2. Systematics of Living Organisms

Can you recall?

What is five kingdom system of classification?

There is great diversity of organisms around us. Since time immemorial, we humans have been exploiting this wealth for our own benefit. During this process man tried to differentiate between and identify the organisms. Eventually this evolved into a branch of biology known as systematics or classification. The methods of classification dates back to ancient time when Indian, Greek and Roman philosophers have contributed their might to systematise science.

2.1 Systematics :

"Systematics is the study of kinds and diversity of organisms and their comparative and evolutionary relationship"(G. Simpson, 1961).

Taxonomy :

Taxonomy means classification following certain rules or principles. Word Taxonomy comes from two Greek words, taxis – meaning arrangement and nomous meaning law or rule. **The term taxonomy was first introduced by A. P. de Candolle (Swiss Botanist) [1778-1841].**

2.2 Classification :

It is the arrangement of organisms or groups of organisms in distinct categories in accordance with a particular and well established plan. This classification is based on similarities and dissimilarities among the organisms.

Artificial :

It is the classification that is based on few easily observable and non-evolutionary featurs such as habit, colour, form, etc.; often irrespective of their affinity (relationship) with other organisms. e.g. Linnaeus system of classification.

Natural : It is the classification which is based on objectively significant rather than being selected for convenience like artificial system of classification e.g. Bentham and Hooker's system of classification.

Phylogenetic : It is the classification based on common evolutionary descent. e.g. Engler and prantles classification.

In the system of classification the terms like 'taxa' and 'categories' are often used. Each category is referred to as a unit of classification. In fact, it represents a rank and is commonly termed as taxon.

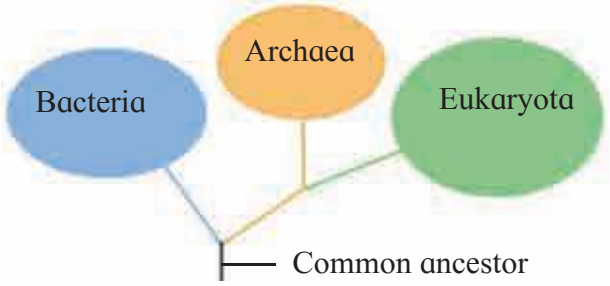


Fig 2.1 Phylogenetic descent

2.3 Three domains of life :

It is believed that the life originated on earth in its very simple form. Constant struggle of the early living beings gave rise to more and more perfect forms of life. This struggle and progress is evolution which led to formation of diverse life forms. Carl Woese in 1990 proposed three domains of life to classify life forms. They are Archaea, Bacteria and Eukarya. Domain is an unit larger than Kingdom in the system of classification.

Bacteria and Archaea both have prokaryotic cells where as Eukarya have eukaryotic cell. All the three domains have very unique ribosomal RNA (rRNA). Archaea are known for their survival in very extreme conditions like high tempreature, salinity, acidic conditions, etc. Bacteria, though are prokaryotes differ from Archaea in structure of cell wall.

2.4 Chemotaxonomy :

It is method of biological classification based on similarities and differences in structure of certain compounds present among the organisms being classified. In short, it is the classification based on chemical constituents of organisms. e.g. Archaea cell wall is without peptidoglycan and that of Prokarya is with peptidoglycan. Among Eukarya, fungi have chitinous cell wall while plants have cellulosic cell wall.

2.5 Numerical taxonomy :

The system is based on quantification of characters and develops an algorithm for classification. The basic aim of this taxonomy was to create a taxonomy using numeric algorithms like cluster analysis rather than using subjective evaluation of their propertise. This system was first proposed by Sokel and Sneath in 1963.

2.6 Cladogram :

It is a typical branching pattern. As shown on previous page, a diagram of three domains of life is a cladogram. It represents a hypothetical relationship denoting a comparison of organisms and their common ancestors.

2.7 Phylogeny :

It is evolutionary relationship of organism. It is an important tool in classification as it takes into account not merely the morphological status but also the relationship of one group of organism with other groups of life. The system helps to understand the evolution and also focuses on the similarities of their metabolic functioning. Woese's three domain concept as well as Whittakar's five kingdom system are very good examples of phylogenetic relationship.

2.8 DNA barcoding :

DNA barcoding, is a new method for the identification of any species based on its DNA sequence from a tiny tissue sample of the organism under study.

It helps to study newly identified species as well as understanding ecological and evolutionary relationships between living beings. The process of DNA barcoding includes two basic steps: (a) collecting DNA barcode data of known species and (b) matching the barcode sequence of the unknown sample against the barcode library for identification. DNA barcoding has many applications. A few to mention are, protection of endangered species, preservation of natural resources, pest control in agriculture, identifying disease vectors, authentication of natural health products and identification of medicinal plants.

Can you tell?

1. Which characters of organisms are visible characters?
2. Name the recent approaches in taxonomy.
3. What is DNA barcoding?
4. What is evolution?
5. Enlist uses of taxonomy.

2.9 Taxonomic Categories :

Classification is not a single step process but involves hierarchy of steps in which each step represents a rank or category. Since the category is a part of overall taxonomic arrangement it is called taxonomic category and all categories together constitute the taxonomic hierarchy. Kingdom, division, class, order, family, genus, species are the categories in hirarchial sequence. These are compulsory categories. Besides, there are some facultative categories like sub-order, sub-family, etc. to be used as per need.

2.10 Taxonomic Hierarchy :

Taxon : A taxon is the taxonomic group of any rank in the system of classification (H.J. Lam 1948) e.g. in plant kingdom each one of the following such as Angiosperms, Dicotyledonae, Polypetalae, Malvaceae represents a taxonomic group i.e. a taxon.

Category	Taxon	Taxon
Kingdom	Plantae	Animalia
Division/Phylum	Angiospermae	Chordata
Class	Dicotyledonae	Reptilia
Sub-class	Polypetalae	Diapsida
Series	Thalamiflorae	-
Order	Malvales	Squamata
Family	Malvaceae	Elapidae
Genus	*Hibiscus*	*Naja*
Species	*rosa-sinensis*	*naja*

Table 2.2 Classification of China-rose and Cobra

2.11 Units of Classification :

- **Species :** Species is the principal natural taxonomic unit, ranking below a genus and denoted by latin binomial (considered as the basic) unit of classification. It is a group of organisms that can interbreed under natural condition to produce fertile offspring. It was thought to be an indivisible, stable and static unit. However in the modern taxonomy, sub-division of species such as sub-species, varities and populations are seen and given more importance.

- **Genus :** Genus is a taxonomic rank or category larger than species used in the biological classification of living and fossil organisms. Genus is a group of species bearing close resemblance to one another in their morphological characters but they do not interbreed. e.g. Tiger, Leopard, Lion all three belong to same genus *Panthera.* They have common characters yet are different from each other because their genus is same but species is different. Another example is genus *Solanum.* Brinjal and potato both belong to this genus.

- **Family :** It is one of the major hierarchial taxonomic rank. A family represents a group of closely related genera. e.g. genera like *Hibiscus, Gossypium, Sida, Bombax* are included in same family Malvaceae. Cat also belongs to family of leopards, tigers and lions, family Felidae but dog belongs to different family Canidae.

- **Cohort / Order :** It is taxonomic rank used in the classification of organisms and recognised by nomenclature codes. An order is a group of closely related families showing definite affinities. Order thus is a step above family in taxonomic hierarchy. Members belonging to same order but different families may show very few dis similarities. e.g. family - Papavaraceae, Brassicaceae, Capparidaceae, etc with parietal plancentation are grouped in order Parietales. Families of dogs and cats though are different, they belong to same order Carnivora.

- **Class :** The class is the distinct taxonomic rank of biological classification having its own distinctive name. A group of higher taxonomic rank than order. Class is the assemblage of closely allied orders. Orders **Carnivora** and order **Primates** belong to class **Mammalia**. Thus monkeys, gorillas, gibbons (Primates) and dogs, cats, tigers (**Carnivora**) belong to same class.

- **Division / Phylom :** The division is a category composed of related classes e.g. division. **Angiospermae** includes two classes - **Dicotyledonae** and **Monocotyledonae** (In animal classification division is a sub-unit of Category / Phylum).

- **Sub-kingdom :** Different divisions having some similarities form sub-kingdom. e.g. The divisions **Angiospermae** and **Gymnospermae** will the sub-kingdom **Phanerogams** or **Spermatophyta**.

- **Kingdom :** It is the highest taxonomic category composed of different sub-kingdoms. e.g. sub-kingdom **Phanerogams** and **Cryptogams** form the Plant kingdom or Plantae which includes all the plants while all animals are included in kindom Animalia.

The taxonomic categories we have considered so far are broad categories. Scientists have added sub-categories to these in order to place organisms in more scientific manner. You will observe that as we go higher in taxonomical ladder, number of common characters go on decreasing.

If we are comparing two organisms that are related to each other only at division or phylum level, their classification may become difficult.

Can you tell?

1. Why horse and ass are considered to be two different species or animals?
2. Make a flow chart showing taxonomic hierarchy.

2.12 Nomenclature :

Any object that becomes known to human intelligence must possess a name. It may not be possible or convenient to describe it in order to communicate ideas about it. The art of naming the objects is in fact, a science called nomenclature. All living organisms are known by a particular name.

1. Vernacular / Local names / Common names: Widely distributed organisms have a large number of common names. Pansy (*Viola tricolor* L.) grown in most European and American gardens has about 50 common English names. In a multilingual country like India, almost all useful plants have local names which differ from language to language and even from dialect to dialect. As in Ayurveda, mango (*Mangifera indica* L.) is known by over 50 different names, all in the Sanskrit language.

Hence the common names obviously have limited usage and for universal applications, a unique name for a particular individual is very much essential.

2. Scientific Names : To overcome the difficulties raised by common names, scientists have given scientific names to all the known organisms. These are systematic, thus provide means for international communication. Initially the polynomial system was used but Carl Linnaeus used binomial system of nomenclature. He introduced this system in his book "Species Plantarum" published in 1753. International Code of Botanical Nomenclature (ICBN) has been set up to confirm the scientific names.

Before 2011, the code which was set up to confirm the scientific names was ICBN means International Code of Botanical Nomenclature. Recently XIX International Botanical Congress (IBC) was held in Shenzhen, China in July 2017. This code is also called "Shenzhen code", so the old code ICBN has been changed to ICNAFP means "International Code of Nomenclature for Algae, Fungi and Plants". This code was published on 26th June 2018.

According to this system the scientific name of sunflower is *Helianthus annus*. In the above *Helianthus* indicates name of the genus (generic name) and second word *annus* denotes name of the species.

The Binomial Nomenclature system follows certain rules.

- Name of organism is composed of two Latin / Greek words.
- Generic name is a simple noun. It should come first and begin with capital letter.
- Specific name is the descriptive adjective which should come later and begin with small letter.
- Scientific names must be underlined separately if hand written and must be printed in italics.
- The generic and specific name should not have less than three letters and more than thirteen letters.
- Usually the name of the author who names a plant or animal is also written in full or abbreviated form after scientific name. e.g. *Mangifera indica* L. Where L stands for Linnaeus.

Internet my friend

1. Collect the information about most recent system of classification of living organisms and Kingdom System of Classification. e.g. Search for APG system of classification for Plants.
2. Collect the information about classification systems for all types of organisms.

Know the scientists

Carl Linnaeus classified living organisms in two kingdoms based on mode of nutrition, whether they are migratory, sedentary, etc. But this broad classification as Kingdom Plantae and Kingdom Animalia was found inadequate. It could not classify the organisms that show characters of both the Kingdoms for ex. Bacteria, Fungi, Euglena etc. Hence to avoid confusion scientist R.H. Whittaker (1969) proposed Five Kingdom system of classification. This system shows the Phylogenetic relationship between the organisms. The five kingdoms are.

1. Kingdom Monera
2. Kingdom Protista
3. Kingdom Plantae
4. Kingdom Fungi
5. Kingdom Animalia

R. H. Whittaker

2.13 Salient features of Five Kingdoms :

1. Kingdom Monera :

It contains unicellular organisms with prokaryotic cellular organization. Monera includes unicellular prokaryotic organisms. These are omnipresent. They are found in all types of environment which are not generally inhabited by other living beings. Few are photoautotrophs or chemoautotrophs; but majority are heterotrophic in nature. These organisms do not have well defined nucleus. DNA exists as a simple double stranded circular single chromosome called as nucleoid. Smaller circular molecules of DNA as extra-chromosomal genetic elements called plasmids are often present. Cell wall is made up of peptidoglycan (also called murein) which is a polymer of sugars and amino acids.

Membrane bound organelles e.g. mitochondria, chloroplast, endoplasmic reticulum are absent. Ribosomes are smaller in size (70S) than in eukaryotic cells. The mode of reproduction in monera is asexual or with the help of binary fission or budding. Very rarely, sexual reproduction is by conjugation method.

Morphologicaly, bacteria are categorised into four groups, the spherical- **Coccus**, the rod-shaped **bacillus**, the comma or kidney shaped- **vibrio** and the spiral- **spirillum**.

On the basis of evolution, bacteria can be classified as Archaebacteria and Eubacteria.

a. Archebacteria :

These are differentiated from other bacteria on the basis of their different cellular features. These bacteria are mostly found in the extreme environments; hence termed **extremophiles**. They are found in a variety of places from volcanic craters to salty lakes and hot springs. Their ability to withstand such hostile environment speaks of their capacity to survive in very severe conditions. Bacteria that can withstand high salinities are called **halophiles** while those that withstand extreme temperature are known as **thermophiles**. A very common example is of methanogenic bacteria found in gut of ruminants (cows and buffaloes). These bacteria help in production of methane in biogas plants.

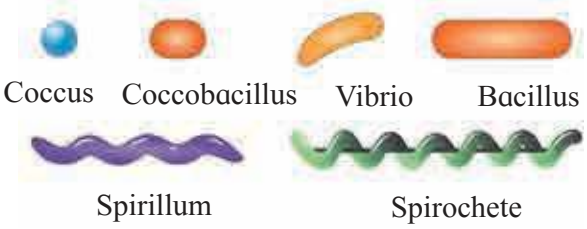


Fig. 2.3 Different shapes of bacterial cells

b. Eubacteria :

These are commonly referred as true bacteria. They have cell wall of peptidoglycan. They are found as autotrophs and heterotrophs. The autotrophs can be photosynthetic like *Chlorobium* (Green sulphur bacteria) and *Chromatium* or chemosynthetic like sulphur bacteria.

These are mostly multicellular filamentous forms living in fresh water. The body is covered by mucilagenous sheath. The genetic material is typical prokaryotic. Chl-a, Chl-b, carotenes and xanthothylls are the photosynthetic pigments. Filaments show heterocyst which helps in nitrogen fixation.

Heterotrophs are the most abundant. Most of them are decomposers and known for breaking down large molecules in simple molecules or minerals. They can be anaerobes helping in curdling of milk (*Lactobacilli*), fixation of nitrogen (*Azotobacter*), antibiotic production (*Streptomyces*), composting and degrading oil. But the story doesn't end here, some of them are pathogens i.e. causing disease (typhoid, cholera, tuberculosis, tetanus).

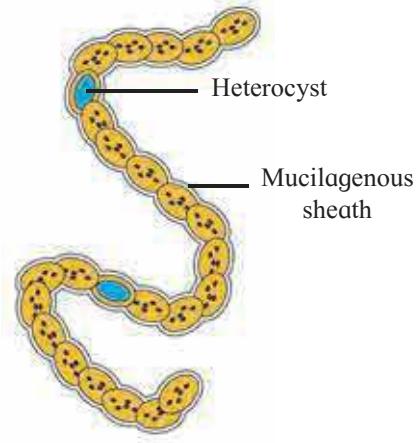


Fig. 2.4 Cynaobacterium (*Nostoc*)

Can you tell?

1. What are salient features of Monera?
2. What will be the shape of a bacillus and coccus type of bacteria?
3. Write a note on useful and harmful bacteria.

Mycoplasma :

These are smallest of the living forms. They do not have cell wall. Many forms are pathogenic. They are found resistant to common antibiotics due to absence of cell wall.

2. Kingdom Protista :

This group includes all the unicellular but eukaryotic organisms. These organisms show link with all eukaryotic Kingdoms like Plantae, Fungi and Animalia.

a. Plant like protista :

They are also termed **Chrysophytes**. They are commonly termed phyto-planktons. They are microscopic and mostly photosynthetic and are major producers in oceans. Most of them are referred to as **diatoms** as the have body wall made up of two soap-box like fitting silica covers. "Diatomaceous earth" is nothing but these shells left behind for so many years. Diatomaceous earth is granular hence finds use in polishing and filtration.

Fig. 2.5 Diatoms

b. Animal like Protista :- They are also termed protozoans. They lack cell wall. They are heterotrophs. They are believed to be primitive animal forms. Amoeboid protozoans have pseudopodia as locomotory organs. *Amoeba* is free living form but *Entamoeba* is endoparasite and causes amoebic dysentery. Flagellated protozoans have flagella as locomotory organ. *Trypanosoma* is a common flagellated pathogen which causes sleeping sickness.

Paramoecium is a cilliate protozoan having cilia for locomotion. In *Paramoecium*, gullet (a cavity) opens on the cell surface. *Plasmodium* is a sporozoan protozoa. It causes malaria. It forms spores in one of its life stage.

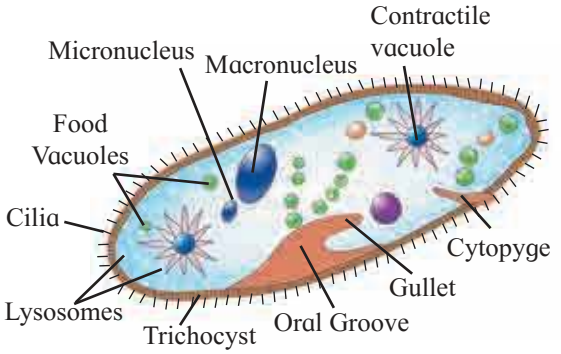


Fig. 2.6 *Paramoecium*

c. Dinoflagellates :- These are aquatic (mostly marine) and photosynthetic. The cell wall is made up of cellulosic stiff plates. They possess a pair of flagella. They have a wide range photosynthetic pigments, which can be yellow, green, brown, blue and red. *Gonyaulax* is dinoflagellate that is responsible for famous 'red tide'. It makes even sea appear red.

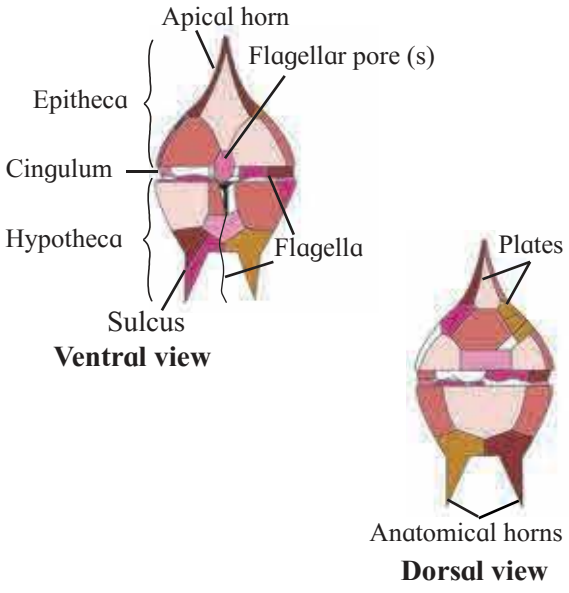


Fig. 2.7 *Gonyaulax*

d. Fungi like protista :- They are commonly from the group **Myxomycetes**. These are saprophytic organisms found on decaying leaves. Their cells aggregate to form a large cell mass called plasmodium (not a malaria parasite). The spores produced by plasmodium are very tough and survive even very harsh conditions.

e. Euglenoids :- They lack cell wall but have a tough covering of proteinaceous pellicle.

They possess two flagella, one short and other long. They behave as heterotrophs in absence of light but possess pigments, similar to that of higher plants, for photosynthesis.

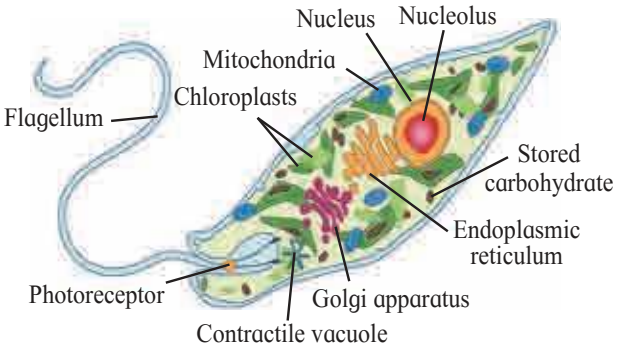


Fig. 2.8 *Euglena*

3. Kingdom Plantae:

The kingdom is dominated by autotrophs. It also includes some semi-autotrophic members, the insectivorous plants like Venus fly trap, pitcher plant, bladderwort, as well as heterotrophic parasitic members like *Cuscuta*. Members of this kingdom are multicellular, having eukaryotic cells containing chlorophyll. Cells have cell wall mostly made up of cellulose. Plants exhibit alternation of generation i.e., life cycle has two distinct phases. Kingdom Plantae is divided into two major groups *Cryptogamae* / Cryptogams and *Phanerogamae* / Phanerogams.

We will study this kingdom in detail in next chapter.

4. Kingdom Fungi : These are eukaryotic heterotrophs showing extracellular digestion. They are found in warm and humid places. They have simple body which may be unicellular or made up of long thread like structures called hyphae. Large fungi such as mushrooms have a compact mass of cells. Unicellular organisms have a protoplast with many nuclei. e.g. *Rhizopus*, *Saccharomyces* (Yeast-unicellular fungus).

Filamentous fungi consist of a body called mycellium in which hyphae are present. The hyphae may be with septa or without septa. They may be uni or multinucleate. The non-septate multinucleate hyphae are called coenocytic hyphae. The cell wall in fungi is composed of chitin, a polysaccharide or fungal cellulose. The fungi exhibit hetrotrophic mode of nutrition. Mostly they are saprophytic, some are parasitic or predators. They reproduce sexually as well as asexually. Asexual reproduction takes place by fragmentation, fission and budding. Some fungi are symbiotic; either live with algae as lichens or as mycorrhiza in association with roots of higher plants.

They are useful as well as harmful. Mushrooms are consumed as food, yeast is used in bakery and breweries. *Penicillium*, a fungus, is well known for antibiotic production. Harmful fungi cause diseases in plants and animals. e.g. *Puccinia.*

The fungi are further classified on the basis of their structure, mode of spore formation and fruiting bodies as follows-

a. Phycomycetes :

These are commonly called algal fungi. Mycelium is made up of aseptate coenocytic hyphae. They commonly grow in moist and damp habitats, on decaying organic matter as well as in aquatic habitats or as parasites on plants.

e.g. *Mucor, Rhizopus* (bread mould), *Albugo* (parasitic fungus on mustard).

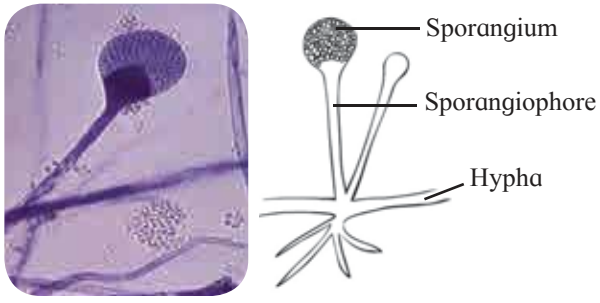


Fig. 2.9 *Mucor*

b. Ascomycetes :

These are called as sac-fungi. These fungi are mostly multicellular. Rarely unicellular varieties include yeast. The hyphae are branched and septate. Sac fungi can be decomposers, parasites or coprophilous (grow on dung). Morels and truffles are varieties of sac fungi that are consumed as delicacies. *Neurospora* is useful in genetic and biochemical assays.

Ex. *Aspergillus*, *Penicillium*, *Claviceps*, *Neurospora*, *Saccharomyces*.

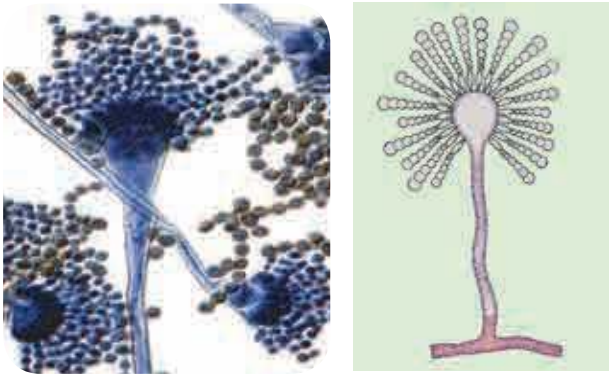


Fig. 2.10 *Aspergillus*

c. Basidiomycetes :

These are commonly called club fungi. They have branched, septate hyphae. e.g. *Agaricus* (mushrooms), *Ganoderma* (bracket fungi), *Ustilago* (smuts), *Puccinia* (rusts), etc.

Fig. 2.11 Mushroom

d. Deuteromycetes :

These are called imperfect fungi, which are known to reproduce only asexually.

e.g. *Alternaria, Colletotrichum.*

Fig. 2.12 *Alternaria*

Can you tell?

1. Write a note on economic importance of fungi.
2. Why are fungi considered as heterotrophic organisms?
3. What are coenocytic hyphae?
4. Classify fungi into their types.

5. Kingdom Animalia : Members of this kingdom are heterotrophs; adapted to holozoic nutrition. Most of them have capacity of locomotion. They are multicellular eukaryotes where cells lack chlorophyll as well as cell wall. Growth is determinate (follow definite pattern).

In chapter four, we will study about Kingdom- Animalia and its further classification.

Can you tell?

1. Differentiate between Plantae and Animalia.
2. How are fungi different from plants?
3. Have you seen any diseased plant in your farm?

Do you know ?

New variety of Banana seedlings produced by tissue culture technique like 'Shrimanti', Basarai, G-9 are virus free varieties.

Viruses, Viroids are groups of acellular organisms that are not included in Whitaker's Five Kingdom classification.

2.14 Acellular organisms :

a. Viruses : Viruses were named so by Louis Pasteur; considering the meaning, Venom or poison. These obligate parasites were given the name 'virus' by M. J. Beijernek, after observation that they were able to migrate in an agar gel. Thus, being and infectious soluble agent, he called the filtrate as 'contagium vivum fluidum'. It was scientist Stanley who demonstrated that viruses are inert outside the host cell and can be crystallised. They are made up of proteins.

Viruses lack their own cell machinery. They have protein coat (capsid) around nucleic acid strand, thus considered to be acellular organisms. Viruses are inactive outside a host cell; but once they enter their specific host cell, they take charge of cellular machinery of host cell and duplicate themselves. Viruses thus can be called infectious nucleoprotein particles.

Types of viruses :

As per genetic material, viruses are grouped as DNA or RNA viruses.

Do you know ?

Viruses have either DNA or RNA as their genetic material but never DNA as well as RNA.

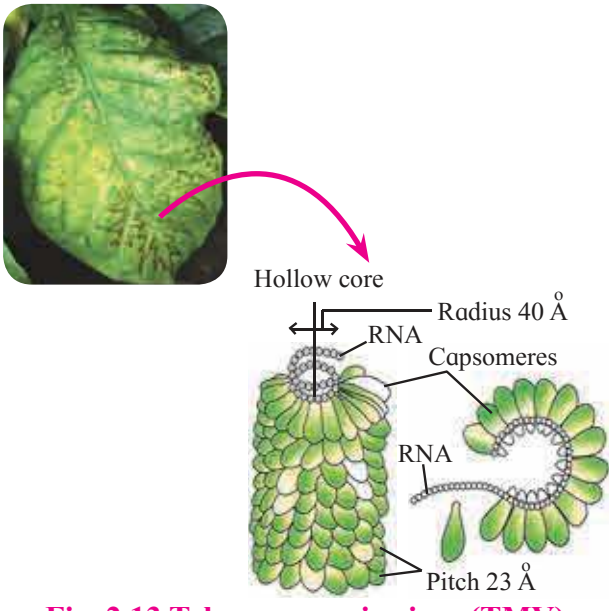


Fig. 2.13 Tobacco mosaic virus (TMV)

Protein coat called capsid is made up of smaller units, the capsomeres. Capsomeres are arranged in polyhedral or helical forms. Capsid protects genetic material.

The genetic material in viruses is either single-stranded RNA or single or double-stranded RNA or double-stranded DNA. Viruses that infect bacterial cells are called bacteriophages which normally have double-stranded DNA.

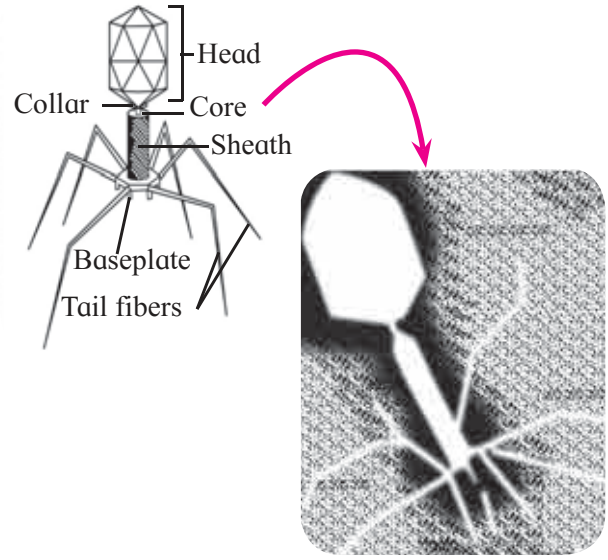


Fig. 2.14 Bacteriophage

Viruses cause disorders like leaf curling, yellowing, mosaic formation etc. in plants. You have heard of foot and mouth disease in animals or swine flu which are viral diseases. Small pox, mumps, herpes to common cold, viruses are the causative agents of many diseases in humans. The list includes AIDS too!

b. Viroids : Potato spindle tuber disease was found to be caused by single stranded RNA which lacks protein coat. T. O. Diener in 1971 reported that this is low molecular weight RNA and smaller in size than viruses. These infectious RNA strands are called viroids.

c. Lichens : Lichen is co-existence of algae and fungi for mutual benefit. Algal member, the phycobiont as it is called, mostly belongs to cyanobacteria (blue-green algae) or green algae. Fungal member is called mycobiont. They are excellent example of symbiosis. The algal component of lichens provides food to fungal part while fungus provides shelter to alga and also absorbed water and minerals to alga. The association is intense and it is difficult to identify them as separate living beings.

Though found in extreme environments like snow clad poles, lichens are sensitive to pollution. They are not found in polluted regions, hence are considered as pollution indicators. Lichens also play important role in soil formation by using specific acid productions.

Fig. 2.15 Lichens

Can you tell?

1. Why are viruses called infectious nucleoproteins?
2. Describe genetic material in plant and animal viruses as well as in bacteriophages.
3. Differentiate between viruses and viroids.

Internet my friend

Prions : In modern medicine, certain infectious neurological diseases were found to be transmitted by abnormally folded proteins. These proteins are called prions. The word prion comes from 'proteinaceous infectious particle'. e.g. mad cow disease in cattle, Jacob's disease in human. Find more information about prions.

Observe and Discuss

Complete the following table on the basis of previous knowledge.

Characters	Monera	Protista	Fungi	Plantae	Animalia
Cell type	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
Cell wall	--------	Present in some organisms	.....	Present (cellulose)	.....
Nuclear membrane	Absent	Present	Present	.....	Present
Body organization	Unicellular	.....	Multicellular/ loose tissue	Tissue /organ	Tissue / organ /system
Mode of nutrition	.....	**Autotrophic** Photosynthetic **Heterotrophic**	.....	**Autotrophic** (Photosynthetic)	--------
Ecological role	Decomposers	.....	Decomposers	.....	Consumers

Do Yourself

Complete the following table through collecting information about sunflower, tiger with characteristic features.

Sunflower

Category	Taxon	Characteristics
Kingdom		

Tiger

Category	Taxon	Characteristics
Kingdom		

Exercise

1. Choose correct option

A. Which of the following shows single stranded RNA and lacks protein coat?
   a. Bacteriophage b. Plant virus
   c. Viroid d. Animal virus

B. Causative agent of red tide is _____.
   a. Dinoflagellate b. Euglenoid
   c. Chrysophyte d. Lichen

C. Select odd one out for Heterotrophic bacteria.
   a. Nitrogen fixing bacteria
   b. Lactobacilli
   c. Methanogens
   d. Antibiotic production

D. *Paramoecium* : Ciliated Protist
   Plasmodium : _____
   a. Amoeboid protozoan b. Ciliophora
   c. Flagellate protozoan d. Sporozoan

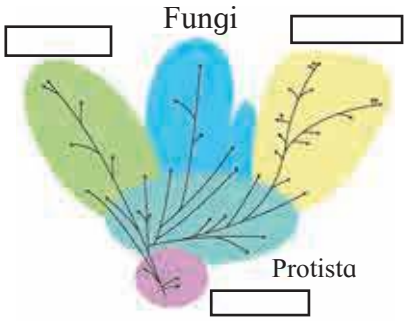
2. Answer the following

A. What are the salient features of monera?
B. What will be the shape of bacillus and coccus type of bacteria?
C. Why is binomial nomenclature important?

3. Write short notes

A. Useful and harmful bacteria.
B. Five Kingdom system
C. Useful Fungi

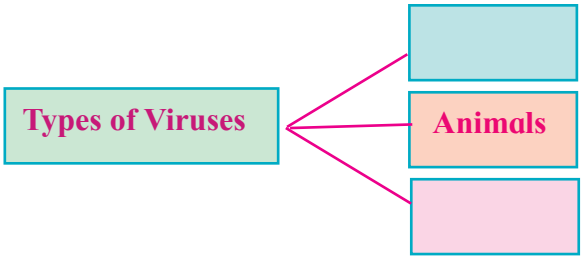
4. Complete tree diagram in detail



5. Draw neat labelled diagrams

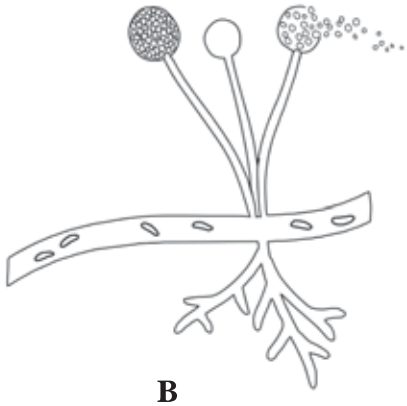
A. Paramoecium
B. Euglena
C. TMV

6. Complete chart and explain in your word

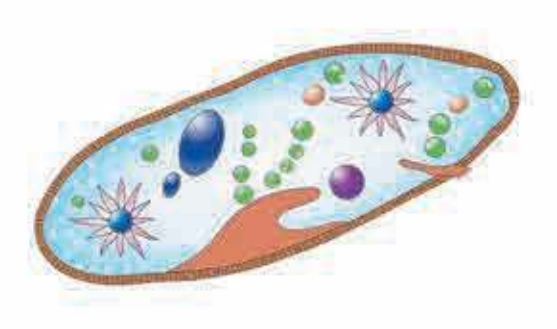


7. Identify the following diagrams, label them and write detail information in your words

A

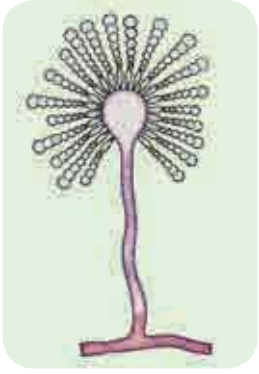


B

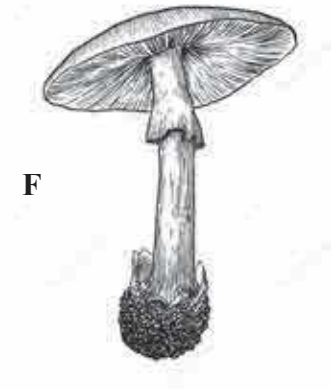


C

D



E



F

8. The scientific name of sunflower is given below. Identify the correctly written name.

A. *Helianthus annus*

B. *Helianthus Annus*

9. Match the following.

Kingdom	**Examples**
i. Monera	a. Lichen
ii. Protista	b. Cyanobacteria
iii. Plantae	c. *Rhizopus*
iv. Fungi	d. *Spirogyra*

10. Complete the following

A. Plant-like Protista - ( )

B. ( ) - *Entamoeba*

Practical / Project :

1. **Make a group of students. Observe living organisms in your school/college campus and try to write their characters with respect to habit, habitat, mode of nutrition, growth- determinate or indeterminate, type of reproduction - vegetative reproduction - asexual reproduction - Sexual reproduction.**

   With the help of similarity and dissimilarity, try to classify organisms into different categories. Similar work should implement for animal group.

2. **Find out types of lichens and its economic importance.**