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# UNIT 12 PLANT ANATOMY AND PLANT PHYSIOLOGY

## Learning Objectives

At the end of this lesson the students will be able to:

- Understand vascular tissue system- their types and functions.
- Know the structure of dicot root, stem, leaf and monocot root, stem, leaf.
- Differentiate the internal structure of dicot root, stem, leaf with that of monocot root, stem, leaf.
- Name the different pigments found in chloroplast.
- Elaborate on the structure and functions of plastids.
- Enumerate the steps involved in photosynthesis.
- Understand the structure of mitochondria
- List the basic events of aerobic and anerobic respiration.

## Introduction

Plants exhibits varying degrees of organization. Atoms are organized into molecules, molecules into organelles, organelles into cells, cells into tissues and tissues into organs. The first account of internal structure of plants was published by English Physician **Nehemiah Grew**. He is known as **Father of Plant Anatomy**. Plant anatomy (Gk *Ana* = as under; *Temnein* = to cut) is the study of internal structure of plants. You have already studied the different kinds of tissues in standard IX. In this lesson, you will study about the internal structure of plant tissues, process of photosynthesis and respiration.

## 12.1 Tissues

Tissues are the group of cells that are similar or dissimilar in structure and origin, but perform similar function. Plant tissues can be broadly classified into two, based on their ability to divide. They are

i) Meristamatic tissue
ii) Permanent tissue.

## 12.2 Tissue system

Sachs (1875) classified tissue system in plants into three types

i) Dermal or Epidermal tissue system
ii) Ground tissue system
iii) Vascular tissue system

The functions of these tissues are given in Table 12.1.

### 12.2.1 Dermal or Epidermal Tissue System

It consists of epidermis, stomata and epidermal outgrowths. Epidermis is the outer most layer. It has many minute pores called stomata.

**Table 12.1** Tissue system and its functions

| Tissue System | Components | Functions |
|---|---|---|
| Dermal Tissue System | Epidermis and Periderm (in older stems and roots) | • Protection<br>• Prevention of water loss |
| Ground Tissue System | Parenchyma tissue<br><br>Collenchyma tissue<br>Sclerenchyma tissue | • Photosynthesis<br>• Food storage<br>• Regeneration<br>• Support<br>• Protection |
| Vascular Tissue System | Vascular tissues<br>- Xylem tissue<br>- Phloem tissue | • Transport of water and minerals<br>• Transport of food |

Cuticle is present on the outer wall of epidermis to check evaporation of water. Trichomes and root hairs are the epidermal outgrowths.

**Functions:**

i) Epidermis protects the inner tissues.

ii) Stomata helps in transpiration.

iii) Root hairs help in absorption of water and minerals.

## 12.2.2 Ground Tissue System

It includes all the tissues of the plant body except epidermal and vascular tissues like (i) Cortex (ii) Endodermis (iii) Pericycle (iv) Pith

## 12.2.3 Vascular Tissue System

It consists of xylem and phloem tissues. They are present in the form of bundles called vascular bundles. Xylem conducts water and minerals to different parts of the plant. Phloem conducts food materials to different parts of the plant.

There are three different types of vascular bundles namely (i) Radial (ii) Conjoint (iii) Concentric

**(i) Radial Bundles**

Xylem and phloem are present in different radii alternating with each other. e.g. roots

**(ii) Conjoint bundles**

Xylem and phloem lie on the same radius. There are two types of conjoint bundles.

**a) Collateral**

Xylem lies towards the centre and phloem lies towards the periphery.

When cambium is present in collateral bundles, it is called open. e.g. dicot stem and collateral bundle without cambium is called closed. e.g. monocot stem.

**b) Bicollateral**

In this type of bundle, the phloem is present on both outer and inner side of xylem. e.g. *Cucurbita*

**(iii) Concentric Bundles**

Vascular bundle in which xylem completely surrounds the phloem or viceversa is called concentric vascular bundle. It is of two types:

1. **Amphivasal:** Xylem surrounds phloem. e.g. *Dracaena*
2. **Amphicribral:** Phloem surrounds xylem. e.g. Ferns

**Endarch:** Protoxylem lies towards the centre and metaxylem lies towards the periphery. e.g. stem.

**Exarch :** Protoxylem lies towards the periphery and metaxylem lies towards the centre. e.g. roots.

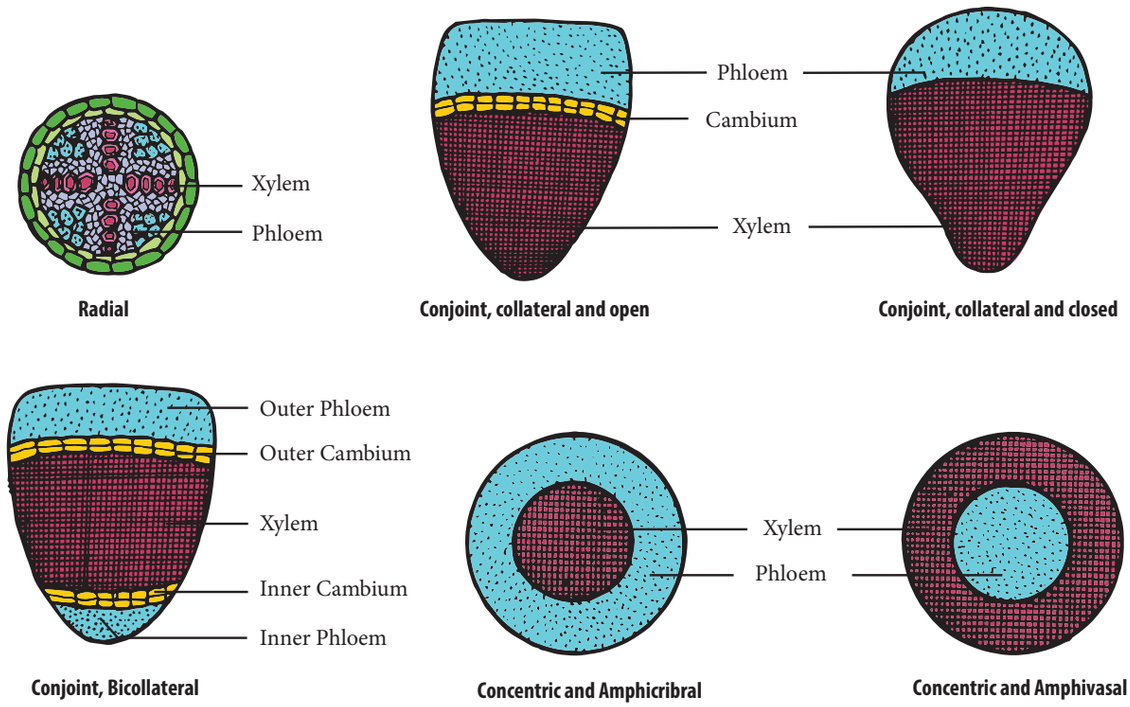


**Figure 12.1** Types of vascular bundle

## 12.3 Internal Structure of Dicot Root (Bean)

A thin transverse section of dicot root shows the following structures.

**(i) Epiblema:** It is the outermost layer. Cuticle and stomata are absent. Unicellular root hairs are present. It is also known as **Rhizodermis** or **Piliferous layer**.

**(ii) Cortex:** It is a multilayered large zone made of thin-walled parenchymatous cells with intercellular spaces. It stores food and water.

**(iii) Endodermis:** It is the innermost layer of cortex. The cells are barrel - shaped, closely packed, and show band like thickenings on their radial and inner tangential walls called **casparian strips**. But these casparian strips are absent in the endodermis cells which are located opposite the protoxylem these thin walled cells without casparian strips are called passage cell. It helps in the movement of water and dissolved salts from cortex into xylem.

**(iv) Stele:** All tissues inner to endodermis constitute stele. It includes pericycle and vascular bundle.

**(a) Pericycle:** Inner to endodermis lies a single layer of pericycle. It is the site of origin of lateral roots.

**(b) Vascular bundle:** It is radial. Xylem is **exarch** and **tetrach**. The tissue present between xylem and phloem is called conjunctive tissue. In dicot root, it is made up of parenchyma.

**(c) Pith:** Young root contains pith whereas in old root pith is absent.

## 12.4 Internal Structure of Monocot Root (Maize)

A thin transverse section of monocot root, shows the following characteristic features.

**i. Epiblema or Rhizodermis:** It is the outermost layer of the root, and is made up of single layer of thin walled, parenchymatous cell. Stomata and cuticle are absent. The root hair helps in absorption of water and minerals from the soil. This layer also protects the inner tissues.

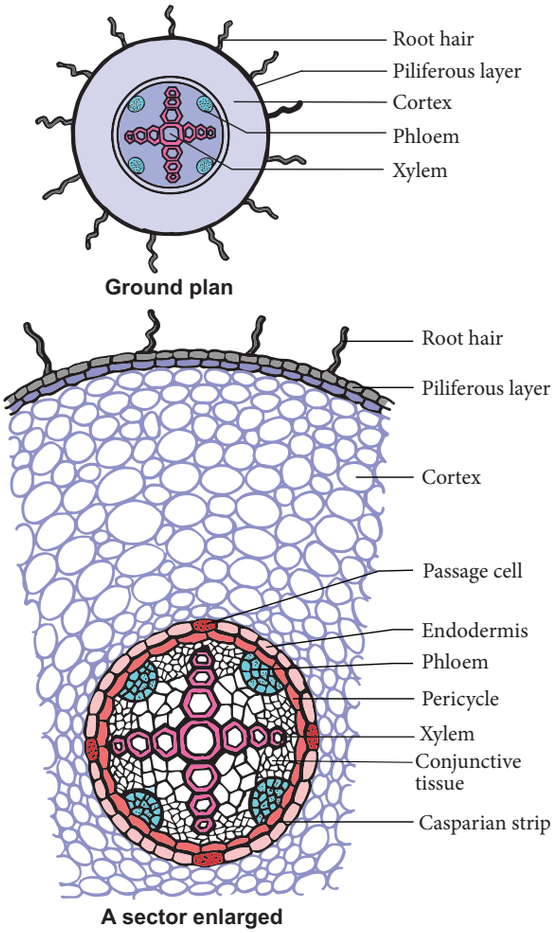


**Figure 12.2** Transverse section of Dicot root

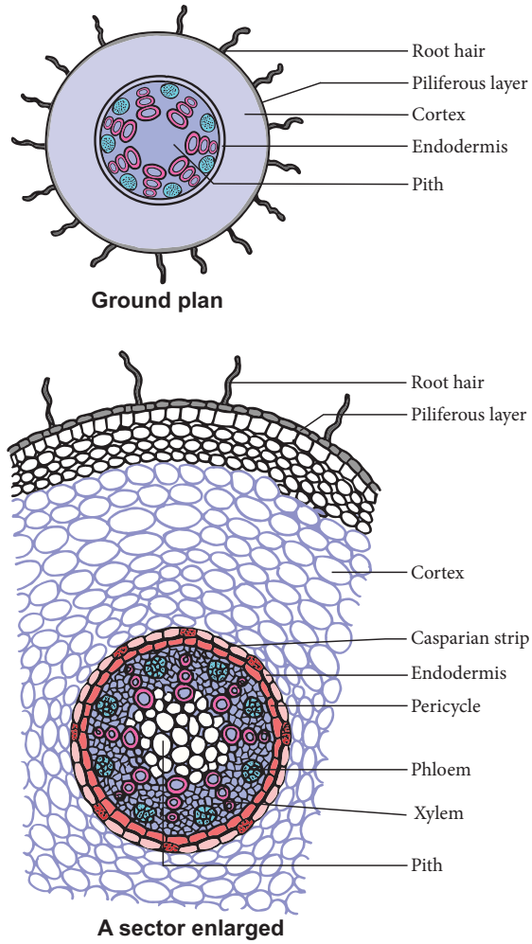


**Figure 12.3** Transverse section of Monocot root

**ii. Cortex:** It is multilayered large zone, composed of parenchymatous cells with intercellular spaces. It stores water and food material.

**iii. Endodermis:** It is the innermost layer of cortex with characteristic casparian strips and passage cells. **Casparian strips** are band like thickening made of **suberin**.

**iv. Stele:** All the tissues inner to endodermis constitute stele. It includes pericycle, vascular tissues and pith.

**a) Pericycle:** It is a single layer of thin walled cells. The lateral roots originate from this layer.

**b) Vascular tissues:** It consists of many patches of xylem and phloem arranged radially. The xylem is exarch and polyarch. The conjunctive tissue is made up of sclerenchyma.

**c) Pith:** It is present at the center. It is made up of parenchyma cells with intercellular spaces. It contains abundant amount of starch grains. It stores food.

## 12.5 Internal Structure of Dicot Stem (Sunflower)

The transverse section of a dicot stem reveals the following structures.

1. **Epidermis:** It is the outermost layer. It is made up of single layer of parenchyma cells, its outer wall is covered with cuticle. It is protective in function.
2. **Cortex:**- It is divided into three regions:

(i) **Hypodermis:** It consists of 3 - 6 layers of collenchyma cells. It gives mechanical support.

**Table 12.2** Differences between Dicot and Monocot root

| S. No. | Tissues | Dicot Root | Monocot Root |
|---|---|---|---|
| 1 | Number of Xylem | Tetrarch | Polyarch |
| 2 | Cambium | Present (During secondary growth only) | Absent |
| 3 | Secondary Growth | Present | Absent |
| 4 | Pith | Absent | Present |
| 5 | Conjunctive Tissue<br>Ex. | Parenchyma<br>Bean | Sclerenchyma<br>Maize |

**(ii) Middle cortex:** It is made up of few layers of chlorenchyma cells. It is involed in photosynthesis due to the presence of chloroplast.

**(iii) Inner cortex:** It is made up of few layers of parenchyma cells. It helps in gaseous exchange and stores food materials.

**Endodermis** is the inner most layer of cortex it consists of a single layer of barrel shaped cells, these cells contain starch grains. So it is also called **starch sheath**.

3. **Stele:** The central part of the stem inner to endodermis is known as stele. It consists of pericycle, vascular bundle and pith.

**(i) Pericycle:** It occurs between vascular bundle and endodermis. It is multilayered, parenchymatous with alternating patches of sclerenchyma.

**(ii) Bundle Cap:** There is a patch of hard sclerenchyma tissue outside to the phloem of vascular bundle is calld Bundle Cap.

**(iii) Vascular bundle:** Vascular bundles are conjoint, collateral, endarch and open. They are arranged in the form of a ring around the pith.

**(iv) Pith:** The large central parenchymatous zone with intercellular spaces is called pith. It helps in the storage of food materials.

## 12.6 Internal Structure of Monocot Stem (Maize)

A transverse section of monocot stem reveals the following structures.

1. **Epidermis:** It is the outermost layer. It is made up of single layer of parenchyma cells. It is covered with thick cuticle. Multicellular hairs are absent and stomata are also less in number.
2. **Hypodermis:** It is made up of few layers of sclerenchyma cells interrupted by chlorenchyma. Sclerenchyma provides mechanical support to plant.
3. **Ground tissue:** The entire mass of parenchyma cells next to hypodermis

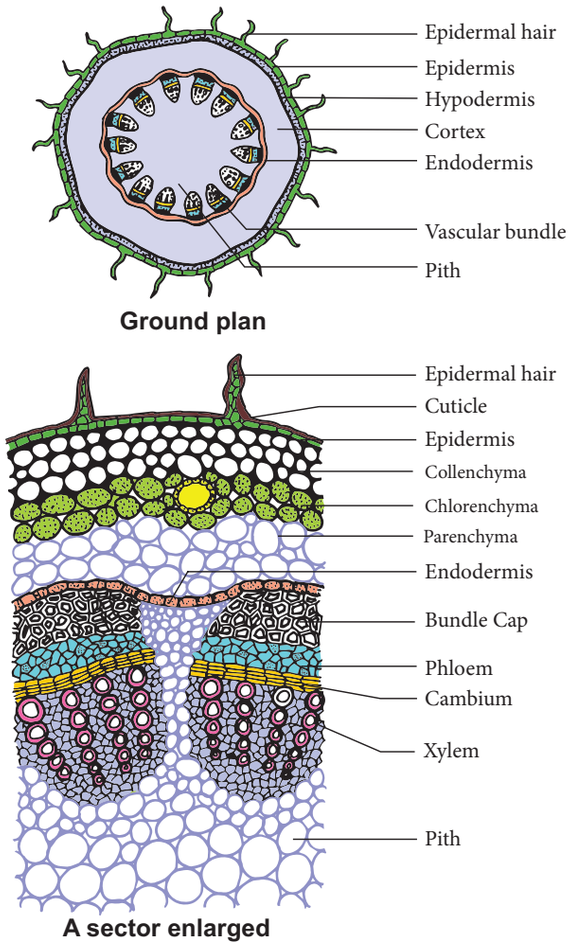


**Figure 12.4** Transverse section of Dicot stem

and extending to the centre is called **ground tissue**. It is not differentiated into endodermis, cortex, pericycle and pith.

4. **Vascular Bundle:** Vascular bundles are skull shaped and scattered in the ground tissue. Vascular bundles are conjoint, collateral, endarch and closed. Each vascular bundle is surrounded by few layer of sclerenchyma cells called **bundle sheath**.
   (a) **Xylem:** It consists of metaxylem and protoxylem. Xylem vessels are arranged in V or Y shape. In mature vascular bundle, the lower most protoxylem disintegrates and form a cavity. This is called **protoxylem lacuna.**
   (b) **Phloem:** It consists of sieve tube elements and companion cells. Phloem parenchyma, and phloem fibers are absent.
5. **Pith:** Pith is not differentiated in monocot stems.

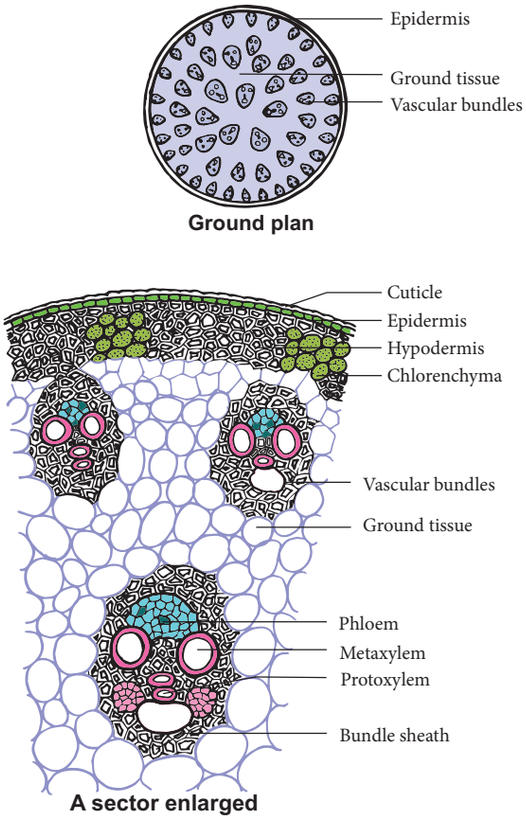


**Figure 12.5** Transverse section of Monocot stem

**Table 12.3** Differences between Dicot Stem Ex.Sunflower and Monocot Stem Ex.Maize

| S. No. | Tissues | Dicot Stem | Monocot Stem |
|---|---|---|---|
| 1 | Hypodermis | Collenchymatous | Sclerenchymatous |
| 2 | Ground tissue | Differentiated into cortex, endodermis, pericycle and pith | Undifferentiated |
| 3 | Vascular bundles | (i) Less in number<br>(ii) Uniform in size<br>(iii) Arranged in a ring<br>(iv) Open (Cambium present)<br>(v) Bundle sheath absent | (i) Numerous<br>(ii) Smaller near periphery, bigger in the centre<br>(iii) Scattered<br>(iv) Closed (Cambium absent)<br>(v) Bundle sheath present |
| 4 | Secondary growth | Present | Mostly absent |
| 5 | Pith | Present | Absent |
| 6 | Medullary rays | Present | Absent |

## 12.7 Internal Structure of Dicot Leaf (Dorsiventral Leaf) Ex. Mango Leaf

The transverse section of leaf shows the following structures.

(i) **Upper epidermis:** This is the outermost layer made of single layered parenchymatous cells without intercellular spaces. The outer wall of the cells are cuticularized. Stomata are less in number.

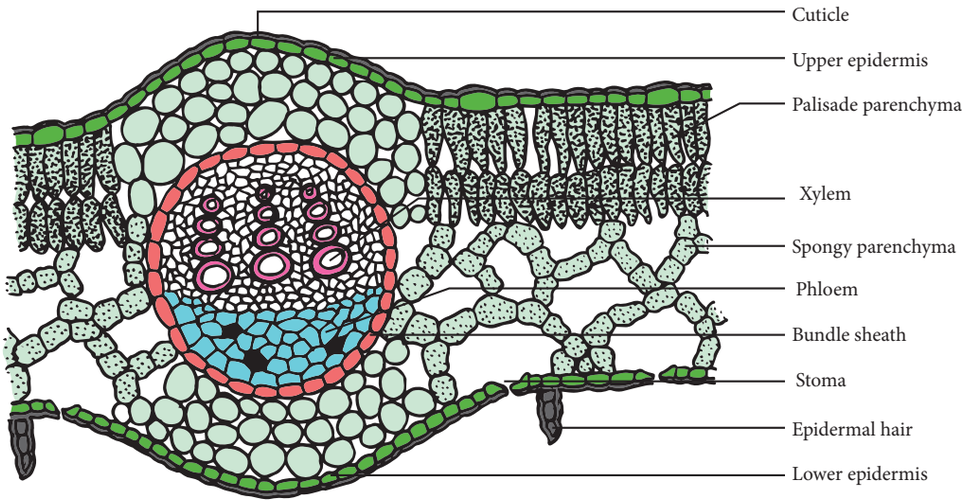


**Figure 12.6** Transverse section of Dicot leaf

(ii) **Lower epidermis:** It is a single layer of parenchymatous cells with a thin cuticle. It contains numerous stomata. Chloroplasts are present only in guard cells. The lower epidermis helps in the exchange of gases. The loss of water vapour is facilitated through this chamber.

(iii) **Mesophyll:** The tissue present between the upper and lower epidermis is called mesophyll. It is differentiated into Palisade parenchyma and Spongy parenchyma.

a) **Palisade parenchyma:** It is found just below the upper epidermis. The cells are elongated. These cells have more number of chloroplasts. The cells do not have intercellular spaces and they take part in photosynthesis.

b) **Spongy parenchyma:** It is found below the palisade parenchyma tissue. Cells are almost spherical or oval and are irregularly arranged. Cells have intercellular spaces. It helps in gaseous exchange.

(iv) **Vascular bundles:** Vascular bundle are present in mid-rib and lateral veins. Vascular bundles are conjoint, collateral and closed. Each vascular bundle is surrounded by a sheath of parenchymatous cells called **bundle sheath**. Each vascular bundle consists of xylem lying towards the upper epidermis and phloem towards the lower epidermis.

## 12.8 Internal Structure of Monocot Leaf (Isobilateral Leaf) Ex.Grass Leaf

The transverse section of a monocot leaf reveals the following structures.

(i) **Epidermis:** Monocot leaf has upper and lower epidermis. Epidermis is made up of parenchyma cells. Cuticle is present on the outer wall stomata are present on both upper and lower epidermis. Some cells of upper epidermis are large and thin walled they are known as **bulliform cells**.

(ii) **Mesophyll:** It is the ground tissue that is present between both epidermal layers. Mesophyll is not differentiated into palisade and spongy parenchyma. The cells are irregularly arranged with inter-cellular spaces. These cells contain chloroplasts.

(iii) **Vascular bundles:** Large number of vascular bundles are present, some of which are small and some are large.

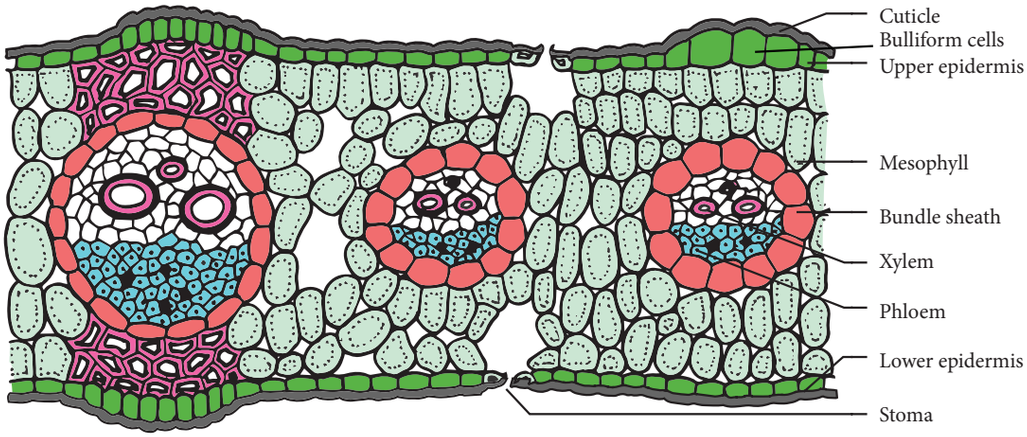


**Figure 12.7** Transverse section of Monocot Leaf

Each vascular bundle is surrounded by parenchymatous bundle sheath. Vascular bundles are conjoint, collateral and closed. Xylem is present towards upper epidermis and phloem towards lower epidermis.

**Table 12.4** Differences between of Dicot and Monocot Leaf

| S. No. | Dicot Leaf | Monocot Leaf |
|---|---|---|
| 1 | Dorsiventral leaf | Isobilateral leaf |
| 2 | Mesophyll is differentiated into palisade and spongy parenchyma | Mesophyll is not differentiated into palisade and spongy parenchyma |

## 12.9 Plant Physiology

### 12.9.1 Plastids

Plastids are double membrane bound organelles found in plants and some algae. They are responsible for preparation and storage of food. There are three types of plastids.

Chloroplast - green coloured plastids
Chromoplast - yellow, red, orange coloured plastids
Leucoplast - colourless plastids

### 12.9.2 Structure of Chloroplast

Chloroplasts are green plastids containing green pigment called **chlorophyll**. Chloroplasts are oval shaped organelles having a diameter of 2-10 micrometer and a thickness of 1-2 micrometer.


**Figure 12.8** Ultrastructure of Chloroplast

1. **Envelope:** Chloroplast envelope has outer and inner membranes which is seperated by intermembrane space.
2. **Stroma:** Matrix present inside to the membrane is called stroma. It contains DNA, 70 S ribosomes and other molecules required for protein synthesis.
3. **Thylakoids:** It consists of thylakoid membrane that encloses thylakoid lumen. Photosynthetic pigments are present in thylakoids. Thylakoids forms a stack of **disc like structures** called a grana (singular-granum).
4. **Grana:** Thylakoids arranged in the form of discs stacked one above the other called granum. Grana are inter connected by stroma lamella.

### 12.9.3 Functions of Chloroplast

1. Photosynthesis 2. Storage of starch 3. Synthesis of fatty acids 4. Storage of lipids 5. Formation of chloroplasts

### 12.9.4 Photosynthesis

Photosynthesis (Photo = light; synthesis = to build) is a process by which autotrophic organisms like green plants, algae and chlorophyll containing bacteria utilize the energy from sunlight to synthesize their own food. In this process, carbon dioxide combines with water in the presence of sunlight and chlorophyll to form carbohydrates. During this process oxygen is released as a byproduct.

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$$6CO_2 + 12H_2O \xrightarrow[\text{chlorophyll}]{\text{Light}} C_6H_{12}O_6 + 6\,H_2O + 6O_2\uparrow$$

Carbon dioxide + Water ⟶ Glucose + Water + Oxygen

### 12.9.5 Where does photosynthesis occur?

Photosynthesis occurs in all green parts of the plant especially in green leaves.

### 12.9.6 Photosynthetic Pigments

Pigments involved in photosynthesis are called **Photosynthetic pigments.** Photosynthetic pigments are of two classes namely, the primary pigments and accessory pigments. Chlorophyll a is the **primary pigment** that traps solar energy and converts it into electrical and chemical energy. Thus it is called the reaction centre. Other pigments such as chlorophyll b and carotenoids are called **accessory pigments** as they pass on the absorbed energy to chlorophyll a (Chl.a) molecule. Reaction centre (Primary pigments) and harvesting centre (Accessary pigments) together form Pigment systems.

### 12.9.7 Role of Sunlight in Photosynthesis

The entire process of photosynthesis takes place inside the chloroplast. The structure of chloroplast is such that the light dependent (**Light reaction**) and light independent (**Dark reaction**) take place at different sites in the organelle

**1. Light dependent Reaction (Hill reaction \ Light reaction)**

This was discovered by **Robin Hill** (1939). This reaction takes place in the presence of light energy in **thylakoid membranes** (grana) of the chloroplasts. Photosynthetic pigments absorb the light energy and convert it into chemical energy ATP and $NADPH_2$. These products of light reaction move out from the thylakoid to the stroma of the chloroplast.

**More to Know**

| | |
|---|---|
| ATP | Adenosine Triphosphate |
| ADP | Adenosine Diphosphate |
| NAD | Nicotinamide Adenine Dinucleotide |
| NADP | Nicotinamide Adenine Dinucleotide Phosphate |

DO YOU KNOW?

A cell cannot get its energy directly from glucose. So in respiration the energy released from glucose is used to make ATP (Adenosine Triphosphate)

**2. Light independent reactions (Dark reaction) (Biosynthetic phase)**

Dark reaction or biosynthetic pathway is takes place in **stroma**. During this reaction $CO_2$ is reduced into carbohydrates with the help of light generated **ATP** and **$NADPH_2$**. This is also called as **Calvin cycle** and is carried out in the absence of light. It is called dark reaction.

In Calvin cycle the inputs are $CO_2$ from the atmosphere and the ATP and $NADPH_2$ produced from light reaction.

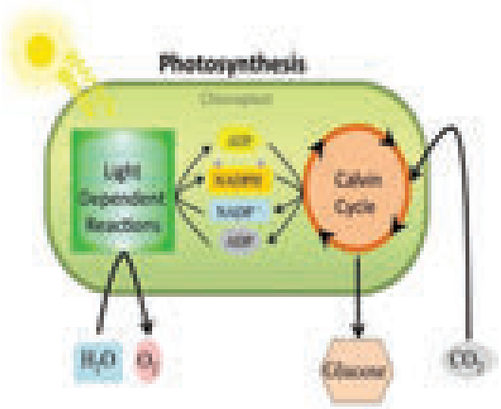



**Figure 12.9** Overview of Hill and Calvin cycle

Melvin Calvin, an American biochemist, discovered chemical pathway for photosynthesis. The cycle is named as Calvin cycle. He was awarded with Nobel Prize in the year 1961 for his discovery.

### 12.9.8 Factors Affecting Photosynthesis

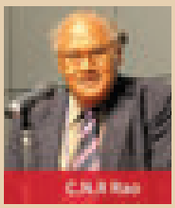
**a) Internal Factors**:

i) Pigments ii) Leaf age iii) Accumulation of carbohydrates iv) Hormones

**b) External Factors**:

i) Light ii) Carbon dioxide iii) Temperature iv) Water v) Mineral elements

**Info bit**



Artificial photosynthesis is a method for producing renewable energy by the use of sunlight. Indian scientist C.N.R. Rao who was conferred the Bharat Ratna (2013) is also working on similar technology of artificial photosynthesis to produce - Hydrogen fuel (renewable energy).

## 12.10 Mitochondria

Mitochondria are filamentous or granular cytoplasmic organelles present in cells. The mitochondria were first discovered by Kolliker in 1857 as granular structures in striated muscles. Mitochondria (singular: mitochondrion) are organelles within eukaryotic cells that produce adenosine triphosphate (ATP) which form the energy currency of the cell, for this reason, the mitochondria is referred to as the "**Power house of the cell**". Mitochondria vary in size from 0.5 µm to 2.0 µm. Mitochondria contain 60-70% protein, 25-30% lipids, 5-7% RNA and small amount of DNA and minerals.

### 12.10.1 Structure of Mitochondria

**Mitochondrial Membranes:** It consists two membranes called inner and outer membrane. Each membrane is 60-70 Å thick. Outer mitochondrial membrane is smooth and freely permeable to most small molecules. It contains enzymes, proteins and lipids. It has **porin molecules** (proteins) which form channels for passage of molecules through it.

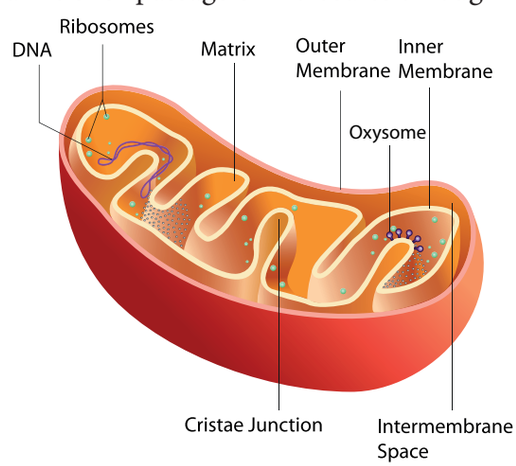



**Figure 12.10** Structure of Mitochondria

Inner mitochondrial membrane is semi permeable membrane and regulates the passage of materials into and out of the mitochondria. It is rich in enzymes and carrier proteins. It consists of 80% proteins and lipids.

**Cristae:** The inner mitochondrial membrane gives rise to finger like projections called cristae. These cristae increase the inner surface area (fold in inner membrane) of the mitochondria to hold variety of enzymes.

**Oxysomes:** The inner mitochondrial membrane bear minute regularly spaced tennis racket shaped particles known as oxysomes ($F_1$ particle). They involve in ATP synthesis.

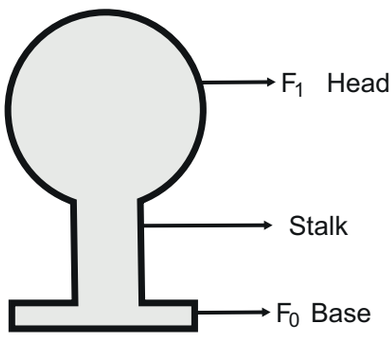



**Figure 12.11** Structure of Oxysomes

**Mitochondrial matrix** - It is a complex mixture of proteins and lipids. Matrix contains enzymes for Krebs cycle, mitochondrial ribosomes(70 S), tRNAs and mitochondrial DNA.

### 12.10.2 Functions of Mitochondria

- Mitochondria is the main organelle of cell respiration. They produce a large number of ATP molecules. So they are called as **power houses of the cell** or **ATP factory of the cell**.
- It helps the cells to maintain normal concentration of calcium ions.
- It regulates the metabolic activity of the cell.

## 12.11 TYPES OF RESPIRATION

Respiration involves exchange of gases between the organism and the external environment. The plants obtain oxygen from their environment and release carbon dioxide and water vapour. This exchange of gases is known as **external respiration**. It is a physical process. Biochemical process occurs within cells where the food is oxidized to obtain energy, this is known as cellular respiration

### 12.11.1 Aerobic respiration

Aerobic respiration is the type of celluar respiration in which organic food is completely oxidized with the help of oxygen into carbon dioxide, water and energy. It occurs in most plants and animals.

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + ATP$

#### Stages of Aerobic respiration

**a. Glycolysis** (Glucose splitting): It is the breakdown of one molecule of glucose (6 carbon) into two molecules of pyruvic acid (3 carbon). Glycolysis takes place in cytoplasm of the cell. It is the first step of both aerobic and anerobic respiration.

**b. Krebs Cycle:** This cycle occurs in mitochondria matrix. At the end of glycolysis, 2 molecules of pyruvic acid enter into mitochondria. The oxidation of pyruvic acid into $CO_2$ and water takes place through this cycle. It is also called **Tricarboxylic Acid Cycle** (TCA).

**c. Electron Transport Chain:** This is accomplished through a system of electron carrier complex called **electron transport chain** (ETC) located on the inner membrane of the mitochondria. $NADH_2$ and $FADH_2$ molecules formed during glycolysis and Krebs cycle are oxidised to $NAD^+$ and $FAD^+$ to release the energy via electrons. The electrons, as they move through the system, release energy which is trapped by ADP to synthesize ATP. This is called **oxidative phosphorylation**. In this

process, $O_2$ the ultimate acceptor of electrons gets reduced to water.

### 12.11.2 Anaerobic respiration

Anaerobic respiration takes place without oxygen. Glucose is converted into ethanol (Ethanol fermentation by yeast) or lactic acid (lactic acid fermentation by bacteria).

$$C_6H_{12}O_6 \rightarrow 2CO_2 + 2C_2H_5OH + \text{Energy (ATP)}$$

### 12.11.3 Respiratory quotient (R.Q)

Respiratory quotient is the ratio of volume of carbon dioxide liberated and the volume of oxygen consumed during respiration. It is expressed as

$$RQ = \frac{\text{Volume of } CO_2 \text{ liberated}}{\text{Volume of } O_2 \text{ consumed}}$$

**Points to Remember**

- Tissue is a group of similar or dissimilar cells, having a common orgin and performing similar functions.
- Plants are capable of synthesizing glucose from $CO_2$ and $H_2O$ in the presence of light, by the process of photosynthesis.
- Light reaction takes place in grana of chloroplast.
- Dark reaction takes place in stroma of chloroplast.
- Respiration involves both external and cellular respiration.
- Aerobic respiration takes place in the presence of oxygen.
- Aerobic respiration occurs in three major steps like Glycolysis, Krebs cycle and Electron transport chain.

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## TEXTBOOK EVALUATION

### I. Choose the correct answer

1. Casparian strips are present in the _____ of the root.
   a) cortex b) pith
   c) pericycle d) endodermis
2. The endarch condition is the characteristic feature of
   a) root b) stem
   c) leaves d) flower
3. The xylem and phloem arranged side by side on same radius is called _____
   a) radial b) amphivasal
   c) conjoint d) None of these
4. Which is formed during anaerobic respiration
   a) Carbohydrate b) Ethyl alcohol
   b) Acetyl CoA d) Pyruvate
5. Kreb's cycle takes place in
   a) chloroplast
   b) mitochondrial matrix
   c) stomata
   d) inner mitochondrial membrane
6. Oxygen is produced at what point during photosynthesis ?
   a) when ATP is converted to ADP
   b) when $CO_2$ is fixed
   c) when $H_2O$ is splitted
   d) All of these

### II. Fill in the blanks.

1. The innermost layer of cortex in root is called _____.
2. Xylem and phloem are arranged in an alternate radii constitute a vascular bundle called _____.

3. Glycolysis takes place in _____.
4. The source of $O_2$ liberated in photosynthesis is _____.
5. _____ is ATP factory of the cells

## III. State whether the statements are true or false. Correct the false statement.

1. Phloem tissue is involved in the transport of water in plant.
2. The waxy protective covering of a plant is called as cuticle.
3. In monocot stem cambium is present in between xylem and phloem.
4. Palisade parenchyma cells occur below upper epidermis in dicot root.
5. Mesophyll contains chlorophyll.
6. Anaerobic respiration produces more ATP than aerobic respiration.

## IV. Match the following

| | | | |
|---|---|---|---|
| 1. | Amphicribal | - | *Dracaena* |
| 2. | Cambium | - | Translocation of food |
| 3. | Amphivasal | - | Fern |
| 4. | Xylem | - | Secondary growth |
| 5. | Phloem | - | Conduction of water |

## V. Answer in a sentence

1. What is collateral vascular bundle?
2. Where does the carbon that is used in photosynthesis come from?
3. What is the common step in aerobic and anaerobic pathway?
4. Name the phenomenon by which carbohydrates are oxidized to release ethyl alcohol.

## VI. Short answer questions

1. Give an account on vascular bundle of dicot stem.
2. Write a short note on mesophyll.
3. Draw and label the structure of oxysomes.
4. Name the three basic tissues system in flowering plants.
5. What is photosynthesis and where in a cell does it occur?
6. What is respiratory quotient?
7. Why should the light dependent reaction occur before the light independent reaction?
8. Write the reaction for photosynthesis?

## VII. Long answer questions

1. Differentiate the following
   a) Monocot root and Dicot root
   b) Aerobic and Anaerobic respiration
2. Describe and name three stages of cellular respiration that aerobic organisms use to obtain energy from glucose.
3. How does the light dependent reaction differ from the light independent reaction? What are the end product and reactants in each? Where does each reaction occur within the chloroplast?

## VIII. Higher Order Thinking Skills(HOTS)

1. The reactions of photosynthesis make up a biochemical pathway.
   A) What are the end product of light and dark reaction of photosynthesis?
   B) Explain how the biochemical pathway of photosynthesis recycles many of its own reactions and identify the recycled reactants.
2. Where do the light dependent reaction and the Calvin cycle occur in the chloroplast?

## REFERENCE BOOKS


1. Bajracharya D, Experiments in Plant Physiology, Narosa Publishing House, New Delhi
2. Pandey B.P. Plant Anatomy, S. Chand and Company Ltd, New Delhi
3. Verma P.S. and Agarwal V.K. Cytology, S.Chand and Company Ltd, New Delhi


## INTERNET RESOURCES

www.science daily.com
www.britannica.com

# Concept Map


## ICT CORNER

## PLANT ANATOMY

**PHOTOSYNTHESIS – This application enables students to play a game to adjust sunlight rays to reach the plant.**

### Steps

- Access the application Photosynthesis with the help of the provided URL or QR code. Install in your device. After opening the app, Click LEVELS to begin the game.
- A palnt sapling will be in one side, and sun rays will be at the other side. You have to drag and adjust the mirror so that the sunlight rays will fall on the plant.
- At the top left, there is a indicator to show the timings.
- Explore and complete the other levels gradually.

Step1

Step2

Step3

Step4

**Cells alive**

URL : https://play.google.com/store/apps/details?id=com.Rinekso.PhotoSHinythesis

*Pictures are indicative only

B375_10_SCIENCE_EM

# UNIT 13 STRUCTURAL ORGANISATION OF ANIMALS

## Learning Objectives

KEUPC9

At the end of this lesson the students will be able to:

- Understand the external morphology of the leech and rabbit.
- Recognise the structural features of different organ systems.
- Will be able to understand the physiology of various organ systems of leech and rabbit.
- Learn the parasitic adaptations of leech.
- Identify the type of dentition and its significance in rabbit.
- Perceive the differences between the structural organisation of an invertebrate (leech) and vertebrate (rabbit).

## Introduction

The variety in nature and habits of animals in the biosphere are quite amazing and interesting. What we see around us may be just few, but there are innumerable species living in this world. You have learnt in lower classes about the classification of animal kingdom. We will recall here that **'Kingdom Animalia'** is divided into two groups, **Invertebrates** and **Chordates**.

There occurs a great diversity in the habit, habitat, structural organisation and mode of reproduction between the animals existing on earth. In this chapter, you will understand the structural morphology and anatomy of an Invertebrate (Leech) and a Vertebrate (Rabbit).

The scientific name of the Indian cattle leech is ***Hirudinaria granulosa*** which belongs to **Phylum Annelida**. Annelids are **metamerically segmented worms** with well developed organ systems.

The scientific name of the common rabbit is ***Oryctolagus cuniculus***. It is represents **Phylum Chordata** and **Class Mammalia**. Mammals occupy the highest group in the animal kingdom and show advancement over the other groups of animals. They are warm blooded and possess covering of hair on the body. Mammary gland in females is the most striking feature of a mammal. Let us now study about the morphology of leech and rabbit in detail.

## 13.1 The Indian Cattle Leech (*Hirudinaria granulosa*)

| Taxonomic Position | |
|---|---|
| Phylum | Annelida |
| Class | Hirudinea |
| Order | Gnathobdellida |
| Genus | *Hirudinaria* |
| Species | *granulosa* |

### 13.1.1 Habit and Habitat

*Hirudinaria granulosa* (Indian Cattle Leech) is found in India, Bangladesh, Pakistan, Myanmar and Srilanka. It lives in freshwater ponds, lakes, swamps and slow streams. They are **ectoparasitic** and feed on the blood of fishes, frogs, cattle and human. It is **sanguivorous** (blood sucking) in nature.

### 13.1.2 External Morphology

**Shape and Size:** The body of a leech is soft, vermiform, elongated and segmented. It becomes ribbon shaped when extended and almost cylindrical when contracted. Leeches may grow to a length of 35cm.

**Colouration:** Dorsal surface is olive green in colour and the ventral surface is orange yellow or orange red in colour.

**Segmentation: Metamerism** is the segmentation of the body. The body of leech is metamerically divided into 33 **segments.** The segments are arranged one behind the other. Each segment is further superficially subdivided into *rings* or *annuli*. A temporary **clitellum** is formed on segments 9-11, which is meant to produce a **cocoon** during the breeding season.

**Receptors:** On the dorsal side there are five pairs of eyes on the first five segments. Each segment bears a number of sensory projections called receptors. **Annular receptors** are located in each annulus and **segmental receptors** are located on the first annulus of each segment.

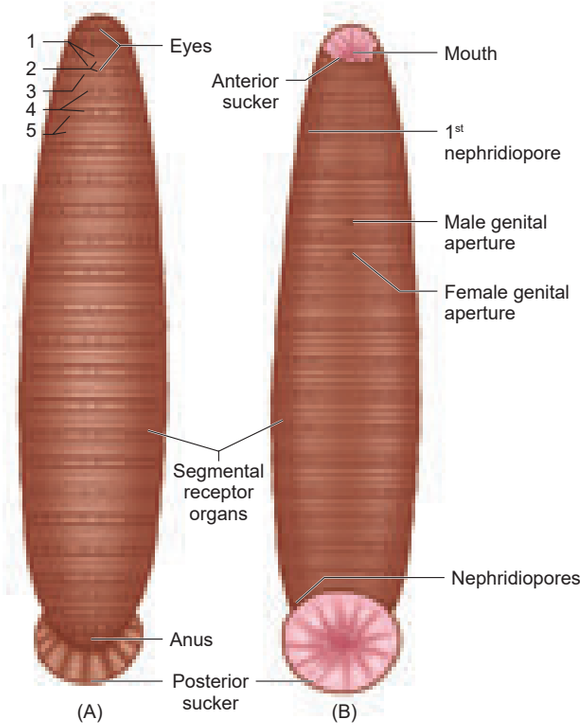


**Figure 13.1** External morphology of Leech

A. Dorsal View B. Ventral view

**Suckers:** Leech has two suckers. The sucker located at the anterior end is called **anterior sucker** or **oral sucker** which is ventral in position occupying the first five segments. The **posterior sucker** is formed by the fusion of the last seven segments. The anterior sucker helps in feeding, while both the suckers help in attachment and locomotion.

**External apertures**

(i) **Mouth:** It is located in the middle of anterior sucker.

(ii) **Anus:** Anus is a small aperture that opens on the mid-dorsal side of 26th segment.

(iii) **Nephridiopores:** Nephridia open to the exterior by 17 pairs of nephridiopores. They lie ventrally on the last annulus of each segment from 6 to 22.

(iv) **Male genital pore:** It is a mid-ventral opening, situated between second and third annuli of 10th segment.

**Activity 1**

(i) Observe the external morphology of leech specimen in your biology laboratory.

(ii) Can you find leeches in your locality?

(iii) In which geographical areas are leeches found more predominantly in India?

(v) **Female genital pore:** It lies mid-ventrally between second and third annuli of 11th segment.

### 13.1.3 Divisions of the Body

The body of leech is divided into six regions.

| Region | Segments |
|---|---|
| Cephalic region | 1st - 5th |
| Pre-clitellar region | 6th, 7th and 8th |
| Clitellar region | 9th, 10th and 11th |
| Middle region | 12th - 22nd |
| Caudal region | 23rd - 26th |
| Posterior sucker | 27th - 33rd |

### 13.1.4 Body wall

Body wall of leech includes five layers: (i) **cuticle** (outermost layer) (ii) **epidermis** which lies below the cuticle (iii) **dermis** which lies below the epidermis formed of connective tissue (iv) **muscular layer** formed of circular and longitudinal muscles (v) **botryoidal tissue** lies beneath longitudinal muscles and fills the entire coelom around the gut.

### 13.1.5 Locomotion

Locomotion in leech takes place by (i) looping or crawling movement (ii) Swimming movement.

**(i) Looping or Crawling movement**

This type of movement is brought about by the contraction and relaxation of muscles. The two suckers serve for attachment during movement on a substratum.

**(ii) Swimming movement**

Leeches swim very actively and perform undulating movements in water.

### 13.1.6 Digestive System

The digestive system includes the long alimentary canal and the digestive glands.

#### Alimentary Canal

The alimentary canal of leech is a straight tube running from the mouth to the anus. **Mouth** is a **triradiate** aperture situated in the middle of the anterior sucker that leads into the small buccal cavity. The wall of the buccal cavity bears three jaws with single row of minute teeth. The jaws are provided with **papillae** which bear the openings of salivary glands. Mouth and buccal cavity occupy the first five segments.

The buccal cavity leads into muscular **pharynx.** It is surrounded by salivary glands. The secretion of saliva contains **hirudin** which prevents the coagulation of blood. Pharynx leads into crop through a short and narrow **oesophagus.**

**Crop** is the largest portion of the alimentary canal. It is divided into a series of 10 chambers. The chambers communicate with one another through circular apertures surrounded by **sphincters.** A pair of lateral, backwardly directed caecae arises as blind outgrowth from each chamber known as **caeca** or **diverticula.** Crop and its diverticula can store large amount of blood which can be slowly digested.

The last chamber of crop opens into stomach. The stomach leads into **intestine** which is a small straight tube that opens into **rectum.** The rectum opens to the exterior by anus.

### Food, Feeding and Digestion

The leech feeds by sucking the blood of cattle and other domestic animals. During feeding the leech attaches itself to its victim strongly by the posterior sucker. The leech makes a **triradiate** or **Y shaped incision** in the skin of the host by the jaws protruded through the mouth. The blood is sucked by muscular pharynx and the salivary secretion is poured.

The ingested blood is stored in crop chambers and its diverticulum. The blood passes from the crop into the stomach. Digestion takes place in stomach by the action of proteolytic enzyme. The digested blood is then absorbed slowly by the intestine. Undigested food is stored in rectum and egested through anus.

Leeches prevent blood clotting by secreting a protein called **hirudin**. They also inject an anaesthetic substance that prevents the host from feeling their bite.

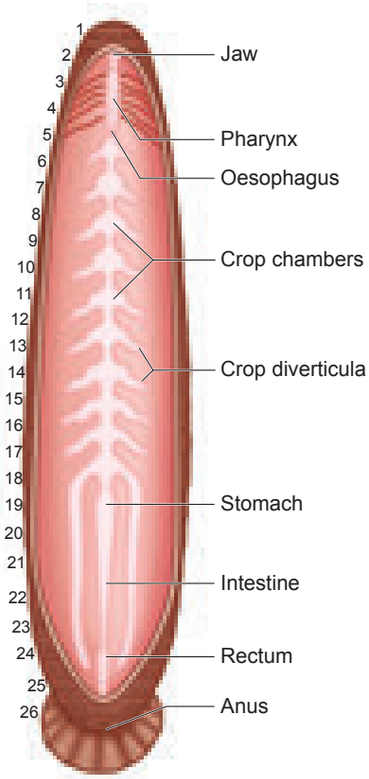


**Figure 13.2** Digestive system of Leech

### More to Know

- Leeches do not have ear, hence can sense vibrations through their skin.
- Leeches have 2 to 10 tiny eyes, which helps them to locate their food.
- Leeches can suck blood five times more than their body weight.
- It may take more than a year for the complete digestion and absorption of a full meal.

**Table 13.1** Segmentation of Leech

| External and Internal features | Segments in which the structures are present |
|---|---|
| Body segments | 33 |
| Anterior Sucker, Mouth, Eyes | 1st - 5th |
| Posterior sucker | 27th - 33rd |
| Pharynx | 5th - 8th |
| Crop | 9th - 18th |
| Stomach | 19th |
| Intestine | 10th - 22nd |
| Rectum | 23rd - 26th |
| Anus | 26th |
| Nephridiopores | 6th - 22nd |
| Male genital aperture | 10th |
| Female genital aperture | 11th |

## 13.1.7 Respiratory System

Respiration takes place through the **skin** in leech. Dense network of tiny blood vessels called as **capillaries** containing the haemocoelic fluid extend in between the cells of the epidermis. The exchange of respiratory gases takes place by diffusion. Oxygen dissolved in water diffuses through the skin into haemocoelic fluid, while

carbon dioxide diffuses out. The skin is kept moist and slimy due to secretion of mucus which also prevents it from drying.

### 13.1.8 Circulatory System

In leech, circulation is brought about by **haemocoelic system**. There are no true blood vessels. The blood vessels are replaced by channels called **haemocoelic channels** or **canals** filled with blood like fluid. The coelomic fluid contains haemoglobin.

There are four longitudinal channels. One channel lies above (dorsal) the alimentary canal, one below (ventral) the alimentary canal. The other two channels lie on either (lateral) side of the alimentary canal which serve as heart and have inner valves. All the four channels are connected together posteriorly in the 26th segment.

### 13.1.9 Nervous System

The central nervous system of leech consists of a nerve ring and a paired ventral nerve cord. The nerve ring surrounds the pharynx and is formed of **suprapharyngeal ganglion** (brain), **circumpharyngeal connective** and **subpharyngeal ganglion**. The subpharyngeal ganglion lies below the pharynx and is formed by the fusion of four pairs of ganglia.

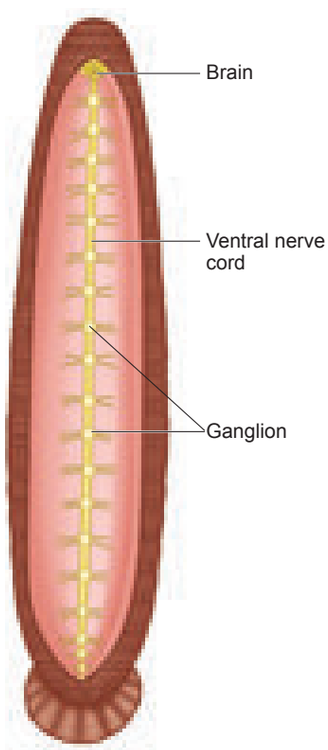


**Figure 13.3** Nervous system of Leech

### 13.1.10 Excretory System

In leech, excretion takes place by segmentally arranged paired tubules called **nephridia**. There are 17 pairs of nephridia which open out by **nephridiopores** from 6th to 22nd segments.

### 13.1.11 Reproductive System

Leech is hermaphrodite because both the male and female reproductive organs are present in the same animal.

#### Male Reproductive System

There are eleven pairs of testes, one pair in each segment from 12 to 22 segments. They are in the form of spherical sacs called **testes sacs**. From each testis arises a short duct called **vas efferens**, which join with the vas deferens. The vas deferens becomes convoluted to form the **epididymis** or **sperm vesicle**, to store spermatozoa.

The epididymis leads to a short duct called ejaculatory duct. The **ejaculatory ducts** on both sides join to form the **genital atrium**. The atrium consists of two regions, the coiled prostate glands and the penial sac consisting of penis that opens through the male genital pore.

#### Female Reproductive System

It consists of ovaries, oviducts and vagina. There is a single pair of ovary in the 11th segment on the ventral side. Each ovary is a coiled ribbon-shaped structure.

The ova are budded off from the ovary. From each **ovary** runs a short oviduct. The **oviducts** of the two sides joins together, to form a common oviduct. The common oviduct opens into a pear-shaped **vagina** which lies mid-ventrally in the posterior part of the 11th segment.

### Development

(i) Internal fertilization takes place. This is followed by cocoon formation. **Cocoon** is also known as **egg case** which is formed around the 9th, 10th and 11th segments.

(ii) Development is direct and proceeds in cocoon which contain one to 24 embryos.

(iii) Young leech resembling the adult emerges.

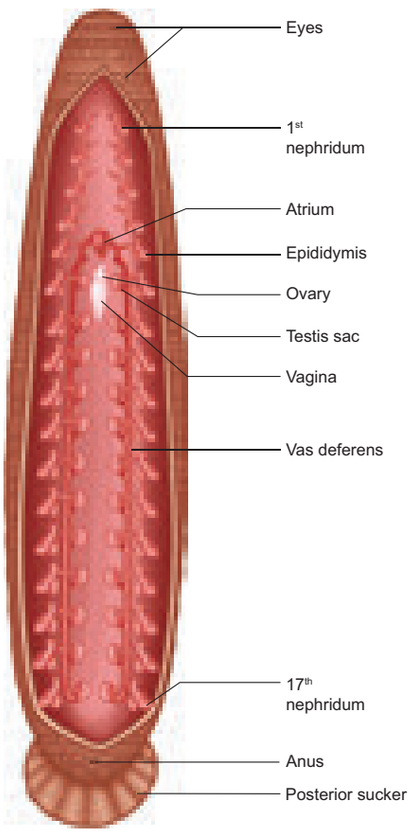


**Figure 13.4** Reproductive system of Leech

### More to Know

**Medicinal value of Leech**

Leeches are effective in increasing blood circulation and breaking up blood clots. It is surprising that they can be used to treat cardiovascular diseases. Biochemical substances derived from leech saliva are used for preparation of pharmaceutical drugs that can treat hypertension.

### 13.1.12 Parasitic Adaptations of Leech

KUDJDK

Leeches lead a parasitic mode of life by sucking the blood of vertebrates and show several important adaptations in their structure.

1. Blood is sucked by pharynx.
2. Anterior and posterior ends of the body are provided with suckers by which the animal attaches itself to the body of the host.
3. The three jaws inside the mouth, causes a painless Y-shaped wound in the skin of the host.
4. The salivary glands produce hirudin which does not allow the blood to coagulate. Thus, a continuous supply of the blood is maintained.
5. Parapodia and setae are completely absent
6. Blood is stored in the crop. It gives nourishment to the leech for several months. Due to this reason there is no elaborate secretion of the digestive juices and enzymes.

**DO YOU KNOW?**

Blood letting is a technique of bleeding in a patient to remove toxic impurities from the body.

## 13.2 Rabbit (*Oryctolagus cuniculus*)

| Taxonomic Position | |
|---|---|
| Phylum | Chordata |
| Sub-phylum | Vertebrata |
| Class | Mammalia |
| Order | Lagomorpha |
| Genus | *Oryctolagus* |
| Species | *cuniculus* |

### 13.2.1 Habit and Habitat

Rabbits are gentle and timid animals. They show leaping movement and live in burrows.

They are distributed throughout the world. They are herbivorous animals feeding on grass and vegetables like turnips, carrots and lettuce. Rabbits are **gregarious** (moving in groups) animals

**DO YOU KNOW?**

The pygmy rabbit was listed as a threatened species in Washington in 1990, because of decline in its population size and distribution due to habitat loss. In March 2003, the Columbia Basin Pygmy Rabbit was federally listed as an endangered species.

## 13.2.2 External Morphology

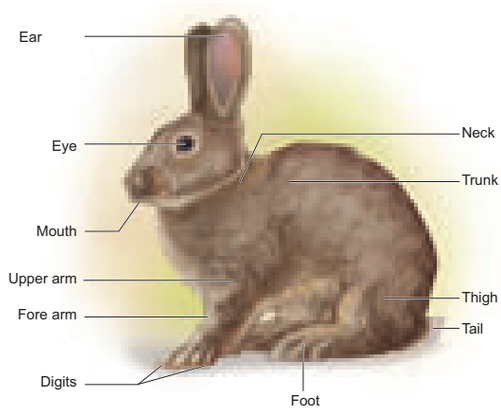


**Figure 13.5** Rabbit- External features

**Shape, Size and Colouration:** It has an elongated and cylindrical body. Males and females are of the same size. They grow about 45 cm in length and weigh about 2.25 kg as adult. The colour varies from white to black and white. Body is covered with fur which serves to keep it warm.

**Body-division:** The body of the rabbit is divisible into the head, neck, trunk and tail.

**Head:** Head is ovoid, flattened and bears a truncate snout. It contains mouth, external nares, eyes, ears and vibrissae. The **mouth** is a transverse slit-like bounded by upper lip and lower lip. Just above the mouth are two oblique openings called **nostrils**. From each side of the upper lip tactile hairs or **vibrissae** (whiskers) project outwards. A pair of large, movable **external ear** or **pinnae** is situated at the top of the head.

**Neck:** The neck connects the head with the trunk. It helps to turn the head.

**Trunk:** The trunk is divisible into an anterior **thorax** and a posterior **abdomen**. In females, four or five **teats** or **nipples** are present on the ventral surface between the thorax and abdomen.

The trunk bears two pairs of **pentadactyl limbs**. The forelimbs are shorter than the hind limbs. All the digits bear claws.

The anus is present at the posterior end of the abdomen at the base of tail. In females on the ventral side a slit like **vulva** is present. In males **penis** is present in the ventral side of anus. The male has a pair of testes enclosed by **scrotal sacs**.

**Tail:** The tail is short. It is used to give signals to other rabbits in the event of danger.

**Integument (Skin):** The integument forms the outer covering of the body. The structures which are derived from it are **hairs, claws, nails** and glands like **sweat glands, sebaceous glands** and **mammary glands**.

Mammary glands are modified glands of the skin. They secrete milk and help in nourishing young ones. The sweat glands and sebaceous glands embedded in the skin regulate the body temperature.

## 13.2.3 Coelom (Body cavity)

Rabbit is a coelomate animal. The body is divisible into **thoracic cavity** and **abdominal cavity** separated by transverse partition called **diaphragm**. Diaphragm is the characteristic feature of mammals. Breathing movements are brought by the movement of the diaphragm.

Lungs and heart lie in the thoracic cavity, whereas, abdominal cavity encloses digestive and urinogenital system.

## 13.2.4 Digestive System

The digestive system includes the **alimentary canal** and the **associated digestive glands**. The alimentary canal consists of mouth, buccal cavity, pharynx, oesophagus, stomach, small intestine, caecum, large intestine and anus.

Mouth is a transverse slit bounded by upper and lower lips. It leads into the **buccal cavity**. The floor of the buccal cavity is occupied by a muscular tongue. Jaws bear teeth.

The buccal cavity leads into the oesophagus through the pharynx. **Oesophagus** opens into the stomach followed by small intestine. **Caecum** is a thin walled sac present at the junction of small intestine and large intestine. It contains bacteria that helps in **digestion of cellulose**. The **small intestine** opens into the **large intestine** which has **colon** and **rectum**. The rectum finally opens outside by the anus.

### Digestive glands

The digestive glands are salivary glands, gastric glands, liver, pancreas and intestinal glands. The secretions of digestive glands help in digestion of food in the alimentary canal.

### Dentition in Rabbit

Teeth are hard bone-like structures used to cut, tear and grind the food materials. The rabbit has two sets of teeth. The existence of two sets of teeth in the life of an animal is called **diphyodont dentition**. The two types of teeth are **milk teeth** (young ones) and **permanent teeth** (in adults).

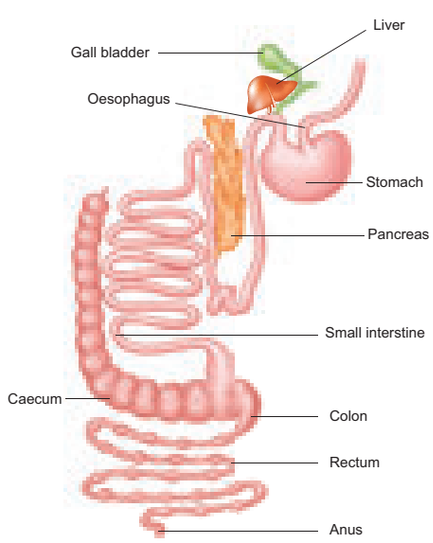


**Figure 13.6** Digestive System of Rabbit

In rabbit the teeth are of different types. Hence, the dentition is called **heterodont**. There are four kinds of teeth in mammals viz. the **incisors** (I), **canines** (C), **premolars** (PM) and **molars** (M). This is expressed in the form of a dental formula.

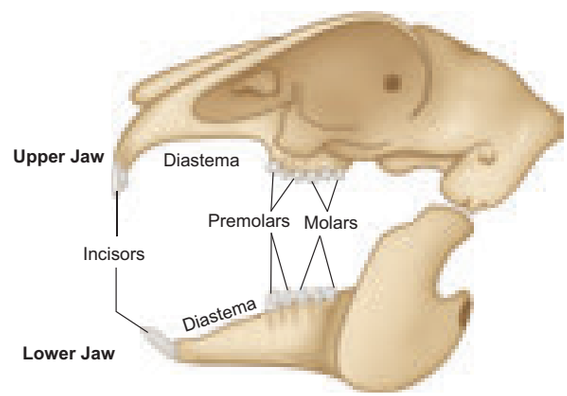


**Figure 13.7** Dentition of Rabbit (Arrangement of teeth in jaws)

Dental formula is the simple method of representing the teeth of a mammal. The number of each kind of tooth in the upper and the lower jaws on one side is counted.

Dental formula is $(I\ \frac{2}{1}, C\ \frac{0}{0}, PM.\ \frac{3}{2}, M\ \frac{3}{3}.)$ in rabbit which is written as $\frac{2033}{1023}$. Canines are absent. The gap between the incisors and premolar is called **diastema**. It helps in mastication and chewing of food in herbivorous animals.

## 13.2.5 Respiratory System

Respiration takes place by a pair of **lungs**, which are light spongy tissues enclosed in the thoracic cavity. The thoracic cavity is bound dorsally by the vertebral column and ventrally by the sternum, laterally by the ribs. On the lower side of the thoracic cavity is the dome shaped **diaphragm**.

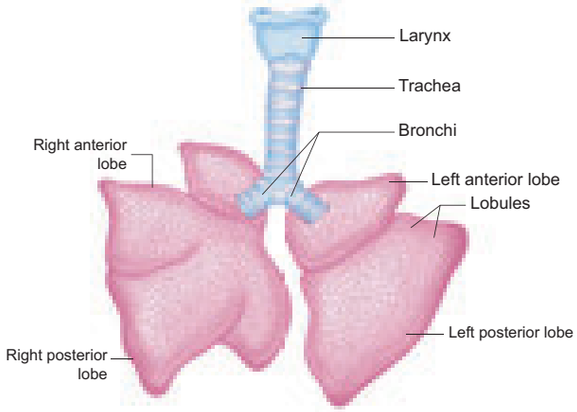


**Fig. 13.8** Lungs of Rabbit

Each lung is enclosed by a double membranous **pleura**. Atmospheric air passes through the external nostril and nasal passages into the pharynx. From the pharynx it passes through the glottis into the wind pipe.

The anterior part of the wind pipe is enlarged to form the **larynx** or **voice box** with its wall supported by four cartilaginous plates. Inside the larynx lies the vocal cord and its vibrations result in the production of sound. The larynx leads into **trachea** or **wind pipe**.

Tracheal walls are supported by rings of cartilage which help in the free passage of air. The **epiglottis** prevents the entry of food into the trachea through the glottis. The trachea divides into two branches called the **bronchi** one entering into each lung and dividing into further branches called **bronchioles** which end in alveoli.

The respiratory events consist of **inspiration** (breathing in) and **expiration** (breathing out) allowing exchange of gases (oxygen and carbon dioxide). Inspiration is an active process while expiration is a passive process.

## 13.2.6 Circulatory System

The circulatory system is formed of blood, blood vessels and heart. The heart is pear shaped and lies in the thoracic cavity in between the lungs. It is enclosed by **pericardium**, a double layered membrane.

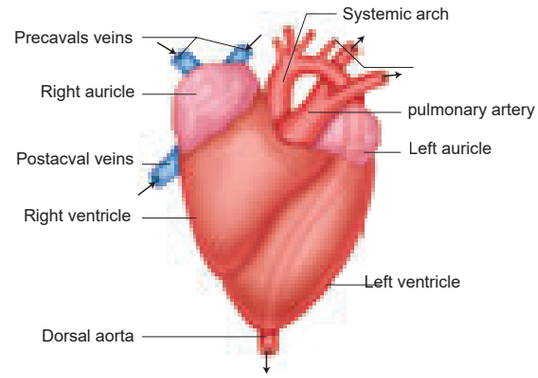


**Fig. 13.9** Heart of Rabbit - Ventral View

The heart is four chambered with two auricles and two ventricles. The right and left auricles are separated by **interauricular septum**, similarly right and left ventricles are separated by **interventricular septum**.

The right auricle opens into the right ventricle by right **auriculoventricular aperture**, guarded by a **tricuspid valve**. The left auricle opens into the left ventricle by left auriculoventricular aperture guarded by a **bicuspid valve** or **mitral valve**. The opening of the pulmonary artery and aorta are guarded by three **semilunar valves**.

The right auricle receives deoxygenated blood through two **precaval** (superior vena cava) and one **postcaval** (inferior vena cava) veins from all parts of the body. The left auricle receives oxygenated blood from the pulmonary veins from the lungs. From the right ventricle arises pulmonary trunk which carries the deoxygenated blood to the lungs and from the left ventricle arises the systemic arch (aorta) which supplies oxygenated blood to all parts of the body.

## 13.2.7 Nervous System

The nervous system in rabbit is formed of the central nervous system (CNS), peripheral nervous system (PNS) and autonomic nervous system (ANS).

CNS consists of brain and spinal cord. PNS is formed of 12 pairs of cranial nerves and 37 pairs of spinal nerves. ANS comprises sympathetic and parasympathetic nerves.

Brain is situated in the cranial cavity and covered by three membranes called an outer **duramater**, an inner **piamater** and a middle **arachnoid membrane**. The brain is divided into **forebrain** (prosencephalon), **midbrain** (mesencephalon) and **hindbrain** (rhombencephalon).

Forebrain consists of a pair of olfactory lobes, cerebral hemispheres and diencephalon. The right and left cerebral hemispheres are connected by transverse band of nerve tissue called **corpus callosum**.

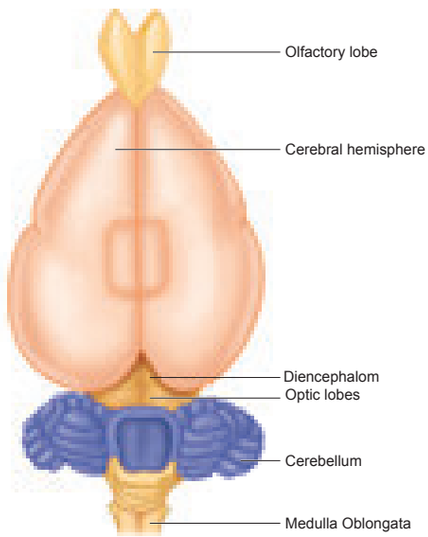


**Fig. 13.10** Brain of Rabbit (Dorsal view)

The midbrain includes the optic lobes. The hindbrain consists of the cerebellum, pons varolii and medulla oblongata. You will study about the details of mammalian brain in the chapter on nervous system.

## 13.2.8 Urinogenital System

It comprises the urinary or excretory system and the genital or reproductive system. Therefore, they are usually described as urinogenital system in vertebrates.

### Excretory system

Each kidney is made of several nephrons. It separates the nitrogenous wastes from blood and excretes it in the form of urea. Kidneys are dark red, bean shaped organs situated in the abdominal cavity. From each kidney arises the **ureters** which open posteriorly into the **urinary bladder** and leads into a thick walled muscular duct called **urethra**.

### Reproductive System

Sexual dimorphism is exhibited in rabbits. The male and female sexes are separate and are morphologically different.

### Male Reproductive system

The male reproductive system of rabbit consists of a pair of testes which are ovoid in shape. Testes are enclosed by scrotal sacs in the abdominal cavity. Each testis consists of numerous fine tubules called **seminiferous tubules**. This network of tubules lead into a coiled tubule called **epididymis,** which lead into the sperm duct called **vas deferens**. The vas deferens join in the urethra just below the urinary bladder. The urethra runs backward and passes into the penis.

There are three accessory glands namely prostate gland, cowper's gland and perineal gland. Their secretions are involved in reproduction.

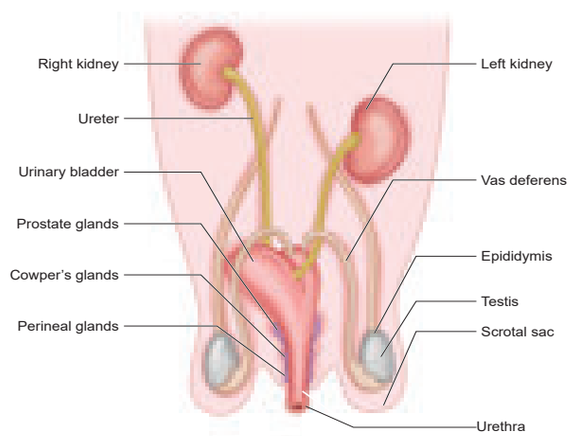


**Fig. 13.11** Male reproductive system of Rabbit

### Female reproductive system

The female reproductive system of rabbit consists of a pair of ovaries which are small

ovoid structures. They are located behind the kidneys in the abdominal cavity.

A pair of oviducts opens into the body cavity by a funnel shaped opening from each side of the ovary. The anterior part of the oviduct is the fallopian tube. It leads into a wider tube called the **uterus**. The uterus join together to form a median tube called **vagina**. The common tube is formed by the union of urinary bladder and the vagina and is called the **urinogenital canal** or **vestibule**. It runs backwards and opens to the exterior by a slit-like aperture called **vulva**.

A pair of **Cowper's gland** and **perineal gland** are the accessory glands present in the female reproductive system.

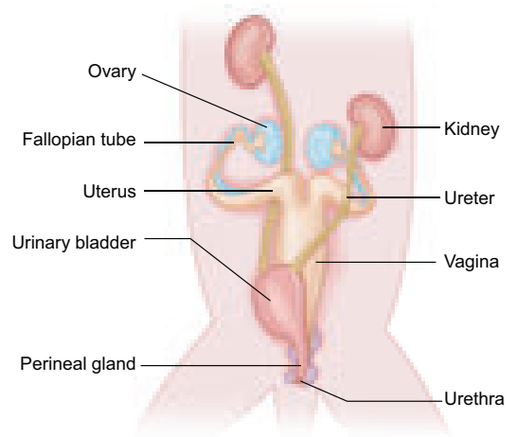


**Fig. 13.12** Female reproductive system of Rabbit

## Points to Remember

- Leech is metamerically segmented and has 33 segments.
- It has two suckers which are used to attach to the body of the host. It is also involved in locomotion.
- The salivary glands of leech produce an anticoagulating substance called hirudin.
- Leech is a hermaphrodite.
- Rabbits are warm blooded vertebrates.
- Canine teeth are absent in rabbit.
- Respiration takes place through a pair of lungs in rabbit.
- The heart is four chambered consisting of two auricles and two ventricles.
- Urinogenital system comprises the urinary (or) excretory system and the genital (or) reproductive system.
- Mammary glands are modified glands of the skin and help in nourishing the young ones.

L9WEEW

## TEXTBOOK EVALUATION

### I. Choose the correct answer

1. In leech locomotion is performed by
   a) Anterior sucker
   b) Parapodia
   c) Setae
   d) Contraction and relaxation of muscles
2. The segments of leech are known as
   a) Metameres (somites) b) Proglottids
   c) Strobila d) All the above
3. Pharyngeal ganglion in leech is a part of
   a) Excretory system b) Nervous system
   c) Reproductive system d) Respiratory system
4. The brain of leech lies above the
   a) Mouth b) Buccal Cavity
   c) Pharynx d) Crop
5. The body of leech has
   a) 23 segments b) 33 segments
   c) 38 segments d) 30 segments
6. Mammals are _____ animals.
   a) Cold blooded b) Warm blooded
   c) Poikilothermic d) All the above

7. The animals which give birth to young ones are
   a) Oviparous b) Viviparous
   c) Ovoviviparous d) All the above

## II. Fill in the blanks

1. The posterior sucker is formed by the fusion of the _____ segments.
2. The existence of two sets of teeth in the life of an animal is called _____ dentition.
3. The anterior end of leech has a lobe-like structure called _____.
4. The blood sucking habit of leech is known as _____.
5. _____ separate nitrogenous waste from the blood in rabbit.
7. _____ spinal nerves are present in rabbit.

## III. Identify whether the statements are True or False. Correct the false statement

1. An anticoagulant present in saliva of leech is called heparin.
2. The vas deferens serves to transport the ovum.
3. Diastema is a gap between premolar and molar teeth in rabbit.
4. The cerebral hemispheres of rabbit are connected by band of nerve tissue called corpora quadrigemina.

## IV. Match columns I, II and III correctly

| Organs | Membranous Covering | Location |
|---|---|---|
| Brain | pleura | abdominal cavity |
| Kidney | capsule | mediastinum |
| Heart | meninges | enclosed in thoracic cavity |
| Lungs | pericardium | cranial cavity |

## V. Answer in a sentence

1. Give the common name of the *Hirudinaria granulosa*.
2. How does leech respire?
3. Write the dental formula of rabbit.
4. How many pairs of testes are present in leech?
5. How is diastema formed in rabbit?
6. What organs are attached to the two bronchi?
7. Which organ acts as suction pump in leech?
8. What does CNS stand for?
9. Why is the teeth of rabbit called heterodont?
10. How does leech suck blood from the host?

## VI. Short answer questions

1. Why are the rings of cartilages found in trachea of rabbit?
2. List out the parasitic adaptations in leech.

## VII. Long answer questions

1. How is the circulatory system designed in leech to compensate the heart structure ?
2. How does locomotion take place in leech?
3. Explain the male reproductive system of rabbit with a labelled diagram.

## VIII. Higher Order Thinking Skills (HOTS)

1. Arjun is studying in tenth standard. He was down with fever and went to meet the doctor. As he went to the clinic he saw a patient undergoing treatment for severe leech bite. Being curious, Arjun asked the doctor why leech bite was not felt as soon as it attaches to the skin ? What would have been the reply given by the doctor?
2. Shylesh has some pet animals at his home. He has few rabbits too, one day while feeding them he observed something different with the teeth. He asked his grandfather, why is it so? What would have been the explanation of his grandfather?

## IX. Value based questions

1. Leeches do not have an elaborate secretion of digestive juices and enzymes -Why ?
2. How is the digestive system of rabbit suited for herbivorous mode of feeding?

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2. Ekambaranatha Ayyar M and Anantha krishnan T. N. 2003. Manual of Zoology, Vol I, Part I & II (Invertebrates), S. Viswanathan Printers and Publishers Pvt Ltd.
3. Kotpal R.L, 2012 Modern Text Book of Zoology -Vertebrates, Rastogi Publications, Meerut
4. Jordan E.L. and Verma P.S. 2003 Chordate Zoology, S. Chand and Company Ltd, New Delhi.


## INTERNET RESOURCES

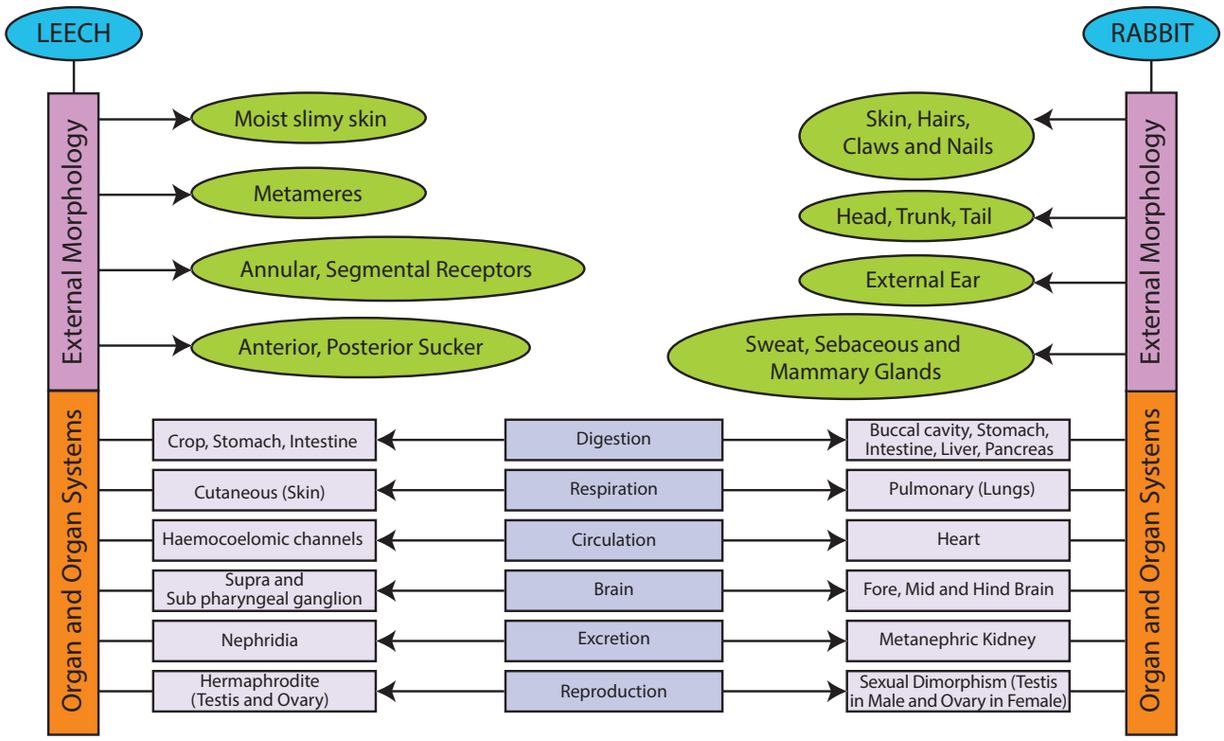
http://leeches-medicinalis.com/

http://www.biologydiscussion.com/zoology

http://animaldiversity.org/accounts/Hirudo_medicinalis/

http://www.notesonzoology.com/rabbit/external-morphology/external-morphology-of-rabbit-with-diagram-chordata-zoology/7642

# Concept Map



# UNIT 14

# TRANSPORTATION IN PLANTS AND CIRCULATION IN ANIMALS

LP6DEK

## Learning Objectives

At the end of this lesson the students will be able to :

- Learn how the water and minerals move from soil to the plant.
- Learn how prepared food by the leaf is translocated to various parts of the plant.
- Understand the role of osmosis and transpiration.
- Understand the composition of blood.
- Identify and explain the structure of heart and associated blood vessels.
- Understand systemic, pulmonary and coronary circulation.
- Differentiate the events of the cardiac cycle.
- Know about blood pressure and heart beat.
- Understand the use of stethoscope and sphygmomanometer.
- Identify the different blood groups.
- Understand the role of lymphatic system.

## Introduction

Multicellular organisms possess millions of cells in their body. Every cell needs a constant supply of essential substances like nutrients and oxygen to maintain life and survival. Food is the only source of energy and every cell gets its energy by the breakdown of glucose. The cells utilise this energy and govern various vital activities of life.

Have you ever wondered how water and nutrients absorbed by the root are transported to the leaves? How is the food prepared by the leaves carried to the other parts of the plant? Do you know how water reaches the top of tall plants inspite of not having a circulatory system like animals? Water absorbed by the roots have to reach entire plant and the food synthesised by the leaves have to be distributed to all the parts of the plant. To understand this we need to recall the anatomy of the plants. Water and mineral salts absorbed by the roots reach all parts of the plant through the xylem. The food synthesised by the leaves are translocated to all parts of the plant through the phloem. The bulk movement of substances through the vascular tissue is called Translocation.

'Transport' means to carry things from one place to another. Have you ever wondered how in animals the useful substances are transported to other cells and toxic substances are removed? In larger organisms transport of nutrients, salts, oxygen, hormones and waste products around the body are performed by the **'Circulatory system'**. The circulatory system consists of the circulating fluids, **the blood and lymph** and **the heart and blood vessels** which form the collecting and transporting system.

## 14.1 Means of Transport in Plants

The transport of materials in and out of the cells is carried out by diffusion and active transport in plants.

### 14.1.1 Diffusion

The movement of solid liquid and gaseous molecules from a region of higher concentration to a region of their lower concentration without the utilization of energy is called **diffusion**. This is a passive process.

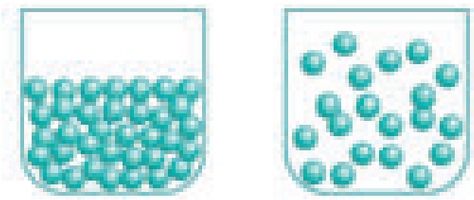



**Figure 14.1** Diffusion

### 14.1.2 Active Transport

Active transport utilizes energy to pump molecules against a concentration gradient. Active transport is carried out by membrane bound proteins. These proteins use energy to carry substances across the cell membrane hence they are often referred to as **pumps**. These pumps can transport substances from a low concentration to a high concentration (**'uphill' transport**).

### 14.1.3 Osmosis

Osmosis is the **movement of solvent** or water molecules from the **region of higher concentration** to the region of lower concentration through a semi-permeable membrane. This process is carried out till an equilibrium is reached. Osmosis is the passive movement of water or any other solvent molecules.

**Plasmolysis**

It occurs when a living plant cell is placed in a hypertonic solution water molecule moves out of the cell and resulting in the shrinkage of protoplasm away from the cell wall.

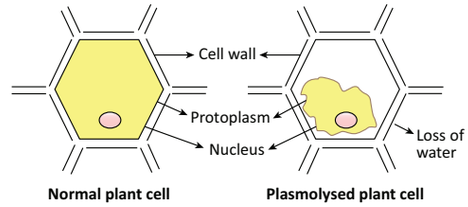
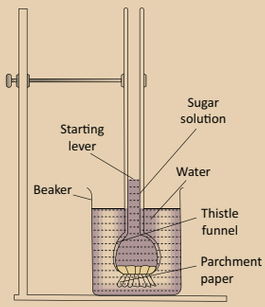



**Figure 14.2** Plasmolysis

**Activity 1**

**Demonstration of Osmosis**

A thistle funnel whose mouth is covered with a semipermeable membrane, is filled with sucrose solution. It is kept inverted in a beaker containing water. The water will diffuse across the membrane due to osmosis and raise the level of the solution in the funnel.




**Imbibition**

**Imbibition** is a type of diffusion in which a solid plant material absorbs water and gets swelled up. eg. absorption of water by dry seeds and grapes. If it were not for imbibition, seedlings would not have been able to emerge out of the soil.

## 14.2 Root Hair-Water Absorbing Unit

There are millions of root hairs on the tip of the root which absorb water and minerals by diffusion. Root hairs are thin walled, slender extension of epidermal cell that increase the surface area of absorption.

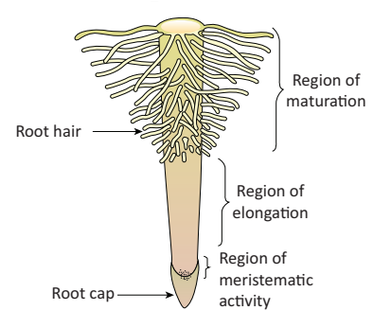



**Figure 14.3** Root Tip with Root Hairs

## 14.3 Pathway of Water Absorbed by Roots

Once the water enters the root hairs, the concentration of water molecules in the root hair cells become more than that of the cortex. Thus water from the root hair moves to the cortical cells by osmosis and then reaches the xylem. From there the water is transported to the stem and leaves.

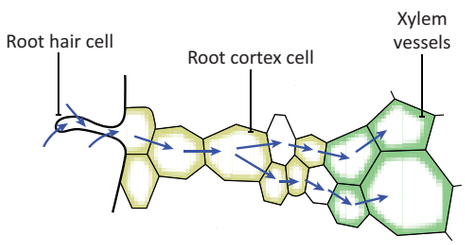



**Figure 14.4** T. S. of the root showing movement of water from soil to xylem

## 14.4 Types of Movement of Water into the Root Cells

Once water is absorbed by the root hairs, it can move deeper into root layers by two distinct pathways:

- Apoplast pathway
- Symplast pathway

### 14.4.1 Apoplast Pathway

The **apoplastic** movement of water occurs exclusively through the intercellular spaces and the walls of the cells. Apoplastic movement does not involve crossing the cell membrane. This movement is dependent on the gradient.

### 14.4.2 Symplast Pathway

In this method, water molecules move to the adjacent cells, through the plasma membrane, cytoplasm and plasmodesmata. This method of transport is slow as water moves through plasma membrane. It is in accordance to the concentration gradient.

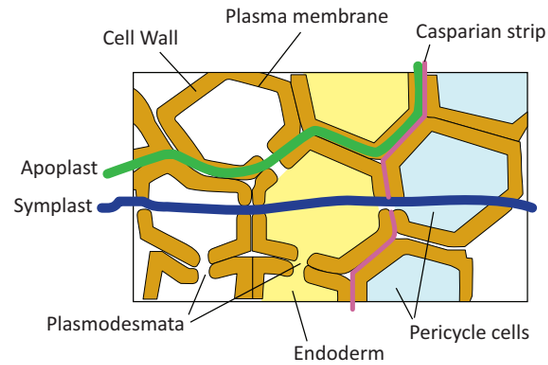



**Figure 14.5** Symplastic and Apoplastic pathways of Water

## 14.5 Transpiration

Transpiration is the evaporation of water from the aerial parts of the plant especially through stomata in leaves. Stomata are open in the day and closed at night. The opening and closing of the stomata is due to the change in turgidity of the guard cells. When water enters into the guard cells, they become turgid and the stoma open. When the guard cells lose water, it becomes flaccid and the stoma closes.

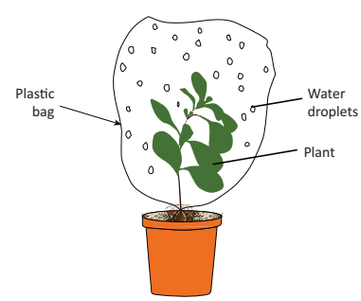



**Figure. 14.6** Process of Transpiration

Water evaporates from mesophyll cells of leaves through the open stomata, this lowers water concentration in mesophyll cells. As a result, more water is drawn into these cells from the xylem present in the veins through the process of osmosis. As water is lost from the leaves, pressure is created at the top to pull more water from the xylem to the mesophyll cells, this process is called **transpiration pull**. This extends up to the roots causing the roots to absorb more water from the soil to ensure continuous flow of water from the roots to the leaves.

### 14.5.1 Factors affecting Transpiration

Transpiration is affected by several external factors such as temperature, light, humidity, and wind speed. Internal factors that affect transpiration include number and distribution of stomata, percentage of open stomata, water status of the plant, canopy structure etc.

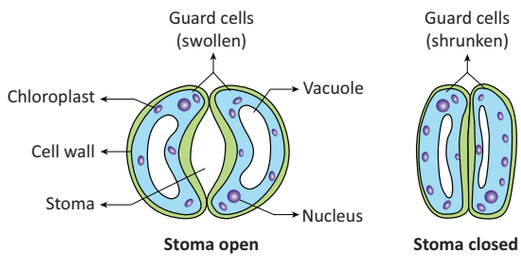



**Figure. 14.7** Guard cell in turgid and flaccid condition

**Significance of Transpiration**

- Creates transpirational pull for transport of water
- Supplies water for photosynthesis
- Transports minerals from soil to all parts of the plant
- Cools the surface of the leaves by evaporation.
- Keeps the cells turgid; hence, maintains their shape

## 14.6 Root Pressure

As mineral ions from the soil are actively transported into the xylem tissue of the root, water moves along and increases the pressure inside the xylem. This pressure is called root pressure and is responsible for pushing water upward to some extent.

## 14.7 Uptake of Minerals

Plants depend on minerals from soil for its nutritional requirements. All minerals cannot be passively absorbed by the roots. Two factors account for this: (i) minerals are present in the soil as charged particles (ions) that cannot move across cell membranes and (ii) the concentration of minerals in the soil is usually lower than the concentration of minerals in the root. Therefore, most minerals enter the root by active absorption through the cytoplasm of epidermal cells. This needs energy in the form of ATP. Then it is transported to all parts by transpiration pull.

## 14.8 Translocation of Mineral Ions

Minerals are remobilised from older dying leaves to younger leaves. This phenomenon can be seen in deciduous plants. Elements like phosphorus, sulphur, nitrogen and potassium are easily mobilised, while elements like calcium are not remobilised. Small amounts of material exchange takes place between xylem and phloem.

## 14.9 Phloem Transport

The food synthesised by the leaves are transported by the phloem either to the area of requirement or stored. Phloem tissue is composed of sieve tubes which have sieve plates. Cytoplasmic strands pass through the pores in the sieve plates.

Phloem transports food (sucrose) from a source to a sink. The source is part of the plant that synthesize food, i.e., the leaf, and sink, is the part that needs or stores the food. But, the source and sink may be reversed depending on the season, or the plant's need.

Since the source-sink relationship is variable, the direction of movement in the phloem can be upwards or downwards, i.e., **bidirectional**. In contrast, the movement is always **unidirectional** in xylem i.e., upwards.

## 14.10 Translocation of Sugars

The mechanism of translocation of sugars from source to sink is through pressure flow hypothesis Glucose prepared at source (by

photosynthesis) is converted to sucrose. Sucrose moves into the companion cells, then into the living phloem sieve tube cells by active transport. This process produces a hypertonic condition in the phloem. Water in the adjacent xylem moves into the phloem by osmosis. As osmotic pressure builds up, the phloem sap moves to areas of lower pressure. By active transport sucrose moves into the cells where it is utilised or stored. As sugars are removed, the osmotic pressure decreases and water moves out of the phloem.

## 14.11 Ascent of Sap and its Events – An Overview

The upward movement of water and minerals from roots to different plant parts is called ascent of sap. A number of factors play a role in ascent of sap and it takes places in following steps

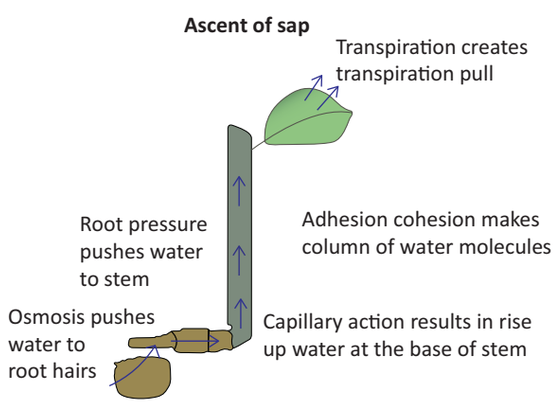



**Figure 14.8** Ascent of Sap

1. **Root Pressure:** Water from soil enters the root hairs due to osmosis. Root pressure is responsible for movement of water up to the base of the stem.
2. **Capillary Action:** Water or any liquid rises in a capillary tube because of physical forces, this phenomenon is called capillary action. In the same way, in stem water rises up to certain height because of capillary action.
3. **Adhesion-cohesion of Water Molecules:** Water molecules form a continuous column in the xylem because of forces of adhesion and cohesion among the molecules.
4. **Cohesion:** The force of attraction between molecules of water is called cohesion.
5. **Adhesion:** The force of attraction between molecules of different substances is called adhesion.Water molecules stick to a xylem because of force of adhesion.

### More to Know

Dews like water droplets on the leaves of grass seen in the early mornings, when the climate is humid and excess of water is present in the plants, the excess water is exudated in the form of liquid. This is due to root pressure .This phenomenon is called **Guttation** which takes place through specialized cells called **Hydathodes**.

**Transpiration Pull:** Transpiration through stomata creates vacuum which creates a suction. called transpiration pull. The transpiration pull sucks the water column from the xylem tubes and thus water is able to rise to great heights even in the tallest plants.

### Activity 2

**Demonstration of Root Pressure**

Choose a small soft stemed plant. Cut the stem horizontally near the base with a blade in the morning. You will see drops of solution oozing out of the cut stem due to root pressure.

## 14.12 Blood

Blood is the main circulatory medium in the human body. It is a red coloured fluid connective tissue.

**Components of Blood:** The blood consists of two main components. The fluid **plasma** and the **formed elements** (blood cells) which are found suspended in the plasma.

**Plasma:** It is slightly alkaline, containing non-cellular substance which constitutes about 55% of the blood. Organic substances like proteins, glucose, urea, enzymes, hormones, vitamins and minerals are present in the plasma.

**Formed Elements of Blood:** Blood corpuscles are of three types

1. **Red blood corpuscles** (RBC) or **Erythrocytes**
2. **White blood corpuscles** (WBC) or **Leucocytes**
3. **Blood platelets** or **Thrombocytes**.

### Red blood corpuscles (Erythrocytes)

**Erythrocytes**

They are the most abundant cells in the human body. RBCs are formed in the bone marrow. The RBCs impart red colour to the blood due to presence of respiratory pigment **haemoglobin.** Matured mammalian RBCs do not have cell organelles and nucleus. They are biconcave and disc-shaped. Their life span is about 120 days. RBC is involved in the transport of oxygen from lungs to tissues.

**DO YOU KNOW?**

Why does mammalian RBC lack cell organelles and nucleus?

Mammalian RBC lack nucleus and makes the cells biconcave and increase surface area for oxygen binding, loss of mitochondria allows the RBC to transport all the oxygen to tissues, and loss of endoplasmic reticulum allows more flexibility for RBC to move through the narrow capillaries.

### White blood corpuscles (Leucocytes)

WBC's are colourless. They do not have haemoglobin and are nucleated cells. It is found in the bone marrow, spleen, thymus and lymph nodes. They are capable of amoeboid movement

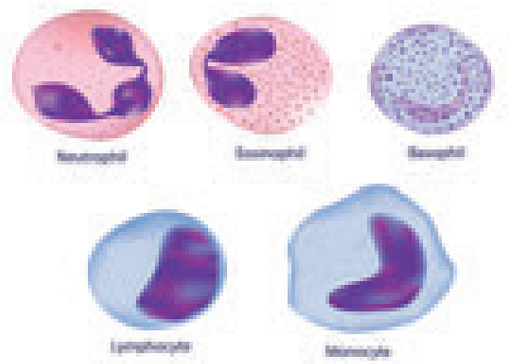


**Figure 14.9** Leucocytes

The white blood corpuscles can be grouped into two categories:

**1. Granulocytes 2. Agranulocytes.**

### Granulocytes

They contain granules in their cytoplasm. Their nucleus is irregular or lobed. The granulocytes are of three types

(i) Neutrophils (ii) Eosinophils
(iii) Basophils

#### *(i) Neutrophils*

They are large in size and have a 2 - 7 lobed nucleus. These corpuscles form 60% - 65% of the total leucocytes. Their numbers are increased during **infection** and **inflammation**.

#### *(ii) Eosinophils*

It has a bilobed nucleus and constitute 2% - 3% of the total leucocytes. Their number increases during conditions of **allergy** and **parasitic infections.** It brings about detoxification of toxins.

#### *(iii) Basophils*

Basophils have lobed nucleus. They form 0.5-1.0% of the total leucocytes. They release chemicals during the process of **inflammation.**

### Agranulocytes

Granules are not found in the cytoplasm of these cells. The agranulocytes are of two types:

(i) Lymphocytes (ii) Monocytes

### *(i) Lymphocytes*

These are about 20-25% of the total leucocytes. They produce **antibodies** during bacterial and viral infections.

### *(ii) Monocytes*

They are the largest of the leucocytes and are amoeboid in shape. These cells form 5 - 6 % of the total leucocytes.They are **phagocytic** and can **engulf bacteria.**

### Blood Platelets or Thrombocytes

These are small and colourless. They do not have nucleus. There are about 2,50,000 – 4,00,000 platelets / cubic mm of blood. Life span of platelets is 8–10 days. They play an important role in clotting of blood. Platelets form clot at the site of injury and prevent blood loss.

**Thrombocytes**

**More to Know**

**Anaemia:** Decrease in number of erythrocytes.
**Leucocytosis:** Increase in the number of leukocytes.
**Leukopenia:** Decrease in number of leukocytes.
**Thrombocytopenia:** Decrease in the number of thrombocytes.

### Functions of blood

i) Transport of respiratory gases (Oxygen and $CO_2$).
ii) Transport of digested food materials to the different body cells.
iii) Transport of hormones.
iv) Transport of nitrogenous excretory products like ammonia, urea and uric acid.
v) It is involved in protection of the body and defense against diseases.
vi) It acts as buffer and also helps in regulation of pH and body temperature.
vii) It maintains proper water balance in the body.

## 14.13 Blood Vessels - Arteries and Veins

Blood vessels are a network of branched tubes that transport blood. There are three types of blood vessels namely **arteries, veins** and **capillaries**

**Arteries:** They are **thick** and **elastic vessels** that carry blood away from the heart to various organs of the body. All arteries carry oxygenated blood except the pulmonary artery which carry deoxygenated blood to the lungs.

**Veins:** Veins are **thin** and **non-elastic vessels** that transport blood to the heart from the different organs. All veins carry deoxygenated blood except the pulmonary vein which carry oxygenated blood from the lungs to the heart.

**Capillaries:** Capillaries are narrow tubes formed by branching of arterioles which then unite to form the venules and veins. They are about 8 μm in diameter. Capillaries are formed of single layer of endothelial cells.

**Table 14.1** Differences between Artery and Vein

| S.No | Artery | Vein |
|---|---|---|
| 1 | Distributing vessel | Collecting vessel |
| 2 | Pink in colour | Red in colour |
| 3 | Deep location | Superficial in location |
| 4 | Blood flow with high pressure | Blood flow with low pressure |
| 5 | Wall of artery is strong, thick and elastic | Wall of vein is weak, thin and non-elastic |
| 6 | All arteries carry oxygenated blood except pulmonary arteries | All veins carry deoxygenated blood except pulmonary veins |
| 7 | Internal valves are absent | Internal valves are present |

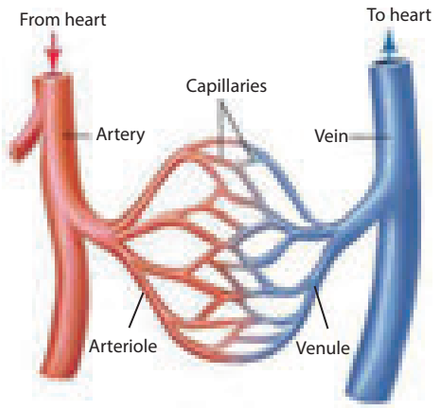



**Figure 14.10** Structure of blood vessel

## 14.14 Types of Circulatory System

Animals possess two types of circulatory system. They are

1. Open type
2. Closed type

### Open type

In open type the blood is pumped by heart into blood vessels that open into blood spaces called as **sinuses**. These sinuses are the body cavities which are called **haemocoel**. Capillary system is absent. e.g. Arthropods, Molluscs and Ascidians.

### Closed type

In closed type the blood flows in a complete circuit around the body through specific blood vessels. The blood flows from arteries to veins through small blood vessels called capillaries. e.g Vertebrates.

**More to Know**

Closed circulatory system was discovered by William Harvey (1628) who is regarded the Father of Modern Physiology.

## 14.15 Structure of Human Heart

Heart is a muscular pumping organ that pumps out the blood into the blood vessels. Human heart is situated between the lungs, slightly tilted toward the left and above the diaphragm in the **thoracic cavity.** The heart is made of specialized type of muscle called the **cardiac muscle.**

The heart is enclosed in a double walled sac called **pericardium**. It contains lubricating **pericardial fluid** which reduces **friction** during heart beat and protects it from mechanical injuries.

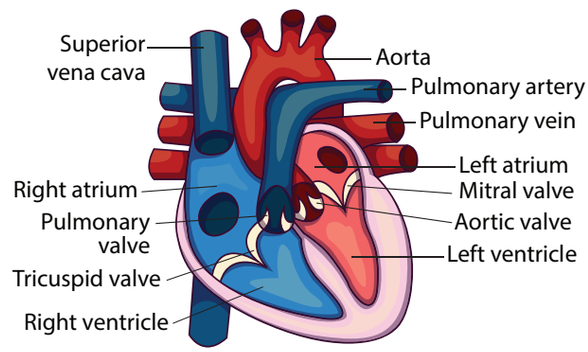



**Figure 14.11** External structure of human heart

The human heart is four chambered. The two upper **thin** walled chambers of the heart are called auricle or **atria** (sing: atrium) and two lower **thick** walled chambers are called **ventricles.** The chambers are separated by partition called **septum.** The septum between auricles and ventricles prevents the mixing of oxygenated and deoxygenated blood.

The two auricles are separated from each other by **interatrial septum**.The left atrium is smaller than the right atrium. The right atrium receives deoxygenated blood from different parts of the body through the main veins **superior vena cava**, **inferior vena cava** and **coronary sinus. Pulmonary veins** bring **oxygenated blood** to the left atrium from the lungs. The right and left auricles pump blood into the right and left ventricles respectively.

The ventricles form the lower part of the heart. The two ventricles are separated from each other by an **interventricular septum**. The left and right ventricles have **thick walls** because the ventricles have to pump out blood with force away from the heart. From the **right ventricle**

arises the **pulmonary trunk** which bifurcates to form right and left pulmonary arteries. The right and left pulmonary arteries supply **deoxygenated blood** to the lungs of the respective side. The left ventricle is longer and narrower than the right ventricle. The walls are about three times thicker than the right ventricle. The **left ventricle** gives rise to **aorta**. The **oxygenated blood** is supplied by the aorta to various organs of the body. The **coronary arteries** supply blood to the heart.

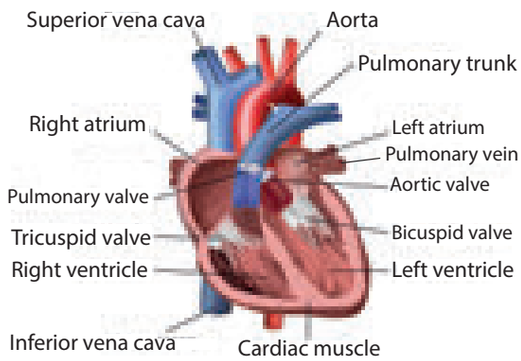



**Figure. 14.12** Internal structure of human heart

**Valves:** The valves are the muscular flaps that regulate the flow of blood in a single direction and prevent back flow of blood. The heart contains three types of valves.

**Right atrioventricular valve:** It is located between the right auricle and right ventricle. It has three thin triangular leaf like flaps and therefore called **tricuspid valve.** The apices of the flaps are held in position by **chordae tendinae** arising from the muscular projection of the ventricle wall known as **papillary muscles.**

**Left atrioventricular valve:** It is located between the left auricle and left ventricle. It has two cusps and therefore called **bicuspid** or **mitral valve.**

### More to Know

**Heart chambers in vertebrate animals**
**Two chambered:** Fishes
**Three chambered:** Amphibians
**Incomplete four chambered:** Reptiles
**Four chambered:** Aves, Mammals and Crocodiles (Reptile)

**Semilunar valves:** The major arteries (pulmonary artery and aorta) which leave the heart have semilunar valves which prevent backward flow of blood into the ventricles. They are the pulmonary and aortic semilunar valves.

## 14.15.1 Types of Blood Circulation

The blood circulates in our body as oxygenated and deoxygenated blood. The types of circulation are:

LPF9G8

i **Systemic circulation**: Circulation of oxygenated blood from the left ventricle of the heart to various organs of the body and return of deoxygenated blood to the right atrium. Aorta carries oxygenated blood to all the organs of the body.

ii **Pulmonary circulation:** The path of pulmonary circulation starts in the right ventricle. Pulmonary artery arises from the right ventricle and reaches the lungs with deoxygenated blood. Pulmonary veins collect the oxygenated blood from the lungs and supplies it to the left atrium of the heart.

iii **Coronary circulation:** The supply of blood to the heart muscles (cardiac muscles) is called as **coronary circulation.** Cardiac muscles receive oxygenated blood from **coronary arteries** that originate from the **aortic arch.** Deoxygenated blood from the cardiac muscles drains into the right atrium by the **coronary sinuses.**

When the blood circulates twice through the heart in one complete cycle it is called **double circulation.** In double circulation the oxygenated blood do not mix with the deoxygenated blood.

However, in some animals the oxygenated and deoxygenated blood are mixed and pass through the heart only once. This type of circulation is called **single circulation**. e.g., fishes, amphibians and certain reptiles.

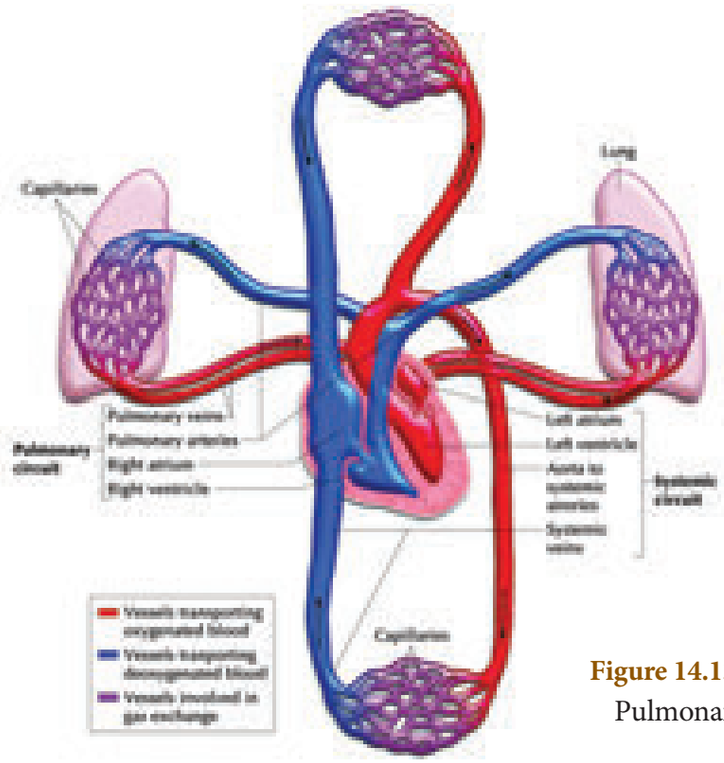



**Figure 14.13** Systemic and Pulmonary circulation

## 14.15.2 Heart Beat

One complete **contraction** (**systole**) and **relaxation** (**diastole**) of the atrium and ventricles of the heart constitute heartbeat. The heart normally beats 72 – 75 times per minute.

### More to Know

**Neurogenic and Myogenic Heart Beat**

Neurogenic heart beat is initiated by a nerve impulse caused from a nerve ganglion situated near the heart. e.g. Annelids, most arthropods

Myogenic heart beat is initiated by a specialized group of modified heart muscle fibres. e.g. Mollusca and Vertebrates

**Initiation and conduction of Heart beat**

The human heart is **myogenic** in nature. Contraction is initiated by a specialized portion of the heart muscle, the **sino-atrial** (SA) **node** which is situated in the wall of the right atrium near the opening of the **superior vena cava**. The SA node is broader at the top and tapering below. It is made up of thin fibres.

**Sino-atrial node** acts as the **'pacemaker'** of the heart because it is capable of initiating impulse which can stimulate the heart muscles to contract. The impulse from the sinoatrial node spreads as a wave of contraction over the right and left atrial wall pushing the blood through the **atrioventricular** valves into the ventricles. The wave of contraction from SA node reaches the **atrioventricular** (AV) **node** which is stimulated to emit an impulse of contraction spreading to the ventricular muscle via the **atrioventricular bundle** and **the Purkinje fibres**.

DO YOU KNOW?

Atrioventricular bundle was discovered by His (1893). So is called Bundle of His.

**Pulse:** When the heart beats the blood is forced into the arteries. The expansion of the artery every time the blood is forced into it is called pulse. It can be felt by placing the fingertip on the artery near the wrist. Normal pulse rate ranges from 70 – 90 / min.

### Activity 3

**Determining Heart Rate**

***Materials :***

Stop watch or Stop clock.

***Procedure:***

1. Have your partner to find the pulse in your wrist and count your heartbeats for 15 seconds while you are seated. Calculate your resting heart rate in beats per minute.
2. Have your partner to count your heart beats for 15 seconds after you jog or run for 5 minutes. Calculate your heart rate in beats per minute.

***Analyse:***

- What causes your pulse ?
- What causes the change in your heart beat rate in each situation ?

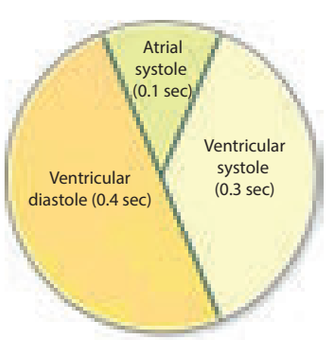
### 14.15.3 Cardiac Cycle

The sequence of events occurring from the **beginning** to the **completion of one heart beat** is called cardiac cycle. During cardiac cycle blood flows through the chambers of the heart in a specific direction. Each cardiac cycle lasts about **0.8 second**. The events during a single cardiac cycle involves

**(a) Atrial systole:** Contraction of auricles (0.1 sec)

**(b) Ventricular systole:** Contraction of ventricles (0.3 sec)

**(c) Ventricular diastole:** Relaxation of ventricles (0.4 sec)




### 14.15.4 Heart Sound

The rhythmic closure and opening of the valves cause the sound of the heart.

The **first sound LUBB** is of longer duration and is produced by the closure of the tricuspid and bicuspid valves after the beginning of ventricular systole. The **second sound DUPP** is of a shorter duration and produced by the closure of semilunar valves at the end of ventricular systole.

## 14.16 Blood pressure

Blood pressure is the **force exerted** during the flow of blood against the **lateral walls of arteries.** The blood pressure is high in the arteries gradually drops in the arterioles and capillaries and become very low in the veins.

Blood pressure is usually expressed in terms of the systolic pressure and diastolic pressure**.**

**Systolic pressure:** During ventricular systole, the left ventricle contracts and forces blood into the aorta. The pressure rises to a peak which is referred as systolic pressure.

**Diastolic pressure:** During diastole, the ventricles relax and the pressure falls to the lowest value which is referred as diastolic pressure**.**

In an healthy adult during normal resting condition systolic and diastolic blood pressure is expressed as **120mm / 80mm Hg.** Blood pressure varies during conditions of physical exercise, anxiety, emotions, stress and sleep.

A prolonged or constant elevation of blood pressure is a condition known as **hypertension (High blood pressure)** can increase the risk of heart attack and stroke. Decrease in blood pressure is termed hypotension **(Low blood pressure)**.

### Stethoscope

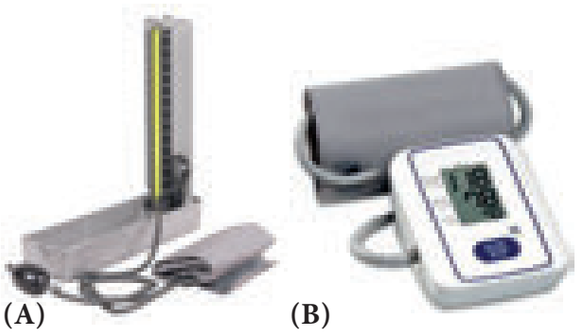
A stethoscope is used to detect the sound produced by the internal organs of human body. The heart sound is heard by placing the

stethoscope on the chest. It is a useful diagnostic tool to identify and localize health problems and diagnose disease. The modern electronic stethoscopes are high precisioned instruments.

**Figure 14.14** Stethoscope

### Sphygmomanometer

Sphygmomanometer is a clinical instrument used to measure blood pressure when a person is in a relaxed and resting condition. The pressure of the brachial artery is measured. It helps to estimate the state of blood circulation and the working of the heart. It helps to diagnose conditions such as increased or decreased blood pressure. **Monometric** and **modern digital** types are the apparatus used to measure blood pressure.



**(A)** **(B)**

**Figure 14.15** Monometric (A) and Digital (B) type blood pressure apparatus

## 14.17 Blood Groups

The concept of blood grouping was developed by **Karl Landsteiner** (1900). He identified blood groups **A**, **B** and **O. AB** blood group was recognized by **Decastello** and **Steini** (1902).

Human blood contains certain specific substances called **agglutinogens** or **antigens (Ag)** and **agglutinins** or **antibodies** (**Ab**). Antigens are found on the membrane surface of **RBC**. Antibodies are present in blood plasma. Based on the presence or absence of antigen and antibodies human blood group is classified into four groups called **A, B, AB** and **O**. An individual has one of the four blood groups.

(i) 'A' group individuals: **Antigen A** is present on the surface of RBC and **antibody b (anti-b)** is present in the plasma.

(ii) 'B' group individuals: **Antigen B** is present on the surface of RBC and **antibody a (anti - a)** is present in the plasma.

(iii) 'AB' group individuals: **Antigens A and B** are present on the surface of RBC and both the **antibodies are absent** in the plasma.

(iv) 'O' group individuals: **Antigen A or B** are absent on the surface of RBC. However, the plasma **contains both the antibodies** a and b **(anti a** and **b)**.

### Blood donation

In blood transfusion one must consider the antigen and antibody compatibility (matching) between the donor and the person receiving blood (recipient). When an individual receives a mismatched blood group from the donor **agglutination (clumping)** of blood occurs in the body which leads to death.

Persons with '**AB**' blood group are called '**Universal Recipient**' as they can **receive blood** from persons with any blood group.

Persons with '**O**' blood group are called '**Universal Donor**' as they can **donate blood** to persons with any blood group.

### Rh factor

Rh factor was discovered by **Landsteiner** and **Wiener** in 1940 in **Rhesus monkey.** The surface of RBC contains the antigen for Rh factor. **Rh**$^{+}$ ( positive) persons have Rh antigen on the surface of RBC while, **Rh**$^{-}$ (negative)

**Table 14.2** Distribution of Antigen (RBC) and Antibody (Plasma) in different Blood Groups

| Blood Group | Antigens on RBC | Antibodies in Plasma | Can donate to | Can receive from |
|---|---|---|---|---|
| A | Antigen A | anti- b | A and AB | A and O |
| B | Antigen B | anti- a | B and AB | B and O |
| AB | Antigen A and B | No antibody | AB | A, B, AB and O (Universal Recipient) |
| O | No Antigen | Both anti a and b | A, B, AB and O (Universal Donor) | O |

persons do not have Rh antigen on the surface of RBC. Antibodies developed against this Rh antigen is called **Rh antibodies.**

## 14.18 Lymphatic System

The lymphatic system comprises of lymphatic capillaries, lymphatic vessels, lymph nodes and lymphatic ducts. Lymph is the fluid that flows through the lymphatic system.

The **lymphatic capillaries** unite to form large **lymphatic vessels**. **Lymph nodes** are small oval or pear shaped structures located along the length of lymphatic vessels.

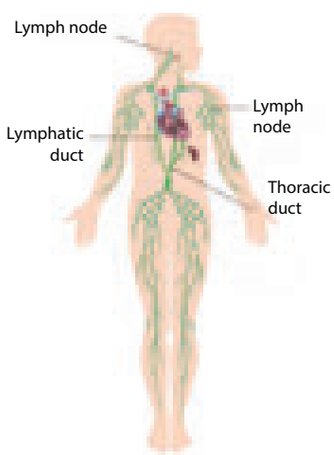



**Figure 14.16** Lymphatic System in Man

### Lymph

Lymph from the intercellular spaces drains into lymphatic capillaries. Lymph is a colourless fluid formed when plasma, proteins and blood cells escape into intercellular spaces in the tissues through the pores present in the walls of capillaries. It is similar to blood plasma, but is colourless and contains less proteins.The lymph contains very small amount of nutrients, oxygen, $CO_2$, water and WBC.

### Functions of Lymph

- Supplies nutrients and oxygen to those parts where blood cannot reach
- It drains away excess tissue fluid and metabolites and returns proteins to the blood from tissue spaces.
- The lymph also carries absorbed fats from small intestine to the blood. The lymphatic capillaries of intestinal villi (lacteals) absorb digested fats.
- Lymphocytes in the lymph defend the body from infections.

### Points to Remember

- The movement of molecules from a region of higher concentration to a region of their lower concentration without the utilization of energy is called diffusion.
- Osmosis is the movement of solvent or water molecules from the region of higher concentration to the region of lower concentration through a semi-permeable membrane.
- Transpiration is the evaporation of water in plants through stomata in the leaves.
- The circulatory system consists of the circulating fluids, the blood and lymph and the heart and its blood vessels.

- The blood consists of two main components. The fluid plasma and the formed elements (blood cells) which are found suspended in the plasma.
- A muscular pumping organ that pumps out the blood into the blood vessels is called heart.
- The blood circulates in our body as oxygenated and deoxygenated blood.
- The supply of blood to the heart muscles (cardiac muscles) is called as coronary circulation.
- One complete contraction (systole) and relaxation (diastole) of atrium and ventricles of heart is called a heartbeat.
- The sequence of events which occur during the beginning and completion of one heart beat is called cardiac cycle.
- Blood pressure is usually expressed as systolic pressure and diastolic pressure (120mm / 80 mm Hg)
- An individual has one of the four blood groups A, B, AB and O.
- Rh factor was discovered by Landsteiner and Wiener in 1940.
- Lymph is a colourless fluid formed when plasma, proteins and blood cells escape into intercellular spaces in the tissues through the pores present in the walls of capillaries.

## TEXTBOOK EVALUATION

M4P8FW

### I. Choose the correct answer

1. Active transport involves
   a) movement of molecules from lower to higher concentration
   b) expenditure of energy
   c) it is an uphill task
   d) all of the above

2. Water which is absorbed by roots is transported to aerial parts of the plant through
   a) cortex b) epidermis
   c) phloem d) xylem

3. During transpiration there is loss of
   a) carbon dioxide b) oxygen
   c) water d) none of the above

4. Root hairs are
   a) cortical cell b) projection of epidermal cell
   c) unicellular d) both b and c

5. Which of the following process requires energy?
   a) active transport b) diffusion
   c) osmosis d) all of them

6. The wall of human heart is made of
   a) Endocardium b) Epicardium
   c) Myocardium d) All of the above

7. Which is the correct sequence of blood flow
   a) ventricle → atrium → vein → arteries
   b) atrium →ventricle → veins → arteries
   c) atrium → ventricle → arteries → vein
   d) ventricles → vein → atrium → arteries

8. A patient with blood group **O** was injured in an accident and has blood loss. Which group of blood should be used by doctor for transfusion?
   a) O group b) AB group
   c) A or B group d) all blood group

9. **'Heart of heart'** is called

   a) SA node  b) AV node

   c) Purkinje fibres  d) Bundle of His

10. Which one of the following shows correct composition of blood

    a) Plasma - Blood + Lymphocyte

    b) Serum - Blood + Fibrinogen

    c) Lymph - Plasma + RBC + WBC

    d) Blood - Plasma + RBC+ WBC +Platelets

## II. Fill in the blanks

1. _____ involves evaporative loss of water from aerial parts.
2. Water enters into the root hair cell through _____ membrane.
3. Part of the root that absorbs water from the soil is _____.
4. Normal blood pressure is _____.
5. The normal human heartbeat rate is about _____ time per minute.

## III. Match the following

### *Section I*

1. Symplastic pathway - Leaf
2. Transpiration - Plasmodesmata
3. Osmosis - Pressure in xylem
4. Root Pressure - Pressure gradient

### *Section II*

1. Leukemia - Thrombocytes
2. Platelets - Phagocyte
3. Monocytes - Decrease in leucocytes
4. Leucopenia - Blood Cancer
5. AB blood group - Allergic condition
6. O blood group - Inflammation
7. Eosinophil - Absence of antigen
8. Neutrophils - Absence of antibody

## IV. State whether True or False. If false write the correct statement

1. The phloem is responsible for the translocation of food.
2. Plants lose water by the process of transpiration.
3. The form of sugar transported through the phloem is glucose.
4. In apoplastic movement the water travels through the cell membrane and enter the cell.
5. When guard cells lose water the stoma opens.
6. Initiation and stimulation of heart beat take place by nerves.
7. All veins carry deoxygenated blood.
8. WBC defend the body from bacterial and viral infections.
9. The closure of the mitral and tricuspid valves at the start of the ventricular systole produces the first sound 'LUBB'.

## V. Answer in a word or sentence

1. Name two layered protective covering of human heart.
2. What is the shape of RBC in human blood?
3. Why is the colour of the blood red ?
4. Which kind of cells are found in the lymph?
5. Name the heart valve associated with the major arteries leaving the ventricles.
6. Mention the artery which supplies blood to the heart muscle.

## VI. Short answer questions

1. What causes the opening and closing of guard cells of stomata during transpiration?
2. What is cohesion?
3. Trace the pathway followed by water molecules from the time it enters a plant root to the time it escapes into the atmosphere from a leaf.

4. What would happen to the leaves of a plant that transpires more water than its absorption in the roots?
5. Describe the structure and working of the human heart.
6. Why is the circulation in man referred to as double circulation?
7. What are heart sounds? How are they produced?
8. What is the importance of valves in the heart?
9. Who discovered Rh factor? Why was it named so?
10. How are arteries and veins structurally different from one another?
11 Why is the Sinoatrial node called the pacemaker of heart?
12. Differentiate between systemic circulation and pulmonary circulation.
13. The complete events of cardiac cycle last for 0.8 sec. What is the timing for each event?

## VII. Give reasons for the following statements

1. Minerals cannot be passively absorbed by the roots.
2. Guard cells are responsible for opening and closing of stomata.
3. The movement of substances in the phloem can be in any direction.
4. Minerals in the plants are not lost when the leaf falls.
5. The walls of the right ventricle are thicker than the right auricles.
6. Mature RBC in mammals do not have cell organelles.

## VIII. Long answer questions

1. How do plants absorb water? Explain.
2. What is transpiration? Give the importance of transpiration.
3. Why are leucocytes classified as granulocytes and agranulocytes? Name each cell and mention its functions.
4. Differentiate between systole and diastole. Explain the conduction of heart beat.
5. Enumerate the functions of blood.

## IX. Assertion and Reasoning

**Direction**: In each of the following questions a statement of assertion (A) is given and a corresponding statement of reason (R) is given just below it. Mark the correct statement as.

a. If both A and R are true and R is correct explanation of A

b. If both A and R are true but R is not the correct explanation of A

c. A is true but R is false

d. Both A and R are false

1. **Assertion:** RBC plays an important role in the transport of respiratory gases.
   **Reason:** RBC do not have cell organelles and nucleus.
2. **Assertion:** Persons with AB blood group are called an universal recipients, because they can receive blood from all groups.
   **Reason:** Antibodies are absent in persons with AB blood group.

## X. Higher Order Thinking Skills (HOTS)

1. When any dry plant material is kept in water, they swell up. Name and define the phenomenon involved in this change.
2. Why are the walls of the left ventricle thicker than the other chambers of the heart?
3. Doctors use stethoscope to hear the sound of the heart. Why?
4. How does the pulmonary artery and pulmonary vein differ in their function when compared to a normal artery and vein?
5. Transpiration is a necessary evil in plants. Explain.

## REFERENCE BOOKS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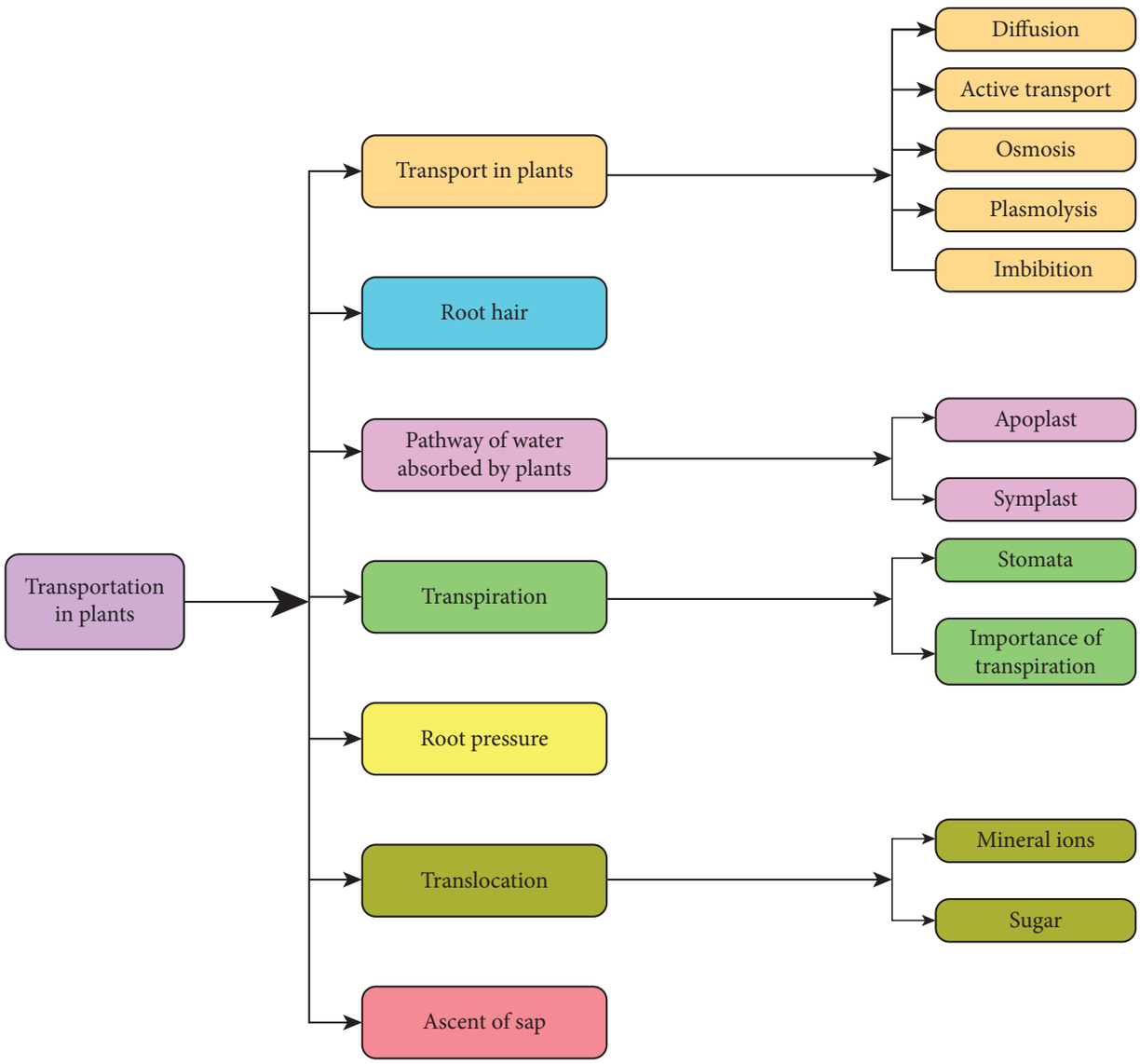
2. D.G Maclean and Dave Hayward, Biology Cambridge IGCSE
3. S.C.Rastogi., Essential of Animal Physiology, 4th Edition, New Age International Publishers
4. Elain N. Marieb and Katja Hoehn, 2011, Anatomy and Physiology, 4th Edition, Pearson Publications.

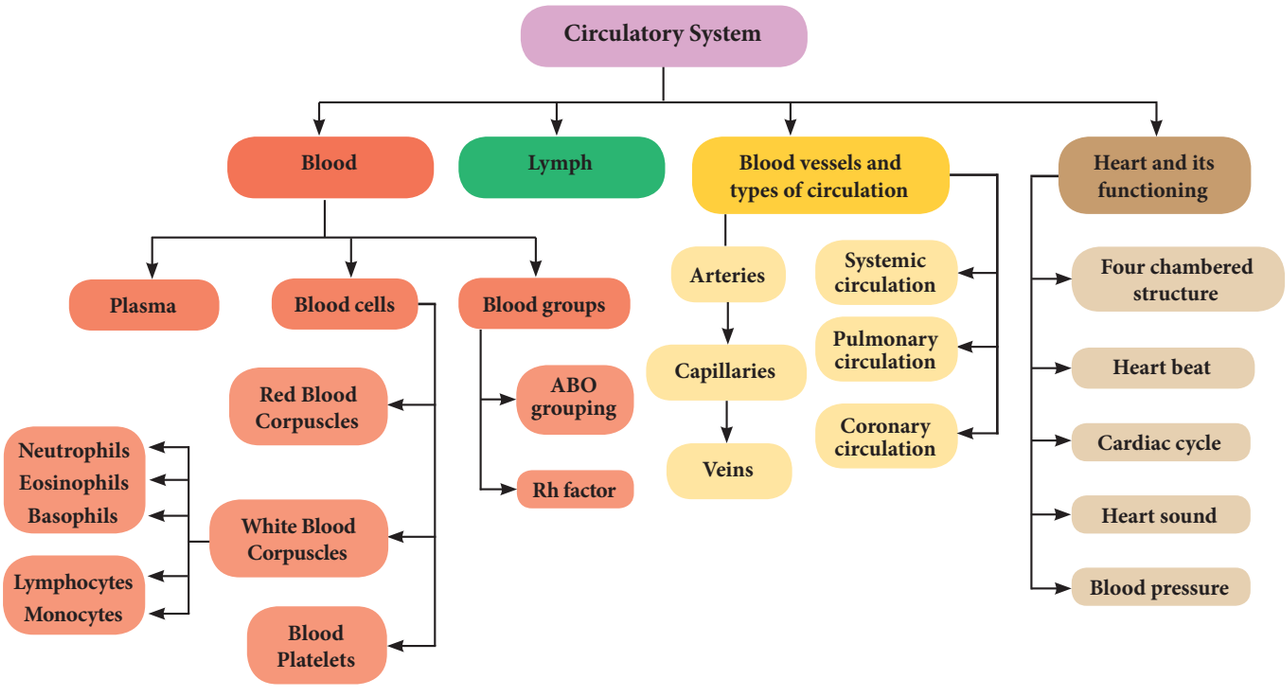

## INTERNET RESOURCES

http://www.britannica.com/science/human-circulatory-system

http://biologydictionary.net/circulatory-system/

## Concept Map

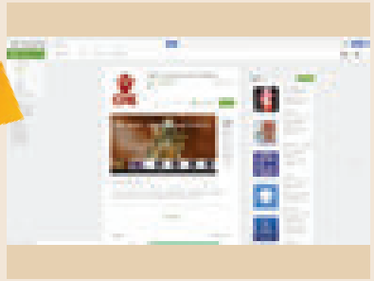





## ICT CORNER

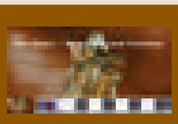
## CIRCULATION IN ANIMALS

**CHE-cardiovascular system- This 3D application enables the student to know about the structure and functions of cardio vascular system.**



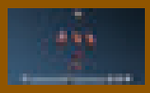
### Steps

- Access the application CHE – cardiovascular system with the help of URL or QR code given below. After installing it in your device, when you open the app, you can see 4 sections as Introduction, Heart – structure & functions, Blood circulatory system and Blood.
- In each section, description as well as supportive images will be given.
- If you click the picture, a video will be played in it. You can zoom in and zoom out the images and also you can see its any direction by making movements.
- We can maximize as well as minimize the speed of the 3D animation to get clear details of it.

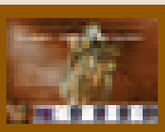


Step1

Step2



Step3



Step4

**Cells alive**

URL : https://play.google.com/store/apps/details?id=com.bodyxq.appbookCardio

*Pictures are indicative only

B375_10_SCIENCE_EM

# UNIT 15

# NERVOUS SYSTEM

## Learning Objectives

At the end of the lesson the students will be able to :

- Admire nervous system as the control and coordinating centre of the body.
- Learn the components of the nervous system.
- Analyse the transmission of nerve impulses.
- Understand the divisions of human nervous system.
- Interpret the different sections of brain which handle different functions.
- Know the significance of reflex action and its operative pathway.

## Introduction

One of the characteristic features of all living organisms is responding to stimuli. '**Stimulus**' refers to the changes in the environmental condition, that are detected by receptors present in the body. Relevant changes in the activities of organisms to a particular stimuli are called their **reactions** or **responses**. Living organisms show their response to different kinds of stimuli like light, heat, cold, sound, smell, taste, touch, pressure, pain or the force of gravity etc. For example, withdrawal of hand when we touch hot objects or closing the eyes when flashed with bright light, in this condition heat or light is the stimulus to which the body shows its response. Thus, on receiving a stimulus, the body responds in a manner that is most appropriate for its survival and functioning.

To provide the correct response to a stimulus, it is necessary that all the organs work together in a proper coordinated manner. This working together of various organs in a systematic, controlled and efficient way to produce proper response to various stimuli is called **coordination**. In animals including human the coordination between the various cells and organs is essential for their diverse activities to maintain physiological balance called **homeostasis**. In this unit we shall learn about one of the major regulatory systems the nervous system and its control over the body activities.

## 15.1 Nervous System

The nervous system is made up of nervous tissues. It is formed of three distinct components namely the neurons, neuroglia and nerve fibres.

(i) **Neuron or nerve cell:** A neuron or nerve cell is the structural and functional unit of the nervous system. It is the longest cell of the human body with a length of over 100µm. These cells are highly specialised to detect, receive and transmit different kinds of stimuli. Information is conducted through neurons in the form of electrical impulses from one part of the body to another.

(ii) **Neuroglia**: Neuroglia are also called as **glial cells.** They are non-exciting, supporting cell of the nervous system. They do not initiate or conduct nerve impulses.

(iii) **Nerve fibres:** The nerve fibres are the long slender processes of neurons. A number of nerve fibres are bundled up together to form **nerves**.

### 15.1.1 Structure of Neuron

A neuron typically consists of three basic parts: Cyton, Dendrites and Axon.

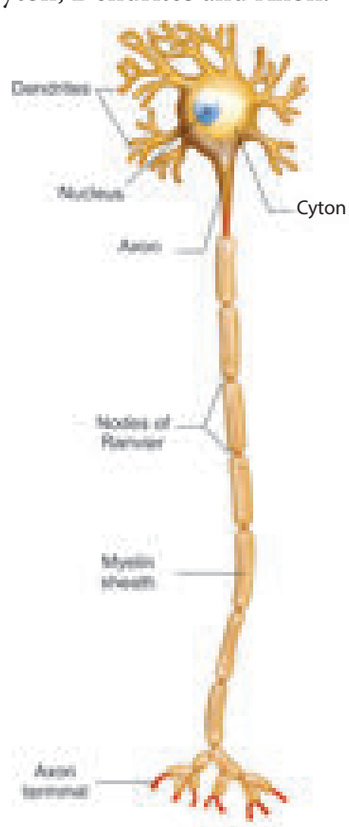



**Fig. 15.1 Structure of Neuron**

(i) **Cyton**: Cyton is also called cell body or perikaryon. It has a central nucleus with abundant cytoplasm called **neuroplasm**. The cytoplasm has large granular body called **Nissl's granules** and the other cell organelles like mitochondria, ribosomes, lysosomes, and endoplasmic recticulum. Neurons do not have the ability to divide. Several neurofibrils are present in the cytoplasm that help in transmission of nerve impulses to and from the cell body.

(ii) **Dendrites**: These are the numerous branched cytoplasmic processes that project from the surface of the cell body. They conduct nerve impulses towards the cyton. The branched projections increase the surface area for receiving the signals from other nerve cells.

(iii) **Axon**: The axon is a single, elongated, slender projection. The end of axon terminates as fine branches which terminate into knob like swellings called **synaptic knob**. The plasma membrane of axon is called **axolemma,** while the cytoplasm is called **axoplasm.** It carries impulses away from the cyton. The axons may be covered by a protective sheath called **myelin sheath** which is further covered by a layer of **Schwann cells** called **neurilemma**. Myelin sheath breaks at intervals by depressions called **Nodes of Ranvier**. The region between the nodes is called as **internode**. Myelin sheath acts as insulator and ensures rapid transmission of nerve impulses.

**Synapse:** A junction between synaptic knob of axon of one neuron and dendron of next neuron is called **synaptic junction**. Information from one neuron can pass to another neuron through these junctions with the release of chemicals known as neurotransmitters from the synaptic knob.

**Activity 1**

Create a model of a neuron using clay or beads.

### 15.1.2 Types of Neurons

The neurons may be of different types based on their structure and functions.

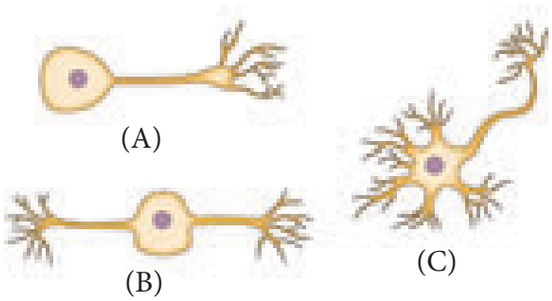



**Fig. 15.2** Unipolar (A), Bipolar (B) and multipolar (C) neurons

Structurally the neurons may be of the following types:

(i) **Unipolar neurons**: Only one nerve process arises from the cyton which acts as both axon and dendron.

(ii) **Bipolar neurons**: The cyton gives rise to two nerve processes of which one acts as an axon while another as a dendron.

(iii) **Multipolar neurons**: The cyton gives rise to many dendrons and an axon

| | |
|---|---|
| **Unipolar Neurons** | Found in early embryos but not in adult |
| **Bipolar Neurons** | Found in retina of eye and olfactory epithelium of nasal chambers |
| **Multipolar Neurons** | Found in cerebral cortex of brain |

On the basis of functions neurons are categorised as:-

(i) **Sensory or afferent neurons** which carry impulses from the sense organ to the central nervous system.

(ii) **Motor or efferent neurons** which carry impulses from the central nervous system to effector organ such as the muscle fibre or the gland.

(iii) **Association neurons** conduct impulses between sensory and motor neurons.

### 15.1.3 Types of Nerve Fibres

Nerve fibres are of two types based on the presence or absence of myelin sheath.

(i) **Myelinated nerve fibre:** The axon is covered with myelin sheath

(ii) **Non-myelinated nerve fibre:** The axon is not covered by myelin sheath.

Myelinated and non-myelinated nerve fibres form the white matter and grey matter of the brain.

## 15.2 Transmission of Nerve Impulse

All the information from the environment are detected by the receptors located in our sense organs such as the eyes, the nose, the skin etc. Information from the receptors is transmitted as **electrical impulse** and is received by the dendritic tips of the neuron. This impulse travels from the dendrite to the cell body and then along the axon to its terminal end. On reaching the axonal end, it causes the nerve endings to release a chemical (**neurotransmitter**) which diffuses across a synapse and starts a similar electrical impulse in the dendrites of the next neuron, then to their cell body to be carried along the axon.

In this way, the electrical signal reaches the brain or spinal cord. The response from brain (or spinal cord) is similarly passed on to the effector organs such as the muscle or gland cell, that undergoes the desired response.

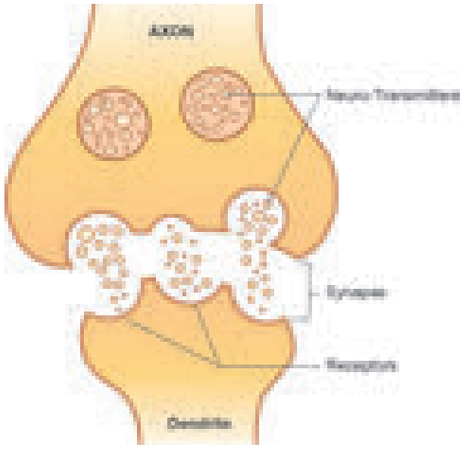


**Fig. 15.3** Nerve impulse transmission

The flow of nerve impulses from axonal end of one neuron to dendrite of another neuron through a **synapse** is called **synaptic transmission**.

> **DO YOU KNOW?** Each neuron can transmit 1,000 nerve impulses per second and make as many as ten thousands of synaptic contacts with other neurons.

### 15.2.1 Neurotransmitters

Neurotransmitters are the chemicals which allow the transmission of nerve impulse from the axon terminal of one neuron to the dendron of another neuron or to an **effector organ.** The important neurotransmitter released by neurons is called **Acetylcholine**.

## 15.3 Human Nervous System

The complexity of nervous system can be observed during the course of evolution. We the human beings differ from other animals in our ability to think and take actions, which is due to the well developed nervous system. Human nervous system is differentiated into **central nervous system (CNS), peripheral nervous system (PNS)** and **autonomic nervous system (ANS).**

The CNS acts as centre for information processing and control. It consists of the brain and the spinal cord. The PNS is made up of the nerves which connect the brain and spinal cord to all parts of the body. The ANS is formed of sympathetic and parasympathetic nerves.

### 15.3.1 Central Nervous System

The brain and the spinal cord being delicate vital structures are well protected in bony cavities of the skull and the vertebral column respectively. CNS is formed of two types of matter such as white matter or grey matter with respect to the presence or absence of myelin sheath which we have discussed earlier.

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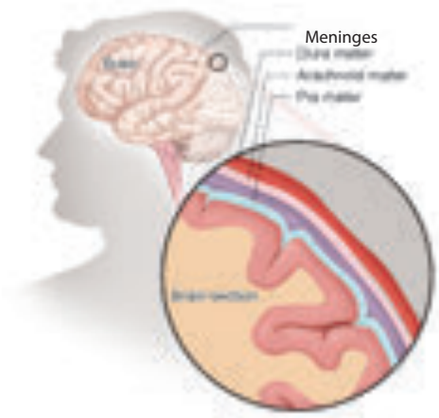



**Fig. 15.4** Meninges of Brain

The brain is the controlling centre of all the body activities. It is covered by three connective tissue membrane or **meninges** :

(i) **Duramater** (*dura:* tough; *mater*: membrane)is the outermost thick fibrous membrane

(ii) **Arachnoid membrane** (*arachnoid*: spider) is the middle, thin vascular membrane providing web like cushion

(iii) **Piamater** (*Pia*: soft or tender) is the innermost, thin delicate membrane richly supplied with blood.

Meningeal membranes protect the brain from mechanical injury.

DO YOU KNOW?

Meningitis is an inflammation of the meninges. It can occur when fluid surrounding the meninges becomes infected. The most common causes of meningitis are viral and bacterial infections.

A human brain is formed of three main parts: (a) forebrain (b) midbrain and (c) hindbrain.

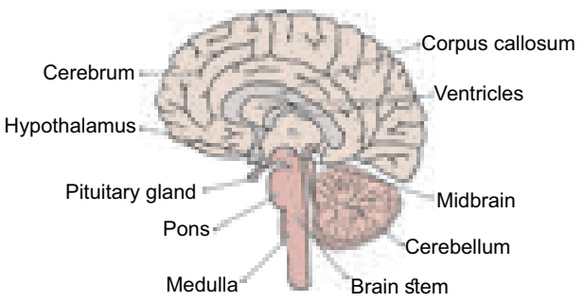



**Fig. 15.5** L.S of Human Brain

**Forebrain:** The forebrain is formed of **cerebrum** and **diencephalon**. The latter consists of dorsal *thalamus* and ventral *hypothalamus*.

## Cerebrum

It is the largest portion forming nearly two-third of the brain. The cerebrum is longitudinally divided into two halves as right and left **cerebral hemispheres** by a deep cleft called **median cleft**. Two cerebral hemispheres are interconnected by thick band of nerve fibres called **corpus callosum.** The outer portion of each cerebral hemisphere is formed of grey matter and is called **cerebral cortex.** The inner or deeper part is formed of white matter and is called **cerebral medulla.** The cortex is extremely folded forming elevations called **gyri** with depressions between them termed as **sulci** that increase its surface area.

Each cerebral hemisphere is divisble into a frontal lobe, a parietal lobe, a temporal lobe and an occipital lobe. These lobes are also known as **cerebral lobes** and are associated with specific functions. Any damage in specific lobe inturn affects its function.

The cerebrum is responsible for the thinking, intelligence, consciousness, memory, imagination, reasoning and willpower.

## Thalamus

Thalamus present in cerebral medulla is a major conducting centre for sensory and motor signalling. It acts as a **relay centre.**

## Hypothalamus

It lies at the base of the thalamus. It controls involuntary functions like hunger, thirst, sleep, sweating, sexual desire, anger, fear, water balance, blood pressure etc. It acts as a **thermoregulatory** (temperature control) **center** of the body. It controls the secretion of hormones from anterior pituitary gland and is an important link between nervous system and endocrine system.

## Midbrain

It is located between thalamus and hind brain. The dorsal portion of the mid brain consists of four rounded bodies called **corpora quadrigemina** that control visual and auditory (hearing) reflexes.

## Hindbrain

It is formed of three parts **cerebellum, pons** and **medulla oblongata**.

DO YOU KNOW?

The human brain constitutes nearly 60 percent of fat. The most crucial molecules that determine our brain's integrity and the ability are Essential Fatty Acids (EFAs). EFAs cannot be synthesised and must be obtained from food. Fish, green leafy vegetables, almond, walnut are rich sources of EFAs.

### Cerebellum

It is second largest part of the brain formed of two large sized hemispheres and middle vermis. It coordinates voluntary movements and also maintains body balance.

### Pons

'*Pons*' a latin word meaning bridge. It is a bridge of nerve fibre that connects the lobes of cerebellum. It relay signals between the cerebellum, spinal cord, midbrain and cerebrum. It controls respiration and sleep cycle.

### Medulla Oblongata

Medulla oblongata is the posterior most part of the brain that connects spinal cord and various parts of brain. It has cardiac centres, respiratory centres, vasomotor centres to control heart beat, respiration and contractions of blood vessels respectively. It also regulates vomiting and salivation.

**Table 15.1** Overview of brain functions

| Structure | Functions |
|---|---|
| Cerebral cortex | Sensory preception, control of voulntary functions, language, thinking, memory, decision making, creativity |
| Thalamus | Acts as relay station |
| Hypothalamus | Temperature control, thirst, hunger, urination, important link between nervous system and endocrine glands |
| Cerebellum | Maintenance of posture and balance,coordinate voluntary muscle activity |
| Pons and medulla | Role in sleep-awake cycle, cardiovascular, respiratory and digestive control centers |

### More to Know

Electroencephalogram (EEG) is an instrument which records the electrical impulses of brain. An EEG can detect abnormalities in the brain waves and help in diagnoses of seizures, epilepsy, brain tumors, head injuries,etc.

### Spinal Cord

Spinal cord is a cylindrical structure lying in the neural canal of the vertebral column. It is also covered by meninges. It extends from the lower end of medulla oblongata to the first lumbar vertebra. The posterior most region of spinal cord tapers into a thin fibrous thread like structure called **filum terminale.**

Internally, the spinal cord contains a cerebrospinal fluid filled cavity known as the **central canal**. The grey matter of spinal cord is 'H' shaped. The upper end of letter 'H" forms **posterior horns** and lower end forms **anterior horns**. A bundle of fibres pass into the posterior horn forming **dorsal** or **afferent root**. Fibres pass outward from the anterior horn forming **ventral** or **efferent root**. These two roots joins to form **spinal nerves**. The white matter is external and have bundle of nerve tracts. Spinal cord conducts sensory and motor impulses to and from the brain. It controls reflex actions of the body.

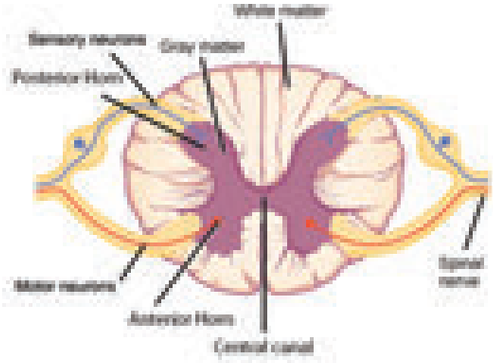


**Fig. 15.6** Structure of spinal cord

## 15.4 Cerebrospinal Fluid

The brain is suspended in a special fluid environment called **cerebrospinal fluid** (CSF). It is lymph like, watery fluid that surrounds and protects the brain within the skull. It also fills the central canal of the spinal cord.

**Functions:**

(i) It acts as shock absorbing fluid and protects the brain from damage when it is subjected to sudden jerk.

(ii) It supplies nutrients to the brain.

(iii) It collects and removes wastes from the brain.

(iv) It is also responsible for maintaining a constant pressure inside the cranium.

## 15.5 Reflex Action

A reflex is any response that occurs automatically without consciouness. There are two types of reflexes.

(i) **Simple or basic reflexes**: These reflexes are inbuilt and unlearned responses. Many of the actions we perform in our day to day life are simple reflexes. e.g., winking of eyes when any dust particles enters, sneezing, coughing, yawning, etc. We perform these actions without thinking.

(ii) **Acquired or conditioned reflexes**: These reflexes are the result of practice and learning. Playing harmonium by striking a particular key on seeing a music note is an example of conditioned reflexes which required conscious training effort. Can you think of some more examples of conditioned reflexes?

Most of the reflex actions are monitored and controlled by the spinal cord, hence also known as **spinal reflexes**.

The pathway taken by nerve impulse to accomplish reflex action is called **reflex arc**. Now, let us understand how the body executes reflex action when we touch a hot plate.

(i) When we touch a very hot pan, the stimulus is the heat which is sensed by receptor called as **heat receptors** or **thermoreceptors** in our hand. This stimulus (heat) inturn triggers an impulse in sensory neuron.

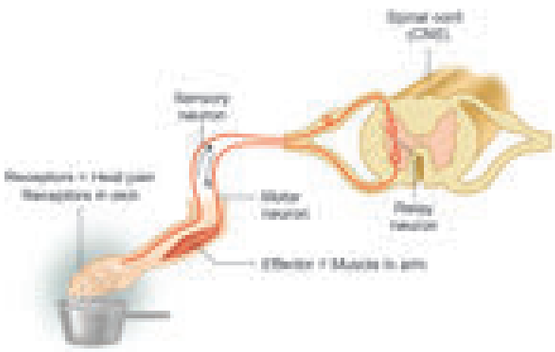


**Fig. 15.7** Reflex action and its pathway

(ii) The **sensory neuron** transmits or conveys the message to the spinal cord.

(iii) **Spinal cord** interprets the stimulus and the impulse is passed on to the relay neuron which inturn transmits it to a motor neuron.

(iv) **Motor neurons** carry command from spinal cord to our arm.

(v) Muscle in our arm contracts and we withdraw our hand immediately from the pan.

In this example, muscle is an effector organ which has responded to the heat. You will study in higher classes how the neuronal impulse triggers the muscular movement.

## 15.6 Peripheral Nervous System

Peripheral nervous system is formed by the nerves arising from the brain and the spinal cord. The nerves arising from the brain

### Activity 2

You must say the colour of the word but not the name of the word.

| | | | |
|---|---|---|---|
| BLUE | RED | YELLOW | ORANGE |
| GREEN | BLUE | PURPLE | RED |
| PURPLE | YELLOW | RED | BLUE |

are called **cranial nerves**. Nerves arising from spinal cord are called **spinal nerves**.

### Cranial Nerves

In man, there are **12 pairs** of cranial nerves. Some of the cranial nerves are sensory e.g. optic nerve which innervates the eye. Some are motor nerves which helps in rotation of eyeball. It also innervates the eye muscles, muscles of iris and tear gland.

### Spinal Nerves

There are **31 pairs** of spinal nerves. Each spinal nerve has a dorsal sensory root and the ventral motor root. The direction of impulses in dorsal spinal root is towards the spinal cord and in ventral spinal root away from the spinal cord.

## 15.7 Autonomic Nervous System

Autonomic nervous system (ANS) is also called as visceral nervous system as it regulates the function of internal visceral organs of our body through its two antagonistic (opposite) components **sympathetic** and **parasympathetic systems**. They enable the body to perform rapid and specific visceral activities in order to maintain steady state. It controls the involuntary functions of the visceral organs.

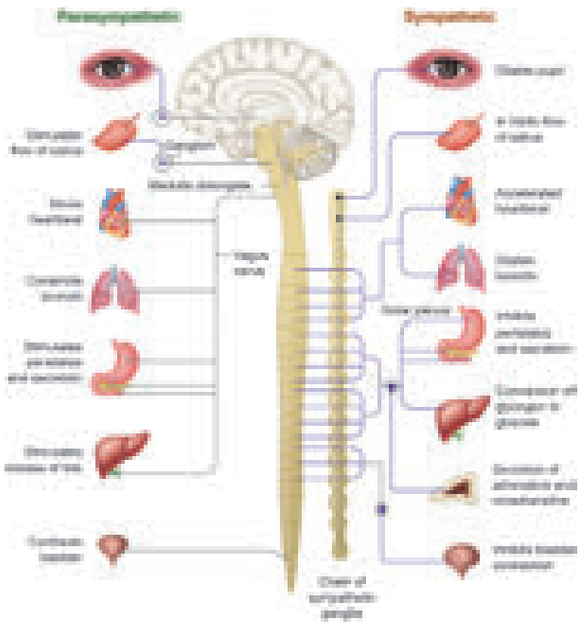


**Fig. 15.8** Sympathetic and Parasympathetic nervous system

### Activity 3

Use the letter and number code to decode the given information

24 18 13 26 8 2 15 24 4 9 4 5 8 25 7

19 1 15 21 1 9 8 7 22 2 7 18 23

25 1 4 12 10 8 2 13 8 13 5 1 5

B Z 19 1 15 21 1 9 8 7 22 8 7 8 24 26

1 9 1 15 12 23 24 9 18 7 3 23 12 1 9

| A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | 2 | 21 | 18 | 1 | 22 | 12 | 10 | 4 | 16 | 14 | 26 | 20 |

| N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | 7 | 19 | 6 | 15 | 5 | 8 | 13 | 11 | 25 | 3 | 23 | 0 |

## Points to Remember

- Nervous system controls and coordinates the activities of our body.
- Neuron is the structural and functional unit of the cell and has three parts- cyton, dendrites and axon.
- A receptor is a cell or group of cells that receives the stimuli. An effector is a part of the body which can respond to a stimulus according to the instructions from the brain or the spinal cord.
- CNS is formed of brain and spinal cord. PNS consists of all nerves which connect brain and spinal cord to all parts of the body. ANS operates automatically and formed of sympathetic and parasympathetic nerves
- A reflex action is a rapid, automatic response to a stimulus which is not under the voluntary control of the brain.

## TEXTBOOK EVALUATION

NDZWI8

### I. Choose the correct answer

1. Bipolar neurons are found in
   (a) retina of eye (b) cerebral cortex
   (c) embryo (d) respiratory epithelium
2. Site for processing of vision, hearing, memory, speech, intelligence and thought is
   (a) kidney (b) ear
   (c) brain (d) lungs
3. In reflex action, the reflex arc is formed by
   (a) brain, spinal cord, muscle
   (b) receptor, muscle, spinal cord
   (c) muscle, receptor, brain
   (d) receptor, spinal cord, muscle
4. Dendrites transmit impulse _____ cell body and axon transmit impulse _____ cell body.
   (a) away from, away from
   (b) towards, away from
   (c) towards,towards
   (d) away from, towards
5. The outer most of the three cranial meninges is
   (a) arachnoid membrane (b) piamater
   (c) duramater (d) myelin sheath
6. There are _____ pairs of cranial nerves and _____ pairs of spinal nerves.
   (a) 12, 31 (b) 31, 12 (c) 12, 13 (d) 12, 21
7. The neurons which carries impulse from the central nervous system to the muscle fibre.
   (a) afferent neurons (b) association neuron
   (c) efferent neuron (d) unipolar neuron
8. Which nervous band connects the two cerebral hemispheres of brain?
   (a) thalamus (b) hypothalamus
   (c) corpus callosum (d) pons
9. Node of Ranvier is found in
   (a) muscles (b) axons
   (c) dendrites (d) cyton
10. Vomiting centre is located in
    (a) medulla oblongata (b) stomach
    (c) cerebrum (d) hypothalamus
11. Nerve cells do not possess
    (a) neurilemma (b) sarcolemma
    (c) axon (d) dendrites
12. A person who met with an accident lost control of body temperature, water balance, and hunger. Which of the following part of brain is supposed to be damaged?
    (a) Medulla oblongata (b) cerebrum
    (c) pons (d) hypothalamus

## II. Fill in the blanks

1. _____ is the longest cell in our body.
2. Impulses travels rapidly in _____ neurons.
3. A change in the environment that causes an animal to react is called _____ .
4. _____ carries the impulse towards the cell body.
5. The two antagonistic component of autonomic nervous system are _____ and _____.
6. A neuron contains all cell organelles except _____ .
7. _____ maintains the constant pressure inside the cranium.
8. _____ and _____ increases the surface area of cerebrum.
9. The part of human brain which acts as relay center is _____ .

## III. State whether true or false, if false write the correct statement

1. Dendrons are the longest fibres that conducts impulses away from the cell body.
2. Sympathetic nervous system is a part of central nervous system.
3. Hypothalamus is the thermoregulatory centre of human body.
4. Cerebrum controls the voluntary actions of our body.
5. In the central nervous system myelinated fibres form the white matter.
6. All the nerves in the body are covered and protected by meninges.
7. Cerebrospinal fluid provides nutrition to brain.
8. Reflex arc allows the rapid response of the body to a stimulus.
9. Pons helps in regulating respiration.

## IV. Match the following

| Column I | Column II |
|---|---|
| A. Nissil's granules | Forebrain |
| B. Hypothalamus | Peripheral Nervous system |
| C. Cerebellum | Cyton |
| D. Schwann cell | Hindbrain |

## V. Understand the assertion statement. Justify the reason given and choose the correct choice

a. Assertion is correct and reason is wrong

b. Reason is correct and the assertion is wrong

c. Both assertion and reason are correct

d. Both assertion and reason are wrong

1. **Assertion:** Cerebrospinal fluid is present throughout the central nervous system.
   **Reason:** Cerebrospinal fluid has no such functions.
2. **Assertion:** Corpus callosum is present in space between the duramater and piamater.
   **Reason:** It serves to maintain the constant intracranial pressure.

## VI. Short answer questions

1. Define stimulus.
2. Name the parts of the hind brain.
3. What are the structures involved in the protection of brain?
4. Give an example for conditioned reflexes.
5. Which acts as a link between the nervous system and endocrine system?
6. Define reflex arc.

## VII. Differentiate between

1. Voluntary and involuntary actions.
2. Medullated and non-medullated nerve fibre.

## VIII. Long answer questions

1. With a neat labelled diagram explain the structure of a neuron.

2. Illustrate the structure and functions of brain.
3. What will you do if someone pricks your hand with a needle? Elucidate the pathway of response with a neat labelled diagram.
4. Describe the structure of spinal cord.
5. How nerve impulses are transferred from one neuron to next neuron?
6. Classify neurons based on its structure.

## IX. Higher Order Thinking Skills (HOTS)

1. 'A' is a cylindrical structure that begins from the lower end of medulla and extend downwards. It is enclosed in bony cage 'B' and covered by membranes 'C'. As many as 'D' pairs of nerves arise from the structure 'A'.
   (i) What is A?
   (ii) Name (a) bony cage 'B' and (b) membranes 'C'
   (iii) How much is D?
2. Our body contains a large number of cells 'L' which are the longest cells in the body. L has long and short branch called as 'M' and 'N' respectively. There is a gap 'O' between two 'L' cells, through which nerve impulse transfer by release of chemical substance 'P'.
   (i) Name the cells L
   (ii) What are M and N?
   (iii) What is the gap O?
   (iv) Name the chemical substance P

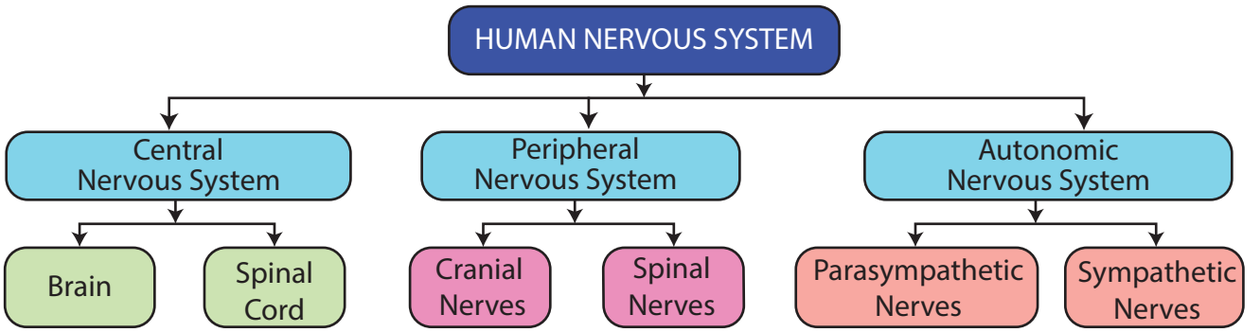
## REFERENCE BOOKS


1. Guyton and Hall, 2003, Textbook of Medical Physiology; Harcourt Indian Private Limited.
2. Sherwood. L., 2007, Human Physiology: From cells to systems 6th Edition, Indian edition, Thomson Brooks/Cole.
3. Singh, H.D., 2007, Handbook of Basic Human Physiology for Paramedical Students. S. Chand and Company Ltd. New Delhi.


## INTERNET RESOURCES

1. http://www.britannica.com/science/nervous-system
2. http://www.sumanasine.com/webcontent/animations/neurobiology.html

## Concept Map



UNIT 16

# PLANT AND ANIMAL HORMONES

## Learning Objectives

NTIRJJ

At the end of this lesson the students will be able to:

- Define hormone.
- List out plant hormones.
- Classify plant hormones into growth promoters and growth inhibitors.
- Differentiate the physiological effects of various plant hormones.
- Understand how plant hormones control and coordinate various physiological activities in plants.
- Know the various endocrine glands in the human body.
- Identify the location and structure of the endocrine glands in the human body.
- Differentiate exocrine and endocrine glands.
- Know the specific site of action and their functions.
- Identify the disorders which occur due to decreased or increased hormone secretion.

## Introduction

The word hormone is derived from the Greek word "hormon" meaning " to excite". The function of control and coordination in plants is performed by chemical substances produced by the plants called **plant hormones**. In plants several cells are capable of producing hormones. These phytohormones are transported to different parts of the plants to perform various physiological functions.

**Endocrine glands** in vertebrate animals possess a diversified communication system to co-ordinate physiological and metabolic functions by **chemical integration.** The endocrine system acts through chemical messengers known as hormones which are produced by specialized glands. Physiological processes such as digestion, metabolism, growth, development and reproduction are controlled by hormones.

## 16.1 Plant Hormones

**Plant hormones** are **organic molecules** that are produced at extremely low concentration in plants. These molecules control morphological, physiological and biochemical responses.

**Types of Plant Hormones**

There are five major classes of plant hormones. They are:

1. Auxins
2. Cytokinins
3. Gibberellins
4. Abscisic Acid (ABA)
5. Ethylene

Among all these plant hormones auxins, cytokinins and gibberellins promote plant growth while abscisic acid and ethylene inhibit plant growth.

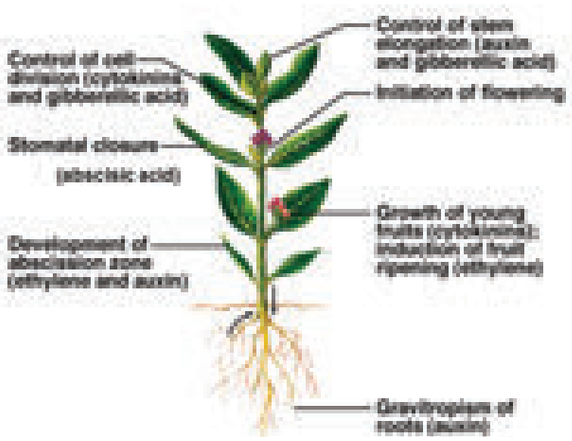



**Figure 16.1** Hormonal interaction in plant growth and development

## 16.1.1 Auxins

Auxins (Gk. auxein = to grow) were the first plant hormones discovered. The term auxin was introduced by Kogl and Haagen-Smith (1931). Auxins are **produced at the tip of stems and roots** from where they migrate to the zone of elongation. Charles Darwin (1880), observed unilateral growth and curvature of canary grass *(Phalaris canariensis)* coleoptiles. He came to the conclusion that some 'influence' was transmitted from the tip of the coleoptile to the basal region. This 'influence' was later identified as Auxin by Went.

### 16.1.1.1 Went's Experiment

Frits Warmolt Went (1903– 1990), a Dutch biologist demonstrated the existence and effect of auxin in plants. He did a series of experiments in Avena coleoptiles.

In his first experiment he removed the tips of Avena coleoptiles. The cut tips did not grow indicating that the tips produced something essential for growth.In his second experiment he placed the agar blocks on the decapitated coleoptile tips. The coleoptile tips did not show any response. In his next experiment he placed the detached coleoptile tips on agar blocks. After an hour, he discarded the tips and placed this agar block on the decapitated coleoptile. It grew straight up indicating that some chemical had diffused from the cut coleoptile tips into the agar block which stimulated the growth.

From his experiments Went concluded that a chemical diffusing from the tip of coleoptiles was responsible for growth, and he named it as "**Auxin**" meaning '**to grow**".

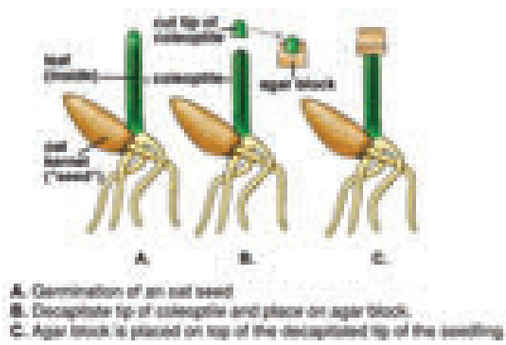



**Figure 16.2** Went's Experiment

**Types of Auxins:** Auxins are classified into two types, namely natural auxins and synthetic auxins.

1. **Natural Auxins:** Auxins produced by the plants are called natural auxins. Example: IAA (Indole – 3 - Acetic Acid)
2. **Synthetic Auxins:** Artificially synthesized auxins that have properties like auxins are called as synthetic auxins. Example: 2, 4 D (2,4 Dichlorophenoxy Acetic Acid).

**Physiological effects of auxins:** Auxins bring about a variety of physiological effects in different parts of the plant body.

1. Auxins promote the **elongation of stems** and **coleoptiles** which makes them to grow.

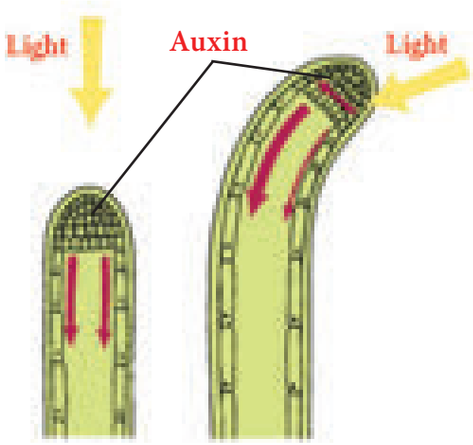



**Figure 16.3** Cell Elongation

2. Auxins **induce root formation** at low concentration and inhibit it at higher concentration.
3. The auxins produced by the apical buds suppress growth of lateral buds. This is called **apical dominance**.
4. Seedless fruits without fertilization are induced by the external application of auxins. (**Parthenocarpy**). Examples: Watermelon, Grapes, Lime etc.
5. Auxins **prevent** the formation of **abscission layer**.

DO YOU KNOW?

Phenyl Acetic Acid (PAA) and Indole 3 Acetonitrile (IAN) are natural auxins. Indole 3 Butyric Acid (IBA), Indole-3-Propionic Acid, α-Naphthalene Acetic Acid (NAA), 2, 4, 5-T (2,4,5 Trichlorophenoxy Acetic Acid) are some of the synthetic auxins.

## 16.1.2 Cytokinins

Cytokinins (Cytos - cell; kinesis - division) are the plant hormones that **promote cell division** or cytokinesis in plant cells. It was first isolated from Herring fish sperm. Zeatin was the cytokinin isolated from *Zea mays*. Cytokinin is found abundantly in liquid endosperm of coconut.

**Physiological effects of cytokinins**

1. Cytokinin induces **cell division** (cytokinesis) in the presence of auxins.
2. Cytokinin also causes **cell enlargement**.
3. Both auxins and cytokinins are essential for the formation of new organs from the callus in tissue culture (**Morphogenesis**).
4. Cytokinins promote the growth of **lateral buds** even in the presence of apical bud.
5. Application of cytokinin delays the process of ageing in plants. This is called **Richmond Lang effect**.

## 16.1.3 Gibberellins

Gibberellins are the most abundantly found plant hormones. Kurosawa (1926) observed **Bakanae disease** or **foolish seedling disease** in rice crops. This internodal elongation in rice was caused by fungus *Gibberella fujikuroi*. The active substance was identified as **Gibberellic acid**.

**Physiological effects of gibberellins**

1. Application of gibberellins on plants stimulate extraordinary **elongation of internode**. e.g. Corn and Pea.

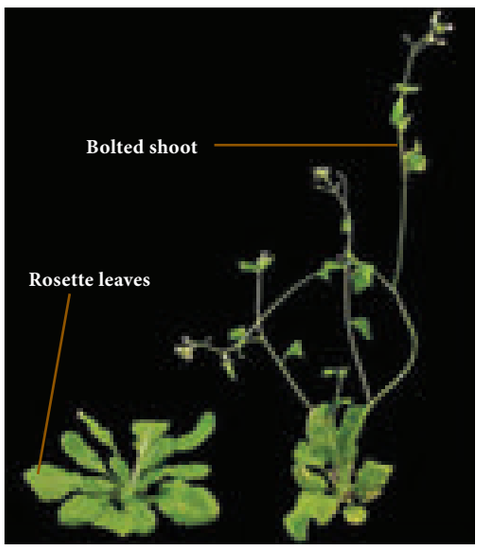



**Figure 16.4** Bolting

2. Treatment of rosette plants with gibberellin induces sudden shoot elongation followed by flowering. This is called **bolting**.

3. Gibberellins promote the **production of male flowers** in monoecious plants (Cucurbits).
4. Gibberellins **break dormancy** of potato tubers.
5. Gibberellins are efficient than auxins in inducing the formation of seedless fruit - **Parthenocarpic fruits** (Development of fruits without fertilization) e.g. Tomato.

### 16.1.4 Abscisic Acid

Abscisic acid (ABA) is a **growth inhibitor** which **regulates abscission** and **dormancy**. It increases tolerance of plants to various kinds of stress. So, it is also called as **stress hormone**. It is found in the chloroplast of plants.

**Physiological effects of abscisic acid**

1. ABA promotes the process of **abscission** (separation of leaves, flowers and fruits from the branch).
2. During water stress and drought conditions ABA **causes stomatal closure**.

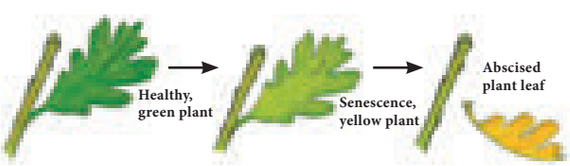



**Figure 16.5** Senescence and abscission

**Activity**

Place two or three unripe tomatoes in a brown paper bag with a ripe bananas and roll the top closed. In another bag place two or three unripe tomatoes only and roll the top closed, Observe what happens to the tomatoes? Why?

As the banana continues to ripen in the first bag, it produces ethylene gas. The gas trapped in the bag will cause tomatoes to ripen.The tomatoes remain unripe in the second bag.

3. ABA **promotes senescence** in leaves by causing loss of chlorophyll.
4. ABA **induces bud dormancy** towards the approach of winter in trees like birch.
5. ABA is a powerful **inhibitor of lateral bud growth** in tomato.

### 16.1.5 Ethylene

Ethylene is a **gaseous plant hormone**. It is a **growth inhibitor**. It is mainly concerned with maturation and ripening of fruits. Maximum synthesis of ethylene occurs during ripening of fruits like apples, bananas and melons

**Physiological effects of ethylene**

1. Ethylene promotes the **ripening of fruits**. e.g. Tomato, Apple, Mango, Banana, etc.

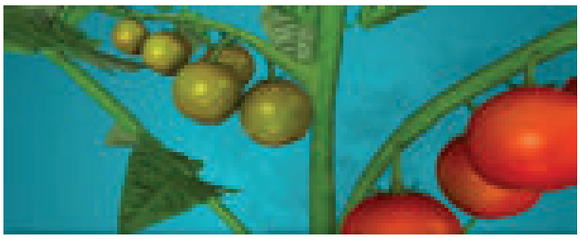


**Figure 16.6** Ethylene

2. Ethylene **inhibits** the **elongation** of stem and root in dicots.
3. Ethylene hastens the **senescence** of leaves and flowers.
4. Ethylene stimulates **formation of abscission zone** in leaves, flowers and fruits. This leads to premature shedding.
5. Ethylene **breaks the dormancy** of buds, seeds and storage organs.

## 16.2 Human Endocrine Glands

Endocrine glands in animals possess a versatile communication system to coordinate biological functions. Exocrine glands and endocrine glands are two kinds of glands found in animals. Endocrine glands are found in different regions of the body of animals as well as human beings. These glands are called **ductless**

**glands**. Their secretions are called **hormones** which are produced in **minute quantities**. The secretions diffuse into the blood stream and are carried to the distant parts of the body. They act on specific organs which are referred as **target organs**.

DO YOU KNOW?

The branch of biology which deals with the study of the endocrine glands and its physiology is known as '**Endocrinology**'. **Thomas Addison** is known as Father of Endocrinology. English physiologists **W. M. Bayliss** and **E. H. Starling** introduced the term ***hormone*** in 1909. They first discovered the hormone secretin.

Exocrine glands have specific ducts to carry their secretions e.g. salivary glands, mammary glands, sweat glands.

Endocrine glands present in human and other vertebrates are

a. Pituitary gland
b. Thyroid gland
c. Parathyroid gland
d. Pancreas (Islets of Langerhans)
e. Adrenal gland (Adrenal cortex and Adrenal medulla)
f. Gonads(Testes and Ovary)
g. Thymus gland

## 16.2.1 Pituitary Gland

The **pituitary gland** or **hypophysis** is a pea shaped compact mass of cells located at the base of the midbrain attached to the hypothalamus by a **pituitary stalk**. The pituitary gland is anatomically composed of two lobes and perform different functions. They are the anterior lobe (**adenohypophysis**) and the posterior lobe (**neurohypophysis**). The intermediate lobe is non-existent in humans.

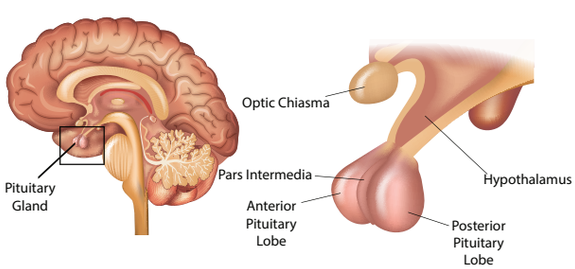



**Figure 16.7** Pituitary Gland

The pituitary gland forms the major endocrine gland in most vertebrates. It regulates and controls other endocrine glands and so is called as the "**Master gland**".

**Hormones secreted by the anterior lobe (Adenohypophysis) of pituitary**

The anterior pituitary is composed of different types of cells and secrete hormones which stimulates the production of hormones by other endocrine glands. The hormones secreted by anterior pituitary are

a. Growth Hormone
b. Thyroid stimulating Hormone
c. Adrenocorticotropic Hormone
d. Gonadotropic Hormone which comprises the Follicle Stimulating Hormone and Luteinizing Hormone
e. Prolactin

**a. Growth hormone (GH)**

GH promotes the development and enlargement of all tissues of the body. It stimulates the growth of muscles, cartilage and long bones. It controls the cell metabolism.

The improper secretion of this hormone leads to the following conditions.

**Dwarfism:** It is caused by decreased secretion of growth hormone in children. The characteristic features are stunted growth, delayed skeletal formation and mental disability.

**Gigantism:** Oversecretion of growth hormone leads to gigantism in children. It is characterised by overgrowth of all body tissues and organs. Individuals attain abnormal increase in height.

**Acromegaly:** Excess secretion of growth hormone in adults may lead to abnormal enlargement of head, face, hands and feet.

**b. Thyroid stimulating hormone (TSH)**

TSH controls the growth of thyroid gland, coordinates its activities and hormone secretion.

**c. Adrenocorticotropic hormone (ACTH)**

ACTH stimulates adrenal cortex of the adrenal gland for the production of its hormones. It also influences protein synthesis in the adrenal cortex.

**d. Gonadotropic hormones (GTH)**

The gonadotropic hormones are follicle stimulating hormone and luteinizing hormone which are essential for the normal development of gonads.

**Follicle stimulating hormone (FSH)**

In male, it stimulates the germinal epithelium of testes for formation of sperms. In female it initiates the growth of ovarian follicles and its development in ovary.

**Luteinizing hormone (LH)**

In male, it promotes the Leydig cells of the testes to secrete male sex hormone testosterone. In female, it causes ovulation (rupture of mature graafian follicle), responsible for the development of corpus luteum and production of female sex hormones estrogen and progesterone.

**e. Prolactin (PRL)**

PRL is also called **lactogenic hormone**. This hormone initiates development of mammary glands during pregnancy and stimulates the production of milk after child birth.

**More to Know**

Melatonin is a hormone produced by the pineal gland. It is known as a 'time messenger'. It signals night time information throughout the body.

Exposure to light at night, especially short-wavelength light, can decrease melatonin production interrupting sleep. Suppression of melatonin has been implicated in sleep disturbances and related metabolic disorders.

**Hormones secreted by the posterior lobe (Neurohypophysis) of pituitary**

The hormones secreted by the posterior pituitary are

a. Vasopressin or Antidiuretic hormone

b. Oxytocin

**a. Vasopressin or Antidiuretic hormone (ADH)**

In kidney tubules it increases reabsorption of water. It reduces loss of water through urine and hence the name antidiuretic hormone.

Deficiency of ADH reduces reabsorption of water and causes an increase in urine output (polyuria). This deficiency disorder is called **Diabetes insipidus**.

**b. Oxytocin**

It helps in the contraction of the smooth muscles of uterus at the time of child birth and milk ejection from the mammary gland after child birth.

## 16.2.2 Thyroid Gland

The thyroid gland is composed of two distinct lobes lying one on either side of the trachea. The two lobes are connected by means of a narrow band of tissue known as the **isthmus**. This gland is composed of glandular follicles and

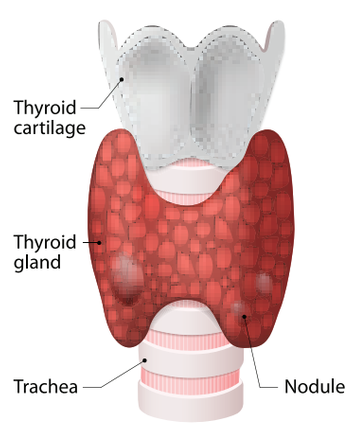



**Figure 16.8** Thyroid Gland

lined by cuboidal epithelium.The follicles are filled with colloid material called **thyroglobulin.**

An amino acid **tyrosine** and **iodine** are involved in the formation of thyroid hormone. The hormones secreted by the thyroid gland are

a. Triiodothyronine ($T_3$)
b. Tetraiodothyronine or Thyroxine ($T_4$)

**Functions of thyroid hormones**

The functions of thyroid hormones are

- Production of energy by maintaining the **Basal Metabolic Rate** (BMR) of the body.
- Helps to maintain normal body temperature.
- Influences the activity of central nervous system.
- Controls growth of the body and bone formation.
- Essential for normal physical, mental and personality development .
- It is also known as **personality hormone**.
- Regulates cell metabolism.

**More to Know**

Edward C. Kendal in 1914 first crystallised thyroxine hormone. Charles Harrington and George Barger identified the molecular structure of thyroxine in 1927. Thyroid gland requires "120 µg" of iodine everyday for the production of thyroxine.

**Thyroid Dysfunction**

When the thyroid gland fails to secrete the normal level of hormones, the condition is called **thyroid dysfunction**. It leads to the following conditions

**Hypothyroidism**

It is caused due to the decreased secretion of the thyroid hormones. The abnormal conditions are simple goitre, cretinism and myxoedema.

**Goitre**

It is caused due to the inadequate supply of iodine in our diet. This is commonly prevalent in Himalayan regions due to low level of iodine content in the soil. It leads to the enlargement of thyroid gland which protrudes as a marked swelling in the neck and is called as **goitre.**

**Cretinism**

It is caused due to decreased secretion of the thyroid hormones in children. The conditions are stunted growth, mental defect, lack of skeletal development and deformed bones. They are called as **cretins**.

**Myxoedema**

It is caused by deficiency of thyroid hormones in adults. They are mentally sluggish, increase in body weight, puffiness of the face and hand, oedematous appearance.

**Hyperthyroidism**

It is caused due to the excess secretion of the thyroid hormones which leads to Grave's disease. The symptoms are protrusion of the eyeballs (Exopthalmia), increased metabolic rate, high body temperature, profuse sweating, loss of body weight and nervousness.

## 16.2.3 Parathyroid Gland

The parathyroid glands are four small oval bodies that are situated on the posterior surface of the thyroid lobes. The **chief cells** of the gland are mainly concerned with secretion of **parathormone**.

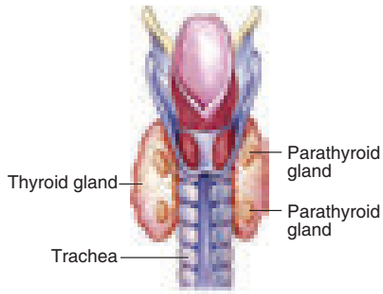



**Figure 16.9** Parathyroid Gland

### Functions of Parathormone

The parathormone regulates calcium and phosphorus metabolism in the body.They act on bone, kidney and intestine to maintain blood calcium levels.

### Parthyroid Dysfunction

The secretion of parathyroid hormone can be altered due to the following conditions.

Removal of parathyroid glands during thyroidectomy (removal of thyroid) causes decreased secretion of parathormone. The conditions are

- Muscle spasm known as **Tetany** (sustained contraction of muscles in face, larynx, hands and feet).
- Painful cramps of the limb muscles.

## 16.2.4 Pancreas (Islets of Langerhans)

Pancreas is an elongated, yellowish gland situated in the loop of stomach and duodenum. It is **exocrine** and **endocrine** in nature. The exocrine pancreas secretes pancreatic juice which plays a role in digestion while, the endocrine portion is made up of Islets of Langerhans.

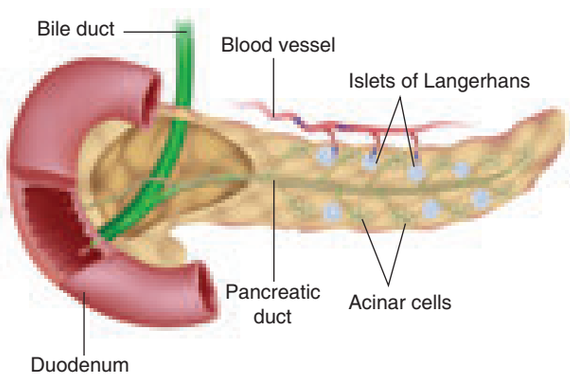



**Figure 16.10** Pancreas

DO YOU KNOW?

Human insulin was first discovered by Fredrick Banting, Charles Best and MacLeod in 1921. Insulin was first used in treatment of diabetes on 11th January 1922.

The Islets of Langerhans consists of two types of cells namely alpha cells and beta cells. The **alpha cells** secrete **glucagon** and **beta cells** secrete **insulin**.

### Functions of Pancreatic hormones

A balance between insulin and glucagon production is necessary to maintain blood glucose concentration.

### Insulin

- Insulin helps in the conversion of glucose into glycogen which is stored in liver and skeletal muscles.
- It promotes the transport of glucose into the cells.
- It decreases the concentration of glucose in blood.

### Glucagon

- Glucagon helps in the breakdown of glycogen to glucose in the liver.
- It increases blood glucose levels.

Diabetes mellitus

The deficiency of insulin causes **Diabetes mellitus**. It is characterised by

- Increase in blood sugar level (Hyperglycemia).
- Excretion of excess glucose in the urine (Glycosuria).
- Frequent urination (Polyuria).
- Increased thirst (Polydipsia).
- Increase in appetite (Polyphagia).

## 16.2.5 Adrenal Gland

The adrenal glands are located above each kidney. They are also called **supra renal glands**.

The outer part is the adrenal cortex and the inner part is the adrenal medulla. The two distinct parts are structurally and functionally different.

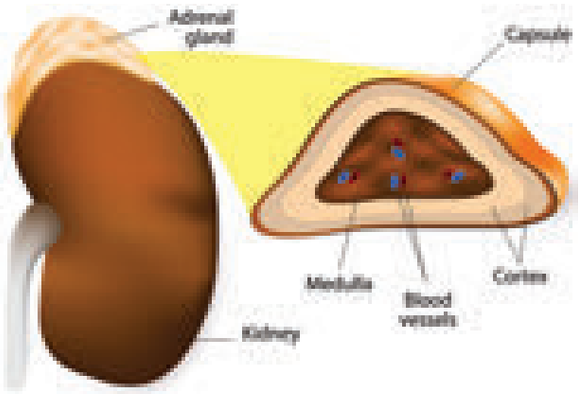



**Figure 16.11** Adrenal Gland

## Adrenal Cortex

The adrenal cortex consists of three layers of cells. They are **zona glomerulosa**, **zona fasciculata** and **zona reticularis**

### Hormones of Adrenal Cortex

The hormones secreted by the adrenal cortex are corticosteroids. They are classified into

a. Glucocorticoids

b. Mineralocorticoids

### Functions of adrenocortical hormones

**Glucocorticoids**

The glucocorticoids secreted by the zona fasciculata are **cortisol** and **corticosterone**

- They regulate cell metabolism.
- It stimulates the formation of glucose from glycogen in the liver.
- It is an anti-inflammatory and anti-allergic agent.

**Mineralocorticoids**

The mineralocorticoids secreted by zona glomerulosa is **aldosterone**

- It helps to reabsorb sodium ions from the renal tubules.
- It causes increased excretion of potassium ions.
- It regulates electrolyte balance, body fluid volume, osmotic pressure and blood pressure.

**More to Know**

The **cortisol** hormones of adrenal cortex serves to maintain the body in living condition and recover it from the severe effects of stress reactions. Thus an increased output of cortisol is "life saving" in "shock conditions". It is also known as life-saving hormone.

## Adrenal Medulla

The adrenal medulla is composed of **chromaffin cells**.They are richly supplied with sympathetic and parasympathetic nerves.

### Hormones of Adrenal Medulla

It secretes two hormones namely

a. Epinephrine (Adrenaline)

b. Norepinephrine (Noradrenaline)

They are together called as "**Emergency hormones**". It is produced during conditions of stress and emotion. Hence it is also referred as "flight, fright and fight hormone".

### Functions of adrenal medullary hormones

**Epinephrine (Adrenaline)**

- It promotes the conversion of glycogen to glucose in liver and muscles.
- It increases heart beat and blood pressure.
- It increases the rate of respiration by dilation of bronchi and trachea.
- It causes dilation of the pupil in eye.
- It decreases blood flow through the skin.

**Norepinephrine (Noradrenalin)**

Most of its actions are similar to those of epinephrine.

## 16.2.6 Reproductive Glands (Gonads)

The sex glands are of two types the **testes** and the **ovaries**. The testes are present in male, while the ovaries are present in female.

## Testes

Testes are the reproductive glands of the males. They are composed of seminiferous tubules, Leydig cells and Sertoli cells. **Leydig cells** form the endocrine part of the testes. They secrete the male sex hormone called **testosterone**.

### Functions of testosterone

- It influences the process of spermatogenesis.
- It stimulates protein synthesis and controls muscular growth.
- It is responsible for the development of secondary sexual characters (distribution of hair on body and face, deep voice pattern, etc).

## Ovary

The ovaries are the female gonads located in the pelvic cavity of the abdomen. They secrete the female sex hormones

a. Estrogen

b. Progesterone

**Estrogen** is produced by the **Graafian follicles** of the ovary and **progesterone** from the **corpus luteum** that is formed in the ovary from the ruptured follicle during ovulation.

### Functions of estrogens

- It brings about the changes that occur during puberty.
- It initiates the process of oogenesis.
- It stimulates the maturation of ovarian follicles in the ovary.
- It promotes the development of secondary sexual characters (breast development, high pitched voice etc).

### Functions of progesterone

- It is responsible for the premenstrual changes of the uterus.
- It prepares the uterus for the implantation of the embryo.
- It maintains pregnancy.
- It is essential for the formation of placenta.

## 16.2.7 Thymus Gland

Thymus is partly an endocrine gland and partly a lymphoid gland. It is located in the upper part of the chest covering the lower end of trachea. **Thymosin** is the hormone secreted by thymus.

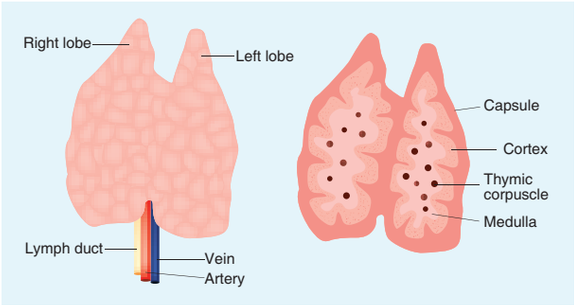



**Figure 16.12** Thymus Gland

### Functions of Thymosin

- It has a stimulatory effect on the immune function.
- It stimulates the production and differentiation of lymphocytes.

### Points to Remember

- Auxins are produced at the tip of stems and roots from where they migrate to the zone of elongation.
- Cytokinins are the plant hormones that promote cell division or cytokinesis in plant cells.
- Gibberellins induce the formation of seedless fruit and parthenocarpic fruits.
- Abscisic acid is a growth inhibitor which regulates abscission and dormancy. It increases tolerance of plants to various kinds of stress.
- Ethylene is a gaseous plant hormone mainly concerned with maturation and ripening of fruits.

- The pituitary gland regulates and controls other endocrine glands and so is called as the "Master gland".
- The hormones secreted by the thyroid gland are triiodothyronine ($T_3$), and tetraiodothyronine or thyroxine ($T_4$)
- The parathormone act on bone, kidney and intestine to maintain blood calcium levels.
- Pancreas secretes insulin and glucagon. They maintain blood glucose level.
- Adrenal cortex secrete coritsol and aldosterone and adrenal medulla secretes epinephrine and norepinephrine.
- The sex glands are of two types the testes and the ovaries which secrete testosterone and estrogens respectively.

## TEXTBOOK EVALUATION

PNBKKJ

### I Choose the correct answer

1. Gibberellins cause:
   a) Shortening of genetically tall plants
   b) Elongation of dwarf plants
   c) Promotion of rooting
   d) Yellowing of young leaves
2. The hormone which has positive effect on apical dominance is:
   a) Cytokinin b) Auxin
   c) Gibberellin d) Ethylene
3. Which one of the following hormones is naturally not found in plants:
   a) 2, 4-D b) GA3
   c) Gibberellin d) IAA
4. Avena coleoptile test was conducted by
   a) Darwin b) N. Smit
   c) Paal d) F.W. Went
5. To increase the sugar production in sugarcanes they are sprayed with _____
   a) Auxin b) Cytokinin
   c) Gibberellins d) Ethylene
6. LH is secreted by
   a) Adrenal gland b) Thyroid gland
   c) Anterior pituitary d) Hypothalamus.
7. Identify the exocrine gland
   a) Pituitary gland b) Adrenal gland
   c) Salivary gland d) Thyroid gland
8. Which organ acts as both exocrine gland as well as endocrine gland
   a) Pancreas b) Kidney c) Liver d) Lungs
9. Which one is referred as "Master Gland"?
   a) Pineal gland b) Pituitary gland
   c) Thyroid gland d) Adrenal gland

### II Fill in the blanks

1. _____ causes cell elongation, apical dominance and prevents abscission.
2. _____ is a gaseous hormone involved in abscission of organs and acceleration of fruit ripening.
3. _____ causes stomatal closure.
4. Gibberellins induce stem elongation in _____ plants.
5. The hormone which has negative effect on apical dominance is _____.
6. Calcium metabolism of the body is controlled by _____.
7. In the islets of Langerhans, beta cells secrete _____.
8. The growth and functions of thyroid gland is controlled by _____.
9. Decreased secretion of thyroid hormones in the children leads to _____.

### III a) Match Column I with Columns II and III

| Column I | Column II | Column III |
|---|---|---|
| Auxin | *Gibberella fujikuroi* | Abscission |
| Ethylene | Coconut milk | Internodal elongation |
| Abscisic acid | Coleoptile tip | Apical dominance |
| Cytokinin | Chloroplast | Ripening |
| Gibberellins | Fruits | Cell division |

### III b) Match the following hormones with their deficiency states

| *Hormones* | | *Disorders* |
|---|---|---|
| a) Thyroxine | - | Acromegaly |
| b) Insulin | - | Tetany |
| c) Parathormone | - | Simple goitre |
| d) Growth hormone | - | Diabetes insipidus |
| e) ADH | - | Diabetes mellitus |

### IV State whether True or false, If false write the correct statement

1. A plant hormone concerned with stimulation of cell division and promotion of nutrient mobilization is cytokinin.
2. Gibberellins cause parthenocarpy in tomato.
3. Ethylene retards senescence of leaves, flowers and fruits.
4. Exopthalmic goiter is due to the over secretion of thyroxine.
5. Pituitary gland is divided into four lobes.
6. Estrogen is secreted by corpus luteum.

### V Assertion and Reasoning

**Direction:** In each of the following questions a statement of assertion (A) is given and a corresponding statement of reason (R) is given just below it. Mark the correct statement as.

a. If both A and R are true and R is correct explanation of A

b. If both A and R are true but R is not the correct explanation of A

c. A is true but R is false

d. Both A and R are false

1. **Assertion:** Application of cytokinin to marketed vegetables can keep them fresh for several days.

   **Reason:** Cytokinins delay senescence of leaves and other organs by mobilisation of nutrients.

2. **Assertion (A):** Pituitary gland is referred as "Master gland".

   **Reason (R):** It controls the functioning of other endocrine glands.

3. **Assertion (A):** Diabetes mellitus increases the blood sugar levels.

   **Reason (R):**Insulin decreases the blood sugar levels.

### VI Answer in a word or sentence

1. Which hormone promotes the production of male flowers in Cucurbits?
2. Write the name of a synthetic auxin.
3. Which hormone induces parthenocarpy in tomatoes?
4. What is the hormone responsible for the secretion of milk in female after child birth?
5. Name the hormones which regulates water and mineral metabolism in man.
6. Which hormone is secreted during emergency situation in man?
7. Which gland secretes digestive enzymes and hormones?
8. Name the endocrine glands associated with kidneys.

### VII Short answer questions

1. What are synthetic auxins? Give examples.
2. What is bolting? How can it be induced artificially?

3. Bring out any two physiological activities of abscisic acid
4. What will you do to prevent leaf fall and fruit drop in plants? Support your answer with reason.
5. What are chemical messengers?
6. Write the differences between endocrine and exocrine gland.
7. What is the role of parathormone?
8. What are the hormones secreted by posterior lobe of the pituitary gland? Mention the tissues on which they exert their effect.
9. Why are thyroid hormones refered as personality hormone?
10. Which hormone requires iodine for its formation? What will happen if intake of iodine in our diet is low?

## VIII. Long answer questions

1. (a) Name the gaseous plant hormone. Describe its three different actions in plants. (b) Which hormone is known as stress hormone in plants ? Why?
2. Describe an experiment which demonstrates that growth stimulating hormone is produced at the tip of coleoptile.
3. Write the physiological effects of gibberellins.
4. Where are estrogens produced? What is the role of estrogens in the human body?
5. What are the conditions which occur due to lack of ADH and insulin? How are the conditions different from one another?

## IX Higher Order Thinking Skills (HOTS)

1. What would be expected to happen if
   a. Gibberellin is applied to rice seedlings.
   b. A rotten fruit gets mixed with unripe fruits.
   c. When cytokinin is not added to culture medium
2. A plant hormone was first discovered in Japan when rice plants were suffering from Bakanae disease caused by *Gibberella fujikoroi*. Based on this information answer the following questions:
   a. Identify the hormone involved in this process.
   b. Which property of this hormone causes the disease?
   c. Give two functions of this hormone.
3. Senthil has high blood pressure, protruded eyeball and an increased body temperature. Name the endocrine gland involved and hormone secretion responsible for this condition.
4. Sanjay is sitting in the exam hall. Before the start of the exam , he sweats a lot, with increased rate of heart beat. Why does this condition occur?
5. Susan's father feels very tired and frequently urinates. After clinical diagnosis he was advised to take an injection daily to maintain his blood glucose level. What would be the possible cause for this? Suggest preventive measures.

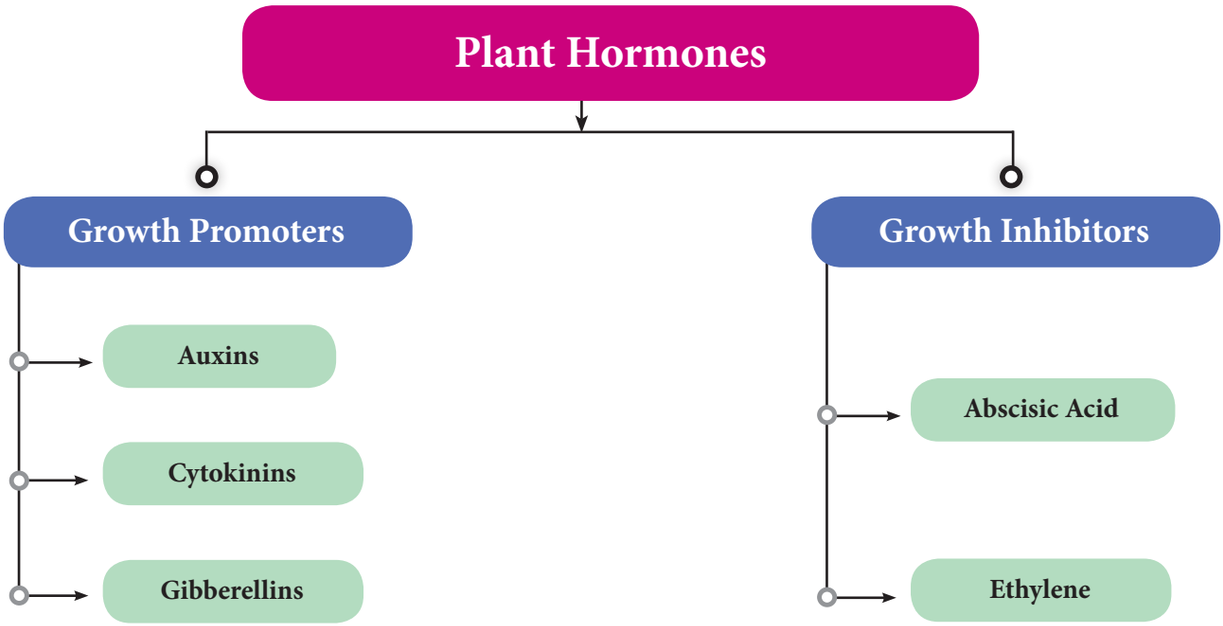
## REFERENCE BOOKS


1. Helgi Opik and Stephen Rolfe, The Physiology of Flowering Plants, Cambridge University Press.
2. Berry AK, A Textbook of Endocrinology, 11th edition, Emkay Publications, New Delhi
3. Prakash S Lohar, Endocrinology, Hormones and Human Health, MJP Publishers (TamilNadu Book House), Chennai

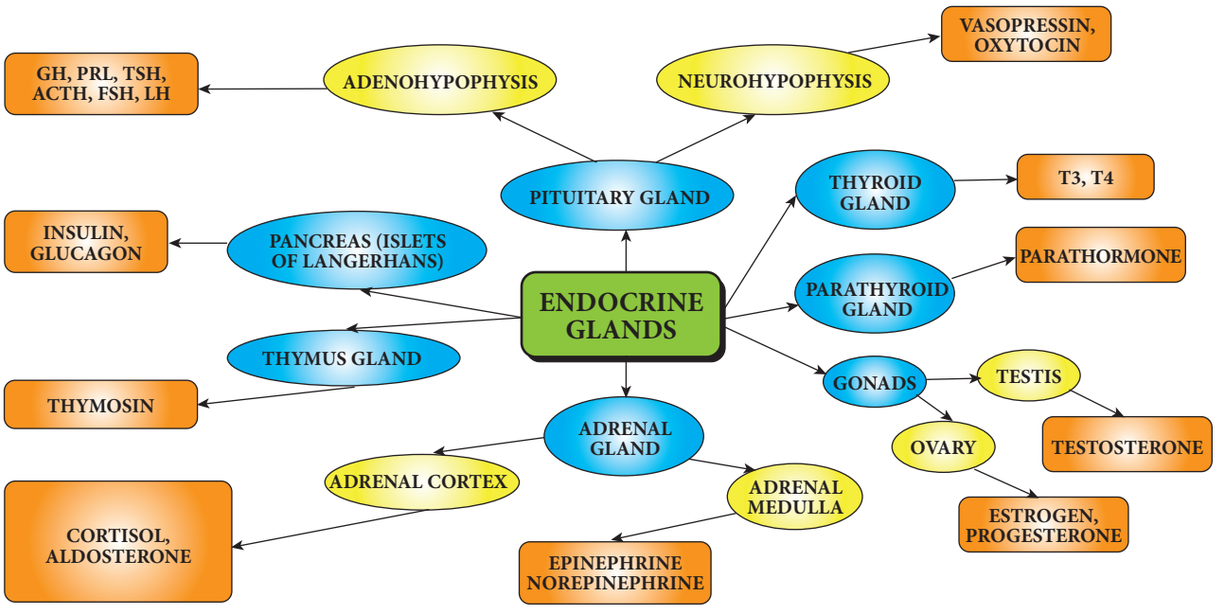

## INTERNET RESOURCES

1. https://www.biologydiscussion.com > auxins-his
2. https://www.mcdaniel.edu/biology/Bot.(dia)
3. https://www.ndsu.edu/pubweb/chiwonlee/plsc210

## Concept Map




## Human Endocrine Glands - Concept Map



# UNIT 17

# REPRODUCTION IN PLANTS AND ANIMALS

## Learning Objectives

PNKGM7

At the end of this lesson the students will be able to:

- Differentiate vegetative, asexual and sexual reproduction.
- Describe parts of flower and their functions.
- Understand the types and modes of pollination and their significance.
- Understand the process of double fertilization, steps involved in fertilization (syngamy and triple fusion), embryo development, endosperm development and formation of seed.
- Understand the process of sexual reproduction in human beings.
- Know the structure of testicular and ovarian cells.
- Know the structural details of human sperm and ovum.
- Realize the events of menstrual cycle and fertilization.
- Gain awareness on reproductive health and strategies.
- Gain knowledge on personal and social hygiene.

## Introduction

"Living organisms cannot survive for an indefinite period on earth. All living organisms have the ability to produce more of its own kind by the process called reproduction. Reproduction is the unfolding of life forms where new individuals are formed. It ensures continuity and survival of the species. This process is to preserve individual species and it is called as self-perpetuation. The time required to reproduce also varies from organism to organism. You may find great variations in period of reproduction in yeast, bacteria, rat, cow, elephant and humans. In sexual reproduction offsprings are produced by the union of male and female gametes (sperm and egg). The male and female gametes contain the genetic material or genes present on the chromosomes which transmit the characteristic traits to the next generation. There are three types of reproduction in plants namely i) Vegetative ii) Asexual and iii) Sexual reproduction.

## 17.1 Vegetative Reproduction

In this type, new plantlets are formed from vegetative (somatic) cells, buds or organs of plant. The vegetative part of plant (root, stem, leaf or bud) gets detached from the parent body and grows into an independent

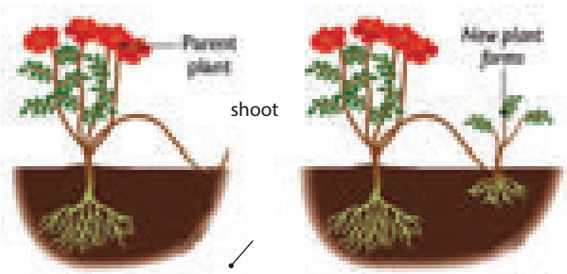
daughter plant. It has only mitotic division, no gametic fusion and daughter plants are genetically similar to the parent plant.

Vegetative reproduction may take place through

**(i) Leaves:** In Bryophyllum small plants grow at the leaf notches


**Figure 17.1** Vegetative reproduction by leaf

**(ii) Stems:** In strawberry aerial weak stems touch the ground and give off adventitious roots and buds. When the connections with the parent plant is broken, the offspring beomes independent.




**Figuer 17.2** Vegetative reproduction by stem

**(iii) Root:** Tuberous roots (Asparagus and Sweet potato) can be used for vegetative propagation.

**(iv) Bulbils:** In some plants the flower buds modified into globose which are called as bulbils. When these falls on the ground they grow into new plants. e.g. Agave.

**(v) Other types of Vegetative Reproduction**

**a. Fragmentation:** In filamentous algae, breaking of the filament into many fragments is called fragmentation. Each fragment having atleast one cell, may give rise to a new filament of the algae by cell division e.g. Spirogyra.

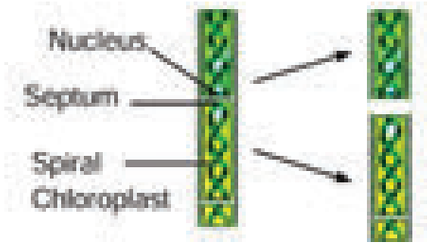



**Figure 17.3** Fragmentation in Spirogyra

**b. Fission:** In this type the parent cell divides into two daughter cells and each cell develops into a new adult organism e.g. Amoeba.

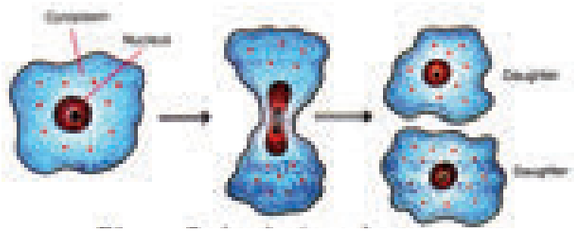


**Figure 17.4** Fission in Amoeba

**c. Budding:** Formation of a daughter individual from a small projection, the bud, arising on the parent body is called budding. e.g. Yeast.

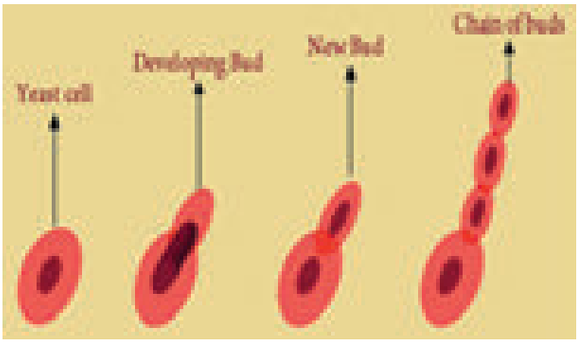



**Figure 17.5** Budding in Yeast

**d. Regeneration:** The ability of the lost body parts of an individual organism to give rise to an whole new organism is called regeneration. It takes place by specialized mass of cells e.g *Hydra* and *Planaria.*

## 17.2 Asexual Reproduction

Production of an offspring by a single parent without the formation and fusion of gametes is called asexual reproduction. It involves only mitotic cell divisions and meiosis does not occur. Offspring produced by asexual reproduction are not only identical to parents but are also exact copies of their parent.

Asexual reproduction occurs by **spore formation.** This is the most common method of asexual reproduction in fungi and bacteria.

During spore formation a structure called **sporangium** develops from the **fungal hypha**. The nucleus divides several times within the sporangium and each nucleus with small amount of cytoplasm develops into a spore. The spores are liberated and they develop into new hypha after reaching the ground or substratum.

**Figure 17.6** Spore formation in *Rhizopus*

### Activity 1

- Wet a slice of bread, and keep it in a cool, moist and dark place.
- Observe the surface of the slice with a magnifying glass.
- Record your observations for a week.

## 17.3 Sexual Reproduction in Plants

Sexual reproduction is the process in which two gametes (male and female) are fused to produce offspring of their own kind. In such cases both sexes, male and female sex organs are needed to produce gametes. You have already learnt that the flower is a reproductive organ of a flowering plant. To understand this further we need to study the structure of a flower.

### 17.3.1 Parts of a Typical Flower

A flower is a modified shoot with limited growth to carry out sexual reproduction. A flower consists of four whorls borne on a thalamus. These whorls are from outside

a) Calyx – consisting of sepals
b) Corolla – consisting of petals
c) Androecium – consisting of stamens
d) Gynoecium or pistil – consisting of carpels

**Figure 17.7** Parts of a flower

### Activity 2

- Take a shoe flower from a growing plant.
- Observe the floral parts Calyx, Corolla, Androecium and Gynoecium.
- Separate the stamens and carpels and observe the parts.
- Dust the pollen grains on a slide and observe under a microscope.

The **two outermost whorls calyx** and **corolla** are **non–essential** or **accessory whorls** as they do not directly take part in the reproduction. The other two whorls **androecium** and **gynoecium** are known as the **essential whorls**, because both take part directly in reproduction.

**Androecium:** Androecium, the **male part** of flower is composed of **stamens**. Each stamen consists of a stalk called the **filament** and a small bag like structure called **anther** at the tip. The pollen grains are produced in the anther within the pollen sac.

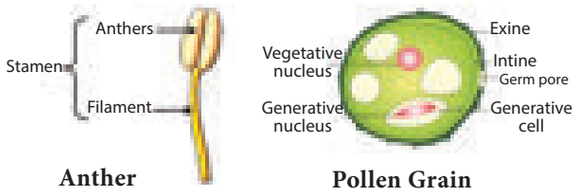



**Figure 17.8** Structure of Anther and Pollen grain

**Pollen grain:** Pollen grains are usually spherical in shape. It has two layered wall. The hard-outer layer is known as **exine**. It has prominent apertures called germpore. The inner thin layer is known as **intine**. It is a thin and continuous layer made up of cellulose and pectin. Mature pollen grains contain two cells, the **vegetative** and the **generative cell**. Vegetative cell contains a large nucleus. The generative cell divides mitotically to form two male gametes.

**Gynoecium:** Gynoecium is the female part of the flower and is made up of carpels. It has three parts:

1. Ovary
2. Style
3. Stigma

The ovary contains the ovules.

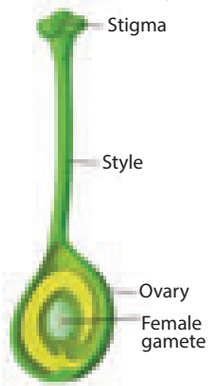



**Figure 17.9** Gynoecium

### 17.3.2 Structure of the Ovule

The main part of the ovule is the **nucellus** which is enclosed by two integuments leaving an opening called as **micropyle**. The ovule is attached to the ovary wall by a stalk known as **funiculus**. **Chalaza** is the basal part.

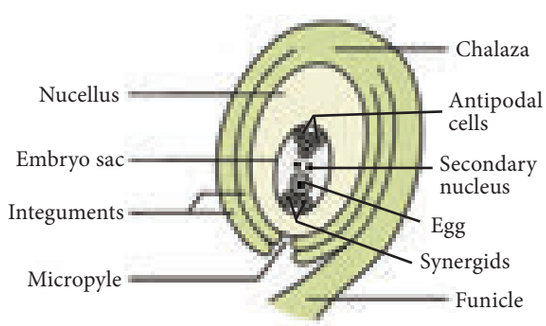



**Figure 17.10** Structure of an Ovule

The embryo sac contains seven cells and the eighth nuclei located within the **nucellus**. Three cells at the **micropylar** end form the egg apparatus and the three cells at the **chalaza** end are the antipodal cells. The remaining two nuclei are called **polar nuclei** found in the centre. In the egg apparatus one is the egg cell (female gamete) and the remaining two cells are the **synergids**.

Process of sexual reproduction in flowering plants. It involves:

1. Pollination
2. Fertilization

## 17.4 Pollination

The transfer of pollen grains from anther to stigma of a flower is called as pollination

Q3UFLV

### Importance of Pollination

1. It results in fertilization which leads to the formation of fruits and seed.
2. New varieties of plants are formed through new combination of genes in case of cross pollination.

### 17.4.1 Types of Pollination

1. Self-pollination
2. Cross pollination

### Self-pollination (Autogamy)

Self-pollination is also known as autogamy. The transfer of pollen grains from the anther to the stigma of same flower or another flower borne on the same plant is known as self-pollination. e.g. *Hibiscus*.

**Advantages of self-pollination**

1. Self-pollination is possible in bisexual flowers.
2. Flowers do not depend on agents for pollination.
3. There is no wastage of pollen grains.

**Disadvantages of self-pollination**

1. The seeds are less in numbers.
2. The endosperm is minute. Therefore, the seeds produce weak plants.
3. New varieties of plants cannot be produced

### Cross pollination

Cross-pollination is the transfer of pollen from the anthers of a flower to the stigma of a flower on another plant of the same species e.g. apples, grapes, plum, etc.

**Advantages of cross pollination**

1. The seeds produced as a result of cross pollination, develop and germinate properly and grow into better plants, i.e. cross pollination leads to the production of new varieties.
2. More viable seeds are produced.

**Disadvantages of cross-pollination**

1. Pollination may fail due to distance barrier.
2. More wastage of pollen grains
3. It may introduce some unwanted characters
4. Flowers depend on the external agencies for pollination

**Activity 3**

- Observe the flowers in a garden. Identify the insects and birds that act as pollinating agents.
- Maintain a record of pollinating agents and the plants.

## 17.5 Agents of Cross Pollination

In order to bring about cross pollination, it is necessary that the pollen should be carried from one flower to another of a different plant. This takes place through the agency of animals, insects, wind and water.

1. **Pollination by wind**

The pollination with the help of wind is called **anemophily**. The anemophilous flowers produce enormous amount of pollen grains. The pollen grains are small, smooth, dry and light in weight. Pollen of such plants are blown off at a distance of more than 1,000 km. The stigmas are comparatively large, protruding and sometimes hairy to trap the pollen grains. e.g. Grasses and some cacti.

2. **Pollination by insects**

Pollination with the help of insects like honey bees, flies are called **entomophily**. To attract insects these flowers are brightly coloured, have smell and nectar. The pollen grains are larger in size, the exine is pitted, spiny etc., so they can be adhered firmly on the sticky stigma. Approximately, 80% of the pollination done by the insects is carried by honey bees.

3. **Pollination by water**

The pollination with the help of water is called **hydrophily**.This takes place in aquatic plants.

(i) Pollen grains are produced in large numbers.

(ii) Pollen grains float on surface of water till they land on the stigma of female flowers e.g. *Hydrilla, Vallisneria*.

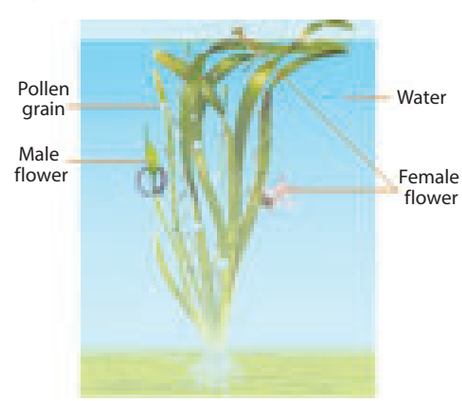



**Figure 17.11** Hydrophily

3. **Pollination by Animals**

When pollination takes place with the help of animals, it is called **Zoophily**. Flowers of such plants attract animals by their bright color, size, scent etc. e.g. sun bird pollinates flowers of *Canna, Gladioli* etc., Squirrels pollinate flowers of silk cotton tree.

## 17.6 Fertilization in Plants

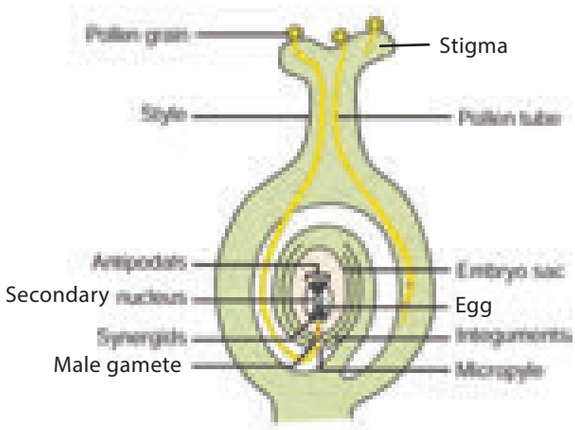



**Figure 17.12** Process of Fertilization

- Pollen grains reach the right stigma and begin to germinate.
- Pollen grain forms a small tube-like structure called pollen tube which emerges through the germ pore. The contents of the pollen grain move into the tube.
- Pollen tube grows through the tissues of the stigma and style and finally reaches the ovule through the micropyle.
- Vegetative cell degenerates and the generative cell divides to form two sperms (or male gametes).
- Tip of pollen tube bursts and the two sperms enter the embryo sac.
- One sperm fuses with the egg (syngamy) and forms a diploid zygote. The other sperm fuses with the secondary nucleus (Triple fusion) to form the primary endosperm nucleus which is triploid in nature. Since two types of fusion syngamy and triple fusion take place in an embryo sac the process is termed as **double fertilization**.
- After triple fusion, primary endosperm nucleus develops into an endosperm.
- Endosperm provides food to the developing embryo.
- Later the synergids and antipodal cells degenerate.

### Significance of Fertilization

(i) It stimulates the ovary to develop into fruit.

(ii) It helps in development of new characters from two different individuals.

**Post fertilization changes:**

1. The ovule develops into a seed.
2. The integuments of the ovule develop into the seed coat.
3. The ovary enlarges and develops into a fruit.

The seed contains the future plant or embryo which develops into a seedling under appropriate conditions.

## 17.7 Sexual Reproduction in Human

You have studied the structural details of the male and female reproductive system in 9th standard. In human beings the male and female reproductive organs differ anatomically and physiologically. New individuals develop by the fusion of gametes. Sexual reproduction involves the fusion of two haploid gametes (male and the female gametes) to form a diploid individual (zygote).

Organs of the reproductive system are divided into primary and secondary (accessory) sex organs.

- Primary reproductive organs include the gonads (Testes in male and Ovaries in female).
- Accessory sex organs
  - **Male:** Vas deferens, epididymis, seminal vesicle, prostate gland and penis.
  - **Female:** Fallopian tubes, uterus, cervix and vagina.

The secondary (accessory) sex organs include those structures which are involved in the

- Process of ovulation
- Fusion of the male and female gametes (fertilization)
- Division of the fertilized egg upto the formation of embryo
- Pregnancy
- Development of foetus
- Child birth.

Now let's see the cells of the primary reproductive organs in human male and female and their role in reproduction.

### 17.7.1 Male Reproductive Organ - Structure of Testes

Testes are the reproductive glands of the male that are oval shaped organs which lie outside the abdominal cavity of a man in a sac like structure called **scrotum**. Now we shall study the various cells which are present in the testes.

Each testes is covered with a layer of fibrous tissue called **tunica albuginea**. Many septa from this layer divide the testes into pyramidal lobules, in which lie seminiferous tubules, cells of Sertoli, and the Leydig cells (interstitial cells).

The process of **spermatogenesis** takes place in the **seminiferous tubules**. The **Sertoli cells** are the supporting cells and provide **nutrients** to the developing sperms. The **Leydig cells** are polyhedral in shape and lie between the seminiferous tubules and secrete **testosterone**. It initiates the process of **spermatogenesis.**

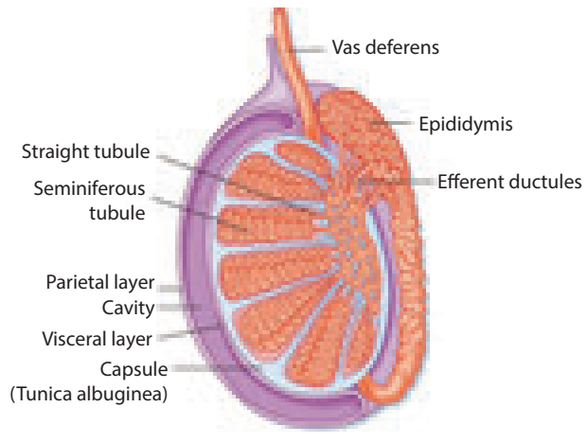



**Figure 17.13** L.S of human testes

### 17.7.2. Female Reproductive Organ - Structure of Ovary

The ovaries are located on either side of the lower abdomen composed of two almond shaped bodies, each lying near the lateral end of fallopian tube. Each ovary is a compact structure consisting of an outer cortex and an inner medulla. The cortex is composed of a network of connective tissue called as stroma and is lined by the **germinal epithelium**. The epithelial cells called the **granulosa cells** surround each ovum in the ovary together forming the primary follicle. As the egg grows larger, the follicle also enlarges and gets filled with the fluid and is called the **Graafian follicle**.

**Info bits**

The number of primordial follicles in new born female child ranges over 7 million and during reproductive period (at puberty) the number is around 60,000 to 70,000. During a woman's lifetime, she will only ovulate 300 to 400 of the 1-2 million eggs, she was initially born with. On the other side, men will produce over 500 billion sperms in their lifetime.

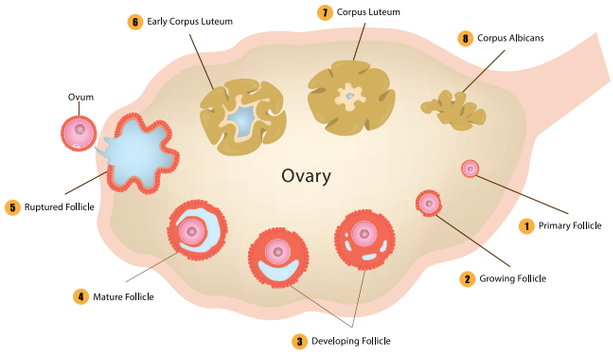



**Figure 17.14** L.S of human ovary

## 17.8 Gametogenesis

The **formation of the sperm in male** and the **ovum in female** is called **gametogenesis**. It involves **spermatogenesis** (formation of spermatozoa) and **oogenesis** (the formation of ova). Gametes with **haploid cells** are produced through gametogenesis.

### 17.8.1 Structure of Human Sperm

The spermatozoan consists of head, a middle piece and tail. The **sperm head** is elongated and formed by the condensation of nucleus. The anterior portion has a cap like structure called **acrosome**. It contains **hyaluronidase** an enzyme that helps the sperm to enter the ovum during fertilization. A short neck connects the head and **middle piece** which comprises the **centrioles**.The middle piece contains the **mitochondria** which provides energy for the movement of tail. It brings about **sperm motility** which is essential for fertilization.

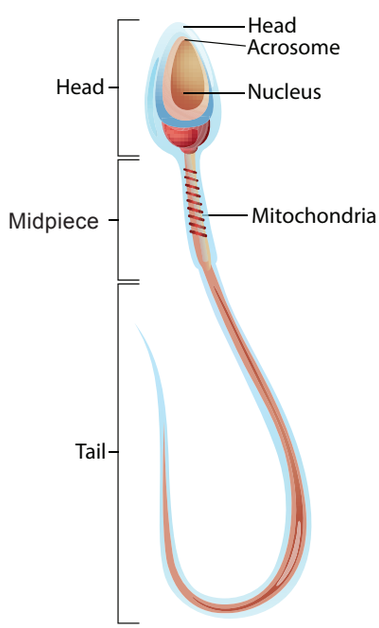



**Figure 17.15** Structure of sperm

### 17.8.2 Structure of Human Ovum

The mature ovum or egg is spherical in shape.The ovum is almost free of yolk. It contains abundant cytoplasm and the nucleus. The ovum is surrounded by three membranes. The **plasma membrane** is surrounded by inner thin **zona pellucida** and an outer thick **corona radiata**. The corona radiata is formed of **follicle cells**. The membrane forming the surface layer of the ovum is called **vitelline membrane**. The fluid-filled space between zona pellucida and the surface of the egg is called **perivitelline space**.

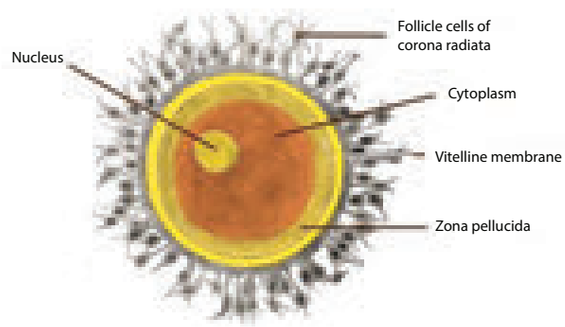



**Figure 17.16** Structure of ovum

#### Puberty

The reproductive system in both males and females becomes functional and an increase in sex hormone production resulting in puberty. This phenomenon tends to start earlier in females than in males. Generally boys attain puberty between the age of 13 to 14 years, while girls reach puberty between 11 to 13 years. In male, the onset of puberty is triggered by the secretion of the hormone testosterone in the testes, in female the secretion of estrogens and progesterone from

the ovary. The secretion of both male and female hormones are under the control of the pituitary gonadotropins luteinizing hormone (LH) and follicle stimulating hormone (FSH).

## 17.9 Menstrual Cycle-Process of Ovulation

The cyclic events that take place in a rhythmic fashion during the reproductive period of a woman's life is called menstrual cycle. In human females the menstrual cycle starts at the age of 11-13 years which marks the onset of puberty and is called **menarche**, and ceases around 48-50 years of age and this stage is termed **menopause**. The reproductive period is marked by characteristic events repeated almost every month in physiologically normal women (28 days with minor variation) in the form of a menstrual flow. The menstrual cycle consists of 4 phases

1. Menstrual or Destructive Phase
2. Follicular or Proliferative Phase
3. Ovulatory Phase
4. Luteal or Secretory Phase

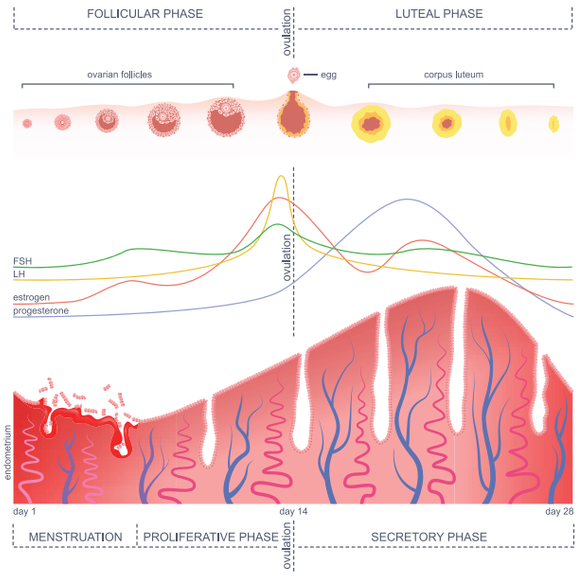



**Figure 17.17** Menstrual cycle

These phases show simultaneous synchrony of events in both ovary and uterus. Changes in the ovary and the uterus are

**Table 17.1** Events of Menstrual Cycle and the Role of Hormones

| Phase | Days | Changes in Ovary | Changes in Uterus | Hormonal Changes |
|---|---|---|---|---|
| Menstrual phase | 4–5 days | Development of primary follicles | Breakdown of uterine endometrial lining leads to bleeding | Decrease in progesterone and oestrogen |
| Follicular phase | 6th–13th day | Primary follicles grow to become a fully mature Graafian follicle | Endometrium regenerates through proliferation | FSH and oestrogen increase |
| Ovulatory phase | 14th day | The Graafian follicle ruptures, and releases the ovum(egg) | Increase in endometrial thickness | LH peak |
| Luteal phase | 15th–28th day | Emptied Graafian follicle develops into corpus luteum | Endometrium is prepared for implantation if fertilization of egg takes place, if fertilization does not occur corpus luteum degenerates, uterine wall ruptures, bleeding starts and unfertilized egg is expelled | LH and FSH decrease, Corpus luteum produces progesterone and its level increases followed by a decline, if menstrual bleeding occurs |

induced by the pituitary hormones (LH and FSH) and ovarian hormones (estrogen and progesterone).

**Info bit**

Menstruation is a periodical phenomenon that continues from puberty to menopause. This will happen if the released ovum is not fertilized by the sperm. Lack of menstruation generally indicates pregnancy.

## 17.10 Fertilization to Foetal Development

### Fertilization

Fertilization in human is internal and occurs in the oviduct of the female genital tract. It takes place usually in the ampulla of the fallopian tube. An oocyte is alive for about 24 hours after it is released from the follicle. Fertilisation must take place within 24 hours. The sperm enters into the ovum and fuses with it, resulting in the formation of a '**zygote**'. This process is called fertilization. The zygote is a **fertilized ovum**.

### Cleavage and Formation of Blastula

The first cleavage takes place about 30 hours after fertilization. Cleavage is a series of rapid mitotic divisions of the zygote to form many celled blastula (**Blastocyst**) which comprises an outer layer of smaller cells and inner mass of larger cells.

### Implantation

The blastocyst (fertilized egg) reaches the uterus and gets implanted in the uterus. The process of attachment of the blastocyst to the uterine wall (**endometrium**) is called implantation. The fertilized egg becomes implanted in about 6 to 7 days after fertilization.

### Gastrulation

The transformation of blastula into gastrula and the formation of **primary germ layers** (ectoderm, mesoderm and endoderm) by rearrangement of the cells is called gastrulation. This takes place after the process of implantation.

**Info bits**

Normally one egg matures in the ovary each month. Ovulation is the rupture of the follicle releasing the egg or ovum . The uterus prepares itself to receive the fertilized egg every month. The uterine lining becomes thick and spongy for implantation of the fertilized egg.

**Events leading to when fertilization occurs and does not occur**

If fertilization takes place the corpus luteum persists, continues to secrete progesterone maintains the thickened state of uterine wall and prevents maturation of another follicle till the end of pregnancy

If fertilization does not occur, corpus luteum degenerates, the egg disintegrates and the uterine lining slowly breaks, discharged as blood and mucus leading to menstrual events.

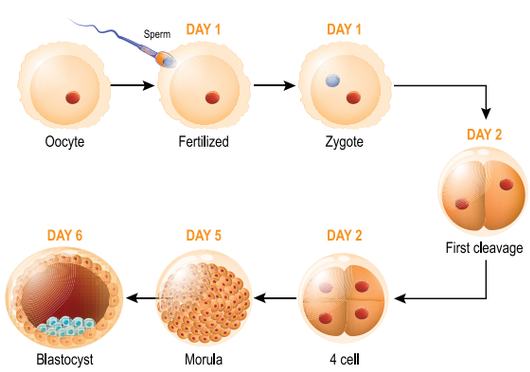



**Figure 17.18** Developmental stages of zygote from cleavage to blastocyst formation

### Organogenesis

The establishment of the germ layers namely ectoderm, mesoderm and endoderm initiates the final phase of embryonic

development. During organogenesis the various organs of the foetus are established from the different germ layers attaining a functional state.

### Formation of Placenta

The placenta is a disc shaped structure attached to the uterine wall and is a temporary association between the developing embryo and maternal tissues. It allows the exchange of food materials, diffusion of oxygen, excretion of nitrogenous wastes and elimination of carbon dioxide. A cord containing blood vessels that connects the placenta with the foetus is called the **umbilical cord**.

### Pregnancy (Gestation)

It is the time period during which the embryo attains its development in the uterus. Normally gestation period of human last for about 280 days. During pregnancy the uterus expands upto 500 times of its normal size.

### Parturition (Child Birth)

Parturition is the **expulsion** of young one from the mother's uterus at the end of gestation. **Oxytocin** from the posterior pituitary stimulates the **uterine contractions** and provides force to expel the baby from the uterus, causing birth.

DO YOU KNOW?

Sometimes ovaries releases two eggs and each is fertilised by a different sperm, resulting in **Non-Identical Twins (Fraternal Twins)**. If single egg is fertilised and then divides into two foetus, **Identical Twins** develop.

### Lactation

The process of milk production after child birth from mammary glands of the mother is called lactation. The first fluid which is released from the mammary gland after child birth is called as **colostrum.** Milk production from alveoli of mammary glands is stimulated by **prolactin** secreted from the anterior pituitary. The **ejection of milk** is stimulated by posterior pituitary hormone **oxytocin**.

**Info bits**

The milk produced from the breast during the first 2 to 3 days after child birth is called colostrum. It contains immune substances and provides immunity to the new born which is essential for the body.

## 17.11. Reproductive Health

According to World Health Organization (WHO) reproductive health means a total well being in all aspects of reproduction, ability to reproduce and regulate fertility, women's ability to undergo pregnancy and safe child birth,maternal and infant survival and well being.

Several measures were undertaken by the government to improve the reproductive health of the people by launching **National Health Programmes** such as the

i. Family Welfare Programme
ii. Reproductive and Child Health Care (RCH) Programme

**Family welfare programme:** The National Family Welfare Programme is a comprehensive scheme which includes:

1. Maternal and child health care (MCH)
2. Immunization of mothers, infants and children.
3. Nutritional supplement to pregnant women and children.
4. Contraception with health education, to motivate couples to accept contraceptive methods and to have small family norms, which improve economic status, living status and the quality of life.

**Reproductive and Child Health Care (RCH) Programme:** It has integrated all services which include

- Pregnancy and child birth
- Postnatal care of the mother and child

- Importance of breast feeding
- Prevention of reproductive tract infections and sexually transmitted diseases.

## 17.12 Population Explosion and Family Planning

Population explosion defined as the sudden and rapid rise in the size of population, especially human population. Realizing the dangers inherent in population growth, the Government of India has taken several measures to check population growth and introduced family planning. **India** has been one of the **first country in the world to launch the nation wide family planning programme in 1952**.

Family planning is a way of living that is adopted voluntarily by couples on the basis of knowledge and responsible decisions to promote the health and welfare of the family group and society. The WHO (World Health Organisation) has also stressed the importance of family planning as global strategy health for all.

DO YOU KNOW?

The inverted red triangle is a symbol of family planning in India for family welfare. It is displayed prominently at all hospitals, primary health clinics and family welfare centres where any help or advice about family planning is available free of cost. The symbol is displayed along with a slogan *Small Family, Happy Family.*

### 17.12.1. Contraception

Contraception is one of the best **birth control measures**. A number of techniques or methods have been developed to prevent pregnancies in women. The devices used for contraception are called **contraceptive devices**. Common contraceptive methods used to prevent pregnancy are discussed here.

1. Barrier methods
2. Hormonal methods
3. Intra-Uterine Devices (IUDs)
4. Surgical methods

#### Barrier Methods

This method prevents sperms from meeting the ovum. Its entry into the female reproductive tract is prevented by barrier.

**(a) Condom:** Condom prevents deposition of sperms in the vagina. Condoms are made of thin rubber or latex sheath. Condom also protect against sexually transmitted diseases (STD) like syphilis, AIDS.

**(b) Diaphragm (Cervical cap):** Vaginal diaphragm fitting into the vagina or a cervical cap fitting over the cervix. This prevents the entry of sperms into the uterus.

#### Hormonal Methods

Hormonal preparations are in the form of **pills** or **tablets** (contraceptive pills). These hormones stop (**interfere with ovulation**) the release of egg from the ovary.

#### Intra-Uterine Devices (IUDs)

The intrauterine device (IUD) are contraceptive devices inserted into the uterus. There are two synthetic devices commonly used in India are **Lippe's Loop** and **Copper-T** made of copper and plastic (non irritant). This can remain for a period of 3 years. This reduces the sperm fertilizing capacity and prevents implantation. This also helps to give adequate time interval between pregnancies.

**Figure 17.19**
Copper-T

#### Surgical Methods

Surgical contraception or sterilization techniques are terminal methods to prevent any pregnancy. This procedure in males is **vasectomy (ligation of vas deferens)** and in females it is

**tubectomy (ligation of fallopian tube)**. These are methods of permanent birth control.

## 17.13 Urinary Tract Infection (UTI)

Many diseases affect both women and men, but a few diseases occur at a higher frequency in woman. Woman are susceptible to UTI from the bacteria that are present on skin, rectum or vagina. This will enter the urethra, before moving upwards. The types of UTI are:

**1. Cystitis or Bladder infection**

Bacteria lodged in the urinary bladder thrive and multiply leading to **inflammation**. It is most common in the age group of 20 to 50.

**2. Kidney Infection**

The bacteria can travel from the urinary bladder and upward to ureter and **affect one or both the kidneys**. It also **infects the blood stream** and leads to serious life-threatening complications.

**3. Asymptomatic Bacteriuria**

The bacteria present in the urinary bladder which may not show any symptoms.

## 17.14 Personal Hygiene

Hygiene is the practice of healthy living and personal cleanliness. Personal hygiene is caring of one's own body and health. Social hygiene is proper care of the surrounding environment. The main aspect of hygiene are body hygiene, food hygiene, sanitary hygiene and hygienic environment.

### 17.14.1 Body Hygiene

Washing is vital to all age group of people which maintains our personal hygiene. A daily bath regularly keeps skin clean and free of germs. Hair should be kept clean by frequent washing. Mouth wash should be done after every meal. We should wash our hands many times during the day.

Cloth towels used to dry our hands or body should be dried after each use and laundered regularly. Clothes, handkerchief, undergarments and socks should be washed daily. Washing prevents body odour, infections and skin irritation.

### 17.14.2 Toilet Hygiene

The toilet has a lot to do with personal hygiene and general health as it is a place that cannot be avoided and used regularly. Parents should guide and practice their children on how to use the toilets at home, in schools and other public places so that it will protect the children from various contagious infections and diseases.The following measures can ensure toilet hygiene

1. The floors of the toilet should be maintained clean and dry. This helps to reduce the bad odour and also infection.
2. Toilet flush handles, door knobs, faucets, paper towel dispensers, light switches and walls should be cleaned with disinfectants to kill harmful germs and bacteria.
3. Hands should be washed thoroughly with soap before and after toilet use.

### 17.14.3 Menstrual and Napkin Hygiene

Women's health depends upon the level of cleanliness to keep them free from skin and genitourinary tract infection.

**Menstrual hygiene**

Maintaining menstrual hygiene is important for the overall health of women. The basic menstrual hygiene ways are

1. Sanitary pads should be changed regularly, to avoid infections due to microbes from vagina and sweat from genitals.
2. Use of warm water to clean genitals helps to get rid of menstrual cramps.

3. Wearing loose clothing rather than tight fitting clothes will ensure the airflow around the genitals and prevent sweating.

### More to Know

Every year May 28 is observed as Menstrual Hygiene day to make girls and women aware of maintaining menstrual hygiene and importance of menstrual hygiene for good health. By way of awareness through films, discussions and campaigns menstrual hygiene has taken quite the centre stage in recent days.

### Napkin hygiene

The parents and teachers are to create awareness among the school girls about the use of napkins and their proper disposal. Girls should be educated in the following ways

1. The sanitary pad and tampons should be wrapped properly and discarded because they can spread infections.
2. Sanitary pad or tampon should not be flushed down the toilet.
3. Napkin incinerators are to be used properly for disposal of used napkins.

### Info bits

The menstrual hygiene scheme to provide subsidized sanitary napkins was launched by the Health ministry in 2011.

In Tamil Nadu, UNICEF has developed an affordable incinerator that uses firewood to handle sanitary napkin waste at schools and special wells are equipped where sanitary napkins are composted.

### Points to Remember

- Many bacteria and protozoa simply divide into two or more daughter cells by fission.
- Organisms such as hydra can regenerate if they are broken into pieces. They can also give out buds which mature into new individuals.
- Reproduction in flowering plants involves transfer of pollen grains from the anther to the stigma which is referred to as pollination. This is followed by fertilization.
- Sexual reproduction involves the fusion of two haploid gametes (male and the female gametes) to form a diploid individual (zygote).
- The formation of the sperm in male and the ovum in female is called gametogenesis. It involves spermatogenesis (formation of spermatozoa) and oogenesis (the formation of ova).
- The cyclic events that take place in a rhythmic manner during the reproductive period of a woman's life is called menstrual cycle.
- The process of attachment of the blastocyst to the uterine wall (endometrium) is called implantation.
- The placenta is a temporary association between the developing embryo and maternal tissues.
- Parturition is the expulsion of young one from the mother's uterus.
- Contraception is one of the best birth control measures. The devices used for contraception are called contraceptive devices.

## TEXTBOOK EVALUATION

QIDAN7

### I. Choose the correct answer

1. The plant which propagates with the help of its leaves is _____ .
   a) Onion b) Neem
   c) Ginger d) *Bryophyllum*

2. Asexual reproduction takes place through budding in _____ .
   a) *Amoeba* b) Yeast
   c) *Plasmodium* d) Bacteria

3. Syngamy results in the formation of _____ .
   a) Zoospores b) Conidia
   c) Zygote d) Chlamydospores
4. The essential parts of a flower are _____ .
   a) Calyx and Corolla
   b) Calyx and Androecium
   c) Corolla and Gynoecium
   d) Androecium and Gynoecium
5. Anemophilous flowers have _____ .
   a) Sessile stigma
   b) Small smooth stigma
   c) Colored flower
   d) Large feathery stigma
6. Male gametes in angiosperms are formed by the division of _____ .
   a) Generative cell
   b) Vegetative cell
   c) Microspore mother cell
   d) Microspore
7 What is true of gametes?
   a) They are diploid
   b) They give rise to gonads
   c) They produce hormones
   d) They are formed from gonads
8. A single highly coiled tube where sperms are stored, get concentrated and mature is known as
   a) Epididymis b) Vasa efferentia
   c) Vas deferens d) Seminiferous tubules
9. The large elongated cells that provide nutrition to developing sperms are
   a) Primary germ cells b) Sertoli cells
   c) Leydig cells d) Spermatogonia
10 Estrogen is secreted by
   a) Anterior pituitary b) Primary follicle
   c) Graffian follicle d) Corpus luteum
11. Which one of the following is an IUCD?
   a) Copper – T b) Oral pills
   c) Diaphragm d) Tubectomy

## II. Fill in the blanks

1. The embryo sac in a typical dicot at the time of fertilization is _____ .
2. After fertilization the ovary develops into _____ .
3. *Planaria* reproduces asexually by _____ .
4. Fertilization is _____ in humans
5. The implantation of the embryo occurs at about _____ day of fertilization
6. _____ is the first secretion from the mammary gland after child birth
7. Prolactin is a hormone produced by _____ .

## III. (a) Match the following

| Column 1 | Column 2 |
|---|---|
| Fission | Spirogyra |
| Budding | Amoeba |
| Fragmentation | Yeast |

## III. (b) Match the following terms with their respective meanings

a) Parturition - 1) Duration between pregnancy and birth
b) Gestation - 2) Attachment of zygote to endometrium
c) Ovulation - 3) Delivery of baby from uterus
d) Implantation - 4) Release of egg from Graafian follicle

## IV. State whether the following statements are True or False. Correct the false statement

1. Stalk of the ovule is called pedicle.
2. Seeds are the product of asexual reproduction.

3. Yeast reproduces asexually by means of multiple fission.
4. The part of the pistil which serves as a receptive structure for the pollen is called as style.
5. Insect pollinated flowers are characterized by dry and smooth pollen.
6. Sex organs produce gametes which are diploid.
7. LH is secreted by the posterior pituitary.
8. Menstrual cycle ceases during pregnancy.
9. Surgical methods of contraception prevent gamete formation.
10. The increased level of estrogen and progesterone is responsible for menstruation.

## V. Answer in a word or sentence

1. If one pollen grain produces two male gametes, how many pollen grains are needed to fertilize 10 ovules?
2. In which part of the flower germination of pollen grains takes place?
3. Name two organisms which reproduces through budding.
4. Mention the function of endosperm.
5. Name the hormone responsible for the vigorous contractions of the uterine muscles.
6. What is the enzyme present in acrosome of sperm?
7. When is World Menstrual Hygiene Day observed?
8. What is the need for contraception ?
9. Name the part of the human female reproductive system where the following occurs.
   a. Fertilization b. Implantation

## VI. Short answer question

1. What will happen if you cut planaria into small fragments?
2. Why is vegetative propagation practiced for growing some type of plants?
3. How does binary fission differ from multiple fission?
4. Define triple fusion.
5. Write the characteristics of insect pollinated flowers.
6. Name the secondary sex organs in male
7. What is colostrum? How is milk production hormonally regulated ?
8. How can menstrual hygiene be maintained during menstrual days?
9. How does developing embryo gets its nourishment inside the mother's body?
10. Identify the parts A, B, C and D


11. Write the events involved in the sexual reproduction of a flowering plant.
    a. Discuss the first event and write the types.
    b. Mention the advantages and the disadvantages of that event.
12. Why are the human testes located outside the abdominal cavity? Name the pouch in which they are present .
13. Luteal phase of the menstrual cycle is also called the secretory phase. Give reason.
14. Why are family planning methods not adopted by all the people of our country?

## VII. Long answer questions

1. With a neat labelled diagram describe the parts of a typical angiospermic ovule.
2. What are the phases of menstrual cycle? Indicate the changes in the ovary and uterus.

## VIII. Higher Order Thinking Skills (HOTS)

1. In angiosperms the pollen germinates to produce pollen tube that carries two gametes. What is the purpose of carrying two gametes when single gamete can fertilize the egg?
2. Why menstrual cycle does not take place before puberty and during pregnancy ?
3. Read the following passage and answer the questions that follow

Rahini and her parents were watching a television programme. An advertisement flashed on the screen which was promoting use of sanitary napkins. Rahini's parents suddenly changed the channel, but she objected to her parents and explained the need and importance of such advertisement.

a) What is first menstruation called? When does it occur ?

b) List out the napkin hygiene measures taken during menstruation ?

c) Do you think that Rahini's objection towards her parents was correct? If so, Why?

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2. http://www.yourarticlelibrary.com/population/3-important...control-overpopulation/26950
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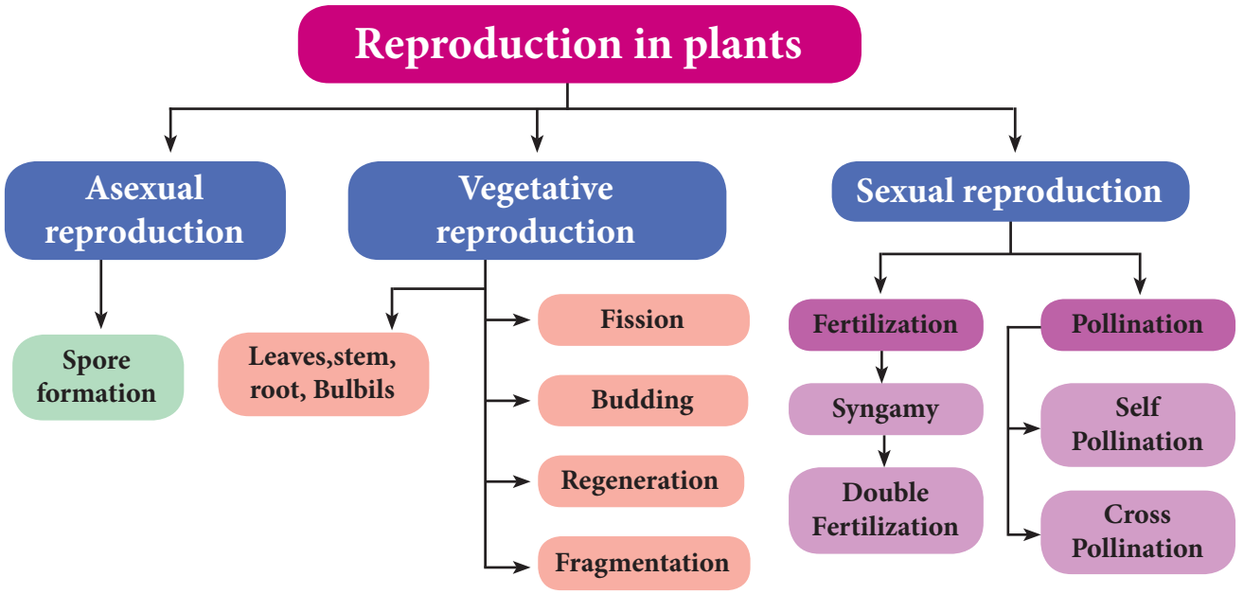
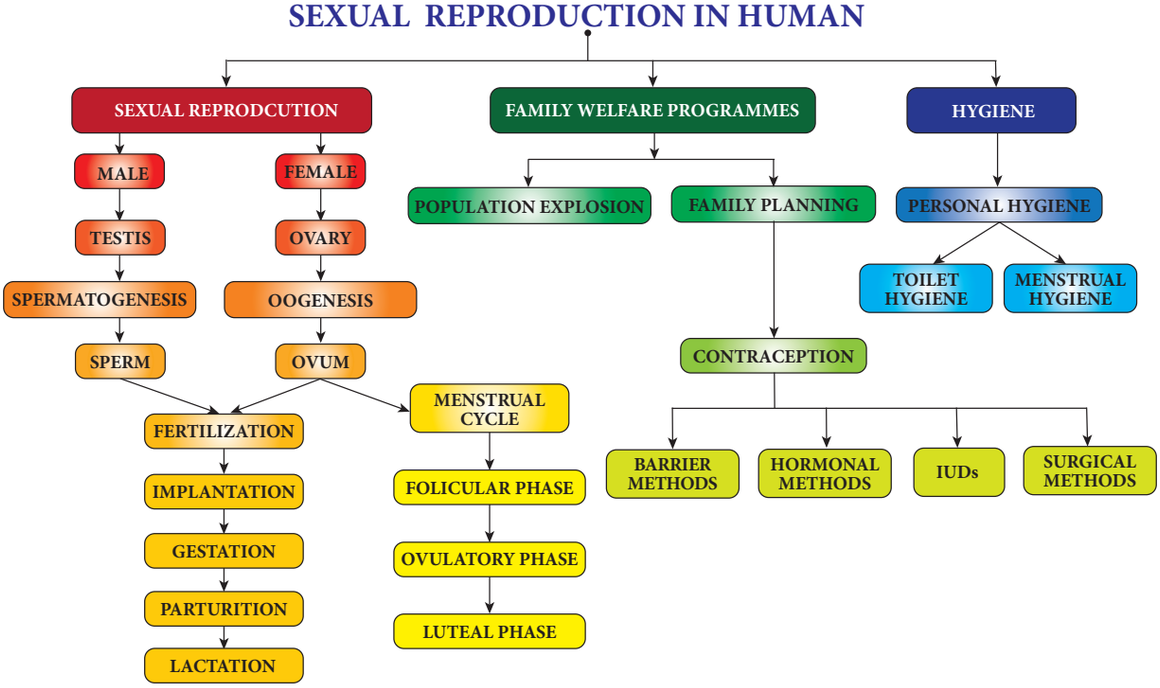
## Concept Map



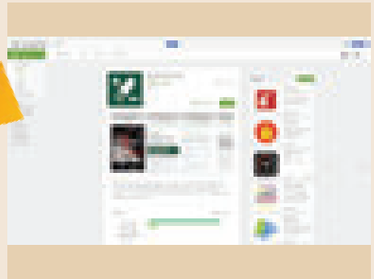
## SEXUAL REPRODUCTION IN HUMAN




## ICT CORNER

## REPRODUCTION

**WHO HTS INFO – This application enables the students to know about HIV tests and information. It was created by World Health Organization.**



### Steps

- You can see the moving Menu bar at the top of the home screen. The same thing can be accessed from the Menu at the left bottom.
- You can view the latest news and events about HIV by clicking the News button.
- It includes many updates and information in Testing strategies, Pre and Post test service.
- You can reach the home page from any page of the application by clicking HOME button.


Step1


Step2


Step3


Step4

**Cells alive**

**URL : https://play.google.com/store/apps/details?id=com.whohtsinfo**

*Pictures are indicative only

B375_10_SCIENCE_EM


## Learning Objectives

At the end of this lesson the students will be able to :

- Know about Mendelian laws.
- Differentiate between phenotype and genotype.
- Understand the process of monohybrid and dihybrid cross.
- Differentiate between a chromosome, DNA and gene.
- Understand the structure of chromosome.
- Classify the chromosomes based on the position of centromere.
- Understand the structure and replication of DNA.
- Define mutation and classify the chromosomal and gene mutation.
- Identify the chromosomal abnormality of Down's syndrome.

## Introduction

"Like Begets Like" is an important and universal phenomenon of life as the living beings produce offspring of their own kind. Colour of eye, color of hair, shape of nose, type of earlobe, etc, are inheritable traits. Have you ever wondered, how do we inherit traits and characteristics from our father and mother? Some of our characteristics might have been inherited from our grandparents. How do we inherit characters from one generation to another? It is because of the genes we inherit from our parents. These genes are responsible for the physical outlook and biological functions. The branch of biology that deals with the genes, genetic variation and heredity of living organisms is called genetics.

Heredity is transmission of characters, from one generation to the next generation, while variation refers to the differences shown by the individuals of the same species and also by the offspring of the same parents. All these can happen only due to chromosomes. Now let's see what chromosomes are and how they are composed with DNA, that form the genetic material.

## 18.1 Gregor Johann Mendel - Father of Genetics

**Mendel** (1822-1884) was an Austrian monk who discovered the basic principles of heredity through his experiments. His experiments are the foundation for modern genetics. He was born in 1822 to a family of farmers in Silesian of Czechoslovakia. After finishing his high school

at the age of 18, he entered the Augustinian Monastery at Brunn as a priest. From there he went to the University of Vienna for training in physics, mathematics and natural science. Mendel returned to the monastery in 1854 and continued to work as a priest and teach in high school. In his leisure time he started his famous experiments on the garden pea plant. He conducted his experiments in the monastery for about nine years from 1856 to 1865. He had worked on nearly 10000 pea plants of 34 different varieties. Mendel noted that they differ from one another in many ways.

Thus Mendel had chosen 7 pairs of contrasting characters for his study as shown in the table.

**Table 18.1** Constrasting characters of pea plant used by Mendel

| Characteristic studied | Dominant character | Recessive character |
|---|---|---|
| Stem length | Long | Short |
| Flower Position | Axillary | Terminal |
| Flower colour | Blue | White |
| Pod shape | Inflated | Constricted |
| Pod colour | Green | Yellow |
| Seed shape | Round | Wrinkled |
| Seed colour | Yellow | Green |

### Reasons for Mendel's success

He chose the pea plant as it was advantageous for experimental work in many aspects

1. It is naturally self-pollinating and so is very easy to raise pure breeding individuals.
2. It has a short life span as it is an annual and so it was possible to follow several generations.
3. It is easy to cross-pollinate.
4. It has deeply defined contrasting characters.
5. The flowers are bisexual.

## 18.2 Monohybrid Cross – Inheritance of One Gene

Crosses involving **inheritance of only one pair of contrasting characters** are called monohybrid crosses. For example it is a cross between two forms of a single trait like a cross between tall and dwarf plant.

### Mendel's Explanation of Monohybrid Cross

**Parental generation:** Pure breeding tall plant and a pure breeding dwarf plant.

**$F_1$ generation:** Plants raised from the seeds of pure breeding parental cross in $F_1$ generation were tall and monohybrids.

**$F_2$ generation:** Selfing of the $F_1$ monohybrids resulted in tall and dwarf plants respectively in the ratio of 3:1. The actual number of tall and dwarf plants obtained by Mendel was 787 tall and 277 dwarf. External expression of a particular trait is known as phenotype. So the phenotypic ratio is 3:1.

In the $F_2$ generation 3 different types were obtained:

Tall Homozygous – TT (Pure) – 1

Tall Heterozygous – Tt – 2

Dwarf Homozygous – tt – 1

So the **genotypic ratio 1:2:1**. A genotype is the genetic expression of an organism

### Mendel's Interpretation on Monohybrid cross

Based on these observations it was confirmed by Mendel that 'factors' are passed on from one generation to another, **now refered to as genes**. Tallness and Dwarfness are determined by a pair of contrasting factors , tall plant possess a pair of factors (represented by T- taking the first letter of the dominant character) and a plant is dwarf because it possess factors for dwarfness (represented as t- recessive character). These factors occur

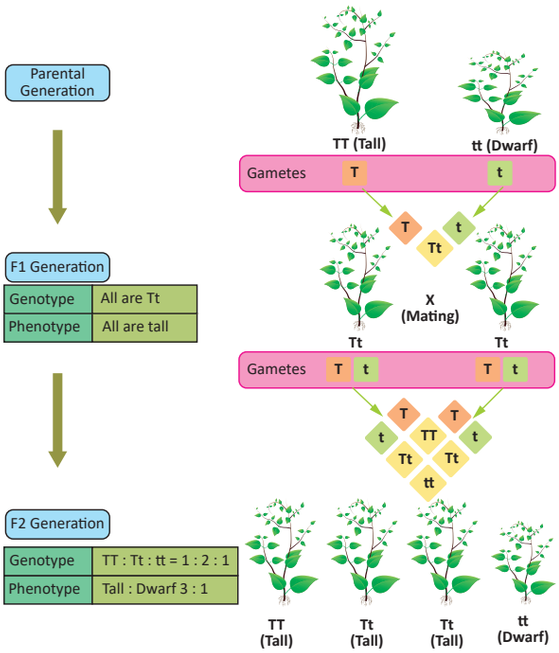



**Figure 18.1** Monohybrid cross

in pairs and may be alike as in pure breeding tall plants (TT) and dwarf plants (tt). This is referred to as **homozygous**. If they are unlike (Tt) they are referred to as **heterozygous**.

1. Two factors making up a pair of contrasting characters are called **alleles.** Phenotypic expression of alleles are called **allelomorphs**. One member of each pair is contributed by one parent.
2. When two factors for alternative expression of a trait are brought together by fertilization. The **character which expresses itself** is called **dominant (Tallness)** condition and that which is **masked** is called **recessive condition (Dwarfness)**.
3. The factors are always pure and when gametes are formed, the unit factors segregate so that each gamete gets one of the two alternative factors. It means that factors for tallness(T) and dwarfness(t) are separate entities and in a gamete either T or t is present. When $F_1$ hybrids are self crossed the two entities separate and then unite independently, forming tall and dwarf plants.

**Info bits**

Punnett square is a checker board form devised by a British geneticist R.C.Punnett for study of genetics. It is a graphical representation to calculate the probability of all possible genotypes of offsprings in a genetic cross.

## 18.3 Dihybrid Cross-Inheritance Two Genes and Law of Independent Assortment

Dihybrid cross involves the **inheritance of two pairs of contrasting characteristics** (or contrasting traits) at the same time. The two pairs of contrasting characteristics chosen by Mendel were **shape and colour of seeds: round-yellow seeds and wrinkled-green seeds**.

Mendel crossed pea plants having round-yellow seeds with pea plants having wrinkled-green seeds. Mendel made the following observations:

1. Mendel first crossed pure breeding pea plants having round-yellow seeds with pure breeding pea plants having wrinkled-green seeds and found that only round-yellow seeds were produced in the first generation ($F_1$). No wrinkled-green seeds were obtained in the $F_1$ generation. From this it was concluded that **round shape and yellow colour of the seeds were dominant traits over the wrinkled shape and green color of the seeds.**
2. When the hybrids of $F_1$ generation pea plants having round-yellow seeds were cross-bred by self pollination, then four types of seeds having different combinations of shape and color were obtained in second generation or $F_2$ generation. They were

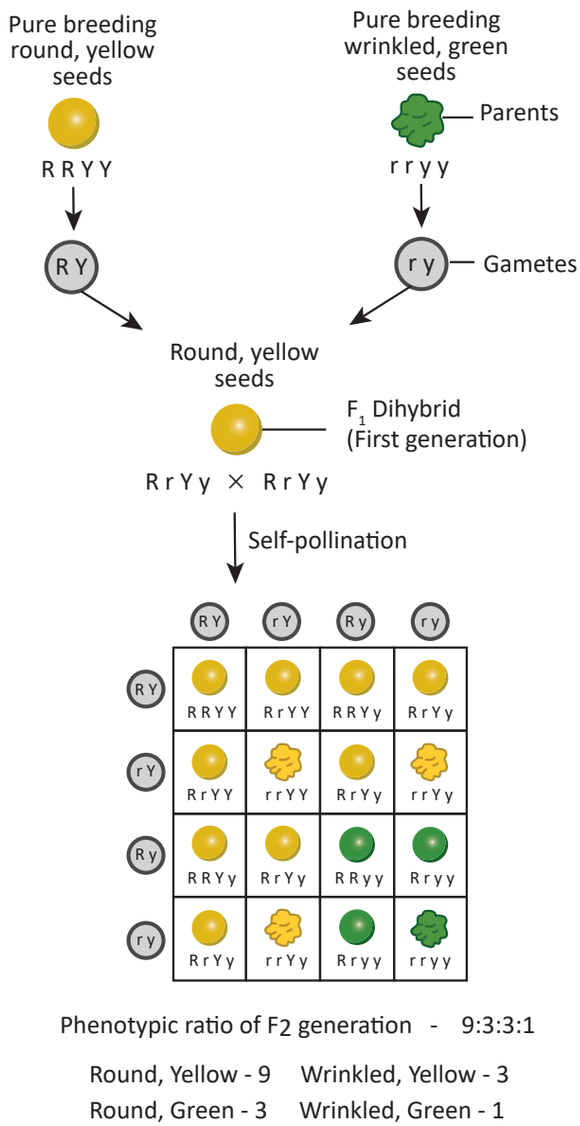



**Figure 18.2** Dihybrid Cross

**round yellow**, **round-green**, **wrinkled yellow** and wrinkled-green seeds.

The ratio of each phenotype (or appearance) of seeds in the **$F_2$ generation is 9:3:3:1**. This is known as the **Dihybrid ratio**.

From the above results it can be concluded that the factors for each character or trait remain independent and maintain their identity in the gametes. The factors are independent to each other and pass to the offsprings (through gametes).

**Results of a Dihybrid Cross:**

Mendel got the following results from his dihybrid cross

1. **Four Types of Plants:** A dihybrid cross produced four types of $F_2$ offsprings in the ratio of 9 with two dominant traits, 3 with one dominant trait and one recessive trait, 3 with another dominant trait and another recessive trait and 1 with two recessive traits.
2. **New Combination:** Two new combinations of traits with round green and wrinkled yellow had appeared in the dihybrid cross ($F_2$ generation).

## 18.4 Mendel's Laws

Based on his experiments of monohybrid and dihybrid cross, Mendel proposed three important laws which are now called as Mendel's **Laws of Heredity**.

- **Law of Dominance:**

  "When two homozygous individuals with one or more sets of contrasting characters are crossed, the characters that appear in the $F_1$ hybrid are dominant and those that do not appear in $F_1$ are recessive characters".

- **Law of Segregation or Law of purity of gametes:**

  "When a pair of contrasting factors are brought together in a $F_1$ hybrid. The two factors of the allelic pair remain together without mixing and when gametes are formed, the two separate out, so that only one enters each gamete."

- **Law of independent assortment:**

  "In case of inheritance of two or more pairs of characters simultaneously, the

factors or genes of one pair assort out independently of the other pair."

**More to Know**

T.H. Morgan was awarded Nobel Prize in 1993 for determining the role of chromosomes in heredity.

## 18.5 Chromosomes, DNA and Genes

The human body is made up of million cells. The nucleus of each cell contains thin thread like structures called **chromosomes**. The term 'chromosomes' was first coined by **Waldeyer** in 1888. The chromosomes are the carrier of genetic material which contain the heredity information.

The chromosomes are highly condensed coiled chromatin fibres packed with the **DNA** (Deoxyribonucleic acid) that forms the genetic material. **Genes** are segments of DNA, which are responsible for the inheritance of a particular phenotypic character. Each gene is present at a **specific position** on a chromosome called its **locus**. During cell division, the genetic information present in the genes are passed from one generation to another.

### 18.5.1 Structure of a Chromosome

The chromosomes are thin, long and thread like structures consisting of two identical strands called sister chromatids. They are held together by the centromere. Each **chromatid** is made up of spirally coiled thin structure called **chromonema.** The chromonema has number of bead-like structures along its length which are called **chromomeres.** The chromosomes are made up of DNA,RNA, chromosomal proteins (histones and non-histones) and certain metallic ions. These proteins provide structural support to the chromosome .

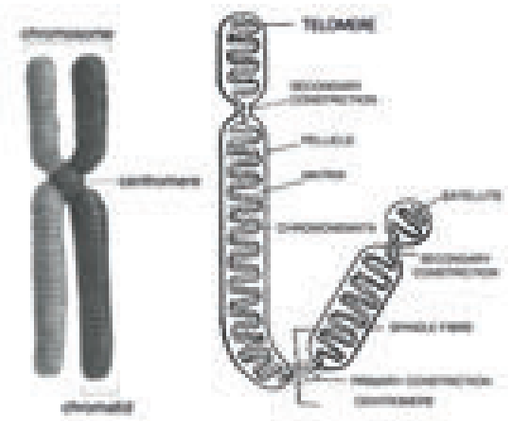


**Figure 18.3** Structure of chromosome

A chromosome consists of the following regions

**Primary constriction:** The two arms of a chromosome meet at a point called **primary constriction** or **centromere**. The centromere is the region where spindle fibres attach to the chromosomes during cell division.

**Secondary constriction:** Some chromosomes possess secondary constriction **at any point** of the chromosome. They are known as the nuclear zone or **nucleolar organizer** (formation of nucleolus in the nucleus).

**Telomere:** The **end of the chromosome** is called telomere. Each extremity of the chromosome has a polarity and prevents it from joining the adjacent chromosome. It maintains and provides **stability to the chromosomes.**

**Satellite:** Some of the chromosomes have an elongated **knob-like appendage** at one end of the chromosome known as satellite. The chromosomes with satellites are called as the **sat-chromosomes**.

DO YOU KNOW?

**Telomeres act as aging clock in every cell.**

Telomeres are protective sequences of nucleotides found in chromosomes. As a cell divides every time, they become shorter. Telomeres get too short to do their job, causing our cells to age.

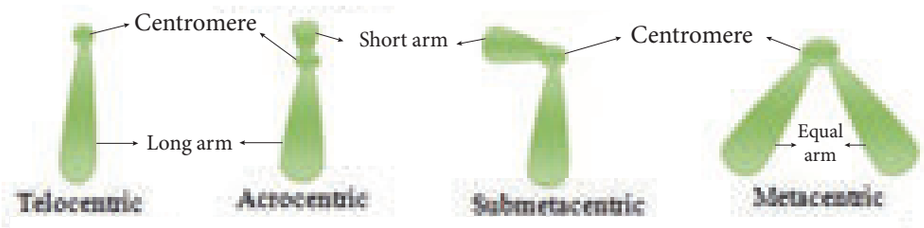



**Figure 18.4** Types of chromosomes based on position of centromere

### 18.5.2 Types of Chromosomes based on the position of Centromere

Based on the position of centromere, the chromosomes are classified as **Telocentric**, **Acrocentric, Submetacentric** and **Metacentric**

1. **Telocentric**– The centromere is found on the proximal end. They are rod shaped chromosomes.
2. **Acrocentric** – The centromere is found at the one end with a short arm and a long arm. They are also rod-shaped chromosomes.
3. **Submetacentric** – The centromere is found near the centre of the chromosome. Thus forming two unequal arms. They are J shaped or L shaped chromosomes.
4. **Metacentric** – The centromere occurs in the centre of the chromosome and form two equal arms. They are V shaped chromosomes

### 18.5.3 Types of Chromosomes based on function

The eukaryotic chromosomes are classified into **autosomes** and **allosomes.**

Autosomes contain genes that determine the somatic (body) characters**.** Male and female have equal number of autosomes**.**

Allosomes are chromosomes which are responsible for determining the sex of an individual. They are also called as **sex chromosomes** or **hetero-chromosomes**. There are two types of sex chromosomes, X and Y- chromosomes. Human male have one X chromosome and one Y chromosome and human female have two X chromosomes.

### 18.5.4 Karyotype

The number of chromosomes in any living organism (animal or plant) is constant. In human, each cell normally contains **23 pairs** of chromosomes. Out of which 22 pairs are autosomes and the 23rd pair is the allosome or sex chromosome.

In the body cells of sexually reproducing organisms, the chromosomes generally occur in pairs. This condition is called **diploid (2n)**. The gametes produced by the organisms contain a single set of chromosomes. Hence, the gametes are said to be **haploid (n).**

Karyotype is the **number, size and shape of chromosomes** in the cell nucleus of an organism. **Idiogram** is the diagrammatic representation of karyotype of a species. It consists of all the metaphasic chromosomes arranged in homologous pairs according to decreasing length, thickness, position of centromere, shape etc., with the sex chromosomes placed at the end.

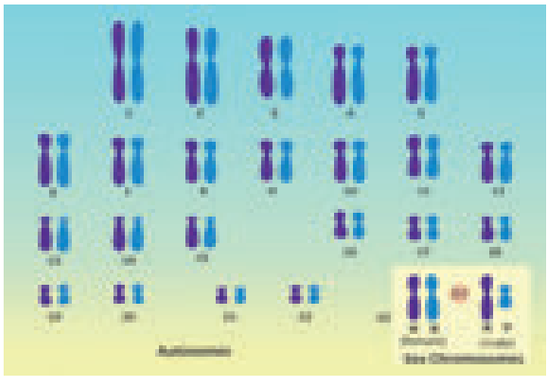


**Figure 18.5** Normal human karyotype

## 18.6 Structure of DNA

DNA is the hereditary material as it contains the genetic information. It is the most important constituent of a chromosome. The most widely

accepted model of DNA is the double helical structure of **James Watson** and **Francis Crick**. They proposed the **three-dimensional model of DNA** on the basis of X-ray diffraction studies of DNA obtained by Rosalind Franklin and Maurice Wilkins. In appreciation of their discoveries on the molecular structure of nucleic acids Watson, Crick and Wilkins were awarded Nobel prize for Medicine in 1962.

QXW5PI

**Chemical Composition of DNA molecule**

DNA is a large molecule consisting of millions of nucleotides. Hence, it is also called a **polynucleotide**. Each nucleotide consists of three components.

1. A sugar molecules – Deoxyribose sugar.
2. A nitrogenous base.
   There are two types of nitrogenous bases in DNA. They are
   (a) Purines (Adenine and Guanine)
   (b) Pyrimidines (Cytosine and Thymine)
3. A phosphate group

**Nucleoside and Nucleotide**

Nucleoside = Nitrogen base + Sugar

Nucleotide = Nucleoside + Phosphate

The nucleotides are formed according to the purines and pyrimidines present in them.

## 18.6.1 Watson and Crick model of DNA

1. DNA molecule consists of two **polynucleotide** chains.
2. These chains form a **double helix** structure with two strands which run **anti-parallel** to one another.
3. **Nitrogenous bases** in the centre are linked to **sugar-phosphate** units which form the backbone of the DNA.
4. Pairing between the nitrogenous bases is very specific and is always between purine and pyrimidine linked by hydrogen bonds.
   * Adenine (A) links Thymine (T) with two hydrogen bonds (A = T)
   * Cytosine (C) links Guanine (G) with three hydrogen bonds( C ≡ G)

This is called **complementary base pairing**.

**Figure 18.6** Structure of DNA

5. Hydrogen bonds between the nitrogenous bases make the DNA molecule stable.
6. Each turn of the double helix is 34 A° (3.4 nm). There are ten base pairs in a complete turn.
7. The nucleotides in a helix are joined together by phosphodiester bonds.

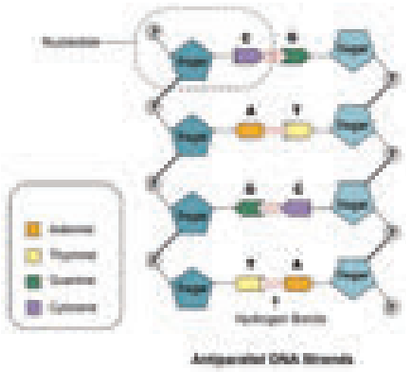


**Figure 18.7** Nucleotides in a DNA

**More to Know**

**Chargaff rule of DNA base pairing**

**Erwin Chargaff** states that in DNA, the proportion of adenine is always equal to that of thymine. and the proportion of guanine always equal to that of cytosine.

## 18.6.2 DNA Replication

DNA replication is one of the basic process that occurs within a cell. DNA molecule produces exact copies of its own structure during replication process. The two strands of a DNA molecule have complementary base pairs, the nucleotides of each strand provide the information needed to produce its new strand. The two resulting daughter cells contain exactly the same genetic information as the parent cell. DNA replication involves the following steps

**Origin of replication**

The specific points on the DNA, where the replication begins, is the **site of origin** of replication. The two strands open and separate at this point forming the **replication fork**.

**Unwinding of DNA molecule**

The enzyme called **helicase**, bind to the origin of replication site. Helicase separates the two strands of the DNA. The enzyme called **topoisomerase** separates the double helix above the replication fork and removes the twists formed during the unwinding process. Each of the separated DNA strands function as a template.

**Formation of RNA primer**

An RNA primer is a short segment of RNA nucleotides. The primer is synthesized by the DNA template close to the origin of replication site.

**Synthesis of new complementary strand from the parent strand**

After the formation of RNA primer, nucleotides are added with the help of an enzyme **DNA polymerase** and a new complementary strand of DNA is formed from each of the parent strand. The synthesis is unidirectional.

In one strand, the daughter strand is synthesized as a continuous strand which is called **leading strand.** In the other strand, short segments of DNA are synthesized. This strand is called **lagging strand.** The short segments of DNA are called **Okazaki fragments**. The fragments are joined together by the enzyme, **DNA ligase**.

The replication stops when the replication fork of the two sides meet at a site called **terminus**, which is situated opposite to origin of replication site

## 18.6.3 Significance of DNA

- It is responsible for the transmission of hereditary information from one generation to next generation.

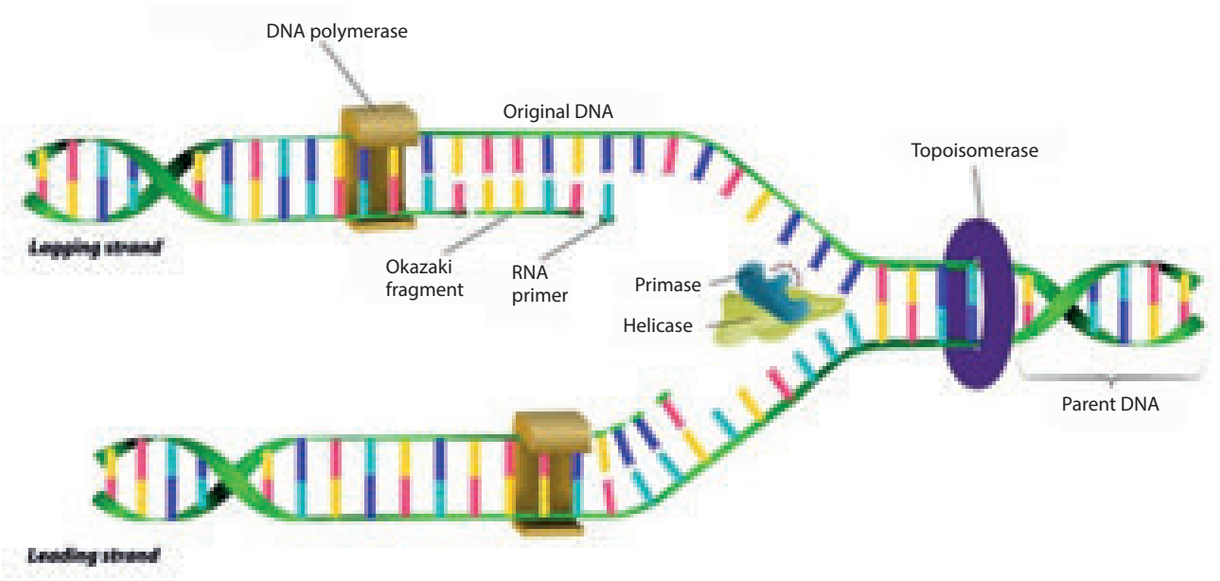



**Figure 18.8** Replication of DNA

- It contains information required for the formation of proteins.
- It controls the developmental process and life activities of an organism.

## 18.7 Sex Determination

The formation of zygote into male or female sex during development is called sex determination. Sex is determined by the chromosomes of an individual.

### 18.7.1 Sex Determination in Human

Recall that human beings have 23 pairs of chromosomes out of which 22 pairs are autosomes and one pair (23rd pair) is the sex chromosome. The female gametes or the eggs formed are similar in their chromosome type (22+XX). Therefore, human females are **homogametic**.

The male gametes or sperms produced are of two types. They are produced in equal proportions. The sperm bearing **(22+X)** chromosomes and the sperm bearing **(22+Y)** chromosomes. The human males are called **heterogametic.**

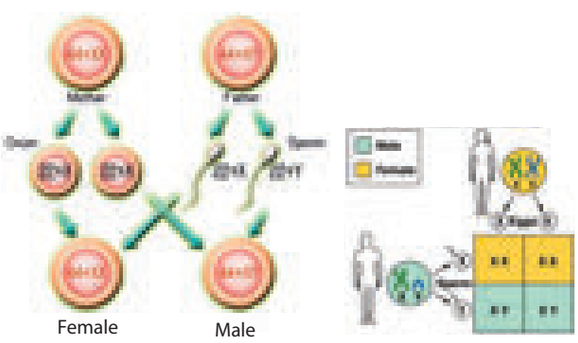



**Figure 18.9** Sex determination in human

It is a chance of probability as to which category of sperm fuses with the egg. If the egg (X) is fused by the X-bearing sperm an **XX individual (female)** is produced. If the egg (X) is fused by the Y-bearing sperm an **XY individual (male)** is produced. The sperm, produced by the father, determines the sex of the child. The mother is not responsible in determining the sex of the child.

Now let's see how the chromosomes take part in this formation. Fertilization of the egg (22+X) with a sperm (22+X) will produce a female child (44+XX). while fertilization of the egg (22+X) with a sperm (22+Y) will give rise to a male child (44+XY).

### 18.7.2 Mutation

The term mutation was introduced by **Hugo De Vries** in 1901 when he observed phenotypic changes in the evening primrose plant, *Oenothera lamarckiana*. Mutation is an inheritable sudden change in the genetic material (DNA) of an organism. Mutations are classified into two main types, namely chromosomal mutation and gene mutation.

1. **Chromosomal mutation**

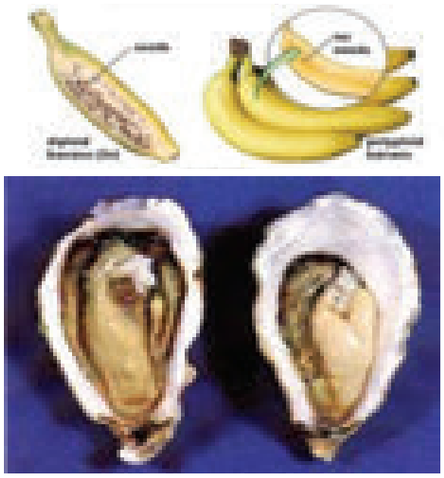
The **sudden change** in the **structure** or **number of chromosomes** is called chromosomal mutation. This may result in

**(i) Changes in the structure of chromosomes:** Structural changes in the chromosomes usually occurs due to errors in cell division. Changes in the number and arrangement of genes takes place as a result of deletion, duplication, inversion and translocation in chromosomes.

**(ii) Changes in the number of chromosomes:** They involve addition or deletion in the number of chromosomes present in a cell. This is called **ploidy**. There are two types of ploidy

(a) Euploidy (b) Aneuploidy.

**Euploidy:** It is the condition in which the individual bears **more than the usual number** of diploid (2n) chromosomes. If an individual has three haploid sets of chromosomes, the condition is called **triploidy** (3n). Triploid plants and animals are typically sterile.If it has four haploid sets of chromosomes, the condition is called **tetraploidy** (4n). Tetraploid plants are advantageous as they often result in increased fruit and flower size.



Triploid Oyster Diploid Oyster

**Figure 18.10** Euploidy

**Aneuploidy:** It is the **loss** or **gain** of **one** or **more chromosomes** in a set. It is of three types. **Monosomy** (2n-1), **Trisomy** (2n+1)and **Nullisomy** (2n-2). In man, Down's syndrome is one of the commonly known aneuploid condition.

**Down's syndrome**

This condition was first identified by a doctor named **Langdon Down** in1866.

It is a genetic condition in which there is an extra copy of **chromosome 21 (Trisomy 21)**. It is associated with mental retardation, delayed development, behavioural problems, weak muscle tone, vision and hearing disability are some of the conditions seen in these children.

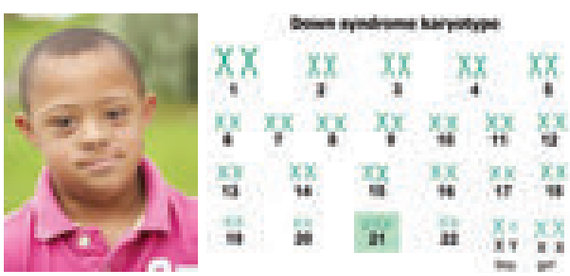


**Figure 18.11** Aneuploidy

**2. Gene or point mutation**

Gene mutation is the **changes** occurring in **nucleotide sequence of a gene**. It involves substitution, deletion, insertion or inversion of a single or more than one nitrogenous base. Gene alteration results in abnormal protein formation in an organism.

DO YOU KNOW?

**Sickle cell anaemia** is caused by the mutation of a single gene. Alteration in the gene brings a change in the structure of the protein part of haemoglobin molecule. Due to the change in the protein molecule, the red blood cell (RBC) that carries the haemoglobin is sickle shaped.

## Points to Remember

- Variations are quite apparent among closely related groups of organisms.
- Mendel had choosen seven pairs of distinguishing traits: flower colour, position, seed colour, shape, pod colour, pod shape, stem length.
- Every pea plant has two 'factors' which are responsible for producing a particular character or trait is called allele.
- The process of acquiring characters or traits from parents is called 'Heredity'.
- Each human cell contains 23 pairs of chromosomes. Out of these 22 pairs are called autosomes and one pair is called allosomes.
- A chromosome consists of the regions: primary constriction, centromere, secondary constriction, telomere and satellite.
- Based on the position of the centromere, the chromosomes are classified as telocentric, acrocentric, sub metacentric and metacentric chromosomes.
- Each nucleotide of DNA consists of a deoxyribose sugar, a nitrogenous base and a phosphate group. Pairing is always between a purine and a pyrimidine.
- The sperm, produced by the father, determines the sex of the child. The mother is not responsible in determining the sex of the child.
- Mutation is an inheritable change in the genetic material of an organism.

## TEXTBOOK EVALUATION

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### I. Choose the correct answer

1. According to Mendel alleles have the following character
   a) Pair of genes
   b) Responsible for character
   c) Production of gametes
   d) Recessive factors

2. 9 : 3 : 3 : 1 ratio is due to
   a) Segregation b) Crossing over
   c) Independent assortment d) Recessiveness

3. The region of the chromosome where the spindle fibres get attached during cell division
   a) Chromomere b) Centrosome
   c) Centromere d) Chromonema

4. The centromere is found at the centre of the _____ chromosome.
   a) Telocentric b) Metacentric
   c) Sub-metacentric d) Acrocentric

5. The _____ units form the backbone of the DNA.
   a) 5 carbon sugar b) Phosphate
   c) Nitrogenous bases d) Sugar phosphate

6. Okasaki fragments are joined together by _____.
   a) Helicase b) DNA polymerase
   c) RNA primer d) DNA ligase

7. The number of chromosomes found in human beings are _____.
   a) 22 pairs of autosomes and 1 pair of allosomes.
   b) 22 autosomes and 1 allosome
   c) 46 autosomes
   d) 46 pairs autosomes and 1 pair of allosomes.

8. The loss of one or more chromosome in a ploidy is called _____.
   a) Tetraploidy b) Aneuploidy
   c) Euploidy d) polyploidy

### II. Fill in the blanks

1. The pairs of contrasting character (traits) of Mendel are called _____.
2. Physical expression of a gene is called _____
3. The thin thread like structures found in the nucleus of each cell are called _____.
4. DNA consists of two _____ chains
5. An inheritable change in the amount or the structure of a gene or a chromosome is called _____.

### III. Identify whether the statement are True or False. Correct the false statement

1. A typical Mendelian dihybrid ratio of $F_2$ generation is 3:1.
2. A recessive factor is altered by the presence of a dominant factor.
3. Each gamete has only one allele of a gene.
4. Hybrid is an offspring from a cross between genetically different parent.
5. Some of the chromosomes have an elongated knob-like appendages known as telomere.
6. New nucleotides are added and new complementary strand of DNA is formed with the help of enzyme DNA polymerase.
7. Down's syndrome is the genetic condition with 45 chromosomes.

## IV. Match the following

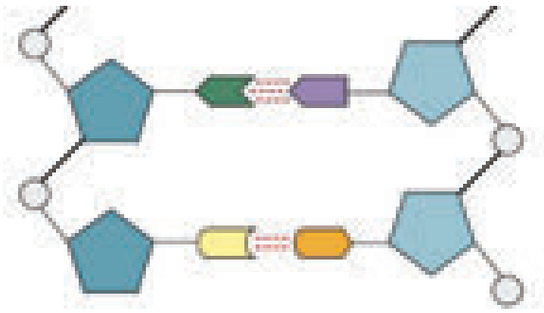
1. Autosomes - Trisomy 21
2. Diploid condition - 9:3:3:1
3. Allosome - 22 pair of chromosome
4. Down's syndrome - 2n
5. Dihybrid ratio - 23rd pair of chromosome

## V. Answer in a sentence

1. What is a cross in which inheritance of two pairs of contrasting characters are studied?
2. Name the conditions when both the alleles are identical?
3. A garden pea plant produces axial white flowers. Another of the same species produced terminal violet flowers. Identify the dominant trait?
4. What is the name given to the segments of DNA, which are responsible for the inheritance of a particular character?
5. Name the bond which binds the nucleotides in a DNA.

## VI. Short answers questions

1. Why did Mendel select pea plant for his experiments?
2. What do you understand by the term phenotype and genotype?
3. What are allosomes?
4. What are Okazaki fragments?
5. Why is euploidy considered to be advantageous to both plants and animals?
6. A pure tall plant (TT) is crossed with pure dwarf plant (tt), what would be the $F_1$ and $F_2$ generations? Explain.
7. Explain the structure of a chromosome.
8. Label the parts of the DNA in the diagram given below. Explain the structure briefly.



## VII. Long answer questions

1. Explain with an example the inheritance of dihybrid cross. How is it different from monohybrid cross?
2. How is the structure of DNA organised? What is the biological significance of DNA?
3. The sex of the new born child is a matter of chance and neither of the parents may be considered responsible for it. What would be the possible fusion of gametes to determine the sex of the child?

## VIII. Higher Order Thinking Skills (HOTS)

1. Flowers of the garden pea are bisexual and self-pollinated. Therefore, it is difficult to perform hybridization experiment by crossing a particular pistil with the specific pollen grains. How Mendel made it possible in his monohybrid and dihybrid crosses?
2. Pure-bred tall pea plants are first crossed with pure-bred dwarf pea plants. The pea plants obtained in $F_1$ generation are then selfed to produce $F_2$ generation of pea plants.
   a. What do the plants of $F_1$ generation look like?
   b. What is the ratio of tall plants to dwarf plants in $F_2$ generation?
   c. Which type of plants were missing in $F_1$ generation but reappeared in $F_2$ generation?

3. Kavitha gave birth to a female baby. Her family members say that she can give birth to only female babies because of her family history. Is the statement given by her family members true. Justify your answer.

## IX. Value based question

1. Under which conditions does the law of independent assortment hold good and why?

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2. P.S. Verma and V.K. Agarwal, Genetics, S. Chand and Company, New Delhi
3. Gerald Karp, Janet Iwasa and Wallace Marshall, Cell and Molecular Biology - Concepts and Experiment, 8th Edition, Wiley and Sons Publishers


## INTERNET RESOURCES

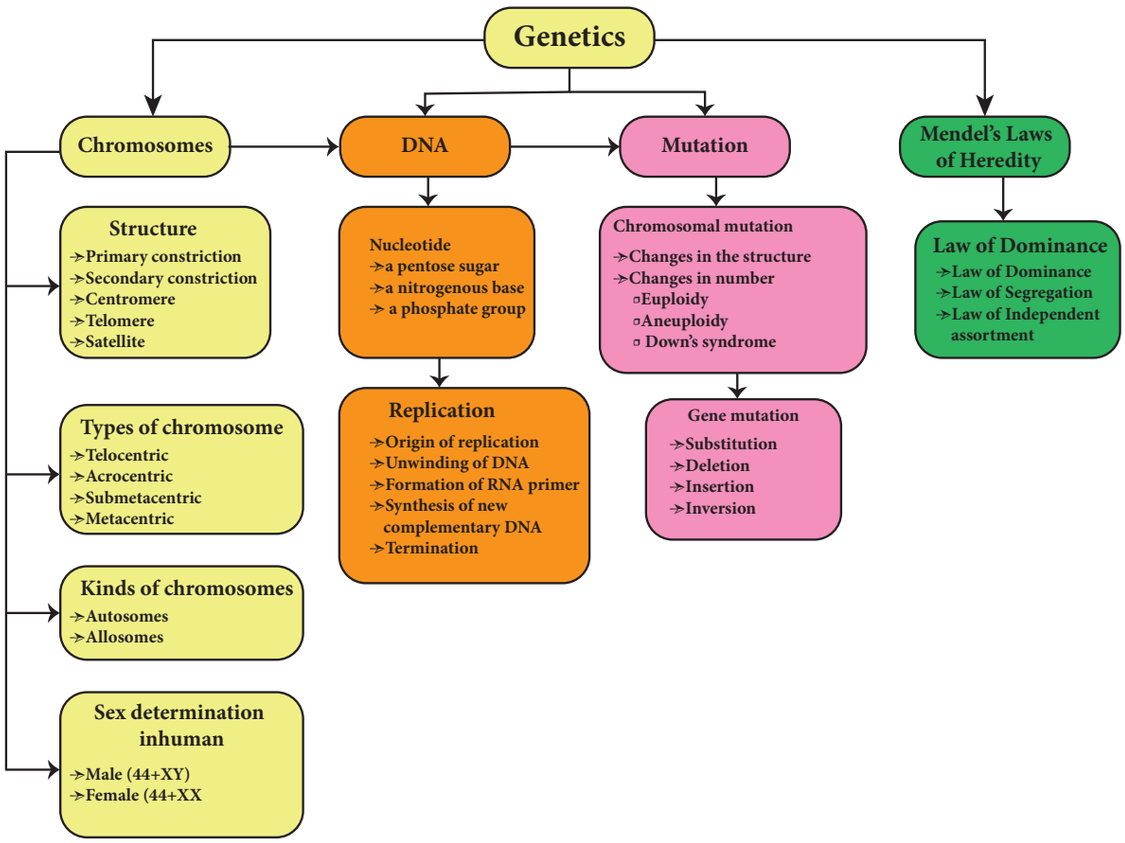
https://www.genome.gov

https://www. genetics.edu.au

https://www.bioexplorer.net/chromosomal-mutation.html/

https://www.ndss.org/about-down-syndrome/down-syndrome/

# Concept Map




## Learning Objectives

RSNYQI

At the end of this lesson the students will be able to:

- Know about Big Bang theory on the origin of universe.
- Understand theories of origin of life.
- Discuss the process of evolution on the basis of the available evidences.
- Relate the principles of Lamarck and Darwin with evolution.
- Know how variation occurs and its significance.
- List the importance of fossils and describe the process of fossilization.
- Identify the plants of ethnobotanical importance.
- Realize about extraterrestrial life.

## Introduction

Living organisms possess distinct characteristics, display organisational and functional unity, entail a mechanism of origin and evolution of diversities and maintain a balanced relationship with nature. Most aspects of evolution indicate that the knowledge of the past has become essential for fully understanding the present. Life since its beginning on earth had changed through time. The history of life comprises of two aspects, one is the origin of life on earth and the other is mechanism involved in the gradual changes and adaptations of living organisms through time which is known as the evolution of life.

**Origin of Earth:** Origin of life is linked with the origin of earth. The **Big Bang theory** explains the **Origin of Universe**. It proposes that the universe had an explosive beginning (Big Bang) and originated 15 billion years ago. The universe comprised of stars, clouds of gas and dust which form the galaxies. The solar system was probably created when the gaseous clouds started to collapse due to the force of its own gravity forming atoms and particles. Atoms, dust grains and gaseous disc aggregated to form clumps and gave rise to planets. This forms the solar system of the milky way galaxy. Earth was supposed to have been formed about 4.5 billion years back. Life appeared 500 million years after the formation of earth.

## 19.1 Theories on Origin of Life

Many theories have been postulated to explain the origin of life. The views on the origin of life has been putforth as

**Special creation:** This idea embodies that life on Earth is a divine creation and also

attributes to **supernatural event** at a particular time in the past.It also emphasizes that life has not changed ever since its origin.

**Spontaneous generation (Abiogenesis):** According to this theory **life originated** spontaneously from **lifeless matter**. It was believed that fishes originated from mud, frogs from moist soil and insects from decaying matter.

**Biogenesis:** It was speculated by **Louis Pasteur** (1862) that **life originates from pre-existing life**. He showed that pre-sterilised flasks kept closed airtight, with killed yeast, did not give rise to any life form, while in another flask kept open to air living organisms arose from killed yeast.

**Extraterresterial or Cosmic origin:** Some scientists still believe that life came from outer space. This states that units of life called **spores** (**Panspermia**) were transferred to different planets including earth. This is still an idea of some astronomers.

**Chemical Evolution of Life:** This idea was developed by **Oparin (1922)** and **Haldane (1929).** They proposed that with the conditions prevailing on earth, life arose by a series of sequential **chemical reactions**. The first form of life could have come from pre-existing **non-living inorganic molecules** which gave rise to formation of **diverse organic molecules** which are transformed into **colloid system** to produce life. The modern concept on chemical evolution regarding origin of life was accepted.

## 19.2 Evidences of Evolution

Evolution can be better understood only by observing the interrelationship between the existing organisms and also relating the similarities with the extinct organisms. The inter relationship of the organisms is also supported by evidences from different branches of biology. These evidences support the concept that all organisms have evolved from common ancestors.

### 19.2.1 Evidences from Morphology and Anatomy

The comparative study of morphology and anatomy of animals, reveal that they possess common set of characteristics.

i. **Homologous organs:** The homologous organs are those which have inherited from common ancestors with similar developmental pattern in embryos. The fore limbs of mammals are homologous structures. A human hand, a front leg of a cat, flipper of a whale and a bat's wing **look dissimilar and adapted for different functions**. Their mode of development and basic structure of bone are similar.

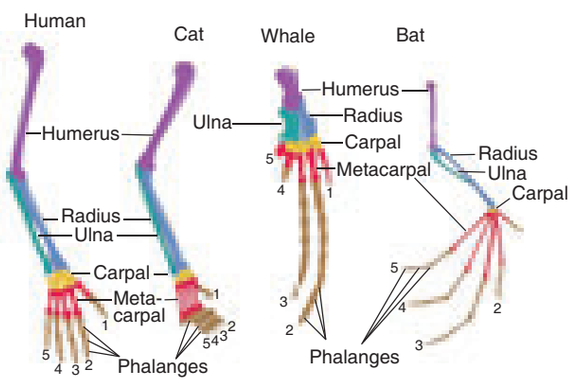



**Figure 19.1** Forelimbs of vertebrates showing homologous structure

ii. **Analogous organs:** The analogous organs **look similar** and **perform similar functions** but they have different origin

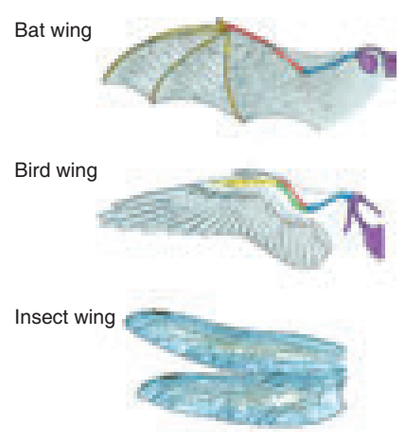



**Figure 19.2** Analogous structure showing a bat wing, a bird wing and an insect wing

and developmental pattern. The function of the wings of a bat, the wings of a bird and wings of an insect are similar, but their basic structures are different.

iii. **Vestigial organs:** The **degenerated** and **non-functional organs** of animals are called vestigial organs. The same organs are found to be well-developed and functional, in some of the related forms. Some of the vestigial organs in man are vermiform appendix, nictitating membrane, caudal vertebra, coccyx etc.

iv. **Atavism:** The **reappearance of ancestral characters** in some individuals is called atavism. e.g. Presence of rudimentary tail in new born babies, presence of thick hair on the human body.

### 19.2.2 Evidences from Embryology

The study of comparative embryology of different animals, supports the concept of evolution. The embryos from fish to mammals are similar in their early stages of development. The differentiation of their special characters appear in the later stages of development.

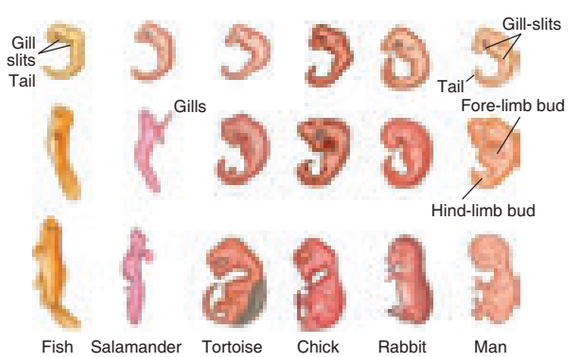



**Figure 19.3** Embryonic development of vertebrates

**Biogenetic law** or **Recapitulation theory** was given by **Ernst Haeckel**. According to this theory, **Ontogeny recapitulates Phylogeny**. The stages of development of the individual animal repeats the evolutionary history of the entire race of the animal.

### 19.2.2 Evidences from Palaeontology

Palaeontology deals with the **study of fossils**. **Leonardo da Vinci** is called the **Father of Palaeontology**. The study of fossils helps us to understand the line of evolution of many invertebrates and vertebrates. Fossil records show that the evolution has taken a gradual process from simple to complex organisms. The origin of modern birds is supported by the evidences from palaeontology.

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**Archaeopteryx**: Archaeopteryx is the oldest known **fossil bird**. It was an early bird-like form found in the Jurassic period.It is considered to be a **connecting link** between reptiles and birds. It had wings with feathers, like a bird. It had long tail, clawed digits and conical teeth, like a reptile.

**Figure 19.4** Archaeopteryx - Fossil bird

## 19.3 Theories of Evolution

Life had evolved along with evolution of earth towards the end of 18th century. **Evolution** is the **gradual change** occurring in living organisms over a period of time. Formation of new species due to changes in specific characters over several generations as response to natural selection, is called evolution. The natural changes occuring is explained through the theories of evolution as proposed by Lamarck and Darwin.

### 19.3.1 Lamarckism

Jean Baptiste Lamarck (1744-1829) was a French naturalist, well known for his theory of evolution. Lamarck's theory of evolution was published in '**Philosophic Zoologique'** in the year 1809. It is popularly known as '**Theory of inheritance of Acquired Characters**" or "**Use and Disuse theory**" or **Lamarckism**.

**Principles of Lamarckism**

i. **Internal vital force**
Living organisms or their component parts tend to increase in size continuously. This increase in size is due to the inherent ability of the organisms.

ii. **Environment and new needs**
A change in the environment brings about changes in the need of the organisms. In response to the changing environment, the organisms develop certain adaptive characters. The adaptations of the organisms may be in the form of development of new parts of the body.

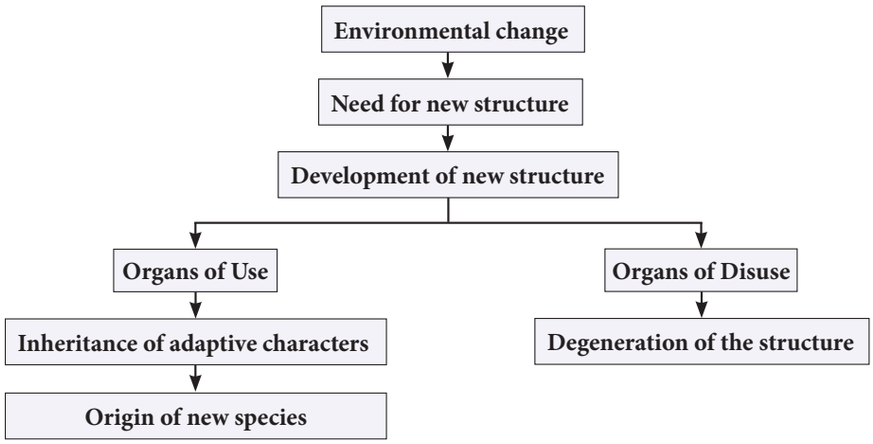
iii. **Use and disuse theory**
Lamarck's **use and disuse theory** states that if an organ is used constantly, the organ develops well and gets strengthened. When an organ is not used for a long time, it gradually degenerates.

The ancestors of giraffe were provided with short neck and short forelimbs. Due to shortage of grass, they were forced to feed on leaves from trees. The continuous stretching of their neck and forelimbs resulted in the development of long neck and long forelimbs which is an example for constant use of an organ. The degenerated wing of Kiwi is an example for organ of disuse.

iv. **Theory of Inheritance of acquired characters**
When there is a change in the environment, the animals respond to the change. They develop adaptive structures. The characters developed by the animals during their life time, in response to the environmental changes are called **acquired characters**. According to Lamarck, the acquired characters are transmitted to the offspring by the process of inheritance.

### 19.3.2 Darwinism or Theory of Natural Selection

**Charles Darwin** (1809-1882) was one of the great naturalist and philosopher of 18th century. He was born in England in 1809. While studying in college through his friendship with Professor J.S.Henslow he was fascinated towards nature. At that time the British Admiralty planned a **voyage of exploration** for 5 years on a ship named **H.M.S. Beagle** around **South America**. Dr Henslow was asked to nominate a young naturalist for the voyage. Darwin was given the opportunity. During his five years (1831–1835) voyage he visited many parts of




**Flow chart showing the postulates of Lamarckism**

the world, a number of islands including the **Galapagos island** and **Pacific island**. Darwin made elaborate observations on nature of the land, plants and animals of the regions he visited. He further worked for a period of 20 years to develop the theory of natural selection.

Darwin published his observations and conclusions under the name '**Origin of species**' in **1859**. The book of Darwin demonstrates the fact of evolution. It elaborates on the **theory of Natural selection** for evolutionary transformation,

**Principles of Darwinism**

**i. Overproduction**

Living beings have the ability to reproduce more individuals and form their own progeny. They have the capacity to multiply in a geometrical manner. This will increase reproductive potential leading to overproduction.

**ii. Struggle for existence**

Due to over production, a geometric ratio of increase in population occurs. The space to live and food available for the organisms remain the same. This creates an intense competition among the organisms for food and space leading to struggle. The struggle for existence are of three types:

a. **Intraspecific struggle:** Competition among the individuals of same species.

b. **Interspecific struggle:** Competition between the organisms of different species living together.

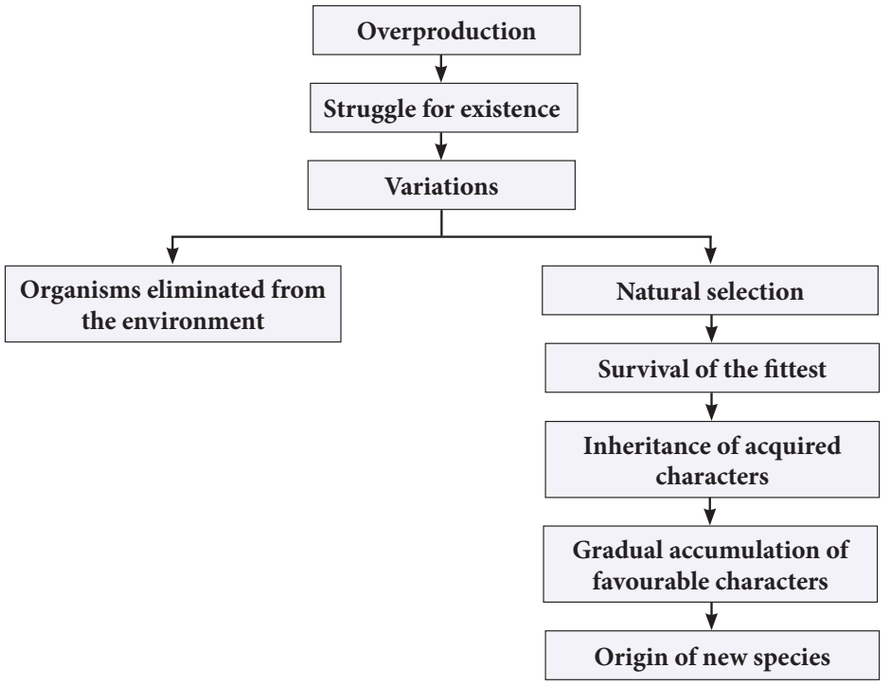
c. **Environmental struggle:** Natural conditions like extreme heat or cold, drought and floods can affect the existence of organisms

**iii. Variations**

The occurrence of variation is a characteristic feature of all plants and animals. **Small variations** are important for evolution. According to Darwin **favourable variations** are useful to the organism and **unfavourable variations** are harmful or useless to the organism.

**iv. Survival of the fittest or Natural selection**

During the struggle for existence, the organisms which can overcome the challenging situation, **survive** and **adapt** to




**Flowchart showing the postulates of Darwinism**

the surrounding environment. Organisms which are unable to face the challenges, are unfit to survive and disappear. The process of selection of organisms with favourable variation is called as natural selection.

v. **Origin of species**
According to Darwin, **new species originates by the gradual accumulation of favourable variations** for a number of generations.

## 19.4 Variation

Sexual reproduction, which involves meiosis helps in **recombination of genes** during gametic fusion. This leads to differences in the phenotype of the offspring from its parents. These differences are called variation.

Variation is the difference found among individuals of the same species and the offspring of the same parent. **Variation** is the **raw material** which plays an important **role in evolution**. Evolution would not be possible without variation.

### Types of variations

**Somatic variation:** These are the variations which affect the body (somatic) cells of the organisms. They are **not heritable**. They occur due to environmental factors.

**Germinal variation:** These variations are produced in germ cells of an organism. They are **inherited**. They may be present in ancestors or may occur suddenly. They are classified into two types:

1. Continuous variation
2. Discontinuous variation

**Continuous variation:** These are small variations which occur among individuals of a population. They are also called as **fluctuating variations**. They occur by **gradual accumulation** in a population. e.g. skin colour, height and weight of an individual, colour of eye, etc.

**Discontinuous variation:** These are **sudden changes** which occur in an organism due to mutations. They do not have any intermediate forms. These large variations are not useful for evolution. e.g. short legged Ancon sheep, six or more digits (fingers) in human, etc.

Discontinuous variation form the basis for **Mutation theory** proposed by **De Vries**.

**Relationship between Mutation and Variation**

**Mutation and Variation** are two events involved in the process of evolution. Mutation arises due to errors occurring in DNA during replication or exposure to UV rays or chemicals. Mutation leads to variation. It brings about changes in a single individual.

## 19.5 Paleobotany

Paleobotany is derived from Greek words *paleon* that means "old" and *botany* the study of plants. It is the branch of paleontology that deals with **recovery and identification of plant remains of geological past**.

A plant fossil is any preserved part of a plant that has died long back. Fossils may be a prehistoric impression that may be hundred to millions of years old. Majority of the plant fossils are disarticulated parts of plants, it is rare to find plants to be preserved as whole.

### Importance of fossils

i They throw light on phylogeny and evolution of plants.
ii Fossil plants give a historical approach to plant kingdom.
iii Fossils are useful in classification of plants.
iv. Fossil plants can be used in the field of descriptive and comparative anatomy.

**Kaspar Maria Von Sternberg**

He is the "**Father of Paleobotany**" (1761–1838) was born in Europe. He established the Bohemian National Museum in Prague and is deemed to be the founder of Modern Paleobotany.

**Birbal Sahani**

He is the "**Father of Indian Paleobotany**" (1891–1949). He presented his research on two different areas of Paleobotany (i) The anatomy and morphology of Paleozoic Ferns (ii) The fossil plants of the Indian Gondwana Formations.

## 19.5.1 Fossilization

The process of formation of fossil in the rocks is called fossilization.

Common methods of fossilization includes petrifaction, molds and cast, carbonization, preservation, compression and infiltration.

**Petrifaction**

Minerals like silica slowly penetrate in and replace the original organic tissue and forms a rock like fossil. This method of fossilization can **preserve hard and soft parts**. Most bones and wood fossils are petrified.

**Mold and Cast**

A replica of a plant or animal is **preserved in sedimentary rocks**. When the organism gets buried in sediment it is dissolved by underground water leaving a hollow depression called a mold. It shows the **original shape but does not reveal the internal structure**. Minerals or sediment fill the hollow depression and forms a cast.

**Preservation**

Original remains can be preserved in **ice** or **amber** (tree sap). They protect the organisms from decay. The entire plant or animal is preserved.

**Compression**

When an organism dies, the hard parts of their bodies settle at the **bottom of the sea bed** and are **covered by sediment**. The process of sedimentation goes on continuously and fossils are formed.

**Infiltration or Replacement**

The **precipitation of minerals** takes place which later on infiltrate the cell wall. The process is brought about by several mineral elements such as silica, calcium carbonate and magnesium carbonate. Hard parts are dissolved and replaced by these minerals.

DO YOU KNOW?

**Living Fossils:** These are living organisms that are similar in appearance to their fossilized distant ancestors and usually have no extinct close features. e.g. *Ginko biloba*.

## 19.5.2 Determination of age of Fossils

The age of fossils is determined by radioactive elements present in it. They may be carbon, uranium, lead or potassium. It is used in paleobotany and anthropology for determining the age of human fossils and manuscripts.

**Radioactive carbon($C^{14}$) dating method**

This method was discovered by **W.F. Libby** (1956). Carbon consumption of animals and plants stops after death and since then, only the decaying process of $C^{14}$ occurs continuously. The time passed since death of a plant or animal can be calculated by measuring the amount of $C^{14}$. present in their body.

### More to Know

**What is the Geologic Time Scale?**

The geological time scale is a system of chronological dating that relates geological rock strata to time, and is used by geologists, paleontologists, and other Earth scientists to describe the timing and relationships of events that have occurred during Earth's history.

DO YOU KNOW?

**Thiruvakkarai fossil wood park (Villupuram district, Tamil Nadu):** 2 million years ago tree trunks that got buried along the river, incourse of time the organic matter was replaced by silica and was fossilized. They retained their color, shape and texture and was converted into solid rocks. The annular rings, the texture, colors of the layers, nodes and every properties of plants are still visible.

## 19.6 Ethnobotany

Ethnobotany is the **study of a region's plants** and their **practical uses** through the **traditional knowledge** of the local culture of people. The term Ethnobotany was coined by **J.W. Harshberger** in 1895 to include the study of plants used by the primitive and aboriginal people. Though this discipline has existed for ages, ethnobotany emerged as a distinct academic branch of natural science in 20th century.

### Aspects of ethnobotany

Ethnobotany has relevance with problems of nutrition, health care and life support system, faith in plants, cottage industries, economic upliftment, conservation of biodiversity and sustainable use of plant resources.

### Importance of Ethnobotany

- It provides traditional uses of plant.
- It gives information about certain unknown and known useful plants.
- The ethnomedicinal data will serve as a useful source of information for the chemists, pharmacologists and practitioners of herbal medicine.
- Tribal communities utilize ethnomedicinal plant parts like bark, stem, roots, leaves, flower bud, flowers, fruits, seeds, oils, resins, dyes, gum for the treatment of diseases like diarrhoea, fever, headache, diabetes, jaundice, snakebites, leprosy, etc.

## 19.7 Astrobiology/Exobiology

Are we alone in the universe? If your answer is no, then how do you detect the existence of life in space? Astrobiology/exobiology is the science which looks for the presence of **extra terrestrial life in the universe**.

Astrobiology deals with the **origin, evolution** and **distribution of life in the universe** and to investigate the possibility of life in other world.

The major concept in astrobiology is the **habitable zone**. The theory explains that any **planets can support the existence of life**, if it fulfills two important criteria.

i It must have a right mass to retain an atmosphere.

ii It must have an orbit at just the right distance from its star (Sun) that it allows liquid water to exist. Thus, the distance need to be neither too hot or not too cold and is often referred as **Goldilock Zone for life**.

In our solar system 'Earth' is the only planet in the goldilock zone. Since, this zone varies at times as the star evolves, we know that Mars have also been habitable. The life on Mars are likely to be the creatures, we find in extreme environments on earth.

The organisms which live in extreme environmental conditions on earth are called **extremophiles.** Thus, within our own Solar System, there are many areas that are different from the Earth where it is probable to find the presence of life similar to extremophile bacteria.

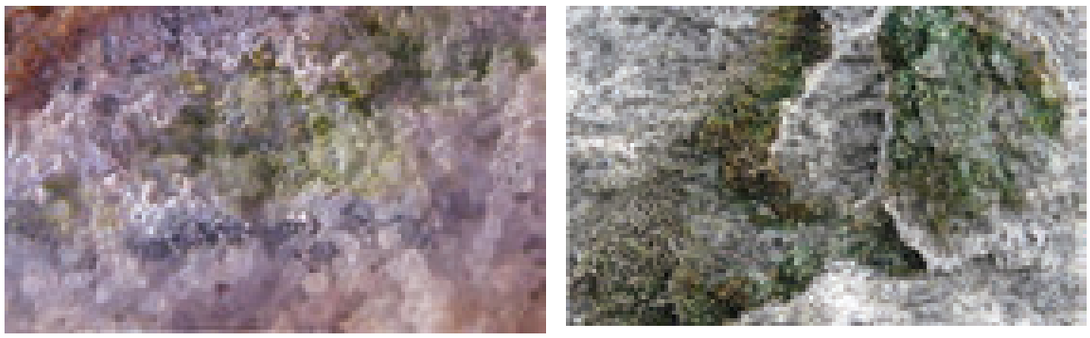


**Figure 19.5** Microbial diversity from sandstone and granite from the McMurdo Dry Valleys, Antarctica

**DO YOU KNOW?**

NASA is developing the Mars 2020 astrobiology to investigate an astrobiologically relevant ancient environment on Mars, its surface geological processes and the possibility of past life on Mars and preservation of biosignatures within accessible geological materials.

## Points to Remember

- Lamarck proposed that the acquired characters are passed on to the offsprings in the next generation
- Internal vital force, environment and new needs, use and disuse theory and inheritance of acquired characters are the main principles of Lamarckism.
- Overproduction, struggle for existence, variations, survival of the fittest or Natural selection and origin of species are the main postulates of Darwinism.
- Each species tends to produce large number of offsprings, but only the fittest can survive.
- Homologous, analogous organs and embryological evidences explain evolutionary relationships.
- Some traits in organisms would be similar because they are inherited from a common ancestor.
- Fossils are evidences of ancient life forms or ancient habitats which have been preserved by natural processes.
- Ethnobotanical importance of various types of plants are know through traditional knowledge.
- Astrobiology/exobiology is the science which looks for the presence of extra terrestrial life in the universe

## TEXTBOOK EVALUATION

SMGSRI

### I Choose the correct answer

1. Biogenetic law states that _____
   a. Ontogeny and phylogeny go together
   b. Ontogeny recapitulates phylogeny
   c. Phylogeny recapitulates ontogeny
   d. There is no relationship between phylogeny and ontogeny

2. The 'use and disuse theory' was proposed by _____.
   a. Charles Darwin
   b. Ernst Haeckel
   c. Jean Baptiste Lamarck
   d. Gregor Mendel

3. Paleontologists deal with
   a. Embryological evidences
   b. Fossil evidences
   c. Vestigial organ evidences
   d. All the above

4. The best way of direct dating fossils of recent origin is by
   a. Radio-carbon method
   b. Uranium lead method
   c. Potassium-argon method
   d. Both (a) and (c)

5. The term Ethnobotany was coined by
   a. Khorana  b. J.W. Harsbberger
   c. Ronald Ross  d. Hugo de Vries

## II Fill in the blanks

1. The characters developed by the animals during their life time, in response to the environmental changes are called _____.
2. The degenerated and non-functional organs found in an organism are called _____.
3. The forelimbs of bat and human are examples of _____ organs.
4. The theory of natural selection for evolution was proposed by _____.

## III State true or false. Correct the false statements

1. The use and disuse theory of organs' was postulated by Charles Darwin.
2. The homologous organs look similar and perform similar functions but they have different origin and developmental pattern.
3. Birds have evolved from reptiles.

## IV Match the following

| | Column A | Column B |
|---|---|---|
| a) | Atavism | caudal vertebrae and vermiform appendix |
| b) | Vestigial organs | a forelimb of a cat and a bat's wing |
| c) | Analogous organs | rudimentary tail and thick hair on the body |
| d) | Homologous organs | a wing of a bat and a wing of an insect |
| e) | Wood park | radiocarbon dating |
| f) | W.F. Libby | Thiruvakkarai |

## V Answer in a word or sentence

1. A human hand, a front leg of a cat, a front flipper of a whale and a bat's wing look dissimilar and adapted for different functions. What is the name given to these organs?
2. Which organism is considered to be the fossil bird?
3. What is the study of fossils called?

## VI Short answers questions

1. The degenerated wing of a kiwi is an acquired character. Why is it an acquired character?
2. Why is Archaeopteryx considered to be a connecting link?
3. Define Ethnobotany and write its importance.
4. How can you determine the age of the fossils?

## VII Long answer questions

1. Natural selection is a driving force for evolution-How?
2. How do you differentiate homologous organs from analogous organs?
3. How does fossilization occur in plants?

## IX Higher Order Thinking Skills (HOTS)

1. Arun was playing in the garden. Suddenly he saw a dragon fly sitting on a plant. He observed the wings of it. He thought it looked similar to a wing of a crow. Is he correct? Give reason for your answer.
2. Imprints of fossils tell us about evolution- How?
3. Octopus, cockroach and frog all have eyes. Can we group these animals together to establish a common evolutionary origin. Justify your answer.

## REFERENCE BOOKS


1. B.S.Tomar and S.P. Singh, An Introduction to General Biology, 9th Edition, Rastogi Publications, Meerut.
2. Stephen. C. Stearns and Rolf. F. Hoekstra Evolution - An introduction
3. Archer, S.D.J., Asuncion de los, R., Lee, K.C., Niederberger, T.S., Cary, S.C., Coyne, K.J., Douglas, S., Lacap-Bugler, D.C. and Pointing, S.B., 2017. A Endolithic microbial diversity in sandstone and granite from the McMurdo Dry Valleys, Antarctica. *Polar biology,* 40 (5): 997-1006.

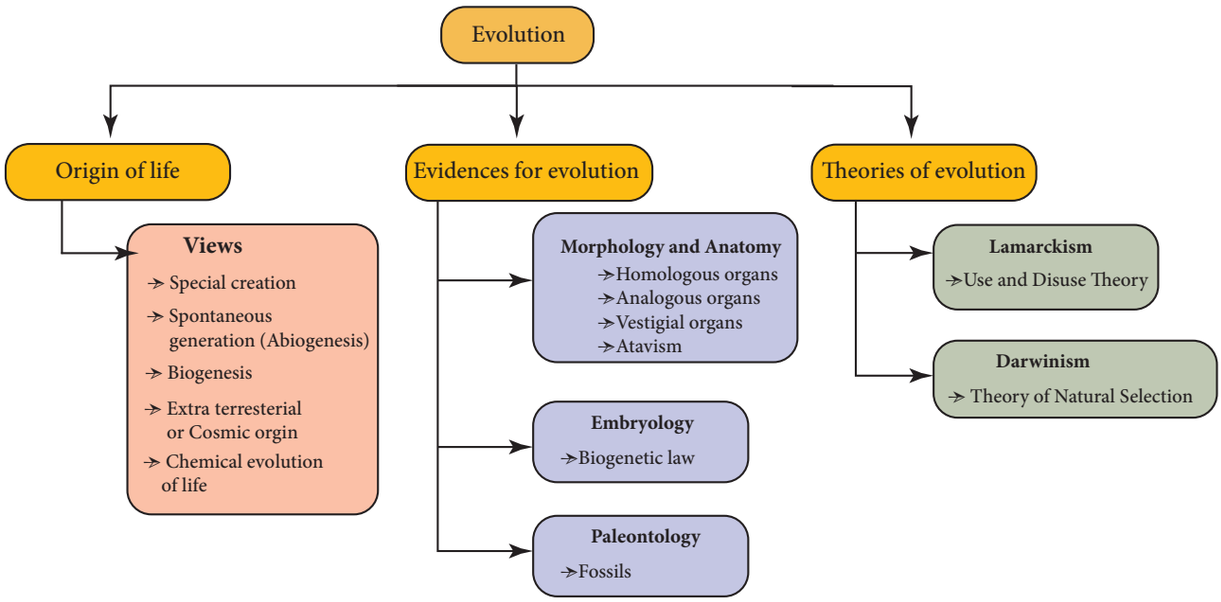

## INTERNET RESOURCES

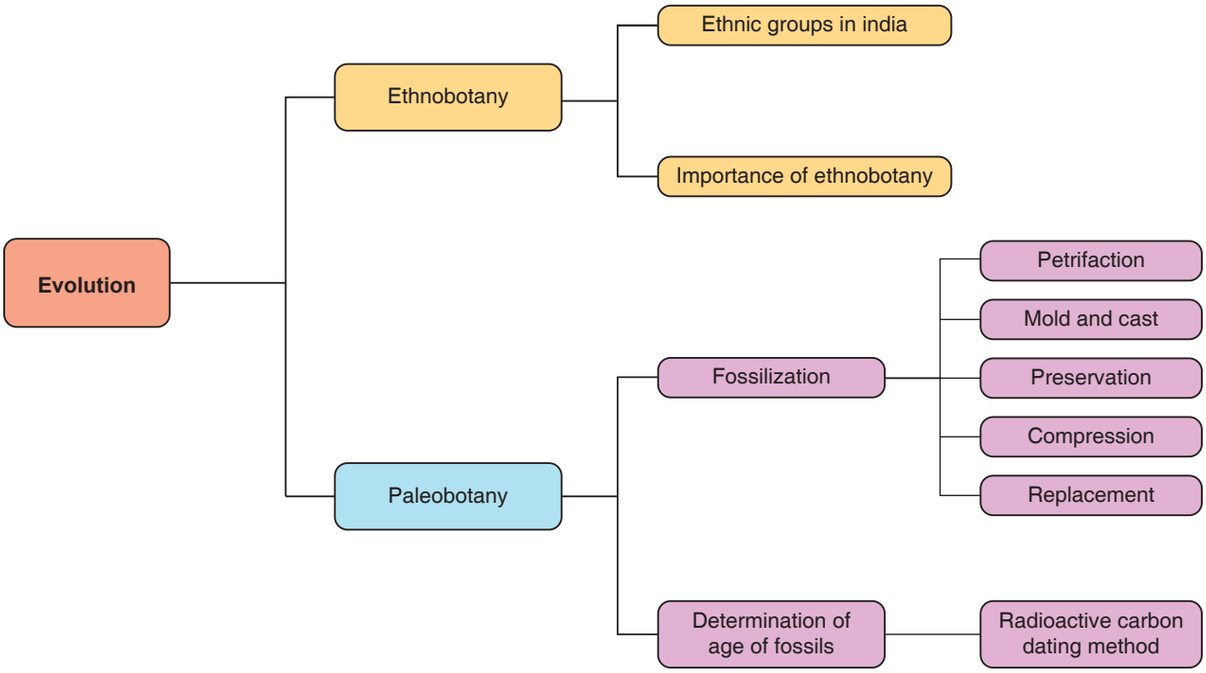
http://www.nhs.uk

http://www.eniscuola.net/en/2012/11/29/exobiology/

https://en.wikipedia.org/wiki/Astrobiology

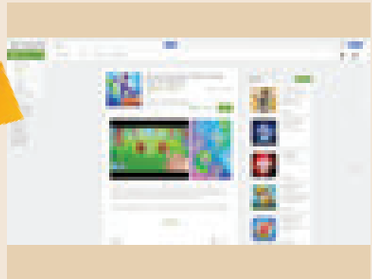
# Concept Map





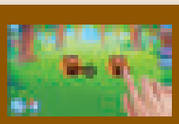

# ICT CORNER ORIGIN AND EVOLUTION OF LIFE

**This game will enable the students to understand the evolution of living organisms. But it was created on the basis of general truths and not specific scientific related.**

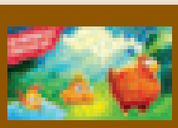


## Steps

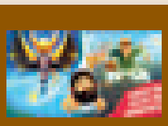
- Access the application "HUMAN EVOLUTION CLICKER GAME:RISE OF MANKIND" with the help of provided URL or QR code. Download and Install it in the mobile.
- You can view a bubble for ten seconds, touch it to reveal the hidden DNA.
- By joining two DNAs, a bacteria will be formed. By joining two bacteria, amoeba will be appeared.
- Continue the same to form many other species by combining different species. There are 52 living organism exist now in the application. Explore everything.



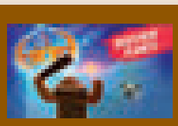
**Step1**



**Step2**



**Step3**



**Step4**

**Cells alive**

https://play.google.com/store/apps/details?id=com.banana4apps.evolution&hl=en

*Pictures are indicative only

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UNIT 20

# BREEDING AND BIOTECHNOLOGY

## Learning Objectives

SMQNT6

At the end of this lesson the students will be able to :

- Define and discuss the steps and methods involved in plant breeding.
- Know the crop varieties produced by crop improvement.
- Understand animal breeding and its implications.
- Point out the differences between inbreeding and outbreeding.
- Know what is hybrid vigour and its importance.
- Identify the steps involved in genetic engineering.
- Understand the practical applications of DNA fingerprinting.
- Gain knowledge on gene therapy.
- Know the importance of stem cell technology.

## Introduction

India's population is likely to reach 1.7 billion by 2050. Current rate of India's food production will be able to meet only 59% of the country's food demand at that time. How can India feed 1.7 billion people by 2050? This can be made possible by 'Plant breeding' and 'Animal husbandry'.

Plant breeding is the art of developing economically important plants with superior quality.

Animal husbandry involves the breeding of animals. It aims at improving the genotypes of animals to make them more useful to the welfare of mankind.This emphasizes domestication and propagation of animals,under controlled conditions to enhance food production and food quality.

Another breakthrough was the emergence of biotechnology as an entity of modern biology, which paved way to develop advanced healthcare products, diagnostic kits and food production to improve the quality of human life.

## 20.1 Modern Agricultural Practices and Crop Improvement

Modern agricultural practices are activities carried out to improve cultivation of plants. It includes preparation of soil, sowing, application of manures and fertilizers, proper irrigation, protection from weeds and pests harvesting, threshing and storage.

The aim of crop improvement is to develop improved crop varieties possesing higher yield, better quality, resistance to diseases and shorter duration.

## 20.2 Green Revolution

Green Revolution is the process of increasing food production through high

yielding crop varieties and modern agricultural techniques in underdeveloped and developing nations. **Dr. Norman E. Borlaug**, an American agronomist the "**Father of the Green Revolution**", received the Nobel Peace Prize in 1970. In India **Dr. M. S. Swaminathan** joined with Dr.Borlaug in bringing Green Revolution by introducing Mexican wheat varieties. This eventually increased wheat and rice production between 1960 and 2000.

### 20.2.1 Breeding for high yield and better quality

Major challenge that India faced during post-independance period was having enough food production for the growing population. Efforts were taken to develop high yielding varieties of crops, leading to Green Revolution.

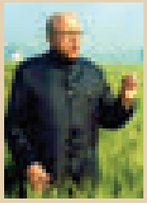
**Semi-Dwarf varieties in Wheat and Rice**

**Sonalika**, **Kalyan Sona** are semi-dwarf varieties of wheat developed from high-yielding, semi-dwarf, fertilizer responsive wheat varieties from **Mexico. IR-8** (Miracle rice) is a high-yielding semi-dwarf rice variety developed by International Rice Research Institute (IRRI),Philippines. In 1966, this was first introduced in Philippines and India. It was a hybrid of a high yielding rice variety **Peta** from Indonesia, and **Dee-geo-woo-gen** (DGWG) a dwarf variety from China.


**Figure 20.1** IR-8

**More to Know**

**Dr. M. S. Swaminathan**



Dr. Mankombu Sambasivan Swaminathan is an Indian scientist known for his leading role in India's Green Revolution. His research on potato, wheat, rice and jute are well known plant breeding experiments. Due to his efforts the wheat production increased from twelve million tonnes in 1960's to seventy million tonnes now. He is aptly called as the "Father of Indian Green Revolution".

**More to Know**

**Dr. G. Nammalvar**

Dr. G. Nammalvar (1938-2013) was a Tamil agricultural scientist, environmental activist and organic farming expert. He founded Nammalvar Ecological Foundation for Farm Research and Global Food Security Trust (NEFFFRGFST-Vanagam) to create public awareness about the benefits of organic farming.

### 20.2.2 Plant Breeding for Disease Resistance

Plant diseases are caused by pathogens like viruses, bacteria and fungi. This affects crop yield. Hence, it is important to develop disease resistant varieties of crops, that would increase the yield and reduce the use of fungicides and bactericides. Some disease resistant varieties developed by plant breeding are given below:

**Table 20.1** Disease resistant crop varieties

| Crop | Variety | Resistance to diseases |
|---|---|---|
| Wheat | Himgiri | Leaf and stipe rust, hill bunt |
| Cauliflower | Pusa Shubhra, Pusa Snowball K-1 | Black rot |
| Cowpea | Pusa Komal | Bacterial blight |

### 20.2.3 Plant Breeding for Insects/Pests Resistance

In addition to microorganisms, a large number of insects and pests also cause damage to the crops. Hence, insect and pest resistant crop varieties were developed. Some of them are given below:

**Table 20.2** Insects /pests resistant varieties

| Crop | Variety | Resistant to Insects/Pests |
|---|---|---|
| Brassica | Pusa Gaurav | Aphids |
| Flat Bean | Pusa Sem 2, Pusa Sem 3 | Leaf hopper, aphids and fruit borer |
| Lady's finger | Pusa Sawani, Pusa A4 | Shoot and fruit borer |

### 20.2.4 Plant Breeding for Improved Nutritional Quality

Undernutrition and protein malnutrition among human population is a major health problem which has been receiving much focus throughout the world. Apart, from humans it also affects the health of farm animals. To combat these conditions, human and animal health are to be determined by the nutritional quality of the feed crops. The nutritional quality of crops depends on quality and quantity of nutrients.The nutritional quality may be improved with respect to its

1. Protein content and quality of protein
2. Oil content
3. Mineral content

**Biofortification**

Biofortification is the scientific process of developing crop plants enriched with high levels of desirable nutrients like vitamins, proteins and minerals. Some examples of crop varieties developed as a result of biofortification are given below:

1. Protina, Shakti and Rathna are lysine rich maize hybrids (developed in India).

**Figure 20.2** Protina–lysine rich Maize

2. Atlas 66, a protein rich wheat variety.

**Figure 20.3** Atlas 66-protein rich Wheat

3. Iron rich fortified rice variety.
4. Vitamin A enriched carrots, pumpkin and spinach.

## 20.3 Methods of Plant Breeding for Crop Improvement

Methods of plant breeding to develop high yielding varieties are given below:

1. Introduction of new varieties of plants
2. Selection
3. Polyploidy breeding
4. Mutation breeding
5. Hybridization

### 20.3.1 Introduction of New Varieties of Plants

It is a process of introducing high yielding varieties of plants from one place to another. Such plants are called as **exotic species**. These imported plant materials may carry pathogens and pests, hence they are thoroughly tested in a plant quarantine before being introduced to the fields. e.g *Phaseolus mungo* was introduced from China.

## 20.3.2 Selection

Selection is one of the oldest methods of plant breeding in which individual plants or groups of plants are sorted out from a mixed population based on the morphological characters.

**Methods of selection**

There are three methods of selection. They are

1. Mass selection
2. Pureline selection
3. Clonal selection

**1. Mass selection**

Seeds of best plants showing desired characters are collected from a mixed population. The collected seeds are allowed to raise the second generation. This process is carried out for seven or eight generations. At the end, they will be multiplied and distributed to the farmers for cultivation.

Some common examples for mass selection are groundnut varieties like TMV–2 and AK–10. Its schematic representation is given below.

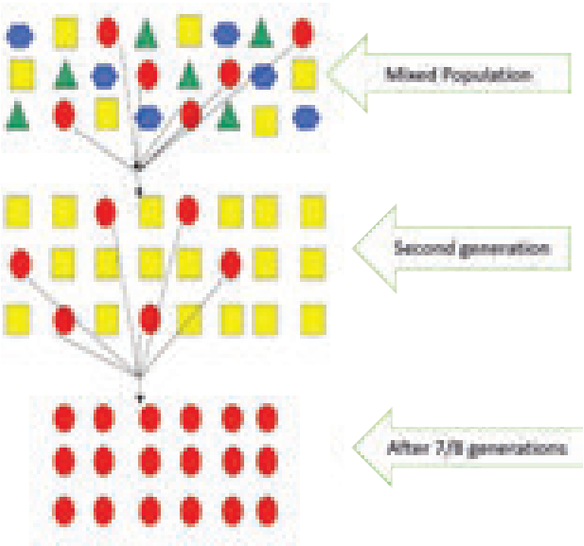



**Figure 20.5** Mass Selection

**2. Pureline selection**

Pureline is "the progeny of a single individual obtained by self breeding". This is also called as individual plant selection. In pureline selection large numbers of plants are selected from a self-pollinated crop and harvested individually.

Individual plant progenies from them are evaluated separately. The best one is released as a pureline variety. Progeny is similar both genotypically and phenotypically.

**3. Clonal selection**

A group of plants produced from a single plant through vegetative or asexual reproduction are called **clones**.

All the plants of a clone are similar both in genotype and phenotype. Selection of desirable clones from the mixed population of vegetatively propagated crop is called **clonal selection**.

## 20.3.3 Polyploidy Breeding

Sexually reproducing organisms have two complete set of chromosomes in their somatic cells. This is called **diploid** (2n). The gametic cells have only one set of chromosome. This is called **haploid** (n). An organism having more than two sets of chromosomes is called **polyploid** (Greek : Polys = many + aploos = one fold + eidos = form). Such condition is called Polyploidy. It can be induced by **physical agents** such as heat or cold treatment, X-rays and **chemical agents** like colchicine.

**Achievements of polyploidy breeding**

Some achievements of polyploidy breeding are

a. Seedless watermelons (3n) and bananas (3n).
b. TV-29 (triploid variety of tea) with larger shoots and drought tolerance.
c. *Triticale* (6n) is a hybrid of wheat and rye. To make this plant fertile polyploidy is induced. It has higher dietary fibre and protein.
d. *Raphano brassica* is an allotetraploid by colchicine treatment.

### 20.3.4 Mutation Breeding

Mutation is defined as the sudden **heritable change** in the nucleotide sequence of DNA in an organism. It is a process by which **genetic variations** are created which in turn brings about changes in the organism. The organism which undergoes mutation is called a mutant.

The factors which induce mutations are known as mutagens or **mutagenic agents**. Mutagens are of two types namely physical mutagens and chemical mutagens.

**More to Know**

**Gamma Garden**

Gamma garden or Atomic garden is a concept popularised after World War II for the peaceful use of atomic energy for crop improvement. This is a type of induced mutation breeding where radioactive sources particularly gamma rays from Cobalt-60 or Caesium-137 are used to induce desirable mutations in crop plants.

**i Physical mutagens**

Radiations like X-rays, α, β and γ-rays, UV rays, temperature etc. which induce mutations are called physical mutagens

**ii Chemical mutagens**

Chemical substances that induce mutations are called chemical mutagens. e.g. Mustard gas and nitrous acid. The utilisation of induced mutation in crop improvement is called **mutation breeding**.

**Achievements of mutation breeding**

Some achievements of mutation breeding are

a. **Sharbati Sonora** wheat produced from Sonora-64 by using gamma rays.
b. **Atomita 2 rice** with saline tolerance and pest resistance
c. **Groundnuts** with thick shells

### 20.3.5 Hybridization

Hybridization may be defined as the process of crossing two or more types of plants for bringing their desired characters together into one progeny called **hybrid**. Hybrid is superior in one or more characters to both parents. Hybridization is the common method of creating genetic variation to get improved varieties.

**Hybridization Experiment: *Triticale* (The first man – made cereal)**

*Triticale* is the first man- made cereal hybrid. It is obtained by crossing wheat (*Triticum durum*, 2n = 28) and rye (*Secale cereal*, 2n = 14). The $F_1$ hybrid is sterile (2n = 21). Then the chromosome number is doubled using colchicine and it becomes a hexaploid *Triticale* (2n = 42).

The cycle of crop raising and selection continues till the plants with the desired characters are finally obtained. The development of new varieties is a long-drawn process. Two main aspects of hybridization are to combine the characters of two plants in one plant and to utilize hybrid vigour.

## 20.4 Animal Breeding

A **breed** is a group of animals of common origin within a species that has certain distinguishing characters that are not found in other members of the same species like general appearance and others striking features.

**Breeding** involves mating parents of different varieties each having some desired trait which are passed onto the offspring.

**Objectives of Animal Breeding**

**Animal breeding** aims at improving the genotypes of domesticated animals to increase their yield and improve the desirable qualities to produce milk, egg and meat.

When breeding takes place between animals of the same breed, it is called **inbreeding**. The cross between different breeds is called **outbreeding**.

## 20.4.1 Inbreeding

Inbreeding refers to the **mating of closely related animals within the same breed** for about 4-6 generations. Superior males and superior females of the same breed are identified and mated in pairs. It helps in the accumulation of superior genes and elimination of genes which are undesirable.

*Hissardale* is a new breed of sheep developed in Punjab by crossing Bikaneri (Magra) ewes and Australian Marino rams.

**Inbreeding depression:** Continued inbreeding reduces fertility and productivity. Inbreeding exposes harmful recessive genes that are eliminated by selection.

## 20.4.2 Outbreeding

It is the **breeding of unrelated animals**. The offsprings formed are called hybrids. The **hybrids** are stronger and vigorous than their parents. Cross between two different species with desirable features of economic value are mated. Let's see what cross produce a mule.

**Cross breeding**

**Male Donkey** X **Female Horse**

↓

**Mule**

Mule is superior to horse in strength, intelligence, ability to work and resistance to diseases but they are sterile.

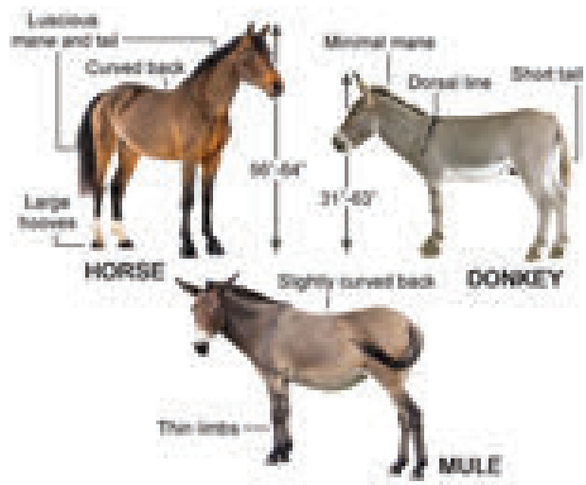



**Figure 20.6** Cross breeding to produce Mule with superior characters

**Info bits**

**Cross breed of fowls:**

White Leghorn X Plymouth Rock

↓

Hybrid fowl - yield more eggs

**Cross breed of cows:**

Developed by mating the bulls of exotic breeds and cows of indigenous breeds.

Brown Swiss X Sahiwal

↓

Karan Swiss - yield 2-3 times more milk than indigenous cows.

## 20.4.3 Heterosis

The superiority of the hybrid obtained by cross breeding is called as **heterosis** or **hybrid vigour.**

**Effects of hybrid vigour in animal breeding**

- Increased production of milk by cattle
- Increased production of egg by poultry
- High quality of meat is produced
- Increased growth rate in domesticated animals

## 20.5 Genetic Engineering

Genetic engineering is the manipulation and transfer of genes from one organism to another organisms to create a new DNA called as **recombinant DNA(rDNA)**. The term recombinant is used because DNA from two different sources can be joined together. Hence, genetic engineering is also called as **recombinant DNA technology.**

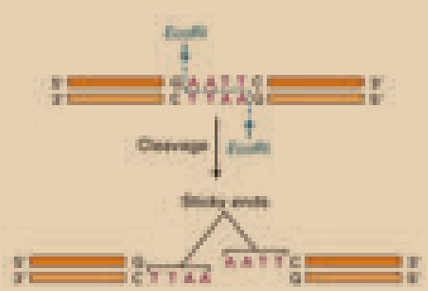
T2ZMSU

DO YOU KNOW?

Plasmid is the small circular double stranded DNA molecule found in the cytoplasm of bacterial cell and separated from chromosomal DNA. It can replicate independently.


### More to Know

**Restriction enzymes** recognises a specific base pair sequence (palindromic sequence) in DNA called as restriction site and cleaves the phosphodiester bond within DNA.




### 20.5.1 Techniques of Genetic Engineering – Basic Requirements

Important discoveries that led to the stepping stone of rDNA technology were

a. Presence of **plasmid** in bacteria that can undergo replication independently along with chromosomal DNA.

b. **Restriction enzymes** cuts or break DNA at specific sites and are also called as molecular scissors.

c. **DNA ligases** are the enzymes which help in ligating (joining) the broken DNA fragments.

### 20.5.2 Gene Cloning

What reminds to your mind when you hear the word clone? Of course, 'DOLLY' the cloned sheep. The carbon copy of an individual is often called a **clone**. However, more appropriately, a clone means to make a **genetically exact copy of an organism**.

In gene cloning, a gene or a piece of DNA fragment is inserted into a bacterial cell where DNA will be multiplied (copied) as the cell divides. A brief outline of the basic steps involved in gene cloning are:

i. Isolation of desired DNA fragment by using restriction enzymes

ii. Insertion of the DNA fragment into a suitable vector (Plasmid) to make rDNA

iii. Transfer of rDNA into bacterial host cell (Transformation)

iv. Selection and multiplication of recombinant host cell to get a clone

v. Expression of cloned gene in host cell.

Using this strategy several enzymes, hormones and vaccines can be produced

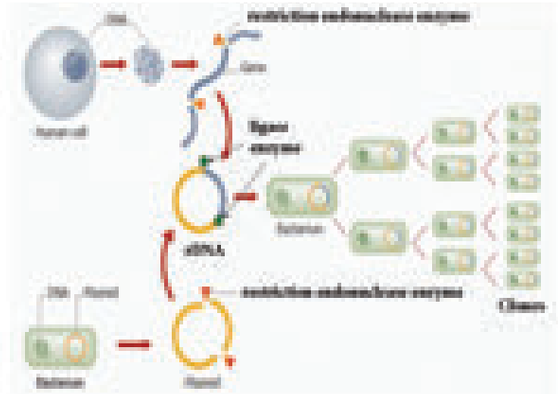
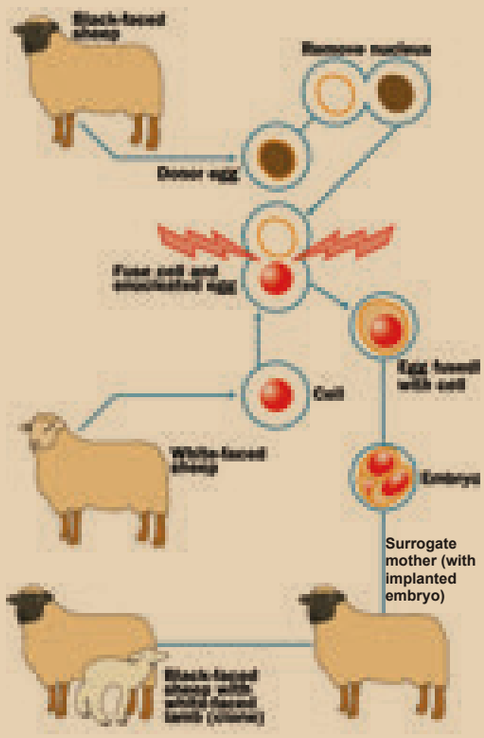


**Figure 20.7** Genetic engineering technique (Gene cloning)

**Info bits**

**Development of Dolly**

Dolly was the first cloned female sheep, developed by Dr. Ian Wilmut and his colleagues at the Roslin Institute, Scotland in July 1996. She was created by somatic cell **nuclear transfer** technique. She lived for 6.5 years and died in 2003 because of lung disease.




## 20.6 Biotechnology in Medicine

Using genetic engineering techniques medicinally important valuable proteins or polypeptides that form the potential pharmaceutical products for treatment of various diseases have been developed on a commercial scale.

**Pharmaceutical products developed by rDNA technique**

a. Insulin used in the treatment of diabetes.

b. Human growth hormone used for treating children with growth deficiencies.

c. Blood clotting factors are developed to treat haemophilia.

d. Tissue plasminogen activator is used to dissolve blood clots and prevent heart attack.

e. Development of vaccines against various diseases like Hepatitis B and rabies

**DO YOU KNOW?**

Eli Lilly and Company, United States, in 1979 first started commercial production of human insulin by using rDNA technology.

**Gene Therapy**

Gene therapy refers to the replacement of defective gene by the direct transfer of functional genes into humans to treat genetic disease or disorder. The genetic makeup of the 'patient' cell is altered using recombinant DNA technology. It was first successfully implemented in 1990.

**Somatic gene therapy** is the replacement of defective gene in somatic cells.

**Germ line gene therapy** replacement of defective gene in germ cell (egg and sperm).

Gene therapy conducted till date has targeted only somatic (non-reproductive) cells. Correction of genetic defects in somatic cells may be beneficial to the patient but the corrected gene may not be carried to the next generation.

## 20.7 Stem Cells

Our body is composed of over 200 specialised cell types, that can carry out specific functions. e.g. neurons or nerve cell that can transmit signals, or heart cells which contract to pump blood or pancreatic cells to secrete insulin. These specialised cells are called as **differentiated cells**.

In contrast to differentiated cells, stem cells are **undifferentiated or unspecialised** mass of cells. The stem cells are the cells of

variable potency. Potency refers to the number of possible fates that a cell can acquire. The two important properties of stem cells that differentiate them from other cells are:

i. its ability to divide and give rise to more stem cells by self-renewal

ii. its ability to give rise to specialised cells with specific functions by the process of differentiation.

### Types of stem cells

**Embryonic stem cells** can be extracted and cultured from the early embryos. These cells are **derived from the inner cell mass of blastocyst**. These cells can be developed into any cell in the body.

**Adult stem cell** or **somatic stem cell** are found in the neonatal (new born) and adults. They have the ability to divide and give rise to specific cell types. Sources of adult stem cells are amniotic fluid, umbilical cord and bone marrow.

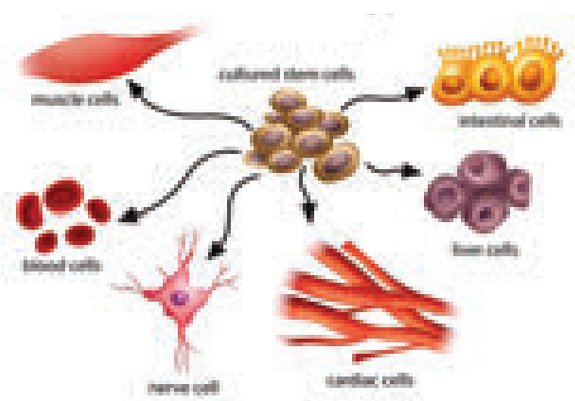



**Figure 20.8** Differentiation of stem cells

### Stem-cell therapy

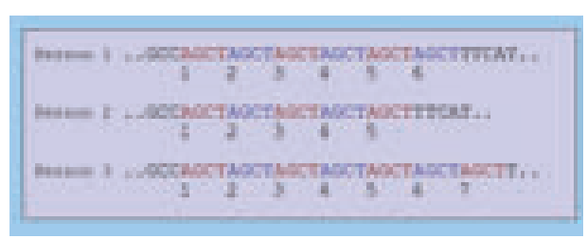
Sometimes cells, tissues and organs in the body may be permanently damaged or lost due to genetic condition or disease or injury. In such situations stem cells are used for the treatment of diseases which is called **stem-cell therapy**. In treating **neurodegenerative disorders** like Parkinson's disease and Alzheimer's disease **neuronal stem cells** can be used to replace the damaged or lost neurons.

## 20.8 DNA Fingerprinting Technology

The human genome has 3 billion base pairs. Did you know that the DNA pattern of two individuals cannot be same except for identical twins. Each person's DNA sequence is unique due to the small difference in the base pairs. Therefore, if we want to compare the genetic difference among the two individuals, **DNA fingerprinting** is the easier and quicker method. This technique was developed by **Alec Jeffrey**.

The technique analyses each individual's unique DNA sequences and provides distinctive characteristics of individual which helps in identification. **Variable number of tandem repeat sequences** (VNTRs) serve as molecular markers for identification.

In human beings, 99 % of the DNA base sequences are the same and this is called as bulk genomic DNA. The remaining 1 % DNA sequence differs from one individual to another. This 1 % DNA sequence is present as small stretch of repeated sequences which is known as **satellite DNA.** The number of copies of the repeat sequence also called as **VNTRs** differs from one individual to another, and results in variation in the size of the DNA segment.



**VNTRs illustration of three persons**

As shown in the illustration, the sequence AGCT is repeated six times in first person, five times in second person and seven times in third

person. Because of this, DNA segment of third person will be larger in size followed by DNA segment of first person and then the second person. Thus, it is clear that satellite DNA bring about variation within the population. Variation in DNA banding pattern reveals differences among the individuals.

**Applications of DNA Fingerprinting**

i. DNA fingerprinting technique is widely used in forensic applications like crime investigation such as identifying the culprit. It is also used for paternity testing in case of disputes.
ii. It also helps in the study of genetic diversity of population, evolution and speciation.

## 20.9 Genetically Modified Organisms (GMOs)

One of the most tremendous development of genetic engineering is the production of genetically modified (GM) plants and animals. **Genetic modification** refers to the alteration or manipulation of genes in the organisms using rDNA techniques in order to produce the desired characteristics. The DNA fragment inserted is called **transgene**. Plants or animals expressing a modified endogenous gene or a foregin gene are also known as **transgenic organisms**.

The transgenic plants are much stable, with improved nutritional quality, resistant to diseases and tolerant to various environment conditions. Similarly transgenic animals are used to produce proteins of medicinal importance at low cost and improve livestock quality.

Some examples of genetically modified plants and animals are given in the table below.

**Genetically Modified Plants**

| Objective | Gene inserted | Achievement |
|---|---|---|
| Improved nutritional quality in Rice | Beta carotene gene (In humans, Beta carotene is required for the synthesis of Vitamin A) | **Golden Rice** (Genetically modified rice can produce beta carotene, that can prevent Vitamin A deficiency) |
| Increased crop production | Bt gene from bacteria *Bacillus thuringiensis.* (Bt gene produces a protein that is toxic to insects) | **Insect resistant plants** (These plants can produce the toxin protein that kills the insects which attack them) |

**Genetically Modified Animals**

| Objective | Gene inserted | Achievement |
|---|---|---|
| Improved wool quality and production | Genes for synthesis of amino acid, cysteine | **Transgenic sheep** (gene expressed) |
| Increased growth in fishes | Salmon or Rainbow trout or Tilapia growth hormone gene | **Transgenic fish** (gene expressed) |

**Points to Remember**

- Crop improvement is the development of improved crop varieties possesing higher yield, better quality, resistance to diseases and shorter duration.
- When breeding takes place between animals of the same breed, it is called inbreeding.The cross between different breeds is called outbreeding.
- The superiority of the hybrid obtained by cross breeding is called as heterosis or hybrid vigour.
- Genetic engineering is the manipulation and transfer of genes from one organism to another organism.
- Stem cells are undifferentiated or unspecialised mass of cells and can be used for the treatment known as stem cell therapy.

## TEXTBOOK EVALUATION

THIHU6

### I Choose the correct answer

1. Which method of crop improvement can be practised by a farmer if he is inexperienced?
   a. clonal selection b. mass selection
   c. pureline selection d. hybridisation
2. Pusa Komal is a disease resistant variety of _____.
   a. sugarcane b. rice
   c. cow pea d. maize
3. Himgiri developed by hybridisation and selection for disease resistance against rust pathogens is a variety of _____.
   a. chilli b. maize
   c. sugarcane d. wheat
4. The miracle rice which saved millions of lives and celebrated its 50th birthday is _____
   a. IR 8 b. IR 24 c. Atomita 2 d. Ponni
5. Which of the following is used to produce products useful to humans by biotechnology techniques?
   a. enzyme from organism
   b. live organism
   c. vitamins
   d. both (a) and (b)
6. We can cut the DNA with the help of
   a. scissors b. restriction endonucleases
   c. knife d. RNAase
7. rDNA is a
   a. vector DNA
   b. circular DNA
   c. recombinant of vector DNA and desired DNA
   d. satellite DNA
8. DNA fingerprinting is based on the principle of identifying ---------- sequences of DNA
   a. single stranded b. mutated
   c. polymorphic d. repetitive
9. Organisms with modified endogenous gene or a foregin gene are also known as
   (a) transgenic organsims
   (b) genetically modified
   (c) mutated
   (d) both a and b

10. In a hexaploid wheat( 2n = 6 x = 42 ) the haploid (n) and the basic(x) number of chromosomes respectively are

a. n = 7 and x = 21 b. n = 21 and x = 21
c. n = 7 and x = 7 d. n = 21 and x = 7

## II Fill in the blanks

1. Economically important crop plants with superior quality are raised by_____.
2. A protein rich wheat variety is _____.
3. _____is the chemical used for doubling the chromosomes.
4. The scientific process which produces crop plants enriched with desirable nutrients is called _____.
5. Rice normally grows well in alluvial soil, but _____ is a rice variety produced by mutation breeding that grows well in saline soil.
6. _____ technique made it possible to genetically engineer living organism.
7. Restriction endonucleases cut the DNA molecule at specific positions known as _____.
8. Similar DNA fingerprinting is obtained for _____.
9. _____ cells are undifferentiated mass of cells.
10. In gene cloning the DNA of interest is integrated in a _____.

## III State whether true or false. If false, write the correct statement

1. *Raphano brassica* is a man-made tetraploid produced by colchicine treatment.
2. The process of producing an organism with more than two sets of chromosome is called mutation.
3. A group of plants produced from a single plant through vegetative or asexual reproduction are called a pureline.
4. Iron fortified rice variety determines the protein quality of the cultivated plant
5. Golden rice is a hybrid.
6. Bt gene from bacteria can kill insects.
7. *In vitro fertilisation* means the fertilisation done inside the body.
8. DNA fingerprinting technique was developed by Alec Jeffrey.
9. Molecular scissors refers to DNA ligases.

## IV Match the following

| | Column A | Column B |
|---|---|---|
| 1. | Sonalika | *Phaseolus mungo* |
| 2. | IR 8 | Sugarcane |
| 3. | Saccharum | Semi-dwarf wheat |
| 4. | Mung No. 1 | Ground nut |
| 5. | TMV – 2 | Semi-dwarf Rice |
| 6. | Insulin | *Bacillus thuringienesis* |
| 7. | Bt toxin | Beta carotene |
| 8. | Golden rice | first hormone produced using rDNA technique |

## V Understand the assertion statement, justify the reason given and choose the correct choice

a. Assertion is correct and reason is wrong
b. Reason is correct and the assertion is wrong
c. Both assertion and reason is correct
d. Both assertion and reason is wrong.

1. **Assertion:** Hybrid is superior than either of its parents.
**Reason:** Hybrid vigour is lost upon inbreeding.
2. **Assertion:** Colchicine reduces the chromosome number.
**Reason:** It promotes the movement of sister chromatids to the opposite poles.
3. **Assertion:** rDNA is superior over hybridisation techniques.

**Reason:** Desired genes are inserted without introducing the undesriable genes in target organisms.

## VI Answer in a sentence

1. Give the name of wheat variety having higher dietary fibre and protein.
2. Semi-dwarf varieties were introduced in rice. This was made possible by the presence of dwarfing gene in rice. Name this dwarfing gene.
3. Define genetic engineering.
4. Name the types of stem cells.
5. What are transgenic organisms?
6. State the importance of biofertiliser.

## VII Short answers questions

1. Discuss the method of breeding for disease resistance.
2. Name three improved characteristics of wheat that helped India to achieve high productivity.
3. Name two maize hybrids rich in amino acid lysine
4. Distinguish between
   a. somatic gene therapy and germ line gene therapy
   b. undifferentiated cells and differentiated cells
5. State the applications of DNA fingerprinting technique.
6. How are stem cells useful in regenerative process?
7. Differentiate between outbreeding and inbreeding.

## VIII Long answers questions

1. What are the effects of hybrid vigour in animals.
2. Describe mutation breeding with an example.
3. Biofortification may help in removing hidden hunger. How?
4. With a neat labelled diagram explain the techniques involved in gene cloning.
5. Discuss the importance of biotechnology in the field of medicine.

## IX Higher Order Thinking Skills (HOTS)

1. A breeder wishes to incorporate desirable characters into the crop plants. Prepare a list of characters he will incorporate
2. Organic farming is better than Green Revolution. Give reasons
3. Polyploids are characterised by gigantism. Justify your answer.
4. 'P' is a gene required for the synthesis of vitamin A. It is integrated with genome of 'Q' to produce genetically modified plant 'R'.

   i. What is P, Q and R?

   ii. State the importance of 'R' in India.

## REFERENCE BOOKS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2. Dubey, R.C., A Text book of Biotechnology. 5th Edition. S. Chand and Company Pvt. Ltd. NewDelhi.


## INTERNET RESOURCES

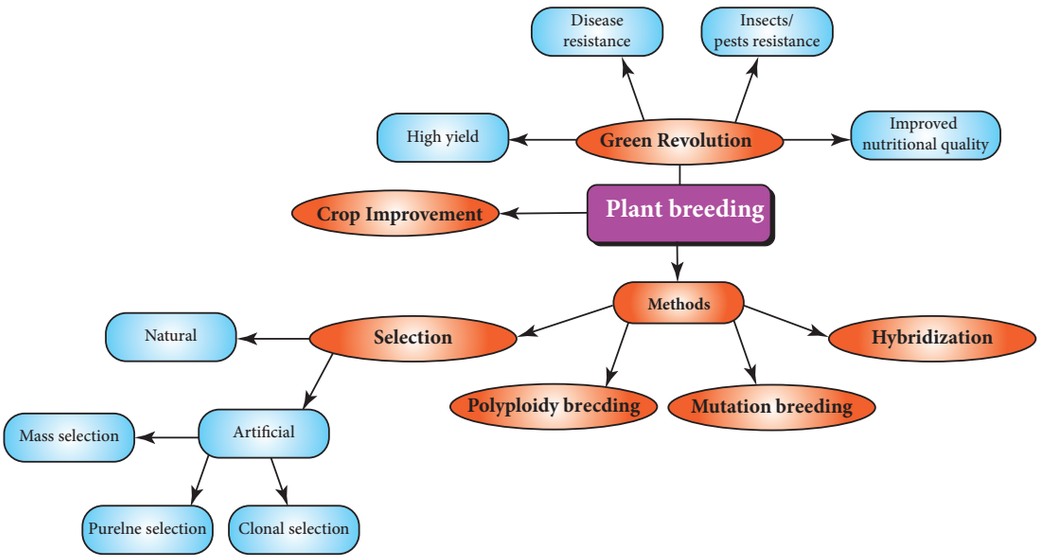
https://www.embibe.com/study/transgenic-cow-rosie-concept

https://en.wikipedia.org/wiki/DNA_profiling

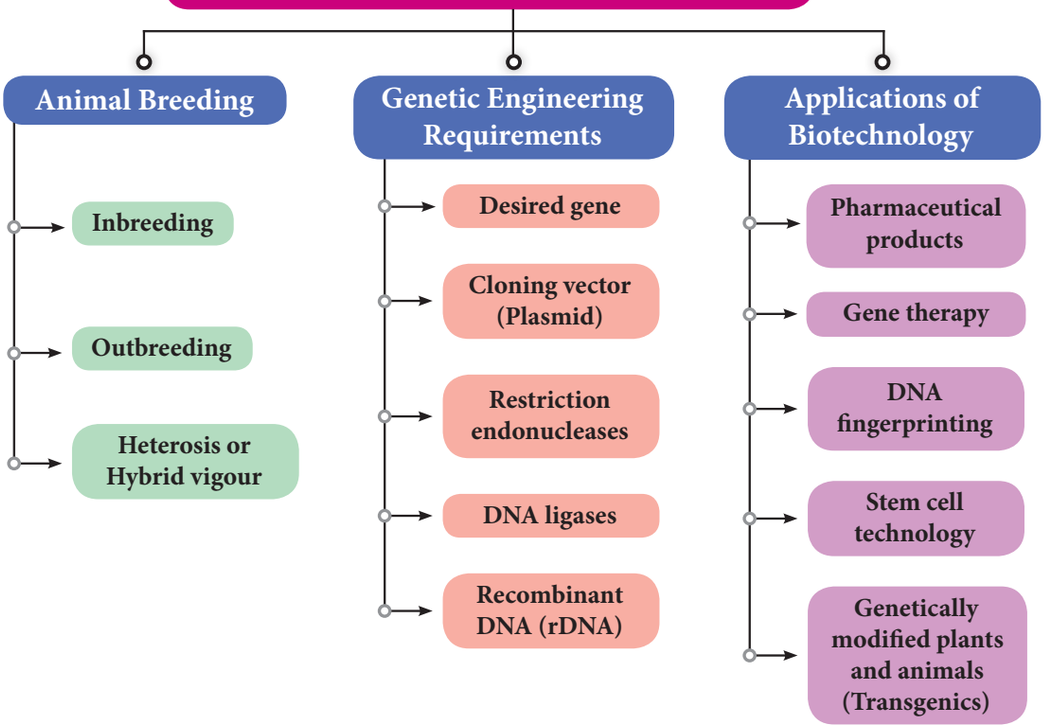
https://www.krishijagran.com/news/tomato-at shoots-potato-in-roots

# Concept Map

## Plant Breeding




## Animal Breeding and Biotechnology



# UNIT 21 HEALTH AND DISEASES

## Learning Objectives

TWSGTU

At the end of this lesson the students will be able to:

- Understand the types of abuses and associated behavioural changes.
- Gain knowledge of prevention and protection from child sexual abuse.
- Know the causes for drug, tobacco and alcohol addiction and its effects on health.
- Analyse the possible ways of de-addiction.
- Know about the diseases and disorders associated with lifestyle modification.
- Compare the features of Type-1 and Type-2 diabetes mellitus and relates the signs and symptoms.
- Explain the underlying cause and symptoms for obesity, heart disease, cancer and AIDS.
- Suggest remedial measures for prevention and control of these diseases and disorders.
- To create awareness among the individuals in the society to lead healthy life.

## Introduction

Abuses occur in a variety of forms and are deeply rooted in cultural, social and economic practices. Solving this global problem however requires a much better understanding of its occurrence, causes and consequences with context to sexual and childhood abuse, this is followed by substance abuse. Are people leading healthier lives in today's modern world than their generations did in the past? For instance, smoking cigarettes, alcohol addiction, use of drugs, eating high fat and cholesterol rich diets, excessive intake of junk foods, reduced physical activity are some of the risk factors for illness and early death. The role of behaviour in health has been receiving increased attention in countries around the world. The health habits of the individuals and their behaviour influence the development of chronic and fatal diseases such as diabetes, obesity, heart disease, cancer and AIDS. These conditions can be substantially reduced by adopting lifestyles that promote wellness and protect their health by taking nutritious diet, regular exercise and by avoiding drugs, alcohol and smoking.

## 21.1 Abuse and Types of Abuse

**Abuse** refers to cruel, violent, harmful or injurious treatment of another human being. It includes **physical**, **emotional** or **psychological**, **verbal, child** and **sexual** abuses. Abuse can occur within the family and with people who are not associated with the family.

These days the use of drugs, alcohol and tobacco has been increasing especially among teenagers and adolescents for adventure, excitement, curiosity and experimentation.

Let's analyse some of the consequences of sexual and childhood abuse, its prevention and protection.

### 21.1.1 Child Abuse

Child abuse constitutes all forms of physical or emotional ill treatment, sexual abuse, **exploitation** resulting in child's ill health, survival and development. **Physical abuse** of a child is defined as those acts that cause physical harm such as threatening, beating, kicking and hitting the child.

### 21.1.2 Sexual Abuse

Sexual harassment is a form of power and dominance of one person over another, which can result in harmful consequence to the victim. It refers to inappropriate or forced sexual contact. Adolescent girls and women encounter sexual harassment in different forms. Sexual abuse is more common at work places. Verbal remarks, comments, gestures and looks are the most common forms of abuse. This results in psychological distress, physical illness and eating disorders in the affected individuals.

**More to Know**

The Ministry of Women and Child Development championed the introduction of the Protection of Children from Sexual Offences (POCSO) Act, 2012. People who traffic children for sexual purposes are also punishable under the provisions relating to the Act.


**Objectives of the POCSO Act, 2012**

- To protect children from the offences of
  - Sexual assault
  - Sexual harassment
  - Pornography
- To establish Special Courts for speedy trial of such offences.

### 21.1.3 Child Sexual Abuse

Children are considered soft targets for sexual abuse because they may not realize that they are being abused. Commonly, abusers are persons well known to the child, may even be living in the same locality. Abusers also bribe (use chocolates and toys) to lure children and take advantage of the child's innocence.

Sexually abused children show symptoms of genital injury, abdominal pain, frequent urinary infection and behavioural problems.

### 21.1.4 Approaches for Protection of an Abused Child

Measures adopted for monitoring and assessment of abused child who have undergone signs and symptoms of distress are:

**Child Helpline:** The Child Helpline provides a social worker who can assist the child by providing food, shelter and protection.

**Counselling the child:** Psychologists and social workers should provide guidance, counselling and continous support to a victimized child.

**Family support**: The victimized child should be supported by the family members. They should be provided with proper care and attention to overcome their sufferings.

**Medical care:** A child victim of sexual offences should receive medical care and treatment from health care professionals to overcome mental stress and depression.

**Legal Counsel:** The family or the guardian of the child victim shall be entitled to free assistance of a legal counsel for such offence.

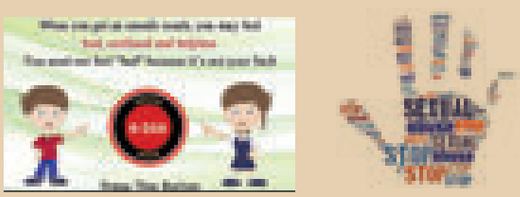
**Rehabilitation:** Enrolling in schools and resuming their education is an important step towards rehabilitation of the child. It is essential that the child's life is gradually returned to normal after the incidence of abuse.

**Community based efforts:** Conducting awareness campaign on child abuse and its prevention.

### More to Know

The National Commission for Protection of Child Rights (NCPCR) was set up in March 2007 under the Commissions for Protection of Child Rights (CPCR) Act, 2005. This act emphasizes the principle of universality and inviolability of child rights and recognizes the tone of urgency in all the child related policies of the country.

Protection of all children of all age group upto 18 years of age is of equal importance. Policies define priority actions for the most vulnerable children.



CHILD HELPLINE 1098

**Prevention of child sexual abuse**

The most important social policy proclaimed universally is the prevention of child abuse. Taking steps to prevent childhood sexual abuse is parental and institutional responsibility. Instructions to be given by parents and teachers to the child are.

- Do not talk to any suspected person or strangers and to maintain a distance.
- Not to be alone with unknown person.
- To be careful while travelling alone in public or private transport.
- Not to receive money, toys, gifts or chocolates from known or unknown person to them without the knowledge of their parents.
- Not to allow known or unknown person to touch them.

It is the responsibility of every individual living in a society to ensure a safe and protected environment for our children to enable them to live with dignity and free from any form of violence.

## 21.2 Drug, Alcohol and Tobacco Abuse

The physical and mental dependency on alcohol, smoking and drugs is called addiction. The addictive potential of these substances pulls an individual into a **vicious cycle** leading to **regular abuse and dependency**. This is of serious concern because abuse of tobacco, alcohol or drugs produce many harmful effects in an individual, to the family and even to the society. This dangerous behavior pattern among youth can be prevented through proper guidance.

## 21.3 Drug Abuse

Drugs are normally used for the treatment of disease on advice of a physician and withdrawn after recovery. A person who is habituated to a drug due to its prolonged use is called **drug addict**. This is called **drug addiction** or **drug abuse**.

A drug that modifies the physical, biological, psychological or social behaviour of a person by stimulating, depressing or disturbing the functions of the body and the mind is called **addictive drug**. These drugs interact with the

central nervous system and affect the individual physically and mentally.

### 21.3.1 Types of Drugs

There are certain drugs called **psychotropic drugs** which acts on the brain and alter the behaviour, consciousness, power of thinking and perception. They are referred as **mood altering drugs**.

### 21.3.2 Drug Dependence

Persons who consume these drugs become fully dependent on them, they cannot live without drugs. This condition is referred as **drug dependence**.

- **Physical and mental dependence** Dependence on the drug for normal condition of well being and to maintain physiological state.
- **Psychological dependence** is a feel that drugs help them to reduce stress.

DO YOU KNOW?

- International Day against Drug Abuse and Illicit Trafficking - June 26.
- Narcotic Drugs and Psychotropic Substances Act was introduced in 1985.

### 21.3.3 Behavioural Changes of Drug Users

Adverse effects of drug use among adolescents are

- Drop in academic performance, absence from school or college.
- Lack of interest in personal hygiene, isolation, depression, fatigue and aggressive behaviour.
- Deteriorating relationship with family and friends.
- Change in food and sleeping habits.
- Fluctuation in body weight and appetite
- Always looking out for an easy way to get money for obtaining drugs.
- Prone to infections like AIDS and Hepatitis-B.

DO YOU KNOW?

World Health Organization (WHO) 1984 suggested the use of the term drug dependence in place of drug addiction or drug abuse

### 21.3.4 Drug De-addiction

Management of de-addiction is a complicated and difficult task. The path to recovery of drug addicts is long and often slow.

Family members, friends and society on the whole have a very important role to play.

TX2CVH

**Detoxification:** The first phase of treatment is detoxification. The drug is stopped gradually and the addict is helped to **overcome the withdrawal symptoms**. The addict undergoes severe physical and emotional disturbance. This is taken care by specific medication.

**Psychotherapy:** Individual and group counselling is given by psychologists and counsellors. The treatment includes efforts to reduce the addict's stress, taught new ways to solve everyday's problems, adequate diet, rest and relaxation.

**Counselling to family members:** Social workers counsell family members in order to change the **attitude of rejection** so that the addict is accepted by the family and the society.

**Rehabilitation:** They are given proper **vocational training** so that they can lead a healthy life and become useful members of the society.

## 21.4 Tobacco Abuse

Tobacco is obtained from the tobacco plant *Nicotiana tobaccum* and *Nicotiana rustica*. The dried and cured leaves of its young branches make the commercial tobacco used worldwide. Addiction to tobacco is due to '**nicotine**' an alkaloid present in it. Nicotine is a **stimulant**, highly harmful and poisonous substance.

### 21.4.1 Tobacco Use

Tobacco is used for smoking, chewing and snuffing. Inhaling tobacco smoke from cigars, cigarettes, bidis, pipes, hukka is called **smoking**. Tobacco in powder form is **chewed** with pan. When powdered tobacco is taken through nose, it is called **snuffing**.

### 21.4.2 Smoking Hazards and Effects of Tobacco

When smoke is inhaled, the chemicals get absorbed by the tissues and cause the following harmful effects

(i) **Benzopyrene** and **polycyclic hydrocarbons** present in tobacco smoke is carcinogenic causing lung cancer.

(ii) Causes inflammation of throat and bronchi leading to conditions like **bronchitis** and **pulmonary tuberculosis.**

(iii) Inflammation of lung alveoli, decrease surface area for gas exchange and cause **emphysema.**

(iv) **Carbon monoxide** of tobacco smoke binds to haemoglobin of RBC and decreases its oxygen carrying capacity causing **hypoxia** in body tissues.

(v) **Increased blood pressure** caused by smoking leads to increased risk of heart disease.

(vi) Causes **increased gastric secretion** which leads to gastric and duodenal ulcers.

(vii) Tobacco chewing causes **oral cancer** (mouth cancer).

**Info bits**

World Health organization (WHO) 1984 suggested the use of the term drug. WHO issued a directive under which all cigarette advertisements and packs carry a statutory warning **"Smoking is injurious to Health".**

**Activity 1**

Collect pictures of people affected by tobacco chewing and tobacco smoking. Identify which part of the body is affected and the health hazards it can lead to.

### 21.4.3 Prevention of Smoking

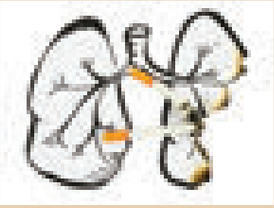
Knowing the dangers of smoking and chewing tobacco adolescents and the old people need to avoid these habits. Proper counselling and medical assistance can help an addict to give up the habit of smoking.

**More to Know**

Anti Tobacco Act was passed on May 1st 2004. By 2030 tobacco is expected to be single biggest cause of death worldwide accounting for 10 million deaths per year.

May 31st is observed as No Tobacco Day (World Anti-Tobacco Day)





## 21.5 Alcohol Abuse

The consumption of alcohol is a social evil practiced by the wealthier and poorer sections of the society. The dependence of alcohol is called **alcoholism** and the addict is termed as **alcoholic**. It is called **alcohol abuse**. Drinking of alcohol impairs one's physical, physiological and psychological functions.

### Activity 2

Collect pictures of individuals with normal liver and alcoholic liver, compare and indicate the changes you find in them.

### 21.5.1 Harmful Effects of Alcohol to Health

Prolonged use of alcohol depresses the nervous system, by acting as a sedative and analgesic substance. Some of the harmful effects are

- Nerve cell damage resulting in various mental and physical disturbances
- Lack of co-ordination of body organs
- Blurred or reduced vision, results in road accidents
- Dilation of blood vessels which may affect functioning of the heart
- Liver damage resulting in fatty liver which leads to cirrhosis and formation of fibrous tissues
- Body loses its control and consciousness eventually leading to health complications and ultimately to death


## 21.6 Rehabilitation Measures for Alcoholics

**Education and counselling**: Education and proper counselling will help the alcoholics to overcome their problems and stress, to accept failures in their life.

**Physical activity**: Individuals undergoing rehabilitation should be channelized into healthy activities like reading, music, sports, yoga and meditation.

**Seeking help from parents and peer groups**: When a problematic situation occurs, the affected individuals should seek help and guidance from parents and peers. This would help them to share their feeling of anxiety, wrong doing and get rid of the habit.

**Medical assistance**: Individual should seek help from psychologists and psychiatrists to get relieved from this condition and to lead a relaxed and peaceful life.

Alcohol de-addiction and rehabilitation programmes are helpful to the individual so that they could get rid of the problem completely and can lead a normal and healthy life.

## 21.7 Diseases and Disorders due to Lifestyle Modifications

Diseases are prevalent in our society due to our improper way of living, conditions of stress and strain. These diseases are non-communicable and affect the person who are suffering from particular symptoms. It is an impairment of the body tissue or organ, disturbances in metabolic function which require modification of an individual's normal life.

## 21.8 Diabetes Mellitus

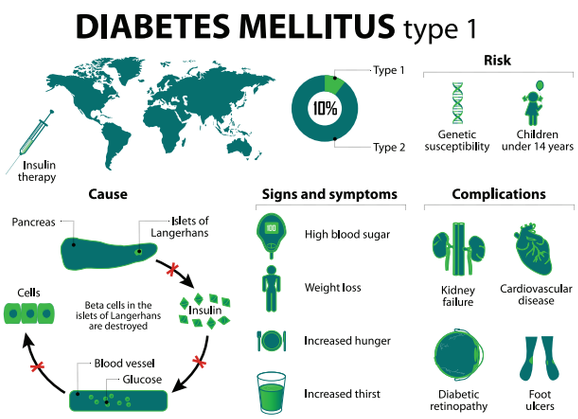
Diabetes mellitus is a chronic metabolic disorder. In Greek (Diabetes – running through; mellitus- sweet). It is characterised

by **increased blood glucose level** due to **insufficient**, **deficient** or **failure of insulin secretion**. This is the most common pancreatic endocrine disorder. The incidence of Type-1 and Type-2 diabetes is increasing worldwide.

### 21.8.1 Type-1 Insulin Dependent Diabetes Mellitus (IDDM)

IDDM accounts for 10 to 20% of the known diabetics. The condition also occurs in children (**juvenile onset diabetes**) and **young adults**, the onset is usually sudden and can be life threatening. This is caused by the **destruction of β-cells of the pancreas**. It is characterized by abnormally elevated blood glucose levels (**hyperglycemia**) resulting from **inadequate insulin secretion**.

**Causes**: Genetic inheritance and environmental factors (infections due to virus, acute stress) are the cause for this condition.




### 21.8.2 Type-2 Non-Insulin Dependent Diabetes Mellitus (NIDDM)

This is also called as **adult onset diabetes** and accounting for 80 to 90% of the diabetic population. It develops slowly, usually milder and more stable. **Insulin production by the pancreas is normal** but its **action is impaired**. The target cells do not respond to insulin. It does not allow the movement of glucose into cells.

**Causes**: The causes are multifactorial which include increasing age (affecting middle aged and older people), obesity, sedentary life style, overeating and physically inactive.

**More to Know**

One in every 8 individuals in India is a diabetic. The revised WHO estimates for the year 2025 is 57.2 million diabetics in India. The average age for the onset of diabetes is 40 years, while it is 55 years in other countries. World Health Organizaation projects that diabetes will be 7th leading cause of death by the year 2030.

**Symptoms:** Diabetes mellitus is associated with several metabolic alterations.The most important symptoms are

- Increased blood glucose level (**Hyperglycemia**)
- Increased urine output (**Polyuria**) leading to dehydration
- Loss of water leads to thirst (**Polydipsia**) resulting in increased fluid intake
- Excessive glucose excreted in urine (**Glycosuria**)
- Excess hunger (**Polyphagia**) due to loss of glucose in urine.
- Fatigue and loss of weight

**DO YOU KNOW?**

According to WHO recommendation, if the fasting blood glucose is greater than 140 mg/dl or the random blood glucose is greater than 200 mg /dl on more than two occasions, diagnosis for confirming diabetes is essential.

### 21.8.3 Prevention and Control of Diabetes

Diet, hypoglycemic drugs, insulin injection and exercise are the management options based on the type and severity of the condition. The overall goal of diabetes management is to maintain normal blood glucose level.

**Table 21.1** Differences between Type-1 and Type-2 Diabetes Mellitus

| Factors | Type-1 Insulin dependent diabetes mellitus (IDDM) | Type-2 Non-insulin dependent diabetes mellitus (NIDDM) |
|---|---|---|
| Prevalence | 10-20% | 80-90% |
| Age of onset | Juvenile onset (< 20 years) | Maturity onset (>30 years) |
| Body weight | Normal or Underweight | Obese |
| Defect | Insulin deficiency due to destruction of β-cells | Target cells do respond to insulin |
| Treatment | Insulin administration is necessary | Can be controlled by diet, exercise and medicine |

**Dietary management**: Low carbohydrate and fibre rich diets are more appropriate. Carbohydrates should be taken in the form of starch and complex sugars. Refined sugars (sucrose and glucose) should be avoided. Diet comprising whole grains, millets (jowar, bajra, ragi), green leafy vegetables, wheat and unpolished rice should be included in diet regularly.

Carbohydrates is maintained to about 50-55% of the total calories. High protein content of 10-15% of the total intake is required to supply essential amino acids. Fat content in the diet should be 15-25% of the total calories. Saturated fat intake should be reduced. Polyunsaturated fatty acid content should be higher.

**Management with insulin**: Commercially available insulin preparations (short and long acting) are also used to maintain blood glucose levels.

**Physical activity**: Exercise plays an important role in facilitating a good control of diabetes, in addition to strengthening and toning up the muscles.

**Education and Awareness**: People with diabetics should be educated on the nature of disease they have and the possibility of complications of the disease, if blood sugar is not kept under control. Instructions regarding diet, exercise and drugs should be explained.

**Info bits**

Flax seeds containing insoluble fibre, Guavas, Tomatoes and Spinach are foods which help reduce blood sugar levels.

## 21.9 Obesity

Obesity is the state in which there is an accumulation of excess body fat with an **abnormal increase in body weight**. Obesity is a complex multifactorial chronic disease developing from influence of social, behavioural, psychological, metabolic and cellular factors.

Obesity occurs if intake of calories is more than the expenditure of energy. Over weight and obesity are conditions where the body weight is greater than the mean standard weight for age and height of an individual. Body mass index (BMI) is an estimate of body fat and health risk.

$$\text{BMI} = \text{Weight (kg)} / \text{Height (m)}^2$$

**More to Know**

Every 7 calories of excess consumption leads to 1 gm fat deposit and increase in body weight. Weight due to fat in adipose tissue exceeds more than 20% to 25 % of body weight. An adult weighing 10% more than the standard weight is OVERWEIGHT and 20% more is OBESE.

**Causes and risk factors**: Obesity is due to genetic factors, physical inactivity, eating habits (overeating) and endocrine factors. Obesity is a positive risk factor in development of hypertension, diabetes, gall bladder disease, coronary heart disease and arthritis.

### 21.9.1 Prevention and Control of Obesity

**Diet Management:** Low calorie, normal protein, vitamins and mineral, restricted carbohydrate and fat, high fiber diet can prevent overweight. Calorie restriction for weight reduction is safe and most effective.

**Physical exercise**: A low calorie diet accompanied by moderate exercise will be effective in causing weight loss. Meditation, yoga and physical activity can also reduce stress related to overeating.

## 21.10 Heart Disease

Cardiovascular disease (CVD) is associated with diseases of the heart and blood vessels. **Coronary heart disease** (CHD) is the most common form and is caused by **deposition of cholesterol in the blood vessels**.

It usually develops slowly over many years beginning from childhood, they may form a fatty streak to a fibrous complicated **plaque**. It leads to the narrowing of blood vessels leading to **atherosclerosis** in the large and medium sized arteries that supply the heart muscle with oxygen. It leads to sudden **ischemia** (deficient blood supply to heart muscle) and **myocardial infarction** (death of the heart muscle tissue).

**More to Know**

Desirable level for blood cholesterol should be less than 200 mg/dl for Indians. The risk of coronary heart disease increases slowly as blood cholesterol levels increases from 200 to 300 mg/dl.

**Risk factors**: Hypercholesterolemia (High blood cholesterol) and high blood pressure (Hypertension) are the major causes and contributing factors for heart disease and if untreated may cause severe damage to brain, kidney and eventually lead to stroke.

**Causes**: Heredity (family history), diet rich in saturated fat and cholesterol, obesity, increasing age, cigarette smoking, emotional stress, sedentary lifestyle, excessive alcohol consumption and physical inactivity are some of the causes.

**Symptoms:** Shortness of breath, headache, tiredness, dizziness, chest pain, swelling of leg, and gastrointestinal disturbances.

DO YOU KNOW?

**HDL** (High Density Lipoprotein) or "**good**" cholesterol lowers risk of heart disease while **LDL** (Low Density Lipoprotein) or "**bad**" cholesterol increases risk of heart disease.

### 21.10.1 Prevention and Control of Heart Disease

**Diet management:** Reduction in the intake of calories, low saturated fat and cholesterol rich food, low carbohydrates and common salt are some of the dietary modifications. Diet rich in polyunsaturated fatty acids (PUFA) is essential. Increase in the intake of fibre diet, fruits and vegetables, protein, minerals and vitamin are required.

**Physical activity:** Regular exercise, walking and yoga are essential for body weight maintenance

**Addictive substance avoidance**: Alcohol consumption and smoking are to be avoided.

**Activity 3**

Prepare a chart showing the food items which are preferable and which should be avoided to prevent high blood pressure and heart disease. Apart from diet what are the other lifestyle modifications to be followed to manage this condition.

## 21.11 Cancer

Cancer causes about 4 million deaths annually throughout the world. In India more than one million people suffer from cancer. Cancer is derived from Latin word meaning crab. The study of cancer is called **Oncology** (**Oncos- Tumor**).

Cancer is an abnormal and uncontrolled division of cells that invade and destroy surrounding tissue forming a tumor or **neoplasm** (new growth). It is a heterogenous group of cells that do not respond to the normal cell division.

The cancerous cells migrate to distant parts of the body and affect new tissues. This process is called **metastasis**. The frequent sites of metastasis are lungs, bones, liver, skin and brain.

**More to Know**

World Cancer Day - 4th February

National Cancer Awareness Day -7th November

### 21.11.1 Types of Cancers

Cancers are classified on the basis of the tissues from which they are formed.

1. **Carcinomas** arise from **epithelial** and **glandular tissues**. They include cancers of skin, lung, stomach and brain. About 85% of the tumours are carcinomas
2. **Sarcomas** are occur in the **connective** and **muscular tissue.** They include the cancer of bones, cartilage, tendons, adipose tissue and muscles. These form 1% of all tumours.

**More to Know**

**Types of Tumours**

**Benign tumours or Non malignant tumours**: Remain confined in the organ affected and do not spread to other parts of the body.

**Malignant tumours**: Mass of proliferating cells which grow very rapidly invading and damaging the surrounding normal tissues.

3. **Leukaemia** are characterized by an increase in the formation of white blood cells in the bone marrow and lymph nodes. Leukaemia are called **blood cancers.** Most common type of cancer which also affect children below 15 years of age.

### 21.11.2 Carcinogenic Agents

Cancer causing agents are called **carcinogens**. They are physical, chemical agents, ionizing radiations and biological agents.

**Physical Irritant:** Heavy smoking causes lung cancer and cancers of oral cavity, pharynx (throat) and larynx. Betel and tobacco chewing causes oral cancer. Excessive exposure to sunlight may cause skin cancer.

**Chemical agents**: Nicotine, caffeine, products of combustion of coal and oil, pesticides, asbestos, nickel, certain dyes and artificial sweetners induce cancer.

**Radiations:** Ionizing radiations like X-rays, gamma- rays, radioactive substances and non-ionising radiations like UV rays cause DNA damage leading to cancer.

**Biological agents:** Cancer causing viruses are called oncogenic viruses.

### 21.11.3 Treatment of Cancer

The treatment of cancer involves the following methods:

**Surgery:** Tumours are removed by surgery to prevent further spread of cancer cells.

**Radiation therapy**: Tumour cells are irradiated by lethal doses of radiation while protecting the surrounding normal cells.

**Chemotherapy:** It involves administration of anticancerous drugs which prevent cell division and are used to kill cancer cells.

**Immunotherapy:** Biological response modifiers like interferons are used to activate the immune system and help in destroying the tumors.

### 21.11.4 Preventive measures for Cancer

Cancer control programmes should focus on primary prevention and early detection.

To prevent lung cancer tobacco smoking is to be avoided and protective measures to be taken against exposure to toxic pollutants of industries. Excessive exposure to radiation is to be avoided to prevent skin cancer.

## 21.12 AIDS (Acquired Immunedeficiency Syndrome)

AIDS is a severe viral disease and caused by Human Immunodeficiency Virus (HIV). It is a condition in which immune system fails and **suppress the body's disease fighting mechanism**. They **attack the lymphocytes** and the affected individual is prone to infectious diseases.

DO YOU KNOW?

Dr. Suniti Solomon, pioneered HIV research and treatment in India. She set up the first voluntary testing and counselling centre and an AIDS Research group in Chennai during 80's. Her team was the first to document evidence of HIV infection in India in 1985 (First Indian AIDS patient in Chennai).

### 21.12.1 Transmission of HIV

AIDS virus has been found in urine, tears, saliva, breast milk and vaginal secretions. The virus is transmitted by an infected patient who comes in contact with blood of a healthy person. HIV/AIDS is not transmitted by touch or any physical contact. It spreads through contact of body fluids or blood.

HIV is transmitted generally by

(i) Sexual contact with infected person

(ii) Use of contaminated needles or syringes especially in case of intravenous drug abusers

(iii) By transfusion of contaminated / infected blood or blood products

(iv) From infected mother to her child through placenta.

### 21.12.2 Symptoms and Treatment of AIDS

**Symptoms:** Infected individuals become immunodeficient. The person becomes more susceptible to viral, bacterial, protozoan and fungal infections. Swelling of lymph nodes, damage to brain, loss of memory, lack of appetite and weight loss, fever, chronic diarrhoea, cough, lethargy, pharyngitis, nausea and headache.

**Diagnosis:** The presence of HIV virus can be confirmed by **Western Blot** analysis or **Enzyme Linked Immunosorbent Assay** (ELISA)

**Treatment:** Anti-retroviral drugs and immunostimulative therapy can prolong the life of the infected person.

### 21.12.3 Prevention and Control of AIDS

The following steps may help in controlling and prevent the spreading of HIV infection

(i) Screening of blood from blood banks for HIV before transfusion.

(ii) Ensuring the use of disposable needles and syringes in hospitals and clinics.

(iii) Advocating safe sex and advantages of using condoms.

(iv) Creating awareness campaign and educating people on the consequences of AIDS.

(v) Persons with HIV/AIDS should not be isolated from the family and society.

## More to Know

Many people are ignorant about AIDS and it has been said that – "don't" die of ignorance". In our country NACO (National AIDS Control Organization) and other NGO'S (Non- Governmental Organizations) are educating people about AIDS. Every year December 1st is observed as the "World AIDS Day".

## Points to Remember

- Use of certain drugs by an individual as a regular habit. This is called drug addiction or drug abuse.
- Tobacco is used for smoking, chewing and snuffing. Inhaling tobacco smoke is called smoking.
- The dependence of alcohol is called alcoholism and the addict is termed as alcoholic.
- Prolonged use of alcohol depresses the nervous system, by acting as a sedative and analgesic substance and causes fatty liver (cirrhosis).
- Diabetes mellitus is a chronic metabolic disorder. It is characterised by increased blood glucose level due to insufficient, deficient or failure of insulin secretion and insulin resistance.
- Obesity is the state in which there is an accumulation of excess body fat with an abnormal increase in body weight.
- Coronary heart disease is the most common form and is caused by deposition of cholesterol in the blood vessels.
- Cancer is an abnormal and uncontrolled division of cells that invade and destroy surrounding tissue forming a tumor or neoplasm.
- AIDS is caused by Human immunodeficiency virus.

## TEXTBOOK EVALUATION

UCBBV6

### I. Choose the correct answer

1. Tobacco consumption is known to stimulate secretion of adrenaline. The component causing this could be
   a) Nicotine b) Tannic acid
   c) Curcumin d) Leptin
2. World 'No Tobacco Day' is observed on
   a) May 31 b) June 6
   c) April 22 d) October 2
3. Cancer cells are more easily damaged by radiations than normal cells because they are
   a) Different in structure
   b) Non-dividing
   c) Mutated Cells
   d) Undergoing rapid division
4. Which type of cancer affects lymph nodes and spleen?
   a) Carcinoma b) Sarcoma
   c) Leukemia d) Lymphoma
5. Excessive consumption of alcohol leads to
   a) Loss of memory
   b) Cirrhosis of liver
   c) State of hallucination
   d) Supression of brain function
6. Coronary heart disease is due to
   a) *Streptococci* bacteria
   b) Inflammation of pericardium
   c) Weakening of heart valves
   d) Insufficient blood supply to heart muscles
7. Cancer of the epithelial cells is called
   a) Leukemia b) Sarcoma
   c) Carcinoma d) Lipoma

8. Metastasis is associated with
   a) Malignant tumour b) Benign tumour
   c) Both (a) and (b) d) Crown gall tumour
9. Polyphagia is a condition seen in
   a) Obesity b) Diabetes mellitus
   c) Diabetes insipidus d) AIDS
10. Where does alcohol effect immediately after drinking?
   a) Eyes b) Auditory region
   c) Liver d) Central nervous system

## II. State whether True or False, if false write the correct statement

1. AIDS is an epidemic disease.
2. Cancer causing genes are called Oncogenes.
3. Obesity is characterized by tumour formation.
4. In leukemia both WBCs and RBCs increase in number.
5. Study of cause of disease is called etiology.
6. AIDS is not transmitted by contact with a patient's clothes.
7. Type 2 diabetes mellitus results due to insulin deficiency.
8. Carcinogens are cancer causing agents.
9. Nicotine is a narcotic drug.
10. Cirrhosis is associated with brain disorder.

## III. Expand the following abbreviations

1. IDDM 2. HIV 3. BMI
4. AIDS 5. CHD 6. NIDDM

## IV. Match the following

| | | |
|---|---|---|
| 1. Sarcoma | - | Stomach cancer |
| 2. Carcinoma | - | Excessive thirst |
| 3. Polydipsia | - | Excessive hunger |
| 4. Polyphagia | - | Lack of blood flow to heart muscle |
| 5. Myocardial Infarction | - | Connective tissue cancer |

## V. Fill in the blanks

1. Cirrhosis is caused in liver due to excessive use of _____
2. A highly poisonous chemicals derived from tobacco is _____
3. Blood cancer is called _____.
4. Less response of a drug to a specific dose with repeated use is called _____
5. Insulin resistance is a condition in _____diabetes mellitus

## VI. Analogy type questions. Identify the first words and their relationship and suggest a suitable word for the fourth blank

1. Communicable: AIDS: Non communicable: _____
2. Chemotherapy: Chemicals: Radiation therapy: _____
3. Hypertension: Hypercholesterolomia: Glycosuria: _____

## VII. Answer in a sentence

1. What are psychotropic drugs ?
2. Mention the diseases caused by tobacco smoke.
3. What are the contributing factors for Obesity?
4. What is adult onset diabetes?
5. What is metastasis?
6. How does insulin deficiency occur?

## VIII. Short answer questions

1. What are the various routes by which transmission of human immuno deficiency virus takes place ?
2. How is a cancer cell different from a normal cell ?
3. Differentiate between Type-1 and Type-2 diabetes mellitus
4. Why is a dietary restriction recommended for an obese individual ?
5. What precautions can be taken for preventing heart diseases ?

## IX. Long answer questions

1. Suggest measures to overcome the problems of an alcoholic.

2. Changes in lifestyle is a risk factor for occurrence of cardiovascular diseases. Can it be modified ? If yes, suggest measures for prevention.

## X. Higher Order Thinking Skills (HOTS)

1. What is the role of fat in the cause of atherosclerosis ?
2. Eating junk food and consuming soft drinks results in health problems like obesity, still children prefer. What are the suggestions you would give to avoid children eating junk food/ consumption of soft drinks?
3. Regular physical exercise is advisable for normal functioning of human body. What are the advantages of practising exercise in daily life?
4. A leading weekly magazine has recently published a survey analysis which says that number of AIDS patient in the country is increasing day by day. The report says that the awareness among the people about AIDS is still very poor. You are discussing the magazine report in your class and a team of your class decides to help people to fight against the dreadful disease.
   a) What problem you face when trying to educate the people in your village near by your school?
   b) How do you overcome the problem ?

## XI. Value based questions

1. Once a person starts taking drugs or alcohol it is difficult to get rid of the habit. Why ?
2. Men addicted to tobacco lead to oxygen deficiency in their body. What could be the possible reason?
3. Name any three foods that are to be avoided and included in the diet of a diabetic patient. Why should it be followed?
4. How can informational efforts change people's HIV knowledge and behaviour?

## XII. Assertion and Reasoning

In each of the following questions, a statement of Assertion is given and a corresponding statement of Reason is given just below it. Of statements given below mark the correct answer as

a. If both Assertion and Reason are true and Reason is the correct explanation of Assertion
b. If both Assertion and Reason are true that Reason is not the correct explanation of Asssertion
c. Assertion is true but Reason is false
d. Both Assertion and Reason are false

**1.** **Assertion:** All drugs act on the brain.
**Reason:** Drugs disturb the functioning of the body and mind.

**2.** **Assertion:** Excretion of excess glucose in urine is observed in a person with diabetes mellitus.
**Reason:** Pancreas is unable to produce sufficient quantity of insulin.

## REFERENCE BOOKS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3. Sathyanarayana U. Biochemistry – Revised Edition, Books and (P) Ltd, Kolkata.

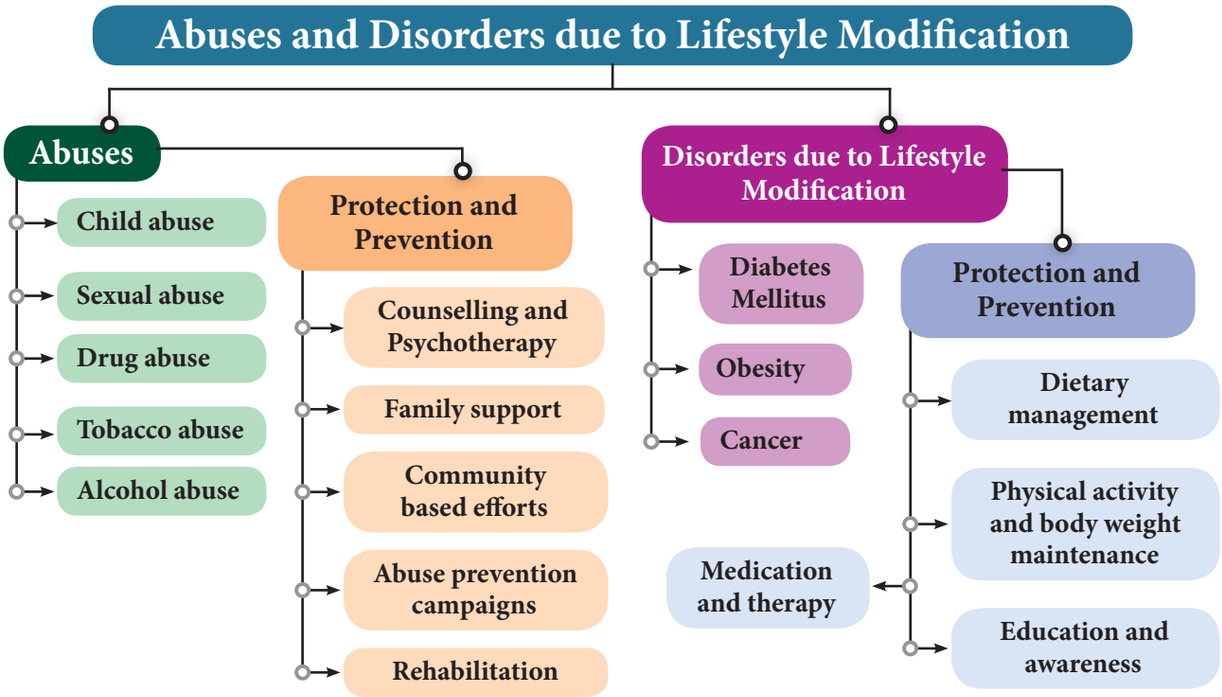

## INTERNET RESOURCES

https://www. ross and wilson.com / lecturers

https://www.elsevier health.com

https://www.ncpcr.gov.in

# Concept Map



# UNIT 22 ENVIRONMENTAL MANAGEMENT

## Learning Objectives

URU6WH

At the end of this lesson the students will be able to:

- Differentiate between renewable and non-renewable resources.
- Gain knowledge about the need for conservation of various natural resources.
- To know the various methods which can be adopted of conservation of natural resources.
- Create awareness about the limited exploitation of natural resources.
- Get motivated to participate in the protection of environment and its management.

## Introduction

Environmental management deals with the different aspects of environment, its structure, function, its quality and its maintenance including conservation of its living and non-living components. The diversified natural resources on this earth provide the necessities for survival of all forms of life including man. Everything that comes from nature has some utility for man but its utilization is possible based on the availability of appropriate technology.

Resources can be renewed simultaneously along with their exploitation (forests, crops, wildlife, groundwater, wind and solar energy). They can maintain themselves by natural recycling or can be replenished by proper management. Simultaneously, non-renewable resources cannot be recycled and can get exhausted by unlimited and continous use (mineral ores, coal, petroleum etc). They cannot be replaced easily. This would lead to a situation where non-renewable resources may come to an end after a certain period of time.

Expanding human population resulted in expanding needs of man. With scientific and technological advancement man started utilizing natural resources at a much larger scale. Continuous increase in population caused an increased demand for resources. Therefore, conservation of natural resources makes important contributions to the social and economic development of the country.

## 22.1 Conservation and Judicious Use of Resources

Natural resources are conserved for their biological, economic and recreational values. The use of natural resources in excess and unplanned way leads to imbalance in the environment. A judicious balance should be maintained between exploitation of resources and its replenishment. Proper utilization and

management of nature and its resources is termed as **conservation**.

We have to build a sustainable world, which should last forever. Some of the ways to sustain continuous use of resources are practices to utilise energy efficiently, avoid wastage of water, avoid usage of plastics and other non-biodegradable materials and to take care for the environment we live. It is important that we manage and use our resources carefully so as to preserve for the future generations.

## 22.2 Forest and its Importance

Forests are an important component of our environment and are dominated by microorganisms, flowering plants, shrubs, climbers, dense trees and provide a vast habitat for wild animals. Forests also contribute to the economic development of our country. Forests are vital for human life, it is a source for a wide range of **renewable natural resource**. They provide wood, food, fodder, fibre and medicine.

Forests are major factor of environmental concern. They act as carbon sink, regulate climatic conditions, increase rainfall, reduce global warming, prevent natural hazards like flood and landslides, protect wildlife and also act as catchments for water conservation. They also play a vital role in maintaining the ecological balance.

### 22.2.1 Deforestation and its Effects

Deforestation is the destruction of large area of forests. This happens for many reasons like intensive agriculture, urbanization, construction of dams, roads, buildings and industries, hydroelectric projects, forest fires, construction of mountain and forest roads. It is a threat to the economy, quality of life and future of the environment. India is losing about 1.5 million hectares of forest cover every year.

**More to Know**

**Chipko movement**

The Chipko movement was a non-violent agitation in 1973 that was aimed at protection and conservation of trees. The name of the movement '**Chipko**' comes from the word 'embrace', as the villagers hugged the trees and encircled them to prevent them from being cut. The movement originated in the Chamoli district of Uttar Pradesh (now Uttarakhand). The protest of Chipko movement achieved a major victory in 1980 with a 15 year ban on cutting trees in the Himalayan forests.

#### Effects of Deforestation

Deforestation gives rise to ecological problems like floods, drought, soil erosion, loss of wild life, extinction of species, imbalance of biogeochemical cycles, alteration of climatic conditions and desertification.

### 22.2.2 Conservation of Forests

India has an area of 752.3 lakh hectare classified as **reserved forests** and 215.1 lakh hectare as **protected forests**. The important measures taken for conservation of forests are as follows

**Afforestation:** Activities for afforestation programme (**Van Mahotsav**) includes planting and protecting trees with multiple uses which help in restoration of green cover. Destruction of trees should be curtailed.

**Social forestry programme:** It should be undertaken on a large scale with active participation of the public and utilization of common land to produce firewood, fodder and timber for the benefit of the rural community. This relieves pressure on existing forests and to safeguard future of tribals.

**Forest Conservation through Laws:** Adopting stringent laws and policies to conserve and protect forests are through National Forest Policy, (1952 and 1988) and Forest Conservation Act, 1980.

## 22.3 Wildlife and its Conservation

Wild life refers to the undomesticated animals living in their natural habitats (forests, grasslands and deserts) an area without human habitation. They are needed for maintaining biological diversity. It also helps in promoting economic activities that generates revenue through tourism. Conservation of forest and wildlife is interrelated with each other.

### 22.3.1 Decline in Wildlife Population

Wildlife of India is a great natural heritage. Exploitation of wildlife resources has decreased global wildlife population by 52% between 1970 and 2014. Over exploitation and shrinking of forest cover areas has resulted in animals becoming extinct, some are threatened and some are on the verge of extinction. In recent years, increase in human encroachment has posed a threat to India's wildlife.

### 22.3.2 Aims of Wildlife Management

The main aim of wildlife conservation are:

- To control and limit exploitation of species.
- To preserve the plants and animals from extinction.
- Maintenance of threatened species and protect species which are on the verge of extinction.
- Preserve the endangered species.
- To study the ecological relationship of the plants and animals in natural habitat.
- Hunting and poaching should be prohibited.
- Establishment of National parks, Wildlife sanctuaries, protected areas and Biosphere reserves.

**The Wildlife protection Act** was established in **1972.** The provisions of the act are

- Prohibit killing and hunting of specified animals.
- Constitute sanctuaries, national parks, and closed areas for wildlife conservation.
- Special schemes for preservation of endangered species.
- Constitute Central Zoo Authority and recognition of zoos.
- Restrict, regulate or prohibit trade in wild animals and products obtained from them.

DO YOU KNOW?

- Jim Corbett National Park was the first to be established in 1936 in Uttarakhand, India.
- There are 15 biosphere reserves in India.
- The Nilgiris is a biosphere reserve in Tamil Nadu.

### 22.3.4 Organisations Involved in Conservation of Wildlife

(i) Indian Board for WildLife (IBWL)

(ii) World Wildlife Fund (WWF) for Nature

(iii) World Conservation Union (WCN)

(iv) International Union for Conservation of Nature and Natural resources (IUCN)

(v) Convention of International Trade in Endangered Species (CITES)

(vi) Bombay Natural History Society (BNHS)

(vii) Wild life Preservation Society of India, Dehradun

DO YOU KNOW?

Rathika Ramasamy, a native of Venkatachalapuram village, Theni District in Tamil Nadu was the first Indian woman to strike an International reputation as wildlife photographer. Her passion is towards bird photography. A photobook on wildlife titled "The best of wildlife moments" was published in November 2014.

**Info bits**

**Wildlife Conservation Initiatives In India.**

- Project Tiger and Project Elephant has been launched in 1973 and 1992 respectively
- Crocodile Conservation Project was launched in 1976.
- Sea Turtle Conservation Project was launched in 1999.
- Indian Rhino Vision 2020 is to conserve at least 3000 greater one-horned rhinos in Assam, India by 2020.

## 22.4 Soil Erosion

The top layers of soil contain humus and mineral salts, which are vital for the growth of plants. Removal of **upper layer of soil** by wind and water is called soil erosion. Soil erosion causes a significant loss of humus, nutrients and decrease the fertility of soil.

### 22.4.1 Agents of Soil Erosion

Agents of soil erosion are high velocity of wind, air currents, flowing water, landslide, human activities (deforestation, farming and mining) and overgrazing by cattle.

### 22.4.2 Management of Soil Erosion

- Retain vegetation cover, so that soil is not exposed.
- Cattle grazing should be controlled.
- Crop rotation and soil management improve soil organic matter.
- Runoff water should be stored in the catchment.
- Reforestation, terracing and contour ploughing.
- Wind speed can be controlled by planting trees in form of a shelter belt.

## 22.5 Renewable and Non-Renewable Energy Resources

Energy is an important input for development. The expansion of possible energy resources has been directly related with the pace of agricultural and industrial development in every part of the world. Energy resources can be classified as non-renewable and renewable.

**Non-renewable (Exhaustible) energy resources**

Energy obtained from sources **that cannot renew themselves** over a short period of time is known as non-renewable energy. These are available in limited amount in nature. They include coal, petroleum, natural gas and nuclear power. These **conventional energy resources** account for 90% of the world's production of commercial energy and nuclear power account for 10%.

**Renewable (Inexhaustible) energy resources**

These energy resources are available in unlimited amount in nature and they can be **renewed over a short period of time**, inexpensive and can be harvested continuously. These comprise the vast potential of **non-conventional energy resources** which include biofuel, biomass energy, geothermal energy, water energy (hydroelectric energy and tidal energy), solar energy, wave energy and wind energy.

### 22.5.1 Fossil Fuels

Fossil fuels are found inside the earth's crust and are energy rich substances formed by natural process, such as **anaerobic decomposition of buried dead organisms**, over millions of years. As the accumulating sediment layers produce heat and pressure, the remains of the organisms are gradually transformed into hydrocarbons. e.g. petroleum, coal and natural gas.

### 22.5.2 Coal and Petroleum

Coal and Petroleum are **natural resources**. They are called **fossil fuels** as they are formed from the degradation of biomass buried deep under the earth millions of years ago.

DO YOU KNOW?

India is the third largest consumer of crude oil in the world, after the United States and China.

**Coal** is used for **generation of electricity** at Thermal power plants. **Petroleum** also known as **crude oil** is processed in oil refineries to produce **petrol** and **diesel** which are used to run automobiles, trucks, trains, ships and airplanes etc. **Kerosene** and **LPG** (Liquefied Petroleum Gas) obtained from petroleum is used as domestic fuel for cooking food.

The coal and petroleum reserves can get exhausted if we continue using them at a rapid rate. The formation of these fossil fuels is a very slow process and takes very long period of time for renewal.

### 22.5.3 Steps to Conserve Coal and Petroleum Resources

It is necessary to conserve or save coal and petroleum resources for the future use, which can be done by reducing their consumption.

(i) If electricity is saved, it will inturn reduce the use of coal

(ii) Using bicycle for covering short distances instead of using cars, scooters or motorcycles

(iii) Using pressure cooker can reduce the consumption of kerosene and LPG while cooking food. Solar cooker and solar heaters can be used wherever possible

(iv) Motor vehicles should be designed with fuel efficient engines to increase efficiency and also reduce air pollution

**Case study of Taj Mahal**

The Taj Mahal is one of the seven wonders of the world and is located in Agra, Uttarpradesh. It is built with white marble. The Mathura oil refinery owned by Indian Oil Corporation present around this area produce sulphur and nitrogen oxides. The white marble became yellow due to air pollution. The Government of India has set up emission standards around the monument to protect it from the damage.

## 22.6 Non-Conventional (Alternative) Energy Resources

The energy crisis has shown that for sustainable development in energy sector we must conserve the non-renewable conventional resources from its rapid depletion and replace them by non-polluting, renewable sources which are environmentally clean.

Efforts are made to develop new sources of energy which is called non-conventional sources of energy. It would provide greater initiative to local people who could assess their needs and resources and plan a strategy that could be useful to them.

### 22.6.1 Solar Energy

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Solar energy is the **energy obtained from the sun**. The sun gives out vast amount of light and heat. It is only a little less than half (47 %) of solar energy which falls on the atmosphere reaches the earth's surface. If we could use just a small part of this energy it would fulfill all the country's need for power. Solar energy has advantages and also certain limitations.

**Solar Energy Devices**

The energy from the sun can be harnessed to provide power. The various devices used for harnessing sun's energy are called solar energy devices.

### Solar Cells

Solar cells (Photovoltaic devices) is made up of silicon that **converts sunlight directly into electricity**. Solar cell produces electricity without polluting the environment. Since it uses no fuel other than sunlight, no harmful gases, no burning and no wastes are produced. These can be installed in remote and inacessible areas (forests and hilly regions) where setting up of power plant is expensive.

### Uses of Solar cells

(i) It can be used for street lighting, traffic signals, water pumping, battery charging system etc.

(ii) It is used in artificial satellites and space probes

(iii) It provides radio and TV transmission to remote areas

(iv) It is used in calculators, electronic toys and watches.

### Solar Panel

Arrangement of many solar cells side by side connected to each other is called solar panel. The capacity to provide electric cuurent is much increased in the solar panel. But the process of manufacture is very expensive.

**Figure 22.1** Solar Panel

### Solar Cooker

It consist of an insulated metal box or wooden box which is painted from inside so as to absorb maximum solar radiations. A thick glass sheet forms the cover over the box. The reflector is the plane mirror which is attached to the box. The food is cooked by energy radiated by the sun.

**Solar Cooker**

### Solar thermal power plant

In solar thermal power plants, many solar panels are used to concentrate sun rays, to heat up water into steam. The steam is used to run the turbines to produce electricity.

DO YOU KNOW?

A capacity of 100 litres solar heater can save upto 1500 units of electricity per year.

### Advantages of Solar Energy

(i) It is available in abundance in our country and is free of cost.

(ii) It is a renewable source of energy.

(iii) It can be used for generating electricity or heat.

(iv) It does not cause pollution.

## 22.6.2 Biogas

Biogas is the mixture of methane (nearly 75 %), hydrogen sulphide, carbon dioxide and hydrogen. It is produced by the **decomposition of animal wastes** (cow dung) and plant wastes in the absence of oxygen. It is also commonly called as '**Gobar gas**' since the starting material used is cow dung which means gobar in Hindi.

### Uses of biogas

(i) It is used as fuel for cooking .

(ii) It is used to run motors and pump sets.

(iii) It is used to generate electricity.

### Advantages of biogas

(i) It burns without smoke and therefore causes less pollution.

(ii) An excellent way to get rid of organic wastes like bio-waste and sewage material.

(iii) Left over slurry is a good manure rich in nitrogen and phosphorus

(iv) It is safe and convenient to use

(v) It can reduce the amount of greenhouse gases emitted.

### 22.6.3 Shale gas

Shale refers to the **soft finely stratified sedimentary rock** that is formed from the compaction of small old rocks containing mud and minerals – such as quartz and calcite, trapped beneath earth's surface. These rocks contain fossil fuels like oil and gas in their pores.

The fuel is extracted by a technique called **hydraulic fracturing** (drilling or well boring of sedimentary rocks layers to reach productive reservoir layers).

**Environmental concerns of shale gas**

(i) Shale drilling could affect groundwater reserves, which can contaminate the drinking water resources and also affect the fertility of the soil.

(ii) Million gallons of water is needed to break and release the shale gas, which inturn can affect the water table.

**More to Know**

India has identified six basins as areas for shale gas exploration: Cambay (Gujarat), Assam-Arakan (North East), Gondwana (Central India), Krishna Godavari onshore (East Coast), Cauvery onshore and Indo-Gangetic basins.

### 22.6.4 Wind Energy

The **kinetic energy** possessed by the wind is due to its high speed, that can be **converted into mechanical power by wind turbines**. The rotatory motion of wind mill produces wind energy. It can be used for generating electricity, run water pumps, flour mills, draw water from wells etc.,

DO YOU KNOW?

- The world's largest and tallest wind turbine is situated in Hawaii.
- One wind turbine can produce electricity for 300 homes.

**Windmill**

Windmill is a machine that converts the energy of wind into rotational energy by broad blade attached to the rotating axis. When the blowing air strikes the blades of the windmill, it exerts force and causes the blades to rotate. The rotational movement of the blades operate the generator and the electricity is produced. The energy output from each windmill is coupled together to get electricity on a commercial scale.

**Figure 22.2** Windmill

**Advantages of Wind energy**

(i) Wind energy is free, eco-friendly, renewable source of energy.

(ii) It does not cause pollution.

(iii) Expenses on periodic maintenance is low when compared to the other power sources.

**Activity 1**

Collect information regarding the

(i) Tehri Dam project

(ii) Sardar Sarovar Dam project

### 22.6.5 Water Energy

Earth's surface is covered with nearly 71 % of water. **Harnessing the energy from the flowing water** can be used to produce electricity. The technique to harness the **water energy** is called **Hydropower**.

The electrical energy is derived from water flow, water falling from a height. Hilly areas are suitable for this purpose where there is continous flow of water in large amounts falling from high slopes. It does not cause environmental pollution or waste generation.

**Hydropower plants** converts the kinetic energy of flowing water into electricity. This is called hydroelectricity.

### 22.6.6 Tidal Energy

Tidal energy is the **energy obtained from the movement of water due to ocean tides**. Tides are the rise and fall of sea levels caused by the combined effects of the gravitational forces exerted on the oceans of the earth.

A tidal stream is a fast flowing body of water created by tides. Turbines are placed in tidal streams. When the tides hit the turbine, the turbine rotates and converts the tidal energy into electric energy

**Advantages of tidal energy**

(i) Tidal energy does not produce any pollution.

(ii) It does not use any fuel and does not produce any waste.

(iii) Tides are predictable, so tidal energy can be produced at any time.

(iv) Water is denser than air and therefore can generate electricity at lower speeds than wind turbines.

## 22.7 Rainwater Harvesting

Rainwater harvesting is a technique of **collecting and storing rainwater** for future use. It is a traditional method of storing rain water in underground tanks, ponds, lakes, check dams and used in future.

The main purpose of rainwater harvesting is to make the rainwater percolate under the ground so as to recharge '**groundwater level**'.

**Methods of rainwater harvesting**

**(i) Roof top rainwater harvesting:** Roof-tops are excellent **rain catchers**. The rain water that falls on the roof of the houses, apartments, commercial buildings etc. is collected and stored in the surface tank and can be used for domestic purpose.

**(ii) Recharge pit:** In this method, the rainwater is first collected from the roof tops or open spaces and is directed into the **percolation pits** through pipes for filtration. After filtration the rainwater enters the **recharge pits** or **ground wells**.

**Figure 22.3** Rain water Harvesting

People living in rural areas adopt a variety of water collecting methods to capture and store as rain water. Some of the methods used are

**(i) Digging of tanks or lakes (Eris):** It is one of the **traditional water harvesting system** in Tamil Nadu. Eris are constructed in such a way that if the water in one eri overflows, it automatically gets diverted to the eri of the next village, as these eris are interconnected.

**(ii) Ooranis:** These are **small ponds** to collect rainwater. The water is used for various domestic purposes (drinking, washing and bathing). These ponds cater the nearby villages.

**More to Know**

kallanai Dam, also known as Grand Anicut, is the fourth oldest dam in the world, constructed by King Karikala Chola of the Chola Dynasty in the 2nd century A.D.(CE). It still serves the people of Tamilnadu, The dam is located on the River Kaveri, approximately 20 km from the city of Tiruchirapalli.

**Advantages of rainwater harvesting**

Rainwater harvesting helps to

(i) Overcome the rapid depletion of ground water levels.

(ii) To Meet the increase demand of water.

(iii) Reduces flood and soil erosion

(iv) Water stored in ground is not contaminated by human and animal wastes and hence can be used for drinking purpose.

## 22.8 Electrical Energy Management

Electricity or electric power is produced by generators. The generators are operated by the turbines attached to it. The turbines are rotated by steam, moving water or wind power to produce electricity.

**Conservation of electrical energy**

The following measures can be taken even at home and school to save electricity

(i) Use energy efficient appliances to save electricity like Compact Fluorescent Lamps (CFL), Light Emiting Diode (LED) bulbs and other electric equipments.

(ii) Switch off the lights and fans, television and other electrical appliances when not in use.

(iii) Switch of the mobile phone chargers when not in use.

(iv) Maximise the use of solar radiation. Solar water heating system can be used instead of electric geysers.

(v) Minimise the use of air conditioners.

## 22.9 E-Wastes and its Management

E-wastes are generally called as **electronic wastes**, which includes the spoiled, outdated, non-repairable electrical and electronic devices. These wastes contain toxic metals like lead, cadmium, chromium and mercury, though also contain iron, copper, silicon, aluminum and gold which can be recovered. Neverthless, only 5 % of e-wastes produced are recycled.

**Sources of e-wastes**

**Electronic devices:** Computers, laptops, mobile phones, printers, monitors, televisions, DVD players, calculators, toys, sport equipments, etc.

**Household electrical appliances:** Refrigerators, washing machine, microwave oven, mixer, grinder, water heater, etc.

**Accessories:** Printing cartridges, batteries and chargers.

DO YOU KNOW?

**E-wastes include**

| | |
|---|---|
| Computer components | - 66% |
| Telecommunication components | - 12 % |
| Electronic components | - 5 % |
| Biomedical components | - 7 % |
| Other components | - 6 % |

**Environmental impact of e-wastes**

Disposal of any kind of electrical and electronic devices without knowledge can become the landfill and water pollutants.

**More to Know**

**Health Effects of E- Wastes**

**Lead**: Damages central and peripheral nervous system; affect brain development in children

**Chromium**: Asthmatic bronchitis

**Cadmium**: Accumulates in kidney and liver; neural damage

**Mercury**: Chronic damage to brain and respiratory system

**Plastics including Polyvinyl Chloride (PVC)**: Burning produces dioxin which can cause developmental and reproductive problems, damages the immuns system.

Electronic equipments contain many hazardous heavy metals such as lead, cadmium that can cause severe soil and groundwater pollution.

E-waste dumping yards and the places nearby are polluted and cause severe health hazard.

## 22.10 Sewage Management

Untreated sewage or wastewater generated from domestic and industrial process is the leading polluter of water sources in India. Sewage water results in agricultural contamination and environmental degradation.

**Sources of Sewage/wastewater**

- Domestic purpose or household activities
- Dye and textile industries
- Leather industries
- Sugar and breweries industries
- Paper and pulp industries

**Figure 22.4** A view of sewage treatment plant

**Sewage/wastewater treatment method**

The conventional wastewater treatment methods involve the following steps (a) Pre-screening (b) Aeration (c) Sludge Management and (d) Water Reuse.

**Pre-screening**: Wastewater generated from domestic and industrial activities is screened to remove soil and solid particulates.

**Aeration**: Screened wastewater is then pumped to an aeration tank. Here the microbial contaminants are removed by the biological degradation that occurs in the presence of air.

**Sedimentation process**: In this process, the solid particles in suspension form are allowed to settle. The particles that settle out from the suspension is known as sludge.

**Sludge removal**: The sludge generated by the degradation process is transferred periodically from the tank for safe disposal.

**Disinfection:** Chlorination and ultraviolet (UV) radiation of treated water is required to remove any microorganism contamination.

**Water recycling:** The water will then be supplied for domestic or industrial purposes.

## 22.11 Solid Waste Management

Solid wastes mainly include municipal wastes, hospital wastes, industrial wastes and e- wastes etc. The solid wastes are dumped in the soil which results in landscape pollution.

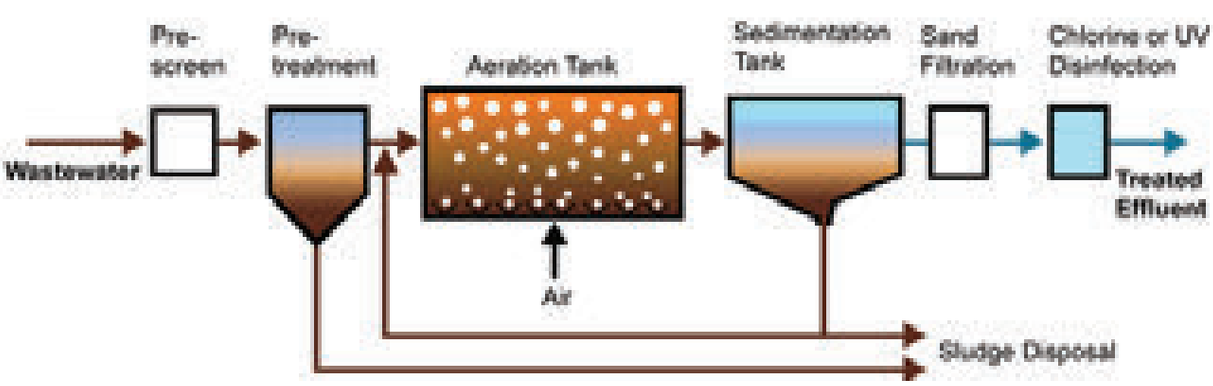


**Figure 22.5** Conventional Wastewater Treatment

Solid-waste management involves the collection, treatment and proper disposing of solid material that is discarded from the household and industrial activities.

**Methods of solid wastes disposal**

(i) **Segregation**: It is the separation of different type of waste materials like biodegradable and non biodegradable wastes.

(ii) **Sanitary landfill**: Solid wastes are dumped into low lying areas. The layers are compacted by trucks to allow settlement. The waste materials get stabilised in about 2-12 months. The organic matter undergoes decomposition.

**Figure 22.6** Collection of degradable and non-degradable solid wastes

(iii) **Incineration**: It is the burning of non-biodegradable solid wastes (medical wastes) in properly constructed furnace at high temperature.

(iv) **Composting**: Biodegradable matter of solid wastes is digested by microbial action or earthworms and converted into humus.


**Figure 22.7** Collection of various types of solid wastes in separate bins

## Recycling of wastes

- Papers from old books, magazines and newspapers are recycled to produce papers in papermills.
- Agricultural wastes like coconut shells, jute cotton stalk, bagasse of sugarcane can be used to make paper and hard board. Paddy husk can be used as livestock fodder.
- Cowdung and other organic wastes can be used in gobar gas plant to provide biogas and manure for fields.

## 4R Approach

The 4R approach such as Reduce, Reuse, Recovery and Recycle may be followed for effective waste management.

## Points to Remember

- Conservation is a process which is concerned with the use, preservation and proper management of natural resources from destructive activities of human being.
- Conservation of natural resources contributes to the social and economic development of the country.
- Forests of a country constitute a major asset for the people of the country.
- National park is a reserved area for the conservation of entire wildlife including plants and animals.
- Sanctuary is a place reserved exclusively for the use of animals.
- Solar cell is a device that absorbs sunlight and converts it into electric energy.
- Solar water heater does not require electricity, they heat up water directly from sunlight.
- Biogas is produced by the anaerobic decomposition of cow dung.
- The technique of collecting and storing rain water for future purpose is known as rainwater harvesting.
- Unwanted, non-working and outdated electronic products become e-waste.

## TEXTBOOK EVALUATION

VLLZXH

### I. Fill in the blanks

1. Deforestation leads to _____ in rainfall.
2. Removal of soil particles from the land is called _____.
3. Chipko movement is initiated against _____ .
4. _____ is a biosphere reserve in Tamilnadu.
5. Tidal energy is _____ type of energy.
6. Coal, petroleum and natural gas are called _____ fuels.
7. _____ is the most commonly used fuel for the production of electricity.

### II. State whether True or False. Correct the statements which are false

1. Biogas is a fossil fuel.
2. Planting trees increases the groundwater level.
3. Habitat destruction cause loss of wild life.
4. Nuclear energy is a renewable energy.
5. Overgrazing prevents soil erosion.
6. Poaching of wild animals is a legal act.
7. National park is a protected park.
8. Wild life protection act was established in 1972.

### III. Match the following

1. Soil erosion - energy saving
2. Bio gas - acid rain
3. Natural gas - removal of vegetation
4. Green house gas - renewable energy
5. CFL bulbs - $CO_2$
6. Wind - non-renewable energy
7. Solid waste - lead and heavy metals

### IV. Choose the correct answer

1. Which of the following is / are a fossil fuel?
   i. Tar ii. Coal iii. Petroleum
   a) i only b) i and ii
   c) ii and iii d) i, ii and iii
2. What are the steps will you adopt for better waste management?
   a) reduce the amount of waste formed
   b) reuse the waste
   c) recycle the waste
   d) all of the above
3. The gas released from vehicles exhaust are
   i. carbon monoxide
   ii. Sulphur dioxide
   iii. Oxides of nitrogen
   a) i and ii b) i and iii
   c) ii and iii d) i, ii and iii
4. Soil erosion can be prevented by
   a) deforestation b) afforestion
   c) over growing d) removal of vegetation
5. A renewable source of energy is
   a) petroleum b) coal
   c) nuclear fuel d) trees
6. Soil erosion is more where there is
   a) no rain fall b) low rainfall
   c) rain fall is high d) none of these
7. An inexhaustible resources is
   a) wind power b) soil fertility
   c) wild life d) all of the above
8. Common energy source in village is
   a) electricity b) coal
   c) biogas d) wood and animal dung
9. Green house effect refers to
   a) cooling of earth
   b) trapping of UV rays

c) cultivation of plants

d) warming of earth

10. A cheap, conventional, commercial and inexhaustible source of energy is

a) hydropower b) solar energy

c) wind energy. d) thermal energy

11. Global warming will cause

a) raise in level of oceans

b) melting of glaciers

c) sinking of islands

d) all of these

12. Which of the following statement is wrong with respect to wind energy

a) wind energy is a renewable energy

b) the blades of wind mill are operated with the help of electric motor

c) production of wind energy is pollution free

d) usage of wind energy can reduce the consumption of fossil fuels

## V. Answer in a sentence

1. What will happen if trees are cut down?
2. What would happen if the habitat of wild animals is disturbed?
3. What are the agents of soil erosion?
4. Why fossil fuels are to be conserved?
5. Solar energy is a renewable energy. How?
6. How are e-wastes generated?

## VI. Short answer questions

1. What is the importance of rainwater harvesting?
2. What are the advantages of using biogas?
3. What are the environmental effect caused by sewage?
4. What are the consequences of deforestation?

## VII. Long answer questions

1. How does rainwater harvesting structures recharge ground water?
2. How will you prevent soil erosion?
3. What are the sources of solid wastes? How are solid wastes managed?
4. Enumerate the importance of forest.
5. What are the consequences of soil erosion?
6. Why is the management of forest and wildlife resource considered as a challenging task?

## VIII. Assertion and Reasoning

In each of the following question a statement of assertion(A) is given and a corresponding statement of reason (R). Of the four statements given below mark the correct answer.

a. Both assertion and reason are true and reason is correct explanation of assertion.

b. Both assertion and reason are true but reason is not the correct explanation of assertion.

c. Assertion is true but reason is false.

d. Both assertion and reason are false.

1. **Assertion:** Rainwater harvesting is to collect and store rain water.

   **Reason:** Rainwater can be directed to recharge the underground water source.

2. **Assertion:** Energy efficient bulbs like CFL must be used to save electric energy.

   **Reason:** CFL bulbs are costlier than ordinary bulbs, hence using ordinary bulbs can save our money.

## IX. Higher Order Thinking Skills (HOTS)

1. Although coal and petroleum are produced by degradation of biomass, yet we need to conserve them. Why?
2. What are the objectives for replacing non-conventional energy resources from conventional energy resources?
3. Why is the Government imposing ban on the use of polythene bags and plastics? Suggest alternatives. How is this ban likely to improve the environment?

## X. Value based questions

1. Why is it not possible to use solar cells to meet our energy needs? State three reason to support to your answer.
2. How would you dispose the following wastes?

   a. Domestic wastes like vegetable peels

   b. Industrial wastes like metallic cans

   Can the disposal protect the environment? How?
3. List any three activities based on 4R approach to conserve natural resources.

## REFERENCE BOOKS


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2. P.D.Sharma, 2013. Ecology and Environment, Rastogi Publications, Meerut.


## INTERNET RESOURCES

1. http://envfor.nic.in
2. https://www.ovoenergy.com/guides/energy-guides/120-ways-to-save-energy.html

# Concept Map