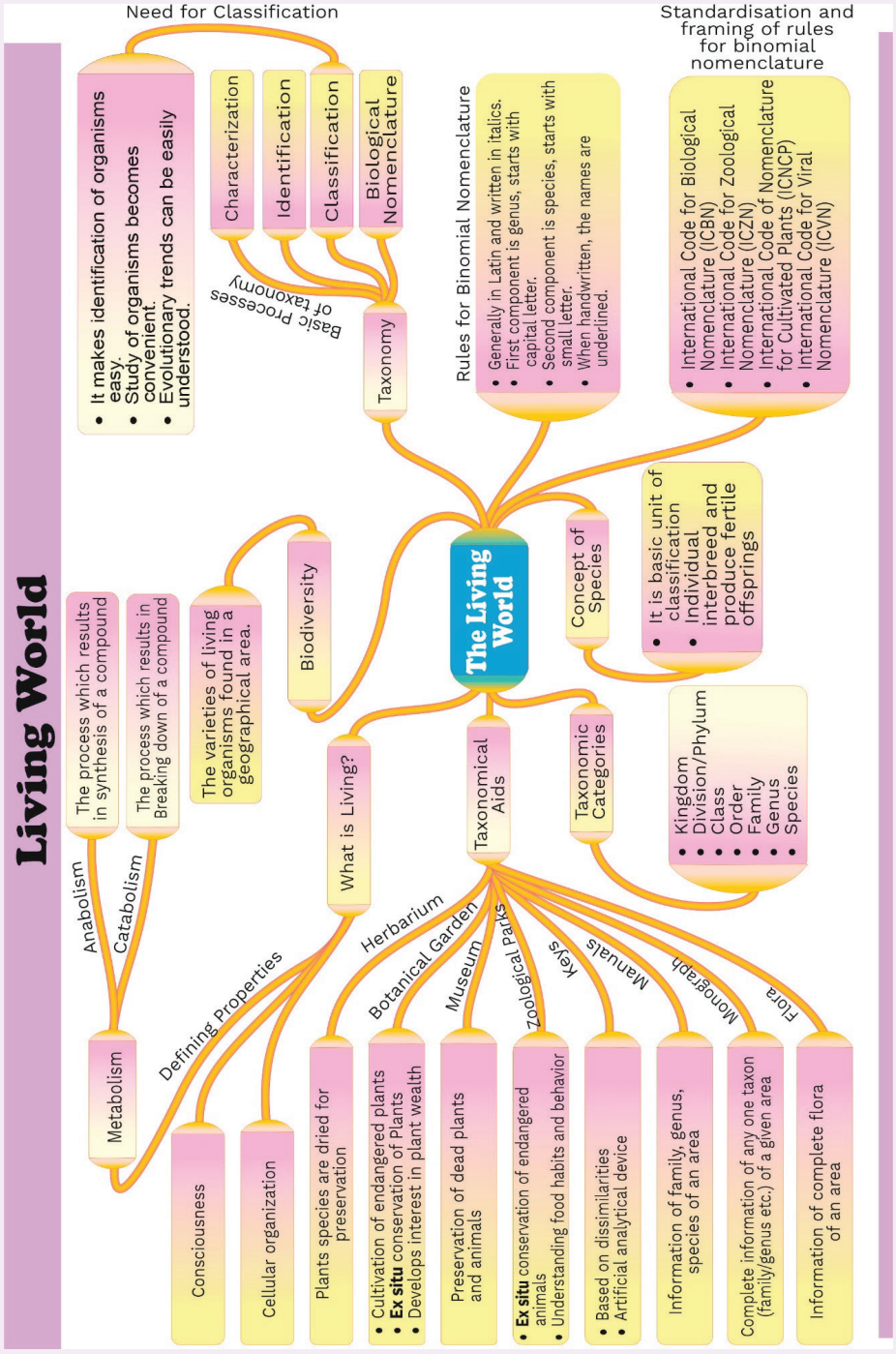
Definition

Key: It is an artificial analytical taxonomic aid used to assign appropriate taxonomic category that is based on contrasting traits.

Rack your Brain

Which is the ideal taxonomic aid to study preserved algae?

Summary


Living World
The Living World
Need for Classification
It makes identification of organisms easy.
Study of organisms becomes convenient.
Evolutionary trends can be easily understood.
Characterization
Identification
Classification
Biological Nomenclature
Basic Processes of taxonomy
Taxonomy
Rules for Binomial Nomenclature
Generally in Latin and written in italics.
First component is genus, starts with capital letter.
Second component is species, starts with small letter.
When handwritten, the names are underlined.
Standardisation and framing of rules for binomial nomenclature
International Code for Biological Nomenclature (ICBN)
International Code for Zoological Nomenclature (ICZN)
International Code of Nomenclature for Cultivated Plants (ICNCP)
International Code for Viral Nomenclature (ICVN)
Concept of Species
It is basic unit of classification
Individual interbreed and produce fertile offsprings
Biodiversity
The varieties of living organisms found in a geographical area.
What is Living?
Metabolism
Anabolism
The process which results in synthesis of a compound
Catabolism
The process which results in Breaking down of a compound
Defining Properties
Consciousness
Cellular organization
Taxonomical Aids
Herbarium
Plants species are dried for preservation
Botanical Garden
Cultivation of endangered plants
Ex situ conservation of Plants
Develops interest in plant wealth
Museum
Preservation of dead plants and animals
Zoological Parks
Ex situ conservation of endangered animals
Understanding food habits and behavior
Keys
Based on dissimilarities
Artificial analytical device
Manuals
Information of family, genus, species of an area
Monograph
Complete information of any one taxon (family/genus etc.) of a given area
Flora
Information of complete flora of an area
Taxonomic Categories
Kingdom
Division/Phylum
Class
Order
Family
Genus
Species

SOLVED EXERCISE

Q1 **The characteristics of growth include.**
(1) increase in mass **(2) increase in number of individuals**
(3) Both (1) and (2) **(4) ability to reproduce**

A1 **(3)**
Increase in mass and increase in number of individuals are twin characteristics of growth.

Q2 **Plants grow throughout life by which method?**
(1) Cell dedifferentiation **(2) Cell differentiation**
(3) Cell division **(4) None of the above**

A2 **(3)**
Plants grow throughout their life by cell division.

Q3 **Growth in unicellular organisms can be observed by**
(1) counting the mass of cultured cells
(2) analysing the amount of nutrients absorbed by living organism
(3) growth cannot be observed
(4) simply counting the number of cells under microscope during In vitro culture

A3 **(4)**
In unicellular organisms, growth can be simply observed by counting the number of cells under microscope during in-vitro culture.

Q4 **In majority of higher animals and plants, reproduction and growth are-**
(1) mutually exclusive events **(2) synonymous events**
(3) synonymous events during in vitro culture **(4) None of the above**

A4 **(1)**
In majority of higher animals and plants, reproduction and growth are mutually exclusive events.

Q5 **In which of the following, metabolic reactions take place?**
(1) In living organisms only (2) Both in living and non-living organisms
(3) In cell-free systems (4) Both (1) and (3)

A5 **(4)**
Metabolic reactions take place in all living organisms and can also be demonstrated outside the body in cell-free systems. They are absent in non-living organisms.

Q6 **The binomial nomenclature system was given by-**
(1) Carol Linnaeus (2) Carolus Linnaeus (3) Aristotle (4) Whittaker

A6 **(2)**
The binomial nomenclature system was given by Carolus Linnaeus.

Q7 **Hierarchy of biological organisation in living beings can be represented as**
(1) Subcellular → Cellular Individual → Population
(2) Atomic → Molecular → Cellular → Tissue → Organ → Organ System → Individual
(3) Organ system → Tissue → Cellular → Molecular → Atomic
(4) Individual → Molecular → Tissue → Organ system → Population

A7 **(2)**
The hierarchy of biological organisation in living beings is in the order given below: Atomic → Molecular → Cellular → Tissue → Organ → Organ-System → Individual.

Q8 **Scientific names are printed in _____and are derived from _____**
(1) Bold and English (2) Italics and Latin
(3) Italics and German (4) Italics and French

A8 **(2)**
Scientific names are printed in italics to indicate their Latin origin.

Q9 **Match the following columns.**

Column I (Botanical gardens/Institutes)	**Column II (Places)**
A. Royal Botanical Garden, Kew	**1. Darjeeling**
B. National Botanical Research Institute	**2. Kolkata**
C. Indian Botanical Garden	**3. Lucknow**
D. Forest Research Institute	**4. Dehradun**
E. Lloyd's Botanical Garden	**5. England**

	A	**B**	**C**	**D**	**E**
(1)	**5**	**3**	**2**	**4**	**1**
(2)	**1**	**3**	**2**	**4**	**5**
(3)	**2**	**5**	**3**	**4**	**1**
(4)	**4**	**1**	**3**	**2**	**5**

A9 **(1)**

Royal Botanical Garden, Kew is located at England.
National Botanical Research Institute is located at Lucknow.
Indian Botanical Garden is located at Kolkata.
Forest Research Institute is located at Dehradun.
Lloyd's Botanical Garden is located at Darjeeling.

Q10 **Potato, tomato and brinjal will show similarities up to which of the lowest taxon?**

(1) Class **(2) Order** **(3) Genus** **(4) Species**

A10 **(3)**

These belong to same genera '*Solanum*'.