33. What are isotopes? Explain with illustrations, the isotopes of carbon, oxygen and chlorine.

## 9.4 Radio Activity

The property of radioactivity was discovered by **Henry Becqueral** in 1896. He found that the atom of uranium emits peculiar radiations which can affect photographic plates and which can ionize gases. It was found that the property of emitting the radiations cannot be changed either by keeping uranium at high temperature or under high pressure. He called uranium as radioactive element and its property as radioactivity.

Madame Curie soon discovered two more elements which were also radioactive. One of them is called radium and the other one is Polonium. Thorium is also a radioactive element. Nowadays we have artificial radioactive elements. For the production of these elements, we follow artificial transmutation. Uranium, thorium, polonium and radium belong to the category of natural radioactive elements.

While the chemical reactions are connected with changes in the outer shells of the atoms, radioactive decay is a process which takes place inside the atomic nucleus.

### Study of Radioactive Phenomena

Radioactive decay is a complex process which occurs in a number of successive stages.

In earlier stages, ZnS coated card-board, when placed close to radioactive compound, started scintillating.

The action of radioactive radiation on a photographic plate forms the basis of another method of detection of radioactivity. The track of the charged particles is traced on the photographic plate.

The 'cloud chamber' method is useful for identifying the track of the charged particle and to study its nature.

Another method is the direct recording of the ionization of air under the action of radioactive radiation. For this 'ionization counter' is used.

Radioactive substances should be handled with care observing precautionary measures.

Three types of rays are emitted out in radioactive phenomenon. They are $\alpha,\beta,\gamma$ rays. $\alpha$ rays containing positively charged particles bend towards negative electrical field. $\beta$ rays which are negatively charged bend towards positive electrical field. $\gamma$ Rays are electromagnetic radiations which are neutral, they are unaffected by electrical field.

Some atoms have nuclei that are unstable because the ratio of the protons and neutrons in the nucleus is greater or less than 1. Such an unstable nucleus will decay leaving behind a new nucleus called a daughter nucleus. This will continue until a stable nucleus is formed.

Such a series of spontaneous decay is called a "decay series" or "disintegration series."

The decay of a nucleus can result in the emission of alpha, beta and gamma radiation.

All the synthetically produced radioactive isotopes are called **radionuclide** or **radioisotopes**.

### Alpha radiation ($\alpha$ particles)

1. Alpha particles are made up of the nucleus of helium atom, $_2He^4$. They possess nearly 4 times the mass of hydrogen atom.

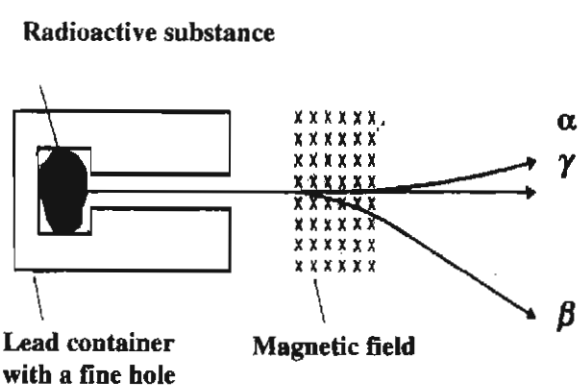



*Fig 9.7 α , β, γ radiations in magnetic field*

2. A well-known source of alpha-radiation is the most abundant isotope uranium-238

3. It is the largest particle emitted by radioactive substances.

4. It has very little penetrating power.

5. Since they are massive and they possess a pretty large velocity, they possess a large amount of kinetic energy. Therefore, they are used as projectiles in artificial transmutation.

6. Due to high energy they possess, they intensively ionize air. Ionizing power of α rays is nearly 100 times more than that of β rays and 10,000 times more than that of γ rays.

7. On account of strong ionization in air, they lose their energy rapidly. They can be stopped within a certain distance in air. The maximum distance they travel in air is called the range of α particles.

8. When α particles fall upon fluorescent screen, they cause scintillations. By counting such scintillations in a given time, we can find the number of α rays emitted per second.

9. α particles being electrically charged, they can be deflected by electric as well as magnetic fields.

10. α particle can affect photographic plate.

11. When a radioactive element emits an α particle it loses its mass by 4 units and charge by 2 units. The new element formed is different in its chemical character. This is called radioactive transformation. This law was put forward by Soddy.

$$_{92}U^{238} \rightarrow {}_{90}Th^{234} + {}_{2}He^{4}$$

12. When α particles are projected through matter, they get diffused or scattered. The extent of scattering increases with thickness and the atomic mass of scattering substance.

## Beta Radiation (β particles)

1. β rays are material particles. They are electrons.

2. They produce moderate ionization in air.

3. Their range is not well defined as that of α rays.

4. They travel with very high velocity and sometimes it reaches nearly the velocity of light.

5. They affect the photographic plate.

6. As they are electrically charged, they are deflected by electric and magnetic fields.

7. Since they do not lose their energy in ionization they can travel greater distances in air than that of α rays.

8. When a β particle is emitted, the emitting nucleus increases its atomic number by 1 because β particle is essentially an electron. So, the nucleus changes its chemical character after β-emission.

$$_{90}Th^{234} \longrightarrow {}_{91}Pa^{234} + {}_{-1}e^{0}$$

9. β particles are 7000 times lighter than α particles. They can produce fluorescence.

10. They can penetrate through aluminium foil

## Properties of γ rays

1. γ-rays are not material particles like α and β rays. But they are electromagnetic waves of extremely small wavelengths.

2. γ-rays are invisible.
3. They can ionize gases.
4. They can produce fluorescence.
5. Being electromagnetic waves, they are not deflected by electric and magnetic fields.
6. They are diffracted by crystals.
7. They are more penetrating than X-rays because their wavelength is shorter than that of X-rays.
8. These rays are most dangerous because they can kill living tissues by their bombardment.
9. When γ rays are emitted by a radioactive nucleus, the nucleus does not change its chemical character.
10. The release of Gamma rays usually occurs together with α and β radiation.

$$_{88}Ra^{226} \longrightarrow {}_{86}Rn^{222} + {}_{2}He^{4} + \gamma$$

11. They emit β rays or electrons when incident on matter. All radioactive emissions affect the atoms or molecules of any material through which they pass. The radiations knock electrons out of atoms to produce positive ions and so these are sometimes called ionizing radiations. If they affect the DNA molecule in a cell, it can die or become cancerous, growing out of control.

The time taken by a radioactive substance to reduce to half of its original mass is constant for a particular radio-isotope. This time is called the half-life period. This is useful for Radio-carbon dating. The age of rocks, wooden and organic objects may be measured by this method.

Radio active rays can be detected using 1) electrometer 2) cloud chamber 3) Geiger Muller counter 4)Semi conductor circuits.

**1. Artificial Radioactivity**

## Radioisotopes

**The transmutation of one element into another by artificial means is called artificial radioactivity or induced radioactivity.** The induced radioactive elements are known as artificial radio-isotopes.

The phenomenon of using radioactive isotopes for curing diseases is known as **radiotherapy.**

**2. Uses of Radioactivity**

**In Medicine**

(1) Radio-cobalt Co-60, U-238 are used in the treatment of cancer and tumors.

(2)Radio-iodine(I-123) is used in the treatment of thyroid cancer.

(3)Phosphorus -32 or Strontium-90 is used to cure skin cancer.

(4)Medical instruments can be sterilized.

(5)Tritium and Carbon-14 are commonly used to label biological molecules.

(6) Radio active – Iron (Fe-59) isotope is used to treat anaemia

**In Agriculture**

(1) Radioactive phosphorous, P-32 is used with fertilizers to study the phosphorous intake in growing plants.

(2) Radiations from Radio-isotopes are used for developing high yield varieties of rice and wheat.

**In Science**

(1) Gamma rays are used in the study of the structure and properties of atomic nuclei.

(2) Radiations are used to analyze the structural formula of substances.

(3) Radio-Iodine can easily identify the Silver remains in a reaction.

(4) Radioisotopes are used as 'tracer' elements in chemical reactions.

(5) Radio isotopes are used in neutron activation analysis to identify Arsenic poisoning.

**In industry**

(1) Radio-isotopes are used to detect leaks in pipelines.

(2) Gamma rays are used to measure the thickness of thin sheets of paper or steel.

(3) $\gamma$-$\beta$ radiation is used to monitor the level of filling in containers.

(4) Radioactive tracing can be used to check the effectiveness of lubricating oil.

**In archeology**

(1) The age of fossils and rocks can be determined using radioactive isotope of carbon since it has half life of 5730 years. This is called **radio-carbon dating**. The oldest rock so far dated was found in northern Canada and is $3.96 \times 10^9$ years old. Radioactive dating of meteorites and rocks from the moon suggests that all the solar systems was formed at the same time-about $4.6 \times 10^9$ years ago.

**In food treatment**

(1) $\gamma$ Radiation is used to kill bacteria. The presence of micro-organisms cause food-spoilage or toxicity or food poisoning. Salmonella and Clostridium are disease carrying organisms. They can be killed on exposure to $\gamma$ radiation.

## Self Evaluation

**Answer briefly**

1. What are the rays emitted in radioactive emission?
2. What are the radioactive elements discovered by Madame Curie?
3. Why do alpha particles ionize air?
4. Why gamma particles are not deflected by electrical or magnetic fields?
5. What are the uses of radioactive isotopes Co-60, P-32 ?

**Answer in detail**

6. Give the properties of alpha particles.
7. Explain in detail the properties of beta particles.
8. Give the properties of gamma rays
9. How radioisotopes are used in the following fields.
   1) medicine 2) agriculture
   3) industry 4) food-industry.

10. Use the periodic table to answer the following questions.

1) How many electrons are there in one atom of strontium -90?
2) How many protons are there in one atom of iodine – 131?
3) How many neutrons are there in an atom of caesium – 137?

11. The radioactive caesium was reacted with Chlorine. Would you expect the caesium Chloride produced to be radioactive? Explain.

12. State the uses of radioactive isotopes in industries.

# 10. PERIODIC CLASSIFICATION OF ELEMENTS

With the discovery of many elements, some chemists attempted to classify them on the basis of their properties. In 1869, the famous Russian scientist **Mendeleev** prepared the first periodic table. It was based on atomic weights of elements. His periodic table (short form) had some defects. Later **Moseley** determined the atomic numbers of elements. He found that the atomic number is a more fundamental property than atomic weight. He stated the **modern periodic law.** After numerous attempts, the scientists were able to group similar elements together. The dissimilar elements were separated.

## 10. 1 Dobereiner's Law of Triads

He identified the relationship between atomic masses and chemical properties of the elements.

"Similar elements exist in groups of **three** elements named **triads.** The atomic mass of middle member is the arithmetic mean of the atomic masses of the other members of the triad". This is known as **law of Triads.**

Eg: Lithium Sodium Potassium

7 23 39

$$\frac{7+39}{2} = 23$$

This concept of triads could be applied to a limited number of elements.

## 10.2 The Law of Octaves

**Newland** arranged the elements in the order of increasing atomic masses and noted a striking similarity between every eighth element. This arrangement has a similarity to the musical scale. (Musical note)

| | | | | | | |
|---|---|---|---|---|---|---|
| Li | Be | B | C | N | O | F |
| Na | Mg | Al | Si | P | S | Cl |
| K | Ca | | | | | |

This law could not be applied beyond calcium as well as the noble gases which were discovered in the later period.

## 10.3 Mendeleev's classification of Elements - Mendeleev's Periodic Table

The **Russian Scientist Dmitri Mendeleev** and the **German Scientist Lothar Meyar** independently developed the Periodic table. Mendeleev proposed that **the properties of the elements are periodic functions of their atomic masses**. This is called the Mendeleev's periodic law. In Mendeleev's periodic table the elements were arranged in the order of their increasing atomic masses.

This periodic table consists of:

**1) Nine vertical columns** called **Groups.** These are numbered from I to VIII and Zero. The members of zero group were not discovered at the time of Mendeleev. Each group, from I to VII, is subdivided into two sub-groups designated as A and B. Group VIII consists of three sets, each one containing 3 elements. Group Zero consists of Inert gases.

**2) Seven horizontal rows** called **periods**, these are numbered from 1 to 7. **First period** consists of two elements.

(H,He) **Second and third periods** contain eight elements each. **(short periods) Fourth and Fifth periods** contain eighteen elements each. **(long periods). Sixth period** contains 32 elements and is the **longest period. Seventh period** is incomplete and contains nineteen elements. (Trans uranium elements). Most of these elements are synthetically prepared.

## 10.4 Merits (or) Uses of Mendeleev's Periodic Table

**Prediction of new elements**

a) Some vacant places were found in this table.This provided a clue for the discovery of new elements. Mendeleev predicted their occurrence on earth and called these elements **Eka-aluminium** and **Eka-silicon**. Later they were discovered and named as gallium and germanium.

## 10.5 Defects (or) Demerits in the Mendeleev's Periodic Table

### 1. Position of Hydrogen

The position of hydrogen in the table is not certain because it can be placed in both I and VII groups as it resembles both the alkali metals of IA group and halogen nonmetals of VII A group.

### 2. Anomalous pairs of elements

Certain elements of higher atomic mass precede those with lower atomic mass. e.g. : Argon (at mass = 40) precedes potassium (at mass=39) in the periodic table.

### 3. Lanthanides and Actinides

A group of 15 elements (atomic number: 57 to 71) called rare earths or **lanthanides** are placed together in one position i.e in group III B of the $6^{th}$ period. Similarly, another group of elements called actinides do not find their proper place in the periodic table.

### 4. Position of Isotopes

Isotopes of elements are placed in the same position in the table. But they should have been placed in different positions according to their atomic masses.

**5.** Certain chemically similar elements like copper and mercury are placed in different groups while some other dissimilar elements like copper, silver and gold have been placed in the same group.

## 10.6 Modern Periodic Law

In 1912 Moseley observed that physical and chemical properties of the elements are determined by their **atomic numbers.** Based on this, modern Periodic law was stated as **the physical and chemical properties of the elements are the periodic function of their atomic numbers.**

If the elements are arranged in order of **increasing atomic numbers,** the elements with similar properties recur after regular intervals. This is called periodicity.

The most commonly known periodic table is the **long form of the periodic table.**

Based on electron structure, elements are classified as:

1) Inert gas elements
2) Representative elements
3) Transition elements
4) Inner transition elements

## 10.7 Features of Modern Periodic Table

I. Horizontal rows of the periodic table are called periods. A period consists of a series of elements having same valence shell. There are seven periods.

1. The first period has 2 elements – hydrogen and helium (the shortest period)

2. The second and third periods have 8 elements each. (short periods)
3. The fourth and fifth periods have 18 elements each (long periods)
4. The sixth period has 32 elements, including lanthanides. (the longest period)
5. The seventh period includes actinide elements and is incomplete.

**Table 10.1 Number of elements in each period.**

| *Period* | *Principal valence shell (=n)* | *Electrons to be accommodated* | *No. of elements* |
|---|---|---|---|
| First | n=1 | 2 | 2 |
| Second | n=2 | 2+6 | 8 |
| Third | n=3 | 2+6 | 8 |
| Fourth | n=4 | 2+10+6 | 18 |
| Fifth | n=5 | 2+10+6 | 18 |
| Sixth | n=6 | 2+14+10+6 | 32 |
| Seventh | n=7 | 2+14+10+6 | 32* |

*At present 7$^{th}$ period is incomplete and contains 19 elements

II. In the modern periodic table there are eighteen groups. "A vertical column of the periodic table is called a group".

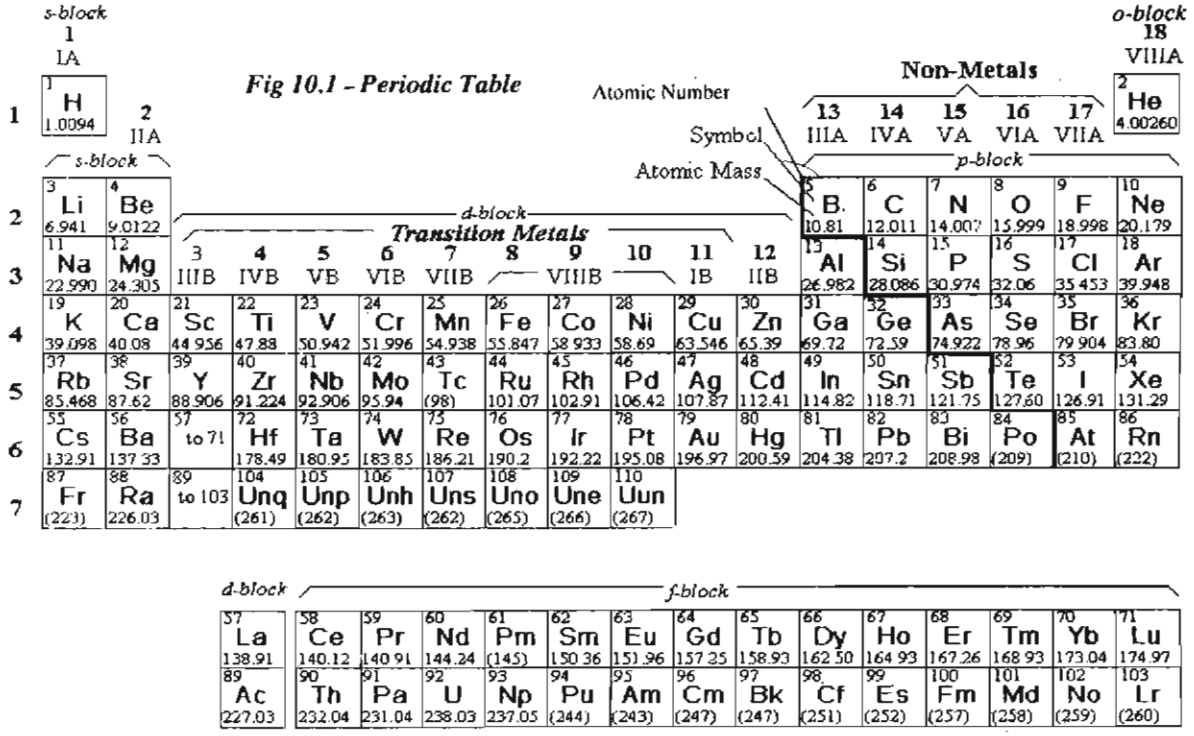
A group consists of a series of elements having similar configuration of the outer energy shell.

The elements belonging to the same group are said to constitute a family.

1. The elements of groups IA to VII A are called representative elements.
2. The IA group elements are called alkali metals.
3. The II A group elements are called alkaline-earth metals.
4. The VI A group (16) elements constitute chalcogen or oxygen family.
5. The VIIA group (17) elements constitute halogen family.
6. The elements of IB to VIIB and VIII are called transition elements.
7. The elements of zero group are called inert gases (noble gases).

The lanthanides and actinides falling under the same group are shown separately below the table.

*Fig 10.1 - Periodic Table*



**Do You Know?**

There are 94 naturally occurring elements. Some are very rare. Francium, for instance, has never been isolated.

The radioactive metals neptunium and plutonium, which are made artificially in quite large amounts, occur in very small amount in nature.

Most of the elements (70) can be classified as metals. They form a group of elements in which atoms are held together by a particular type of bonding. They have identical physical properties. A few metalloids (semi metals) are also present. The rest are non-metals.

## 10.8 Electron Arrangement and the Periodic Table

The elements present in Groups I to 0 of the table are sometimes known as main-group elements.

1) The properties of elements, their position in the table, electron arrangement can be linked directly.

2) The elements in Group II have two outer electrons

3) A magnesium atom has two electrons in its third outer shell and is in Group II.

4) An argon atom has an outer shell containing eight electrons – a very stable arrangement – and is in Group 0

5) A potassium atom has one electron in its outer most shell and is in Group I and period 4.

6) It is the outer electrons of an atom that are mainly responsible for the chemical properties of any element. Therefore, elements in the same group will have similar properties.

7) The most stable electronic arrangements are those of the noble gases. So they are unreactive.

**Do you Know?**

***Trends in the periodic Table***

- atomic size increases on going down a group, but decreases across a period.
- elements become more metallic as we go down a group and to the left of a period.
- in the metallic groups, reactivity increases down a group.
- the most reactive metal is at the bottom of Group I.
- non-metals are found at the right of a period.
- in a group of non-metals, the most reactive element is at the top of a group.
- The most reactive non-metal is at the top of Group VII

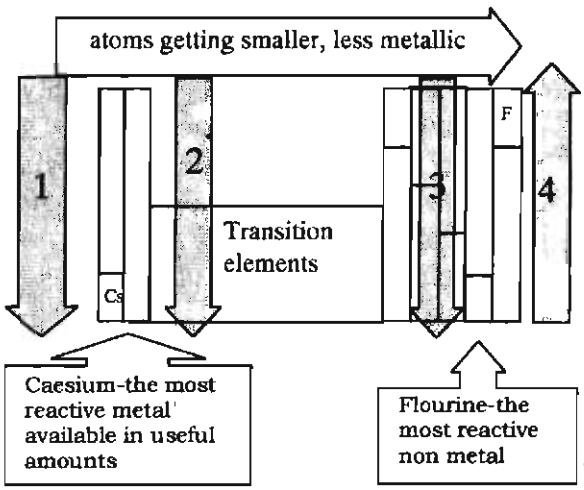
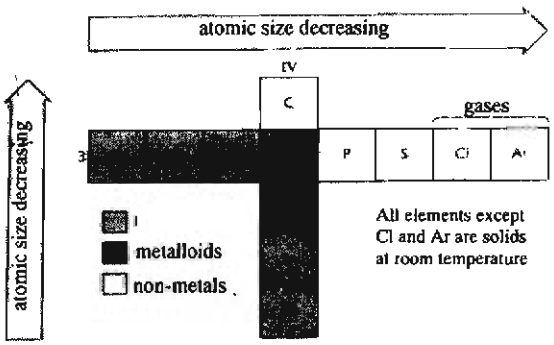



*Fig. 10.2*
*1.metals getting more reactive*
*2.Densities & melting point increase down any group*
*3.Atoms getting larger,more metallic*
*4.Non metals getting more reactive*




*The changes in properties of the elements in Period 3 and in Group IV of the Periodic table*

*Fig. 10.3*

## 10.9 Family Profiles of Groups I, VII & 0

### Group I

1. The metals in Group I (Li, Na, K, Rb, Cs and Fr) are often called 'alkali metals'.
2. They are soft solids with relatively low melting points and low densities.
3. They are highly reactive and stored in oil to prevent them from reacting with oxygen and water.
4. When cut, all these metals have a silvery surface which quickly tarnishes.
5. Reactivity increases as we go down the group. Francium is the most reactive element. However, it is highly radioactive and very rare. It decays with a half-life of 5 minutes. It has been estimated that there are only 17 atoms of francium (Fr) in existence on earth at any one moment of time.

### Group - VII

6. The most reactive non-metals are the Halogens in Group-VII of the table. Here reactivity decreases down the group, in contrast with Group-I
7. Fluorine is a dangerously reactive, pale yellow gas.
8. There is a steady increase in melting point and boiling point as we go down the group. The elements change from gases through, liquid to solid with increasing atomic number.
9. The lowest element in this group is highly radioactive and rare element 'astatine' (At)

### Trends across a period

1. The vertical groups of elements show similar properties, but following a period across the table highlights the trend from metallic to non-metallic properties.
2. The first period contains two elements (H, He) both are distinctive in different ways. The final period is incomplete.
3. Other five remaining periods of elements start with a reactive alkali metal and ends with an unreactive noble gas. There is a gradual change in physical properties across the period.

### New elements

1. The heaviest atom made so far has an atomic number of 112. These heavy elements are extremely unstable and highly radioactive.
2. Calculations suggest that there would be more stability for atoms of atomic numbers below 82. Super-heavy elements might be formed naturally. But they would be radioactive, would only last for a few months.

### Electropositive nature and metallic character

Electropositive nature is the tendency of an element to lose its electron readily, it is said to be strongly electropositive and more metallic.

Electropositive nature and metallic character decrease from left to right along a period. This is due to increase in ionization energy. In the extreme left of the table metals are found and in the extreme right non-metals are present.

***Example***

3 rd period

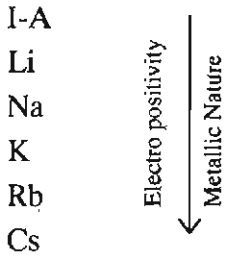
| Na | Mg | Al | Si | P | S | Cl |
|---|---|---|---|---|---|---|
| Metals strongly electro positive | | | | Non-metals strongly electro negative | | |

***Example***

In the 2nd period Lithium and Beryllium are metals. Boron is a semimetal; carbon, nitrogen, oxygen and fluorine are non-metals.

Down the group in the periodic table, the electro – positive and metallic nature increase from top to bottom. This is due to decrease in ionization energy.

**Alkali metals**




***Example***

In Group 14, C and Si are non-metals

Ge is a metalloid. Sn and Pb are metals.

## 10. Periodic Trends in Properties

The periodic trends with respect to (1) ionization energy (2) electro negativity (3) electron affinity (4) atomic size are discussed below.

### 1) Ionization energy

The amount of energy required to remove the most loosely bound electron from an isolated gaseous atom to form a gaseous positive ion is called Ionization energy (or ionization potential)

a) Variation of ionization energy along a period: -

In a period from left to right, the ionization energy increases. (This is because of the increase in nuclear charge and decrease in atomic size)

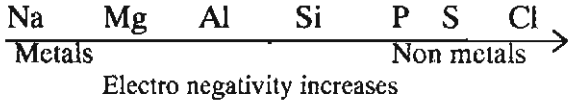
b) Variation of ionization energy along a group:-

The ionization energy decreases down the group. For eg : among alkali metals of 1 group (Li,Na,K,Rb,Cs) Li has the highest ionization energy (520.3 kJ) caesium has a low value of 374 kJ.

### 2) Electro negativity

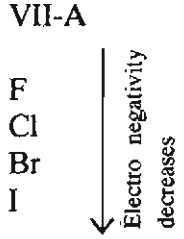
It is a measure of the tendency of an atom to attract electrons to itself.

Along a period, electro negativity or non-metallic nature increases from left to right. Halogens have the highest value of electro negativity in their respective periods.




Down the group electro negativity decreases from top to bottom.

**Halogens**




(i) I Group (or alkali metals) have lowest electro negativities.

(ii) Inert gases (or group 18 elements) have zero electro negativities

(iii)Halogens (or group 17 elements) have highest electro negativities. Electro negativity is a property of a bonded atom, whereas ionization energy and electron affinity are properties of isolated gaseous atoms.

### 3) Electron affinity

It is the amount of energy released when an isolated gaseous atom accepts an electron to form a monovalent gaseous anion. The factors which affect electron affinity are nuclear charge, atomicsize, electronic configuration.

Electron affinity, in general, increases in a period from left to right, some important features of electron affinity are:

a) Halogens have the highest electron affinities.

b) Electron affinities of noble gases are Zero.

c) Electron affinities of Be, Mg are almost Zero.

d) Electron affinities of N and P are extremely low.

The electron affinity decreases on going down the group. However the electron affinity of chlorine is unexpectedly higher than that of fluorine.

**4) Atomic size**

In dealing with atomic size, the atom is assumed to be a sphere and its radius determines the size.

The distance between the outermost electron and the nucleus is known as the size of the atom.

**Atomic radius is defined as the distance between the centre of nucleus of the atom to the outer most shell of electrons.**

**i) Variation in a Period**

In general, the atomic radii decrease with the increase in the atomic number in a period.

Example: Atomic radii decrease from lithium to fluorine in second period.

**ii) Variation in a group**

In general the atomic radii increase from top to bottom within a group of the periodic table.

Example : Atomic radii increase from Li to Cs and also from F to I.

iii) Metallic elements at the left hand side of the table will have large atomic radii and the non-metals at the upper right –hand side of the table will have small radii.

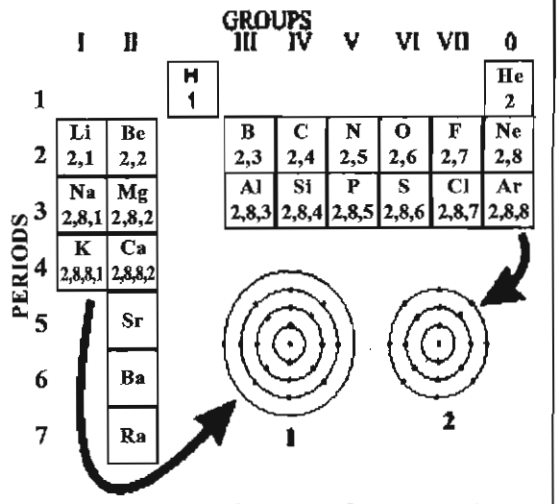
It is impossible to measure the exact size of an atom because we cannot pinpoint the exact position of electrons around the nucleus.

**Activity:** Some elements in the Periodic table, represented by the letters A to E, are given in Fig 10.5.

Choose from A to E:

a) a noble gas, b) a halogen,
c) the most reactive metal,
d) the most reactive non-metal

**Extension**




1. a potassium atom, 2. an argon atom

*Fig 10.4*

There is a relationship between electron arrangement and position in the Periodic Table for the main group elements. The elements in Group II have two outer electrons. The elements in Group III have three electrons in the outermost shell. A magnesium atom has two electrons in its third, outer, shell and is in Group II.

An Argon atom has an outer shell containing eight electrons- a very stable arrangement – and is in Group 0. A potassium atom has one electron in its outer shell, and is in Group I and Period 4

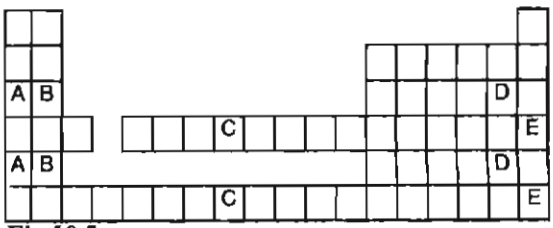



*Fig 10.5*

**Activity**

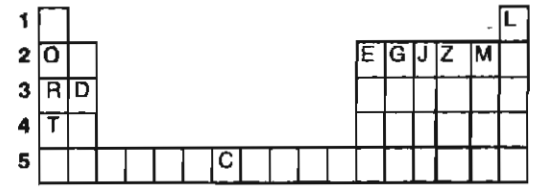



*Fig 10.6*

1) How many protons does an atom of element L contain?

2) Which element shown forms ions with a single negative charge?

3) Which metallic element is more reactive than R?

4) Which element has its electrons arranged in four shells?

5) How many neutrons are there in an atom of element **M** (mass number 19)?

6) The table below gives data about three additional elements from one group of the Periodic Table..

**Table 10.2**

| *Physical state at room temperature* | *Colour* |
|---|---|
| Gas | Greenish yellow |
| Liquid | Reddish brown |
| Solid | Violet |

To which group do these elements belong?

7) What is the electron arrangement of the atom J?

**Activity:** This question refers to the Group VII elements (the halogens). Copy out and fill in the gaps in the table below:

**Table 10.3**

| *Name of element* | *Symbol* | *State at room temp. and Pressure* | *Reaction with Element Hydrogen* |
|---|---|---|---|
| Fluorine | F | | Very fast |
| Chlorine | Cl | Gas | Fast |
| Bromine | Br | Liquid | Slow |
| Iodine | I | Solid | Very |
| Astatine | At | | slow |

### Activity

1) Use the Periodic Table to write down the chemical symbol of:

i) a semi-metal (an element that has the properties of both a metal and a non-metal);

ii) an element in the third period;

iii) the element which has four electrons shells and five electrons in the outermost shell.

2) Predict two chemical properties or reactions of the element caesium (Cs).

3) Use the Periodic table to help you describe the structure of an atom of sulphur that has a mass number of 32.

## 10.11 Merits of the long form of the Periodic Table

1) It relates the position of an element to its electronic configuration.

2) It reflects the similarities, differences and trends in chemical properties clearly.

3) It is an easy chart to remember and reproduce

4) Elements of Groups 1 and 2 are called s-block elements, those of 13 to 18 are called p block. Elements between groups 3 and 10- are known as d-block (transition elements)

### Defects

1) Hydrogen is not assigned to any 'family'. It resembles both alkali metals and halogens

2) The inner Transition elements– Lanthanides, actinides are placed separately.

### Self Evaluation

**Choose the correct answer**

1. The following result signifies

| Element | At. Mass | |
|---|---|---|
| Chlorine | 35.5 | $\frac{35.5+127}{2} = 81.25$ |
| Bromine | 79.9 | |
| Iodine | 127 | |

a) Mendeleev b) New lands
c) Dobereiner d) Lother Mayer

2. The law of Octaves is due to
a) Mendeleev b) Dobereiner
c) Lother Mayer d) New lands
3. The Number of elements in second and third periods of the periodic table is respectively
a) 5 and 2 b) 2 and 8
c) 8 and 18 d) 8 and 8

4. Atomic number of first inert gas, Helium is 2. Hence the atomic number of the 4th inert gas is
   a) 8 b) 18 c) 36 d) 54
5. Electron affinity of halogens
   a) lowest b) highest
   c) moderate d) very low.
6. The alkali metals have _____ electron(s) in the valence shell.
   a) 1 b) 2 c) 3 d) 4
7. The shortest period contains _____ elements
   a) 3 b) 4 c) 5 d) 2
8. The short period contains _____ elements
   a) 8 b) 4 c) 2 d) 5
9. Atomic radii of the elements increase from
   a) Na to Cs b) Cs to Na
   c) I to F d) Li to F
10. In IA Group from Na to Cs the metallic nature
    a) decreases b) fluctuates
    c) steady d) increases.

**Fill in the Blanks**

11. In the periodic table, the horizontal rows are called _____ and the vertical columns are _____.
12. Atomic weight is basically a property of the _____.
13. Elements with intermediate properties between metals and non-metals are known as _____.
14. In modern periodic table the elements are arranged in the increasing order of _____.

**State true or false**

15. Potassium is an electronegative element.
16. Lanthanides and Actinides have similar properties.
17. In a period the density decreases progressively from left to right.
18. In halogens the only liquid is Bromine.

**Answer briefly**

19. State the modern periodic law.
20. List the elements present in the second period of the periodic table.
21. Define the electropositive nature of an element .How does it vary in a period and group in the periodic table.

**Answer in detail**

22. Discuss the structure of modern periodic table with special reference to the groups and Periods.
23. How do the following vary in a group and in a period of the periodic table:
    (a) Metallic character.
    (b) Ionization energy
    (c) Electro negativity.
    (d) Electron affinity.
    (e) Atomic size.
24. What is the number of periods in the long form of the periodic table? Briefly indicate their characteristics.
25. What is the criterion for forming a group of elements? Indicate some groups of elements with their common names.
26. Define the following:
    a) Ionization energy
    b) Electron affinity
    c) New elements
    d) Periodicity
    e) Inner transition elements.

# 11. CHEMICAL BONDING

Matter around us is made up of variety of molecules. Molecules are formed from atoms of elements. Different types of attractive forces hold the atoms together in a molecule. These attractive forces are called chemical bonds. The formation of different types of bonds and the properties of the molecules on the basis of chemical bonding are discussed in this chapter.

## 11.1 Formation of Chemical Bond - Octet Rule

All noble gases are inert and do not react with other atoms easily. All of them except helium have eight electrons in their outermost orbit. The outermost orbit with eight electrons is called octet and this configuration is stable because it represents completely filled energy level.

### The Octet Rule

All other elements other than inert gases have less than eight electrons in their valence shell and they try to achieve this stable electronic configuration. This tendency of the elements to achieve noble gas configuration (8 electrons in valence shell) is thus called **Octet rule.**

This rule is applicable to all types of chemical bonds between atoms. The following table explains the electronic configuration of inert gases or group 18 elements.

An atom can achieve the inert gas electron arrangement in three ways (i) by losing one or more electrons, (ii)by gaining one or more electrons and (iii) by sharing one or more electrons with another atom(s).

**Table : 11.1 Electronic configuration of Group 18 elements**

| *S.No* | *Element* | *Atomic Number* | *Configuration* |
|---|---|---|---|
| 1. | Helium (He) | 2 | 2 |
| 2. | Neon (Ne) | 10 | 2, 8 |
| 3. | Argon (Ar) | 18 | 2, 8, 8 |
| 4. | Krypton (Kr) | 36 | 2, 8, 18, 8 |
| 5. | Xenon (Xe) | 54 | 2, 8, 18, 18, 8 |
| 6. | Radon (Rn) | 86 | 2, 8, 18, 32, 18, 8 |

### Formation of ions

When an atom loses electrons to attain octet configuration, it becomes an ion called **cation.** In the same way if an atom gains an electron to attain octet configuration, the ion is called **anion.**

When an electron is removed from neutral gaseous atom to form a cation, the energy required is called **Ionization energy**. Similarly when an electron is added, a neutral gaseous atom becomes anion and energy is released. This energy is called **electron affinity**.

The atoms of elements which have more tendency to lose electrons to become cations are called electro positive elements. For example group I and group II, alkali and alkaline earth elements have this tendency. Therefore, they are all called **electropositive elements.**

Similarly the atoms of elements which have more tendency to gain electrons to become anion are called **electro negative elements.**

### Formation of cations

All the alkali metals of Group I have the tendency to lose one electron present in the outermost shell and to acquire the

electronic configuration of the nearest noble gas. That is why all the alkali metals are highly reactive.

1. Formation of sodium ion

Sodium atom acquires the nearest noble gas, neon's electronic configuration by losing an electron.

$Na \longrightarrow Na^+ + e^-$ (electron)

| Atom | Ion |
|---|---|
| 2, 8, 1 | 2, 8 |
| No. of protons–11 | Number of protons- 11 |
| No. of electrons–11 | Number of electrons-10 |
| Neutral but reactive | Stable(2,8-neon configuration) |

Sodium atom contains equal number of protons and electrons. Hence it is neutral in nature. After losing an electron, one proton is more than the number of electrons present in the atom. Hence it assumes mono positive charge and becomes sodium ion.

Atoms are neutral, whereas ions are charged particles and the charge may be negative or positive. Since ions have stable configuration, they are less reactive than atoms.

2. Formation of potassium ion from its atom

$K \longrightarrow K^+ + e^-$

| Potassium atom electronic configuration=2,8,8,1 | Potasium ion electronic configuration 2,8,8 (electronic structure of Argon) |
|---|---|

3. Formation of Lithium ion from Lithium atom

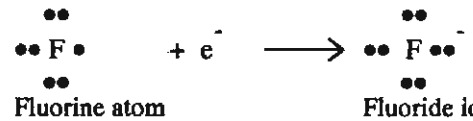
$Li \longrightarrow Li^+ + e^-$

| Lithium atom electronic configuration 2, 1 | Lithium ion electronic configuration 2 (Structure of Helium) |
|---|---|

**Formation of anion**

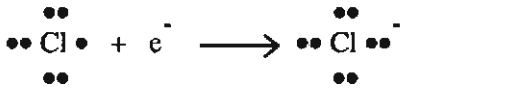
The elements of $17^{th}$ group in the periodic table are short of one electron to attain the stable configuration of the nearest noble gas. Therefore they accept one electron from the metals, and become negatively charged ions. For example,

1. Fluorine atom gains an electron to form Fluoride ion.



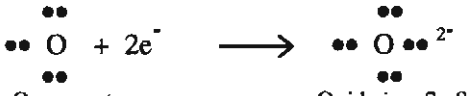
| Fluorine atom electronic configuration 2, 7 | Fluoride ion electronic configuration 2, 8 (neon gas configuration) |
|---|---|

2. Chlorine atom accepts an electron to form chloride ion.



| Chlorine atom electronic configuration 2,8,7 | Chloride ion electronic configuration(Argon structure) 2,8,8 |
|---|---|

3. An element of $16^{th}$ group short of two electrons for the nearest noble gases, accepts two electrons to form negative ion, For example oxygen accepts two electrons to form oxide ion.



| Oxygen atom electronic Configuration 2,6 | Oxide ion 2, 8 (neon configuration) |
|---|---|

## 11. 2 Types of bonds

Atoms can lose or gain electrons to acquire stable electronic configuration. If they gain electrons they become anions. If they lose electrons they become cations. The bond between the anion and cation is the electro static force of attraction.

This type of chemical bond which is formed between electropositive elements and electro negative elements is called **ionic bond or electrovalent bond or polar bond.**

Atoms can achieve stable outer electronic configuration by mutual sharing of electrons. This is called **covalent bonding.** A covalent bond consists of shared pair of electrons.

However, in some molecules and ions, both the shared pair of electrons come from one atom. This is called **co-ordinate bonding** or dative bond.

## 1. Electrovalent Bond

Let us consider the chemical bond formed between sodium and chlorine to form sodium chloride (NaCl).

### The formation of ions by electron transfer

The electronic configuration of sodium is 2,8,1. By losing one electron, it gets the stable configuration 2, 8 same as that of nearest noble gas neon.

The energy applied to remove an electron from the outermost shell of sodium is equal to the Ionization energy. The ionization energy of sodium is 496KJ per mole.

$$Na + 496\ KJ\ mol^{-1} \longrightarrow Na^{+} + e^{-}$$

Energy is consumed in this process. So it is **endoergic process.**

The electronic configuration of chlorine is 2, 8, 7. It needs just one electron to complete its octet and it acquires one electron from sodium atom and forms the electronic configuration of nearest inert gas argon, 2, 8, 8. Now chlorine has one electron more than its number of protons and forms chloride ion.

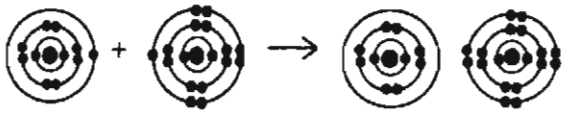
$$Cl + e \longrightarrow Cl^{-} + 349KJ\ mol^{-1}$$

This process is accompanied by a release of energy which is equal to the electron affinity of chlorine atom. The electron affinity of chlorine atom is 349KJ $mol^{-1}$.

Since energy is released in this process, it is known as **exoergic process.**

When sodium atom interacts with chlorine atom, sodium atom transfers one electron to chlorine atom so that both of them acquire the structure of inert gases, Neon and Argon respectively.

This results in the formation of sodium and chloride ions which are oppositely charged. They attract each other by an electrostatic force of attraction. This force between the ions is known as ionic or electrovalent bond.



| Na | Cl | $Na^{+}$ | $Cl^{-}$ |
|---|---|---|---|
| (2, 8, 1) | (2, 8, 7) | (2, 8) | (2, 8, 8) |

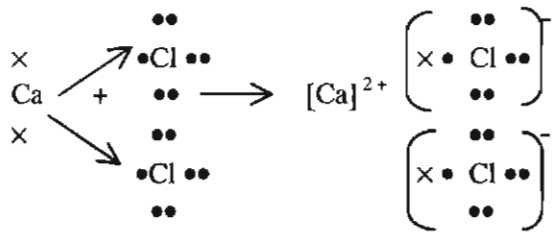
*Fig 11.1 Formation of NaCl*

### Examples of ionic compounds

#### Formation of calcium chloride

Calcium, a group II element has the electronic configuration of 2, 8, 8, 2. By losing two electrons it assumes the structure of argon to become $Ca^{2+}$ ion. Two chlorine atoms accept one electron each to attain the configuration of argon to become two $Cl^{-}$ ions.

Calcium and chloride ions approach each other by electrostatic force of attraction to form ionic bond.



In this case, the valency of calcium is two and that of chlorine is one.

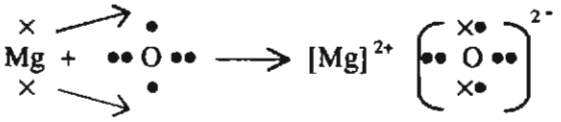
#### Formation of magnesium oxide

The electronic configuration of magnesium and oxygen atoms are

Mg Atomic number 12 : 2, 8, 2

O Atomic Number 8 : 2, 6

It is clear that magnesium can lose two electrons to form $Mg^{2+}$ ion, which is the configuration of neon (2, 8). On the otherhand, oxygen atom gains two electrons from magnesium atom to achieve the configuration of neon (2, 8). As a result, oxygen changes to $O^{2-}$ ion. These two ions are held together by ionic bond.



In this case the valency of magnesium is 2 and oxygen is also two.

## 2. Covalent Bond

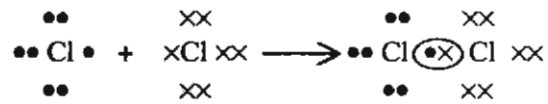
The covalent bond is formed by mutual sharing of electron pairs between the atoms of the same or different elements to acquire noble gas configuration. The arrangement of electrons in a covalent molecule is shown by **Lewis structure.**

For example, let us consider the formation of hydrogen molecule from two hydrogen atoms. These two atoms contribute one electron each and mutually share the pair of contributed electrons as shown below by Lewis structure. For clarity, dots and crosses are used to denote electrons from atoms.

Thus if one pair of electrons is shared it is called as single covalent bond. It is represented by H-H. Now both hydrogen atoms acquire stable configuration of helium gas.

### Chlorine molecule

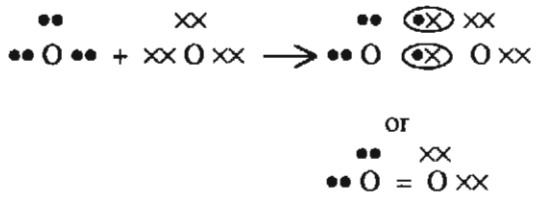
Similarly two chlorine atoms (atomic no.17) combine to form a molecule of chlorine by sharing a pair of electrons. Each chlorine atom has seven electrons in its valence shell and it is short of one electron than the stable octet. Therefore the two atoms contribute one electron each. They mutually share the contributed pair and form chlorine molecule.



This is represented by Cl – Cl

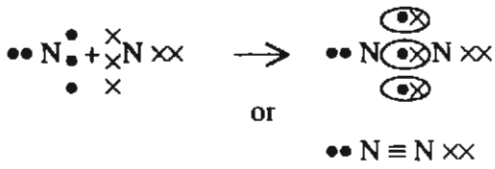
### Oxygen molecule $O_2$

The electronic configuration of oxygen is 2,6. The outermost shell is short of two electrons to complete its octet. Here sharing of two electron pairs results in the formation of a double bond.



### Nitrogen molecule $N_2$

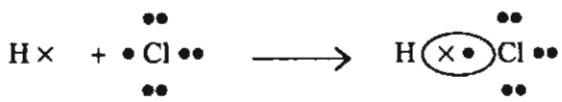
Nitrogen has five electrons in the valence shell. It is short of three electrons to complete the octet configuration (eight electrons). Therefore two nitrogen atoms form nitrogen molecule by sharing three electron pairs.



Since three electron pairs are shared between two atoms, this is triple bond and is represented as N ≡ N

### Hydrogen Chloride molecule HCl

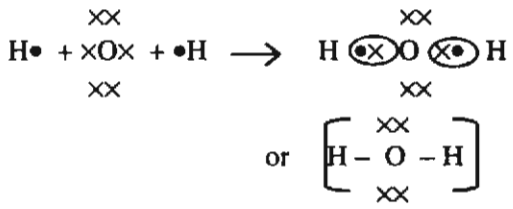
Hydrogen chloride molecule is formed by sharing one electron pair between hydrogen and chlorine.



Therefore single bond exists between hydrogen and chlorine as H – Cl

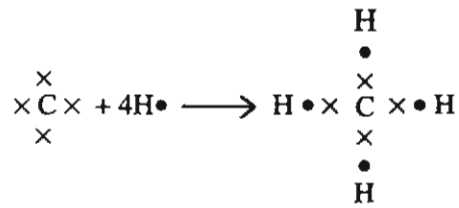
**Water molecule $H_2O$**

A molecule of water is formed by sharing of two electron pairs between one oxygen and two hydrogen atoms

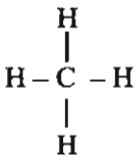


**Methane molecule $CH_4$**

In methane molecule each of four hydrogen atom is bonded to the carbon atom by a pair of shared electrons.



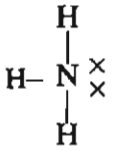
In this process each hydrogen atom gains an electron and assumes the **stable** configuration of the inert gas helium Four shared pair of electrons around carbon makes it to attain Octet configuration.

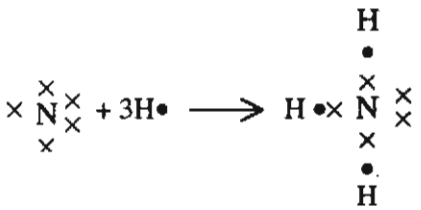


**Ammonia molecule $NH_3$**

Nitrogen atom has five electrons in the valence shell and it shares three electrons with three hydrogen atoms to get the stable configuration of neon whereas each hydrogen attains the structure of helium

It is represented as





In ammonia, Nitrogen has an unshared pair of electrons. It is called as lone pair of electrons.

**Properties of Ionic (Electrovalent) Compounds**

1) Ionic compounds are mostly hard solids because the electrostatic force of attraction between the ions is strong.
2) Ionic compounds are electrolytes because their ions can move when the compounds are melted or dissolved in suitable solvents.
3) The energy required to break the bonds in ionic crystals is high and therefore the melting points are high.
4) Ionic compounds are usually soluble in water and insoluble in organic solvents.
5) They do not exhibit structural and stereo isomerism.

**Properties of Covalent Compounds**

1. State of existence

Most of the covalent compounds are either gases or liquids.

2. Low melting and boiling points

Force of attraction between atoms in a molecule is a weak intermolecular force. A little energy is needed to overcome the inter molecular force. Hence covalent compounds have low melting and boiling points.

3. Non Conductivity

The electrical conductivity of these compounds is poor because of the non-existence of ions.

4. Solubility

They are soluble in organic solvents such as benzene, carbon tetra chloride, ether etc and insoluble in water.

5. Isomerism

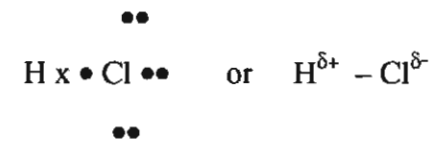
The covalent compounds generally exhibit isomerism. **Isomerism is a phenomenon in which a single molecular formula can represent two or more compounds.**

## 11.3 Electro negativity and polar covalent bond

When a covalent bond is formed between two dissimilar atoms, the bonded electrons are not equally shared between the two atoms.

Let us, for example, consider the case of hydrogen chloride molecule. Chlorine attracts the shared pair of electrons to a greater extent when compared to hydrogen. The property of attracting electrons of a covalent bond towards the bonded atom is known as **electronegativity.** Chlorine has more electronegativity than hydrogen. The shifting of bonding pair of electrons from one atom to another causes the formation of a dipole. Such a bond is known as a **Polar covalent bond.**

The more electronegative element gains a very small amount of negative charge and denoted by $\delta$- and the less electronegative element gains a very small amount of positive charge denoted by $\delta$+



The molecule containing polar covalent bond is known as polar molecule and HCl is a polar molecule.

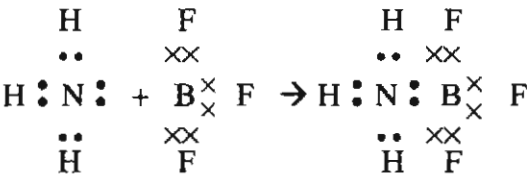
### Coordinate Bond

In some cases a bond is formed between atoms by sharing a pair of electrons which are supplied by any one of the atoms. This type of bond is called as **coordinate bond.** The atom which gives a pair of electrons for sharing is known as donor and the atom which accepts the lone pair of electrons is known as acceptor.

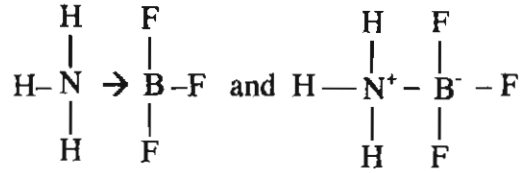
Consider the formation of the compound $NH_3BF_3$. In ammonia the nitrogen atom contains a lone pair of electrons after completing its octet by sharing an electron with each of three hydrogen atoms.

In $BF_3$ molecule, the valence shell of Boron atom contains only six electrons after forming covalent bonds with three fluorine atoms. Hence boron atom needs two more electrons to complete its octet. So it gains a pair of electrons from Nitrogen atom of ammonia molecule to form $NH_3BF_3$ molecule.

Here Nitrogen is the donor and Boron is the acceptor. The bond formed between nitrogen and boron in this molecule is called as coordinate bond or dative bond. The formation of the molecule is represented as follows



Two other ways of representing the compound are



The arrow indicates the donation of lone pair of electrons from Nitrogen to Boron atom.

### Some basic concepts

* According to the electronic theory of valency, atoms try to achieve the most stable (that is, the lowest energy) electronic configuration when they form bonds.

* The Octet rule states that an atom tries to achieve the electronic configuration of a noble gas when it forms a bond.

* Noble gases have stable electronic configuration.

* An ionic bond is an electrostatic force of attraction between two oppositely charged ions.

* When an atom loses electron it becomes cation and when an atom gains electron it becomes anion.

* The energy required to remove an electron from neutral gaseous atom is known as ionisation energy.

* When an electron is added to neutral gaseous atom, the energy released is known as electron affinity.

* A covalent bond consists of two electrons shared between two adjacent atoms. Each atom contributes one electron.

* A coordinate bond is a type of covalent bond, formed by the donation of a lone pair of electrons by one atom.

## Self- Evaluation

### Choose the correct answer

1. The tendency of the elements to achieve noble gas configuration is called.

a) Avogadro's rule b) Newton's rule

c) Dobereiner rule d) Octet rule

2. Number of electrons in sodium ion.

a) 11 b) 12 c) 10 d) 8

3. The electronic configuration of argon.

a) 2,8,7 b) 2,8,8, c) 2,8 d) 2,8,8,1

3. The ionization energy of sodium in kJ per mole is

a) 596 b) 496 c) 4632 d) 5926

5. The bond formed between nitrogen and boron in the compound $H_3NBF_3$ is

a) Ionic b) Covalent

c) Polar covalent d) Co-ordination.

### Fill in the blanks

6. The Neon consists of _____ electrons in the outer most shell.

7. When the atom loses electron it becomes _____ and when an atom gains electron it becomes _____.

8. All the noble gases except helium have _____electrons in their outer most orbit.

9. When an atom loses an electron it becomes an ion called_____

10. The atoms of elements which have more tendency to lose electrons to become cations are called _____

11.After the loss of an electron lithium attains the structure of _____

12.The electron affinity value of chlorine atom is _____ kJ $mol^{-1}$

### 13. Match the following

| | |
|---|---|
| 1) Electrovalent bonding | i)$NH_3BF_3$ |
| 2) Co-ordinate bonding | ii)2,8,8 |
| 3) $Ca^{2+}$ | iii) 2,8 |
| 4) $Mg^{2+}$ | iv)Polar bond |

### Answer briefly

14. Sodium chloride conducts electricity in molten state but not in solid state. Give reasons.

15. Why electrovalent compounds have high melting points?

16. Explain the difference between an atom and an ion.

### Answer in detail

17. State and explain Octet rule

18. How is Sodium Chloride formed from sodium and chlorine?

19. Mention the type of bonding present in

a) HCl b) NaCl

c) $N_2$ d) $O_2$

20.Tabulate the differences between ionic and covalent compounds.

21. Why is bonding in HCl called as polar covalent bond?

# 12.CHEMICAL REACTIONS

The reaction in which new substances with entirely different properties are formed from the original substances is called chemical reaction.

***For example.***

1) Burning of sulphur to form sulphurdi-oxide

2) Magnesium ribbon burns in air to form a white powder of magnesium oxide

3) Decomposition of acidulated water into hydrogen and oxygen

## 12.1 Formulae of compounds with reference to 1:1, 1:2, 1:3 and 2:2 compounds

The molecular formula of a molecule of elements or compounds consists of symbols of the element(s) and the number of atoms of each element in one molecule. This is also called as molecular formula. For example one molecule of oxygen contains two atoms of oxygen. Its formula is $O_2$. One molecule of ammonia contains one atom of nitrogen and three atoms of hydrogen. Its formula is $NH_3$.

***Table 12.1 Valency –1***

| Positively Charged ions | | Negatively Charged ions | |
|---|---|---|---|
| $H^+$ | Hydrogen ion | $Cl^-$ | Chloride ion |
| $Li^+$ | Lithium ion | $Br^-$ | Bromide ion |
| $Na^+$ | Sodium ion | $I^-$ | Iodide ion |
| $K^+$ | Potassium ion | $OH^-$ | Hydroxide ion |
| $Cu^+$ | Copper (I) ion | $NO_3^-$ | Nitrate ion |
| $Ag^+$ | Silver ion | $HCO_3^-$ | Bicarbonate ion |
| $NH_4^+$ | Ammonim ion | | |

The number of electrons an atom shares or transfers to combine with other atom or atoms is the combining capacity and is called **valency**. Valencies are always small whole numbers. Valencies depend on the charge of the ions of a particular element or group of elements.

***Table 12.2 Valency –2***

| Positively Charged ions | | Negatively Charged ions | |
|---|---|---|---|
| $Mg^{2+}$ | Magnesium ion | $O^{2-}$ | Oxide ion |
| $Ca^{2+}$ | Calcium ion | $S^{2-}$ | Sulphide ion |
| $Ba^{2+}$ | Barium ion | $SO_3^{2-}$ | Sulphite ion |
| $Fe^{2+}$ | Iron (II) ion | $SO_4^{2-}$ | Sulphate ion |
| $Cu^{2+}$ | Copper (II) ion | $CO_3^{2-}$ | Carbonate ion |
| $Zn^{2+}$ | Zinc ion | | |
| $Pb^{2+}$ | Lead (II) ion | | |
| $Hg^{2+}$ | Mercury (II)ion | | |

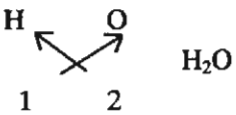
***Table 12.3 Valency –3***

| Positively Charged ions | | Negatively Charged ions | |
|---|---|---|---|
| $Fe^{3+}$ | Iron (III) ion | $PO_4^{3-}$ | Phosphate ion |
| $Al^{3+}$ | Aluminium ion | | |

Using symbols and valency of elements and radicals (group of atoms having specific number of valency) the molecular formula is written by crisscross method as follows

### Formulae of some compounds

### 1. Water

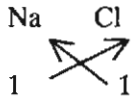



The formula of water is $H_2O$

### 2. Sodium chloride

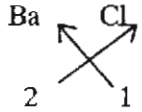
The symbol of metal is written first and then the non metal. The valencies are written as subscripts on the right side of

elements using crisscross method valency 1 is not written as subscript



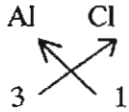

The formula of sodium chloride is NaCl.

**3. Barium chloride**




The formula of barium chloride is $BaCl_2$.

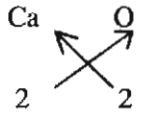
**4. Aluminium chloride**




The formula of aluminium chloride is $AlCl_3$.

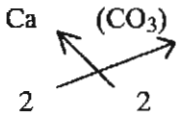
**5. Calcium oxide**

The ratio of atoms of the elements is used in the formula.



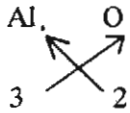

The formula of calcium oxide is CaO.

**6. Calcium carbonate**



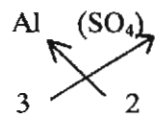

The formula of calcium carbonate is $CaCO_3$ (Carbonate ion acts as one unit).

**7. Aluminium oxide**




The formula of aluminium oxide is $Al_2O_3$.

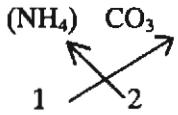
**8. Aluminium sulphate**




The formula of aluminium sulphate is $Al_2(SO_4)_3$.

The brackets are needed because the sulphate ion is made up of more than one element.

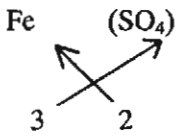
**9. Ammonium carbonate**




The formula of ammonium carbonate is $(NH_4)_2CO_3$.

The brackets are put round the ammonium ion to show that the whole of ammonium ions is used. If the brackets were not used we would have $NH_4{}_2$, and that would be meaningless. Brackets are used when the formula needs two or more ions which are made up from more than one element.

**10. Iron (III) sulphate**




The formula of Iron (III) sulphate is $Fe_2(SO_4)_3$.

## 12.2 Chemical Equation

A chemical equation is a short scientific representation of a chemical reaction

The stoichiometry of a reaction is the description of the relative quantities of the reactants and product in terms of moles.

**1. Equations of simple chemical reactions and balancing**

Writing chemical equation involves four stages

***Stage 1:*** The equation is written in words. For example the formation of water is written as follows

Hydrogen + Oxygen $\longrightarrow$ Water

***Stage 2 :*** The words are replaced by formulae and symbols. Since hydrogen and

oxygen exist as diatomic molecules they are represented as $H_2$ and $O_2$

$$H_2 + O_2 \longrightarrow H_2O$$

This is called skeleton equation.

***Stage 3*** : The number of atoms of each element on either side of the equation must be equal in accordance with the law of conservation of matter.

The skeleton equation must be balanced as follows

| | Reactant side | Product side |
|---|---|---|
| Number of H atoms | 2 | 2 |
| Number of O atoms | 2 | 1 |

The number of Hydrogen atoms is equal on both sides. But the numbers of oxygen atoms are not equal. To make the number of oxygen atoms equal on both sides multiply $H_2O$ by 2 so that

$$H_2 + O_2 \longrightarrow 2H_2O$$

Again count the number of various atoms on both sides

| | Reactants | Products |
|---|---|---|
| **H** | 2 | 4 |
| **O** | 2 | 2 |

Even though the number of oxygen atoms are equal on both sides, the number of hydrogen atoms is not equal. To have four hydrogen atoms on left side multiply $H_2$ by 2 and write the equation as

$$\underset{H=2\times2=4}{2H_2} + \underset{O=2}{O_2} \longrightarrow \underset{\substack{H=2\times2=4\\O=2\times1=2}}{2H_2O}$$

Since the numbers of hydrogen and oxygen atoms are equal on both sides, the equation is balanced.

***Stage 4*** : The physical state may be mentioned

$$2H_{2\,(g)} + O_{2(g)} \longrightarrow 2H_2O_{(l)}$$

The following symbols are used :

| | |
|---|---|
| g | gaseous substance |
| s | solid |
| l | liquid |
| ↑ | gaseous state |
| ↓ | precipitate |

Symbols for allotropic forms are also used.

$S_{(m)}$ - monoclinic sulphur

$S_{(r)}$ - rhombic sulphur.

**Interpreting Chemical equation**

From the above equation, it is meant that two moles of hydrogen molecules react with one mole of oxygen molecules to give two moles of water molecules. This is called **molar interpretation**.

Otherwise we could say that two molecules of hydrogen react with one molecule of oxygen to give two molecules of water.

**1. Formation of HCl**

Hydrogen has great affinity for chlorine. Therefore hydrogen reacts with chlorine to form hydrogen chloride.

Hydrogen + chlorine ⟶ Hydrogen chloride

$$\underset{H=2}{H_2} + \underset{Cl=2}{Cl_2} \longrightarrow \underset{\substack{H=1\\Cl=1}}{HCl}$$

skeleton or unbalanced equation

Two hydrogen and two chlorine atoms are at the left but only one hydrogen and one chlorine atoms are at the right. To have two hydrogen and two chlorine atoms on the right side, multiply HCl by 2.

$$\underset{H=2}{H_2} + \underset{Cl=2}{Cl_2} \longrightarrow \underset{\substack{H=2\\Cl=2}}{2HCl}$$

The numbers of hydrogen and chlorine atoms are equal on both sides Hence the equation is balanced.

**2. Formation of $CO_2$**

Carbon burns in air to form carbon dioxide.

Carbon + Oxygen ⟶ Carbon dioxide.

$C + O_2 \longrightarrow CO_2$

C=1 O=2 C=1 O=2

balanced equation.

**3. Decomposition of HCl**

Hydrogen chloride decomposes to give hydrogen and chlorine.

Hydrogen chloride ⟶ Hydrogen + chlorine

$HCl \longrightarrow H_2 + Cl_2$

Unbalanced equation

By putting 2 as coefficient for HCl, it becomes a balanced equation.

$2HCl \longrightarrow H_2 + Cl_2$

**balanced equation**

**4. Decomposition of $CaCO_3$**

Calcium carbonate on heating forms carbondioxide and calcium oxide.

Calcium Carbonate $\xrightarrow{\triangle}$ Calcium oxide + Carbondioxide

$CaCO3 \xrightarrow{\triangle} CaO + CO_2$

**balanced equation**

$\triangle$ (Delta) refers to heating.

**5. Decomposition of $H_2O_2$**

Hydrogen peroxide decomposes to give water and oxygen.

Hydrogen peroxide ⟶ Water + oxygen

$H_2O_2 \longrightarrow H_2O + O_2$

skeleton equation

Sometimes it is easier to balance by using fractions and then multiplying the whole equation to remove the fractions. In skeleton, two oxygen atoms are on the left. By putting the fraction ½ as coefficient of oxygen molecule the number of atoms of elements on either side becomes equal

$H_2O_2 \longrightarrow H_2O + ½O_2$

The fraction is removed by multiplying the whole equation by 2

$2H_2O_2 \longrightarrow 2H_2O + O_2$

**balanced equation**

## 12.3 Types Of Chemical Reactions

The elements and compounds interact in different ways and produce a variety of new substances. Therefore chemical reactions can be classified into many types as follows

**1. Combination reaction**

When two or more elements combine to form a new compound, it is known as combination reaction. For example.

i) On burning hydrogen in air, it combines with oxygen to form water.

$2H_2 + O_2 \longrightarrow 2H_2O$

This equation represents the formation of a compound (water) from elements (hydrogen and oxygen)

***Activity:*** Take a strip of magnesium ribbon and hold it with the help of a pair of tongs in the flame. You will notice that magnesium ribbon burns with a dazzling flame and changes into a white substance which is magnesium oxide. This happens due to the following combination reaction.

$2Mg_{(s)} + O_{2(g)} \longrightarrow 2MgO_{(s)}$

ii) Hydrogen combines with chlorine to form a compound, hydrogen chloride.

$H_2 + Cl_2 \longrightarrow 2HCl$

iii) In the same way, hydrogen reacts with bromine to give hydrogen bromide.

$H_2 + Br_2 \longrightarrow 2HBr.$

## 2. Decomposition reaction

Decomposition is the reverse of combination reaction.

The conversion of a single compound into two or more simpler substances is called decomposition reaction.

The decomposition reaction is carried out by heat, light, and electrical energy.

(1) Calcium carbonate(limestone) on heating gives carbondioxide and calcium oxide(lime).

$$CaCO_3 \xrightarrow{\triangle} CaO + CO_2\uparrow$$

Calcium carbonate, a single compound is converted to two simpler compounds namely calcium oxide and carbondioxide.

(2) When potassium chlorate is heated it gives potassium chloride and oxygen gas.

$$2KClO_3 \xrightarrow{\triangle} 2KCl + 3O_2\uparrow$$

A single compound potassium chlorate is decomposed to two simpler substances.

(3) Mercury II oxide decomposes to mercury and oxygen gas

$$2HgO \xrightarrow{\triangle} 2Hg + O_2\uparrow$$

***Activity :*** Take some lead nitrate powder in a test tube and heat it over the flame. You would notice brown fumes coming out of the test tube. The following reaction takes place:

$$Pb(NO_3)_{2(s)} \longrightarrow 2PbO_{(s)} + 4NO_{2(g)} + O_{2(g)}$$

Lead nitrate — Lead oxide — Nitrogen dioxide — Oxygen

The brown fumes evolved in the above reaction are due to nitrogen dioxide gas. The metallurgical processes used in the extraction of metals commonly involve decomposition reaction on heating as follows:

$$ZnCO_{3(s)} \xrightarrow{\triangle} ZnO_{(s)} + CO_{2(g)}$$

Zinc carbonate — Zinc Oxide — Carbondioxide

## 3. Displacement reaction

A displacement reaction involves the displacement of the atoms of one element by the atoms of other element in a compound.

***Activity:*** Take two test tubes each containing about 5ml of dilute solution of copper sulphate. Put an iron nail in one of the test tubes and observe the changes that occur. Compare it with the solution in second test tube. After some time, you would notice that iron nail becomes brownish in colour and blue colour of copper sulphate solution fades. Following chemical reaction takes place in this process:

$$Fe_{(s)} + CuSO_{4(aq)} \longrightarrow FeSO_{4(aq)} + Cu_{(s)}$$

In refining of silver, the recovery of silver from silver nitrate solution involves its displacement by copper metal.

$$Cu_{(s)} + 2AgNO_{3(aq)} \longrightarrow Cu(NO_3)_{2(aq)} + 2Ag_{(s)}$$

This reaction occurs as copper is more reactive than silver.

1) When few pieces of zinc is added to blue colored copper sulphate solution, copper is displaced. The blue colour fades and shiny coat of copper is seen on zinc pieces.

$$Zn + CuSO4 \longrightarrow ZnSO_4 + Cu$$

This is called as single displacement method.

2) When few pieces of zinc is added with any one of the dilute solutions of sulphuric acid, hydrochloric acid, acetic acid or phosphoric acid, hydrogen will be liberated. The gas evolved can be tested by burning splinter which burns with a bang.

$$Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2\uparrow$$

3) When a solution of sodium chloride is mixed with a solution of silver nitrate a curdy white precipitate of silver chloride is precipitated.

$$NaCl_{(aq)} + AgNO_{3(aq)} \longrightarrow \underset{\text{white precipitate}}{AgCl_{(s)}\downarrow} + NaNO_{3(aq)}$$

Here two compounds sodium chloride and sliver nitrate exchange ions to form two new compounds namely silver chloride and sodium nitrate. This type of reactions is called as double displacement reaction.

## 4. Oxidation and Reduction -Electronic Concept

Oxidation and reduction always occur at the same time in a chemical reaction. The term **oxidation refers to the loss of electrons** by one reactant and **reduction refers to the gain of electrons** by another.

***Example 1***

The reaction between sodium and chlorine involves a loss of electron by sodium (oxidation of sodium) and gain of electron by chlorine (reduction of chlorine).

$$Na \longrightarrow Na^+ + e^- \quad \text{(oxidation)}$$

$$Cl_2 + 2e^- \longrightarrow 2Cl^- \text{ (reduction)}$$

We say that sodium is oxidised and chlorine is reduced. Oxidation-reduction reaction is simply called as redox reaction.

The **electron accepting substance** is called the **oxidising agent** because it helps something else to be oxidized. The **substance that supplies electrons** is called as the **reducing agent** because it helps something else to be reduced.

Sodium is a reducing agent as it supplies electron to chlorine. In this process sodium is oxidized. Chlorine is an oxidizing agent as it accepts electron from sodium. Chlorine is reduced to chloride ion.

***Example 2***

Let us consider the reaction between heated copper and oxygen.

$$2Cu + O_2 \longrightarrow 2CuO$$

$$2Cu \longrightarrow 2Cu^{2+} + 4e^- \text{ (oxidation)}$$

$$O_2 + 4e^- \longrightarrow 2O^{2-} \quad \text{(reduction)}$$

***Example 3***

Conversion of ferric ion $Fe^{3+}$ to ferrous ion $Fe^{2+}$

$$Fe^{3+} + e^- \longrightarrow Fe^{2+} \text{ (reduction)}$$

When yellow iron (III) chloride solution is mixed with sodium sulphite solution, the solution changes to a pale green colour. The colour change is due to the reduction of the yellow iron (III) ion to green iron (II) ion.

**Self-Evaluation**

**Choose the Correct answer**

1. The valency of $SO_4^{2-}$ ion is

   a)1 b)2 c)3 d) 4

2. The molecular formula for aluminium sulphate is

   a)$AlSO_4$ b)$Al_2SO_4$

   c)$Al_2(SO_4)_3$ d) $Al_2(SO_4)_2$

3. The colour of the gas liberated when lead nitrate is heated.

   a)Red b)Brown

   c)Yellow d) Colourless

4. The gas liberated when zinc reacts with dilute $H_2SO_4$

   a)$SO_2$ b)$SO_3$ c)$H_2$ d) $O_2$

5. During the reduction of chlorine into chloride, number of electrons gained by chlorine is

   a)One b)Two c)Three d) Four

**Fill in the blanks**

6. Burning of sulphur in air forms _____.

7. The molecular formula for aluminium sulphate is _____.

8. $CaCO_3 \xrightarrow{\Delta} CaO +$ _____.

9. Hydrogen has great affinity to _____.

10. The electron accepting substance is called the _____agent.

**Answer briefly**

11. What is meant by valency?

12. Write the formula of

1) calcium chloride 2) magnesium oxide

3) calcium fluoride 4) Iron (II) bromide

5) silver oxide 6) copper (II) suphide.

**Balance the following equations**

13. $H_2+O_2 \longrightarrow H_2O$

14. $CaCO_3 \longrightarrow CaO+CO_2$

15. $H_2S_{(g)} + SO_{2\,(g)} \longrightarrow S_{(g)} + H_2O_{(l)}$

16. $BaCl_{2(aq)} + Al_2(SO_4)_{3(aq)} \longrightarrow AlCl_{3(aq)} + BaSO_4$

17. $Pb(NO_3)_{2\,(aq)} + Fe_2(SO_4)_{3(aq)} \longrightarrow Fe(NO_3)_{3(aq)}+PbSO_4$

**Classify the following reactions as combination, decomposition, displacement reactions**

18. $2KNO_{3(s)} \longrightarrow 2KNO_{2(s)}+O_{2(g)}$

19. $Zn_{(s)}+2AgNO_{3(aq)} \longrightarrow Zn(NO_3)_{2(aq)}+2Ag_{(s)}$

20. $Ni(NO_3)_{2(aq)}+2NaOH_{(aq)} \longrightarrow 2NaNO_{3(aq)} + Ni(OH)_{2(aq)}$

21. $Zn_{(s)} +2HCl_{(aq)} \longrightarrow ZnCl_{2(aq)} +H_{2(g)}$

22. $2CuO_{(s)} \longrightarrow 2Cu_{(s)}+O_{2(g)}$

23. $Cl_{2(g)} +2NaBr_{(aq)} \longrightarrow Br_2+2NaCl_{(aq)}$

24. $MgO_{(s)} + C_{(s)} \longrightarrow CO_{(g)}+Mg_{(s)}$

25. $2KClO_{3(s)} \longrightarrow 2KCl_{(s)}+3O_{2(g)}$

**Write balanced equation for the following reactions and identify the type of reaction**

26. Zinc carbonate$_{(s)}$ $\longrightarrow$ Zinc oxide$_{(s)}$ + Carbon dioxide$_{(g)}$

27. Magnesium$_{(s)}$ + Hydrochloric acid$_{(aq)}$ $\longrightarrow$ Magnesium chloride$_{(aq)}$ + Hydrogen$_{(g)}$

28. Potassium bromide$_{(aq)}$ + Barium iodide$_{(aq)}$ $\longrightarrow$ Potassium iodide$_{(aq)}$ + Barium bromide $_{(aq)}$

29. Hydrogen$_{(g)}$ + Chlorine$_{(g)}$ $\longrightarrow$ Hydrogen chloride$_{(g)}$

**Give one example each**

30. Double decomposition

31. Displacement

**Answer in detail**

32. Describe the electronic concept of oxidation and reduction.

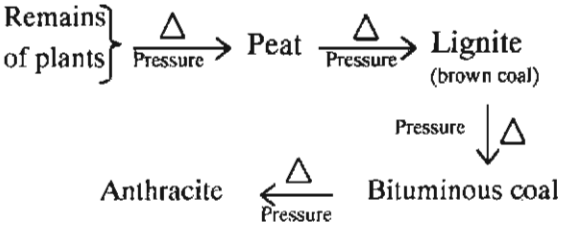
33. What is the difference between combination and decomposition reactions? Write equations for each type.

# 13. COAL AND PETROLEUM

## 13.1 Formation of Coal

Hydrocarbons occur naturally in fossil fuels, petroleum, coal and peat.

Coal occurs in nature in different forms. It is formed by the slow carbonisation of vegetable matter about 340 million years ago under high pressure and temperature in the absence of oxygen. Coal is a black rock like material and an essential input in thermal power plants, steel industry and metallurgical processes. Coal accounts for about 67 per cent of India's commercial requirement of energy. Petroleum is a dark coloured viscous liquid and is a complex mixture of compounds containing mainly carbon and hydrogen. Some of the common and useful products obtained from petroleum are petroleum gas, petrol, diesel, and kerosene. These are used as fuels, for example LPG (liquefied petroleum gas). Kerosene is used as domestic fuel for cooking and for lighting purposes. Petrol and diesel are used in automobiles and industries. Initially bacterial and chemical action on plant debris produce peat as an intermediate product. Peat was transformed into coal under high pressure and temperature under earth surface. Coal is the product of the following sequence of changes:




The conversion of plant material to coal by the above stages is due to progressive decomposition by heat and pressure in the absence of air.

**Table 13.1 Types of coal**

| *Type* | *Description* | *Heat* | *Sulphur content* |
|---|---|---|---|
| Peat (not a coal) | Partially decayed plant matter in bogs and swamps | Low | - |
| Lignite (brown coal) | Limited supplies in most areas | Low | Low |
| Bituminous coal (soft coal) | Heavily used because of high heat content and wide availability | High | High |
| Anthracite (hard coal) | Very desirable because of high heat content and low sulphur content, but limited supplies in most areas | High | Low |

**Table 13.2 Carbon content in coal**

| *Type of coal* | *Carbon* |
|---|---|
| Peat | 60% |
| Lignite | 70% |
| Bituminous coal | 78% |
| Anthracite | 90% |

### 1. Coal as natural source of carbon and its compounds.

Coal is an important source of hydrocarbon. When Bituminous coal is heated in the absence of air (carbonisation) coal tar is obtained as distillate and coke as residue. The coal tar is subjected to

fractional distillation. The various fractions obtained in this process are given below.

**Table 13.3 Fractional distillation of coal tar**

| *Fraction* | *Boiling point range/°C* | *Major components* |
|---|---|---|
| Light oil | 80-170 | Benzene, methylbenzene |
| Middle oil (carbolic) | 170-230 | Phenol, naphthalene |
| Heavy oil (creosote) | 230-270 | Phenol, naphthalene, anthracene |
| Green oil | 270-400 | Anthracene |
| Residue | Over 400 | Pitch |

## 2. Petroleum as the Natural Source of Carbon and its Compounds.

The term 'petroleum' which means 'oil of rock' includes both crude oil and natural gases containing hydrocarbon.

**Petroleum is a complex mixture containing various hydrocarbons** (compounds of carbon and hydrogen) in addition to small amounts of other organic compounds contaning oxygen, nitrogen and sulphur.

Petroleum was formed some 100 to 200 million years ago from microscopic marine plants and animals that became incorporated in the sediments and rocks formed at the bottom of the sea under high temperature and pressure in the absence of oxygen.

Crude petroleum oil is a liquid, varying in colour from dark brown or green. It contains large number of alkanes. It also contains about 10% aromatic hydrocarbons.

### Refining of crude petroleum

The process of separating petroleum into fraction with different boiling ranges and removing impurities is known as **refining**.

The distillation of petroleum is carried out in a tubular furnace with a tall steel fractionating column. The crude oil is pumped into the fractionating column and heated. The vapours raise up the column and condense at various heights at different temperatures. The highest boiling fraction condenses at the bottom and the lowest fraction condenses at the top. The different fraction are withdrawn from the outlets provided at suitable heights of the column.

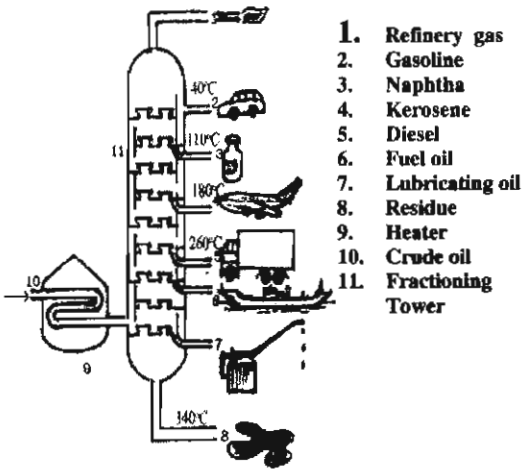



*Fig. 13.1 Fractional distillation of crude oil in a refinery*

The fraction obtained at different boiling ranges are given in the table.

**Table 13.4 Fractional distillation of crude oil**

| *Fraction* | *Boiling range/°C* | *Uses* |
|---|---|---|
| Hydro carbon gases | Below 40 | Fuel: bottled gas |
| Gasoline | 50-175 | Petrol |
| Naphtha | 110 | Chemicals |
| Kerosene (paraffin oil or naphtha) | 175-250 | Fuel: 'Cracked' to form petrol |
| Gas oil or diesel oil | 250-350 | Boiler fuel: diesel fuel |
| Heavy oil | 350-400 | Lubricating oil, fuel oil for furnace Vaseline, paraffin wax. |
| Bitumen | Residue | Road surfaces; roofing material |

## 13.2 Carbon-Tetravalency

An atom of carbon has four electrons in its outermost shell. Its electronic configuration is $1s^2\ 2s^2\ 2p^2$. Carbon requires 4 more electrons to achieve stable configuration. Since it shares four electrons, its valency is four and tetra valent

## 1. Hydrocarbons

The simplest organic compounds, made up of only carbon and hydrogen are known as **hydrocarbons.** In these compounds carbon is tetravalent and hydrogen univalent.

### 1) Classification of Hydrocarbons

The organic compounds are classified into two main types namely (I) open chain or aliphatic compounds and (2) cyclic compounds. In this section we are concerned with aliphatic hydrocarbons only. They are classified into two groups depending on the types of carbon-carbon bonds.

Those in which all the four valences of carbon atoms are satisfied by four atoms or groups through single bond are known as **saturated hydrocarbons** because they cannot take up any more atoms or groups.

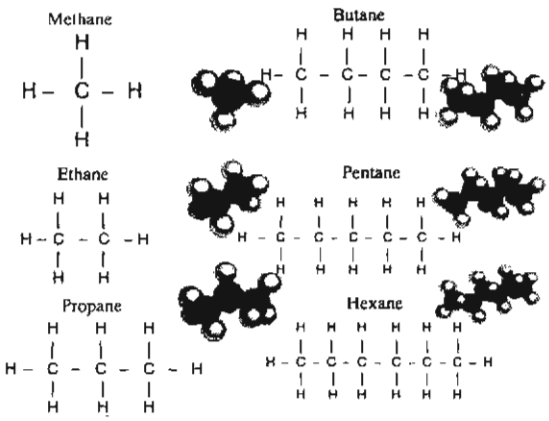



*Fig. 13.2 Structures of first six alkanes*

The compounds in which carbon atoms are linked together by multiple bonds (atleast one double or triple bond) are known as **unsaturated hydrocarbons.**

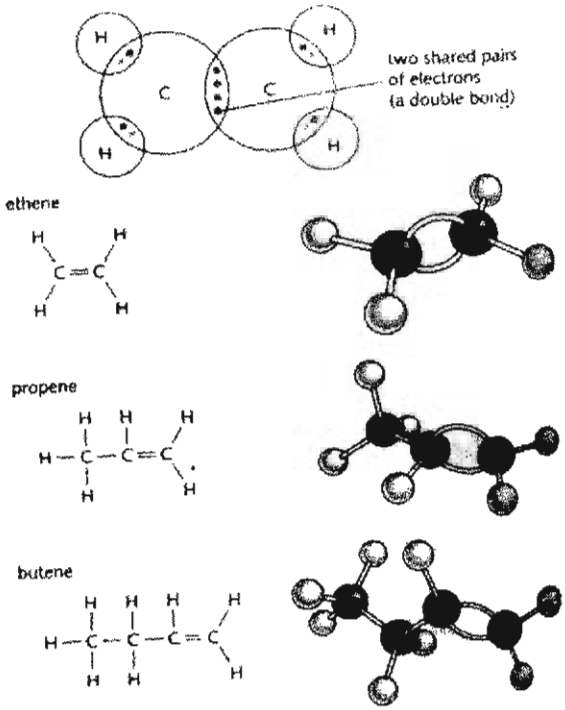



***Fig. 13.3 Structures of first three alkenes and bonding in ethene.***

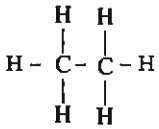
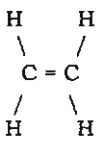
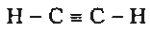
The saturated hydrocarbons are represented by the formula $C_nH_{2n+2}$ (where n=1,2,3,4...etc) The first member methane has the formula $CH_4$ and the second member ethane has the formula $C_2H_6$. They are comparatively stable because of their saturated nature and therefore they are also known as paraffins, (Latin, parum=little, affinis=affinity)

The unsaturated hydrocarbons, alkenes are represented by the general formula $C_nH_{2n}$ and are known as olefins. The simplest olefin has the formula $C_2H_4$ and commonly known as ethylene. Alkenes contain one or more double bonds between carbon atoms. When two atoms form two covalent bonds with each other implying the sharing of two pairs of electrons, they are considered to be joined by a double bond.

Alkynes are another class of unsaturated hydrocarbons having the general formula $C_nH_{2n-2}$. They have

carbon-carbon triple bond as their characteristic and distinguishing feature. The first member of the alkyne series has the formula $C_2H_2$ and is known as acetylene. The alkynes are therefore also known by the general name Acetylenes. The triple bond implies the sharing of three pairs of electrons between two carbon atoms.

**Classification of aliphatic hydro carbons**

| | General formula | Traditional name | Example |
|---|---|---|---|
| I.Alkanes | $C_nH_{2n+2}$ | Paraffins |  |
| ii.Alkenes | $C_nH_{2n}$ | Olefins |  |
| iii.Alkynes | $C_nH_{2n-2}$ | acetylenes |  |

A group of organic compounds having similar structure and chemical properties is known as **Homologous Series**. Successive members in a series differ by a '**$-CH_2$**' group. All the members of a homologous series can be prepared by similar method. The members of a homologous series show a gradual change in their physical properties with increase in molecular mass. For example, in alkanes, as the molecular mass increases the melting and boiling point increases.

**2) Homologous series of alkanes**

**General formula - $C_nH_{2n+2}$** where n is the number of carbon atoms in one molecule of alkane

**Table 13.5**

| Alkane | Molecular formula | Physical state |
|---|---|---|
| 1.Methane | $CH_4$ | gas |
| 2. Ethane | $C_2H_6$ | gas |
| 3. Propane | $C_3H_8$ | gas |
| 4. Butane | $C_4H_{10}$ | gas |
| 5. Pentane | $C_5H_{12}$ | liquid |
| 6. Hexane | $C_6H_{14}$ | liquid |

**3) Homologous series of alkenes**

**General formula $C_nH_{2n}$**

**Table 13.6**

| Alkene | Molecular formula |
|---|---|
| 1. Methene | Not existing |
| 2. Ethene | $C_2H_4$ |
| 3. Propene | $C_3H_6$ |
| 4. Butene | $C_4H_8$ |
| 5. Pentene | $C_5H_{10}$ |
| 6. Hexene | $C_6H_{12}$ |

**4) Homologous series of alkynes**

**General formula $C_nH_{2n-2}$**

**Table 13.7**

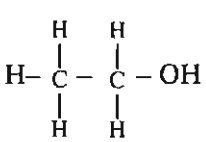
| Alkyne | Molecular formula | Structural formula |
|---|---|---|
| 1. Ethyne | $C_2H_2$ | H-C≡C-H |
| 2. 1-propyne | $C_3H_4$ | $CH_3$-C≡CH |
| 3. 1-Butyne | $C_4H_6$ | $CH_3$-$CH_2$-C≡CH |
| 4. 2-Butyne | $C_4H_6$ | $CH_3$-C≡C-$CH_3$ |

**2. Isomerism**

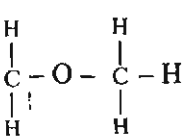
Isomerism is one of the major reasons for the existence of so many organic compounds. Isomerism is the existence of two or more compounds with the same molecular formula but different structural formula.

Examples :

Ethanol — $C_2H_5OH$



Dimethyl ether — $C_2H_6O$



There are two types of isomerism namely structural and stereo isomerism.

**Structural isomerism**

- Two or more compounds are said to exhibit structural isomerism when they possess same molecular formula but different structural formulae

Structural isomerism is classified as

1) Chain isomerism
2) Position isomerism
3) Functional isomerism

**1) Chain Isomerism**

Compounds having the same molecular formula but different carbon skeletons are said to exhibit chain isomerism.

**Example**

$CH_3$-$CH_2$-$CH_2$-$CH_3$ and $CH_3$-CH($CH_3$)-$CH_3$

n - butane

isobutane

Both the isomers have the same molecular formula $C_4H_{10}$ but they differ in the physical and chemical properties.

**2) Position isomerism**

Position isomers are compounds having same molecular formula, carbon skeleton and functional groups, but the functional group located at different position along the carbon skeleton.

**Example**

3 2 1 3 2 1

$CH_3$-$CH_2$-$CH_2$-OH and $CH_3$-CH(OH)-$CH_3$

1- Propanol

2 - Propanol

**3) Functional Isomerism**

Functional isomers are compounds having same molecular formula but different functional groups.

**Example**

$CH_3$-$CH_2$-OH and $CH_3$-O-$CH_3$

Ethanol Dimethylether.

## 13.3 Methane

Molecular formula : $CH_4$

Molecular weight : 16

Structure of methane molecule

Methane has tetra-hedral structure with the carbon atom at the centre and four hydrogen atoms at the four corners of the tetrahedron. The angle H-C-H is 109° 28′ The structure is given below.

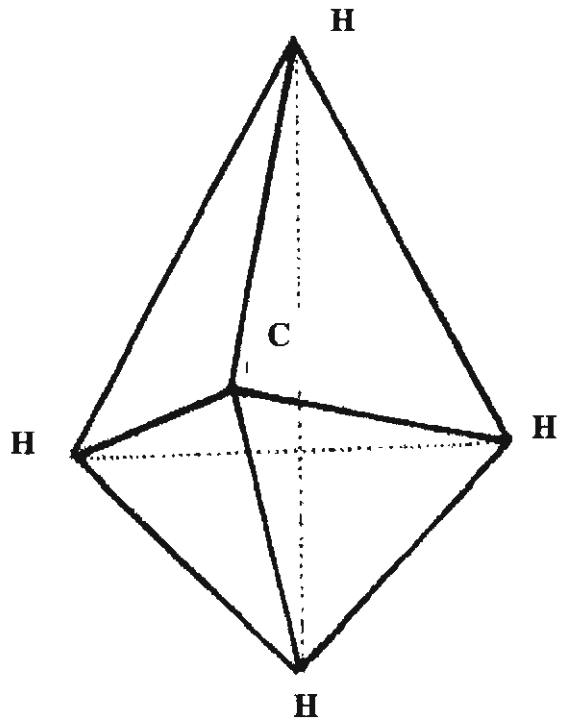



*Fig. 13.4 Structure of Methane*

**Sources of methane**

Methane is produced naturally by the decomposition of organic matter in the absence of air. Methane occurs as firedamp in coal mines, as marsh gas in marshy places and as main constituent of natural gas. It is formed during the putrefaction of sewage and during the decomposition of cellulose in our intestines.

## 1. Preparation

### Laboratory preparation of methane

Methane is prepared in the laboratory by heating the mixture of anhydrous sodium acetate and soda lime (a mixture of sodium hydroxide and calcium oxide) taken in hard glass boiling tube as shown in the figure.

Methane is collected over water by the downward displacement of water.

$$\underset{\text{Sodium acetate}}{CH_3COONa} + NaOH \xrightarrow[\Delta]{CaO} \underset{\text{Methane}}{CH_4} + \underset{\substack{\text{Sodium}\\\text{Carbonate}}}{Na_2CO_3}$$

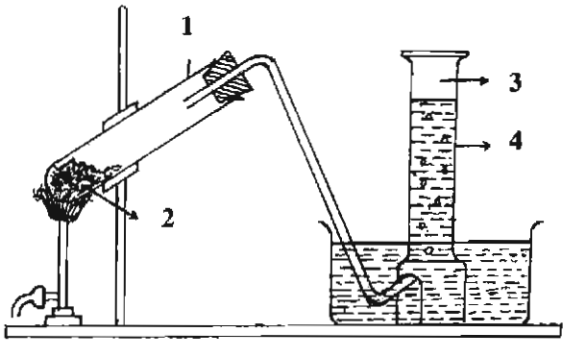



*Fig.13.5 Laboratory preparation of methane*

1. hard glass tube
2. Sodium acetate + soda lime
3. Methane gas 4. Inverted gas jar

## 2. Properties : Physical Properties

Methane is a colourless, odourless gas. It is insoluble in water and soluble in organic solvents like ether and alcohol. It is combustible but not a supporter of combustion. Since methane contains single covalent bond, it is saturated and hence less reactive.

### Chemical Properties

**1) Combustion:** It burns in air with a blue flame forming carbondioxide and water accompanying large amount of heat.

$$CH_4 + 2O_2 \longrightarrow CO_2\uparrow + 2H_2O + \text{Heat}$$

Hence it is used as **gaseous fuel.**

**2) Pyrolysis:** When heated strongly above 1000°C in the absence of air, methane gets decomposed into carbon and hydrogen. The carbon formed is in the form of fine powder and it is used in making rubber tyres and hydrogen is used as fuel.

$$CH_4 \xrightarrow{\text{High temperature}} C + 2H_2\uparrow$$

**3) With Steam:** Methane reacts with steam in presence of heated aluminium oxide, liberating hydrogen gas. This hydrogen gas is used in the synthesis of ammonia gas by Haber process

$$CH_4 + H_2O \xrightarrow[750°C]{Al_2O_3} \underset{\text{Carbon monoxide}}{CO\uparrow} + 3H_2\uparrow$$

### 4) With Chlorine

(1) In bright sunlight, methane reacts with chlorine to give carbon and hydrogen chloride.

$$CH_4 + 2Cl_2 \longrightarrow C + 4HCl$$

(2) **In the presence of diffused sunlight :** Substitution reaction takes place. In this reaction, an atom of chlorine is substituted for a hydrogen atom in the methane molecule.

$$CH_{4(g)} + Cl_{2\,(g)} \longrightarrow \underset{\text{Chloro methane}}{CH_3Cl_{(l)}} + HCl_{(g)}$$

By adding additional molecules of chlorine it is possible to replace all the hydrogen atoms

$$CH_3Cl + Cl_2 \longrightarrow \underset{\text{Dichloro methane}}{CH_2Cl_2} + HCl$$

$$CH_2Cl_2 + Cl_2 \longrightarrow \underset{\text{(Chloroform)}}{CHCl_3} + HCl$$

$$CHCl_3 + Cl_2 \longrightarrow \underset{\substack{\text{Tetrachloro methane}\\\text{(carbontetra chloride)}}}{CCl_4} + HCl$$

## 3. Uses

Methane is used (i) as a fuel,(ii) in the synthesis of ammonia by Haber Process and (iii)in the preparation of carbon black used in printing inks, and filler in rubber industry.

## 13.4 Ethene (Ethylene)

Molecular formula : $C_2H_4$ or $CH_2 = CH_2$
Molecular weight : 28

Ethene belongs to unsaturated Hydro Carbon, Each member of this group contains a **C=C** double bond.

The common name for ethene is ethylene.
The structure of ethene is $CH_2=CH_2$

### Manufacture

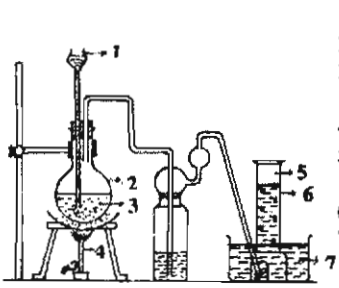
Commercially the alkenes are obtained by the catalytic cracking of long chain alkanes. The breaking down of a bigger alkane molecule into smaller hydrocarbon molecule by the action of heat is known as **cracking.**

### 1. Preparation

**Laboratory preparation of Ethene (Ethylene)**

Ethene can be prepared by heating ethanol with twice its volume of concentrated sulphuric acid at 180°C

$$CH_3\text{-}CH_2\text{-}OH \xrightarrow[180°C]{\text{Con. } H_2SO_4} CH_2=CH_2+H_2O$$




1.Thistle funnel
2.Flask
3.Ethanol+ Con. Sulphuric acid
4.Burner
5.Ethene gas (Ethylene gas)
6.Inverted gas jar
7. Water

*Fig. 13.6 Laboratory preparation of Ethene*

**The gas evolved is passed through sodium hydroxide to remove carbondioxide and sulphurdioxide.** The gas is collected over water by the downward displacement of water.

### 2. Properties of Ethene

**Physical properties**

Ethene is a colourless gas with sweet odour at room temperature. It is insoluble in water and soluble in alcohol and ether. It is combustible and not a supporter of combustion.

**Chemical Properties**

**1) Combustion**

Ethene burns in air with sooty flame, forming carbondioxide and water. The sooty flame is due to higher percentage of carbon in ethene than that of corresponding alkane, ethane.

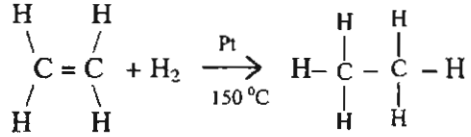
$$C_2H_4+3O_2 \longrightarrow 2CO_2+2H_2O$$

**2) Reactivity**

The alkenes are generally more reactive than alkanes. This is due to the existence of double bonds in their structure. During addition process, the double bond changes to a single bond. **Addition reactions** are the special features of **unsaturated compounds**

**Addition of hydrogen**

When ethene is mixed with hydrogen and passed over a platinum catalyst at about 150°c, addition of hydrogen occurs at the double bond and the corresponding alkane is formed.



The addition of hydrogen to a double bond or triple bond is known as **hydrogenation.** This property is made use of in the preparation of **vanaspati** ghee which is a solid state of vegetable oil.

### 3) Addition of chlorine

One molecule of chlorine is added to the double bond of ethene to form 1,2 dichloro ethane.

$$CH_2=CH_2+Cl_2 \longrightarrow \underset{\text{1,2 - dichloro ethane}}{CH_2(Cl)-CH_2(Cl)}$$

Addition of chlorine to the double bond is known as chlorination reaction.

### 4) Addition of bromine

Ethene decolourises bromine water with the formation of 1,2-dibromoethane.

$$CH_2=CH_2+Br_2 \longrightarrow \underset{\text{1,2-dibromoethane}}{Br\text{-}CH_2\text{-}CH_2\text{-}Br}$$

This reaction is used as a **test for the presence of an unsaturated hydrocarbon.**

### 5) Polymerisation

The union of two or more molecules of a substance to form a large single molecule is called polymerisation and the product formed is called a polymer.

Ethene polymerises to form polyethene or polythene at 200°C under pressure.

$$\underset{\text{Ethane}}{n(CH_2=CH_2)} \xrightarrow[200\text{ atm}]{200^{\circ}C} \underset{\text{Polythene}}{(-CH_2-CH_2-)n}$$

This is a reaction **of great industrial importance**, as it is the whole foundation of plastic industry, Uses: detergent bottles, water storage tank etc.,

### 3. Uses of Ethene or Ethylene

(i) Ethylene is used for ripening of fruits.

(ii) It is used in the preparation of polythene, polypropylene, PVC (Poly Vinyl Chloride)

(iii) Ethylene dichloride which is prepared from ethylene is used in the preparation of a synthetic rubber called **Thiokol**

(iv) It is used in the preparation of glycol.

## 13.5 Ethyne or Acetylene

Molecular formula : $C_2H_2$

Molecular weight : 26

Structure : H-C≡C-H

Ethyne is the first member of the alkyne series in which two of the carbon atoms are joined together by a triple covalent bond. Out of these triple bonds, **two** are weak **π bonds** which can easily be broken to form addition compounds. Since it has three bonds, ethyne is more reactive then corresponding ethene which has only two bonds.

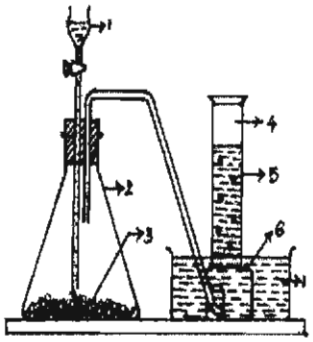
### 1. Preparation

### Laboratory Preparation of ethyne

Ethyne is prepared by the action of water on calcium carbide in cold condition.

$$\underset{\text{Calcium carbide}}{CaC_2}+2H_2O \longrightarrow \underset{\text{acetylene}}{C_2H_2} + Ca(OH)_2$$

The apparatus used is shown in Figure




1. water
2. conical flask
3. calcium carbide
4. ethyne
5. inverted gas jar
6. beehive shelf

*Fig. 13.7 Laboratory preparation of Ethyne*

A few pieces of calcium carbide is taken in a conical flask and water is dropped by a dropping funnel. Water reacts with calcium carbide to produce acetylene. The gas is collected in the gas jar by the downward displacement of water since acetylene is insoluble in water.

## 2. Properties

### Physical Properties

Ethyne is a colourless gas with sweet odour. Ethyne is insoluble in water, but soluble in organic solvents such as acetone, alcohol and ether.

### Chemical Properties

### 1) Combustion

Ethyne burns in air with sooty flame to form carbon dioxide and water. The sooty flame is due to the high percentage of carbon in the molecule.

$$2C_2H_2 + 5O_2 \longrightarrow 4CO_2 + 2H_2O$$

If it is used in a special burner with extra oxygen supplied, ethyne burns brilliantly giving very hot **oxy-acetylene flame** which is used for **welding and cutting of metals.**

### 2) with hydrogen

The reaction proceeds in two stages. Initially one molecule of Hydrogen adds to form an alkenes. Then, second molecule adds to form alkane. Nickel is used as catalyst

$$\underset{\text{Ethyne}}{CH \equiv CH} \xrightarrow[Ni]{H_2} \underset{\text{ethene}}{CH_2 = CH_2} \xrightarrow[Ni]{H_2} \underset{\text{ethane}}{CH_3 - CH_3}$$

### 3) with chlorine

In this reaction, two molecules are added in two stages

$$\underset{\text{Ethyne}}{CH \equiv CH} + Cl_2 \longrightarrow \underset{\text{(Acetylene dichloride)}}{CHCl = CHCl} \longrightarrow \underset{\text{(Acetylene tetrachloride)}}{CHCl_2 - CHCl_2}$$

### 4) with bromine

Acetylene decolourises bromine water and acetylene dibromide is formed . On further addition of bromine, acetylene tetra bromide is formed.

$$\underset{\text{Ethyne}}{CH \equiv CH} + Br_2 \longrightarrow \underset{\text{Acetylene dibromide}}{CHBr = CHBr} \longrightarrow \underset{\text{Acetylene tetrabromide}}{CHBr_2 - CHBr_2}$$

### 5) Polymerisation

When acetylene is passed through red hot tube, it polymerises to give benzene. Three molecules of acetylene form a cyclic compound called **benzene.**

$$3\ CH \equiv CH \xrightarrow[\text{red hot}]{\Delta} C_6H_6$$

## 3. Uses

1) Acetylene is used in **Oxy-acetylene torch** used for welding metals.

2) Acetylene is used as a starting material for the manufacture of PVC, polyvinyl acetate and synthetic rubber.

3) Acetylene is used as a starting material for manufacture of industrially important compounds like acetaldehyde, acetic acid, acetone, benzene and ethanol

**Self Evaluation**

### Answer briefly

1. How is coal formed?
2. What are the different types of coal?
3. Carbon is tetravalent - Explain
4. Define chain isomerism.
5. What are hydrocarbons?
6. What is Homologous series?
7. Give the general formula of (i) alkanes (ii) alkenes (iii) alkynes
8. Write the molecular formula of first four members of alkanes.
9. Define isomerism
10. Illustrate functional isomerism with an example
11. Draw the structure of methane
12. What are the sources of methane?
13. What is known as 'cracking'?
14. What is polymerization?
15. State the uses of acetylene.

### Answer in detail

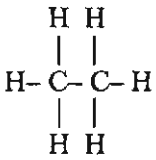
16. Briefly explain the classification of coal.
17. With a neat labeled diagram explain the fractional distillation of crude oil.
18. Explain the different types of isomerism with an example for each.
19. Give a brief account on the laboratory preparation of methane with a neat sketch.

20. How is acetylene prepared in the laboratory?
21. How does methane undergo substitution reaction?
22. What is addition reaction and what type of molecule undergoes addition reaction? Give five examples.
23. How does methane react with
(i) oxygen (ii) heating
(iii) steam (iv) chlorine
24. Starting from ethylene how would you obtain the following:
(i) ethane (ii) acetylene tetrachloride
(iii) acetylene tetra bromide (iv) benzene

## Problems

**25. A to H are the structural formulae of some organic compounds**

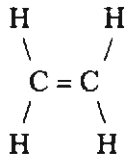
**A**



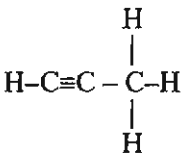
**B**



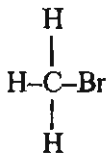
**C**



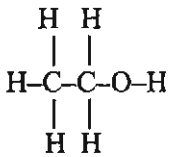
**D**



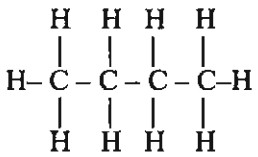
**E**



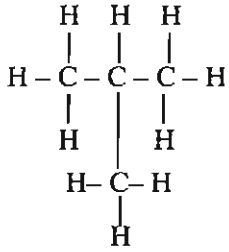
**F**



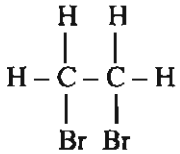
**G**



**H**



**I**



(a) Give the letters which represent i) two alkanes and ii) two compounds which are not hydrocarbons.
iii)B and D are members of a homologous series. Give a reason why this statement is correct.
iv) How could C be converted into A?

**(b)** Bromine is used to produce dibromo ethane which is used as an additive in petrol. It is made by adding bromine to ethene.

i)What is the molecular formula of ethene?
ii) What is the fomula of a bromine molecule?
iii)What is the molecular formula of dibromoethane?

iv) complete the following equation by drawing the structure of molecules:

ethene + bromine → 1,2- dibromoethane

**26.** (a) Coal gas mainly consists of the fourth member of the alkanes called butane. Methane ($CH_4$) is the first member of the alkanes and butane is the fourth member.

(i) Give the formula of the third member of the alkanes.

(ii) Draw the structural formula of butane, and of an isomer of butane.

(b) When butane is burned the following reaction takes place:

$$2C_4H_{10} + 13O_2 \longrightarrow 8CO_2 + 10H_2O$$

How many moles of butane have to be burnt to produce 4 moles of carbon dioxide?

(i) Calculate the mass of one mole of carbon dioxide
(ii)How many grams of carbon dioxide would be produced if 5.8g of butane were burnt?

# BIOLOGY

# 14. LIVING SYSTEMS - LEVELS OF ORGANISATION

The Earth's surface exhibits different zones based on physical and chemical factors. Yet, the living organisms survive under all environmental conditions. The living organisms have different adaptive structural features suited to their habitat. These adaptations are the important reasons for the occurrence of different levels of organisation both in plants and animals. Furthermore, there are structural differences among the simple and complex organisms which arose due to evolutionary development. These structural diversities are clearly evident in morphology, anatomy and physiology of both unicellular and multicellular organisms.

## 14.1 UNICELLULAR LEVEL CHLAMYDOMONAS

Ponds and lakes become greenish, within a few days after the rain. The primary reason for this is the multiplication of reproductive cells of **algae** which have abundant chlorophyll. They have thalloid plantbody and belong to the division **Thallophyta**.

The plant body which is not differentiated into root, stem and leaves is known as **thallus**. The most important form which provides green turbidity to ponds and lakes is an unicellular green alga namely **Chlamydomonas**. Though unicellular, Chlamydomonas is able to carry out all functions as in multicellular organisms.This is significant in the level of organization of living systems.

Chlamydomonas is a greek word which means single organism with a thick mantle.

**SYSTEMATIC POSITION**

*CLASS* : CHLOROPHYCEAE

*ORDER* : VOLVOCALES

*FAMILY* : CHLAMYDOMONADACEAE

*GENUS* : CHLAMYDOMONAS

**HABITAT:- Chlamydomonas** is a motile, fresh water alga. It prefers water rich in nitrogenous matter.

In India, the genus includes 18 species.

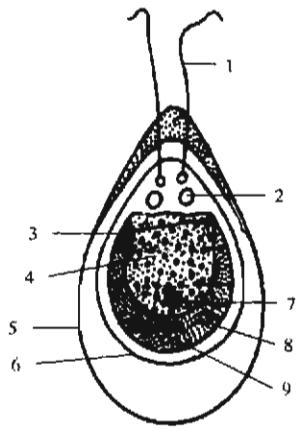



***Fig.14.1.1 Chlamydomonas - Cell Structure***

1. flagella
2. contractile vacuole
3. eyespot
4. cytoplasm
5. cell wall
6. plasma membrane
7. nucleus
8. chloroplast
9. pyrenoid

**Structure of the cell:** (Fig 14.1.1) Chlamydomonas is an unicellular, biflagellate alga. The cell is spherical or ellipsoidal. It is about 30μm in length and 20μm in diameter (1μm = $10^{-6}$mm). The anterior end of the cell is papillate and the posterior part is usually broader. **Cell wall** is made up of cellulose. Inner to cell wall is a thin selectively permeable **plasma membrane**. There is a massive cup-shaped parietal **chloroplast** at the broader part. Many pigments including chlorophyll is found in it. The chloroplast has a single **pyrenoid** which functions as the centre of starch synthesis. Starch is stored as granules around the pyrenoid.

The **nucleus** lies in the centre of the cytoplasm. Two **flagella** are found in the anterior part of the cell which are locomotory organs. Chlamydomonas swims with the help of these flagella. The **eyespot** or **stigma** lies in the anterior part of the cell. It is the photoreceptive organ and helps in the direction of cell movement.

**Acitivity:** Collect and observe some aquatic algae through the microscope.

**REPRODUCTION**: Chlamydomonas reproduces by asexual and sexual methods.

**1. Asexual reproduction:**

Asexual reproduction takes place mainly by zoospores, aplanspores, hypnospores and palmella stage.

1. **Zoospores (Fig. 14.1.2) :** These are formed under favourable conditions usually during night in the presence of abundant water. At the time of their formation, the parent cell divides several times to produce small daughter cells. They resemble the parent cell in structure and shape and are motile. These are called **zoospores**. They are released on the rupture of the parent wall. Each zoospore increases in size and forms a new Chlamydomonas cell which is capable of producing new zoospores after 24 hrs. Thus a single cell may produce as many as 200,000 daughter cells within a week.

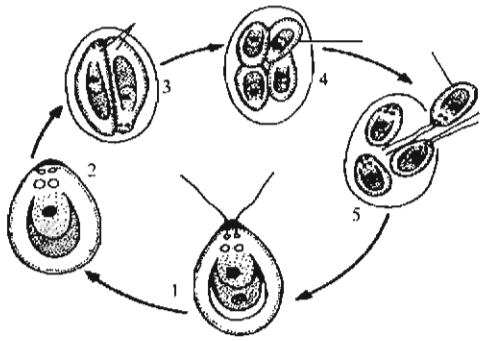



*Fig.14.1.2 Chlamydomonas - Asexual reproduction-formation of zoospores*

1. thallus 2. resting stage 3. division of protoplast
4. formation of zoospores 5. release of zoospores

**2. Aplanospores** : Under conditions of drought, the cells withdraw their flagella and their protoplasts divide into 2-16 daughter protoplasts. Each protoplast secretes a thin wall but does not develop flagella. These non-molite cells are called **aplanospores.**

In some species, aplanospores secrete a thick wall under severe drought. These thickwalled nonmotile spores are called **hypnospores.**

**3. Palmella stage (Fig 14.1.3)** : Under unfavourable conditions, the parent cell wall dissolves and produces a gelatinous substance. The nonmotile daughter protoplasts are found embedded within this matrix. This temporary colony of numerous

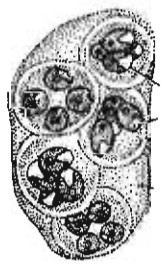



*Fig.14.1.3 Palmella stage*

cells in a common gelatinous matrix is called **palmella stage**.

### 2. Sexual Reproduction (Fig 14.1.4)

Sexual reproduction in Chlamydomonas takes place through **isogamy** due to the deficiency of nutritious compounds in its habitat.

**Isogamy:** In this method, sexual process starts with the division of the cell protoplast into 8 to 64 biflagellate gametes. The gametes are similar in structure and function. So, these are called **isogametes**. The isogametes fuse in pairs to form **zygotes**.

**Zygotes:** The wall at the point of fusion between the two gametes soon dissolves producing a quadriflagellate Zygote. At this time, the flagella disappear. It secretes a primary zygote wall. At this stage, the zygote has two nuclei which undergo fusion. It accumulates large amounts of oils and starch. The zygote enlarges in size before germination.

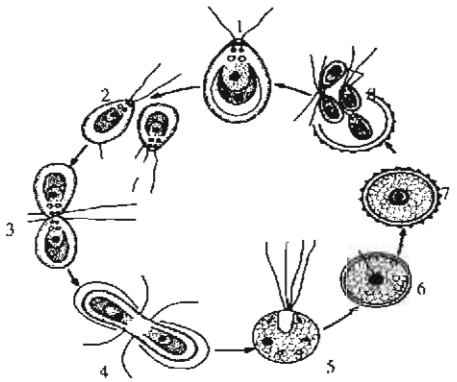
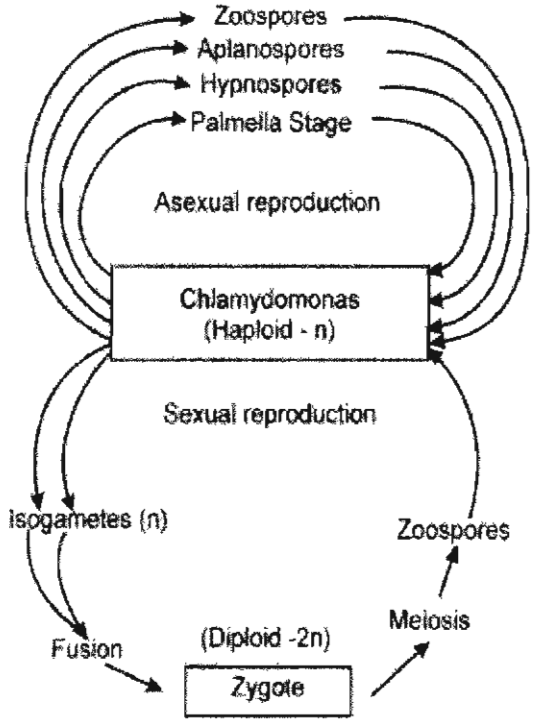



***Fig.14.1.4. Chlamydomonas - sexual reproduction - Isogamy***

1. thallus 2. isogametes 3. fusion of isogametes
4. fusion at anterior end 5. quadriflagellate zygote
6,7. zygote 8. germination of zygote

**Germination of Zygote:** The zygote germinates during dark in the water. The diploid nucleus within the zygote undergoes meiosis producing four haploid nuclei. Each haploid nucleus with some protoplast forms a biflagellate zoospore. Thus, four zoospores are formed in each zygote. The inner wall is dissolved and the zoospores are liberated when the outer thick wall splits open. Each zoospore develops into a new Chlamydomonas cell.




***Chlamydomonas - Diagramatic representation of Life - Cycle.***

### Alternation of Generations:

The haploid phase is dominant in the life cycle of Chlamydomonas. The vegetative cell is haploid and produces haploid gametes. The gametes fuse to produce diploid zygote. The diploid nucleus of the zygote divides meiotically before it germinates. Thus the diploid phase occurs for a short duration.

### Biological importance of Chlamydomonas

1. It is an important biological model for genetics research.
2. It is also called green-yeast.
3. It is the source of $H_2$ - 'fuel gas'

**Some basic concepts**

1. Chlamydomonas is a freshwater, unicellular alga.
2. A cupshaped chloroplast, flagella, stigma or eyespot are some important features of this alga.
3. Two whiplash flagella are locomotory organs.
4. Asexual reproduction takes place through zoospores, aplanospores, hypnospores and palmella stage.
5. In Chlamydomonas, sexual reproduction takes place through Isogamy.
6. In the lifecycle of Chlamydomonas, haploid phase is prominent.
7. Chlamydomonas is a biologically important alga.

**Self - Evaluation**

**Choose the Correct Answer**

1. Which of the following is the photoreceptive organ in Chlamydomonas:
   a) Pyrenoid b) Stigma
   c) Chloroplast d) Flagella
2. Find out the motile spores from the following:
   a) aplanospore b) hypnospores
   c) zygote d) zoospores
3. Pick out the wrong pair:
   a) Chloroplast - pyriform
   b) Pyrenoid - protein core
   c) Flagella - whiplash
   d) Isogametes - motile

**State true or false**

4. Nucleus in Chlamydomonas lies in the anterior part of the cell.
5. Zoospores are also involved in sexual reproduction.
6. Hypnospores are nonmotile, asexual and thinwalled spores.

**Fill in the blanks**

7. Chlamydomonas is included under the class _____.
8. The chloroplast has a single _____.
9. _____ stage refers to the formation of many cells in a gelatinous matrix.

**Answer briefly**

10. Draw a labelled diagram of Chlamydomonas cell.
11. What is the function of eyespot?
12. Differentiate between aplanospore and hypnospore.

**Answer in detail**

13. Explain the structure of Chlamydomonas cell.
14. Describe the asexual reproduction by Zoospores.
15. Give an account of the lifecycle of Chlamydomonas.

## 14.2 EUGLENA

The animal kingdom is classified into two subkingdoms, namely **Protozoa** and **Metazoa**. While the subkingdom Protozoa includes all unicellular animals the subkingdom Metazoa includes multicellular animals. Among animals nearly 50,000 species are single celled forms. They are grouped under **Phylum: Protozoa**. The protozoans show a wide range of forms and modes of living. This diversity has always attracted the attention of biologists.

**Phylum : Protozoa**

The protozoans are cosmopolitan in distribution. Majority of them are free living and aquatic (solitary or colonical). Others are parasitic and many cause diseases (Ex: Dysentry). Nutrition among free living forms may be, **holozoic, holophytic or saprozoic.**

**Size and shape**

All protozoans are microscopic and their size is measured in microns (1/1000mm). They may be regular or irregular in shape.

The regular forms may be circular, oval, spherical or spindle shaped.

Some protozoans show characters of both the plants and animals. Euglena is a classical example for such nature. Over 150 species of Euglena are known at present.

**Euglena viridis**

**Systematic Position**

1. ***Phylum*** : Protozoa
2. ***Class*** : Mastigophora
3. ***Order*** : Euglenoidina
4. ***Family*** : Euglenidae
5. ***Genus*** : *Euglena*
6. ***Species*** : *viridis*

Euglena is a common uniflagellate, chlorophyll bearing form. It is a microscopic, solitary and free living organism. It is commonly found in stagnant freshwater pools, ponds, ditches and slow running streams.

**1. Shape**: The body is elongate and spindle shaped. The anterior end is blunt or rounded, The middle part of the body is wider, while the posterior end is pointed.

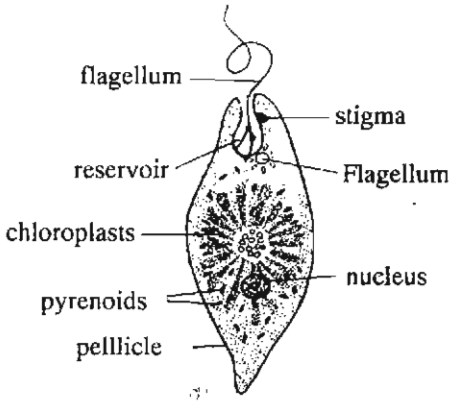



*Fig 14.2.1. Euglena viridis*

**2. Size:** The size varies from 50 microns to 150 microns in length and 15 microns in breadth.

**3. Structure:** The regular shape of Euglena is due to outer covering called, the **pellicle**. Inside the pellicle, the cytoplasm is differentiated into ectoplasm and endoplasm.

The blunt end bears a depression, called the **cytopharynx** (gullet). From the base of the cytopharynx arises a long whip like **flagellum**. The cytopharynx is enlarged at the bottom into a spherical base known as the **reservoir**, close to the cytopharynx on one side is a red spot known as the **stigma** or eye spot It is sensitive to light.

The nucleus is found in the centre of the body. The protoplasm contains the **chloroplasts**, the **paramylum bodies** and **pyrenoids**. Chloroplasts contain **chlorophyll** for photosynthesis. Paramylum bodies contain stored up starch. Pyrenoids are protein bodies responsible for the production of starch.

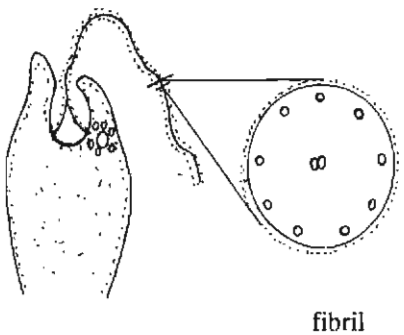



*Fig 14.2.2 Flagellum - ultra structure (C.S)*

The flagellum is contractile in nature. It helps in locomotion by setting up currents in water. It consists of a bundle of eleven **fibrils** enclosed in a sheath. All the fibrils are fused at the base and connected with a **basal granule**.

**Locomotion**

Euglena performs two different kinds of movements namely Flagellar and Euglenoid.

**1. Flagellar Movement** - It happens by active vibrations or lashing movements of the flagellum. The speed of movement ranges upto 3-6mm/minute. This movement happens by two methods.

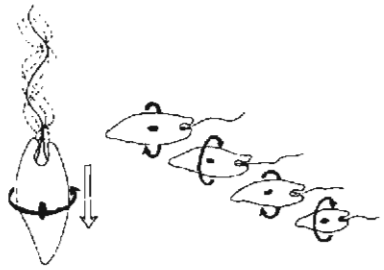


*Fig 14.2.3 Gyration*

**Gyration** - In this type the flagellum is spirally rotated. It beats at the rate of 12 beats / second. The Euglena rotates its body at the rate of one turn per second.

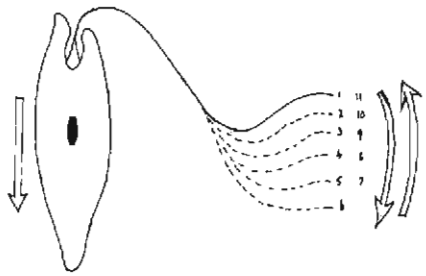


*Fig 14.2.4 paddle storke*

**Paddle stroke** - The flagellum is used like a paddle in a boat.

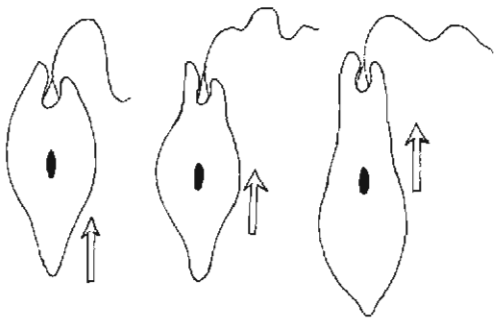


*Fig 14.2.5 Euglenoid movement*

**2. Euglenoid movement** - In this movement the organism changes its shape frequently. The body becomes shorter and wider first at the anterior end, then in the middle and later at the posterior end. This characteristic movement is known as the **euglenoid movement.**

**Nutrition:** Nutrition in Euglena is of **mixotrophic type.** There are two methods of nutrition, namely, **holophytic** and **saprozoic.**

***1. Holophytic (or) Autotrophic nutrition:-*** It is the chief mode of nutrition. In day light it can manufacture its own food by photosynthesis. It happens with the help of chlorophyll.

***2. Saprozoic nutrition:-*** This mode of nutrition takes place in the absence of sunlight. Thus Euglena can live for several months in darkness. During this nutrition the decaying organic substances dissolved in water are absorbed through the general body surface.

**Respiration**

The exchange of gases takes place by diffusion through the semipermeable pellicle. Oxygen diffuses into the cytoplasm and carbon-dioxide diffuses outwards.

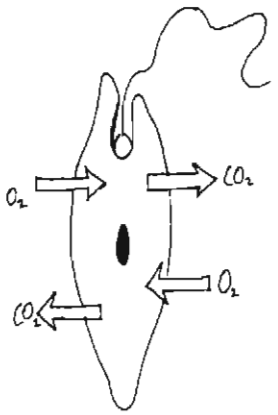


*Fig 14.2.6 Respiration*

**Excretion**

The nitrogenous waste products (ammonia) resulting from catabolism may be emptied by the contractile vacuole into the reservoir.

**Behaviour**

Euglena shows **positive phototaxis.** It avoids strong light. But turns and swims towards a moderately intense light. It orients itself parallel to a beam of ordinary light and swims towards the source of illumination. It also shows shock reaction to sudden illumination. It can also avoid thermal and chemical stimuli.

**Reproduction - Asexual**

1. **Longitudinal binary fission** - Under favourable conditions, Euglena divides into

two daughter individuals by a simple longitudinal binary fission. First, the nucleus divides into two by amitosis. A longitudinal furrow appears at the anterior end and finally divides the parent Euglena into two daughter individuals.

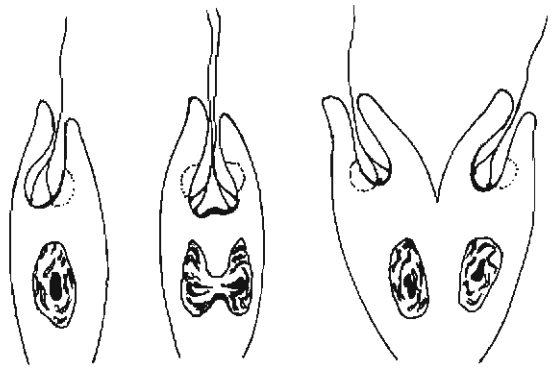


*Fig 14.2.7 Longitudinal binary fission*

2. **Multiple fission** - During unfavourable conditions multiple fission happens in an encysted condition. The active movement ceases. The organism becomes round. It is covered by a mucilaginous covering or cyst. This is followed by repeated fission within the old cyst. Thus as many as 16 to 22 daughter individuals may be produced within a single cyst. The daughter individuals acquire flagella and escape when ponds get filled with water .

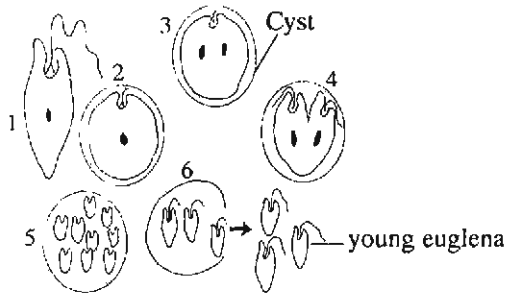



*Fig 14.2.8 Multiple fission*

Thus, Euglena a single cell organism, is able to perform all life activities similar to a multicellular organism.

**Some basic concepts**

1. The method of classifying organisms based on morphology is called as 'Taxonomy'
2. While single celled organisms are included in Protozoa, the multicellular organisms Metazoa.
3. Saprozoic animals feed on decaying organic matter in water.
4. The size of Protozoan micro-organisms is measured in terms of microns (1/1000 millimeters)
5. Cells of Euglena contain chloroplasts.
6. The permanent structure of Euglena is due to outer covering called the pellicle.
7. Contractile vacuoles help in the elimination of water and excretory products.
8. In Euglena, the locomotion is either flagellar or euglenoid.
9. The maximum speed in the locomotion of euglena is 3 - 6 millimeters / minute.
10. The asexual reproductive methods in Euglena are binary fission and multiple fission.

**Self - Evaluation**

**Choose the correct answer**

1. The locomotor sturcture in Euglena is

   a) Cilia b) Flagellum
   c) Pseudopodium d) Tube feet

2. The excretory substance released by Euglena is

   a) Ammonia b) Amino acids
   c) Fatty acids d) Uric acid

3. Euglena belongs to the phylum

   a) Annelida b) Porifera
   c) Protozoa d) Mollusca

**State true or false**

4. In gyration the Euglena rotates its body once in a minute.

5. Euglena possesses both animal and plant cell characteristics.
6. Inside the cyst, the Euglena divides by binary fission.

**Fill in the blanks**

7. Euglena alters its shape during _____ movement.
8. In Euglena respiration happens by _____ method.
9. The filaments found inside the flagellum of Euglena get united and are attached to _____ at the base.

**Answer briefly**

10. Provide the classification of Euglena.
11. What are pyrenoids?
12. Describe the 'Paddle movement' in Euglena.

**Answer in detail**

13. Describe the process of flagellar movement in Euglena.
14. Explain the structure of Euglena.
15. Give an account of the process of binary fission in Euglena.

## 14.3 MULTICELLULAR LEVEL

Multicellular level of organisation represents an advanced state among living organisms. This level is characterized by several organs and organ systems which carry out different functions. In multicellular plants, these include leaves, stem and roots which carry out assimilation, conduction, absorption respectively. In higher animals, the functions such as respiration, excretion etc., are carried out by special organs. In this unit, we learn one example of multicellular plants namely **Nephrolepis**.

**Nephrolepis** (Sword Fern / Boston Fern)
(Nephro - kidney, lepis - scale)

You might have seen the ferns grown as ornamentals in gardens. Ferns belong to the group of plants called **Pteridophytes**. These are included under **Cryptogams** because they do not produce flowers and seeds. Since they have well developed Xylem and Phloem, they are called **Vascular Cryptogams**. Fossil history reveals that pteridophytes have originated about 400 million years ago.

### SYSTEMATIC POSITION

| | | |
|---|---|---|
| *DIVISION* | : | FILICOPHYTA (OR) PTEROPHYTA |
| *CLASS* | : | LEPTOSPORANGIOPSIDA |
| *ORDER* | : | FILICALES |
| *FAMILY* | : | POLYPODIACEAE |
| *GENUS* | : | NEPHROLEPIS |

Nephrolepis is a tropical fern with about 30 species. It is distributed in the west, northwest and south Himalayan regions and also in western ghats. They are commonly found on rocks and in open fields. Most species are terrestrial.

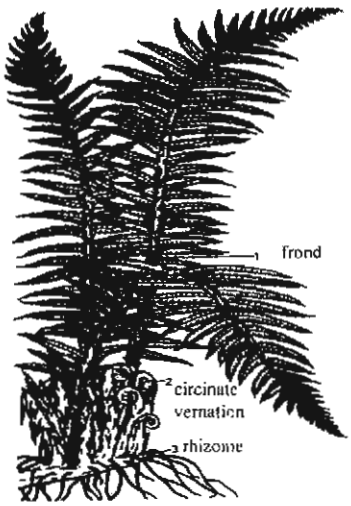



*Fig 14.3.1. Nephrolepis habit*

### SPOROPHYTE

**Habit:** (Fig.14.3.1)

The leafy plant body belongs to **sporophytic** generation. It has rhizome, roots and leaves. Only the leaves or **fronds** are seen above the ground while others are underground.

**Rhizome:**

Rhizome is seen below the soil level. Several stolons arise from the rhizome. Stolons produce adventitious roots and buds. The buds give rise to new plants. Rhizome is covered by many slender and broad scales. Mature parts of rhizome show the presence of leaf bases which belong to the fallen and mature leaves. The plant grows by means of an apical bud, protected by scales and young circinately coiled leaves.

**Roots:**

The primary root is short lived and is replaced by adventitious roots. These roots arise from rhizome and stolons. These slender and blackish roots serve as the organs of fixation and absorption of water and minerals from the soil.

**Fronds:**

Fern leaf is unipinnately compound. These are long and sub-coriaceous. Generally they are 15 to 40 cms long. At young stage, the entire leaf is in the form of a watchspring and this condition is known as **circinate** vernation. Leaves are called as **fronds**. Venation of the leaflets (pinnae) may be either simple or branched.

The leaflets are of two kinds namely sterile and fertile. The veins of the sterile leaflets end in **hydathodes** or water stomata. But the veins of the fertile leaflets terminate in sporangia. Further, petiole, rachis and leaflets are covered by scales or brownish multicellular hairs called **ramenta**.

**Acitivity:** Collect and paste leaves of different kinds of ferns which are grown as ornamentals in gardens.

**Reproduction:**

Vegetative reproduction is by means of adventitious buds. Asexual reproduction takes place by means of spores which are produced within the sporangia. Sexual reproduction is by means of gametes produced within sexorgans.

**Reproduction through Spores: (Fig 14.3.2)**

In Nephrolepis, only one kind of spores is produced. Hence it is a homosporous fern. A group of sporangia is called **sorus**. The leaves bearing sori are called **sporophylls**. Sori are arranged on the ventral side of the leaflets in two rows. Each sorus is protected by a covering called **indusium**. The indusium may be spherical or kidney shaped.

**Sporangia:** (Fig 14.3.3)

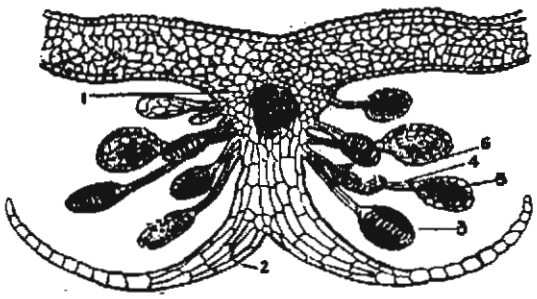


**Fig 14.3.2 Nephrolepis - T.S. through sorus**

1. vascular bundle 2. indusium 3. sporangium
4. stalk 5. annulus 6. stomium

The sporangium consists of a long, slender multicellular **stalk** and the **capsule** or the spore sac. The capsule is filled with spores. The spore mother cells after reduction division produce spores (n). Along the edge of the capsule is a row of 16 specially thickened and cutinised cells called **annulus**. In between the stalk and the annulus on one side, there are elongated, flattened and thin walled cells called **stomium**.

*Fig 14.3.3 - Single Sporangium*

1. Stalk 2. Annulus 3. Stomium

**Dehiscence of Sporangium:**

The sporangia dehisce during dry weather. The annulus and stomium are directly involved in this process. When the sporangium ripens, the annulus shrinks and the capsule breaks open at the stomium to liberate the spores. The spores are carried by wind over long distances. Spores are haploid in nature.

## GAMETOPHYTE

**Prothallus:** (Fig 14.3.4)

Spore is the first cell of gametophytic generation. The spore germinates and gives rise to the young gametophyte called **prothallus**. It is heart shaped, flat and greenish. It is 4 to 8 cells thick at the midrib region and one celled at the margins. There is an apical notch in the anterior region and the growing point is situated in the notch. Many slender, unicellular hair like structures called **rhizoids** arise from the lower surface of the prothallus. They function like roots. The prothallus may be monoecious or dioecious. Normally the cordate prothallus is monoecious (i.e.,) the antheridia and archegonia are present in the same prothallus. During unfavourable conditions, filamentous prothallus is formed which is dioecious. Here antheridia and archegonia occur in different prothalli.

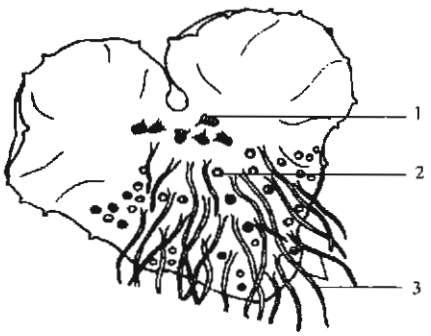



*Fig 14.3.4 Nephrolepis - Prothallus*

1. Archegonium 2. Antheridium 3. Rhizoids

**Antheridium: (Fig 14.3.5)**

Antheridia (male sex organs) arise among the rhizoids on the ventral side of the prothallus. They are small and spherical. The wall consists of three cells namely **basal cell**, a **ring cell** and a **cover cell**. The wall encloses a mass of antherozoid mother cells. Each cell produces a spirally coiled multiciliate **antheroziod**.

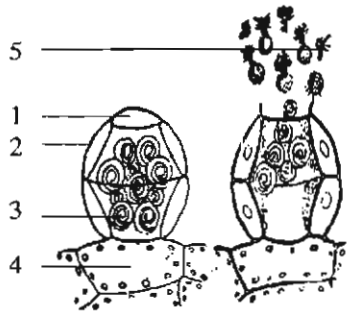



*Fig 14.3.5. Antheridium - Young and mature after dehiscence*

1. Cap cell 2. Ring Cell 3. Antherozoid Mother Cell 4. Prothallus 5. Antherozoids

***Archegonium (Fig 14.3.6) :*** These (female sex organs) are produced in clusters around the apical notch of the prothallus. Each archegonium consists of a basal swollen portion called **venter** and a projecting elongated portion called **neck**. Venter encloses a **venter canal cell** and an **egg cell**. Neck cells surround the neck canal. There is a single **neck canal cell** with two or three nuclei. In the presence of water, the neck and venter canal cells of the mature archegonium produce mucilage. The mucilage swells resulting in the opening of the neck.

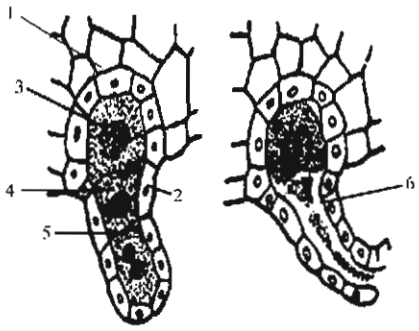



*Fig 14.3.6 Archegonium : Young and mature*

1. venter 2. neck 3. egg 4. venter canal cell 5. neck canal cell 6. mucilage

## Fertilization

Fertilization takes place in the presence of water. The mucilage in the neck contains malic acid. This attracts the antherozoids which swim towards the open neck of the archegonium. Many antherozoids enter the venter and reach the egg. But only one fuses with the egg nucleus. Thus fertilization is effected. The fertilized egg secretes a wall around it and becomes a zygote. Zygote is the first cell of sporophytic generation. The cells of the venter divide rapidly and form a caplike **calyptra** around the zygote.

The zygote divides into an embryo. This is dependent on the gametophyte (prothallus) during early stages for nutrition. The embryo divides further and develops into a young sporophyte with roots and leaf. (Fig 14.3.7) This later becomes independent and forms a mature sporophyte.

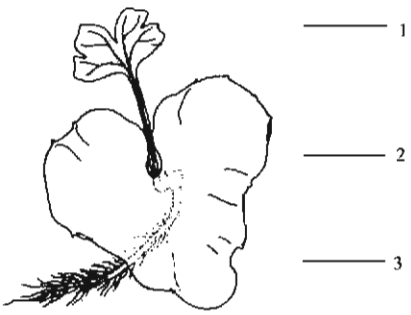


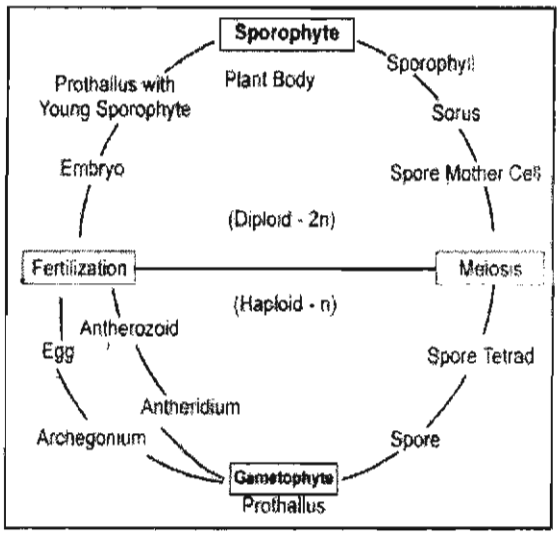

*Fig 14.3.7 Prothallus with young sporophyte*

1. young sporophyte 2. prothallus
3. primary root

## Alternation of Generations

There are two generations in the lifecycle of a fern. The plantbody is a sporophyte and it is diploid (2n). Prothallus is a gametophyte and it is haploid (n). Sporophyte reproduces by means of spores which develop into gametophyte (prothallus). The prothallus produces gametes through the sex organs. The gametes fuse and give rise to the zygote. This germinates into an embryo which in turn grows into sporophyte. Thus there is a regular alternation of generations.

**Nephrolepis - Life Cycle**




## Activities:

1. Make a field trip to places such as Ooty and Kodaikanal with your teacher and observe the habitat and habit of ferns.

2. Observe keenly the kidneyshaped structures present in two rows on the ventral side of the fronds. Find out the colour and give reason for that colour.

3. Collect pictures or stamps of various kinds of ferns and prepare on album.

## Some basic concepts

1. Nephrolepis is a tropical fern, widely distributed in the himalayan regions.
2. Plantbody is a sporophyte and is differentiated into rhizome, roots and leaves.
3. Rhizome is underground, with numerous leafbases along with many stolons. Several slender, blackish adventitious roots arise from the rhizome. Leaves or fronds are unipinnately compound and the young ones exhibit **circinate** vernation.
4. Nephrolepis is a homosporous fern. Group of sporangia called sori are found

on the ventral side of sporophylls. Each sorus is protected by an indusium.

5. Capsule has thickwalled cells called annulus and thinwalled cells called stomium.

6. The spore germinates into the young gametophyte namely prothallus which is either monoecious or dioecious.

7. Prothallus bears antheridia and archegonia.

8. Fertilization takes place in the presence of water resulting in diploid zygote which develop into an embryo which then forms the sporophyte.

9. Nephrolepis exhibits heteromorphic alternation of generations.

**Self - Evaluation**

**Choose the correct answer**

1. The first cell of the gametophytic generation in Nephrolepis is

   a) Zygote b) Spore
   c) Prothallus d) egg cell

2. Annulus is distinguished from stomium by the presence of

   a) thickwalled cells b) thinwalled cells
   c) elongated cells d) flat cells

3. The shape of the indusium is said to be

   a) Reniform b) Cordate
   c) Pyriform d) Sagittate

**State true or false:**

4. Nephrolepis is a heterosporous fern.

5. Function of indusium is to protect the sori.

6. The underground rhizome is covered with scales.

**7. Match the following**

| | | |
|---|---|---|
| 1) Leaves | - | (i) dehiscence |
| 2) Rhizome | - | (ii) reniform |
| 3) Stomium | - | (iii) rhizoids |
| 4) Archegonium | - | (iv) fronds |
| 5) Prothallus | - | (v) adventitious roots |
| | - | (vi) mucilage |
| | - | (vii) sori |

**Fill in the blanks:**

8. Fronds exhibit _____ vernation.

9. Spores are involved in _____ reproduction.

10. Antheridia are found near the _____ of prothallus.

**Answer briefly**

11. What is the function of annulus?

12. What is the function of rhizoids in prothallus?

13. What is monoecious condition?

**Answer in detail**

14. Write down the systematic postion of Nephrolepis. Add a note on its habitat.

15. Describe the rhizome of Nephrolepis.

16. Give a schematic representation of lifecycle of Nephrolepis.

## 14.4 MULTICELLULAR LEVEL - A FISH

Subkingdom Metazoa includes two branches namely, **Parazoa** and **Eumetazoa**.

**Parazoa**: It includes all sponges. These are multicellular organisms, consisting of loosely arranged cells. The 'tissue organisation' is lacking..

**Eumetazoa**:- It includes animals having tissue grade of organisation. In this organisation, the tissues join to form organs

and organ systems. This group is further divided into **Diploblastic** and **Triploblastic** animals. The Triploblastic animals have 3 body layers, namely, outer **Ectoderm**, inner **Endoderm** and middle **Mesoderm**, (Ex: fish)

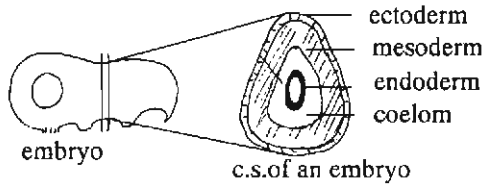



*Fig 14.4.1 Body cavity - layers*

The Triploblastic animals are further subdivided into.

1. **Acoelomata** (no coelom or body cavity) Ex. Tape worm.
2. **Pseudocoelomata** (False coelom) Ex. Ascaris.
3. **Coelomata** (True coelom) Ex. fish.

### Mullet

It is a type of bony fish commonly found in the seas and estuaries of India.

### External Morphology:

The body is streamlined and boat like. This shape is more suited for swimming in water. The body shows three main regions, namely the head, trunk and tail. Between the head and trunk the neck region is absent. The tail lies behind the anal opening.

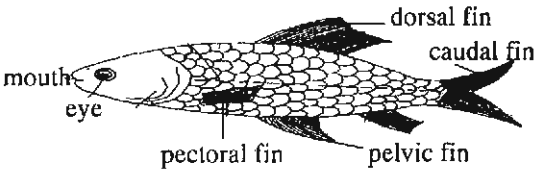



*Fig 14.4.2 Mullet*

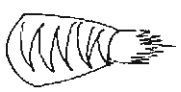


*Fig 14.4.3 Ctenoid scale*

### Scales:

There are several types of scales on fishes. The scales on Mullet are named as **ctenoid scales**. These scales are large in size. They are arranged over the body as the tiles fixed on the roof. This arrangement reduces the resistance of body while swimming. As the fish grows scales increase in size. Hence the number of scales remain constant in young and mature stages. The scales are marked by concentric lines.

Their free borders are produced into spines. The concentric lines grow close in winter than in summer. Hence by observing the rings on scales the age of the fish can be determined. The scales are protective in function.

The skin secretes a slimy substance which makes the body slippery. This helps in locomotion and protection from enemies. The slime prevents the growth of bacteria and other parasites on the skin.

### Head:

The head bears no scales. The mouth is large and wide. It is surrounded by an upper and a lower jaw. There are two nostrils on each side of the upper jaw. A pair of eyes without eyelid are found on the two sides of the head. The ears are embedded in the bones of the skull and they have no external openings. The ears help in balancing and perception of sound vibrations. On either side of the head there are bony plate like coverings called the **opercula**, which protect the gills. (Operculum - singular)

### Fins:

The trunk and the tail bear two kinds of fins that are paired and unpaired.

### THE PAIRED FINS:

**1. A pair of pectoral fins** are located close to the head and correspond to the forelimbs of other vertebrates.

**2. A pair of pelvic fins** correspond to the hindlimbs.

**THE UNPAIRED FINS**

i) Dorsal fin situated along the top middle line of the trunk.

ii) Caudal fin which grows from the tail.

iii) Anal or ventral fin which grows along the middle or the lower side behind the anus.

**Functions of fins in swimming**

The main force for the fish to swim is provided by the entire body. The fins help the fish in several ways.

i) The caudal fin creates a propelling force, it also acts as a rudder and helps in changing the direction.

ii) The median fins control the fish by preventing rolling over its body.

iii) **The paired fins (Pectoral and Pelvic fins)**

They function in four ways.

1. Control the forward propelling of the fish.

2. Help to swim downward or upward by regulating angle of movement of the fins.

3. Help to maintain the fish at rest in any depth.

4. Help to act as brakes to slow down and stop locomotion.

**Lateral line sense organs:**

On both the lateral sides of the body horizontal row of sense organs are found. These organs are placed below the scales. They are connected to fine nerves. These organs help the fish to feel the pressure of water above its body. By knowing this pressure the fish can understand the depth in which it is swimming.

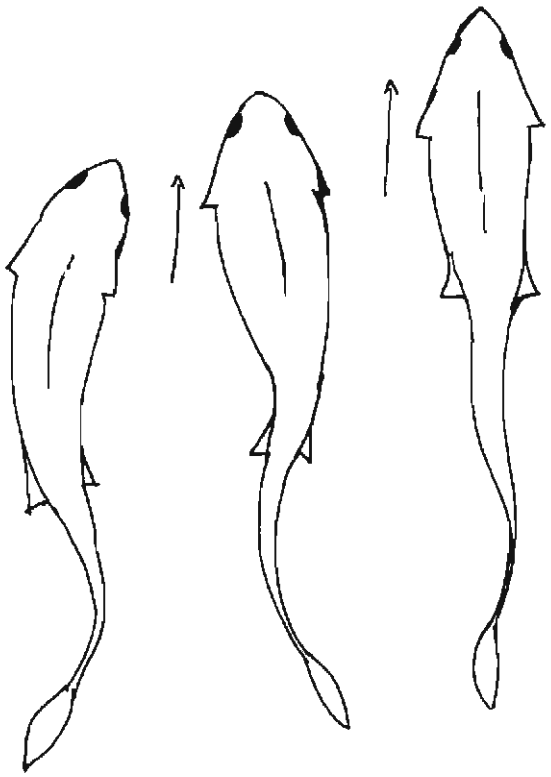


*Fig 14.4.4 Swimming by body moments*

*Carefully watch a fish swimming in an aquarium tank. You can see the fish swimming by moving its body from head to the tail. For this purpose the body muscles of the fish remain as small blocks called* ***myotomes****. Thus, you can notice that the entire body of the fish takes part in swimming.*

***Digestive System:*** The **pharynx** opens into the **oesophagus**. At its junction there are **pharyngeal teeth** which serve as filtering apparatus to strain the mud present in the food. The **stomach** consists of two regions, the cardiac and **pyloric regions**. The wall of the pyloric region is thickened and it forms the **gizzard**. The gizzard continues as the **duodenum**. At its junction there are five blind glandular processes called **pyloric caeca**. The part of the small intestine followed by the duodenum are **ileum**, **rectum** and **anus**.

The **liver** consists of three incompletely divided lobes. The **gall bladder** lies at the lower margin of the right lobe and the **bile**

**duct** leads from it into the duodenum. The **pancreas** is a very thin organ.

***Respiratory System:*** There are four pairs of **gills**. The gills project outside through gill slits. The partitions between the gill slits are narrow. The gills are made up of several filaments.The filaments project freely into the cavity covered by the operculum. Each gill consists of a gill arch. Blood vessels enter the gill arch and supply deoxygenated blood to the filaments through fine capillaries. Another set of blood vessels carry the oxygenated blood away from the filaments. The total gill surface is 2-3 times than that of the body surface of the fish.

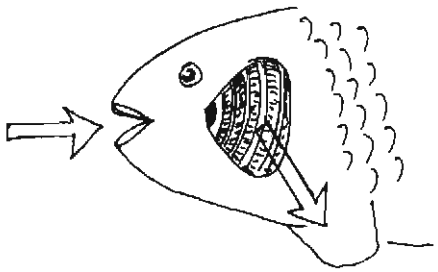


*Fig 14.4.5 Gill respiration*

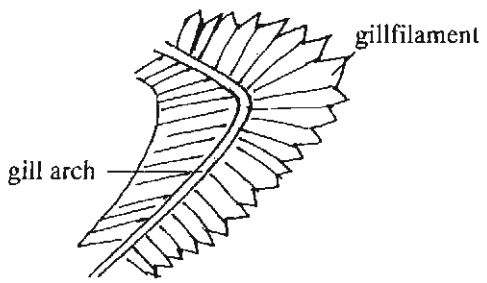



*Fig 14.4.6 Gill structure*

**Some basic concepts**

1. Subkingdom Metazoa is divided into Parazoa and Eumetazoa.
2. Eumetazoa contains Diploblastic and Triploblastic animals.
3. The Triploblastic animals are of 3 types, namely Coelomates, Pseudocoelomates and Acoelomates.
4. Mullet is a coelomate. It is a bony fish.
5. The Mullet has Ctenoid scales.
6. The fins are paired or unpaired.
7. The fishes have lateral line sense organs.
8. The gills are protected by the operculum.

**Self-Evaluation**

**Choose the correct answer**

1. Hydra is a

   a) single celled organism
   b) Diploblastic organism
   c) Triploblastic organism
   d) Coelomate.

2. The sclaes on Mullet are

   a) Placoid b) Cycloid
   c) Ctenoid d) Ganoid

3. The fins that help in changing direction while swimming are

   a) Dorsal fin b) Pectoral fin
   c) Pelvic fin d) Caudal fin

**State true or false**

4. Fishes are acoelomates.
5. Scales help in assessing the age of fishes
6. The liver in fishes is made up of three lobes

**Fill in the blanks:**

7. Sponges belong to phylum----------
8. ---------- fins help in forward movement and changing direction in fishes while swimming
9. The sensory structure found on the two lateral sides, beneath the scales are ------

**Answer briefly**

10. Classify Triploblastic animals.
11. Give an account of paired fins
12. Write notes on lateral line sense organs.

**Answer in detail**

13. Give an account of Ctenoid scales.
14. Describe the process of swimming movement in fishes.
15. Describe the respiratory organs in fishes

## 14.5 PLANT ANATOMY

Many plants are multicellular. These cells arise from a single cell called **zygote**. Group of cells form **tissues**. **Plant anatomy** is the study of internal structure of the plant parts by means of dissection which are then seen under microscope.

The plant body consists of three important tissue systems namely **dermal, fundamental** and **vascular** systems. Dermal system includes the epidermis, which is the outer protective covering of the plant body. Fundamental system consists of the main ground tissues namely parenchyma, collenchyma and sclerenchyma. Xylem and Phloem form the Vascular system.

### Dicot stem:

### Internal structure of sunflower stem: (Fig 14.5.1,2)

Transverse section of sunflower stem in the internodal region shows three different regions namely epidermis, cortex and vascular system.

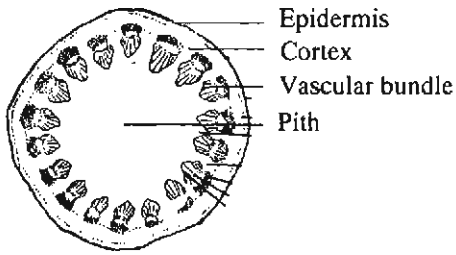



*Fig 14.5.1 T.S. of Dicot stem - ground plan*

### Epidermis:

Epidermis is the outermost layer made up of a row of rectangular cells, covered by **cuticle** made up of cutin. Mulicellular hairs are present on the epidermis. This layer protects the inner tissues and the cuticle helps to check excess transpiration.

### Cortex:

Cortex is below the epidermis and it is extrastelar in position. There are few layers of collenchyma below the epidermis which gives mechanical strength to the stem. This forms the **hypodermis**. Next to the collenchyma, one or two layers of chlorenchyma containing chloroplasts are seen. This region is involved in photosynthesis. The rest of the cortex consists of thin walled parenchymatous cells. The cortical parenchyma serves as the region of storage of food materials. The innermost layer of cortex is wavy in outline and it is made up of more or less barrelshaped, compactly arranged cells. It is called **starch sheath** because of the presence of abundant starch grains.

### Vascular System:

Vascular bundles are wedge shaped and they are arranged in the form of a ring. Each vascular bundle is **collateral** (i.e.) xylem and phloem are arranged side by side on the same radius. Xylem is located towards the centre of the stem and phloem outside it. The vascular bundle is said to be **open** because of the presence of a strip of cambium in between the xylem and phloem.

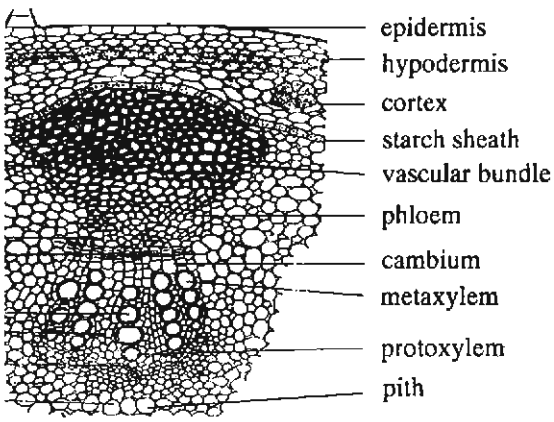



*Fig 14.5.2 Portion enlarged*

**Phloem:**

In the vascular bundle, phloem lies towards the periphery. Each vascular bundle has a few layers of sclerenchyma cells outside the phloem and it is called **bundle cap**. Phloem helps in conduction of food materials from the leaves to the rest of plant.

**Cambium:**

Cambium is said to be **fascicular** because it is present within the vascular bundle. It consists of thin walled rectangular cells. Cambium is res ponsible for secondary growth of the plants.

**Xylem:**

Xylem consists of Xylem vessels, Xylem fibres and Xylem parenchyma. The Xylem of the stem is **endarch** (i.e.) the protoxylem occurs towards the centre of the stem and metaxylem towards the periphery. The vessels are helpful in conducting water and minerals to the leaves. Xylem fibres give mechanical strength to young plants.

**Pith:**

Central portion of the stem is called **pith** and it is composed of parenchyma cells with intercellular spaces. The function of the pith is storage of food.

**Dicot Root - Internal structure (e.g. bean)**

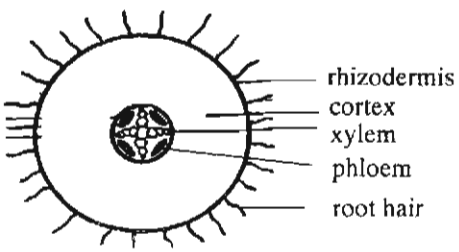



*Fig 14.5.3. T.S.of dicot root*

Transverse section of bean root shows the arrangement of tissues like **Rhizodermis, Cortex** and **stele**. (Fig 14.5.3,4)

**Rhizodermis or Epiblema:**

Epidermis of root is called **rhizodermis** or **epiblema**. It consists of tubular living cells. The outer walls of some of the cells extend as root hairs. Epiblema protects the inner tissues. Root hairs serve as the organs of absorption of water and minerals.

**Cortex:**

Cortex consists of many layers of thin walled parenchyma cells with intercellular spaces. The innermost layer of the cortex is called **Endodermis**. It consists of a single layer of barrel shaped cells without intercellular spaces. The radial and transverse walls of these cells have suberin and are known as **casparian strips**. Endodermal cells opposite to the protoxylem elements are thin walled and are called **passage cells**. Only through these cells, water enters the xylem from cortex.

**Stele:**

Stele is differentiated into pericycle and vascular system.

**Pericycle:**

Inner to the endodermis, there is a single layer of thin walled cells called **pericycle**. Lateral roots arise from the pericycle.

**Vascular System:**

Xylem and Phloem are arranged in separate patches in alternate radii. Such a condition is called **radial** arrangement. Xylem and phloem are separated by parenchymatous cells called **conjunctive tissue**. Xylem occurs in the centre of the root and it extends as ridge like projections. The protxylem elements are located in these projections. Xylem is said to be **tetrarch** because of the presence of four protoxylem points. Xylem of roots is **exarch** because the protoxylem vessels are situated towards the periphery and the metaxylem vessels towards

the centre. Phloem consists of sieve tubes, companion cells and phloem parenchyma. Pith is absent.

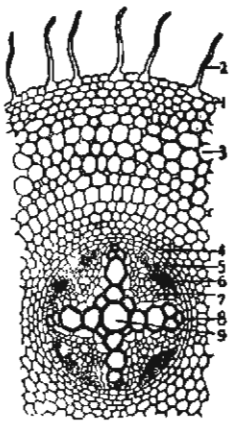


*Fig 14.5.4. Part enlarged*

1.rhizodermis 2. root hair 3.cortex 4. endodermis 5. pericycle 6. phloem 7. conjunctive tissue 8. protoxylem 9. metaxylem

## Transverse section of a dicot leaf (e.g. Sunflower) (Fig. 14.5.5)

Transverse section of dicot leaf includes the three tissue systems namely **dermal, ground** and **vascular**. Dermal system consists of upper epidermis and lower epidermis. Ground tissue lies between the two epidermal layers and is called **mesophyll**. Mesophyll has **palisade parenchyma** on upper side and **spongy parenchyma** on lower side. Vascular tissue system consists of vascular bundles.

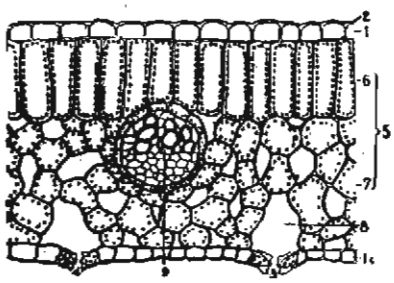


*Fig 14.5.5. T.S. of Dicot leaf*

1. upper epidermis 2. cuticle
3. stoma 4. guard cells
5. mesophyll 6. palisade parenchyma
7. Spongy parenchyma 8. aircavity
9. vascular bundle 10. lower epidermis

**Epidermis:**

Epidermis is the outermost layer of the leaf. There are two layers namely upper epidermis on the adaxial (Upper) surface and lower epidermis on the abaxial (Lower) surface. Cuticle is present on the outer walls of the upper and lower epidermis. Each epidermal layer is made up of single layer of compactly arranged cells. Epidermis protects the mesophyll tissue. **Stomata** are present more frequently on the lower epidermis compared to the upper epidermis. Each stoma is surrounded by two bean shaped **guard cells** which contain chloroplasts.

**Mesophyll:**

The tissue lying between the two epidermal layers is known as mesophyll. It is differentiated into palisade and spongy parenchyma.

**Palisade parenchyma:**

Cells lying below the upper epidermis form palisade tissue. It consists of a single layer of elongated cylindrical cells. As these cells contain chloroplasts, palisade parenchyma helps in the manufacture of starch by photosynthesis.

**Spongy parenchyma:**

Spongy tissue consists of irregularly shaped, loosely arranged parenchymatous cells. They contain many air cavities which help in the diffusion of gases.

**Vascular tissue:**

Vascular tissues are seen in the veins. Vascular bundles are **collateral** and **closed**. Xylem lies towards the upper epidermis and Phloem towards the lower epidermis. Xylem consists of vessels, tracheids, Xylem fibres and Xylem parenchyma. Phloem consists of sieve tubes, companion cells and phloem parenchyma. Each vascular bundle is surrounded by a layer of thin walled cells called as **border parenchyma** or **bundle sheath**.

**Activity:** With the help of permanent slides available in your laboratory, observe the internal structure of dicot stem, root and leaf.

**Some basic concepts**

1. Plant Anatomy is the study of internal structure of the plant parts by means of dissection which are then seen under microscope.
2. The plant body consists of three important tissue systems namely dermal, fundamental and vascular systems.
3. T.S. of Dicot stem reveals an epidermis, followed by a multi layered cortex made up of collenchyma, chlorenchyma and parenchyma and vascular system which is collateral and open. Xylem is endarch. Large Pith is present
4. Internal structure dicot root shows an outer rhizodermis, a multicellular parenchymatous cortex and stele. Xylem and phloem show radial arrangement and closed. Xylem is said to be tetrarch and exarch. Pith is absent.
5. T.S. of dicot leaf consists of upper epidermis, lower epidermis with stomata, mesophyll (Palisade and Spongy parenchyma) and vascular bundles.

**Self-Evaluation**

**Choose the correct answer**

1. Cortex belongs to this system:
   a) dermal b) fundamental
   c) vascular d) storage
2. Vascular Bundle of dicot stem is said to be:
   a. Collateral and open
   b. Collateral and closed
   c. Radial and open
   d. Radial and closed
3. The tissue that lies between the epidermis of dicot leaf is:
   a. Palisade b. Spongy
   c. Mesophyll d. Cortex

**State true or false**

4. Multicellular hairs are present on the epidermis of dicot root.
5. The function of pith is storage of nutrient materials.
6. Stomata are present only on the lower epidermis.

**7. Match the following**

| | | |
|---|---|---|
| 1. Collenchyma | - | a. dicot stem |
| 2. Cambium | - | b. endodermis |
| 3. Chlorenchyma | - | c. rhizodermis |
| 4. Cortex | - | d. Mechanical strength |
| 5. Casparian thickenings | - | e. fascicular |
| | | f. parenchyma |
| | | g. palisade |

**Fill in the blanks**

8. _____ is the innermost layer of cortex.
9. Vascular system of dicot root is said to be _____
10. Each stoma is surrounded by ____ cells.

**Answer briefly**

11. Why the vascular bundle of stem is said to be collateral and open?
12. Differentiate between bundle cap and bundle sheath?
13. What is radial condition ?

**Answer in detail**

14. Explain the internal structure of dicot stem.
15. Explain the transverse section of dicot root with diagram.
16. Describe the internal structure of a dicot leaf with diagram.

## 14.6 Human Anatomy

'Anatomy' is the study of inner organs or organisation of organ systems within an animal or a plant.

The first accurate work on human anatomy was carried out by **Andreas Vesalius** in 1543. His publication in French *'De humani corporis fabricia'* literally means 'On the structure of the human body'. Even before Vesalius, the art of dissection of human body was explained by **Mondino de' luzzi** in his work **'Anatomia'** in 1316. These works were followed by the works of several anatomists. This knowledge of 'Human Anatomy' has formed the basis for all medical practices.

### 1543 A.D - A MILESTONE IN SCIENTIFIC PUBLICATION

*A revolution was made by the publication of 2 books related to Human Body and the Universe in the year 1543 A.D. A book titled, 'De revolutionbus orbium coelestium' written by* ***Nicholas Copernicus*** *revealed the fact that the Earth and other planets revolve around the Sun.*

*Similarly* ***Andreas Vesalius*** *at the age of 30 years, made history through his publication titled, 'De humani corporis fabricia', This book revealed a detailed account of Human Anatomy through beautiful and accurate pictures.*

### ORGANS OF DIGESTION:

The digestive organs include alimentary canal and associated glands. The alimentary canal is a musculo-membranous tube. It is about 8 meters in length. From mouth to anus it is lined by mucus membranes. The wall of the alimentary canal is made up of 3 layers of tissues. They are inner **mucosa, submucosa**, middle *muscularis* and external *serosa*. Depending on function, various regions of the canal have different structures. These organs include **mouth, pharynx, oesophagus, stomach, small intestine (duodenum, jejunum, ileum), large intestine (caecum, colon, rectum)** and glands like **salivary glands, liver** and **pancreas.**

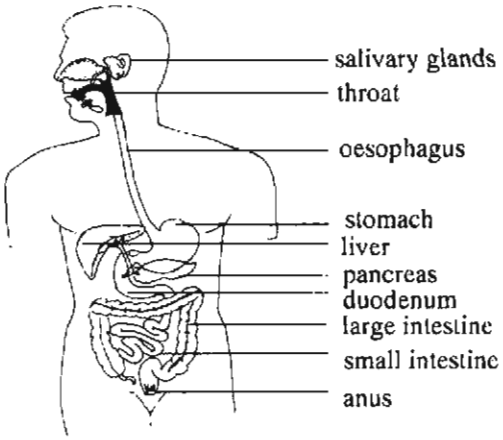



***Fig 14.6.1 Organs of digestion***

**Mouth:** It is an oval shaped cavity bounded infront by lips and laterally by the jaws. The roof of the buccal cavity is lined by a palate. The floor contains a tongue. The jaws are lined by teeth. The lips are fleshy folds. The inner surface of the lips is connected in the middle line to the gum of the jaw by a mucus membrane. The inner linings of the mouth are very delicate in nature.

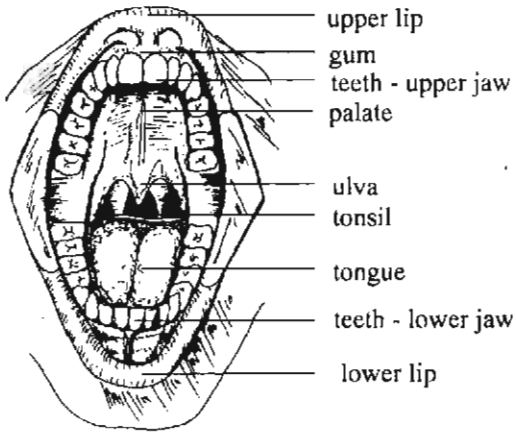



***Fig 14.6.2 Mouth***

**Teeth:** Human beings are provided with 2 sets of teeth in their life time. They appear at different periods of life. The first set appears in childhood. They are called the temporary, **deciduous or milk teeth**. They are 20 in number (4 **Incisors**, 2 **canines** and 4 **molars** in each jaw). The second set starts appearing at an early period and continues until oldage. They are named as **permanent teeth**.

The permanent teeth are 32 in number (4 **Incisors**, 2 **canines**, 4 **Premolars** and 6 **molars**) in each jaw. The **dental formula** is $\frac{2123}{2123} \times 2$ The last set of molar teeth grow after the age of 20. Hence they are named as **wisdom teeth.**

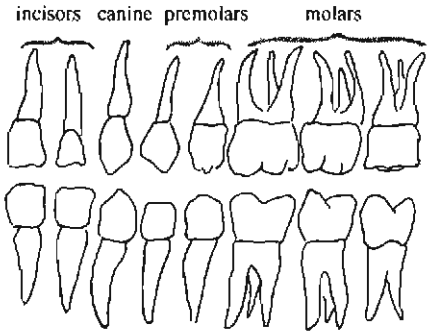



*Fig 14.6.3 teeth arrangements*

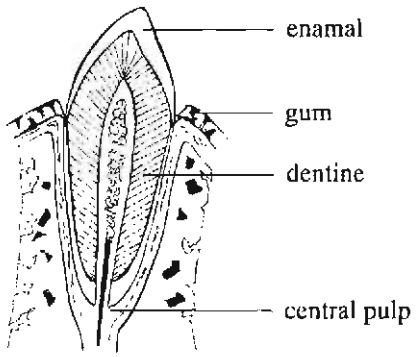



*Fig 14.6.4. L.S. of tooth*

**Structure of a tooth**

Each tooth consists of three regions, namely the **crown, neck** and the **root**. The crown is made up of **dentine** or **ivory** (tooth bone). The dentine is covered by an **enamel**. The enamel is considered as the hardest material in our body. The root contains a central pulp made up of connective tissue, blood vessels and nerves.

**Tongue:**

It is the organ for the sense of taste. It is attached to the floor of the mouth. Its tip is thin and narrow. The undersurface is connected to the lower jaw by muscles. The upper surface of the tongue contains several papillae or sensory buds. Each papilla is like an inverted cup, being attached to fine nerve endings.

**Salivary Glands:**

3 pairs of salivary glands open into the mouth. They are **parotid, submaxillary** and **sublingual**.

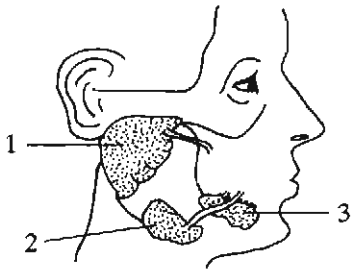



*Fig 14.6.5 Salivary Glands*

**1. Parotid gland**:- (*Paros*-near *Otis*-ear) It is the largest of the three pairs of glands.

**2. Submaxillay gland:-** It is found below the jaw. It is irregular in form.

**3. Sublingual gland:** It is found at the base of the tongue. It is the smallest gland.

**Pharynx**:- It is found behind the nose and mouth. It is about 11cm in length. This region has 7 openings communicating with it. They are 2 **internal nostrils**, 2 **Eustachian tubes** (passage to the middle ear), **mouth, larynx and Oesophagus**. It is lined by a thin mucus membrane having pharyngeal glands.

**Oesophagus:-** It is a musculo - membranous canal about 22cm in length. It extends from pharynx to the stomach. Its wall contains a muscular coat made up of two planes of muscle fibres, longitudinal and circular. The inner lining has a mucus coat and is lined by squamous epithelium.

## Stomach

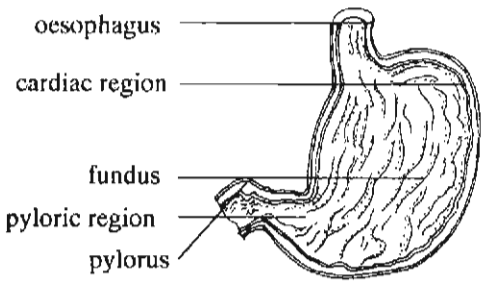



*Fig 14.6.6 Stomach*

Since stomach is the main organ of digestion, it is the most dilated part of the alimentary canal. Its size varies in different humans. When it is full, its transverse diameter and vertical diameter are about 30 cm and 10 cm respectively.

It weighs about 106 g. It is a horizontal chamber containing 3 conspicuous regions. They are **cardiac stomach** (Near the heart), **fundus** (middle region), **pyloric stomach** (near pylorus). The stomach wall is made up of 4 layers, of which the muscular layer is prominent. This layer contains 3 sets of smooth muscles. The inner lining contains mucus membrane having several secretary glands. These glands are meant for the release of mucus, HCl and gastric juices. Thus the inner lining is a very delicate region.

## Small Intestine

The stomach opens into the small intestine through the pylorus. The pyloric region contains a set of sphincter muscles. The small intestene is a convoluted tube, of about 6.5 mts length. It gradually reducess in size from the pylorus. It is divisible into 3 portions **duodenum, jejunum, ileum.**

## Duodenum

It is around 22 cm in length. It is the shortest and widest part of the small intestine. At this region the **liver** and **pancreas** are connected to the alimentary canal.

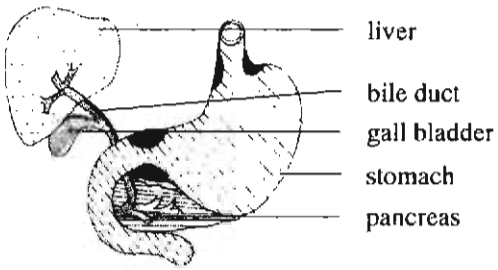



*Fig 14.6.7 Duodenum*

**Liver:** The liver is the largest glandular organ in human. It weights about 1500 gms. Its size ranges from 30 to 40 cm in length and 17 to 22 cm in breadth. Its upper surface is convex. It contains two unequal lobes (the right lobe is larger). Its under surface is concave and it has a large **gall bladder.** The gall bladder is about 10 cm in length and 2.5 cm in breadth. The liver is made up of several secretary units called hepatic lobules having hepatic cells. The **bile** secreted by these cells are stored in the gall bladder. The gall bladder is attached to the **bile duct.** The duct opens into the duodenum. This region also has its association with the pancreas.

**Pancreas:** It is a conglomerate gland resembling the salivary gland. It is transversely oblong. Its length varies from15 to 20 cms. It weighs about 58-90 gms. Pancreas is connected with the duodenum through a pancreatic duet. The upper surface of the pancreas bears a longitudinal endocrine gland called the **Islets of Langerhans.** The pancreatic gland contains lobules capable of secreting pancreatic juice. Thus pancreas is a dual gland (exocrine and endocrine).

**Jejunum:** It constitutes 2/5th of small intestine. It starts from the duodenum and ends with the Ileum.

**Ileum:-** It is a coiled or convoluted tube. It constitutes 3/5th of small intestine. The inner lining contains a thick mucus membrane. It is highly vascularised. It contains numerous minute finger like projections called **villi**

(1mm) in length. They are approximately 4 million in number. Internally each villus contains fine blood capillaries and lacteals (lymphatic system)

**Large Intestine**

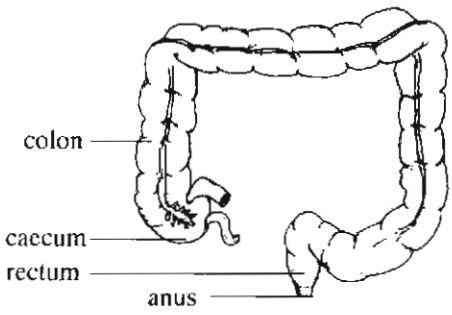



*Fig 14.6.8 Large Intestine*

It extends from the ileum to the anus It is about 1.5 mts in length. It is divided into **caecum, colon** and **rectum.**

**Caecum:** It is a large blind pouch. It measures about 5 cm in length. The terminal part of the caecum is the vermiform appendix, which is 7 - 9 cm in length.

## ORGANS OF MOVEMENT - MUSCLES

The muscular system is organised in two ways. The sets of muscles attached to the bones are called **skeletal muscles**. These are

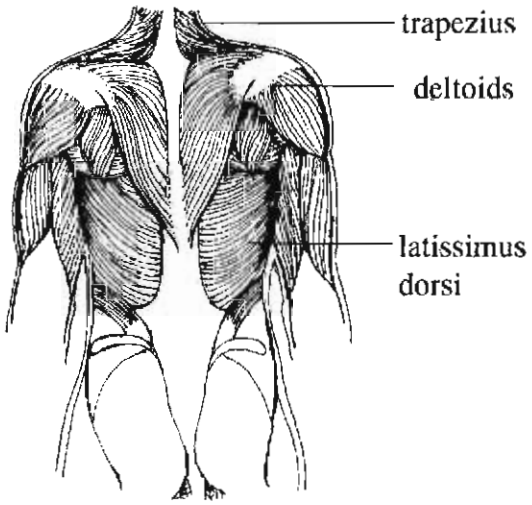



*Fig 14.6.9 dorsal muscles*

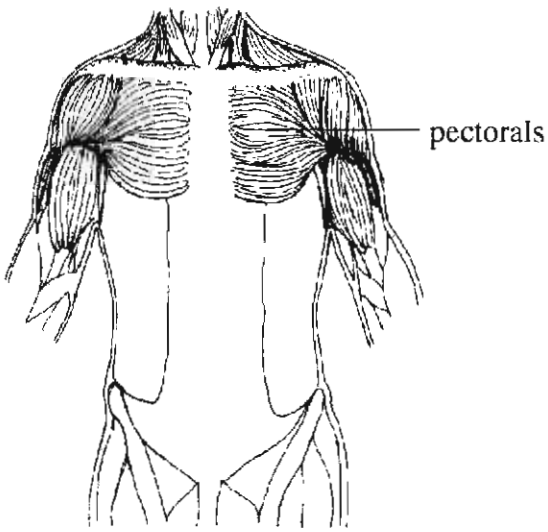



*Fig 14.6.10 Ventral muscles*

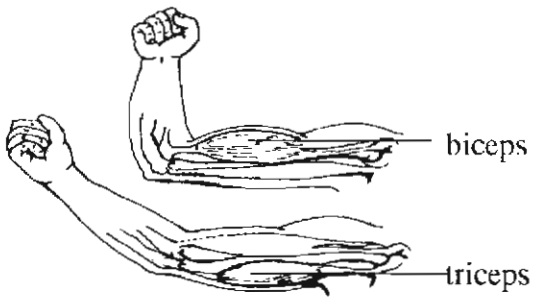



*Fig 14.6.11 Arm muscles*

voluntary in nature. Inner organs of the body like stomach, heart and blood vessels are made up of a set of **smooth muscles** and they are involuntary in nature.

**Skeletal muscles**:- In man around 600 muscles of various sizes and shapes are attached to the skeletal system. These muscles are arranged in four divisions, namely.

1. Muscles of head, face and neck.
2. Muscles of trunk.
3. Muscles of forelimbs
4. Muscles of Hindlimbs.

**Significant muscles, their location and movement:**

| Name | Location | Movement |
|---|---|---|
| 1. Trapezius | Upper back and each side of neck | upper pulling movements. |
| 2. Deltoids | Shoulders | Arm raising. |
| 3. Pectorals | Chest | Horizontal pressing and drawing of arms across the body |
| 4. Latissimus dorsi | Wide back muscle | Pulling and rowing movement |
| 5. Biceps | Front portion of upper arm | Arm bending and twisting |
| 6. Triceps | Back of upper arm | Pushing and straightening of upper arm |
| 7. Calves | Lower leg between ankle and knee | Raising and lowering of toes. |

## ORGANS OF RESPIRATION

The process of respiration involves the following organs:- **nostrils, nasal cavity, pharynx, larynx, trachea, bronchi, bronchioles** and **lungs**.

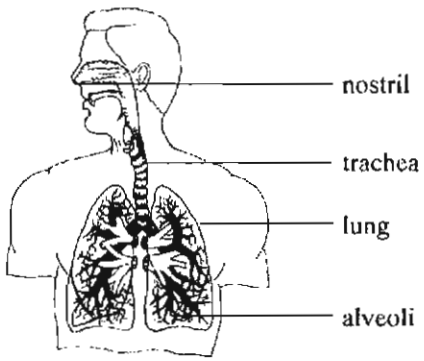



*Fig 14.6.12 Organs of Respiration*

**Nostrils:-** The nasal openings lead into two nasal cavities. The nasal cavity is divided into external and internal nostrils. Both the nostrils are again divided by median septum made up of a cartilage. These cavities are lined by ciliated epithelial cells, mucus cells and sensory cells (smell)

*Place differently fragrant powder / scented materials in blank boxes with holes. Can you identify the various smells from a distance of 10-20 cms. make a survey of the smelling capcites among your class mates. Note the power of recognition using markings +++, ++, +, -*

*Can you feel the smell if you have common cold ?*

**Pharynx / Larynx:-** It is a common passage for both food and air. Its nasal part is called as **nasal pharynx**. It opens into the **larynx** or **voice box**. The larynx is made up of several plates of cartilages, of which the prominent one is the **thyroid cartilage** that forms the **'Adam's apple'** A flap like structure formed from thyroid cartilage is known as the **epiglottis**. It is meant for closing the trachea during swallowing of food. The larynx contains several vocal cords. The vibrations of vocal cords cause voice.

**Know:**

*In birds, larynx is known as Syrinx, found at the base of the trachea.*

**Trachea or Windpipe:-** It is a cartilagenous and membranous cylindrical tube extending for 12 cm. It is made up of 16-20 'C' shaped cartilagenous rings. The trachea is lined by ciliated epithelial and mucus secreting cells.

**Bronchi / Bronchiole:-** The trachea divides into 2 broanchi. The right bronchus is wider and shorter than the left. Each bronchus inturn divides into smaller bronchioles. The terminal bronchioles are respiratory in nature. Each of them end is an alveolar air sac. This complex system is called as the respiratory tree.

**Alveoli:-** They are minute air sacs covered by a thin respiratory membrane (.5u) in

thickness. Each lung has about 200 - 500 million alveoli. The total surface of which will be around 80 - 100 mt. square, and equals the size of a tennis court.

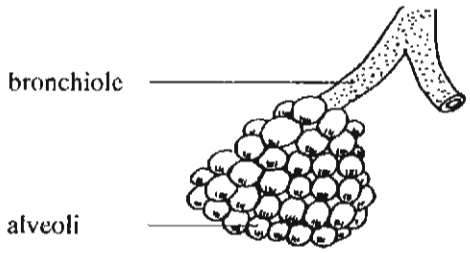



*Fig 14.6.13 Alveoli*

**Lungs:** Bronchi and Bronchioles constitute two lungs. The lungs are coverd by **pleura**. Each lung is constituted by bronchi, bronchioles and alveoli. These are spongy conical bag like structures found within the thoracic cavity. The space between the lungs is called the **mediastinum**. Each lung is surrounded by a **pleural sac** filled with pleural fluid. The wall of the pleural sac is made up of two membranes.

The organs of respiration are enclosed within a compact throacic cavity. This cavity is surrounded by, sternum in front, vertebrae at the back, ribs and intercostal muscles on the sides, clavicle or collar bone at the top and diaphragm at the bottom.

## ORGANS OF CONTROL AND CO-ORDINATION - NERVOUS SYSTEM

This system is meant for co-ordination and control of body activities. it is constitued by **brain, spinal cord** and **nerves**. Its basic functional units are the nerve cells or neurons. The system is divisible into three parts namely:-

A. **Central Nervous system** (CNS). It includes **Brain** and **Spinal cord.**

B. **Peripheral Nervous system** (PNS). It includes nerves from brain and spinal cord.

C. **Autonomic Nerous system** (ANS). It is connected with the visceral organs.

## CENTRAL NERVOUS SYSTEM:

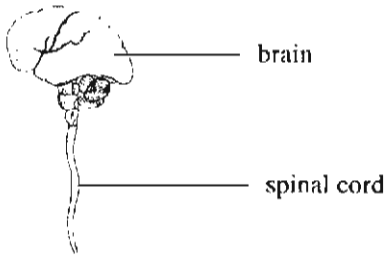



*Fig 14.6.14 CNS*

## THE BRAIN

It is found inside the skull or cranium. Inside skull, the brain is covered by meninges. The brain weighs around 1300 g. in adults. In a new born child, the weight of the brain is around 380 g. As the child grows, the weight increases. The growth may happen up to the age of 20. The brain is made up of nearly 12,000 million neurons or nerve cells.

**Parts of the Brain:** The Brain is divided into three regions namely Forebrain, Midbrain and Hindbrain.

**A) The Forebrain:-** This region is made up of a cerebrum, two olfactory lobes and diencephalon.

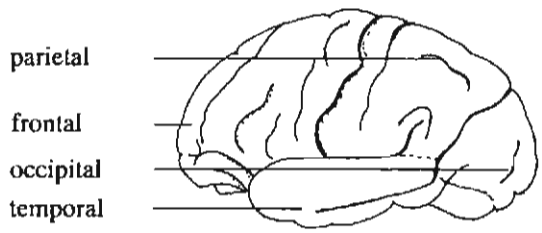



*Fig 14.6.15 Parts of the Cerebrum*

i) **Cerebrum**:- The cerebrum forms the major part of the brain. It is divided into two hemispheres. Both the hemispheres are connected by a sheet of nerve fibres called **corpus callosum** at the base. The outer surface of cerebrum is called the **cerebral cortex**. It is the grey matter of the brain. The inner region is made up of white matter called the **cerebral medulla**. The central cortex has

several foldings or **gyri**. Each gyrus is separated from the other by fissures or **Sulci**. The cerebral hemisphere consists of four lobes namely **frontal, Parietal, temporal** and **occipital** lobes..

**ii) Olfactory lobes:-** These are two small projections formed from the frontal lobe of the cerebrum. These lobes are not conspicuous in man.

**iii) Diencephalon:-** It is found deep inside the cerebrum. It consists of two regions namely **thalamus** and **hypothalamus**. The hypothalamus bears an infundibulum, having the most important Pituitary gland at its tip.

**B. The Midbrain:** It is found in the middle of the forebrain and the hindbrain. It consists of several nerve cells and nerve fibres, connecting sensory regions of the brain.

**C. The Hindbrain:** It is the posterior part of the brain. This region is made up of pons varolii, medulla oblongata and cerbellum. The pons varolii connects the Midbrain with medulla oblongata. The Medulla oblongata is around 2.4 cm in length. It is an enlarged portion of the spinal cord. The nerves of Autonomic nervous system are associated with this region.

Below the posterior edge of cerebrum two small hemispheres are found. These constitute the **cerebellum** (or) the small brain.

Inside the brain there are small cavities called the **ventricles**. These ventricles found inside the various regions of the brain are interconnected and continued down as the central canal inside the spinalcord. These cavities are filled with cerebro-spinal fluid.

**The Spinal cord:**

It is a cylindrical organ extending from the medulla oblongata of the brain. It is found inside the neural canal of the vertebral column. Meninges of the brain continue and cover the spinal cord also. The spinal cord extends up to the lower lumbar vertebrae. Terminally the spinal cord becomes narrow and forms the ***filum terminale***.

**PERIPHERAL NERVOUS SYSTEM:**

**A. Cranial nerves:** These nerves are formed from various parts of the brain. They are mostly concerned with sensation and movements. There are twelve pairs of cranial nerves.

**B. Spinal nerves:** The spinal cord gives off 31 pairs of spinal nerves. These nerves radiate to the neck, forelimbs, trunk, abdomen, hip and hindlimbs.

## ORGANS OF SENSATION

**Organs of vision - Eyes**

The eyes are meant for converting the images of the external world into electrical signals. These signals in turn are conducted to the brain. The pair of eyes are placed in eye sockets of the skull. They are protected by cushions of fat. Externally the eyes are protected by two eye lids. The inner wall of the eye lid has a thin membranous layer. It is called as the **conjunctiva**. **Tear glands** or **lacrymal glands** open in the inner margin of the upper eye lid. The eye balls are fixed in the sockets by three pairs of muscles.

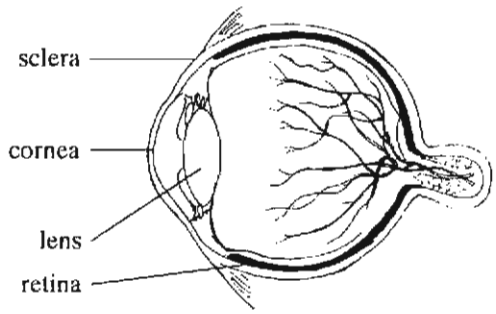



*Fig 14.6.16 Eye ball*

Each eye ball consists of three concentric layers. In the front, these layers are transparent for the passage of light. The outer central, transparent region is called as the **cornea**. The outer layer is called the **sclera**. It is a tough protective covering. It is commonly referred to as the white of the eye.

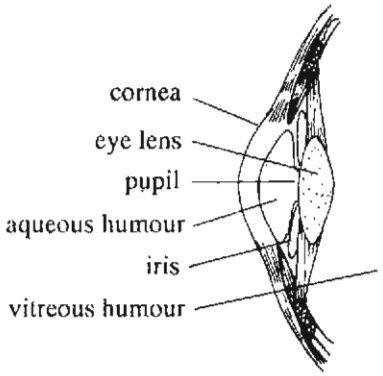



*Fig 14.6.17 Section of the eye - frontal region*

The inner most layer is the **retina.** It is light senstive. The inner cells of this layer can convert light signals into electrical impulses. Such photosensitive cells on the retina are the **rods** and **cones.** The middle layer is vascular in nature. It is called as the **choroid.** In the front it forms the **ciliary body** and the **iris.** The **eye lens** is a small transparent biconvex structure. The shape of the lens can be altered depending on the distance of the object. The region in between the cornea and lens has a clear fluid called the **aqueous humour.** The region between the lens and inner retina contains a clear gel called the **vitreous humour.** The opening for the entry of light rays is called the **pupil.** It is encircled by a circular muscle called the iris. The pupil regulates the entry of light using iris.

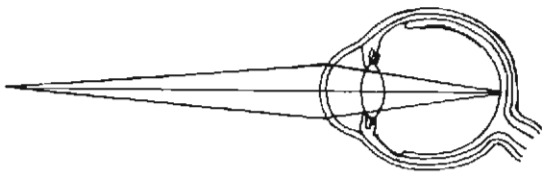


*Fig 14.6.18 Image formation*

The rods and cones of the retina are attached to fine optic nerves. These nerves collectively leave from the posterior part of the eye towards the optic lobes of the brain. In the centre of the retina an area responsible for clear vision is situated. It is called as the **macula.**

**The organs of hearing - Ears**

The ears are the organs of hearing. They also help to maintain the equilibrium (body balance).

The ear is divisible into three regions: the external ear, the middle ear and the internal ear.

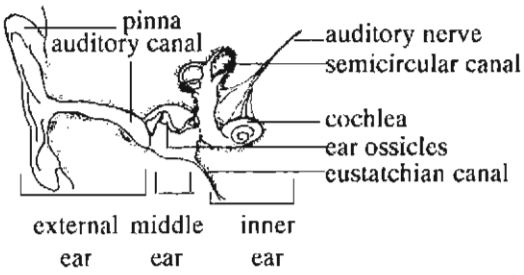



*Fig 14.6.19 Structure of the ear*

**The External ear:**

The external ear consists of the ear lobe or **pinna** and the **auditory canal.** The Pinna is flexible and is made up of cartilage and muscles. The auditory canal terminates into a thin ear drum called the **tympanic membrane.**

**The Middle ear:**

The middle ear consists of a small chamber containing the **ear ossicles.** The ear ossicles are three small bones called **malleus, incus** and **stapes.** Malleus is a hammer shaped bone. It is close to the **ear drum.** Incus is connected to malleus and stapes by hinge joints. It is anvil shaped. The stapes is a stirrup shaped bone. This inturn is connected to the oval window that leads into the inner ear.

**The Inner ear:**

The inner ear consists of a membranous labyrinth consisting of two sac like organs called **Utriculus** and **Sacculus.** Associated with utriculus are three **semi-circular canals.** The ends of these canals are swollen to form the **ampullae.** Associated with the sacculus is the **cochlea.** It is a spirally coiled tube.

The cochlea is a closed tube connected to the sacculus on one end. Internally two membranes divide the cochlea into three canals. These canals contain a fluid called the **perilymph**. The actual organ of hearing are the sensory cells found attached to a thin membrane of the cochlear canal. These sensory cells are in contact with the overhanging **tectorial membrane** which projects upward from the cochlea. This inner organisation is called the **Organ of Corti**. The nerves of the organ of Corti join to form the **auditory nerve**.

## ORGANS OF BLOOD CIRCULATION:

Collectively the organs of blood circulation are referred to as **Cardio-vascular** system. This system consists of **heart** and **blood vessels**. The blood vessels consttitue two types of circulations, namely **systemic** and **pulmonary** as shown in the diagram.

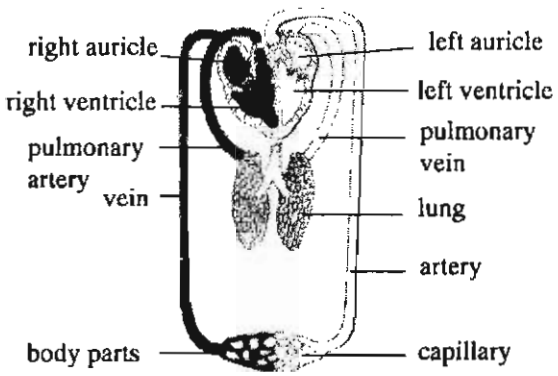



*Fig. 14.6.20 Blood circulation*

The arteries, veins and capillaries constitute a very vast network ranging upto 112,000 kms. In this elaborate system the arteries and veins show characteristic variations in the structure.

### Heart:

It is a hollow, muscular organ. It is conical in form. Heart is placed in between the lungs in the mediastinum. It is covered by a membranous sac called the **pericardium**. The pericardial space is filled with pericardial fluid. The heart is placed obliquely in the chest. While the broad upper end of the heart is towards the right, the lower apex of the heart forwards to the left. In an adult human the heart measures about 13 cm in length and 9 cm in breadth in the broader region. While in males the heart weights 285 - 340 g, in female it weighs 247 - 285 g.

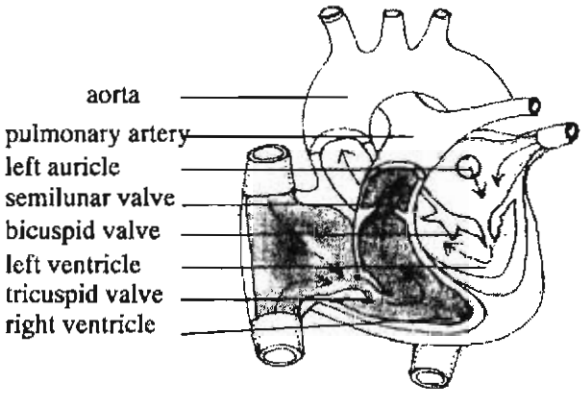



*Fig 14.6.21 L.S of heart*

The wall of the heart is made up of strong involuntary muscles, called as the **cardiac muscles.** Internally the heart is subdivided by a vertical muscular septum into two lateral halves. The septum is named as **auriculo - ventricular septum**. The lateral cavities are subdivided by a transverse constriction. Thus the heart possess four chambers. The two smaller upper chambers are named as **auricles or atria**. The large lower chambers are the **ventricles**. The opening between the right auricle and the ventricle is guarded by a **tricuspid valve**. Similarly the opening inbetween left auricle and ventricle is guarded by a **bicuspid or Mitral valve**.

The venous blood returning from systemic circulation and through superior and inferior vena cavae enter into the right auricle. Correspondingly the oxygenated blood returning from the pulmonary circulation enters into the left auricle through four openings of the pulmonary veins. These openings are provided with valves. From the

upper edge of the right ventricle originates a large pulmonary artery. The opening of the pulmonary artery is guarded by a set of **semilunar valves**. The most important dorsal aorta takes its origin from the upper edge of the left ventricle. This opening is guarded by another set of semilunar valves.

Comparatively the ventricles are larger having thicker walls.

Extenally the heart muscles are supplied by a very important group of **coronay blood vessels.**

## ORGANS OF EXCRETION - KIDNEY

Kidneys are the chief excretory organs. They are dark red, bean shaped, paired structures. They are placed on either side of the median vertebral column in the lumbar region. Each kidney is about 11 cm in length, 6 cm in breadth and 3 cm in thickness. The right kidney is on a slightly lower level than the left. This is because the right side of the abdominal cavity is occupied by the liver. Each kidney is covered by a tough transparent membrane, the **capsule**. The outer surface of the kidney is convex while the inner is concave and it faces the vertebral column.

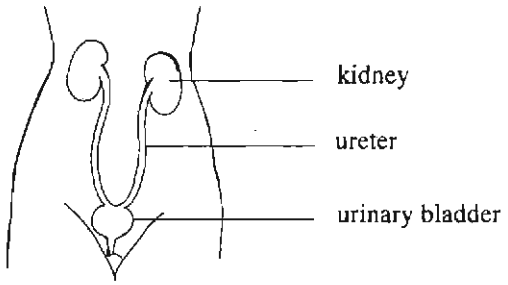



*Fig 14.6.22 organs of excretion*

The depression found in the middle of the inner concave region is known as the **hilus**. The ureter, nerves and the renal vessels emerge out or enter the kidney through the hilus. The two uretes of paired kidneys open into a common bag, the urinary bladder.

If the kidney is sliced lengthwise, it consists of two clear regions, outer dark **cortex**, inner pale **medulla**. The ureter entering through the hilus expands, forming a wide funnel shaped structure called the **renal pelvis**. The medulla shows a number of cone shaped masses, the **renal pyramids**.

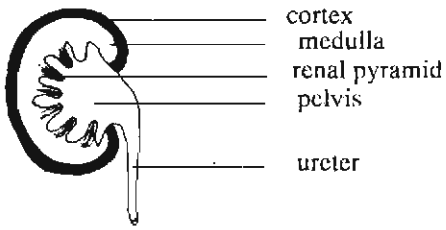



*Fig 14.6.23 L.S. of Kidney*

The cortex contains about one million microscopic excretory units called the **nephrons**. The nephrons are the functional units of the kidney.

### Microstructure of the kidney - Structure of a nephron:-

Each nephron is made up of a **Malpighian capsule** and a long convoluted **uriniferous tubule**. The Malpighian capsule measures about 0.2mm in diameter and it consists of a double walled cup-like structure called the **Bowman's capsule**. The capsule encloses a bunch of afferent and efferent arterioles. This is known as the **glomerulus**. Both the glomeular capillaries and the Bowman's capsule constitute the malpighian capsule it lies inside the cortex and is followed by the uriniferous tubule.

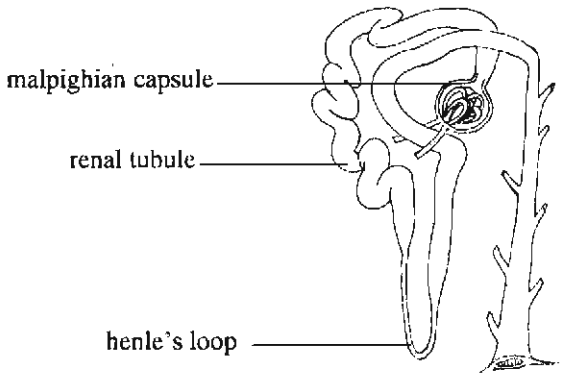



*Fig 14.6.24 Nephron*

| Differences | |
|---|---|
| **Arteries** | **Veins** |
| 1. Carry blood away from the heart. | 1. Carry blood towards the heart. |
| 2. The walls are thick and muscular. | 2. The walls are very thin |
| 3. Found deeper within the body. | 3. Superficial in position. |
| 4. Have no valves | 4. Contain valves. |

The Uriniferous tubule is divided into the following parts:

1. A short neck following the Bowman's capsule.
2. A highly convoluted portion known as the **proximal convoluted tubule.**
3. The proximal convoluted tubule straightens out and forms a 'U'shaped region known as **Henle's loop** which has desending and ascending limbs.
4. The ascending limb of Henle's loop gives rise to a coiled structure known as the **distal convoluted tubule.**

**Urinary Bladder:**

It is a hollow muscular organ serving as a reservoir of the urine.

**Urethra:**

It is a canal passing from the neck of the bladder to the external opening. It is lined with mucous membrane and continues with the lining of the bladder. The junction of the bladder and urethra is guarded by sphincter muscles.

**Some basic concepts**

- Anatomy is the study of internal structure of an organism.

- Organs of digestion include digestive tract and associated glands.

- In every human, milk teeth is replaced by permanent teeth.

- The digestive tract includes mouth, pharynx, oesophagus, stomach, duodenum, jejunum, ileum, colon, rectum and anus.

- Muscles are classified into voluntary and involuntary muscles.

- Respiratory tract includes nostrils, nasal cavity, pharynx, larynx, trachea, bronchi, bronchioles and alveoli.

CNS includes brain and spinal cord.

PNS includes cranial nerves and spinal nerves.

ANS includes sympathetic and parasympathetic nervous systems.

- Eye ball is made up of 3 layers - Sclera, choroid, retina

- Retina has light sensitive cells called rods and cones.

- Human ear is mode up of external ear middle ear and inner ear.

- Heart is made up of involuntary cardiac muscles

- Valves present in the heart are tricuspid, bicuspid and semilunar valves.

- Kidney is the major excretory organ.

- Unit of kidney is nephron.

## Self-Evaluation

### Choose the Correct Answer

1. Which of the following is the largest salivary gland in human mouth.

   a) Sublingual glands
   b) Parotid glands
   c) Submaxillary glands
   d) Mandibular glands

2. Deltoid muscles are found in

   a) Chest b) Shoulder
   c) front of the upper arm d) back of the upper arm.

3. Number of alveoli found in both the lung are

   a) 100 - 200 million
   b) 200-500 million
   c) 500-600 million
   d) 600 -800 million

4. The number of spinal nerves in man are:

   a) 31 pairs b) 31
   c) 13 d) 13 pairs

### State true or false

5. The middle layer of the eyeball forms the retina.

6. There are three ear ossicles in the middle ear.

7. The region inbetween the lungs is known as the mediastinum.

8. The cardiac muscles are involuntary in nature.

9. The diameter of Malpighian capsule is 0.2mm.

### Fill in the blanks

10. The roof of the buccal cavity is known as _____.

11. The inner wall of trachea is lined by __ tissues.

12. The basic functional unit in nervous system is _____.

13. The number of cranial nerves in man are _____

14. The fluid material found between the eye lens and cornea is _____

### Answer briefly

15. Provide the human dentition

16. What is epiglottis?

17. What are meninges?

18. Write notes on nephron

19. What are coronary blood vessels?

### Answer in detail

20. Describe the structure of pancreas

21. Give an account of conspicuous skeletal muscles

22. Write notes on forebrain

23. Draw the vertical section of kidney and label the parts

24. What are the differences between arteries and veins?

# 15. CELL BIOLOGY AND GENETICS

## 15.1. INTRODUCTION TO MICROSCOPES

The introduction of 'Optics' as a field of science in Physics, encouraged the development of Microscopes. The earliest microscope invented by **Anton Van Leeuwenhoek** (1673), opened new fields in Biological Sciences. Further developments in 'lens systems' improved the microscopic techniques. Discovery of electrons and the 'radiation effects' resulted in the development of electron microscopic techniques.

Microscopes are absolutely essential to see microorganisms and study about tissues, cells and their components.

The ability of our eye to see minute structures is much limited. Hence we need microscopes. The power of microscopic vision is expressed in terms of **'resolving power'**. This power refers to the capacity for finding the distance between two particles. In human unaided eye the limit of resolution is about 0.1mm. It means that two particles separated by a distance that is less than 0.1mm will appear as a single particle to our eyes.

Hence objects that are smaller than this distance will be invisible. Human eye has no power of magnification.

| | | |
|---|---|---|
| 1 Micron (μ) | = | 1/1000 mm |
| (μm) | | (or) 0.0001mm |
| 1 Millimicron | = | 10Å (or) 1/1000 |
| (mμ) | | micron |
| 1 Angstrom (Å) | = | 1/10,000 μ (or) 1/10 mμ |

But the microscopes can both resolve and magnify an object. The power of such resolution depends on the quality of light and lens system. An ordinary light microscope can magnify an object from 2000 to 4000 times. Still further magnification and resolution is required to see ultra structures. This problem is solved by electron microscopes. Theoretically an electron microscope can magnify an object 200,000 to 300,000 times.

### LIGHT MICROSCOPE

A conventional light microscope contains the following essential parts.

1. **A light source** : It may be sun's light (or) any other artificial light source.

1a. **A mirror** : It serves as a reflector to make the light fall on the condenser lens.

1b. **A diaphragm** : It controls the amount of light that could fall on the condenser lens.

2. **A condenser lens system** : This system collects the light and focuses it on the specimen.

3. **Stage with clips**: It is meant for keeping specimen / object.

4. **Objective lens** : It is nearer to the object and magnifies the image of the specimen.

5. **An eye piece lens** : It helps to further enlarge the image of the object and projects the image to the eye.

The objective and eye piece lenses are mounted at the two ends of a hollow tube. This arrangement can be raised up or down by coarse and fine adjustment knobs. Magnification of the image can be increased or decreased by changing the objective and eye piece lenses.

## ELECTRON MICROSCOPE

An electron microscope permits the observation of structures as small as 1 mm (10Å). This high resolving power is due to the fact that, these microscopes use electrons instead of ordinary light rays. The wave length of visible light's ray is 5000Å. Whereas an electron microscope uses electrons having wave length of only about 0.05Å. This is 100,000 smaller than the wavelength of visible light.

In an electron microscope the electrons travel within a vacuum. An electron microscope is built with the following basic structures.

1. **Illumination Source** : A cathode filament capable of emitting narrow beam of electrons.
2. **Condenser lens** : It is an electromagnetic structure capable of collecting and focusing electron beams on the object.
3. **Stage** : It is meant for holding the specimen.
4. **Objective lens** : An electromagnetic structure meant for collecting electrons passing through the specimen. This structure may enlarge the image.
5. **'Eye piece' lens** : An electromagnetic projector which further magnifies the image of the specimen and projects it on viewing screen.

Magnification of the image can be increased or decreased by varying current in the projector lens.

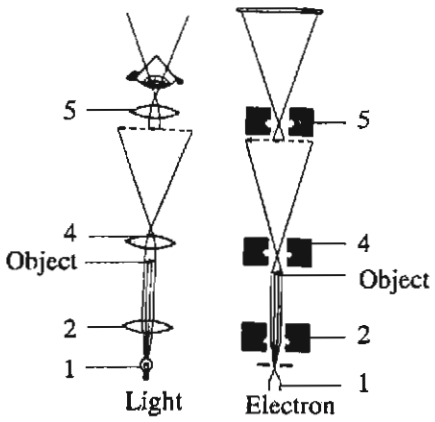



*Fig 15.1.1 Microscopes - fundamentals*

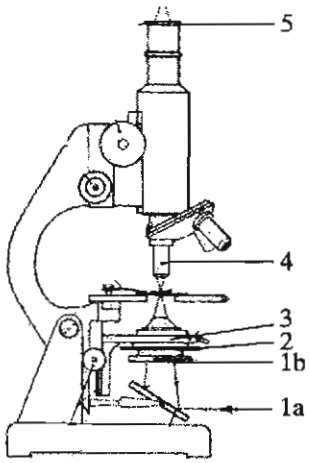



*Fig 15.1.2 Compound light microscope*

## TRANSMISSION ELECTRON MICROSCOPE (TEM)

A transmission electron microscope just enlarges the object several thousand times. It reveals only the two dimensional image of the specimen being examined. A three dimensional idea of a specimen can be constructed only by taking 1000 to 3000 serial sections of the specimen. Hence it is not possible to visualize the structure of a whole cell.

## SCANNING ELECTRON MICROSCOPE (SEM)

This microscope produces a three dimensional image of a specimen. In this microscope instead of just recording the electrons passing out of the specimen, the secondary electrons released from the specimen are focused back into the emerging electrons. This arrangement provides a scanning effect.

**Some basic concepts**

1. Microscope was first used by 'Leuwenhoek in 1673.
2. Resolution is the power of the microscope
3. If the space between two objects is lesser than 0.1 mm, both the objects seem to be a single object to our eye.
4. Microscopes have both resolution and magnification.
5. Through an electron microscope the object can be magnified from 200,000 to 300,000 fold.
6. The lenses present in the compound microscope are eye piece lens and objective lens.
7. The electron radiations are responsible for magnification in electron microscope.
8. Scanning electron microscope shows three dimensional images of an object.

**Self - Evaluation**

**Choose the correct answer**

1. The microscope was first used by

   a) Robert Brown b) Leuwenhoeck

   c) Robert Hooke d) Purkinje

2. The magnifying power is 200,000 to 300,000 times in a

   a) Light microscope

   b) Compound microscope

   c) Electron microscope

   d) Dissection microscope

3. 1 micron is equal to

   a) 1/1000 mm b) 1/1000Å

   c) 1/1000 millimicron d) 1/1000 cm

**State true or false**

4. 'Optics' is a branch of Physics dealing with the study of glasses and lenses.
5. The electron radiation is responsible for magnification in light microscope.
6. Scanning electron microscope shows the three dimensional image of the object.

**Fill in the Blanks**

7. The light microscope can magnify an object _____ times.
8. ___ radiation can pass through vacuum.
9. A microscope shows the_____ dimensional view of the object.

**Answer briefly**

10. What is resolving power ?
11. What are the different parts of the light microscope ?
12. What are the uses of microscopes ?

**Answer in detail**

13. Explain the structure of electron microscope
14. Give an account on Transmission electron microscope.
15. Briefly explain Scanning electron microscope.

## 15.2. & 15.3 PLANT CELL / ANIMAL CELL – ULTRA STRUCTURE

The term 'Cellula' in Latin means 'a small chamber'. This term was adopted and used as 'cell' for the first time by Robert Hooke (1665). Developments in microscope construction and staining procedures provided us an opportunity to know more about the cells. The '**cell theory**' was first proposed by **Schleiden** and **Schwann** of Germany in 1839. According to this theory, 'the cells are the basic and fundamental units of life'. It was also realized that all life activities are due to basic events inside cells. This theory was the cause for the origin of a distinct discipline in Biology called Cytology or Cell Biology.

Further, the discovery of the nucleus and its contents as the cause for heredity or inheritance gave more importance to cytology.

## CELL – GENERAL STRUCTURE

The cell is a mass of protoplasm, surrounded by a plasma membrane. In plant cells, this membrane inturn is covered by a cell wall. It is a nonliving structure made up of cellulose.

## STRUCTURE AND SIZES OF CELLS

Cells differ in their size, shape, structure and contents. The cells may be spherical, cylindrical, many sided, star shaped or irregular in shape. While bacterial cells measure just 0.0001 millimeters, the egg cells of birds are several centimeters in diameter. The body cells are normally less than 1mm in diameter. The size of cells is mentioned in micron units. The cell organelles are measured in terms of millimicrons or Angstroms.

### Protoplasm:

It is the fundamental substance of any living cell. The term 'protoplasm' was first coined by **Purkinje in** 1839. The protoplasm of a cell is divisible into cytoplasm and nucleoplasm. There are several theories to explain the physical structure of the protoplasm. According to Wilson (1925) it is considered as a jellylike colloidal substance. 75-95% of protoplasm contains water. The remaining 5-25% is made of Carbohydrates, Proteins, Fats, Chlorides, Phosphates, Sulphates of Na, K, Ca and Mg.

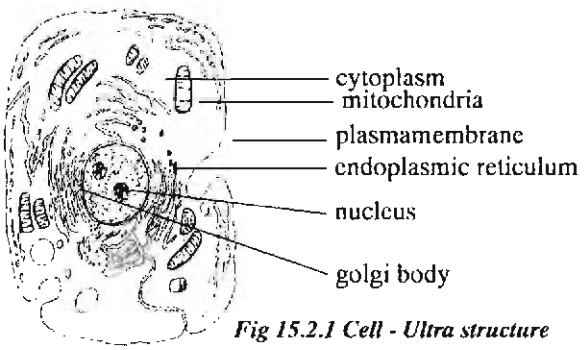



*Fig 15.2.1 Cell - Ultra structure*

**The Cell Wall**: The cell wall of plant cells contains 2 layers. These are the Primary and Secondary layers. The primary cell wall is made up of **pectin** and **cellulose**. It is thin and elastic. The secondary cell wall is supportive in nature. It is made up of several fibrous bundles of cellulose. Each bundle is 250Å in its diameter.

**Plasma Membrane** – It is the outer limiting membrane. It is 75Å in thickness. Its structure is not simple. It contains two outer protein layers. Internally two layers of fat molecules are found. Water and other substances are selectively permeable through this membrane.

### Endoplasmic Reticulum (ER)

It was first described by **Porter** in 1947. The ER extends as a canal like structure from the nuclear membrane upto the plasma membrane. It provides support to the cell. It also helps to conduct substances within the cell.

**Golgi bodies**: It was first described by the Italian scientist **Camillo Golgi** (1898). It is 1-3 microns in size. These are called as 'Cell secretary centres'.

**Ribosomes** – These structures were discovered by **Palade** in 1955. These are formed from the endoplasmic reticulum. A cell may have millions of ribosome's. These are meant for producing proteins according to the genetic information.

**Mitochondria**: These are called as the **'Power Houses'** of the cell. The number of mitochondria in a cell varies according to the energy requirement of the cell. They are 3-5 microns in length and 0.5 microns in diameter. Its wall is made up of two membranes. The inner membrane has several infoldings called **'cristae'**. This membrane contains several enzymes. These enzymes are meant for breakdown and oxidation of glucose to release energy. The energy is stored

in the form of **ATP** (Adenosine triphosphate) molecules.

**Centrosome** – These are absent in plant cells. In an animal cell it is found near the nucleus. It helps in cell division. It contains two centrioles. These centrioles play a direct role in Mitosis and Meiosis cell divisions.

**Lysosomes** – Each lysosome is a small saclike structure enclosed by a thin membrane. These sacs contain enzymes meant for dissolving unwanted particles within the cells. Since these sacs contain substances that could destroy cell contents, these are called as 'suicidal bags'.

**Plastids**: These are found only in the plant cells. These structures help in the storage of food. Some plastids contain colour pigments. These are called as **chromoplasts**. Chromoplasts are responsible for the beautiful colours of the flowers. The green colour in plant leaves and stems is due to chloroplasts. These plastids contain the green coloured pigment, **chlorophyll**.

**Chloroplast** – Each chloroplast is made up of two membranes. It has a complicated structure. The inner, flat, bag like structures are called as **thylakoids**. The layers of thylakoids are called as **grana**. The chlorophyll pigments are found embedded in the thylakoid layer. The chlorophyll pigment can get excited by light rays of specific wavelength. It promotes a series of chemical reactions called 'light and dark' reactions. During these reactions water and carbon dioxide are linked to synthesize complex Glucose molecules.

$$6Co_2 + 6H_20 \xrightarrow{\text{Sunlight}} C_6 H_{12} O_6 + 60_2$$

This process in termed as **photosynthesis.**

**Nucleus**: The nucleus was first discovered by Robert Brown (1871). The cells having nucleus are termed as **eukaryotes.**

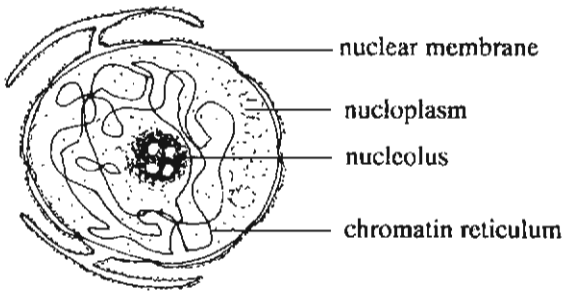



*Fig 15.2.2 Nucleus*

**Nuclear membrane** – This membrane has two layers. Each layer is 90Å in thickness. The gap between the two layers is 100–700Å. This membrane protects the nucleus.

**Chromatin reticulum**: Each species of animals and plants have specific number of chromosomes within the nucleus. During resting stage since there is no cell division the chromosomes are elongate and form the chromatin reticulum.

**Nucleolus**: It is a spherical structure containing DNA or RNA molecules.

**Functions of Nucleus**

1. It controls the activities of the cell.

2. The genes in the chromosomes carry hereditary characters from one generation to the other.

3. The DNA molecules in the genes send information to the ribosomes for the synthesis of proteins. This is done according to the genetical message found in the DNA.

**Some basic concepts**

· The term 'Cell' was first used by Robert Hooke.

· Cell Theory was putforth by Schleiden & Schwann.

· Cell is made up of plasma membrane and protoplasm.

· In plant cells, the cell wall is made up of cellulose. It gives protection.

· In animal cells the Plasma membrane is lipoprotein in nature. It acts as a limiting membrane.

· Golgi bodies are secretary structures.

· Ribosomes are called protein factories.

· Mitochondria are called the 'power houses' of the cell.

· Centrosomes help in cell division.

· Lysosomes are called the 'suicidal bags' of the cell.

· Plasmids help in storage and pigmentation.

· Nucleus is made up of Nucleoplasm, Chromatin reticulum and Nucleolus.

**Self - Evaluation**

**I. Choose the correct answer**

1. Cell theory was postulated by
   i) Rober Hooke ii) Robert Brown
   iii) Purkinje iv) Schleiden & Schwann
2. The 'power houses' of the cell are
   i) Ribosomes ii) Mitochondria
   iii) Lysosomes iv) Golgi bodies
3. The cell organelle found only in the plants is
   a) Plastids b) Nucleus
   c) Centrosome d) Mitochondria

**State true or false**

4. The endoplasmic reticulum is a canalicular structure which connects nuclear membrane with plasma membrane
5. The Ribosomes are called as 'suicidal bags' of the cell.
6. The nucleolus is made up of DNA and RNA.

**Fill in the blanks**

7. Ribosomes synthesize _____.
8. The inner flattened sac like structure found in the inner surface of the chloroplast is called _____
9. $6CO2 + 6H2O \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} \text{———} + 6O2$

**Answer briefly**

10. What is cell Theory ?
11. What is the chemical composition of protoplasm ?
12. What are Eukaryotic cells ?

**Answer in detail**

13. Describe the structure of an animal cell.
14. Explain the structure and function of chloroplast
15. List out the functions of nucleus.

## 15.4. CELL DIVISION

Since cells originate from pre-existing cells, it is commonly stated that 'cells never die". The cells are formed from mother cells by cell divisions. There are three types of cell divisions. All types of cell divisions have 2 main stages. They are

1. **Karyokinesis** – Nuclear division

2. **Cytokinesis**- Cytoplasmic division

### TYPES OF CELL DIVISIONS

1. **Amitosis** (or) **Direct nuclear division**.

This type is common in single celled organisms. During the division the nucleus elongates and constricts in the middle. Later, it divides into two nuclei. The nuclear division is followed by the cytoplasmic division.

**2. Mitosis (or) Indirect Nuclear Division**

In this division the chromosomes are divided and equally distributed from the mother cells to the daughter cells. Thus the chromosome number is kept constant in the daughter cells. Hence, this cell division is known as the 'equalizing division".

This division takes place in 4 stages namely Prophase, Metaphase, Anaphase and Telophase.

1. PROPHASE : In this stage the chromosomes inside the nucleus get spirally coiled and become shorter. The two **centrioles** found inside the **centrosome** divide and move towards opposite poles. From the poles they develop **spindle fibres** towards the centre for dividing the chromosomes. The nuclear membrane and the nucleolus disappear.

2. METAPHASE: The nuclear membrane totally disappears. Except for the centromere, in other regions, the chromosome divides into two. Thus each chromosome comes to possess 4 chromatids. All the chromosomes get arranged in the middle of the cell. The spindle fibres get attached to the centromeres of the chromosomes. Later, the spindle fibres pull the chromosomes to their respective poles. The chromosomes get split at the centromere region and move towards the opposite poles.

3. ANAPHASE : The chromosomes move towards opposite poles. The spindle fibres slowly disappear. The nuclear membrane starts appearing around the chromosomes at both the poles.

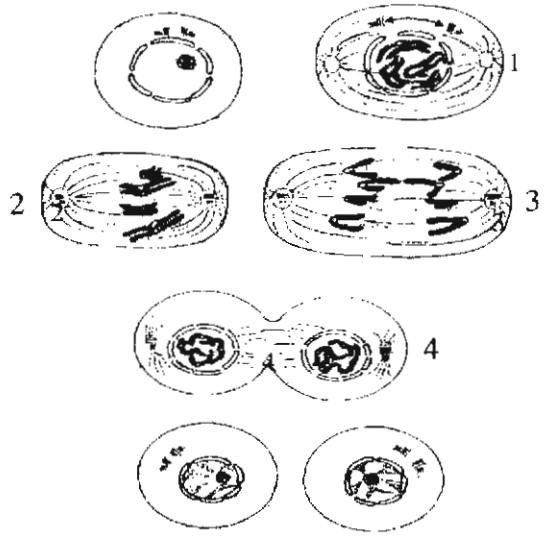



*Fig. 15.4.1 Mitosis cell division*

4. TELOPHASE: The nuclei are fully formed. Each cell now has two nuclei. This division of nucleus is called as **karyokinesis**. Later, in between the nucleus the cell membrane slowly appears. Thus the mother cell, divides into two daughter cells.

Mitotic cell division happens during embryological development, growth and for the renewal of old tissues.

### III. Meiosis or Reduction Division

This division produces male and female sex cells for reproduction in animals and plants. During this division the original chromosome number (2n) gets reduced into half (n) This division helps to keep the chromosome number constant in further generations.

### Some basic concepts

1. Cells are formed from Pre-existing cells
2. While the division of nucleus is termed as karyokinesis, the cytoplasmic division is called cytokinesis,
3. In amitosis the nucleus divides by itself, without any assistance
4. In mitotic cell division the chromosome number is not altered in daughter cells
5. The actual duplication of chromosomes happen during metaphase
6. During Meiosis the chromosome number gets reduced.
7. Meiosis occurs during formation of sex cells.

**Self-Evaluation**

### Choose the Correct Answer

1. The division of nucleus alone is called as

   a) Karyokinesis b) Cytokinesis
   c) Amitosis d) Mitosis

2. The nucleolus and nuclear membrane disappear during

   a) Prophase b) Metaphase
   c) Anaphase d) Telophase

3. The cell division occurring in the formation of reproductive cells is called.

   a) Binary fission b) Mitosis
   c) Meiosis d) Multiple fission

**State true or false**

4) Amitosis occurs in the unicellular organisms.

5) Spindle fibres are formed during anaphase.

6) During meiosis the chromosome is reduced to half the number.

**Fill in the blanks**

7. _____ coined the term mitosis.

8. Two nuclei are seen in the same cell during ____ phase of mitosis.

9. During meiosis the chromosome number in reproductive cells become _____ in nature.

**Answer briefly**

10. What is Amitosis ?

11. What are the changes occurring during Anaphase of mitotic cell division ?

12. What is the significance of mitosis ?

**Answer in detail**

13. Write notes on meiosis.

14. Give an account of Metaphase in Mitosis.

## 15.5 CANCER BIOLOGY

During growth, the body cells divide by mitosis. When the cell divisions become more frequent and uncontrollable, the condition is called as cancer. The cells thus formed are called as cancer cells. The cancer cells may spread all over the body and spread the disease. A study of such cells is called as **Oncology**.

The conversion of a normal body cell into a cancerous cell is mostly due to changes in the nucleus. The rapid cell division in cancer may be due to several stimulants, or inheritance. It may also happen due to viruses.

The abnormal process of cell division if spreads to the neighbouring tissues, the condition is named as **metastasis**. In the first stage, the cancer cells multiply in number. Later, through blood or lymph fluid they may spread to other regions of the body. These cells will affect several organs and cause the death of the person.

### CARCINOGENIC AGENTS

As a result of research several agents that could cause cancer had been identified.

**I. Tobacco usage**: Tobacco used in various forms such as Cigarette, Beedi, Pan products, Snuff etc can cause cancer., Any form of tobacco can directly affect the buccal cavity, pharynx, oesophagus and lungs. Organs like kidney, pancreas and urinary bladder can also be affected.

**II) Food factors:** Processed and smoked food are considered carcinogenic.

**III) Diseases:** Certain viruses can cause cancer. The viruses causing hepatitis (jaundice) are considered carcinogenic. Sexually transmitted diseases can also result in cancer.

**IV) Hereditary factors:** The ***retinoblastoma*** affecting the retina of the eye is considered to be hereditary.

**V) Radiations:** Organs such as breasts, bone marrow and thyroid glands can be affected by radiations. **Blood cancer** or **Leukemia** can be caused due to radiation treatments. The UV rays from sun's light can cause skin cancer.

**VI) Factories:**

| Factory Products | Organs Affected |
|---|---|
| 1. Plastics | Liver |
| 2. Radiations | Several inner organs |
| 3. Benzene | Blood |
| 4. Asbestos | Lungs |
| 5. Arsenic | Lungs, Skin and Liver |

## TYPES OF CANCER

There are 2 types of cancers.

**1. Benign Tumour:** In this type a tumour is formed due to uncontrollable cell divisions. The tumour is localized in a particular organ. It may spread to other organs too.

**2. Malignant Tumour:** It is the most dangerous form of cancer. The cancerous cells start spreading to neighbouring tissues.

## CANCER TREATMENT

For proper treatment, the type of cancer and the extent of spreading should be determined. After confirming the cancerous nature of the tumour, the stage of cancer is assessed. A specialist doctor can make such an assessment and prescribe the treatment procedure.

**1) Surgery:** The cancerous part of the organ affected can be removed by surgical operation.

**2) Radiation therapy:** This treatment is made possible due to the discovery of 'X-rays' by Roentgen (1895) and radiations by Madam Curie (1899). In Radiotherapy radiation from an emitting source is made to fall on the small cancerous region. This treatment can destroy or destabilize cancerous cells.

3) Depending on the intensity of the disease, other treatments like **chemotherapy, hormonal treatment and laser treatment** may be adopted.

Eventhough several treatment procedures are available, an earlier diagnosis will be more effective.

## PREVENTION OF CANCER:

For cancer, the saying 'prevention is better than cure' is more true. An avoidance of cancer causing agents can prevent cancer. A social awareness has to be created in this regard.

1. Usage of tobacco and related products such as cigarette, beedi, snuff, chewing of tobacco, pan masala and related substances should be totally avoided.

2. Consuming large amount of fatty food substances may be avoided.

3. Salted and pickled food are to be avoided.

4. Alcohol drinking is harmful.

5. Avoid places nearer to irradiations.

6. Avoid being a passive smoker by remaining nearer to a smoking person.

7. Consumption of fibrous food, fresh fruits vegetables, vitamin C can be much beneficial.

**Some basic concepts:**

1. The study of cancer is called Oncology.

2. Spreading of cancer to other organs is called metastasis.

3. The factors causing cancer are usage of tobacco smoking, Food preservatives. Diseases, Genetic, Radiation, Industrial Wastes.

4. The types of cancers are Benign and Malignant

5. Treatment of cancer is by Surgery, Radiations and Chemotherapy.

## Self-Evaluation

### Choose the Correct Answer

1. The blood cancer is called

   a) Sarcoma b) Carcinoma

   c) Leukaemia d) Lymphoma

2. The ultraviolet rays from the sunlight causes.

   a) Skin Cancer b) Blood Cancer

   c) Lung cancer d) Bone Cancer

3. Which method is not applicable for treatment of cancer

   a) Chemotherapy b) Hormone therapy

   c) Laser therapy d) vaccination

### Fill in the Blanks

4. The process by which the cancerous cells invade other organs is called _____.
5. The cancer occurring in the retina of the eye is called ____.
6. 'The X-rays' was discovered by _____.

### State true or false

7. The study of tumour is called Oncology.
8. Liver cancer is caused by Asbestos.
9. Consumption of alcohol induces cancer.

### Answer briefly

10. What is Malignant tumour?
11. Explain the method of radiation therapy?
12. What is carcinoma ?

### Answer in detail

13. Explain the different carcinogenic agents.
14. Explain the methods for the treatment of cancer.
15. List out the preventive measures for cancerous growth.

## 15.6 MENDELISM

In living organisms, parental characters are transmitted from one generation to next generation. For example a child looks like the parent; bean plant grows from a bean seed; cat begets kitten. Thus the resemblance of children to their parents is called **heredity**. Sometimes, children differ from their parents in some characters. This is called as **variation. Genetics** is the branch of biology which deals with the concepts and laws controlling heredity and variation.

**Activity:** 1. Tabulate the hereditary characters of living organisms. 2. List out the special genetic characters among yourselves.

Though the branch of genetics started around 1900, it has developed very rapidly. Today we have amazing achievements in the fields of agriculture, horticulture, medicine and also in genetic engineering where genes can be manipulated as we desire. There is an ongoing **gene revolution** with the production of sheep which is now extended to human beings and other animals through cloning technique. 21st century can very well be named as 'Century of Genes". The man who planted the first seeds for this modern development in genetics is **Gregor Johann Mendel,** the great geneticist.

**Activity:** Collect materials related to genetic engineering from media like newspapers, radio and T.V and prepare a handbook.

The principles of Mendel which deal with the functioning of heredity are known as **Mendelism**. Because of his famous hybridization experiments on pea plant (*Pisum sativum*) which laid the foundation for genetics, he was rightly named as **'Father of Genetics'**. (Fig 15.6.1)

### Mendel and his experiments:

Mendel was born on 22nd July 1822, in Heinzendorf, a small village in Czechoslovakia. His father was a poor farmer. After his

*Fig 15.6.1 Mendel*

higher education in 1843, he joined a monastry at Brunn as a monk. From there he was sent to the University of Vienna for higher studies, where he studied mathematics along with science. He worked as a teacher of natural science for sometime. He started his experiments in 1856 to understand the concepts and the functioning of heredity. The main cause for his success was his selection of garden pea plant. Mendel selected this plant because of the following reasons:

1. Pea plants are normally self pollinating.

2. Different types of phenotypic characters are seen.

3. Cross pollination is easy to be carried out.

At the conclusion of his experiments after 8 years (1856-1864), Mendel presented his findings entitled as **'Experiments on hybridization'** at the Natural History Society at Brunn in 1866. At that time, biologists were attracted towards the theory of Darwin and scientists hesitated to interrelate science with mathematics. So, no one realized the significance of Mendel's findings until his death in 1884. At the beginning of 20$^{th}$ Century in 1900, three scientists namely Hugo De vries of Holland, Carl Correns of Germany and Tschermak of Austria made known Mendelian principles worldwide. After that only **Genetics** was considered as a distinct branch of Science.

Mendel observed a number of variations among as many as 34 varieties of pea plants which he cultivated in his garden. Of these, Mendel studied the inheritance of only seven pairs of contrasting characters.

| | | |
|---|---|---|
| 1. Height of the plant | - | Tall/dwarf |
| 2. Position of flowers | - | Axillary/terminal |
| 3. Pod shape | - | Inflated/ constricted |
| 4. Colour of unripe pod | - | Green/yellow |
| 5. Seed shape | - | Round/wrinkled |
| 6. Seed coat colour | - | Grey brown/white |
| 7. Cotyledon colour | - | Yellow/green. |

**Activity:** Examine the parts of different plants and tabulate their different morphological variations.

**Parental Generation**: Mendel selected pure breeding plants with contrasting traits for his experiments as parental generation. A **pure breeding** variety is one which gives rise to the same kind of offspring on self-pollination for any number of generations. Parental generation was given the symbol P.

**First Filial Generation ($F_1$)** : The offsprings raised through artificial cross pollinations between the parental plants are called as First Filial generation or $F_1$ plants.

**Second Filial Generation**: The offsprings raised through self pollination among $F_1$ plants are known as a Second filial generation or $F_2$ plants.

Mendel published his historically significant **monohybrid** and **dihybrid** ratios and basic theories in genetics based on the phenotypic characters and numbers of $F_1$ and $F_2$ progeny. His experimental results became the key to research works carried out by other geneticists.

**Activity:** Find out if there is any phenotypic variation among the plants grown in your garden.

**Vocabulary of Genetical terms:**

**1. Factors or genes:** The units which control the appearance of a particular character.

**2. Phenotype:** External appearance of a particular character.

**3. Genotype:** Genetic constitution of a particular trait.

**4. Alleles:** The members of a gene pair that control the contrasting expression of a single character Eg T and t.

**5. Homozygous:** When the alleles are alike, it is homozygous (TT or tt)

**6. Heterozygous:** When the alleles are dissimilar, it is heterozygous (Tt)

**7. Dominant character** : The character that is expressed in $F_1$ generation.

**8. Recessive character:** The character that is not expressed in $F_1$ generation.

**9. Hybrid:** The offspring produced from the cross between two pure breeding parents.

## MONOHYBRID CROSS:

A cross between two pure breeding plants differing in a pair of contrasting characters is known as **monohybrid cross**. The first filial generation obtained from monohybrid cross is known as **monohybrids.**

Mendel selected the height of the plant as an experimental character for his monohybrid cross. Mendel chose a pure breeding tall pea plant (180 cm) and a pure breeding dwarf pea plant (45 cm) as parental plants. He artificially crossed these two varieties. All the $F_1$ pea plants were tall. Mendel termed the character which is expressed in $F_1$ generation as dominant character. Dwarfness which is not expressed in $F_1$ generation is recessive character. The symbol T was given for tallness and the symbol t for recessive character.

Mendel produced $F_2$ generation through self pollination among $F_1$ hybrids, He got total of 1064 $F_2$ plants. Of these, 787 plants were tall and 277 plants were dwarf. Among the two different expressions, tallness and dwarfness, the phenotypic ratio of the $F_2$ progeny was 3:1.

The genotypic ratio of $F_2$ plants was 1:2:1. In $F_2$ plants, the gene constitution is expressed as pure (homozygous) tall 1, the hybrid (heterozygous) tall 2 and the pure (homozygous) dwarf 1. Punnet explained Mendel's experimental results through a square. It was called as Checker Board.

## MONOHYBRID CROSS

| | Tall | duarf |
|---|---|---|
| Parents | TT | tt |
| gametes | Ⓣ | ⓣ |
| $F_1$ generation | Tt | |
| | Tall | |
| $F_1$ selfed | $\rightarrow F_1 \times F_1$ | |
| gametes | ⓉⓉ x ⓉⓉ | |

male

$F_2$ female

| gamete | Ⓣ | ⓣ |
|---|---|---|
| Ⓣ | TT | Tt |
| ⓣ | Tt | tt |

Phenotype ratio: Tall : dwarf

3 : 1

Genotype ratio:

| Homozygous tall | | Heterozygous tall | | Homozygous dwarf |
|---|---|---|---|---|
| TT | : | Tt | : | tt |
| 1 | : | 2 | : | 1 |

**BACK CROSS:**

A cross between a hybrid and any one of the pure breeding parental type is called a **back cross.**

1. $F_1$ hybrid Tall X Dominant Tall
   Tt x TT

2. $F_1$ hybrid Tall X Recessive Dwarf
   Tt x tt

**TEST CROSS:**

A cross between a hybrid and the pure breeding recessive parent is called as **test cross.**

Hybrid Tall x Recessive dwarf
T t x tt

gametes (T)(t) (t)

| gamete | (t) |
|---|---|
| (T) | Tt |
| (t) | tt |

Test cross phenotype ratio : tall : dwarf 1:1
genotype ratio : Tt : tt 1:1

A test cross is so named because it helps to determine whether an individual with a dominant character is homozygous or heterozygous.

**Acitivity:**

1. Using colour beeds, Teacher can demonstrate Monohybrid cross.

2. Flowers can also be used instead of beeds.

3. Genetics problems can be given as follows: eg. Tomato

Red fruits x yellow fruits.

(Red - dominant, Yellow - recessive)

**DIHYBRID CROSS**: A cross between two pure breeding plants differing in two pairs of contrasting characters is known as **'Dihybrid Cross".**

Mendel chose two pure breeding pea plants differing in two pairs of contrasting characters as parental plants. The pure breeding pea plant with dominant characters of yellow cotyledons (YY) and round seeds (RR) was artificially cross-pollinated with the pure breeding pea plant with recessive characters such as green cotyledons (yy) and wrinkled green (rr). Thus the genotype of dominant and recessive parents were YYRR and yyrr respectively.

The $F_1$ plants obtained from this cross had yellow cotyledons and round seeds. They were called as Dihybrids. The $F_1$ plants were allowed to self - pollinate and $F_2$ progeny was obtained. The phenotypic ratio for the two pairs of experimental characters was 9:3:3:1.

Out of 16 combinations observed in $F_2$ plants, 9 plants expressed yellow and round, 3 plants with yellow and wrinkled, 3 plants showed green and round and one plant expressed green and wrinkled.

Pure breeding dominant parental plant YYRR and pure breeding recessive parental plant yyrr produced Yr and yr gametes respectively. By the fusion of these gametes, $F_1$ hybrid with the genotype YrRr was produced. On selfing, $F_1$ hybrid produced 4 types of gametes. Through punnet square, the combinations of all these gametes and the resulting phenotypes and genotypes of $F_2$ progeny were clearly illustrated.

Parent → Yellow Round x Green wrinkled
YYRR x yyrr

gametes → (YR) (yr)

$F_1$ → Yellow Round YyRr

$F_1$ selfed → YyRr x YyRr

gametes (YR) (Yr) (yR) (yr)

**DIHYBRID CROSS**

| Gametes | (YR) | (Yr) | (yR) | (yr) |
|---|---|---|---|---|
| (YR) | YYRR ● | YYRr ● | YyRR ● | YyRr ● |
| (Yr) | YYRr ● | YYrr ✹ | YyRr ● | Yyrr ✹ |
| (yR) | YyRR ● | YyRr ● | yyRR ○ | yyRr ○ |
| (yr) | YyRr ● | Yyrr ✹ | yyRr ○ | yyrr ☼ |

● Yellow Round ✹ Yellow wrinkled ○ Green Round ☼ Green wrinkled

## LAWS OF MENDEL

### 1. Law of Segregation

Based on his monohybrid cross, Mendel formulated his first law namely Law of Segregation.

This law states that the two alleles in a monohybrid remain together without mixing and separate at the time of gamete formation.

A gamete will carry only one gene of allelic pairs. So this law is otherwise called **Law of Purity of gametes.**

### 2. Law of Independent Assortment

Based on dibybrid cross, Mendel formulated his second law known as Law of Independent assortment.

During the inheritance of more than one pair of contrasting characters, the members of allelic pair get assorted independently. The inheritance of genes of each pair in a dihybrid during gamete formation is independent of one another.

The geneticists followed Mendel's principles and discovered new gene expressions in organisms. Mendelism is used to solve many hereditary diseases. It is remarkable to note that modern branches of genetics such as tissue culture, protoplasmic fusion, genetic engineering, cloning and plant breeding employ Mendelian principles in large measures.

### Some basic concepts

1. Mendel is called as 'Father of Genetics' because of his famous experiments on garden pea plants.
2. Mendel chose the inheritance of seven pairs of contrasting characters in garden pea.
3. Some genetical terms are phenotype, genotype, dominant and recessive, homozygous and heterozygous.
4. The phenotypic ratio of Monohybrid cross is 3:1, the genotypic ratio is 1:2:1
5. The testcross ratio is 1:1. It helps to determine whether an individual showing a dominant character is homozygous or heterozygous.
6. The phenotypic ratio of the dihybrid cross is 9:3:3:1
7. Mendel proposed the first law namely the Law of segregation based on monohybrid experiments.
8. Based on dihybrid cross, Mendel proposed the second law namely the Law of independent assortment.

## Self - Evaluation

**Choose the correct answer:**

1. Pick out the correct pair:

   a) Mendel - Czechoslovakia
   b) Hugo De vries - Austria
   c) Correns - Holland
   d) Tschermak - Germany

2. Which of the following was not the character chosen by Mendel?

   a) Flower position b) Length of stem
   c) Fruit shape d) cotyledon colour

3. Monohybrid test cross ratio:

   a) 1:2:1 b) 3:1
   c) 1:1 d) 9:3:3:1

4. The law based on the dihybrid cross:

   a) law of dominance
   b) law of independent assortment
   c) law of segregation
   d) law of purity of gametes

5. Tt, YyRr, TT is:

   a) homozygous tall, heterozygous tall and homozygous yellow round

   b) heterozygous tall, homozygous yellow round and homozygous tall

   c) heterozygous tall, heterozygous yellow round and homozygous tall

   d) none of the above

**State true or false**

6. The offsprings which arose due to selfing between the parents were called $F_1$ plants.

7. Genotype refers to the genetic constitution of a particular trait.

8. Phenotypic ratio of monohybrid cross is 1:2:1

9. Back cross is the cross between hybrid and recessive parent.

10. Principles of Mendelism are still being employed in modern branches of Genetics.

**Fill in the blanks**

11. The scientists who made known the results of Mendel's work worldwide were _____, _____ & _____.

12. Round and wrinkled are _____ and _____ characters respectively.

13. The members of a gene pair that control the contrasting characters are called _____.

14. Punnet represented the results of Mendel's work in the form of _____.

15. 1:1 is _____ ratio.

**16. Match the following**

| | |
|---|---|
| 1. dominance | a. Law of segregation. |
| 2. purity of gametes | b. phenotype ratio |
| 3. 3:1 | c. branch of genetics |
| 4. genetic engineering | d male gamete |
| 5. pollen | e. ovule |
| | f. Mendel |
| | g. yellow cotyledon |

**Answer briefly**

17. Why Mendel is called as Father of Genetics?

18. What are the phenotypic and genotypic ratios of Monohybrid cross?

19. Define: 1. hybrid 2. alleles

**Answers in detail**

20. Explain the two laws of Mendel.

21. Draw the checker board for dihybrid cross.

# 16. REPRODUCTIVE BIOLOGY

Reproduction is the basic characteristic feature of all living organisms. Due to reproduction organisms are able to survive in any changing environmental condition. There are various reproductive methods in uni and multi-cellular organisms. The methods vary according to the environment, structures and needs. For sexual reproduction, organisms have specific male and female sex organs and specialised sex cells. Basically the success of a species depends on its reproductive capability.

## 16.1 REPRODUCTION - AN INTRODUCTION

The structure and living characteristics of all animals and plants are basically adaptations for successful living and reproduction. Depending on living conditions the methods of reproduction vary in the living world.

### I. Asexual reproduction

For this reproduction there are no sex cells or sex organs. Asexual reproduction can happen through cutting, grafting or through spreading of roots. This type of reproduction can not provide the oppurtunity for mixing up of hereditary characters and production of new varieities.

### II. Sexual reproduction

Both animals and plants have specialised reproductive organs for sexual reproduction. Male and female sex cells are produced from such organs. These cells are produced by meiotic cell divisions. Because of meiosis, the chromosome number remains conastant in subsequent generations. Further, sexual reproduction provides an oppurtunity for producing variations. These variations in turn help animals and plants in their survival.

**Regeneration**:- Regeneration of certain organisms is comparable to reproduction. The organs or structures lost can be regenerated in some animals.

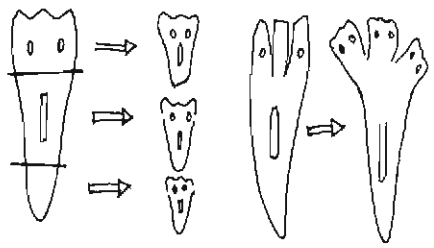


*Fig. 16.1.1 Regeneration of planaria*

Animals like planaria can get split into 2 or 3 pieces and regenerate their lost parts.

### Some basic Concepts

1. There is no possibility for variations in Asexual reproduction
2. Due to meiosis chromosome number remains constant in subsequent generations.
3. Planaria is one good example for regeneration.

## 16.2 PARTS OF A FLOWER

The flower is considered as a condensed modified reproductive shoot. It has a floral axis and consists of nodes and internodes similar to the vegetative shoot. The tip of the floral axis is known as **thalamus** or **torus** or **receptacle**. The floral leaves are arranged on the floral axis.

Generally a flower consists of four whorls of floral parts. The outermost whorl is **Calyx** composed of sepals. The second whorl is **Corolla** made up of petals. These two whorls do not directly take part in reproduction and they are known as **non-essential whorls** or **accessory whorls**. Inner to corolla, **Androecium** is present made up of stamens. The innermost whorl is represented by **Gynoecium** made up of carpels. Since androecium and gynoecium directly take part in reproduction, they are called **essential whorls**.

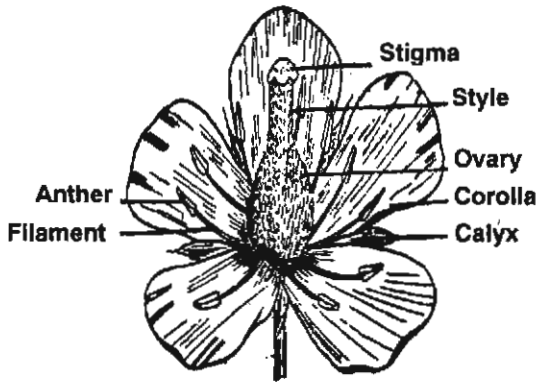



*Fig. 16.2.1 Flower - entire*

If the flower is with stalk or pedicel, it is called as **pedicellate**. If it is without stalk, then it is called as **sessile. Complete** flower is one in which all the four floral parts are present. **Incomplete** flower is one in which any one or more of the floral parts are absent. In **bisexual** or **perfect** flowers both essential whorls are present. In **unisexual** or **imperfect** flowers only one essential whorl namely either the androecium or the gynoecium is present.

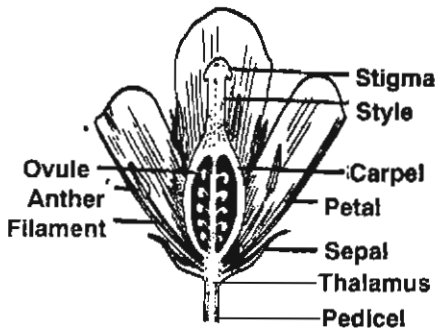



*Fig. 16.2.2 Flower - L.S.*

A flower which can be cut into two exactly similar halves along any vertical plane in said to be **actiomorphic**. (e.g.) Hibiscus. A flower which can be cut into two similar halves only along one particular plane is said to be **zygomorphic**. (e.g.) Crotalaria.

When other parts of the flower are below the gynoecium, the flower is said to be **hypogynous** and ovary is said to be superior. (e.g.) Thespesia. When other parts of the flower are above the gynoecium, the flower is said to be **epigynous** and ovary is said to be inferior. (e.g) Guava.

**Calyx:**

The individual units of calyx called **sepals** are usually green and leaf-like. Calyx protects the floral parts in the bud stage. Sometimes it may be modified to do other functions. In **Mussaenda**, one of the sepals grows out as a large petal like structure. In Asteraceae members, the sepals are hairy, useful in fruit dispersal.

*Fig. 16.2.3 Mussaenda - petaloid sepal*

When the sepals are free, then the calyx is said to be **polysepalous** and when they are united, it is called as **gamosepalous**.

**Corolla:**

Corolla is the second whorl of the flower composed of petals. They are brightly coloured and scented to attract insects for cross pollination. If all the petals are similar in size and shape, it is said to be **regular**. If they vary in size and shape, they are called as

**irregular**. When the petals are free, they are called as **polypetalous**, and when they are united, they are called as **gamopetalous**.

Papilionaceous corolla is an example for polypetalous irregular corolla. There are five petals resembling a butterfly. The posterior petal is large and outermost and is called the **standard** petal. There are two lateral **wing** petals and two anterior united **keel** petals (e.g.) *Crotalaria*.

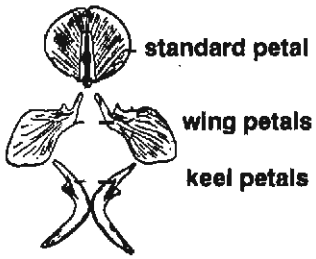



*Fig. 16.2.4 Papilionaceous corolla*

**Perianth :**

In monocots, the outer whorls are not differentiated into calyx and corolla. The individual units of such perianth are called **tepals**. If the tepals are free, they are said to be **polyphyllous** and if they are united, they are called **gamophyllous**.

**Aestivation:**

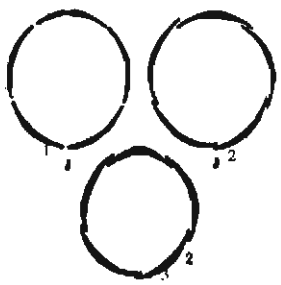


*Fig. 16.2.5 Aestivation*

1. valvate 2. twisted 3. imbricate

Aestivation is the arrangement of sepals or petals in relation to one another in bud condition. There are mainly three types of aestivation.

**Valvate:**

Here the petals or sepals just touch one another without overlapping (e.g.) *Annona*.

**Twisted or contorted:**

Here the sepals or petals overlap one another in a regular manner. (e.g.) Petals of *Hibiscus*.

**Imbricate:**

Here the sepals or petals overlap one another in an irregular manner. This may be ascendingly imbricate as in *Caesalpinia* or descendingly imbricate as in *Crotalaria*.

**Activity:** Take young buds of different plants namely shoeflower, bean flower and Annona. Take cross sections of these buds and see the arrangement of petals and sepals. Collect different flowers and find out the nature of calyx and corolla.

**Androecium:**

Androecium or the male part is the third whorl of the flower and it consists of stamens or microsporophylls. Each stamen has a basal **stalk**, the **filament** and **anther lobes** at its top. It is connected by means of a special tissue called **connective**. Anther lobes contain pollen grains or microspores. When the anthers are two chambered, they are named as **dithecous** and if they are single chambered, they are termed as **monothecous**.

**Union of Stamens:**

In Malvaceae, all the stamens are united to form a single bundle and this condition is said to be **monadelphous**. In **diadelphous** condition, nine stamens are

*Fig. 16.2.6 Union of Stamens-syngenesious*

united to form one bundle and the tenth one remains free (e.g.) Fabaceae. When anthers are united and the filaments remain free, it is said to be **syngenesious.** (e.g.) Asteraceae. In **epipetalous** condition, the stamens are attached to petals as in Rubiaceae.

**Gynoecium:**

Gynoecium or pistil forms the fourth whorl of the flower and it is the female part of the flower. It has a swollen base called **ovary** and a slender **style** that ends in **stigma.** The pistil is made up of one or more carpels. The gynoecium may be monocarpellary (Fabaceae), bicarpellary (Rubiaceae) or multicarpellary (Malvaceae). Monocotyledonous flowers are characterised by tricarpellary ovary whereas dicotyledonous flowers have tetracarpellary or pentacarpellary ovary. If the carpels are free from one another, it is termed as apocarpous pistil (e.g.) *Annona.* When the carpels are united, the pistil is called syncarpous pistil (e.g.) *Hibiscus.*

**Placentation:**

*Fig. 16.2.7 Gynoecium*

The special tissue with which the ovules are attached to the ovary wall is called **placentum.** The distribution of placenta inside the ovary wall is called **placentation.** These are of different kinds namely marginal, axile, parietal and basal.

1. **Marginal placentation:** In a monocarpellary pistil, the ovules are attached to a single placentum on the ventral side (e.g.) *Crotalaria.*

2. **Axile placentation:** In this case, the ovules are found at the inner angles of the placentas. This condition is seen usually in multicarpellary syncarpous ovaries. (e.g.) *Hibiscus.*

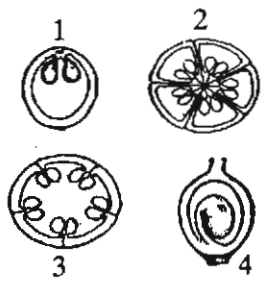



*Fig. 16.2.8 Placentation*

1. Marginal 2. Axile 3. Parietal 4. Basal

3. **Parietal placentation:** Here the ovules are attached to the placentas which are found along the inner wall of the ovary which is unilocular (e.g.) *Cucumis.*

4. **Basal Placentation:** When there is only one ovule at the base of the bicarpellary, unilocular ovary, it is said to be basal (e.g.) *Helianthus.*

**Activity:** Take cross sections of a young ladies finger fruit and a bean fruit and observe the number of carpels inside it and also the types of placentation.

**Some basic concepts**

1. Flower is considered as a condensed modified reproductive shoot.

2. Flower consists of four whorls namely Calyx, Corolla, Androecium and Gynoecium.

3. Calyx consists of sepals; Corolla consists of petals; Androecium is made up of stamens and Gynoecium is made up of carpels.

4. Calyx and Corolla are accessory whorls and Androecium and Gynoecium are essential whorls.

5. Complete flower is one where all the four whorls are present. If any one of them is absent, it is called incomplete flower.

6. In bisexual flowers, both the essential whorls are present. In unisexual flowers, only one essential whorl is present.

7. When calyx and corolla is not differentiated as in monocots, it is called Perianth and the individual units are known as Tepals.

8. Aestivation is the arrangement of sepals or petals in bud condition. There are different types namely valvate, twisted and imbricate.

9. Androecium is the male part of the flower consists of Stamens. Based on the union of stamens, they are classified as monadelphous, diadelphous, syngenesious and epipetalous.

10. Gynoecium is the female part of the flower. Based on the number of carpels, they are known as monocarpellary, bicarpellary and multicarpellary ovaries.

11. The distribution of placenta inside the ovary wall is called Placentation. Marginal, axile, parietal and basal are the different kinds of placentation.

## Self - Evaluation

**Choose the correct answer**

1. Tip of the floral axis is called

   a) petal b) carpel
   c) receptacle d) sepal

2. In *Mussaenda*, a large leaf like structure is produced from

   a) stamen b) petal
   c) petiole d) sepal

3. When the anthers are two chambered, it is said to be

   a) dithecous b) monothecous
   c) syngenesious d) connective

**State true or false**

4. In dicots, calyx and corolla are called perianth.
5. *Crotalaria* is the example for polypetalous irregular corolla.
6. Special tissue connecting the anther lobes is called staminode.

**7. Match the following**

| | | |
|---|---|---|
| 1) Fabaceae | - | i) Monocots |
| 2) Perianth | - | ii) Accessory whorl |
| 3)Valvate | - | iii) Carpels |
| 4) Calyx | - | iv) Syngenesious |
| 5) Gynoecium | - | v) Annona |

**Fill in the blanks:**

8. _____ is the male part of the flower.
9. Tricarpellary ovary is the characteristic feature of _____.
10. Stalk of a stamen is called _____

**Answer briefly**

11. What are essential whorls? Why are they called so?
12. Define bisexual flower.
13. Differentiate polysepalous condition from gamosepalous condition.

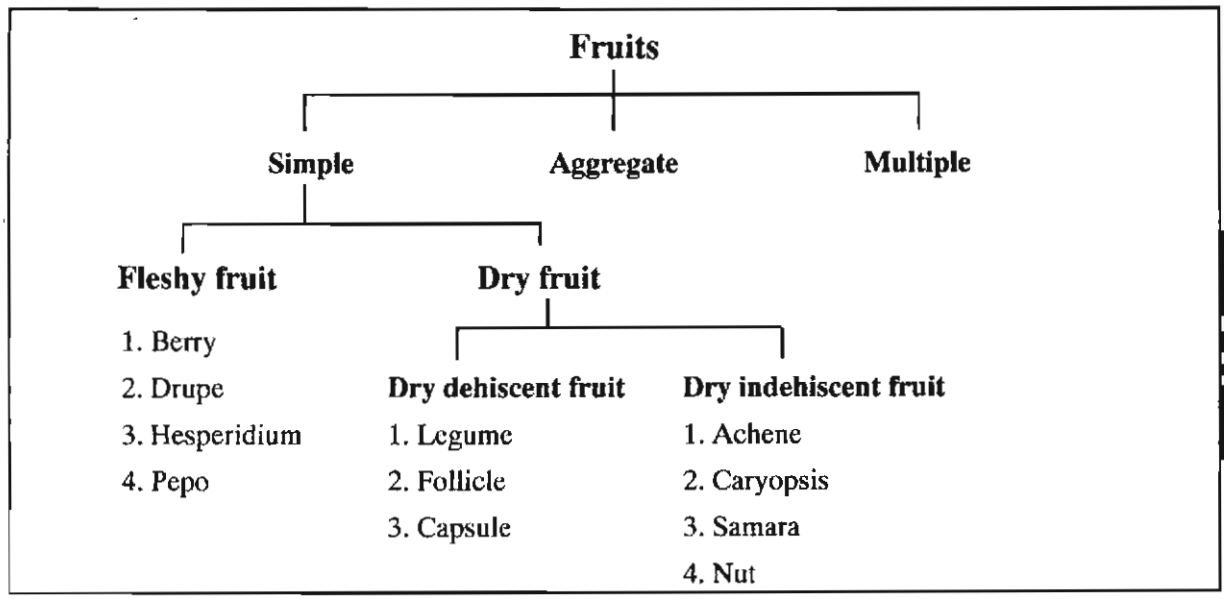
**Answer in detail**

14. Explain the types of aestivation with neat diagrams.
15. Explain papilionaceous corolla with diagrams.
16. What are the different types of placentation?

## 16.3 FRUITS AND SEEDS

After pollination and fertilisation, the ovary of a flower is converted into a fruit and the ovule into a seed. So fruit may be defined as the fertilised and ripened ovary. The three parts of the fruit wall (pericarp) are the outermost epicarp, middle mesocarp and inner endocarp.

Fruits can be classified into three types namely **simple**, **aggregate** and **multiple** or **composite** fruits.




### Simple fruits:

When the fruit is developed from a single pistil, whether monocarpellary or multicarpellary syncarpous ovary, it is known as a **simple** fruit. Simple fruits are of two kinds. Based on the nature of the pericarp, they are classified into **fleshy** fruits and **dry** fruits. In fleshy fruits the pericarp is fleshy, juicy and smooth. In the dry fruits, the pericarp is hard and dry.

Dry fruits are further classified into dry **dehiscent** and dry **indehiscent** fruits. In dry dehiscent fruits, pericarp splits open and liberates the seeds. In dry indehiscent fruits, pericarp will never break open to liberate the seeds.

### Simple fleshy fruits:

Fleshy fruits are normally indehiscent and their seeds are released only after the decay of the pericarp. There are different kinds of fleshy fruits namely Berry, Drupe, Hesperidium and Pepo.

### Berry: (eg. Tomato)

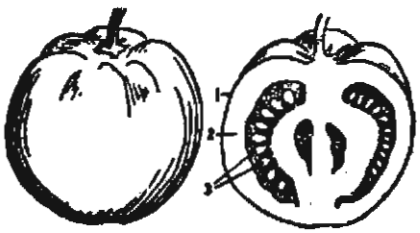



*Fig. 16.3.1 Simple fleshy fruit - Berry - Tomato*

1. Outer epicarp 2. Inner fleshy layer 3. seeds

The fruit is fleshy and is derived from multicarpellary, syncarpous ovary. The pericarp is thick and succulent. It is differentiated into an outer epicarp and inner fleshy layer. The epicarp is thin and forms the skin of the fruit. Mesocarp and endocarp are fused to form the fleshly pulp where seeds are buried. There are many seeded berries as in Tomato and Banana. There are also one seeded berries developing from monocarpellary pistil as in Date.

**Simple dry dehiscent fruits:**

Here the dry pericarp splits or breaks open in order to liberate the seeds. Dry dehiscent fruits are of different types namely legume, follicle and capsule.

**Legume or Pod:**

The fruit is developed from a monocarpellary pistil where the pericarp splits open along both the margins so as to liberate the seeds. The seeds are attached in two rows to the ventral suture of the fruit. (e.g.) Bean.

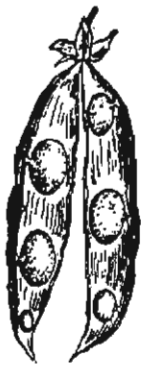


*Fig. 16.3.2 Legume - Bean*

**Dry indehiscent fruits:**

In the dry indehiscent fruits, there is no splitting open of the pericarp to liberate the seeds but the seeds are liberated only after the decay of the pericarp.

**Caryopsis:**

This is a small one-seeded fruit developing from a superior monocarpellary ovary. The pericarp is fused with the seed coat as seen in the cereals. Usually the grain is covered by the persistent bract and bracteoles.(e.g.) Paddy.

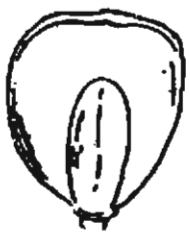


*Fig. 16.3.3 Caryopsis*

**Aggregate fruits:**

An aggregate fruit develops from a single flower with apocarpous pistil. Each free carpel develops into a fruitlet which is attached to a common stalk. (e.g.) Polyalthia.

*Fig. 16.3.4 Polyalthia*

**Multiple or Composite fruit:**

Multiple fruit develops from an inflorescence. Many flowers of an inflorescence combine to give rise to a single fruit. Sorosis is a kind of multiple fruit.

*Fig. 16.3.5 Sorosis*

The fruit is derived from a head of flowers with inferior ovaries. On the surface of the fruit, there are many hexagonal areas. Each area represents the ovary of a single flower. The small circular rings in the centre represent the calyces of the flowers. The remains of the style can be made out in the centre of the circular portion in the form of small dots.

**Seed:**

As a result of fertilization, the ovary and the ovule become the fruit and the seed respectively. Seed is covered by the two seed coats which are formed from the two integuments. Outer seed coat is called as **testa** and the innner one as **tegmen**. Embryo contains the three parts namely radicle (the

rudimentary root portion), plumule (the rudimentary shoot portion) and the cotyledons. Two cotyledons are seen in dicotyledonous seeds and a single cotyledon is seen in the the monocotyledonous seeds. The seeds may be endospermous (e.g.) Castor or nonendospermous (e.g.) Bean.

**Activity:** Collect various fruits and classify them into different types. Collect the pictures of different kinds of fruits and prepare an album.

**Some basic concepts**

1. After pollination and fertilisation, the ovary of a flower develops into fruit and ovules into seeds.

2. Three types of fruits namely simple fruits, aggregate fruits and multiple fruits.

3. Simple fruit is developed from a single pistil whether monocarpellary or syncarpous. There are two kinds namely fleshy fruits and dry fruits.

4. Fleshy fruits are again divided into Berry, Drupe, Hesperidium and Pepo. Example for berry is tomato.

5. The dry fruits are divided into dry dehiscent and dry indehiscent. In dry dehiscent fruits the fruit wall dehisces and liberates the seeds. (e.g.) legume - bean.

6. In dry indehiscent fruits, the seeds are released only after decay of the pericarp. Caryopsis is a type of dry indehiscent fruit.

7. Aggregate fruit develops from a single flower with apocarpous pistil. (e.g.) Polyalthia.

8. Multiple fruit develops from an entire inflorescence from all the flowers. (e.g.) Morinda.

9. The fertilised ovule is called as the seed. The seed coats are formed from the two integuments

**Self - Evaluation**

**Choose the correct answer**

1. Pick out the odd one out:

   a) Berry b) Capsule
   c) Drupe d) Pepo

2. Which of the following is a one seeded berry?

   a) mango b) paddy
   c) date d) cashewnut

3. Name the feature which distinguishes caryopsis from legume

   a) it is a dry fruit
   b) it is a simple fruit
   c) pericarp is fused with the seedcoat
   d) a superior monocarpellary ovary

**State true or false**

4. Aggregate fruit develops from monocarpellary, apocarpous pistil.

5. In berry seeds are embedded within endocarp.

6. Pollination brings about many changes in ovary and ovule.

**7. Match the following**

| | |
|---|---|
| 1) Hesperidium | i) inflorescence |
| 2) Aggregate fruit | ii) dehiscent fruit |
| 3) Date | iii) apocarpous pistil |
| 4) Legume | iv) simple multiseeded fruit |
| 5) Caryopsis | v) single seeded dry fruit |

**Fill in the blanks**

8. Multiple fruit is derived from _____ .

9. _____ pericarp is seen in berry.

10. In paddy, bracts and bracteoles are found as _____ .

**Answer briefly**

11. Define fruit.
12. What are the kinds of fruits?
13. Differentiate between dry dehiscent and dry indehiscent fruits.
14. Why is berry considered as fleshy fruit?

**Answer in detail**

15. Explain the different kinds of fleshly fruits.
16. How do you differentiate legume from caryopsis?

## 16.4 PARTHENOCARPY

Have you ever tasted seedless grapes, guava and pomegranate which are so easily available in fruit markets nowadays? These fruits are produced by a phenomenon called **parthenocarpy**. Parthenocarpy means the development of fruits without pollination or any other stimulus. Noll (1902) first introduced this term. According to the present concept, it refers to the formation of fruit without fertilization (Nitsch 1965).

Parthenocarpy is of widespread occurrence especially among plants which have larger number of ovules in each fruit (e.g.) pine apples, tomatoes, figs and melons.

Parthenocarpy may occur as follows (i) fruit development without any pollination (ii) fruit development stimulated by pollination (iii) seedlessness as a result of the abortion of the embryos before the fruit reaches maturity.

According to Nitsch (1965), there are three types of parthenocarpy namely (i) Genetical (ii) Environmental (iii) Chemically induced.

### i) Genetical parthenocarpy

This type of parthenocarpy is due to mutations or hybridization. An example for this could be seen in oranges which are developed through mutations in an axillary bud. This bud grew out into a branch bearing seedless oranges. Parthenocarpic cucumber is produced by hybridization.

### ii) Environmental parthenocarpy

Parthenocarpy may result due to variation in environmental conditions such as frost, fog and low temperatures. Such environmental conditions interfere with normal functioning of sex organs leading to parthenocarpy. Heavy fog in the month of June caused the formation of seedless olives. If pear fruits are exposed to freezing temperatures for 3-19 hours, they grew into parthenocarpic fruits. Parthenocarpic chilly fruits are obtained by shifting the plants from temperatures of $32^{o} - 38^{o}C$ to $10^{o} - 16^{o}$ C at the time of dehiscence of anther. Parthenocarpy is induced in tomatoes with low temperatures and high light intensity. Under these conditions, pollination is poor.

### iii) Chemically induced parthenocarpy

Plant hormones such as auxins and gibberellins in low concentrations have been very successfully employed to induce parthenocarpy in many plants which normally bear seeded fruits. These are applied in the form of paste or sprays. As a result of artificial pollination, most of the guava varieties developed ,into seeded fruits except an 'Allahabad Round' variety. In this variety, parthenocarpy could also be induced by treating the emasculated flowers with an aqueous extract of pollen. This "**pollen hormone**" effect could be duplicated by the application of indole acetic acid and indole-butyric acids. Other plants where auxins could bring about parthenocarpic development of fruits include tomato, black berry, figs cucurbits and citrus. Gibberellic acid has been reported to induce parthenocarpy in a number of rosaceous fruit trees, grapes, figs and tomato.

It has been suggested that for the induction of parthenocarpy through auxin treatment, the growth substance should be applied sometime after anthesis (dehisence of anthers) because an early application may damage the flowers and cause seed abortion and consequently fruit drop. On the contrary, gibberellic acid is applied preferably at anthesis.

Parthenocarpy finds its importance in horticulture because seedless fruits are ideal for consumption either as such or in the juice and jam industries. Parthenocarpy may also increase proportion of edible part of the fruit.

**Some basic concepts**

1. Parthenocarpy means the development of fruit without fertilization.

2. There are three types of parthenocarpy namely (i) genetical (ii) environmental and (iii) chemically induced.

3. Parthenocarpic cucumber is produced by hybridization.

4. Environmental conditions such as frost, fog and low temperatures are responsible for environmental parthenocarpy.

5. Plant hormones such as auxins and gibberellins in low concentrations induce parthenocarpy in many plants.

6. Parthenocarpic fruits increase the proportion of edible part of the fruit and also useful in juice and jam industries.

**Activity:** Find out the names of the different seedless fruit varieties like tomatoes, guavas, grapes, oranges, pomegranates from the horticulture or agriculture department and also the methods by which they are produced.

## Self - Evaluation

**Choose the correct answer**

1. Which of the following is not a type of parthenocarpy?

   a) genetic  b) environmental
   c) physical  d) chemical

2. Parthenocarpy refers to the formation of

   a) seeds without fertilization
   b) fruits without pollination
   c) seeds after fertilization
   d) fruits without fertilization.

3. In tomatoes, parthenocarpy could be induced with

   a) high temperature and low light intensity
   b) low temperature and low light intensity
   c) low temperature and high light intensity
   d) high temperature and high light intensity.

**4. Match the following**

| | |
|---|---|
| 1) hybridization | i) tomatoes |
| 2) fog | ii) guava |
| 3) low temperature | iii) citrus |
| 4) artificial pollination | iv) cucumber |
| 5) auxins | v) olives |

**Fill in the blanks**

5. Genetic parthenocarpy arises due to _____ or _____.

6. Variation in the environment interferes with the normal ____ of sex organs.

7. Parthenocarpy finds its importance in _____.

**Answer briefly**

8. What is parthenocarpy ?
9. Name any four environmental factors which bring about parthenocarpy.
10. What is pollen hormone effect ?

**Answer in detail**

11. Write about any two types of parthenocarpy.
12. Why auxin treatment should be given after anthesis?
13. Give reasons to say parthenocarpy is important in horticulture.

## 16.5 SEXUAL REPRODUCTION IN ANIMALS

There are various methods of sexual reproduction in different groups of animals. These methods are progressive in nature.

In **Paramoecium**, a Protozoan, sexual reprdocution happens by a simple union or **conjugation**. There are no sex organs or sex cells in Paramoecium. During sexual reproduction, two Paramoecia come nearer to each other and get attached. The cell membranes in between them get dissolved. The nuclear contents are exchanged and fertilisation results.

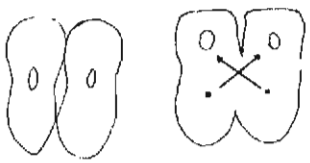


*Fig. 16.5.1 Paramoecium - conjugation*

In animals like **Hydra**, testes and ovaries are formed as temporary reproductive organs. After reproduction these organs disappear.

**Tapeworms** and **liverflukes** are bisexual. The reproductive organs are well developed in these worms. These organs can produce enormous number of eggs. Reproduction happens either by self fertilisation or cross fertilisation through copulation.

**Earthworms** are bisexual. Each earthworm has both male and female reproductive organs. Sexual reproduction happens by copulation between two worms.

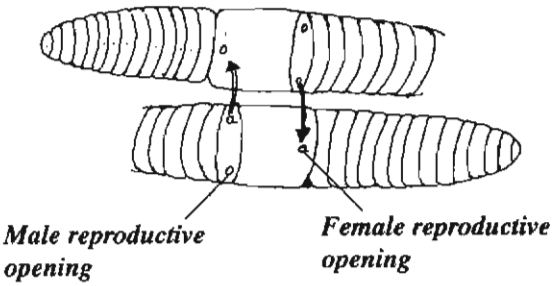



*Fig. 16.5.2 Earthworms - copulation*

**Arthropods, Molluscs, Echinoderms** and **Vertebrates** are unisexual. The male and female organisms can be externally identified. The sex organs and associated structures are well developed in males and females. This phenomenon of distinctiveness in male and female structure is known as **'sexual dimorphism'**. The external dimorphism is due to **'secondary sexual characters'**. The primary sex organs are the **testis** and **ovary**.

**Some basic concepts**

1. Most of the animals adopt sexual reproduction.
2. **'Conjugation'** is the reproductive method in Paramoecia.
3. The reproductive organs are not permanent in Hydra.
4. In earthworms reproduction happens by copulation.
5. The 'physical differences' between males and females is called as **'sexual dimonphism'.**

## 16.6 SEXUAL ORGANS IN HUMANS

As in other animals, human beings also have sex organs for reproduction. These organs produce male and female sex cells. An union of **male** and **female sex cells** is known as **fertilisation**. It results is a **zygote** that could develop into an **embryo**.

**Male Sex organs:**

**1. Testis**:- A male has 2 **testes**. They are found inside the scrotum. Each testis is made up of 15-20 small lobes. Each lobe contains **seminiferous tubules** and interstitial cells. The sperms are collected and stored in **epididymis** found above the testis.

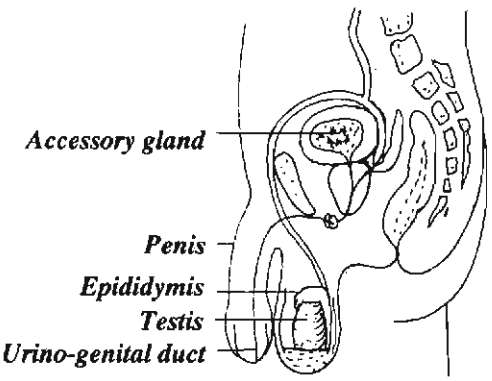



*Fig. 16.6.1 Male reproductive organ*

**2. Sperm ducts**:- The sperm ducts from the testes open into the urinary duct. The common duct in turn opens into the canal inside the male copulatory organ called the **penis**. Penis is used for voiding of urine and ejaculation of sperms.

**3. Accessory glands**:- These glands provide the fluid material needed for the swimming movement of the sperms.

Thus, the male reproductive organs are more sophisticated and well developed structures. Immoral practices, infestation by sexually transmitted diseases may cause problems in the functioning of sex organs. However, a moral and hygenic life can avoid troubles.

**Female reproductive organs:**

The important sex organs are the ovaries. They are found in the lower part of the abdomen. Each ovary is made up of several filamentous follicles. The cells of the follicells produce the ova. The ovum passes down through the oviduct and reaches the uterus for fertilisation. The uterus opens into the vagina, a passage for the entry of sperms. After fertilisation the Zygote or egg gets implanted in the inner wall of the uterus. Later, the egg develops into an embryo.

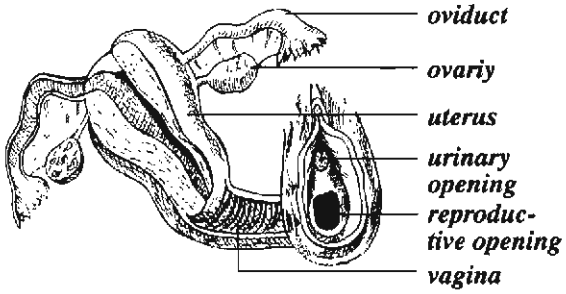



*Fig. 16.6.2 Female reproductive organ*

The preparation of the uterine wall for the implantation of the egg happens in a 28 days cycle. In this cycle, if there is no fertilisation, the inner wall of the uterus peels off. It is sent out along with blood discharge. This cyclic event is called as the **'menstrual cycle'**. A similar cycle happens in other mammals in a slightly modified manner. It is called as the oestrous cycle. It should be realised that menstrual cycle is a normal physiological process.

**Problems related to Adolescence and Maturation**

The period of life in between childhood and adult stage is called as the **'adolescent period'**. In females, this stage is attained at 9-10 years of age and in males at 12 or 13 years of age. It is a critical period for youngsters. During this period several bodily changes happen. Changes can also happen in behaviour, emotions and intellect. These changes are very rapid.

Such changes happen due to hormones secreted by pituitary glands and reproductive organs.

An 'adolescent' is emotional in nature. Certain misconceptions and related problems can also arise during this stage of human development. An understanding of the following characteristics is essential.

**14-19 years of age:**

* Physical features of males and females get developed.
* Initially the growth rate in females is more than that of the males. In later stages the males can outgrow the females.
* Emotional upsets and anger may happen as normal psychological responses. Youth can learn to control such behaviour and realise that human relationships are more precious.
* There is a need for making conscious efforts to avoid confrontation with friends and others.
* Positive attitudes can be developed even on facing failures. Youth can know that every success shall be preceeded by failures.

  This is the period to develop self-esteem. It will help to fix a goal in life and avoid worries and confusions.
* A healthy attitude and thinking will provide good friendship with members of the opposite sex.
* The following bodily changes that happen during this period are to be accepted as normal growth processes.

**Girls:**

1. The development of breasts as milk secreting glands. This happens between 8 - 13 years of age. It is a natural growth process.
2. There is an enlargement of the pelivic region. It is essential for future child bearing.
3. There is sudden increase in height.
4. Hairs grow in specific regions of the body.
5. The first menstrual event happens.
6. The sweat glands and oil glands are activated. It may be a cause for having pimples on the face.
7. The development of reproductive organs gets completed.

**Boys:**

1. The testis grow in size.
2. Hairs grow in specific regions of the body
3. There will be release of seminal fluid.
4. There will be a rapid growth in body organs.
5. The larynx enlarges and causes changes in the voice.
6. The sweat glands and oil glands are activated. It may be a cause for having pimples on the face.
7. There will be a growth of facial hairs.

The adolescents have to realise that all the above mentioned changes are common to all. However the rates of changes need not be similar for all.

The following practices such as playing, getting involved in music, poetry, reading and art and other hobbies, Yoga and transcendental meditation can control and tune up the mind for achieving success in life.

**Some basic concepts**

* The testes are found in the scrotum
* The sperm cells are stored in the epididymis.
* In females there are 2 ovaries.
* The functions of sex organs are controled by hormones.
* The duration of the menstrual cycle is 28 days.
* The adolescent period commences at the age of 9 or 10 in females and 12 or 13 in males.
* There are several problems related to adolescence.
* All problems are natural and controllable.

## Self - Evaluation

**Choose the correct answer**

1. Unique characteristic feature of Planaria is

   a) Binary fission b) Multiple fission
   c) Regeneration d) Sporulation

2. The type of sexual reproduction found in paramoecium is

   a) Conjugatioun b) Budding
   c) Sporulation d) Encystment

3. In human, male reproductive system the sperms are stored in

   a) Testes b) Epididymis
   c) Scrotum d) Urino-genital duct

**State true or false**

4. The period between childhood and adult is called the adolescent stage.
5. In asexual reproduction there is chance for the origin of new species.
6. Fallopian tube carries eggs to the uterus.

**Fill in the blanks**

7. Earthworm and other annelids are ____in nature.
8. Presence of testes and ovary are ____ sexual characters.
9. From the Zygote ____ develops.

**Answer briefly**

10. What is asexual reproduction ?
11. What is sexual dimorphism ?
12. What is the function of associated glands in male reproductive system?

**Answer in detail**

13. Explain the structure of male reproductive system.
14. Give an account of the structure of ovary.
15. What are the problems occuring during adolescence.

# 17. DISEASES AND THEIR CONTROL

In nature several factors affect the normal life of living organisms. These factors include biological agents too. In human beings diseases cause many problems and may even lead to death. The research works in the fields of agriculture, veterinary science and medicine have made amazing progress in the areas of transmission, diagnosis, treatment and prevention of diseases. Yet there is need for further research in these areas as we encounter new diseases in recent times.

## 17.1. PLANT DISEASES

Plant diseases are mainly due to negative interactions between host and pathogen or between host and unfavourable environmental factors. Due to these, many symptoms are produced in plants. These diseases may be classified according to their causal agents which include bacteria, viruses and fungi.

**Viral diseases:**

Bunchy top of banana, leaf roll of potato and tobacco mosaic.

**Bacterial diseases:**

Citrus canker, Wilt disease of carrot and Leaf blight of paddy.

**Fungal diseases:**

White rust of crucifers, Wheat rust, Red rot of sugarcane and Late blight of potato.

In this chapter we will learn about citrus canker (bacterial disease) and white rust of radish (fungal disease).

**1. Citrus Canker:**

This is a common disease occuring in citrus plants.

**Pathogen:** *Xanthomonas citri*

**Systematic position:**

**Class** : Schizomycetes (Bacteria)

**Order** : Eubacteriales.

**Family** : Xanthomonadaceae

The causal organism *Xanthomonas citri* is a short, rod shaped organism, with a single polar flagellum. It is about 1.5 – 3 μ long and 0.5 – 1.5 μ broad. It is gram negative and is strictly aerobic.

**Symptoms: (Fig. 17.1.1)**

The diseases affects the leaves, twigs, thorns and fruits. All green parts and maturing fruits become more or less covered with brown scabby spots surrounded by dark brown glassy margins. The lesions appear as

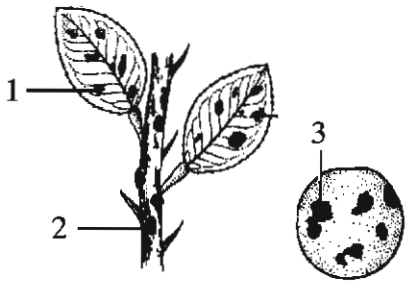



*Fig.17.1.1 Citrus Canker*

1. Canker in leaves 2. in stem 3. in fruit

small yellowish spots, which enlarge to a diameter of 3 or 4 mm and become raised and turn brown. The market value of the fruits is reduced because of the appearance of scabby lesions.

**Disease Cycle: (Fig. 17.1.2)**

Bacteria enter the host through stomata, lenticels and wound. They perennate in the affected host tissues. The inoculum is disseminated by wind, rain and sometimes by insects. But the disease is commonly disseminated through infected nursery stock. Mild temperature accompanied humid condition is very favourable for the disease. The most suitable range of temperature for the disease is between 20°C and 35°C.

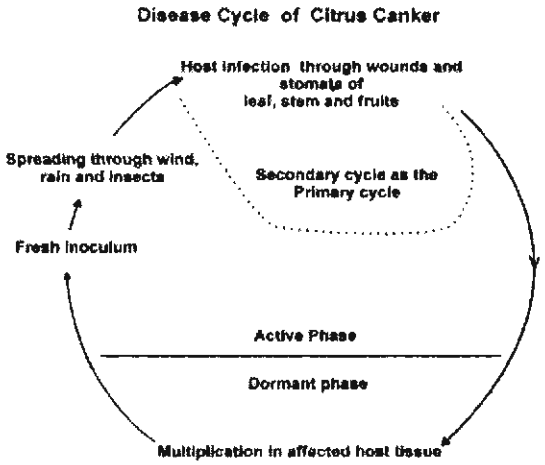



*Fig. 17.1.2 Citrus Canker - Disease cycle*

**Control measures:**

1. Pruning of infected twigs and foliage.
2. Burning of diseased parts.
3. Spraying of neem cake at the rate of about 7 kg per acre.
4. Spray application of Bordeaux mixture and lime sulphur are quite effective. It should be done during the first three months of the development of fruits.
5. Cultivation of disease resistant citrus varieties.

**2. White Rust in Radish:**

White rust is the most common fungal disease of radish and other crucifers.

**Pathogen:** *Albugo candida*

**Systematic position:**

| | | |
|---|---|---|
| **Class** | : | Oomycetes |
| **Order** | : | Peronosporales |
| **Family** | : | Albuginaceae. |

The fungus is an obligate parasite reproducing both asexually and sexually. It forms an intercellular aseptate mycelium which produces knob shaped haustoria inside the host cells to draw the nutrients. Numerous short **conidiophores** arise from the mycelium arranged in rows beneath the host epidermal layer. These press on the epidermis to cause pustules. **Conidia** (also called sporangia) are formed in the form of chains and they are spherical, thickwalled, hyaline and inter-connected by a pad of gelatinous disc like tissue called **isthmus**.

*Fig. 17.1.3 White Rust pustules on the leaf*

**Symptoms: (Fig. 17.1.3)**

The disease is characterized by the formation of rust like white pustules on the leaves and stem. They are raised from the surface and are 1-2mm in diameter. Often several pustules coalesce to form large irregular erupted patches. The host epidermis ruptures easily, giving a white powdery appearance to the lesions. The infection is mostly seen on the lower surface of the leaves, but sometimes it may also be found on the upper surface. The root tuber yield may also be considerably reduced.

**Disease cycle: (Fig. 17.1.4)**

The fungus produces localized rust pustules on the host resulting in masses of sporangia, which spread through the air causing secondary infection in the field, repeating the cycle several times in a season.

Under dry conditions due to nonavailability of water, the spores function as conidia. These germinate into hyphae. In the presence of water and proper moisture, the spores behave as zoosporangia, producing zoospores. These zoospores may swim in the water droplets and each one,causes infection.

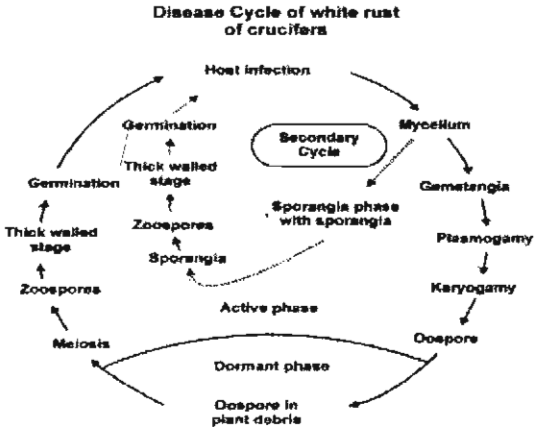



*Fig. 17.1.4 White rust - Disease cycle*

**Control measures**

It is difficult to control the disease because of the strictly parasitic nature of the pathogen. Since the damage caused is not much of economic significance, no control measures have been worked out so far. Wherever the disease occurs in severe form, the affected plants may be cut and burnt. Spraying of 0.8% Bordeaux mixture is also very effective. The susceptible weeds are destroyed and crops are rotated.

**Activity:**

1. Collect the affected parts of citrus, namely stem, leaf and fruit and observe the canker symptoms.

2. White rust is common among the greens. Collect the affected leaves and observe the pustules.

**Some basic concepts**

1. Plant diseases are classified according to their causal agents such as (i) bacterial diseases (ii) viral diseases (iii) fungal diseases.

2. Citrus canker is caused by *Xanthomonas citri*. The disease affects the leaves, twigs, thorns and fruits producing canker spots on them. The market value of the fruit is reduced because of these lesions.

3. It can be controlled by burning diseased parts and by spraying neem cake.

4. White rust is the common fungal disease of radish caused by *Albugo candida*. Masses of conidia are formed in chain like manner.

5. It is difficult to control the disease because of the strictly parasitic nature of the pathogen. The affected plants may be cut and burnt.

## Self - Evaluation

**Choose the correct answer**

1. Citrus canker is caused by a
   a) bacterium b) fungus
   c) virus d) nematode
2. Which is not true of *Xanthomonas citri*?
   a) Short rodshaped organism
   b) Strictly anaerobic
   c) Single polar flagellum
   d) pathogen of citrus
3. Albugo is said to be an obligate parasite because
   a) It reproduces asexually and sexually.
   b) It forms intercellular aseptate mycelium.
   c) It produces knobshaped haustoria.
   d) It gets its food only from living tissues of the host.

**Say true or false:**

4. Bunchy top of banana is a viral disease.
5. Citrus canker is commonly disseminated through insects.
6. Sporangia of Albugo are spherical, thinwalled and hyaline.

**7. Match the following:**

| | |
|---|---|
| 1. Leaf blight | - fungus |
| 2. Leaf roll | - active phase |
| 3. Late blight | - paddy |
| 4. Inoculum | - aseptate |
| 5. Mycelium | - dormant phase |
| | - potato |

**Fill in the blanks:**

8. Xanthomonas belongs to the order _____.
9. The sporangia in Albugo are connected by _____.
10. Zygote of Albugo is also known as _____.

**Answer briefly:**

11. Name some viral diseases of plants?
12. What are the control measures of white rust?
13. What are the symptoms of citrus canker?

**Answer in detail:**

14. Explain the disease cycle of citrus canker.
15. What are the symptoms of white rust?

## 17.2 HUMAN DISEASES

Healthy feeling is a state of mind. Healthiness is due to good feeding, protected surrounding and being free from infections. A disease may be considered as a deviation from a normal healthy state. A disease may affect an organ, a particular region of the body or entire body. The diseases are of two types. They are 1. Non-communicable 2. Communicable

**Non communicable diseases:**

These diseases are caused due to defective metabolic processes or defects in the functioning of organs within the body or damage to organs and organ systems. Such diseases can also be caused due to life style and changes in the environment. Inadequate nutrients in feeding can also cause non-communicable disease. These diseases can easily be diagnosed. If proper care is taken at an early stage, they can be controlled.

**Communicable diseases:**

These diseases are due to infections caused by disease producing agents such as viruses, bacteria, protozoans, helminthic worms and fungi. The invention of microscopes has greatly helped us to identify the causative organisms and diagnose the disease. Such studies have also helped us to provide effective treatments or 'therapy' Several organic chemicals obtained from natural sources are found to be antibiotic. Suitable application of an antibiotic can control the disease.

The perpetual continuance of the causative organism is due to various transmission methods. The transmission could be either biological or non-biological. The **biological transmissions** are caused by intermediary agents such as mosquitoes, houseflies, dogs, cats etc., **Non biological transmissions** may be due to agents such as water, air, soil and clothing. Physical contact between humans can also transmit diseases.

The disease causing organism is called a **pathogen**. The infected organism is called as the **host**. Pathogens have host specificity. After entering the body of a host the pathogen may require an **incubation period**. During this period and during the period of infection the pathogens release toxic substances. These are called **antigens**. The host body produces certain proteins to suppress the harmful effects of the antigen. These substances are called **antibodies**.

The **'antigen-antibody reaction'** is very much specific. In this reaction the infected host may develop resisistance to the disease. This is known as **Immunity**. If the immune system is weak or it fails, the disease is expressed and the host suffers.

### TUBERCULOSIS (T.B)

This disease is caused by a bacterium called **Mycobacterium tuberculosis**. The most common form of T.B is pulmonary tuberculosis. It affects the lungs in many ways.

1. **Primary tuberculosis**: In 95% of the cases it is silent. It occurs in non-immune individuals. The risk of infection is due to closeness and duration of the patient's contact with the carrier. Coughing and sneezing of the carrier can spread the disease.

Tuberculosis is identifed by cough, moderate fever and sweating. It can be confirmed by X-rays and tuberculin skin test.

2. **Miliary tuberculosis**: This disease spreads to many organs. It affects 3-6 months after primary infection.

**Treatment:**

1. One of the earliest practice for T.B. Treatment was isolating the patients and make them live in a healthy surrounding.

2. There are good drugs available. These drugs act against both inter and extra cellular ***M. tuberculosis.***

## CHOLERA

Cholera is charactersed by severe diarrhoea and vomitting. Hence there is a great loss of body fluid. It results in body dehydration and muscular cramps. Death may be caused due to renal failure.

The causative organism for cholera is a bacterium called ***Vibrio cholerae*** or 'Comma bacillus'. This bacterium produces a toxic substance, which causes accumutation of fluid in the intestine. The incubation period of this bacterium is 1 - 2 days.

**Diagnosis:** Microscopic examenation of the 'rice-water stool'.

As a preventive method vaccines obtained from killed bacteria are available.

## ANTHRAX

This disease normally affects sheep and cattle. In these animals the lungs, spleen may be affected. It is not a common disease in man. Only persons who work with animals have a chance of getting infected. In man the disease affects skin, lung and the intestine. Of the three the respiratory(lung) anthrax is more harmful.

The disease is caused by a bacterium called "Bacillus anthracis". It spreads by production of spores.

## LEPROSY

The disease Leprosy or Hansen's disease is caused by the bacterium ***Mycobacteruim leprae***. These bacteria normally affect the skin. The skin on exposed parts of the body such as face, hands, arms and legs are normally affected. Initially it starts as insensitive white patches. The children are more prone to infection. The incubation period ranges from 2- 4 years.

Treatment: Fortunately leprosy can be cured and controlled. Effective drug therapy is available.

## LEPTOSPIROSIS

This discase is caused by the microrganism ***Leptospira*** sp. Its infestation is characterised by high fever. A continuance of the disease affects most of the visceral organs. Human infection is mostly due to water containmented by urine of animals such as rats. Infection can also occur as a result of bathing in infected water. Infections may be caused through cuts and lacerations of the skin.

Diagnosis is done by blood studies. The treatment involves administration of antibiotics.

## HIV / AIDS

The name AIDS is an acronym formed from the following words.

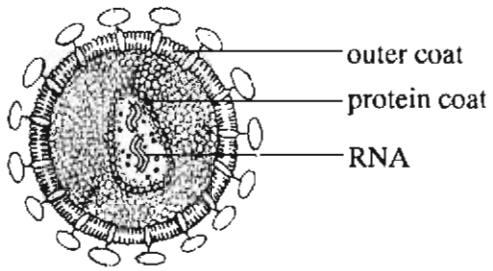



*Fig. 17.2.1 HIV*

**A**cquired - Characters obtained during life time.
**I**mmune - Bodily resistance to infections.
**D**eficiency - Short coming or inadequate
**S**yndrome - A collection of symptoms

The disease AIDS is caused by HIV (Human Immunodeficiency Virus) The

charactertic and dangerous nature of this virus is the destruction of body's immune systems. Hence a person infected by HIV can get affected very easily by other lethal diseases. The body completely loses its protection.

HIV is called as a retrovirus containing RNA (Ribose nuclic acid)

It is surrounded by a protein and a lipid coat. In our blood it selectively infects specific white blood cells responsible for immune defence system. It can also affect nerve cells directly.

**Transmission:** It is conclusively proved that the modes of transmission are sexual, parenteral and mother to child in the uterus. The parenertal tramission involves tranfusion of infected blood or use of contaminated needles and syringes.

**Symptoms:** After infestatation it may take 6 months to many years to observe symptoms of AIDS. Some people appear healthy for a long time and function as 'carriers'

**Major symptoms:**

1.Weight loss 2. Prolonged Fever
3.Chronic diarrhoea 4. Night sweat

**Diagnosis:**

The easiest and cheapest method of diagnosis is testing blood by **ELISA** (Enzyme Linked Immuno Sorbent Assay) The confirmatory test is the expensive **Western Blot Test.**

**Prevention of AIDS**

Since no specific drug to cure AIDS has been discovered the only alternative is prevention of infection. It can be prevented by

1. Avoiding improper / illicit sexual practices.
2. Insisting on usage of sterile, disposable needles and syringes.
3. Obtaining proper reproductive health education.
4. Ensure screening of blood before transfusion.

**Some basic concepts**

1. Healthy feeling is a state of mind.
2. The diseases are classified into non-communicable and communicable diseases.
3. Non communicable diseases may be due to defective metabolic processes. Communicable diseases are due infection caused by disease producing agents (Pathogen).
4. The substances produced in response to antigen is called antibody.
5. Tuberculosis is caused by ***Mycobacterium tuberculosis.***
6. Cholera is caused by ***Vibrio cholerae.*** It can be treated by oral rehydration and administration of drugs.
7. Anthrax is caused by ***Bacillus anthracis*** and can be treated by antibiotics.
8. Leprosy is caused by **Mycobacterium leprae** and can be treated by drugs.
9. Leptospirosis is treated by antibiotics.
10. AIDS is caused by HIV. It has symptoms.
11. Diagnosis is done by ELISA test and confirmation by Western Blot technique.

## Self - Evaluation

**Choose the correct answer**

1. Dehydration is a symptom of
   a) tuberculosis b) Cholera
   c) Leprosy d) Anthrax
2. The disease causing organism is called a / an
   a) Pathogen b) Antigen
   c) Antibody d) Host
3. The confirmatory test for AIDS is
   a) X-ray b) Biopsy
   c) Western Blot test d) ELISA

**Say true or false**

4. Syndrome is the collection of symptoms
5. *Bacillus anthracis* spreads Leptospirosis.
6. Cholera is caused by comma bacillus

**Answer briefly**

7. What are communicable diseases ?
8. What is Immunity ?
9. What are the major symptoms of AIDS

**Answer in detail**

10. Give an account of Anthrax
11. Provide the symptoms and treatment for cholera
12. Give an account of non-communicable diseases.

# 18. OUR ENVIRONMENT

All living organisms are the components of Nature. Hence no organism can survive independently. Any change in natural environment will affect living organisms directly and produce harmful effects. Thus the study of living organisms in relation to its surrounding has developed into an unique branch of science called **'Environmental Biology'**. This discipline enables an understanding of the interrelationships between organisms and environment. Further, a study of food chain and food web helps us to understand the interdependent nature of all living organisms. The advancements in this field have enabled progress in agriculture, aquaculture and other useful practices. Through this science, conservation of nature and natural resources becomes a reality.

## 18.1 ECOSYSTEM

Environmental pollution, over population, communicable diseases, newer pests and loss of natural resources are today's global problems. Mankind is interested in solving these problems. So there is an urgent need for us to understand our environment properly. Life is interdependent at all levels with our environment.

The place where an organism lives is called its **habitat**. The different species living in a habitat form a **community**. The community with its natural surroundings is called an **ecosystem**. An ecosystem is the basic functional unit of biosphere.

### Types of Ecosystems

Our planet earth itself is considered as a unique, giant ecosystem. This is also called the biosphere or the ecosphere. It is divided into two major kinds.

### I. Natural ecosystem

The ecosystem which operates by itself under natural conditions is known as natural ecosystem.

Based upon the particular kind of habitat, these are divided into two groups such as

A) Terrestrial ecosystem and

B) Aquatic ecosystem.

**Activity:** Find out other ecosystems in your school environment.

**A. Terrestrial ecosystems:** (Examples) deserts, grasslands, and forests.

**B. Aquatic ecosystem:** It is classified into two types.

**1.Fresh water or limnetic ecosystem:** This ecosystem is further divided into

i) **Lentic:** Here the water is stationary as in a pond or lake.

ii) **Lotic:** In this type, the fresh water flows as in a river or stream.

**2. Salt water or marine ecosystem:** this includes seas, oceans, coral reeves and the estuaries.

### II. Artificial ecosystem:

This is operated by man. It is of two types,

1. Cropland – (eg) Rice field
2. An Aquarium

**Activity:** Find out the working principle of an aquarium at home.

**Components of an ecosystem**

An ecosystem has two major interacting components. (a) abiotic and (b) biotic

**(a) Abiotic component:** The nonliving components which are essential for the maintenance of the ecosystem include:

(1) the energy of sunlight.

(2) different types of inorganic compounds like water and salts like $SO_4$, $NO_3$, $PO_4$ of different elements like Ca, K, Na, Mg

(3) atmospheric gases like $CO_2$, $O_2$, $N_2$

(4) climatic factors like Temperature and humidity.

**(b) Biotic Component**: This component consists of both micro and macroorganisms. The two major biotic components are plants and animals. The biotic component has many levels and each level is referred to as the **trophic level.**

All plants which are capable of synthesizing their own food are called as the **producers**. These are considered as **first trophic level**. They generate the energy needed for the functioning of an ecosystem.

All other biotic forms are called **consumers**. They cannot make their own food. They are:

i) macroconsumers
ii) microconsumers

**i) macroconsumers:** They are large sized organisms. They are included under the following three types:

**1. Primary consumers**. These directly depend on the producers for food source. An insect or a herbivore that feeds on leaves is a common example of a primary consumer. Primary consumers belong to **second trophic level.**

**2. Secondary consumers:** They include different organisms that feed on primary consumers. (Examples) A frog eating an insect, a snake feeding on a rat. These organisms are assigned to **third trophic level.**

**3. Tertiary Consumers:** They feed upon secondary consumers. A king cobra eating another snake or a predatory bird like an eagle eating a snake are examples of tertiary consumers. These belong to **fourth trophic level.**

**ii) Microconsumers:** These are represented commonly by bacteria and fungi. They are also called **detrivores.** The microconsumers decompose excreta of animals and dead parts of plants and animals. They belong to **fifth trophic level.** They are also called **natural scavengers of ecosystem.**

**Pond ecosystem: (Fig. 18.1.1)**

A pond ecosystem is a fresh water ecosystem with a nonflowing body of water. There is an abundance of all the biotic and abiotic components in a continuous state of interaction in a pond.

**Abiotic or nonliving component:** This group of components include the energy of sunlight,

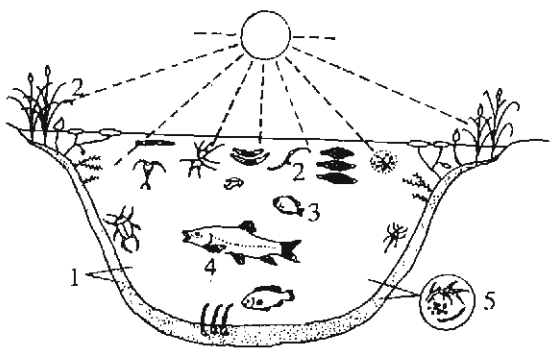



*Fig. 18.1.1 Pond ecosystem*

1. abiotic 2. producers 3. primary consumers
4. secondary consumers 5. decomposers

temperature, $O_2$, $CO_2$, water and the salts dissolved in it.

**Activity:** Compare the state of pond during dry season and the changes after the rains.

**Biotic or living component:** The biotic component has producers, consumers and decomposers.

**Producers:** These are classified as (a) microscopic phytoplanktons (e.g.) Chlamydomonas and diatoms. (b) macroscopic plants (e.g.) algae like Chara and angiosperms like Hydrilla and Vallisneria.

**Consumers:** These include

**Primary consumers.** The zooplanktons which feed on the phytoplanktons are the primary consumers of a pond. (e.g.) Daphnia, Copepods.

**Secondary consumers:** Aquatic insects like Ranatra (Water scorpion) and Bellostoma are some examples of secondary consumers. These feed on primary consumers.

The larger fish and water snakes which feed on smaller fish represent **tertiary consumers.**

**3. Decomposers**

Aquatic bacteria and fungi decompose the dead bodies and the excretory matter of animals and plants.

**Functions of different components of a pond ecosystem.**

Abiotic components like light, water and $CO_2$ function as raw materials for photosynthesis by green plants, the producers.

The producers function as primary energy producers. The energy present in the plants is passed on sequentially to the primary consumers, seconday and tertiary consumers due to interaction with abiotic components.

## FOREST ECOSYSTEM

The forest has the same structural organisation as of a pond.

**Abiotic components:** The most important non living component is sunlight which is the principal source of energy. The other abiotic components are soil water, various soil salts and different atmospheric gases like $O_2$, $CO_2$ and $N_2$.

**Biotic components:** These include producers, macroconsumers and microconsumers.

**1) Producers:** (e.g.) bryophytes, pteridophytes, dicot and monocot plants. There is a four tiered stratification of vegetation in a forest namely tree layer, shrub layer, herb layer and ground layer.

**2) Macroconsumers:** There are three categories.

**a. Primary Consumers:** These are the herbivorous animals like rats, ants, grasshoppers, millipedes, fruit eating birds, deers, monkeys and elephants.

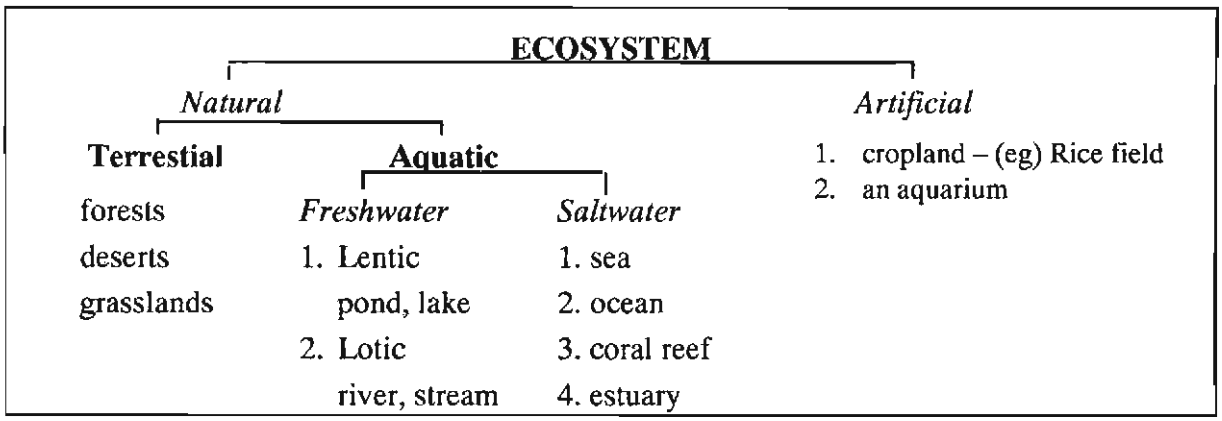
**b. Secondary consumers:** These include wild dogs, jackals, tigers, snakes and frogs which feed on primary consumers. Hence they are the primary carnivores.

**c. Teritary consumers:** These are referred to as secondary carnivores (e.g.) eagles and hawks.

**3) Microconsumers:** These are micro-organisms such as bacteria and fungi. They are also called as decomposers.

**Activity:** Make a field trip to forest areas.

It is our duty to save such precious ecosystem in our environment and make it a happier place of living for generations to come.




**Basic concepts**

1. Ecosystem is the basic unit which arises due to interactions between organisms and environmental factors. There are two major types of ecosystems namely natural and artificial.

2. Natural ecosystem includes terrestrial and aquatic.

3. Artificial ecosystems are those produced and controlled by man.

4. Abiotic constituents of an ecosystem are light, inorganic compounds, gases and climatic factors whereas microscopic and macroscopic organisms form the biotic components.

5. The trophic levels in an ecosystem include producers, consumers decomposers.

6. Pond ecosystem is a classical example of an ecosystem.

7. Forest ecosystem is an example for terrestrial ecosystem.

**Self - Evaluation**

**Choose the correct answer**

1. The type of ecosystem where the water is stationary is called
   a) Lentic b) Limnetic
   c) Lotic d) Lake
2. Which of the following belong to trophic levels III and IV respectively:
   a) snake and eagle
   b) rabbit and eagle
   c) eagle and bacterium
   d) eagle and snake
3. Decomposers are important in an ecosystem because:
   a) they are the primary energy producers
   b) they are microscopic and nonphotsynthetic
   c) they help in chemical transformation
   d) they feed on producers

**Say true or false:**

4. Man made ecosystem can be called as an artificial ecosystem.
5. The first trophic level includes all the primary consumers.
6. In an aquatic ecosystem, zooplanktons are examples of trophic level II.

**7. Match the following**

| | |
|---|---|
| 1. field layer | i) fungi |
| 2. microconsumer | ii) light |
| 3. macroconsumer | iii) ferns |
| 4. abiotic | iv) grasshoppers |
| 5. phytoplanktons | v) tree ecosystem |
| | vi) land |

**Fill up the blanks**

8. Limnetic ecosystem includes _____ and _____.

9. Producers are also known as _____.

10. _____ are freefloating microscopic forms.

**Answer briefly**

11. Distinguish between lotic and lentic zones.

12. What role does light play in an ecosystem?

13. Name any four carnivores in a forest ecosystem.

**Answer in detail**

14. Describe an aquatic ecosystem.

15. Discuss the producer components of a forest ecosystem.

## 18.2 FOOD CHAIN AND FOOD WEB

There is a nutritional interrelationship among the biotic components of an ecosystem.

In an ecosystem, there are several levels based on feeding habits. Each level is known as a **trophic level.** Plants which are producers belong to the first trophic level ($T_1$). The primary consumers form the second Trophic level ($T_2$). Carnivores, the secondary consumers are at the third trophic level ($T_3$) and the top carnivores, the tertiary consumers form the fourth trophic level ($T_4$). The decomposers comprising bacteria and fungi form the last or fifth trophic level ($T_5$).

A **food chain** is defined as the transfer of energy and nutrients through a succession of organisms through repeated process of eating and being eaten.

A food chain has the producer (autotrophs) at the starting point and the tertiary consumer at the end point.

**Types of food chains**

There are two types of food chains in nature:

1. Grazing food chain
2. Detritus food chain

1. **Grazing food chain**: This type starts from green plants proceeds to herbivores and ends in carnivores.

Examples of grazing food chain.

1. Grass → Cattle → Man.

2. Grass → rabbit → fox → wolf → tiger.

3. Plants → mouse → snake → hawk.

Food chain in Terrestrial Ecosystem may be represented as follows.

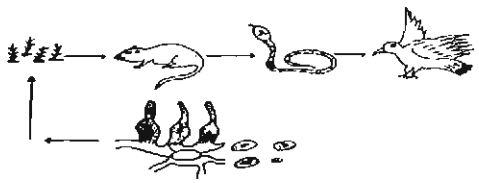


*Fig. 18.2.1 Grazing food chain*

**Activity:** Discuss a simple food chain known to you with your teacher

Food chain in an aquatic ecosystem.

Phytoplankton → zooplankton → fish → snake.

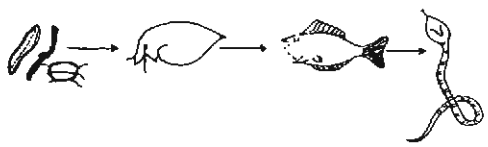


*Fig 18.2.2. Aquatic food chain.*

**TROPHIC CHART**

| Plants ⟶ | Herbivores ⟶ | Carnivores ⟶ | Top carnivores |
|---|---|---|---|
| Producers | Primary consumers | Secondary consumers | Tertiary consumers |
| $T_1$ | $T_2$ | $T_3$ | $T_4$ |

**2. Detritus food chain:**

The dead organisms and the debris are termed as **detritus**. They are decomposed and taken as food by detrivores. Thus they release the essential elements into the environment. Producers use these elements for their life processes.

Termites, beetles and worms are some of the detrivores in the terrestrial ecosystem. Insect larvae are aquatic decomposers. The saprophytic fungi and bacteria come under this category. The detrivores are eaten up by some protozoans. They are in turn preyed upon by small fishes. Larger carnivorous fishes feed on these small fishes.

organic wastes → detrivores → protozoa→ small fish → large fish.

The energy in the form of food is transferred between the grazing food chain and detritus food chain. This enables the maintenance of an equilibrium in an ecosystem.

**FOOD WEB**

In an ecosystem, number of food chains function in an interlinked manner. The food chains are not independent. The organisms at one trophic level of a food chain are eaten by animals belonging to different food chains. (example).

Grass → mouse → snake → hawk.

Grass is eaten by field mouse. But sometimes, grass can be eaten by grasshopper and rabbit; likewise mice are eaten by hawks directly. This type of interrelationship connects the various food chains. Complex of interrelated food chains make up a **food web**. Each organism may obtain food from more than one trophic level.

In the following example of a grassland ecosystem, there is a food web showing five linear interconnected food chains. They are

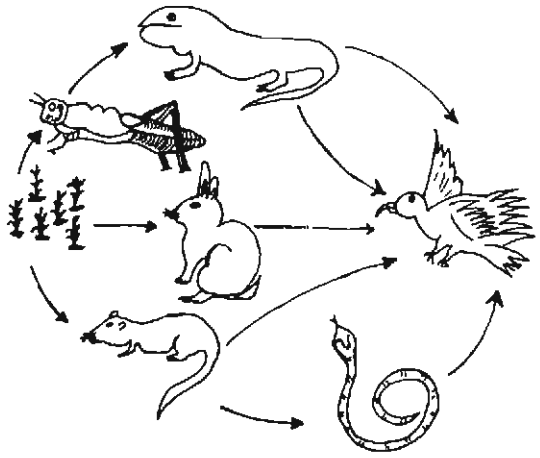


*Fig 18.2.3 Food chain*

1. Grass → Grasshopper → hawk.
2. Grass → grasshopper → garden lizard → hawk.
3. Grass → rabbit → hawk.
4. Grass → mouse → hawk
5. Grass → mouse → hawk

Food webs play an important role in maintaining stability in an ecosystem.

**Some basic concepts**

1. Food chain is the transfer of energy and nutrients through a succession of organisms through repeated process of eating and being eaten.

2. There are two types of food chains namely (1) grazing and (2) detritus food chains.

3. Producers form the First trophic level while the primary consumers or the herbivores represent the second trophic level. The third trophic level is occupied by secondary consumers or carnivores. There is a fourth trophic level prepresented by top carnivores.

4. In an ecosystem, number of food chains function in an interlinked manner. A complex of interrelated food chains make up a foodweb.

5. Foodwebs play an important role in maintaining stability in an ecosystem.

## Self - Evaluation

**Choose the correct answer**

1. Which of the following belong to the first trophic level ?

   a) grasshopper b) cockroach
   c) bacteria d) rose plant

2. Pick out the ones which belong to the same trophic level from among the following:

   a) frog and grass hopper
   b) hawk and frog
   c) grass and algae
   d) grass and grass hopper

3. A complex of interrelationships among foodchains form

   a) Foodweb b) Food pyramid
   c) Food energy d) Food world

**Say true or false**

4. Food chains are independent.
5. Carnivores, the secondary consumers belong to the fourth trophic level.
6. Grasshopper and elephants belong to the same trophic level.

**7. Match the following**

| | |
|---|---|
| 1. Grass | i) Second trophic level |
| 2. Frogs | ii) Tertiary consumers |
| 3. Hawks | iii) Primary producer |
| 4. Insects | iv) Detrivores |
| 5. Snakes | v) Fifth trophic level |
| | vi) Secondary consumers |

**Fill in the blanks**

8. Fungi are ____ organisms.
9. A food chain has _____ consumers at the end point.
10. The dead organisms and the debris in an ecosystem is termed as _____.

**Answer brielfy**

11. Define food chain
12. What are the two types of food chain?
13. What is a food web?

**Answer in detail**

14. Give an account of producers and consumers in a food chain.
15. Explain a food web.
16. Describe a grazing food chain with suitable examples.

## 18.3 ECOLOGICAL PYRAMIDS

Ecological pyramid is a graphic representation of various trophic levels of a food chain in an ecosystem These pyramids clearly reveal the trophic structure and function of the ecosystem. In this representation, producer level is represented at the base of the pyramid, herbivores lie above the base, followed by first order carnivores and so on with tertiary carnivores at the top.

These pyramids are of three types.

1. Pyramids of Numbers
2. Pyramids of Biomass
3. Pyramids of Energy

### 1. Pyramid of Numbers: (Fig. 18.3.1)

These reveal the relationship between the numbers of organisms at various trophic levels. The number of primary consumers is less than that of the producers and those of consumers of different orders decrease further in that sequential order. If these numbers are represented in a diagrammatic way, an upright pyramid is formed as in a grassland ecosystem. Here, the wide base of the pyramid represents the large number of primary producers namely grasses. These support a few number of rabbits (herbivores). The

rabbits support only a few number of foxes (first order carnivores) which in turn support a very few number of lions (top carnivores).

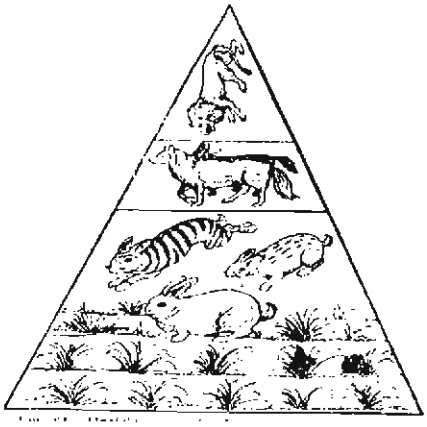


*Fig. 18.3.1 Pyramid of numbers - grass land*

In certain other cases, the reverse is true. For example, in a tree ecosystem, the number of the primary producers is the least and that of the ultimate consumers is the maximum. A single fruit tree supports a large number of fruit eating herbivorous birds. These in turn support a still higher number of parasitic insects which are further consumed by microbial parasites such as bacteria and fungi. In this case, there is an increase in numbers from producer to consumers of different orders, constituting an inverted pyramid (Fig. 18.3.2).

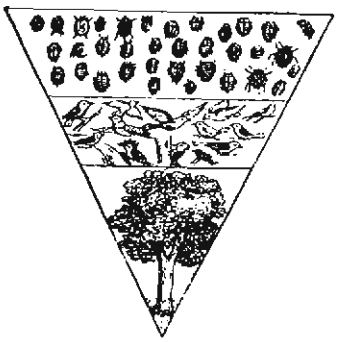


*Fig. 18.3.2 Pyramid of numbers - Tree ecosystem*

## 2. Pyramid of biomass

Biomass is the total amount of organic matter present in the organism at a given time per unit area. Pyramid of biomass is a graphical representation of biomass present per unit area in different trophic levels. In grassland and forest ecosystem, the biomass of producers is the highest of all the trophic levels. The biomass goes on decreasing from primary producers to the top carnivores. Thus it forms an upright pyramid. (Fig. 18.3.3)

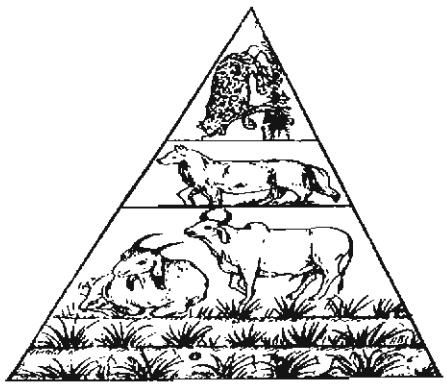


*Fig. 18.3..3 Pyramid of numbers - Forest*

In an aquatic ecosystem like that of a pond, the situation is entirely reverse. The biomass of diatoms and phytoplanktons (Primary producers) is very little compared to small herbivorous fishes (primary consumers) that feed on them. The biomass of large carnivorous fishes (secondary consumers) which feed on the smaller fishes is the highest of all trophic levels. Thus the relationship of biomass among organisms in such a food chain results in an inverted pyramid (Fig. 18.3.4).

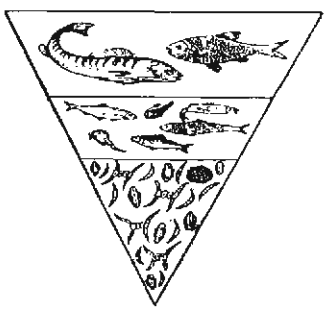


*Fig. 18.3.4 Pyramid of biomass - Pond*

Pyramid of biomass follows 10 percent law. Thus, 1000 Kg of grass would form only 100 Kg of biomass in mice while the latter would produce only 10 kg of biomass in snakes. The snakes would produce only 1 Kg of biomass in hawks.

Plants → mice → snakes → Hawk

1000Kg → 100Kg → 10Kg → 1Kg

**3. Pyramid of Energy (Fig. 18.3.5)**

It is a graphic representation of amount of energy trapped in different trophic levels in a food chain. The primary producers of an ecosystem trap the radiant energy of the sun and convert it into potential chemical energy.

This trapped energy flows in the food chain from the producers to the top carnivore which decreases at successive tropic levels, Thus an upright pyramid is always formed.

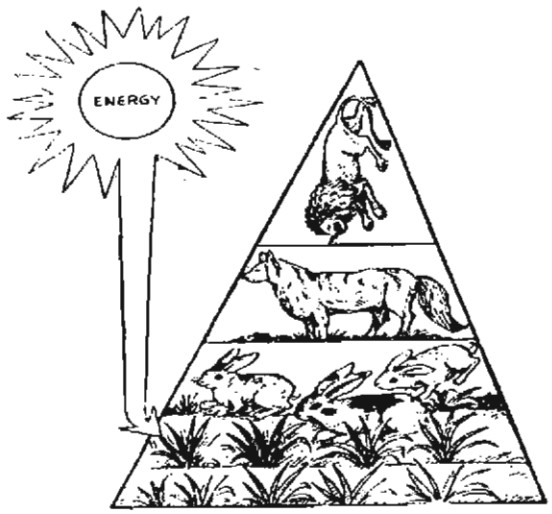



*Fig. 18.3.5 Pyramid of energy*

**Vegetarian food habits help in getting more energy than nonvegetarian food habits.**

Pyramid of energy clearly indicates that their is decrease of energy available for the next trophic level. Therefore, if we are closer to the producer level, we can receive more energy from foods because the energy available is highest at the producer level. A vegetarian gets his food directly from producer level (plants) while a nonvegetarian receives his food from herbivore level (sheep or goat). If a particular amount of energy could be used for 100 vegetarians, the same energy is available only for 10 nonvegetarians.

**Activity:**

1. Observe the happenings in a pond near your place. Construct your own ecological pyramid. Find out the type of pyramid constructed by you.

2. Observe the different kinds of organisms in a grassland. If possible, make a count of the number of organisms. Put them in different trophic levels and construct a pyramid of numbers based on your observation.

3. Collect pictorial representations of different kinds of organisms belonging to various trophic levels in a foodchain.

**Some basic concepts:**

1. Ecological pyramid is the graphic representation of various trophic levels of a food chain in an ecosystem.

2. Three types of pyramids namely pyramids of numbers, pyramids of biomass and pyramid of energy.

3. Pyramids of numbers and those of biomass can be represented either as upright or inverted pyramids. The pyramid of energy is always shown as upright ones.

**Self - Evaluation**

**Choose the correct answer**

1. Which group of organisms in an aquatic ecosystem contains the largest amount of energy ?

   a) herbivores b) primary consumers
   c) producers d) top carnivores

2. The maximum number of trophic levels found in a foodchain is:

   a) six b) four c) ten d) one

3. Pyramid of biomass could be:

   a) upright b) inverted
   c) none of the above d) both of the above

**Fill in the blanks**

4. In a food chain, each level is known as a _____ level
5. Energy stored by producers travels from one trophic level to another in the form of ____.
6. Tree ecosystem shows _____ pyramid

**7. Match the following**

| | |
|---|---|
| 1. Producer | i) snakes |
| 2. Top carnivore | ii) frog |
| 3. Secondary consumer | iii) grasshopper |
| 4. Primary consumer | iv) phyto plankton |
| 5. Tertiary consumer | v) hawk |
| | vi) grass |

**Answer briefly**

8. Define Ecological pyramid
9. What is energy pyramid?
10. Arrange the following in a foodchain: fish, algae, small animals, big fish.

**Answer in detail**

11. Explain the pyramid of biomass in an aquatic ecosystem.
12. Give reasons as to why the pyramid of energy considered to be the most important among the three types of pyramids.
13. Is it possible for the pyramid of numbers to be represented in an inverted manner ? Explain.
14. How much energy will be available to hawk in the foodchain comprising hawk, snakes, paddy and mice if 10000 Joules (J) of energy are available to paddy from sun ?

## 18.4 ENERGY FLOW

Every organism is a chemical factory that capture energy from environment and utilizes it for life processes. The initial point where the energy enters into the ecosystem from the environment is green plants. Diverse organisms in the biosphere depend upon sun for energy.

By the time the solar energy reaches the earth's surface, most of the short wave radiation are filtered out. It has been estimated that only one percent sun's energy reaches the outer part of earths atmosphere. The dominant form of solar energy that reaches the earth's surface is of visible light. The amount of solar radiation is enormous, about 1372 watts/$M^2$. However more than half of the incoming sunlight gets reflected or could be absorbed by clouds, gases and dusts.

About 35% is used to heat water and land areas. The plants get the remaining 8% of light energy. Out of this 8%, 90% is reflected through leaves. An average of only 2% of total light energy striking on leaf surface in used for photosynthesis.

The flow of energy in an ecosystem is unidirectional and non cyclic.

In the one way flow of energy with living systems, the two laws of thermodynamics are well proved. The first law of thermodynamics states that 'energy can neither be created nor destroyed'. This law is applicable when there is a transfer of energy from one trophic level to the next in a food chain. The energy flows in a unidirectional and noncyclic way through the feeding levels without any loss or gain. During its transfer, some amount of energy is degraded without any use for the consumer. This is known as **entropy** and can be measured.

The second law of thermodynamics states that 'during energy transformation large part of energy is degraded as heat'. In an ecosystem there is a loss of energy in the form of heat when the food passes from producers to carnivores gained through herbivores.

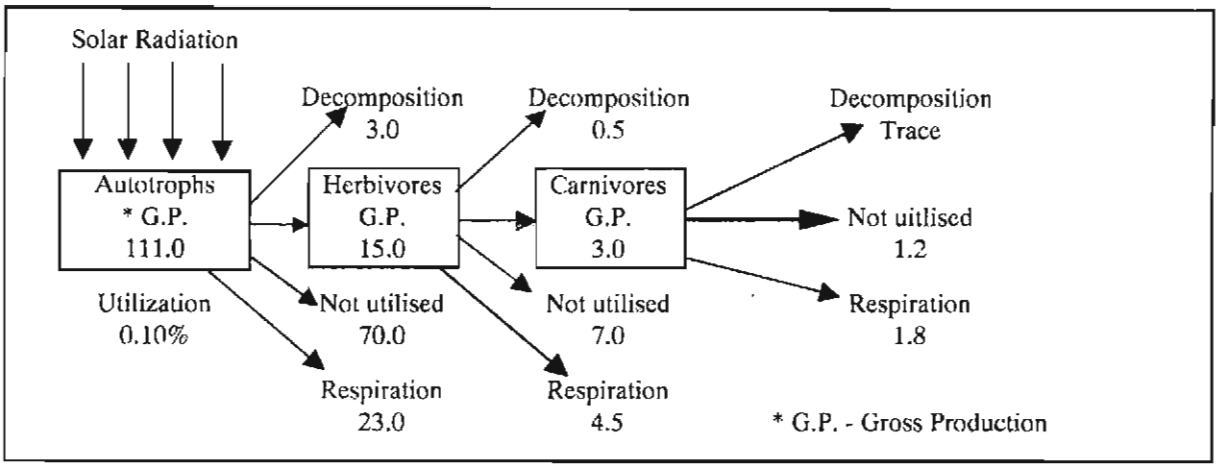



*Fig 18.4.1 Energy flow*

## Conversion of Solar Energy

The green plants absorb the radiant energy of the sun, with the help of green pigment called chlorophyll. The plants after trapping the energy convert it into chemical energy in the form of carbohydrates. Thus the manufacturing of complex organic food by the autotrophs of the ecosystem in the presence of sunlight of known as photosynthesis. Photosynthesis fixes energy in the form of ATP molecules. Plants utilize these high eregy molecules for their metabolic activities like growth, respiration and tissue building.

Organisms that do not photosynthesis are consumers because they get nutrients and energy by ingesting other organisms.

Some of the stored energy of plants in the form of nutrients is consumed by the herbivores or primary consumers. They assimilate only 10% of the ingested food. The unassimilated materials are excreted as waste.

Photosynthesis or the primary productivity provides energy for all living members of the ecosystem. It is the basic process for all the energy conversion.

## Some basic concepts

1. The initial point where the energy enters into the ecosystem is green plants.

2. Sun is the unlimited, ultimate source of energy for all the organisms in biosphere.

3. An average of 2% of total light energy is used for photosynthesis.

4. The flow of energy in an ecosystem is unidirectional and non-cyclic.

5. In the one way flow of energy in the living systems, the two laws of thermodynamics are well proved.

6. The Four components involved in energy flow are producers, herbivores, carnivores and decomposers.

7. During the transfer, only 10% is passed onto next higher level and so on. This is the way the energy flows in an ecosystem.

## Self - Evaluation

**Choose the correct answer**

1. An average of _____% of light energy is used for photosynthesis.

   a) 2 b) 8 c) 35 d) 57

2. Which of the following is not a part of the biotic envirnment?

   a) man b) air c) trees d) insects

3. In the food chain consisting of lion, grass, hawk and deer, which one will transfer

maximum energy to the next trophic level.

a) Lion b) grass c) deer d) hawk

4. Those which feed upon dead organisms of plants and animals are called. ---------

a) decomposers b) consumers
c) carnivores d) producers

**True or False**

5. Sun is unlimited but polluted source of energy

6. The second law of thermodynamics states that energy can neither be created nor destoyed.

7. Organisms that do not photosynthesis are consumers.

8. Large part of energy is lost as heat.

**9. Match the following**

| | |
|---|---|
| 1. Sun | a. Solar radiation |
| 2 Energy | b. energy molecule |
| 3. Green plants | c. Carnivore |
| 4. Abiotic | d. hydrogen |
| 5. ATP | e. Unidirectional |
| | g. biosphere |

**Fill in the blanks**

10. Approximately _____ % of sunlight is absorbed in the atmosphere.

11. Energy can neither be _____ or _____.

12. _____ fixes energy is the form of sunlight.

13. Only ____ % is passed on to the next trophic level.

**Short answers**

14. What is 10% law ?

15. Correlate the second law of thermodynamics to an ecosystem.

16. Write about conversion of solar energy?

**Detailed answers**

17. What is energy flow?

18. Describe the flow of energy from producer to top carnivore.

## 18.5 BIO-GEOCHEMICAL CYCLES

**Biosphere**

The earth surface accommodating several types of living organisms constitutes the **'biosphere'**. The biosphere ranges between 6 kms above sea level and 10 kms below the sea. In this area the living organisms remain dependent on natural materials.

**Bio-Geochemical Cycles**

The survival of living organisms in the biosphere is due to utilisation of natural chemicals in cyclic methods. The interchange of chemical substances between living and non-living systems is known as **bio-geochemical cycle**. Any area or location where a material gets concentrated is called a **bio-geochemical pool**. These pools are of two types.

1. **Active pools :** In these pools the materials are in a free state. They are easily accessible to life processes. e.g. atmosphere.

2. **Storage pools :** In this pool the materials are more or less inaccessible. e.g. coral reef.

There are several chemical cycles related to these pools.

**Carbon cycle**

There are many carbon compounds in the biosphere. These substances are constantly generated and destroyed. Carbon is mostly available in the form of $CO_2$. In the atmospheric air, $CO_2$, is generated by several methods.

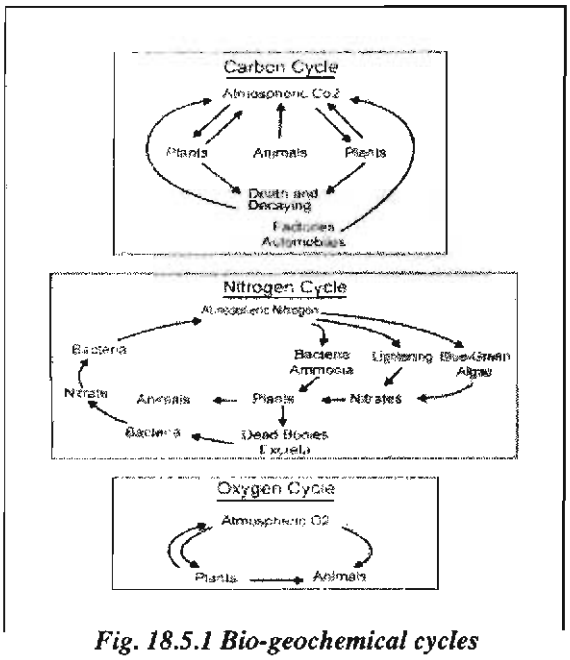



*Fig. 18.5.1 Bio-geochemical cycles*

1. Through metabolic processes in animals and plants.
2. Decaying from storage pools.
3. Released from storage pools.
4. Burning of petroleum products.

Through photosynthesis the plants convert atmospheric $CO_2$ into compound organic substances. This process can also happen in planktonic organisms on the sea surface. Dissolved $CO_2$ in sea water is converted into salts of Ca and Mg and gets deposited as insoluble salts in the deeper seas.

### $CO_2$ and Man

Due to industrialisation and increase in number of automobiles more amount of petrol and coal are getting burnt. This increases $CO_2$ level in the air. For the past 2000 years the $CO_2$ level remained at 280 parts/million. But recently the level has increased to 360 parts/ million. This is 27% increase. This increase is in the rate of 3 parts/million. This increase in $CO_2$ level may cause increase in'Earth's temperature. In the past 150 years the temperature increase is found to be 0.6°C. The current rate of increase is 0.02°C/10 years.

### Nitrogen cycle

Proteins are essential for structure and life of organisms. Proteins are nitrogenous compounds. Hence from natural sources Nitrogen should enter into living systems. For Nitrogen, soil and decaying matter are active pools. Soil deposits and air are storage pools.

In the composition of air 79% is Nitrogen. However, the living organism can not utilise it directly. The atmospheric Nitrogen should be fixed in an usable form.

### Nitrogen fixation methods

#### 1. Fixaton of atmospheric nitrogen

Due to lightning and radiations atmospheric nitrogen gets converted into compounds like ammonia and nitrogen oxide. The rain water washes down these substances into the soil. In the soil they get converted into nitrates.

#### 2. Fixation through Industries

Using ammonia through industrial processes fertilisers like ammonium nitrate and urea can be synthesised. These are nitrogenous compounds.

#### 3. Fixation by living organisms

Nitrogen fixing bacteria found in the root nodules of Leguminous plants can convert atmospheric nitrogen into ammonia. ***Nitrosomonos*** is more effective in the synthesis of soil nitrates. Similar processes happen in the sea water through the marine algae

### Nitrogen and man

Chemical fertilisers are much in demand for producing required amount of food grains. Due to excessive use, the fertilisers, can get dissolved in soil water and enter into freshwater ponds and pools. In freshwater, the fertilisers can encourage the growth of algae. Enormous growth of algae will reduce the oxygen content in water. This

will cause death of other aquatic animals. Further, nitrogen oxide can get dissolved in atmospheric air and cause acid rain. Acid rains can affect soil fertility.

**Oxygen cycle**

Atmospheric air contains 21% oxygen. Oxygen is supplied to air by plants through photosynthesis. The $O_2$ used by animals and plants during respiration is sent back into the atmosphere as $CO_2$. During photosynthesis plants make use of $CO_2$ and release $O_2$ into the atmosphere.

**Oxygen and man**

Uncontrolled felling of trees and destruction of forests can reduce the amount of $O_2$ that could be generated by plants. Planting more trees can enrich atmosphere with more $O_2$.

**Phosphorus Cycle**

Phosphorus is essential for formation of DNA and ATP molecules in plants and animal cells. Animals need phosphorus for building muscles and bones. It is obtained through food by animals. Plants get phosphorus through soil water. Death and decay of organisms can enrich the soil with phosphorus.

**Sulphur cycle**

Sulphur is needed for protein synthesis. Animals and plants obtain sulphur through soil water. For sulphur, while air is the active pool, rock deposits remain as storage pools.

**Some basic concepts**

1. The biosphere extends 6kms above sea level and 10 kms below the sea.
2. Industrialisation causes increase in $CO_2$ level.
3. Nitrogen is needed for protein synthesis.
4. Phosphorus is needed for producing DNA and ATP.

## Self - Evaluation

**Choose the correct answer**

1. Rate of photosynthesis and amount of $O_2$ get reduced in
   a) Deforestation
   b) Carbon assimilation
   c) Carbon compound synthesis
   d) Deposition
2. Which of the following is not a gaseous cycle.
   a) Phosphorus b) Carbon
   c) Oxygen d) Nitrogen

**Say true or flase**

3. From storage pools materials can be easily obtained.
4. Increase in $CO_2$ amount and increase in temperature are directly related.
5. Since the amount of Nitrogen is 79% in air, living organisms can easily obtain the same.

**Fill in the blanks**

6. Biosphere extends ---------- kms above sea level and ------ kms below sea level.
7. Air is a storage pool for ----------.
8. The current rate of increase in Earth's temperature is ----------.

**Answer briefly**

9. What is Oxygen cycle?
10. What is acid rain?
11. What are sulphur pools?

**Answer in detail**

12. Explain the process of carbon cycle.
13. What are Nitrogen fixation methods?
14. What is the role of man in chemical cycles?

# 19. APPLIED BIOLOGY

Man by nature is curious. Man's inquisitive nature was the cause for the development of various scientific disciplines. In course of time this attitude for knowing nature has helped us to make use of the same, for our living. Thus, the agricultural practice that started 10,000 years ago has, developed into an '**agricultural revolution**' that could support more than 6 billion human population. Apart from food we obtain medicines, materials for clothing, cosmetic materials and other necessities of the modern times. Thus human life is dependent on other living organisms and the natural environment provided by them.

## 19.1. NATURAL RESOURCES

The total surface area of the earth is 510,100,500 square kilo metres. Of this surface 70.9% is covered by water and the exposed land surface is only 29.1%. The large earth surface contains several natural resources. These resources basically support life on earth. The natural resources along with their dependent living organisms constitute the '**Biosphere**'. The biosphere contains water, oxygen, nitrogen, carbon di-oxide, potassium, magnesium and all other substances that are essential for living systems. Any excessiveness or deficiency of these resources can upset life on earth. Thus it is essential to protect various types of living organisms along with their natural surroundings and their resources.

### Water resource

The total amount of water present on earth is 1,460,000 square kilometers. Of this, 97.3% is found in the sea as saltwater. Only the balance of 2.7% is available as fresh water. Even in this amount a major part is found in the polar regions as ice, 0.5% of the freshwater alone is available for our direct use. This available fresh water is utilized for different activities. In our country the available fresh water is utilized in the following manner.

| | |
|---|---|
| Agriculture | 83% |
| Industries | 2.7% |
| Power generation | 1.8% |
| Domestic usage | 4.5% |

A major part of the water in domestic usage comes from ground water resources. It is known that most of us are now facing a severe water scarcity. Population increase and improper water management are the reasons for this scarcity. By adopting appropriate methods water problem can be brought under control.

### Methods

1. Desilting and deepening of ponds and lakes will increase water storage capacity.
2. Regular maintenance of water passages.
3. Connecting rivers
4. Controlling the usage of water.
5. Develop cost effective methods for converting sea water into fresh water.
6. Adopting suitable rain water harvesting methods.

As shown in the picture, from the terraces of houses water can be collected. This water can be sent into the soil by digging suitable pits connected to pipes laid

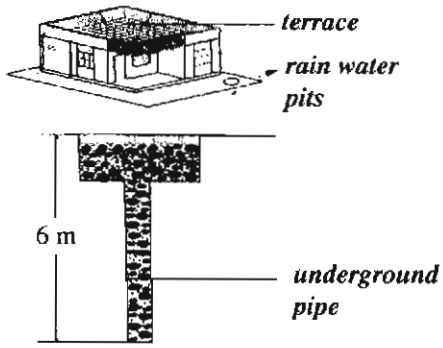



*Fig 19.1.1 Rain water harvesting*

underground. This will enrich the ground water and prevent rain water flow into the sea.

**Soil resources**

The fertility and richness of the soil could be assessed from the plants grown. Several organic materials, minerals, water and micro-organisms contribute to the richness of the soil. The fertility can be affected by following factors.

1. Excessive plantations.
2. Water scarcity
3. Usage of chemical fertilizers and insecticides
4. Affecting the life of micro-organisms through indiscriminate use of detergents and other chemicals
5. Soil erosion
6. Cultivating plants not suited for the soil.
7. Deforestation and utilizing cultivable lands for construction purposes.

The total forest area available in our country is 637, 293 sq.kilometers. It is 19.39% of the total land surface. Our forest area is distributed as found below

| | |
|---|---|
| Dense tropical forests | - 11.48% |
| Open forest lands | - 7.76% |
| Swampy forest | - 0.15% |

Due to development methods adopted by the Government 10,098 square kilo metres have been added to our forest cover. Protection of forests and their resources will ensure the survival of man on earth.

**Natural energy resources**

99.98% of the energy requirement to the Biosphere is contributed by the sun. However, due to human activities the energy demand is on the increase. The invention and usage of several machineries is the direct cause for the requirement. The energy consumed in the last 50 years far exceeds the total amount of energy used by man in the earlier historical period. Coal and petroleum energy resources are fully exploited and their availability is getting reduced. Hence, we need to generate energy from air and sunlight and find safe methods of storing and conducting the same.

**Living organisms**

The earth contains 5-30 million different types of living organisms. Of this nearly 2.5 million had been identified and named. In the history of life ranging back to several million years, nearly 90% of the organisms that lived became extinct. Since 1600AD nearly 700 organisms have vanished from the surface of the earth. All nations of the world have adopted strict rules and regulations to conserve living beings.

In India we have 87 National parks, 447 Wild life sanctuaries, 200 Zoological gardens and 23 Tiger sanctuaries.

## 19.2 CROP PRODUCTION

The three major necessities of life are food, shelter and clothing. Food is the basic need of all living organisms for their existence. From the beginning, mankind depended on plants for food and plants still remain the major source of staple food. Food is required for several functions such as growth, development and tissue repair.

Crop plants supply the major ingredients of food such as cereals, pulses, fbres, oils, vegetables, beverages, condiments and drugs. As there is population explosion, there is an urgent need to increase crop production to meet the food requirement.

Plant breeders and biotechnologists all over the world are applying both conventional and modern means to achieve self sufficiency in crop production.

**Crops** are plants grown in a community on a large scale. **Crop production** is the main focus of agriculture and plant breeding. **Agriculture** can be defined as the cultivation of crop plants. It provides food, feed, fibre and fuel. It is oriented towards health and wealth. The major occupation of 70% of Indians is agriculture. India has achieved a phenomenal growth in agriculture as there is a four-fold increase in food grain productivity since Independence through green revolution.

**Agronomy** is the recent branch of agriculture. It is the field of study and practice of ways and means of production of food, feed and fibre crops. Agronomy deals with the activities of raising the yields of crops.

**Cultivation of crops**

There are three major types of crop plants according to the range of cultivation:

1. **Garden Crops**: They are grown in small scale in gardens. Eg: Onion, Brinjal.
2. **Plantation Crops**: They are grown on a large scale in estates. Eg: Tea, Coffee.
3. **Field Crops**: Those which are grown on a large scale in fields. Eg. Rice, Cotton.

Commercially, depending on the plant products, crops are classified into.

1. **Food crops**: Rice, Wheat, Soybean, Groundnut.
2. **Cash crops**: Cotton, Sugarcane, Jute, Tobacco.

**Cultivation practice of one common food crop : (RICE) - *Oryza sativa*:**

Cereals are the cultivated grasses grown for their edible, starchy grains. We use cereals such as rice, wheat, maize and barley. Among the food crops, rice is the staple food of Asia. Rice is extensively cultivated throughout India. The best quality of rice is that it grows in fields which are not flooded. The seasons for cultivation of rice varies in different areas.

**Rice seasons of Tamilnadu**

| | | |
|---|---|---|
| Kar | - | May to June |
| Kuruvai | - | June to July |
| Samba | - | August |
| Thaladi | - | September - October |

**Seasons based on Cultivation**

1. Adipattam - July Sowing - Dryland crops
2. Puratasipattam - September Sowing - Medium rainfall crops.
3. Ippasipattam - October Sowing - Rainy season crops
4. Karthikaipattam - November Sowing - cold weather crops.
5. Thaipattam - January sowing - Winter crops.
6. Chitiraipattam - April sowing - Summer crops

Farmers start the cultivation of rice at appropriate seasons. There are several steps involved in rice production:

1. **Seed selection**: A seed is defined as the living organ of the crop in rudimentary form that is used for propagation. Good qualtiy seed is important for high quality crops. The following should be qualities of a seed:

* The seed should belong to the proper variety and strain of the crop.
* It should be mature, well developed and plumpy.
* It should have high germinating capacity.
* It should be free from pests, and diseases

**2. Soil Preparation:**

Ploughing and cross ploughing should be made before sowing seeds. The usual manures used while ploughing are ashes,

cowdung and oil cakes. Sometimes green manure is also used.

**3. Sowing:**

Rice grains are sown either directly in the field (Seed bed) or on a nursery bed. These seedlings are raised and transplanted later.

Direct seedling may be produced by:

(i) **Broadcasting**: the scattering or spreading of seeds in the soil.

(ii) **Dibbling**: a method of dropping the seeds in the localised pits.

(iii) **Drilling**: a practice of dropping seeds in furrows.

**4. Transplanting** It is the removal of actively growing seedlings from nursery beds and then in furrows for further growth and development.

**Advantages:**

1. It is possible to select healthy, vigourous, and strong seedings.
2. All seedlings mature uniformly

It will take nearly three months time for ripening of grains (108 days). Application of pesticides and weedicides, use of disease control methods, field irrigation, addition of manures and fertilizers are to be done periodically according to the needs of crops.

**5. Harvesting**: It is the last part of cultivation. It is defined as the removal of entire plants or useful parts from the field after maturity. The entire crop is cut close to the ground level. The sheaves are bundled and are taken to the threshing floor. Threshing is done manually by beating the sheaves against any hard wood or stone. Grains are collected, dried and bagged.

**Nutrients required for crops:**

Food required by plants is composed of certain chemical elements known as plant **nutrients.** There are three different sources of nutrients for plants:

| Air | Water | Soil |
|---|---|---|
| Carbon, Oxygen | Hydrogen | Nitrogen, Phosphorus, Potassium, Calcium, Magnesium,Sulphur, Iron, Manganese, Boron, Zinc,Copper, Molybdenum and Chlorine |

**Classification of nutrients:**

Of the 13 soil nutrients mentioned above, six are more essential for the plants. Nitrogen, Phosphorus, Potassium, Calcium, Magnesium and Sulphur are used by plants in large quantities. These are called **macronutrients**. The other nutrients which are required in small quantities are known as **micronutrients**. These are iron, manganese, zinc, copper, molybdenum and chlorine.

**Organic Nutrients:**

Manures supply organic matter in large quantities. Manures include farmyard manure, compost and green manures. They increase the organic content of the soil.

**Farmyard manure**: The decomposed mixture of cattle excreta (dung) and urine along with fodder is called Farmyard manure.

This is collected from the cattle shed and stored in a pit for decomposition by the microbes. A well decomposed Farmyard manure contains about 0.5% $N_2$, and 0.5% $K_2O$, 0.2% $P_2O_5$.

**Compost:** It is the bulky source of organic matter. It is prepared from vegetable and animal refuse, sewage waste, weeds, crop stubble and straw. Aerobic and anaerobic microorganisms decompose the organic matter. Compost contains about 1.4% Nitrogen, 1% Phosphorus penta oxide and 1.5% potassium oxide.

**Green Manure:**

When a crop is raised in a field, ploughed and made to remain there, it is called green manuring. The main aim is to add nitrogen to the soil cheaply. (E.g) Calotropis, Pungam, Neem, Kolinji (suitable for wetland).

The other examples of green manures are *Aschynomene aspera, Cassia alata, Tephrosia purpurea,* and *Asperagus racemosus.*

**INORGANIC NUTRIENTS:**

**Chemical fertilizers**: Generally these are called inorganic manures. Since organic manures contain very low nutrients, farmers prefer inorganic chemical fertilizers which carry appreciable quantity of plant nutrients.

**Nitrogenous fertilizers**: To increase the yield of crops, we have to apply fertilizers which contain nitrogen. The nitrogenous fertilizers used in large quantitites in Tamilnadu are:

Ammonium Sulphate, Urea, Ammonium Chloride, Calcium ammonium nitrate and Ammonium sulphate nitrate.

Urea is very unique among nitrogenous fertilizers. It is also applied to sugarcane, wheat, cotton, vegetables and fruit crops.

**Phosphorous:**

It is yet another nutrient required for plant growth. The important fertilizer is superphosphate. Dicalcium phosphate is suitable for crops since it also increases the crop yield. Tricalcium phosphate is also a useful one.

**Potassium**: The examples of potassium fertilizers are potassium chloride and potassium sulphate. These are purified from the potassium ores extracted from soil.

To alleviate the micronutrient deficiency in soil, micro nutrient fertilizers are generally added by dissolving in water and are then sprayed.

In Tamilnadu, Zinc deficiency is very widespread in rice, cumbu, ragi and maize cultivated soils.

Chemical fertilizers play a key role in sustaining production and productivity in agriculture.

**BIOFERTILIZERS**

Modern agriculture relies heavily on chemical fertilizers. By using these we get high yield of crops. But these chemicals get washed off through rains and irrigation. They reach the nearby rivers and lakes and pollute them. Thus the natural ecosystems get disturbed. Therefore in recent times, Biofertilizers are introduced. They are ecofriendly, economic and more effective than chemical fertilizers. They enhance the soil fertility. The microbial population in the soil is capable of converting insoluable materials into soluble organic form. Some microorganisms are able to fix atmospheric nitrogen.

The microbial preparation containing the living cells of these nitrogen fixing bacteria or phospho bacteria or fungi or the blue green algae is known as **Biofertilizer.** They can be used by mixing with seeds during cultivation practices.

**Mircrobes used as Biofertilizers in agriculture**

1. Nitrogen fixing bacteria: *Rhizobium, Azotobacter* and bluegreen algea *Anabaena, Oscillatoria.*
2. Phosphate solubilizing bactera: *Bacillus circulans.*
3. Fungi helping in absorption of nutrients: *Glomus, Gigaspora.*

**Advantages:**

1. They are helpful in reducing the use of chemical fertilizers.
2. Promote germination of seeds and the growth of seedlings.

3. The grain crops like rice, wheat, barley get high yield.
4. They help in the absorption of more phosphates in agricultural crops.
5. Plants get high concentration of proteins.

**Activity:**

1. Visit to a nearby field. Discuss with the farmer about the use of fertilizers.

2. Collect samples of both chemical and biofertilizers.

3. Collect data about the yield of crops after the use of both chemical and biofertilizers.

4. Prepare a comparative chart based on your data.

## WATER REQUIREMENTS

**Irrigation** can be defined as the artificial application of water to the soil for crop growth and development. It provides sufficient water for crops.

**Water requirement** of a crop is defined as the quantity of water needed for normal growth and yield. It may be supplied through rain water or irrigation methods.

**Water requirement range for different crops.**

| Crop | Range (mm) |
|---|---|
| Rice | - 1200 - 1400 |
| Maize | - 400 - 550 |
| Wheat | - 450 - 550 |
| Pulses | - 350 - 450 |
| Cotton | - 600 - 850 |
| Groundnut | - 350 - 650 |
| Sugarcane | - 1400 - 2000 |
| Banana | - 1650 - 2250 |

The water requirement of any crop depends upon crop factors, soil factors, climatic factors and crop management practices. Scientific management of irrigation techniques is called **irrigation scheduling**. Different irrigation methods are used to apply water to the crops to facilitate better environment for crop growth.

**Irrigation methods are:**

1. **Surface Method:** Water is applied on the soil surface.

2. **Sub-surface method:** Water is applied below the ground surface through the network of pipes of some devices.

3. **Sprinkler:** Water is made to spray through nozzles fitted in the water conveying pipes over the foliage of the crop plants.

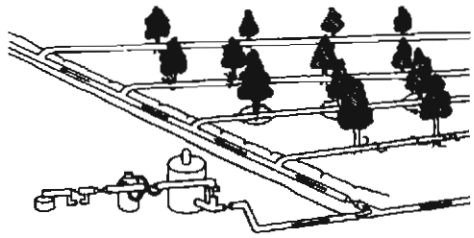


*Fig 19.2.1 Drip irrigation*

4. **Drip method:** In this system, water is delivered to each plant at its root zone through a network of tubing of by special device called emitters or drippers.

## CROP PROTECTION

The crops get damaged to the extent of 50 to 70% by diseases and pests. The farmers are advised several methods to control this. The use of pesticides is the common and effective method. They can be easily sprayed on crop plants.

Since pesticides are chemicals, they may be major source of environmental pollutions. Instead of using pesticides in large scale, we should follow preventive steps to protect crops from infection. Some of the preventive measures are.

1) Use of resistant varieties
2) Crop rotation and cropping system.

3) clean cultivation

4) Summer ploughing.

**Weed control**: During cultivation, some unwanted plants grow abundantly along with the major crops. They are known as **weeds**. They compete with the crops for space, light, water and nutrients. So, they suppress the growth of crops. Barley or mustard plant in the wheat field in also considered as weeds. Some of the important weeds are 1. Nutgrass 2. Wild sorghum 3. *Amaranthus*. 4. *Trianthema* 5. *Chenopodium*.

**Weeds can be controlled by following measures:**

1. **Mechanical Methods**: Uprooting, weeding with instruments, ploughing, burning and flooding.

2. **Cultural methods**: Proper seedbed preparation, timely sowing of crops, intercropping and crop rotation.

3. **Chemical Methods**: Spraying of chemicals known as herbicides or weedicides.

4. **Biological methods**: Prickly pear (Opuntia) weed is controlled by cochneal insects.

**M.S. SWAMINATHAN – A tribute**

*Dr. M.S. Swaminathan has been working with dedication for the past 50 years and more for the agricultural development of our country.*

*By his extensive and continuous contact with the farming community, he is able to identify the problems of Indian agriculture and find solutions for them. He is the architect of green revolution in India.*

*He has been chosen to lead the Pugwash Conferences on Science and World Affairs, a movement started by the famous personalities namely Albert Einstein and Bertrand Russell This is the first time an Indian has been given this honour.*

**Some basic concepts**

1. Crops are plants grown is community on a large scale.
2. The three major types of crop plants based on cultivation are garden crops, plantation crops and field crops.
3. On commercial basis, crops are classified as food crops and cash crops.
4. There are four rice seasons in Tamilnadu.
5. Several steps are involved in rice production which include seed selection, soil preparation, sowing and harvesting.
6. Nutrients are required for crops. These are organic and inorganic nutrients.
7. In recent times, biofertilizers are very much used in agriculture. These are ecofriendly, economic and more effective.
8. Irrigation can be defined as the artificial application of water to the soil which helps in crop growth and development.

**Self - Evaluation**

**Choose the correct answer**

1. In rice cultivation, which of the following seasons occurs between June and July:

   a) Kar b) Thaladi c) Kuruvai d) Samba

2. Based on cultivation, which seasson has January sowing?

   a) Adipattam b) Puarattasipattam
   c) Chittiraipattam d) Thaipattam

3. How much time is taken for the ripening of rice grains?

   a) 1 month b) 2 months
   c) 5 months d) 3 months

**Say true or false**

4. Compost contains much of phosphate
5. Green revolution in our country is associated with wheat.
6. Wild Sorghum is a weed plant.

**Fill in the blanks**

7. Tea and coffee are _____ crops.
8. Scientific name for rice is ____ ____
9. Manure prepared from fodder and dung is _____ manure.

**Answer briefly**

10. What is seed selection?
11. What are cash crops?
12. Give the meaning of green manure.

**Answer in detail**

13. What are the qualities of a seed used in crop production?
14. Write about organic nutrients applied in agriculture.
15. Explain biofertilizers.

## 19.3 PLANT PESTS AND CONTROL

The terms Pest is broadly used to insects, invertebrates and vertebrates that cause significant economic damage to crops, stored products and animals. Insects occupy major portion of pest population.

Almost all the plant parts such as roots, stem, bark, leaves, buds, flowers and fruits are infested by insects. They cause damage to grains stored in mills, houses and godowns.

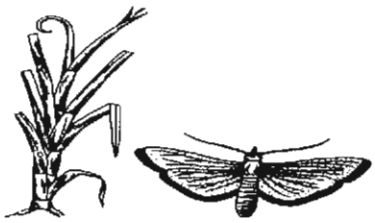


*Fig 19.3.1 Sugarcane-Stem borer*

**Activity:** Visit a Godown where grains are stored and find out the names of insect pests. Collect infect infested plant parts and make an assessment of the damage parts.

**Pest control**

Pest control refers to the elimination of pests. There are two methods of pest control namely natural and artificial.

**I. Natural Control**

1. **Climatic factors**: These factors are the most important and effective ones in controlling insects. Temperature affects the insects directly. Extreme hot and cold weather will directly kill the insects. Heavy rains have an adverse effect on small insects like aphids and thrips insects. Flying insects are swept to death during strong winds.

2. **Topographic factors**: Major topographic factors such as mountain ranges and seas act as physical barriers to the spread of insects. The character of ponds, streams, and lakes influence the life of pests. Soil type decides the suitability of an area for the pest.

3. **Natural enemies** : Every insect has a number of natural enemies, eg, Birds feed on grass hoppers and caterpillars. The wood peckers and sun birds subsist largely on insect diet. King crows, mynahs, and owls catch insects in flight. Soil inhabiting insects are eaten by garden lizards and toads. Viruses, bacteria and fungi cause diseases in insects and reduce the population.

**II. Artificial Control**

The control measures adopted by man to check the insect population come under artificial control. There are different methods of artificial control. These are:

1. **Cultural methods**: The common farm practices like crop rotation, and mixed cropping are helpful in reducing the insect population are called as cultural methods. They are the simplest of all measures.

2. **Mechanical Method**: In this method, insect populations are directly hit and killed by mechanical devices or manual operation.

3. **Physical method**: Artificial heating or cooling of stored products are employed for eradication of insects.

4. **Chemical method**: Many chemicals are used for reducing the pest population.

5. **Biological Method**: The successful control of a pest species by another living organism is called the biological control.

## LIST OF SOME INSECT PESTS

| No. | Name of the Crop | Name of Insect pests | Nature of damage |
|---|---|---|---|
| 1. | Rice | 1. Stem borer *(Chilo Polychrysa)*<br>2. Leaf borer *(Marasmia patnalis)* | The transformation of central shoot into a tubular structure; shoot growth arrested.<br>Appearance of white transparent patches on greenish leaf tissues. |
| 2. | Sugarcane | Shoot borer *(Chilo infuscatellus)* (Fig 19.3.1) | Feeding of caterpillars as they bore into the central shoot. |
| 3. | Groundnut | Leaf feeder *(Amsacta albistriga)* | The caterpillars feed on the entire leaves. |
| 4. | Coconut | Rhinoceros beetle *(Oryctes rhinoceros)* | The beetle attacks the growing point and chews out large holes in the young leaves. |
| 5. | Tomato | Heliothis armigera | Larva bores into flower buds and developing fruits making fruits unfit for consumption. |

### PESTICIDES: Types and applications

The pesticide is a chemical used to poison and control the pests which cause economic damage to crops.

A pesticide can be described as a chemical or biological agent that eliminates the pests for the benefit of man. The pesticides are generally classified into various types based on pest organism. Some of the types of pesticides are tabulated below.

| Type | Examples |
|---|---|
| 1. Insecticide | Endosulfan, Malathion |
| 2. Rodenticide | Zinc phosphate<br>Thallium sulphate |
| 3. Fungicide | Copper oxychloride,<br>Bordeaux mixture |
| 4. Nematicide | Carbofuran, Parathion |
| 5. Weedicide | Fluchloralin, Atrazine. |
| 6. Bactericide | Aureomycin,<br>Streptomycin |

### Biopesticides

The preparation of either bacteria of a virus or a fungus is used to eliminate the pests. These preparations act on pathogens to the particular insects and other pests.

Examples: 1. A pathogenic virus is used to eliminate rhinoceros beetle

2. Mosquito larvae are destroyed by *Bacillus sphaericus*.

3. Beetles and cater pillar are killed by fungi.

Advantage: They are very much ecofriendly and economic.

### Application techniques:

The pesticides should be applied at an appropriate time and in a proper method for desired effect. These methods will depend upon the properties of the pesticide, formulation, pests to be managed and the site

of application. There are four methods such as foliar application, soil application, whorl application and fumigation.

**1. Foliar application:** There are two methods:

a) **Spraying**: Application of insecticide in liquid form through the aid of solvent or water based emulsion

b) **Dusting** Manually or mechanically operated dusters are used for dusting the pesticide. Uniform flow of dust at constant rate of discharge is achieved.

**2. Soil application**: The pesticide is mixed with equal quantity of sand and applied on the paddy nursery beds. It can be mixed with water for soil application. Furrows can be made around the plants and the pesticides can be applied in that furrows.

3. **Whorl application**: The granules of pesticides are mixed with some sand and applied on leaf whorls.

4. **Fumigation**: The fields are exposed to the action of fumes in order to disinfect or kill the insect pests.

**Someasic concepts**

1. Pests are animals that affects the productivity of crops and other cultivable plants. Among them, insects form the major component.
2. Pests can be controlled both by natural and artificial means.
3. Natural methods of control include climatic and topographic factors as well as natural enemies.
4. Artificial control methods are grouped as cultural, mechanical, physical, chemical and biological.
5. Pesticides are classified based on the target organisms such as insecticide, rodenticide etc.,
6. These pesticides are applied in different ways such as foliar application, soil application, whorl application and fumigation.

## Self - Evaluation

**Choose the correct answer**

1. Which of the following cause great damage to plants:
   a) insects b) bacteria
   c) vertebrates d) viruses
2. Beetles and caterpillars can be killed by using :
   a) bacteria b) fungi
   c) algae d) machines
3. *Chilo polychrysa* infests:
   a) sorghum b) brinjal
   c) rice d) cocanut

**Say true or false**

4. Cultural method is one kind of artificial control method.
5. There are no natural enemies to insects.
6. Atrazine is an example for bactericide.

**Fill in the blanks**

7. Temperature comes under _____ factors.
8. Rhinoceros beetles are controlled by _____
9. *Bacillus thuringiensis* is an example for _____ .

**10. Match the following**

| | |
|---|---|
| 1. Insecticide | i) Bordeaux mixture |
| 2. Rodenticide | ii) Aureomycin |
| 3. Fungicide | iii) Endosulphan |
| 4. Bactericide | iv) Thalium sulphate |
| | v) Atrazine |

**Answer briefly**

11. What are pests?
12. Mention two methods of artificial control.
13. List out any two advantages of bioinsecticides.

**Answer in detail**

14. Explain natural methods of control.
15. What are the various types of pesticides? Explain the methods of their application.