Classification of Plants

Introduction to the Five Kingdom Classification

We have learned about the history of biological classification previously. We have learned how Aristotle classified living organisms on the basis of superficial similarities such as habitat. Consequently, many unrelated organisms got grouped together and many organisms with similarities got divided.

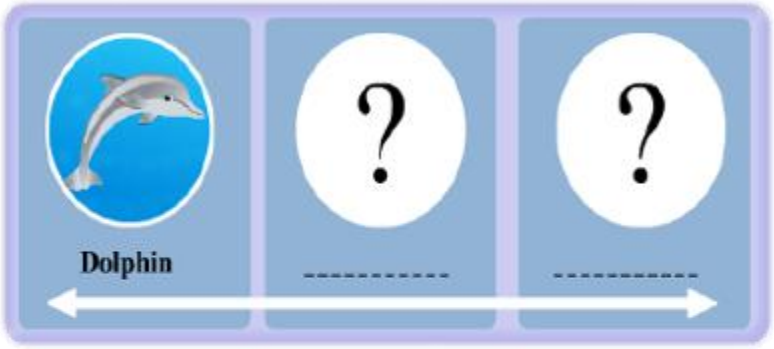
This system of classification did not prove useful in studying about the diverse life forms on Earth. Later, many other scientists came up with their own systems of classification. Among these, the one that is popularly followed today is the **five kingdom classification** by Robert Whittaker.

We have already studied about some of the basic characteristics used by Whittaker to classify living organisms. These are nature of cell, cellularity and mode of nutrition. In this lesson, we will study how Whittaker used these characteristics to make broad divisions called kingdoms.

Introduction to the Five Kingdom Classification

But before that, let us test how smart you are!

Among the given organisms, choose two that are closely related to the dolphin.



Tuna fish Shark Hippopotamus Whale

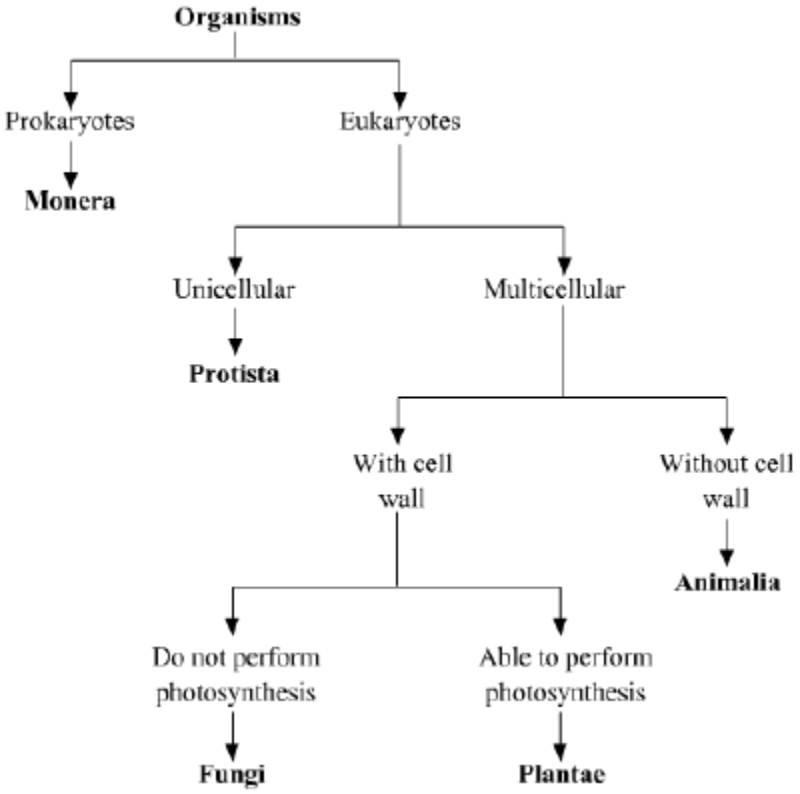
On the basis of Aristotle's method of classifying organisms according to their habitats, the dolphin should be closely related to the tuna fish, the shark and the whale. However, this method of classification is not correct.

If you consider evolutionary history, then you will realize that the dolphin is closely related to the hippopotamus and the whale, and not to the tuna fish and the shark. To understand why this is so, read on about Whittaker's five kingdom classification.

Five Kingdom Classification

In 1969, Robert Whittaker classified all organisms present on Earth into five major groups called kingdoms. This is known as the five kingdom classification.

Here is a branch diagram that shows how Whittaker used the fundamental characteristics of nature of cell, cellularity and mode of nutrition for classifying different life forms into the five kingdoms.



It is clear from the above diagram that the first organisms to evolve were the prokaryotes. Eukaryotes evolved next and, after a period of time, some of the unicellular eukaryotes evolved into multicellular organisms.

This agrees with the fact that classification of life forms is closely related to their evolution. Further categorization of multicellular eukaryotes is then made on the bases of the presence or absence of cell wall and the mode of nutrition.

Kingdom Monera

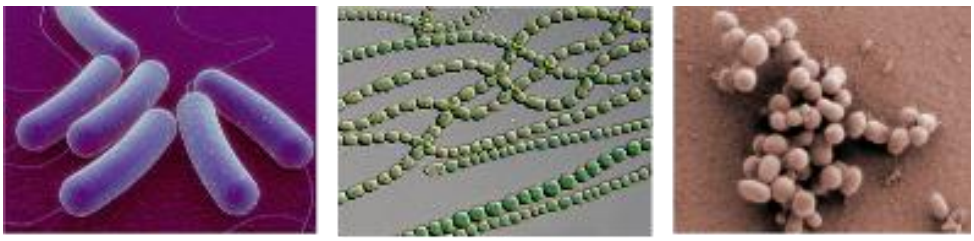
You do wash your hands before eating anything, don't you? Why do you think this is important?

Washing our hands before eating is important because most of the time our hands carry germs. Germs are basically the different types of bacteria, fungi, protozoans, viruses, etc. Most of them cannot be seen with the naked eye.

Bacteria and other organisms such as the blue-green algae (cyanobacteria) are grouped in **kingdom Monera**. The organisms of this kingdom are called prokaryotes.

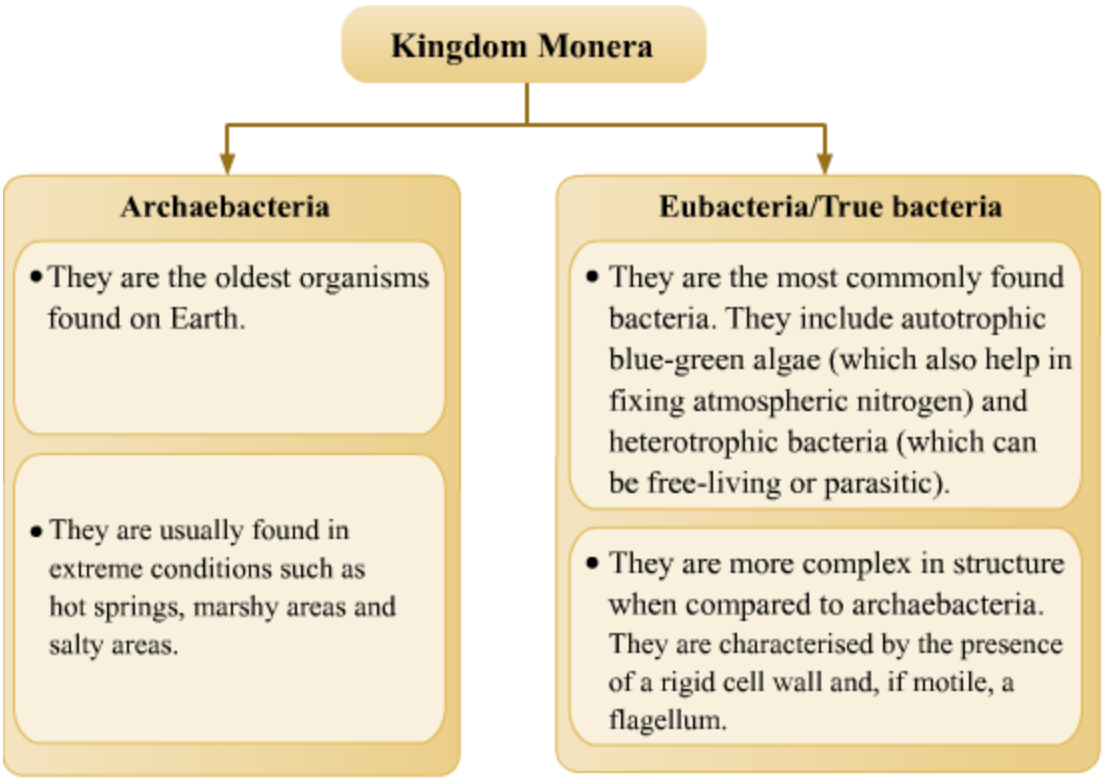
General features of monerans

- There is an absence of a well-defined nucleus and other membrane-bound cell organelles in monerans, i.e., they show a prokaryotic organisation.
- All monerans are unicellular organisms; they do not have any multicellular body design.
- The cell wall may be present (as in bacteria and blue-green algae) or absent (as in *Mycoplasma*).
- The mode of nutrition could be **autotrophic** (as in blue-green algae and some bacteria) or **heterotrophic** (as in most bacteria and *Mycoplasma*).
- Examples of monerans: bacteria, blue-green algae, *Mycoplasma*



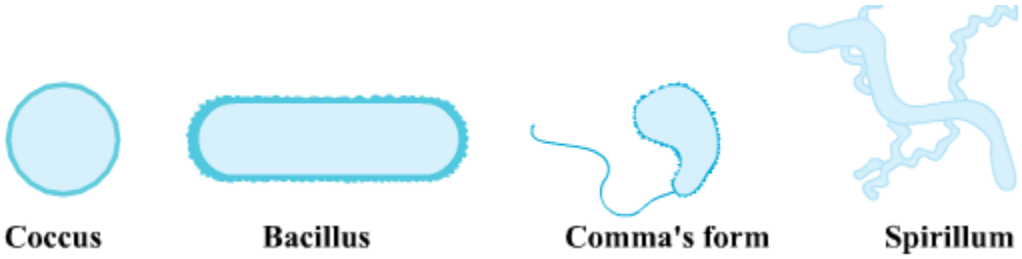
Bacteria Blue-green algae *Mycoplasma*

Kingdom Monera



Know More

Bacteria have different shapes, such as



General features of protists

- All protists are single-celled eukaryotes.
- They have a well-defined nucleus and other membrane-bound cell organelles.
- Protists form a link between plants, animals and fungi.
- They can be autotrophic (e.g., diatoms) or heterotrophic (e.g., protozoans).
- Some protists have cilia or flagella which help in locomotion.
- Examples of protists: *Amoeba*, *Paramecium*, **slime moulds**, *Euglena*

Whiz Kid

Interesting Fact

Kingdom Protista was initially known as ‘Protoctista’ which means ‘first established beings’. The term ‘Protista’ was coined later by Ernst Haeckel in 1866.

Know More

What are cilia and flagella?

Cilia are hair-like projections while flagella are lash-like appendages. Both cilia and flagella help in locomotion in prokaryotic and eukaryotic cells. Basically, cilia and flagella have the same structure. However, cilia occur in greater number (as in *Paramecium*) than flagella. In fact, some organisms may have only a single flagellum (e.g., *Euglena*).

Classification of Protists

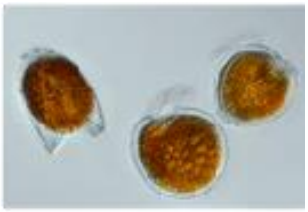
On the basis of mode of nutrition and movement, protists are classified as:

- Plant-like protists
- Animal-like protists
- Fungus-like protists

Plant-like protists

- They are the major producers of energy.
- They contain chlorophyll and carry out photosynthesis. Thus, they have autotrophic mode of nutrition.

Diatoms



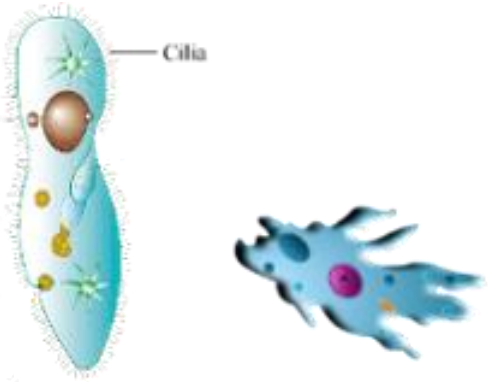
Dinoflagellates

Classification of Protists

Animal-like protists

- They exhibit pseudopodia, cilia or flagella.

- They are found in water, soil and other habitats.
- They can be free-living or parasitic.
- They have heterotrophic or saprophytic mode of nutrition.



Paramecium *Amoeba*

Fungus-like protists

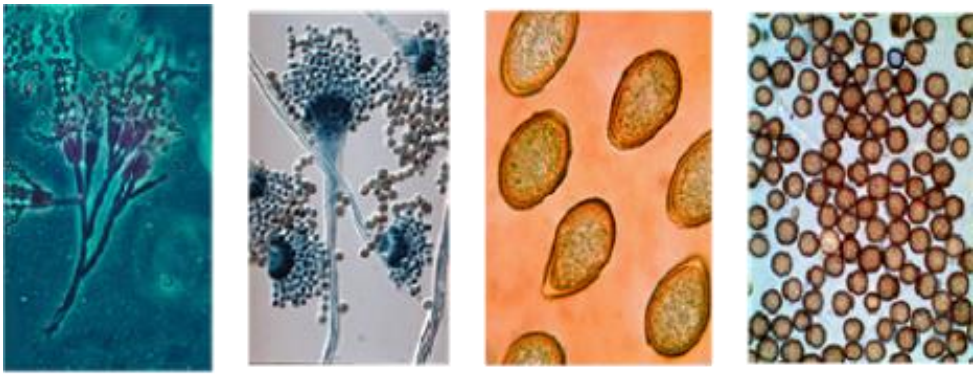
- They include slime moulds.
- They are heterotrophs or decomposers.

Slime mould

Kingdom Fungi

General features of fungi

- They are multicellular eukaryotic organisms. Some exceptions of unicellular fungi are yeasts.
- They are heterotrophic organisms and obtain nutrition from decaying organic matter; so, they are called saprophytes.
- The body of a fungus consists of **mycelium**, which is made up of multicellular filamentous hyphae.
- The cell wall is made up of a tough complex sugar called **chitin**.
- Examples of some commonly known fungi: *Penicillium*, *Aspergillus*, *Puccinia*, *Ustilago*



Penicillium *Aspergillus* *Puccinia* *Ustilago*

Importance of fungi

- They are used for producing antibiotics.
- Yeasts are used in the manufacture of bread and beer.
- Some fungi decompose organic matter and enhance the fertility of soil.
- Fungi such as mushroom are also consumed as food.

Know More

Some fungi live in a mutually beneficial relationship with cyanobacteria or green algae to form lichens. This kind of relationship is called **symbiosis**.

Lichens grow very slowly. A colony of lichens in the Arctic takes around 1000 years to grow two inches!

Kingdoms Plantae and Animalia

General features of plants

- They are multicellular eukaryotic organisms.
- The cell wall is made up of cellulose.
- Most plant cells contain chlorophyll pigments. Hence, they are autotrophic.
- They are non-motile.

General features of animals

- They are multicellular eukaryotes.
- The cell wall is absent.
- Animal cells do not contain chloroplast. Hence, they have heterotrophic mode of nutrition.

General Study of Bacteria and Fungi

A General Study of Bacteria

Bacteria are the most primitive and diverse unicellular organisms found in living world. They are prokaryotic in nature as their genetic material, i.e. DNA, is not enclosed within a nuclear membrane. Because of their unique biochemical pathways and properties, they are of high economic importance to the human beings. Let us take a look at a general account of various features of bacteria.

Occurrence

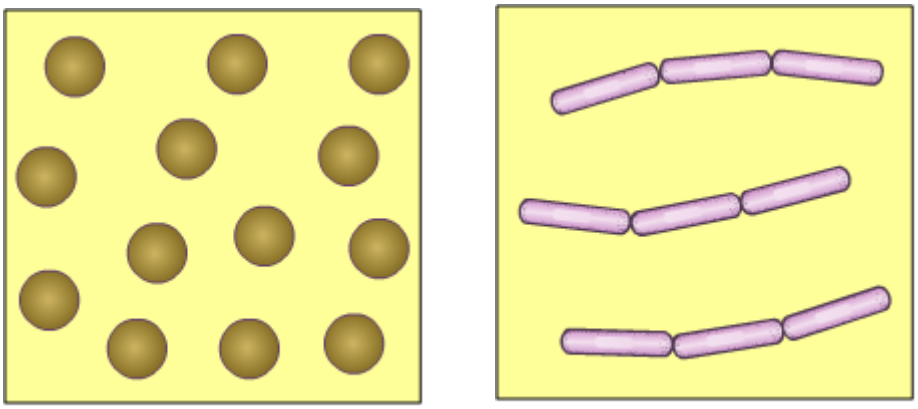
- Bacteria are known to exist in almost every corner of the Earth.
- There are several thousands of bacteria in the air we breathe, water we drink and food we eat. In fact our own body is a home to various bacteria.
- Some species of bacteria are also found to inhabit some of the most unfavourable conditions on Earth, such as hot water springs, geothermal vents, acidic lakes, etc.

Size

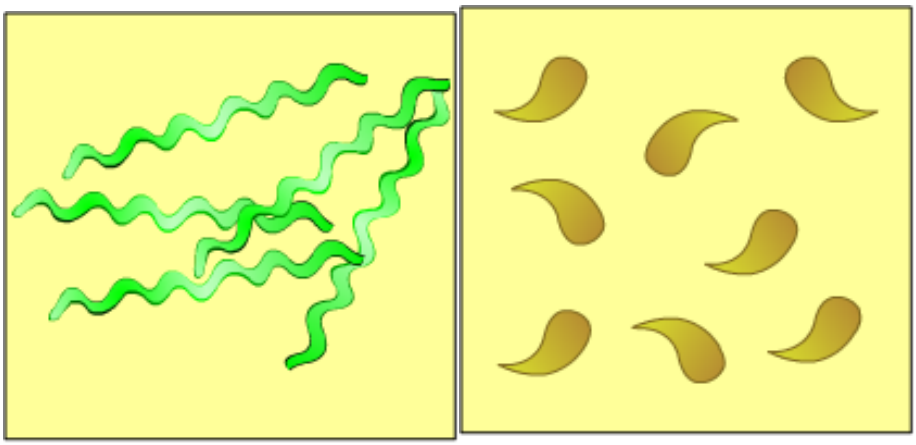
Bacteria are the smallest living organisms, ranging from size 0.2 - 2.0 µm.

Shape

Bacteria are found in diverse shapes. On the basis of shape, they can be broadly classified as cocci (spherical bacteria), bacilli (rod-shaped bacteria), spirilla (spiral bacteria), and vibrio (comma-shaped bacteria).



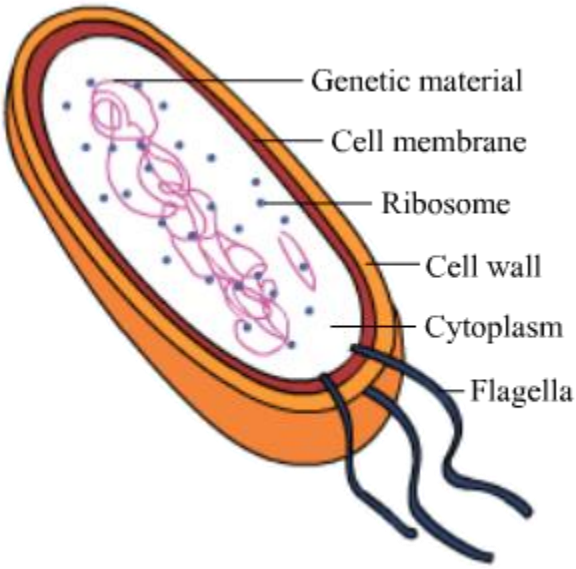
Cocci Bacilli



Spirilli Vibrio

Structure

- Bacterium is unicellular in nature, consisting of a cell wall made up of peptidoglycan, cell membrane and protoplast.
- The cytoplasm lacks any cell organelle, except vacuoles and ribosomes.
- DNA lies freely in the central region of the cytoplasm.
- In some cases, the cell wall is further surrounded by a slimy protective layer, called capsule.
- Some bacteria also contain whip-like flagella that help them in their movement.



A Bacterial Cell

Nutrition

Most bacteria are heterotrophic in nature. Some of them are saprophytes and derive nutrition from dead, decaying organisms. Others are parasitic on other living organisms and derive nutrition from them.

Reproduction

- Almost all bacteria reproduce asexually by means of binary fission.
- Very few bacteria are also found to reproduce sexually through **conjugation**.

It is an extremely simple mode of sexual reproduction in which two bacteria of different strains (but same species) come together and transfer of plasmid (an extra-chromosomal small circular DNA) occurs between them.

Under unfavourable conditions, the bacterial cell can transform into a spore. A spore is a spherical mass of bacterial cell surrounded by a thick, hard protective wall.

Due to presence of this wall, a spore can tolerate extreme weather conditions as well as exposure to harmful chemicals. On the return of favourable conditions, it germinates into a new bacterium.

Bacteria have wide scale applications in various industries and day to day life. They play important role in many biological and ecological processes.

Importance of bacteria:

- They are used in the food industry for various purposes, such as fermenting fruit juices into vinegar, making curd from milk (which is done by bacteria *Lactobacillus),* making cheese, etc.
- They are used in tanning of leather, where animal hides are cured using bacteria.
- They are used in the synthesis of antibiotics (medicines which can destroy disease causing germs). Streptomycin is one such antibiotic obtained from bacteria.
- *E. coli* is a bacteria which lives in the large intestine of humans and produces vitamin B and K which is required by the body.
- Compost and manures are produced due to decomposition of cow dung, horse dung and animal waste by bacteria.

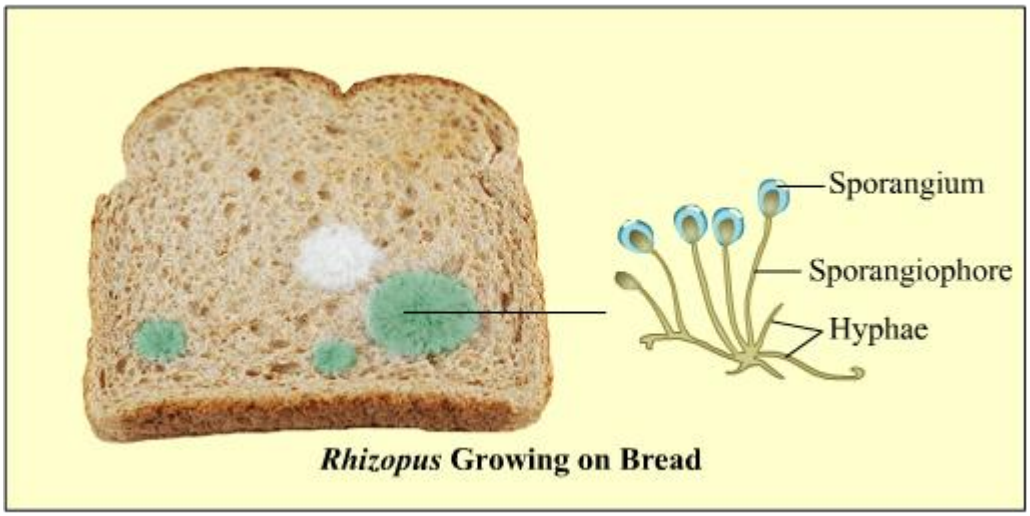
From the above examples we can understand how important bacteria are.
However, bacteria are also capable of causing various kinds of harmful effects. Some examples of them are as follows:

- Spoilage of food, such as milk, fish, meat, etc, is the result of bacterial action. They are responsible for spoilage of tinned foods as well.

- They are responsible for causing a number of diseases in humans as well as animals. For example: cholera is caused by *Vibrio cholerae* and tuberculosis is caused by *Mycobacterium tuberculosis*.

A General Study of Fungi

Fungi is a group of eukaryotic, unicellular as well as multicellular, non-photosynthetic organisms that includes mushrooms, moulds and yeasts. These organisms have a rigid cell wall made up of chitin and are found in diverse shapes and sizes. Most common fungi to be found in nature are moulds, which grow on various food materials, wood and even leather. One such mould is *Rhizopus* which is the common bread mould.



***Rhizopus* Growing on Bread**

Structure of *Rhizopus*

- *Rhizopus* consists of a network of transparent, fine thread-like structure, called hypha.
- The collective mass of hyphae is referred as mycelium.
- Some hyphae, called sporangiophore, are specialised to form spores.
- The sporangiophore consists of a swollen tip which is covered with a sac-like structure. This enclosed structure is known as sporangium.
- Inside the sporangia, spores are formed, which are the means of asexual reproduction in fungi.
- Once the spores get mature, the sporangium burst opens, liberating the spores in the atmosphere.
- On finding suitable substratum, these spores germinate and form a new mycelium.

Nutrition

Most of the fungal species are saprophytic in nature. Some of them are parasitic on various plants and animals as well.

Reproduction in Fungi

- Most fungi reproduce asexually, though sexual reproduction may also take place in few cases.
- Asexual reproduction may occur in the form of spore formation (as in *Rhizopus)* or as budding (as in yeast).

Just as bacteria, fungi too can have both useful as well as harmful impacts.

Useful Fungi:

- Some fungi, like mushrooms, are an important source of food.
- Yeast is a fungi which is commonly used in baking processes.
- Vitamin B is also produced by some kinds of fungi.
- Some species of fungi are also used in cheese making. For example, species of *Mucor* and *Rhizopus.*
- Antibiotic penicillin is obtained from a fungus called *Penicillium notatum.*

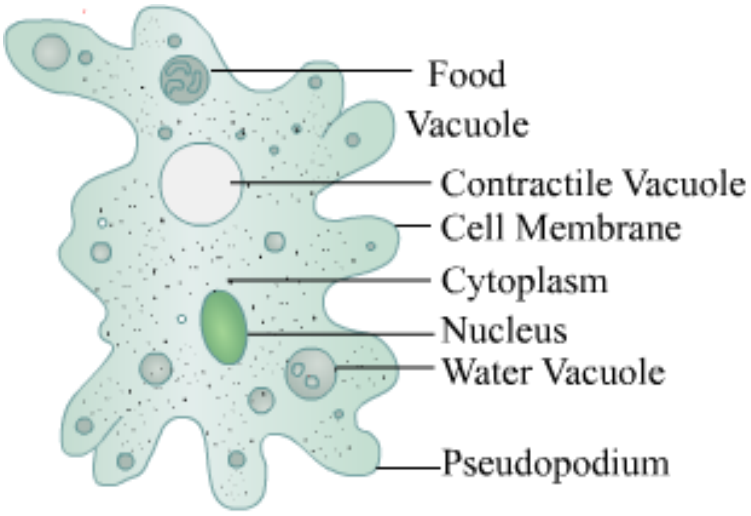
Harmful fungi:

- Molds are responsible for the spoilage of food, leather goods and textiles.
- Some fungi can attack crops and lead to huge losses to farmers.
- They can cause various kinds of skin and lung infections. For example, Athlete's foot and ringworm.

General Study of Amoeba

Amoeba

Amoeba belongs to the Kingdom Protista. It is the simplest unicellular organism and can be observed only under the microscope. It is irregular in shape and covered by an outer membrane called cell membrane. It has a nucleus which is surrounded by the cytoplasm. It is found in ponds, ditches and places where there is stagnant water.



Locomotion

Amoeba moves with the help of an organ called pseudopodia. They are finger like projections which are formed due to flow of cytoplasm. Pseudopodia extends longer in

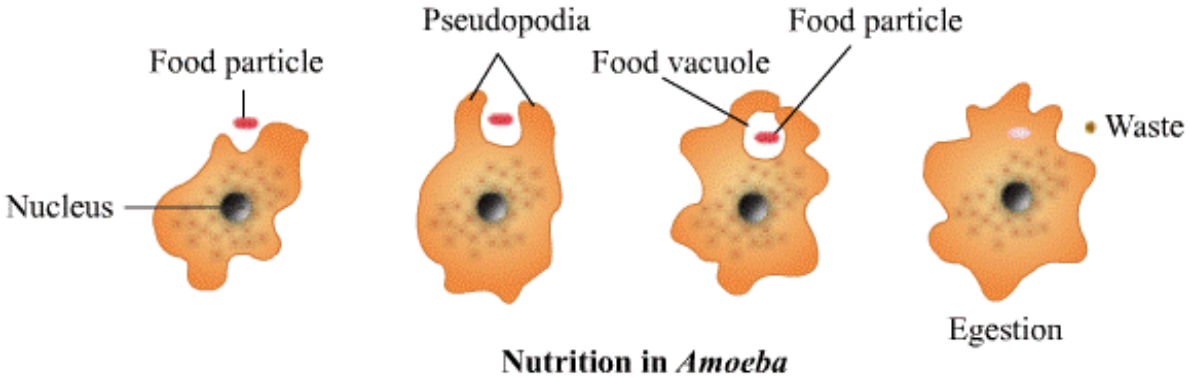
the direction of movement and helps the *Amoeba* to move forward. It is termed as amoeboid movement.

Digestion

Pseudopodia helps in the feeding process of *Amoeba*. When *Amoeba* senses food near it, it extends its pseudopodia in that direction and moves forward. Once it reaches the food, it extends two of its pseudopodia and surrounds the food particles.

The tip of these pseudopodia fuse together to from a small space which has the food in it. This gives rise to food vacuole.

Digestion of food occurs in the food vacuoles with the help of digestive juices secreted by the cytoplasm. The waste/undigested food is expelled out through the cell membrane.



Nutrition in *Amoeba*

Excretion

The main waste which is formed by *Amoeba* is ammonia. Excretion occurs through the cell surface and the contractile vacuole.

Ammonia diffuses out of the body through the cell surface, whereas extra water is collected in the contractile vacuole and released through it in the surrounding environment.

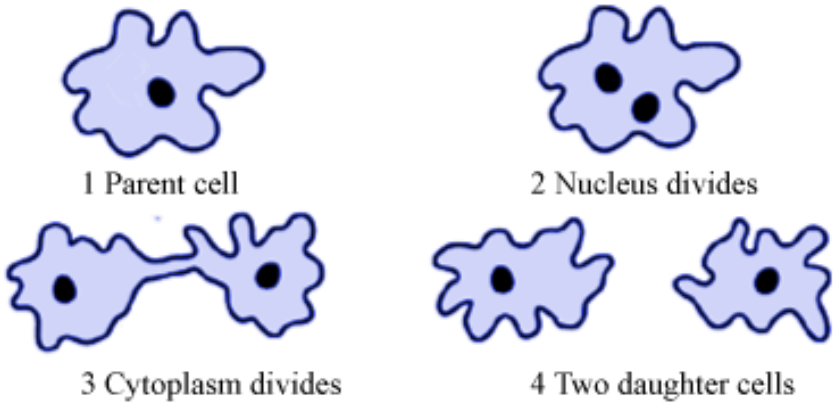
Respiration

Exchange of gases occurs in *Amoeba* through the cell membrane. Oxygen from the surrounding water diffuses into the the cytoplasm whereas carbon dioxide produced by it is diffused out in the surrounding water.

Reproduction

Amoeba reproduces by a process called **binary fission**. In this type of reproduction, the nucleus of the fully grown *Amoeba* divides into two nuclei, followed by division of the whole cell.

This division is in such a way that each half (or daughter cell) gets one nucleus. Two daughter amoeba are thus formed who grow independent of each other.

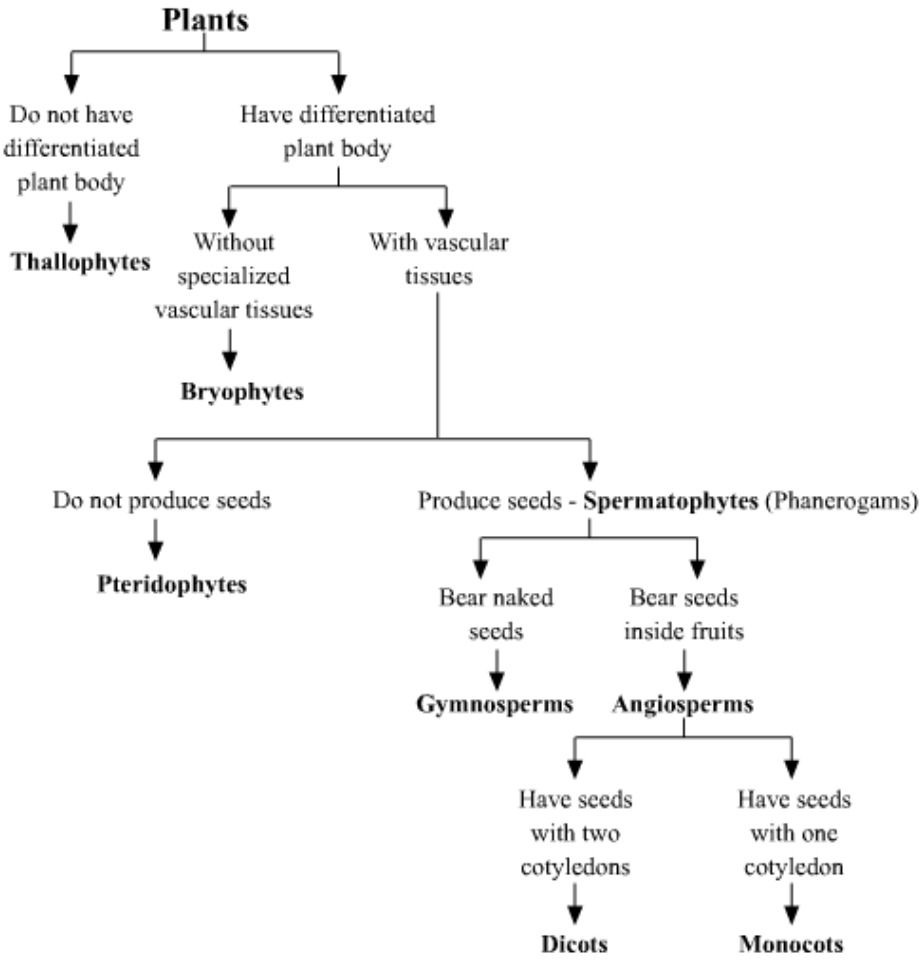


Sometimes, it may reproduce by multiple fission. It happens when the conditions are unfavourable. *Amoeba* develops into small rounded speck and forms a thick wall around itself, called cyst.

The nucleus divides multiple times within the cyst and when the conditions are favourable, the cysts break and several amoebulae are released. Each of them undergoes development to form a new *Amoeba*.

Introduction to the Plant Kingdom

Classification of Plants



Classification of Plants

After going through the branch diagram on previous slide, can you point out the bases on which plants are classified?

Plants are classified in terms of the following characteristics.

- Differentiation of plant body into roots, stem and leaves
- **Vascular tissues**
- Production of seeds
- Covering of seeds
- Number of **cotyledons** in a seed

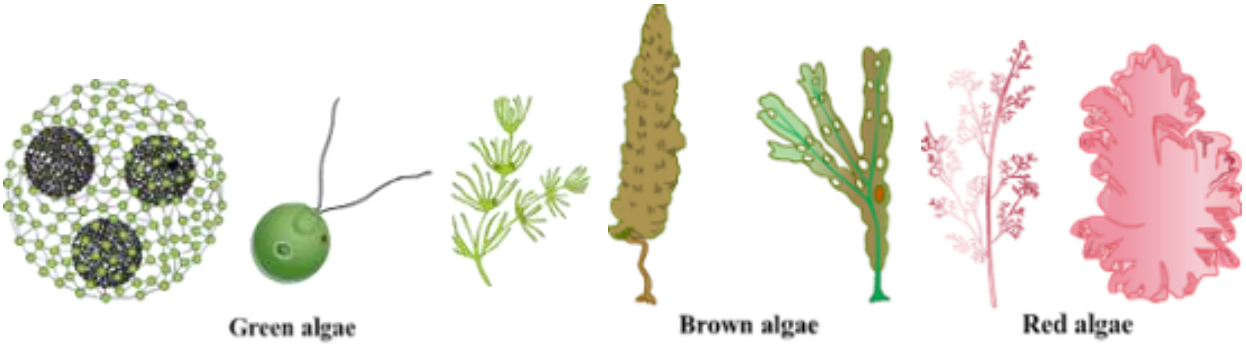
Let us now study each division of the plant kingdom in detail.

Division Thallophyta

The word ‘Thallophyta’ comprises the words ‘thallus’ meaning ‘undifferentiated body’ and ‘phyton’ meaning ‘plant’.

General features of thallophytes

- The plant body of a thallophyte is not differentiated into roots, stem and leaves.
- Thallophytes are mostly aquatic. They can be green or non-green.
- They do not bear flowers and seeds. They reproduce by means of asexually produced spores.
- Thallophytes are essentially algae.
- Algae are economically important. Several algae are used as sources of food.
- **Algin**, extracted from brown algae, is used in making dairy products.
- **Seaweeds** are commercially used for making cosmetics, pharmaceuticals, etc.
- Examples of algae: Based on the pigment they contain, algae are further classified as green algae, brown algae, red algae, etc.



Know More

Division of algae

Let us read about the different classes of algae listed in this table.

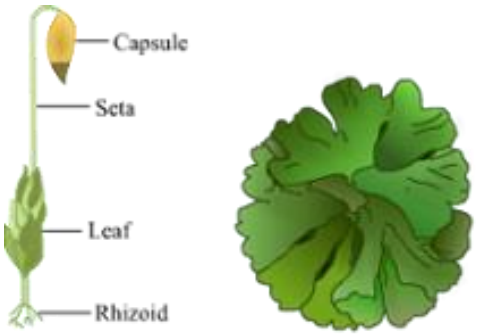
Classes	Common names	Major pigments	Cell wall	Habitat
Chlorophyceae	Green algae	Chlorophyll a and b	Cellulose	Fresh water, brackish water, salt water
Phaeophyceae	Brown algae	Chlorophyll a and c, fucoxanthin	Cellulose and algin	Fresh water (rarely), brackish water, salt water
Rhodophyceae	Red algae	Chlorophyll a and d, phycoerythrin	Cellulose and pectin	Fresh water (sometimes), brackish water, salt water

Division Bryophyta

The word ‘Bryophyta’ comprises the words ‘bryon’ meaning ‘moss’ and ‘phyton’ meaning ‘plant’.

General features of bryophytes

- They are the first plants to live on land, but require moist conditions to survive. For this reason they are called ‘the amphibians of plant kingdom’.
- They are non-vascular, i.e., they do not have specialized vascular tissues (xylem and phloem) for the conduction of water and food.
- They lack true roots, stem and leaves. But, they show more body differentiation than thallophytes.
- They have **rhizoids** instead of true roots.
- They do not bear flowers and seeds.They reproduce both sexually as well as asexually.
- Bryophytes exhibits 'alternation of generations' in which gametophytic phase (haploid) alternates with sporophytic phase (diploid).
- Liverworts and mosses have been found to be good indicators of environmental conditions. Some aquatic mosses can be used as indicators of calcium content in water.
- Some mosses prevent soil erosion. Certain mosses also provide fuel.
- Examples of bryophytes: *Riccia*, *Marchantia*, *Funaria*



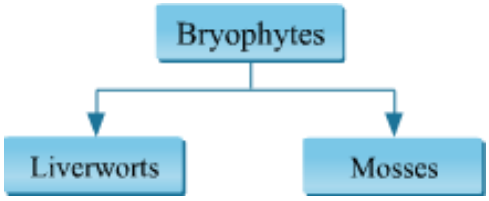
Funaria *Riccia*

Did You Know?

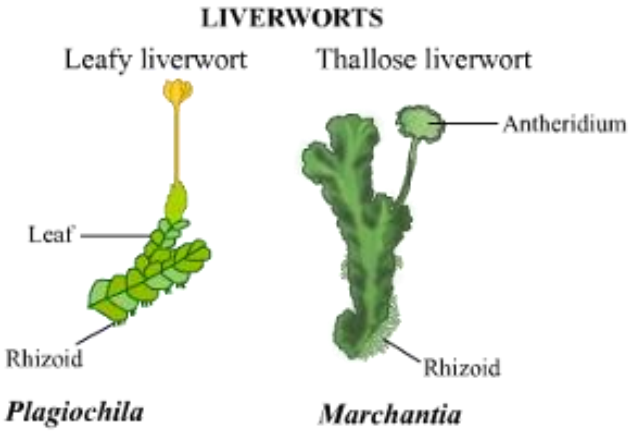
Sphagnum or peat moss can soak up to twenty-five times its weight of water. This is why it is used as a soil conditioner.

Know More

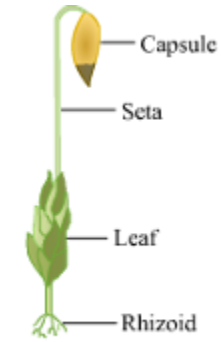
Classes of bryophytes



General features of liverworts



- They are non-vascular, spore-producing land plants. The thallus is dorsiventrally flattened.
- Filamentous structures called rhizoids anchor most liverworts to their substrata.
- Liverworts are of two types: thallose liverworts and leafy liverworts.
- A thallose liverwort has a dorsiventrally lobed thallus.
- Leafy liverworts look very similar to mosses, but their leaves are arranged in rows. Seta and capsule are the structures that help in the production of spores.
- Examples of liverworts: *Riccia*, *Plagiochila*, *Marchantia*



Funaria

General features of mosses

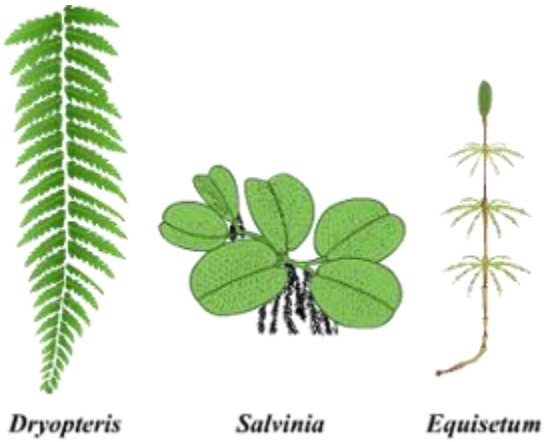
- A moss has an erect thallus that is differentiated into root-, stem- and leaf-like structures. Its leaves are spirally arranged.
- Mosses are often **epiphytes**.
- Moist and shady areas are their more common habitats. Some of them are found on rocks and in arid locations.
- Seta and capsule are the structures that arise from the main plant body and help in the production of spores. They develop from the zygote.
- Examples of mosses: *Funaria*, *Pogonatum*

Division Pteridophyta

The word ‘Pteridophyta’ comprises the words ‘pteris’ meaning ‘fern’ and ‘phyton’ meaning ‘plant’.

General features of pteridophytes

- The plant body of a pteridophyte is differentiated into roots, stem and leaves.
- Pteridophytes are found in cool, damp and shady places.
- They have specialized tissues for the conduction of water and food.
- They have **inconspicuous** or less-differentiated reproductive organs. For this reason they are categorised as **Cryptogamae** or **cryptogams**.
- They produce naked **embryo** called spores.
- Pteridophytes are economically important. They are used for medicinal purposes.
- They act as soil binders. They are also frequently grown as ornamental plants.
- Examples of pteridophytes: *Dryopteris, Salvinia*, *Equisetum*



Know More

Evolutionarily, pteridophytes are the first terrestrial plants to possess vascular tissues, i.e., xylem and phloem.

Cryptogamae and Phanerogamae

Do you know what plants can be categorised as Cryptogamae or cryptogams?

The word ‘Cryptogamae’ comprises the words ‘kryptos’ meaning ‘hidden’ and ‘gamos’ implying ‘reproduction’. This category includes all plants having hidden or inconspicuous reproductive parts. Cryptogams are flowerless and seedless plants that reproduce through spores (also called naked embryos).

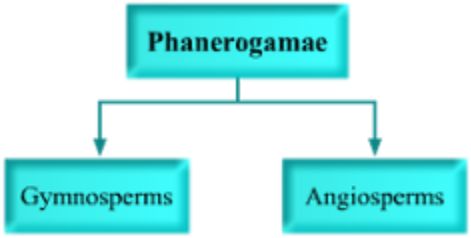
Thallophytes, bryophytes and pteridophytes are all cryptogams, i.e., spore-producing plants.

Let us now look at another category of plants called **Phanerogamae or phanerogams.**

The word ‘Phanerogamae’ comprises the words ‘phaneros’ meaning ‘visible’ and ‘gamos’ implying ‘reproduction’. This category consists of plants with well-differentiated and visible reproductive tissues that ultimately make seeds.

The seed of a phanerogam consists of the embryo along with stored food which helps in the initial growth of the embryo during germination. Gymnosperms and angiosperms

(plants belonging to the division Spermatophyta) are phanerogams, i.e., seed-producing plants.



Class Gymnospermae

The word ‘Gymnospermae’ comprises the words ‘gymno’ meaning ‘naked’ and ‘sperma’ meaning ‘seed’.

General features of gymnosperms

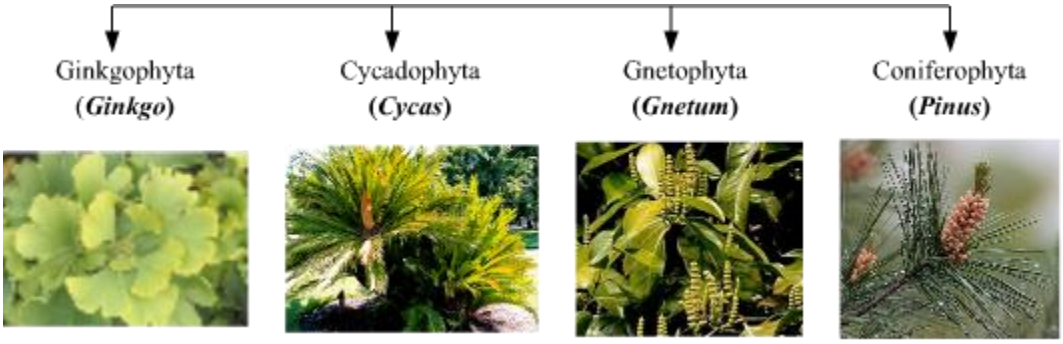
- They are seed-bearing, non-flowering plants. They are more primitive than angiosperms.
- They produce naked seeds, i.e., the seeds are not enclosed inside fruits.
- Instead of flowers, they have male and female cones.
- They are perennial, evergreen plants that grow as woody trees or bushy shrubs.
- A gymnosperm has a tap-root system.
- It has vascular bundles, but the xylem lacks **vessels** and the phloem lacks **companion cells**.
- Gymnosperms are economically important.
- The trees are used for timber.
- The resin obtained from the trees is used in varnishes, medicines, ointments, etc.
- They are also used as ornamental plants.
- Examples of gymnosperms: *Pinus*, cedar, fir, juniper, *Cycas*

Cycas

Know More

The tallest tree in the world is a gymnosperm named *Sequoia sempervirens* (coast redwood), which belongs to the genus *Sequoia*.

Four Major Plant Divisions within Gymnosperms



Class Angiospermae

The word ‘Angiospermae’ comprises the words ‘angio’ meaning ‘covered’ and ‘sperma’ meaning ‘seed’.

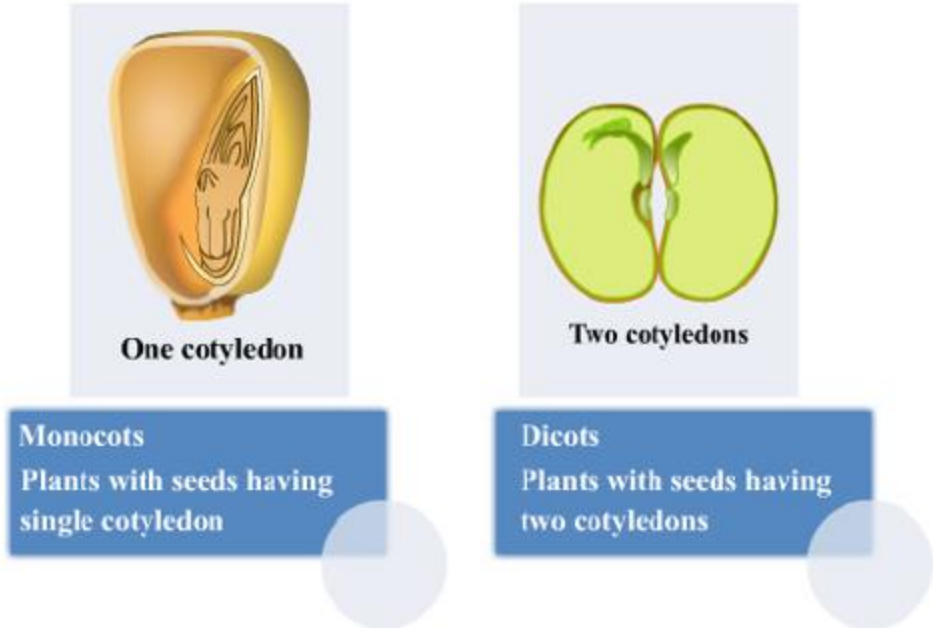
General features of angiosperms

- They are flowering plants in which seeds are enclosed inside fruits.
- They include around 250000 species of plants.
- They are the most recent and highly evolved group of plants.
- They bear flowers that consist of four **whorls**— **calyx**, **corolla**, **androecium** and **gynoecium**.
- The seeds develop inside the ovary, which develops into a fruit.
- Angiosperms are economically important.
- Most angiosperms provide a significant amount of **livestock** feed.
- They are the sources of paper, wood, fibre, medicines and perfumes.
- Many angiosperms are used for decorative purposes.

Class Angiospermae

General features of angiosperms

- The embryos in the seeds have structures called cotyledons or seed leaves. These cotyledons emerge and become green when the seeds germinate.
- On the basis of cotyledons, angiosperms are divided into two groups as shown in the figure.



- Examples of angiosperms: all flowering plants like rose, mango, wheat, maize etc.

Know More

Interesting Facts

- In dicot trees such as mango and guava, the trunk and the old branches increase in girth each year by forming a new layer that replaces the old bark and causes it to peel off.
- Monocot trees such as palm and coconut do not increase in girth because no new wood is formed in them.

Classification of Angiosperms

Dicotyledons and Monocotyledons

Finding Cotyledons

Activity Time

- Place a few bean, sunflower, wheat and corn seeds in water for one night. This will make them tender, making it easier for the seed coat to come off. The seeds can then be split easily.
- Remove the seed coat from each soaked seed. Then, try to split the seed into two equal parts using a toothpick.
- **Which seeds can be broken into two equal parts?**
- Bean and sunflower seeds can be broken into two equal parts as they have two cotyledons. Such seeds are called dicots.

- Wheat and corn seeds cannot be broken into two equal parts as they have only one cotyledon. Such seeds are called monocots.

Solved Examples

Medium

Example:

What are the differences between monocots and dicots?

Solution:

Monocots	Dicots
The embryo in a monocot seed has one cotyledon.	The embryo in a dicot seed has two cotyledons.
The sepals or petals are in multiples of three.	The sepals or petals are in multiples of four or five.
The stem vascular bundles are scattered.	The stem vascular bundles are arranged in a ring.
The leaves have parallel venation.	The leaves have reticulate venation.
They have fibrous or adventitious roots.	They have a tap-root system.