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SIERRA INNOVATIONS

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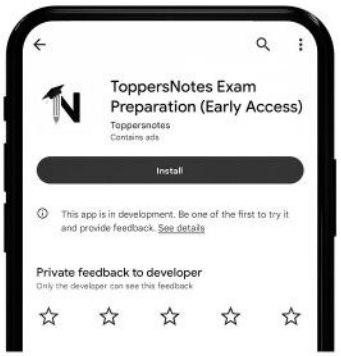

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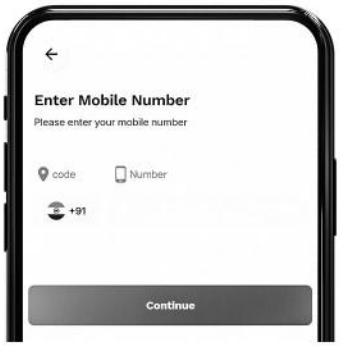

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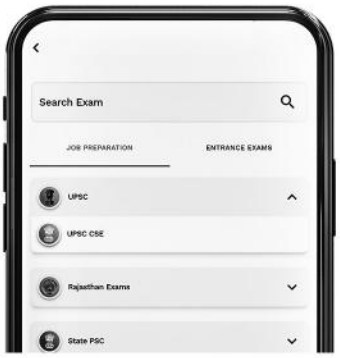

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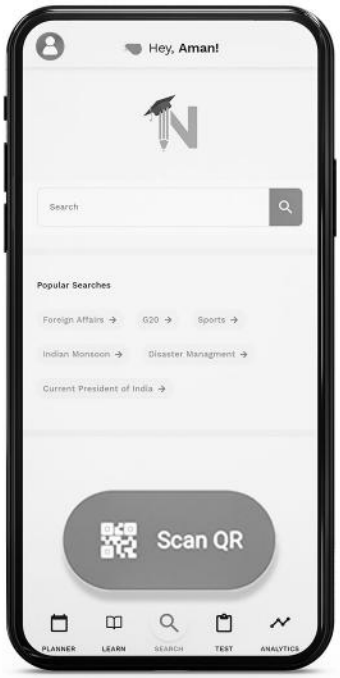

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CHAPTER 1

Diversity in Living World

CHAPTER OUTLINE

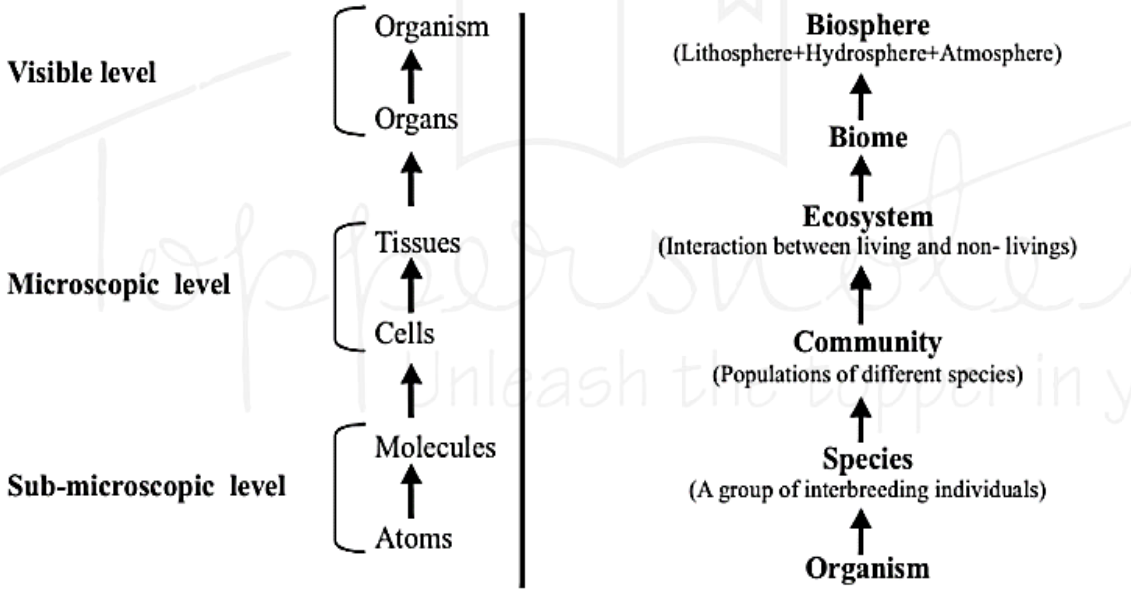
- Introduction
- Diversity in the Living World
- Binomial Nomenclature
- Levels of Organization
- Taxonomy and Systematics
- Taxonomic Categories

INTRODUCTION

Life is a unique and complicated organization of molecules that expresses itself through chemical reactions that result in growth, development, responsiveness, adaptation, and reproduction.

LEVELS OF ORGANIZATION

- The living world are organized into different levels.
- It starts from sub microscopic molecular level and ends up to ecosystem or biome.

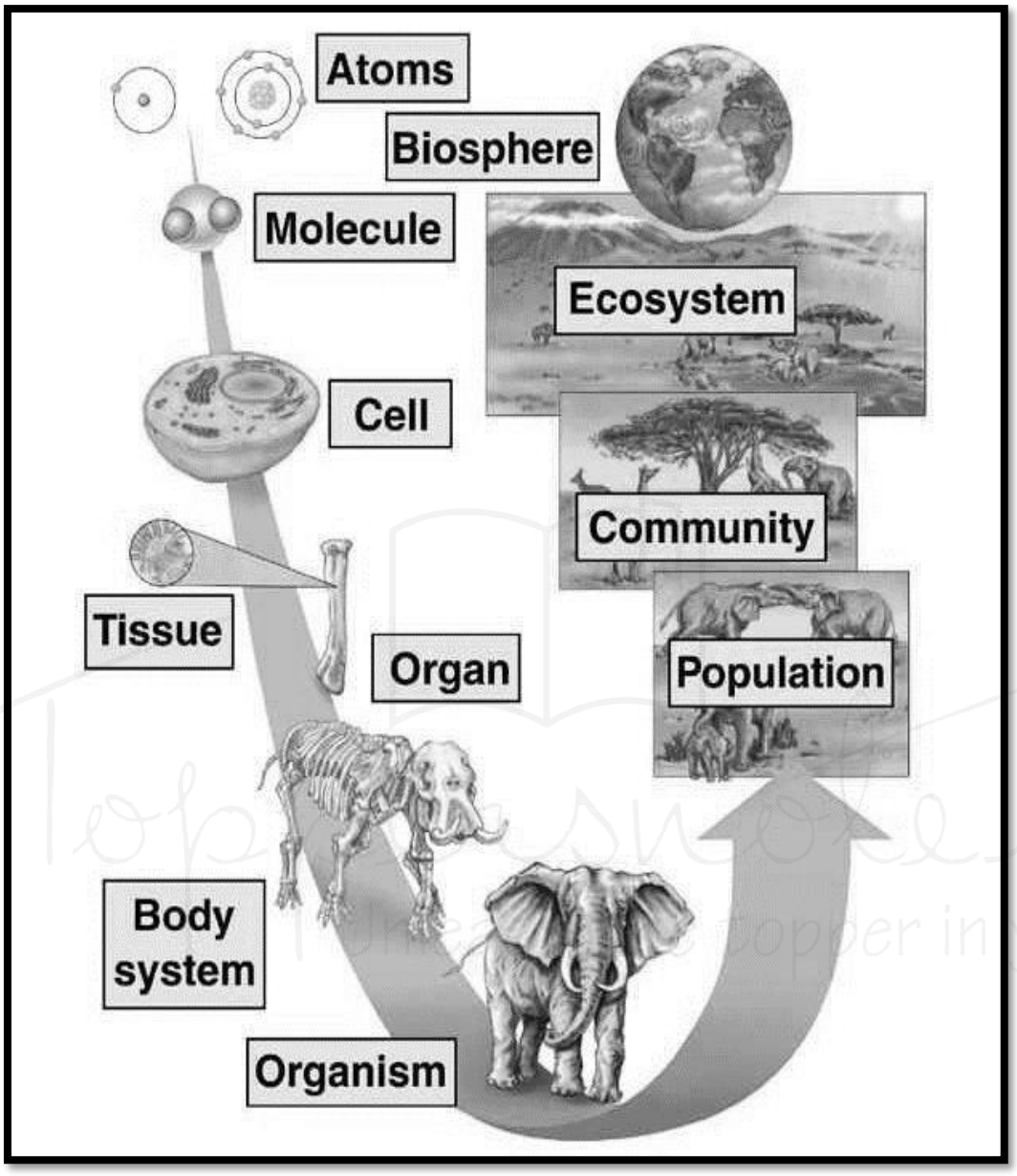


I. Levels of Organization below individual *II. Levels of Organization above individual*

Definitions

Cell	Basic unit of all living things
Tissue	Group of cells of the same kind
Organ	Structure composed of one or more types of tissues
Organ system	Group of organs that work together to do a certain work.
Population	Organisms of the same species that live in the same area form a population.
Community	All of the populations that live in the same area form a community
Ecosystem	All the living things in a given area, together with the non-living environment (water, sunlight etc.)

Biome	A group of similar ecosystems with the similar type of physical environment.
Biosphere	A part of Earth where all life exists, including all the land, water, air where living things can be found.



DIVERSITY IN THE LIVING WORLD

- **Biodiversity** refers to the number of plant and animal species that exist on earth. On the planet Earth, there is a wide variety of living organisms. Their structure, behavior, habitat, mode of nutrition, and physiology vary.
- The number of known and described species ranges between **1.7 and 1.8 million**.
- Even though there is such variety and diversity among living organisms, they share so many similarities and characteristics that they can be categorized into numerous categories.
- In order to understand and systematically study these living organisms, primarily plants and animals, they are classified into various categories.

- There are millions of plants and animals in the globe; we know the local names of the plants and animals in our region.
- These local names would vary from location to location, even within the same nation.

TAXONOMY AND SYSTEMATICS

- **Taxonomy** is the branch of biology concerned with the identification, nomenclature, and classification of living organisms according to their similarities and differences.
- **Augustin-Pyramus de Candolle** (1778-1841), a Swiss-French botanist, coined the term Taxonomy, the discipline of identifying and classifying organisms.
- **Systematics** (Latin'systema') refers to the systematic arrangement of organisms into groups or taxa on the basis of certain interrelationships. Classification principles and procedures are studied.
- This term was first used by **Carolus Linnaeus** in his book **Systema Naturae**.
- Sir Julian Huxley introduced the term "New systematics" in 1940.

Processes of Taxonomy

Characterization	Understanding of characters of organisms like external and internal structure, structure of cell, development process, ecological information etc.
Identification	Correct description of an organism and its recognition in its scientific name.
Classification	Grouping of organisms into convenient categories (taxa) based on characters.
Nomenclature (naming)	Providing of standardized names to the organisms so that a particular organism is known by the same name all over the world.

- Carolus Linnaeus proposed the system of designating with two components (**Binomial nomenclature**). Each scientific name has two components, according to binomial nomenclature: the **generic name** and the **specific epithet**.
- Botanical names adhere to the guidelines outlined in the **International Code for Botanical Nomenclature (ICBN).**
- **The International Code for Zoological Nomenclature (ICZN**) is the basis for zoological names.

Need for classification

- To organise the vast number of plants and animals into categories that could be named, remembered, studied and understood.
- Study of one organism of a group gives the idea about rest of the members of that group.
- Classification allows us to understand diversity better.

History of classification

- In the third and fourth centuries B.C., **Aristotle** and others classified organisms as either plants or animals. They even identified several thousand or more organisms that are alive.
- The **Father of Medicine**, **Hippocrates** (460-377 BC), enumerated organisms with medicinal value.
- The first attempt to classify organisms without emphasizing their medicinal value was made by **Aristotle** and his student **Theophrastus** (370-282 BC). They attempted to classify the vegetation and animals according to their appearance and habitat.
- In his book **'Historia Naturalis'**, Pliny the Elder (23-79 AD) introduced the first artificial classification system.
- **John Ray**, an English naturalist, was the first to apply the term species to all forms of life.

- In the 18th century, the Swedish naturalist **Carolus Linnaeus**, also known as the **Father of Taxonomy**, created the **Binomial System of Nomenclature**, which is the current scientific system for naming species.
- In his famous work **Species Plantarum** (1753), he described 5,900 plant species, and in **Systema Naturae** (1758), he described 4,200 animal species.

Advantages of classification

- Classification facilitates the identification of living organisms.
- It facilitates systematic study of such a wide diversity of living organisms.
- It helps us learn about the differences and similarities between various vegetation and animals.
- It enables us to understand the evolution of complex organisms over time.
- It helps us know the interrelationships between various organizations.
- It provides a methodical means of identifying known and unknown organisms.
- Classification systems are internationally adapted. This facilitates communication among scientists.

BINOMIAL NOMENCLATURE

Nomenclature is the method of assigning plants and animals scientific names. A binomial system of nomenclature was created by Carolus Linnaeus, in which an organism is assigned two names.

(i) A **generic name** shared with other closely related organisms whose characteristics are sufficiently similar to position them in the same group.

(ii) A **species name** is that differentiates the organism from all other species. No other organism can have the same genus and species combination.

Following a set of principles outlined in the **International Code of Nomenclature**, the scientific name derived from the system of nomenclature is used everywhere in the world.

Universal Rules of Binomial Nomenclature

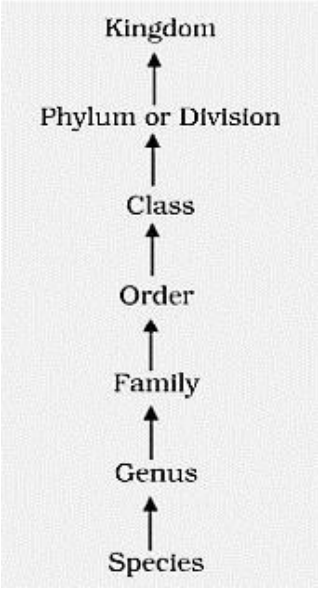
- Scientific names are generally in Latin language and written in italics.
- The first word is name of the genus (**Generic** name) whereas the second word is the species name (**Specific epithet**).
- When handwritten, the names are underlined.
- The first name (Genus) starts with capital letter and the second name (Species) starts with small letter.
  Example: *Homo sapiens*
  Here, *Homo* represents the genus name and *sapiens* represents the species name.
- Name of the author appears after the specific epithet, i.e., at the end of the biological name and is written in an abbreviated form, e.g., *Mangifera indica* Linn. It indicates that this species was first described by Linnaeus.

Codes for Nomenclature

1. International code of Botanical nomenclature (ICBN)
2. International code of Zoological nomenclature (ICZN)
3. International code of Bacteriological nomenclature
4. International code of viral nomenclature (not based on binomial nomenclature)
5. International code of nomenclature for cultivated plants

TAXONOMIC CATEGORIES

- Classification involves hierarchy of steps in which each step represents a **rank** (taxonomic category or taxon). All categories together constitute the **taxonomic hierarchy**. Each **taxon** represents a **unit** of **classification**.



Definitions

1. Species

- The **species** is the **fundamental classification** unit. It is a collection of organisms that share fundamental similarities.
- It is defined as the group of individuals who share similar morphological and reproductive traits and who interbreed and produce fertile progeny.
- Mayr proposed this as the biological concept of species.
- **Example**: There are two species of crows. One is the common house crow that inhabits the plains surrounding our homes. The alternative is the hill or forest crow. Both the intensity of black on the neck and the size and form of the mandible vary between the two crows.
- Both are crows, but they cannot mate. Therefore, they are **distinct species**.

Common Name	Generic Name	Specific Epithet
Mango	*Mangifera*	*indica*
Potato	*Solanum*	*tuberosum*
Nightshade	*Solanum*	*nigrum*
Lion	*Panthera*	*leo*
Peepal	*Ficus*	*religiosa*
Modern man	*Homo*	*sapiens*
Cat	*Felis*	*domesticus*
Tiger	*Felis*	*tigris*
Honey bee	*Apis*	*indica*
Housefly	*Musca*	*domestica*
Rubber plant	*Ficus*	*elastica*
House crow	*Corvus*	*splendens*

2. Genus

- These are the **populations of closely related species.** It consists of a group of closely related species that share more characteristics than species from other genera.

  Examples:

  (a) Genus *Solanum* = Potato, tomato and brinjal

  (b) Lion (*Panthera leo*), leopard (*P. pardus*) and tiger (*P. tigris*) are species of genus *Panthera*.

  (c) Genus *Felis* which includes cats.

3. Family

- It is a **group of related genera** with less number of similarities as compared to genus and species.

  Examples:

  (a) Family Solanaceae involves Genus *Solanum*, Genus *Petunia* and Genus *Datura*.

  (b) Family Felidae involves Genus *Panthera* and Genus *Felis*.

4. Order

- It is the **assemblage of related families.**

  Examples:

  (a) Order Polymoniales includes Family Convolvulaceac and Family Solanaceae.

  (b) Order Carnivora includes Family Felidae and Canidae (dog).

5. Class

- It is the **assemblage of related orders.**

  Examples:

  (a) Order Primata, Carnivora etc. is placed in class Mammalia.

  (b) Order Polymonials and Order Sapindales etc. is placed in class Dicotyledonae.

6. **Phylum (in animals) or Division (in plants)**
   - It is the **assemblage of related classes.**
     Examples:
     (a) Classes Amphibia, Reptilia, Aves, Mammalia etc. come under phylum Chordata.
     (b) Class dicotyledonae and class monocotyledonae is place under division Angiospermae.

7. **Kingdom**
   - The assemblage of various phyla.
   - It is the highest category.
   - Examples: Kingdom Plantae, Kingdom Animalia.

Organisms with their Taxonomic Categories

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

CHAPTER 2

Biological Classification

CHAPTER OUTLINE

- Importance of Classification
- Two Kingdom Classification
- Four Kingdom Classification
- Six Kingdom Classification
- Kingdom Protista
- Kingdom Plantae
- Viruses
- Lichens
- Three types of Classification
- Three Kingdom Classification
- Five Kingdom Classification
- Kingdom Monera
- Kingdom Fungi
- Kingdom Animalia
- Virion, viroid and Prions
- Mycorrhizae

INTRODUCTION

The process of classifying organisms into groups and subgroups according to their similarities and differences is known as biological classification.

IMPORTANCE OF CLASSIFICATION

(i) It facilitates the study of several biological organisms.

(ii) It provides a general understanding of the diversity that can be found in organisms.

(iii) It offers details on the interactions between different organisms.

(iv) It provides insight into how diverse organismal groups have evolved.

(v) It provides a method for identifying both known and unknown species.

THREE TYPES OF CLASSIFICATION

(i) Artificial system of classification

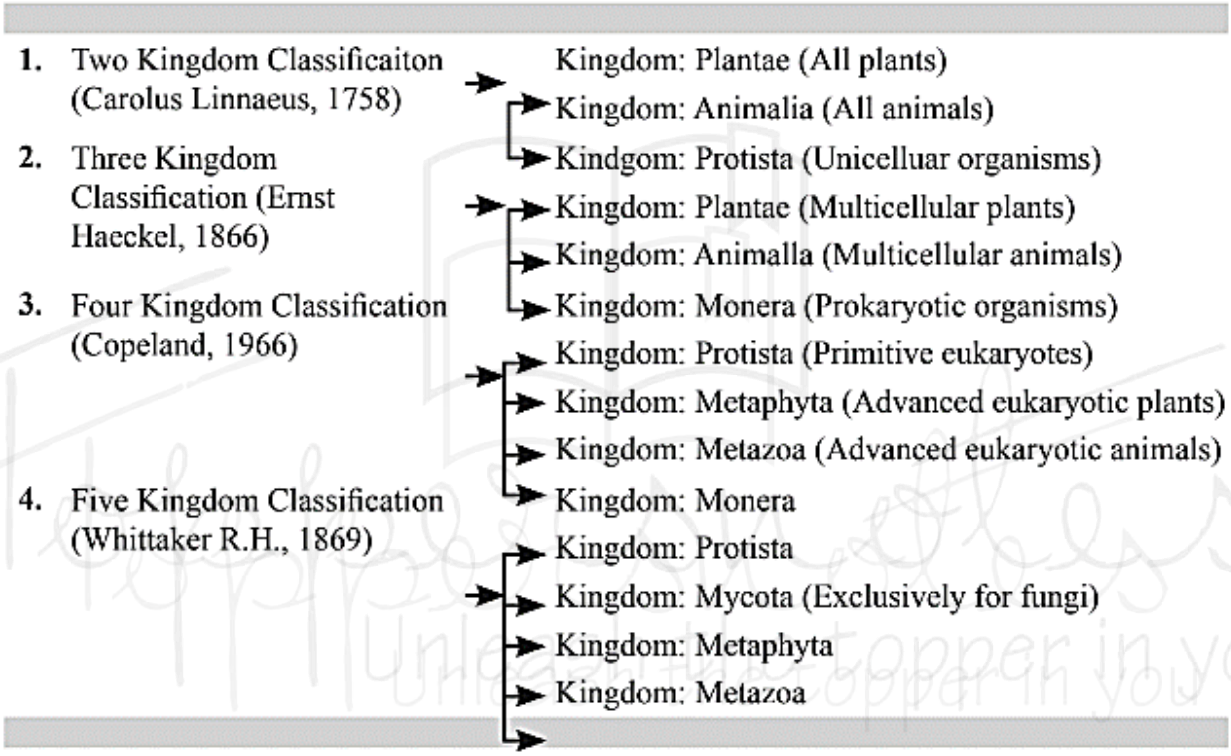
- It is a classification system that groups organisms based on one or two morphological characteristics.
- Aristotle, for example, attempted to classify species in 350BC based on their form and habitat. He classified plants using simple morphological characteristics.
- He classified plants as herbs, shrubs, or trees. He separated the animals into those who had RBCs and those who did not.
- There are numerous other instances of old classification systems based mostly on superficial characteristics.
- As a result, this artificial categorization system has several severe flaws, including:
  - the classification criteria are shallow and does not reflect natural relationships.
  - The system does not reflect the creatures' evolutionary relationship.
  - Many unrelated organisms are grouped together based on their habitats (dwelling place) (for example, whales and fishes are grouped together).
  - Because of differences in habitat, feeding patterns, and so on, closely related creatures have been classified into separate groups.

(ii) Natural system of classification: It is a classification system that uses many physical characteristics to group species in order to reveal natural similarities and dissimilarities, and thus natural relationships between the animals.

- The natural system of categorization offers several advantages over the artificial system of classification, including
  - The avoidance of heterogeneous groupings of unrelated animals and the ability to put only related groups of organisms together.
  - It denotes the natural interactions between organisms.
  - It also offers a clear picture of the evolutionary link between various groupings of living species.

(iii) Two kingdom classification: The natural system of classification was introduced by the Swedish biologist, **Carolus Linnaeus** (1707-1778).

Evolution of classification



- **Linnaeus** is known as **father of classification** as he classified the living organisms in a systematic way for the first time.

TWO KINGDOM CLASSIFICATIONS

Linnaeus classified all the living organisms under two huge kingdoms.

- **Kingdom Plantae**: Bacteria (Prokaryotes), photosynthetic plants, and non-photosynthetic fungus are all members of this kingdom.
- **Kingdom Animalia**: This kingdom contains both unicellular protozoans and multicellular animals, known as **metazoans**.

Limitations of Two Kingdom System of Classification

(i) Some creatures, such as *Euglena* and Sponges, exhibit features of both plants and animals.

Example:

- Some *Euglena* species have chlorophyll and are autotrophic like plants.
- A few *Euglena* species lack chloroplasts and are hence colorless and non-photosynthetic (heterotrophic), with a saprotrophic method of nutrition that involves extra-cellular digesting.

- Other colorless forms consume small food particles and digest them within the cell (holozoic nutrition).
- The presence of an animal pigment known as taxanthin in the eye spot distinguishes Euglena.

(ii) Fungi and moulds were classified as Kingdom Plantae, but they share many characteristics with plants. Fungi do not have chlorophyll. They, like animals, are heterotrophic.

(iii) Bacteria and Cyanobacteria (blue-green algae) share many similarities yet differ greatly from other creatures. As a result, classifying them as plant or animal is challenging.

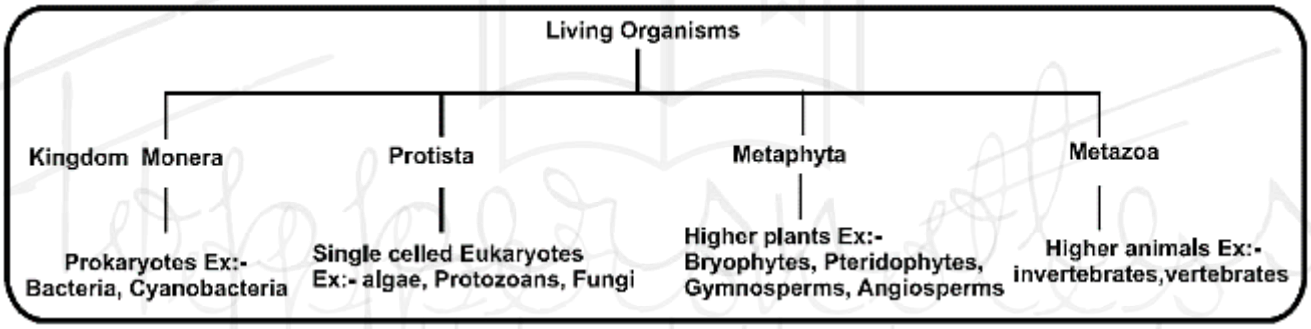
(iv) Whether viruses are living or non-living is still a topic of debate.

THREE KINGDOM CLASSIFICATION

- In 1866, Haeckel proposed three kingdom classifications.
- He divided the living organisms into three kingdoms:-
  (a) Plantae
  (b) Protista
  (c) Animalia

FOUR KINGDOM CLASSIFICATION

- Copeland established the kingdom of Monera in 1956.
- The living world was separated into four kingdoms: Monera, Protista, Metaphyta, and Metazoa.



FIVE KINGDOM CLASSIFICATION

- R.H. Whittaker (1969), an American Taxonomist, classified every organism into five kingdoms based on their evolutionary relationships.

The five-kingdom classification is based on the following criteria:

- **Complexity of Cell structure** - Prokaryote and Eukaryote
- **Mode of nutrition** - Autotrophs and heterotrophs
- **Body organization** - Unicellular or multi-cellular
- **Phylogenetic or evolutionary relationship**

The five kingdoms are:

Monera	Prokaryotes	Bacteria and cyanobacteria
Protista	Unicellular eukaryotes	Unicellular algae, diatoms and protozoa
Fungi	Multicellular decomposers	Fungi and moulds
Plantae	Multicellular producers	Plants
Animalia	Multicellular consumers	Animals

Characteristics of Five Kingdom System of Classification

Characteristics	Five Kingdoms				
	Monera	**Protista**	**Fungi**	**Plantae**	**Animalia**
Cell type	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
Cell organization	Mostly unicellular	Mostly unicellular	Multicellular and unicellular	Mostly multicellular (Tissue/Organ system)	Mostly multicellular (Tissue/organ/organ system level)
Cell wall	Non-cellulosic (Polysaccharide + amino acid)	May or may not be present.	Present (without cellulose)	Present (cellulose)	Present
Mode of Nutrition	Autotrophic (chemosynthetic and Photosynthetic) Heterotrophic (Saprophytic and Parasitic)	Autotrophic and Heterotrophic	Heterotrophic (Saprophytic and parasitic)	Autotrophic by photosynthesis	Heterotrophic by ingestion
Motility	Motile or non-motile	Motile or non-motile	Non motile	Mostly non-motile	Mostly motile
Reproduction	Conjugation/Transduction/Transformation or None	Syngamy and meiosis, conjugation or None	Fertilization and meiosis. Dikaryosis or none	Fertilization and meiosis	Fertilization and meiosis

Merits of five kingdom classification

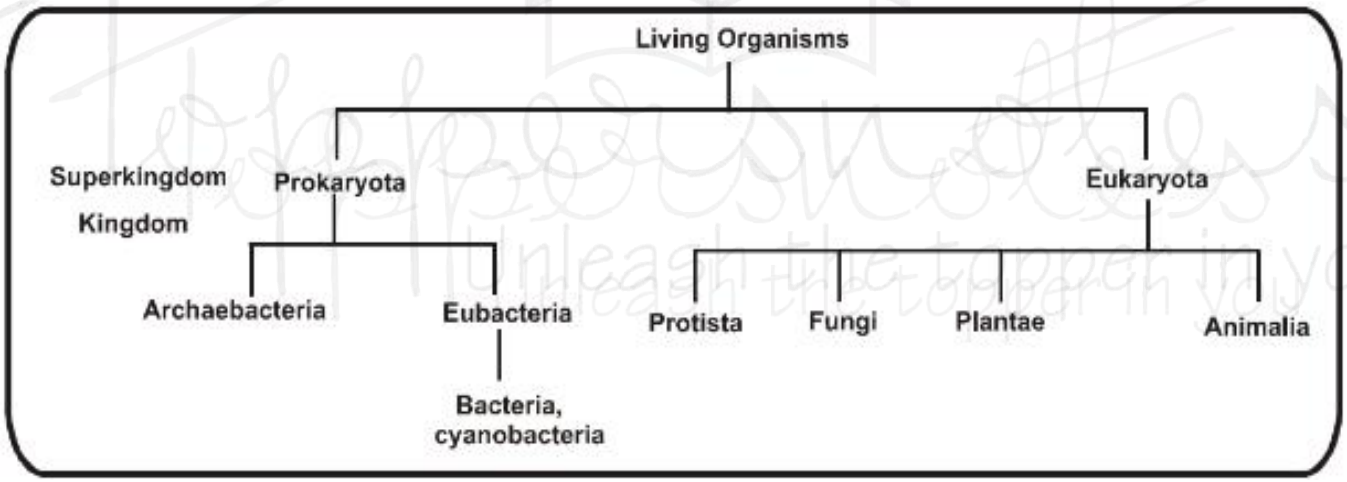
- It reflects a better relationship between organisms in terms of levels of organization and mode of nutrition.
- It reflects a better evolutionary trend signifying the gradual emergence of complex organisms from simpler ones.
- It elevates the ranking of controversial groups such as cyanobacteria, fungi, Euglena, etc.
- Division of the kingdom, as fungi have their own structural, physiological, and biochemical characteristics, the separation of fungi from plants seems justified.

Demerits of five kingdom classification

- The position of the virus is unclear.
- Kingdom Protista contains organisms with diverse form, structure, and life cycles; therefore, it does not appear to be a legitimate grouping.
- Some organisms included in Protista (e.g., dinoflagellates) are not eukaryotic but rather mesokaryotic.
- Slime molds classified under Protista differ significantly from the rest of the protists. Plantae, Fungi, and Animalia appear to be polyphyletic.
- Despite all of these errors, however, Whittaker's five kingdom system is widely accepted.

SIX KINGDOM CLASSIFICATION

It was introduced by Gray and Doolittle (1982).



KINGDOM MONERA (KINGDOM OF PROKARYOTES)

- This kingdom contains **all prokaryotic organisms**, including **mycoplasma**, **bacteria**, **actinomycetes** (filamentous bacteria), and **cyanobacteria** (also known as blue-green phytoplankton).
- They are **very small**.
- Monera is the only kingdom of prokaryotes. They **lack** a **real nucleus**. They **lack organelles** bound to membranes.
- Bacteria were the first organisms to evolve on Earth following the origin of life approximately 3.5 billion years ago. They are the most abundant of all life forms.
- **Bacteria and cyanobacteria** are both unicellular organisms.
- Bacteriology is the field of study devoted to the study of microorganisms.

Shapes of Bacteria

Based on their shape, bacteria are grouped under four categories:

Coccus (Spherical)	Bacillus (Rod- shaped)	Vibrio (Comma-shaped)	Spirillum (Spiral Shaped)
• **Monococcus (occur singly)** • **Diplococcus (occur in pairs)** • **Tetracoccus (occur in groups of four)** • **Streptococcus (occur in the form of a filament) and** • **Staphylococcus (occur in the form of sheets).**	• Monobacillus (single) • Diplobacillus (in pairs) • Streptobacillus (in filamentous form) and • Palisade Bacillus (in the form of a stack)		

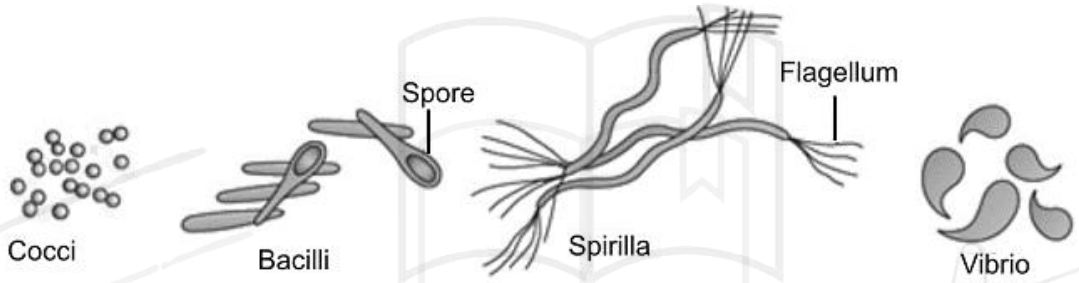


Figure: Bacteria of different shapes

Structure of a bacterial cell

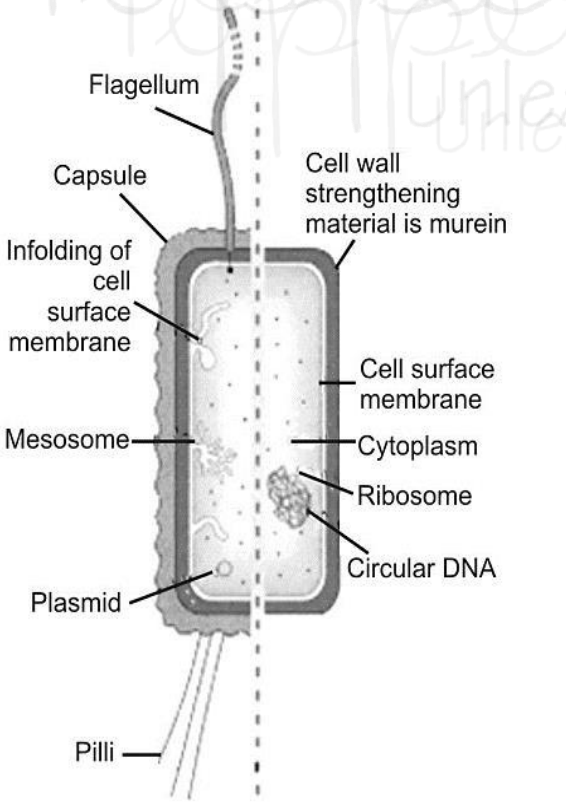


Figure: Structure of a bacterial cell

Cell wall	Cell wall is the bacterial cell's outermost covering. The rigidity of the cell wall protects and shapes the cell. The cell wall is composed of peptidoglycan.
Plasma membrane	Below the cell wall, the plasma membrane encloses the cytoplasm and other cell contents. It comprises lipids and proteins
Pili	Pili are short, thread-like structures that protrude from the cell wall of certain microorganisms.
Flagella	Some microbes move with the assistance of one or two flagella. Flagella have a microtubule arrangement of 9+1. Flagella are more extensive and robust than pili.

Genetic material (DNA)	Bacteria have one circular chromosome composed of a double-helical molecule of genetic material (DNA). It is located in the nucleoid region of the cytoplasm. Bacteria are designated prokaryotes because their chromosomes are not housed in a true nucleus. In addition to the chromosome, many bacterial species possess plasmids, which replicate alongside the chromosome and contain genes for antibiotic resistance, sex factor, etc.
Cell organelles	There are ribosomes in the cell, but no membrane-bound organelles.

Note:
Prokaryotes lack a nuclear membrane surrounding their genetic material, as well as cell organelles. They only possess ribosomes.

Gram staining

- In 1884, the Danish physician Christian Gram invented gram staining, a method of differential staining for bacterial cells.
- Gram staining is one classification technique for bacteria. Gram-positive and Gram-negative bacteria are distinguished by their capacity to retain a purple dye. The ability of a bacterium to retain the dye depends on its cell wall and outer membrane.

Gram-positive bacteria	**Gram-negative bacteria**
Stains purple with Gram stain. This is because they have a thick cell wall (made of peptidoglycan) without an outer membrane.	Stains red with Gram stain. This is because they have a thin cell wall (peptidoglycan layer) with an outer membrane composed of Lipopolisakarisa (LPS) and protein.
Examples: Cyanobacteria, *Treponema pallidum, Escherichia coli, Shigella sp., Yersinia pestis, Vibrio cholerae*.	Examples: *Salmonella, Corynebacterium diptheriae, Mycobacterium tuberculosis*

Nutrition

The **four nutritional categories** found in bacteria are:

Nutritional categories	**Meaning**	**Examples**
Autotrophs	Some bacteria are autotrophic and are photosynthetic i.e. they can synthesize their organic food in the presence of sunlight	Example: *Spirillum*
Chemotrophs	Some bacteria are chemosynthetic i.e. they can synthesize their organic food by deriving energy from some chemical reactions.	Examples: *Nitrosomonas* and *Nitrobacter* Other bacteria like *Rhizobium, Azotobacter* and *Clostridium* can fix atmospheric nitrogen into ammonia. This phenomenon is called biological nitrogen fixation.

Saprotrophs	Some bacteria feed on dead and decaying matter.	Examples: *E. coli, Spirochaeta*
Symbionts (Mutualism)	Some use food from other living organisms with which they are associated for mutual benefit.	Example: Some bacteria live in the roots of legumes, such as pea plants. The bacteria turn nitrogen containing molecules into nitrogen that the plant can use. Meanwhile, the root provides nutrients to the bacteria. In this relationship, both the bacteria and the plant benefit, so it is known as a **mutualism**.
Parasites	They absorb food from living organisms and cause harm to them.	Examples: *Salmonella typhi, Diplococcus pneumoniae, Mycobacterium leprae*

Respiration

- Bacterial respiration can be either (i) **aerobic**, i.e. using oxygen, or (ii) **anaerobic**, i.e. take place in the absence of oxygen.
  Example: Archaebacteria are monerans.
- **Cellular respiration** or the decomposition of food to release energy occurs in **mesosomes**, the inner extensions of the cell membrane.

Reproduction

Asexual Reproduction	**Sexual Reproduction**
Bacteria reproduce asexually through binary fission when conditions are favorable. During binary fission, the chromosome replicates itself, producing two identical copies. The cell then grows in size and divides into two daughter cells. Binary fission can occur very quickly. By means of binary fission, one bacterium divides into two in approximately 20 minutes.	There is no sexual reproduction in bacteria. Not all new bacteria, however, are clones. Because microorganisms can still combine and exchange DNA, this is the case.
	This interaction occurs in three distinct ways: **(a)** **<u>Conjugation</u>**: Involves transfer of DNA from one bacterium to another through an extension on the surface. **(b)** **<u>Transformation</u>**: Bacteria pick up pieces of DNA from their environment. **(c)** **<u>Transduction</u>**: Viruses that infect bacteria carry DNA from one bacterium to another.

Asexual Reproduction

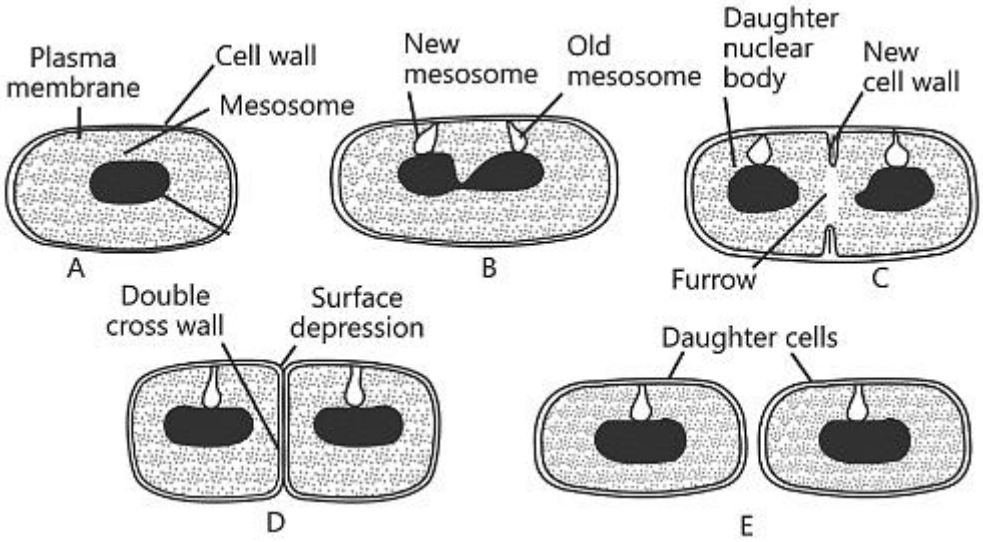


Figure: Various stages (A - E) of cell division in a Bacteria

Beneficial and harmful bacteria

A. Beneficial Activities of Bacteria

Bacterium	**Function**
Rhizobium	Found in the roots of legumes (peas, grams and pulses), Fixes atmospheric nitrogen into ammonia
Azotobacter	Makes the soil fertile along with fixing atmospheric nitrogen.
Streptomycetes	Production of the antibiotic called **Streptomycin**.
Lactobacillus	Ferments the lactose sugar into lactic acid which helps in settling down the milk to curd.
Methanogen	Helps in sewage treatment.

B. Diseases Caused by Bacteria

Bacterium	**Disease caused**
Vibrio cholerae	Cholera
Salmonella typhi	Typhoid
Clostridium tetani	Tetanus
Corynebacterium diptheriae	Diphtheria
Mycobacterium tuberculosis	Tuberculosis

Cyanobacteria

These were formerly known as blue-green algae. On prehistoric Earth, it is a highly successful group. They engaged in photosynthesis and released oxygen into the earth's atmosphere, thereby progressively increasing the concentration of oxygen in the atmosphere.

DIFFERENCE IN BACTERIA AND CYANOBACTERIA

Bacteria	**Cyanobacteria**
They are smaller in size.	They are comparatively larger cells.
They may have flagella.	They do not have flagella.
Some of them carry out photosynthesis which are green in color in a different way and in this process, oxygen is not released.	All of them carry out photosynthesis in the same manner when compared to green plants and in this process oxygen is released.

Kingdom Monera includes two groups:

(a) Archaebacteria

(b) Eubacteria