A Textbook of Biology

Grade X

KHYBER PAKHTUNKHWA
TEXTBOOK BOARD, PESHAWAR

A Textbook of

BIOLOGY

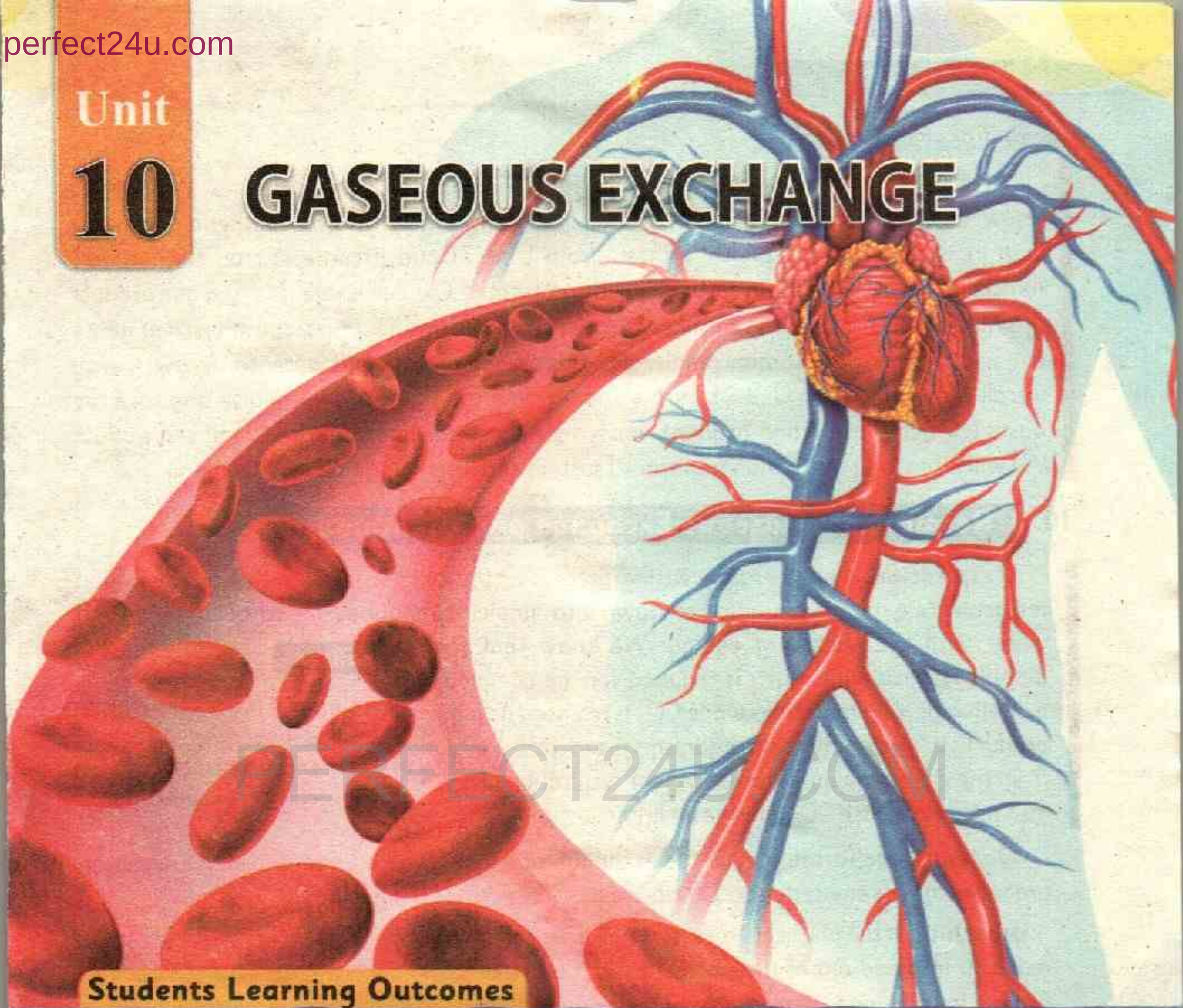
Grade X

KHYBER PAKHTUNKHWA
TEXTBOOK BOARD, PESHAWAR

CONTENTS

Unit

10 GASEOUS EXCHANGE



Students Learning Outcomes

The students will be able to:

- Differentiate among respiration, gas exchange and breathing.
- Describe the process of gaseous exchange in plants by comparing photosynthesis and respiration.
- Describe the role of the parts of the air passageway and of the lungs.
- Describe the mechanism of breathing in term of movements of ribs and diaphragm.
- State the rate of breathing at rest and after exercise.
- Differentiate between the composition of inspired and expired air.
- Describe briefly diseases related to the respiratory system like bronchitis, emphysema, pneumonia, asthma, and lung cancer.
- Describe the biological consequences of smoking in relation to the lungs and circulatory system.

Introduction

All living organisms need energy to perform their life sustaining activities. We already know that the ultimate source of energy for life is sunlight. Photosynthetic organisms capture sunlight (recall photosynthesis from Unit 7) and prepare energy rich organic molecules (food) by utilising carbon dioxide and water. Oxygen is released as a bye product of photosynthesis. Respiration takes place in all organisms. During respiration they utilise oxygen to break down organic molecules into carbon dioxide and water to release energy (recall respiration from Unit 7). In this unit we will study how organism give and take the gases (carbon dioxide and oxygen) which are needed for photosynthesis and respiration. We will also study the human respiratory system and its common diseases in detail.

10.1 Respiration, Gaseous Exchange and Breathing

Respiration is an energy releasing process at the cellular level. In this process, food molecules (e.g. glucose) are broken down into simpler compounds like carbon dioxide and water with the release of energy. We know that for aerobic respiration, oxygen is required for the complete oxidation of food molecules while CO_2 is released as a by product. It means that all organisms need to take O_2 from the environment (air or water) for respiration. They also need to release CO_2 into the environment.

Recalling

Diffusion is a process in which molecules move from a region of higher concentration to a region of lower concentration.

Gaseous exchange means the exchange of oxygen and carbon dioxide between an organism and its environment. Gaseous exchange occurs by diffusion.

Breathing is the physical process in which animals move air into and out of their body. It is done to get oxygen from air and to release carbon dioxide in it. In higher animals, lungs are the organs of breathing. In breathing, fresh air is made available to the respiratory surface of the lung for gaseous exchange. As fresh air has a higher concentration of oxygen than is present in the blood, therefore, it diffuses into the blood. At the same time, the concentration of carbon dioxide is higher in the blood, so it is diffuses into the lungs and is expelled out by the process of breathing.

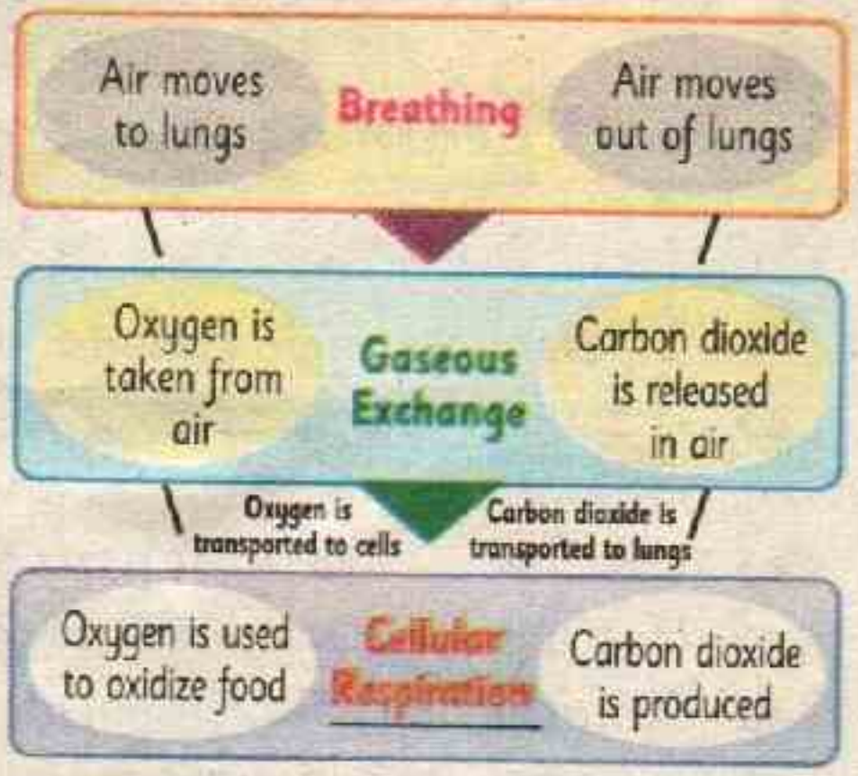


Fig 10.1 Relationship between respiration, gaseous exchange and breathing.

10.2 Gaseous Exchange in Plants

During the daytime, all plant cells are carrying out respiration. The green parts (leaves) of plants are also carrying out photosynthesis. For photosynthesis, the leaves use carbon

dioxide which is produced during respiration. They also take carbon dioxide from the environment. For respiration, leaves use oxygen which is produced during photosynthesis. During respiration, they release carbon dioxide which is used in photosynthesis. So, during daytime leaves are taking carbon dioxide from the environment and releasing oxygen in it.

During the night, all cells are carrying out respiration while there is no photosynthesis. So, the cells get oxygen from the environment and release carbon dioxide.

In plants, the gaseous exchange between the body and the environment occurs through the surface. The outer surface of the root, stem and leaves is called the **epidermis**. This layer allows the exchange of gases between the inner cells and the environment. At some parts a thick cuticle is present over the epidermis. It also allows the exchange of gases.

In leaves and young stems, the epidermis has small pores called **stomata**. In these parts, the air moves in and out through the stomata. Inside the body, gaseous exchange occurs between the cells and air. In woody stems, the entire surface is covered by bark. Gaseous exchange cannot occur through bark. The bark contains special pores called **lenticels**, which allow the gaseous exchange with the environment.

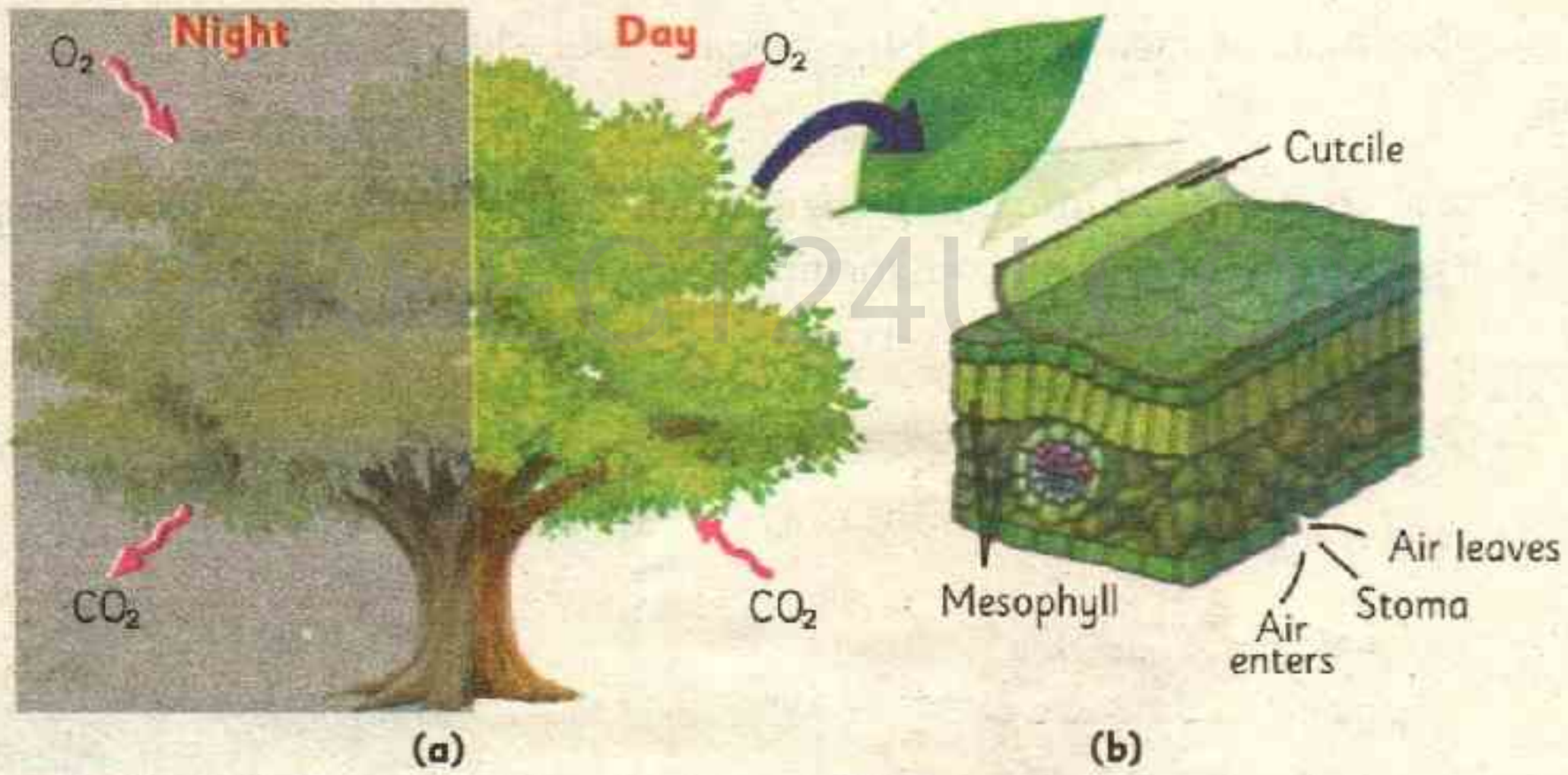


Fig.10.2 (a). Gaseous exchange in plants; (b). Gaseous exchange in a leaf.

Science, Technology and Society

Effects of Tilling

You might have seen the farmers and gardeners tilling the soil. Tilling helps soil drainage and aeration.

It creates air spaces between soil particles. These spaces in turn allow better exchange of gases between roots and the air.

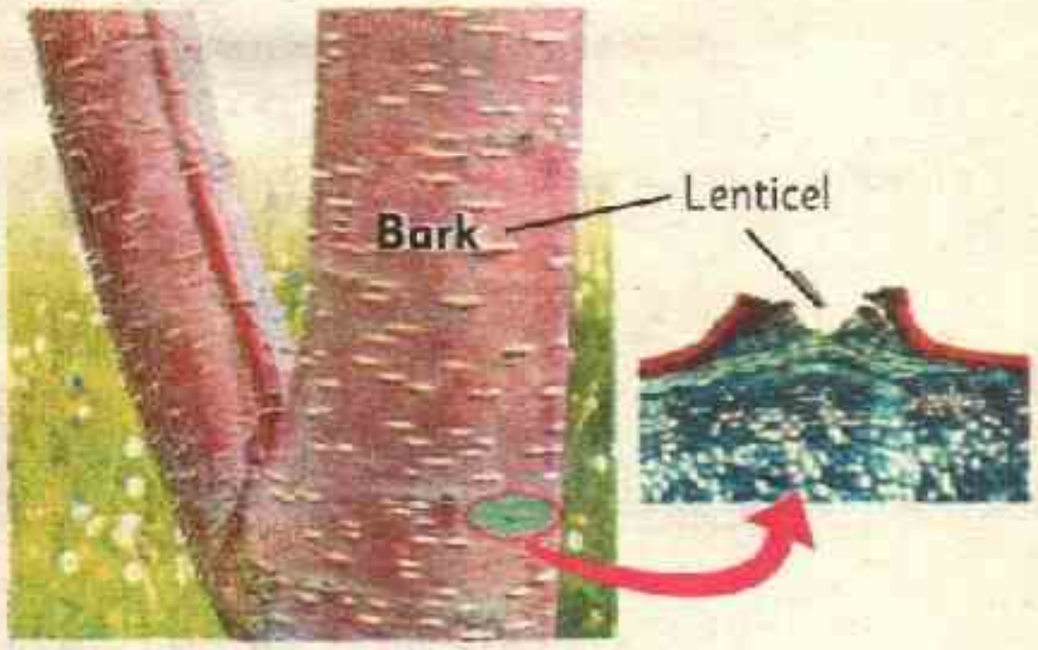


Fig.10.3 Lenticels in a bark

10.3 Gaseous Exchange in Humans

Humans have an efficient respiratory system adopted well for the terrestrial mode of life. This system ensures a smooth exchange of gases between the environment and the human body. This system can be divided into two main components which are: air passageway and lungs.

a). Air Passageway

When air enters the body, it passes through connected tubes to reach the lungs. After gaseous exchange, air moves from the lungs to the outside through the same connected tubes. These connected tubes are collectively called the air passageway. It consists of nostrils and nasal cavities, pharynx, larynx, trachea, bronchi and bronchioles.

Two openings or **external nostrils** lie on the ventral side of the head. They allow the air from the outside into two **nasal cavities**. Here the air is warmed, moistened and dust freed by the hairs and the mucous membrane of the nasal cavity.

For Your Information

We should breathe through the nose and not through the mouth to keep ourselves healthy.

The nasal cavities lead into the **pharynx** which is about a 4.5 inches long muscular passage. It is also lined by the mucous membrane.

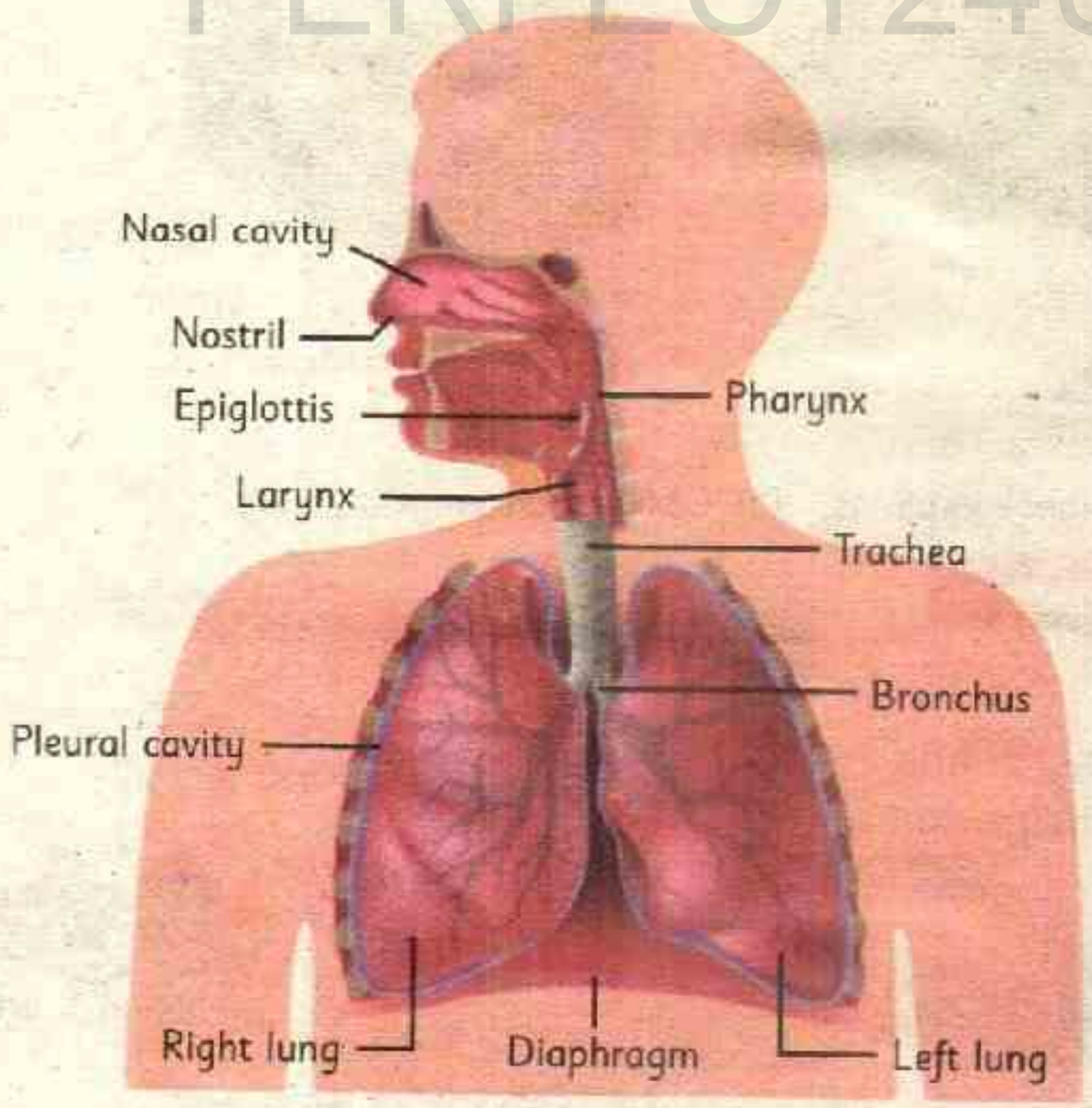


Fig. 10.4 General Outline of the Air Passageway and Lungs

For Your Information

The pharynx contains tonsils and adenoids, which are organs of lymphatic tissue used to trap and filter microorganisms.

The air moves from the pharynx into the **larynx** or voice box. It surrounds the upper part of the trachea. The cavity of the larynx is also lined by the mucous membrane. At the back of the pharynx are two passages, one opens into the esophagus on the dorsal side and the other opens through the **glottis** into the trachea on the ventral side. The glottis is guarded by a lid like structure called the epiglottis.

Tidbit

Why is it advised to breathe through the nose and not through the mouth?

The larynx opens into the **trachea** or wind pipe. It is a tubular structure. It lies ventral to the esophagus and extends to the chest cavity or thorax. The inner surface of the trachea is ciliated and secretes mucus. This helps to filter, moisten and warm the incoming air. The trachea has 16 to 20 C-shaped **cartilaginous rings** which prevent it from collapsing and keep the passage of air open.

Recalling

Transpiration is the loss of water from a plant surface in the form of vapours.

Inside the thorax, the trachea divides into two branches called **bronchi**. Each bronchus enters the lung on its own side. The bronchi also possess the cartilaginous rings but smaller than those of the trachea. Each bronchus, on entering the lungs, divides and sub-divides progressively into smaller bronchi. When the smaller bronchi attain the diameter of one millimeter or less, then they are called **bronchioles**. Bronchioles have no cartilage.

Each bronchiole ends in a duct. The duct opens in a cluster of pouches, which resemble bunches of grapes. Each pouch is microscopic structure and is called **alveolus** (plural: Alveoli). The alveoli are thin-walled and provide the surface for gaseous exchange. Their walls are covered with a network of blood capillaries where gaseous exchange occurs.

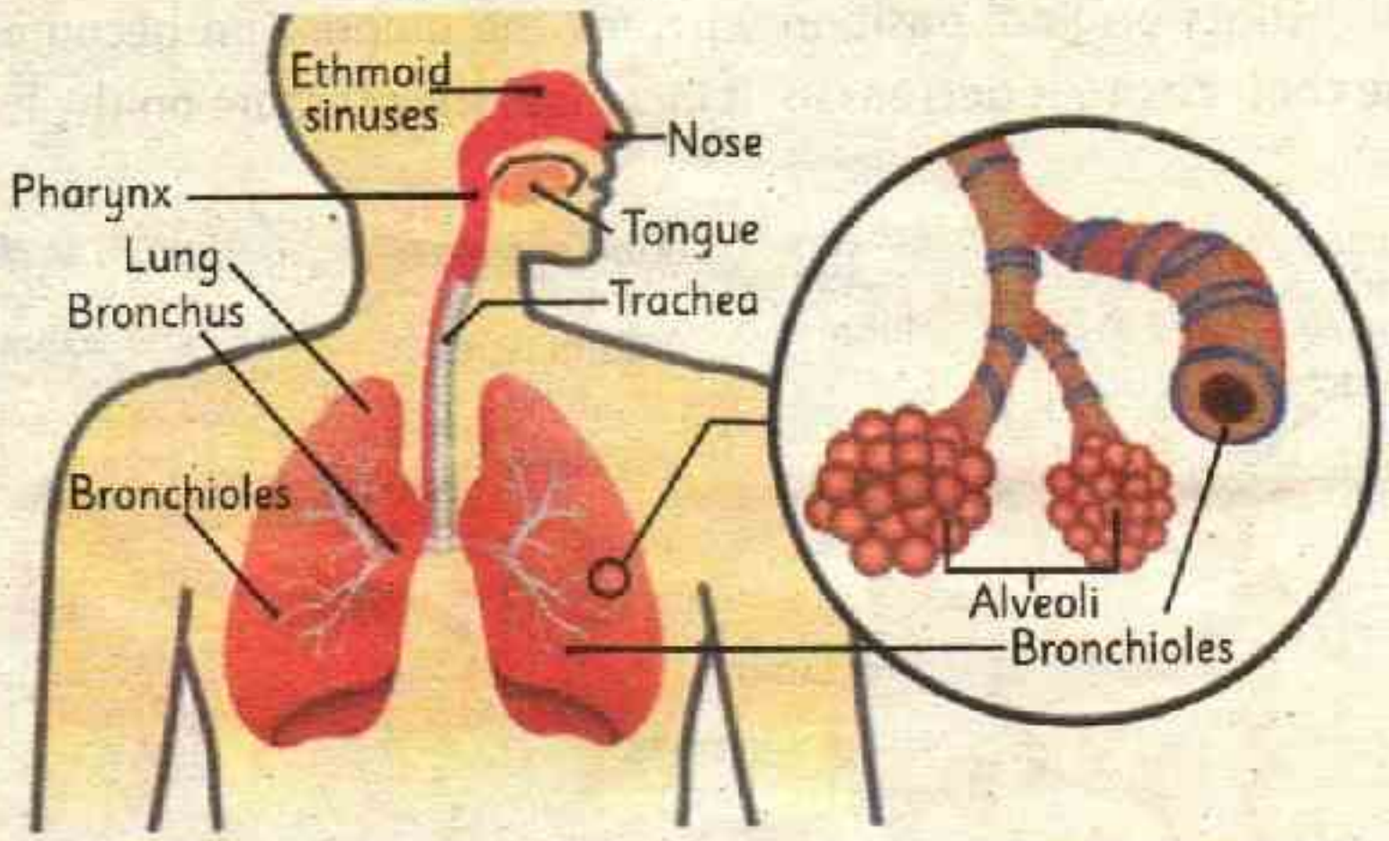


Fig. 10.5 General Outline of Respiratory System in the Human Body.

b). Lungs

The lungs are placed in the chest cavity. From above and sides, lungs are enclosed by the chest wall, while there is a thick muscular structure called the **diaphragm** below the lungs.

Each lung is enclosed in a double membrane called **pleura**. It contains a **pleural fluid**. This fluid makes the movements of the lungs (expansion and contraction) easy.

10.3.1 Mechanism of Breathing

Breathing consists of two phases, the taking in of air called inspiration and letting out of air called expiration. These two phases take place continuously one after the other. Air moves in when the air pressure in the lungs is lower than the pressure outside the body and it moves out when the pressure in the lungs is greater than the atmospheric pressure.

For Your Information

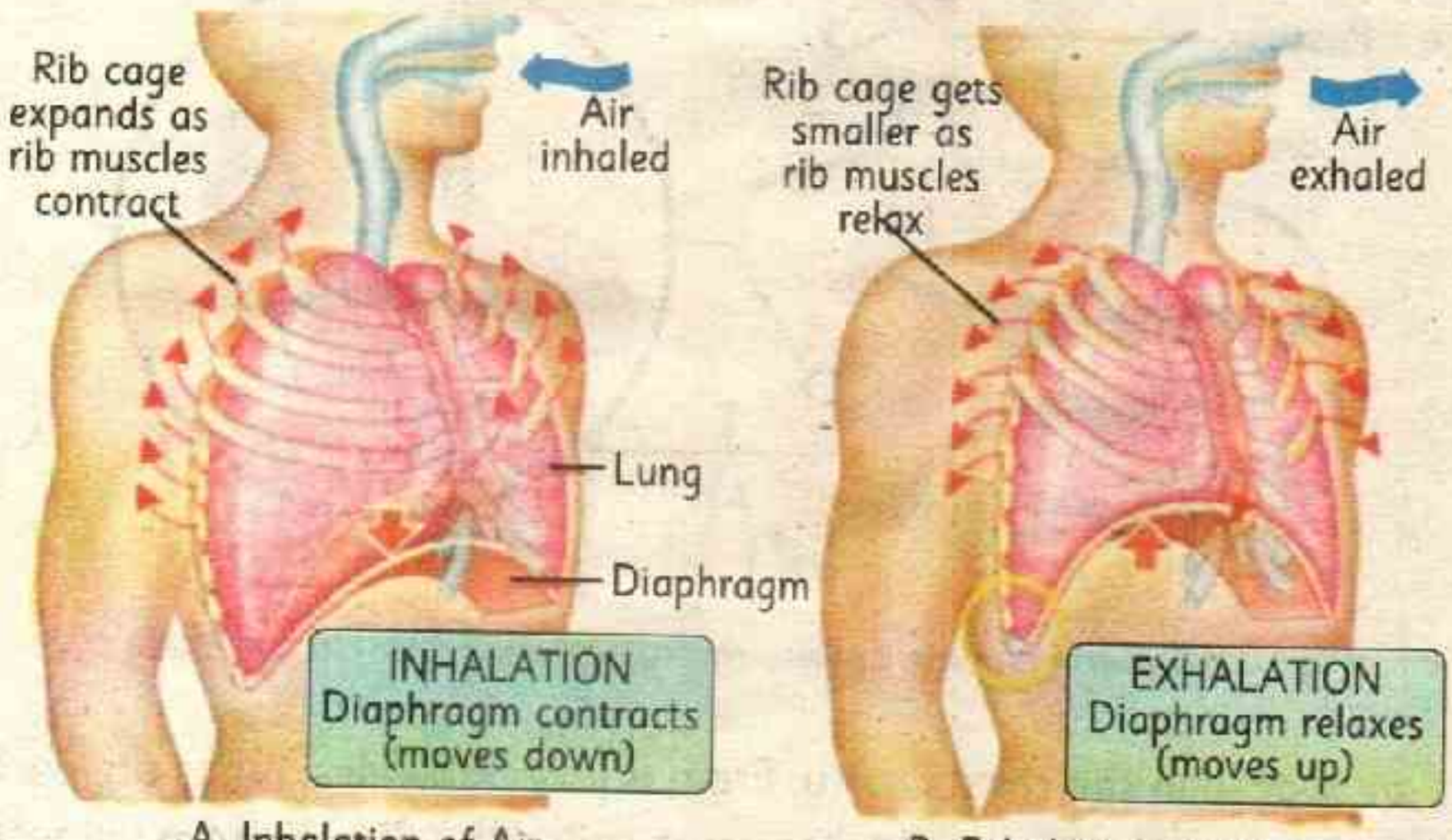
The thorax or chest-cavity is bound by the ribs and muscles at the sides, by the sternum (or chest bone) on the ventral side, by the backbone on the dorsal side and by the diaphragm at the posterior end. The diaphragm is a dome-shaped sheet of skeletal muscles. The muscles in between the ribs are called intercostal muscles.

a) Inspiration: During inspiration, the volume of the chest cavity increases and the pressure in the lungs decreases. It happens due to two reasons.

- The muscles of the diaphragm contract, so it becomes flat instead of its domed position.
- The intercostal muscles present between the ribs, contract. Due to their contraction, the ribcage expands.

Due to these movements the volume of the chest cavity increases and so pressure on the lungs decreases. As a result, the atmospheric air rushes in to the lungs through the air passageway.

b) Expiration: During this process, the muscles of the ribs and the diaphragm relax. The ribcage goes down to its original position whereas the diaphragm becomes dome-shaped. The volume of the chest cavity is decreased. It increases the pressure on the lungs to expel the air out.



A. Inhalation of Air B. Exhalation of Air

Fig. 10.6 Mechanism of Breathing in Humans

10.3.2 Gaseous exchange in Lungs

We know that the alveoli are very thin-walled and have a network of blood capillaries. So they are an excellent site for gaseous exchange. The blood which enters these capillaries has a low oxygen concentration whereas the inhaled air present in the alveoli has a higher oxygen concentration. Therefore, oxygen from the alveoli diffuses into the capillaries. Similarly, the carbon dioxide concentration in the blood present in the capillaries is more than that of the alveoli. Therefore carbon dioxide diffuses out of the blood and into the alveoli.

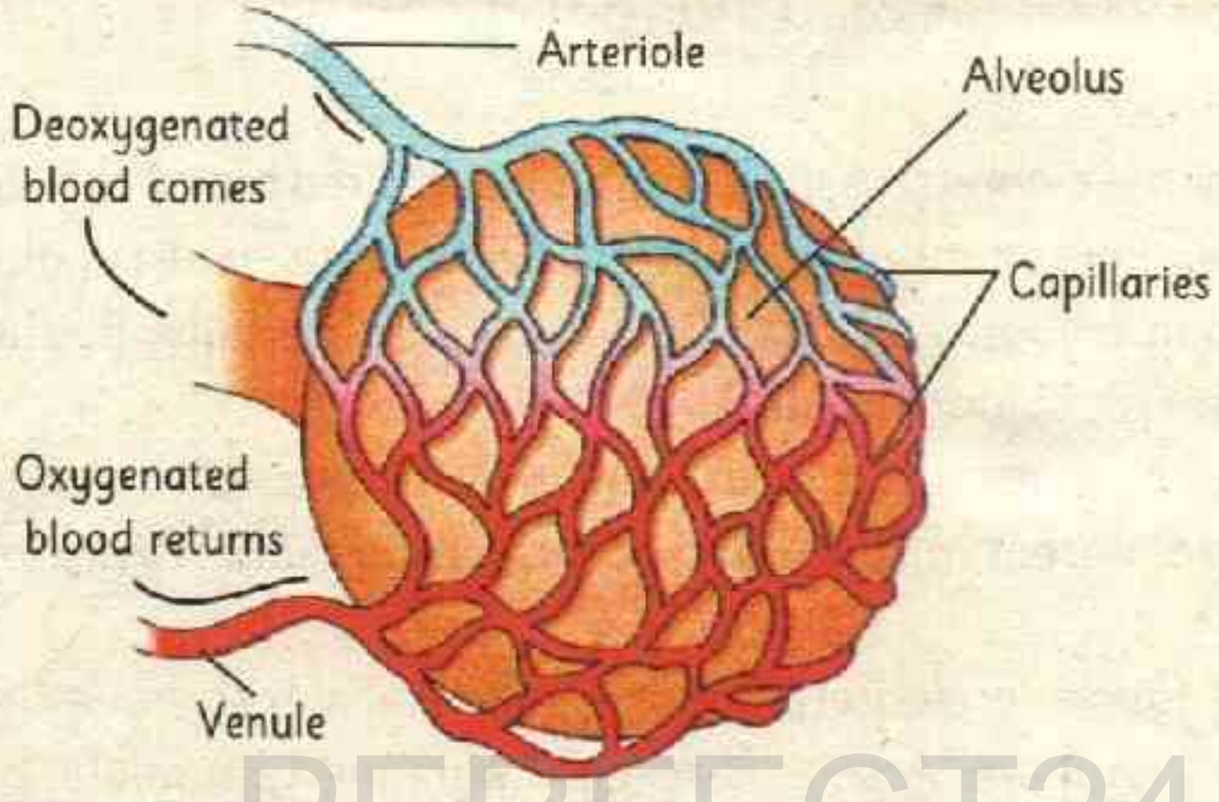


Fig. 10.7 Blood circulation in the lungs (around an alveolus)

Tidbit

The size of the lungs of any organism is related to the activities and body form of that organism. Cheetah and elephant have large lungs. What do you think why they have large lung sizes?

10.4 Biological Consequences of Smoking

Smokers have a much higher risk of developing life threatening diseases. The most crucial risk of smoking is cancer in the lungs, kidneys, oral cavity, larynx, breast, bladder, oesophagus, pancreas and stomach.

Tobacco smoke contains over 4,000 different chemicals. Out of these, there are more than 69 known **carcinogens** (cancer causing chemicals). The effects of some chemicals found in cigarettes are given below.

The majority of the particulate matter inhaled by a smoker is composed of **tar**. Within tar, there are many carcinogens. Tar in its solid form also stains the teeth and

Bad Social Effects of Smoking

Breathing of smoke-laden air by nonsmokers is known as **passive smoking**. The majority of the nonsmokers are allergic to cigarette smoke as it produces irritation in their eyes and throats. They can also develop cancer by continuously living in an environment polluted with cigarette smoke. Moreover, people tend do not like the company of cigarette smokers due to the bad smell that comes from their mouth. For this reason there are separate zones in public places such as offices, hotels and restaurants for smokers. The Government has banned smoking at public places and on public transport.

fingers of smokers. It can also stain and damage the lung tissue. Tar also increases the production of mucous and phlegm.

Nicotine has many harmful effects such as increased heart rate and blood pressure, constriction in the blood vessels, damage to the muscles, and disturbance in hormonal systems and metabolism. Nicotine can also increase platelet stickiness in the blood which can cause blockage and cause coronary diseases.

For Your Information

The World Health Organization has called the governments to stop tobacco advertisements to prevent young people to start smoking.

(Reference: Document number: WHO/NMH/PND/13.1)

Carbon monoxide is formed when a cigarette is lit. It combines with red blood cells and prevents oxygen transportation. When carbon monoxide enters the air ways, it stays along with other toxic chemicals contained in cigarette smoke. These toxins cause inflammation, impair lung functions, and increase the risk of lung diseases.

Benzene is a major component of cigarettes. It is a carcinogen and causes blood cancer (leukaemia). Similarly, **formaldehyde** present in cigarettes causes cancers and respiratory, skin and gastrointestinal problems.

Thirty different **metals** are also found in cigarette smoke, many of which have been linked to cancer. A few of the metals found are; Arsenic, Nickel, Cadmium, Chromium, and Lead. **Radioactive compounds** are also found in cigarettes, all of them are carcinogens.

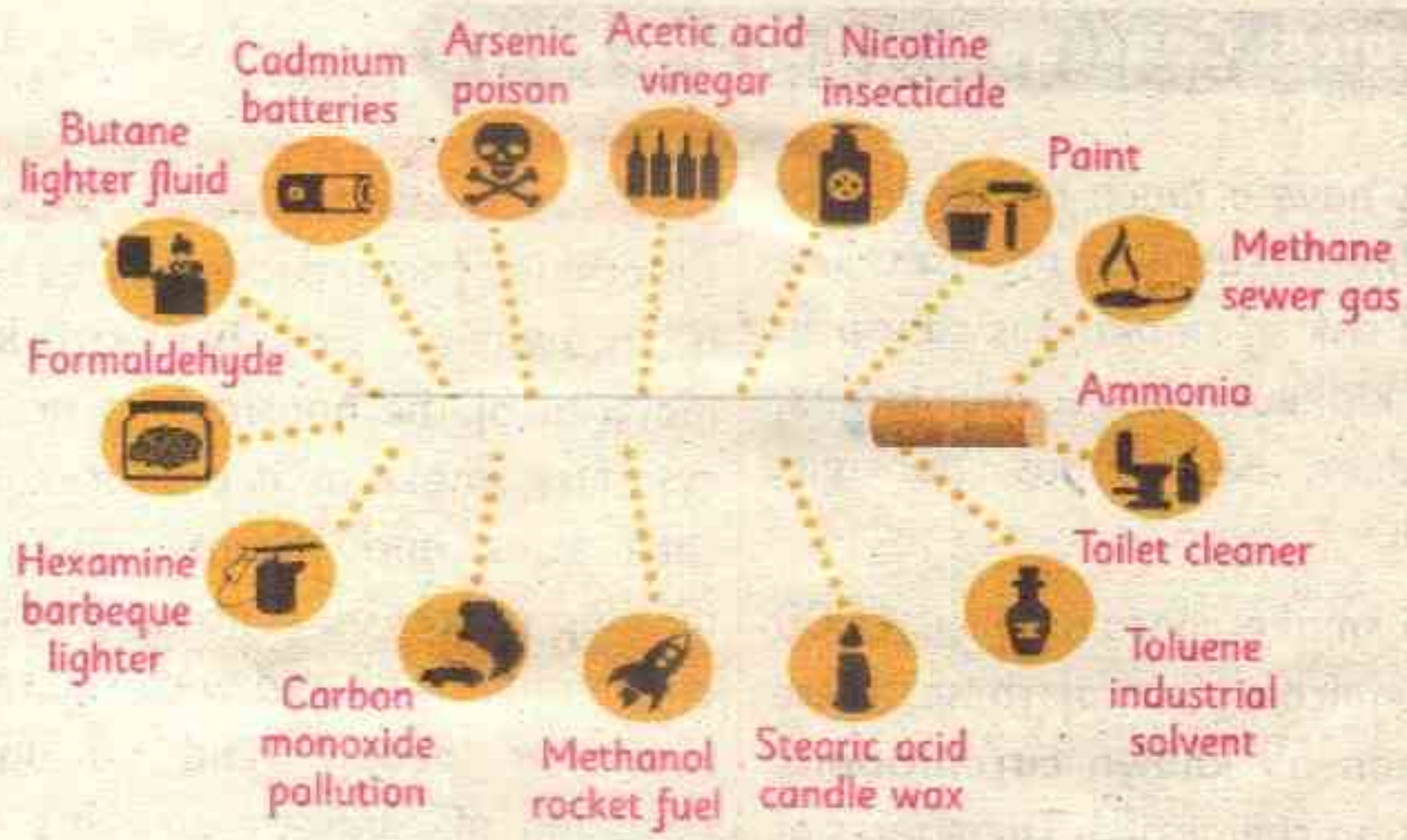


Fig. 10.8 Some of the Contents of a Cigarette

10.4.1 Effect of Exercise on the Rate of Breathing

Under resting condition the rate of breathing is **15-20 times per minute**. During exercise this rate increases instantly. This is due to the fact that more oxygen is required for the oxidation of glucose molecules to get more energy. As a result of this, more CO_2 is produced which thus accumulates in the blood.

When this blood reaches the brain, the medulla **(breathing centre)** detects more carbon dioxide in the blood and sends nerve impulses to the diaphragm and rib muscles at greater speed. So the speed of contraction and relaxation of these muscles increases. It increases the rate and depth of breathing. During exercise, the breathing rate increases up to **30-40 times per minute**.

Proper Ventilation for Healthy Living

A home ventilation system is used to maintain a healthy living environment by supplying fresh air inside the home while at the same time removing stale and polluted air. Home ventilation also helps to maintain proper humidity levels. With insufficient home ventilation, pollutants can build up and become very concentrated. Proper home ventilation can help reduce allergy and asthma symptoms and help ease other respiratory disorders.

Air components	Inspired Air	Expired Air
Oxygen	21%	16%
Carbon dioxide	0.04%	4%
Water vapours	Variable	Saturated
Temperature	Variable	38 °C

Table 10.1 Composition of Inspired and Expired Air

Activities

Morning walk is traditionally considered beneficial for health. Analyse this sentence in the context of better gaseous exchange.

10.5 Respiratory Disorders

Sometime the normal functioning of the respiratory system is disrupted due to certain factors which can lead to serious respiratory disorders. Some of these disorders are discussed below.

1. Bronchitis

When the lining of the bronchi or bronchioles becomes inflamed or infected, this condition is called bronchitis. Bronchitis reduces the amount of air that can flow and causes formation of mucus in the airways. Bronchitis is caused by viruses, bacteria, and their particles that irritate the bronchial tubes.

Short-term bronchitis resolves without treatment in two weeks. If conditions do not improve, the patient is given medicines. Antibiotics are used when bronchitis is due to bacterial infection. When bronchitis is due to viral infection, anti-viral medicines are used. Coughing helps to remove irritants from the bronchi.

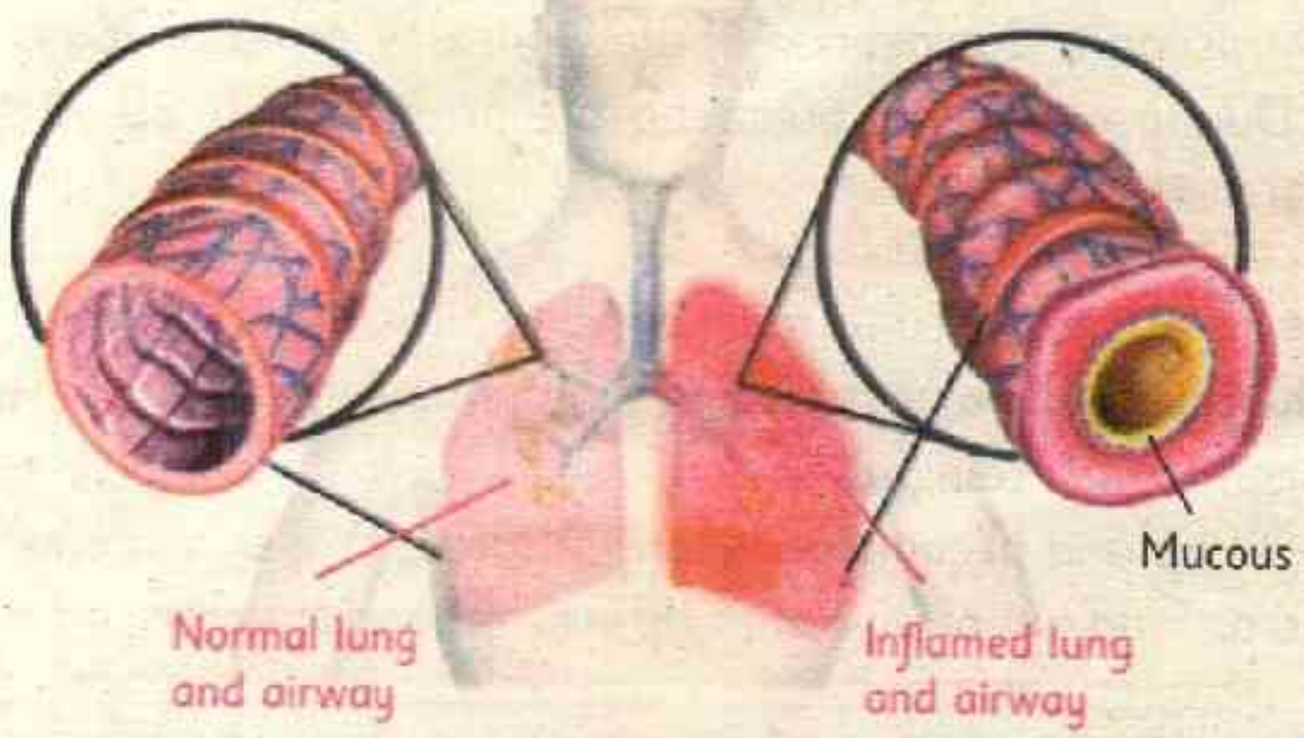


Fig. 10.9 Mucous in air ways accumulates and causes bronchitis

2. Emphysema

This is a severe type of lung disease in which due to extensive cough walls of the alveoli are damaged. Environmental pollution can cause emphysema. Cigarette smoke is the most common cause. The effects of emphysema are permanent and irreversible, however if smoking is stopped, further damage might be reduced.

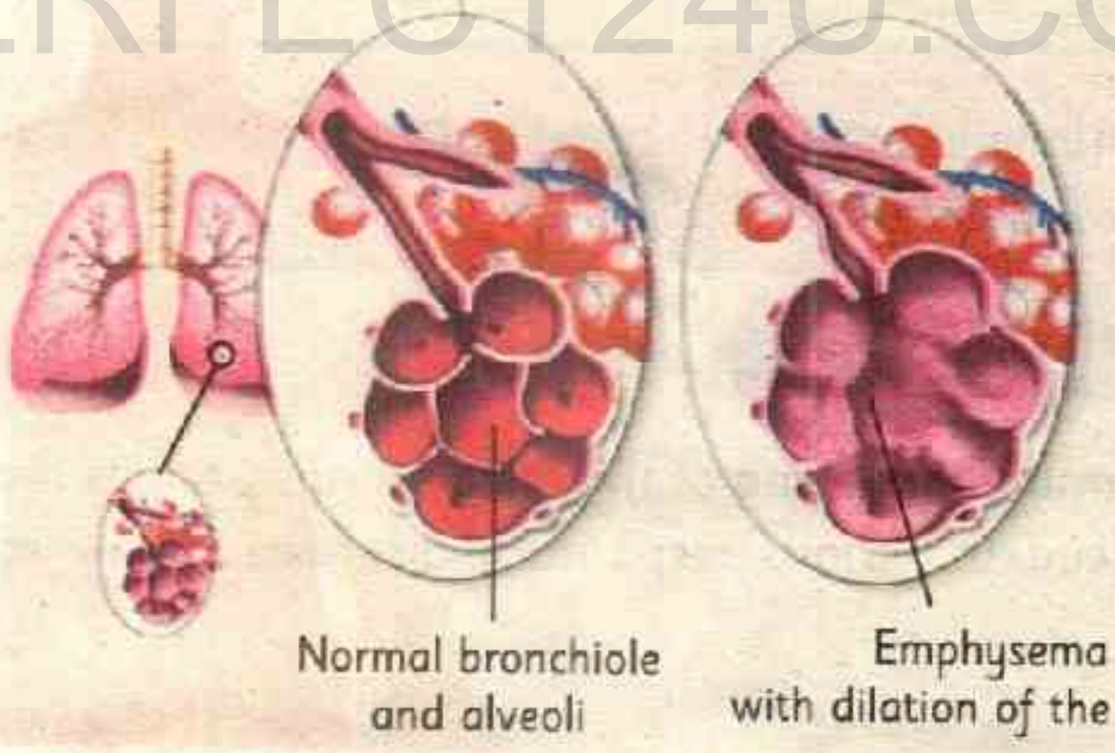


Fig. 10.10 Emphysema

3. Pneumonia

Pneumonia is an inflammation in the lungs, due to infection in the alveoli. Due to pneumonia, the alveoli are filled with pus. It is caused by bacteria, viruses or fungi. General symptoms of pneumonia are cold (upper respiratory infection, for example, sneezing sore throat, cough), which

For Your Information

Pneumonia can be transmitted by breathing in air with small droplets. These droplets get into the air when an infected person (having these germs) coughs or sneezes.

Key Points

- For aerobic respiration, oxygen is required for the complete oxidation of food molecules while carbon dioxide is released as a by product.
- Gaseous exchange means the exchange of oxygen and carbon dioxide between an organism and its environment.
- Breathing is the physical process in which animals take air in and out of their body, to get oxygen from this air and to release carbon dioxide in it.
- In plants, the gaseous exchange between the body and the environment occurs through the general surface, stomata and lenticels.
- The air passageway consists of nostrils, nasal cavities, pharynx, larynx, trachea, bronchi and bronchioles.
- Through external nostrils, air enters into two nasal cavities, from where it goes into the pharynx and then into larynx or voice box.
- The larynx opens into the trachea or wind pipe which divides into two bronchi. Each bronchus enters the lungs on its own side and divides and sub-divides into smaller bronchi and finally into bronchioles. Each bronchiole end at a duct which opens in a cluster of alveoli.
- The alveoli are very thin-walled and provide the surface for gaseous exchange. Their walls are covered with a network of blood capillaries where gaseous exchange occurs.
- Each lung is enclosed in a double membrane called pleura which contains a pleural fluid.
- During inspiration, the muscles of the diaphragm contract, so it becomes flat. The intercostal muscles also contract, so the ribcage expands. In this way the volume of chest cavity increases, pressure on the lungs decreases and so the atmospheric air rushes in to the lungs.
- During expiration, the muscles of the ribs and the diaphragm relax. In this way, the volume of the chest cavity is decreased, pressure on lungs is increased and so the air is expelled out. Smokers have a much higher risk of developing life threatening diseases.
- Tobacco smoke contains more than 69 known carcinogens.
- Tobacco contains tar which has many carcinogens. It also stains and damages the lung tissue.
- Nicotine has many harmful effects such as increased heart rate and blood pressure, constriction in the blood vessels, damage to the muscles, disturbance in hormonal system and metabolism.
- Carbon monoxide is formed when a cigarette is lit. It combines with red blood cells and prevents oxygen transportation.
- Benzene (major component of cigarettes) is a carcinogen and causes blood cancer (leukaemia).
- Under resting condition the rate of breathing is 15-20 times per minute. During exercise this rate increases up to 30-40 times per minute.
- When the lining of bronchi or bronchioles becomes inflamed or infected, the condition is called bronchitis.
- In emphysema, the walls of the alveoli are damaged and the patient feels difficulty in breathing (shortness of breath). Pneumonia is an inflammation in the lungs, due to infection in the alveoli.

Exercise

A. Select the correct answer.

1. The correct order of the structures involved in the flow of air in the human body is:
   a. Pharynx — Trachea — Larynx — Bronchi — Bronchioles
   b. Larynx — Pharynx — Trachea — Bronchioles — Bronchi
   c. Trachea — Pharynx — Larynx — Bronchi — Bronchioles
   d. Pharynx — Larynx — Trachea — Bronchi — Bronchioles
2. Food is prevented from entering into the Larynx by:
   a. Glottis b. Epiglottis c. Vocal cards d. Internal nostrils
3. Oxygen from the lungs enter into the blood due to:
   a. Diffusion b. Less affinity of O_2 for air
   c. Higher affinity of CO_2 for air d. Osmosis
4. Which part of the air passageway is also called the windpipe?
   a. Bronchus b. Alveolus c. Larynx d. Trachea
5. In which disease are the walls of the alveoli are broken?
   a. Pneumonia b. Bronchitis c. Emphysema d. Asthma
6. The diaphragm is flat, the ribs move out; this occurs during:
   a. Expiration b. Inspiration c. Lungs expansion d. Breathing
7. The chest cavity is separated from the abdominal cavity by a muscle called:
   a. Larynx b. Trachea c. Bronchus d. Diaphragm
8. Respiration at cellular level is known as:
   a. Breathing b. Ventilation c. Oxidation d. Inhalation
9. High fever, cold and cough with sputum production are symptoms of:
   a. Emphysema b. Asthma c. Pneumonia d. Bronchitis
10. Chemotherapy is a treatment of:
    a. Emphysema b. Bronchitis c. Asthma d. Lung cancer

B. Write short answers to the following questions.

1. Why do plants not need a specialised respiratory system?
2. Differentiate between the terms "respiration" and "breathing".
3. How are the surface area of leaves and lungs important for gaseous exchange?
4. What is the function of the cartilage present in the walls of the trachea and bronchi?

5. What is a diaphragm and what is its role in breathing?
6. What are carcinogens? Name any two carcinogens present in tobacco.
7. Compare the composition of inhaled and exhaled air.

C. Write detailed answers to the following questions:

1. The gaseous exchange in plants is important for photosynthesis and respiration. Explain the types of gases exchanged and its mechanism.
2. Describe the mechanism of breathing in human beings.
3. Draw a diagram of the air passage in the human body and describe the role of different parts in the flow of air through it.
4. What are the causes of respiratory disorders such as bronchitis, pneumonia and lung cancer?

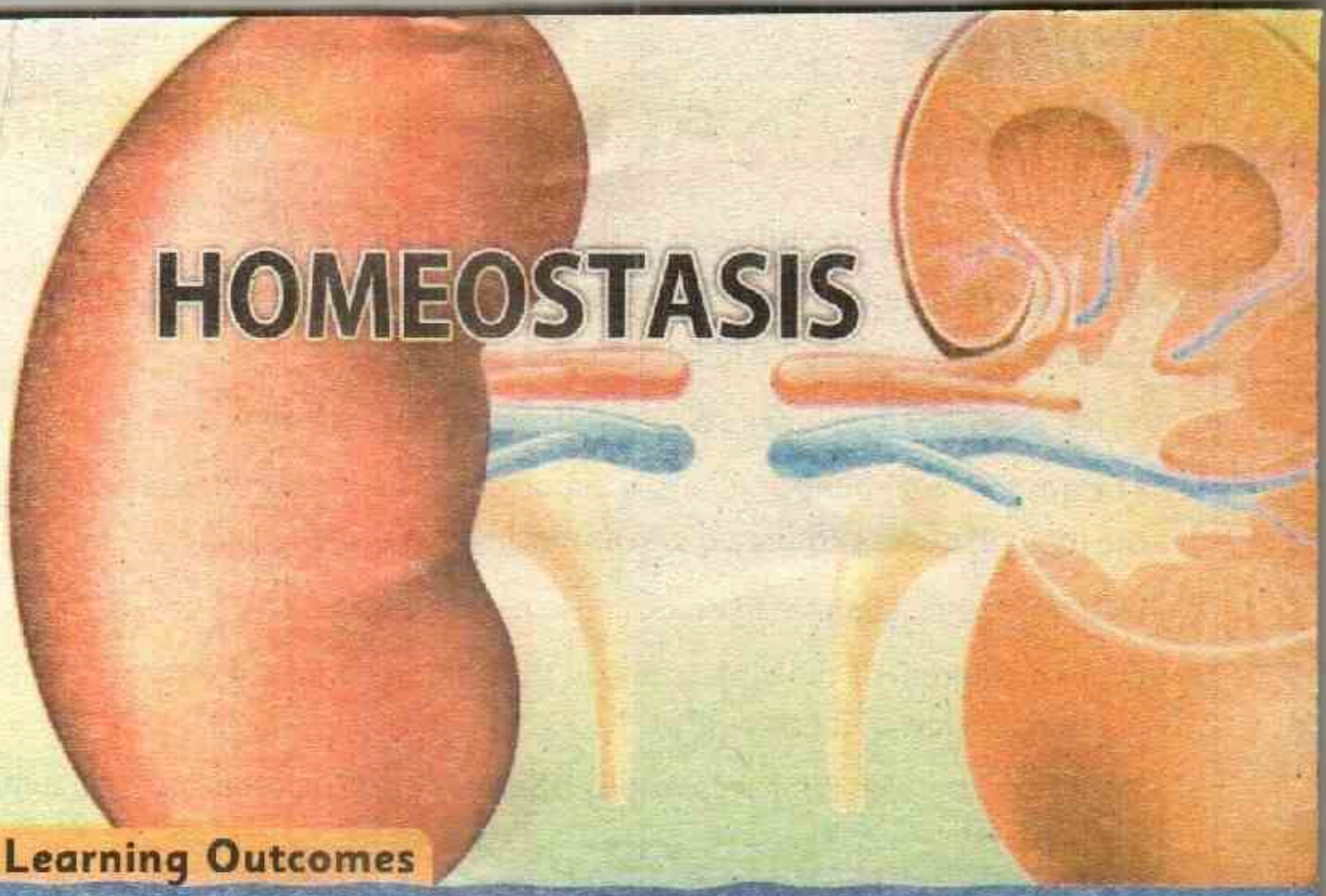
Activities

1. Investigate the effect of light on the net gaseous exchange from a leaf, by using bicarbonate as the indicator.
2. Investigate the breathing rate at rest and after exercise.
3. Find out how much air a person can take into his lungs.
4. Demonstrate through experiment, that carbon dioxide is exhaled during respiration.

Unit

11

HOMEOSTASIS



Students Learning Outcomes

The students will be able to:

- Define homeostasis and describe its importance.
- Describe the mechanisms/adaptations in plants for the excretion/storage of CO_2, H_2O, O_2, latex, resins and gums.
- Explain osmotic adjustments in plants.
- State skin, lungs and kidneys as the major organs involved in homeostasis.
- Explain the role of the skin in regulating body temperature.
- Describe how lungs keep the carbon dioxide concentration down to certain level.
- Explain that kidneys control the blood composition.
- Identify the different organs of urinary system.
- Relate the structure of kidney with its function.
- State that nephron is the excretory unit of the kidney.
- Locate the different parts of nephrons and relate them with their function.
- State that the main role of the kidney is urine formation.
- Describe that urine formation involves three processes i.e. filtration, reabsorption and secretion.
- Explain that kidney plays an important role in osmoregulation.
- Identify the causes of kidney stones.
- Identify lithotripsy and surgery as the methods to remove kidney stones.
- Outline the causes of kidney failure.
- Explain that dialysis is one of the treatments in kidney failure.
- Describe the types of dialysis.
- Describe the contributions of Al-Farabi and Abul-Qasim in introducing the method of removing stones from the urinary bladder.

Introduction

Living organisms have been evolved and adapted according to their environment. The conditions and components of the external environment keep on changing continuously. The changes in the external environment affect the internal environment too. However, the organisms overcome the effect of these changes. They make adjustments in their internal environment. In this way, they try to maintain their internal environment in a constant state. The ability to maintain the internal environment constant is called homeostasis. Homeostasis helps an organism to survive and utilise its environment in the best possible way.

The most important components of internal environment which are readily affected by fluctuations in external environments are **water, solutes** and **temperature**.

For your Information

The terms internal environment and external environment were coined by Claude Bernard a century ago.

Body fluids are important components of the internal environment. These fluids are made up of water and solutes. The water-solute balance (commonly called water-salt balance) in body fluids is very important. During homeostasis, organisms maintain the water-solute balance. The process by which the amount of water and solutes are maintained in the body, is called **osmoregulation**. **Excretion** is the elimination of harmful solutes (e.g. nitrogenous wastes) and extra water from the body.

We know that all metabolic reactions in the bodies of living organisms are catalyzed by enzymes. We also know that each enzyme works best at a suitable body temperature. Changes in the temperature of the external environment affect the internal body temperature. In homeostasis, organisms maintain their internal temperature within a tolerable range. It is called **thermoregulation**.

11.1 Homeostasis in Plants

Like other organisms, plants also respond to the changes occurring in the external environment and keep their internal conditions constant.

11.1.1 Osmoregulation in Plants

On the basis of the availability of water, there are four groups of plants. The process of osmoregulation differs in all these groups according to their need and structure.

Mesophytes (meso: medium, phyte: plant) are the terrestrial plants which live where sufficient quantity of water is available. They absorb water through their roots. In sufficient supply of water, the stomata are kept open to promote loss of excess water. When they face a shortage of water, they control extra

Fig.11.1 Mesophytes

transpiration by closing their stomata. Most of their body surface is covered with waxy cuticle, which prevents water loss. Examples of mesophytes are maize (corn), clover and rose etc.

Hydrophytes (hydro: water, phyte: plant) are the plants which live in freshwater (ponds, rivers streams lakes etc.) or in wet soil. Water keeps on entering their bodies through their whole surface. They remove this extra water from their bodies by different ways. For example, many hydrophytes have broad leaves which float on the surface of the water. These leaves have a large number of stomata on their upper surfaces. Water moves out of their bodies through these stomata. The most common example of such plants is the water lily.

Fig.11.2 Water lilies (common hydrophytes)

Xerophytes (xero: dry, phyte: plant) live in dry environments (e.g. deserts). They have deep roots to absorb water from almost dry soil. Their body surface has very few stomata. It is also covered with thick waxy cuticles to reduce the loss of water. Some xerophytes e.g. Cacti (singular: Cactus) store water in their specialised stems or roots. Such stems or roots are soft and juicy and are called succulent organs.

Fig.11.3 The thick stems of xerophytes store water and carry out photosynthesis.

Halophytes (halo: salt, phyte: plant) live in habitats with salty waters (e.g. sea or salty marshes). Since their bodies have less salt concentration as compared to the external environment, water tries to move out from their bodies into the environment. Such plants absorb salts from external water by active transport. In this way, water does not move out of the cells. The excess salt can be stored in cells or excreted out from salt glands on leaves. Many sea grasses are included in this group.

11.1.2 Excretion in Plants

Plants do not possess any special organs for excretion. They get rid-off different wastes in different ways, to maintain their internal environment. The materials which plants require to excrete are carbon dioxide produced during respiration, oxygen and water released as a by product of photosynthesis and some metabolic products like latex, resins and gums.

Excretion of Carbon Dioxide and Oxygen: During the day time, when active photosynthesis is going on, CO_2 is retained in the leaves of plants and is used for photosynthesis. At night when there is no photosynthesis it is excreted through the open

stomata of the leaves. During the day, the oxygen produced during photosynthesis is utilised in cellular respiration. The extra oxygen is released out through the stomata.

Excretion of extra water: Plants store large amounts of water in the vacuoles of their cells. It results in turgor, which provides support to the soft parts of the body. If plants have extra amounts of water, they remove it in two ways.

1. Transpiration: During the day, plants remove their extra water by transpiration. There are three types of transpiration i.e. through the stomata (stomatal transpiration), cuticle (cuticular transpiration) and through lenticels (lenticular transpiration).

Recalling

Transpiration is the loss of water from the plant surface in the form of vapours.

Fig.11.4 Types of transpiration

2. Guttation: Transpiration does not occur at night. Some plants such as grasses use a special method to remove extra water at night. They have small pores at the tips or edges of their leaves. They remove extra water through these pores. This water comes out in the form of little drops. This process is called guttation.

Fig.11.5 Water drops emerging from the margins of the leaves

Excretion of other wastes: Plants use different methods to excrete other wastes. Some plants store wastes in their bodies (stems, leaves or roots) in the form of harmless crystals. Some plants store their wastes in their leaves. When their leaves fall the plant body also gets rid of these wastes.

Some plants excrete their wastes through special pores by applying force. For example, the rubber plant excretes **latex**, the Acacia tree excretes **gums**, coniferous trees excrete **resins**, and the ladyfinger excretes **mucilage**.

For Your Information

Resins, gums and latex are very important plant products. They are economically very important and are used in many industrial products.

latex from a rubber plant — Gum from an Acacia tree — Resins from a coniferous tree

Fig.11.6 Excretion in Plants

11.2 Homeostasis in Humans

In human beings the main organs involved in homeostasis are skin, lungs and kidneys

a) Lungs as Homeostatic Organs

During cellular respiration, CO_2 and water are produced in every cell along with energy. CO_2 is a waste product for the body. It is an acidic gas, so, its accumulation can make the blood and other body tissues more acidic. Blood transports CO_2 from the cells to lungs. This carbon dioxide diffuses from the blood into the air in the alveoli. The air is then exhaled and so carbon dioxide is removed from the body.

b) Skin as a Homeostatic Organ

The skin of human beings and other mammals has been adapted as the organ for thermoregulation. There is a thin layer of fat cells beneath the epidermis of the skin. It does not allow heat to enter or leave the body. In cold conditions, muscles attached at the base of the hair on the skin contracts. As a result, the hairs on the skin stand up and goose bumps are formed on the skin. These goose bumps and hair make a blanket of warm air. It does not allow the body's heat to go out.

In warm conditions, the skin provides a cooling effect when sweat is produced by the sweat glands. In this way, excess body heat escapes through evaporation. Sweating also helps in the removal of some amounts of extra water, salts, and nitrogenous wastes from the body.

Do You Know?

Dogs have less number of sweat glands in their skin. Hence they keep their tongue hanging outside their mouth to increase the evaporation of water, which in response produces a cooling effect.

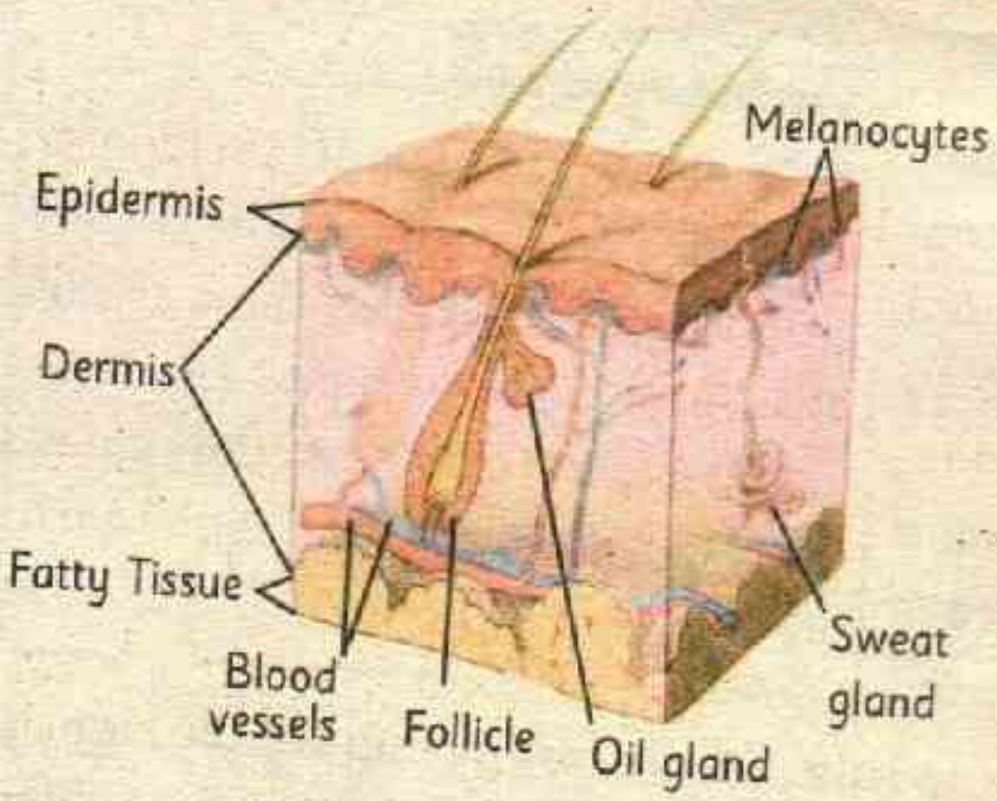


Fig 11.7 Human Skin

c) Kidneys as Homeostatic Organs

Kidneys are the most important organs of homeostasis in human beings and other animals. Kidneys are part of the urinary system of the body.

Kidneys filter the nitrogenous wastes from the blood and excrete them from the body. In addition to this, kidneys also control the water-solute balance. If there are more solutes in the blood, kidneys excrete them and retain water in the body. But if there is more water, kidneys produce more urine to remove excess water from the body. In this way, kidneys perform osmoregulation.

For Your Information

In bacterial and viral infections, leukocytes increase in number. When leukocytes kill pathogens, special chemicals are produced. These chemicals displace the set point of the hypothalamus of the brain above the normal point of 37°C. Brain sends messages to body parts to produce heat. It results in the body temperature to increase. This condition is called fever. This fever helps in stimulating the protective mechanisms against the pathogens.

For Your Information

Liver also plays role in homeostasis. It breaks the haemoglobin of dead red blood cells. The products of haemoglobin breakdown are sent to kidneys for removal. Liver changes the ammonia (produced in the metabolism of proteins) to urea. Urea is then removed from the body by kidneys.

11.3 Urinary System of Humans

The human urinary system (excretory system) consists of the following parts;

1. A pair of kidneys
2. A pair of ureters
3. A urinary bladder
4. A urethra

The kidneys remove extra water, salts and nitrogenous wastes from the blood and produce urine. From each kidney, a tube called the **ureter** carries urine to the urinary bladder. The **urinary bladder** temporarily stores urine. The **urethra** is the tube that carries urine from the urinary bladder to the outside.

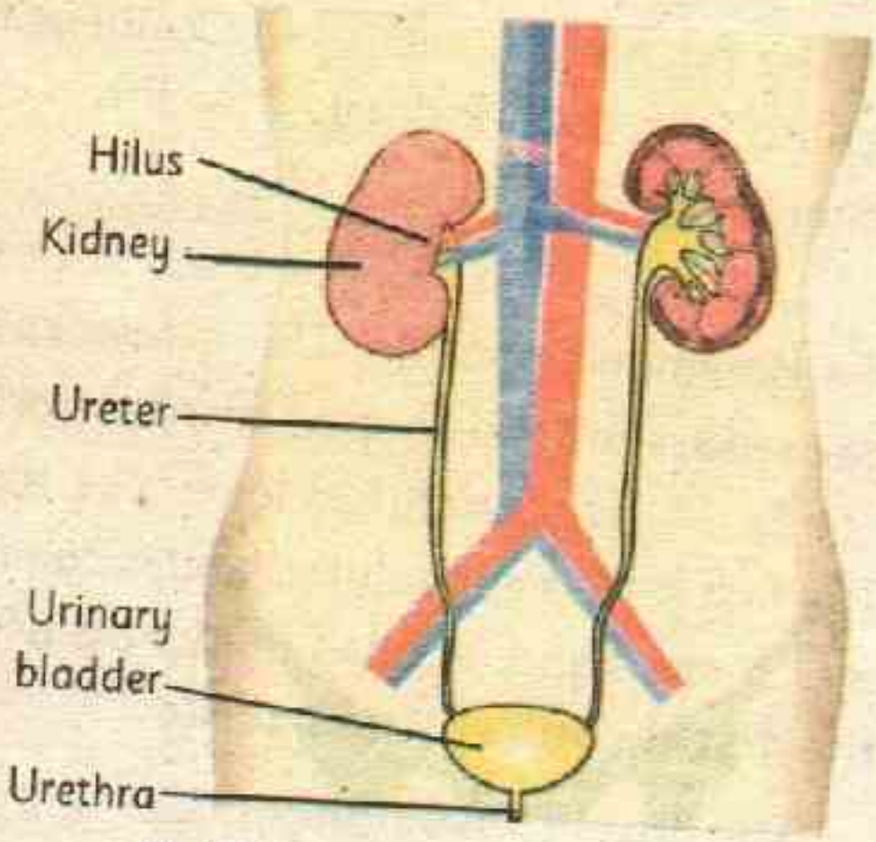


Fig 11.8 The Urinary System

11.3.1 Structure of the Human Kidney

Human beings possess a pair of kidneys. They are present below the diaphragm in the abdominal cavity, on the sides of vertebral column. They are attached to the dorsal body wall. The right kidney is slightly lower and smaller than the left one. Kidney is a dark brown and bean shaped organ (having a concave and a convex side). The concave side of each kidney is towards the vertebral column.

Do You Know?

Each kidney is about 10 cm long, 5 cm wide and 4 cm thick. The weight of both kidneys is less than 1% of the total body weight. However they receive 20% of the blood supplied to the body with each heartbeat.

Kidney is enclosed in a tissue called the **renal capsule**. On the concave side of the kidney, there is a depression called the **hilus**. It is the point where the renal artery enters the kidney and where the renal vein and ureter leave the kidney.

A longitudinal section of the kidney shows that it consists of two regions. The outer region is called the **renal cortex** whereas the inner region is called the **renal medulla**. There are many cone-shaped areas in renal medulla called the **renal pyramids**. The base of each pyramid faces the renal cortex while its tip is in a cavity called the **renal pelvis**. The pelvis extends to the outside of the kidneys and forms the ureter.

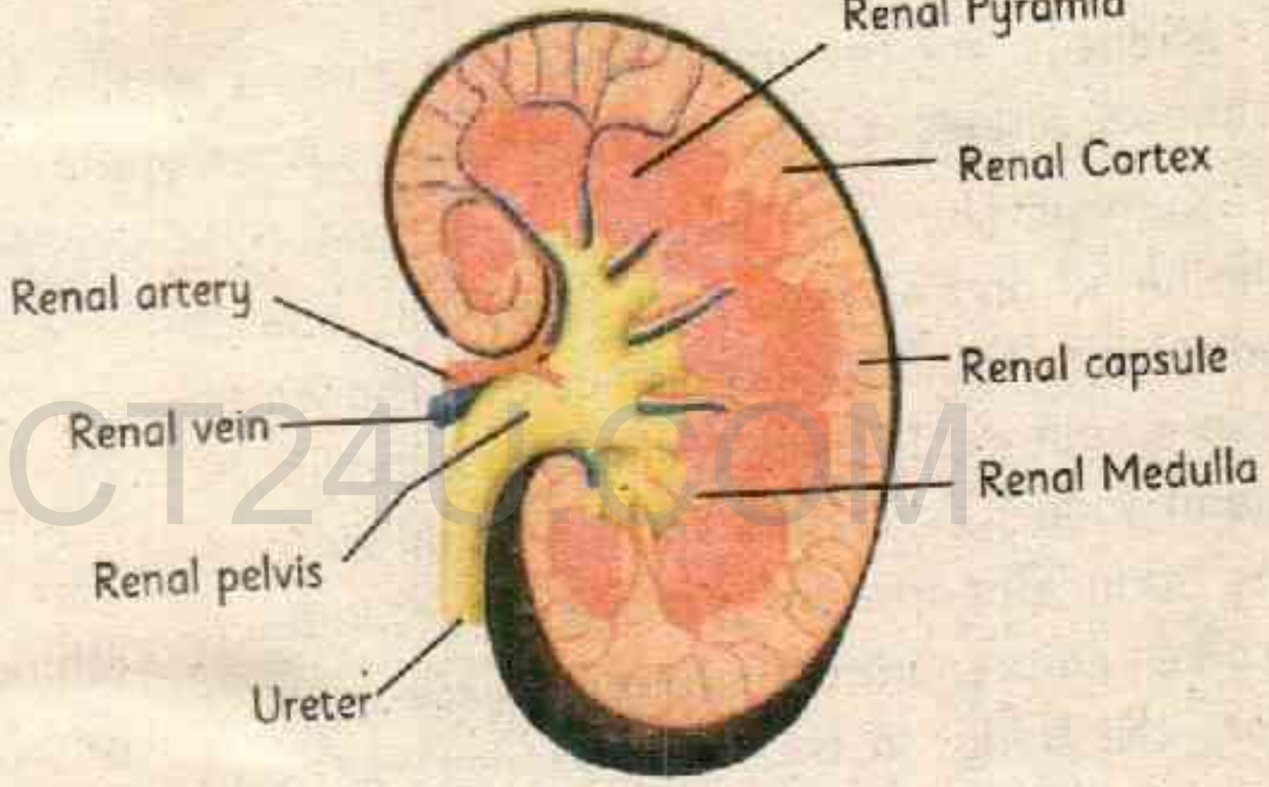


Fig. 11.9 Structure of the Kidney

The functional units of the kidneys are called nephrons. There are more than one million nephrons in each kidney. A nephron consists of two parts i.e. the renal corpuscle and the renal tubule.

1. **Renal corpuscle:** It is the first part of the nephron and is composed of glomerulus and the Bowman's capsule. The **glomerulus** is a network of capillaries while the **Bowman's capsule** is the cup-shaped structure around the glomerulus.
2. **Renal tubule:** It is a long tube attached with the Bowman's capsule. It has three parts. The first part is convoluted and is called the **proximal convoluted tubule**. The middle part is U-shaped and is called the **Loop of Henle**. The last part is again convoluted and is called the **distal convoluted tubule**.

The distal convoluted tubules of many nephrons open in a single **collecting duct**. Many collecting ducts join together and open into the renal pelvis.

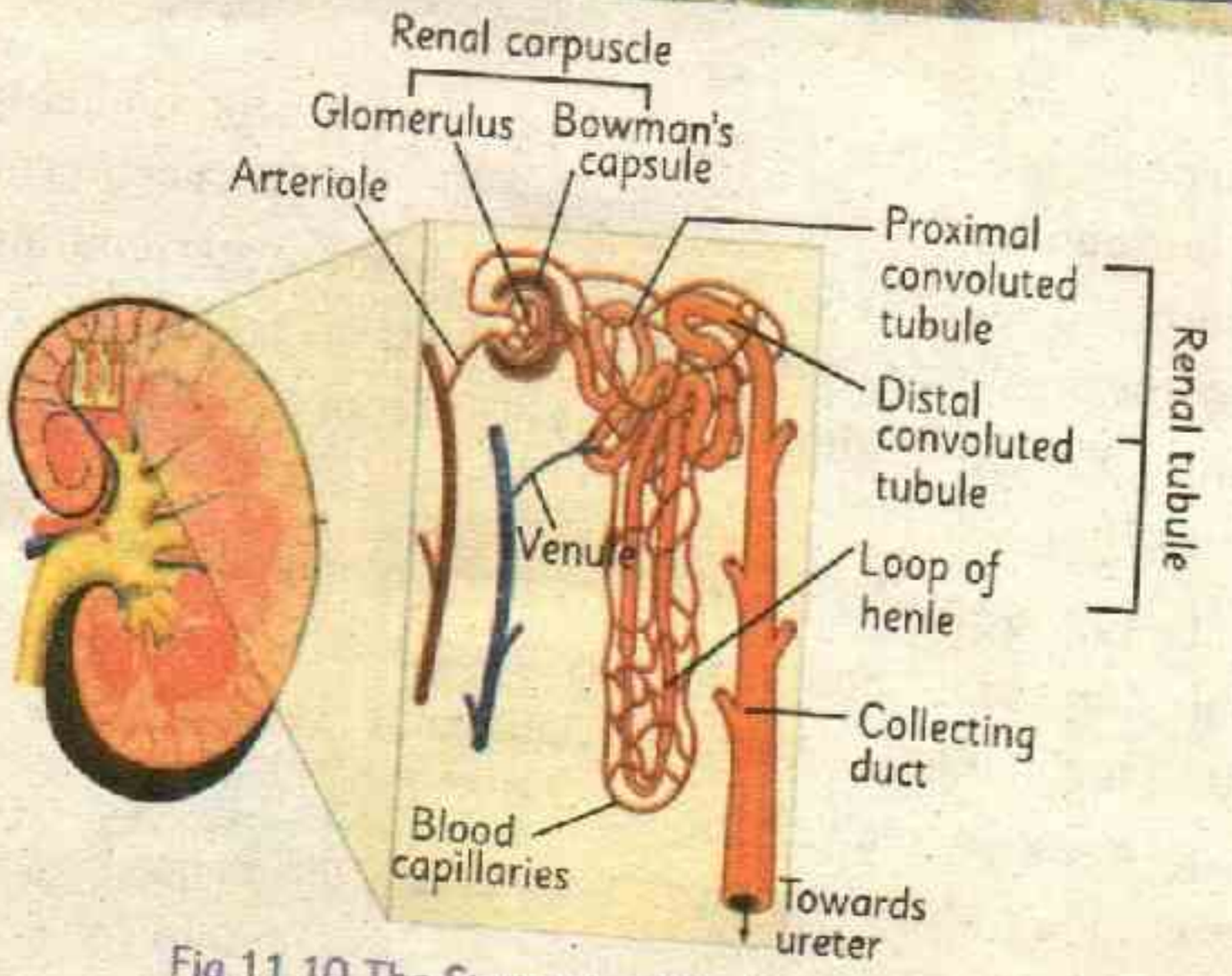


Fig.11.10 The Structure of Nephron

11.3.2 Process of Urine Formation

Process of urine formation can be divided into three sub processes.

(i). Pressure Filtration

A renal artery carries blood to the kidney. The artery divides into many arterioles. Each arteriole divides further into the capillaries of the glomerulus. When blood reaches the glomerulus, its pressure is very high. Due to the high pressure of blood in the glomerulus, a lot of materials in blood i.e. water, salts, sugars and nitrogenous wastes are filtered out of the glomerulus into the Bowman's capsule. As this filtration takes place due to the pressure of the blood in the glomerulus, it is called pressure filtration. The filtered material collected in the glomerulus is called **glomerular filtrate**. Blood cells and plasma proteins are not filtered out because they are larger in size.

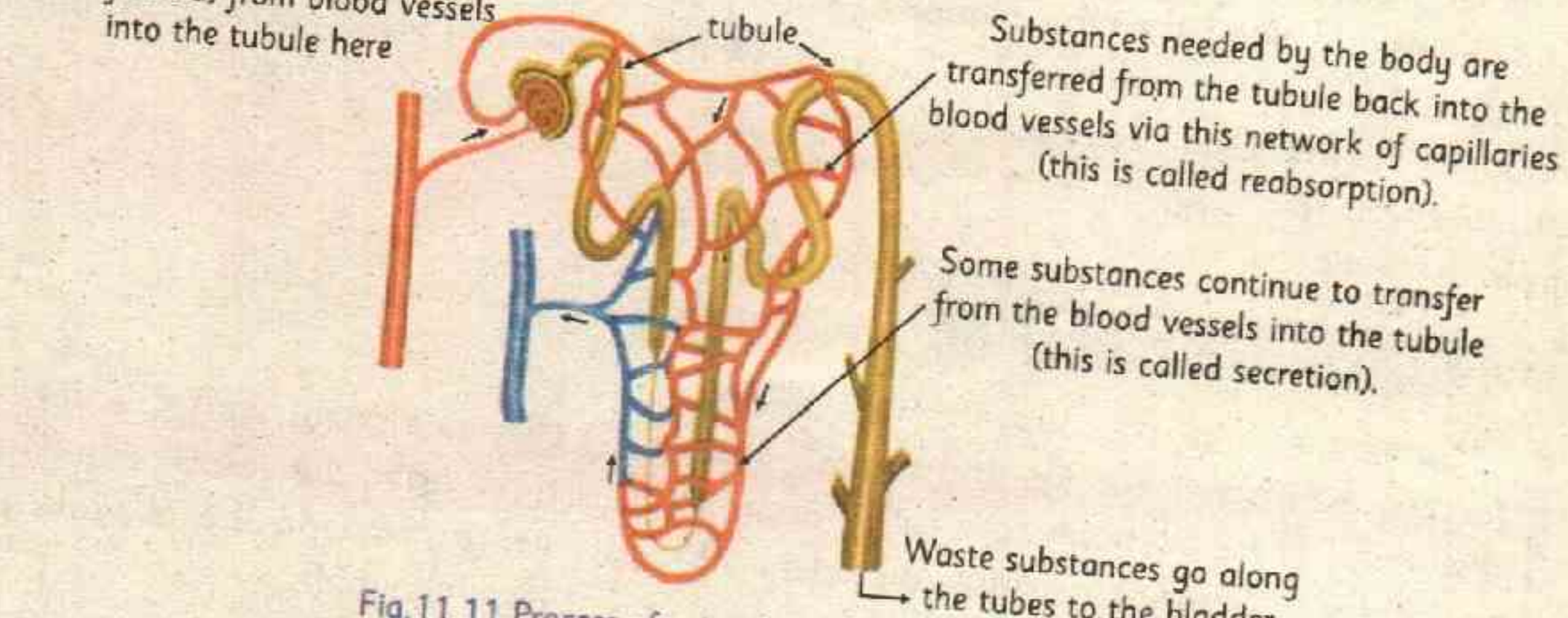


Fig.11.11 Process of urine formation in the nephron

(ii). Reabsorption

The glomerular filtrate moves to the next part of the nephron i.e. the renal tubule. The renal tubule is surrounded by blood capillaries. The useful constituents of the glomerular filtrate are reabsorbed into the blood capillaries. Some water and most of the glucose is reabsorbed from the proximal convoluted tubule. Salts are reabsorbed from the loop of Henle while most of the water is reabsorbed from the distal convoluted tubule and collecting duct.

(iii). Tubular Secretion

When useful materials are reabsorbed from the glomerular filtrate into the blood, some waste materials (e.g. salts, hydrogen ions, urea etc.) are again added from the blood capillaries to the renal tubule. This step is called tubular secretion.

After pressure filtration, reabsorption and tubular secretion, the filtrate present in the renal tubule is called urine. Urine from the collecting ducts moves to the renal pelvis. From the renal pelvis, urine moves to the urinary bladder via ureters. Here it is stored. When the urinary bladder is filled, urine is passed out through the **urethra**.

Do You Know?

A ring of sphincter muscles near the junction of the urethra and the urinary bladder controls the urine in the bladder. When about 300 to 400 ml urine is collected in the bladder, we need to discharge it. In babies this sphincter is not developed properly hence they are not able to control their urination.

11.3.3 Osmoregulation and Kidneys

Kidneys play the most important, function in the homeostasis of the body. They mainly perform the osmoregulatory and excretory functions. When body fluids including blood have limited amount of water, there is more reabsorption of water from the glomerular filtrate into the blood capillaries. As a result the net volume of urine decreases and the water is conserved in the body.

In contrast, when there is an excess of water in the body fluids and blood, the reabsorption of water from the glomerular filtrate is reduced. So, more water remains in the renal tubule and more urine is produced. In this way, the excess water is released from the body.

Tidbit

Kidney is adopted to conserve water by over 99.5% reabsorption of glomerular filtrate.

11.4 Disorders of Kidnys

Sometimes due to some internal or external factors, the normal working of the kidneys may be disturbed. These situations are called disorders of the kidney. Some important disorders of the kidneys and their treatment is described below.

Tidbit

Human kidneys start functioning right after the fourth month of gestation and keep working throughout life.

Science, Technology and Society

How does diabetes cause kidney disease?

The blood vessels in the kidneys which function as filter are damaged when there is high sugar in the blood. The damaged blood vessels then do not function as filters and the blood cannot be cleaned properly. The body will have more water and salts which can result in weight gain and ankle swelling. Urine may have more proteins and the blood may have more wastes. Many people with diabetes also develop high blood pressure, which can also damage their kidneys.

11.4.1 Kidney Stones

We know that kidneys filter harmful substances from the blood. Sometimes, the filtered harmful substances (e.g. calcium oxalate, calcium and ammonium phosphate, uric acid etc.) gather in the kidneys and make larger objects. Such objects cannot pass in the urine and are called **kidney stones**. Some stones may leave the kidneys and get trapped in the ureter or urinary bladder. These can then cause obstruction in the urinary tract.

The presence of more calcium oxalate, calcium and ammonium phosphates in a person's diet (green vegetables, fats, dairy products) is the major cause of kidney stones. Extra amounts of vitamins C and D in a diet may also cause stones. The other causes of kidney stones are reduced water intake, excess uric acid in the blood, urinary tract infections, and alcohol consumption.

For Your Information

Calcium oxalate type stones are 70% of all the kidney stones. Oxalates are present in green vegetables and tomatoes. Therefore eating green leafy vegetables and tomatoes may form oxalate stones.

Patients of kidney stones feel severe pain in kidney or lower abdomen. Other symptoms of kidney stones include nausea, vomiting, burning in urethra, frequent urination, foul-smelling urine, blood and pus in the urine and bloating.

Treatment of kidney stones

If kidney stones are small in size, the patient is advised to drink **plenty of water** so that stones can pass through the urine. If stones are large and cannot pass easily, the patient has to undergo **surgery**. Patient's kidney, ureter or urinary bladder is opened and stones are removed.

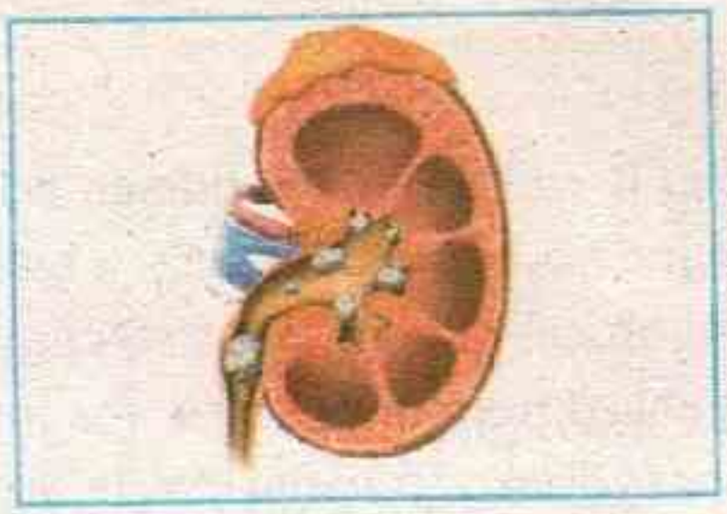


Fig. 11.12 Kidney with stones

Tidbit

Lithotripsy works best with stones between 4 mm to 2 cm in diameter that are still located in the kidney. It can be used to break up stones which are located in a ureter too, but with less success.

The most recent method of removing kidney stones is called lithotripsy. It is the non-surgical removal of kidney stones. This technique is used to break up stones present in the kidney, ureter or urinary bladder. In this method, the stone inside the kidney is targeted by shock-waves. The shock waves break the stone into tiny pieces, which are passed out of the body in the urine.

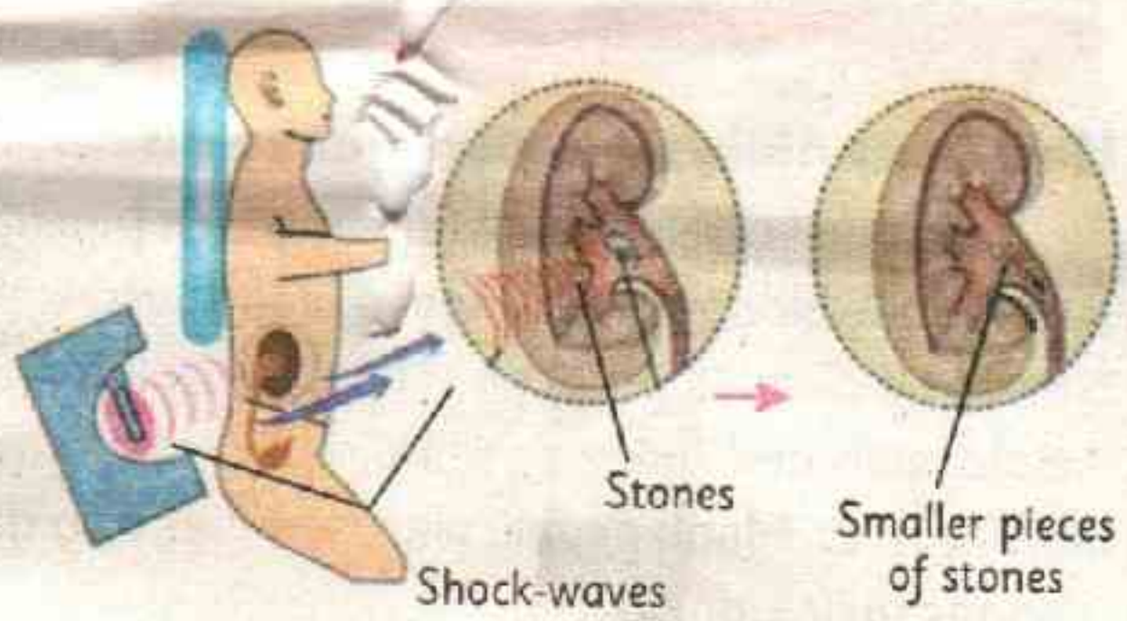


Fig.11.13 Lithotripsy

11.4.2 Kidney (Renal) Failure

Due to various reasons, the nephrons are progressively destroyed and stop functioning. This condition is termed as renal failure or kidney failure. The most common causes are long-term diabetes mellitus, and hypertension. Severe infections in the kidney and the overuse of medicine (aspirin, ibuprofen, cocaine and acetaminophen) can also cause kidney failure. In renal failure, nephrons are not able to filter the blood properly therefore the level of urea and other nitrogenous wastes in the blood increases. It causes complications like increase in blood pressure and anaemia etc. Other symptoms include weight loss, vomiting, nausea, and blood in the urine. Due to excess fluid in the body, there is swelling in the legs, feet and face.

Two types of treatments are given to the patients of renal failure.

1- Dialysis

The cleaning of the blood of a patient suffering from renal failure (by using artificial methods) is called dialysis. In dialysis, the blood and a dialysis fluid are kept on opposite sides of a membrane. The nitrogenous wastes of blood pass through the membrane and enter the **dialysis fluid**. In this way, the blood is purified. There are two methods of dialysis.

a). Haemodialysis: In this method blood is passed through a machine called a **dialyzer**. The dialyzer contains tubes, the walls of which are made of semi-permeable membranes. Blood flows inside the tubes while the dialysis fluid flows outside. Extra water and wastes diffuse from the blood into the dialysis fluid. The purified blood is then returned back to the body.

Science, Technology and Society

Science, Technology and Society

Drinking plenty of water (at least eight glasses) daily is crucial for the human body. It regulates the body temperature and transports nutrients and oxygen into the cells. It moistens the air in our lungs, protects our organs and helps them obtain nutrients. It also detoxifies, protects and moistens the joints. Waste products are removed from our body in the form of solutions. Dehydration can be dangerous so it is important to drink water and stay hydrated.

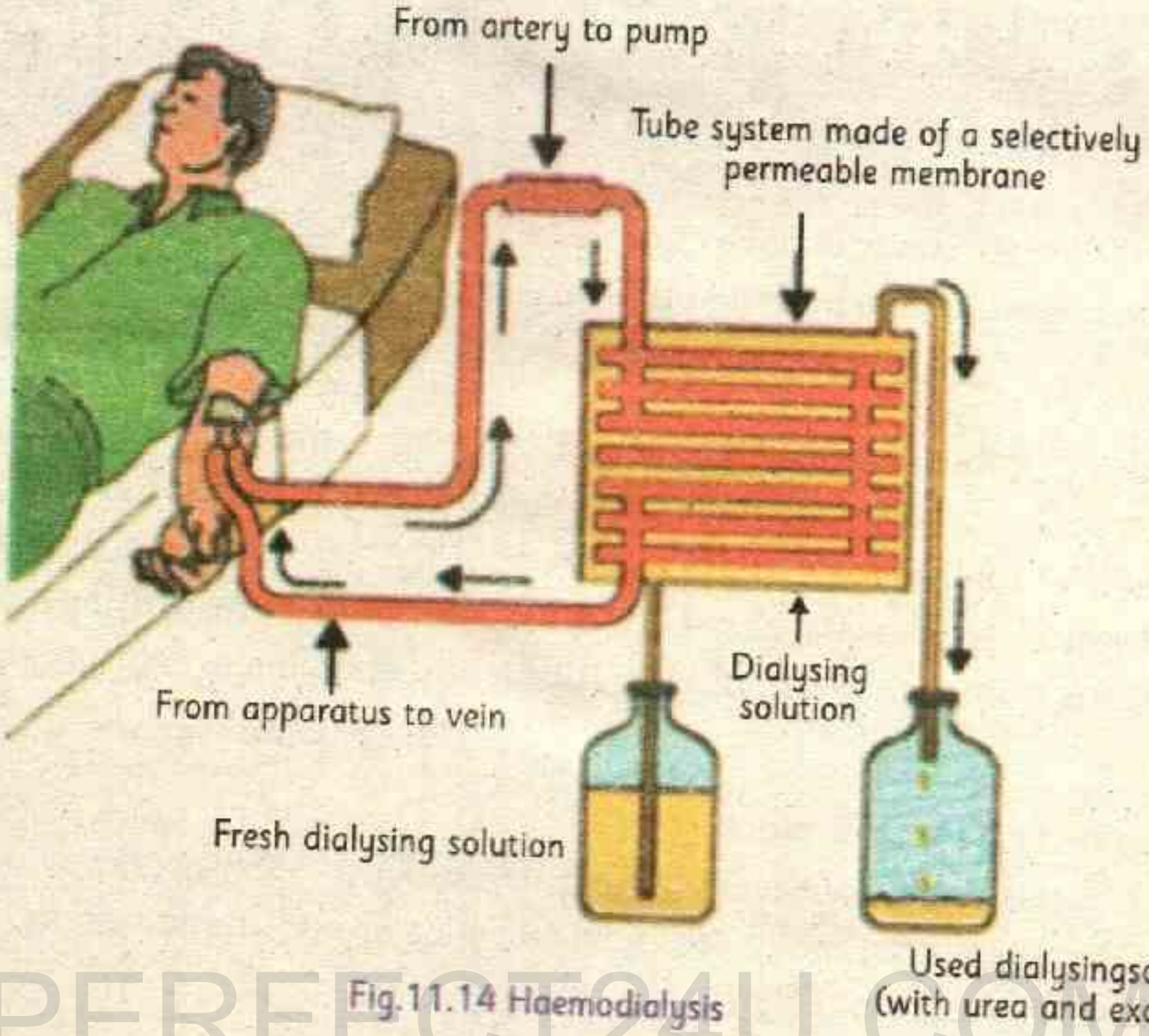


Fig.11.14 Haemodialysis

b). Peritoneal dialysis: In the abdomen, the space around the gut (alimentary canal) is called the peritoneal cavity. The walls of peritoneal cavity are lined by a thin membrane called the **peritoneum**. The peritoneum has a large number of blood vessels in it.

In this method, the dialysis fluid is filled in the peritoneal cavity through a catheter. The waste materials present in the blood vessels of the peritoneal membrane diffuse into the dialysis fluid. After some time, the dialysis fluid is drained. This form of dialysis can be done at home.

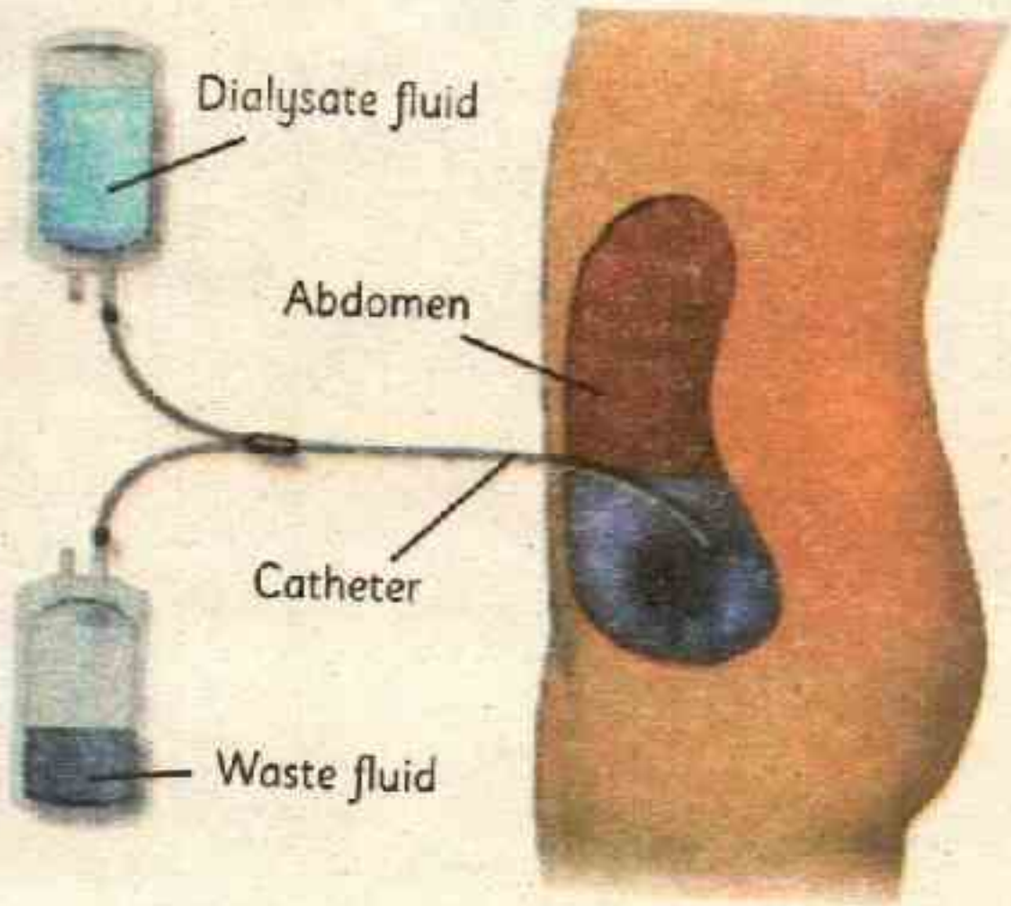


Fig.11.15 Peritoneal Dialysis

2- Kidney Transplantation

It is the advanced treatment of kidney failure. In this treatment, a healthy kidney from donor is transplanted in the patient's body. The donor of kidney may be a deceased person or a living one. A living-donor may or may not be a relative of the patient. In all cases, the donor's kidney is matched with the patient's immune system.

11.5 Contributions of Muslim Scientists to the treatment of Kidney problems

Various Muslim scientists have contributed to the studies of kidneys at various times. Among them, Abul- Qasim and Al-Farabi are well known.

Abul-Qasim

Abul-Qasim al-Zahrawi (936-1013 AD) is known in the west as Abulcasis. He is best known for his early and original breakthrough in surgery. His famous Medical Encyclopedia called Al-Tasrif is composed of thirty volumes. In this encyclopedia, he described various aspects of surgical treatments based on the operations performed by him, including the removal of stone from the urinary bladder, dissection of animals, and surgery of the eye, ear and throat.

Contributions of Al-Farabi

The great Turkish philosopher and scientist Abu Nasr Al-Farabi (known as Alpharabius: 872-950 AD) wrote many books. He provided a lot of information about kidney diseases, including stones in the urinary bladder.

For Your Information

Abu Bakar Muhammad ibn Zakariya Al Razi was a born in 865 A.D in Persia. He was famous Muslim doctor, scholar and philosopher. His most appreciated work was on kidney and bladder stones. He introduced techniques to remove kidney stones. His book, "The book of Formation of small stones" received critical acclaim all over the world.

Key Points

- The maintenance of the internal environment as constant or nearly constant is called homeostasis.
- Regulation of the amount of water in body fluids is called osmoregulation while the regulation of internal body temperature is called thermoregulation.
- Guttation is the removal of extra water through small pores at the tips of leaves.
- Some plants remove wastes in the form of latex (e.g. rubber plant), gums (e.g. Acacia tree), resins (e.g. coniferous trees) and mucilage (e.g. ladyfinger).
- Hydrophytes have broad leaves with a large number of stomata on their upper surface.
- Xerophytes have thick cuticle and deep roots, and special juicy stems or roots.
- Halophytes take salts from sea water. Therefore, water does not move out of their bodies.
- The human urinary system consists of a pair of kidneys, a pair of ureters, a urinary bladder and a urethra.
- The functional unit of the kidneys is called nephrons.
- A nephron consists of two parts. (i) Renal corpuscle is composed of glomerulus and the Bowman's capsule. (ii) Renal tubule has three parts i.e. the proximal convoluted tubule, the Loop of Henle, and the distal convoluted tubule.
- When the glomerular filtrate moves to the renal tubule, useful materials are reabsorbed from the glomerular filtrate into the blood.
- In tubular secretion, some waste materials (e.g. salts, urea etc.) are added from the blood capillaries to the renal tubule.
- Urine from all the nephrons moves to the renal pelvis and then to the urinary bladder via ureters. From the bladder, urine is passed out through the urethra.
- Kidney stones are formed when calcium oxalate, calcium and ammonium phosphate, and uric acid etc.) gather in the kidneys and make larger objects.
- In lithotripsy, shock waves are targeted at stones from the outside to break the stones into smaller pieces.
- When one or both kidneys are not able to perform their function, the condition is called kidney failure.
- In haemodialysis, the patient's blood is pumped through a dialyzer. The blood flows inside the tubes while dialysis fluid flows outside. Extra water and wastes move from the blood and enter the dialysis fluid.
- In peritoneal dialysis, dialysis fluid is pumped into the peritoneal cavity. The waste materials pass from the blood present in the blood vessels into the dialysis fluid.

Exercise

A. Select the correct answer.

1. Organisms have the ability to change and modify their internal conditions according to the environment through:
   a. Osmoregulation b. Excretion c. Thermoregulation d. All of the above
2. All of the following are the adaptation of xerophytes except:
   a. Thick cuticle b. Large number of stomata
   c. Sunken stomata d. Deep root system
3. The loss of water from the plants in the form of small droplets is:
   a. Stomatal transpiration b. Cuticular transpiration
   c. Lenticular transpiration d. Guttation
4. From a nephron, wastes enter into the
   a. Collecting tubules b. Ureter c. Convoluted tubules d. Medulla
5. The tube between the kidney and urinary bladder is the:
   a. Ureter b. Urethra c. Renal tubule d. Nephron
6. Waste products excreted by the kidneys are:
   a. Urea, water and salts b. Salts, water and carbon dioxide
   c. Urea and water d. Urea and salts
7. Secretion of urea in sweat makes skin a:
   a. Respiratory organ b. Breathing organ
   c. Excretory organ d. Digestive organ
8. The two main functions of sweat are to;
   a. Keep the body cool and to remove excess proteins
   b. Keep the body warm and to filter the blood
   c. Filter the blood and to remove waste products
   d. Remove waste products and to cool the body
9. Which is NOT present in the filtrate entering the Bowman's capsule of a nephron?
   a. Water b. Calcium ions c. Blood cells d. Urea
10. Liver also plays a role in excretion. It makes urea from;
    a. Uric acid b. Ammonia c. Carbon dioxide d. Amino acids

B. Write short answers to the following questions.

1. Define homeostasis and osmoregulation.

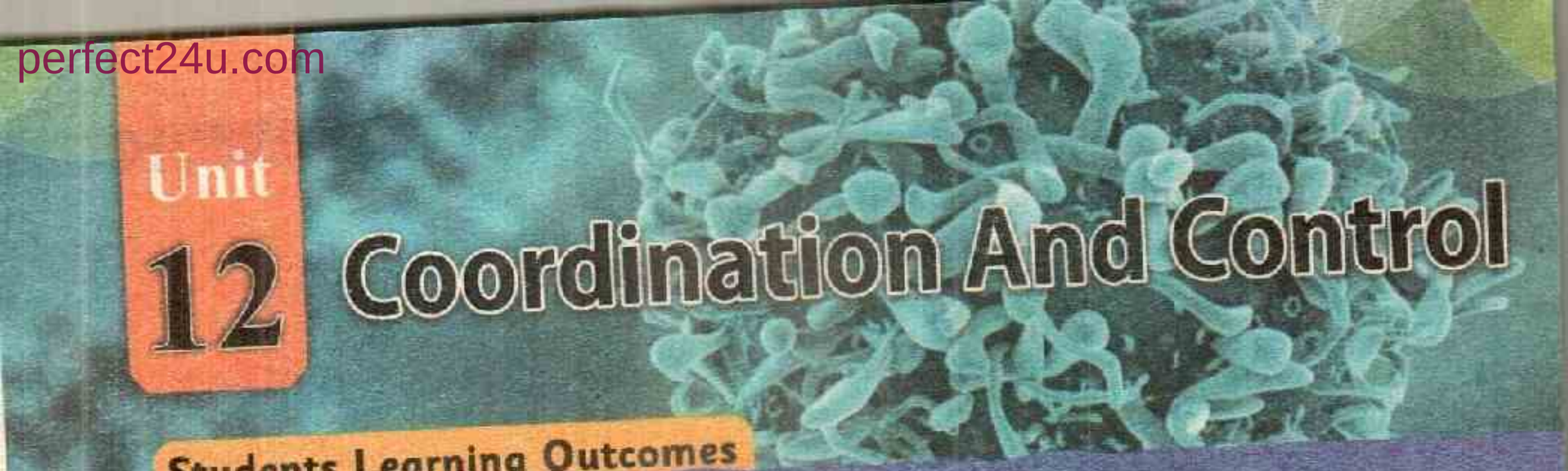
2. Differentiate between the adaptations of hydrophytes and xerophytes for osmoregulation.
3. Briefly describe how kidneys control the composition of blood.
4. Enlist materials in our diet which are more likely to cause kidney stones?
5. Define lithotripsy?
6. What is the role of the skin in thermoregulation?
7. Which term is used for the disease where one or both kidneys do not perform their function?

C. Write detailed answers to the following questions.

1. Describe the structure of kidneys in human beings.
2. Why do plants excrete? What are the different mechanisms through which plants excrete different substances?
3. What are kidney stones and how are they formed? Suggest ways in which these stones can be removed from the body.
4. Define haemodialysis. How is it performed?
5. How does a dialyzer work? Relate the function of a dialyzer with that of the kidney.

Activities

1. Examine the structure of a kidney (sheep or goat kidney / model).
2. Trace the movement of a molecule of urea from the blood to the urethra, using a flow chart diagram.



Unit 12 Coordination And Control

Students Learning Outcomes

The students will be able to:

- Explain what coordination means.
- Identify the two main types of coordination in living organisms, i.e. Nervous and Hormonal (chemical).
- Differentiate between the modes of coordination i.e. electrical in case of nervous and chemical in case of hormonal.
- Identify the main organs responsible for coordination and control.
- State that receptors receive stimuli and transmit information to effectors through CNS.
- Label the diagram of a human brain.
- Explain the function of these parts of the brain; cerebrum, cerebellum, pituitary gland, thalamus, hypothalamus, medulla oblongata.
- Differentiate between the cross sectional views of the brain and spinal cord, with reference to white and grey matter.
- Define a neuron and describe the structure of a general neuron.
- Define reflex action and reflex arc.
- Name the three types of neuron involved in reflex action.
- Trace the path of a nervous impulse in the case of a reflex action.
- Describe the structure of human auditory and visual receptors.
- Describe the pupil reflex in dim and bright light.
- State how short and long sightedness can be treated.
- Associate the role of Vitamin A with vision and effects of its deficiency on the retina.
- Explain the role of the ear and the eye in the maintenance of homeostasis through balance and accommodation.
- Relate the contribution of Ibn-al-Haitham and Al-Ibn-Isa in providing knowledge about the structure of the eye and treatment of various ophthalmic diseases.
- Define the terms; hormone and endocrine system.
- Outline the parts of the endocrine system; major glands of this system (Pituitary, Thyroid, Pancreas, Adrenal, Gonads) and names of their respective hormone.
- Describe the term "Negative feedback" with reference to insulin and glucagon.
- Explain how adrenaline may be involved in exercise and emergency conditions and use gained knowledge to apply to different hormones.
- Explain the two common kinds of nervous disorders (Vascular i.e. paralysis and Functional i.e. epilepsy).
- Enlist some of the symptoms and treatments of paralysis and epilepsy.

Introduction

All organisms interact with their environment and respond to the changes (stimuli) taking place in the environment. You perform daily activities in a very coordinated way. If you want to write a letter, you first take a pen and a paper, then think about what to write, and then start writing. Similarly, if a nail comes under your bare foot, you at once lift your foot, sit down somewhere and pull out the nail. How does this all happen in such specific way? The answer is that in our body there is a system working to coordinate and control all the actions (responses).

12.1 Coordination in Organisms

Coordination means to integrate among different parts of the body and to respond to stimuli in order to keep harmony with the environment. Coordination is the property of all living organisms. There are two types of coordination i.e. nervous coordination and chemical coordination. **Nervous coordination** is performed by the nervous system. **Chemical coordination** takes place through certain chemicals called **hormones.** Animals possess both these types of coordination. Plants and other organisms (unicellular organisms, fungi etc.) have only chemical coordination.

Tidbit

The response of chemical coordination is slower than the response of nervous coordination, which works at the speed of electricity.

12.1.1 Mechanism of Coordination

Phase I: Receiving Stimulus: When some change occurs in our internal or external environment, specific parts of the body feel that change. Any change in the environment which can initiate a response in the body is called a **stimulus** (Plural: stimuli). For example, touch, light, and sound etc. are the stimuli. The parts of the body which receive or feel the stimuli are called **receptors**. Special organs, tissues or even cells of the body may act as receptors. For example, our sense organs (eye, ear, skin, tongue and nose) are the main receptors of the body.

Phase II: Message to Coordinator: The receptors send the information of stimulus to a **coordinator**. It analyses the information and makes a decision. In nervous coordination, the **brain** and **spinal cord** are the coordinators. They receive and send messages through **neurons** in the form of electrical signals (nerve impulses). In chemical coordination, the **endocrine glands** are the coordinators. They receive information in the form of chemicals and send messages by secreting **hormones** in the blood.

Phase III: Producing Response: The coordinator sends a message to special parts of the body for proper action (response). These parts are called **effectors**. In nervous coordination, **muscles** and **glands** are the effectors. While in chemical coordination, different tissues of the body act as **effectors**. On receiving the coordinator's message, the effectors carry out actions (responses) according to their specialisation.

This can be understood through a simple example. When the door of your house is knocked, the sound produced by knocking is a stimulus. Your ears (receptor) receives this stimulus and sends a massage to your brain (coordinator). The brain analyses the information and sends a message to the muscles (effectors) of your legs to move and take you to the door. Then signals are communicated to the hand to move and open the door.

Science, Technology and Society

The nervous system helps to coordinate complex and intricate movements of the hand to play a piano or write alphabets. The intention begins in the special area of the brain. The neurons of this area compile a set of information required for an action such as typing or speaking. The information is then transmitted to another area of the brain. It integrates information and ensures that all the muscles work together to produce well-coordinated movements.

	Nervous Coordination	Chemical Coordination
Modes of coordination	Electrical	Hormonal
Receptors	Sense organs (eyes, ears, nose, tongue, skin)	Many body parts (e.g. kidneys, liver etc.)
Coordinator	Brain and Spinal cord	Endocrine glands
Effectors	Muscles and Glands	Many body parts (e.g. kidneys, liver, stomach etc.)
Nature of message	Electrical (Nerve impulse)	Chemicals (e.g. hormones)
Carrier of message	Neurons	Blood
Nature of response	▪ Contraction of muscles ▪ Secretions from glands	▪ Various types (e.g. growth, reabsorption of water by kidneys)

Table 12.1 Difference between Nervous and Chemical Coordination

12.2 Human Nervous System

In humans and other higher animals, the nervous system has two major components i.e. the central nervous system (CNS) and the peripheral nervous system. The central nervous system comprises of coordinators i.e. brain and spinal cord. The peripheral nervous system consists of nerves that arise from the brain and spinal cord that spread in different parts of the body.

12.2.1 Neuron

A neuron is the basic unit of structure and function of the nervous system. Neurons are also called nerve cells. These are the cells that are specialised to conduct messages in the form

of **nerve impulses** among various body parts. A nerve impulse is a wave of electrochemical change that travels through neurons.

The nervous system is composed of billions of neurons of different sizes and shapes. Let us study the structure of a typical neuron.

A typical neuron has three main parts; cell body, dendrites and axon.

Cell body consists of a cell membrane encircling cytoplasm, nucleus and other cell organelles like Golgi complex, mitochondria, ribosome, endoplasmic reticulum etc.

Tidbit

In the CNS, myelinated axons form the **white matter**, and the non-myelinated axons, dendrites and cell bodies form the **grey matter**.

One or more short processes called **dendrites** arise from the cell body. Their function is to bring the impulses towards the cell body.

Axon is a long thread-like, unbranched process which extends from one side of the cell body. It takes nerve impulses away from the cell body. Axons of large neurons are generally covered by a white sheath called a **myelin sheath.** This sheath is made of fatty material which insulates the axon. The sheath is broken at different intervals called **nodes.** The distance between two nodes is covered by a **Schwann cell.**

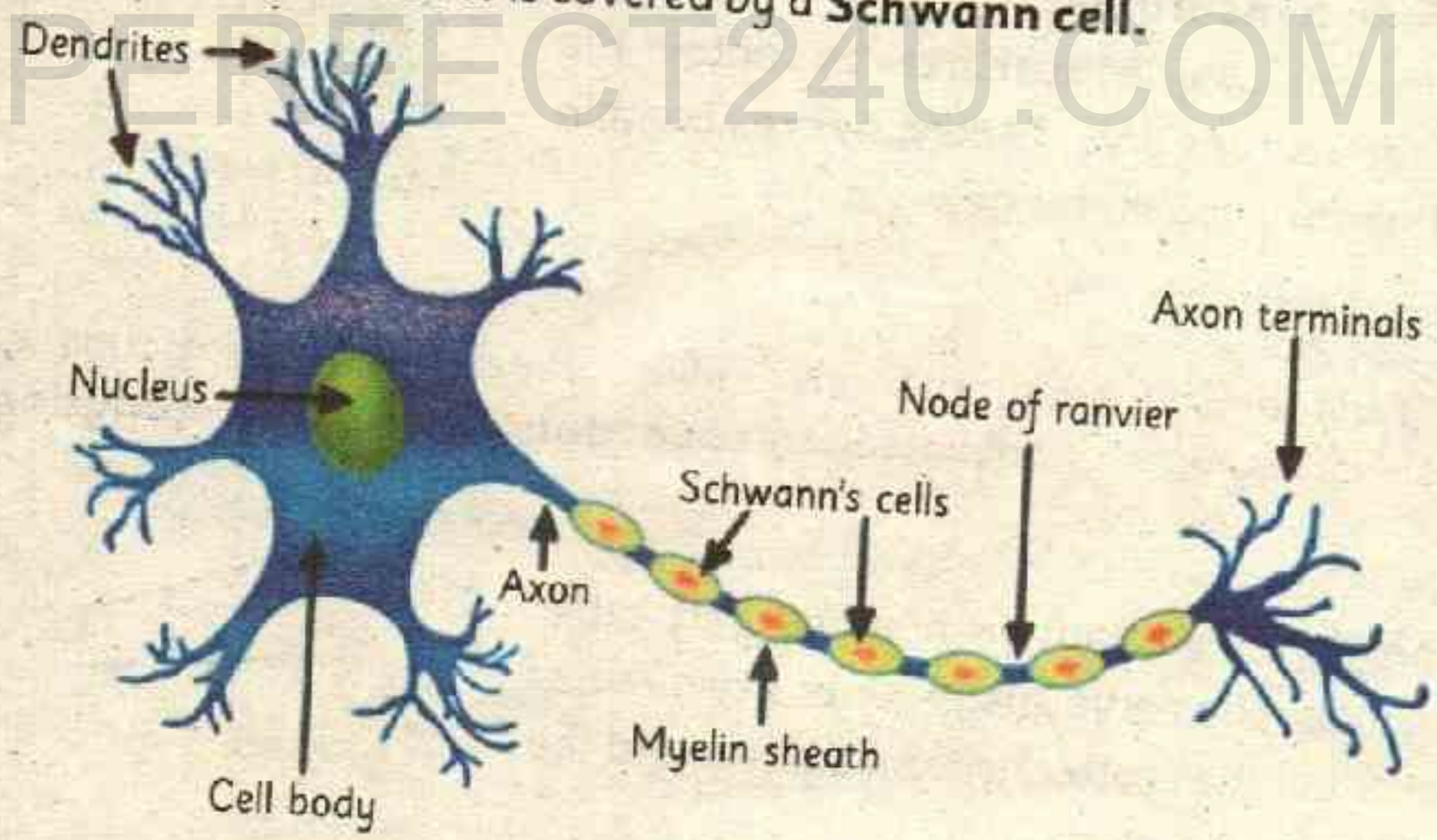


Fig. 12.2 (a) Structure of a Typical Neuron

On the basis of function, neurons may be classified into three groups.

a. Sensory neurons carry impulses from sense organs to the CNS. In these neurons, the axon is short whereas there is a single long dendrite (called dendron).

b. Motor neurons take impulses away from the CNS to effectors. They have long axon and many short dendrites.

c. Associative neurons link sensory and motor neurons with each other. They are found in the CNS and make up the brain and spinal cord. They have short dendrites and axons.

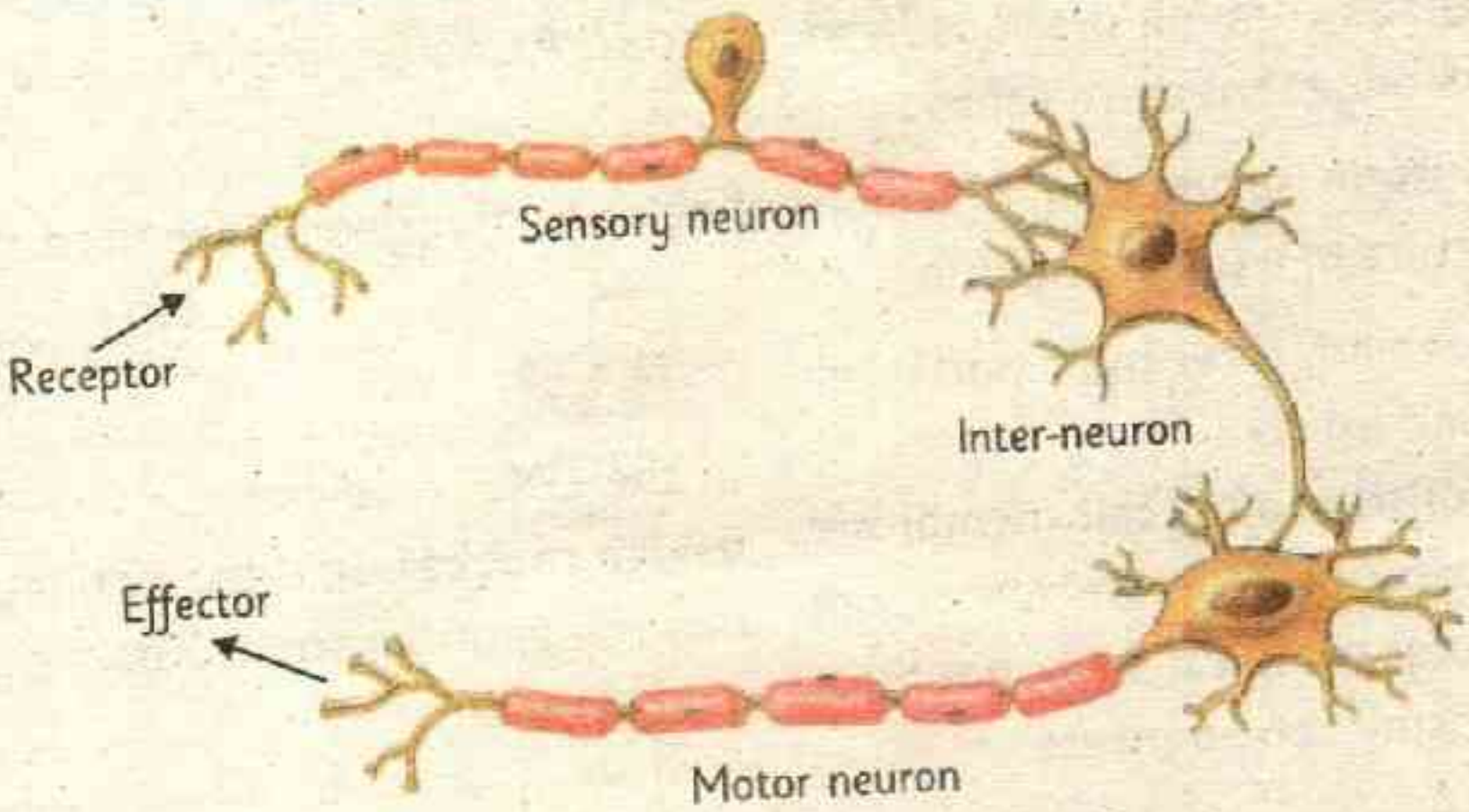


Fig. 12.2 (b) Types of Neuron

Nerve

A nerve is a collection of axons that are enveloped by a covering. Nerves arise from the brain and spinal cord and make the peripheral nervous system. There are three types of nerves, on the basis of axons present in them. **Sensory nerves** contain the axons of sensory neurons only. **Motor nerves** contain the axons of motor neurons only. **Mixed nerves** contain the axons of sensory and motor neurons.

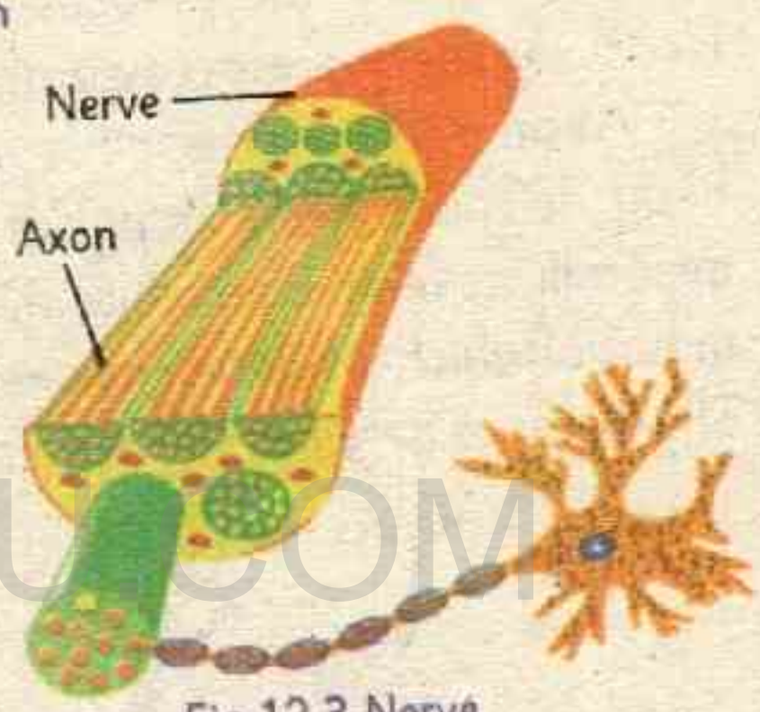


Fig. 12.3 Nerve

For Your Information

In certain parts of the body, the cell bodies of neurons form groups enveloped by membranes. These groups of cell bodies are called **ganglia** (Singular: **ganglion**).

12.2.2 Divisions of the Nervous System

We have studied that in humans and other higher animals, the nervous system has two major components i.e. the central nervous system and the peripheral nervous system.

(A). Central Nervous System (CNS)

The central nervous system (CNS) consists of the brain and the spinal cord. The brain is present in the part of the skull called the **cranium**. The spinal cord extends from the posterior side of the brain and is present in the **vertebral column** (backbone). Cranium and vertebral column provide protection to the CNS.

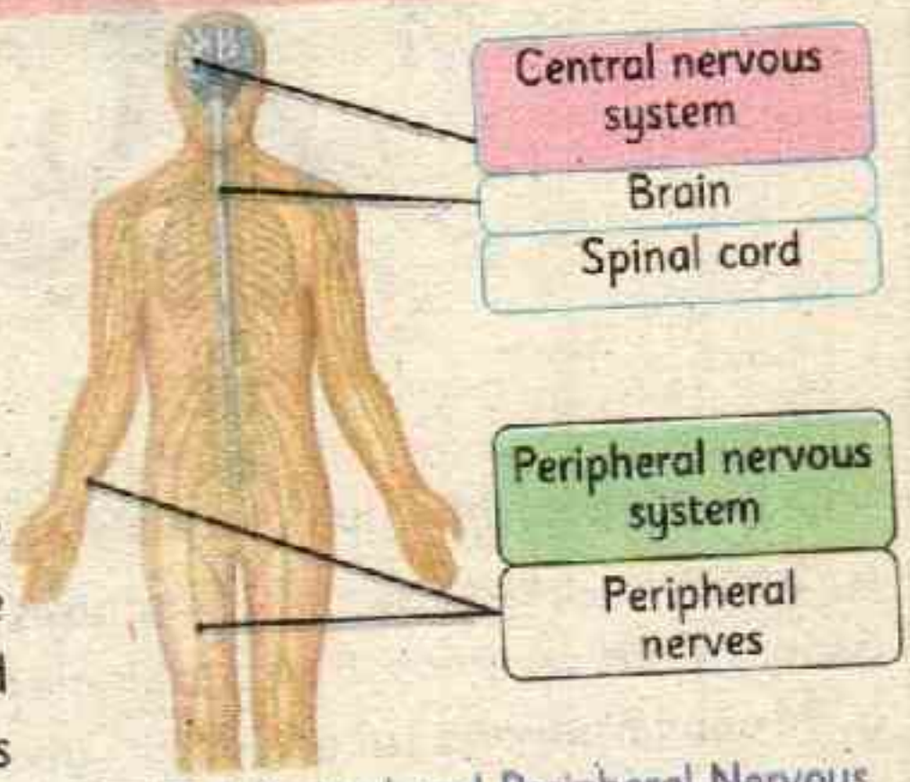


Fig. 12.4 Central and Peripheral Nervous system

1. Brain

In animals, all life activities are under the control of the brain. Inside the cranium, the brain is covered by three layers of membranes, collectively called **meninges**. Their function is to protect the brain from harmful substances. The brain contains fluid-filled ventricles. The ventricles of the brain are continuous with the central canal of the spinal cord. The fluid within the ventricles and the central canal of the spinal cord is **called the cerebrospinal fluid (CSF)**. It bathes the neurons of the brain and the spinal cord and cushions against physical and mechanical stresses.

Human brain can be divided into three parts; forebrain, midbrain and hindbrain.

a) Forebrain

This is the largest area of the brain. It is most highly developed in humans. The following are the most important parts of this region.

(I) Cerebrum: This is the largest part of the brain. It is divided into two halves, called **cerebral hemispheres.** These halves communicate with each other by means of a large band, called the **corpus callosum.** The outer region of the cerebrum called the **cerebral cortex.** It has many folds and convolutions, which increase its surface area. It is made of **grey matter** (containing cell bodies and non-myelinated axons). The material beneath the cortex is **white matter** (containing myelinated axons).

Do You Know?

Cerebrum consists of billions of neurons packed together. The left cerebral hemisphere controls the right side of the body, and right cerebral hemisphere controls the left side of the body.

The cerebrum is the most important part of the brain. It receives sensory information, processes it, stores some in memory for future use, directs voluntary movements, and is responsible for intelligence, thinking, reasoning and decision making. The speech centre is also present in the cerebrum which is unique to human beings.

(ii) Thalamus: This is wrapped by the cerebrum. It carries sensory information especially from the eyes and ears and generally from the skin and other internal organs of the body to the limbic system and cerebrum.

iii) Limbic system: It is located in an arc between the thalamus and cerebrum. This system processes responses like hunger, thirst, fear, anger, tranquillity, pleasure and sexual responses. A portion of the limbic system is also important in the formation of memories. **Hypothalamus** is a part of the limbic system. It lies below the thalamus.

b). Midbrain

The midbrain is reduced in human beings and is present under the cerebral hemisphere. It controls reflex movements of the eyes and hearing reflexes. The midbrain is a relay centre that connects the forebrain with the hindbrain.

c). Hindbrain

Hindbrain consists of cerebellum, pons and medulla oblongata.

Cerebellum controls balance of the body and coordinates the voluntary movements of the body as well. We can pick up a book from a table or touch our foot without mistake because of a healthy cerebellum. It is also involved in the learning and memory storage for showing different behaviours.

Pons is located above the medulla. It controls transitions between sleep and wakefulness, and the rate and pattern of breathing.

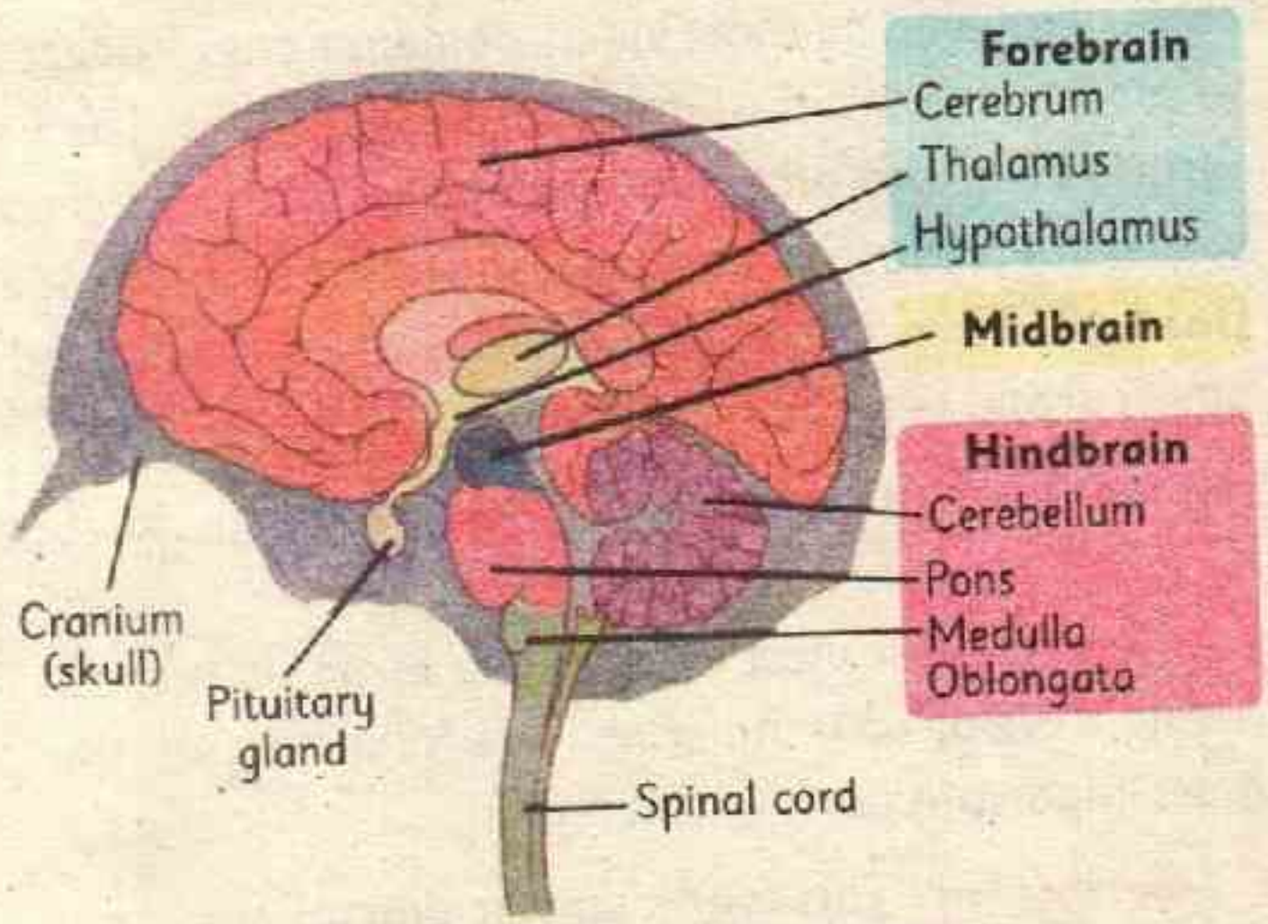


Fig.12.5 Structure of the Human Brain

Medulla oblongata is the posterior part of the brain. It controls automatic functions like breathing, heart rate, circulation of blood, blood pressure, swallowing and vomiting.

Tidbit

Medulla oblongata, pons, and midbrain connect the rest of brain to spinal cord. They are collectively called brain stem.

2. Spinal Cord

The medulla oblongata narrows down into an oval-shaped hollow cylinder i.e. the spinal cord. It travels through the vertebral column. The spinal cord is also covered by **meninges**. The spinal cord transmits impulses from the body parts to the brain and from the brain to the body parts. It also acts as a coordinating centre for some simple responses (e.g. reflex actions).

In cross section, the spinal cord shows two distinct parts: an inner butterfly-shaped part containing **grey matter** around a central canal and the outer part which is composed of **white matter**. The most important function of spinal cord is to control the reflex action of the body (below head level). It conducts the sensations from trunk and limbs and other lower regions of the body to brain for final response and transmits the messages from the brain to the lower part of the body.

There are 31 pairs of spinal nerves that arise from the spinal cord. All the spinal nerves are **"mixed"** nerves because each contains axons of both sensory and motor neurons. Each spinal nerve arises by two roots. Both roots unite and form the mixed spinal nerves.

- The dorsal root contains sensory axons and a ganglion where cell bodies are located.
- The ventral root contains axons of the motor neurons.

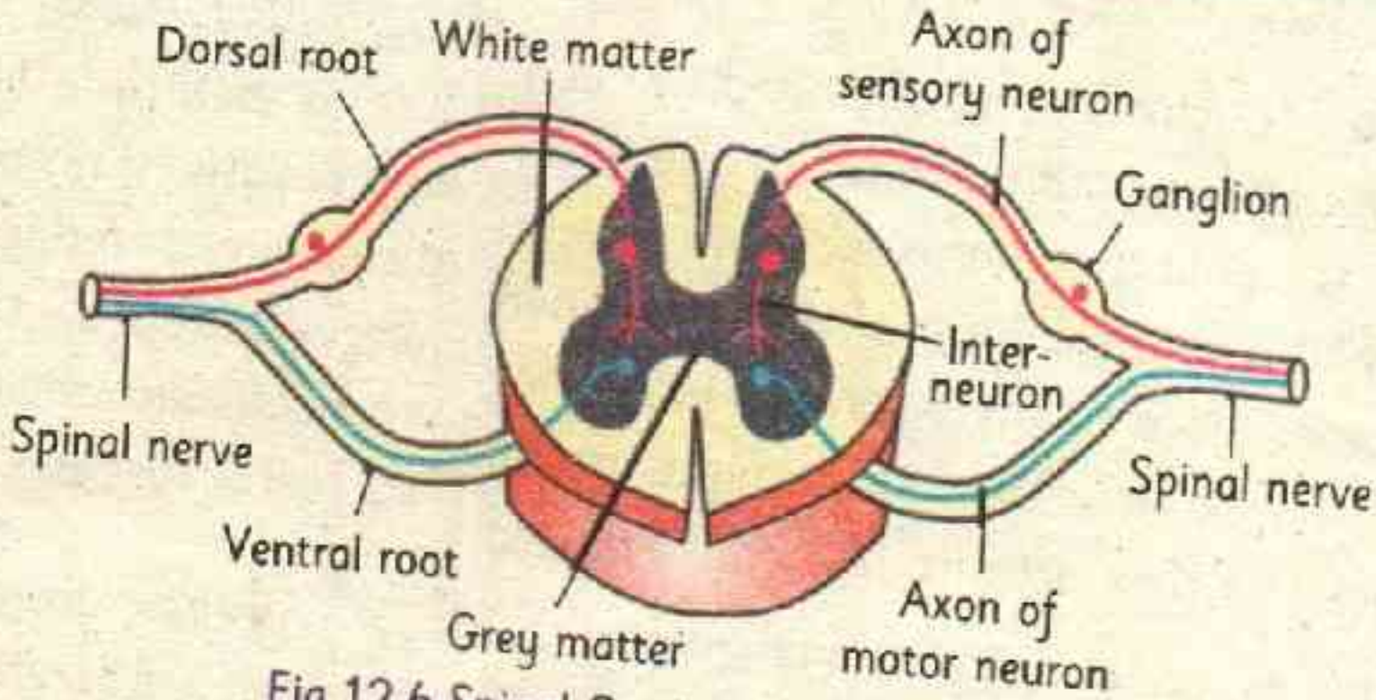


Fig.12.6 Spinal Cord and Spinal Nerves

(B). Peripheral Nervous System

This is composed of nerves which arise from the CNS. The nerves which arise from the brain are called **cranial nerves**. Humans have 12 pairs of cranial nerves. The nerves which arise from the spinal cord are called **spinal nerves**. Humans have 31 pairs of spinal nerves. Some cranial nerves are sensory, some are motor and some are mixed. All the spinal nerves are mixed.

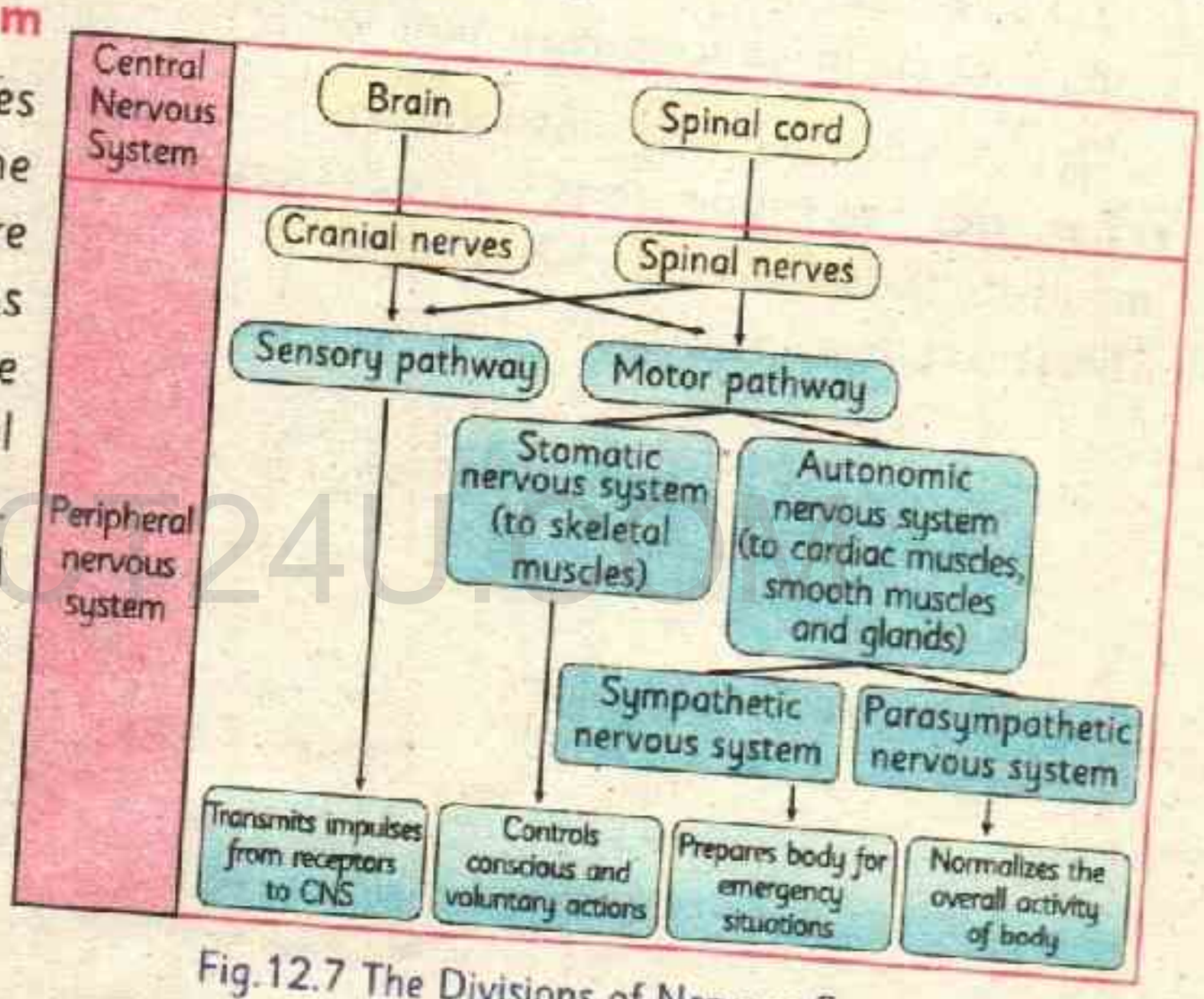


Fig.12.7 The Divisions of Nervous System

The cranial and spinal nerves make two pathways i.e. sensory pathway (conducting impulses from receptors to CNS) and motor pathway (conducting impulses from CNS to effectors). Motor pathway makes two systems.

Somatic Nervous System: It controls conscious and voluntary actions. It includes all of the motor neurons that are connected to skeletal muscles.

Autonomic Nervous System: It consists of motor neurons that are connected to cardiac muscles, smooth muscle and glands. It is generally without conscious control. Autonomic nervous system consists of sympathetic and parasympathetic systems. The **Sympathetic** nervous system prepares body to deal with emergency situations. This is often called the **"fight or flight"** response. This system dilates pupils, speeds up heartbeat, increases breathing rate and inhibits digestion. When there is little or no stress, the **parasympathetic** nervous system normalizes the overall activity of the body. It is called the **"rest and digest"** response. It causes pupils to contract, it promotes digestion, and it brings the rate of the heartbeat to normal.

12.2.3 Reflex Action

If your finger touches the tip of a needle, you at once retract your hand without thinking. Similarly, if something is coming towards your face, you move your head away. Blinking of the eyes when something comes close to the eyes and jerking of the knee, when it is hit with a hard object are all different types of reflex actions. We can define a **reflex action** as an automatic, immediate, quick involuntary, fixed response to an environmental change (stimulus). Generally the brain is not involved in reflex actions. We can say these are the **involuntary** responses of the body on which we do not have any control.

Do You Know?

Use of medicines like sleeping pills and sedatives, narcotics like heroin, alcohol etc. reduce the speed of nerve impulses. Therefore people who consume these substances do not feel or respond rapidly.

A Reflex action is performed through a short and simple pathway of neurons, called the **reflex arc.** This action starts with a sensory neuron present in a receptor which takes the impulse to the spinal cord. Here an associative neuron shifts the impulse to the motor neuron which takes the impulse to the effector.

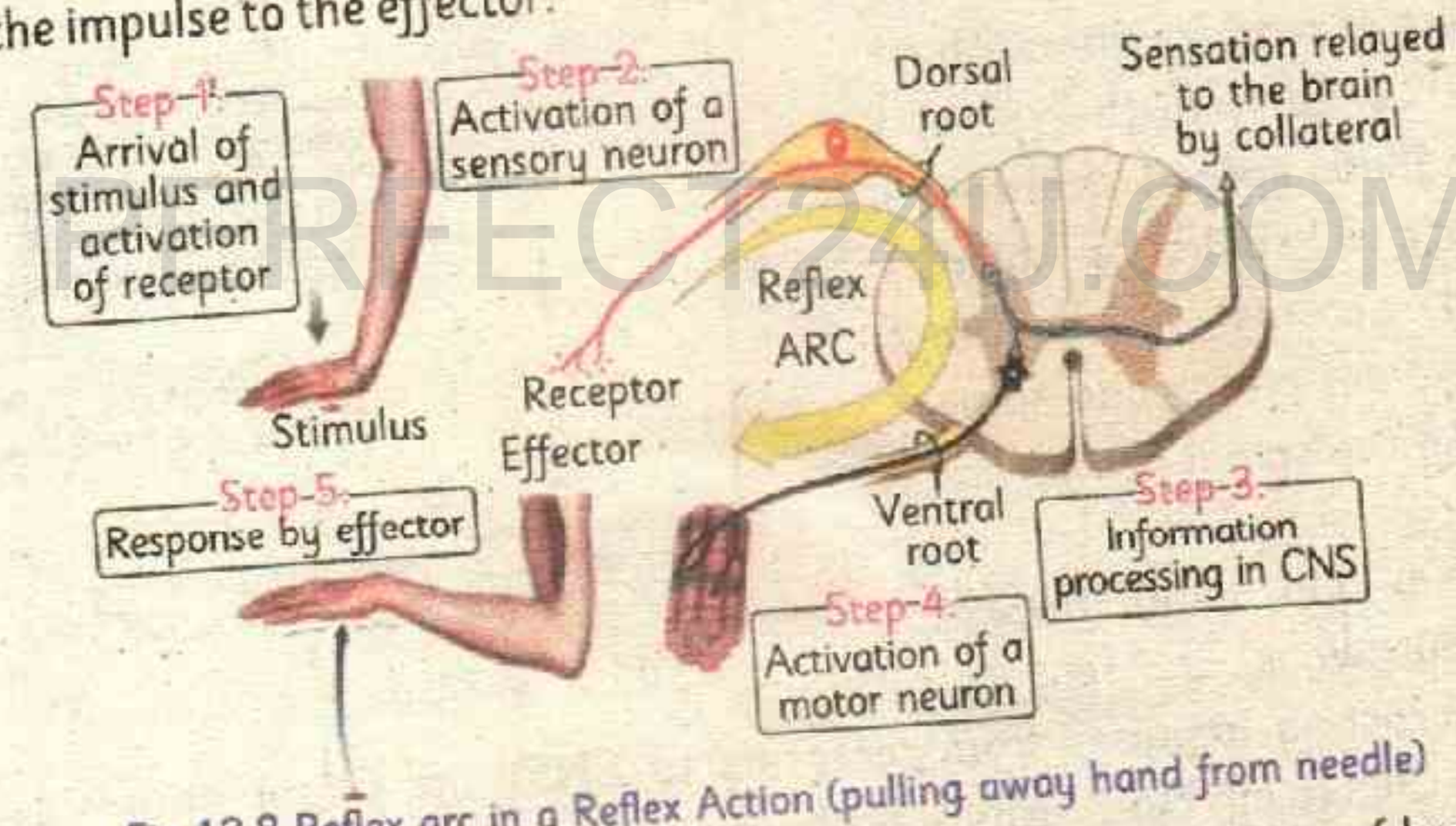


Fig.12.8 Reflex arc in a Reflex Action (pulling away hand from needle)

You might have noticed that pain of pricking is felt after retraction of hand because we feel pain when the message is sent to brain. This is why we can say that reflex actions are important for survival as they help to protect us without our will or wish.

Science, Technology and Society

The digestive system is an involuntary system as it works on its own such as blinking of the eyes. Digestion starts from the mouth by the secretion of saliva. As soon as our eyes see delicious food it sends a message to the glands present in the mouth to release saliva, so that the food can be chewed and broken into small pieces. Looking at a food item, the digestive system gets activated, enzymes are released in the mouth cavity in the form of saliva and hence our mouth starts watering.

12.3 Receptors in the Human Body

In this unit you have come across the term receptors many times. You know that **receptors** are the parts of the body which receive the changes (stimuli) taking place in our environment. In the human body there are many types of receptors, which perform different functions.

- Photoreceptors which perceive light e.g. eyes
- Sono-receptors which perceive sound waves e.g. ears
- Chemoreceptors which perceive different chemicals like the tongue and nose.
- Mechanical receptors which perceive pressure mostly found in skin

There are many other receptors which feel pain, hunger, thirst, pleasure, emotions etc. but here in this chapter we will describe only two types of receptors and their working.

12.3.1 Photoreceptor: Eye

These are also known as visual receptors. Eye is an organ used as a photoreceptor in the human body. A pair of eyes is present in human beings which are present in the orbits on the face. The eye is a very complex structure. It is in the form of a ball. The wall of the eyeball consists of three layers.

The outer most white, tough, muscular layer is called the **sclera** which covers the eye from the outside. Its anterior part is transparent and bulging.

The middle layer is the **choroid**. It gives a darker colour to the inner eye. The choroid layer is thick in the anterior part and makes the **ciliary body**. The coloured portion of the choroid in the anterior centre is called the **iris.** In the centre of the iris, there is a small hole called **pupil** which controls the amount of light entering the eye. Behind the pupil, a **lens** is present which focus images from different distances on to the retina. The lens is held by **suspensory ligaments** which are attached with the ciliary body. The muscles of the ciliary body control the focussing of the lens.

Do You Know?

The contraction and dilation of the pupil is also a reflex function as it automatically adjusts to the intensity of light. You may observe the contraction of the pupil in the eyes of your friend by suddenly throwing strong light in his eyes.

The third innermost layer of the eye is the **retina.** It contains photoreceptor cells and neurons. There are two types of photoreceptor cells i.e. **rods** and **cones**. Rods are used to perceive dim light. They give us the image of the object but not its colours and detail. Cones are responsible for visualising colours.

Rods contain a purplish-red pigment called the **rhodopsin**. The body synthesises rhodopsin from **vitamin A**. If there is a deficiency of vitamin A, the body cannot prepare rhodopsin in the required amounts. Therefore, the eyes cannot see clearly in dim light. This problem is called **night blindness**.

The cones also contain a pigment called **iodopsin**. There are three types of cones. Each type contains specific iodopsin for red, green or blue light. The sensations of different colours are produced by various combinations of these cones. When all cones are stimulated equally, a sensation of white light is produced.

The **optic nerve** leaves the eye at the posterior pole of the eyeball. At this spot, photoreceptor cells are not present and hence it is called the **blind spot**. At the posterior pole of the eye, opposite to the lens, there is a yellowish spot called the **fovea**. It is a thin portion of the retina where only cones are densely packed. Here, the visual acuity (resolution) is the greatest.

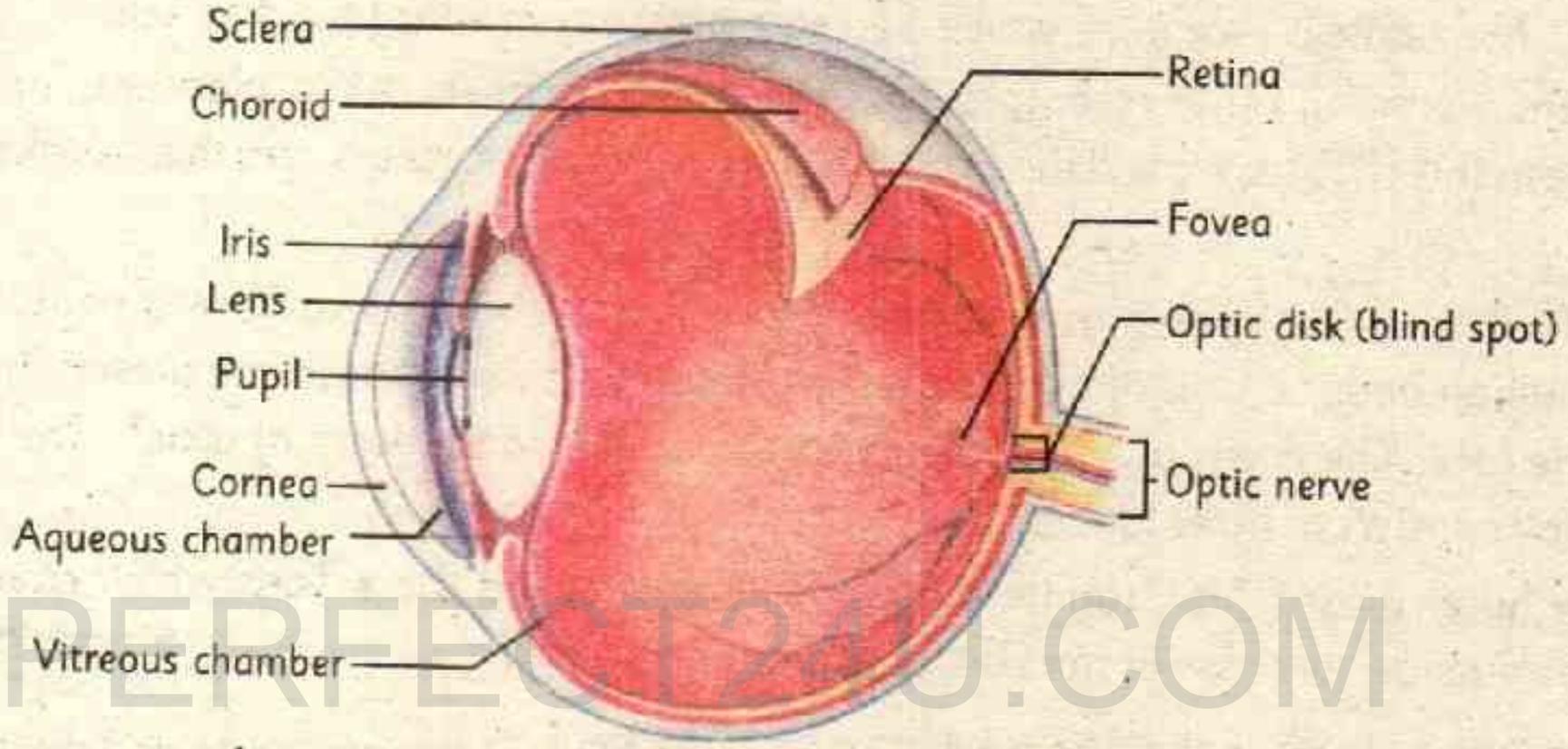


Fig. 12.9 Structure of the Human Eye

The space between the cornea and the lens is called the **aqueous chamber**. It contains a thin watery fluid called the aqueous humor. The space between the lens and the retina is called the **vitreous chamber**. It is filled with a transparent gel called the vitreous humor.

Mechanism of Vision

The light rays coming through the cornea and lens make an image on the retina. The photoreceptor cells i.e. rods and cones of the retina produce nerve impulses in the neurons present in the retina. The axons of these neurons are part of the optic nerve. The optic nerve carries information in the form of nerve impulses from the retina to the cerebrum of the brain. Here, the impulses are processed to produce a meaningful sensation of shape and colour.

Disorders of the Eye

Eyes send a huge amount of information to the brain. Sometimes a defect occurs in the working of eyes which causes great disturbance in the life of the person. Some of these disorders are very serious and lead to blindness but some disorders are easily curable. Two disorders generally known as long sightedness and short sightedness are very common. In these disorders the lens of the eye is not able to adjust itself to focus the image on the retina, hence the vision is disturbed.

Short sightedness or near sightedness, is an eye disorder in which a person can see closer objects clearly, but the distant objects are not clearly visible. Technically this disorder is known as **myopia.** It is caused by an unusually long eyeball. In short sightedness, light rays do not focus on the surface of the retina. Rather, the rays focus in front of the retina. Since the light is focussed too early, a blurred image is left on the retina.

This problem can be rectified by using **concave lenses** in glasses or in contact lenses. Concave lens ensures that light is focussed onto the retina of the eye, so that distant objects do not appear blurry. Short-sightedness can also be cured with **laser eye surgery**. In laser eye surgery a laser is used to reshape the cornea to correct its curve. Therefore, light is better focussed on the retina.

Long sightedness or farsightedness, is a disorder in which a person can see distant objects clearly, but the close objects are not clearly visible. The disorder is caused when the eyeball is too short or the shape of the lens is not round. Technically this disorder is known as **hypermetropia.** In long-sightedness, light rays do not focus on the surface of retina. Rather, the rays focus behind the retina. Since the light is focussed behind the retina, a blurred image is left on the retina.

Long-sightedness is rectified by using **convex lens** in glasses or in contact lenses. Convex lens ensures that light is focussed onto the retina of eye, so that close objects do not appear blurry. Long-sightedness can also be cured with **laser eye surgery**. In laser eye surgery a laser is used to reshape the cornea and improve the curve. Therefore, light is better focussed on the retina.

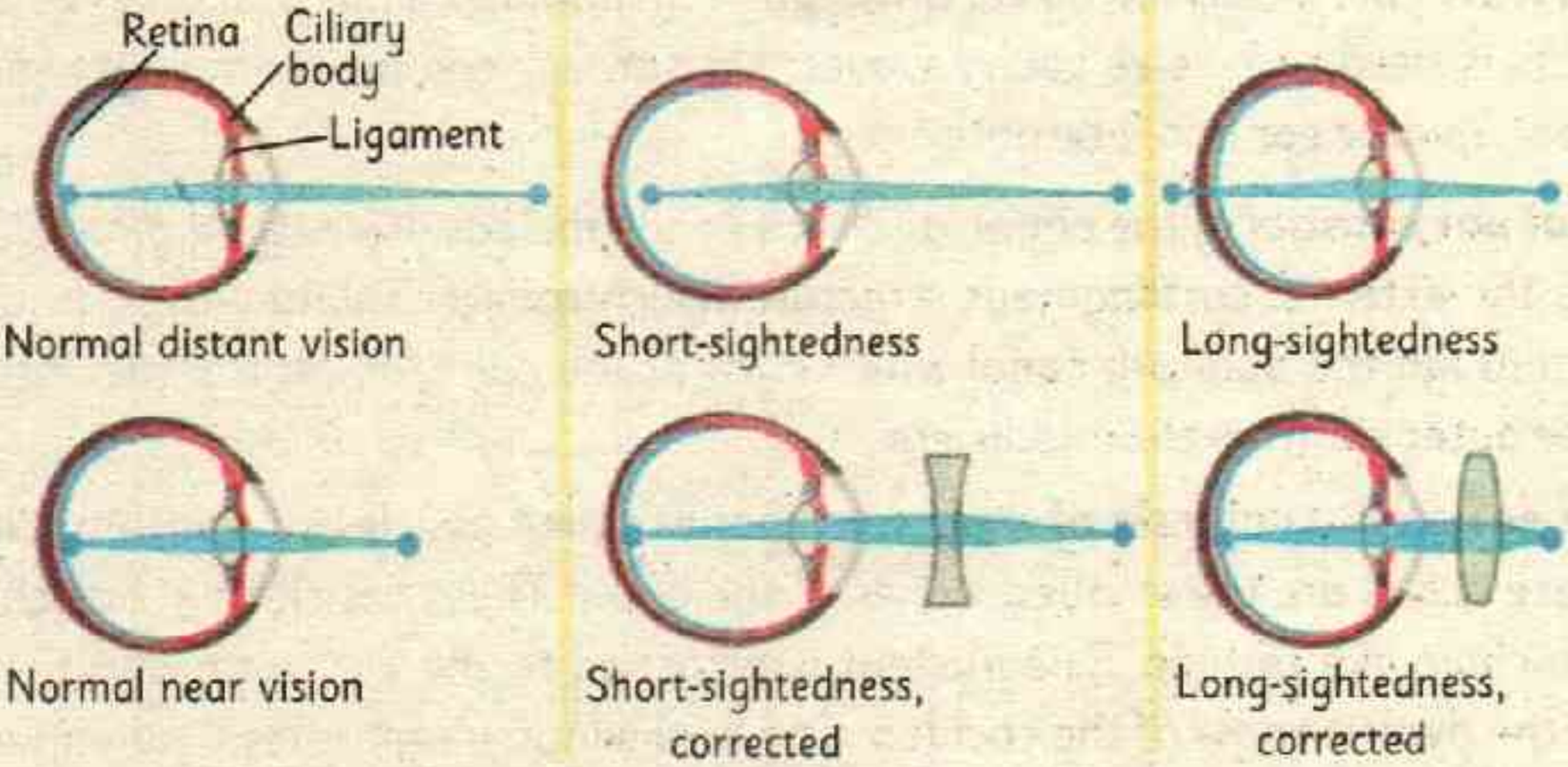


Fig.12.10 Short sightedness and Long sightedness

12.3.2 Muslim Scientists in Ophthalmology

Like other scientific fields, the early work in optics and ophthalmology was done by Muslim scientists. In the field of ophthalmology and optics, some great Muslim scientists will be remembered forever.

a). Ibn Al Haitham

His name was Abu Ali al Hasan Ibn-al Hasan-Ibn-al–Haitham. In the West, he is known as Alhacen or Alhazen. He was born in Basra in 965 AD. He is regarded as the "father of modern optics" for his influential book **"Kitabul Manazir** (Book of Optics)". This book has seven volumes and was written between 1011 to 1021 AD. He performed experiments in different fields of optics, including lenses, mirrors, refraction, reflection and dispersion of light. He studied binocular vision and the moon illusion and described the finite speed of light. He postulated that light has made of particles, traveling in straight lines. One of his most important works was the description of the functional anatomy of the eye. He was the first person who rejected the old concept of sight that rays come out of the eye to see. He also made the first camera, the pinhole camera.

b). Ali bin Isa

Ali bin Isa (940-1010 AD) was an Afro-Arab ophthalmologist, astronomer and geographer. He was born in Baghdad and is considered as one of the most famous physicians of the 10th century. He wrote the monumental book **"Tashkirat ul Kahhalin** (Notebook of Oculist)". The book is mostly based on his personal observations. The book contains information on the treatment and classification of over 100 different eye diseases. This book was translated in Latin in 1497. Afterwards, it was also translated in English. The book was widely used by European physicians for hundreds of years.

12.3.3 Sono-receptor - Ear

Sound waves are perceived by sono-receptors. In human beings and other vertebrates a pair of ears is used to receive sound waves. Human ear can be divided into three parts; external ear, middle ear and internal ear.

External ear consists of the pinna, auditory canal and ear drum (tympanum). The pinna or earflap is the external cartilaginous structure which collects sound waves. Sound waves then travel through the auditory canal which ends at the ear drum. It is a membrane which separates the outer ear from the middle ear.

Middle ear consists of a set of three small bones called ossicles i.e. **malleus, incus** and **stapes**. These bones are the smallest bones of the body. These ossicles are attached to one another in a chain-like fashion. The malleus is attached to the ear drum and the stapes is attached to the oval window of the cochlea. The oval window separates the middle ear from the inner ear. A **Eustachian tube** connects the middle ear cavity with the pharynx. The Eustachian tube helps in equalising the pressures between the middle ear and the environment.

Internal ear is a fluid-filled chamber after the oval window. It contains two important structures i.e. a coiled tubule called the **cochlea** and a set of three **semi-circular canals**. The middle chamber of the cochlea has the hearing apparatus, called the **organ of Corti**. Special

hair cells are present in the organ of Corti, which are the receptor cells for sound. The semi-circular canals help in maintaining the balance of the body.

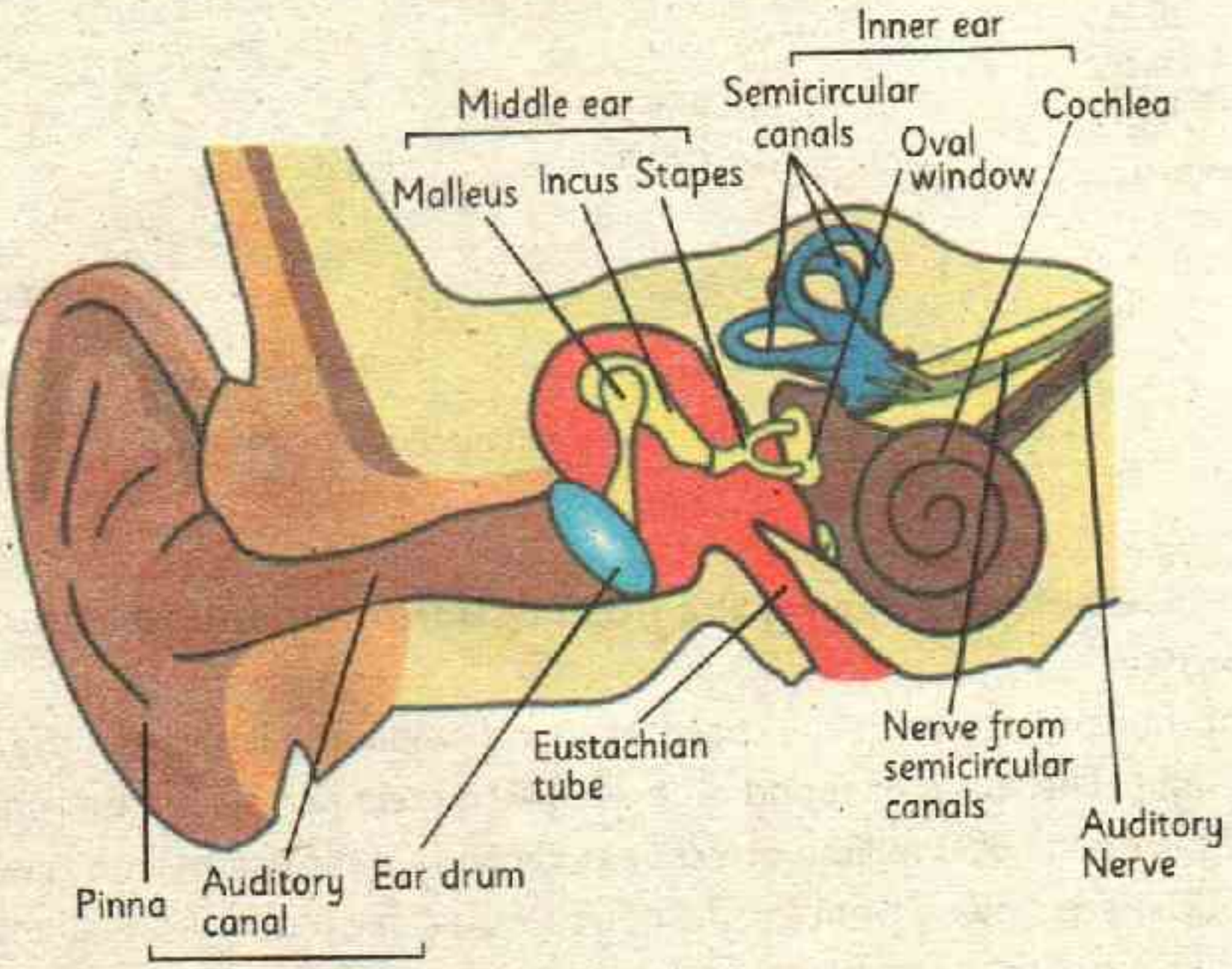


Fig.12.11 Structure of Human Ear

Mechanism of Hearing

The outer ear receives sound waves and directs them to the ear drum. The ear drum vibrates and these vibrations are transmitted to the ear ossicles (malleus, incus and stapes) and then to the oval window. From the oval window, the vibrations are passed to the cochlea. Vibrations produce pressure waves in the fluid present in the chambers of cochlea. The waves in the fluid of the middle chamber cause bending of the hair cells present in the organ of Corti. The bending of hair cells generates a nerve impulse in the associated sensory neurons. These impulses are transmitted via auditory nerves to the cerebrum. Here the impulses are analysed and the sound is recognised.

Mechanism of Balancing

The ear also helps to maintain balance. This function is performed by the three semi-circular canals of the internal ear. The semi-circular canals are filled with fluid. Their inner walls have hair cells and tiny particles. When the head moves, the fluid inside the semi-circular canals flows. As a result, the particles are pushed and so the hair cells bend. This bending of hair cells generates nerve impulse in the nerve attached with the semi-circular canals. The message of these movements is sent to the cerebellum through the auditory nerve. The brain interprets the head's motion and orientation and sends the proper message to the muscles to maintain balance.

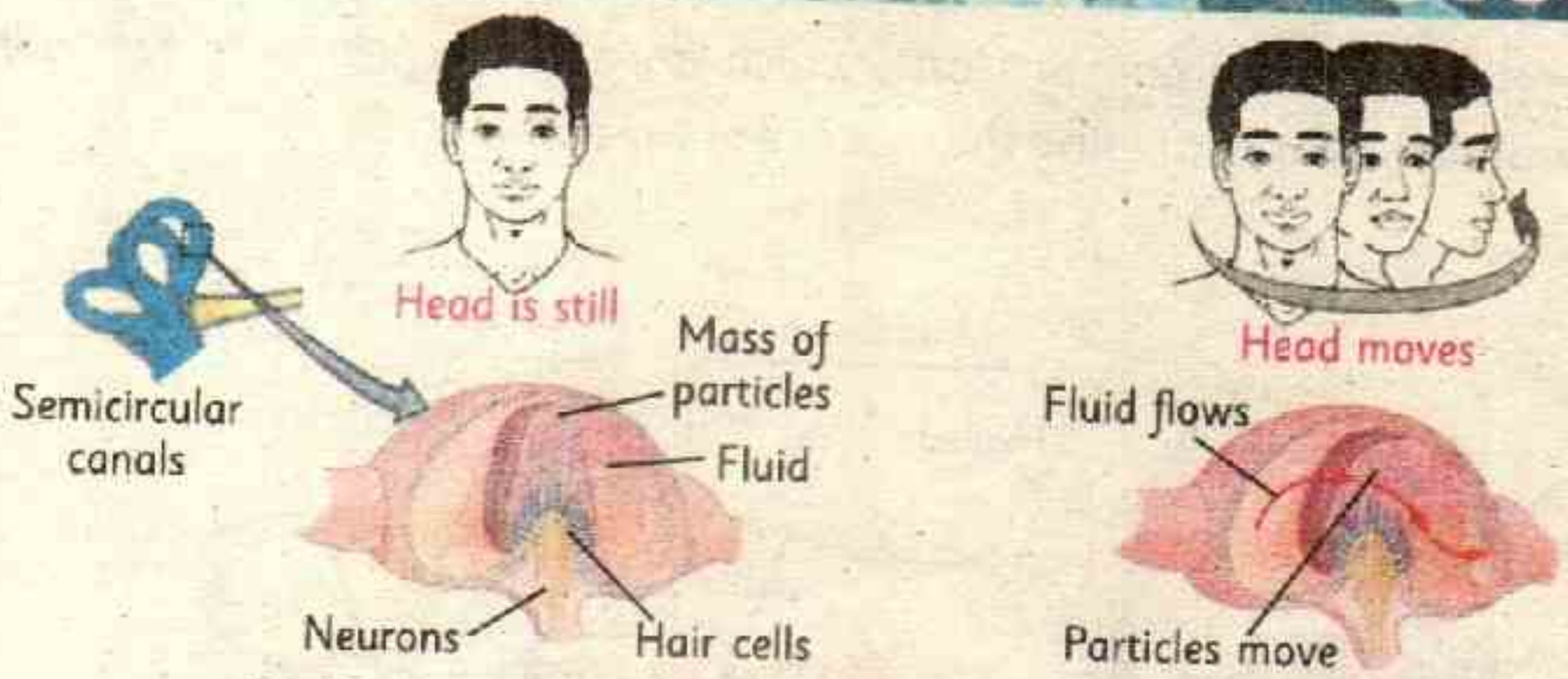


Fig 12.12 Semi-circular canals and mechanism of balancing

Science, Technology and Society

Time difference between seeing the flash of lightning and hearing the roar of a thunderstorm

The sound of thunder travels at the speed of sound, while the light from the flash travels at the speed of light. The speed of sound is about 340 meters per second through air, while the speed of light is about 300 million meters per second - almost a million times faster. So, if you were 1500 meters away from the flash, you would see it about 5 millionths of a second after it actually occurred, but you would not hear the thunder until about 5 seconds later.

12.4 Chemical Coordination

You studied earlier in this chapter that chemical coordination is done through special chemicals called **hormones.** In animals, hormones are synthesised in **endocrine glands** which are also called **ductless glands**. This is because these glands do not have any duct or tube to release their secretion at the site of action or target site. They release their secretion in the blood which takes it to the tissues or organs where it is required.

Do You Know?

Many glands in our body have ducts for releasing their secretions e.g. digestive glands, skin glands etc. Such glands are called **exocrine glands.**

Hormones are organic compounds produced in the endocrine glands, poured directly into the blood and are transported to respective target tissues where they affect. Hormones do not initiate new biochemical reactions but produce their effects by regulating the reactions. They may either stimulate or inhibit a function. Hormones also control some long term changes in the body such as the rate of metabolic activity, rate of growth, and sexual maturity. Most hormones are chemically proteins but some are derivatives of fatty acids i.e. steroids.

12.4.1 Human Endocrine Glands

Human endocrine system consists of about 20 endocrine glands found in different parts of the body. Here you will study about some important glands and their hormones.

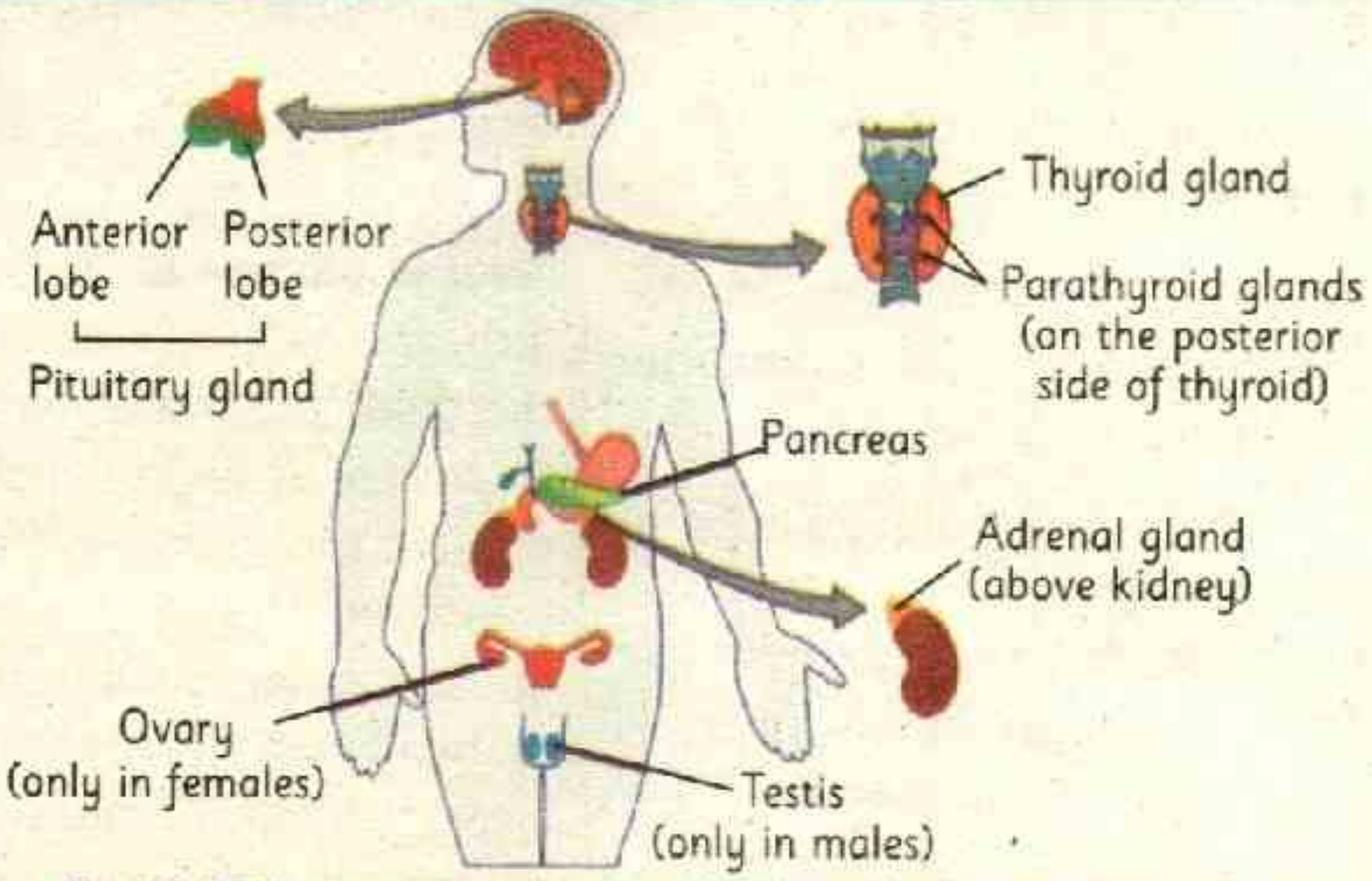


Fig.12.13 Important endocrine glands in the human body

1. The Pituitary Gland

This is an oval structure attached to the hypothalamus of the brain. It is about the size of a pea seed and weighs about 0.5 gm in adults. It is generally termed as "the master gland" of the body. It has two main lobes i.e. anterior and posterior.

Anterior Lobe of Pituitary Gland: It secretes the following hormones.

Do You Know?

Naseer Soomro (the tallest man in Pakistan) developed a pituitary gland problem at the age of 10. His pituitary gland produces excess amounts of the **Growth Hormone**.

(i). Growth Hormones: This hormone increases the cell division of somatic cells and promotes the growth of the body. It is secreted more in childhood but in adults the secretion becomes normal. If it is secreted in excess during early life it results in a disorder called **gigantism.** Its under-secretion in early life causes **dwarfism** in which the body of the child does not grow.

(ii). Thyroid Stimulating Hormone (TSH): This hormone controls the development and secretion of the thyroid hormone (thyroxin).

(iii). Adreno-Cortico-Trophic Hormone (ACTH): It acts on the cortex part of the adrenal gland to release the adrenal hormone.

(iv). Luteinising hormone (LH): It is needed for the release of egg cells from the ovary (ovulation) in females. In males, it stimulates the testes to produce sex hormones.

Posterior lobe of Pituitary Gland: It secretes the following hormones:

(i). Antidiuretic Hormone (ADH) or Vasopressin: This hormones affects the renal tubules to reabsorb large quantities of water from the glomerular filtrate.

(ii). Oxytocin: Its main function is to contract the uterus muscles during childbirth. It also stimulates the flow of milk from the breasts during lactation

2. Thyroid Gland

The thyroid gland is situated above the larynx. It consists of two lobes; one on each side of the larynx. It secretes two hormones.

(i). Thyroxine: This hormone increases the metabolism of the body and produces heat in the body. It promotes growth, hence it is secreted more in young age. Thyroxine is an iodine containing compound.

If thyroxine is produced less than the required amount, cellular metabolism slows. It results in lethargy, weight gain, and low heart rate and body temperature.

If thyroxine is produced more than required, cellular metabolism becomes faster than normal. It results in weight loss; and high blood pressure, heart rate, and body temperature.

Do You Know?

If there is deficiency of iodine in the body, the thyroid gland is not able to produce thyroxine. When the gland when tries to produce the hormone, it swells up and the condition is called **Goitre.** This disease become endemic among the people living at high altitudes because they do not have sufficient iodine in their water. Iodized salt is recommended to overcome the deficiency of iodine and avoid goitre.

(ii). Calcitonin: It stimulates the transfer of calcium ions from the blood to bone, where the calcium ions can be used to generate bone tissue. In this way, calcitonin maintains blood calcium levels.

3. Pancreas

Pancreas have both exocrine and endocrine activity. As an exocrine gland, it is part of the digestive system and produces pancreatic juice which helps in digestion of food.

As an endocrine gland, it secretes two hormones **insulin** and **glucagon.** The endocrine function is performed by the special cells present in pancreas called **islets of Langerhans.**

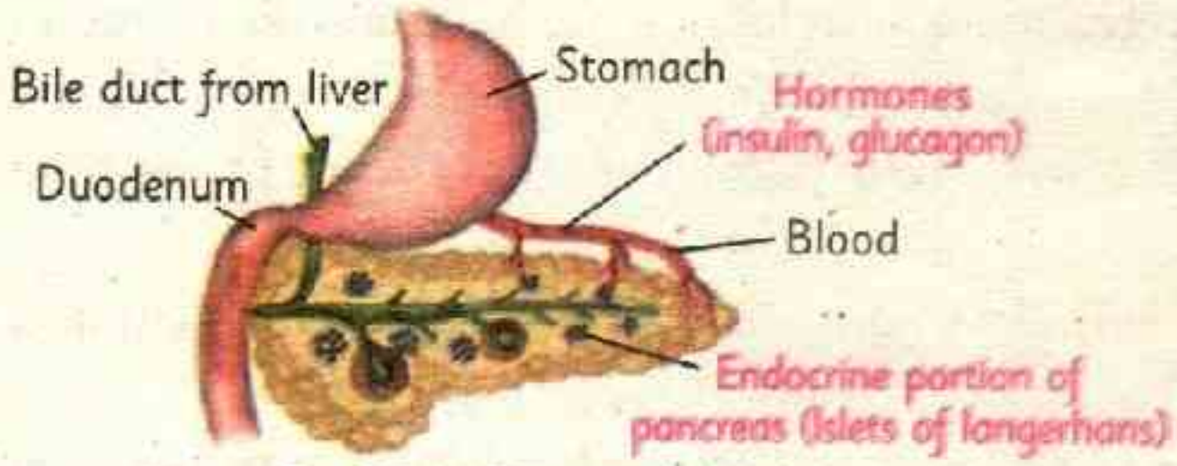


Fig.12.14 Pancreas gland

For Your Information

In diabetes, excess glucose inhibits water reabsorption by the kidneys, producing large amounts of urine. It results in dehydration and can cause kidney damage. Diabetic patients also experience loss of body weight, weakening of muscles and tiredness.

Science, Technology and Society

Example of Genetically Engineered Bacteria – Production of Human Insulin

One of the examples of genetically engineered bacteria is in the production of human insulin. With the help of recombinant DNA technology scientists are able to insert a human gene into bacterium. For example, gene coded for the production of insulin are inserted into the plasmid of a bacterium. As the bacterium undergoes binary reproduction, bacteria with the insulin gene are then multiplied and each bacterium will produce a tiny volume of insulin. By culturing the genetically engineered bacteria, limitless supplies of insulin may be produced which is used for the treatment of diabetic patients.

Insulin decreases blood glucose levels either by metabolizing it or by converting it into fats. If the body fails to produce insulin it leads to diabetes mellitus. Conversely glucagon increases blood glucose levels by promoting breakdown of glycogen to glucose in the liver and muscles. It also increases the release of glucose from liver to blood.

Do You Know?

Blood Glucose Concentration (BGC) Test: The amount of glucose in blood is measured by this test. It is used to diagnose diabetes. Blood glucose may be measured on a fasting basis (collected after an 8 to 10 hour fast), randomly (anytime) and after a meal. The results of some BGC tests are given here.

Blood Glucose After 8 – 10 hours Fast	
BGC	**Diagnosis**
From 70 to 99 mg/100ml	Normal
From 100 to 125 mg/100ml	Pre-diabetes
126 mg/100ml and above	Diabetes

Blood Glucose 2 hours after a 75-gram Glucose intake	
BGC	**Diagnosis**
Less than 140 mg/100ml	Normal
From 140 to 200 mg/100ml	Pre-diabetes
Over 200 mg/100ml	Diabetes

4. Adrenal Gland

A pair of adrenal gland is present, one on top of each kidney. The outer layer of this gland is called the **adrenal cortex** and the inner layer as the **adrenal medulla.**

(i). Hormones of the Adrenal Cortex:

The adrenal cortex works under the action of ACTH from anterior pituitary.

It secretes many steroid hormones collectively known as **corticosteroids.** These hormones control the metabolism of minerals and glucose.

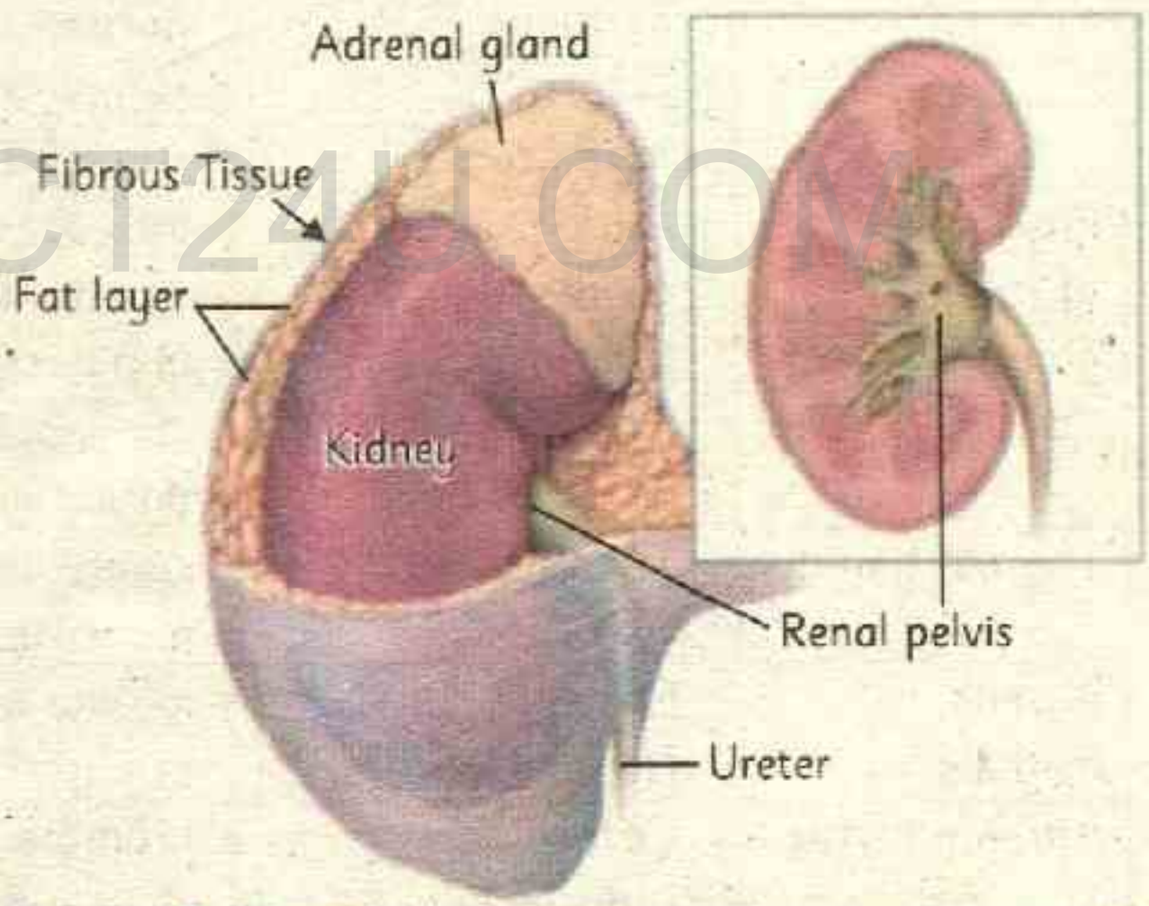


Fig.12.15 Adrenal gland present on the top of the kidney

(ii). Hormones of the Adrenal Medulla:

The adrenal medulla produces two hormones called the adrenaline and the noradrenaline.

These hormones are also called epinephrine and nor epinephrine respectively.

Adrenaline and noradrenaline hormones

These hormones are secreted in stressful situations. **Adrenaline** essentially dilates blood vessels in certain parts of the body such as the skeletal muscles and increases the heart's output. It is secreted in emotions and anger, hence the face becomes red.

Noradrenaline constricts blood vessels in certain areas of the body such as the gut and face. This is why in fear the face becomes pale or white and a person feels hollow in the gut.

5. Gonads

Gonads are the reproductive organs, which produce gametes. The male gonads are called testes and the female gonads are called ovaries, both produce many important hormones.

Hormones of the Ovary

(i). Oestrogens: It brings about the development of the secondary sexual characters in the female (e.g. development of breast).

(ii). Progesterone: It prepares the female body for maintaining the state of pregnancy.

Hormones of the Testes

The testes produce a hormone called **testosterone.** It brings about development of the male secondary sexual characteristics like growth of hair on face, thickening of voice etc.

Gland	Hormone	Functions
Anterior lobe of Pituitary gland	■ Growth hormone ■ Adrenocorticotropic hormone ■ Thyroid stimulating hormone ■ Luteinising hormone	■ regulates development of muscles and bones ■ stimulates secretion of cortisol and aldosterone by the adrenal cortex ■ stimulates the thyroid gland to produce its hormone ■ stimulates the ovary to release egg ■ stimulates the testes to produce testosterone
Posterior lobe of Pituitary gland	■ Antidiuretic hormone ■ Oxytocin	■ increases the reabsorption of water from nephrons ■ initiates uterine contractions during childbirth ■ stimulates the flow of milk from the breasts during location
Thyroid gland	■ Thyroxine ■ Calcitonin	■ stimulates enzymes of cellular metabolism ■ decreases blood calcium concentration
Adrenal medulla	■ Epinephrine, ■ Norepinephrine	■ initiate body's response to stress and the "fight or-flight" response to danger
Adrenal cortex	■ Cortisol ■ Aldosterone	■ promotes production of glucose from proteins ■ promotes salt and water retention by the kidneys
Pancreas	■ Insulin ■ Glucagon	■ lowers the blood glucose level by stimulating body cells to store glucose or use it ■ stimulates release of glucose from the liver into the blood
Ovaries	■ Oestrogen ■ Progesterone	■ cause the release of an egg from the ovary and regulates female secondary sex characteristics
Testes	■ Androgens (Testosterone)	■ regulate male secondary sex characteristics

Table 12.2: Summary of Major Endocrine Glands and their Functions

12.5 Mechanism of Hormonal Secretion

Who controls the secretion of a hormone? This question puzzled the scientists for many decades. Now, we have lot of information regarding the secretion of hormones. There are many controlling pathways for different glands and different hormones from the same gland. One of them is described below called as negative feedback mechanism

Feedback mechanism means "regulation of a process by the output of the process". When the output of a process slows down or stops the process, it is called negative feedback mechanism.

Negative Feedback Mechanism

The thermostat of an air conditioner controls the functioning of the air conditioner by using negative feedback. We set the thermostat of the conditioner at a certain temperature (say at 20°C). The thermostat detects the room temperature. When it finds its above 20°C, it turns on the air conditioning to cool the room. Once the room temperature reaches its thermostat setting (20°C), the thermostat turns off the air condition to stop further cooling.

The same negative feedback mechanism controls the secretion of hormones. Let us take the example of insulin secreted by the Islets of Langerhans. When we take a meal, the carbohydrates are digested and converted into glucose. Glucose is absorbed into the blood from the small intestine. This increases the glucose level in the blood. When this blood passes through the pancreas, the Islets of Langerhans sense this increase. They start secreting insulin in the blood. Insulin reduces the blood glucose level by promoting its entry into the body cells. When this blood (with normal glucose level) passes through the Islets of Langerhans, they stop the secretion of insulin. This process is called as the negative feedback mechanism of the hormone action.

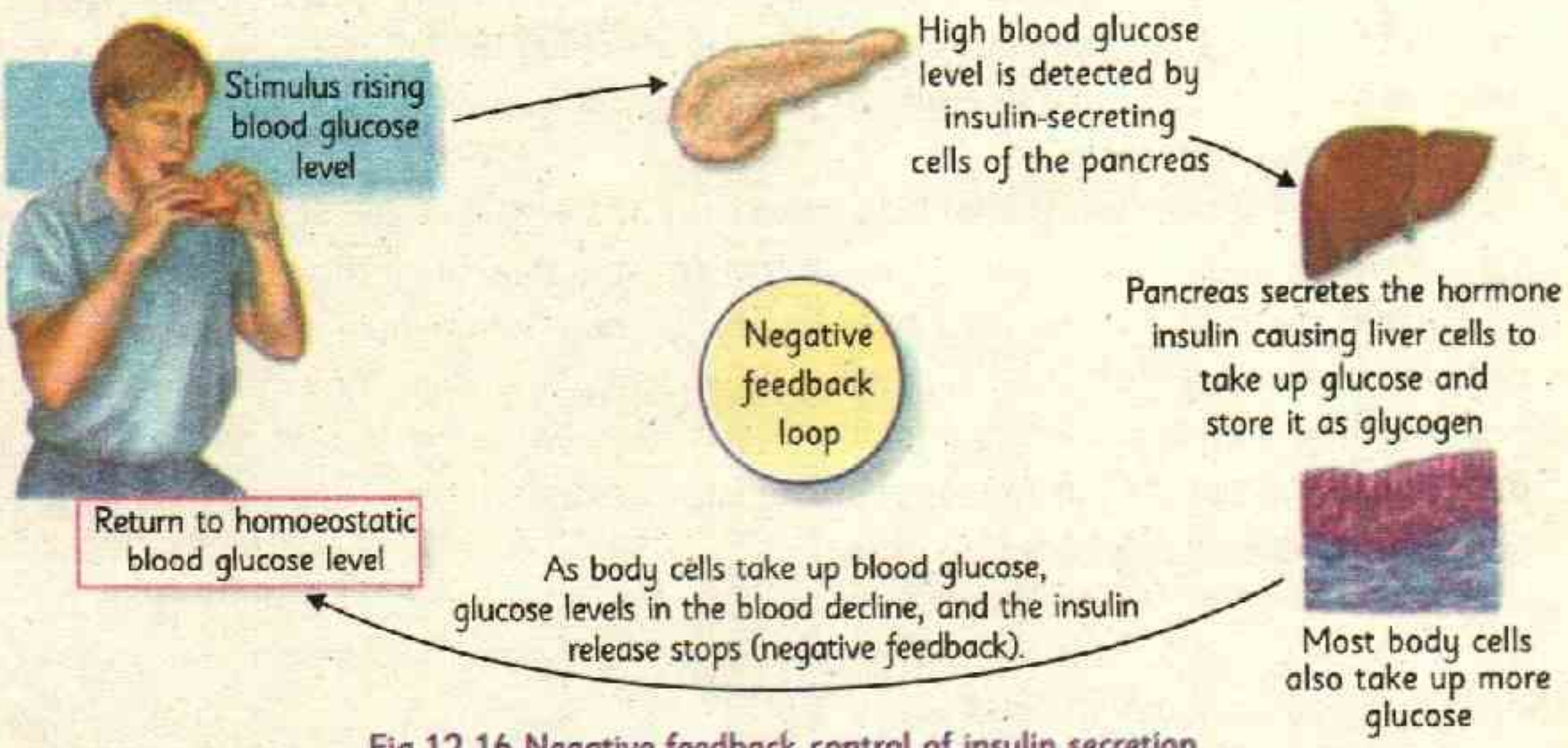


Fig.12.16 Negative feedback control of insulin secretion

12 .6 Disorders of the Nervous System

a). Epilepsy (fits or "mirgi")

This is a type of functional disorder of the nervous system in which suddenly excessive discharge of nerve impulses takes place from the brain. The abnormal bursts of impulses from neurons which cause the body to behave strangely are called **seizures**. People generally call it fits.

Some epilepsy patients simply experience an odd feeling. Others may have convulsions (shaking of the body) or may lose consciousness. The body becomes rigid and stiff. The patient's hands are clenched and they frequently bites their tongue.

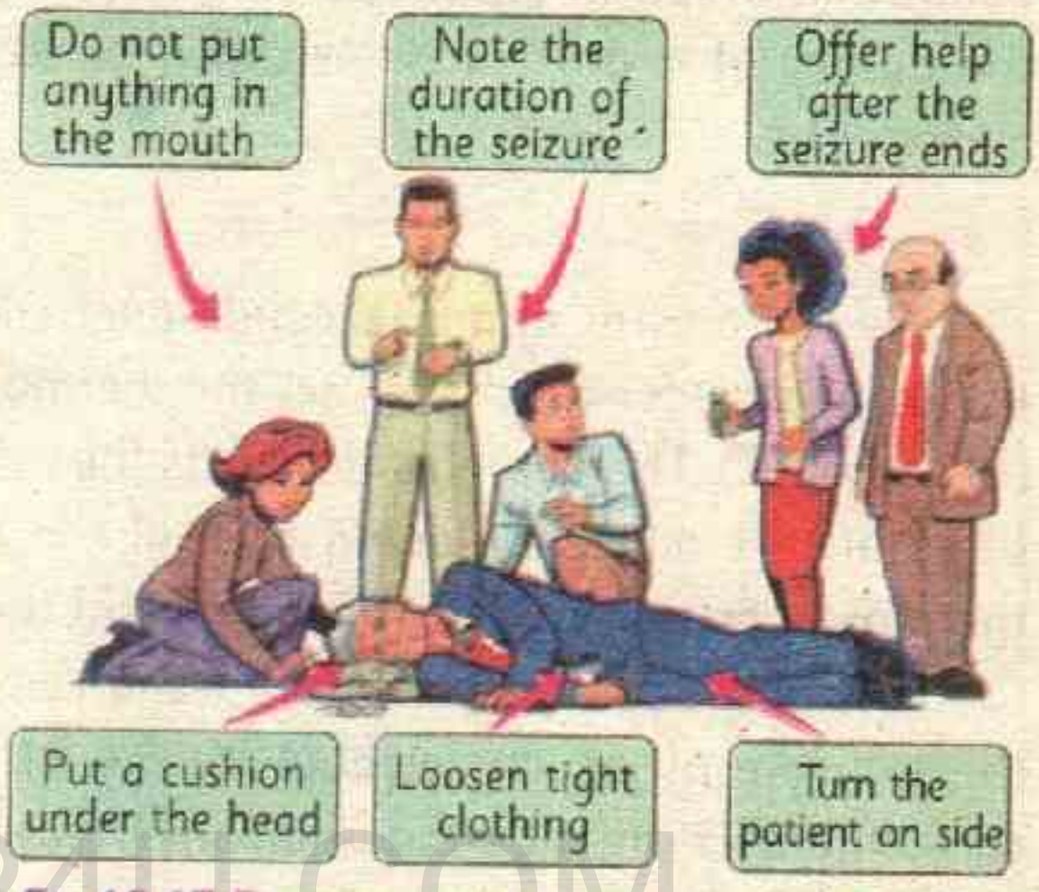


Fig. 12.17 Emergency aid to a patient who suffered from a seizure

Epilepsy may be caused by changes in the brain due to genetic reasons. Severe head injuries, stroke, brain infections and drug abuse may also cause epilepsy. In the treatment for epilepsy, seizures are controlled. Anti-epileptic drugs (AEDs) are used for the treatment of epilepsy. AEDs do not cure epilepsy, but can prevent seizures from occurring.

b). Paralysis

Paralysis is a vascular disease of the brain. It occurs when either a blood clot is stuck in the fine blood vessels of the brain or due to the rupturing of blood vessels in the brain due to high blood pressure. This causes damage to that part of the brain. This damage may be permanent or temporary. As a result; the part of the body controlled by the affected part of the brain stops functioning.

The patient of paralysis is unable to move the muscles of one side of their body or both sides. Paralysis may also affect the arms or the legs, and sometimes the whole body.

There is currently no cure for paralysis. The existing treatments only help a person to adapt to this way of life by making them independent. Patients are given physiotherapy to improve their muscle weakness. Mobility aids such as wheelchairs and orthoses (braces designed to improve the function of a limb) are also used for patients of paralysis.

Science, Technology and Society

Explain the way nervous system helps to coordinate complex and intricate movements of hand to play a piano, or write alphabets.

Key Points

- The cooperative working of cells, organs and systems with one another to perform proper functions is called coordination.
- Coordination provides chances for better survival.
- Coordination is brought about by the nervous system and hormonal system.
- Sensitivity in animals is more than that in plants. It is because animals possess sense organs
- Stimulus is a change in the environment, which can be detected through the receptors.
- Response is a reaction to the stimulus.
- Receptors are organs in the body, which receive stimuli e.g. eyes, ears, nose, tongue, etc.
- Effectors are the organs which produce a response for the stimulus e.g. muscles or glands.
- The central nervous system consists of the brain and the spinal cord.
- Sensory neurons carry nerve massages from the central nervous system to the effectors.
- Motor neurons carry nerve massages from the central nervous system to the effectors.
- Associative neurons occur in the brain and spinal cord. They link the sensory neurons with the motor neurons.
- The spinal cord receives commands from the brain. It controls parts of the body and the limbs.
- Spinal cord is the centre of many reflex actions.
- Nerves arising from the brain are called cerebral nerves or cranial nerves.
- Nerves arising from the spinal cord are called spinal nerves.
- Short sighted person cannot see distant objects clearly.

Exercise

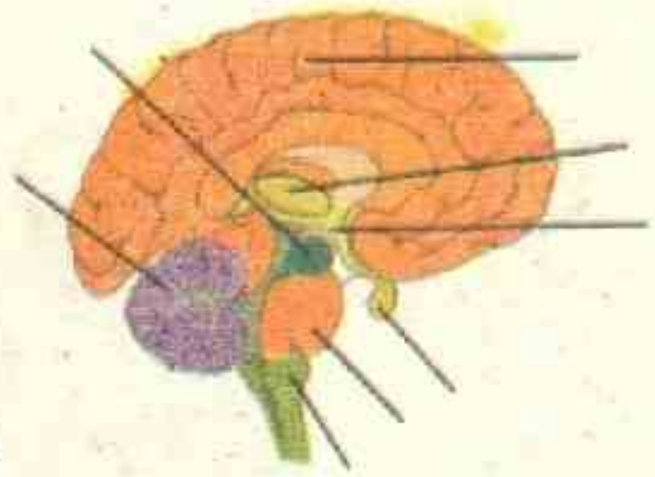
A. Select the correct answer.

1. Insulin is a hormone and is secreted by;
   a. Liver b. Pancreas c. Stomach d. By both liver and pancreas
2. One of the following is a muscular layer of the eyeball:
   a. Retina b. Sclera c. Cornea d. Cone
3. The part of neuron that carries the signals away from the cell body:
   a. Axon b. Dendrite c. Schwann cell d. Myelin sheath
4. One of the following is responsible for the detection of changes in the environment:
   a. Receptors b. Neurons c. Effectors d. All of them
5. Which of the following is true about the cerebral cortex?
   a. It is located deep in the brain. b. It is the folded outer covering of the brain.
   c. It is located at the back of the brain. d. It is part of the peripheral nervous system.
6. Light rays focus behind the retina, instead of focussing on the surface of the retina. This condition is known as:
   a. Myopia b. Hypermetropia c. Short sightedness d. Normal vision
7. Microscopic gaps between the neuron endings are
   a. Transmitters b. Synapses c. Pores d. Nodes
8. The largest part of the brain is:
   a. Cerebrum b. Cerebellum c. Medulla oblongata d. Thalamus
9. Intelligence is under the control of:
   a. Cerebrum b. Cerebellum c. Thalamus d. Hypothalamus
10. Mixed nerves are made of;
    a. Axons of sensory and motor neurons b. Cell bodies of sensory and motor neurons
    c. Axons of inter-neurons d. Cell bodies of inter-neurons
11. The part of the brain which you use in recalling your memories is:
    a. Cerebellum b. Limbic system c. Thalamus d. Hypothalamus
12. Which of these acts an exocrine as well as endocrine gland?
    a. Pituitary b. Thyroid c. Adrenal d. Pancreas
13. In the inner ear, vibrations make pressure waves in the fluid of;
    a. Cochlea b. Stapes c. Auditory nerve d. Semi-circular canals

B. Write short answers to the following questions.

1. How do reflex action work in human beings?
2. What are the causes of epilepsy and paralysis?

3. What happens if Islets of Langerhans secrete insulin but not glucagon?
4. Why is the pituitary gland known as the master gland?
5. Differentiate between the two types of coordination system.
6. What is the role of insulin and glucagon?
7. What characters are controlled by the ovarian hormones?
8. State the hormones of the pituitary and thyroid glands and write their functions.
9. Label the different parts of the brain in the following diagram.



C. Write detailed answers to the following questions:

1. Explain the different types of receptors in human beings.
2. Describe the structure of the human brain.
3. Write a comprehensive note on chemical coordination in human beings.
4. Discuss any two disorders of the human eye.
5. Describe the causes, symptoms and treatments of paralysis.
6. Describe the causes, symptoms and treatments of epilepsy.
7. Explain the mechanism of vision by the eyes.

Initiating and Planning

1. Analyse why plants (like sunflower) have a very slow response to stimuli.
2. Visualise nervous and hormonal coordination by comparing electrical transmission in wires with the transmission of nerve impulse in neurons and by comparing convection currents in liquids to the hormonal transmission in blood.
3. Compare the BGC (blood glucose concentration) of a healthy person with a patient suffering from Diabetes mellitus.

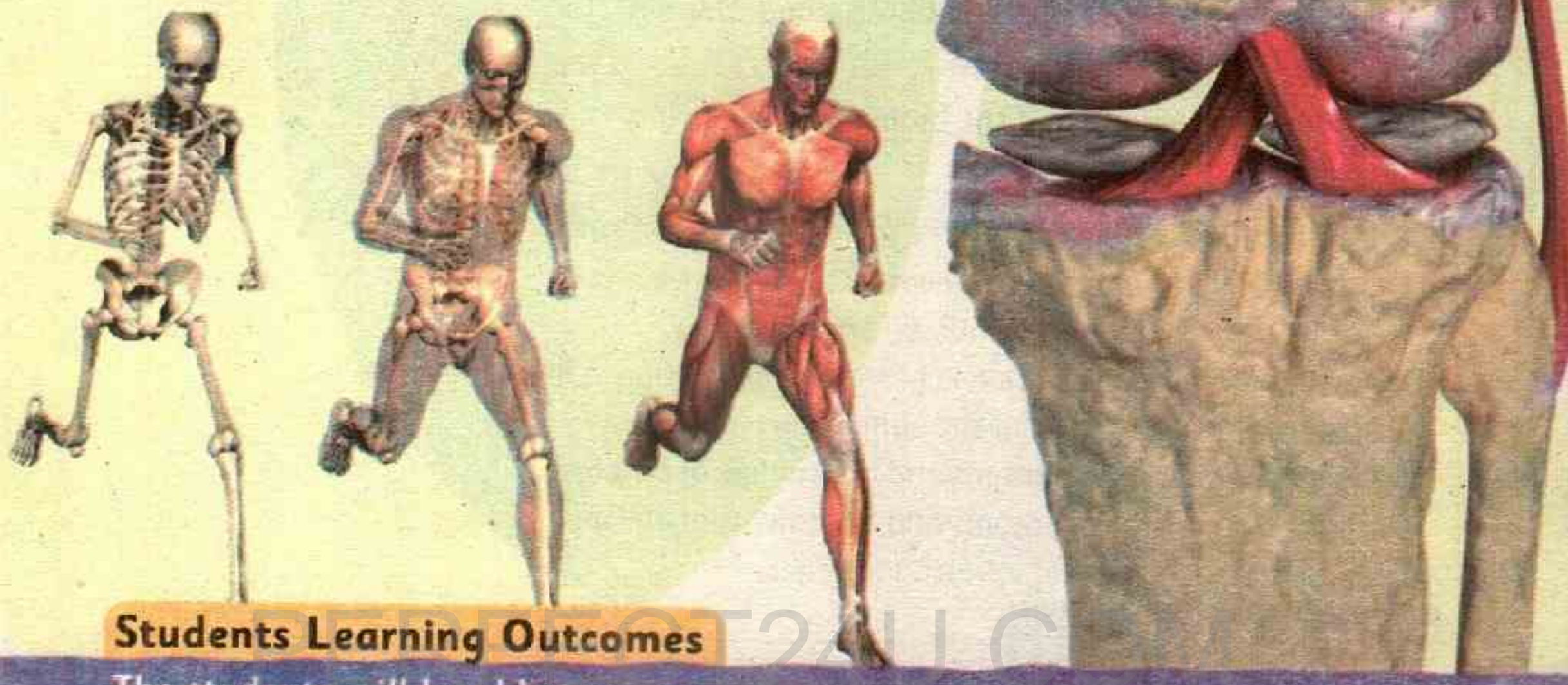
Activities

1. Record the difference in quickness of response of the two types of coordination (by asking a student to say a few words in front of the class and observe the change in heartbeat).
2. Perform an experiment in which a scale held at its lower end between the thumb and index finger is allowed to fall and then recording the time taken to catch it again.
3. Identify different parts and draw a labelled diagram of the longitudinal section of the eye of a sheep or bull.
4. Perform an experiment in which the shin muscle of a frog is made to contract in a Petri dish filled with methylene blue and using 12 V DC current.
5. Check the vision of a friend to diagnose whether he/she is suffering from long or short-sightedness.
6. Perform an experiment in which one student flashes a spotlight into the eye of another and record the time taken for the eye to contract its pupil.

Unit

13

SUPPORT AND MOVEMENT



Students Learning Outcomes

The students will be able to:

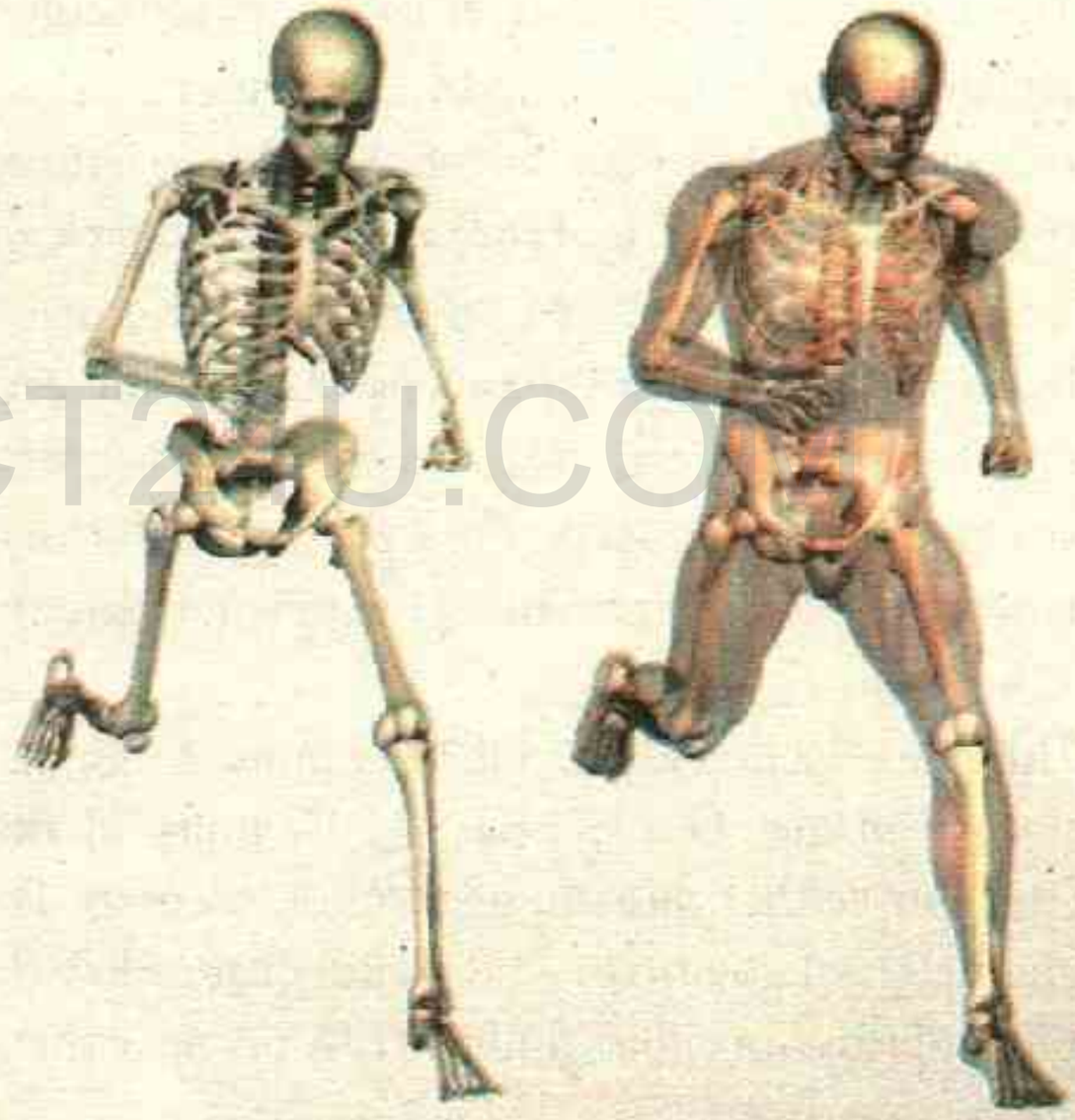
- Define a skeleton and differentiate between cartilage and bone.
- Describe the role of the skeleton in support and movement.
- Explain that skeleton system is actually a dynamic, living tissue that is capable of growth, adapts to stress and repairs itself after injury.
- Describe the main components of the axial skeleton and the appendicular skeleton.
- Describe the contribution of Vesalius in describing the bones and muscles in human.
- Differentiate between moveable joints and immovable joints.
- State the role of ligaments and tendons.
- Describe the location and movement of hinge joints.
- Identify ball and socket joints in the human body.
- Define antagonism.
- Describe the action of flexors and extensors as a pair of opposing muscles selecting biceps and triceps as an example.
- Describe the effect of deficiency of calcium on bones and relate this deficiency with osteoporosis.
- Discuss the causes, symptoms, and treatment of arthritis.
- Relate the onset of arthritis with age and weight-bearing joints.

Introduction

You might have seen a very common invertebrate the earthworm, which is generally found in the soil. Have you ever thought why it always crawls on the ground? Why it moves so slowly? Why it can not stand erect like human beings and other mammals? The answer to these questions is, "It does not have any skeleton which can support it to stand erect and move faster". In previous classes you have studied the human skeleton, which not only gives proper shape to the human body but also provides support for movement. All animals, which can move fast, possess some type of skeleton. Free movement, also known as locomotion is a life characteristic of all living animals. It enables them to utilize the environment in the best possible way and to save themselves from predators and a range of environmental factors. For all types of movements, the skeleton plays a basic role.

13 .1) Human Skeleton

A skeleton is defined as the framework of hard structures that provide physical support and protection for the bodies of animals. The skeleton also provides helps in locomotion. Like other vertebrates, the human skeleton is inside the body i.e. it is an endoskeleton. The skeleton is made of living tissues. It contains living cells and also has nerves and blood vessels. It can also grow and repair itself.



Science, Technology and Society

The skeleton performs various functions in the living body. These functions include shape, support, movement, protection and blood cells production. In different animals, these functions are variously performed and the shape of the skeleton is in accordance with the requirement of the particular animal's types.

The human skeleton is composed of two parts i.e. the axial skeleton and the appendicular skeleton. The axial skeleton consists of 80 bones of the head, neck, and chest. The appendicular skeleton consists of 126 bones of the limbs, and the pectoral and pelvic girdles.

For Your Information

The skeletal system of some invertebrates e.g. arthropods, is outside the body, and is called an **exoskeleton**.

13 .1) Axial Skeleton

The term axis means the central point around which other structures are distributed. The axial skeleton lies in the centre of the body around which the whole body is built. The axial skeleton includes the skull, the vertebral column, the ribs and the sternum. .

Tidbit

At the time of birth human infants have 350 bones in their body. As a baby grows up towards adult stages, many of these bones fuse together and their number reduces to 206. The largest bone is the femur whereas the smallest bone is found in the internal ear.

1. Skull

The skull is made up of the cranium and facial bones. The cranium consists of 8 bones, which protect the brain. There are 14 facial bones, which make the skeletal part of our face.

2. Vertebral Column

The vertebral column extends from the skull to the pelvis. It consists of the backbone, which not only allows us to stand erect but also protects the spinal cord. The vertebral column consists of 33 vertebrae. The vertebrae are named according to their location in the body. Those 7 vertebrae present in neck are called cervical vertebrae. 12 vertebrae which lie in the chest region are called thoracic vertebrae. Those five vertebrae which lie in the back region are termed as the lumbar vertebrae and those nine found between the lower limbs area are called the pelvic vertebrae. The pelvic vertebrae make two sets i.e. the sacrum and the coccyx. The sacrum is formed by the fusion of anterior five vertebrae, whereas coccyx is formed by the fusion of four posterior vertebrae.

3. Chest bone and Ribs

There are 12 pairs of ribs in the human body, which are attached on dorsal (back) side with the vertebrae. Out of the 12, 10 pairs of ribs connect anteriorly with the chest bone (sternum) either directly or through an arch. The rib cage provides support to the thoracic cavity (chest cavity) in which vital organs like the heart, lungs etc. are present. The lower 2 pairs of ribs are called floating ribs because they do not attach with the sternum.

4. Middle Ear Bones

Each human ear has three bones called ossicles. These are the malleus, the incus and the stapes.

5. Neck bone

There is one bone in the neck called the **hyoid** bone.

13.1.2 Appendicular Skeleton

The appendicular skeleton consists of the following parts.

1. Pectoral Girdle

The pectoral girdle attaches the forelimbs to the vertebral column. It is comprised of 4 bones of the shoulder (2 bones on each side).

2. Forelimbs (Arms and Hands)

The arms contain 6 bones (3 in each arm). The hands contain 54 bones (27 in each hand).

3. Pelvic Girdle

The pelvic girdle attaches the hind limbs to the vertebral column. It consists of 2 bones.

4. Hind limbs (Legs and Feet)

The legs contain 8 bones (4 in each leg) while both feet contain 52 bones (26 in each foot).

Activities

Identify and draw labelled diagrams of different bones of the human skeleton from real specimen models or charts.

3.1.3 Role of the Skeletal System

The skeleton performs the following functions in the body.

- The skeleton forms the hard structure of the body and gives it a definite shape.
- the skeletal muscles are attached to the bones. Hands, legs, pectoral girdle and the pelvic girdle help in movement. The muscular system has an important role in movement. Due to the attachment of muscles with the bones, these bones can move and thus we can move.
- The skull protects the brain and the vertebral column protects the spinal cord. Similarly, the lungs and heart are protected in the rib cage.
- Bone marrow produces the red blood cells, platelets and white blood cells.
- Bones store mineral salts (calcium, potassium, phosphorus). This is the reason why the bones remain hard and strong.

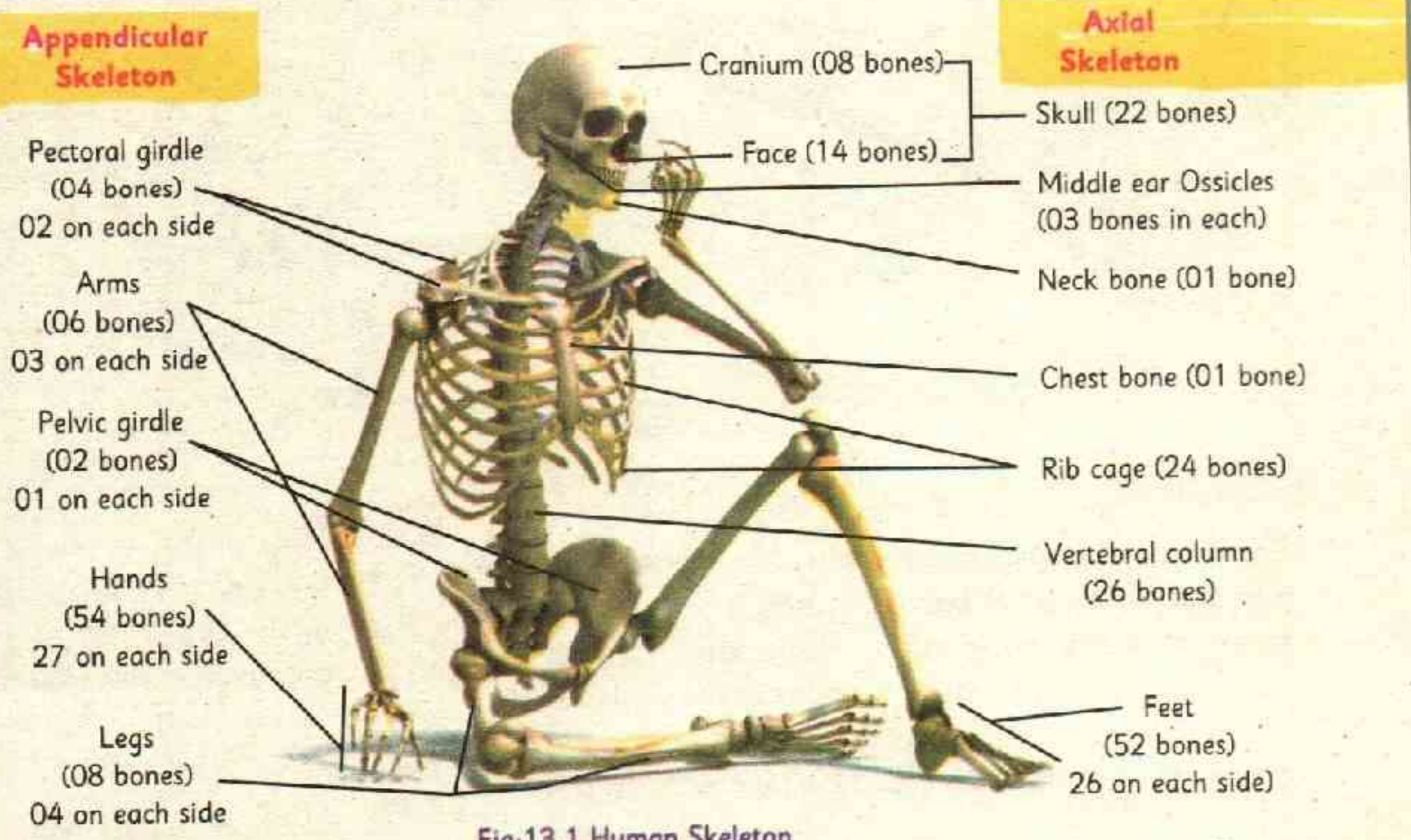


Fig:13.1 Human Skeleton

13.2 Composition of Skeleton

The human skeleton is made up of two types of connective tissue i.e. bones and cartilage.

1. Bones

Bones are the hardest and the most rigid form of connective tissue in the human body. Muscles pull our bones to enable movements. Bones give shape and structure to the body. It provides support and protect delicate internal organs. In addition, the internal portion of many bones produce red blood cells, platelets, and white blood cells.

The hard, white outer layer of the bone is called compact bone. The matrix (plural: matrices) is the material (or tissue) in animal cells in which more specialised structures are embedded. The bone matrix contains collagen fibres. The matrix is also saturated with calcium phosphate. It gives strength to the bone. Within the bone matrix, bone cells called osteocytes are present in spaces called lacunae. The bone matrix contains nerve fibres and blood vessels, which keep the osteocytes alive. Beneath the compact bone the spongy bone is present. The spaces within the spongy bone contain bone marrow, where most blood cells are formed.

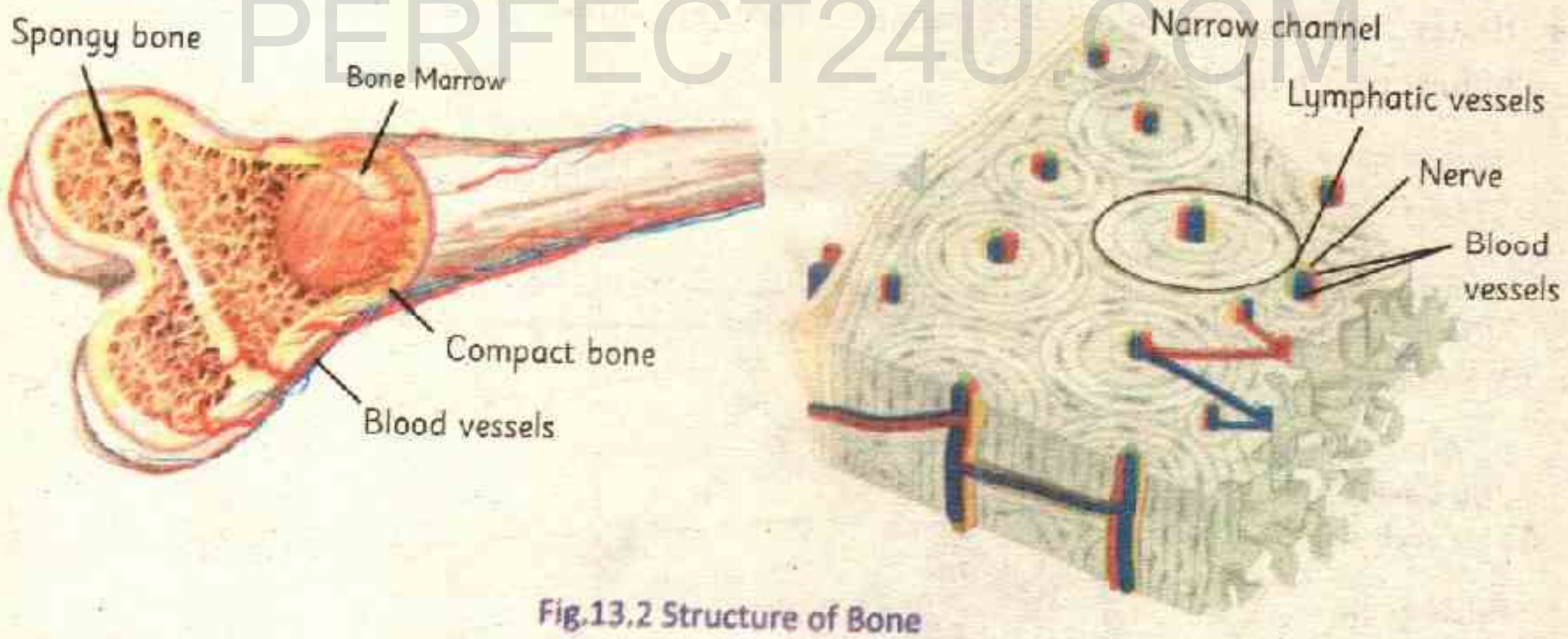


Fig.13.2 Structure of Bone

2. Cartilage

Cartilage is a specialised connective tissue, which is firm and flexible and does not stretch. It has great tensile strength and is much softer than bone. In adults the cartilage covers the ends of the bone at the joints like the knee joints. It also supports the flexible portion of nose the and the external ears called the pinna.

Tidbit

In common words, cartilage is referred to as "soft bone". In early embryonic life, the whole skeleton is made of cartilage which then gradually turns into bones.

Ground substance is the amorphous gel like substance present in extracellular spaces. The ground substance of cartilage contains **collagen fibers** in parallel arrangements. The cells of the cartilage are called **chondrocytes**. These are also present in this ground substance within spaces called **lacunae**. The number of chondrocytes found in cartilage determines how flexible or elastic the cartilage is. One of the main functions of some cartilage types is to keep bones from rubbing together, thus reducing friction. There are no blood vessels present in the ground substance of cartilage. There are three types of cartilage i.e. hyaline, elastic, and fibrous cartilage.

Activities

Investigate the nature of bones (by putting three pieces of lamb rib bone in water, sodium hydro-oxide and dilute Hydrochloric acid). Observe the changes in the nature of bone after 60 minutes.
What will students learn from this? Explain what is expected to happen...

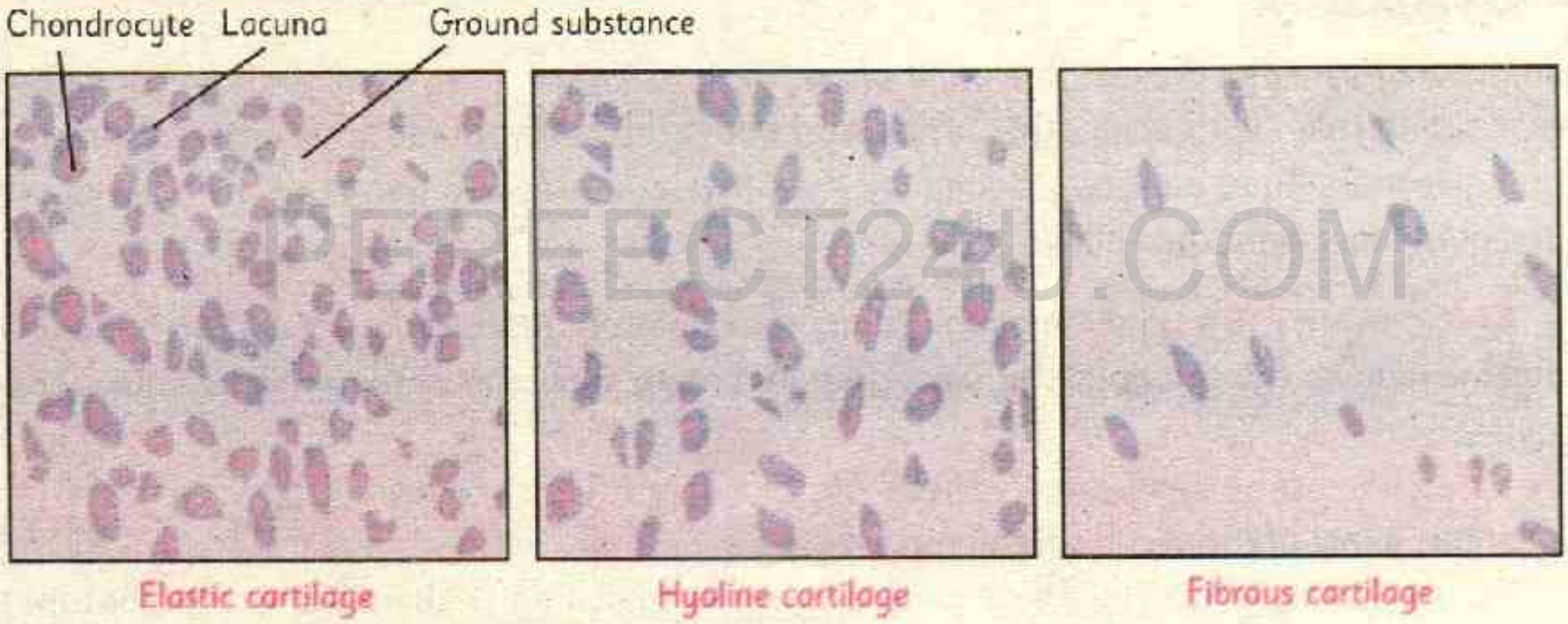


Fig.13.3 Structure of Cartilage and its Types

In **elastic cartilage** the cells are closer together and there is less ground substance. Elastic cartilage is found in the external ear flaps and in the epiglottis.
Hyaline cartilage has less number of cells and more ground substance. Hyaline cartilage is found at the ends of long bones, in the nose, ears, trachea, larynx, and bronchi.
Fibrous cartilage has the least number of cells so it has maximum ground substance. Fibrous cartilage is found in the inter-vertebral disc.

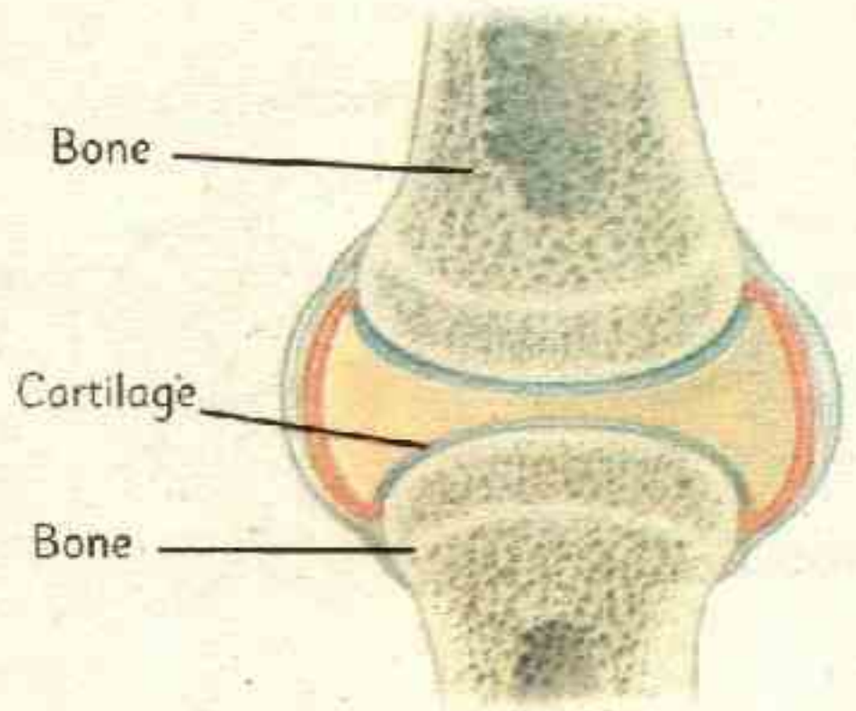


Fig.13.4 Location of Hyaline Cartilage

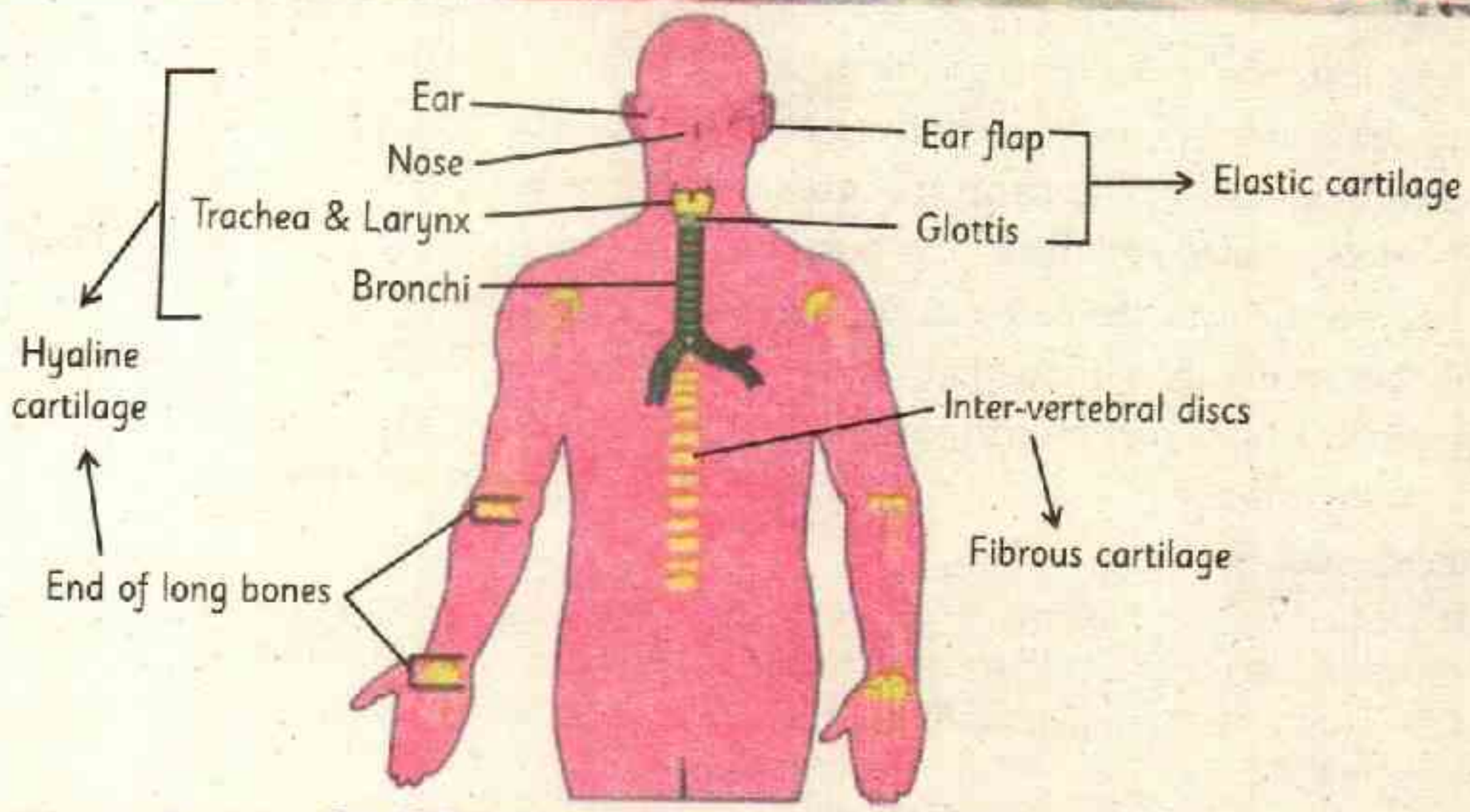


Fig.13.5 Locations of the Types of Cartilage

13.3 Joints

Joints are formed at the meeting point of two or more bones. They keep our bones together by holding them with each other. They also allow the bones to move to different extents and give mobility to our body. Joints are classified into three categories on the basis of the extent of movement they allow:

a. Immovable joints: In immovable joints the bones are fused together and do not allow any movement. For example, the joints present among the bones of the skull are immovable joints.

b. Slightly movable joints: These are the joints which allow little movement for example. joints of the vertebral column, ribs etc.

c. Freely movable joints: These joints allow free movements. There are two major types of freely moveable joints i.e. hinge joint and ball-and-socket joints.

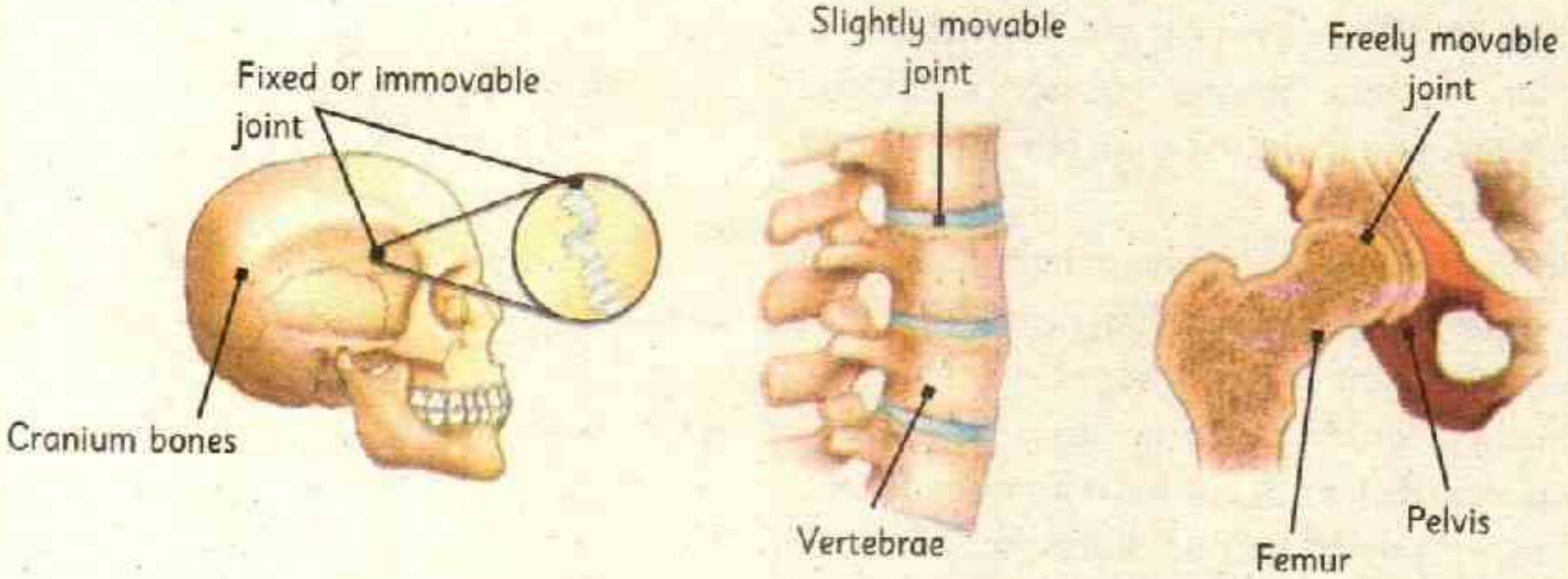


Fig.13.6 Immovable, slightly movable and freely movable joints

13.6 Muscles and its Types

Locomotion and all other types of movements are due to the contraction of muscles of the body. We have three types of muscles in our body.

(i). The **Cardiac muscle** (heart muscle) is an involuntary muscle – meaning we cannot control its function. Contractions of the cardiac muscle help the heart to pump blood throughout the body. Cardiac muscles keep on contracting throughout our life.

(ii). Smooth muscles are found in the walls of organs e.g. the digestive tract, air passageways, blood vessels and the urinary bladder etc. Their contractions move the materials present in the organs.

(iii). Skeletal muscles are attached to the bones of the skeleton. Their contractions help us in movement and locomotion.

13.6.1 Antagonistic Movement of Skeletal Muscle

We know that muscles are attached to bones by tough connective tissue called **tendons**. Skeletal muscles move the body. These muscles are under voluntary control, meaning you consciously control what they do. Almost all body movement, like walking and waving your hand is caused by skeletal muscle contraction.

One end of a skeletal muscle is always attached with some fixed bone while the other end is attached to a moving bone. The point where the muscle attaches to the fixed bone is called the **origin**. The point where the muscle attaches to the moving bone is called the **insertion**.

Interesting facts

Muscles can only pull bones. They cannot push bones.
The human body has over 500 muscles responsible for all types of movement.

For Your Information

It should be remembered that the arm does not has these two muscles only. Many other muscles are also present, which work at the same time e.g. muscles which work to give direction to these movement.

Most skeletal muscles are arranged in **pairs**. One muscle in a pair moves a bone in one direction, the other muscle moves it in the opposite direction. In other words when one muscle in the pair contracts to exert a pull, the other muscle will relax or elongate to allow the effect of the contraction of the prior muscle. The phenomenon in which a muscle opposes the action of the other is called **antagonism** and the muscles which show antagonism are called **antagonistic muscles**.

An example of this type of movement is the movement of arm muscles. Our upper arm has two major muscles called **biceps** and **triceps**. When the lower arm is bent it is called in **flexed state**. When the lower arm is in hanging condition, it is called in **extended state.** This extension and flexion is caused by the above mentioned pair of muscles i.e. biceps and triceps.

(i). Hinge joints: Hinge joints allow movements only in two directions. These are present at the elbow and the knee.

(ii). Ball-and-socket joint: Ball-and-socket joints allow movement in all directions (up, down, forward, and backward). Hip joint and shoulder joint are examples of ball-and-socket joints.

Activities

Observe models for the movements at joints and describe how joints allow various movements.

Fig.13.7 Hinge; and ball-and-socket joints in the human body

13.3.1 Roles of Tendons and Ligaments

Ligaments are tough bands of connective tissue, which hold the bones at the joints, in place.

Tendons are tough connective tissues, which attach muscles to bones. When a muscle contracts, the tendon exerts a pulling force on the attached bone. As a result the bone is pulled towards the muscle.

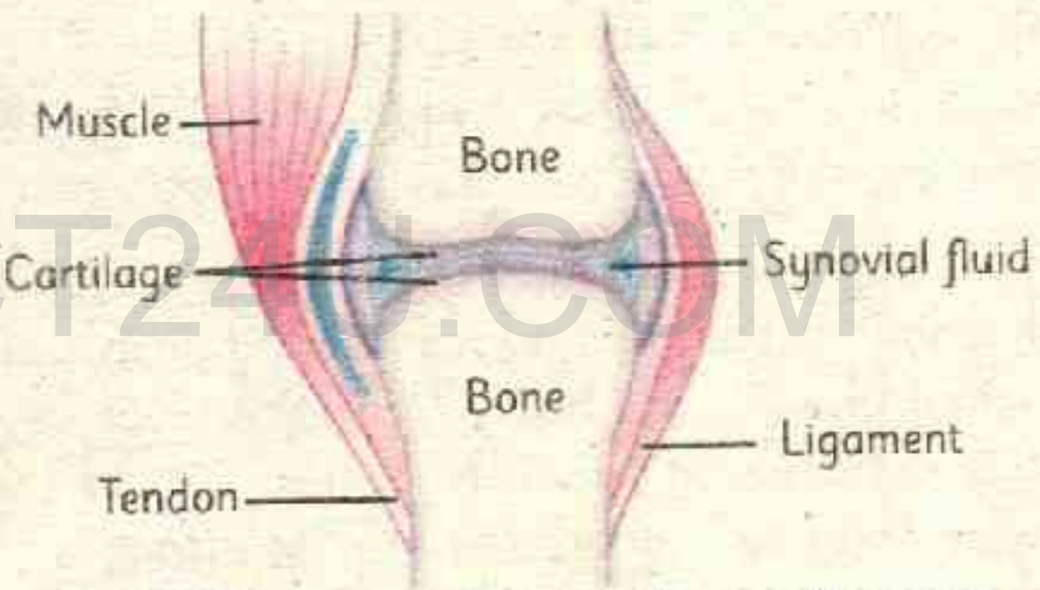


Fig.13.8 Structure of a joint (showing ligament and tendon)

13.5 Contributions of Vesalius (1514-1564)

Andreas Vesalius was born in Brussels. He was professor of Anatomy at Padua University in Italy. In 1543, he wrote the first major book on human anatomy. It was called **'de Humani Corpris Fabrica'** (The Fabric of the Human Body). Vesalius worked closely with the famous artist Titian who produced 277 anatomical illustrations for his book. He explained the different parts of the human skeleton, including the number of bones. He also described the source and position of each muscle and provided information on their respective functions.

Fig.13.9 Andreas Vesalius

When the biceps muscle contracts, its insertion with the radius bone, pulls the bone upward. At the same time the triceps muscle relaxes and the lower arm moves upwards causing a flexion. The bicep muscle in this case is the flexor and the triceps muscle the extensor.

For Your Information

Similarly there are more complex movements of fingers and wrists about which you will study in detail in higher classes

On the other hand when triceps muscle contracts, its insertion with the ulna bone pulls the bone back. At the same time the biceps muscle relaxes and allows the ulna bone to move down easily. It results in the extension of the lower arm. This example explains the general principal of the working of skeletal muscles.

Fig. 13.10 Action of biceps and triceps at the elbow

Activities

Describe the movement of biceps and triceps through presentation of the movement of your elbow.

13.7 Disorders of Skeletal Muscles

From your day-to-day experience you might have learnt about many problems associated with skeletal system. Sometimes during a cricket match the muscle of a fast bowler gets pulled, joint of a wrestler may get dislocated, the bones of a person may be fractured in an accident and so on. Some of the disorders of skeletal system are described here briefly.

13.7.1 Osteoporosis

You learned in this chapter that the process of mineralisation, forms bones. Calcium phosphate is deposited in collagen fibres to make the bones hard. This calcium is absorbed from the food we eat.

When a person is not taking sufficient calcium in their daily diet, their bones start becoming weak. Demineralisation is the process in which calcium moves from the bones to the blood in order to maintain its level. If this situation prolongs the bones become soft and fragile and start bending and can be broken easily. This disorder is known as osteoporosis. Osteoporosis occurs especially in old people and in women.

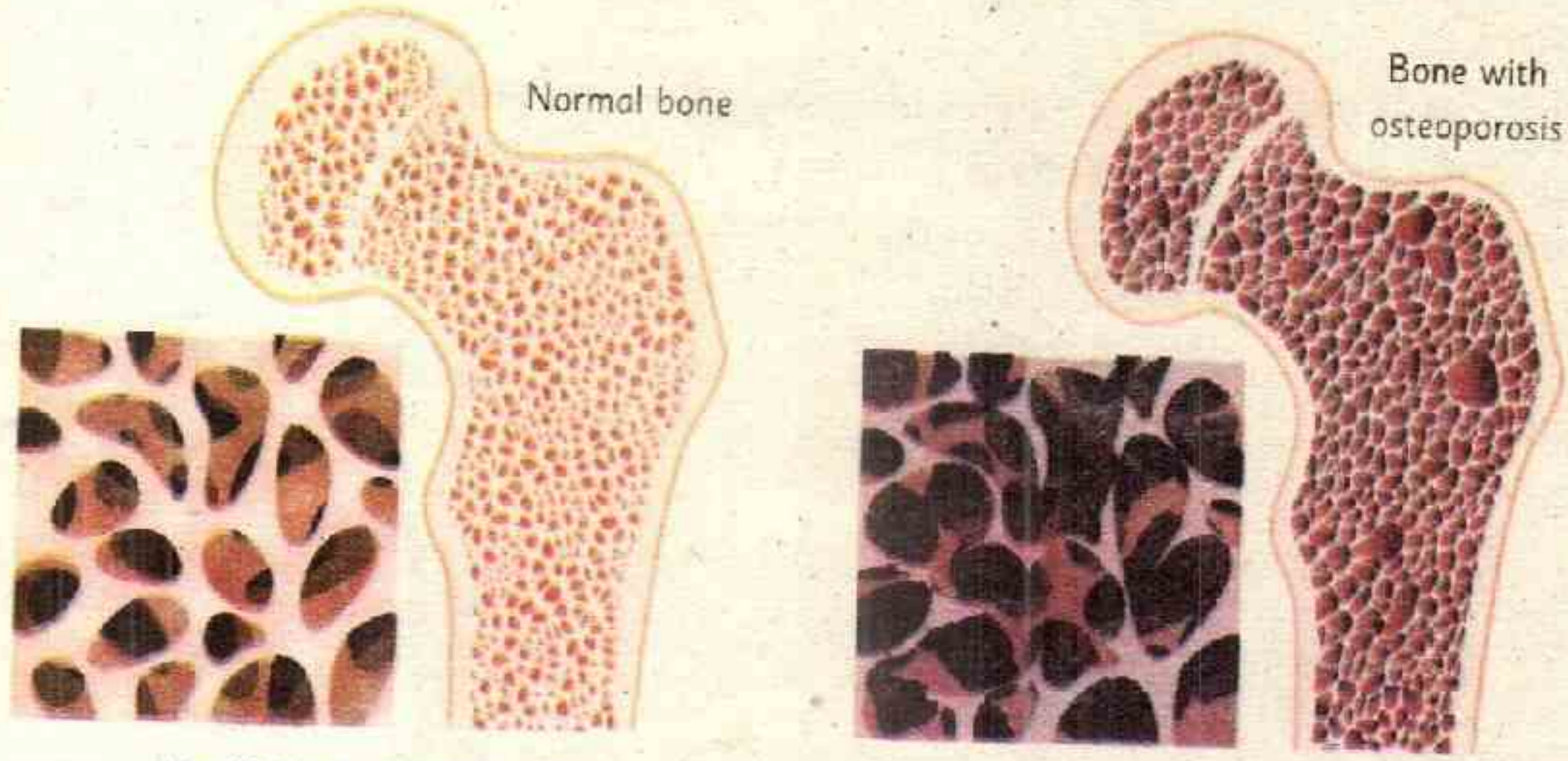


Fig. 13.11 Comparison of normal bone with the bone affected by osteoporosis

13.7.2 Arthritis

Arthritis is the disorder of the joints where they get inflamed. This is a degenerative disease that damages the joints permanently. As a result, pain, stiffness and swelling of the joints takes place. The different types of arthritis are osteoarthritis, rheumatoid arthritis, and gouty arthritis. In this disorder, membranes lining the joints thicken and fluid production is decreased, which results in increased friction causing severe pain and in later stages complete immobility. With the passage of time the joints become permanently swollen and get de-shaped.

a. Osteoarthritis: Osteoarthritis is the most common type of arthritis. This disease affects the cartilage, which starts to wear away over time. In extreme cases, the cartilage can completely wear away, leaving nothing to protect the bones in a joint, causing direct bone-on-bone contact. It occurs most often in older people. Osteoarthritis usually affects the **weight-bearing joints** (the joints of the vertebrae, knee and hip). Osteoarthritis causes joint pain and can limit a person's normal range of mobility.

b. Rheumatoid arthritis: Rheumatoid arthritis is an autoimmune disease in which the body's immune system attacks healthy joints, which become inflamed and swollen. It can destroy cartilage and bone within the joint. It usually affects joints in the fingers, wrists, knees and elbows. It causes pain, stiffness, swelling, and loss of function in joints.

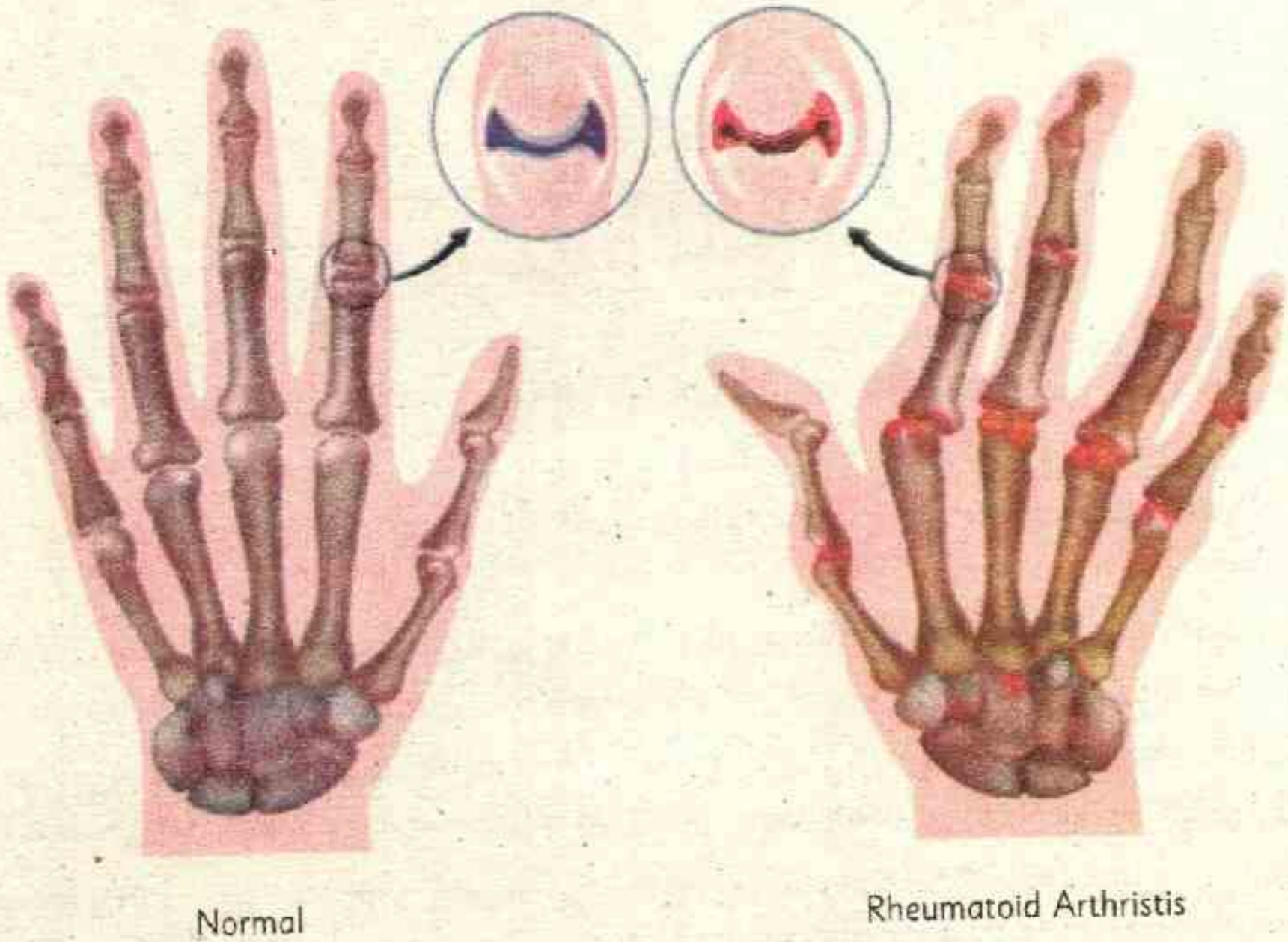


Fig.13.12 Rheumatoid arthritis in finger joints

c. Gouty arthritis: Gouty arthritis is caused by higher than normal levels of uric acid in the blood and the deposit of large amounts of uric acid in the lining of the joints in the form of crystals. It causes inflammation in the joints called gout or gouty arthritis. It usually affects the joint at the base of big toe. Other joints (knees, wrists and fingers) may also be affected.

Treatment of arthritis: The treatment of arthritis focuses on relieving symptoms and improving joint function. Analgesics (pain killers), non-steroidal anti-inflammatory drugs (NSAIDs) are used to treat arthritis. Surgery can also be performed in which the affected joint is replaced with an artificial joint.

Science, Technology and Society

Arthroplasty is a surgery that involves replacing a damaged, worn out or diseased joint with an artificial joint. Adults of any age can be considered for a knee replacement, although most are carried out on people between the ages of 60 and 80. The most common reason for knee replacement surgery is osteoarthritis.

Key Points

- A skeleton consists of a hard living substance, which provides a framework for maintaining the body shape or support.
- Human skeleton can be divided into two further types; the axial skeleton and the appendicular skeleton.
- The axial skeleton includes the skull, the vertebral column, and the ribs with sternum.
- The appendicular skeleton consists of the pectoral girdle and the appendages (fore limbs).
- Human skeleton is made up of two types of materials i.e. bones and cartilage.
- Cartilage is much softer than bone. It is also a form of connective tissue.
- Joints are formed at the meeting point of two or more bones. They keep our bones together by holding them with each other.
- On the basis of the extent of movement allowed by the joints, they are classified into three categories immovable joints, slightly movable joints and freely movable joints.
- There are three types of muscles in our body which are cardiac muscles which make up our heart, smooth muscles are found in digestive, respiratory, circulatory and urinary tract etc and skeletal muscles are found attached to the bones of the skeleton.
- The muscles in our body work in pairs. When one muscle of the pair contracts (shortens) the other relaxes (elongates) to perform a coordinated movement known as the antagonistic movement of muscles.
- Although bones are the hardest parts of our body, however, sometimes our skeletal system becomes weak and results in deformations.

Exercise

A. Select the correct answer.

1. Which of these is a part of the appendicular skeleton?
   a. Ribs b. Sternum c. Pectoral girdle d. Vertebral column
2. The joints between the skull bones are an example of:
   a. Ball and socket joints b. Hinge joints
   c. Immoveable joints d. Slightly moveable joints
3. Which type of joint is present between the vertebrae?
   a. Fixed joint b. Slightly moveable joint
   c. Ball-and-socket joint d. Hinge joint
4. Which of the following is not part of the axial skeleton
   a. Sternum b. Vertebrae c. Leg bones d. Skull
5. Bones are stronger than cartilage due to the presence of:
   a. Collagen fibres b. Osteocytes c. Calcium phosphate d. Lacunae
6. The main protein in the matrix of cartilage is:
   a. Collagen b. Osteo-nectin c. Keratin d. Actin
7. Which connective tissue attaches two bones at a joint?
   a. Ligament b. Tendon c. Cartilage d. Marrow
8. In which disease do the bones become weak and brittle?
   a. Osteoporosis b. Osteoarthritis
   c. Rheumatoid arthritis d. Vertebral column
9. The point where the muscle attaches to the fixed bone is called;
   a. Tendon b. Ligament c. Insertion d. Origin
10. Arthritis is defined as inflammation in:
    a. Bones b. Joints c. Cartilage d. Muscles

B. Write short answers to the following questions.

1. Why are bones considered as dynamic structures?
2. What is the contribution of Vesalius in understanding the human skeleton?
3. Describe the function of three major types of joints and give an example of each.
4. How are different types of arthritis caused?
5. Differentiate between a skeletal muscle's origin and insertion.
6. State the functions of flexors and extensors.

7. What are ligaments and tendons? What function do they perform?
8. State five functions of bones.

C. Write detailed answers to the following questions:

1. Describe the role of the skeleton and muscles in locomotion.
2. Differentiate between the axial and appendicular skeleton and describe the major components of both.
3. Discuss different types of joints and their role.
4. Write the causes and treatments of arthritis and osteoporosis.

Activities

1. Identify and draw labelled diagrams of different bones of the axial and appendicular skeleton from real specimen models or charts.
2. Describe the movement of various human joints through observation of models.
3. Describe the movement of biceps and triceps through presentation of the movement of the elbow.

Science, Technology and Society

1. Relate your skeleton and its functioning with daily life.
2. Relate the principle of leverage to the action of the elbow joint.
3. State the principles of arthroplasty for the replacement of joints.

Unit

14

REPRODUCTION

Students Learning Outcomes

The students will be able to:

- Define reproduction and describe its importance.
- Describe different types of asexual reproduction i.e. binary fission, budding, spore formation and vegetative propagation.
- Distinguish between vegetative propagation and artificial propagation.
- Explain vegetative propagation in plants (through stem, suckers and leaves).
- Describe the two methods of artificial vegetative propagation (stem cuttings and grafting).
- Rationalise how parthenogenesis is a type of asexual reproduction.
- Define cloning.
- Describe sexual reproduction in plants by explaining the life cycle of a flowering plant.
- Describe the adaptations in the structure of wind-pollinated and insect-pollinated flowers.
- Describe the structure of a seed.
- Distinguish between epigeal and hypogeal germination.
- Describe the conditions necessary for germination of seeds.
- State the contributions of Theophrastus in the discovery of sex in plants.
- Outline the binary fission, multiple fission, budding and fragmentation as asexual methods of reproduction in animals.
- Define fertilization and differentiate between external and internal fertilization.
- Describe different organs of the male and female reproductive systems of a rabbit.
- Describe the processes of gametogenesis in rabbit.
- Rationalise the need for population planning.
- Explain AIDS as an example of sexually transmitted diseases.
- State the role of National AIDS Control Program and different NGOs in educating people with reference to AIDS.

Introduction

Reproduction is one of the basic properties of all living organisms. It is a process by which living organisms produce organisms of their own kind. This in turn ensures the continuity of their kind. Plants and animals have different mechanisms and systems for reproduction. Whatever the mode and mechanism of reproduction, it ultimately results in the transmission of genetic material from one generation to the next. This ensures that the advantageous characteristics are transmitted to the next generation. In this chapter we will study various aspects of reproduction in plants and animals.

Tidbit

Although reproduction is a fundamental characteristic of living things, it is not an essential life process. An individual can live without reproduction but a species cannot survive without reproduction.

14.1 Types of Reproduction

Generally reproduction can be divided into two main types which are as follows:

a. Asexual reproduction
b. Sexual reproduction

Asexual reproduction is the type of reproduction in which the offspring are produced without involving the fusion of gametes (sex cells) from two parents. Usually in this type of reproduction the resulting offsprings are similar to the parent. This type of reproduction does not create genetic variations and the offsprings are clones.

Sexual reproduction is the type of reproduction in which gametes of the male and female parents fuse to produce offsprings. The offsprings produced as a result of sexual reproduction have a blend of characteristics from both the parents.

14.2 Asexual Reproduction in Unicellular Organisms and Plants

As discussed earlier, asexual reproduction is the production of one or more offsprings from a single parent. It does not involve the fusion of gametes. This type of reproduction is accomplished by different mechanisms in different organisms. The mechanisms of asexual reproduction in different groups of organisms are given below:

a. Binary Fission

In binary fission the body of the parent organism divides into two daughter organisms. Binary fission is common in Euglena, Amoeba, Chlamydomonas and bacteria.

In **bacteria**, binary fission takes place during favourable conditions. During this process, the DNA molecule of bacterium duplicates (replicates) and forms two DNA molecules. The new DNA molecules move towards the opposite side of cell. At the same time, the cell wall and cell membrane constrict from the two sides and meet in the centre. It separates the cell into two daughter bacterial cells. These daughter cells then start their independent life, grow and divide again.

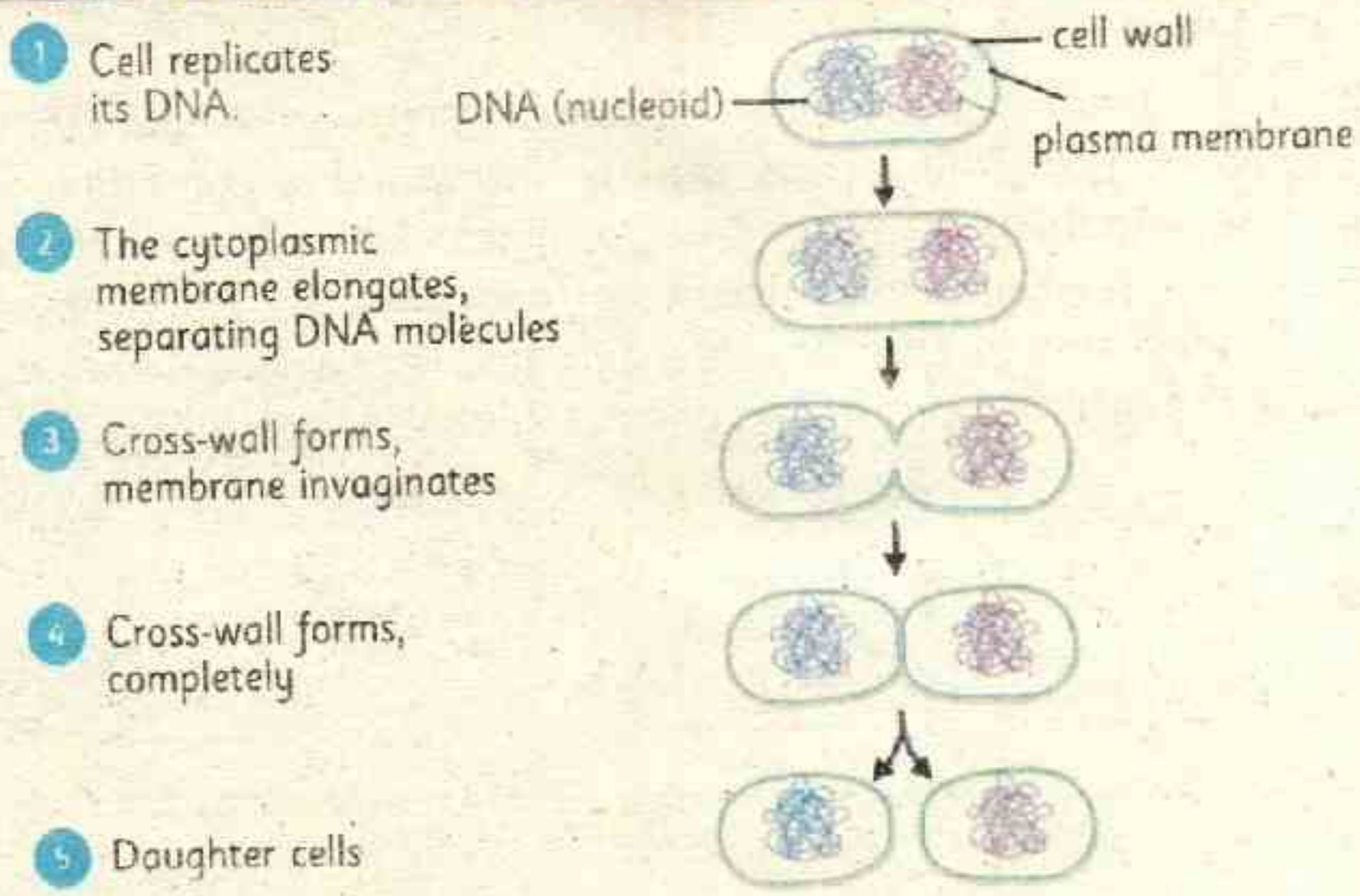


Fig. 14.1 Binary fission in Bacteria

Many **protists** (unicellular eukaryotes e.g. Amoeba, Euglena etc.) also reproduce asexually by binary fission. In protists, the nucleus of the parent organism divides into two. This is followed by the division of cytoplasm. So, two daughter cells of almost equal size are formed.

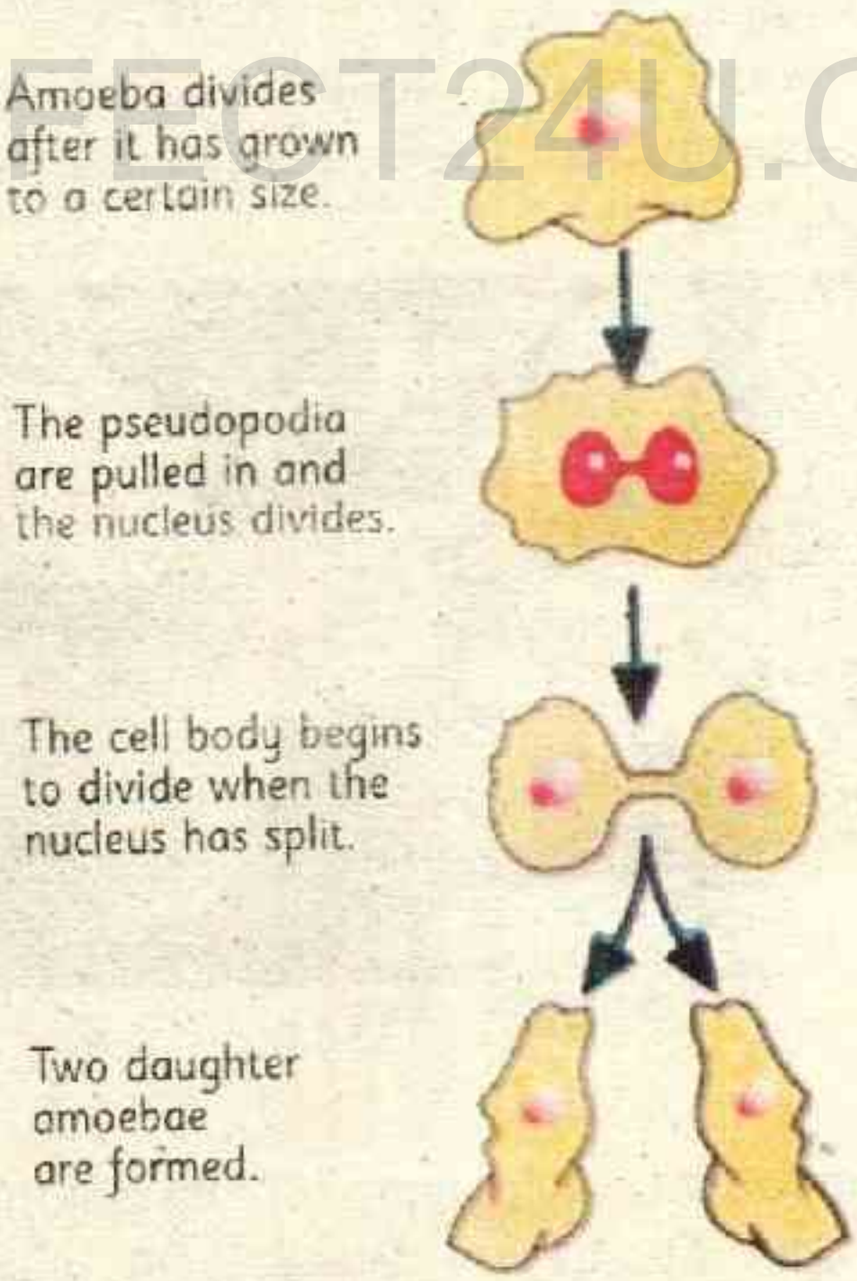


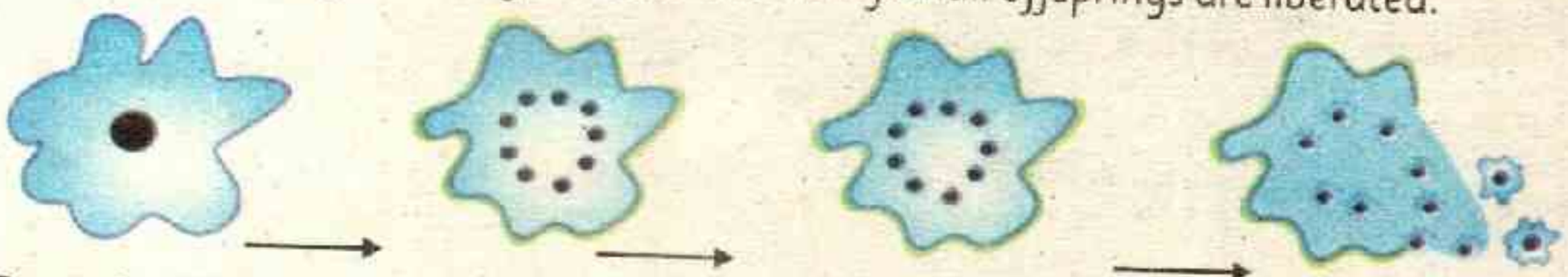
Fig. 14.2 Binary fission in Amoeba

Activities

Draw the different stages of binary fission in Amoeba after observing them on slides or charts.

b. Multiple Fission

Some unicellular organisms like Amoeba, Plasmodium etc. reproduce asexually through the process of multiple fission. It occurs during unfavourable conditions. In this type of reproduction, the unicellular organism develops a protective covering called a cyst over the cell. The nucleus of the cell divides repeatedly and produces many daughter nuclei. Cell membrane is formed around each daughter nucleus. In this way, many daughter cells are produced within the cyst. The cyst breaks and many small offsprings are liberated.



1. Parent Amoeba
2. Cell forms a hard cover
3. Nucleus divides into many.
4. Cell membrane is formed around each nucleus.
5. Many daughter Amoebae are released.

Fig.14.3 Multiple Fission in Amoeba

c. Budding

During budding, an outgrowth arises from the body of the parent. This outgrowth is called a bud. It continues to grow and develops into the offsprings. For example, yeast a unicellular fungus reproduces by budding.

In yeast, a bud grows on the side of the cell. Then the nucleus divides into two. One of the daughter nuclei enters into the bud. The bud grows in size. It may separate from the parent cell or may remain attached to it.

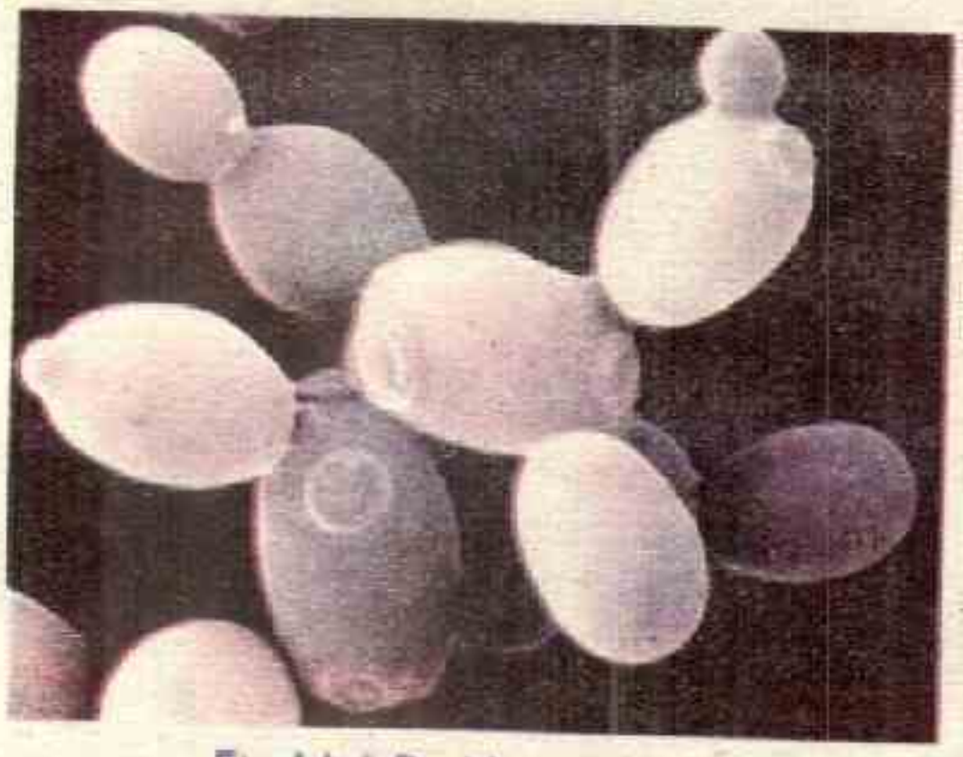


Fig.14.4 Budding in Yeast

d. Spore formation

Many fungi like Rhizopus (bread mould) reproduce by making spores. Spores are thick-walled asexually reproduced cells. Spores are produced in thick-walled sacs called sporangia (Singular: sporangium), which are located at the tips of erect branches of mould. The spores are small, light and dry. When spores mature, the sporangia bursts and spores are dispersed. Spore dispersal occurs in a two-step process. In the first step, the spore is discharged or released. In the second step, it is dispersed away from the parent.

Spores are resistant to adverse environmental conditions due to their thick walls. When favourable conditions are available, the spores germinate to produce new fungus. The most important external factors needed for germination include the optimum temperature, moisture, oxygen and light.

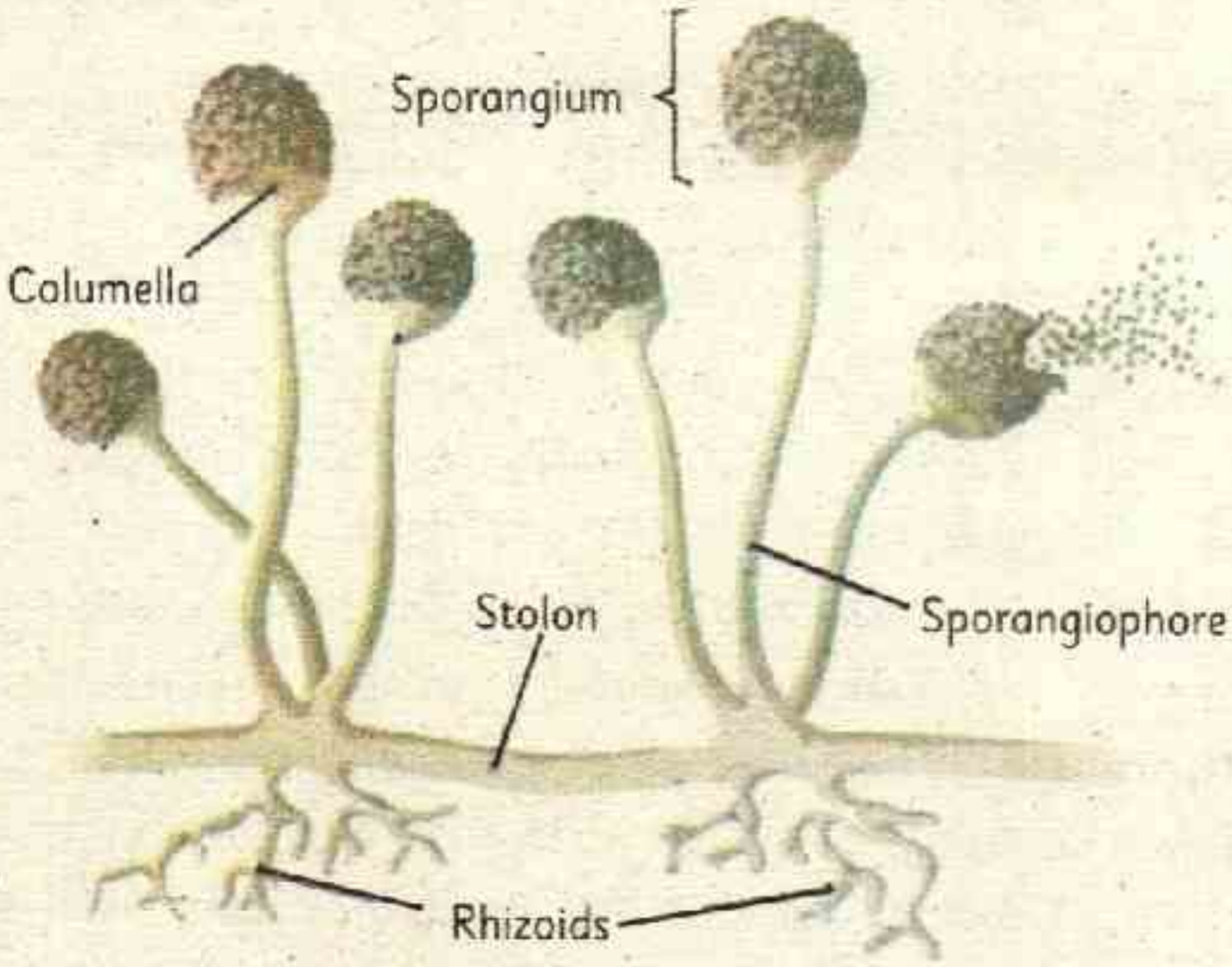


Fig. 14.5 Spores formation in Rhizopus

Tidbit

Some bacteria can also form spores inside their cells. These are called endospores. These are formed when bacteria face harsh conditions. When favourable conditions return, the endospore gives rise to a new bacterium.

e. Vegetative Propagation

Vegetative reproduction is a type of asexual reproduction in which a plant produces a new generation by using its vegetative parts i.e. stems, leaves and roots.

i. Vegetative Propagation through Leaves

In plants such as the Bryophyllum, the leaves have buds at their margins. When a leaf falls on the ground, the buds form tiny shoots. When the shoots break off from the original leaf, they fall on the ground and develop roots.

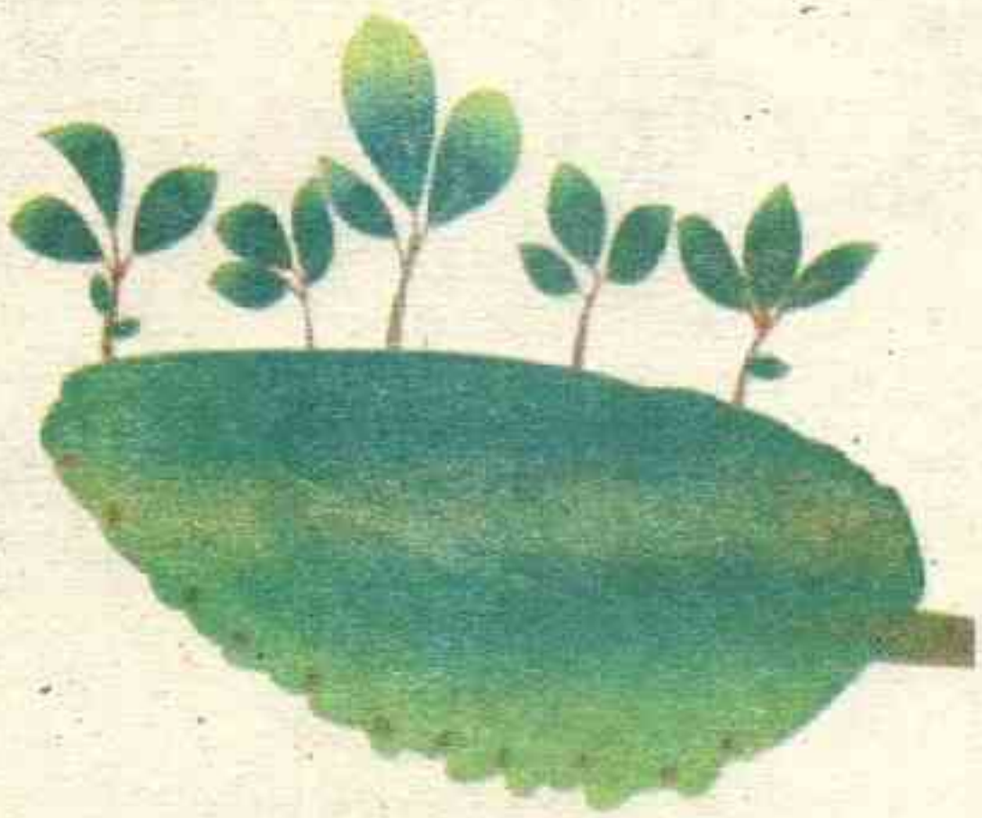


Fig. 14.6 Vegetative Propagation through the leaf in the Bryophyllum

II. Vegetative Propagation through stem

Many plants use their specialised stems to develop a new plant. For example;

- The strawberry plant reproduces by using its above ground horizontal stem called stolon. The stolon is a horizontal, above the ground stem. It produces leaves and roots at its nodes, which develop into plantlets. Thus a new plantlet can grow from each node. If placed in the soil under the suitable conditions, these plantlets grow into strawberry plants.
- Ferns and ginger reproduce from the rhizome. Rhizomes are horizontal underground plant stems capable of producing the shoot and root systems of a new plants, under suitable conditions.
- Tulips, onions and lilies reproduce through bulbs. Bulbs are underground buds that have fleshy leaves extending from them. Bulbs are food storage units for future developing plants. Bulbs contain several buds near the node where leaves are produced. The new buds can eventually develop into new plants. Bulbs divide naturally to produce new plants.
- Colocasia and garlic reproduce through corms. A corm resembles a bulb but does not have fleshy leaves. Almost all of the corms posses a few brown non-functional leaves on the outside. Corms do not store significant amounts of starch. Branches of the corm stem produce new, miniature corms known as cormels. Corms can be dug up and used to propagate or redistribute the plant.
- The potato plant reproduces by an underground, swollen, fleshy stem called the tuber. The tubers have leaves, which are much smaller than the leaves on other parts of the stem. Above each leaf on the tuber is a well-developed axillary bud, commonly called an eye. Eyes can grow into new potato plants.

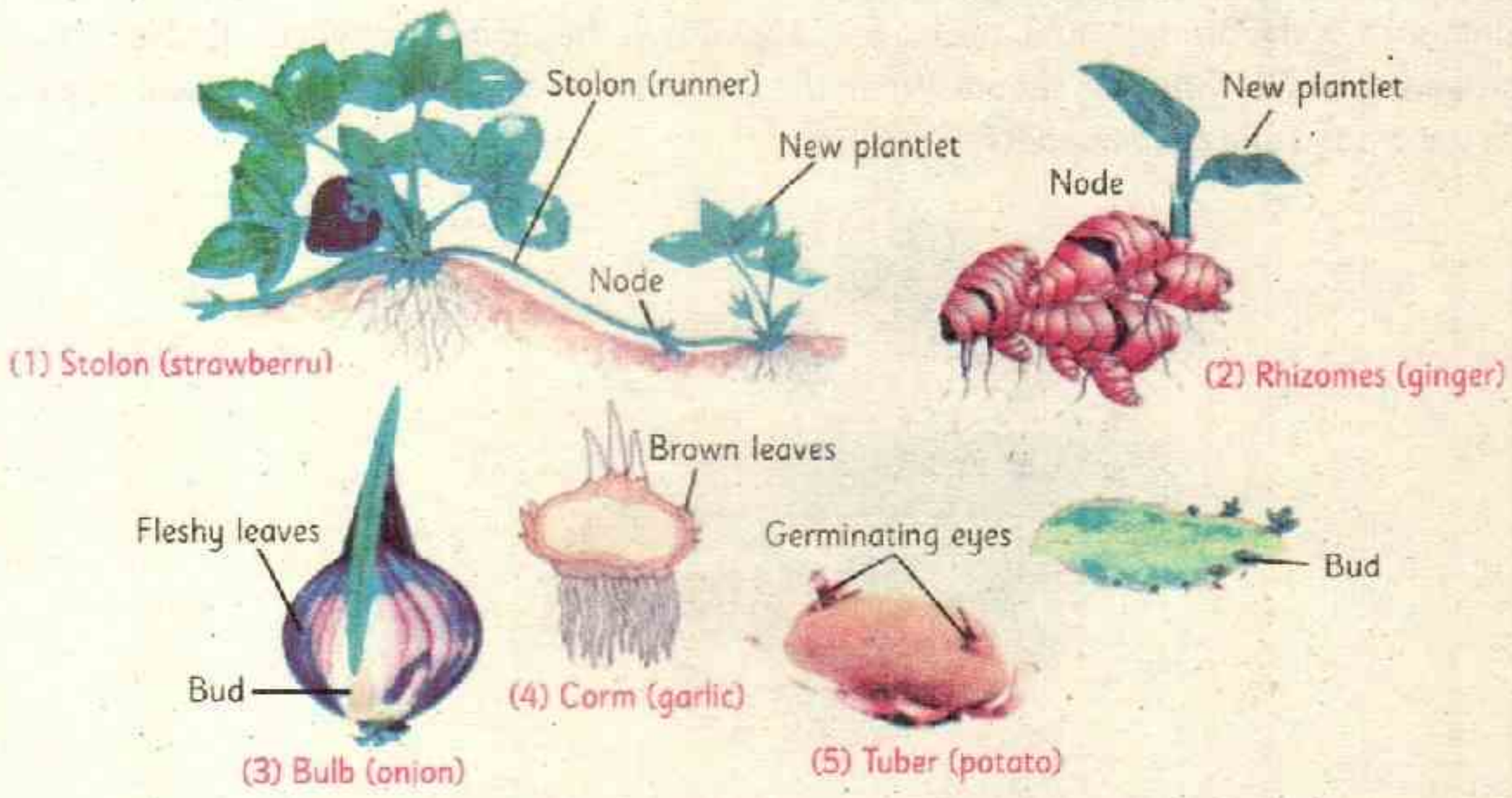


Fig.14.7 Vegetative propagation through the stem

iii. Vegetative Propagation through Root

Red raspberries and many other shrubs can reproduce through their specialised roots. The root can give rise to a shoot, which begins to grow. The new shoots are called root sprouts or "suckers". If these get detached from the original plant they can grow into independent plants.

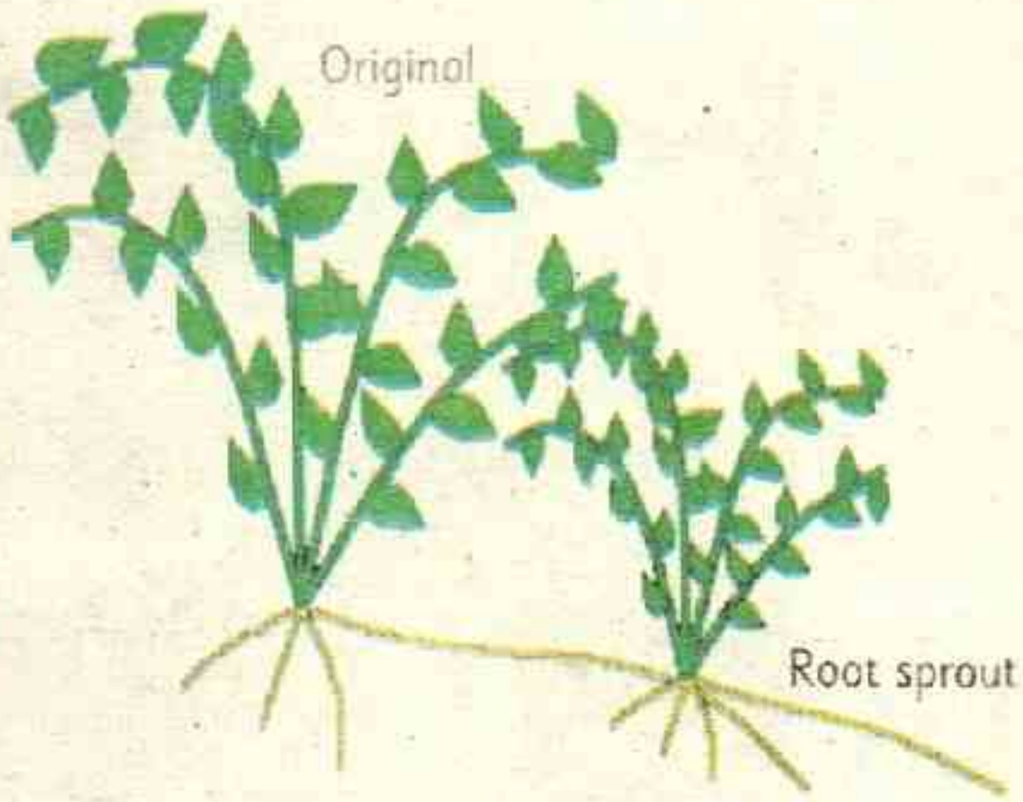


Fig 14.8 Vegetative propagation through the root

Artificial Vegetative Propagation of Plants

Humans have developed methods of using vegetative parts of plants to produce more plants. These methods are called artificial vegetative propagation of plants. The common methods of artificial vegetative propagation are cutting and grafting.

i. Cutting

In some plants, the stem or root is able to make a whole new plant. We can cut such pieces of stems and roots from a plant and use them to grow new plants. Such pieces of stem or root are called cuttings. It is a convenient and inexpensive method of propagation. Stem cuttings are used for the propagation of plants such as grape vine, rose and chrysanthemum etc. Similarly, plants like sweet potato and blackberries are grown by using root cuttings.

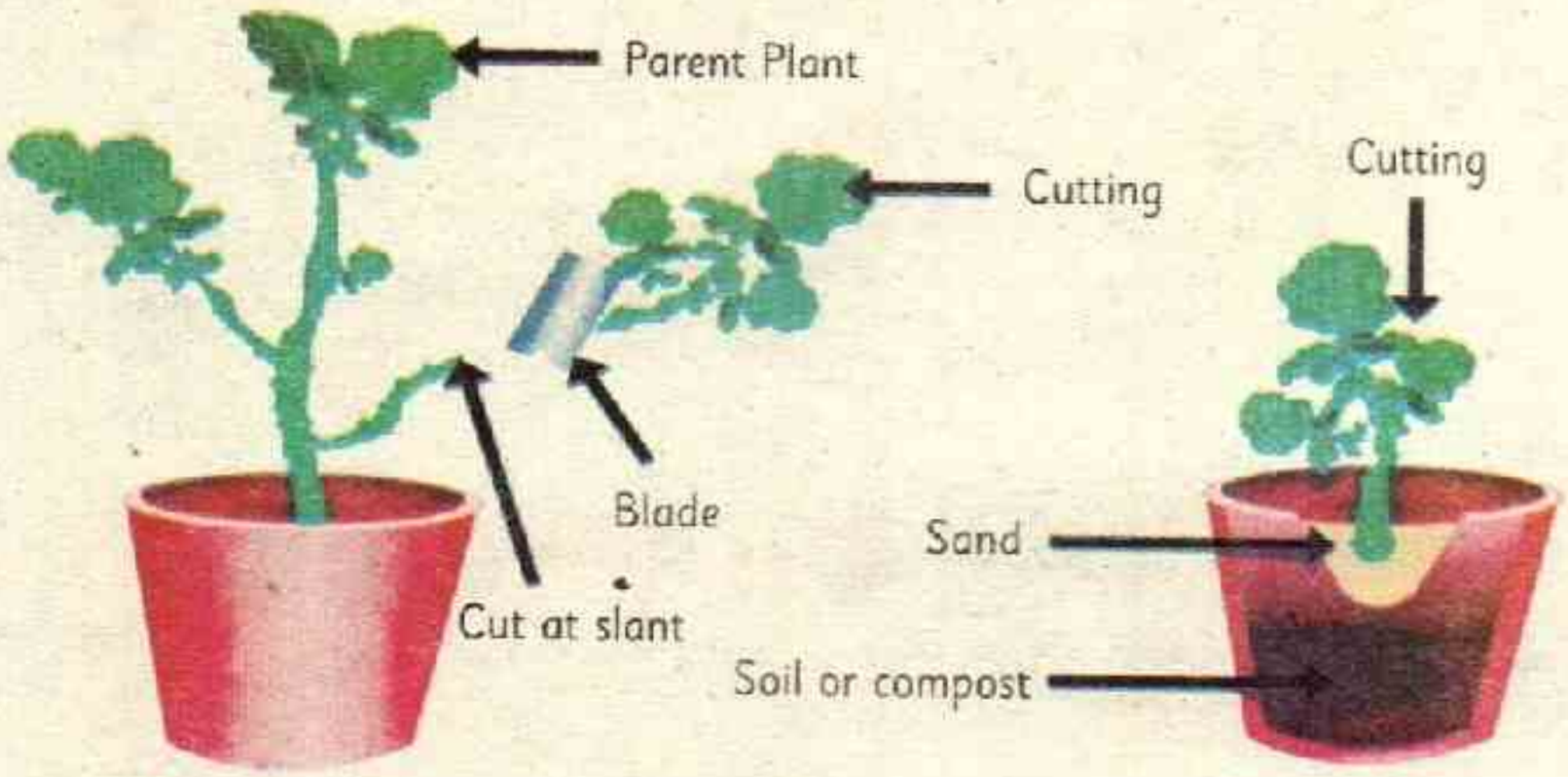


Fig 14.9 Artificial Vegetative propagation through Stem cutting

ii. Grafting

Grafting is a method used to get better quality and quantity of fruits. In grafting, the branch of a desired variety of plant is attached (grafted) on to a stem of an ordinary plant. The grafted branch grows and bears fruits of better quality. This method is used to propagate almost all fruit trees (e.g. almond, plum, cherries etc.), and many ornamental trees.

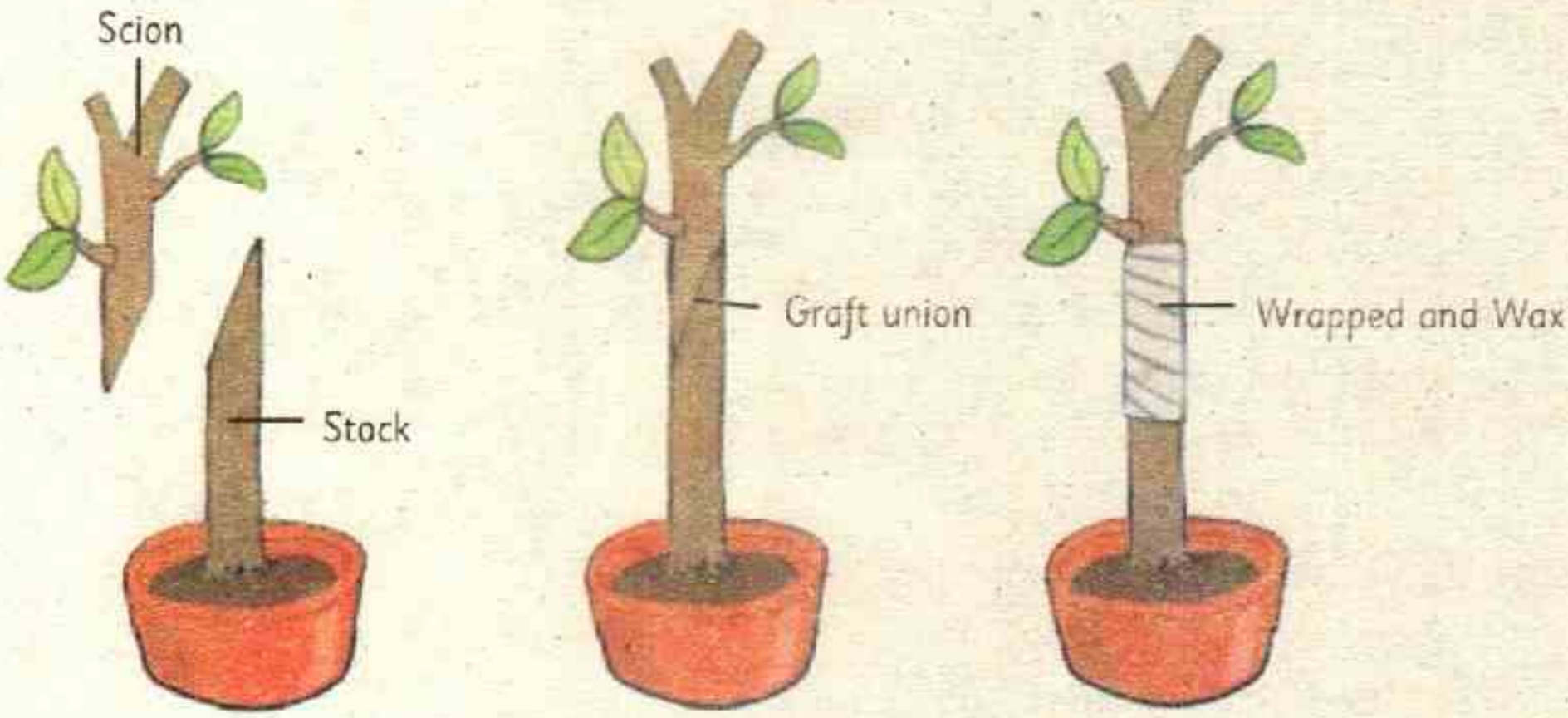


Fig.14.10 Artificial vegetative propagation through grafting

iii. Cloning

Cloning is a technique of asexual reproduction in which a population of genetically identical individuals is produced from a single parent, using tissues or cells of the parent.

Cloning is used for making identical copies of useful plants. This is very helpful in horticulture where we want to preserve the quality of the yield. Cloning also helps us to increase agricultural output.

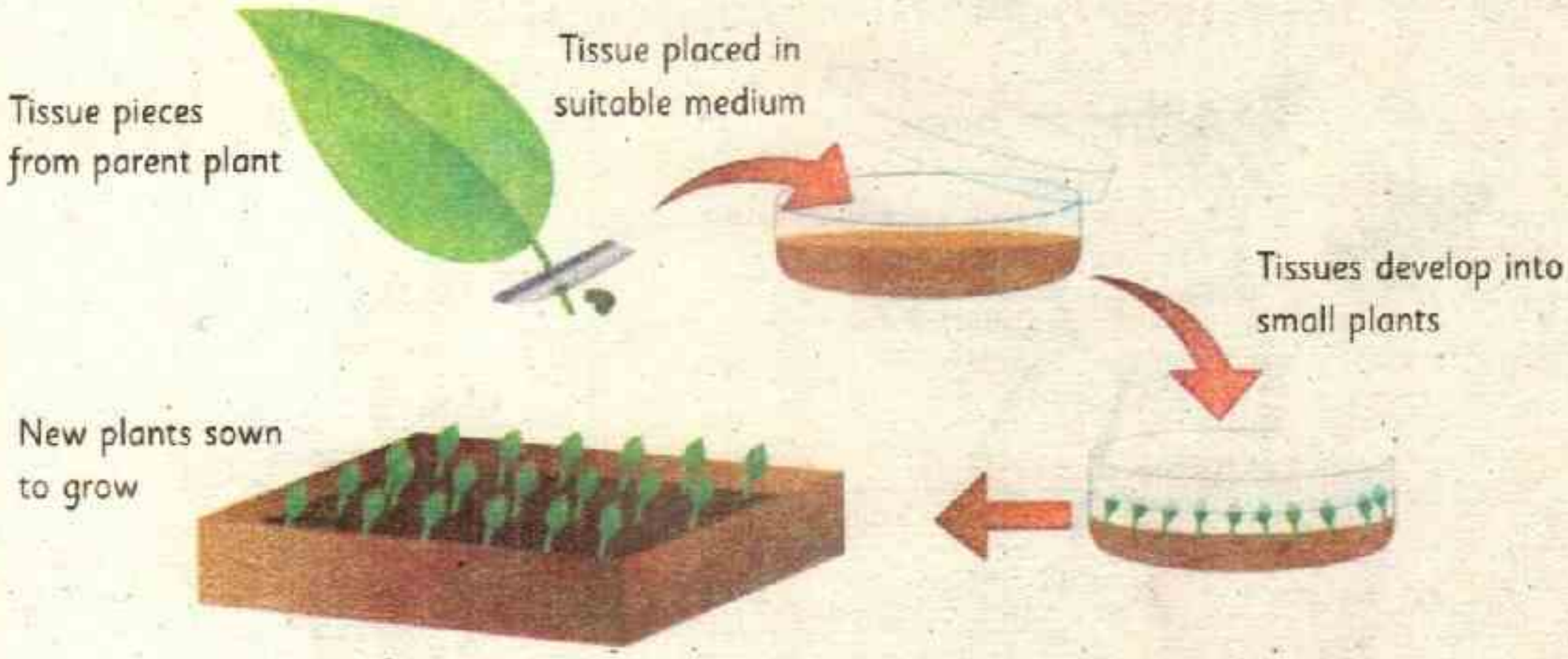


Fig.14.11 Cloning of a plant

Activities

1. Identify the different stages of budding in the prepared slides/charts of yeast and draw diagrams.
2. Examine the specimens of onion, corn, ginger and potato and write the modes of their reproduction.

14.3 Sexual Reproduction in Plants

In previous grades you have learnt that flowers are the reproductive structures of plants. During sexual reproduction, the male and female gametes fuse with each other and form a zygote. The zygote then develops into an offspring.

14.3.1 Parts of a Flower

A flower is made-up of specialised leaves, which are present on the swollen tip called the **receptacle.** Flower parts are in the form of four concentric whorls, or rings. **Sepals** make the outermost whorl **(Calyx)**. Sepals are usually green and they protect the inner parts of a developing flower before it opens. **Petals** make the next whorl **(Corolla)**. Most flowers have coloured petals.

The third whorl **(androecium)** contains the male reproductive structures called **stamens**. Each stamen consists of an anther and a filament. The **Anther** contains pollen sacs **(microsporangia)**, which produce **microspores**. The stalk-like **filament** supports the anther.

The innermost whorl **(gynoecium)** contains the female reproductive structures, which are called **carpels**. The enlarged base of a carpel is called the **ovary,** while, the **style** is stalk-like. Its tip is called the **stigma.** Inside the ovary, there are one or many **ovules (megasporangia),** which produce **megaspores**.

For Your Information

In bisexual flowers, both stamen and carpel are present in the same flower. In unisexual flowers, stamen and carpels are present in separate flowers.

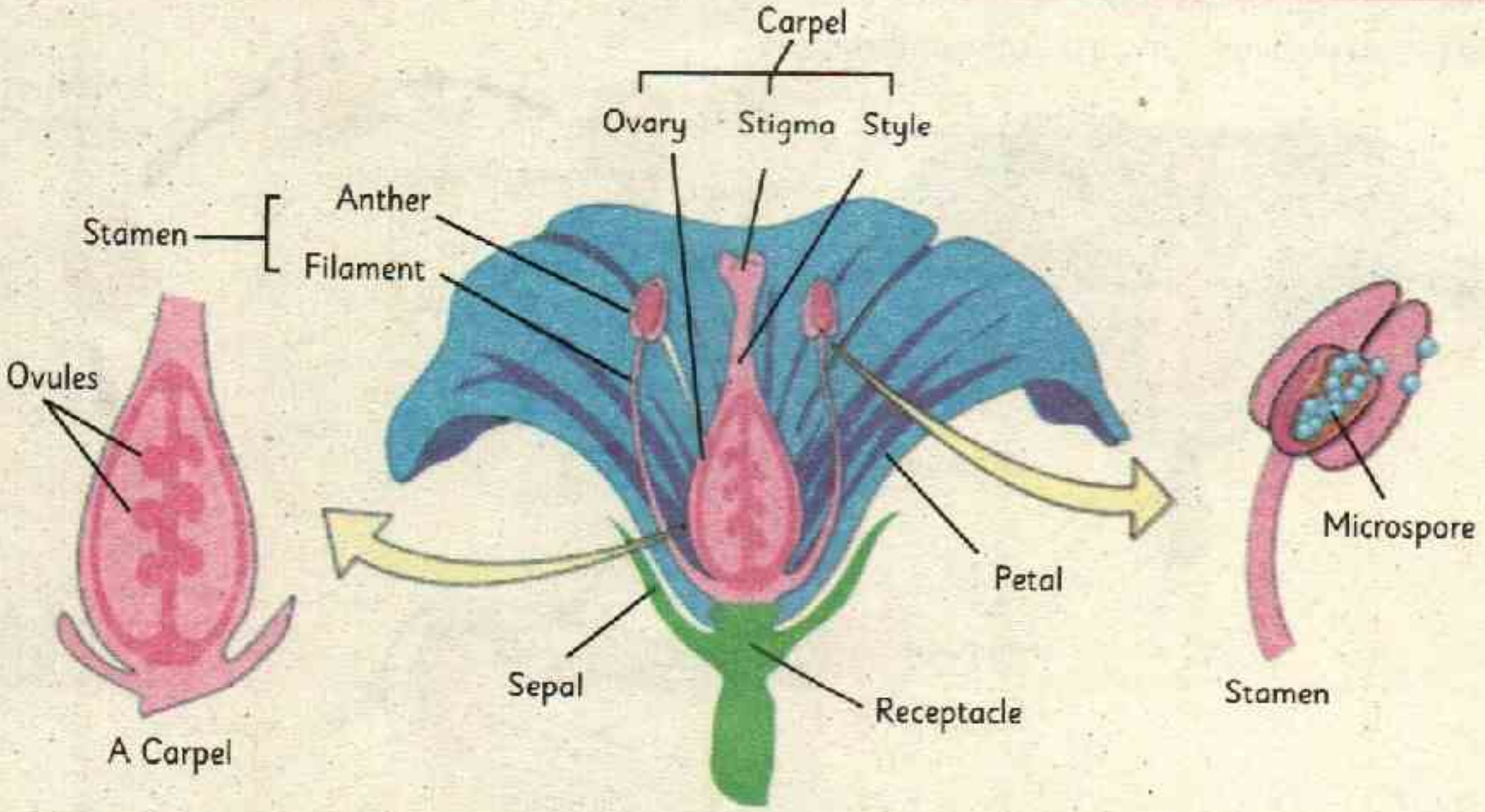


Fig. 14.12 Parts of the a flower

14.3.2 Life Cycle of Flowering Plants

The complete body of a flowering plant represents the sporophyte generation of the plant. It completes its life cycle by going through the following stages.

Stage 1- Development of Gametophytes

Plants have the kind of lifecycle in which there is alternation of generations (see box). Gametophytes develop within the flowers of the plant. The female gametophyte or embryo sac develops from the megaspore.

The ovule (megasporangium) contains a diploid megaspore mother cell. It undergoes meiosis and produces four haploid megaspores. One haploid megaspore survives and divides by mitosis to make eight haploid nuclei. Two nuclei migrate to the centre and fuse to form a fusion nucleus. One nucleus out of the remaining six forms the egg cell.

The resulting structure, which contains seven cells: the egg, the five non-functional cells, and the fusion nucleus; constitutes the embryo sac.

For Your Information

In the life cycle of the major groups of plants, two different stages or generations are involved:

1. **Sporophyte** (spore producing) generation
2. **Gametophyte** (gamete producing) generation

These two generations alternate with each other i.e. the sporophyte develops into gametophyte and vice versa. This type of life cycle is called alternation of generation.

The sporophyte generation is diploid (2n). It produces haploid (n) spores by meiosis. The spores develop into the haploid gametophyte generation. The gametophyte produces haploid gametes by mitosis. The haploid gametes fuse to form diploid zygote, which develops into the next sporophyte stage.

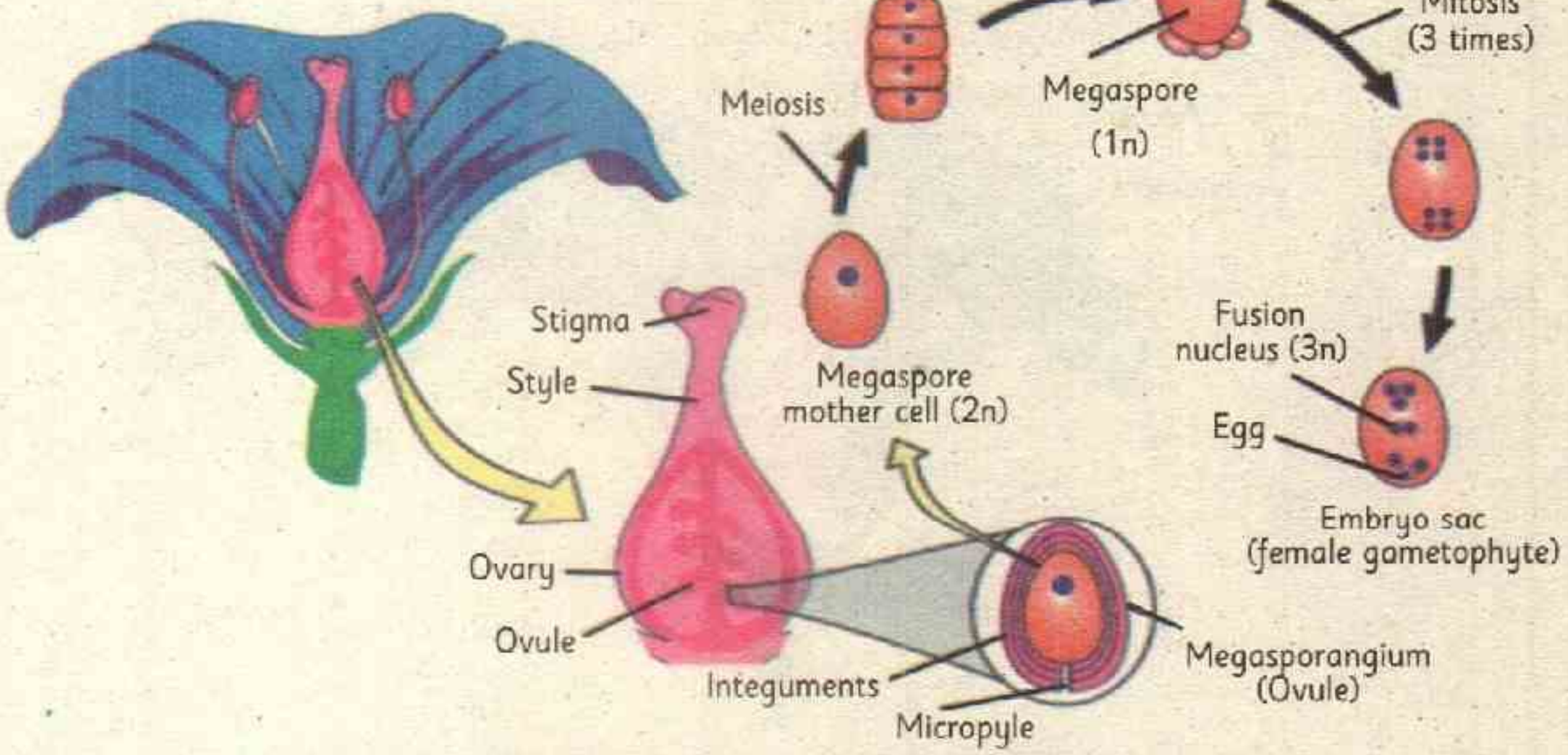


Fig. 14.13 Development of the female gametophyte (embryo sac)

The male gametophyte or **pollen grain** develops from the microspore. An anther contains four pollen sacs (microsporangia), each of which contains many diploid the **microspore mother cells**. Each microspore mother cell undergoes meiosis and produces four haploid **microspores**. A microspore undergoes mitosis. The resulting two-celled structure is a pollen grain, which is the male gametophyte. One cell in the pollen grain is the **tube cell,** which will form the pollen tube. The other cell is the **generative cell**, which will form two sperms.

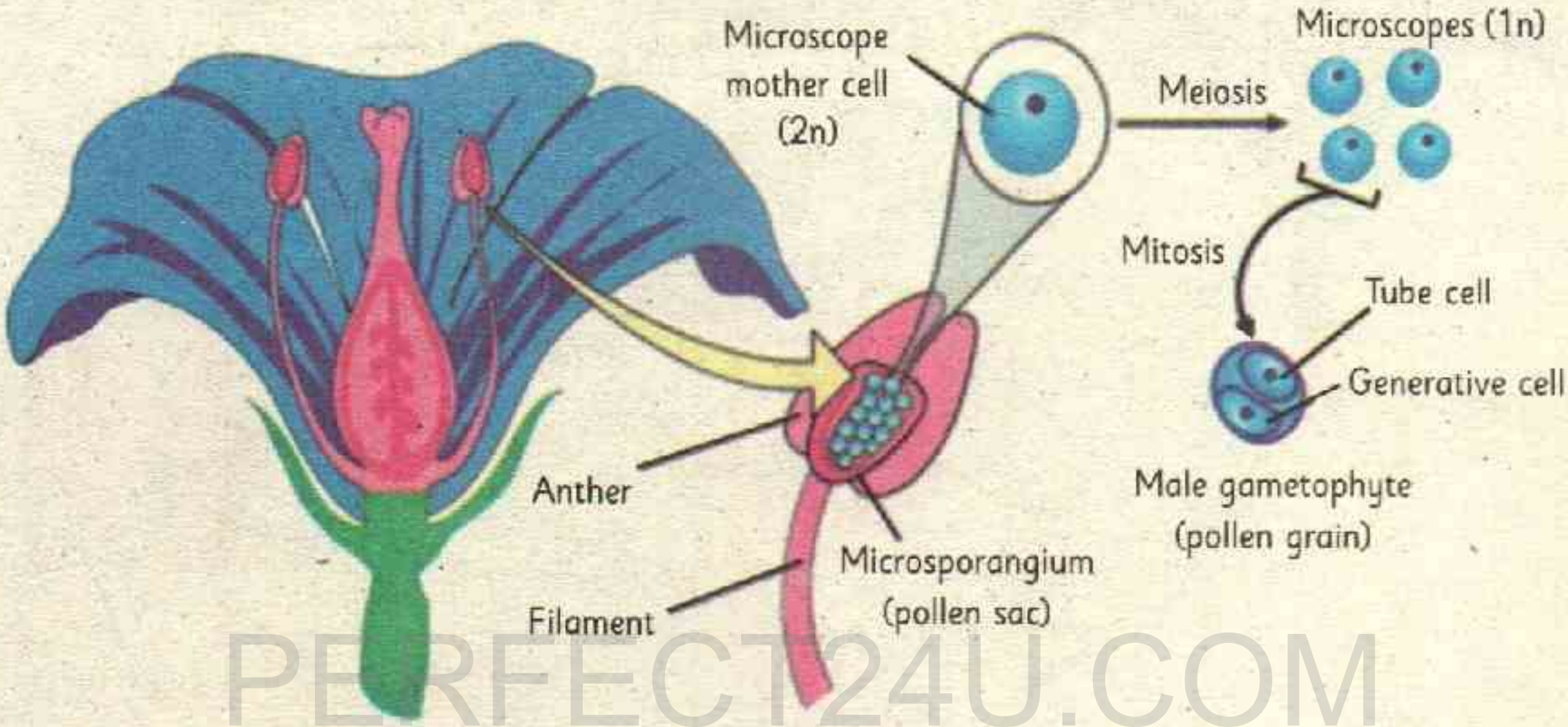


Fig.14.14 Development of the male gametophyte (pollen grain)

Stage 2- Pollination

The male gametophytes (pollen grains) contain sperms while the female gametophytes (embryo sacs) contain an egg. For fertilisation of the egg, the pollen grains are transferred from the anther to the stigma of the flower. This is called pollination.

Pollination that involves just one flower, or flowers on the same plant is called self-pollination. In contrast, pollination that involves two flowers, of different plants of the same species is called cross-pollination.

Stage 3- Fertilisation

When a pollen grain reaches the stigma, its tube cell forms a pollen tube that grows through the stigma and the style. It reaches the ovary and enters the ovule through a small opening called the micropyle. The generative cell of the pollen grain forms two sperms, which enter the embryo sac to reach the egg.

One sperm fuses with the egg and forms a diploid zygote. The zygote develops into an embryo. The second sperm fuses with the fusion nucleus and produces a triploid (3n) nucleus. This nucleus then develops into a tissue called the endosperm, which provides nourishment to the embryo. This process of the fusion of two sperms (one with the egg and the other with the fusion nucleus) is called double fertilisation. It is a unique characteristic of flowering plants.

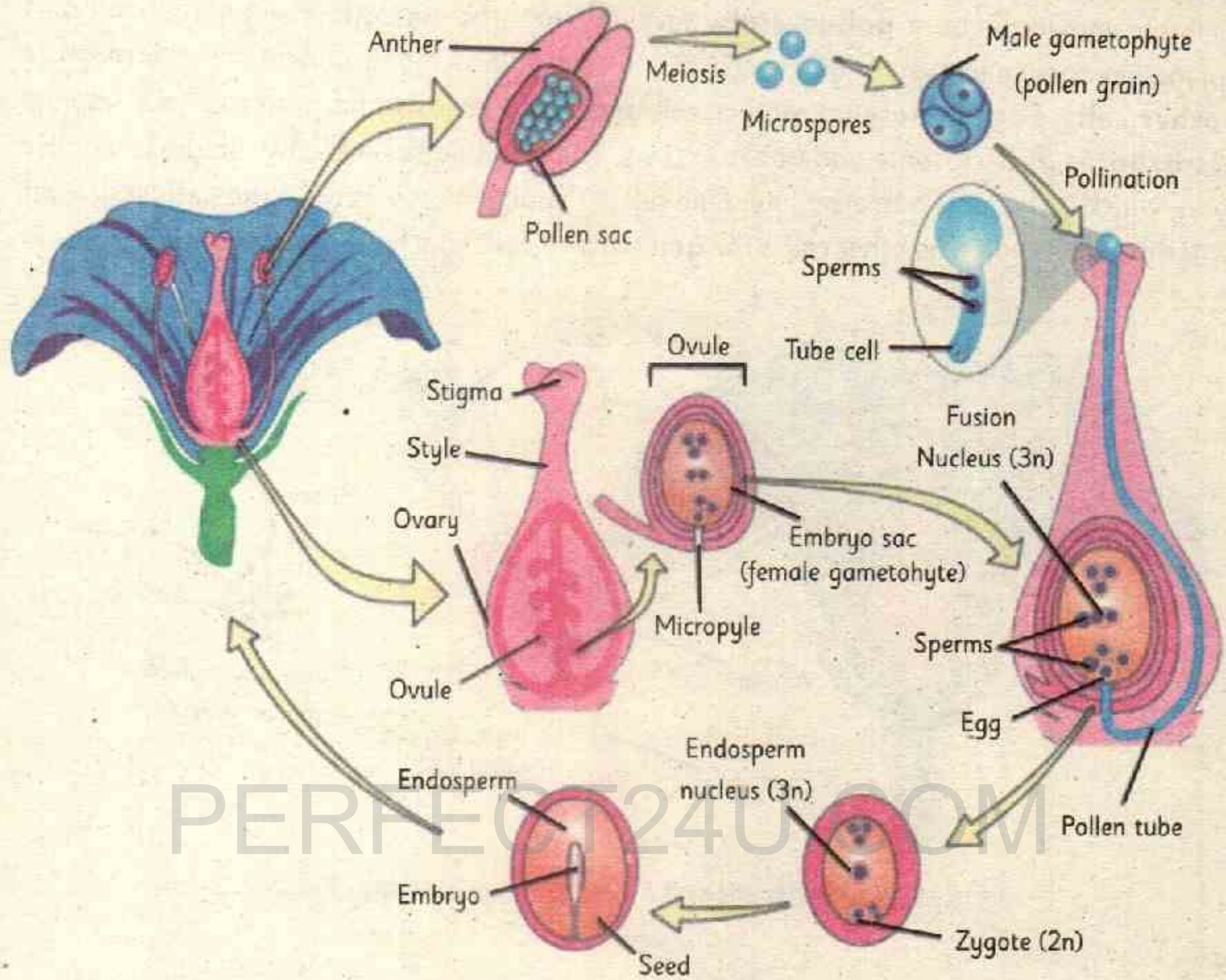


Fig. 14.15 Life cycle of a flowering plant

Stage 4- Seed and Fruit Formation

After fertilisation, the zygote develops into an embryo and the triploid nucleus develops into endosperm tissue. After these developments, the ovule is said to be matured and is now called the seed. The ovary changes into fruit.

For Your Information

In some plants, the ovary develops into a fruit without the fertilisation of the egg present in its ovule. So there is no seed in the fruit. This process is known as **parthenocarpy**. It results in seedless fruits e.g. bananas and seedless varieties of grapes.

Stage 5- Development of Sporophytes

When seeds mature, they are dispersed. If seeds get suitable conditions, their embryos develop into new plants (the sporophytes of the next generation).

14.3.3 Adaptations for Insect and Wind Pollination

These two types of pollination require flowers to have unique characters and certain adaptations in order to carry out pollination.

Adaptations in Insect Pollinated Flowers

Insect pollinated flowers attract and use insects, bats, birds or other animals to transfer pollen from one flower to the other. Such flowers have the following characteristics:

- Brightly coloured and large petals to attract insects.
- Fragrance, which attracts insects.
- Presence of nectar, a solution of sugars which is a food source for many insects.
- Sticky pollens, which stick to the legs of insects visiting the flowers.
- Stigmas of such flowers are sticky or shaped in a way that facilitates the transfer of pollen grains.

Examples of insect pollinated flowers are Bougainvillea, Rose Sunflower and Orchids.

Fig.14.16 Insect-pollinated flowers

Adaptations in Wind Pollinated Flowers

Wind pollination is the distribution of pollen by the wind. Flowers that are pollinated with the help of the wind have the following characteristics.

- Lack of scent or fragrance and do not produce nectar.
- Pollens are small, smooth and easily removable from the anther.
- Presence of wings on the pollen, which increase buoyancy.
- Feathery stigmas to catch pollen from the wind.
- Large anthers borne on long stalks.
- Produce pollens in large numbers to compensate for excessive losses.

Examples of wind pollinated plants include conifers, grasses, cereals, poplar, oak, walnut etc.

Fig.14.17 Some wind pollinated flowers

14.3.4 Structure of a seed

A seed (mature ovule) is a miniature plant with a protective cover. Typically a seed consists of the following structures.

For Your Information

In some seeds (e.g. peanut), the seed coat is very thin. In some seeds (e.g. coconut), it is thick and hard.

Seed coat: The outer covering of a seed is called the seed coat or **testa**. It is black or brown in colour and protects the embryo.

Hilum: On one end of the seed coat, is a small scar or hilum. It indicates the place of attachment of the seed in the fruit.

Micropyle: It is a minute pore near the hilum. The seed absorb, water through the micropyle at the time of germination.

Embryo: It is present beneath the seed coat. The embryo consists of the following parts.

- **Cotyledons:** In a monocot seed there is one leaf-like cotyledon. In a dicot seed, there are two large, fleshy cotyledons.
- **Plumule and radicle:** There is a minute bud (plumule) at the upper end of the hypocotyle. It gives rise to the future stem. The lower part of the hypocotyle is called the radicle. It give rise to the future root. The portion between the plumule and the cotyledons is called the **epicotyl**. The portion between the cotyledons and the radicle is called **the hypocotyl**.
- **Endosperm**: This tissue is formed from endosperm nucleus. It stores nutrients. Dicot seeds have no endosperm while monocot seeds have endosperm. In these seeds, the cotyledon absorbs nutrients from the endosperm and transfers them to the embryo.

Observe in the following diagrams: the main parts of the seed in the structure of maize and castor bean seeds.

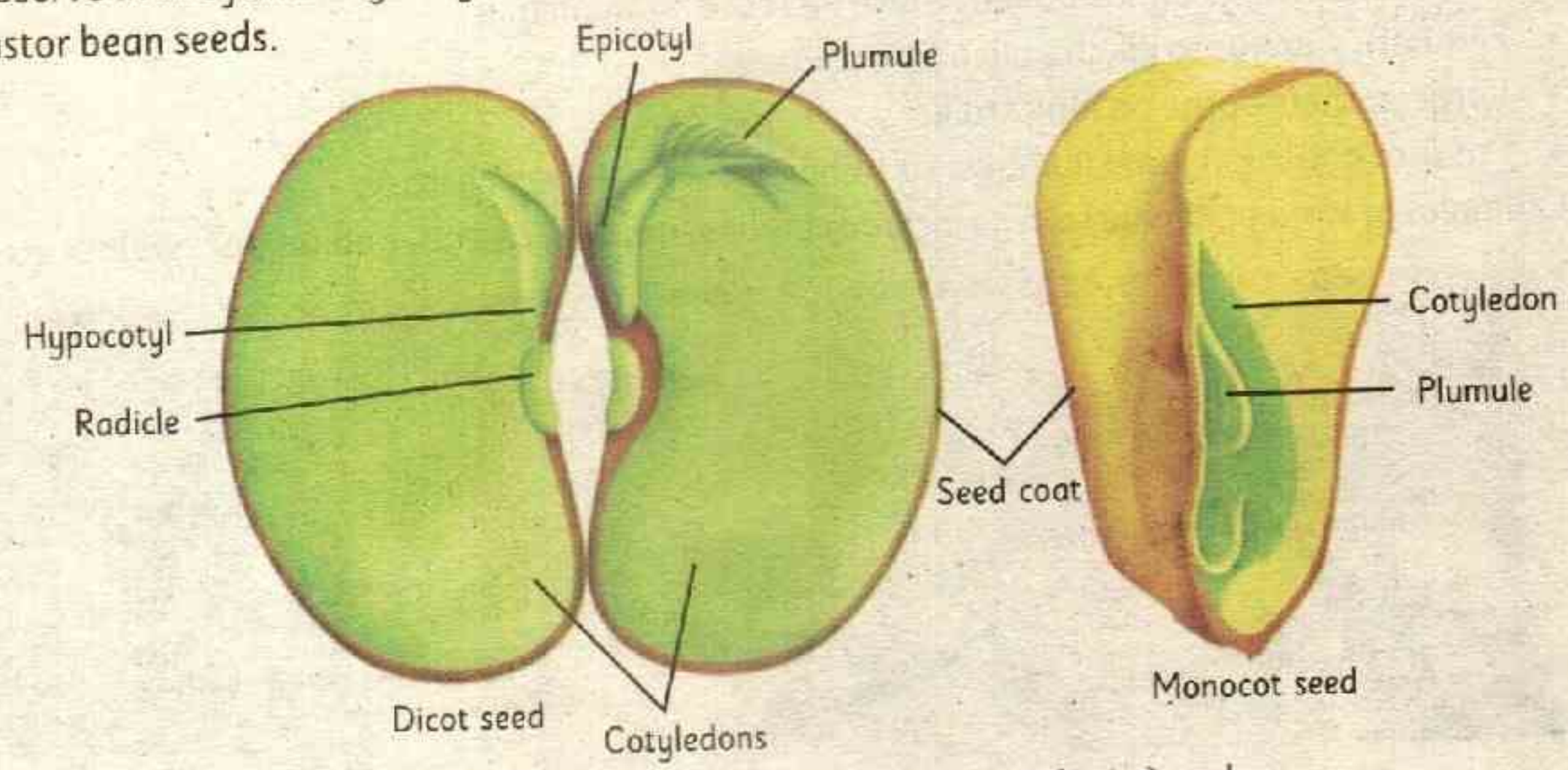


Fig.14.18 Structure of dicot (bean) and monocot (maize) seeds

Seed Germination

The development of the embryo of a seed, into a seedling is called seed germination. In the dry seed the embryo is alive but inactive. When it is placed in the soil under suitable conditions, the embryo becomes active and grows into a seedling.

Germination of the seed starts with the absorption of water through the micropyle. This is followed by the emergance of the radicle, which forms the first root. After the radicle breaks the seed coat, the plumule begins to grow to form a shoot.

On the basis of the growth of the plumule there are two types of germination.

Interesting facts

Each species of seed has a certain length of viability. Seeds of some maple verities need to germinate within two weeks of being dispersed, or they die. Seeds of Lotus plants are known to be upto 2000 years old and still able to germinate.

Epigeal and Hypogeal Germination

In epigeal germination, the hypocotyle elongates and it forces cotyledons to come above the ground. The seed coat also emerges from the soil. Seeds of melons, cucumber and beans show epigeal germination.

During hypogeal germination, the epicotyl elongates and the cotyledons remain below the surface of the ground. e.g. maize grain, pea etc.

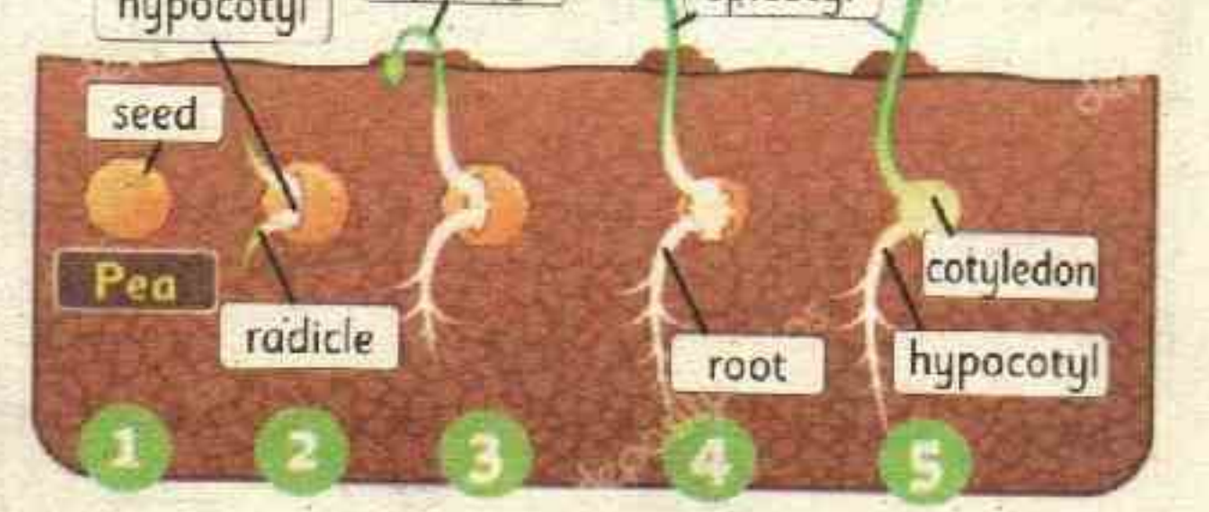


Fig.14.19 Epigeal and hypogeal germination

Conditions Necessary for Germination of Seeds

Viable or living seeds should have sufficient food for germination. Moreover, the following environmental conditions should also be in place which are necessary for the germination of seeds.

1. Water: Seeds absorb water through the micropyle. Water softens the seed coat and makes it burst. Water also helps to activate enzymes that digest the food of seeds, and make it available to the growing embryo.

2. Oxygen: Oxygen is also necessary for seed germination. The cells of the seed embryo use oxygen for cellular respiration so that they can get energy from stored food.

3. Suitable temperature: Germination of seeds occurs over a wide range of temperature between 5°C to 30°C. A suitable temperature is necessary for the enzymes to function properly.

14.3.5 Contribution of Theophrastus (371-287 BC)

Theophrastus is known as the father of botany. He identified over 300 species of plants. His most remarkable contribution is the discovery of sex in plants. He distinguished between sexual and vegetative reproduction, dicot and monocot plants, and angiosperms and gymnosperms. He also gave technical descriptions of grafting and cutting.

His work includes, **historia de plantis** (Enquiry into Plants), and **De Causis Plantarum** (Of Plants, an Explanation)

Fig. 14.20 Theophrastus

Activities

1. Identify different parts of a flower.
2. Identify and draw the components of the seeds of pea or gram.
3. List some of the ripened ovaries and ovules, which are eaten in daily life.
4. Perform an experiment to investigate the necessary conditions for seed germination.

14.4 Asexual Reproduction in Animals

Most animals reproduce sexually. However, only a few groups of animals reproduce asexually. The following are some of the mechanisms of asexual reproduction in different animals.

a. Fragmentation: In this method, the body of the organism breaks into many parts (fragments). Each part develops into a new organism. It occurs in many small animals like planaria.

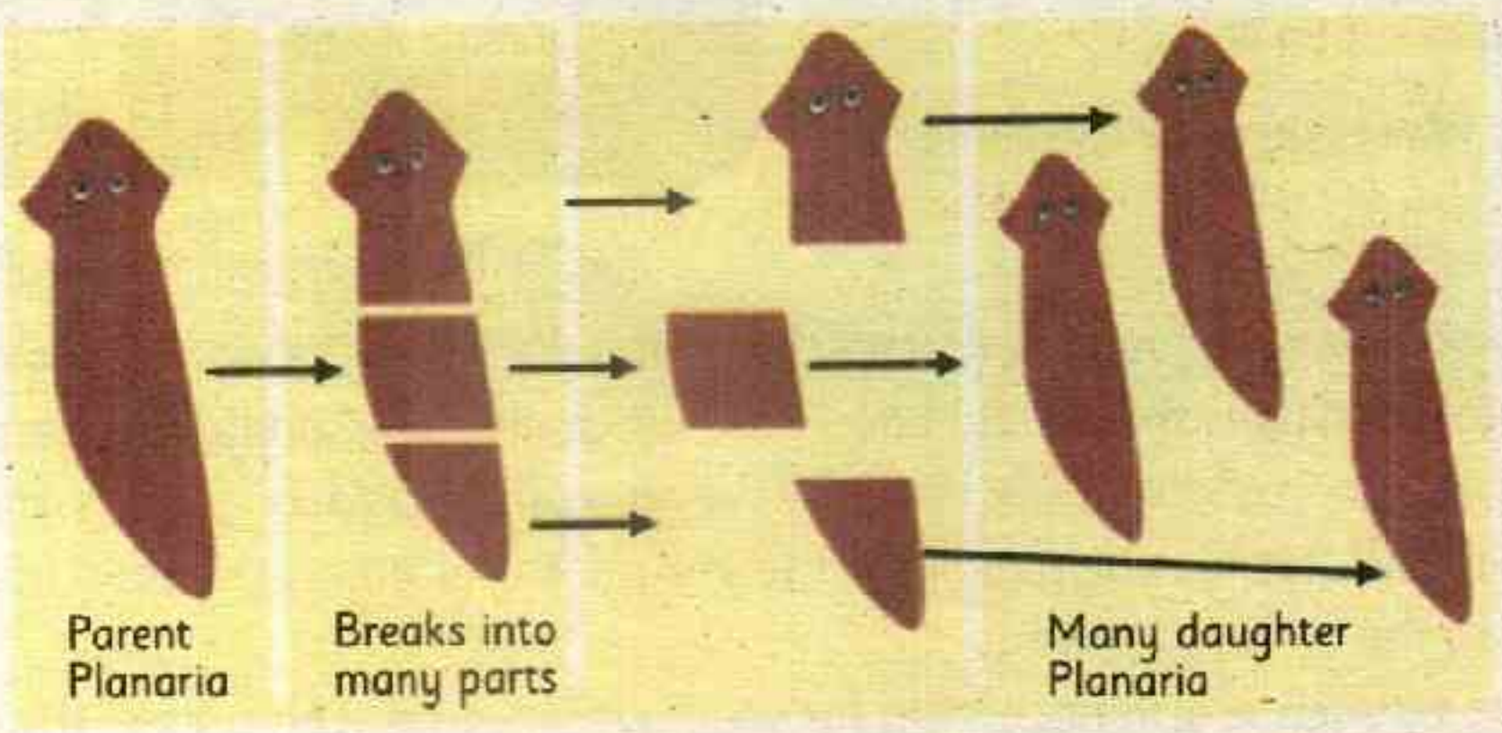


Fig. 14.21 Fragmentation in a Planaria

b. Budding: You are familiar with budding in yeast. Budding also occurs in some animals e.g. Hydra (a freshwater animal). During this process, a small bud is formed on the side of the body of Hydra. This bud enlarges and breaks from the parent body and develops into a new Hydra.

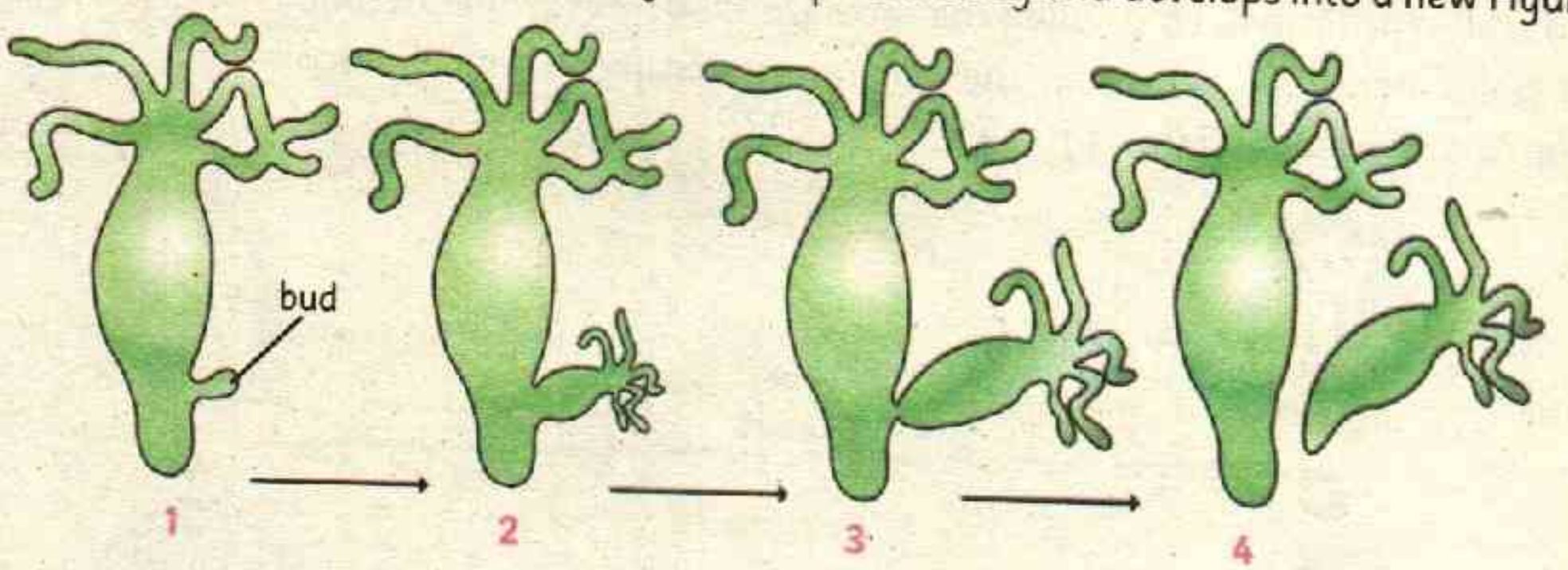


Fig.14.22 Budding in Hydra

c. Parthenogenesis:

Parthenogenesis is a special type of asexual reproduction in some animals. Parthenogenesis is defined as the development of the unfertilized egg cell into a new organism. In parthenogenesis, female animals make gametes (egg cells) but there is no fertilization (fusion of gametes). The unfertilized egg develops into a new animal. For example; in honeybees the fertilized eggs develop into females, but unfertilized eggs develop into males.

14 .5 Sexual Reproduction in Animals

Sexual reproduction is the method of producing new generations in most animals. The male and female animals make gametes in their gonads. This process is called **gametogenesis**. The male gametes join with the female gamete to form zygote, which develops into a new individual.

14.5.1 Formation of Gametes - Gametogenesis

In animals, sex cells or gametes are produced in special organs called **gonads** (testes in males and ovaries in females). The formation of gametes involves meiosis. Meiosis results in a reduction of the number of chromosomes in gametes to haploid (n) as compared to the diploid (2n) number in other body cells. The formation of male gametes or sperms is called **spermatogenesis** while the formation of female gamete or ovum is called **oogenesis**.

Spermatogenesis

In the testes, there are many diploid gametes mother cells called primary spermatocytes. Each primary spermatocyte divides by meiosis and makes four haploid (n) cells called spermatids. Each spermatid develops into a motile sperm.

Oogenesis

In the follicle of the ovary, there are diploid gametes mother cells called primary oocytes. These divide by meiosis. As a result of the first meiotic division, two haploid cells are produced. The larger cell is called the secondary oocytes while the smaller cell is called the first polar body. In meiosis II, the secondary oocyte produces two haploid cells i.e. a second polar body and an egg.

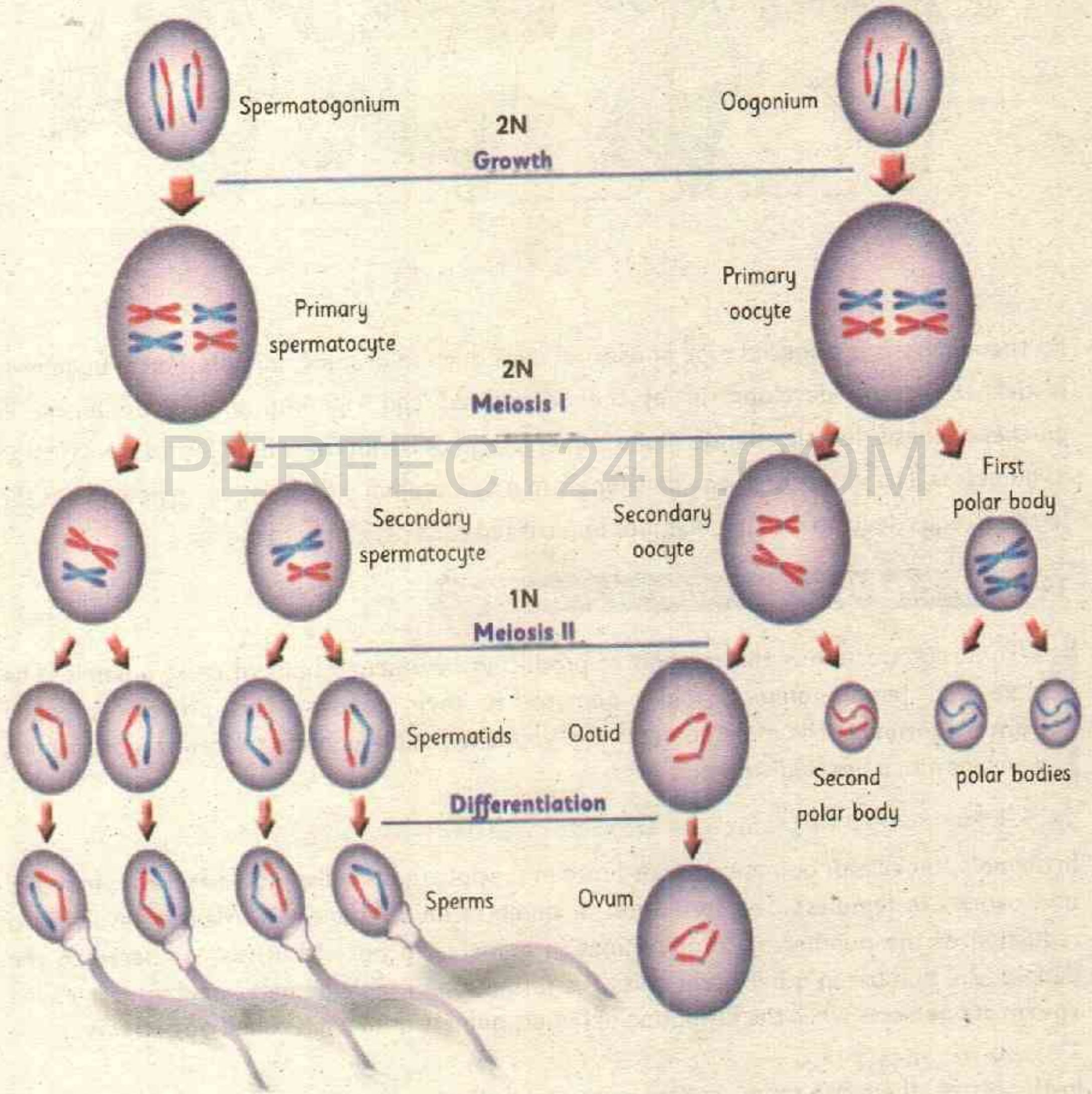


Fig.14.23 Gametogenesis in animals

14.5.2 Fusion of Gametes – Fertilization

Fertilization is a process in which the male and female gametes fuse to form a zygote. The zygote is the first cell of the new offspring, which divides through mitosis and develops into an embryo. The embryo through further developmental changes becomes a new individual. Fertilization is an essential step of sexual reproduction. It restores the diploid number of chromosomes in the zygote. In animals, fertilization may occur outside the bodies of the female (external fertilization) or inside the body of female (internal fertilization).

External Fertilization

External fertilization occurs mostly in aquatic environments. Both the male and female animals release their gametes into their surroundings (usually water). Fusion of gametes takes place outside the body in water, and the young ones also develop outside the mother's body. For external fertilization, both animals release gametes in great numbers because there are more chances of the loss of gametes. Fish and amphibians are examples of animals that reproduce in this way.

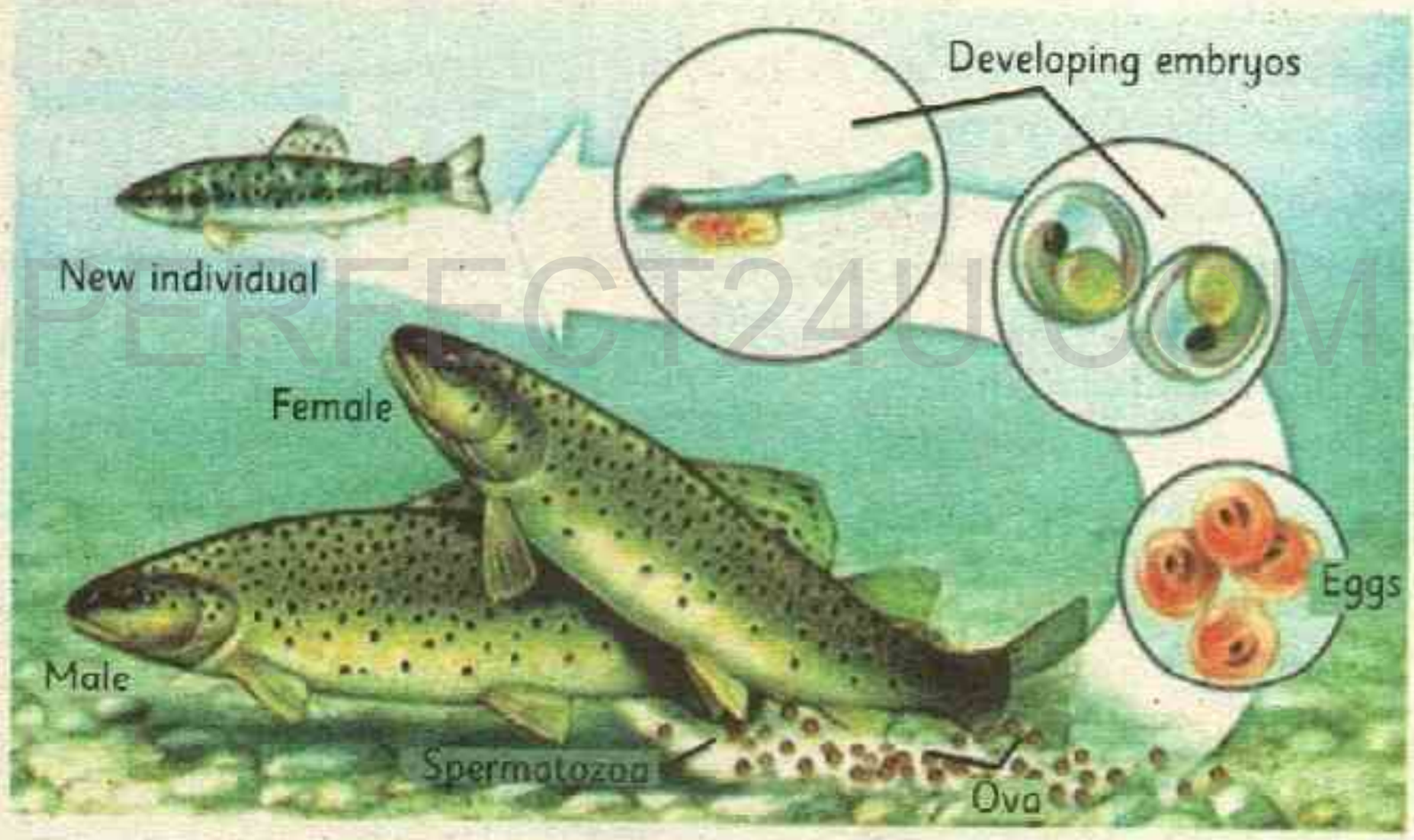


Fig. 14.24 External Fertilization in Fish

Internal Fertilization

Internal fertilization occurs in many land animals. For internal fertilization, the egg (ovum) of the female animal is not released out of the body. It stays in the reproductive duct of the female. The sperm of the male fertilizes the egg. After internal fertilization, there are two ways for the development of the fertilized egg.

Tidbit

In most mammals, the mother supplies everything that the embryo needs. Most mammalian mothers also continue to care for their young ones for several years after birth.

Some animals (e.g. reptiles and birds) lay the fertilized eggs. In such animals the eggs are covered by a hard shell for the protection of the embryo. Further development of embryo takes place inside the egg shell, outside the body of the female.

In some animals (e.g. majority of the mammals), the fertilized egg remains in the reproductive duct of the female. The development of the embryo takes place there. In this case, extra protection is provided to the developing embryo.

14.5.3 Reproductive System of a Rabbit

Rabbits belong to the group Mammalia of vertebrates. The reproductive system of rabbits consists of gonads and the associated ducts and glands. Gonads are organs which make gametes. Gonads also secrete sex hormones. From gonads, the gametes enter in the associated ducts.

Male Reproductive System

In male rabbits there is a pair of gonads, called **testes**. The gonads are located in a sac-like structure, the **scrotum,** which lies outside the body. Each testis (singular) is made of coiled tubes called **seminiferous tubules**. The formation of sperms takes place in the seminiferous tubules.

The associated ducts in the male reproductive system consist of two **epididymis** and two sperm ducts (**vas deferens)**. Both sperm ducts join with the **urethra**, which transports the sperms outside.

Some glands are linked with the associated ducts. These glands add secretions to the sperms. The secretion of **seminal vesicles** has nutrients for the sperms; the secretion of the **prostate gland** neutralizes the acidity; and the secretion of the **Cowper's gland** lubricates the ducts.

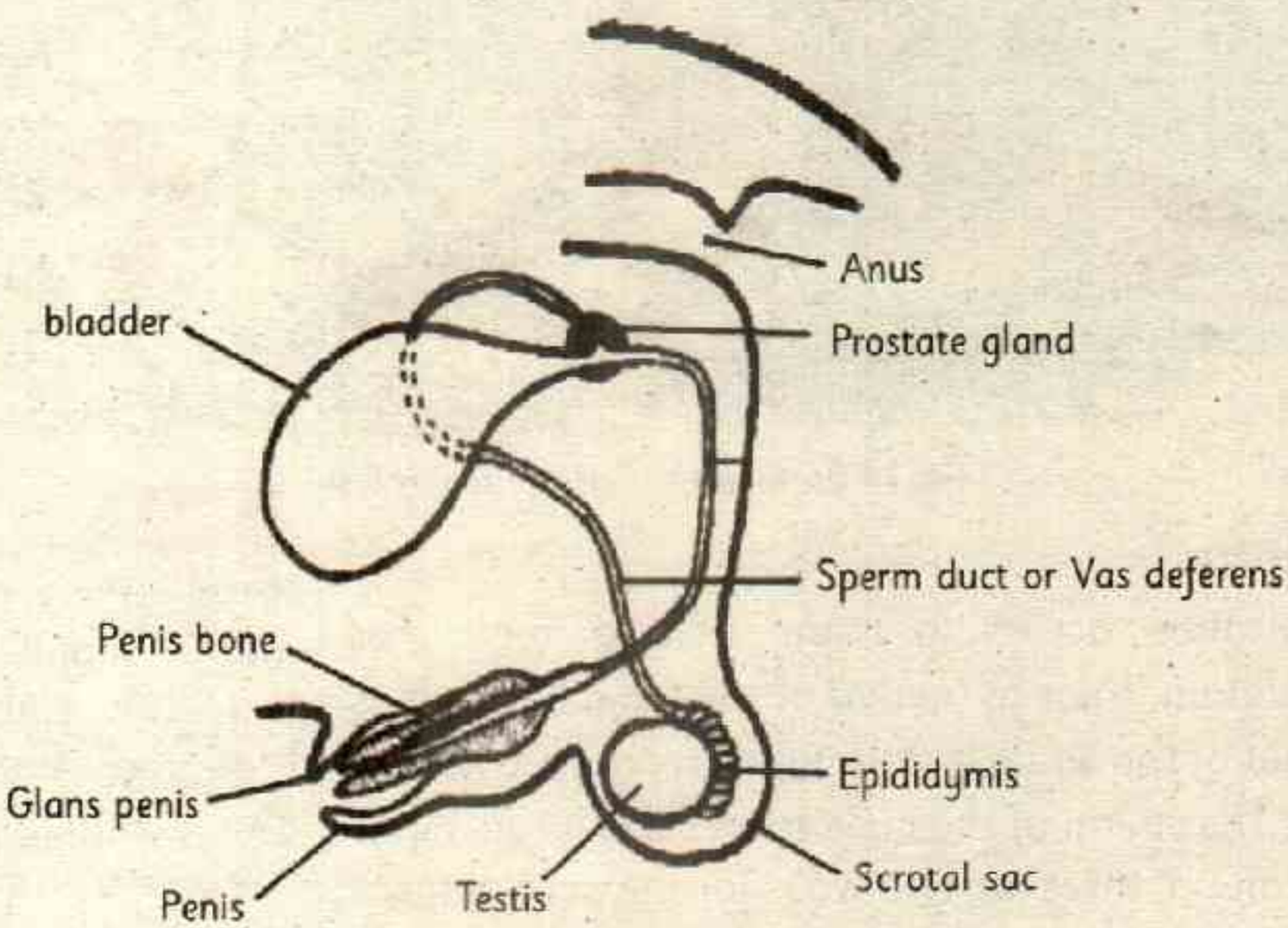


Fig. 14.25 The Male Reproductive System of a Rabbit

Female Reproductive System

In female rabbits there is a pair of gonads, called ovaries, present in the abdominal cavity just ventral to the kidneys. In an ovary, the egg is formed inside a special structure called the follicle.

The associated ducts in the female reproductive system consists of two oviducts (or fallopian tubes) and a uterus. Each oviduct opens into a part of the uterus (horn of uterus). Each horn of uterus opens in a narrow portion called the cervix (plural: cervices). Both cervices open into a single canal, called the birth canal or vagina.

Activities

Draw and label the different organs of a rabbit's reproductive system on a chart (both male and female rabbits).

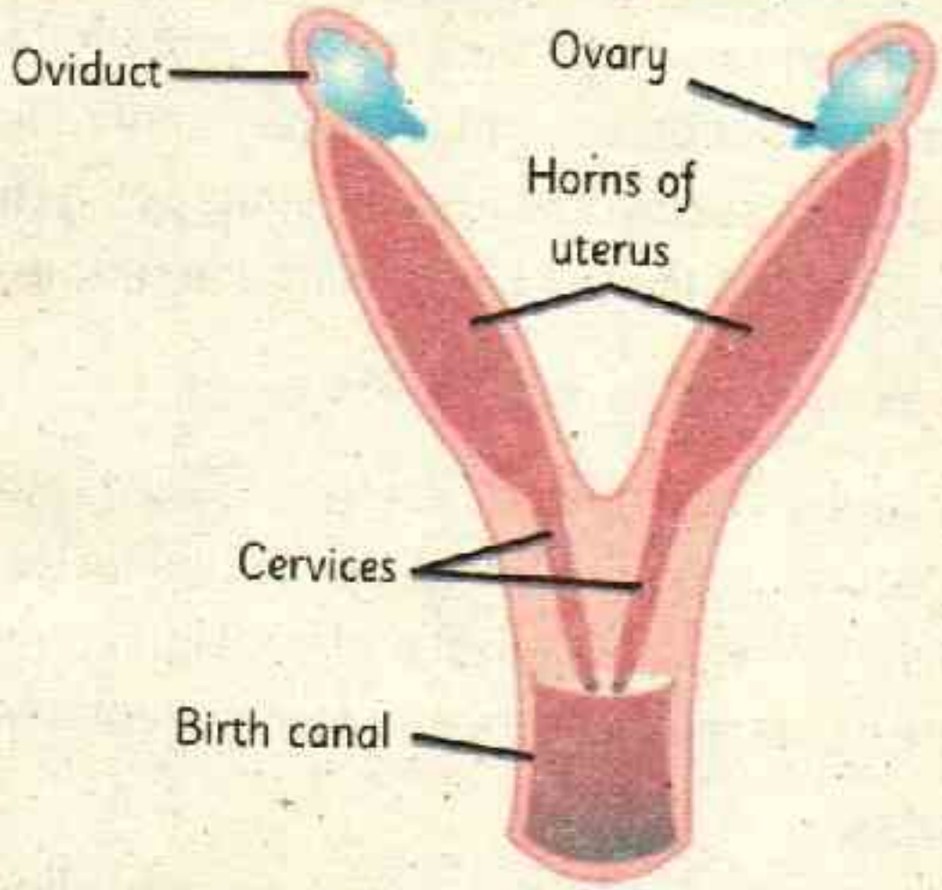


Fig. 14.26 The Female Reproductive System of a Rabbit

14.6 Need of Population Planning

Pakistan has one of the world's highest population growth rates. According to the population census conducted in 2017, Pakistan's population is nearly 208 million. The population of Khyber Pakhtunkhwa is about 30,523,371. Pakistan's average annual growth rate is 2.4% while the average annual growth rate in Khyber Pakhtunkhwa is 2.89%. At the current growth rate of about 2.4% annually, Pakistan's population will exceed 280 million by 2020!

Rapid population growth puts great pressure on agricultural land and hinders prospects from economic and social development. One of the manifestations of poverty is the growth of population beyond available resources, although the pattern of distribution of wealth and income is also a key determinant of poverty. In underdeveloped or developing countries, a growing population requires that job opportunities and some stable source of income is made available. Producing too many children often places poor households under stress due to shortage of resources. Children grow up malnourished and often without access to effective education and healthcare.

Tidbit

61% of children in Pakistan suffer from iron deficiency anaemia, 54% from Vitamin A deficiency, 40% from Vitamin D deficiency and 39% from zinc deficiency.(Source: Save the Children)

Pakistan has been addressing the overpopulation issue in its plans since 1960. By the early 1990s, lowering the population growth rate had become permanent features of Pakistan's five-year plans. The federal and provincial governments have been taking steps to educate the people about the hazards of overpopulation.

We need to accept the fact that population planning has become a compelling need, which simply cannot be ignored any longer. It includes an effective family planning program, changing social attitudes and improving the status of women. It is essential to raise the living standards and avoid increasing the serious problem of rapid population growth.

Sexually Transmitted Diseases

Sexually Transmitted Diseases (STDs), also called Sexually Transmitted Infection (STIs), are infections acquired through sexual activity with infected people. This group of diseases includes many bacterial and viral infections. Acquired Immune Deficiency Syndrome (AIDS) is one of the most severe and fatal sexually transmitted disease.

AIDS

AIDS is a viral infection, caused by Human Immuno-deficiency Virus (HIV). When a person is infected with HIV, the virus attack white the blood cells and destroy them. White blood cells are specialised cells of our bodies which kill pathogens (disease causing germs) that enter the blood. When HIVs destroy white blood cells, the main defence system of our body is weakened.

Tidbit

Practicing Islamic Teaching is the only best remedy in controlling AIDS.

HIV can pass from an infected person to a healthy person through body fluids as a result of engaging in sexual activity. HIV can also be transmitted through the use of infected needles or transfusion of infected blood. There is no cure for HIV or AIDS. The medications usually include antiretroviral drugs that are taken to hinder the growth of HIV..

According to the latest National HIV estimates, there are approximately 97,400 cases of HIV/AIDS in Pakistan. However, according to UNAID's 2015 report, in Pakistan AIDS is more common in people who inject drugs.

The National AIDS Control Programme and its provincial units are currently implementing a comprehensive programme throughout the country to halt the HIV epidemic. They educate common people as well as parliamentarians, media personnel, educationists, and religious leaders etc. They also organise events like in the World AIDS day to raise awareness about the issue.

Role of Non-Governmental Organizations (NGOs)

Many NGOs serve to coordinate HIV/AIDS prevention and control activities in all the provinces of Pakistan. Although NGOs are active in educating people and supporting HIV/AIDS patients, it is believed that they are reaching less than 5 percent of the vulnerable population.

Key Points

- Reproduction is a process by which living organisms produce offsprings of their own kind and this in turn ensures the continuity of their kind.
- Asexual reproduction is a type of reproduction in which the offspring are produced by only involving a single parent.
- Binary fission is a type of asexual reproduction in which the body of the parent organism divides into two daughter organisms.
- During budding, an outgrowth arises from the body of the parent. This outgrowth is called a bud.
- Vegetative reproduction is a type of asexual reproduction in which a plant makes new plants from its vegetative parts, such as specialised stems, leaves and roots.
- Cloning is a technique of asexual reproduction in which a population of genetically identical individuals is produced from a single parent, using the vegetative cell or tissue.
- Transfer of pollen grains from the anther of the stamen to the stigma of the carpal is called pollination.
- A seed (mature ovule) is a miniature plant with a protective cover in a suspended state of development.
- In epigeal germination, the hypocotyl curves and then straightens, due to which the cotyledons are pulled up into the air.
- In hypogeal germination, the cotyledon remains underground.
- In sexual reproduction, fertilization is a process in which male and female gametes fuse to form a zygote.
- The production of gametes in gonads is called gametogenesis.
- In male rabbits, there is a pair of testes made of seminiferous tubules.
- In female rabbits, there is pair of ovaries where the egg is formed inside the follicle.
- A sexually transmitted disease (STD), also known as a sexually transmitted infection (STI), is an illness that has a significant probability of transmission between humans by means of human sexual acts.

Exercise

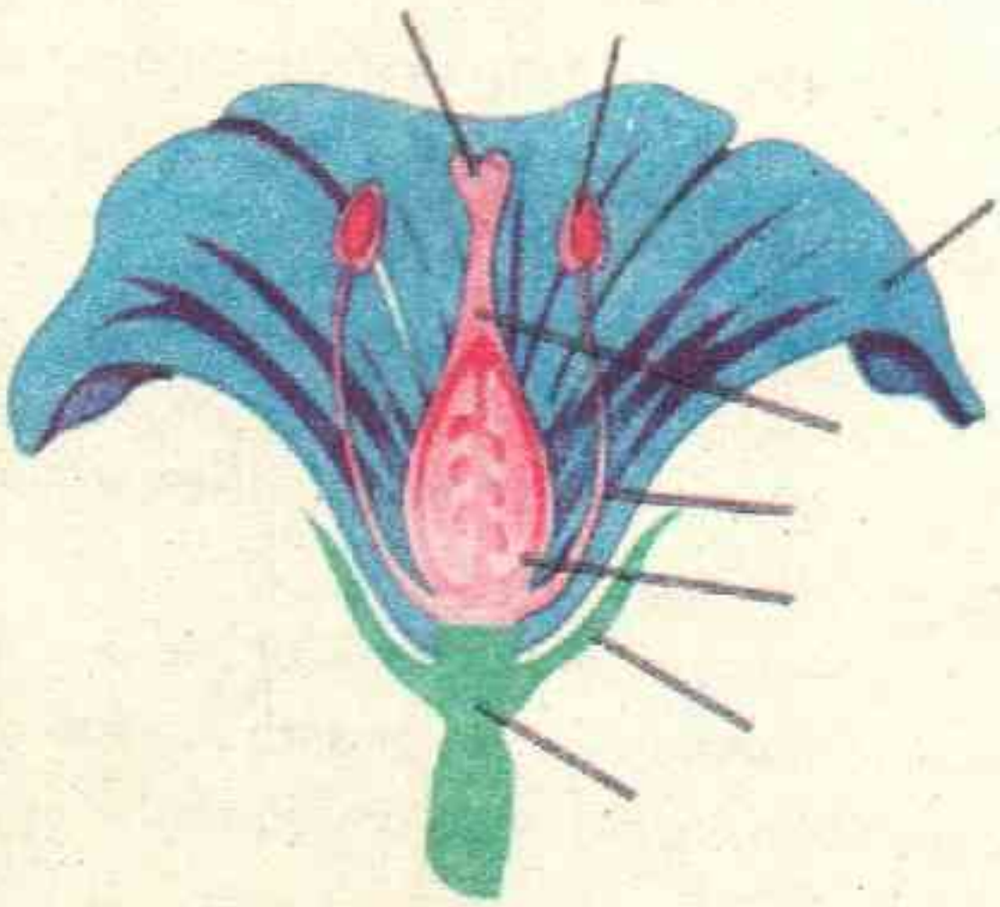
A. Select the correct answer.

1. One of the following is not true for asexual reproduction:
   a. Rapid propagation b. Genetic variations
   c. Mitosis d. Large number of organisms
2. A Hydra reproduces asexually by:
   a. Spore formation b. Multiple fission c. Budding d. Binary fission
3. One of the following methods is artificial vegetative propagation of plants:
   a. Grafting b. Spore formation c. Budding d. Binary fission
4. In parthenogenesis, a new animal develops from:
   a. Sperm b. Fertilized egg c. Unfertilized egg d. Common body cell
5. In a flower, the embryo sac is formed inside the:
   a. Anther b. Filament c. Ovule d. Style
6. The union of male and female gametes is known as:
   a. Fertilization b. Oogenesis c. Spermatogenesis d. Gametogenesis
7. All multicellular animals develop from a single cell, called:
   a. Egg b. Sperm c. Zygote d. Blood cell
8. Which of the following restores diploid number of chromosomes?
   a. Ovulation b. Oogenesis c. Fertilization d. Spermatogenesis
9. In which of the following animals does external fertilization occur?
   a. Fish and amphibians b. Reptiles c. Birds d. Mammals
10. Internal fertilization occurs in:
    a. Fish b. Amphibians c. Aquatic animals d. Mammals

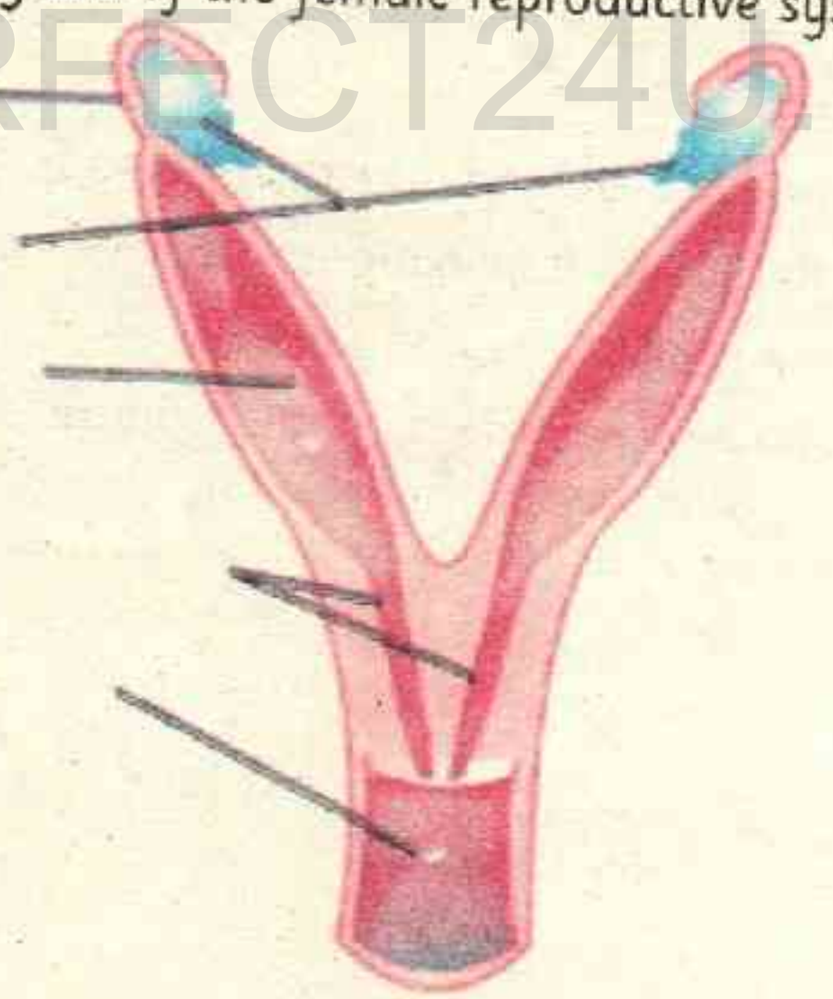
B. Write short answers to the following questions.

1. How can vegetative methods of reproduction, be used to achieve better yield?
2. Differentiate between internal and external fertilization. Which type of fertilization will ensure better chances of fusion of gametes?
3. What is population planning? Why is it important?
4. How does self-pollination bring more variations in plants?
5. How can the spread of HIV be controlled? What is the role of the community and NGOs in the control of AIDS?
6. Name the four whorls present in a flower and also describe the components of each whorl.

7. How are wind-pollinated flowers different from insect-pollinated flowers?
8. Why do seeds need water and oxygen for germination?
9. Label the following diagram of a flower.



10. Label the following diagram of the female reproductive system of a rabbit.



C. Write detailed answers to the following questions:

1. Describe the alternation of generation in a flowering plant.
2. Explain the different plant structures modified for vegetative propagation.
3. Explain gametogenesis.
4. How are seeds produced? What is the structure of a seed?
5. Write a comprehensive note on seed germination and its types.

D. Analyse and interpret the following.

1. Write the mode of reproduction of an onion, corn, ginger and potato.
2. Make a list of ripened seeds and fruits that are eaten in our society.
3. Germinate a few gram seeds and examine the different requirements of water, temperature and oxygen by putting them in various conditions.

Activities

1. Identify different stages of budding in prepared slides of yeast and draw diagrams.
2. Examine the specimens of onion, corn, ginger and potato and write the mode of their reproduction. Describe how these are cultivated to get new plants.
3. Identify different parts of a flower.
4. Identify and draw the component of the seeds of pea or gram.
5. Perform an experiment to investigate the necessary conditions for seed germination.
6. Draw different stages of binary fission in amoeba after observing through slides or charts.

Science, Technology and Society

1. Grow plants at home using asexual reproduction methods.
2. Describe commercially important applications of asexual reproduction in plants.
3. Justify cloning as a form of asexual reproduction.
4. State the advantages and disadvantages of having large families.
5. Debate the social implications of AIDS and other sexually transmitted diseases.

Unit

15

INHERITANCE

Students Learning Outcomes

The students will be able to:

- Define genetics.
- Explain how genes control inheritance of characters.
- Describe the composition of chromatin material.
- Define a gene (a localized region of DNA that codes for a protein).
- State clearly the difference between a gene and an allele.
- Explain that a gene is a unit of inheritance and that it can be copied and passed on to the next generation.
- Describe the central dogma stating the role of a gene in protein synthesis.
- Describe complete dominance using the terms dominant, recessive, phenotype, genotype, homozygous, heterozygous, P1, F1, F2 generations and proving it diagrammatically through a monohybrid genetic cross.
- Demonstrate that the 3:1 monohybrid F-2 phenotypic ratio is an evidence of segregation of alleles.
- State Mendel's law of Segregation.
- Demonstrate that 9:3:3:1 dihybrid F-2 phenotypic ratio is an evidence of independent assortment.
- State Mendel's law of Independent Assortment.
- Selecting the example of ABO blood group system, explain co-dominance.
- Explain incomplete dominance in Japanese 4 O' Clock plant.
- Describe the sources of variation.
- Relate meiosis with variation.
- Describe variation and explain the difference between continuous and discontinuous variation by giving examples like, height, weight, IQ, gender and blood groups in the population.
- Define organic evolution and explain how variation can lead to evolution.
- Describe how variation leads to competition in a population and differential survival by best fitting the environment.
- Assess selection as a possible means of Evolution.
- Develop an understanding of artificial selection as a means of improvement of yield in economically important plants, like wheat, rice etc.

Introduction

You might have seen that the children of the same parents resemble each other in many characters. At the same time these children have some of their unique characteristics (variations) which they do not share with their brothers and sisters. These similarities and differences have led people to wonder how traits (characters) are transferred from one generation to the next. How do the young ones inherit these characteristics from their parents and yet what determines that the young ones are not identical to their parents? The science of genetics enables the study of various phenomena involved in deciding the pattern of inheritance.

15 .1 Introduction to Genetics

Physical and mental characteristics are passed on from one generation to the other. This is observable often in eye colour, complexion of the skin, height, hair colour, etc. in human beings. Although, offsprings and parents in a particular generation may look different, there is a basic similarity that runs from generation to generation. Each generation transfers characters to the next generation. The process by which characters are transferred from parents to offsprings, is called **inheritance** or **heredity**. The branch of biology, which deals with the study of inheritance, variations and factors controlling them, is called **genetics**.

Every cell in the body contains instructions for making characters. These instructions are present in the molecules of **DNA** in the form of chemical codes called **genes**. The cells use instructions present in their DNA to produce particular proteins. The proteins made by a cell make its characters.

15 .2 Chromosomes and Genes

Chromosomes are thread-like structures present in cells. They were discovered by **Waldeyer** in 1876. In prokaryotic cells, chromosomes are not enclosed in a nuclear membrane. In eukaryotic cells, chromosomes are found within the nucleus.

Tidbit

Chromosome is the name given to these structures as they readily absorb dyes and become coloured (Chromo = colour and soma = body).

When a cell is not dividing, its chromatin is in the form of fine threads scattered in the nucleus. During cell division, the chromatin coils and makes compact structures of chromosomes. A chromosome consists of two identical halves. Each half of the chromosome is called a **chromatid**. The two chromatids of a chromosome are attached at a point called the **centromere**. The centromere holds the two chromatids together until they separate during cell division.

15.2.1 Chromatin Material

Chromosomes are composed of chromatin material. In prokaryotes, the chromatin material is made of DNA only. In eukaryotes, the chromatin material is composed of DNA and **histone** proteins. Long molecule of DNA is wrapped around the bundle of histones. The structure made of histones and the DNA wrapped around them, is called a **nucleosome**. Nucleosomes are arranged in the form of beads on a string. This string of beads coils and forms the structure of chromosomes.

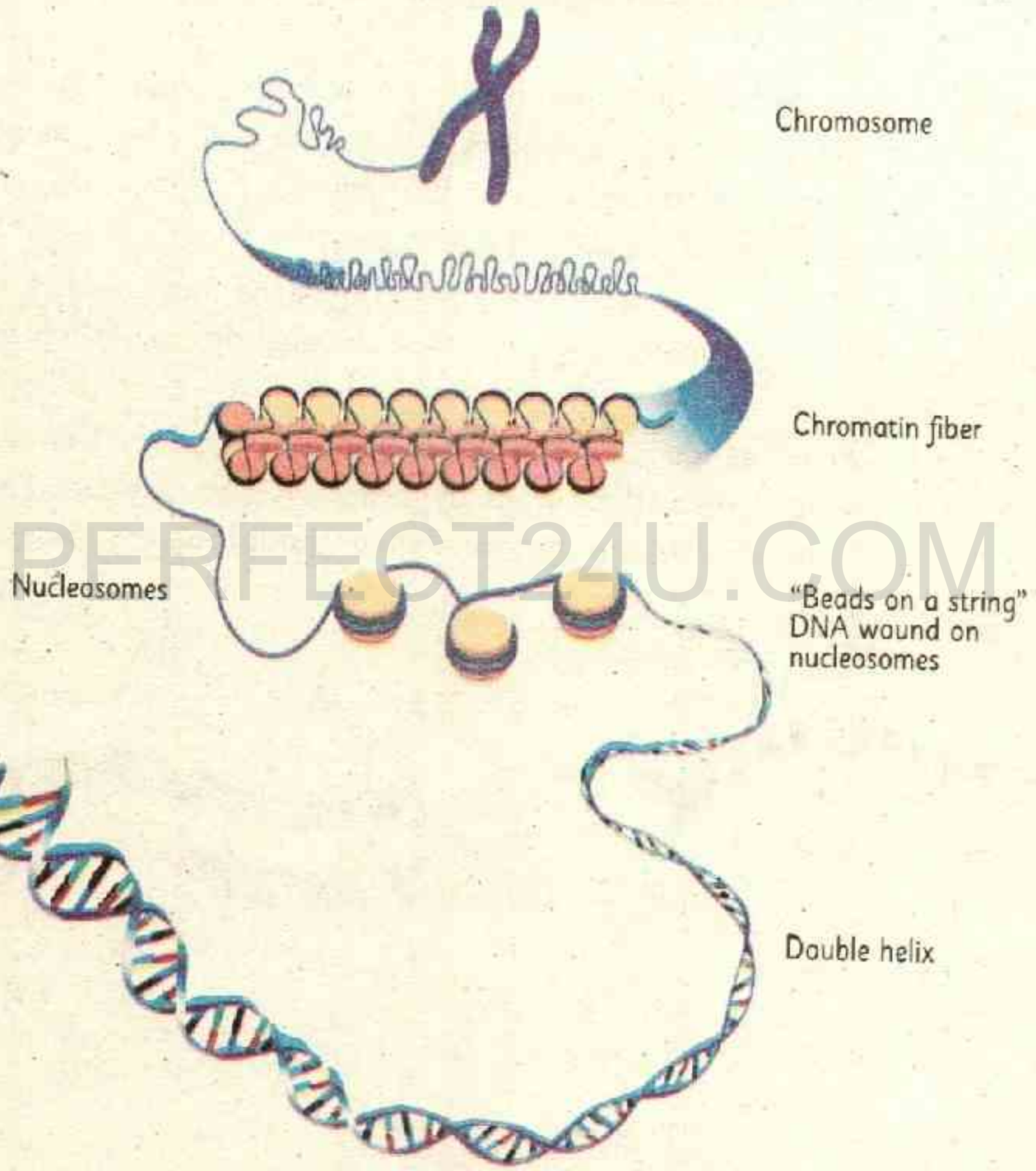


Fig. 15.1 Location and Packing of Hereditary Material (DNA) in the cell

15.2.2 Gene and Allele

A gene is the fundamental physical and functional unit of heredity. A gene determines a trait or character, such as the genes for eye colour, earlobe shape, and hair texture. Genes are segments of DNA, consisting of a specific sequence and number of the nucleotides, that has a code for protein synthesis.

Genes are located on chromosomes. Like chromosomes, genes are also in pairs. Before dividing, a cell duplicates its chromosomes. Its genes are also copied. Thus, each daughter cell has an equal distribution of genes. The transfer of genes to the next generation takes place through gametes. The location of the gene on chromosome is called its **locus.** Each chromosome in a pair may carry alternative forms of the same gene. These alternate (different) forms of a gene are called its **alleles**. For example, the gene controlling height in a pea plant exist in two forms. One allele results in the tallness while the other causes, dwarfness.

The combination of the alleles of a gene pair is called **genotype**. When a gene pair has the same genes, the genotype is called **homozygous**. The genotype, in which the gene pair has different alleles, is called **heterozygous**. In the following figures, the homologous chromosomes has three gene pairs i.e. genes for eye colour, hair shape and ear shape.

- Both allelic pair of the eye colour are similar. It means that the genotype for eye colour is homozygous. Both allelic pair for hair shape are also similar. This means that the genotype for hair shape is homozygous.
- The alleles for the ear shape have instructions for different characteristics. One allele has instructions for making a free earlobe while the other allele has instructions for making an attached earlobe. This means that the genotype for ear shape is heterozygous.

Fig.15.2 Genes and Alleles

15.2.3 Dominant and Recessive Alleles

In the heterozygous genotype one allele may mask the working of the other allele. Such an allele is called the **dominant allele**. The allele which is masked (not expressed) is called a **recessive allele**. The observable outcome of a genotype, in the form of a characteristic, is called **phenotype**. Letters are used to represent alleles. Capital letters refer to dominant alleles, and lowercase letters refer to recessive alleles.

15.2.4 Role of a Gene in Protein Synthesis

How does the gene code for a protein work?

Protein synthesis takes place in two major steps:

Transcription: In the first step of protein synthesis, the two strands of DNA unzip and separate from each other. One strand of DNA acts as a template for making a single strand of Ribonucleic acid (RNA) called the messenger RNA (mRNA). This process is called transcription. In this way, the instructions present in the strand of DNA is copied on the mRNA.

Translation: The mRNA leaves the cell nucleus and travels to the **ribosome**. The ribosome attaches with mRNA. Another type of RNA called the transfer RNA (tRNA) carries specific amino acids to the ribosome. The amino acids are linked together in a specific sequence, eventually forming a protein.

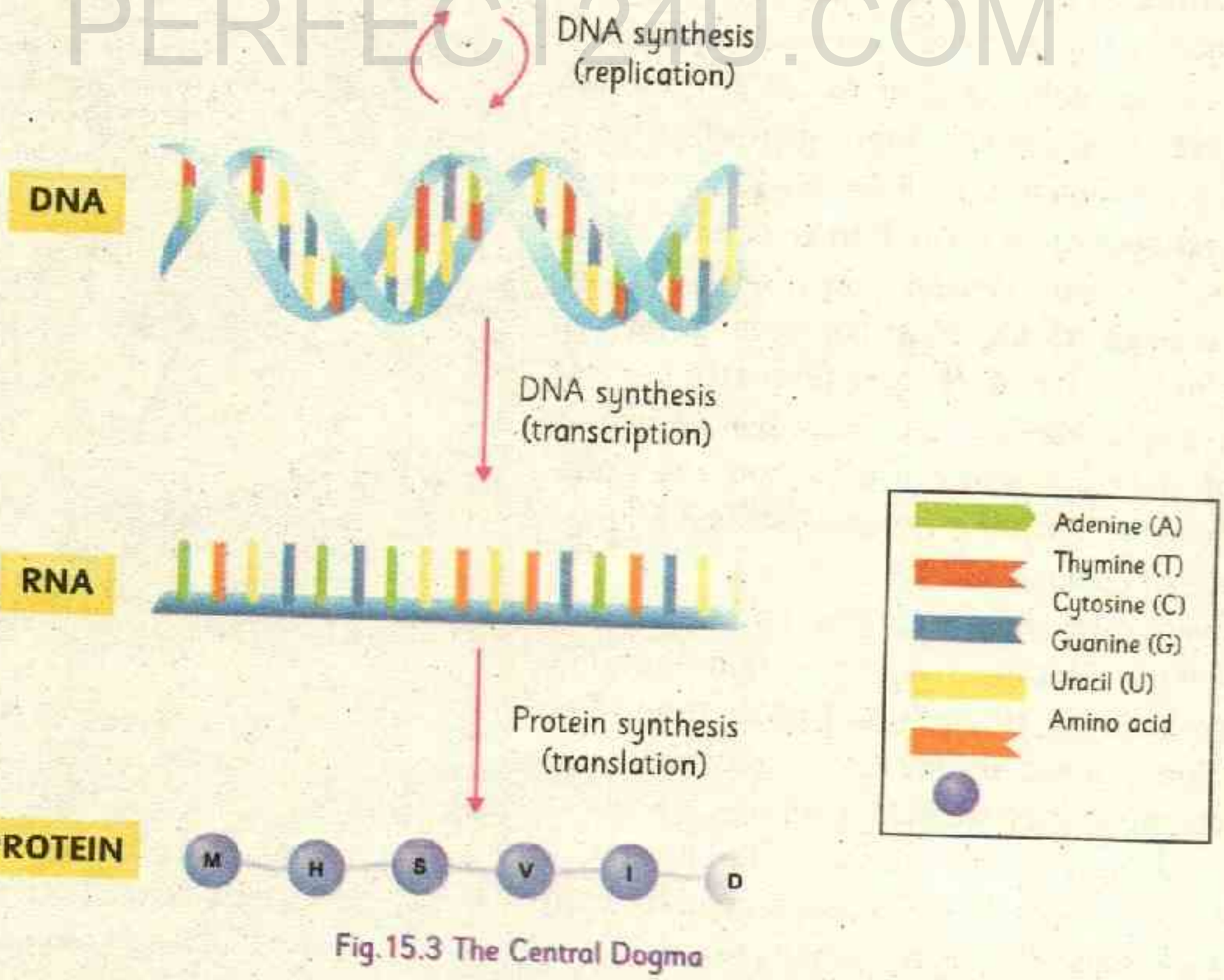


Fig. 15.3 The Central Dogma

15.3 Mendel's Work on Inheritance

Gregor Mendel, an Austrian monk, who lived and worked in a small monastery, discovered the fundamental mechanism of inheritance. In the years 1856-1864, Mendel performed his famous experiments on the garden pea plant.

Mendel was certainly not the first to conduct genetic experiments, but he was fortunate to have selected a relatively simple genetic system for his studies. He examined the inheritance relatively well-defined traits and obtained clear-cut results that led to the discovery of several principles of inheritance.

These principles are now the cornerstone of modern genetics, and Gregor Mendel is generally regarded as the "Father of Genetics".

Fig.15.4 Gregor Mendel

15.3.1 Mendel's Laws of Inheritance

Mendel's most famous experiments were performed on the garden pea plant. It was a good choice, because they are easy to grow and are fairly resistant to pests. Peas also have a reasonably short generation time. They complete their life cycle (from seed to next-generation seed) in three months. Thus, results from breeding experiments could be obtained **rapidly. Most importantly, the pea plants were pure breeding** strains. For example, Mendel had a pure breeding strain of violet-flowered pea that produced violet-flowered offspring exclusively when allowed to self-pollinate.

Every **pea plant** contains both male and female reproductive parts and normally reproduces through self-pollination. Pea plants have seven easily distinguishable characteristics, such as round versus wrinkled seeds and purple versus white flowers. It helped Mendel to easily observe and calculate the results of his crosses among plants.

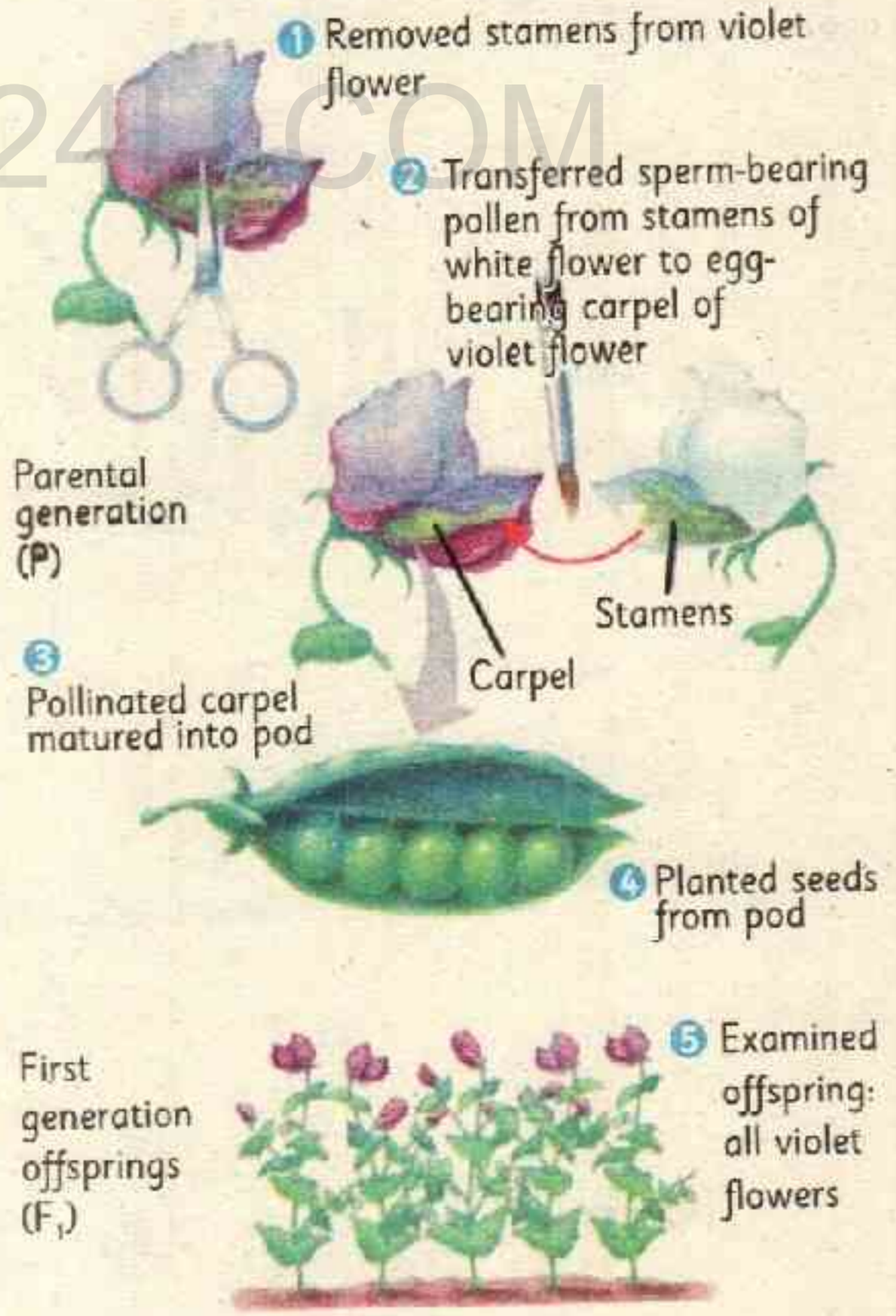


Fig.15.5 Garden pea

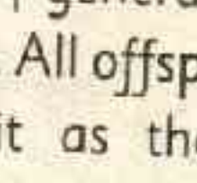
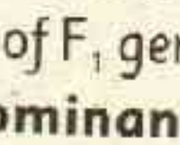
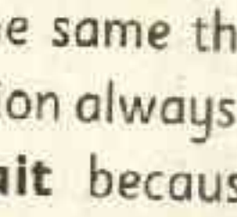
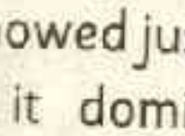
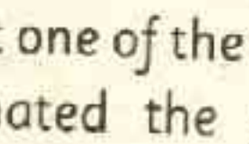
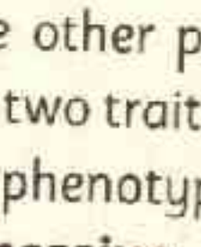
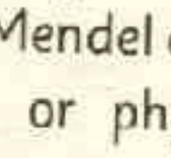
Seed		Flower	Pod		Stem	
Form	Cotyledon	Colour	Form	Colour	Place	Size
						
Round	Yellow	White	Full	Green	Axial pods	Tall
						
Wrinkled	Green	Violet	Constricted	Yellow	Terminal pods	Short
1	2	3	4	5	6	7

Fig.15.6 Seven characters in the Garden pea studied by Mendel

Focusing on only one trait at a time, Mendel cross-pollinated plants with each of the seven contrasting traits and examined their offsprings. He called the original true-breeding parents the P (for parental) generation and called their first set of offsprings the F_1 (for "first filial," from the Latin word **filius**, meaning son). The F_1 offspring that result from two parents with different characteristics are also called **hybrids.**

Mendel crossed a true-breeding tall plant with a true-breeding short plant. All of the offspring in the F_1 generation were tall. The same thing happened with the other pairs of traits he studied. All offspring of F_1 generation always showed just one of the two traits. Mendel called the trait as the **dominant trait** because it dominated the phenotype, or physical appearance, in the F_1 generation. He called the other trait as **recessive,** because it was masked by the dominant trait in the F_1 generation.

Law of Segregation

Mendel discovered that crossing a tall pea with a short pea would produce an F_1 generation of only tall pea plants. But, he wondered, were these offspring tall pea plants really identical to their tall parents, or might they still contain some element of their short parents? To answer this question, Mendel let all seven types of hybrid F_1 generation plant to self-pollinate, producing the F_2 generation.

In each F_2 generation some of the recessive forms of the traits, which had disappeared in the F_1 generation reappeared! Approximately one fourth of the F_2 plants exhibited the recessive characteristic, and three fourths continued to exhibit the dominant form of the trait, like their F_1 parents. This 3:1 ratio of dominant to recessive remained consistent in all of the F_2 offsprings.

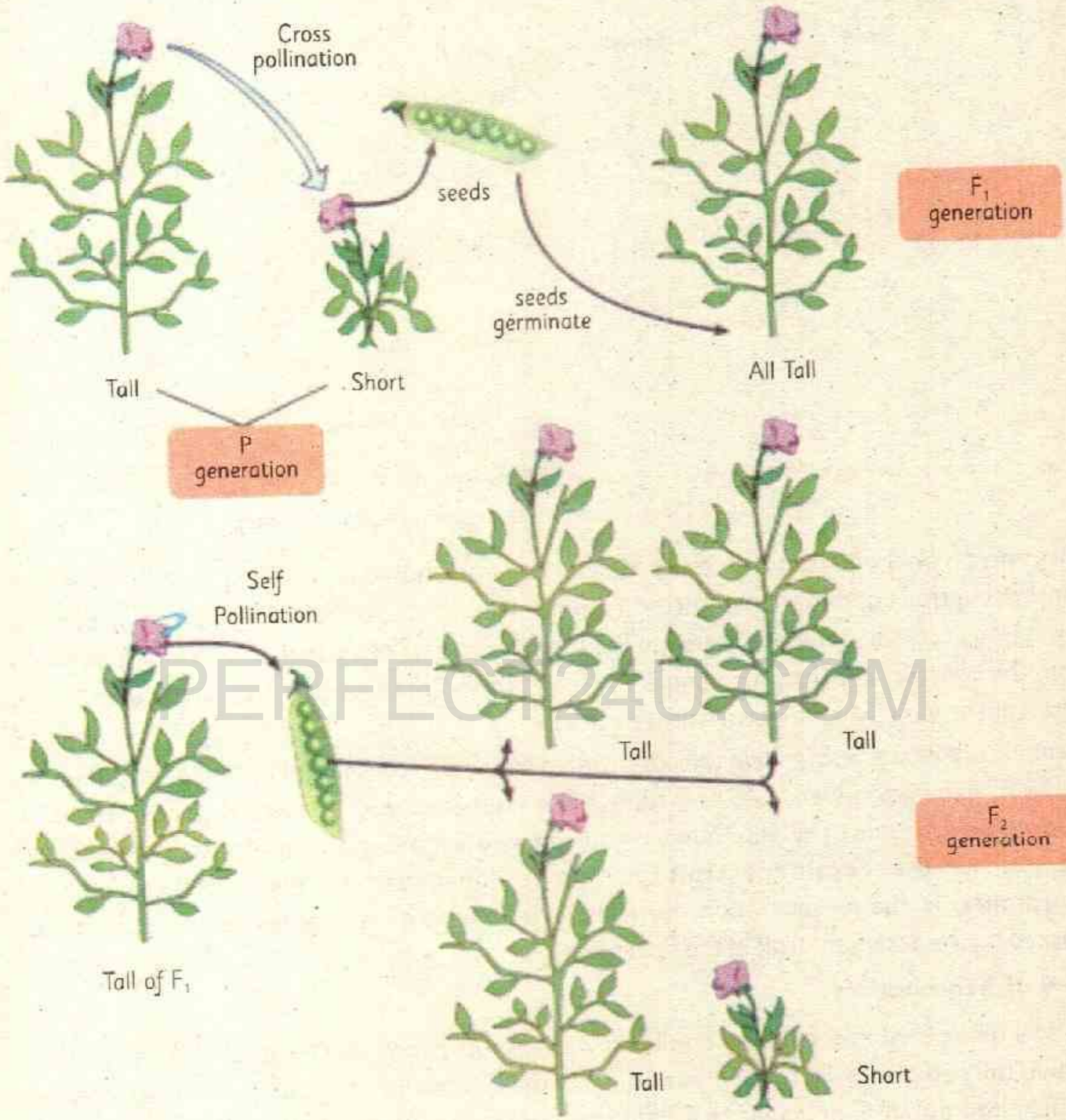


Fig.15.7 Mendel's first experiment (monohybrid cross)

Mendel concluded that within an individual, hereditary information is in the form of paired genes (alleles). During the formation of reproductive cells (gametes), paired genes are separated at random so that each gamete contains only one of the two genes. This led Mendel to propose the law of segregation, which states that; "the paired genes (alleles) are separated during gamete formation and each gamete receives one or the other allele, but not both".

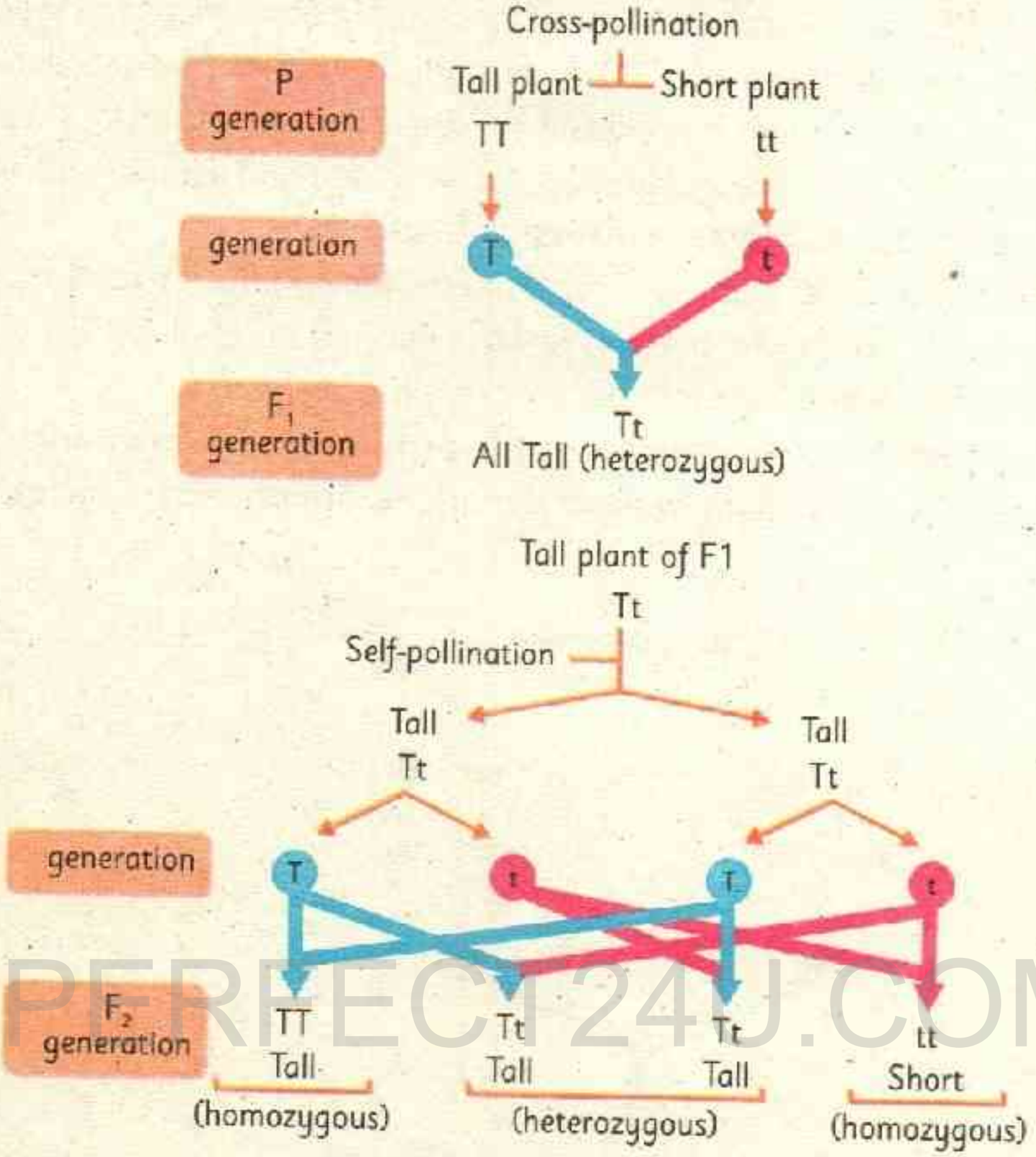


Fig.15.8 Segregation of alleles

In the pea plant, the allele for tallness is dominant. In the F_1 generation, each plant has one allele for tallness (T) and one allele for shortness (t). Each F_1 plant received T allele from one parent and t allele from the other parent. It means, F_1 plants had Tt pair and so were tall. In the F_2 generation, produced by self-pollination of the F_1, 25% of the offspring received both alleles of shortness i.e. tt. So they were short. 50% of F_1 plants received one allele of tallness (T) and one of shortness (t). So they had alleles Tt and were tall. 25% of F_1 plants received both alleles of tallness i.e. TT, so they were also tall.

Law of Independent Assortment

In his next experiments, Mendel did **dihybrid crosses**. In a dihybrid cross, the inheritance of two characteristics is studied at a time. In such experiments, he noticed that the height of the plant and the shape of the seeds and the colour of the pods had no impact on one another. In other words, being tall did not automatically mean the plants had to have green pods, nor did green pods have to be filled only with wrinkled seeds. Different traits seemed to be inherited independently. Mendel crossed true-breeding plants having round yellow seeds (genotype of RRYY) with plants having wrinkled, green seeds (rryy).

The seeds of the F_1 offsprings showed only the dominant characteristics in seeds, which are seeds of a round and yellow phenotype. When F_1 hybrids were self-fertilized, however, four different types of seeds were found among the F_2 generation. The ratio of these types was, 9/16 round and yellow, 3/16 round and green, 3/16 wrinkled and yellow, and 1/16 wrinkled and green. The F_2 generation appeared in the ratio of 9:3:3:1

The F_1 plants (RrYy), produced four types of gametes i.e. RY, Ry, rY, and ry. When these plants were allowed to self-pollinate, there were 16 combinations of alleles in F_2 generation. It means that alleles R and r segregated independently of the alleles Y and y.

Mendel's discovery is referred to as the **law of independent assortment**. It states that "alleles separate independently of one another during the formation of gametes."

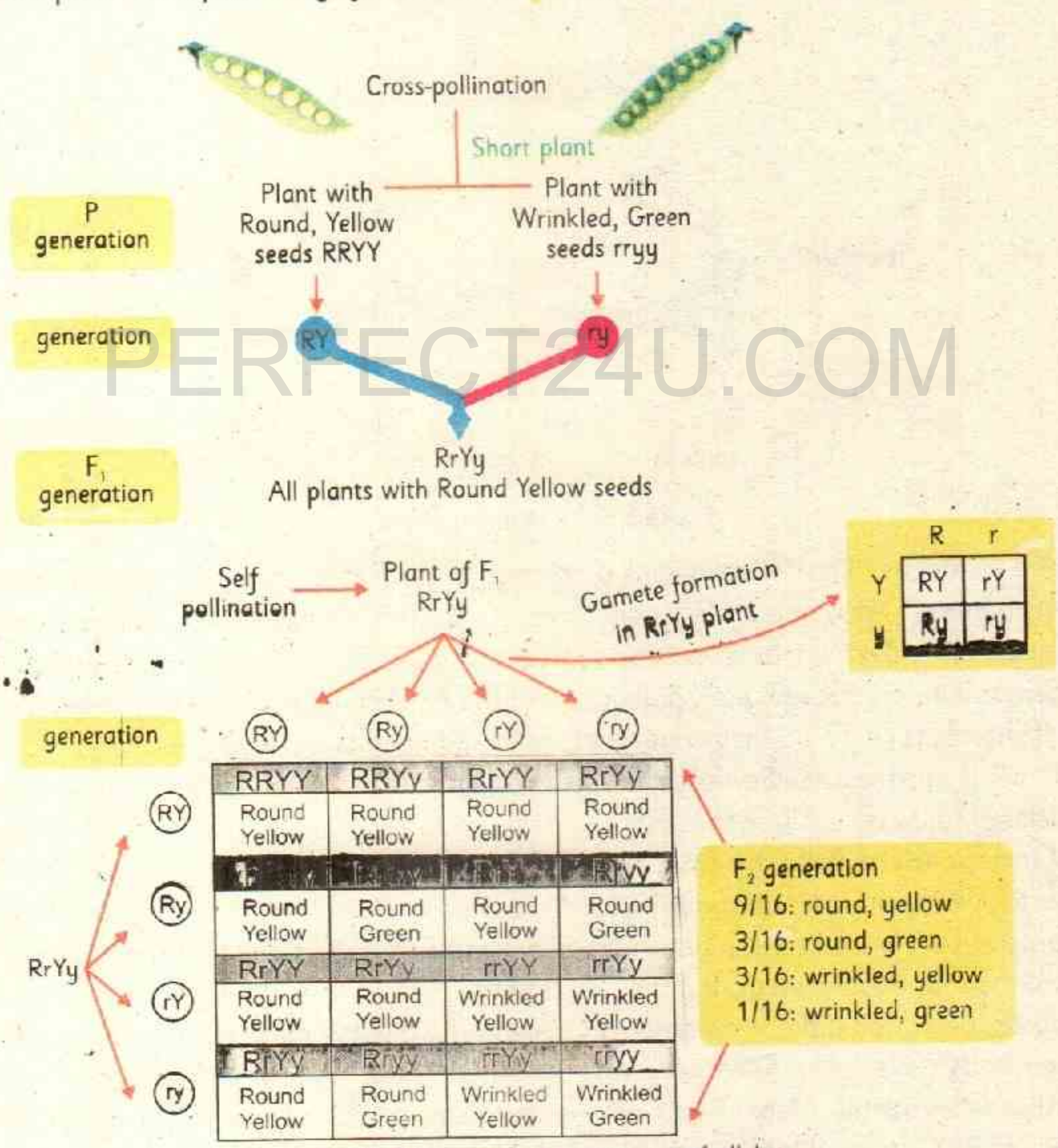


Fig.15.9 Independent assortment of alleles

15.3.2 Dominance Relations

One of Mendel's greatest contributions to the study of heredity was the concept of dominance. Mendel observed that a heterozygous offsprings (e.g. Tt) can show the same phenotype (tall) as the homozygous offsprings (TT). So he concluded that some alleles dominated over the others. However, the relationship of alleles is not as simple as the dominant and recessive patterns described by Mendel. Dominance relations are of three types.

1. Complete dominance 2. Incomplete dominance 3. Co-dominance

1. Complete Dominance: In complete dominance, one allele is completely dominant over the other allele e. g. allele for tallness "T" is completely dominant over the allele for dwarfness "t". So, in the heterozygous condition "Tt", T hides the effect of t and the plant appears tall.

2. Incomplete Dominance: In many cases an allele does not completely mask the action of the second allele. Rather, they interact in such a way that the heterozygous individual shows a blending/mixing of both phenotypes.

In the Japanese 4 O'clock plant, the inheritance of flower colour is an example of incomplete dominance. Two alleles control the characteristic of flower colour i.e. red (R) and white (r). When the red-flowering plant (RR) self-pollinates, it produces only red-flowering offspring. Similarly, when a white-flowering plant (rr) self-pollinates, it produces only white-flowering offspring. However, when a red flower is crossed with a white flower, all of the F_1 offspring have pink flowers. We know that all these F_1 offsprings are heterozygous (Rr). Here, alleles R and r show incomplete dominance. That is why, the phenotype is intermediate.

When two pink flowers (Rr) are crossed, the genotype ratio of F_2 plants is 1 RR : 2 Rr : 1 rr. It results in 1 red : 2 pink : 1 white flowered plants.

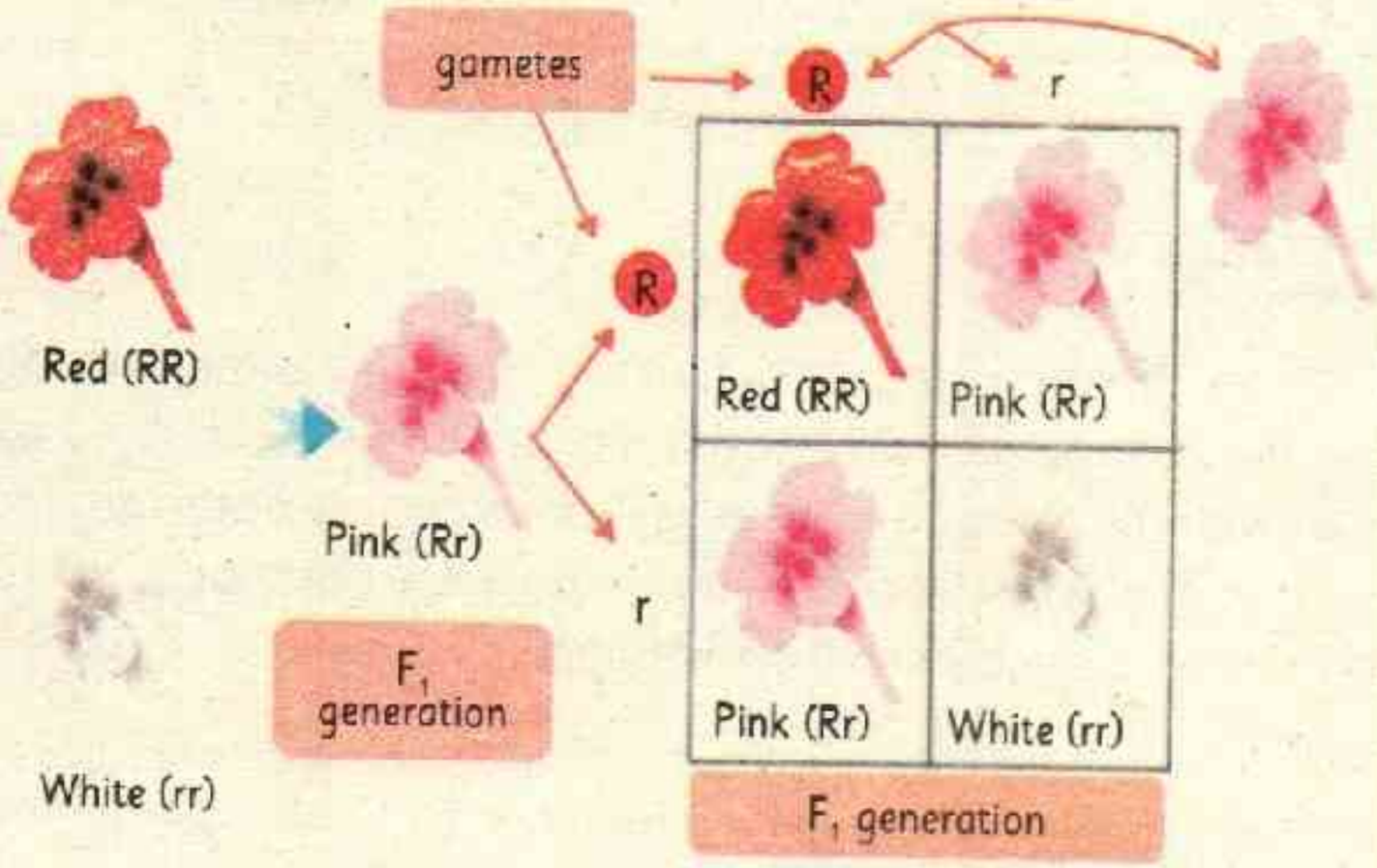


Fig.15.10 Incomplete dominance in Japanese 4 O' Clock plant

Scientific investigation is a pursuit to find the answer to a question using scientific method. In turn, scientific method is a systematic process that involves using measurable observations to formulate, test or modify a hypothesis. In genetics, the information is in the form of large mathematical data. Therefore, knowledge of mathematics is required for data analysis to interpret the data obtained from certain experiments.

3. Co-dominance: It is not an intermediate expression of alleles like incomplete dominance. In co-dominance, different alleles of a gene are completely expressed in a heterozygous condition.

The trait of ABO blood group system shows the example of co-dominance between two alleles. There are three alleles for this trait i.e. I^A, I^B and i.

The allele I^A makes antigen A on RBCs while allele I^B makes antigen B. Allele i does not produce any antigen on RBCs.

Tidbit

In incomplete dominance, the phenotype of a heterozygous offspring is intermediate between the phenotypes of both parents. On the other hand, in co-dominance, the phenotype of heterozygous offspring represents the phenotypes of both parents.

Both the I^A and the I^B alleles are dominant to the i allele. Thus individuals with I^AI^A and I^Ai genotypes have A blood group. Similarly, the individuals with I^BI^B and I^Bi genotypes have type B blood group. Individuals with ii genotype have O blood group. In individuals with I^AI^B genotypes, I^A and I^B alleles are expressed in the phenotype, so the person has AB blood group. It means that alleles I^A and I^B show co-dominance

Genotype	Relationship between alleles	Antigen produced	Phenotype
I^AI^A or I^Ai	Allele I^A is dominant over i	A	Blood Group A
I^BI^B or I^Bi	Allele I^B is dominant over i	B	Blood Group B
ii	Allele i is recessive	No Antigen	Blood Group O
I^AI^B	Allele I^A and I^B are co-dominant	A and B	Blood Group AB

Fig.5.11 ABO blood group - an example of Co-dominance

15.4 Variation and Evolution

Individuals show great differences of form, size, colour, habit and physiology among themselves. These differences are termed as **variations**. Variation can be defined as differences in traits between individuals of the same species. Variations are necessary for natural selection. Natural selection favours individuals with traits that are best adapted to their environment and enable them to change when the environment changes.

15.4.1 Sources of Variations

Variations are produced due to genetic differences among individuals. Sometime environmental conditions also cause variations. The following are the main sources of variations.

a. Genetic recombination of chromosomes

We know that gametes are produced by meiosis. During meiosis, the homologous chromosomes separate and move independently to different nuclei. In this way, new combinations of chromosomes are produced in the daughter cells (gametes).

b. Crossing over

During prophase of meiosis, crossing-over occurs. In this process, the chromatids of homologous chromosomes exchanges genes. It results in chromosomes with different combinations of genes in different gametes.

Science, Technology and Society

The beauty of nature is because of the diversity among living organisms. The basis of biodiversity lies in the genetic variations that occur among organisms. Recombination of chromosomes and crossing over of genes during meiosis are responsible for these variations.

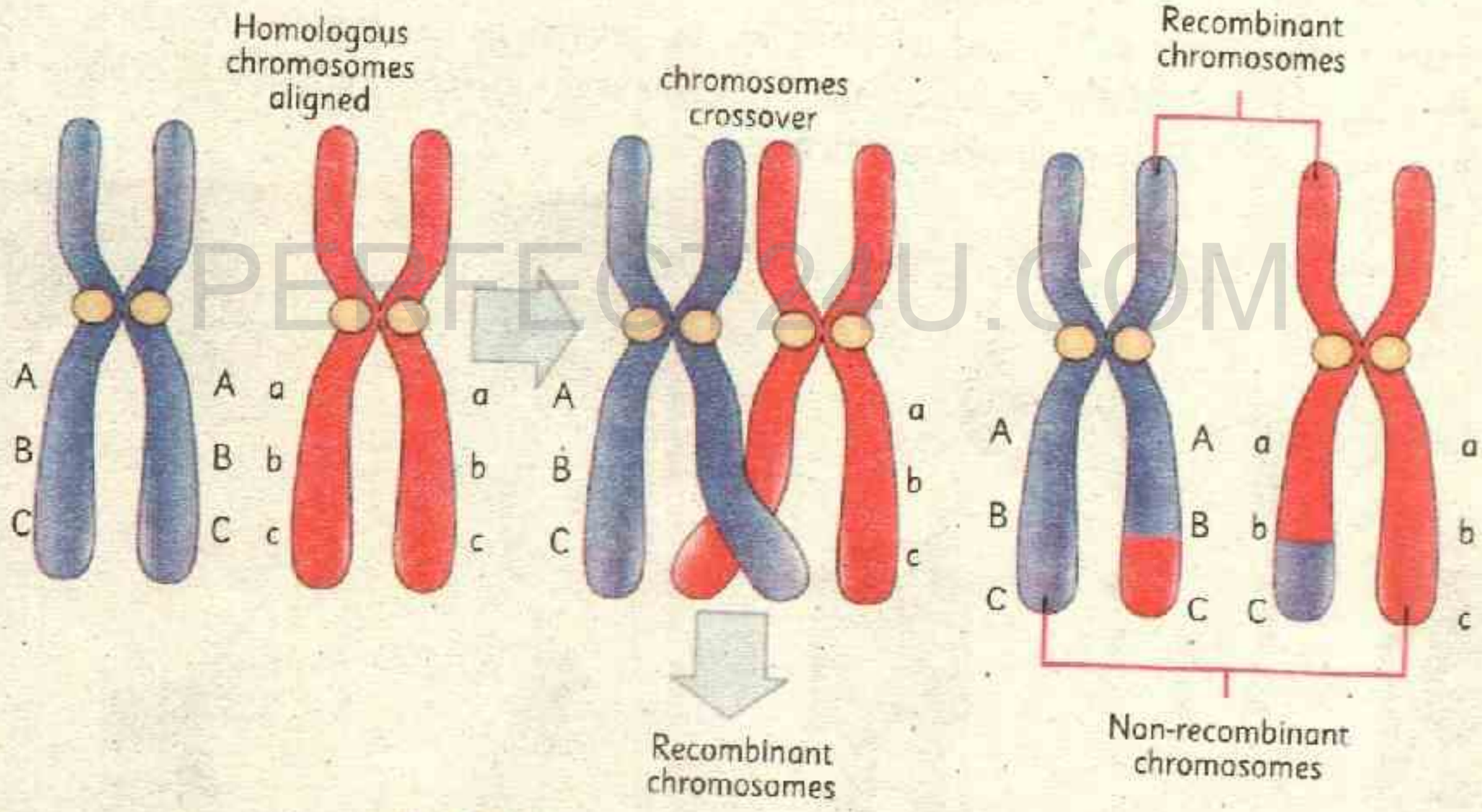


Fig.5.12 Crossing over – a source of variations

c. Random Fertilization

Each gamete has a unique genetic composition, because of the recombination of chromosomes and genes in meiosis. When gametes combine randomly during fertilization, the organisms produced are different from all others of the species.

d. Mutation

Mutation is defined as any change in the nucleotide sequence of DNA. Alleles arise by mutation. The original allele is termed as the wild type, and the new allele as the mutant allele. If there were no mutations, there would be no variation.

e. Environmental conditions

Although the environment has no role in the initial production of variations, once variations are produced, the individuals with variations are best suited to that particular environment and have more chances of survival. Accumulation of such variations, generation after generation, results in the production of new species ultimately.

15.4.2 Continuous and Discontinuous Variations

Variations are generally divided into two types i.e. continuous variations and discontinuous variations:

i. Continuous Variations

These variations deal with a wide range of phenotype ranging from one extreme to the other. It means that a lot of intermediate characters can be observed between the two extremes of a character. The characters that show continuous variations are controlled by many genes. For example, skin colour in humans is controlled by several genes. More dark genes in an individual will result in darker skin colour. The same is the effect of certain other characters like height, weight, IQ (intelligence quotient) etc.

Human height (a continuous variation) Ear shape (a discontinuous variation)

Fig.15.13 Continuous and Discontinuous variations

ii. Discontinuous Variations

These variations show only a few clear-cut phenotypes. A few genes control the characters that show discontinuous variations. Human blood group is an example of discontinuous variation. There are only 4 types of blood groups which are blood group A, B, AB and O. There are no other possibilities and there are no values in between. So this is discontinuous variation. Similarly, the gene controlling ear lobes in humans, is also an example of discontinuous variation.

Activities

1. Record the heights of class fellows to predict which kind of variation it is?
2. Present the data of class fellows' heights in graphical form.

Place these two boxes side by side.

15.4.3 Organic Evolution

Evolution simply means gradual change. Organic evolution is defined as the development of advanced types of organisms from pre-existing types of organisms over time. Various plants and animals, living today, have descended from simpler and imperfect forms, by gradual modification. We call this historical process as organic evolution.

Science, Technology and Society

Humans show wide phenotypic diversity across the globe. This diversity is because of their adaptations to various environmental conditions. Human environments and selective pressures related to these environments vary greatly across geographical regions and across populations. The data available from the genome of different populations shows the exact locations of the genes responsible for these adaptations.

Variations and Natural Selection Lead to Evolution

The English naturalist, **Charles Darwin** (1809–1882) presented the evidence to support that the evolution of new organisms does occur. He developed a theory called **theory of natural selection** to explain evolution. According to this theory, changes in population occur over time through natural selection. In other words, natural selection is the mechanism of evolution.

Natural selection is the process through which individuals with better characters (variations) produce more surviving offsprings than the individuals lacking these variations. As a result, the population gradually includes more individuals with better variations. Natural selection works in the following way.

1. Overproduction: Living organisms tend to produce excessive number of organisms. The resources in the environment are not sufficient for such large populations. Each generation experiences substantial mortality. There are genetic **variations** among individual of a population.

2. Competition: As resources in an environment are limited, organisms compete with one another to get sufficient resources to live. During this competition, the individuals with better variations are able to survive. The individuals with poor adaptability are excluded from the environment. This is called **natural selection.**

3. Reproduction: Better variations assist individuals in their struggle for survival. Such individuals pass on the favourable variations to their offspring.

4. Speciation: When this process repeats over many generations, each new generation has a higher proportion of individuals with better variations. So, after many generations and through continuous natural selection; the population changes entirely and new species may evolve.

Example of Natural Selection

An example of natural selection is the evolution of pesticide resistance in insect species. Pesticides are poisons used to kill pests (harmful insects). When a new type of pesticide is used, a relatively small amount may kill 99 % of pests. But later sprayings are less and less effective.

For example, in the early 1950s, a pesticide was introduced to control flour beetles. Only a small concentration of pesticide was enough to control them. The survivors of the first pesticide treatments had variations that enabled them to resist the chemical attack. Their offsprings inherited the variation for pesticide resistance. In each generation, the percentage of pesticide-resistant individuals increased in population. Thus, the population underwent an evolution that resulted in adaptation against the pesticide. Today, the flour beetles are not killed even by very high concentrations of the same pesticide.

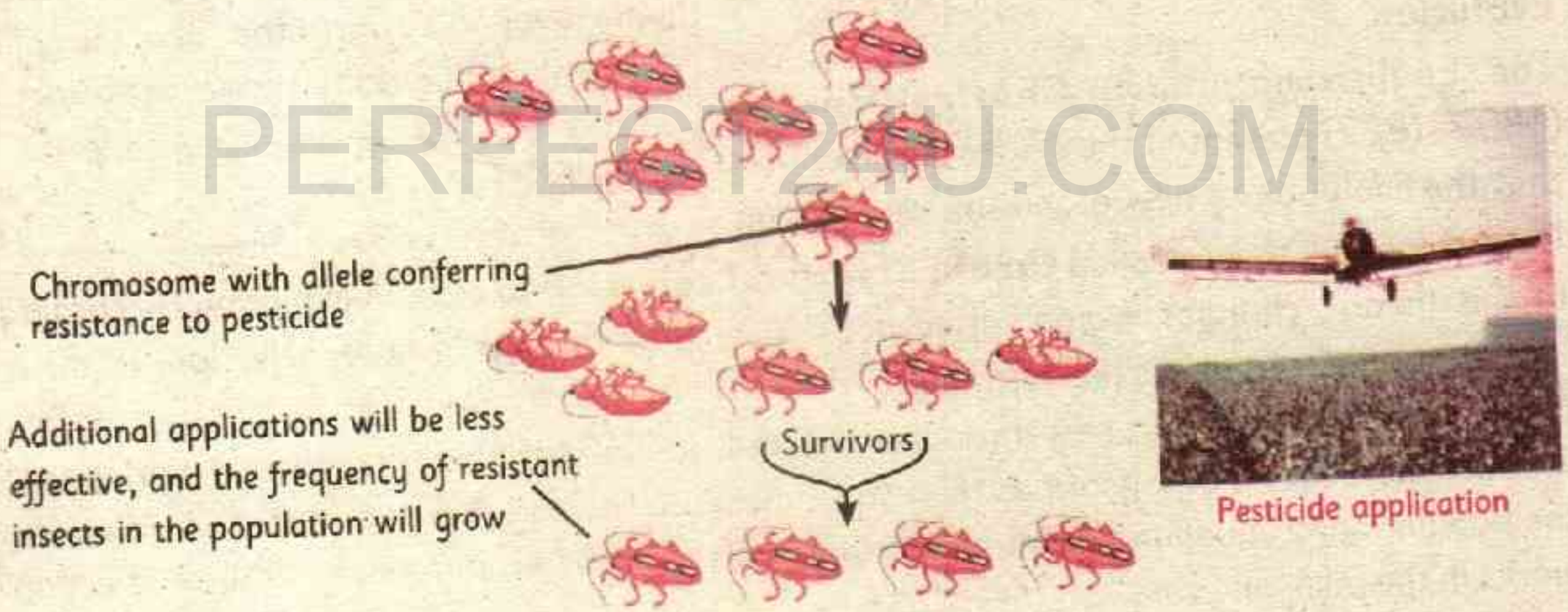


Fig. 15.14 Evolution in insects

15.4.4 Artificial Selection and Crop Improvement

Long before Darwin and Wallace, farmers and breeders were using the idea of selection to cause major changes in the features of their plants and animals. They allowed only the plants and animals with desirable characteristics to reproduce, causing the evolution of farm stock. This process is called artificial selection because people (instead of nature) select the organism they want to reproduce. Essentially all present-day crops have been extensively reshaped from their wild ancestors by the repeated application of artificial selection. For example, the major cereals (rice, wheat, maize, sorghum and millet) were all developed from wild grasses by artificial selection between 7,000 and 12,000 years ago.

The varieties of animals which are artificially bred are called **breeds**. Many breeds of sheep, goat, cow, hen etc. have been produced by artificial selection to increase the production of meat, milk, eggs, wool etc.

Tidbit

In artificial selection, humans favour specific traits while in natural selection the environment selects or rejects variations.
Artificial selection produces a great deal of change in a species in a short time.

Fig.15.15 Different breeds of hen

The varieties of plants which are bred are known as **varieties** or **cultivars**. Many plant varieties (cultivars) have been produced for better quantity and quality of food in plants like wheat, rice, potato, and apple etc.

Fig.15.16 Varieties (cultivars) of potato and apple

Artificial selection has also been used to shape the aesthetic features of organisms that surround us in everyday life. Many ornamental plants breeds of dogs, cats, rabbits, or horses are the result of selection for features that particular breeders regarded as desirable.

For Your Information

The theory proposed by Darwin suggests that unicellular organisms evolved into multicellular organisms. One of the recent theories of evolution, the theory of intelligent design, proposes that certain features of the universe and of living organisms are best explained by an intelligent cause and not by an undirected process such as natural selection. According to this theory, there is a creator of the universe. Therefore there should be a Creator of the universe and an Owner of the balance visibly everywhere from our body to the farthest corners of the vast universe. Who is that Creator? That Almighty Creator is one. He is ALLAH. He brought into existence everything and Whose existence is without any beginning or end.

Key Points

- Genetics is the branch of biological science dealing with heredity.
- Heredity is responsible for transformation of characters of parents to offsprings.
- Mendel is the father of genetics. He formulated laws of inheritance by studying the inheritance of characters in the garden pea.
- True-breeding individuals are genetically homozygous, with similar alleles in a gene pair.
- A cross of two heterozygous individuals for a character gives rise to offspring in 3:1, if there is complete dominance of one allele over the other.
- A dihybrid cross of individuals for two gene pairs yields four different classes of phenotypes in 9:3:3:1 ratio.
- Incomplete dominance of two alleles results in the production of intermediate expression of character in the heterozygous individual.
- More than one gene pair affecting single trait results in gradation in the intensity of expression of character.
- New combination of genes arise by crossing over.
- Variation can be defined as differences in traits between individuals of the same species.
- Continuous variations deals with a variety of phenotypes ranging from one extreme to the other.
- Discontinuous variations deals with a few clear-cut phenotypes and no intermediate characters can be found.
- Evolution means gradual change through the passage of time.
- Evolution by means of natural selection is best explained by Darwin's theory of Natural Selection.
- Artificial selection is used to improve commercially useful plants and animals.

Exercise

A. Select the correct answer.

1. Genes are short segments of:
   a. Proteins b. Carbohydrates c. DNA d. Lipids
2. The various forms of a gene responsible for the same trait are called:
   a. Centromere b. Character c. Trait d. Allele
3. Natural selection operates to produce changes in:
   a. Individuals b. Populations c. Races d. Phyla
4. How many different types of gametes will be produced by a plant having a genotype AaBb?
   a. Three b. Four c. Six d. Eight
5. Speciation is the evolutionary process by which _____.
   a. A new gene pool is formed b. Evolutionary path of a species converge
   c. Hybrid species is formed d. Shows differences in physical traits
6. Phenotype is the expression of:
   a. Genetic makeup b. Physical makeup c. Chemical composition d. Metabolism
7. The round structure formed when DNA coils around the histone protein is:
   a. Centromere b. Chiasma c. Nucleosome d. Chromatin
8. An allele which completely masks the effect of other allele in a heterozygote:
   a. Dominant b. Recessive c. Co-dominant d. Incomplete dominant
9. The central dogma is best represented by
   a. DNA + RNA = Protein b. DNA ⟶ RNA + Protein
   c. DNA ⟶ RNA ⟶ Protein d. Protein ⟶ RNA ⟶ DNA
10. Type of dominance pattern followed by I^A and I^B alleles of the human blood group system:
   a. Complete dominance b. Co-dominance
   c. Incomplete dominance d. None of the above
11. What are the possible genotypes of the parents of homozygous recessive individual?
   a. Homozygous dominant b. Homozygous recessive
   c. Heterozygous d. .Both 'b' and 'c'

B. Write short answers to the following questions.

1. If a man with type AB blood group marries a woman with type O blood group. What type of blood group do you expect in the offsprings?
2. How can crossing bring variations?
3. How are DNA and proteins packed to form a chromosome?

4. How is artificial selection used for the improvement of crops?
5. Differentiate between different types of dominant relations.
6. Write down the phenotypes of the individuals in the following table.

Genotype	Phenotype
I^AI^A or	
I^BI^B	
I^Bi	
I^Ai	
ii	
I^AI^B	

C. Write detailed answers to the following questions:

1. Relate the structure of chromosome with DNA and gene. Draw a concept chart to explain your answer.
2. Explain with the help of a diagram the relationship amongst DNA, RNA and proteins.
3. Explain why Mendel selected peas as a subject for studying genetics?
4. Explain the law of independent assortment with the help of an example and chart.
5. Describe the sources of variations. Explain the importance of variations in organisms.
6. Draw a cross between two pea plants. One of them has round green seeds (RRyy) while the other has wrinkled yellow seeds (rrYY).

Activity

1. Draw the chromosomes of a plant cell after observing it in a prepared slides / unlabelled charts.

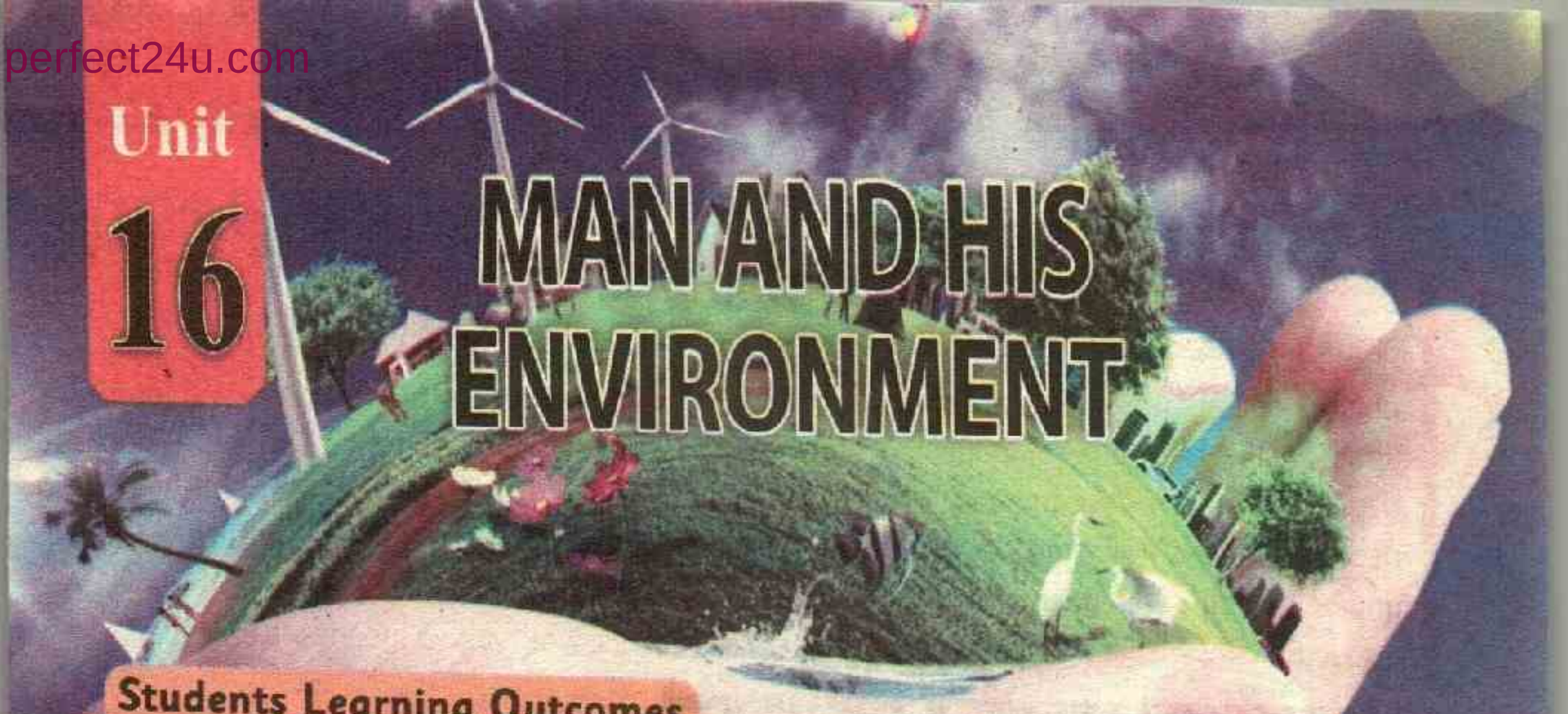
Science, Technology and Society

1. Describe various possibilities if humans could control the functioning of genes.
2. Prepare a report using newspaper clippings on the recent advances and future possibilities in genetics.
3. Rationalise life as a product of the diversity brought about by chromosomes, genes and DNA.
4. Outline the scientific findings and some of the technological advances that led to the modern concept of gene.
5. Analyse the concept of the gene to produce various proteins of the body.
6. Describe the importance of scientific investigation and mathematical knowledge in genetics.
7. Explain how genetics can predict the progeny of two individuals which are crossed.
8. Describe the effects of the environment that lead to the selection of a variant which is more adapted to it.

Unit

16

MAN AND HIS ENVIRONMENT



Students Learning Outcomes

The students will be able to:

- Describe levels of ecological organisation.
- Define ecosystem.
- Describe components of the ecosystem.
- Describe the interrelationships between different components of the ecosystem.
- Explain that the sun is the principal source of energy for all biological systems.
- Compare and contrast the flow of materials (cyclic) and the flow of energy (non-cyclic) in the ecosystem.
- Describe food chains and food webs.
- Describe and compare energy relations between different trophic levels.
- Interpret pyramids of numbers and biomass.
- Describe carbon and nitrogen cycles.
- Relate biogeochemical cycles with flow of energy and ecological balance.
- Explain competition, predation and symbiosis (parasitism, mutualism, commensalisms).
- Relate competition, predation, and parasitism with population growth.
- Describe the importance of balance in nature.
- Explain the human impact on the environment.
- Explain some global and regional environmental problems (population growth, urbanisation, global warming, deforestation, acid rain).
- Explain causes of air, water, and land pollution.
- Describe effects of pollution on plants, animals and human beings.
- Describe possible actions to control pollution.
- Explain conservation of nature.
- Explain different strategies for conservation of nature (reduced resource use, reuse and recycling of materials etc.).

Introduction

Recall from earlier grades that the environment is defined as the surroundings in which and organism lives. You also know that the environment has two components i.e. biotic and abiotic. The abiotic component includes the air (atmosphere), water (hydrosphere) and land (lithosphere). The biotic component includes plants, animals and the microbes. Organisms are dependent on the environment to fullfil their needs. A healthy environment is an absolute necessity for the wellbeing of all organisms, including that of human beings. In this chapter you will study different aspects of the environment and how it is being damaged. You will also learn why we need to conserve our precious resources, which by no means are unlimited.

16 .1) Levels of Ecological Organisation

Environments exhibit different levels of organisation. Each level in this organisation represents its own characteristic nature and function. The various levels of ecological organisation are as under:

1. Species

A species is a group of similar organisms that can breed with one another naturally to produce fertile offsprings. Members of the same species have the same needs (food, living place etc.) and, therefore, compete with one another for their needs.

2. Population

In ecology, population is defined as a group of individuals, belonging to the same species, living in the same place at the same time and sharing the same resources e.g population of students in a school, population of frogs in a pond, population of pine trees in the forest etc.

Do You Remeber?

A specific locality, with a particular set of environmental conditions where an organism lives is called habitat. Freshwater streams and rivers are the habitats of fish, a tree is a habitat of large varieties of birds and a rotten log is a habitat of insects, fungi and microorganisms. In a particular habitat, each organism has a specific role to play. This ecological role that a species plays in a habitat is called niche.

3. Community

A community consists of all the interacting organisms of different populations living in an area. For example, all the fish, turtles, plants, algae, and bacteria in the pond make up a community.

4. Ecosystem

Ecosystem is the basic structural and functional unit of ecology. Ecosystem can be defined as a natural area where the living organisms (plants and animals) and their environment interact and exchange materials between them. This interaction as a result leads to functional stability of an ecosystem.

Do You Remeber?

The regional ecosystems classified according to the predominant vegetation are called biomes. The major biomes of the world are tundra, forest, grassland, desert etc.

5. Biosphere

The parts of the earth where life exists is called the biosphere. It is the broadest level of ecological organisation. The biosphere is about 20 km thick and extends into the atmosphere (air), lithosphere (earth) and hydrosphere (water).

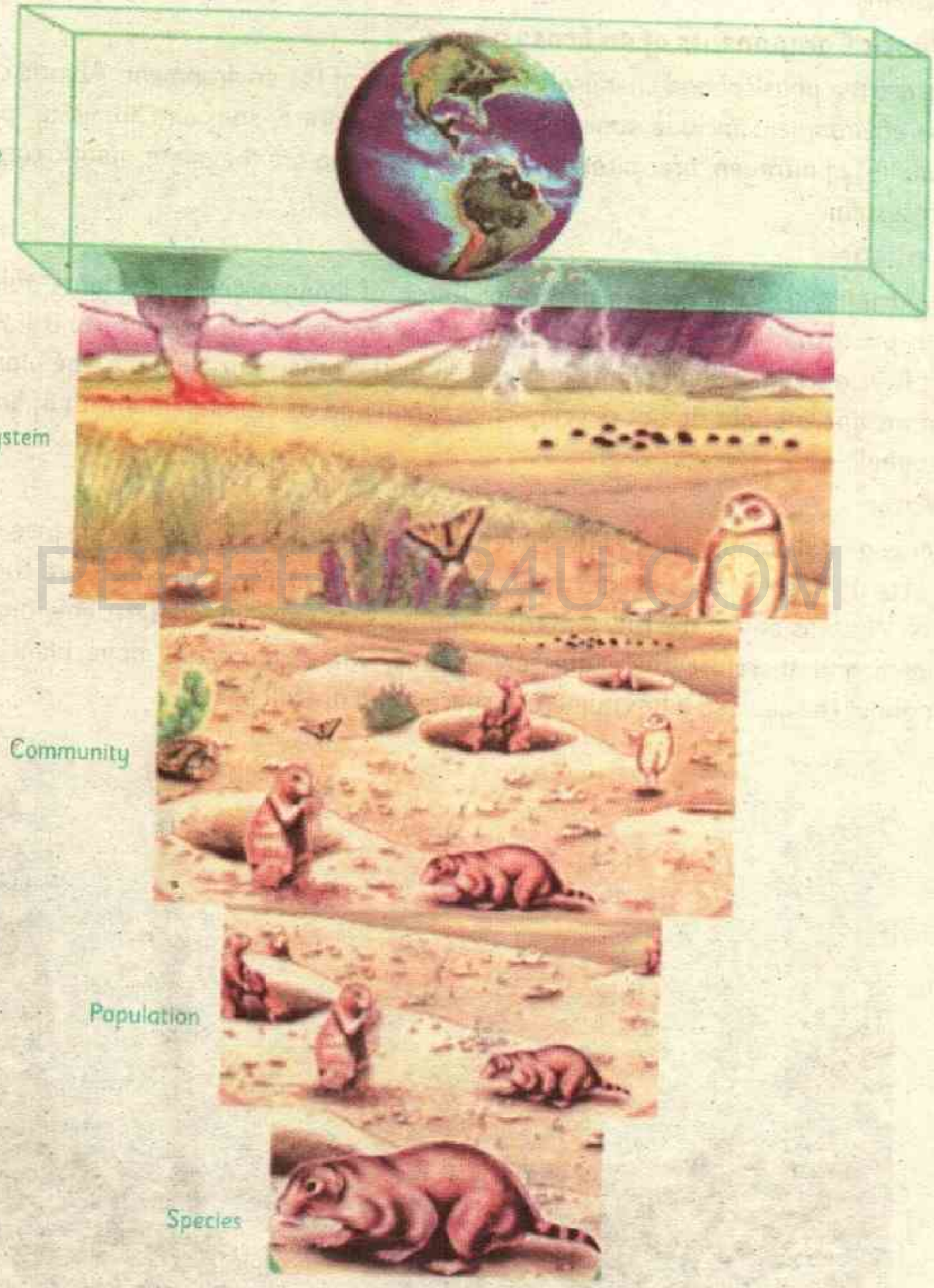


Fig. 16.1 Levels of ecological organisation

16.1.1 Components of an Ecosystem

An ecosystem consists of two major components namely, abiotic components and biotic components. Both these components are equally important for the proper functioning of the ecosystem.

a. Abiotic Components of an Ecosystem

These are the physical and chemical characteristics of the environment. Abiotic components of the environment include sunlight, water, temperature, soil, air, humidity, pH, salinity, availability of nitrogen, precipitation etc. The following are the major abiotic components of an ecosystem.

1. Sunlight

Sunlight influences the growth and distribution of living organisms. Plants utilise sunlight during photosynthesis and prepare food. Light intensity, light quality and light duration affect lives of animals and plants in one way or the other. For example, the plants growing under insufficient light do not develop chlorophyll and a very high intensity of light destroys chlorophyll.

2. Water

Water is a vital component of life. Water covers more than 70% of the surface of the Earth and acts as a universal solvent. It dissolves minerals in the soil, which are then taken by plants. Water is one of the raw materials of photosynthesis. In a deserts environment, water is scarce and therefore there are few species, while rainforests have plenty of rainfall throughout the year, so it has numerous species and are full of life.

Fig.16.2 Rainforests are home to rich biodiversity

3. Temperature

Temperature plays an important role in the distribution of plants and animals. Temperature has great effects on the growth, function and distribution of organisms. The range of temperature for the activity of life lies between 10°C to 45°C. Cells may rupture if water in them freezes at the temperature below 0°C. Enzymes and proteins may denature at temperatures above 45 °C.

Tidbit

At optimum temperature, the activities of organisms are at the maximum. Certain animals migrate to places of optimum temperature. Such movements are called thermal migration.

4. Atmosphere and Wind

Atmosphere is the gaseous reservoir, which surrounds the Earth. It contains nitrogen (78%), oxygen (21%) and carbon dioxide (0.04%).

Nitrogen forms a significant part of proteins, chlorophyll, nucleic acids and vitamins in living things. Some bacteria and algae present in the soil fix nitrogen from the atmosphere and convert it into compounds of nitrogen. Plants utilise these for the synthesis of proteins and other compounds. Animals feeding on plants get these proteins and other nitrogenous compounds. When plants and animals die, bacteria and fungi present in the soil converts the nitrogenous wastes into nitrogenous compounds, which are in turn used by plants again. Certain other bacteria convert some parts of them to nitrogen gas, which goes back into the atmosphere. Therefore, green plants fix nitrogen in the atmosphere and its level remains constant.

Fig.16.3 Flag form trees result from unidirectional movement of wind

Oxygen is required for respiration of organisms. Carbon dioxide is essential for photosynthesis. Humidity is also an important factor in controlling the rate of evaporation and transpiration. It also affects the behaviours of animals e.g. desert animals come out of their hideouts only at the time when moisture in the air at is maximum.

The atmosphere in motion is called wind which is an important abiotic factor. Strong wind can damage buds on the windward side and produce flag form trees. Strong winds cause soil erosion, uproot trees and breaks branches. Wind is also responsible for pollination and dispersal of seeds and fruits.

5. Soil

Soil is the upper layer of the Earth's crust. Plants are anchored in the soil and it is a source of water and nutrients for them. The structure and chemical makeup of soil in an area affect the types of plants that grow there. For example: little grasses often dominate areas with dry soil. These grasses have extensive roots that obtain scarce moisture in the soil. In aquatic environments, the characteristics of the underlying sand affect the types of plants and algae that can grow. This in turn influences the other organisms found there.

For Your Information

Fire is an important abiotic factor. Human and lightning are the causes of fire. Fires can destroy an ecosystem by destroying producers and by driving out consumers from the ecosystem. It also adversely affects the fertility of soil by destroying organic matter in the soil. Fire also release many important nutrients for recycling which help in new growth of plants. Fire improves the growth of grasses.

6. Gravity

Gravity is a constant abiotic factor, which acts as an external stimulus on the growth of the roots of plants. As a result of gravity roots grow downwards into the soil and can access nutrients. Conversely some organisms have adapted to deal with gravity. For instance, birds overcome the problem of the gravitational pull due to wings and light bones.

b. Biotic Components of Ecosystem

These are the living components of an ecosystem. They are of three types, namely producers, consumers and decomposers.

1. Producers

Autotrophs are able to produce food by utilising energy and inorganic nutrients. They are called producers. The producers themselves utilise a part of this food while consumers and decomposers utilise the remaining food. Green plants and algae are the major producers. They carry out photosynthesis in which they use sunlight for the preparation of food. Some types of bacteria are also producers. These bacteria carry out chemosynthesis, in which they use energy stored in inorganic molecules to produce food.

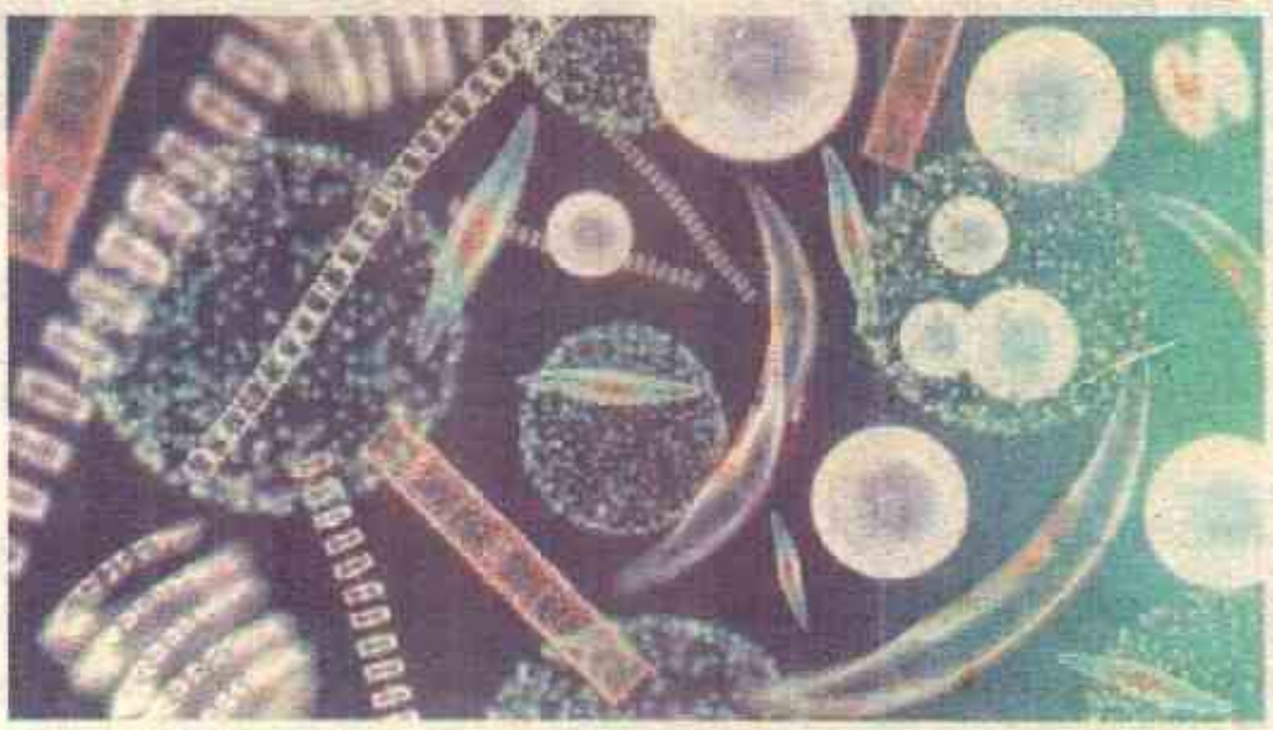


Fig. 16.4 The Algae – major producers in aquatic ecosystems

2. Consumer

Consumers cannot prepare food and depend upon the other organisms for their food. All animals, most protists, all fungi, and many bacteria are included in this group. The consumers are also called heterotrophs. The consumers are of three types, namely primary, secondary and tertiary consumers.

(i) Primary consumers: Also called herbivores, primary consumers feed directly on producers. Primary consumers in the terrestrial habitat are insects, rabbits, goats, sheep, cows etc. In an aquatic habitat the primary consumers are crustaceans (arthropods), molluscs and some fishes.

(ii) Secondary consumers: The secondary consumers feed on primary consumers (herbivores) or producers. Those, which feed on herbivores, are called carnivores like lizards, frogs etc.

(iii) Tertiary consumers: They are the top consumers and get their food from primary consumers and secondary consumers e. g. lion, tiger, hawk etc.

For Your Information

Consumers may also be classified according to what they eat. A consumer that eats only producers is a herbivore (e.g. horse). A consumer that eats only other consumers is a carnivore (e.g. lion). A consumer that eats both producers and consumers is an omnivore (e.g. humans and bear).

3. Decomposers

Decomposers are also called saprophytes. They get their energy by decomposing the remains of dead animals and plants. Many bacteria and fungi are included in this group. The decomposers are also called cleaners of the ecosystem. They help to run various biogeochemical cycles like the nitrogen cycle, carbon cycle etc. In this way valuable nutrients are recycled for reuse.

Observing, Analysing and Interpreting

- Identify and enlist producers and consumers in the pond ecosystem and describe the interactions among biotic and abiotic factors involved.

16.1.2 Interrelationships between Different Components of Ecosystem

Biotic and abiotic components depend on one another. Plants take nutrients from the soil and carbon dioxide from the atmosphere. Then with the help of sunlight they prepare food for themselves and consumers. When the producers and consumers die they are converted into simpler substances like carbon dioxide, nitrogen, water etc. by the action of decomposers. These substances mix with the soil or are released into the air after which they are used again by plants, and the whole cycle is repeated again and again. So, for smooth running of an ecosystem all biotic components interact with each other as well as with the non-living world.

16 .2 Flow of Material and Energy in the Ecosystem

The existence of the living world depends upon the flow of energy and circulation of materials through the ecosystem.

16.2.1 Comparison between Flow of Materials and Energy

The sun is the ultimate source of energy in all ecosystems. It provides energy in the form of sunlight. A tiny fraction of sunlight reaches the Earth. The producers can use a small part of this sunlight. They transform sunlight into chemical energy (food) through photosynthesis. The chemical energy "flows" through the ecosystem in the form of food.

Fig.16.5 Flow of energy in an ecosystem

When respiration occurs, energy is released. The organism uses a portion of this energy for its metabolism and other activities, while the rest of it is lost in the surroundings as heat. The arrows in Figure 16.5 represent the movement of this energy. All energy comes from the Sun, and the ultimate fate of all energy in ecosystems is to be lost as heat. It means that energy does not recycle in the ecosystem.

The other components shown in the diagram are the materials. The producers obtain the inorganic materials (carbon dioxide, water etc.) from the environment and use them to prepare organic material (food). The materials are passed from organism to organism, as one organism is consumed by another. Ultimately, all organisms die and become detritus. Decomposers feed on detritus and break the organic materials into inorganic. The inorganic materials are returned to the environment to be taken up again. In this way, the materials are recycled in the ecosystem.

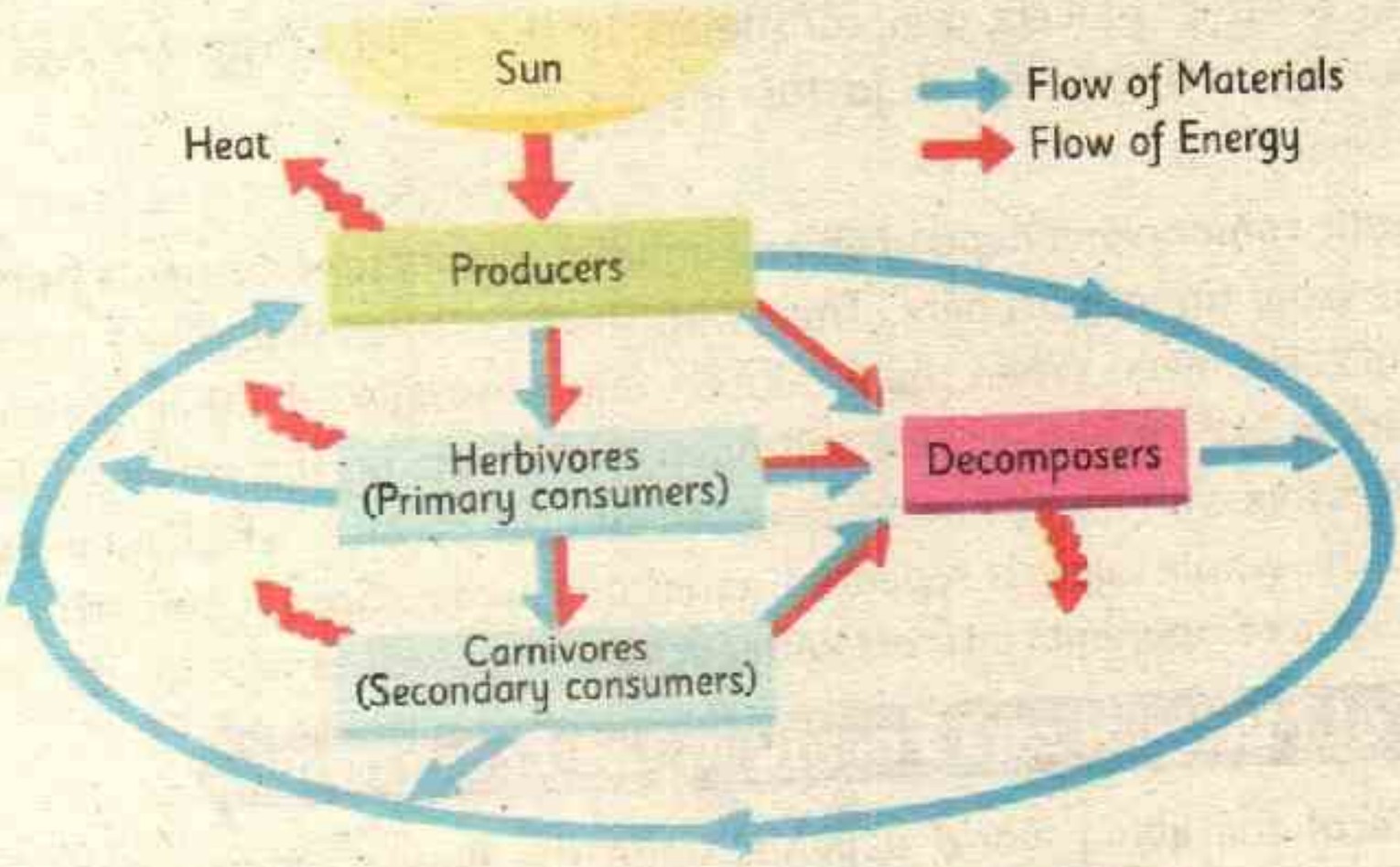


Fig.16.6 Flow of materials and energy in ecosystem

16.2.2 Food Chain

A food chain comprises of a sequence of consumptions through which energy and nutrients are taken in and used up. Simply, a food chain is defined as a process of eating and being eaten.

An example of a simple food chain in a terrestrial ecosystem could be

Grass ⟶ Grasshopper ⟶ Rat ⟶ Snake ⟶ Eagle

Similarly, the following is an example of food chain in a marine ecosystem.

Algae ⟶ Zooplanktons ⟶ Small fish ⟶ Large fish ⟶ Whales

All food chains begin from producers to consumers. The major feeding levels are called **trophic Level.** Producers belong to the **first trophic level.** Primary consumers form the **second trophic level.** Organisms that feed on other consumers belong to the **third tropic level.**

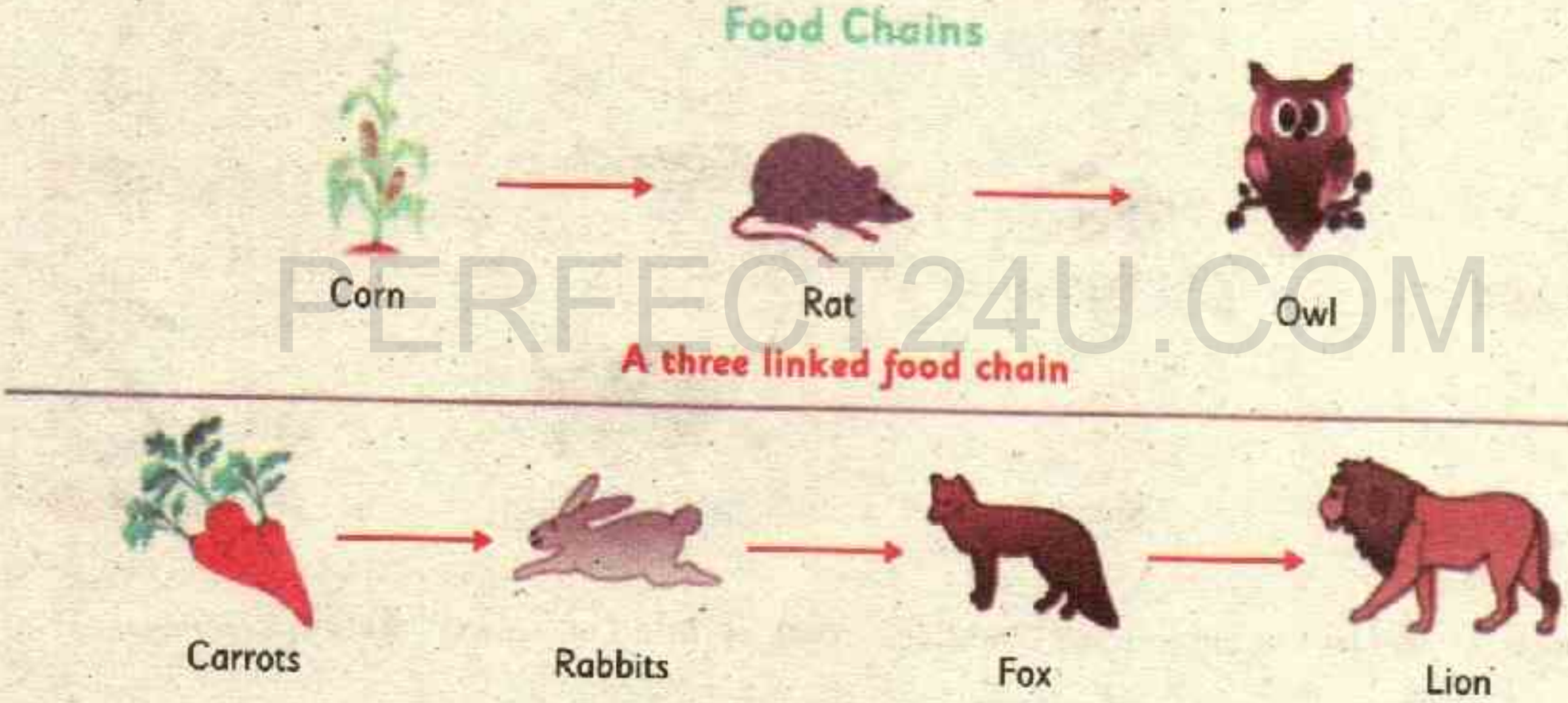


Fig. 16.7 Simple food chains

16.2.3 Food Web

The feeding relationships in a community cannot be represented by simple food chains, because a single consumer eats more than one producer and is eaten by more than one consumer. Thus, many simple food chains are linked together and make a food web. A food web is a graphical description of feeding relationships among the organisms in an ecological community.

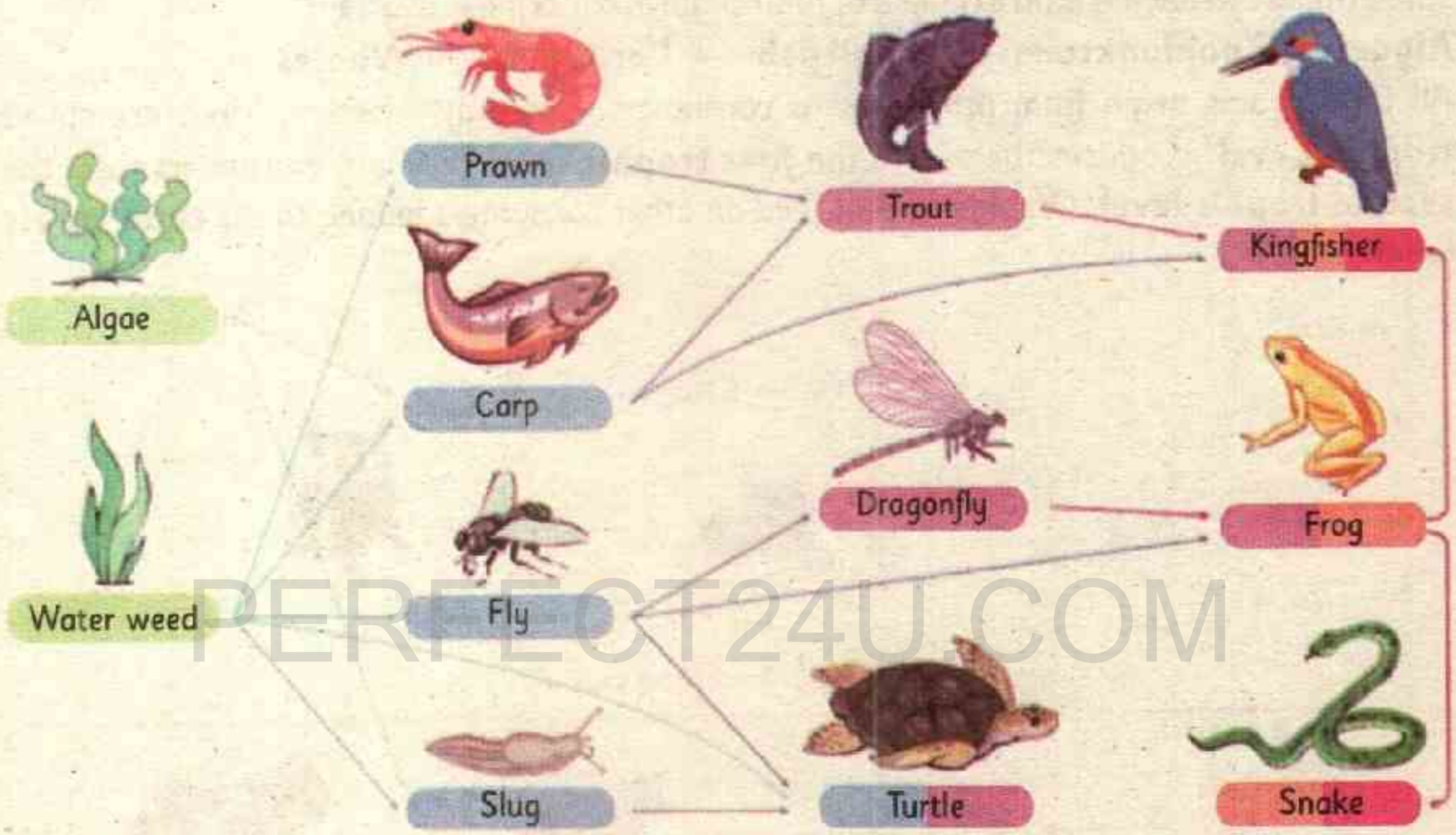


Fig.16.8 Food web in an ecosystem

Observing, Analysing and Interpreting

• Construct food chains, food webs through observation of the local pond or grassland ecosystem.

16.2.4 Energy Relations between different Trophic Levels

The trophic levels in ecosystems can be represented by numbers. Producers are at the first trophic level. The next trophic levels are made of herbivores (primary consumers), carnivores (secondary consumers) and so on.

When producers capture energy (sunlight), they convert a small percentage of it into their biomass while the rest is used in metabolic processes and is also lost. Therefore, at each level the amount of energy reduces during the transfer to the next level. In general only 10% of the

energy consumed by one level is available to the next. For example if rabbits consume 1000 K Cal of plant energy, they might only be able to form 100 K Cal of new rabbit tissues. So the foxes consume about 10 K Cal of rabbit biomass, and convert perhaps 10 K Cal into new fox biomass.

16.2.5 Pyramid of Biomass

The pyramid of biomass represents the amount of biomass (total amount of living or organic matter of all organisms) in each trophic level in an ecosystem. Because biomass is lost in the transfer from one level to the next, there is successively less total biomass as you move up trophic levels. In general, we would expect that higher trophic levels would have less total biomass than those below.

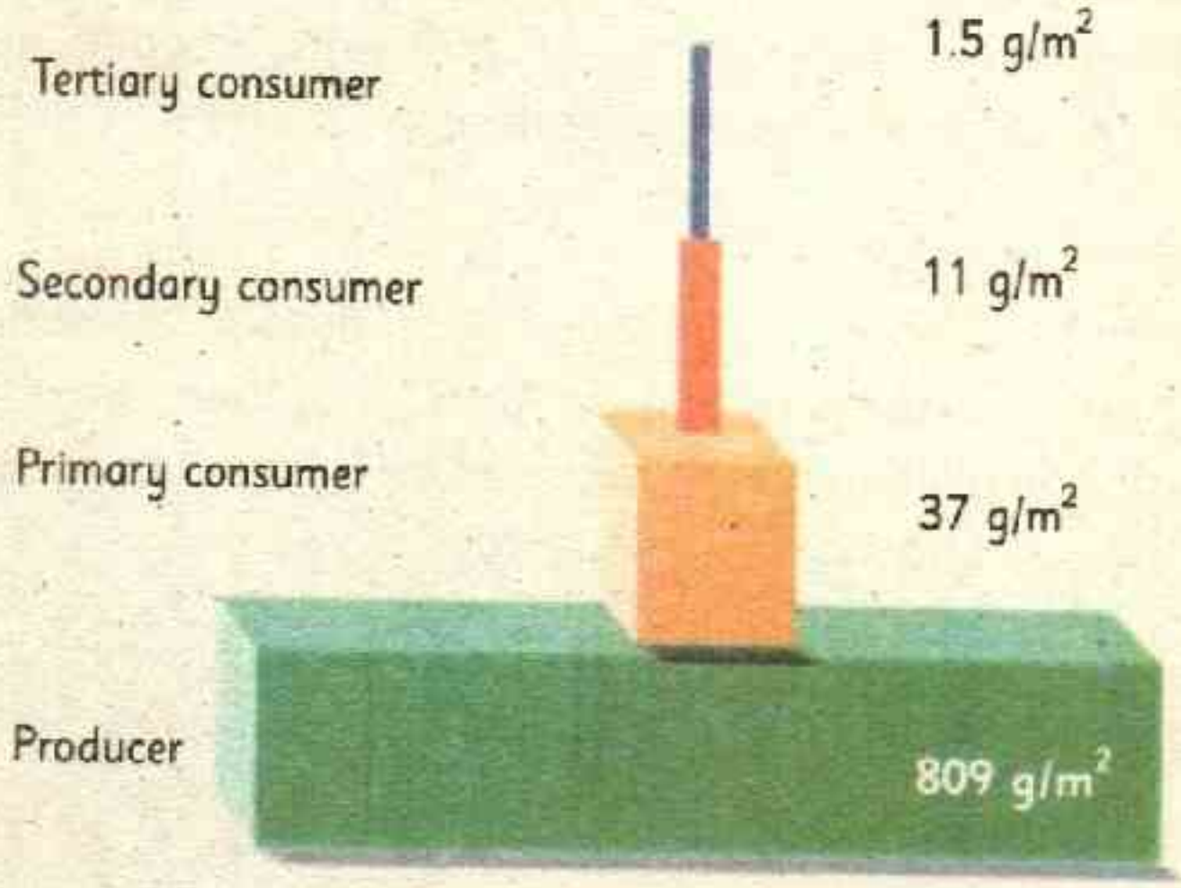


Fig.16.9 Pyramid of biomass

16.2.6 Pyramid of Numbers

It represents the number of organisms at each trophic level in an ecosystem. In pyramids of numbers, each successive trophic level has fewer organisms. The number of producers is largest in an ecosystem. At the next trophic level of primary consumers or herbivores, the number of organisms is less than the previous level. At the third trophic level of secondary consumers or carnivores, there are lesser number of organisms than primary consumers. Similarly, in all successive trophic levels, the numbers of organisms go on decreasing.

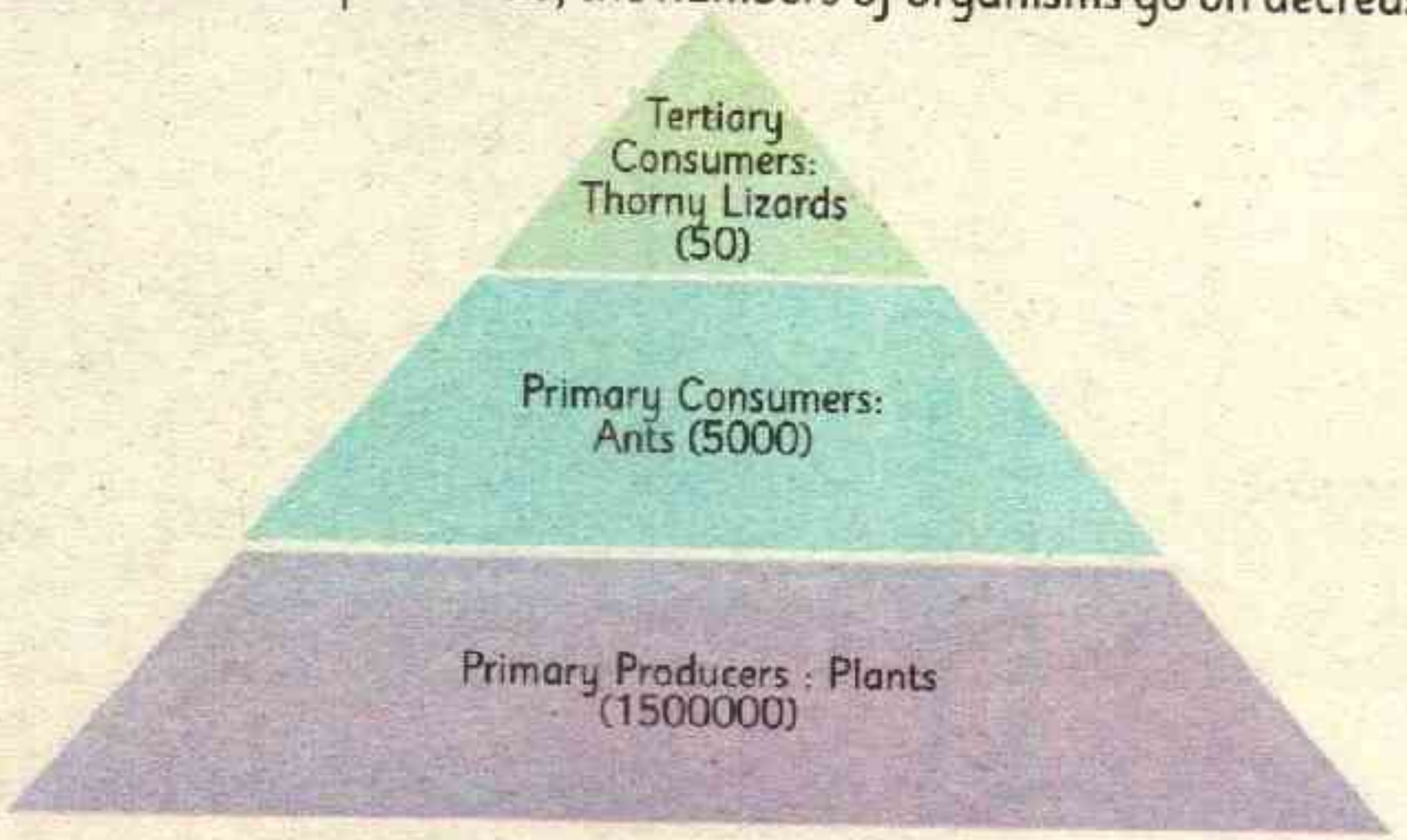


Fig.16.10 Pyramid of numbers

16.3 Biogeochemical Cycles

Dead bodies of living organisms are decomposed by microorganisms which result in the release of nutrients in the environment. These nutrients are used by plants in their growth, which in turn form food for the heterotrophic organisms. These movements of chemical elements between organisms and environment along circular paths are known as biogeochemical cycles. In following section you will study some of the major biogeochemical cycles operating in nature.

16.3.1 Carbon Cycle

Carbon is the main component of organic compounds present in living things. Earth's atmosphere contains almost 0.04% carbon dioxide. By the process of photosynthesis, producers use sunlight to take carbon from environment and make it a part of glucose.

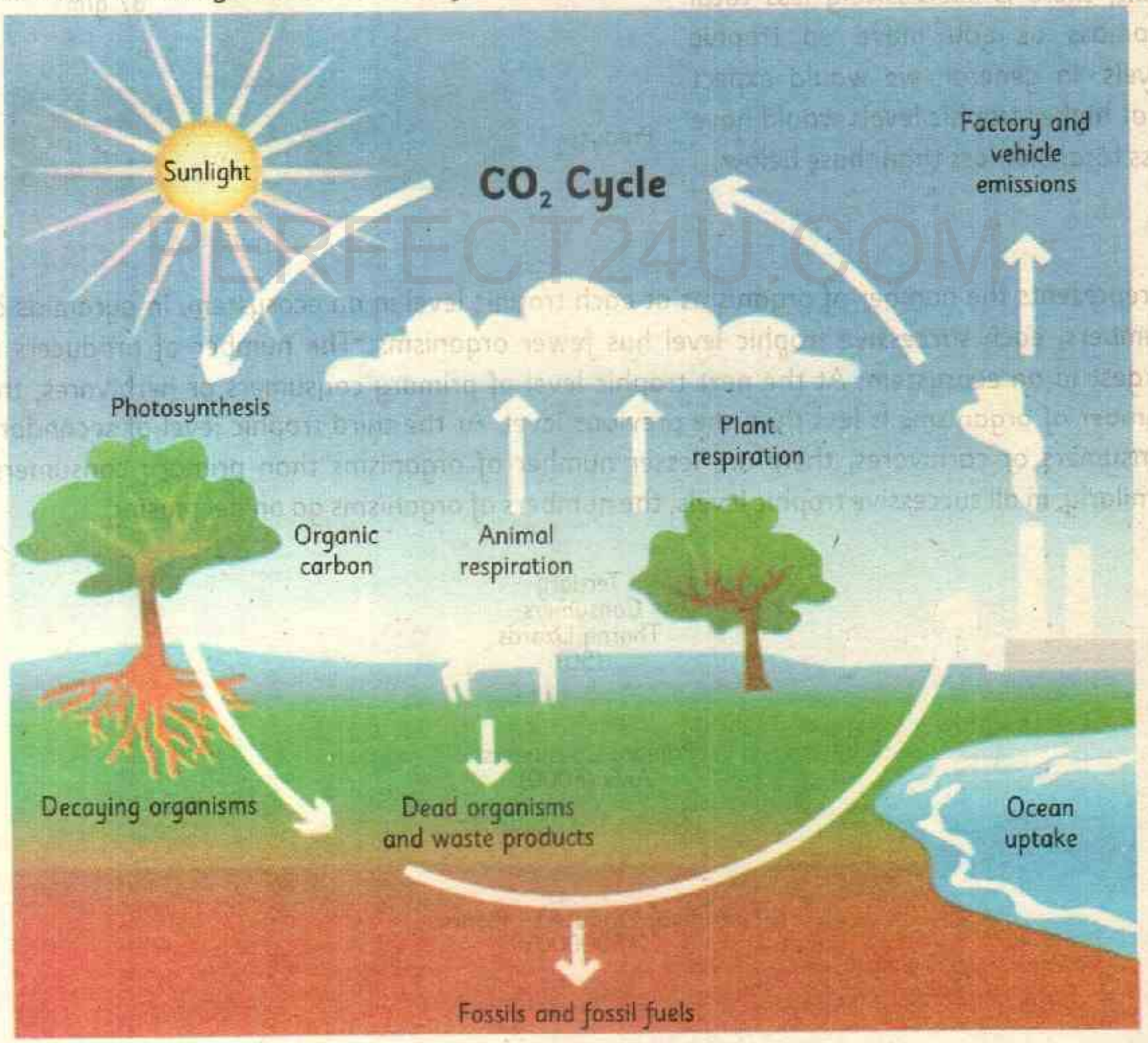


Fig.16.11 Carbon Cycle

Through other metabolic processes, producers convert glucose to other carbohydrates and proteins, or fats. Consumers (animals) obtain their carbon by eating and digesting plants. So carbon moves through the biotic environment through the trophic system. Herbivores eat plants, but are themselves eaten by carnivores.

Carbon returns to the physical environment in a number of ways. Both plants and animals respire, so they release CO_2 during respiration. Another route of CO_2 back to the physical environment occurs through the death of plants and animals. When organisms die, decomposers consume their bodies. CO_2 is released into the atmosphere through the process of decomposition. Some of the carbon returns to the physical environment by way of fossilization. The burning of fossil fuel produces CO_2, which returns to atmosphere.

16.3.2 Nitrogen Cycle

Nitrogen (N) is an essential component of DNA, RNA, and proteins, the building blocks of life. All organisms require nitrogen to live and grow. The nitrogen cycle consists of four main stages, nitrogen fixation, nitrogen uptake, nitrification and denitrification.

1. Nitrogen fixation

Nitrogen fixation is the process where N_2 is converted to ammonium with the help of certain bacteria, for example genus *Rhizobium*. Nitrogen fixing bacteria often form symbiotic relationships with legume (e.g. beans, peas). In addition to nitrogen fixing bacteria, high-energy natural events such as lightning, forest fires, and even hot lava flows can cause the fixation of smaller amounts of nitrogen.

2. Nitrogen uptake and decay

The ammonia produced by nitrogen fixing bacteria is incorporated into proteins and other organic compounds by bacteria themselves, or by another soil organism. When these organisms die, decomposers consume the organic matter. During this process, the organic compounds are broken and nitrogen is converted to ammonium. This ammonium is available for use by plants or for further transformation into a nitrate ion (NO_3^-) through a process called nitrification.

For Your Information

Although the majority of the air we breathe is N_2, most of the nitrogen in the atmosphere is unavailable for use by organisms. This is because the strong triple bond between the N atoms in N_2 molecules makes it relatively inert. In fact, in order for plants and animals to be able to use nitrogen, N_2 gas must first be converted to such forms as ammonium (NH_4^+), nitrate (NO_3^-), or organic nitrogen (e. g. urea – $(NH_2)_2CO$).

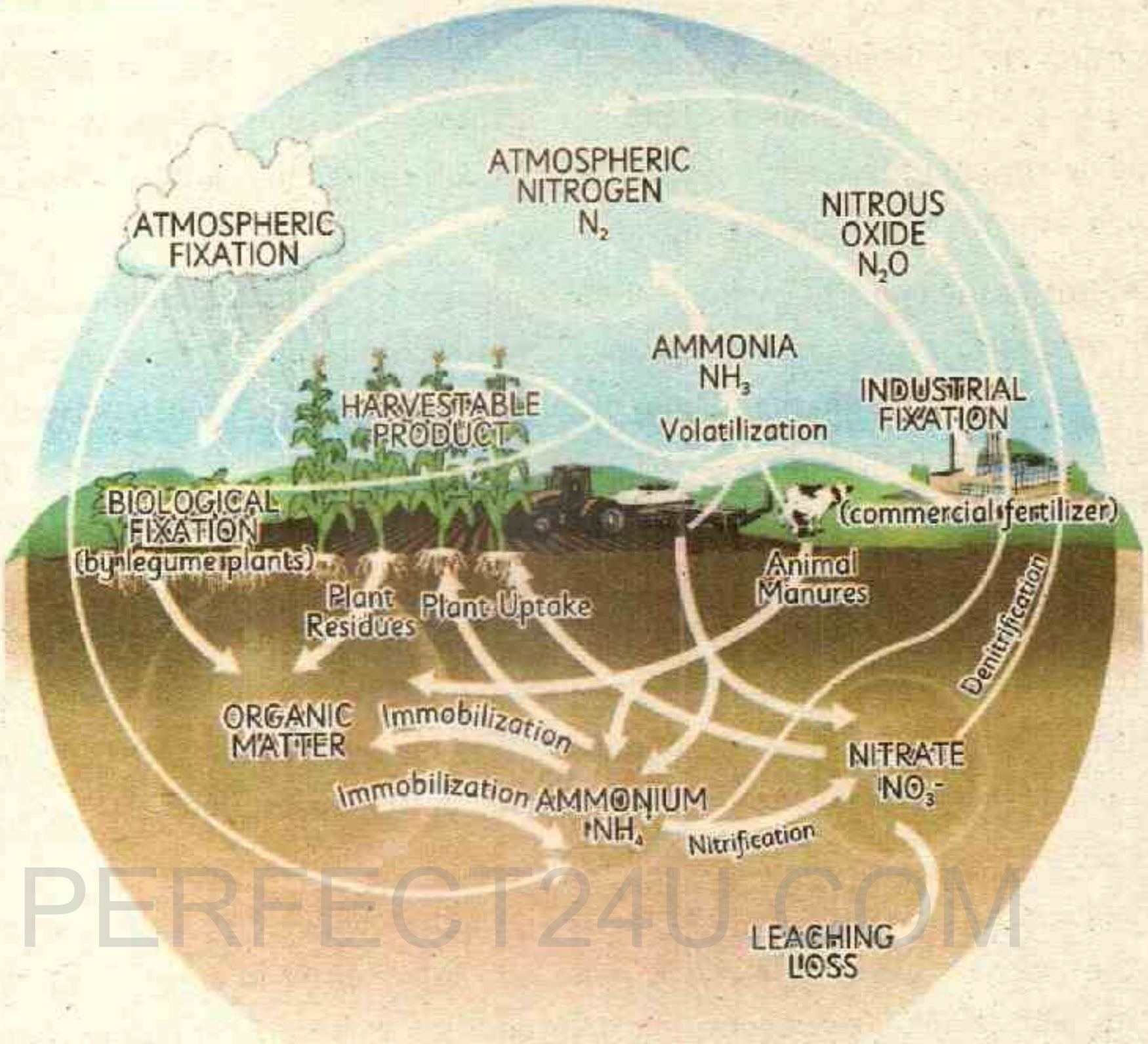


Fig 16.12 Nitrogen Cycle

3. Nitrification

Some of the ammonium produced by decomposition is converted to nitrate via a process called nitrification. Nitrification is accomplished by two groups of bacteria. One group of bacteria *(Nitrosomonas)* converts ammonia into nitrites and a second group of bacteria *(Nitrobacter)* converts nitrites into nitrates.

4. Denitrification

Through denitrification, oxidized forms of nitrogen such as nitrate and nitrite (NO_2) are converted to molecular nitrogen (N_2) and, to a lesser extent, nitrous oxide gas. Denitrification is carried out by bacteria *(Pseudomonas)*, which converts nitrates to molecular nitrogen. Molecular nitrogen is rapidly lost to the atmosphere. Denitrification is the only nitrogen transformation that removes nitrogen from ecosystems, and it roughly balances the amount of nitrogen fixed by the nitrogen fixers described above.

16.4.3 Biogeochemical Cycles and Flow of Energy and Ecological Balance

Through biogeochemical cycles, the chemical elements or molecules cycle through biotic and abiotic components of the environment. These cycles also move energy at different trophic levels.

All the essential nutrients like carbon, nitrogen, oxygen, phosphorus, and sulphur are recycled instead of being lost and replenished constantly. In this way, these cycles help in maintaining the ecological balance in nature.

16.4 Interactions in the Ecosystem

The existence of the living world depends on the flow of energy and circulation of materials through the ecosystem. In all ecosystems, the organisms living in the same area interact with each other. These interactions may be intraspecific i.e. between the organisms of the same species or inter-specific i.e. between the organisms of different species. The following are some of the important interactions among organisms

a. Competition

Competition is an interaction between organisms for limited supply of at least one resource (such as food, water and space). Competition is an important factor that affects the community structure. Competition may be intraspecific (among members of the same species) or inter-specific (among individuals of different species). For example, lions and leopards compete with each other for prey (e.g. zebras). Similarly, many plant species compete for soil or sunlight.

Competition maintains a balance between the resources and the size of populations. In competition, one species is able to use a resource more efficiently than the other. As a result, less of the resource is available to the weaker species. It results in a reduction in the size of the weaker population or its complete elimination.

b. Predation

Predation is an inter-specific interaction i.e. between members of two different species. In predation the predator captures, readily kills and feeds on an individual of another species, called the prey.

Predation has important effects on the distribution and abundance of organisms. A prey in an area without its natural predator becomes a menace for example the introduction of rabbits in Australia where without its predator, they multiplied enormously and became a menace for the local farmers.

Fig. 16.13 An example of a predator and its prey

Predator Plants

Some plants e.g. the pitcher plant; sundew, Venus flytrap etc. live as predators. They capture and eat insects. They attract insects by their colours or nectars. These plants capture their prey with the help of their modified leaves. After capturing it, they secrete enzymes on insects and absorb the digested food. Such plants usually grow in areas where there is deficiency of nitrogen in the soil. They get nitrogen containing compounds e.g. proteins from the prey insects.

Fig.16.14 Leaf modifications in different predator plants

c. Symbiosis

Symbiosis literally means, "living together". It is defined as a close interaction between organisms of different species for an extended time. Although one species always benefits in a symbiotic relationship, the second species may be harmed, not affected or benefited. There are three types of symbiosis.

(i). Parasitism

In parasitism, an organism called a parasite lives on or in the body of a larger living organism called the host. The parasite gets its nourishment from its host's tissues and causes harm to it. Parasites always get benefit from the host. The diseases in host organisms caused by parasites, are called infestations. Parasites such as aphids, lice, leeches, fleas, ticks, and mosquitoes remain on the outside of their hosts' bodies. They are called **ectoparasites**. Many parasites live inside the host's body and are called **endoparasites** e.g. plasmodium, tapeworm, polio virus etc.

Figure 16.15: Female **Anopheles** sucking blood from its victim (Human Being).

Some plants (e.g. cuscuta) also live as parasites. The cuscuta plant does not have green leaves. It cannot manufacture food. It grows on the surface of big plants (hosts). Here, it obtains food and causes harm to the host plant. The cuscuta plant attaches itself to a plant

and wraps itself around it. After which it produces 'haustoria' (root) through which it inserts itself into the host. Subsequently, the original root of the cuscuta in the soil dies. The cuscuta can grow and attach itself to multiple plants. This is how the cuscuta plant draws nourishment from its host and weakens it.

Parasites have a strong negative effect on the growth of the host's population. The epidemics of parasitic diseases can even cause the extinction of the host population.

(ii). Mutualism

In this type of relationship, both the partners are mutually benefited and none of them is harmed. For example, the roots of the leguminous plants (pea, bean etc.) have small nodules, which contain Nitrogen fixing bacteria. These bacteria get food from these plants. In return, bacteria convert the atmospheric nitrogen into nitrates and pass them on to the host plant.

Fig.16.16 Mutualism in beans

Another example of mutualism can be observed between termites and the protists living in their gut. Termites eat wood and the protists help them to digest the cellulose of wood. In return, the termite provides food and shelter to protists. Similarly many bacteria live in our intestine. Our body gives them food and a proper environment to live in. In turn, these bacteria produce vitamin K, which is essential for blood clotting.

Recalling

Do protists have a relationship with some other organism? Find out.

(iii). Commensalism

In commensalism only one partner is benefited and the other is neither benefited nor harmed. For example many epiphytes, such as orchids are found growing on the branches of other trees. These epiphytes use the tree only for the attachment. They prepare their own food by photosynthesis. Here the orchids are benefited but the tree is neither benefited nor harmed. Similarly barnacles attach with the body of marine animals including whales. Barnacles get a ride to better places but the large animals are not affected.

Fig. 16.17 Commensalism: Epiphytic fern growing on a tree (left); Barnacles on the body of whale (right)

Observing, Analysing and Interpreting

• Prepare a list showing predators and their preys, and parasites and their hosts. Elaborate at least one example from your immediate environment.

16.5 Balance in the Ecosystem and Human Impact

All the organisms living on Earth are dependent on the environment for their needs. The environment provides all the resources, which are necessary for the survival of organisms. The species living in an ecosystem get the resources through interactions with the environment and among themselves. Biogeochemical cycles also play an important role in the availability of natural resources to the species. In a balanced ecosystem, the interactions and biogeochemical cycles run smoothly and all the species get natural resources. A balanced ecosystem is important not only for a single species but also for the whole biodiversity of the ecosystem.

However, human beings try to modify their environment to meet their needs. This has disturbed the delicate balance in the environment. For example, until the beginning of the 19th century, the size of the human population was small in relation to environmental resources. So there was no immediate shortage of environmental resources. However, with the increase in population at an unexpected rate, humans are using environmental resources at an increasing rate. This has not only created degradation and depletion of resources but it has also produced some local effects, like pollution, deforestation etc.

Fig. 16.18 Human intervention in the environment has mostly resulted in the degradation and depletion of natural resources

Due to the tremendous increase in population, urbanisation and industrialisation more sewerage enters the rivers and more gases are released into the atmosphere. Thus the environmental conditions become gradually worse. The local problems of environmental pollution have now become global ones. New industrial products, toxic chemicals and solid wastes have made the land, air and water polluted. Thus the degradation and depletion of resources and the modification of the environment are the direct results of human intervention.

16.5.1 Global and Regional Environmental Problems

1. Over Population

Overpopulation is arguably the most critical threat to the environment. Population control is an urgent issue because of the following reasons:

- To reduce burden and stabilise our resources.
- To reduce the incidence of famine.
- To reduce threats to the already stressed ecosystem.
- To give our current and future generations better education.
- To provide chances for employment and better survival.

The ever-increasing human population growth requires an effective method for production of more food, which has resulted in extensive agriculture. Some of the bad effects of extensive agriculture are given below:

a) More land being brought under cultivation results in the destruction of habitats
b) Extensive agriculture requires supply of water and development of canals, which in turn causes waterlogging and salinity.
c) Overuse of fertilizers has polluted the soil and water.
d) Over-use of pesticides and herbicides can make water toxic, which can affect aquatic life.
e) Forests are destroyed to bring land under cultivation
f) Clearing of land for agriculture, results in soil erosion.
g) Excessive irrigation can cause loss of top fertile soil.
h) Soil erosion results in silting, which decrease, the life span of dams.

2. Urbanisation

Urban growth, also known as urbanisation, accelerated dramatically with the advent of industrialisation some 200 years ago. At that time, large numbers of people moved to cities in search of jobs, mostly in factories. While less than one-third of the world's population lived in cities in 1950, about two thirds of humanity is expected to live in urban areas by 2030. Most of that urbanisation is taking place in Asia, Africa, and Latin America.

In cities, people are concentrated in a small space rather than being spread out over a large territory. This allows the government and others to provide more services such as, water, electricity, and transportation to a larger number of people. Schools and shops are more easily accessible than in rural areas.

The current level of urbanisation in Pakistan is about 37%, which has increased uniformly

over the decades. The urban population in Khyber Pakhtunkhwa is about 18.6% of the total 30.5 million of its population. In newly merged districts of FATA regions of KP, only 2.8% of the population lives in urban areas.

Fig.16.19 Slums along side multi-storied skyscrapers as seen in Sao Paulo, Brazil are common sights in megacities of the world

Cities have always been at the centre of economic growth and technological advances. The promise of jobs and prosperity pulls people to cities. However, their rapid growth has also brought many negative effects with it e.g. violence, poverty, overcrowding, health problems, and pollution.

Urban expansion is also encroaching on wildlife habitats everywhere. Increasingly people live and work in close proximity to wild animals whose native habitats have been destroyed. Many animals from mice and cockroaches to pigeons and squirrels have adapted to city life, taking advantage of abundant food and warmer temperatures.

3. Deforestation

The unwise and unplanned destruction or removal of trees is called deforestation. Forests are our most precious wealth. Our life is greatly dependent on forests. They are the natural factories for the production of oxygen. Forests provide green cover to the earth, a living place to wildlife, fuel, timber and recreation to man. They control floods, prevent formation of deserts and keep the air clean. Some of the reasons for deforestation are given below:

a) Urbanisation requires more land, thus forests are cut to build roads and houses etc.
b) More land is required for cultivation.
c) Trees are removed to develop pastures for grazing.
d) Wood is used both as timber or fuel wood.
e) Some plants are collected for their medicinal importance.
f) Some plants are removed to give us fibre.
g) Timber mafia cuts trees for cash.

Fig.16.20 Deforestation in tropical rainforests

Effects on the Environment: Deforestation has many negative effects on the environment. The most dramatic impact is a loss of habitat for millions of species. 70 % of the Earth's land animals and plants live in forests, and many cannot afford deforestation since it results in the destruction of their homes.

Deforestation also results in **climate change.** Forest soils are moist, but without protection from sun-blocking tree cover, they quickly dry out. Trees also help perpetuate the **water cycle** by returning water vapours back into the atmosphere. Without trees to fulfil these roles, many former forest lands can quickly become barren deserts.

Trees also play a critical role in absorbing the greenhouse gases that a responsible for global warming.

4. Acid rain

Acid rain is one of the most dangerous and widespread global environmental problem. Technically, acid rain is the rain that has larger amount of acid in it than normal. The key culprit is smoke and gases emitted by factories and vehicles running on fossil fuels. When these fuels are burnt to produce energy, the sulphur present in the fuel combines with oxygen and becomes sulphur dioxide; some of the Nitrogen in the air becomes nitrogen oxide. These pollutants go into the atmosphere, and become acids.

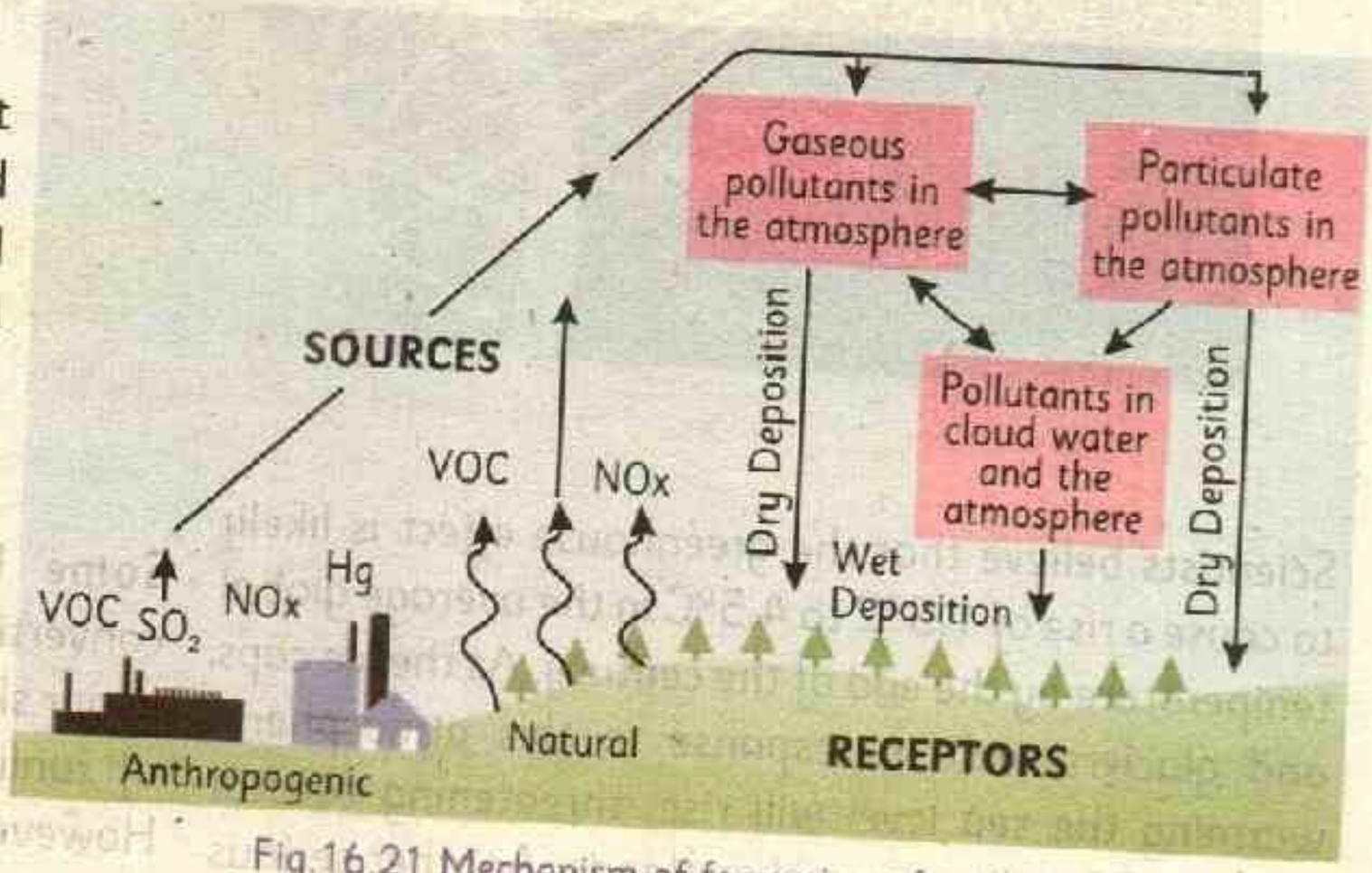


Fig.16.21 Mechanism of formation of acid rain

Sulphur dioxide and Nitrogen oxide are produced especially when coal is burnt for fuel. Automobiles produce Nitrogen oxides (which cause acid rain).

Effects of Acid Rain: Acid rain is extremely destructive and forests, lakes, animals, and plants suffer from it. Acid rain can make trees lose their leaves. Trees can also suffer from stunted growth and have damaged bark. The soil poisons the trees with toxic substances, that have been deposits by the rain.

Lakes are also damaged by acid rain. Fish die, and that removes the main source of food for birds. Acid rain can even kill fish before they are born.

5. Global Warming

The rise in the average temperature of the Earth's atmosphere is called global warming. It is one of the most important environmental issues. There is a direct relationship between average levels of CO_2 in the atmosphere and average global temperatures. Atmospheric CO_2 acts like a glass in a greenhouse, allowing energy in the form of sunlight to enter but absorbing and holding that energy once it has been converted to heat. Several other "greenhouse gases" share this property, including methane, and chlorofluorocarbons (CFCs) as well as water vapours. Fossil-fuel consumption and forest fires are the main causes of carbon dioxide build-up and global warming.

Fig.16.22 Greenhouse Effect

Scientists believe that the greenhouse effect is likely to cause a rise of 1.5°C to 4.5°C in the average global temperature by the end of the century. As the ice caps and glaciers melt in response to this atmospheric warming the sea level will rise, threatening coastal cities and flooding coastal wetlands. Another serious consequence of global warming is a shift in the global distribution of temperature and rainfall.

For Your Information

Some UV rays are helpful in converting cholesterol to vitamin D in our skin. So a reasonable amount of sunlight is good for your body However, prolonged exposure can cause sunburns and increase the risk of skin cancer.

A reason for global warming is also the depletion of the ozone layer. In the stratosphere, there are molecules of ozone (O_3), which form a layer. This layer filters out a lot of the Sun's ultraviolet (UV) rays, which are harmful to life on Earth.

The ozone layer is being depleted by pollutant gases, reaching the stratosphere. It results in more UV rays reaching the Earth's surface. It is increasing the temperature and also causing health problems in human (like skin cancer) and harming plant life.

16 .6 Pollution: Consequences and Control

Pollution is defined as "the undesirable change in the physical, chemical or biological characteristics of the air, land or water that may or will harmfully affect human life or life of other species". So any change in the environment, which disturbs life is called pollution and the agent, which causes pollution is called of a pollutant.

16.6.1 Types of Pollution

1. Air Pollution

Air pollution is defined as the presence of any substance in the atmosphere added by the activities of human beings, which can affect the comfort, safety and health of living organisms. Major causes of air pollution are given below:

(a) Oxides of carbon: Combustion of fuel processes produces oxides of carbon like carbon dioxide and carbon monoxides.

(b) Oxides of nitrogen: The sources of oxides of nitrogen are chemical fertilizers, lightning and decay of organic matter.

(c) Oxides of Sulphur: Burning fuels in cars produces sulphur dioxide. It is also emitted from brick kilns and volcanic eruption.

(d) Chlorofluorocarbons: CFCs emissions from refrigerators and air conditioners are major reasons for depletion of the ozone layer.

(e) Lead compounds: Compounds of lead cause air pollution, which can cause damage to the brain.

(f) Particulates: These are the particles suspended in the air like dust particles, ethylene and acetylene.

Fig.16.23 Factories and vehicles are major sources of air pollutants

Effects of Air Pollution

- Reduced lung functioning
- Irritation of eyes, nose, mouth and throat
- Increased respiratory disease such as bronchitis, asthma
- Reduced energy levels
- Headaches and dizziness
- Disruption of endocrine, reproductive and immune systems
- Cardiovascular problems
- Cancer

2. Water Pollution

Water pollution is the contamination of water bodies (e.g. lakes, rivers, oceans and ground water). Water pollution occurs when pollutants are discharged directly or indirectly into water bodies without adequate treatment to remove harmful compounds. The following are major causes and effects of water pollution:

(a) Incomplete Treatment of Sewage: Domestic sewage water from household is discharged into rivers and lakes. Due to sewage pollution the concentration of ammonia, nitrates and phosphate increases and that of oxygen decreases in water. This results in the death of aquatic life. Sewage serves as food for pathogen. Some waterborne diseases caused as a result include typhoid, amoebiasis, hepatitis, diarrhoea etc.

Fig.16.24 Lack of proper treatment of sewage is a common sight in Pakistan

(b) Oil Spills: Water pollution may also be caused due to oil spills during the filling of oil tankers or due to accidents of tankers. Oil discharged into oceans spreads over the water surface preventing the penetration of sunlight and mixing of oxygen with water. As a result of this marine plants and animals die because of suffocation.

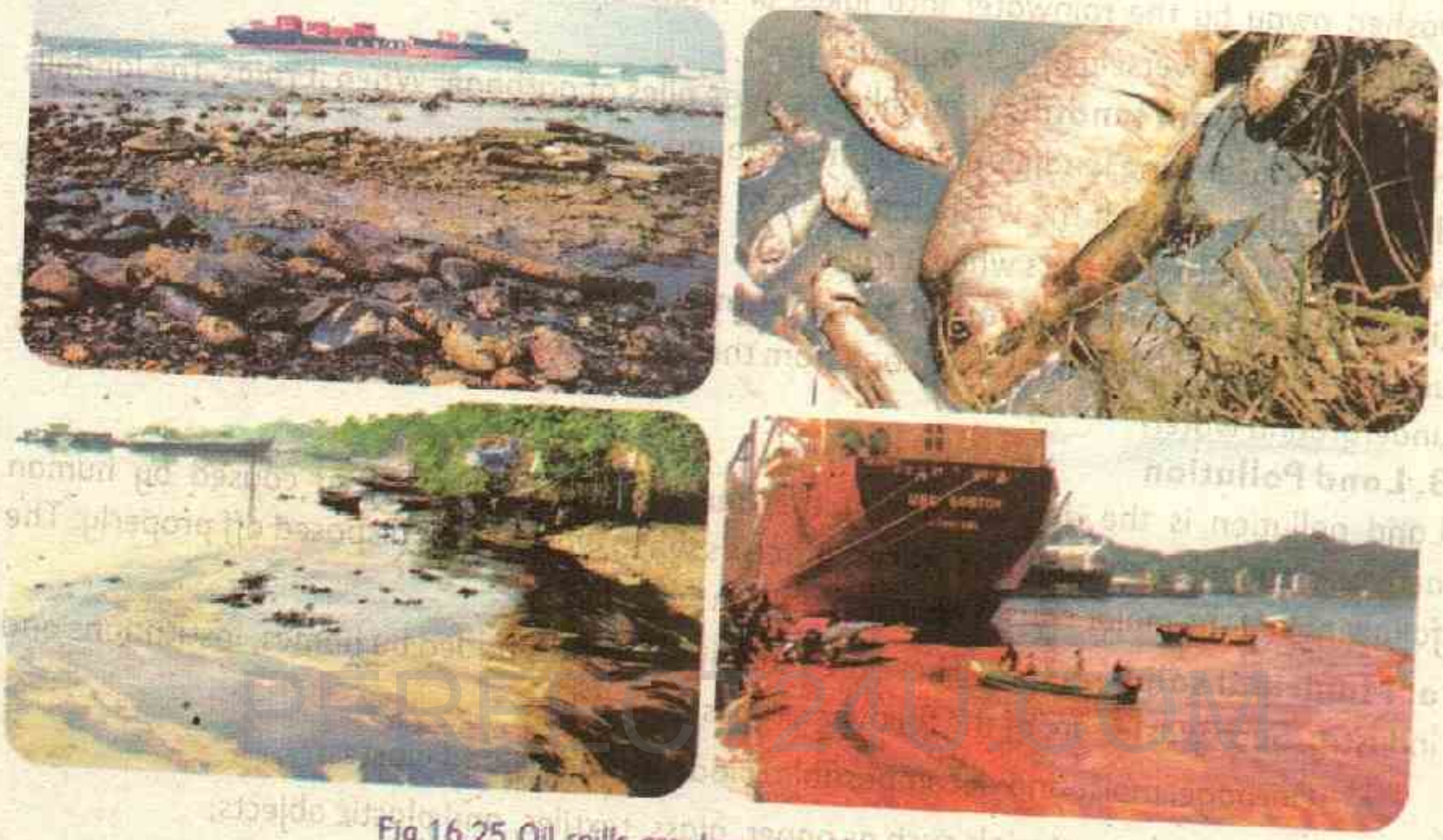


Fig.16.25 Oil spills are dangerous for marine life

(c) Industrial Effluent: Industries generate a lot of waste materials. Some of these wastes contain very toxic compounds of mercury, cadmium, lead, chromium and arsenic.

(d) Insecticides: Decomposers cannot breakdown some insecticides such as DDT. Rainwater may carry such insecticides into streams, river and lakes. The insecticides in water result in the poisoning of fish or other animals drinking such water.

Fig.16.26 Insecticides used in agricultural fields result in polluting water bodies

(e) Herbicides: Herbicides are used to eliminate weeds. Some of the herbicides contain a substance called dioxin, which is harmful. When it is washed by rainwater into streams or rivers, it pollutes that water witch can cause cancer.

(f) Chemical Fertilizers: Most of the fertilizers are not absorbed by the crops and may be washed away by the rainwater into lakes or rivers and thus cause water pollution. Such polluted water adversely affects aquatic life.

(g) Leakage from landfills: Landfills are huge piles of garbage. When it rains, the landfills may leak. The leaking landfills pollute underground water.

(h) Animal wastes: If the waste materials of cattle are not disposed off properly, these are washed away into the rivers when it rains.

(i) Leakage from underground petroleum storage: Petroleum is transported through underground pipes. Accidental leakage from these pipes may cause mixing of petroleum with underground water.

3. Land Pollution

Land pollution is the degradation of the Earth's land surfaces often caused by human activities and misuse of land resources. It occurs when waste is not disposed off properly. The following are the major causes of land pollution.

a. Municipal solid wastes: These are the solid materials added by homes, institutions and industry. Such wastes are of the following types:

- Garbage: moist and decomposable (biodegradable) food wastes;
- Rubbish: dry materials such as paper, glass, textiles, and plastic objects;
- Trash: bulky waste materials (e.g., discarded mattresses, appliances, furniture)
- Medical wastes: surgical gloves, body fluids (e.g. blood), X-ray equipment

Fig. 16.27 If solid waste is not properly treated then such sights will keep on increasing in every nook and corner of Pakistan

b. Agricultural activities: Besides domestic waste, pesticides and herbicides used by farmers to increase crop yields also pollute the land when they are washed into the soil.

c. Construction debris: This includes wood and metal objects, concrete rubble, asphalt, and other materials produced when structures are built or demolished.

d. Air and water pollutants: When polluted water enters the soil, it changes the quality of soil and causes land pollution. Similarly, air pollutants can also lead to land pollution. For example, acid rain dissolves away some of the important nutrients present in the soil and changes the composition of the soil.

16.6.2 Control of Pollution

Pollution causes unexpected and sometimes serious and devastating changes in our land, river and sea environments. Pollution can kill animals and plants and it will harm us too. Some of the control measures for pollution are as under.

Tidbit

When you are recharging electronic items (like mobile phones), do not leave them on indefinitely overnight. Recharge them and then unplug them so as not to waste energy.

Control of Air Pollution

Several attempts are being made on personal, industrial and governmental levels to control air pollution and to stop global warming.

1. Treatment of industrial exhausts: Before their release into the atmosphere, the industrial exhausts should be treated to filter dangerous air pollutants from them.

2. Use of public transportation: Governments should encourage people to use public transportation or adopt car-pooling to save energy and money.

3. Use of lead-free and Low sulphur fuels: Lead-free fuels should be used in vehicles. Similarly, coal with low levels of sulphur should be used in industry.

4. Conservation of energy: Large amounts of fossil fuels are burnt to produce electricity. On a personal level saving electricity should be made a habit. For example switching off fans and lights when not in the room. Energy saver lights/LED consume less electricity as compared to traditional bulbs and tube-lights.

5. Use of clean energy resources: Clean energy technologies like solar, wind and geothermal are in high demand these days. These will reduce the amount of electricity being produced through the burning of fossil fuels.

6. Plantation of trees: Trees absorb carbon dioxide from the air, hence causing its reduction in the air. Governments are establishing new forests on clear lands. This process is called **afforestation**.

Control of Water Pollution

1. Waste water treatment: This is the most direct method to control water pollution. It is the removal of impurities from waste water before it reaches water bodies (lakes, rivers, sea).

2. Removal of pollutants from underground water: Water supply agencies should apply techniques, e.g. reverse osmosis and filtration, for the removal of pollutants from water.

3. Reutilisation and recycling of wastes: Various wastes may be recycled to produce benificial products, e.g. urban wastes may be recycled to generate cheaper biogas and electricity.

4. Absorption by plants: Certain plants can absorb pollutants from the water present in soil. They accumulate such pollutants in their bodies without any harm.

Control of Land Pollution

1. Production of less wastes and recycling: People should produce less waste by using and re-using some products like plastic bags, towels etc. The waste materials (plastics, glass, paper etc.) can be recycled to make new objects.

2. Proper disposal of wastes: If wastes is properly disposed off, the chances of reducing land pollution increases significantly. Throwing garbage on the roads and footpaths causes land pollution and huge inconvenience to passers-bys.

Fig. 16.28 Improper and proper disposal of solid waste

3. Solid waste management: The government should construct standard landfills. Such landfills have an impermeable bottom and do not allow the leakage of pollutants to the underground water. These landfills also do not allow the release of methane gas into the atmosphere. Methane collected in the landfill can be used as biogas.

4. Disposal of dangerous waste: Solid hazardous waste are buried in deep landfills while liquid hazardous wastes are disposed of in deep-wells. The deep landfills have an impermeable bottom and there is 3 metres (10 feet) of soil between the bottom and underlying rock or ground water. Underground deep-wells (into which liquid waste is pumped) are sealed by impermeable layers and are at least 400 metres away from drinking-water suppliers.

Observing, Analysing and Interpreting

- Interpret the data about local environmental problems (data may be collected through surveys or literature review).
- Plan and carry out simple investigations to determine the nature and effects of pollutants.

Pakistan Environmental Protection Agency (Pak-EPA)

Pakistan Environmental Protection Agency was established under the Pakistan Environmental Protection Act, (PEPA) 1997. The basic function of Pak-EPA is to ensure clean environment by;

- Conducting scientific research for the prevention of pollution
- Identifying the needs for various sectors of the environment
- Providing information and guidance to the public on environmental matters
- Specifying safeguards for the prevention of accidents and disasters

Encouraging the formation and working of non-governmental organisations, community organisations, and village organisations to prevent and control pollution and promote sustainable development

16.7 Conservation of Nature

Conservation is the protection and preservation of natural resources. Environmental conservation is the management of the biosphere by humans in a way that it may yield the greatest benefits to the present generation. At the same time maintaining its potential to meet the needs and demands of future generations.

Importance of Conservation

Conservation of natural resources is very essential for ensuring a continuous yield of plants and animals and materials for the fast growing human population. Human activities can upset the balance of nature; therefore conservation of the environment is needed. The following are the main objectives of conservation of nature.

- Ensure the protection of plants and animals species.
- Prevent extinction of plants and animals.
- Maintenance of a stable ecosystem with balanced biochemical cycles.

- Minimise pollution to prevent global warming, greenhouse effect and acid rain.
- Ensure conservation of marine life as it is a major source of food.
- Ensure conservation of forests, which provide fibre, textile, oil, rubber, food, wood, timber, medicine, perfume and furniture.
- Enhance tourism industry.
- Provide employment to people.

Tidbit

Paper is made from wood pulp. So imagine if one ton of waste paper is recycled, it can save approximately 17 trees.

Methods for the conservation of nature

1. Reduce the amount of waste by just curtailing the extra use of resources. Such products should be selected which produce minimum waste e.g. hand-made bags instead of plastic bags. Other examples include use of electronic mail (email) instead of paper, closing water taps when not in use, turning the lights and fans off when not in use, and taking public transport or walking or cycling for short distances.

2. Reuse means utilising the same products again or in another way instead of discarding them. It costs less than purchasing the new product. For example we can reuse plastic bags, aluminium foil, old magazines, newspapers, old clothes, jars, envelopes, and containers. We can also use rechargeable batteries rather than single-use batteries. Use of reusable plates during meals, instead of disposable plates is another method.

3. Recycle products that can be easily recycled. Recycling is the process of taking up of old materials and waste products and using them to make another product. Much of the products used for packaging today like paper, plastic, glass, metal, electronics, aluminium cans are recycled. Recycling is good for the environment. By recycling, resources are saved and less wastes is produced.

Other ways for the conservation of nature

- Plant a tree
- Walk as much as you can
- Ride bikes for short distances
- Use carpooling
- Use less time to take bath
- Use energy-efficient light bulbs
- Use both sides of your paper
- Avoid use of plastic water bottles
- Buy and eat local foods
- Grow your own vegetables
- Go to a car / bike wash rather than washing at home
- Unplug electronics that aren't in use
- Avoid using spray paint

Key Points

- Population is a group of individuals, belonging to the same species living in the same place, at the same time.
- A group of individual belonging to different populations occupying the same area, living at the same time and sharing the same resources is called community.
- Ecosystem is a natural area where living organisms and the environment interact and exchange material between them so as to achieve functional stability.
- The existence of the living world depends upon the flow of energy and circulation of materials through the ecosystem.
- In mutualism, both the partners are mutually benefited and none of them is harmed.
- In commensalism only one partner is benefited and the other is neither benefited nor harmed.
- The living place of an organism together with its surrounding is called the environment.
- An ecosystem consists of two major components namely, abiotic (non-living) components and biotic (living) components.
- Abiotic components of an ecosystem are light, water, temperature, atmosphere, fire, soil, inorganic nutrients and gravity.
- Biotic components of an ecosystem are of three types, namely producers, consumers and decomposers.
- The Sun is the ultimate source of energy flow in the ecosystem.
- Food chain is defined as a process of eating and being eaten.
- Back and forth movements of chemical elements between organisms and environment along characteristics circular paths are known as biogeochemical cycles.
- Interdependence between organisms may be useful (positive), harmful (negative) for one or both interacting organisms and interdependence may be positive-positive or positive-negative.
- Conservation is the protection and preservation of natural resources.

Exercise

A. Select the correct answer.

1. Energy flow through an ecosystem is always:
   a. Unidirectional b. Cyclic c. Reversible d. Multidirectional
2. The largest reservoir of nitrogen on our planet is:
   a. Ocean b. Atmosphere c. Phage DNA d. Fossil fuels
3. Overgrazing results in:
   a. Soil erosion b. Retention of useful species
   c. Productive soils d. All of the above
4. The three R's responsible for a better environment are:
   a. Reduce, Reuse, Recycle b. Read, Register, Recall
   c. Random, Reduce, Recall d. Reduce, Rebuild, Restrict
5. A food web consists of:
   a. Interlocking food chains b. Producers, consumers and decomposers
   c. A portion of a food chain d. A set of similar consumers
6. Predation helps to maintain balance in:
   a. Community b. Population c. Ecology d. Ecosystem
7. An ecological pyramid refers to the:
   a. Pyramid of energy b. Pyramid of number
   c. Pyramid of biomass d. All of the above
8. When the oxides of nitrogen (NO, NO_2) and sulphur (SO, SO_2, SO_3) interacts with water vapours then the acids produced are:
   a. Acetic and Citric acid b. Sulphuric and Nitric acid
   c. Hydrochloric and Nitric acid d. Sulphuric and Citric acid
9. The process in which nitrates and nitrites are reduced to nitrogen gas by bacteria is:
   a. Assimilation b. Denitrification
   c. Ammonification d. Nitrification
10. The relationship between Rhizobium bacteria and leguminous plants is an example of:
    a. Parasitism b. Mutualism c. Commensalism d. None of these

B. Write short answers to the following questions.

1. Define the terms: species, biosphere and ecosystem.
2. Differentiate between population and community.
3. Differentiate between food chain and food web.
4. How does deforestation affect the environment?

5. Distinguish between herbivore, carnivore, and omnivore.
6. Outline the role of bacteria in the nitrogen cycle.
7. How can overpopulation affect the environment?
8. Name any five sources of water pollution.
9. Differentiate between parasitism and mutualism.
10. Define nitrogen fixation and nitrification.

C. Write detailed answers to the following questions:

1. Describe the nitrogen cycle in detail. What would happen if the nitrogen cycle stopped working?
2. Compare the flow of materials and the flow of energy in the ecosystem.
3. Write a note on the energy flow through different components of an ecosystem.
4. What are the different ways through which organisms of the ecosystem interact with each other?
5. Discuss the biotic components of the ecosystem.
6. Write notes on the three types of symbiosis.
7. Enlist the causes of water pollution and also describe how water pollution can be controlled.
8. Write a comprehensive note on land pollution.
9. Explain, by making diagrams, the pyramids of number and biomass.
10. Write a note on the causes and effects of air pollution.

Activities

Visit a pond and compare the abiotic and biotic factors of a pond with that of an aquarium.

Science, Technology and Society

1. State how your city or village is an ecosystem and describe your position and role in that ecosystem.
2. Describe the possible consequences of competition (due to limited resources and overpopulation) in human society.
3. Use data from the Internet and literature on Pakistan's population growth from 1998 to 2017 and interpret this population growth and the possible consequences on our society.
4. Identify the environmental problems in your community. What are the causes and what should be done to solve these problems?
5. How would you design a campaign against pollution in your area? What would the key messages be and what would you prioritise? Give reasons.
6. Organise a poster or picture exhibition at school on some environmental topic.

Unit

17

BIOTECHNOLOGY

Students Learning Outcomes

The students will be able to:

- Define biotechnology and explain its importance.
- Relate biotechnology with genetic engineering and fermentation.
- Define fermentation.
- Explain the method of fermentation by yeast and bacteria.
- Identify different fermentation products and their importance in daily life i.e. yogurt making, bread making, making of cheese and production of alcohol.
- Explain the use of fermenter in large-scale production of microorganisms and their products.
- Describe the procedure of using fermenters.
- Describe the advantages/profitability of using fermenters in preparing medical products.
- Define genetic engineering and describe its objectives.
- Describe how a gene is transplanted.
- Describe major achievements of genetic engineering with reference to improvement in agricultural crops (herbicide resistance, virus resistance and insect resistance).
- Describe major achievements of genetic engineering in curing animal diseases (foot-and mouth disease, Coccidiosis, Trypanosomiasis) and in animal propagation (animal cloning).
- Describe the application of genetic engineering in the production of human insulin and growth hormones.
- Describe single-cell protein and its importance.
- Describe the significance of single-cell protein in animal feed.
- State the significance of single-cell protein in human food.

Introduction

Biotechnology has been flourishing since prehistoric times. It all started when, the first human beings realised that they could plant their own crops and breed their own animals. These people were applying biotechnology. Biotechnology can be seen in action when milk is converted into cheese and yogurt. Or when vinegar is prepared by fermenting solutions of sugar. In the same way, long ago bakers learned and used biotechnology to make soft, spongy bread.

More specifically, the term "biotechnology" refers to the use of living organisms or their products for the welfare of human beings. It has various applications in different fields such as Therapeutics, Diagnostics, Processed Food, Waste Management, Energy Production, Genetically Modified Crops etc. Many life saving drugs, higher yields of crops, stronger and better breeds of animals and livestock, and a variety of processed foods, are all a result of biotechnological advancements.

Tidbit

What do you think of when you hear the word "biotechnology"? May be things you have seen in the news, such as Dolly the cloned sheep or the controversy on genetically modified organisms, or gene therapy.
Research the topic and discuss your findings and opinions with your classmates.

17.1 Importance of Biotechnology

In the 19th century after the discovery of Mendel's laws of heredity, scientists began to explore more about genes and characters. It resulted in new advancements in biotechnology. With the discovery of the structure and function of DNA in 1953, modern biotechnology emerged. The techniques being used in modern biotechnology include fermentation, genetic engineering, and tissue culture.
Biotechnology has its positive impacts almost in every field of life. It finds out the best possible technological measures that prove beneficial for the humankind without disturbing nature. Biotechnologists use microorganisms in various ways for obtaining benefits related to food production, health and the environment.

17.2 Fermentation

The term "fermentation" is used for two concepts i.e. (i) as a type of cellular respiration, and (ii) as a technique in modern biotechnology.

17.2.1 Fermentation as a type of cellular respiration

Anaerobic respiration is also called fermentation. It happens in the absence of oxygen. In this process, glucose is oxidized incompletely and a little amount of energy is released. It occurs in different organisms and is of two types.

a- Alcoholic fermentation by yeast cells

Alcoholic fermentation is a two-step process. In this fermentation, the glucose molecule is first broken down into two molecules of pyruvic acid. This step is called glycolysis. In the next step, pyruvic acid is further broken down into carbon dioxide and ethanol. This fermentation occurs in yeast *(Saccharomyces cerevisiae)*. Scientists use this process to produce alcohol during the making of alcoholic products, ethanol fuel and bread.

Do You Know?

The science of fermentation is known as zymology.

b- Lactic acid fermentation by bacteria

The first step in this fermentation is similar to alcoholic fermentation. The glucose molecule is broken down into two molecules of pyruvic acid. In the second step, hydrogen is added to pyruvic acid (reduction), which changes it to lactic acid. This fermentation occurs in bacteria e.g. *Lactobacillus* and *Streptococcus*. Lactic acid fermentation done by bacteria is used to turn milk into yogurt.

For Your Information

Lactic acid fermentation also occurs in our skeletal muscles, during exercise or other hard jobs.

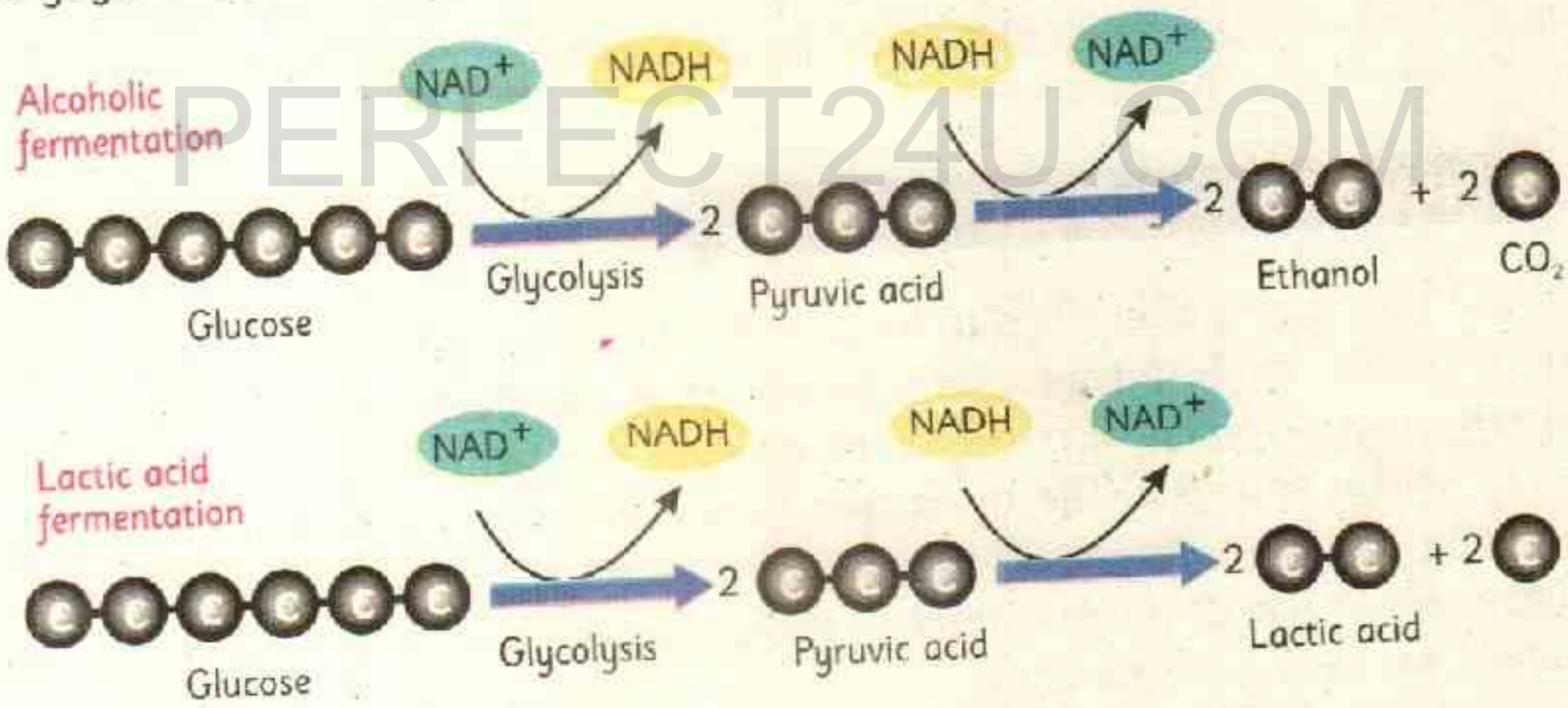
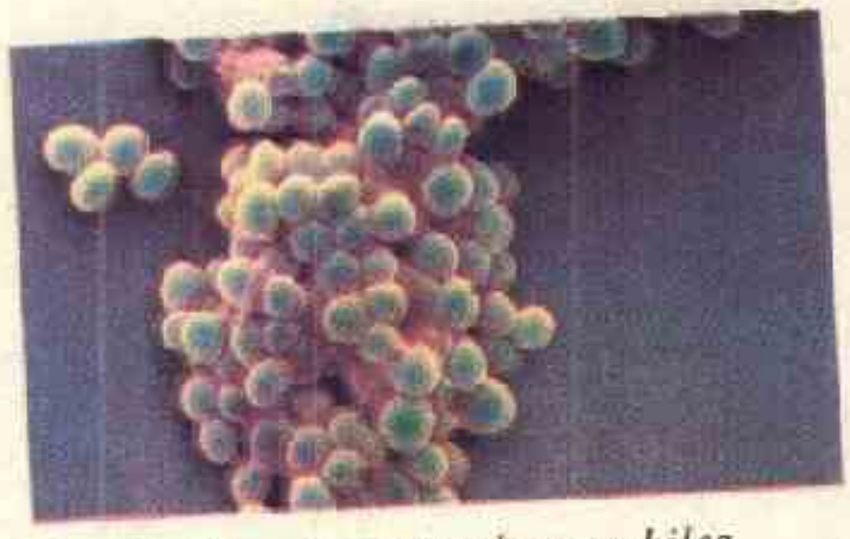


Fig.17.2 Types of fermentation

Fig: 17.3 a. *Lactobacillus bulgaricus*



b. *Streptococcus thermophiles*

Yogurt is produced from whole or skimmed milk. It is inoculated with a starter culture, which usually contains *lactobacillus bulgaricus* and *streptococcus thermophiles*. These bacteria ferment the lactose in the milk to lactic acid which acts on the milk protein to give yogurt its texture and flavour. In this way milk is converted to curd and forms yogurt.

Fermentation Products

The following are the most consumed fermentation products worldwide:

1. **Alcohol** is made as a result of the fermentation of a natural source of sugar with a catalyst, which is usually yeast. During fermentation, the carbohydrates (starch and sugars) are the main source which are converted into carbon dioxide and ethyl alcohol. Alcohol is widely used in medicines.

For Your Information

Cheese, vinegar, pickles, chocolate, coffee, linen methane, and liquor are just a few of the items produced through fermentation. Chemical companies are researching new ways to create vitamins, medicines, organic chemicals (acetic acid, ethylene glycol, amino acids) through biological processes.

2. **Yogurt** is lactic acid containing milk, fermented by bacteria. Lactose present in milk is converted to lactic acid during fermentation.
3. **Bread:** Wheat dough is fermented to make bread. Fermentation plays an important role in softening the bread and is also responsible for its aroma. This fermentation is mainly carried out by yeast and sometimes by bacteria.
4. **Cheese** is formed when bacteria converts milk lactose into lactic acid, due to which milk proteins are also coagulated. In this way, milk changes into cheese.
5. **Pickles** are made as a result of fermentation of fruits and vegetables. The by-products of fermentation turn fruits and vegetables into pickles.
6. **Soy sauce** is made by fermentation of soybeans by fungi.
7. **Chocolate is produced** when cacao beans undergo the process of fermentation.
8. **Many chemical products** are also produced through the fermentation process e.g. formic acid, glycerol and acrylic acid etc.

17.2.2 Fermentation in Modern Biotechnology

In modern biotechnology, the term **"fermentation"** means the large-scale production of any product by the massive culture (population) of microorganisms. Such microorganisms are grown in a large container called a **fermenter**.

Fermenter

This is a large container in which populations of microorganisms are grown to produce large quantities of products. Fermenters (also called bioreactors) provide suitable environment (temperature and pH etc.) for quick metabolism in microorganisms. It provides a specialized medium in which all essential nutrients of microorganisms are present. When raw material is

added to the medium, microorganisms carry out metabolic reactions to make products. Fermenters are used for the manufacture of many products e.g. medicines (antibiotics, vaccines, interferon, hormones etc.), enzymes (cellulose, protease, lipase etc.), and other products (ethanol, lactic acid etc.).

Procedure to use Fermenter

Discontinuous (Batch) fermentation

In this fermentation, the whole process is divided into batches. The tank of the fermenter is filled with the raw materials and nutrients. The population of microorganisms is added which performs fermentation and makes the products. During the reactions occurring in the fermenter, no microorganisms or nutrients are added or removed from the culture. The contents of the fermenter are taken out for further processing after the required time has elapsed/passed. The fermenter is cleaned and the process is repeated.

For Your Information

In a fermenter, temperature, pH and oxygen meters are linked to a computer which monitors the conditions inside the vessel. Paddle stirrers ensure that the microorganisms, and raw material are well mixed.

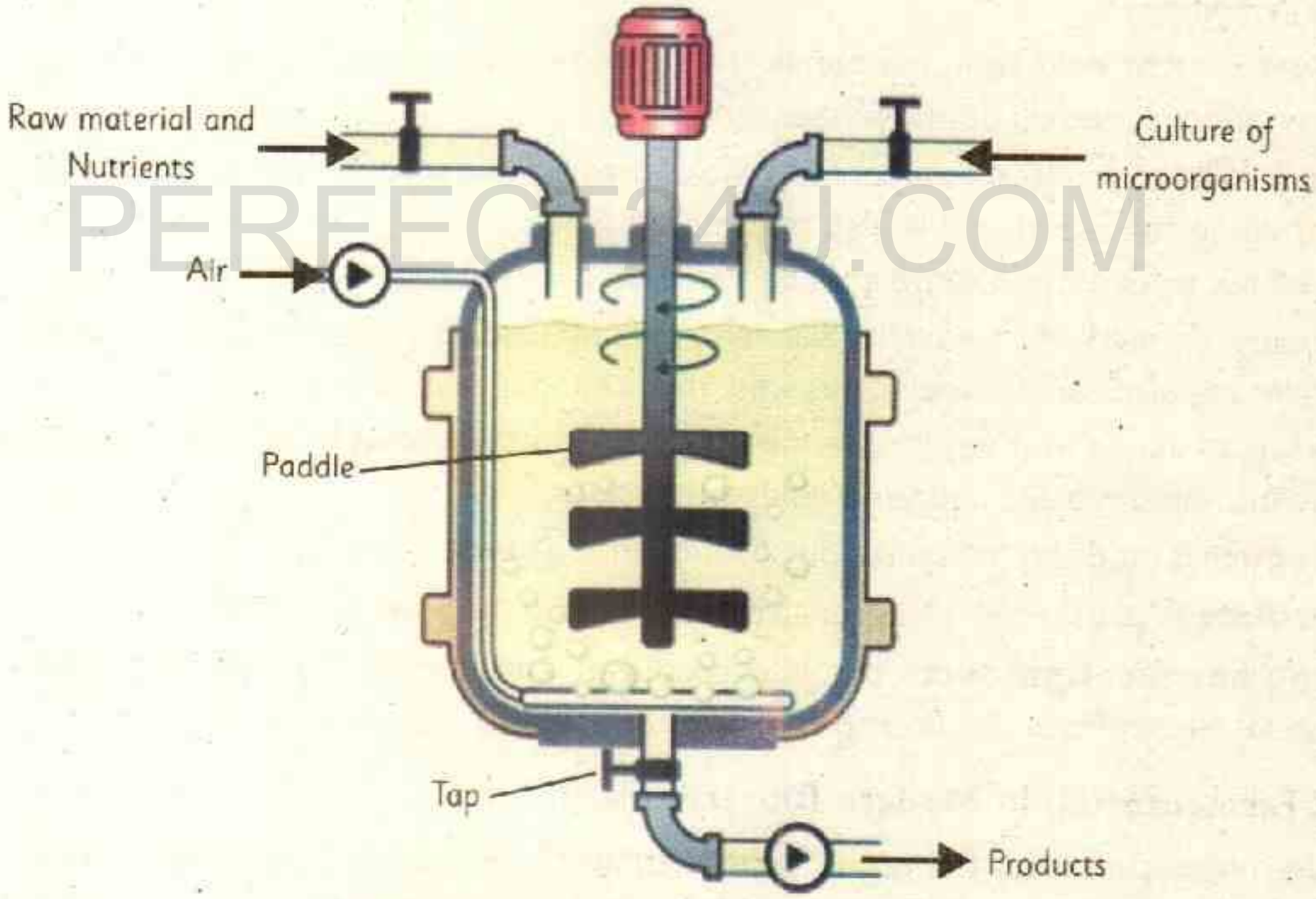


Fig.17.4 Discontinuous (Batch) fermentation

Continuous fermentation

In continuous fermentation, the exponential growth of microbes is maintained in the fermenter for prolonged periods of time. While the population of microorganisms is added to the fermenter once, raw material and nutrients are added continuously at regular intervals.

Thus unlike batch fermentation (above) the, continuous fermentation process never stops in between and it continues to run for a longer period. The fermentation products are also taken out continuously.

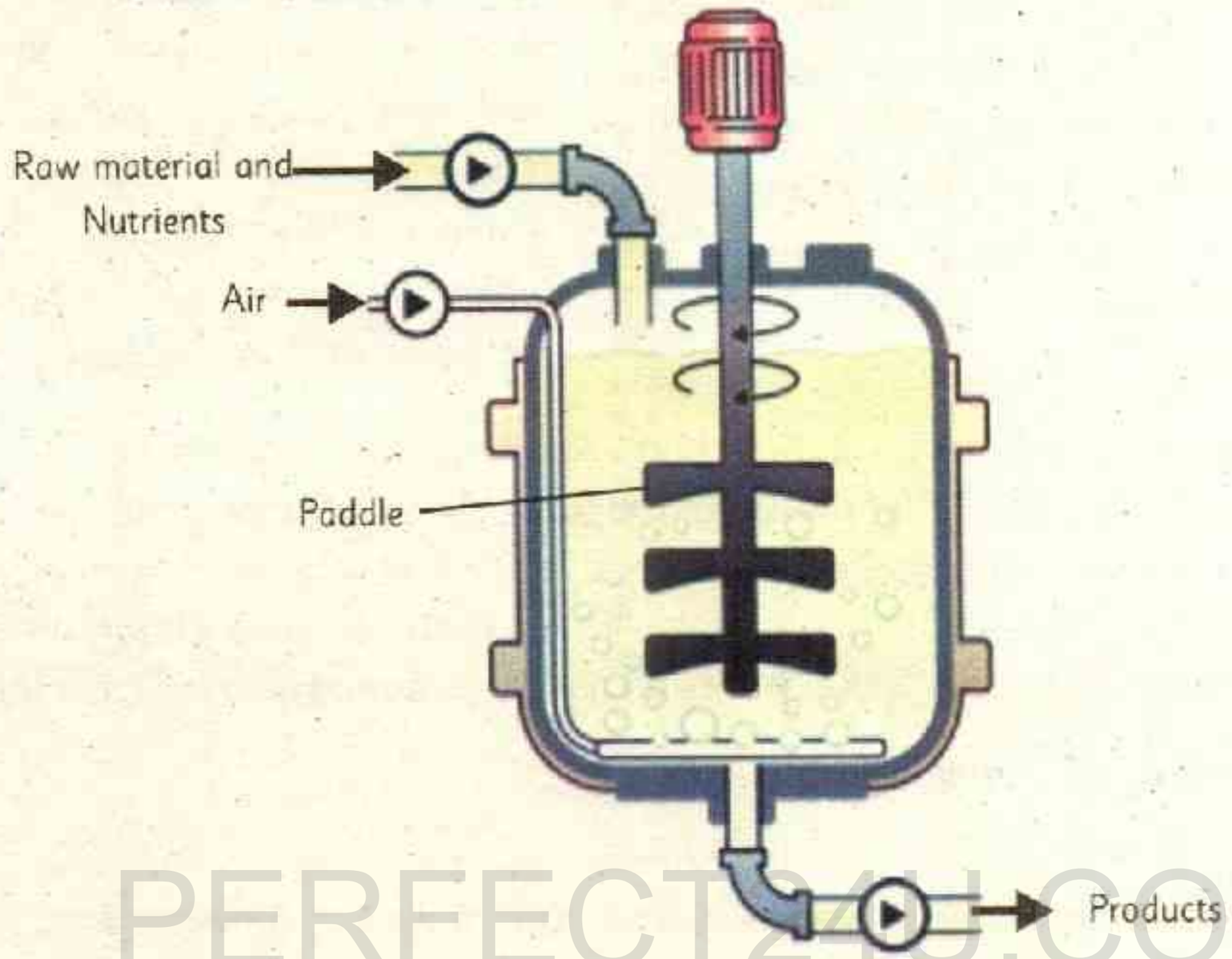


Fig.17.5 Continuous fermentation

Advantages of a Fermenter

1. Fermenters have and auto control system so environmental changes cannot harm microbial growth.
2. Separation of products is easy and safe.
3. Inoculation of microbes is easy.
4. Wastage of materials in handling is minimised by fermenters.
5. They can be installed with ease and take up very little space.
6. Single fermenters can be used for production of a wide range of products.

Fermenters enable the production of medical products, such as penicillin, Insulin, Erythromycin, Streptomycin, Griseofulvin (Antifungal antibiotic) and hundreds of other products from microbes.

Activities

1. Investigate the role of yeast in the fermentation of flour. Use flour, water, salt and yeast to perform your experiment.
2. Investigate the role of bacteria in the fermentation of milk.

17 .3 Genetic Engineering and its Uses

Genetic engineering is considered as the area of biotechnology that induces DNA alterations, artificial manipulation and transfer of genetic material from one organism to another. Genetic engineers have the ability to find specific genes, to cut them away from chromosomes and insert them into the chromosomes of other organisms.

For Your Information

The bacterium that is found in the bowels of humans namely *Escherichia coli* is drawing the attention of genetic engineers. This bacterium has become one of the most powerful tools known in genetic manipulation.

Recombinant DNA technology is a method used in genetic engineering. This technology involves the selection of DNA of one organism (donor) and its introduction to combine with the DNA of another organism (recipient). As a result, the recipient organism acquires the genetic abilities of the donor, and is called Genetically Modified Organism (GMO). The DNA that is a combination of genes from two different sources is called recombinant DNA.

17.3.1 Objectives of Genetic Engineering

The main objectives of genetic engineering are;

1. Identify and isolate genes that cause disease, with a view to repair or eradicate them so that their harmful effects are negated.
2. Find remedies and therapies to treat non-genetic diseases.
3. Develop more sophisticated and effective medicine through genetic engineering for example bio-engineered insulin and human growth hormone (somatotropin).
4. Genetically Modified Organisms (GMOs). GMOs are produced to enhance the food production. Genetically modified crops and cattle produce more food in lesser time. They
5. are made disease resistant so that losses due to pathogens can be reduced.
6. Plants are genetically modified to get substances which they do not produce naturally such as antibiotics, certain proteins, hormones, etc.

Fig.17.6 Genetically modified orange

17.3.2 Basic Techniques in Genetic Engineering

Bacterial cells have different kinds of enzymes. Some of these can cut DNA into fragments and others can join such fragments. For example, **restriction endonucleases** are involved in cutting DNA at specific sites. Hence they are called molecular scissors. The enzyme **DNA ligase** acts like a paste molecule to join DNA fragments. Thus the restriction endonuclease and the DNA ligase are the basic tools required for genetic engineering.

Basic techniques of genetic engineering are as follows.

1. Isolation of gene of interest: The gene (DNA) of donor organism or **gene of interest** is identified. It is then isolated from the chromosome of the donor by using restriction endonucleases.

2. Making Recombinant DNA: The gene of interest is attached to a suitable **vector** (cloning vehicle), to carry the gene to the host organism. The most common vector used in genetic engineering is plasmid. It is the extra chromosomal circular DNA of *Escherichia coli*. Bacteriophages. (viruses that can enter bacteria) are also used as vectors. The DNA of the vector is cut into fragments by the restriction endonucleases. Using the enzyme DNA ligase, the DNA fragments of the donor and vector are joined together. As a result recombinant DNA is obtained.

3. Gene Cloning: The recombinant DNA is introduced into the host bacterial cell. The host cell is treated with enzymes so that their cell wall becomes permeable for the recombinant DNA. The host bacterial cell continues to multiply with the foreign DNA or gene of interest. After a short time, this results in a colony of bacteria having the recombinant DNA. Each colony is grown separately to get a number of colonies having identical copies of recombinant DNA. This is called **gene cloning**.

As a result of the transfer of the donor's gene into the bacteria, the bacteria are genetically modified. They start preparing the product by using the donor's gene.

17.3.3 Major Achievements of Genetic Engineering

Benefits of genetic engineering are experienced in many fields especially in agriculture, in the production of valuable proteins and vaccine production.

1. Achievements in the field of Agriculture

With respect to agriculture, modern biotechnology is seen as the second phase of the green revolution. Many genetically modified organisms (GMOs) have been produced. Some useful benefits of genetically modified plants are: improved nutritional quality; better nitrogen fixation; virus resistance; herbicidal resistance; insect resistance; disease resistance; and enhanced efficiency to use minerals. Details on some of these are provided below.

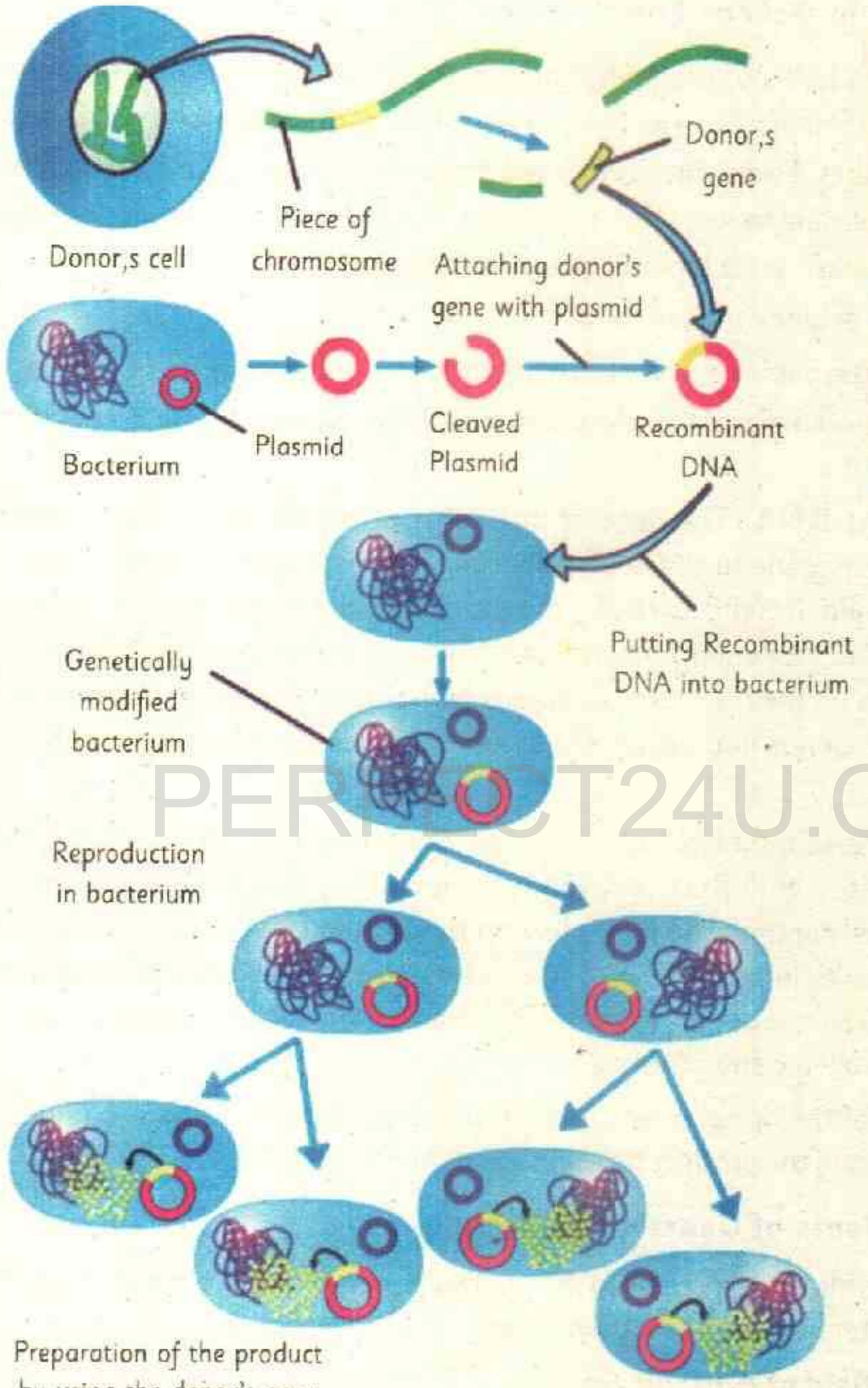


Fig.17.6 *Transfer of a gene to an organism and its cloning*

Resistance against Herbicides

Herbicide resistant genes have been incorporated into many crops of soybean, corn, and cotton. Therefore, herbicides can be used around these plants to kill weeds without harming the crops.

Resistance against Viruses

Virus resistant traits have been introduced into many crops, including squashes, tomatoes, potatoes, tobacco etc. These plants are not affected by viruses and survive viral attacks.

Resistance against Insects

Widespread use of insecticides, fungicides and pesticides for crop protection has damaging effects on the environment. It is important to improve the control of pests by genetic means. Genetic engineers have introduced pest resistant genes into several crops, including tomato and cotton. Such modified plants show resistance against pests.

2. Achievements in Curing Animal Diseases

Human Insulin was the first genetic engineering product. In 1982, the human gene for insulin was inserted into a bacterium. Since then, the modified bacteria are providing large amounts of human insulin.

Vaccine against hepatitis B virus has been produced from yeast through genetic modification.

Human growth hormone was produced in genetically modified bacteria. It is used to treat dwarfism.

Interferon (anti-virus protein) is made in genetically modified bacteria.

Vaccine against Foot and mouth Diseases are being developed for foot-and-mouth disease, a highly contagious viral disease that infects cattle, sheep, and other animals.

Vaccine against Coccidiosis (a parasitic disease of the intestinal tract of animals). This vaccine kills protozoan that causes coccidiosis.

Treatment of Trypanosomiasis (sleeping sickness) may be possible through use of biotechnological techniques. Trypanosomiasis is a parasitic infection transmitted by a fly in humans and other animals. Genetic engineers are doing research to develop such proteins which can kill the parasite of this disease.

Gene Therapy enables the treatment of genetic disorders. Through this technique genetic engineers treat genetic disorders by introducing a gene into the patient's cells. It is being used to treat genetic disorders of the blood (e.g. thalassaemia).

Animal Cloning has become possible due to biotechnology. Genetic engineers have successfully cloned mice, sheep, cows and other mammals. The basic idea behind cloning of animals is to transfer the readymade DNA into the egg and create an identical organism. In this method, the genetic information from a cell of the animal to be cloned, is transferred to an egg whose nucleus has been removed. Then the egg with the new genetic material is stimulated to divide and make a multicellular embryo. When this embryo is sufficiently developed, it is implanted into the uterus of a female host, who acts as its surrogate mother. The rest of the development of the embryo happens just like a normal organism. When the development is complete, the new animal is the exact clone of the parent whose nucleus was used. Dolly the sheep was cloned using this process by the Roslin Institute in Scotland in 1977.

Science, Technology and Society

Human beings rely on genetic engineering for many benefits such as medicines, improved varieties of organisms with novel products, treatment, solutions to environmental problems etc. However, these benefits are tagged with peril. In humans, when the foreign gene is inserted, it may interfere with the normal genes and therefore, affect the normal functioning. It may develop antibiotic resistance in human beings as all GM plants carry antibiotic resistance genes. The genetically modified organism may affect the normal balance in the ecosystem. Critics of rDNA fear that disease-producing organisms used in some rDNA experiments might develop extremely infectious forms that could cause worldwide epidemics.

17 .4 Single Cell Protein

For Your Information

The term 'single cell protein' was coined in 1966. Previously, the dried cells of microorganisms used as food or feed for animals and they were collectively known as Microbial proteins. This term was replaced by a new term 'single cell protein'

For centuries microorganisms have been widely used for preparation of a variety of fermented foods, for example cheese, butter etc. Some microorganisms have long been used as human food, e.g. the blue green alga spirulina, and the fungi like yeasts. More recently, efforts have been made to produce microbial biomass using low-cost substrates. These are used as a supplementary food for humans or as feed for animals. The isolated protein or the total cell material from microorganisms like bacteria, yeasts, filamentous fungi and algae used as food or feed is called single cell protein (SCP).

In view of the insufficient world food supply and the high protein content of microbial cells, the use of biomass produced in the fermenter or bio-reactor would be an ideal supplement for conventional food. Some of the major uses of SCP are as follows:

1. It is a rich source of protein (60 to 72 %), vitamins, amino acids, minerals and crude fibres.
2. It is a popular healthy food. 3. It provides valuable protein-rich supplement in human diet.
4. It lowers blood sugar level of diabetics and prevents the accumulation of cholesterol in human body.

Tidbit

Nowadays, Spirulina tablets are prescribed as enriched vitamin for most people.

In many countries, however people hesitate to use SCP as a major food source because of the following.

1. The high nucleic acid content (4 to 6 % in algae, 6 to 10 % in yeast of SCP) can cause health problems like uric acid formation and kidney stones.
2. Toxic or carcinogenic (cancer causing) substances absorbed from microbial growth substrate may be present.
3. The slow digestion of microbial cell in the digestive tract may cause vomiting, indigestion and allergic reaction.

High cost of production will also be a deciding factor in determining the ultimate place of SCP in the human or animal diet.

Key Points

- The term "biotechnology" refers to the use of living organisms or their products for the welfare of human being.
- Genetic engineering is considered as an area of biotechnology that induces DNA alterations, artificial manipulation and transfer of genetic material from one organism to another.
- Alcoholic fermentation is the conversion of sugar into carbon dioxide gas (CO_2) and ethyl alcohol.
- Alcohol is the fermentation product of yeast or bacteria.
- Yogurt is lactic acid containing fermented dairy product obtained from bacterial fermentation of milk.
- An apparatus that maintains optimal conditions for the growth of microorganisms, used in large-scale fermentation and in the commercial production of antibiotics and hormones, is called a fermenter.
- Recombinant DNA technology is a technique where the selected DNA of one organism (donor) is introduced into the another organisms (recipient).
- The main objective in genetic engineering is to identify and isolate genes which cause disease, with a view to repair or eradicate them so that their harmful effects are negated.
- Extra chromosomal circular DNA found in the cytoplasm of *Escherichia coli* is called plasmid which is regarded as the most suitable vector.
- Organisms whose genes have been altered by manipulation are called genetically modified organism (GMO).

Exercise

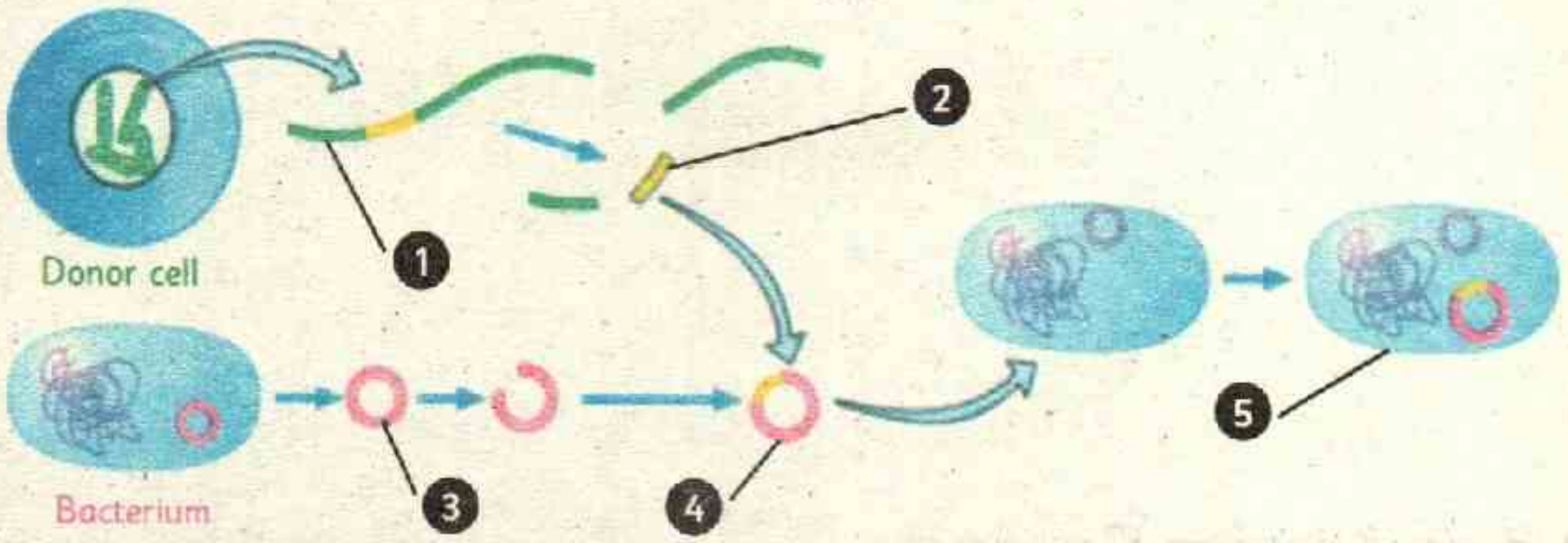
A. Select the correct answer.

1. The enzymes which are used to cut the DNA in specified sequences is:
   a. Ligase b. Protease c. DNAase d. Endonuclease
2. The DNA molecule in which the gene of interest is inserted for carrying to the target cell is:
   a. Transforming DNA b. Carrier DNA c. Phage DNA d. Vector DNA
3. Endonucleases used in genetic engineering are naturally present in:
   a. Bacteriophages b. Bacterial cells c. Plasmids d. Blue green algae
4. Fermenter is a machine which is basically used for:
   a. Increasing fermentation b. Production of enzymes used in fermentation
   c. Production of microorganisms d. Making the conditions optimum
5. *Lactobacillus bulgaricus* is a type of bacteria in the production of:
   a. Alcohol b. Cheese c. Yogurt d. All of the above
6. In a technique for genetic engineering, rDNA stands for:
   a. Genetic makeup b. Replicative DNA c. Recombinant DNA d. Retro DNA
7. Interferons are chemical which are used to:
   a. Kill viruses b. Improve immunity
   c. Work as vaccine d. All of the above
8. Which is a molecule containing DNA from two different organisms?
   a. Vector DNA b. DNA clone c. Plasmid DNA d. Recombinant DNA
9. What term is used for inserting a healthy gene into a person who has a defective gene?
   a. Cloning b. Gene therapy
   c. Vaccination d. Fermentation
10. Which of these can be used as a vector for inserting a gene into bacteria?
   a. Plasmid b. Algae c. Yeast d. E. coli

B. Write short answers to the following questions.

1. Write about any four products developed through fermentation.
2. Name any four microorganisms used in biotechnology. Also name the process in which they are used.
3. Why are vectors used in genetic engineering?

4. Write any five advantages of biotechnology in the field of agriculture.
5. How is yogurt produced through the use of biotechnology?
6. The following diagram shows how a gene is transferred to bacterial cell. Identify the structures labelled as 1 to 5.



C. Write detailed answers to the following questions:

1. Write a comprehensive note on the procedure of recombinant DNA technology.
2. How are single cell proteins produced and what is their significance?
3. What is a fermenter and how does it work?
4. Describe the advantages of using fermenters for getting products from genetically modified organisms.
5. Describe how biotechnology is helping humankind in the fields of food and health.

Activities

1. Investigate the role of yeast in the fermentation of flour.
2. Investigate the role of bacteria in the fermentation of milk.

Science, Technology and Society

1. Apply knowledge to identify different products of animal and human food having single-cell proteins.
2. Develop awareness of some social and ethical issues related to genetic engineering.
3. Describe the ways in which society benefits from the knowledge of genetic engineering.
4. Interpret the data collected from the internet on viral resistant, insect resistant and high yielding varieties of agricultural crops in Pakistan.

PHARMACOLOGY

Students Learning Outcomes

The students will be able to:

- Define pharmacology as the detailed study of drugs.
- Define the term 'drug' (the substance or product that is used to modify physiological systems of the body).
- Enlist the various sources of drugs i.e. minerals, animals, plants, synthetics, microorganisms.
- Describe the principle usages of painkillers, antibiotics, vaccines and sedatives.
- State the contributions of Joseph Lister in the discovery of antiseptics and of Alexander Fleming in the discovery of penicillin.
- Categorize and describe the effects of addictive drugs (sedatives, narcotics and hallucinogens).
- Define hallucinogen (drugs that alter ordinary mental and emotional processes) and relate it with Marijuana.
- Define narcotics (drugs that produce semi-consciousness and sleep to get relief from pain) and relate it with Morphine and Heroine (as the most widely used / abused).
- State the associated problems of drug addiction i.e. severe social abandonment and crimes.
- Identify the symptoms of addiction.
- Name different plants, which are common in Pakistan and used for getting hallucinogens and narcotics.
- Categorise sulfonamides, tetracyclines and cephalosporins as the major groups of antibiotics being used.
- Categorise major antibiotics as per their bactericidal and bacteriostatic effects.
- Rationalise the resistance developed in bacteria against the widely used antibiotics.

Introduction

Pharmacology is the science of the properties and effects of drugs on biological systems. The word "pharmacology" comes from the Greek word "pharmakon" which means drug. Pharmacology deals with the designing, developing, and testing of drugs that have the potential to reduce, and in some cases cure diseases. Pharmacology incorporates other biological sciences such as biochemistry, physiology, microbiology and genetics.

Tidbit

Unlike pharmacy, which is the science of the preparation and dispensing of drugs, pharmacology is the science behind how drugs produce their effects on the body, and what the body does to the drugs.

8.1 Medicinal Drugs

Drug means any compound that can modify the biological functions of living organisms. This definition includes not only medicines that have beneficial effects in the treatment of various disorders, but also chemicals such as caffeine, nicotine, alcohol, illegal substances of abuse, and a variety of man-made or natural environmental toxins. Pharmacologists study the actions of all these substances.

Tidbit

When most people think about the word "drug", they usually associate it only with illegal substances, such as cannabis, heroin or cocaine. However in pharmacology, the word "drug" has a much broader meaning.

The term medicinal drug is used for any chemical substance, which is used to promote healing, cure disease, control or slow down the progression of disease, prevent disease, decrease complications or reduce excessive harmful activity in the body.

We take drugs through two routes i.e. orally or through injections. Oral drugs are absorbed from our digestive tract into the blood. The blood carries the drug to the liver, where its metabolism occurs. From the liver, the metabolic products of the drug enter the blood again and move to its target tissues. When a drug enters the target tissue it performs its action. The by-products of the action of drugs are carried from the tissues to kidneys, which excrete them out. The second route of drug administration is through injections. Drugs are injected in the muscles (intra-muscular) or directly in veins (intra-venous). Such drugs bypass the route to the liver. In this case, the entire drug is distributed to tissues and its action is faster.

18.1.1 Sources of Medicinal Drugs

Many drugs were discovered long ago. For example, when ancient people looked for food they discovered various roots, leaves, and barks. The people ate these and by trial and error, they learned about the healing effects of these plants. They also learned about toxic effects. However, generally we can see the following as major sources of drugs.

1. Many drugs are obtained from the roots, bark, sap, leaves, flowers, and seeds of **plants**. For example, quinine (antimalarial drug) is extracted from the bark of the Cinchona plant. Similarly, ascorbic acid/vitamin C is taken from lime juice and is used for scurvy and gum bleeding. The drug digitalis, which is used to control heart rate, is extracted from the parts of plant Foxglove. The pain reliever, morphine, is taken from opium (sap of the opium poppy plant).

(a) (b) (c)

Fig.18.1 Plant sources of drugs; (a) Poppy plant, (b) Opium, (c) Foxglove plant

2. Many drugs are also obtained from **animals**, for example, fish liver oil, certain hormones and antitoxins are obtained from animals.
3. Some drugs are taken from **minerals**. For example, tincture of iodine (a liquid to prevent skin infections) is made from mineral iodine.
4. **Microorganisms** and fungi are also sources from which drugs are extracted. For example many antibiotics like streptomycin, neomycin, terramycin are synthesised by using bacteria while antibiotic penicillin is taken from a fungus.
5. Many drugs are **synthesised** in laboratories e.g. aspirin. Pharmacologists use genetically modified organisms for the synthesis of many drugs (antibiotics, vaccines, hormones etc.). Such medicinal drugs may be grouped as synthetic drugs but these are actually taken from natural sources.

18.1.2 important uses of Medicinal Drugs

a. Painkillers

These drugs reduce or relieve pains like headaches, sore muscles, arthritis or any number of other aches and pains. Painkiller drugs are also called analgesics. Different painkillers are used in medicine. All these have advantages and they carry risks too. Some types of pain respond better to certain painkillers than others.

Some painkillers act directly at the site of the affected area to relieve inflammation, others act in the brain to alleviate or stop the sensation of pain. Many painkillers are based on two naturally occurring drugs i.e. aspirin and opiates.

b. Antibiotics

Antibiotics are among the most frequently prescribed medications in modern medicine for treatment of bacterial infections. Antibiotics cure diseases by killing bacteria or by stopping their growth (division). The first antibiotic penicillin was discovered accidentally from a fungus (Penicillium). Today, over 100 different antibiotics are available to cure minor, as well as life-threatening infections. Your doctor can best determine if an antibiotic needed to be administered for a disease or not.

Tidbit

It is important to realise that antibiotics only treat bacterial infections. Antibiotics are useless against viral infections (for example, the common cold) and fungal infections (such as ringworm).

c. Vaccines

A vaccine is any preparation intended to produce immunity against a disease by stimulating the production of antibodies. Common examples of vaccines are vaccines against small pox, polio, whooping cough and hepatitis B.

d. Sedatives

Sedatives are the drugs that slow down the brain functions. Sedatives block the brain chemicals that conduct communication between brain cells. In this way, sedatives induce sleep and reduce anxiety. Common sedatives are phenobarbital and diazepam.

Tidbit

Sedatives are used with special care because they can cause psychological dependence when taken for longer period of time. If a dependent stops using sedatives, he may suffer restlessness and insomnia (sleeplessness).

18.1.3 Contributions of Joseph Lister and Alexander Fleming

Joseph Lister (1827 – 1912 AD) was a Scottish surgeon. Lister developed an antiseptic spray from carbolic acid (phenol), which was used in operation theatres during surgery to keep the wound clean. He also developed special dressings, containing carbolic acid for keeping the wound clean. Lister's work revolutionised surgery. Although many new antiseptics and disinfectants have been discovered, aseptic surgery is still the basis of saving millions of lives.

Alexander Fleming (1881 – 1955 AD) a Scottish bacteriologist worked in a hospital in London, where he discovered the antibiotic Penicillin. He was working on a culture of bacteria when he noticed a fungus (Penicillium) in one culture. He observed that the fungus released a chemical, which killed the bacteria. The chemical was

For Your Information

Antiseptics are the chemicals used on injured or cut skin. These substances do not allow bacteria to grow and thus reduce the chances of infections. Chemical substances called disinfectants are used to clean objects like tables, floors, utensils etc. They kill microorganisms present on the surface of the objects. Modern antiseptics and disinfectants usually contain alcohols, boric acid or hydrogen peroxide.

extracted and was named as penicillin. It is one of the most important contributions in the history of medicine.

Tidbit

Though the initial intention was to use penicillin for saving the lives of soldiers of World War II, penicillin was eventually made available worldwide for general use.

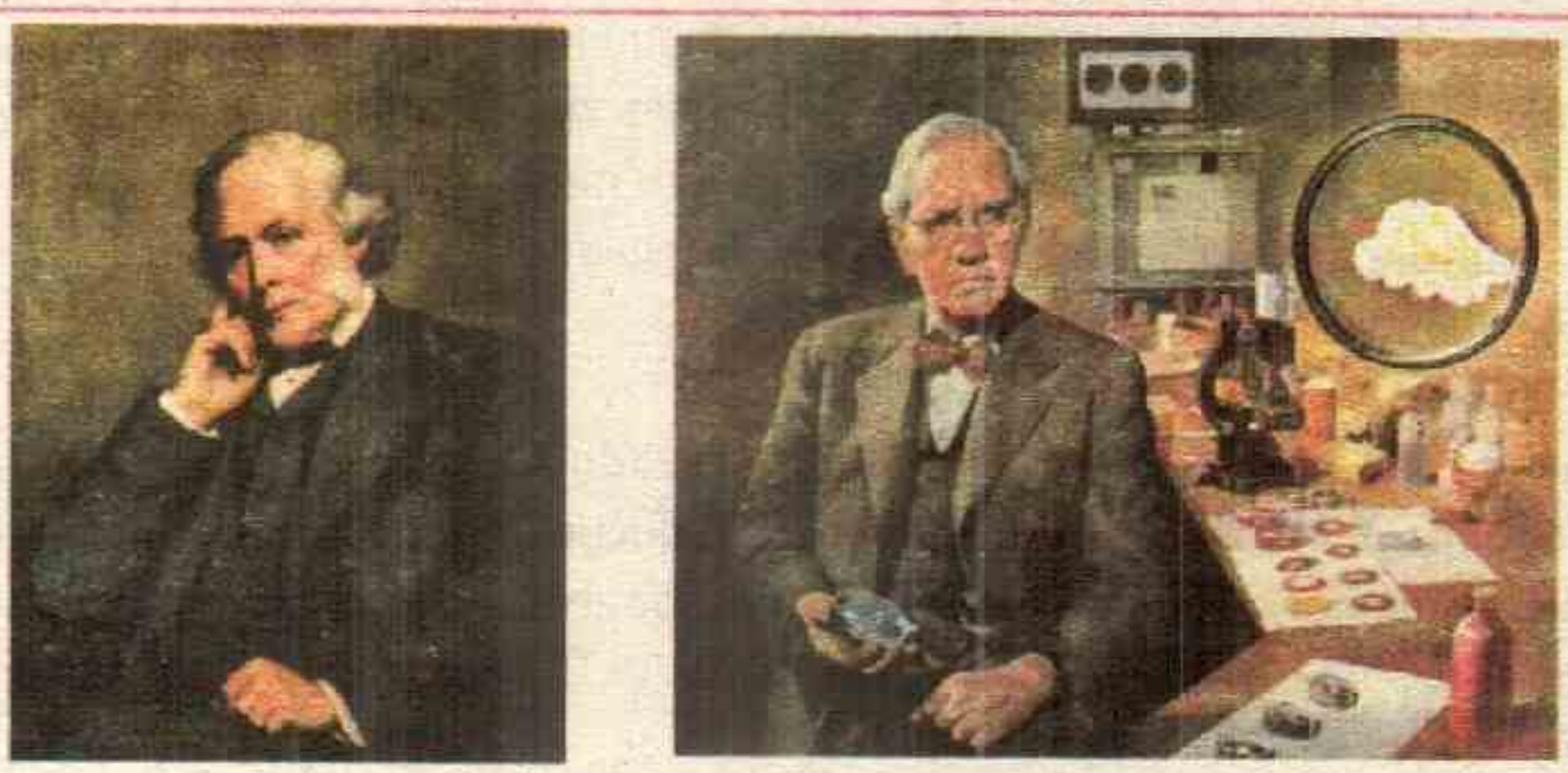


Figure 18.2: Joseph Lister (left); Alexander Fleming (right)

18.2 Addictive Drugs

Drugs are substances that alter the normal functions of the body. There are some drugs, which permanently change the chemistry and neural structures of the brain, if used continuously. As a result, normal functioning without the drug is made nearly impossible. The body craves these drugs if discontinued, often leading to uncontrollable desire for them. This is known as **addiction**. Generally people get drug addicted when they use chemicals which relax them, relieve pain, or heighten their awareness. If it makes them feel good, they want more. Without the drug, they feel tense and tortured. Loss of control and inability to manage without such drugs are the most obvious indicators of drug addiction. Addictive drugs can be categorised as follows:

Tidbit

Sometimes people suffer from emotional trauma and they believe that they need drugs in order to achieve some goals or they-use drugs to avoid feelings of depression or anxiety (common symptoms of mental illness).

1. Sedatives

We know that sedatives slow down the brain functions. Use of a sedative is generally initiated to deal with some health problems, for instance to get better sleep or to reduce anxiety. However if a person uses them for a longer period, they are at risk for developing dependence on it and this leads to addiction. An individual taking a sedative may find the prescribed dosage to their satisfaction for a period of time after which they may increase the dosage to achieve the same effect. Some of the effects of taking sedatives in

higher dosage include decreased awareness, confusion and weak respiration, depression and increased stress. A person with sedative addiction may display hostility or aggression, mood swings, poor judgment, and inability to function appropriately in social settings or at the work place.

2. Hallucinogens

Hallucinogens are drugs that cause hallucinations. Hallucinations can be defined as intensive distortions in a person's perceptions of reality. Under the influence of hallucinogens, people see images, hear sounds and feel sensations that seem real but actually do not exist. Hallucinogens cause their effects by disrupting the interaction of nerve cells and the chemical messengers in the brain. Many types of substances are classified as hallucinogens and are generally illegal to use. Some examples of hallucinogens are given below.

Figure 18.3: ***Cannabis sativa***

- **Marijuana** is a dry, shredded mixture of flowers, stems, seeds and leaves of the hemp plant *Connabis Sativa*. It is a hallucinogen widely used in Pakistan. Taken through smoke or orally, it produces feelings like excitement, relaxation, laughter, and the perception of slowing down of time etc. Its side effects are anxiety, dizziness, fear, increased heart rate, dry mouth, memory loss, less coordination, poor sense of balance, and slower reaction time.
- **Psilocybin** and **mescaline** are other hallucinogens. These drugs are taken orally. Psilocybin is extracted from a mushroom while mescaline is present in the cactus plant.

Figure 18.4: Psilocybin is taken from a mushroom (left) and mescaline is taken from a cactus (right)

- **Dextromethorphan** is another hallucinogen (also used in cough syrups). It is synthesised in laboratories. The chemical structure of dextromethorphan resembles morphine. Dextromethorphan produces the hallucination of being out of one's body.

3. Narcotics

Narcotics are a small family of drugs obtained from opium (sap of poppy plant). Narcotics relieve pain, induce sleep and cause dullness to the senses. Narcotics work on the central nervous system: the brain and spinal cord. These drugs produce euphoria (sense of well-being) and day dreaming (escape from reality) for some time. The following are the examples of common narcotics.

- Opium contains analgesic drugs such as **morphine** and **heroin,** which are highly addictive. Heroin is the most harmful narcotic, which is synthesised from morphine. It is taken in injections and through smoking. It gives a feeling of wellbeing, relaxation and sedation. Its use leads to respiratory depression and ultimately death.
- **Codeine** is also obtained from opium. It is used in cough syrups. Inside the body, codeine changes into morphine and has the same effects like other narcotics.

18.2.1 Associated Problems of Drug Addiction

Apart from the negative physical effects of drug addiction, there are psychological and emotional effects that are equally disturbing. Some associated problems of drug addiction are given below.

- The self-esteem of drug addicts is damaged. It sinks lower and lower and they develops negative feelings of worthlessness, hopelessness, shame and guilt.
- Drug addicts lose their ability to develop caring and honest relationships. They also destroy their existing relationships.
- They become less assertive and have great difficulty expressing opinions or needs.
- Community members characterise drug addicts as morally weak or as having criminal tendencies. Therefore, they are generally marginalised.
- Drug abuse has led to an increase in the crime rate. Drug abusers commit theft or robbery to steal money to pay for drugs. In desperation they may steal household items and sell them to get money.
- Apart from leading to financial instability, addiction increases the occurrence of conflicts and causes emotional pain for every member of the family.

Tidbit

The best way to help addicts is to guide them to stop. If they promises to stop but fails, you may be saving their lives if you take him to an addiction treatment centre such as of **Anti-Narcotics Force, Pakistan**.

Fig.18.5 Drug addicts: a menace for the society but must be cured and reintegrated

18.2.3 Symptoms of Drug Addiction

Although different drugs have different physical effects, the symptoms of addiction are similar. We can study addiction in terms of physical, behavioural and psychological signs.

a. Physical symptoms

- Bloodshot eyes, pupils larger or smaller than usual

- Changes in appetite or sleep patterns
- Sudden weight loss or weight gain
- Deterioration of physical appearance
- Unusual smells on breath, body or clothing
- Tremors, slurred speech, or impaired coordination

b. Behavioural symptoms

- Drop in attendance and performance at work or school
- Unexplained need for money or financial problems
- Engaging in secret or suspicious behaviour
- Sudden change in friends and hobbies
- Frequently getting into trouble (fights, accidents, illegal activities)

c. Psychological symptoms

- Unexplained change in personality or attitude
- Sudden mood swings, irritability, or angry outbursts
- Lack of motivation
- Fear and anxiousness for no reason

For Your Information

Addiction of drugs occurs very quickly. After just one or two uses, the person may develop a strong desire for the drug. It becomes compulsory for them to use the drug again.

18.3 Antibiotics

An antibiotic is a drug that kills bacteria or stops it from increasing in number. Antibiotics are used to prevent or cure bacterial infections. Antibiotics are categorized as bactericidal and bacteriostatic. Bactericidal antibiotics kill the bacteria while bacteriostatic antibiotics stop or inhibit the growth of bacteria.

In general, the use of bactericidal antibiotics is preferred but many factors may also suit the use of a bacteriostatic antibiotics. When a bacteriostatic antibiotic is used, the duration of therapy must be sufficient to allow the body's immune system to prepare proper defence against the invading bacteria.

For Your Information

A more general term, "anti-infective", describes drugs that do the same to any type of organism that could infect humans including; viruses, parasitic protozoans, bacteria or any other.

18.3.1 Categories of Antibiotics

Antibiotics can be categorised on the basis of chemical structure. Some of the major categories of antibiotics are as follows:

1. Sulfonamides

Sulfonamides are synthetic antibiotics that contain the sulfonamide group. These are bacteriostatic in action. They inhibit the synthesis of folic acid in bacteria. Folic acid is required to make new DNA. So bacteria stop dividing. Sulphonamides are used to treat pneumonia and urinary tract infections.

2. Tetracyclines

Tetracyclines are derived from a species of Streptomyces bacteria. Tetracycline antibiotics are bacteriostatic and inhibit bacterial protein synthesis. Tetracyclines are used in the treatment of infections of the respiratory tract, sinuses, middle ear, urinary tract, skin and intestines.

For Your Information

Tetracyclines are not used in children under the age of 8 and specifically during periods of tooth development.

3. Cephalosporins

Cephalosporins are derived from a species of bacteria *Cephalosporium*. Cephalosporins are bactericidal. These antibiotics interfere with the synthesis of the bacterial cell wall. Cephalosporin is used to treat pneumonia, strep throat, tonsillitis, bronchitis, various types of skin infections, gonorrhea, urinary tract infections etc.

Tidbit

The World Health Organisation describes antibiotic resistant bacteria as "nightmare bacteria". They pose a catastrophic threat to people in every country in the world.

18.3.2 Antibiotics Resistance

Antibiotics play an extremely important role in modern medicine. However, bacteria have a tremendous capability of developing resistance to them. When bacteria are exposed to the same antibiotic over and over, the bacteria can change and are no longer affected by the same antibiotic.

Bacteria have a number of ways to become antibiotic-resistant. For example, they possess an internal mechanism of changing their structure so that any given antibiotic no longer works to inhibit or kill them. They can also develop ways to inactivate or neutralise the antibiotic. Some bacteria can transfer the genes coding for antibiotic resistance to other bacteria to acquire resistance.

Resistance to antibiotics poses a serious and growing problem, because some infectious diseases are becoming more difficult to treat. Resistant bacteria do not respond to the antibiotics and continue to cause infection. Some of these resistant bacteria can be treated with more powerful antibiotics.

18.4 Vaccines

A vaccine is a substance prepared to produce immunity against a disease by stimulating the production of antibodies in the body. Vaccines include, for example, suspensions of killed or weakened (harmless) germs, or components or toxins of germs. The most common method of administering vaccines is through injection, but some are given orally or may be in the form of nasal sprays. Some vaccines provide lifetime immunity, but others have to be repeated to maintain continuous protection.

When a vaccine (inactivated or weakened germs or their components or toxins) enters the blood, the white blood cells recognise it as real disease-causing germs. So they start

Introduction

Pharmacology is the science of the properties and effects of drugs on biological systems. The word "pharmacology" comes from the Greek word "pharmakon" which means drug. Pharmacology deals with the designing, developing, and testing of drugs that have the potential to reduce, and in some cases cure diseases. Pharmacology incorporates other biological sciences such as biochemistry, physiology, microbiology and genetics.

Tidbit

Unlike pharmacy, which is the science of the preparation and dispensing of drugs, pharmacology is the science behind how drugs produce their effects on the body, and what the body does to the drugs.

8.1 Medicinal Drugs

Drug means any compound that can modify the biological functions of living organisms. This definition includes not only medicines that have beneficial effects in the treatment of various disorders, but also chemicals such as caffeine, nicotine, alcohol, illegal substances of abuse, and a variety of man-made or natural environmental toxins. Pharmacologists study the actions of all these substances.

Tidbit

When most people think about the word "drug", they usually associate it only with illegal substances, such as cannabis, heroin or cocaine. However in pharmacology, the word "drug" has a much broader meaning.

The term medicinal drug is used for any chemical substance, which is used to promote healing, cure disease, control or slow down the progression of disease, prevent disease, decrease complications or reduce excessive harmful activity in the body.

We take drugs through two routes i.e. orally or through injections. Oral drugs are absorbed from our digestive tract into the blood. The blood carries the drug to the liver, where its metabolism occurs. From the liver, the metabolic products of the drug enter the blood again and move to its target tissues. When a drug enters the target tissue it performs its action. The by-products of the action of drugs are carried from the tissues to kidneys, which excrete them out. The second route of drug administration is through injections. Drugs are injected in the muscles (intra-muscular) or directly in veins (intra-venous). Such drugs bypass the route to the liver. In this case, the entire drug is distributed to tissues and its action is faster.

18.1.1 Sources of Medicinal Drugs

Many drugs were discovered long ago. For example, when ancient people looked for food they discovered various roots, leaves, and barks. The people ate these and by trial and error, they learned about the healing effects of these plants. They also learned about toxic effects. However, generally we can see the following as major sources of drugs.

1. Many drugs are obtained from the roots, bark, sap, leaves, flowers, and seeds of **plants**. For example, quinine (antimalarial drug) is extracted from the bark of the Cinchona plant. Similarly, ascorbic acid/vitamin C is taken from lime juice and is used for scurvy and gum bleeding. The drug digitalis, which is used to control heart rate, is extracted from the parts of plant Foxglove. The pain reliever, morphine, is taken from opium (sap of the opium poppy plant).

(a) (b) (c)

Fig.18.1 Plant sources of drugs; (a) Poppy plant, (b) Opium, (c) Foxglove plant

2. Many drugs are also obtained from **animals**, for example, fish liver oil, certain hormones and antitoxins are obtained from animals.
3. Some drugs are taken from **minerals**. For example, tincture of iodine (a liquid to prevent skin infections) is made from mineral iodine.
4. **Microorganisms** and fungi are also sources from which drugs are extracted. For example many antibiotics like streptomycin, neomycin, terramycin are synthesised by using bacteria while antibiotic penicillin is taken from a fungus.
5. Many drugs are **synthesised** in laboratories e.g. aspirin. Pharmacologists use genetically modified organisms for the synthesis of many drugs (antibiotics, vaccines, hormones etc.). Such medicinal drugs may be grouped as synthetic drugs but these are actually taken from natural sources.

18.1.2 important uses of Medicinal Drugs

a. Painkillers

These drugs reduce or relieve pains like headaches, sore muscles, arthritis or any number of other aches and pains. Painkiller drugs are also called analgesics. Different painkillers are used in medicine. All these have advantages and they carry risks too. Some types of pain respond better to certain painkillers than others.

Some painkillers act directly at the site of the affected area to relieve inflammation, others act in the brain to alleviate or stop the sensation of pain. Many painkillers are based on two naturally occurring drugs i.e. aspirin and opiates.

b. Antibiotics

Antibiotics are among the most frequently prescribed medications in modern medicine for treatment of bacterial infections. Antibiotics cure diseases by killing bacteria or by stopping their growth (division). The first antibiotic penicillin was discovered accidentally from a fungus (Penicillium). Today, over 100 different antibiotics are available to cure minor, as well as life-threatening infections. Your doctor can best determine if an antibiotic needed to be administered for a disease or not.

Tidbit

It is important to realise that antibiotics only treat bacterial infections. Antibiotics are useless against viral infections (for example, the common cold) and fungal infections (such as ringworm).

c. Vaccines

A vaccine is any preparation intended to produce immunity against a disease by stimulating the production of antibodies. Common examples of vaccines are vaccines against small pox, polio, whooping cough and hepatitis B.

d. Sedatives

Sedatives are the drugs that slow down the brain functions. Sedatives block the brain chemicals that conduct communication between brain cells. In this way, sedatives induce sleep and reduce anxiety. Common sedatives are phenobarbital and diazepam.

Tidbit

Sedatives are used with special care because they can cause psychological dependence when taken for longer period of time. If a dependent stops using sedatives, he may suffer restlessness and insomnia (sleeplessness).

18.1.3 Contributions of Joseph Lister and Alexander Fleming

Joseph Lister (1827 – 1912 AD) was a Scottish surgeon. Lister developed an antiseptic spray from carbolic acid (phenol), which was used in operation theatres during surgery to keep the wound clean. He also developed special dressings, containing carbolic acid for keeping the wound clean. Lister's work revolutionised surgery. Although many new antiseptics and disinfectants have been discovered, aseptic surgery is still the basis of saving millions of lives.

Alexander Fleming (1881 – 1955 AD) a Scottish bacteriologist worked in a hospital in London, where he discovered the antibiotic Penicillin. He was working on a culture of bacteria when he noticed a fungus (Penicillium) in one culture. He observed that the fungus released a chemical, which killed the bacteria. The chemical was

For Your Information

Antiseptics are the chemicals used on injured or cut skin. These substances do not allow bacteria to grow and thus reduce the chances of infections. Chemical substances called disinfectants are used to clean objects like tables, floors, utensils etc. They kill microorganisms present on the surface of the objects. Modern antiseptics and disinfectants usually contain alcohols, boric acid or hydrogen peroxide.

extracted and was named as penicillin. It is one of the most important contributions in the history of medicine.

Tidbit

Though the initial intention was to use penicillin for saving the lives of soldiers of World War II, penicillin was eventually made available worldwide for general use.

Figure 18.2: Joseph Lister (left); Alexander Fleming (right)

18.2 Addictive Drugs

Drugs are substances that alter the normal functions of the body. There are some drugs, which permanently change the chemistry and neural structures of the brain, if used continuously. As a result, normal functioning without the drug is made nearly impossible. The body craves these drugs if discontinued, often leading to uncontrollable desire for them. This is known as **addiction**. Generally people get drug addicted when they use chemicals which relax them, relieve pain, or heighten their awareness. If it makes them feel good, they want more. Without the drug, they feel tense and tortured. Loss of control and inability to manage without such drugs are the most obvious indicators of drug addiction. Addictive drugs can be categorised as follows:

Tidbit

Sometimes people suffer from emotional trauma and they believe that they need drugs in order to achieve some goals or they-use drugs to avoid feelings of depression or anxiety (common symptoms of mental illness).

1. Sedatives

We know that sedatives slow down the brain functions. Use of a sedative is generally initiated to deal with some health problems, for instance to get better sleep or to reduce anxiety. However if a person uses them for a longer period, they are at risk for developing dependence on it and this leads to addiction. An individual taking a sedative may find the prescribed dosage to their satisfaction for a period of time after which they may increase the dosage to achieve the same effect. Some of the effects of taking sedatives in

higher dosage include decreased awareness, confusion and weak respiration, depression and increased stress. A person with sedative addiction may display hostility or aggression, mood swings, poor judgment, and inability to function appropriately in social settings or at the work place.

2. Hallucinogens

Hallucinogens are drugs that cause hallucinations. Hallucinations can be defined as intensive distortions in a person's perceptions of reality. Under the influence of hallucinogens, people see images, hear sounds and feel sensations that seem real but actually do not exist. Hallucinogens cause their effects by disrupting the interaction of nerve cells and the chemical messengers in the brain. Many types of substances are classified as hallucinogens and are generally illegal to use. Some examples of hallucinogens are given below.

Figure 18.3: ***Cannabis sativa***

- **Marijuana** is a dry, shredded mixture of flowers, stems, seeds and leaves of the hemp plant *Connabis Sativa*. It is a hallucinogen widely used in Pakistan. Taken through smoke or orally, it produces feelings like excitement, relaxation, laughter, and the perception of slowing down of time etc. Its side effects are anxiety, dizziness, fear, increased heart rate, dry mouth, memory loss, less coordination, poor sense of balance, and slower reaction time.
- **Psilocybin** and **mescaline** are other hallucinogens. These drugs are taken orally. Psilocybin is extracted from a mushroom while mescaline is present in the cactus plant.

Figure 18.4: Psilocybin is taken from a mushroom (left) and mescaline is taken from a cactus (right)

- **Dextromethorphan** is another hallucinogen (also used in cough syrups). It is synthesised in laboratories. The chemical structure of dextromethorphan resembles morphine. Dextromethorphan produces the hallucination of being out of one's body.

3. Narcotics

Narcotics are a small family of drugs obtained from opium (sap of poppy plant). Narcotics relieve pain, induce sleep and cause dullness to the senses. Narcotics work on the central nervous system: the brain and spinal cord. These drugs produce euphoria (sense of well-being) and day dreaming (escape from reality) for some time. The following are the examples of common narcotics.

- Opium contains analgesic drugs such as **morphine** and **heroin,** which are highly addictive. Heroin is the most harmful narcotic, which is synthesised from morphine. It is taken in injections and through smoking. It gives a feeling of wellbeing, relaxation and sedation. Its use leads to respiratory depression and ultimately death.
- **Codeine** is also obtained from opium. It is used in cough syrups. Inside the body, codeine changes into morphine and has the same effects like other narcotics.

18.2.1 Associated Problems of Drug Addiction

Apart from the negative physical effects of drug addiction, there are psychological and emotional effects that are equally disturbing. Some associated problems of drug addiction are given below.

- The self-esteem of drug addicts is damaged. It sinks lower and lower and they develops negative feelings of worthlessness, hopelessness, shame and guilt.
- Drug addicts lose their ability to develop caring and honest relationships. They also destroy their existing relationships.
- They become less assertive and have great difficulty expressing opinions or needs.
- Community members characterise drug addicts as morally weak or as having criminal tendencies. Therefore, they are generally marginalised.
- Drug abuse has led to an increase in the crime rate. Drug abusers commit theft or robbery to steal money to pay for drugs. In desperation they may steal household items and sell them to get money.
- Apart from leading to financial instability, addiction increases the occurrence of conflicts and causes emotional pain for every member of the family.

Tidbit

The best way to help addicts is to guide them to stop. If they promises to stop but fails, you may be saving their lives if you take him to an addiction treatment centre such as of **Anti-Narcotics Force, Pakistan**.

Fig. 18.5 Drug addicts: a menace for the society but must be cured and reintegrated

18.2.3 Symptoms of Drug Addiction

Although different drugs have different physical effects, the symptoms of addiction are similar. We can study addiction in terms of physical, behavioural and psychological signs.

a. Physical symptoms

- Bloodshot eyes, pupils larger or smaller than usual

- Changes in appetite or sleep patterns
- Sudden weight loss or weight gain
- Deterioration of physical appearance
- Unusual smells on breath, body or clothing
- Tremors, slurred speech, or impaired coordination

b. Behavioural symptoms

- Drop in attendance and performance at work or school
- Unexplained need for money or financial problems
- Engaging in secret or suspicious behaviour
- Sudden change in friends and hobbies
- Frequently getting into trouble (fights, accidents, illegal activities)

c. Psychological symptoms

- Unexplained change in personality or attitude
- Sudden mood swings, irritability, or angry outbursts
- Lack of motivation
- Fear and anxiousness for no reason

For Your Information

Addiction of drugs occurs very quickly. After just one or two uses, the person may develop a strong desire for the drug. It becomes compulsory for them to use the drug again.

18.3 Antibiotics

An antibiotic is a drug that kills bacteria or stops it from increasing in number. Antibiotics are used to prevent or cure bacterial infections. Antibiotics are categorized as bactericidal and bacteriostatic. Bactericidal antibiotics kill the bacteria while bacteriostatic antibiotics stop or inhibit the growth of bacteria.

In general, the use of bactericidal antibiotics is preferred but many factors may also suit the use of a bacteriostatic antibiotics. When a bacteriostatic antibiotic is used, the duration of therapy must be sufficient to allow the body's immune system to prepare proper defence against the invading bacteria.

For Your Information

A more general term, "anti-infective", describes drugs that do the same to any type of organism that could infect humans including; viruses, parasitic protozoans, bacteria or any other.

18.3.1 Categories of Antibiotics

Antibiotics can be categorised on the basis of chemical structure. Some of the major categories of antibiotics are as follows:

1. Sulfonamides

Sulfonamides are synthetic antibiotics that contain the sulfonamide group. These are bacteriostatic in action. They inhibit the synthesis of folic acid in bacteria. Folic acid is required to make new DNA. So bacteria stop dividing. Sulphonamides are used to treat pneumonia and urinary tract infections.

2. Tetracyclines

Tetracyclines are derived from a species of Streptomyces bacteria. Tetracycline antibiotics are bacteriostatic and inhibit bacterial protein synthesis. Tetracyclines are used in the treatment of infections of the respiratory tract, sinuses, middle ear, urinary tract, skin and intestines.

For Your Information

Tetracyclines are not used in children under the age of 8 and specifically during periods of tooth development.

3. Cephalosporins

Cephalosporins are derived from a species of bacteria *Cephalosporium*. Cephalosporins are bactericidal. These antibiotics interfere with the synthesis of the bacterial cell wall. Cephalosporin is used to treat pneumonia, strep throat, tonsillitis, bronchitis, various types of skin infections, gonorrhea, urinary tract infections etc.

18.3.2 Antibiotics Resistance

Antibiotics play an extremely important role in modern medicine. However, bacteria have a tremendous capability of developing resistance to them. When bacteria are exposed to the same antibiotic over and over, the bacteria can change and are no longer affected by the same antibiotic.

Tidbit

The World Health Organisation describes antibiotic resistant bacteria as "nightmare bacteria". They pose a catastrophic threat to people in every country in the world.

Bacteria have a number of ways to become antibiotic-resistant. For example, they possess an internal mechanism of changing their structure so that any given antibiotic no longer works to inhibit or kill them. They can also develop ways to inactivate or neutralise the antibiotic. Some bacteria can transfer the genes coding for antibiotic resistance to other bacteria to acquire resistance.

Resistance to antibiotics poses a serious and growing problem, because some infectious diseases are becoming more difficult to treat. Resistant bacteria do not respond to the antibiotics and continue to cause infection. Some of these resistant bacteria can be treated with more powerful antibiotics.

18.4 Vaccines

A vaccine is a substance prepared to produce immunity against a disease by stimulating the production of antibodies in the body. Vaccines include, for example, suspensions of killed or weakened (harmless) germs, or components or toxins of germs. The most common method of administering vaccines is through injection, but some are given orally or may be in the form of nasal sprays. Some vaccines provide lifetime immunity, but others have to be repeated to maintain continuous protection.

When a vaccine (inactivated or weakened germs or their components or toxins) enters the blood, the white blood cells recognise it as real disease-causing germs. So they start

producing antibodies against them. These antibodies remain in the blood. If disease-causing germs enter the blood, the already present antibodies attack and kill them.

For Your Information

During the 1770s, Edward Jenner heard a milkmaid speaking that she would never have the fatal disease smallpox, because she had already suffered from a mild disease cowpox. Taking a clue from it, Jenner took cowpox pus (containing germs) from the hand of a milkmaid and inoculated an 8-year old boy with it. The boy suffered from cowpox. Six weeks later Jenner injected the boy's arm with smallpox germs. The boy did not get smallpox. Jenner claimed that due to cowpox infection, the boy was protected from smallpox.

In 1978, the Government of Pakistan established the Expanded Programme on Immunization (EPI). Its purpose is to vaccinate children aged 0-11 months against nine diseases (Polio, Tetanus, Measles Diphtheria, Whooping cough, Hepatitis B, Pneumonia, meningitis, Tuberculosis,). In 2011, all provinces including Khyber Pakhtunkhwa established their provincial EPI centres. The EPI, Khyber Pakhtunkhwa focuses on polio eradication, increasing immunisation coverage, reducing preventable diseases, increasing immunisation through fixed EPI centres, extending the reach of immunisation services to remote areas, and introducing new vaccines.

Key Points

- Pharmacology is the branch of science, which is concerned with the study of drugs and how they affect living organisms.
- A drug is anything chemical that enters the body and affects the processes in the body.
- Pain relievers are medicines that reduce or relieve pains like headaches, muscular pain, arthritis or any number of other aches and pains.
- The first antibiotic was penicillin, discovered accidentally from a mould culture.
- A vaccine is any preparation intended to produce immunity against a disease by stimulating the production of antibodies.
- Sedatives are drugs that slow down brain functions.
- Drugs if used continuously changes the chemistry and neural structures of the brain. As a result normal functioning without the drug is made nearly impossible. This uncontrollable desire for drugs is known as addiction.
- Hallucinogen is a drug that causes hallucinations, which are intensive distortions in a person's perceptions of reality.
- Narcotics are extracted from Opium (sap of the opium plant). The common narcotics are morphine and codeine.
- An antibiotic is a drug that kills bacteria or stops them from increasing in number.

Exercise

A. Select the correct answer.

1. Any substance that is used to modify the physiological systems for the benefit of the recipient is:
   a. Medicine b. Vaccine
   c. Narcotic d. Drug
2. Oral drugs are absorbed in the blood and are first taken to;
   a. Kidneys b. Lungs
   c. Liver d. Brain
3. Any preparation intended to produce immunity to a disease by stimulating the production of antibodies is:
   a. Drug b. Antibiotic
   c. Analgesic d. Vaccine
4. Drugs that calm patients down, easing agitation and permitting sleep is termed as;
   a. Painkiller b. Hallucinogen
   c. Sedative d. Narcotic
5. There are two types of narcotic drugs; opiates and synthetic; which one of the following is synthetic;
   a. Morphine b. Codeine c. Methadone d. Heroin
6. The uncontrollable desire for drugs is known as;
   a. Addiction b. Vaccination c. Infection d. Heroin
7. All of the following are classes of antibiotics EXCEPT;
   a. Sulfonamides b. Tetracycline c. Penicillin d. Morphine
8. Which of these is the source of narcotics?
   a. Opium plant b. Cactus plant c. Cannabis plant d. Mushroom
9. Vaccines can be administered through;
   a. Injections b. Mouth c. Nose d. All of these
10. Cephalosporins are derived from;
    a. Fungus b. Bacterium c. Cannabis d. Opium

B. Write short answers to the following questions.

1. What is drug addiction and what are the effects of addiction?

2. Differentiate between antibiotics and vaccines.
3. Enlist the bad effects of nicotine, caffeine and cocaine. Are these addictive?
4. What are the responsibilities of society to deal with drug addicts?
5. How are vaccines prepared?
6. Give two examples of drugs, which are extracted from plants.
7. Define drug addiction. What are the three major categories of drugs, which can cause addiction?
8. Define analgesic, antibiotics, and sedatives.
9. Differentiate between bactericidal and bacteriostatic antibiotics.
10. Define narcotics and give examples.

C. Write detailed answers to the following questions:

1. What roles do drugs play in our life?
2. Differentiate between narcotics and drugs. What are the different symptoms of drug addiction?
3. What are hallucinogens? Give examples with their sources.
4. Describe the mechanisms of action of three groups of antibiotics. Also mention the diseases for which each of these groups is used.
5. What are vaccines? Describe the different ways of producing vaccines.
6. What are the different classes of antibiotics and what is resistance to antibiotics?

Science, Technology and Society

1. Compile a list of various painkillers, antibiotics and sedatives being used in your household.
2. Summarise the antisocial effects of the usage of hallucinogens and narcotics.
3. Analyse the effects of possible over-dosage, under-dosage and drug interactions when using antibiotics without a doctor's consultation.

GLOSSARY

A

Abiotic
Nonliving; specifically, the nonliving components of an ecosystem, such as temperature, humidity, the mineral content of the soil, etc.

Abascisic acid (ABA)
A plant hormone that generally acts to inhibit growth, promote dormancy, and help the plant tolerate stressful conditions.

Absorption
The movement of water and dissolved substances into a cell, tissue, or organism.

Active transport
The movement of a substance across a biological membrane against its concentration or electrochemical gradient, with the help of energy input and specific transport proteins.

Adenosine triphosphate (ATP)
An adenine-containing nucleoside triphosphate that releases free energy when its phosphate bonds are hydrolyzed. This energy is used to drive endergonic reactions in cells.

Alternation of generations
A life cycle in which there is both a multicellular diploid form, the sporophyte, and a multicellular haploid form, the gametophyte; characteristic of plants.

Amino group
A functional group that consists of a nitrogen atom bonded to two hydrogen atoms; can act as a base in solution, accepting a hydrogen ion and acquiring a charge of +1.

Amoeboid
Moving or feeding by means of pseudopodia (temporary cytoplasmic protrusions from the cell body).

Anaerobic
Lacking oxygen; referring to an organism, environment, or cellular process that lacks oxygen and may be poisoned by it.

Antheridium *pl.* antheridia
In plants, the male gametangium, a moist chamber in which gametes develop.

Antibiotic
A chemical that kills bacteria or inhibits their growth.

Antibody
An antigen-binding immunoglobulin, produced by B cells, that functions as the effector in an immune response.

Artery
A vessel that carries blood away from the heart to organs throughout the body.

Asexual reproduction
A type of reproduction involving only one parent that produces genetically identical offspring by budding or by the division of a single cell or the entire organism into two or more parts.

B

Bacteria
One of two prokaryotic domains, the other being the Archaea.

Bbacteriophage
[L. *bacterium* + Gk. *phagein*, to eat]
A virus that parasitizes a bacterial cell.

Bark
All tissues external to the vascular cambium in a plant growing in thickness, consisting of phloem, phelloderm, cork cambium, and cork.

Binary fission
The type of cell division by which prokaryotes reproduce; each dividing daughter cell receives a copy of the single parental chromosome.

Biochemical pathway
An ordered series of chemical reactions in a living cell, in which each step is catalyzed by a specific enzyme; different biochemical pathways serve different functions in the life of the cell.

Biomass
The dry weight of organic matter comprising a group of organisms in a particular habitat.

Biosphere
The entire portion of Earth that is inhabited by life; the sum of all the planet's communities and ecosystems.

Biotechnology
The industrial use of living organisms or their components to improve human health and food production.

Biotic
(by-**ot**-ik) [Gk. *bios,* life]
Pertaining to the living organisms in the environment.

Blood pressure
The hydrostatic force that blood exerts against the wall of a vessel.

C

Carcinogen
A chemical agent that causes cancer.

Catabolic pathway
A metabolic pathway that releases energy by breaking down complex molecules into simpler compounds.

Catalyst
A substance that lowers the activation energy of a chemical reaction by forming a temporary association with the reacting molecules; as a result, the rate of the reaction is accelerated. Enzymes are catalysts.

Centromere
The centralized region joining two sister chromatids.

Centrosome
Material present in the cytoplasm of all eukaryotic cells and important during cell division; also called microtubule-organizing center.

Chromatin
The complex of DNA and proteins that makes up a eukaryotic chromosome. When the cell is not dividing, chromatin exists as a mass of very long, thin fibers that are not visible with a light microscope.

Chromosome
A threadlike, gene-carrying structure found in the nucleus. Each chromosome consists of one very long DNA molecule and associated proteins. *See* chromatin.

Codominance
A phenotypic situation in which both alleles are expressed in the heterozygote.

Cytoplasm
The entire contents of the cell, exclusive of the nucleus, and bounded by the plasma membrane.

D

Daughter cell
A cell that is the offspring of a cell that has undergone mitosis or meiosis. The term "daughter" does not indicate the sex of the cell.

Diaphragm
A sheet of muscle that forms the bottom wall of the thoracic cavity in mammals; active in ventilating the lungs.

Diffusion
The spontaneous tendency of a substance to move down its concentration gradient from a more concentrated to a less concentrated area.

Digestion
The process of breaking down food into molecules small enough for the body to absorb.

DNA
Abbreviation of deoxyribonucleic acid.

DNA ligase
A linking enzyme essential for DNA replication; catalyzes the covalent bonding of the 3' end of a new DNA fragment to the 5' end of a growing chain.

Double fertilization
A mechanism of fertilization in angiosperms, in which two sperm cells unite with two cells in the embryo sac to form the zygote and endosperm.

E

Ecological pyramid
A graphic representation of the quantitative relationships of numbers of organisms, biomass, or energy flow between the trophic levels of an ecosystem. Because large amounts of energy and biomass are dissipated at every trophic level, these diagrams nearly always take the form of pyramids.

Ecology
The study of how organisms interact with their environments.

Ecosystem
A level of ecological study that includes all the organisms in a given area as well as the abiotic factors with which they interact; a community and its physical environment.

Energy
The capacity to do work by moving matter against an opposing force.

Epithelial tissue
Sheets of tightly packed cells that line organs and body cavities.

Evolution
All the changes that have transformed life on Earth from its earliest beginnings to the diversity that characterizes it today.

Exocrine glands
Glands, such as sweat glands and digestive glands, that secrete their products into ducts that empty onto surfaces, such as the skin, or into cavities, such as the interior of the stomach.

F

Fermentation
A catabolic process that makes a limited amount of ATP from glucose without an electron transport chain and that produces a characteristic end-product, such as ethyl alcohol or lactic acid.

Fertilization
The union of haploid gametes to produce a diploid zygote.

Filtration
The first stage of kidney function; blood plasma is forced, under pressure, out of the glomerular capillaries into Bowman's capsule, through which it enters the renal tubule.

G

Gametophyte
The multicellular haploid form in organisms undergoing alternation of generations, which mitotically produces haploid gametes that unite and grow into the sporophyte generation.

Glucose
A six-carbon sugar ($C_6H_{12}O_6$); the most common monosaccharide in animals.

Glycerol
A three-carbon molecule with three hydroxyl ($\overline{OH}$) groups attached; a glycerol molecule can combine with three fatty acid molecules to form a fat or an oil.

H

Hemoglobin
An iron-containing protein in red blood cells that reversibly binds oxygen.

Hemophilia
A group of hereditary disorders characterized by failure of the blood to clot and consequent excessive bleeding from even minor wounds.

Herbivore
A heterotrophic animal that eats plants.

HIV

Abbreviation of human immunodeficiency virus, the infectious agent that causes AIDS; HIV is an RNA retrovirus.

Hormone

One of many types of circulating chemical signals in all multicellular organisms that are formed in specialized cells, travel in body fluids, and coordinate the various parts of the organism by interacting with target cells.

Hypothalamus

The ventral part of the vertebrate forebrain; functions in maintaining homeostasis, especially in coordinating the endocrine and nervous systems; secretes hormones of the posterior pituitary and releasing factors, which regulate the anterior pituitary.

I

Inflammation

A body strategy initiated by the release of chemicals following injury or infection which brings additional blood with its protective cells to the injured area.

Interstitial cells

Cells in the testes that produce testosterone, the major male sex hormone.

Internal fertization: The union of sperm and egg inside a chamber in the body. This is the mode of reproduction in terrestrial animals.

L

loop of henle: An elongated section of the renal tubule that dips down into the kidney's medulla and then ascends back up to the cortex, separating the proximal and distal convoluted tubules.

M

Meiosis: The division process that produces cells with one-half the number of chromosomes in each somatic cell. Each resulting daughter cell is haploid (In).

Meiosis I: A process of reductional division in which homologous chromosomes pair and then segregate. Homologues are partitioned into separate daughter cells.

Meiosis II: Second meiotic division. A division process resembling mitosis, except that the haploid number of chromosomes is present. After the chromosomes line up at the metaphase plate, the centromeres split and the two sister chromatids separate.

Messenger rna (mRNA): The RNA that carries genetic information from the DNA in the nucleus to the ribosomes in the cytoplasm, where the sequence of bases in the mRNA is translated into a sequence of amino acids.

Migration: Movements of a population into or out of an area.

Mitosis: The process of cell division producing daughter cells with exactly the same number of chromosomes as in the mother cell.

Muscle tissue: Bundles and sheets of contractile cells that shorten when stimulated, providing force for controlled movement.

Mutation: Random heritable changes in DNA that introduce new alleles into the gene pool.

Mutualism: The symbiotic interaction in which both participants benefit.

N

Negative feedback: Any regulatory mechanism in which the increased level of a substance inhibits further production of that substance, thereby preventing harmful accumulation. A type of homeostatic mechanism.

Nerve: Parallel bundles of neurons and their supporting cells.

Neuron: A nerve cell

O

Osmoregulation: The maintenance of a stable fluid environment using hormones to regulate osmotic gradients that adjust fluid concentration, as in the nephrons of the kidneys.

Osmosis: The diffusion of water through a differentially permeable membrane.

Oxytocin: A female hormone released by the posterior pituitary which triggers uterine contractions during childbirth and the release of milk during nursing.

P

Parathyroid glands: Four glands attached to the thyroid gland which secrete parathyroid hormone (PTH). When blood calcium levels are low, PTH is secreted, causing calcium to be released from bone.

Parthenocarpy: The development of fruits without fertilization.

Parthenogenesis: Process by which offspring are produced without egg fertilization.

Pectoral girdle: The two scapulae (shoulder blades) and two clavicles (collarbones) which support and articulate with the bones of the upper arm.

Plasmid: A small circle of DNA in bacteria in addition to its own chromosome.

R

Recessive: An allele whose expression is masked by the dominant allele for the same trait.

Recombinant DNA: DNA formed by the insertion of foreign genes or foreign sections of DNA from one organism into the chromosomes of a host cell.

Replication: Duplication of DNA, usually prior to cell division.

S

Sex chromosomes: The one chromosomal pair that is not identical in the karyotypes of males and females of the same animal species.

Sex hormones: Steroid hormones which influence the production of gametes and the development of male or female sex characteristics.

Skeletal muscles: Separate bundles of parallel, striated muscle fibers anchored to the bone, which they can move in a coordinated fashion. They are under voluntary control.

Skeleton: A rigid form of support found in most animals either surrounding the body with a protective encasement or providing, a living girder system within the animal.

Symbiosis: A close, long-term relationship between two individuals of different species.

T

Thermoregulation: The process of maintaining a constant internal body temperature in spite of fluctuations in external temperatures.

Transcription: The process by which a strand of RNA assembles along one of the DNA strands.

Transfer rna (tRNA): A type of RNA that decodes mRNA's codon message and translates it into amino acids.

Transformation: A genetic transfer mechanism that produces new DNA in bacteria when DNA from a new organism is combined with the DNA of the host cell.

Translation: The cell process that converts a sequence of nucleotides in mRNA into a sequence of amino acids.

U

Urethra: A tube that extends from the urinary bladder through the length of the penis, conveying both sperm and urine, though not simultaneously.

Urine: The excretory fluid consisting of urea, other nitrogenous substances, and salts dissolved in water. It is formed by the kidneys.

INDEX

مومن تو آپس میں بھائی بھائی ہیں۔
پس اپنے دو بھائیوں میں صلح کرا دیا کرو
اور اللہ سے ڈرتے رہو تا کہ تم پر رحمت کی جائے۔
(سورۃ الحجرات: ۱۰)

Authors Profile

1. Zaigham Hasan

Mr. Zaigham is working as AssociateProfessor in the Zoology Department University of Peshawar. He has been on the Panel of Authors in the Khyber Pakhtunkhwa Textbook Board. In this capacity he was given the Authorship in several textbooks of General Science and Biology. Being an active teacher he has been teaching Biology/Zoology at various levels for the last **20 years.**

2. Faiz Nadeem

Mr. Nadeem is working as a Lecturer in Islamabad Model College I-8/3, Islamabad. He has been involved is the writing of Textbooks of General Science and Biology at primary and secondary level.

3. Shafqat Rasool

Mr. Shafqat is a Lecturer in Islamabad Model College F-8/4, Islamabad, He has been involved in the teaching of General Science and Biology for the last 10 years.

4. Dr. Izhar Ahmad

Dr. Izhar Ahmad has received his Ph.D degree in the field of Molecular Plant Physiology from the Univerisity of York, UK. He has been teaching in Islamia College Peshawar for the last 18 years. He is also supervising M.Phil and Ph.D research scholars. He has 30 research publications in peer review journals and has attended various international conferences. He is also the co-author of several textbooks.