1. INTRODUCTION TO BIOLOGY

Definition

- The word biology is derived from the Greek words, ***bios***, meaning **life,** and ***logos***, meaning **knowledge.**
- Therefore**, Biology** is the branch of science that deals with the study of living **organisms.**
- **Science** is the knowledge about the structure and behaviour of the natural world based on facts that can be approved by experiments.

Branches of Biology

- There are **three main branches** of biology namely:

1. **Zoology-** This is the study of animals. A scientist specialized in this area is called **zoologist.**
2. **Botany-** This is the study of plants. A scientist is called **botanist.**
3. **Microbiology-** This is the study of microscopic organisms. A scientist is called **microbiologist.**

Other branches of biology

1. **Anatomy-** This is the study of the internal structure of living things. A scientist is called **anatomist.**
2. **Physiology-** This is the study of body functions. A scientist is called **physiologist.**
3. **Genetics-** This is the study of inheritance and variation. A scientist is called **genetist.**
4. **Ecology-** This is the study of the relationship between organisms and their environment/ study of living organisms and their surrounding. A scientist is called **ecologist**.
5. **Parasitology-** This is the study of parasites. A scientist is called **parastologist.**
6. **Entomology-** This is the study of insects. A scientist is called **entomologist.**
7. **Cytology-** This is the study of the cell. A scientist is called **cytologist.**
8. **Pathology-** This is the study of diseases. A scientist is called **pathologist.**
9. **Biochemistry-** This is the study of chemical changes inside the organism. A scientist is called **biochemist.**

10. **Morphology-** This is the study of external structure of organisms. The scientist is called **Morphologist.**
11. **Bacteriology-** study of bacteria. The scientist is called **bacteriologist.**
12. **Histology-** study of structure of tissues. The scientist is called **histologist.**
13. **Virology-** study of viruses. The scientist is called **virologist.**
14. **Ornithology-** Study of birds. The scientist is called **ornithologist.**
15. **Ichthyology-** study of fish. The scientist is called **Ichthyologist.**
16. **Taxonomy-** This is the study of classification of organisms. The scientist is called **Taxonomist.**
17. **Embryology-** study of development of organisms from egg to adult. The scientist is called **Embryologist**

Importance of studying Biology.

1. It helps us to understand the developmental stages in human body.
2. It helps in solving environmental problems e.g. ***pollution, shortage of food, global warming / drought, poor health, misuse of natural resources (forests, wildlife, water and soil.***
3. It enables one to pursue careers e.g. ***agriculture, veterinary, public health, medicine, tourism, pharmacy, dentistry, nursing, biology education/ teaching, and horticulture.***
4. It helps us to promote international cooperation in areas like medicine and environmental conservation to solving emerging problems like ***HIV and AIDS.***
5. It helps learner to acquire scientific skills e.g. ***observation , identification, drawing, recording, classifying, measuring, analyzing and evaluating data*** and apply them in daily life.

CHARACTERISTICS OF LIVING ORGANISMS

1. **Nutrition-** a process by which living things acquire and utilize nutrients. Plants synthesize/make their own food using ***light energy, carbon (IV) oxide, water and mineral salts,*** while animals feed on already manufactured foods.
2. **Respiration-** a process in which organic compounds are broken down to produce energy. Energy is used by the organisms to carry out essential activities e.g. growth and movement.

- During respiration, oxygen is usually used while ***energy, carbon (IV) oxide and water*** are the products.
- Living organisms carry out respiration.

3. **Gaseous exchange-** this is the process whereby respiratory gases (oxygen and carbon (IV) oxide) pass across the respiratory surface.

- Examples of respiratory surfaces include **stomata** in leaves, **Alveoli** in lungs, **gills** in fish, **skin** in frogs, **cell membrane** in unicellular organisms.
- Living organisms carry out gaseous exchange.

4. **Excretion-** is the process by which metabolic wastes are separated and eliminated from the body cells. This is to avoid accumulation to toxic levels leading to death.

- Living organisms carry out excretion/ excrete.

5. **Growth and Development-** **Growth** is an irreversible/permanent increase in size and mass while **Development** is the irreversible change in the complexity of the structure of living things.

- Living things grow in order to attain the maximum size and mass which are essential for their body function.
- Living organisms grow and develop.

6. **Reproduction -** is the process by which living organisms give rise to new individuals of the same kind.

- Living organisms reproduce.

7. **Irritability/sensitivity-** This is the ability of living organisms to perceive/detect changes in their surroundings and respond appropriately .

- For example living things react to changes in **temperature, humidity, light, pressure and to presence or absence of certain chemicals.**

6. **Movement**- is a change in position by either a part of or the whole living organism. Living organisms move.

- Movement from one place to another is called **locomotion.**
- Movement in animals include **swimming, walking, running, flying e.t.c.**
- Movement in plants include **closing of leaves, folding of leaves, closing of flowers and growing of shoots towards light.**

Study questions.

1. A car/aeroplane is able to move from place to place and give out exhaust gases however it is not classified as a living organism. Explain.

This is because it does not reproduce, respond to changes in the environment, grow, develop, excrete, carry out nutrition and respire.

2. How does nutrition differ in plants and animals?

Plants manufacture their own food/ are autotrphic; while animals do not manufacture their own food/ are heterotrophic;

3. State the characteristics of living organisms that are specific to plants.

i. ***Autotrophic/ manufacture their own food/ photosynthesis;***

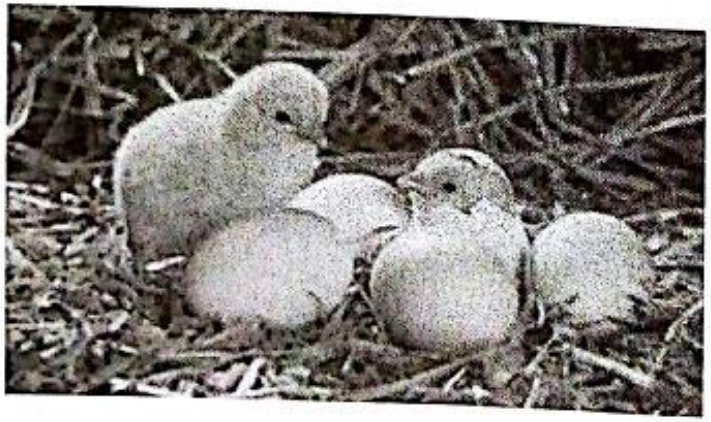
ii. ***Show alternation of generation;***

iii. ***Have limited movement;***

iv. ***Have limited excretory products/ unspecialized respiratory structures;***

v. ***Have localized growth/ growth occurs at specific regions;***

4. The photograph below illustrates living organisms. Study it and answer the question that follow.



- State two characteristics of living organisms illustrated in the photograph

1. ***Reproduction***
2. ***Growth and development.***

5. Name the characteristic of living organisms illustrated by each of the activities described below;

a) Dressing heavily-

✓ **Irritability/ sensitivity/ response to a stimulus**

b) Bursting of the sporangium in *Rhizopus sp.*

✓ Reproduction.

Collection of specimens

- A specimen is a whole organism or part of an organism being studied or examined.

Importance of collection of specimens

- It is important for further study, observations and preservation for future reference in the laboratory.

Precautions during collection and observation of specimens

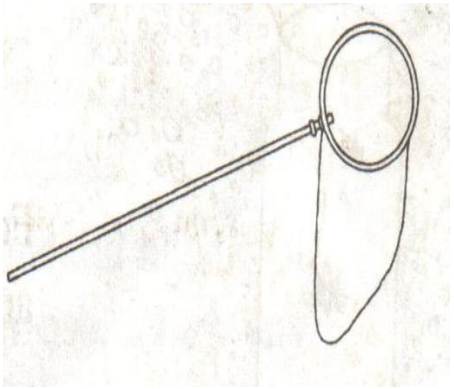
1. Collect only the number of specimens needed to avoid wastage.
2. Do not harm the specimens during the collection exercise because it can distort the features of the specimens
3. Do not destroy the natural habitat of the of specimens.
4. Live specimens should be returned to their habitats whenever possible to maintain ecological balance.
5. Dangerous or injurious specimens (e.g. stinging insects or plants) should be handled with care (using forceps and gloves) to avoid injury/ for protection.
6. Highly mobile animals should be immobilized using suitable chemical substances (e.g. **Chloroform or diethylether)** for easy observation.

Apparatus used for collection of specimens

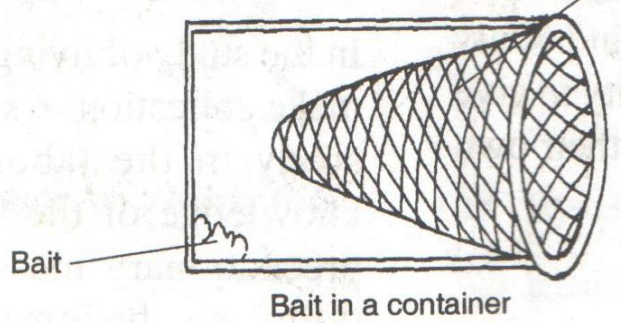
1. **Sweep net-** used to catch flying insects e.g. bees, butterflies, grasshoppers.
2. **Bait trap-**used for attracting and trapping small animals e.g. rats and mice.
3. **Pitfall trap-** it is used for catching crawling animals e.g. millipedes, spiders, ants, cockroach.
4. **Fish net-** used for trapping small fish and other water animals e.g. crabs and shrimps.
5. **Pooter-** it is used for sucking small animals from rock surfaces or barks of trees e.g. ants, termites.
6. **Pair of forceps-** it is used for picking up stinging animals and plants e.g. centipedes, spiders, stinging nettle.
7. **Specimen bottle-** it is required for keeping collected specimens.
8. **Hand lens-** it is used to enlarge objects and observe external features of collected specimens

Apparatus used for collection of specimens

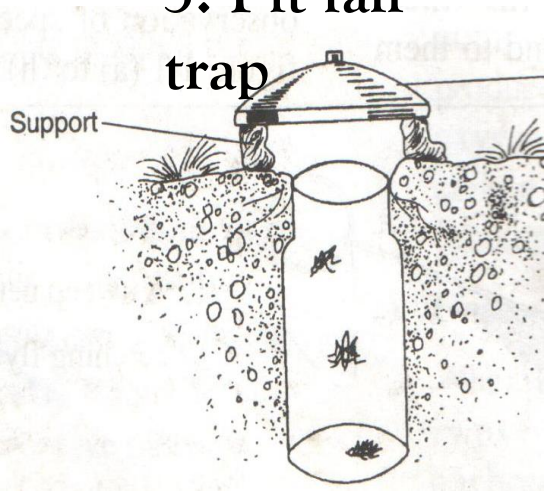
1. Sweep net



2. Bait t

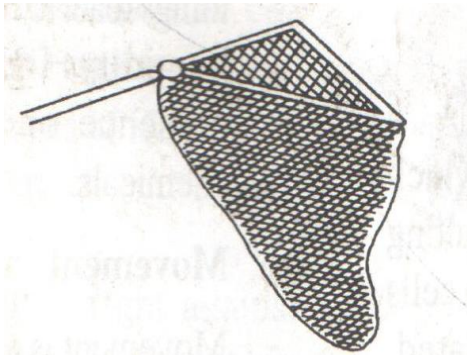


3. Pit fall trap

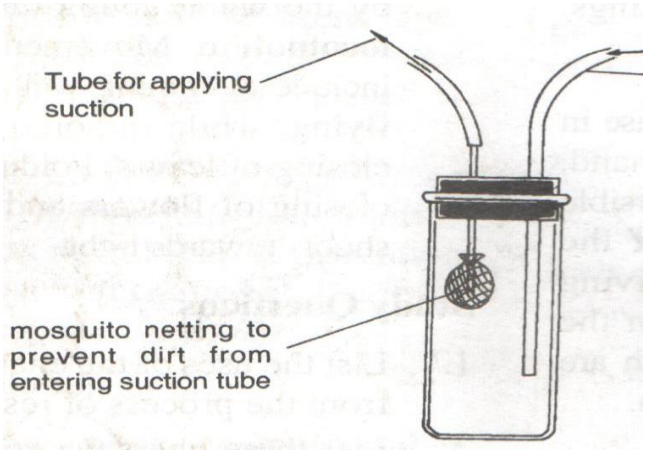


Cover to prevent rain from getting in

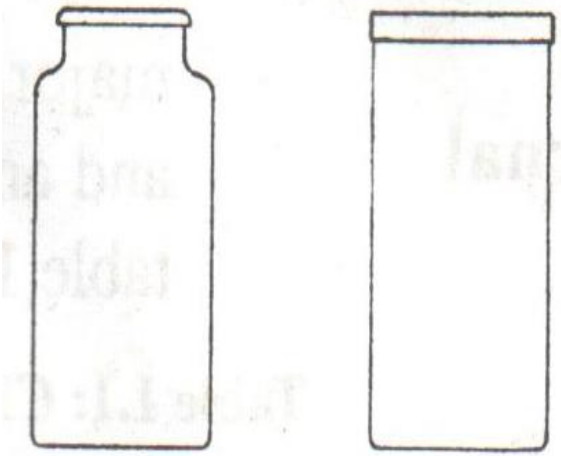
4. Fish net



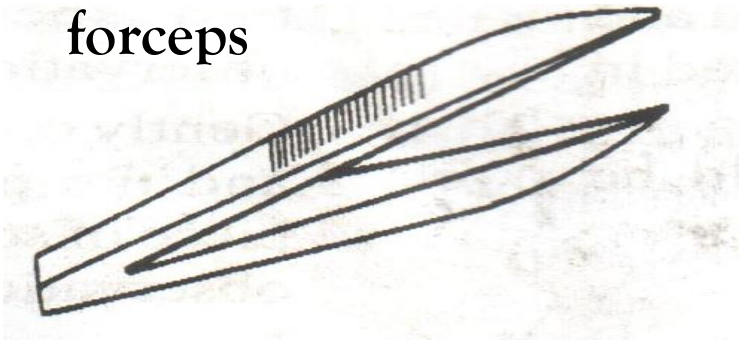
5. Pooter



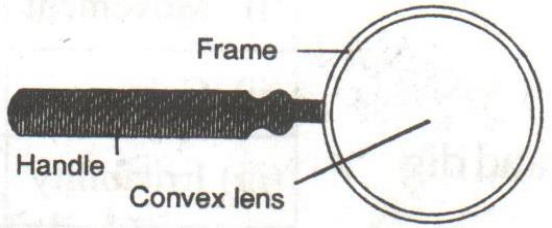
7. Specimen bottle



6. Pair of forceps



8. Hand lens



Differences between plants and animals

Plants	Animals
1. Most plants are green in colour/ have chlorophyll hence make their own food.	1. They lack chlorophyll hence do not make their own food/ feed on already manufactured food.
2. They respond to changes in their environment slowly.	2. They respond to changes in their environment faster.
3. They do not locomote/ move from one place to another.	3. They locomote/ move from one place to another.
4. Growth occurs at specific regions/ meristematic cells only.	4. Growth occurs all over the body.
5. They lack complex excretory and respiratory organs/ structures.	5. They have complex respiratory and excretory organs/ structures.

2. CLASSIFICATION 1

1

- **Classification** is the grouping of living organisms based on their structure.
- Those with similar structures are put under one group called **taxon (plural- taxa)**
- A science/study of classification is called **taxonomy** and scientists are called **taxonomists.**
- Taxonomy involves the placing of organisms into taxa and assigning them names.

- External features are used when classifying organisms e.g.

a) In plants-

i. Rhizoids and seta in moss plant.

ii. Fronds, sori and rachis in ferns.

iii. Roots, stems, leaves, flowers, seeds, fruits and cones in higher plants.

b) In animals-

i. Tentacles in hydra.

ii. Feathers and wings in birds.

iii. Shells in snails.

iv. Sensory organs e.g. eyes, ears, antennae.

v. Fur, hair and mammary glands in mammals.

vi. Scales and fins in fish.

vii. Proglotids and scolex in tapeworms.

viii. Locomotory structures e.g. limbs in arthropods and vertebrates.

ix. Body pigmentation.

Significance/ importance / necessity of classification.

1. It groups together living organisms with similar characteristics but separates those with different features.
2. Helps in placing living organisms into their correct groups for easy reference.
3. Helps to arrange the information about living organisms in an orderly manner to avoid chaos and confusion.
4. Helps to understand the evolutionary relationships between different organisms.
5. It makes it easier for scientists to communicate since the whole world uses the same groupings.

- Some organisms are small or have tiny features which cannot be seen clearly, therefore require the use magnifying instruments
- A common magnifying instrument used is called a **hand lens.**
- It is used to magnify organisms/ make them look bigger.
- It is made up of **a convex lens** mounted on **a frame.**
- **The handle** is either wooden or plastic.

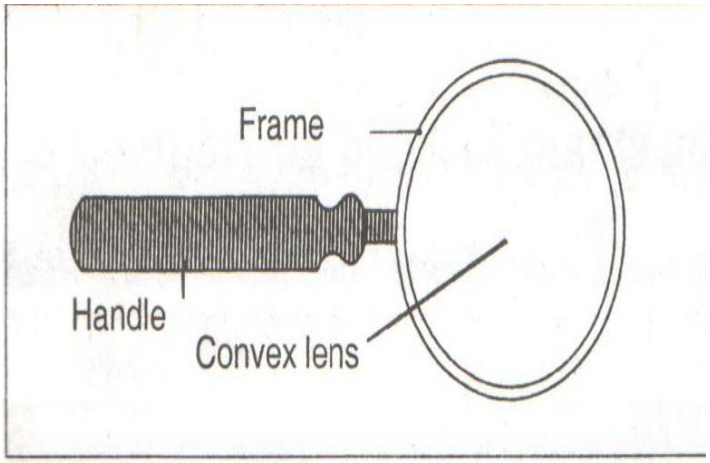


Fig. 2.1 A hand lens

How to use a hand lens.

i. Place the object on the bench near the light source.

ii. Move the lens to and from the eyes until the object becomes clear. When the object is clear, it is said to be in focus and an enlarged image is seen.

iii. If a drawing is made with the help of the magnifying lens then the magnification of the drawing in relation to the size of the object **must** be worked out as shown below.

$$\text{Magnification} = \frac{length\ of\ the\ drawing}{actual\ length}$$

Example 1

- A form one student examined a specimen whose length was 43mm, then drew the diagram whose length was 86mm. Calculate the magnification of the drawing.

Solution.

Magnification = length of the drawing

length of the object

= 86 mm

43 mm

= x2.

Example 2

- If the magnification of a drawing is x5 and the drawing length is 10cm. What is the actual length of the object?

solution

$$\text{Magnification} = \frac{length\ of\ the\ drawing}{actual\ length}$$

$$Actual\ length = \frac{length\ of\ the\ drawing}{magnification}$$

$$Actual\ length = \frac{10cm}{5}$$

$$Actual\ length = 2cm$$

BIOLOGICAL DRAWINGS

- The following are important points to note when making biological diagrams:

1. Use a well sharpened pencil.
2. The drawing should occupy ½ or ¾ of the space provided.
3. Each drawing should have a title.
4. Enough space should be left all round the drawing for labeling.
5. Avoid using double lines when making outlines of a drawing.
6. Label lines should not have arrow heads.
7. The magnification of a drawing should always be worked out.
8. The drawing should not be shaded.
9. The label lines should never cross each other.

Taxonomic Units of Classification.

- These refer to the groups (or taxa) into which organisms are placed.
- There are seven major taxonomic units as shown below.

i. Kingdom.
ii. Phylum (or Division).
iii. Class.
iv. Order.
v. Family.
vi. Genus.
vii. Species.

- Moving down the taxonomic units the number of organisms in each group decreases but the similarities between then increases.
- Phylum is used when classifying animals while division is used when classifying plants.
- The **kingdom** has the highest number of organisms/members while **species** has members with more common characteristics.
- The species is the smallest unit of classification **whose members can naturally and freely interbreed and produce/give rise to fertile offspring.**

KINGDOMS OF CLASSIFICATION

1. **Monera-**This includes the bacteria and viruses.
2. **Protoctista-** This includes the **algae,** e.g. spirogyra and **protozoa, e.g. amoeba, Paramecium and Plasmodium.**
3. **Fungi-** This includes moulds**, e.g. moulds, yeasts and mushrooms.**
4. **Plantae-** Examples include **moss, blacken fern, maize, beans and jacaranda.**
5. **Animalia-** This includes **housefly, spider, crab, lizard, elephant, hawk and cow.**

SCIENTIFIC NAMING OF ORGANISMS.

- The present system of naming organisms is called **Binomial nomenclature.**
- It was developed by Swedish biologist called ***Carolus Linnaeus*** in 18th century.
- It involved giving organisms two latin names because:

i. They rarely change/ are static.

ii. They are written in the same language all over the world.

Importance of giving organisms two names

i. Enables biologists to arrange organisms in an orderly manner.

ii. It provides names that have the same meaning world wide.

BINOMIAL NOMENCLATURE

- This is the scientific system of giving organisms two names, generic/ genus name and specific/ species name.

Rules of binomial nomenclature.

1. The first name/ genus name should begin with capital letter and the second name/ specific name should be written in small letters.
2. The names should be printed in italics in books but underlined separately when handwritten.

Example,

- The lion is called ***Panthera leo*** when printed and **Panthera leo** when hand written the leopard is called ***Panthera pardus*** when typed and **Panthera pardus** when hand written.
- The name ***Panthera*** represents **genus** while ***leo and pardus*** represent **species.**
- Lion and leopard belong to the same genus but different species.

3. THE CELL

- The cell is the basic unit of structure and functions in organism.
- The cells make up the structures of the living organisms and are responsible for carrying out the various biological processes.
- **Unicellular** organisms comprise of only one cell, ***e.g. amoeba, Paramecium, and plasmodium.***
- **Multicellular** organisms are made up of many cells, ***e.g. moulds, grasshopper, moss, eucalyptus, man and elephant.***
- A cell being a very small structure that cannot be seen with the naked eye, hence it requires the use of a powerful magnifying instrument known as the ***microscope***.

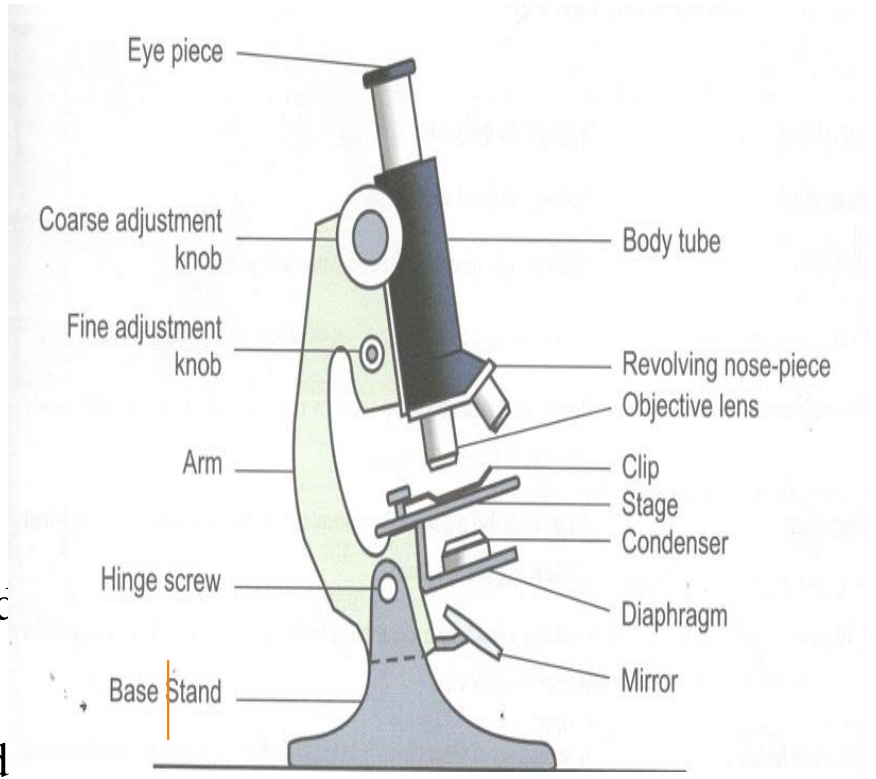
Functions of a microscope.

1. **Magnification-** making very small organisms to appear bigger so that they can be seen.
2. **Resolution-** ability to distinguish two structures that are very close together as distinct entities.

Types of microscope.

1. **Light microscope-** It uses light for illumination of the specimen to be viewed
2. **Electron microscope-** The electron microscope uses an **electron beam** instead of light for illumination of the specimen to be viewed.

LIGHT MICROSCOPE



Uses of different parts of a light microscope.

1. **Arm/ limb-** it supports the body tube and stage.
2. **Base/ stand-** it provides a firm and stable support.
3. **Body tube-** it holds the eye-piece and revolving nose piece.
4. **Eye piece-** it contains a lens which contributes to the magnification of the image of the specimen under view.
5. **Coarse adjustment knob-** it brings image into rough focus (by raising and lowering the body tube through long distances).
6. **Fine adjustment knob-** it brings the image into sharp focus (by raising and lowering the body tube through smaller distances).
7. **Diaphragm-** it is an aperture that regulates the amount of light passing through the condenser to illuminate the specimen.

8. **Objective lenses-** they contribute to the magnification of the image of the specimen.
9. **Mirror-** it reflects light through the condenser onto the stage.
10. **Revolving nose piece-** it holds the objective lens in place thus enabling change from one objective lens to another.
11. **Condenser-** it concentrates light onto the stage.
12. **Stage-** it is a flat platform where specimen on the slide is placed.
13. **Clip-** it holds the slide in position.

HANDLING AND CARE OF A LIGHT MICROSCOPE.

1. Always use both hands when carrying a microscope.
- ☐ One hand should hold the base to provide support while the other hand holds the limb/arm.
2. Never place the microscope too close to the edge of the working bench or table as it can easily fall off.
3. Do not touch the mirror and the lenses with your fingers as it can make them wet or dirty.
4. Dirty lenses should be cleaned using a special soft lens tissue paper or tissue paper moistened with ethanol to avoid scratches.
5. Other parts of the microscope may be cleaned using a soft cloth or tissue paper.
6. Do not wet any part of the microscope as it can cause rusting.
7. Make sure the low power objective lens clicks into position in line with the eye-piece before and after use.
8. After use, always clean and store the microscope in a safe place, free from moisture and dust.

USING THE LIGHT MICROSCOPE

1. Place the microscope on the bench with the stage facing away from you.
2. Turn the low power objective lens until it clicks into position.
3. Ensure that the diaphragm is fully open.
4. Look through the eye-piece with one eye. Meanwhile adjust the mirror under the stage to ensure that maximum light can pass through. The circular area seen is referred to as the **field of view.**
5. Place the slide containing the specimen on the stage and clip it into position. Make sure that it is in the centre of the field of view.
6. Again, look through the eye-piece while adjusting the mirror under the stage to ensure that sufficient light is passing through the specimen.
7. Use the coarse adjustment knob to bring the low power objective lens to the lowest point. Viewing through the eye-piece, turn the coarse adjustment knob gently until the specimen comes into focus.

8. Use the fine adjustment knob to bring the image into sharp focus.
9. Make a drawing of what you see.
10. For higher magnifications, turn the medium power objective lens into position and adjust the focus using the coarse adjustment knob. For sharper images, use the fine adjustment knob.
11. If finer details are required, turn the high power objective lens into position. Now use only the fine adjustment knob to bring details into sharper focus.

- Sometimes a camera can be fixed at the eye piece lens in order to take a photograph of the specimen. The photograph is called ***photomicrograph.***

Study questions

1. **How is the low objective lens manipulated to focus a specimen for observation under a light microscope.?**

- Click the low power objective lens in position (bring it down to the lowest level using coarse adjustment knob)
- With the eyes on the two eye piece lens and using the coarse adjustment knob gradually raise/the low power objective lens to bring the specimen into focus.

2. Give a reason why only the fine adjustment knob should be used when using high power objective/ coarse adjustment knob should not be used to lower the high power objective lens.

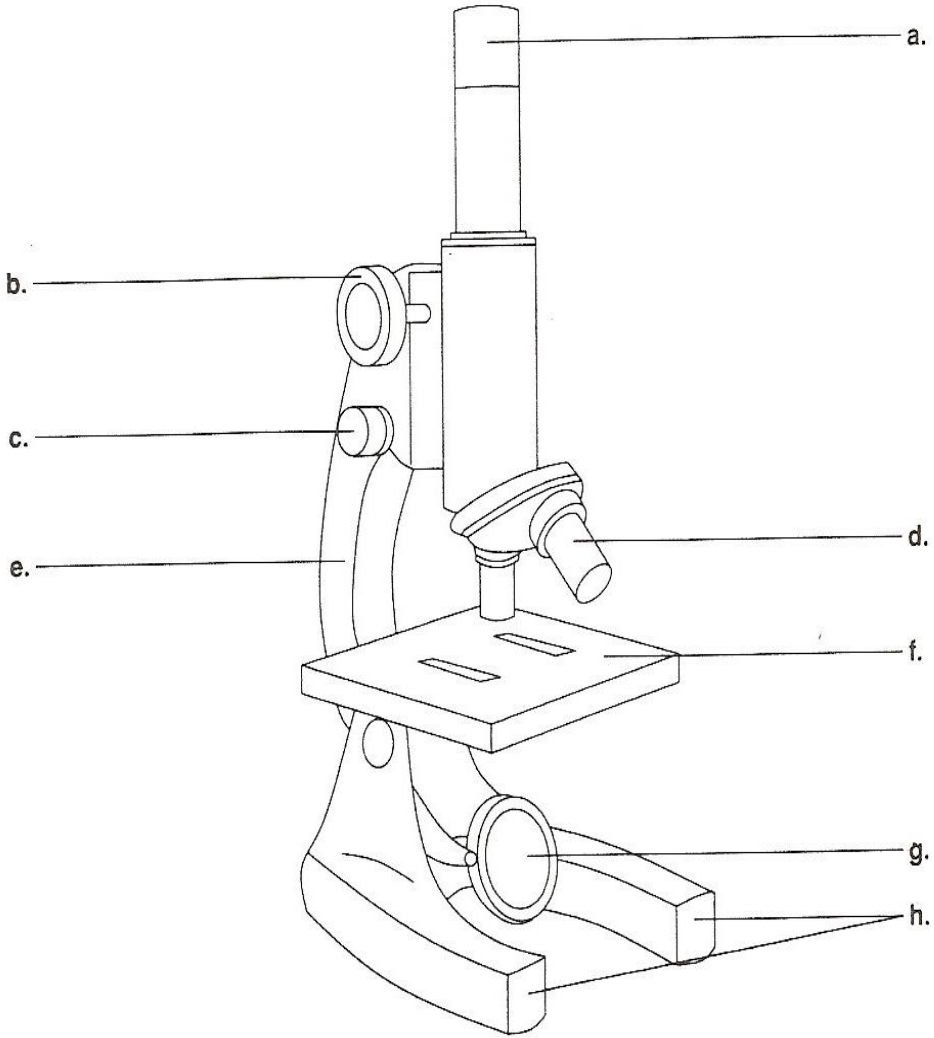
i. **To avoid breaking the slide, cover slip and lens.**

ii. **To avoid destroying the specimen/ dirtfying the lens.**

Differences between the light and electron microscopes

Light microscope	Electron microscope
1. Uses light to illuminate the specimen.	1. Uses a beam of electrons to illuminate the specimen.
2. Uses glass lenses for magnification.	2. Uses magnetic lenses for magnification.
3. Has low resolving power.	3. Has very high resolving power.
4. Has low magnification power.	4. Has very high magnification power.
5. The specimen under view can be living or dead.	5. The specimen under view is dead.
6. The specimen is stained using normal dyes.	6. The specimen is stained using complex stains.
7. The specimen is mounted on a slide and placed on the stage in the open.	7. The specimen is mounted on a grid and placed in a vacuum.

Study question. Name the parts of the light microscope shown below.



a. Eyepiece

b. Coarse Adjustment

c. Fine Adjustment

d. Objectives (LP, HP)

e. Arm

f. Stage

g. Light source

h. Base

i. Diaphragm

Magnification of a light microscope.

- The magnification of the image of the object viewed is calculated by multiplying the eye piece lens magnification by the objective lens magnification i.e.

Magnification = eye piece lens magnification x objective lens magnification.

Example

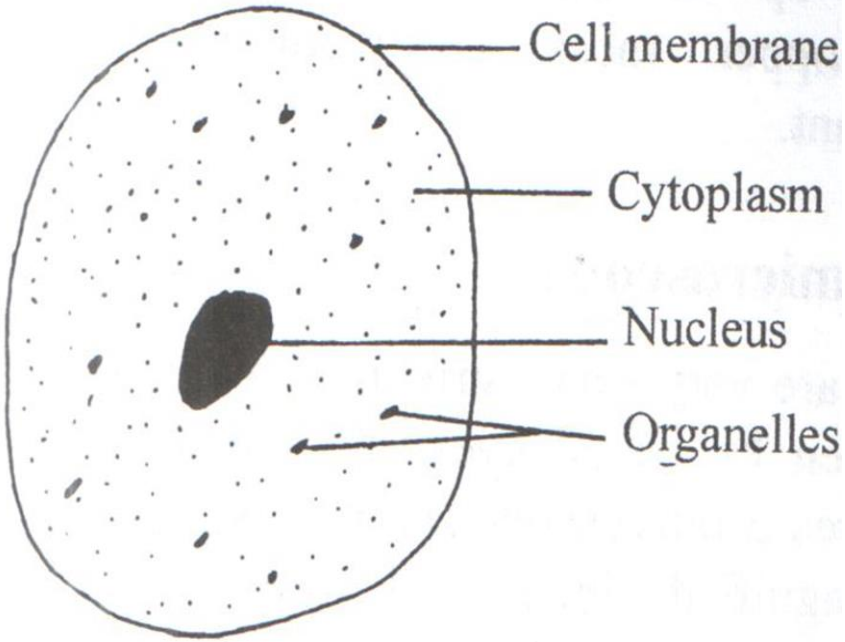
If the eye-piece lens has a magnification of X5 and the low power objective lens has a magnification of X10, then the total magnification is 5 x 10 = X50.

Study question.

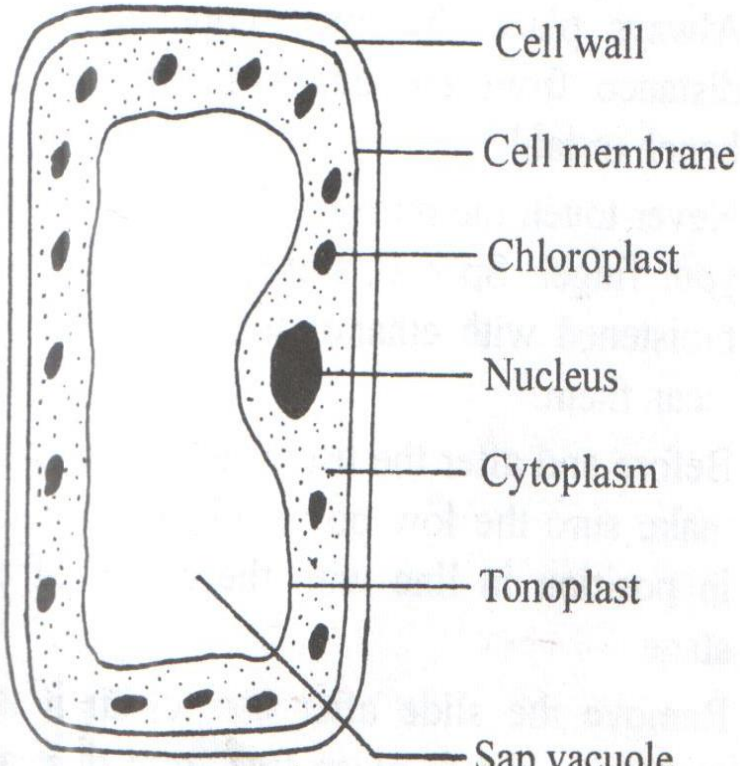
- Copy and complete table below.

Eye-piece lens magnification.	Objective lens magnification.	Total magnification.
X5	X4	X20
X10	X5	
X10		X100
	X40	X600
X10	X100	

PLANT AND ANIMAL CELLS AS SEEN UNDER THE LIGHT MICROSCOPE.

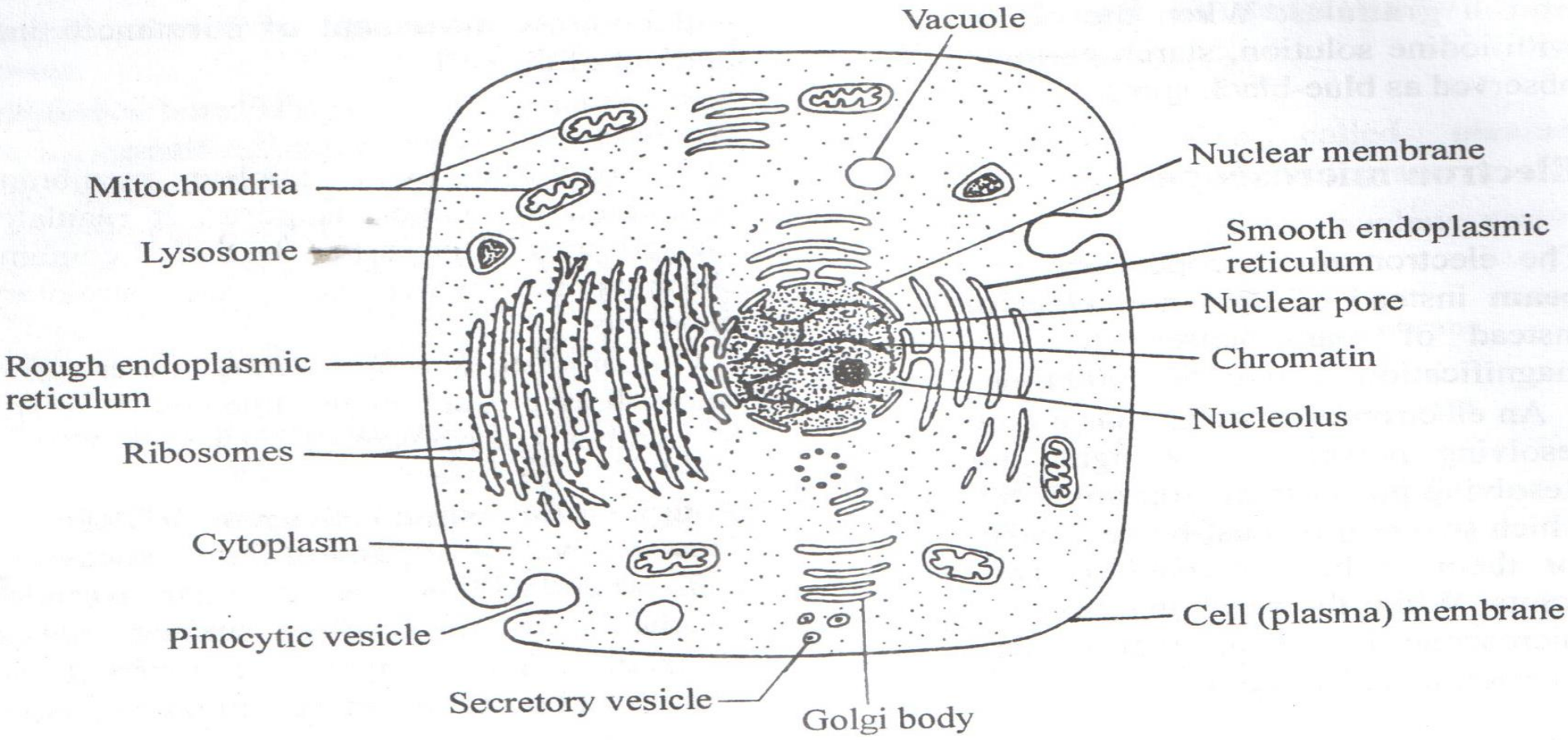


An animal cell

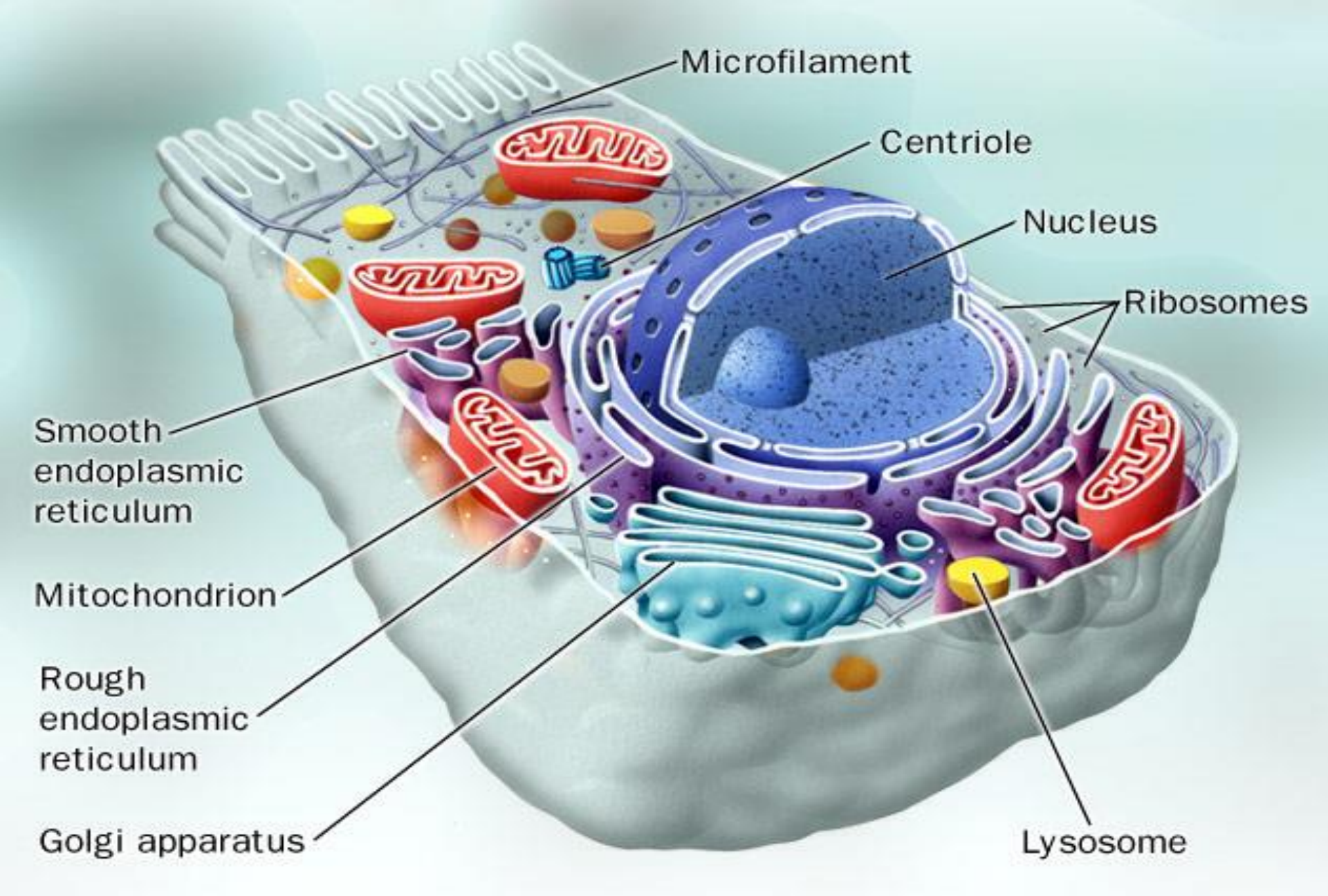


A plant cell

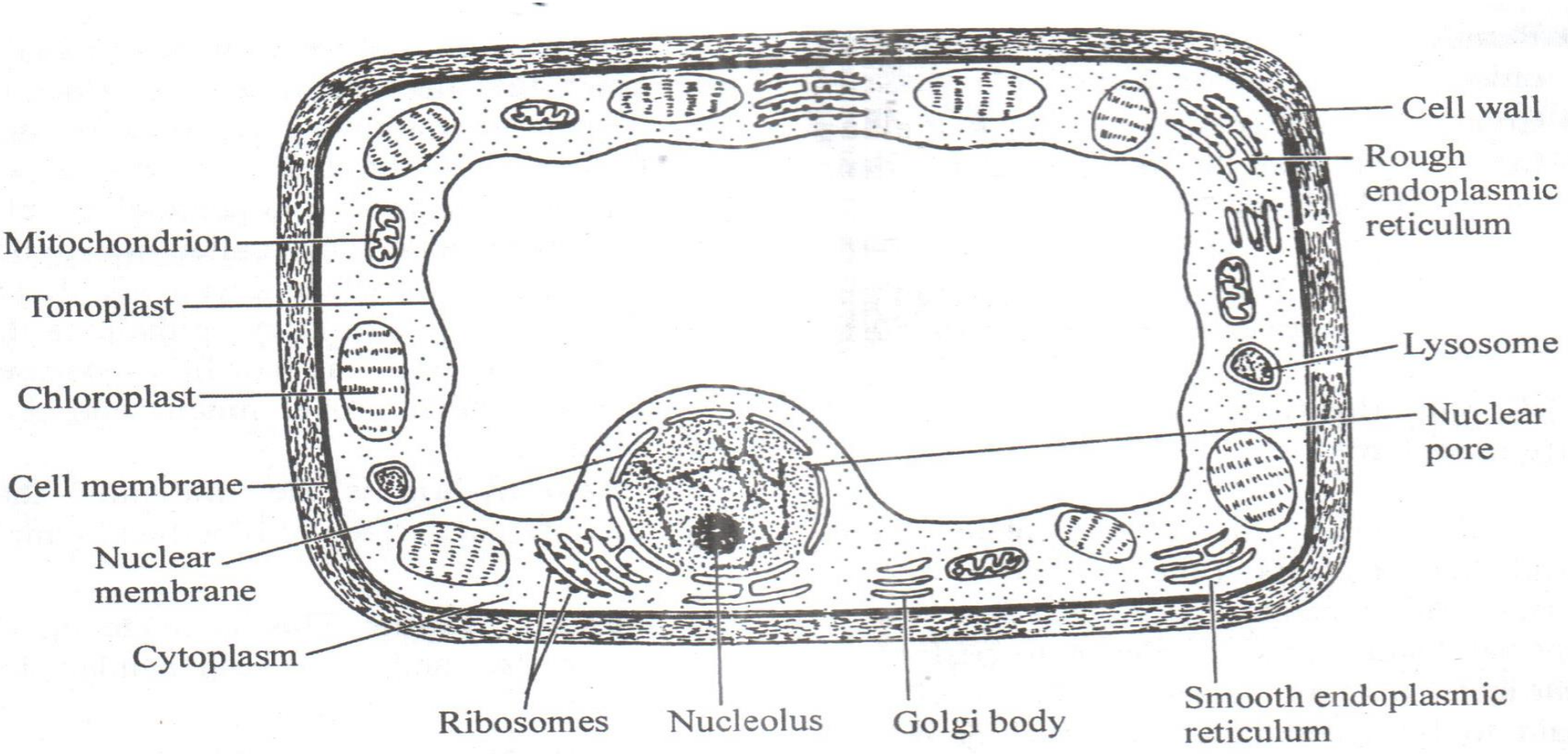
Animal cell as seen under the electron microscope.



Animal cell as seen under the electron microscope


Microfilament
Centriole
Nucleus
Ribosomes
Smooth endoplasmic reticulum
Mitochondrion
Rough endoplasmic reticulum
Golgi apparatus
Lysosome

Plant cell as seen under electron microscope.



Plant cell as seen under the electron microscope

Functions of cell organelles.

- **The cell** is the basic unit of life while **Cell organelles** are structures within the cells

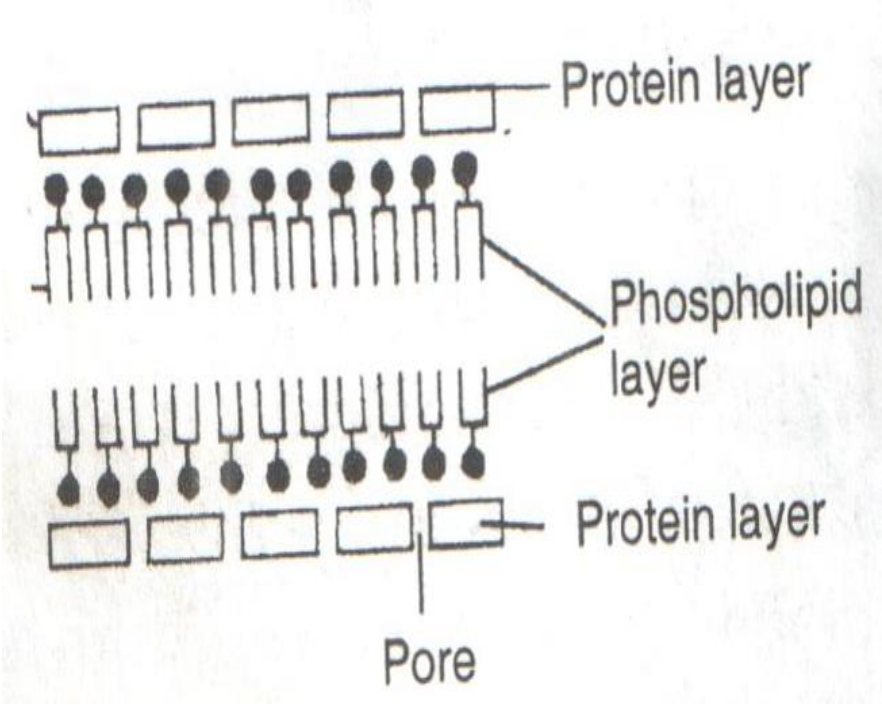
1. **THE CELL MEMBRANE/ PLASMA MEMBRANE/ PLASMALEMMA-**

- It consists of three layers under the electron microscope. The three layers are composed of ***one layer of phospholipid*** found between ***two protein layers.***

Functions of the cell membrane.

i. Enclose the cell contents.

ii. Controls the movement of materials in and out of the cell hence said to be ***semi-permeable/selectively permeable.***



2. **Cytoplasm**

Functions/ roles.

i. It is fluid medium in which chemical reactions take place.

ii. It contains other cell organelles and dissolved substances e.g. starch, glycogen, fat droplets.

- The cytoplasm is not static but has movement called **cytoplasmic streaming.**
- This movement is important because it distributes materials and cell organelles within the cell.

3. **Mitochondria (Singular- mitochondrion)**

Functions/ roles.

i. They provide a site for respiration (to provide energy). Mitochondria are bound by two membranes.

Structure

- The inner membrane is greatly folded into ***cristae*** to increase the surface area for attachment of respiratory enzymes.
- Has the **matrix** to provide a site for respiration.

- N/B Actively/ rapidly respiring cells e.g. muscle cell, sperm cell, apical meristems, kidney cell have numerous mitochondiria. This is because they require a lot of energy.

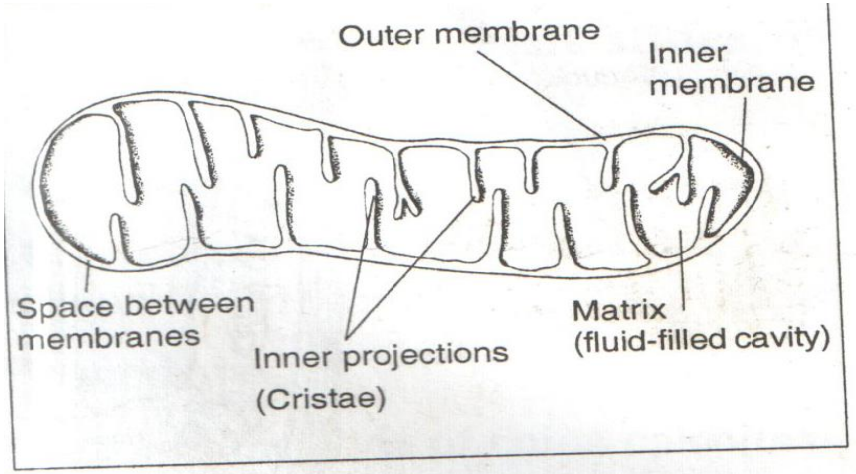


Fig. 3.6: The mitochondrion

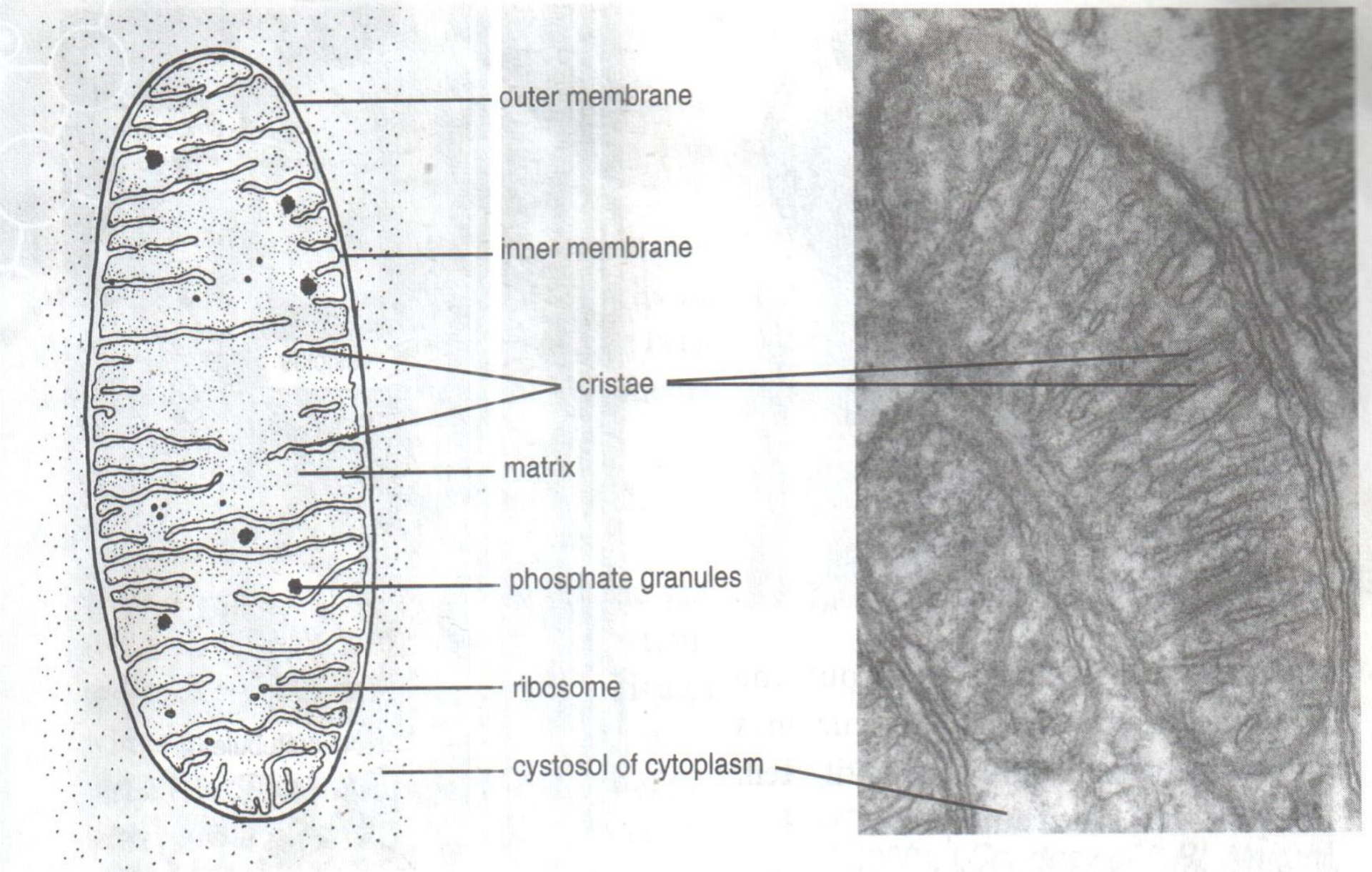


Fig. 2.9: L.S. showing internal structure of a mitochondrion x80,000 (micrograph courtesy of ILRI Nairobi).

4. **Endoplasmic Reticulum (ER)-** they are **interconnected channels** continuous with the outer membrane of the **nuclear membrane.**

- They include:

i. Smooth endoplasmic reticulum- they lack ribosomes on the surface.

ii. Rough endoplasmic reticulum- have ribosomes on the surface.

Functions.

i. The rough endoplasmic reticulum **transports proteins.**

ii. The smooth endoplasmic reticulum **manufactures/ synthesizes and transports lipids.**

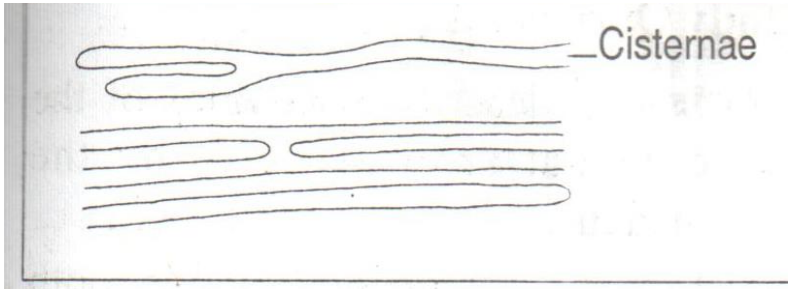


Fig. 3.7 (a): Smooth Endoplasmic reticulum

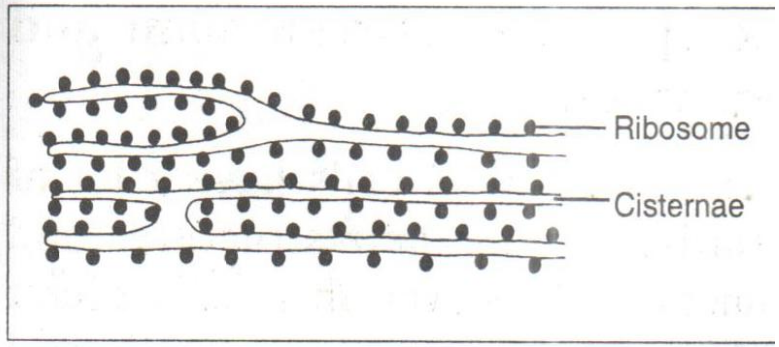


Fig. 3.7 (b): Rough Endoplasmic reticulum

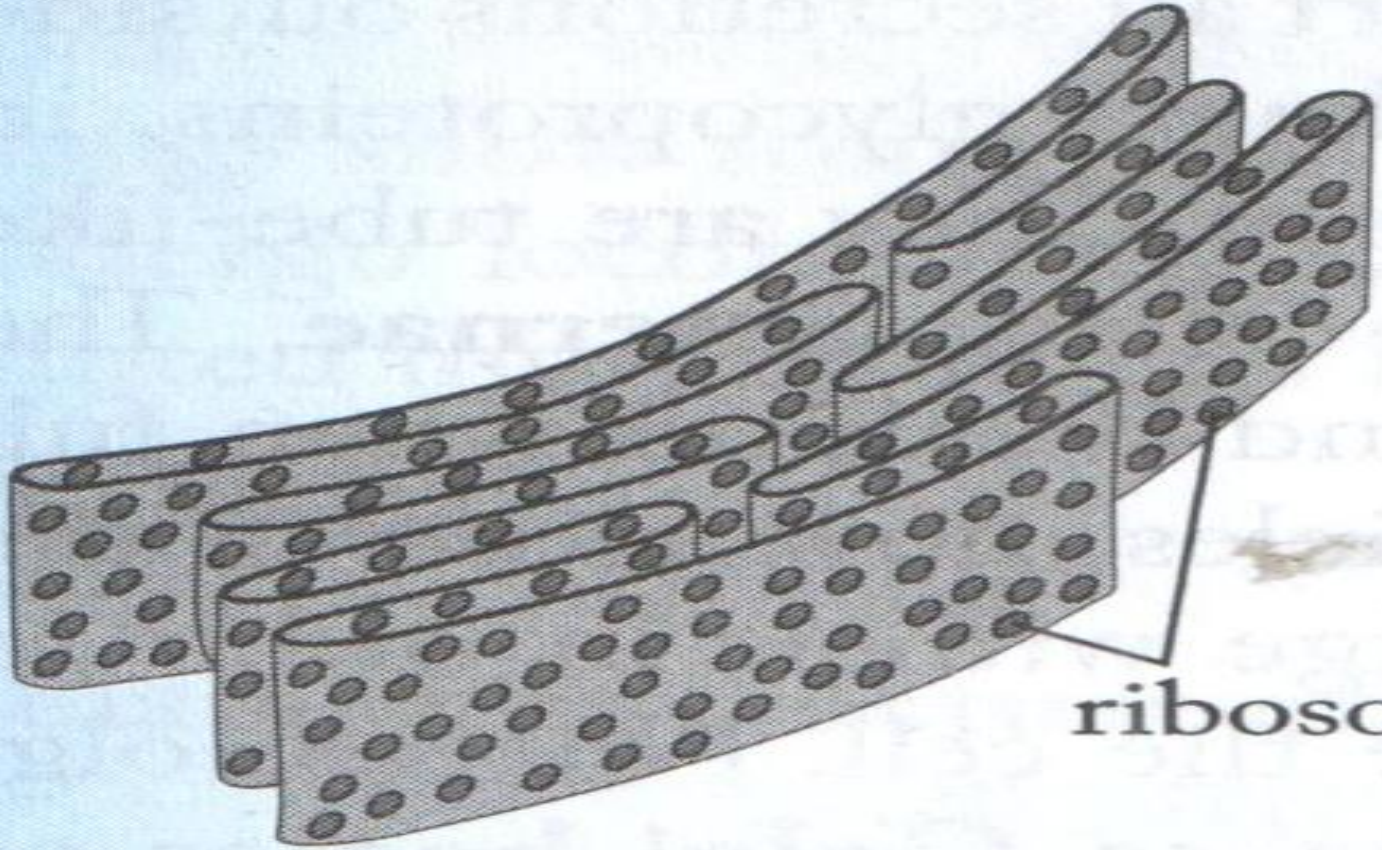


Fig 1.5: Rough Endosplamic reticulum (rER)

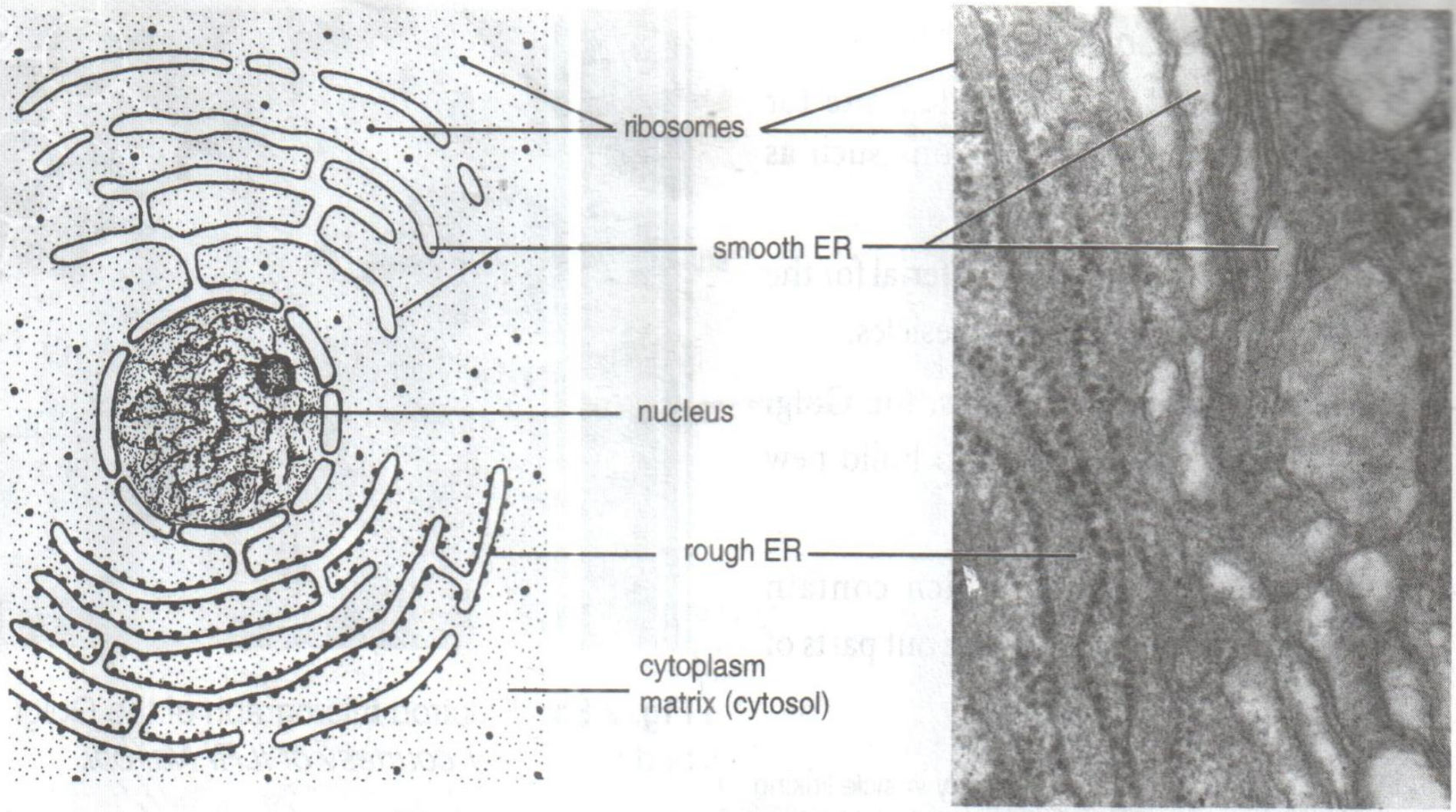


Fig. 2.7a: Rough (RER) and smooth endoplasmic reticulum (SER).

b: Electron micrograph showing RER and SER of part of a cell (x60,000).

5. **Ribosomes-** Ribosomes are spherical in shape.

- Some are scattered within the cytoplasm while others are bound to the surface of rough endoplasmic reticulum.

Function.

i. They form sites for **protein synthesis.**

6. **Lysosomes.**

Functions

i. Contain lytic enzymes which destroy worn out organelles/cells/tissue.

ii. Digestion of food/bacteria.

- White blood cells contain numerous lysosomes because they destroy pathogens hence contain numerous lysosomes because they contain lytic enzymes that destroy pathogens.

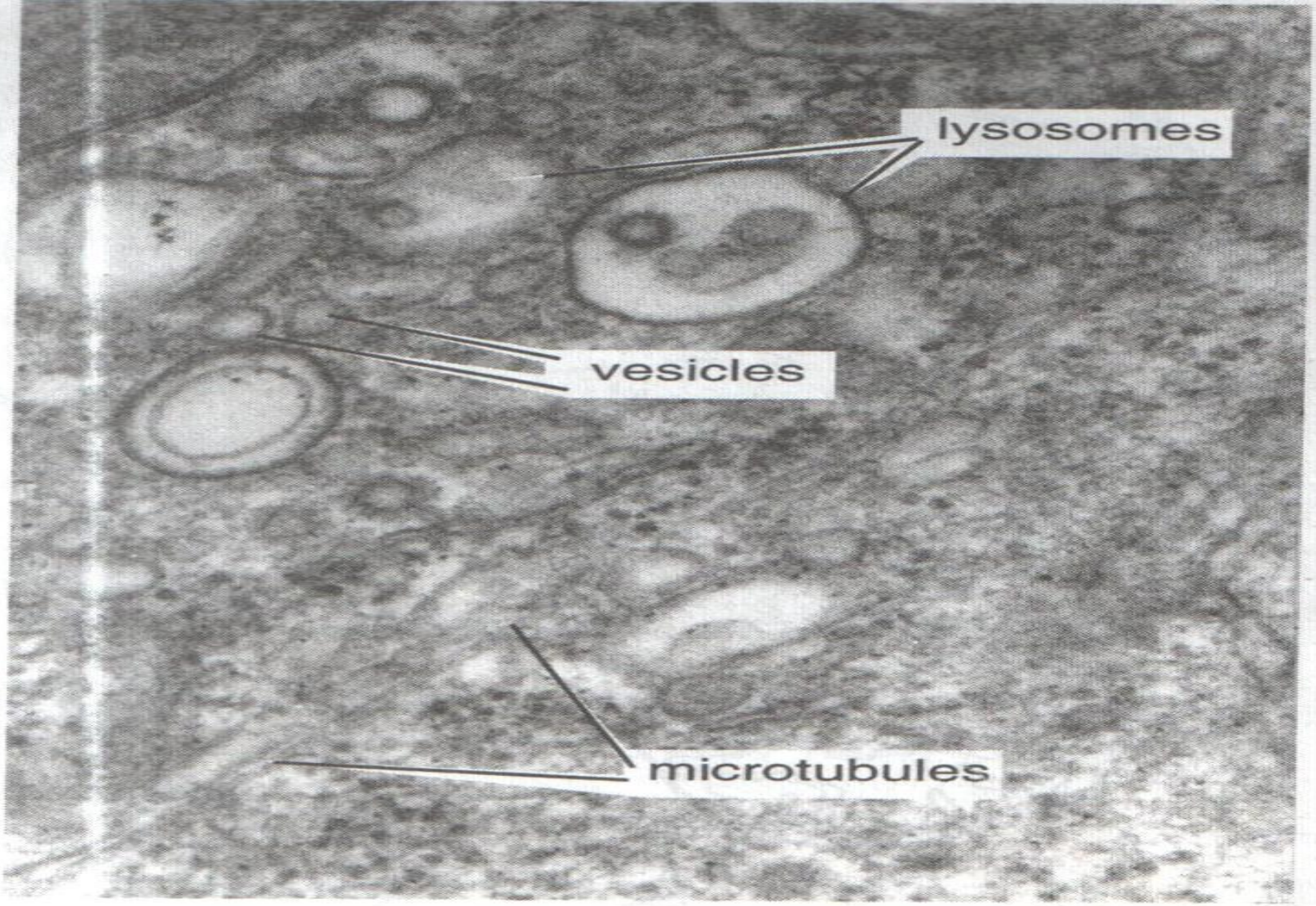


Fig. 2.10b: Electron micrograph of lysosomes.

7. **Golgi bodies (Golgi apparatus)-** they are stacks of membrane-bound **tube like sacs.**

- They are found close to the cell membrane.

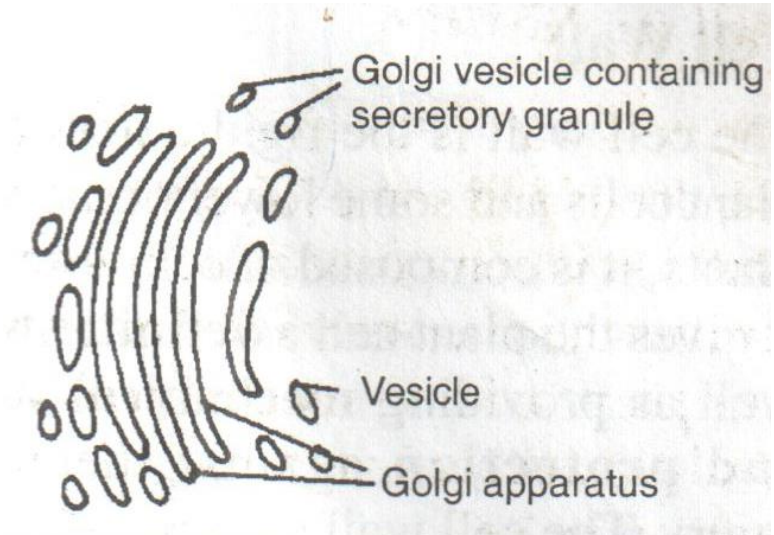
Functions of golgi apparatus/bodies

i. Packaging and transport of glycoproteins (glycogen/ carbohydrates and proteins) as secretions.

ii. Transport of synthesized materials/substances out of the cell as secretions e.g. enzymes.

iii. Secretion of synthesized/ manufactured glycoproteins (proteins and carbohydrates).

iv. Formation of lysosomes.



The golgi apparatus

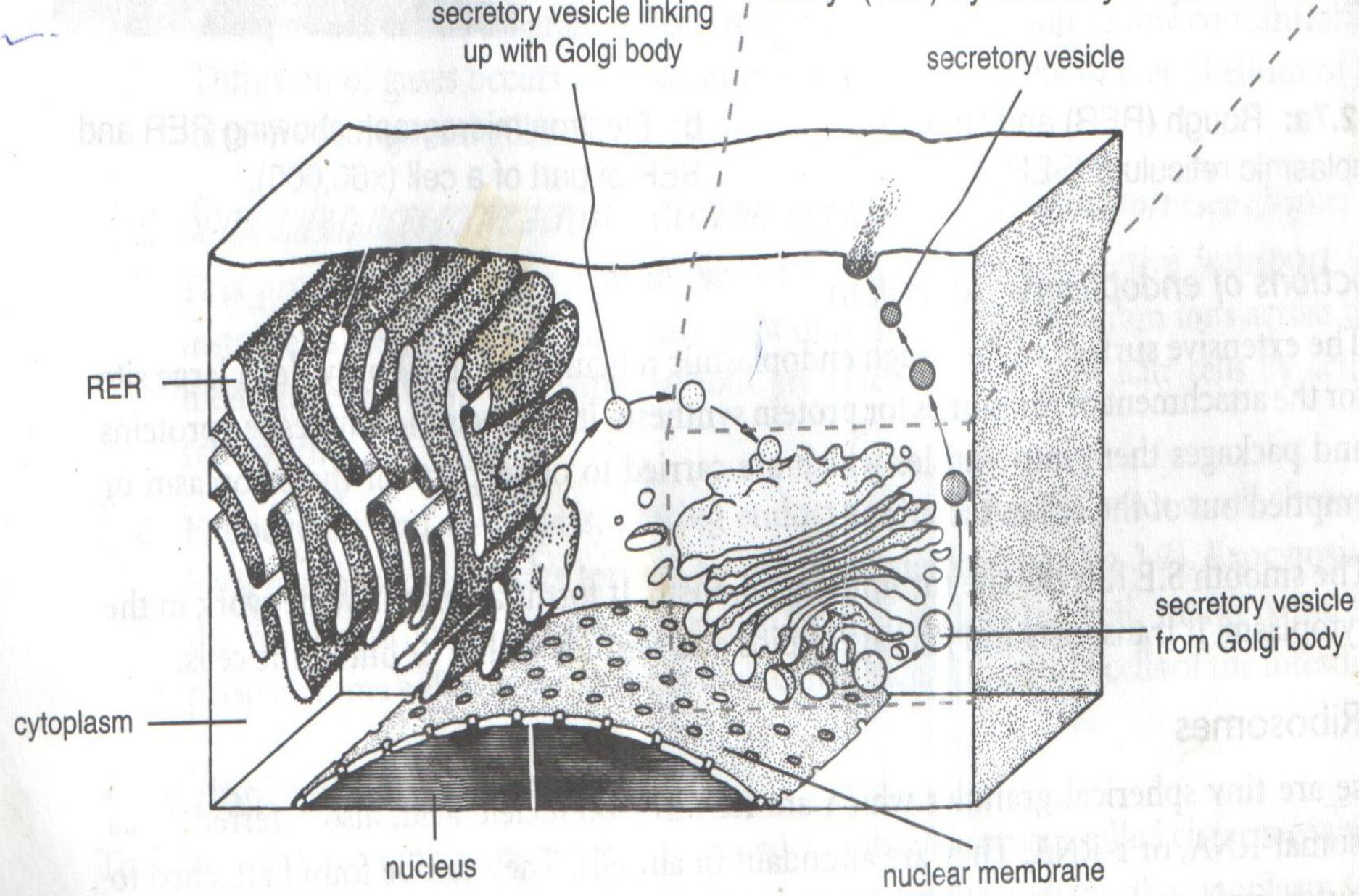


Fig. 2.8a: Three-dimension drawing showing a Golgi body in action.

8. **Centrioles-** they are rod-shaped structures located just outside the nuclear membrane.

Functions.

i. They form spindle fibres during **cell division** in animal cells.

ii. They help in the **formation** of **cilia** and **flagella** in cells and organisms where those structures occur e.g. protoctista.

9. **Chloroplasts-** they are found in plant cells only.

Function.

i. They provide a site for photosynthesis/ they contain chlorophyll that traps light for photosynthesis.

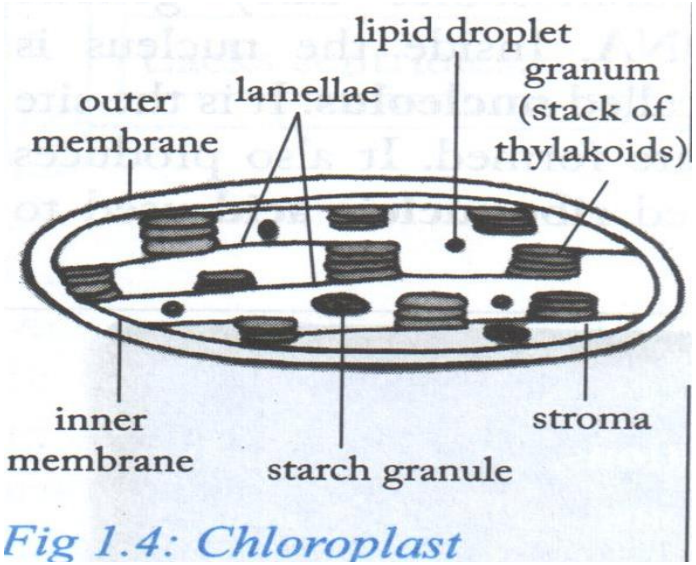


Fig 1.4: Chloroplast

10. **Vacuoles-** they are sacs which are filled with a fluid and vary in size.

- Animal cells contain small vacuoles which are small and temporary while plant cells contain large and permanent vacuoles.
- In plants vacuoles are centrally placed and surrounded by a membrane called **tonoplast.**
- They contain a solution of salt and sugars called cell sap hence they are called sap vacuoles.

Functions/ roles.

i. They store salts and sugars.

ii. The sap contributes to the osmotic properties of the cell.

- In unicellular organisms:

i. Contractile vacuole removes/ excretes excess water (osmoregulation)

ii. Contractile vacuole removes/ excretes metabolic wastes.

iii. Food vacuole is used for feeding/ digestion/ storage of food.

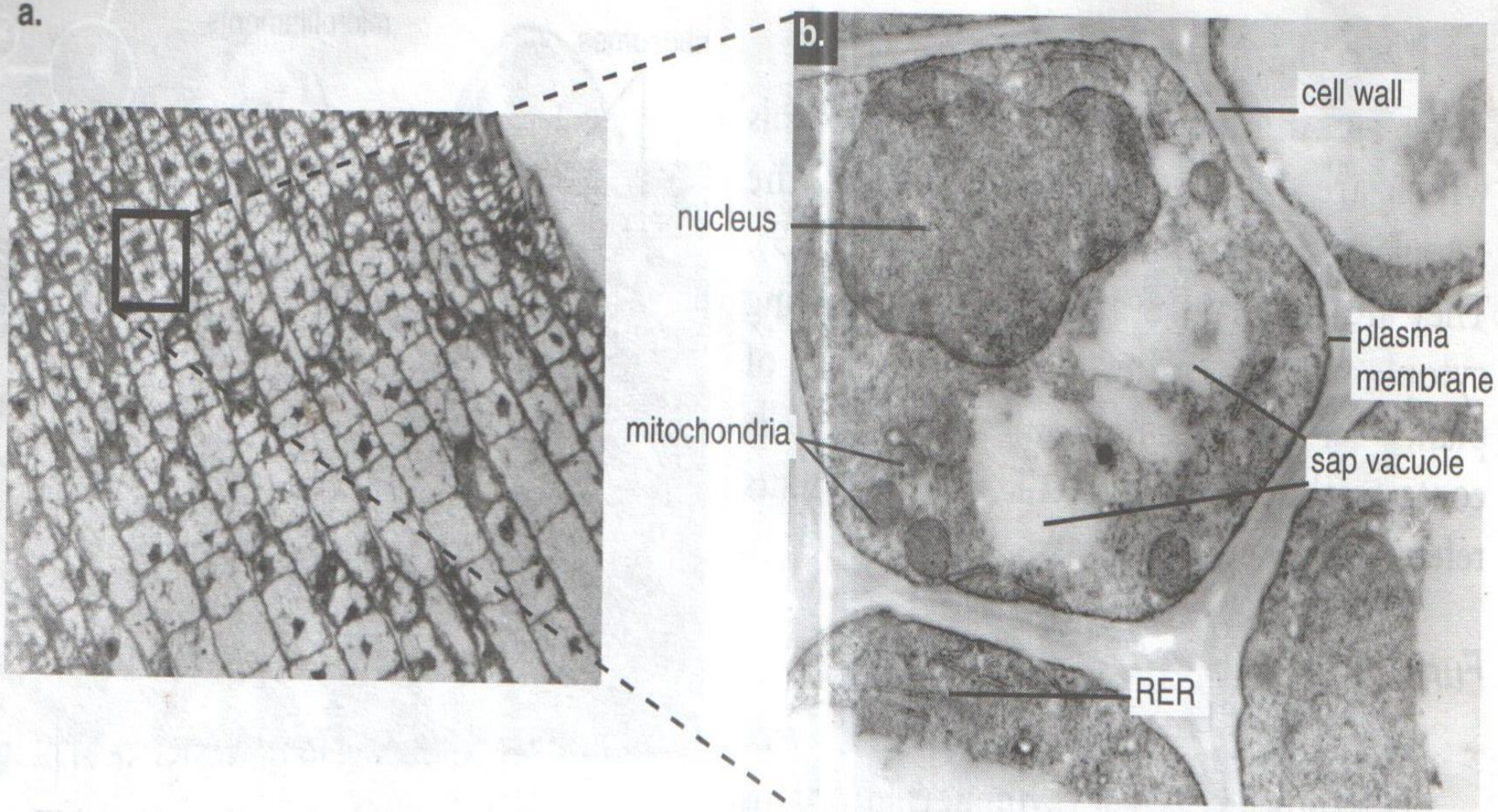


Fig. 2.13: **a)** Light micrograph showing plant cells (x500). **b)** Electron micrograph of plant cells in the root tip (x2,200) (*Courtesy of ICIPE, Nairobi*).

11. **Cell wall-** is is a membrane found in cells of plants and fungi; and in some protoctists but **not** in animal cells.

- It is made up of **cellulose** in plant cells and either cellulose or **chitin** in fungi. It is rigid and tough.

Functions.

i. Protects the cell against mechanical injury.

ii. It gives the cell a definite shape.

iii. Provides mechanical support

12. **Nucleus (plural-nuclei)-** contains:

i. **Nuclear memmbrane** which has **Nuclear pore/ nucleopore–** which allows and controls the movement of substances in and out of the nucleus.

ii. **Nucleoplasm –** it is a viscous fluid which has nucleolus and chromatin.

iii. **Nucleolus-** manufactures the ribosomes.

iv. **Chromatin-** contains hereditary/ genetic materials/ DNA.

Function of nucleus

i. The nucleus controls all the cell activities e.g. cell division, protein synthesis, respiration, cell secretion, excretion and cell growth.

- **N/B A cell without a nucleus would only survive for a short time because it is not able to carry out normal cell functions.**

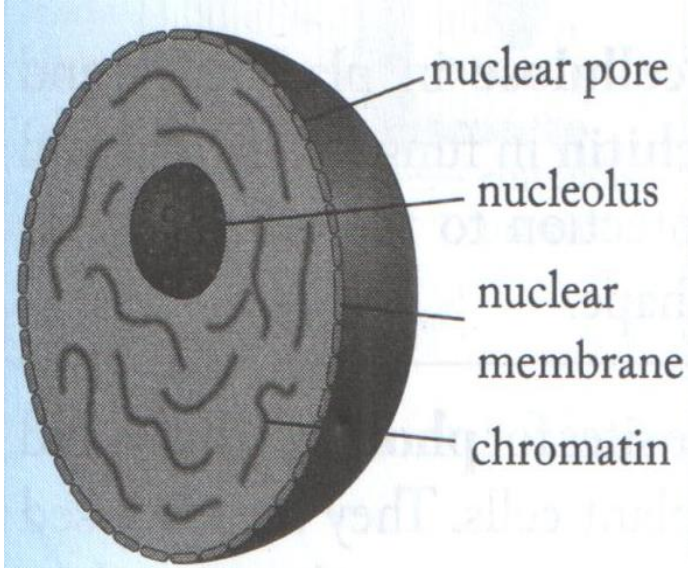


Fig 1.6: Nucleus

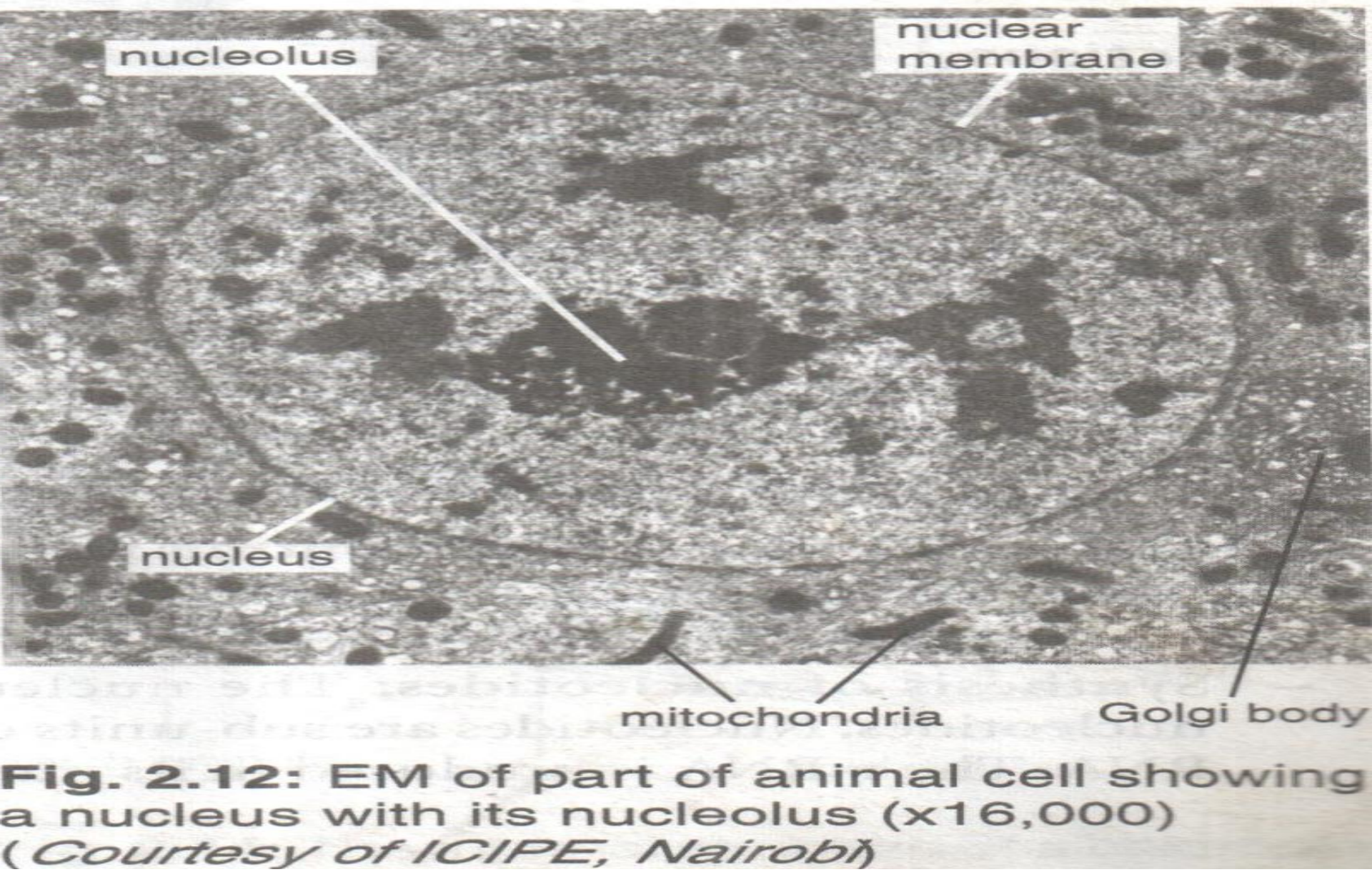


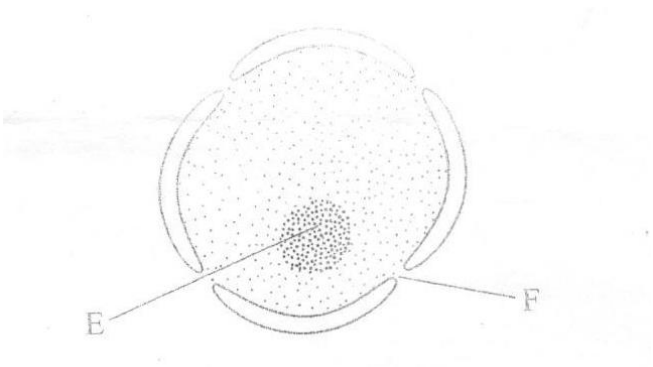
Fig. 2.12: EM of part of animal cell showing a nucleus with its nucleolus (x16,000) (*Courtesy of ICIPE, Nairobi*)

DIFFERENCES BETWEEN PLANT AND ANIMAL CELLS.

Plant cell.	Animal cell
1. It is usually large.	1. It is usually smaller.
2. It is regular in shape.	2. It is irregular in shape.
3. It has a cell wall.	3. It lacks a cell wall.
4. It has a large central vacuole.	4. It has no vacuoles but if they are present , they are small and temporary and scattered within the cytoplasm.
5. The cytoplasm and nucleus are located towards the periphery.	5. The cytoplasm occupies most space in the cell with the nucleus centrally placed.
6. It has chloroplasts.	6. It lacks chloroplasts.
7. It stores starch, oils and proteins.	7. It stores glycogen and fats.
8. It lacks centrioles.	8. It has centrioles.

STUDY QUESTION

1. The diagram below represents a nucleus.



a) Name the structures labeled E and F.

E- Nucleolus.

F- Nuclear pore/ Nucleopore.

b) State the function of F.

- ***Allows/ facilitates the movement of materials in and out of the nucleus.***

2. State two main functions of the vacuole.

i. ***Osmoregulation/ removal of excess water (by contractile vacuole)***

ii. ***Feeding/ digestion of food (by food vacuole)***

iii. ***Excretion/ removal of metabolic wastes.***

3. Name the plant cell organelle:

i) That stores chlorophyll- ***Chloroplast***

ii) Responsible for intracellular digestion- ***Lysosome.***

PREPARATION OF TEMPORARY SLIDES.

- To observe specimen under the microscope, we need to prepare slides.
- There are two types of slides, namely:

a) **Temporary or fresh slides-** for immediate use during a laboratory exercise and

b) **Permanent slides-**which can be preserved for reuse.

Procedures carried out when preparing temporary slides.

1. **Sectioning-** It refers to cutting/ making of thin sections **to allow light to pass through or make them transparent.**

- It is done by use of a **sharp razor blade to ensure that cells are not distorted.**

2. **Adding a drop of water/ placing the sections in water- to keep the cells turgid and prevent dehydration.**
3. **Staining-** to make different parts of the cell more distinct and clear. Stains commonly used are **iodine solution, methylene/bromothymol blue, neutral red and eosin.**
4. **Mounting-** This is putting the specimen on the slide in the appropriate medium before covering it with a cover slip.

Advantages of using/placing a coverslip over the specimen.

1. To hold the specimen in place.
2. Protects specimen from dehydration/drying up/dust particles.
3. Protect the objective lens.

- The stage should be kept dry for easy manipulation of specimen as wetness causes the specimen to stick onto the stage.

5. **Fixation-** It helps to make the specimen hard or stiff for sectioning.

- It can also be done after sectioning to help maintain the structure of the specimen.
- Commonly used fixative is ***70% ethanol.*** Plant materials are stiff enough and do not require fixation.

Practical Activity

Aim: To prepare and observe temporary slide of onion cells under the light microscope.

Requirements:

1. Microscope
2. Clean microscope slides
3. Cover slips
4. Scalpel or a new razor blade
5. Distilled water
6. Iodine solution.
7. Onion bulb.
8. Pair of forceps.
9. Dropper.
10. Mounted needle.

Procedure

1. Cut the onion bulb vertically into four parts.
2. Separate a fleshy leaf from one of the parts.
3. Remove/ peel a thin piece of epidermis from this leaf using forceps. Trim down the epidermis to 5mm long.
4. Place a drop of iodine at the centre of a clean slide. Add a drop of water to dilute it.
5. Quickly spread the piece of epidermis onto the drop of water.
6. Using a mounted needle, lower a clear cover slip on to the epidermis strip. Do this gently to avoid trapping air bubbles.
7. Examine this temporary slide under the low and medium power objective lenses of microscope.

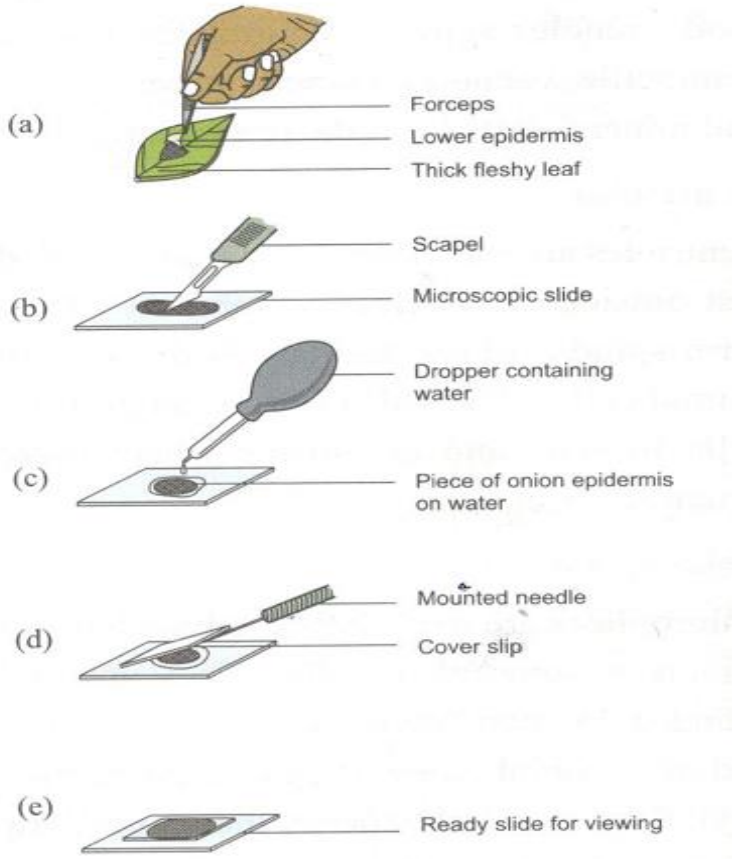


Fig 3.9 (a – e): Preparation of temporary slide of onion epidermis.

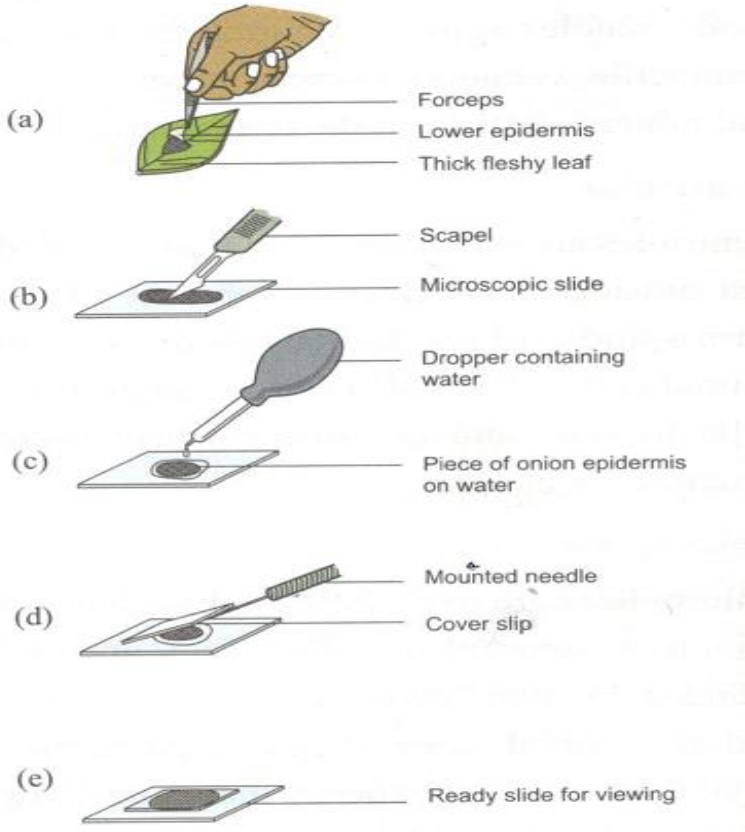


Fig 3.9 (a – e): Preparation of temporary slide of onion epidermis.

Estimation of cell size.

- Most cells are shorter than a millimetre and therefore, their sizes are measured in smaller units called micrometres (µm).
- 1 millimetre (mm) = 1 000 micrometres/microns (µm).
- 1 (µm) = 1 000 nanometres (nm)

Practical activity

Aim: To estimate the size of onion epidermal cells.

Requirements:

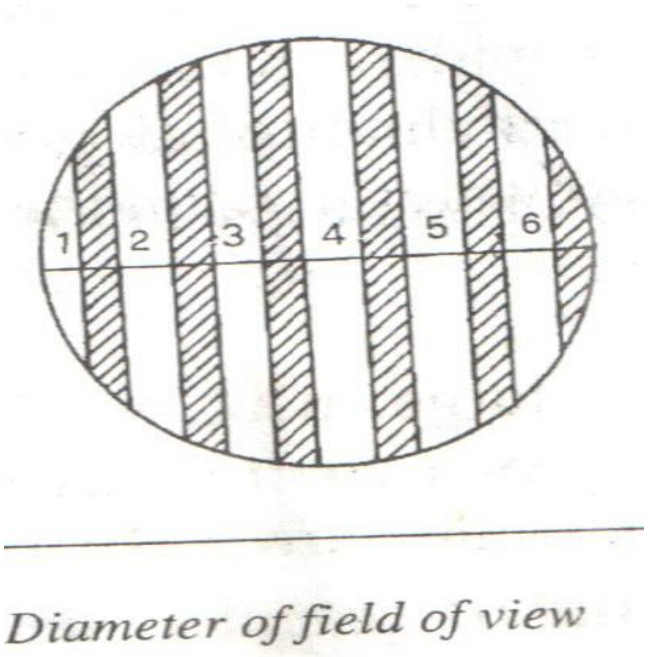
i. Microscope.

ii. Transparent ruler marked in millimetres.

iii. Prepared slide of onion epidermis.

Procedure.

1. With the low power objective lens in place, keep a transparent ruler on the stage of the microscope.
2. Focus so that the millimetres marks on the ruler are seen as thick dark lines.
3. Estimate the diameter of the field of view by counting the one-millimeter spaces between the first mark and the last one across the field of view e.g. from the figure below the diameter of field of view is 6.0 mm.



Diameter of field of view

4. Convert the diameter of the field of view from millimetres to micrometres.

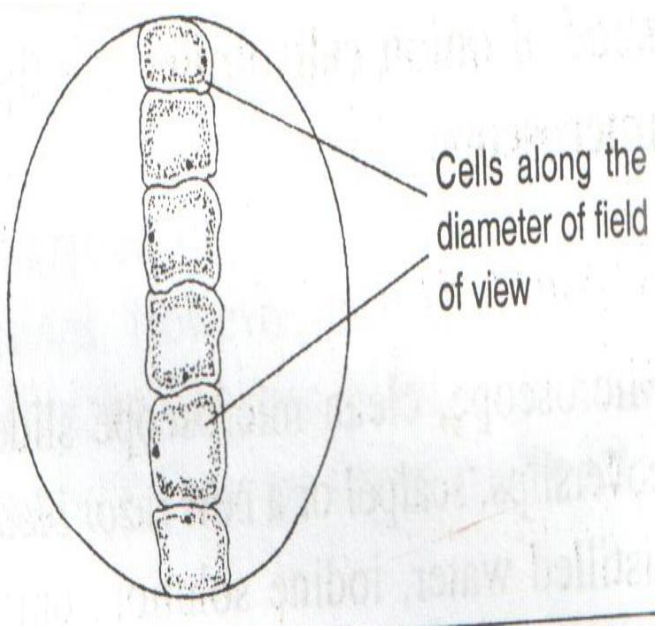
- 1 mm = 1 000 ***µm***

6 mm =(6xl 000) ***µm***

= 6 000 ***µm***

5. Remove the ruler and place the prepared slide of the onion epidermis.

6. Count the number of cells along the diameter of the field of view e.g. 6 cells as shown below.



7. Calculate the diameter of one cell using the following formula

- Cell diameter = Diameter of field of view in ***µm***

  No. of cells along the diameter the field of view.

  Using the example above:

  Cell diameter = 6 000= 1 *000µm*

  6 cells

- Therefore, diameter of 1 cell = 1 000*µm.*

Limitations of using the light microscope to estimate the size of the cells.

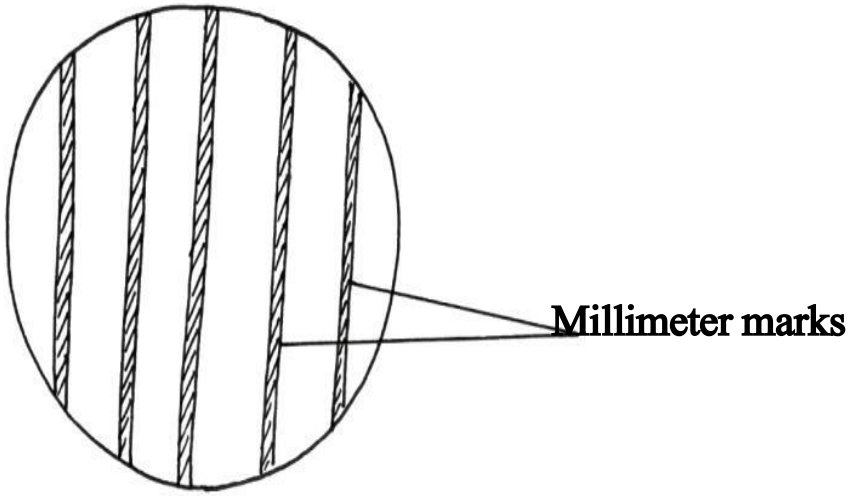
1. Cells vary in size and shape.
2. Cells in a tissue are not linearly arranged (not in a straight line)/cells are irregularly arranged.
3. Changes in osmotic pressure will affect the animal cells.

Other dimensions/parameters used to estimate the cell size.

1) Diameter.
2) Length.

Question 1.

- A student carried out an experiment on microscope work. The field of view was as shown in the following diagram.
- If she counted 20 cells on the diameter of the field of view, what was the approximate size of each cell in micrometers (μm). Show your working.



Solution

- Diameter of field of view

  4 + ½ + ½ = 5 spaces

  space = 1 mm

  1000 μm = mm

  5000 μm = 5mm

- Cell size = Diameter of field of view

  No. of cells

  Cell size = 5000 μm

  20 cells.

  = 250 μm.

Study question 2

- A student viewed and drew a plant cell of a diameter 4mm using a light microscope whose eyepiece lens was marked X1 and objective lens marked X5. How many cells were linearly arranged along the microscope's field of view whose diameter was 8mm. (show your work.)

Solution

1mm = 1 000 µm.

Total magnification= Cell drawing diameter

Actual cell diameter

X 5= 4 000

X

x= 4 000

5

= 800µm

- Cell diameter= Field of view diameter(in micrometers)

No. of cells (Y)

800 µm =8000 µm

Y

Y =8000 µm

800 µm

=10 cells;

Study question 3

- The diameter of the field of view was estimated to be 5mm under a certain magnification. 5 cells were observed along the diameter of the field of view. What was the diameter of one cell in microns (μm)?

Solution

1 mm= 1000 μm

50 mm= $\frac{5 \times 1000}{1}$

= 5,000 μm.

Cell diameter= $\frac{\text{Diameter of field of view}}{\text{Number of cells.}}$

= $\frac{5{,}000}{5}$

= 1,000 μm.

Study Question 4.

A student used a microscope with x40 objective lens and x5 eye piece lens. He observed 5 Cells in the field of view which had 2.2mm radius.

a) Calculate the area of field of view in square micrometers (μm^2).

1 mm = 1 000 µm.

2 mm = 2 x 1 000 µm

= 2 000 µm.

Area = $\frac{22}{7}$ x 2000 x 2000

= 125714.29 μm^2

b) What is the average size of the cell in micrometers?

Size of the cell= $\frac{\text{diameter of field of view}}{\text{number of cells}}$

= $\frac{4\ 000\ \mu m}{5}$

= 800 µm.

c) Estimate the actual size/length of the cell.

Total magnification= eye lens magnification x objective lens magnification

= 5 x 40

= X 200

Total magnification= Size/Length of cell image

Actual length/size of cell (X)

200= 800 µm

x

x= 800

200

= 4 µm.

Study question 5.

- Study the photomicrograph below. Calculate the actual size/diameter of the nucleus in microns (µm).

Solution

Measure the diameter of the organelle nucleus e.g. 35 mm

1 mm = 1 000 µm

35 mm = 35 000 µm.

Total magnification= Diameter of the nucleus photomicrograph.

Actual length/diameter/size

2,200 = 35 000 µm

Actual size (Y)

Y=35 000 µm

2 200

= 15. 90 µm.

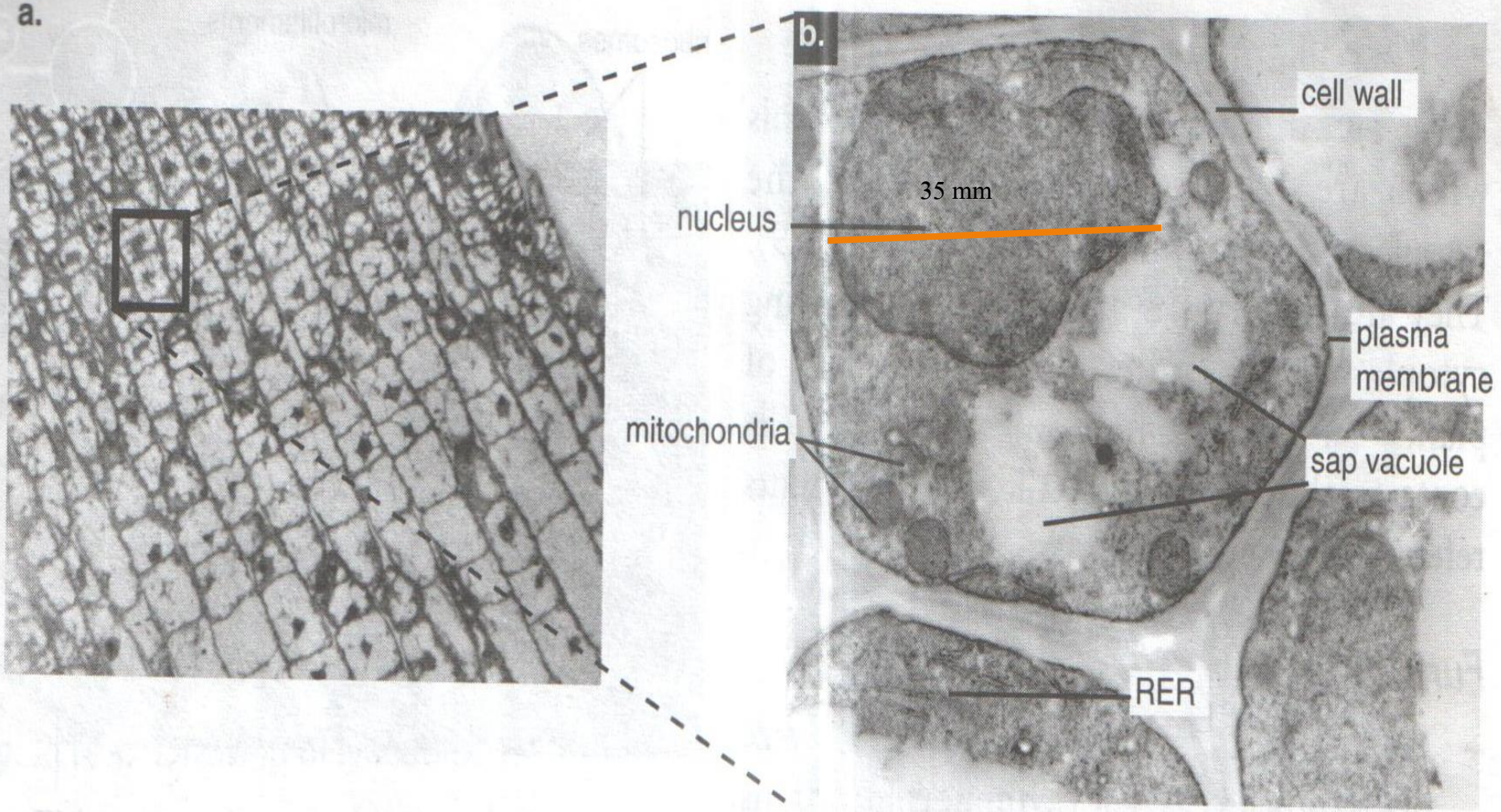


Fig. 2.13: **a)** Light micrograph showing plant cells (x500). **b)** Electron micrograph of plant cells in the root tip (x2,200) (*Courtesy of ICIPE, Nairobi*).

CELL SPECIALIZATION.

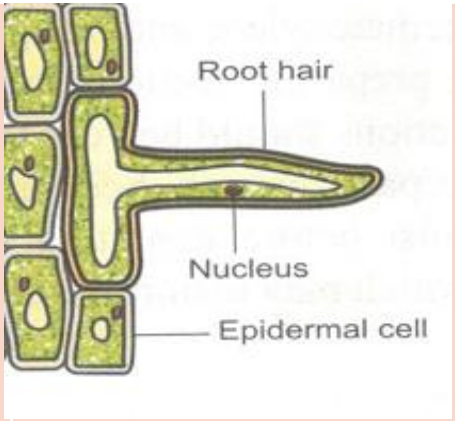
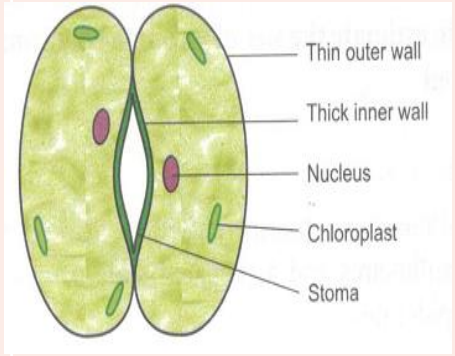
- This is the structural modification of the cells to perform specific functions.

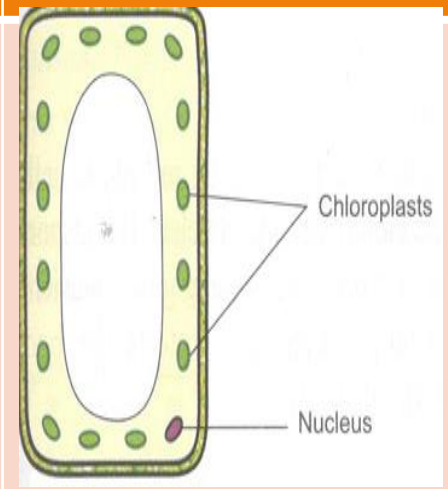
a) **Specialized plant cells**

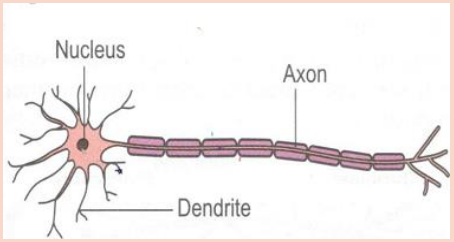
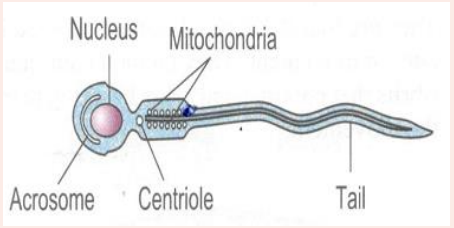
1. Root hair cell.
2. Guard cell.
3. Palisade cell.

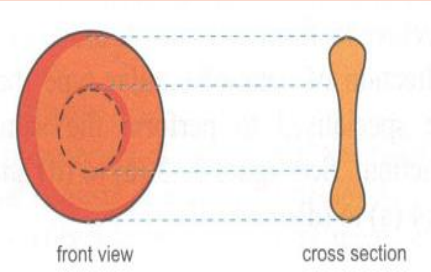
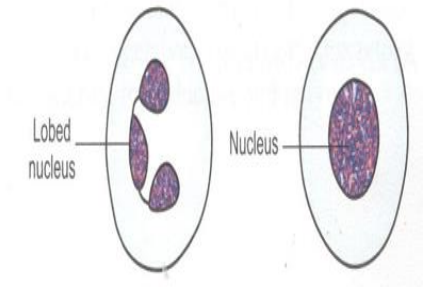
b) **Specialized animal cell**

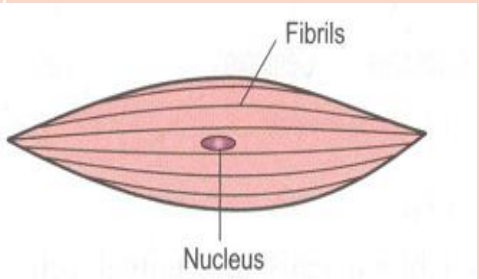
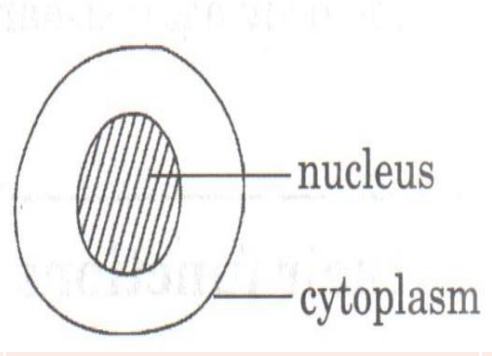
1. Nerve cell
2. Sperm cell.
3. Red blood cell.
4. White blood cell.
5. Muscle cell.

Specialized plant cell	Diagram	Structural modification/ adaptation	Function
1. Root hair cell		- It has extension/ root hair	-Increase surface area for absorption of water and mineral salts from the soil
2. Guard cell		- It has chloroplasts, thick inelastic inner wall and thin elastic outer wall	- Controls opening and closing of stomata. - Carries out photosynthesis.

Specialized plant cell	Diagram	Structural modification/ adaptation	Function
3. Palisade cell		- It contains numerous chloroplasts	- Photosynthesis.

Specialized animal cell	Diagram	Structural modification/ adaptation	Function
1. Nerve cell		- It has axons and dendrites.	- Receive and transmit nerve impulses.
2. Sperm cell		- It has numerous mitochondria and long tail.	- Swim to reach and fertilize egg cell/ ovum

Specialized animal cell	Diagram	Structural modification/ adaptation	Function
3. Red blood cell		- It has biconcave shape, contain haemoglobin and lacks nucleus.	- Transports oxygen and carbon (IV) oxide within the body.
4. White blood cell		- It has large nucleus, show amoebic movement/ are able to change shape.	- Protect the body against infections.

Specialized animal cell	Diagram	Structural modification/ adaptation	Function
5. Muscle cell.		- It has contractile fibrils.	- Brings about movement.
6. Egg cell/ ovum		- Large cytoplasm.	- Stores food for developing embryo.

TISSUES

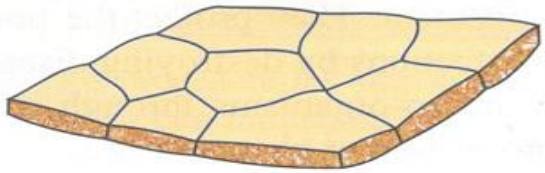
A tissue is a group/ collection of cells that are specialized to perform similar functions

Animal tissues.

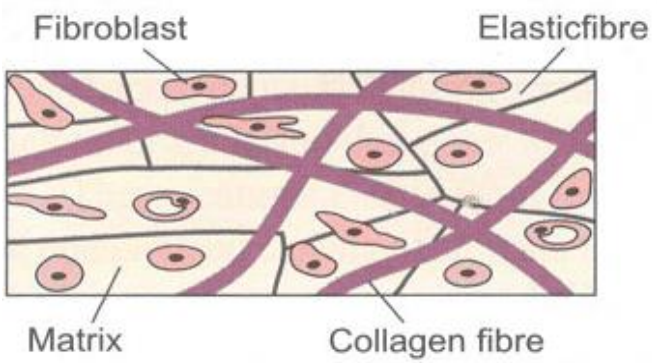
1. **Epithelial tissue-** it consists of epithelial cells that form layers. They are found on the outside of the body or around internal organs.

Function.

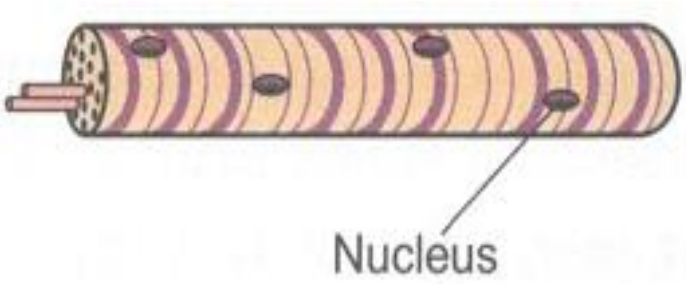
i. It protect the internal and external surfaces.



2. **Connective tissue-** consists of strong fibres that connect other tissues and organs holding them together in position.



3. **Skeletal tissue-** it consists of elongated cells with fibres that contracts and relax to bring about movement.

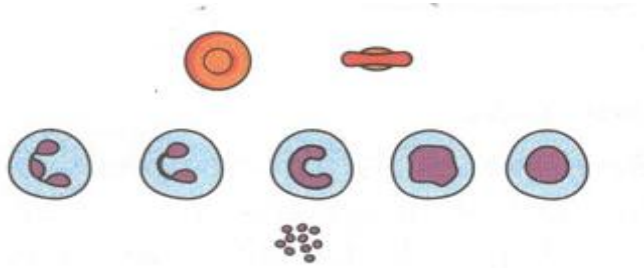


4. **Blood tissue-** it consists of platelets, white blood cells and red blood cells.

Function.

i. Protects the body against infection/diseases.

ii. Transport materials in the body e.g. oxygen, metabolic wastes and nutrients.

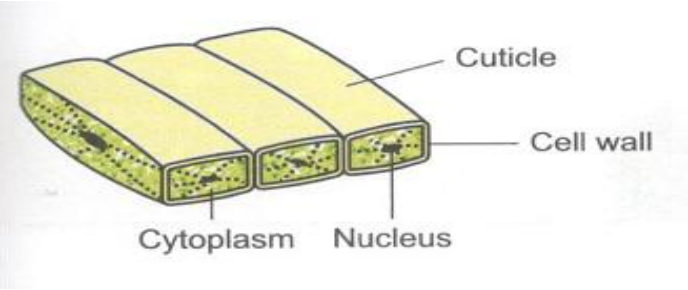


PLANT TISSUES

1. **Epidermal tissue-** It consists of a single layer of epidermal cells covering the outer surface of leaves and on young parts of the stem and roots.

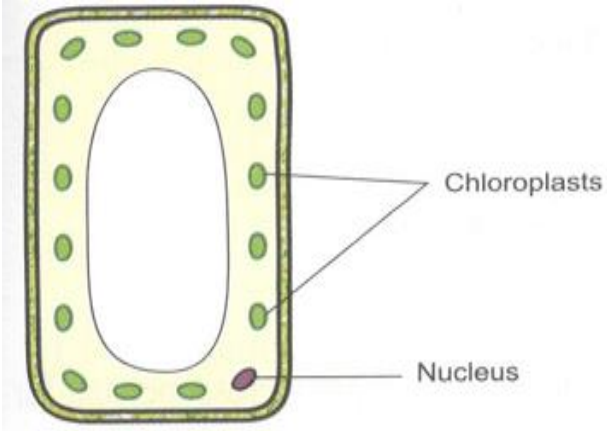
Function

i) It protects inner tissues of plant from mechanical damage and infection.

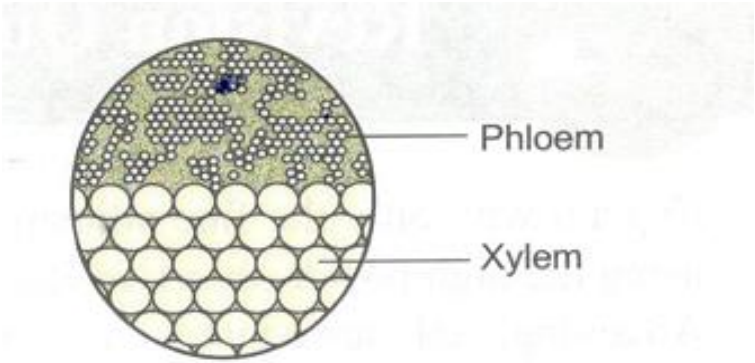


2. **Palisade / photosynthetic tissue.**

- It consists of numerous chloroplasts to trap light energy for photosynthesis.



3. **Vascular tissue-** It is composed of **xylem** which transports water from the roots to the leaves and **phloem** which transports manufactured food from the leaves to other parts of the plant.



4. **Meristematic tissue-** It consists of meristematic cells found at growing regions of plants that **actively divide to allow growth.**

- Apical meristems bring about increase in height of roots and shoots.
- Lateral meristem bring about secondary thickening.

5. **Parenchyma tissue.**

- It consists of thin walled and irregularly shaped cells.

Role/ function.

- Provide mechanical support (packaging) and storage of substances.

ORGANS

- An organ is a group of tissues that are specialized to perform similar/same function.
- Examples of animal organs include: **stomach, brain, kidney, liver, heart, eye, ear e.t.c.**
- Examples of plant organs include: **roots, leaves, flowers, stem e.t.c.**

ORGAN SYSTEM

- An organ system is a group of organs that perform the same/similar function.
- Examples of animal organ systems include: digestive system, circulatory system, respiratory system, excretory system, nervous system, reproductive system e.t.c.

- Example in plants is transport system.

END

4. CELL PHYSIOLOGY

- Cell physiology is the study of functions a cell e.g. photosynthesis, respiration, excretion, protein synthesis,

Membrane Structure and Properties

- A membrane is a surface structure which encloses a cell and its contents. There are different membranes and they are name according to the structure each encloses e.g.

1. Cell membrane- which encloses the cell.
2. Tonoplast- which encloses the plant sap vacuole.
3. Mitochondrial membrane- which encloses the mitochondrion.
4. Chloroplast membrane- which encloses the chloroplast.
5. Nuclear membrane- encloses the nucleus.

* All these membranes have the same structure and function.

Function of a membrane

- It regulates the flow of materials in and out of the cell/ cell organelle.

Structure and functions of Cell/plasma Membrane

Functions of the cell membrane.

1. Encloses the cell contents.
2. Controls/ regulates the movement of materials/ substances in and out of the cell.

Structure of cell membrane.

- It consists of the following components:

a) Two layers of phospholipids.
b) Two protein layers.
c) Small pores that allow the passage of substances into and out of a cell.

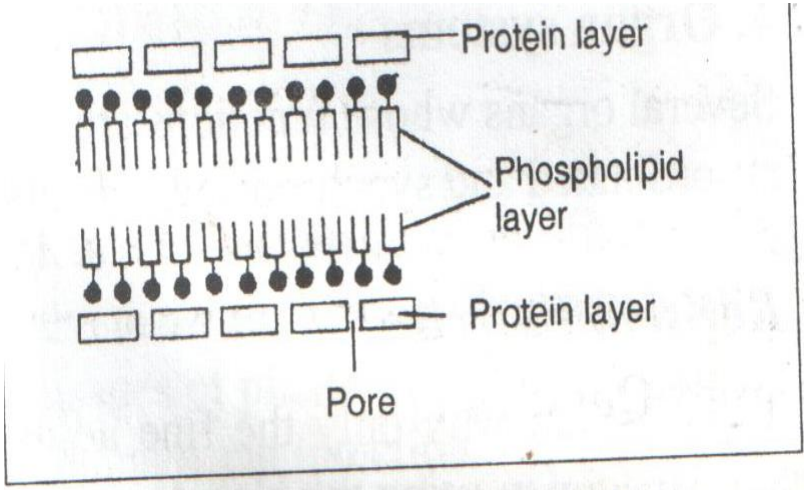


Fig. 4.1: Diagrammatic representation of the structure of a cell membrane

Properties of a Cell Membrane

(a) **Semi-Permeability/selective permeability.**

- The cell membrane has pores that allow molecules of small sizes to pass but not those with large sizes.
- For example, when a cell is surrounded by a dilute sugar solution, water molecules will enter the cell but the larger sugar molecules will not enter.

Importance/ significance of semi-permeability.

- It allows the cell membrane to select what enters and leaves the cell.

(b) **Sensitivity to Changes in Temperature and pH.**

- Cell membrane has proteins which are destroyed by high temperatures and extreme pH e.g. strong acids. This affects the normal functions of the cell membrane.

(c) **Possession of Electric Charges/ it is polarised/ polarization.**

- A membrane has positive charges on the outside and negative charges to the inside.

Importance or significance of polarization of cell membrane

1. It affects the manner in which substances are moved in and out of the cell.
2. It helps the cell membrane to detect changes in the environment.

Difference between cell wall and cell membrane.

- The cell membrane is semi-permeable while the cell wall is permeable i.e. allows both water and sugar molecules to pass through because it has large pores.

Adaptation of the cell membrane to its functions.

1. It has pores for semi-permeability/to allow molecules of small sizes to pass through but not large sized molecules.
2. It is thin to reduce distance hence faster movement of materials.
3. Has electric charges (polarity) to allow movement of materials in and out of the cell and to detect changes in the environment.

Study questions.

1. Name the components of a cell membrane. (2mks)
2. Give two functions of the cell membrane? (2mks)
3. Explain how the cell membrane is adapted to its functions? (3mks)
4. Explain the importance/ significance of the electric charges/ polarity of the cell membrane. (2mks)

Physiological Processes

* The movement of materials across the cell membrane is facilitated by physiological processes namely:

A. Diffusion.

B. Osmosis and

C. Active transport.

A. **DIFFUSION**

- This is the process by which particles/ molecules move from a region of high concentration to a region of low concentration.
- The difference in concentration of molecules between the regions of low concentration and the region of high concentration is called **concentration/ diffusion gradient.**
- Therefore diffusion is a passive process (it is not energy-driven process) where particles/ molecules move along concentration gradient.

Practical activity 1.

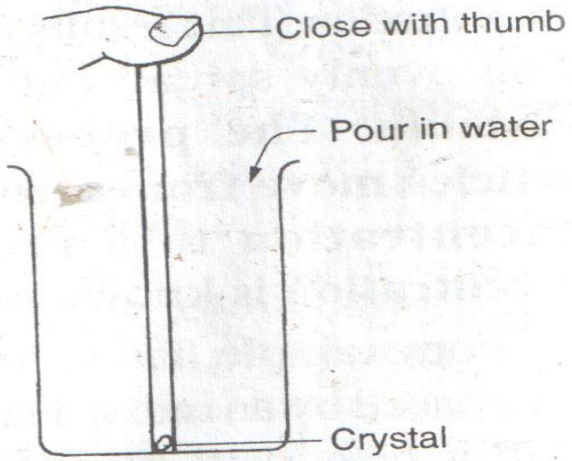
Aim: To demonstrate diffusion using potassium manganate (VII).

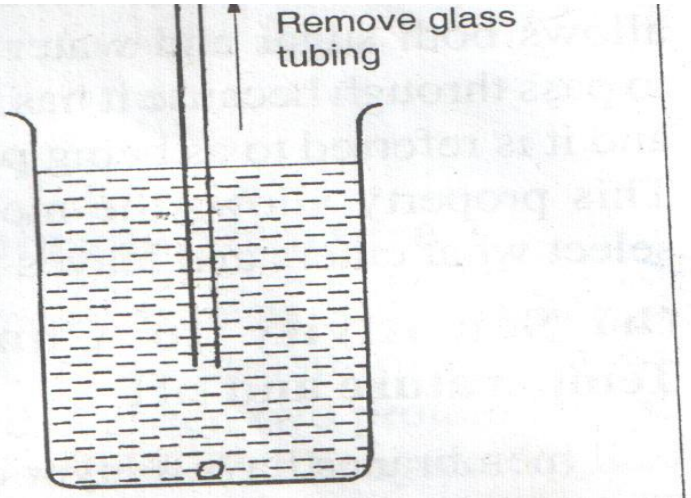
Requirements:

1. Potassium manganate (vii) crystals
2. Glass tubing
3. 100 cm^3 beaker
4. Water.

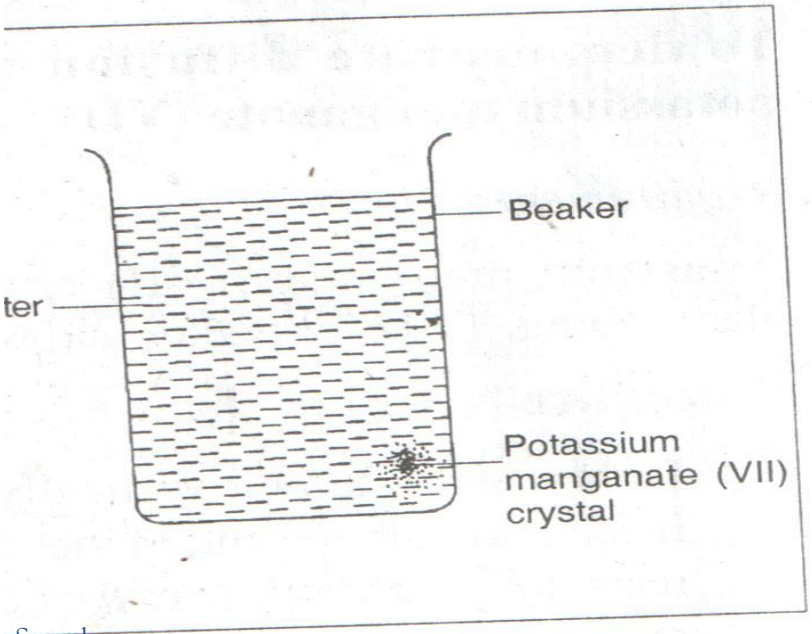
Procedure:

1. Hold a glass tubing vertically in a beaker so that one end of the tubing rests flat on the bottom of the beaker.
2. Carefully drop a crystal of potassium manganate (VII) through the upper opening of the glass tubing.
3. Close the upper end of the glass tubing with the thumb.
4. Half-fill the beaker with water.
5. Carefully withdraw vertically the glass tubing so that the crystal is left undisturbed at the bottom of the beaker.
6. Record your observations for the first 15 minutes.
7. Explain your observations.





To demonstrate diffusion with potassium manganate (VII) crystal



.3 (a): At the beginning

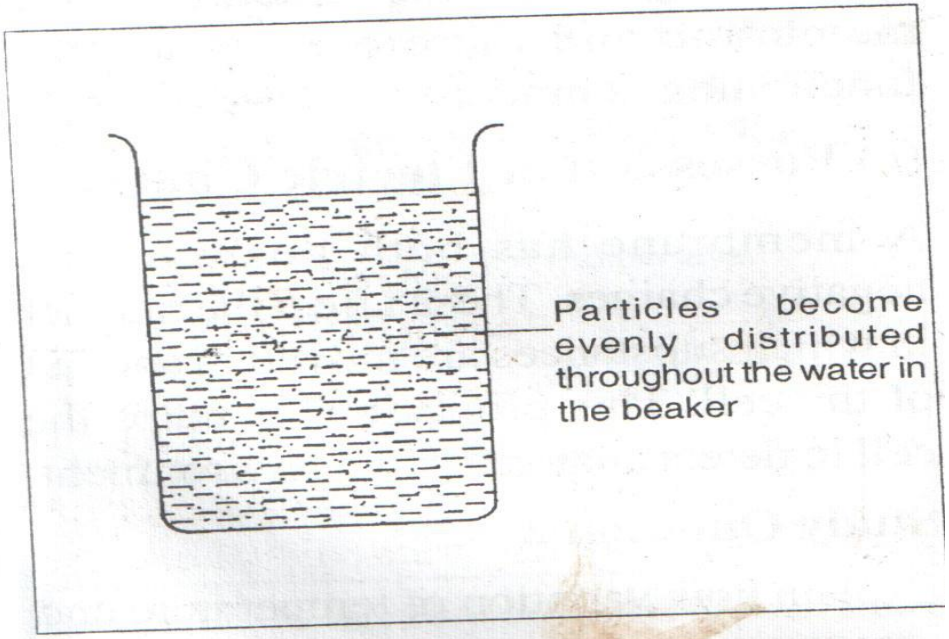


Fig. 4.3 (b): At the end

Observation.

- The **purple** colour of the potassium manganate (VII) which is purple in colour spreads throughout the water and eventually all the water turned purple.

Explanation.

- In the crystals, the particles of potassium manganate (VII) are highly concentrated
- Potassium manganete (VII) particles break away from the crystals, dissolve in water and then **diffuse** through the water until they are evenly distributed.

PRACTICAL ACTIVITY 2

Aim- To demonstrate diffusion using a visking tubing.

Requirements.

1. Visking tubing 8cm long.
2. 5ml Starch solution.
3. 10ml Dilute iodine solution in 100 ml beaker.
4. Thread.
5. Glass rod.
6. Dropper.
7. Water in a beaker.

Procedure

1. Tie one end of the visking tubing using the thread provided.
2. Pour starch solution into the visking tubing to ¾ full and tie the open end of the visking tubing. Ensure that there is no leakage on both ends of the tubing. Rinse the sides of the visking tubing with water. Note the initial color of starch and record in the table below.
3. Immerse the visking tubing in a beaker containing iodine solution and let the set up stand for 20 minutes.
4. After 20 minutes remove the visking tubing from the beaker and record the observations.

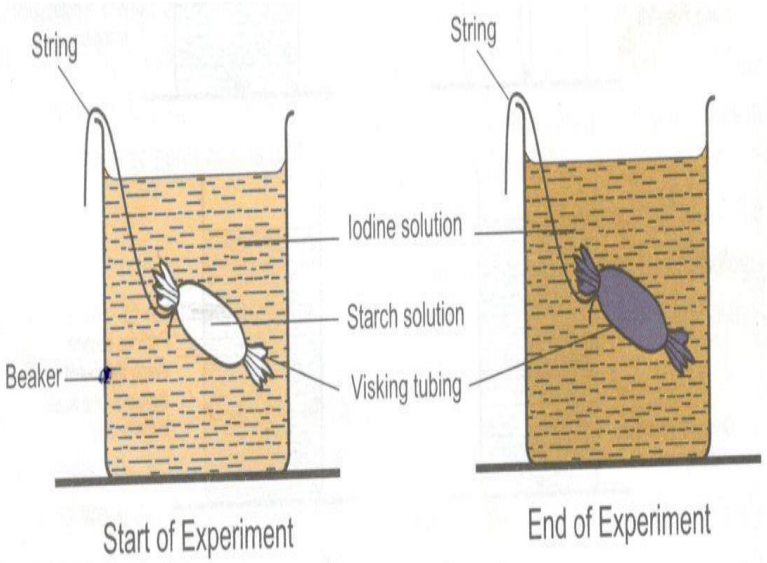


Fig 4.34: Demonstrating diffusion using a visking tubing.

Observation

* The contents of the visking tubing turned blue-black and the contents in the beaker remained brown.

Explanation.

* The wall of the visking tubing is semi-permeable hence allowed small iodine molecules to pass through it from the beaker into the beaker where they reacted with starch to form blue black colour.
* Starch molecules are too large to move out of the tubing into the beaker.

Factors affecting the rate of diffusion.

1. **Temperature-** an increase in temperature **increases the energy content of molecules** (particles) which make them to move faster therefore increasing the rate of diffusion while decrease in temperatures decrease the energy content of the molecules, this decreases diffusion rate.

2. **Concentration / diffusion gradient-** The greater the concentration gradient the higher the rate of diffusion hence increases the rate of diffusion.

* The lower the concentration gradient the lower the rate of diffusion.
* Therefore increasing the concentration of diffusing molecules at one of the points increases the rate of diffusion.

3. **Size of molecules-** small and light molecules diffuse faster than large and heavy molecules.
4. **Surface area to volume ratio-** the higher the ratio the faster the rate of diffusion and the lower the ratio the lower the rate of diffusion. This implies that small organisms have large surface area to volume ratio than large animals.
5. **Thickness of the membrane-** If the membrane is thicker, **it increases the distance travelled by particles** hence slow rate of diffusion. If the membrane is thin, **it decreases the distance travelled by particles** hence faster rate of diffusion.
6. **Surface area-** the larger the surface area over which diffusion occurs, the higher the rate f diffusion.
7. **Type of medium-** diffusion is faster in gases than liquids.

ROLE/IMPORTANCE OF DIFFUSION IN LIVING ORGANISMS

Importance/ role of diffusion in animals

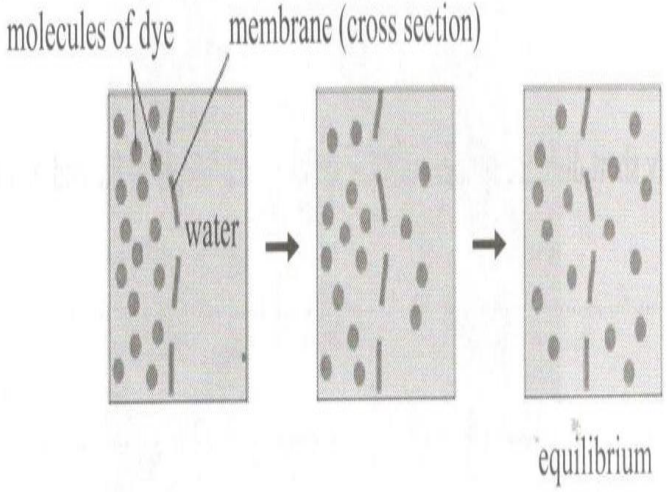
1. Excretion/ removal of nitrogenous wastes in some organisms e.g. unicellular organisms like amoeba found in fresh water.
2. Gaseous exchange in respiratory surfaces e.g. alveoli and gills.
3. Absorption digested food (e.g. amino acids, glucose) in the ileum into blood stream.
4. Reabsorption of useful substances and some salts in the kidney tubules.

Importance/ role of diffusion in plants.

1. Absorption of mineral salts by plant roots from the soil.
2. Helps in gaseous exchange through the stomata and lenticels.
3. Transport/ translocation of manufactured food from the leaves to other parts off the plant.

Study question 1

The set up below illustrates a certain physiological



a) Name the physiological process. (1mk)

✓ ***Diffusion.***

b) Give two examples of the process named in a) above in plants. (2mks)

✓ ***Gaseous exchange/ excretion of carbon (IV) oxide.***

✓ ***Absorption/ uptake of mineral ions.***

✓ ***Translocation/ transport of manufactured food.***

c) State two ways by which the movement of the dye in the set up would be slowed down. (2mks)

- ✓ ***Lowering temperature.***
- ✓ ***Increasing thickness of the membrane.***
- ✓ ***Using less dye/ adding more water/ reducing concentration gradient.***

Study question 2

a) **What is the significance of diffusion in pollination?**

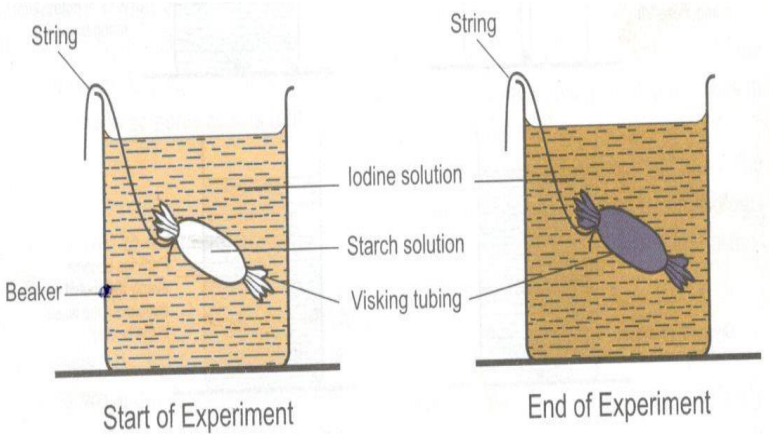
- Insects that carry out pollination are attracted by the smell from the flowers. This may lead to pollination.

b) **Is diffusion an energy driven process? Explain.**

* Diffusion is not energy driven process or it is a passive process. This is because molecules/ particles move along the diffusion/ concentration gradient.

Study question 3

* A group of students set up an experiment to demonstrate a certain process. The experiment was set up as shown in the diagram below.



* After 10 minutes the students recorded their observation in a table as shown below.

	Observation inside the visking tubing	Observation outside the visking tubing
At the start of the experiment	White colour	Brown colour
At the end of the experiment	Black colour	Brown colour

a) Name the physiological process being investigated.

Diffusion.

b) Explain the results obtained in the set up.

* ***The wall of the visking tubing is semi-permeable hence allowed small iodine molecules to pass through it from the beaker into the beaker where they reacted with starch to form blue black colour.***
* ***Starch molecules are too large to move out of the tubing into the beaker.***

c) Explain the results expected if the experiment was repeated using starch solution which has been boiled with dilute hydrochloric acid.

* ***There would be no colour change inside the visking tubing/ the brown colour of iodine would persist.***
* ***This is because hydrochloric acid hydrolyzed/ broke down starch into simple sugars which do not react with iodine.***

(B) OSMOSIS.

Definition of osmosis.

1. This is the movement of water/solvent molecules from a region of **high concentration of water molecules to a region of low concentration of water molecules through a semi-permeable membrane.**
2. This is the process through which solvent/ water molecules move from dilute/ hypotonic solution to a highly concentrated solution across/ through a semi-permeable membrane.

- Osmosis is a special type of diffusion because:

i. It involves the movement **of water molecules only**.

ii. It is involved a **semi-permeable membrane** - which allows some substances to pass through but denies others.

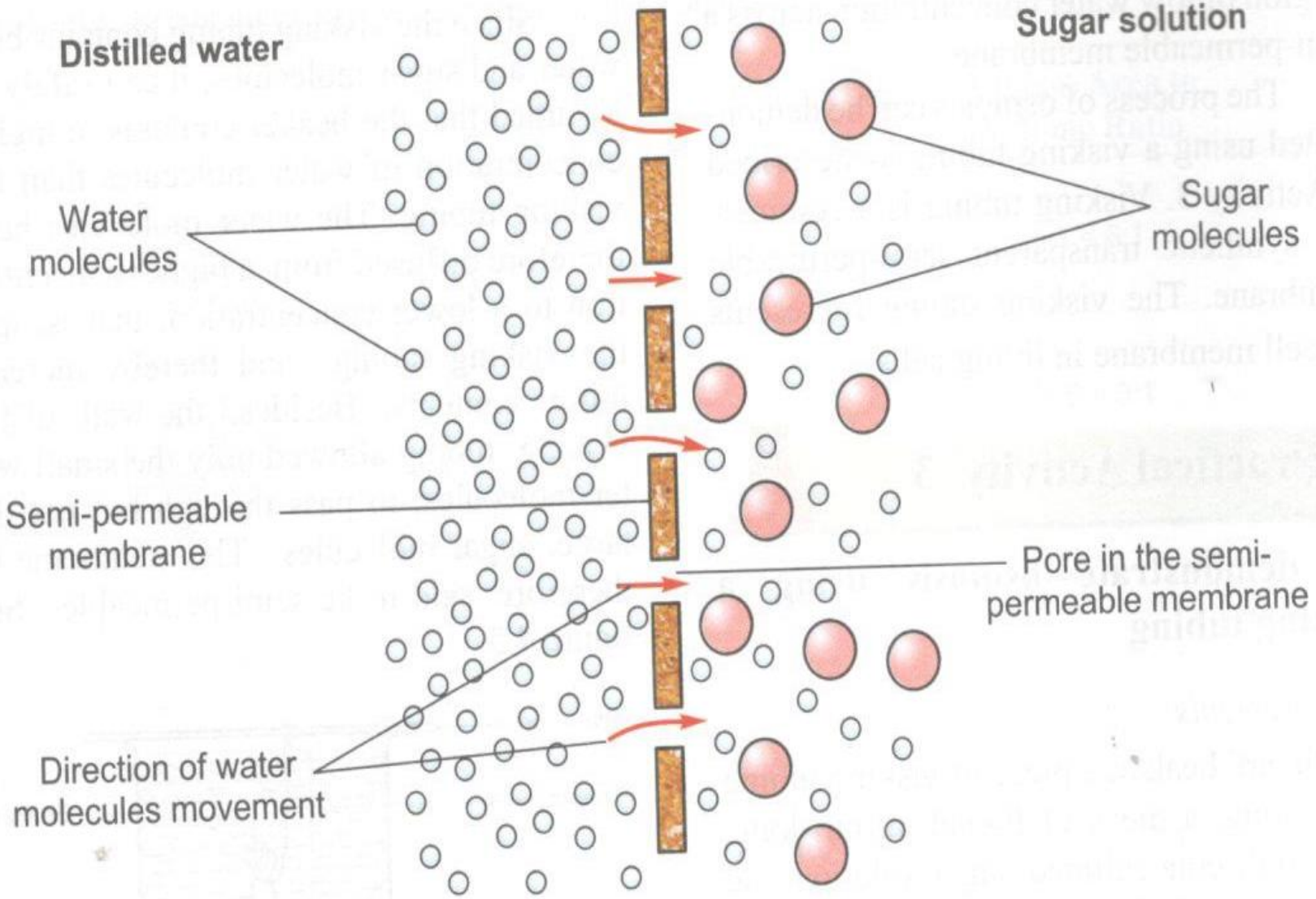


Fig 4.5: Osmosis through a semi-permeable membrane.

Terms used in osmosis.

1. **Isotonic solution-** This is a solution with the **same concentration** as the adjacent/next solution separated by a semi-permeable membrane.

* There is no movement of water/solvent molecules between the two solutions as there is no concentration gradient.

2. **Hypotonic solution-** This is a solution with **low solute (salt/sugar) concentration or dilute or with high water potential/with high water molecules** than the adjacent solution separated by a semi permeable membrane.

* Water/solvent molecules move from the hypotonic solution to the adjacent solution through a semi permeable membrane.

3. **Hypertonic solution-** This is a solution with **high salt/sugar concentration or low water potential or low water concentration than the adjacent solution** separated by a semi permeable membrane.

4. **Osmotic pressure-** This is a force developed by a solution to draw in water through a semi-permeable membrane or to stop water from passing through a semi- permeable membrane.

- Highly concentrated/hypertonic solution has high osmotic pressure while hypotonic solution has low osmotic pressure.

5. **Osmotic potential-** This is a hidden pressure of a concentrated solution which manifests itself when it is placed next to the distilled water separated by a semi-permeable membrane.

- It is also a measure of the pressure a solution would develop to draw water molecules from distilled water when separated by a semi- permeable membrane.

Water relations in plants.

* Plant cells have both cellulose cell wall and cell membrane and the centre of the cell contains a vacuole with sap.
* The sap is a solution of salts and sugar and is surrounded by a membrane called **tonoplast.**
* The cell membrane and tonoplast are semi-permeable while the cellulose cell wall is fully permeable hence allowing solutes and water to pass through.
* When a plant cell is placed in distilled water/ hypotonic solution, water will move into the cell through osmosis and cause the cell wall to distend.
* The plant cell does not burst because it has rigid cellulose cell wall.
* As the cell gains more water through osmosis, its vacuole enlarges and exerts an outward pressure on the cell wall called **turgor pressure.**

* This pressure increases as more water is taken into the vacuole which pushes the cytoplasm against the cell wall which causes increase in length until the cell wall cannot stretch any more. The cell then becomes **firm/ rigid** and is said to be **turgid.**
* When the cell wall is being stretched towards the outside, it develops a resistant pressure on the cell membrane which is equal and opposite to turgor pressure called **wall pressure.**

Study question.

Differentiate between wall pressure and turgor pressure.

* ***Wall pressure is the inward pressure exerted by the cell wall on the cell membrane to resist expansion as the cell takes in water through osmosis.***
* ***Turgor pressure is the outward pressure exerted by the expanded vacuole on the cell wall as the cell takes in water through osmosis.***

* When a plant cell is placed in hypertonic solution, water molecules move out of the cell into the solution through osmosis.
* As water moves out of the cell, the membrane pulls away from the cell wall and the cell becomes **plasmolyzed**.
* **Plasmolysis** is the process by which the cell membrane shrinks and pulls away from the cell wall when the plant cell is placed in a hypertonic solution.
* When the plant cells are plasmolysed, they reduce in length and the tissue becomes **soft and less rigid/ flabby** and the tissue is said to be **flaccid.**
* A plasmolysed/ flaccid cell is made turgid by placing it in distilled water/ hypotonic solution. This process is called **deplasmolysis.**

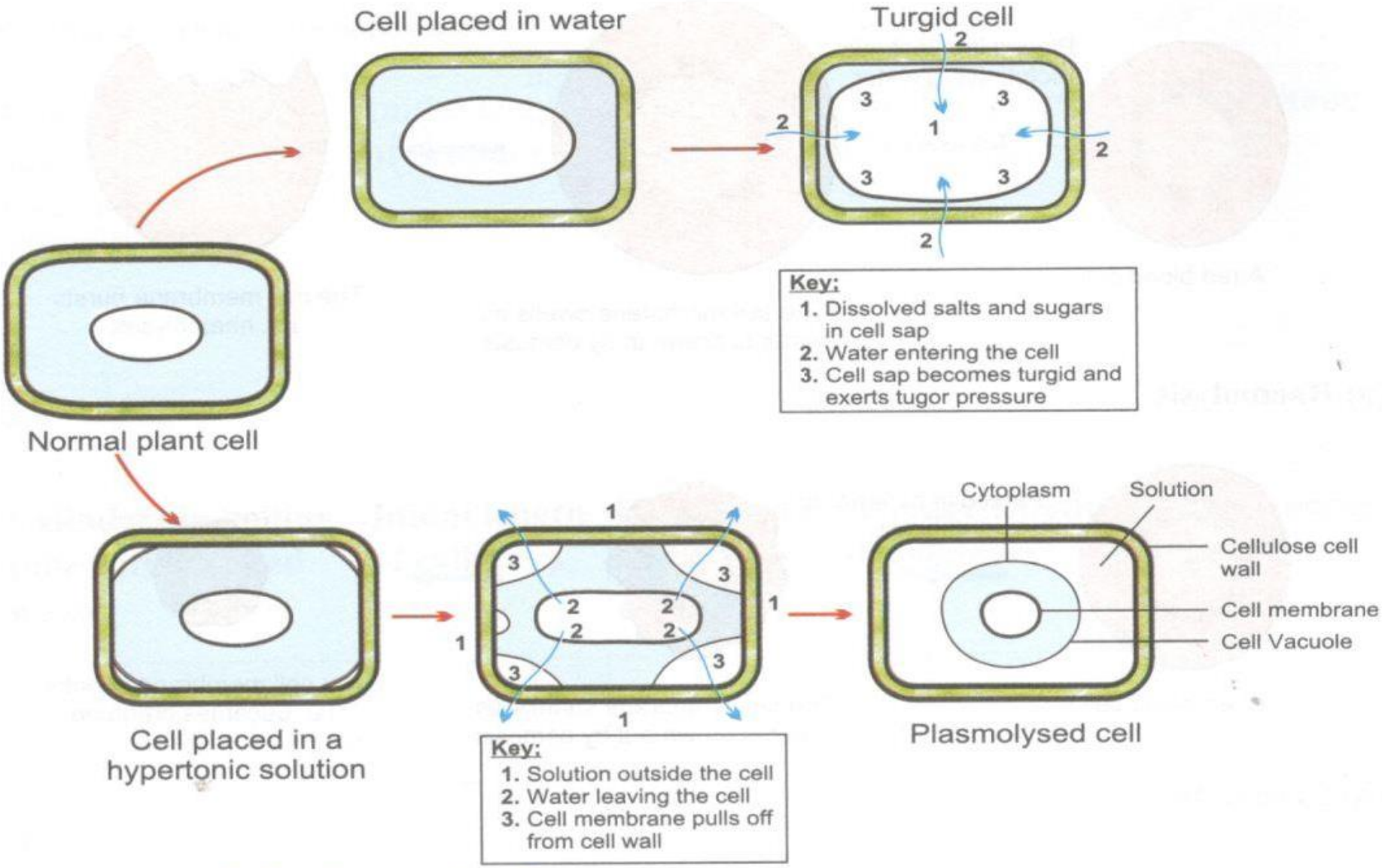


Fig 4.8: Turgor and plasmolysis in a plant cell.

WILTING

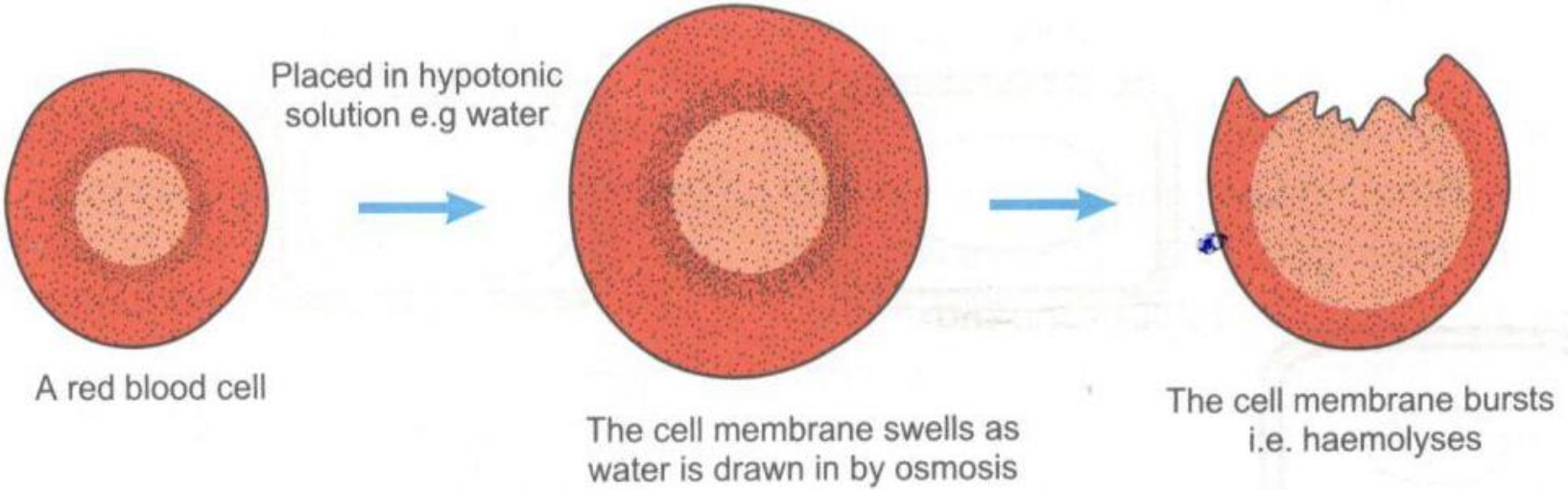
* This is the process where the rate of water loss to the atmosphere is more than that of absorption from the soil.
* Turgor pressure in cells is reduced, the cell wall loses its rigidity, the cells shrink and the plant droops.
* At night, plants recover from wilting because their stomata are closed and the rate of water loss/ transpiration and evaporation are reduced.
* If the water supply from the soil is inadequate, the plants do not recover from wilting and are said to have undergone permanent wilting.

Importance/ significance of wilting.

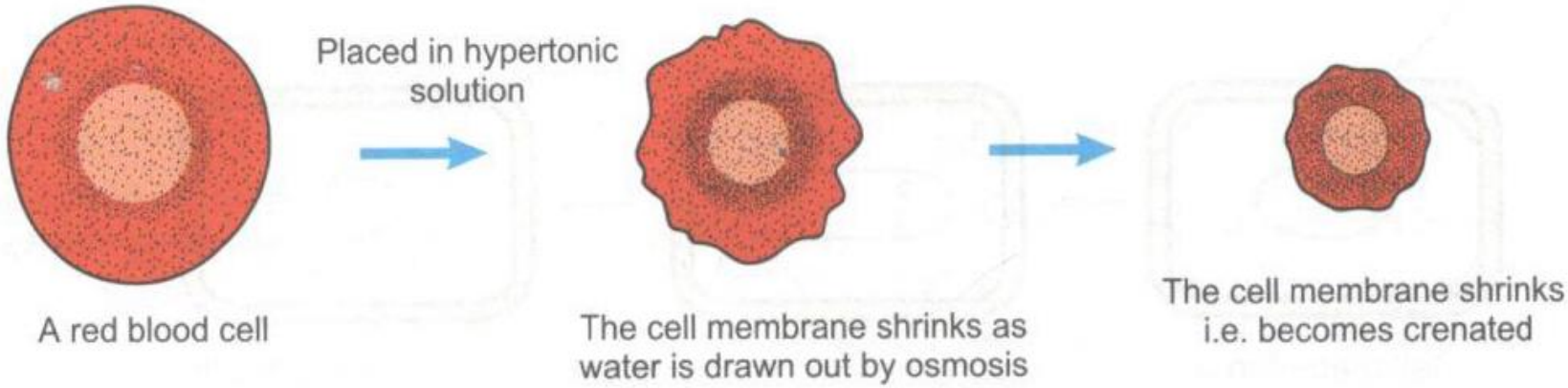
* Wilting results to drooping of leaves. This in turn reduces the total surface area of the leaf exposed to the environment hence reducing water loss.

WATER RELATIONS IN ANIMALS

- The cell membrane of animal cell e.g. red blood cells is semi-permeable and the cytoplasm contains dissolved salts and sugars in solution form.
- If the animal cells are **placed** in a hypertonic/ concentrated solution **e.g. 1.2% sodium chloride**, they will lose water (from the cytoplasm) by osmosis across the semi-permeable membrane, shrink and the cell membrane becomes wrinkled. This is known as **laking or crenation.**
- If the animal cell (e.g. red blood cell) is placed in a **hypotonic solution/ distilled water**, it will take in/gain water by osmosis, swell and burst because it lacks cell wall. This is called **haemolysis.**
- If human red blood cells are placed in a 0.9% sodium chloride solution, **they will neither shrink nor swell.** This is because the **solution is isotonic to human cells.**



(a) Haemolysis



(b) Crenation

FACTORS AFFECTING OSMOSIS

1. **Concentration of solutions and concentration gradient-** the greater the concentration gradient between two solutions the higher the rate of osmosis and vice versa.
2. **pH-** Extreme pH e.g. strong acids destroy the structure of the cell membrane thus hindering osmosis.
3. **Temperature-** low temperature slows down the rate of osmosis. Increase in temperature increases the energy content of water/ solvent molecules increasing the rate of osmosis.

* Extremely high temperature destroys the structure of the cell membrane thus hindering osmosis.

ROLE OF OSMOSIS IN PLANTS.

1. Helps in absorption of water from the soil (through root hair).
2. Helps in support in herbaceous plants/ non-woody plants through turgidity. This is because plant cells take in water through osmosis, become turgid hence become firm/ rigid providing support.
3. Helps in movement of water from cell to cell.
4. Enables opening and closing of stomata to facilitate gaseous exchange.
5. It helps in feeding in insectivorous plants. The plants have special structures that change turgor pressure when touched. The change in turgor pressure causes those structures to close trapping insects.
6. Folding of leaves. This reduces the surface area exposed to the environment reducing water loss.
7. Support in leaves/flowers/seedlings through turgidity.

ROLE OF OSMOSIS IN ANIMALS.

1. Enables re-absorption of water in the kidney nephron (osmoregulation). This helps the animal to regulate its osmotic pressure.
2. Helps in movement of water from cell to cell.
3. Helps in absorption of water from the alimentary canal/ gut (colon) into bloodstream.

Differences between osmosis and diffusion.

Diffusion.

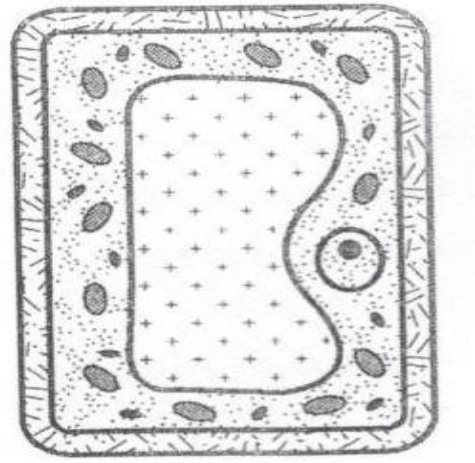
i. Involves the movement of particles or molecules of liquid or gas.
ii. It may be through a membrane or air.
iii. It is not affected by changes in pH.

Osmosis.

i. It involves the movement of solvent/ water molecules.
ii. It is through a semi-permeable membrane.
iii. It is affected by changes in pH.

Study questions

1. The diagram below illustrates the appearance of a plant cell after it had been placed in a certain solution.



a) Explain the appearance of the cell at the end of the treatment.

* ***The cell sap was hypertonic compared to the solution in which it was placed. Water molecules moved into the cell sap through osmosis across its semi-permeable membrane. This causes the cell to swell and become turgid.***

b) Explain the results obtained if the red blood cell is subjected to the same treatment.

* ***The red blood cell lacks a cell wall, water moves across its semi-permeable membrane into the cytoplasm through osmosis. The red blood cell then swells and bursts (haemolyze)***

2. A student at Enkinda secondary school observed that when sodium chloride was poured onto grass, the grass dried up. Explain this observation in relation to osmosis.

* ***Sodium chloride dissolved in the soil solution forming a hypertonic environment. This caused plant cells to lose water by osmosis hence drying up.***

* **Note-** The same phenomenon is observed that around the urinal pit as grass dries up because urine contains salts that dissolve in soil solution forming hypertonic environment.

3. Distinguish between plasmolysis and wilting.

* ***Plasmolysis involves loss of water from plant cells to a hypertonic solution while wilting involves loss of water from plant cells to the atmosphere.***

4. Describe how turgor pressure builds up.

As the cell gains water by osmosis, the cell sap/sap vacuole enlarges pushing the cytoplasm outwards; exerting pressure on the cell wall.

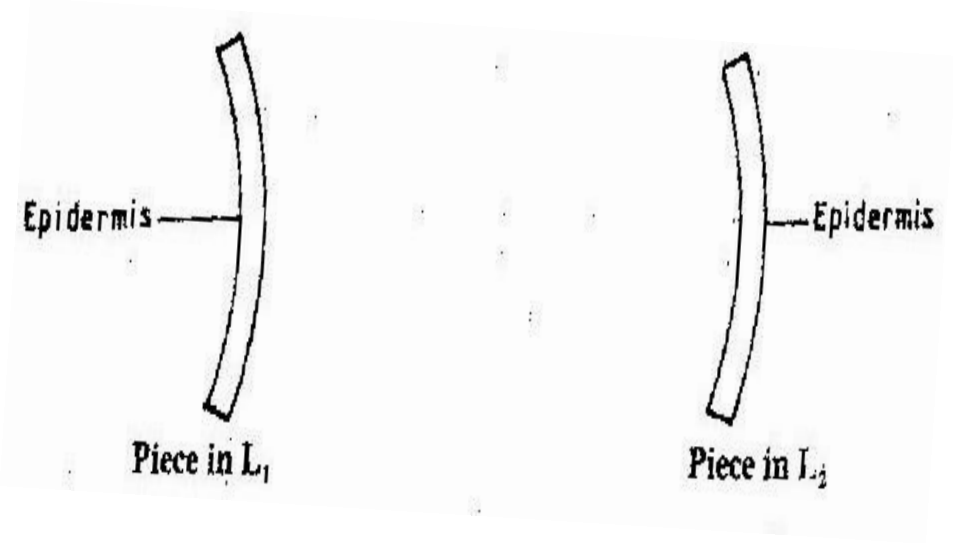
5. Explain what would happen to onion epidermal cells if they were placed in distilled water.

* ***The cells would absorb water through osmosis, the cell swells/becomes turgid but does not burst due to the cell wall.***

6. Explain how the visking tubing is different from the cell membrane.

- ***The visking tubing has a thin layer of polythene with pores while the cell membrane is a layer made up of lipids and proteins (lipo-protein layer).***

7. A freshly obtained dandelion stem measuring 5 cm long was split lengthwise to obtain two similar pieces. The pieces were placed in solutions of different concentrations in Petri dishes for 20 minutes. The appearance after 20 minutes is as shown.



a) Name the physiological process investigated.

* ***Osmosis***

b) Account for the appearance of the pieces in solutions L_1 and L_2

* ***In L_1 cortical cells/cells of the cortex/inner cells gained water by osmosis becoming turgid hence increasing in length. The epidermal cells did not gain water because they are covered by a water proof cuticle leading to curvature.***

* ***In L_2 cortical cells/cells of the cortex/inner cells lost water by osmosis leading to decrease in length. The epidermal cells did not gain water because they are covered by a water proof cuticle leading to curvature.***

8. An experiment was carried out to investigate the effect of different concentrations of sodium chloride on human red blood cells. Equal amounts of blood were added to equal volumes of the salt solution but of different concentrations. The results are shown in the table below.

	Sodium chloride concentration	Number of cells at the beginning of the experiment	Number of cells at the end of the experiment
A	0.9 %	Normal	No change in number
B	0.3%	Normal	Fewer in number

a) Account for the results set up in A and B.

* ***A – There was no change in number because 0.9% sodium chloride solution is isotonic to red blood cell hence they did not lose water through osmosis.***
* B- There was fewer in number because 0.3% sodium chloride solution is hypotonic to red blood cells. This caused the red blood cells to gain water through osmosis, swell and burst/ to haemolyze.

b) If the experiment was repeated using 1.4% sodium chloride solution state the expected results with reference to:

i) The number of red blood cells.

* ***The number of cell will remain the same.***

ii) The appearance of red blood cell if viewed under the microscope.

* ***The red blood cells will appear small in size, wrinkled/ crenated***

(C) ACTIVE TRANSPORT

- **Active transport** is the process by which substances move across the cell membrane against concentration gradient.
- The process **requires energy** and **carriers** for the substances to move across the cell membrane.
- The carrier binds the molecule or ion to be transported on one side of the membrane and takes it to the other side.
- The carrier releases the molecule and returns to the other side where it repeats the process.

Factors affecting active transport.

1. **Concentration of oxygen-** higher oxygen concentration leads to higher rate of respiration to provide enough energy for faster rate of active transport.
2. **Concentration of glucose-** higher glucose concentration increases the rate of respiration thus increasing the rate of active transport.
3. **Temperature-** Respiration is enzyme controlled process Enzymes function best at a given optimum temperature.

4. **Enzyme inhibitors-** they inhibit the process of respiration thus affecting active transport.
5. **Change in pH.-** extreme change in pH affects respiration hence affecting active transport.

Role of active transport in plants.

1. It enables the absorption of mineral salts from the soil by the plants. For example uptake of large quantities of iodide by sea weeds from surrounding sea water

Role of active transport in animals.

1. Helps in the re-absorption of sugars and some salts in the kidney into the blood stream.
2. Helps in absorption of digested food from the alimentary canal into the blood stream
3. Helps in excretion of waste products from the body cells.
4. Helps in pumping of sodium and potassium ions across the nerve cell membrane.
5. It helps in accumulation of substances into the body to offset osmotic imbalance in arid and saline/ salt environments.

Differences between osmosis and active transport.

Osmosis.

i. It involves the movement **water molecules.**
ii. It involves the movement along the concentration gradient.
iii. It does not require energy.
iv. It does not require carriers.

Active transport

i. It involves the movement of ions/particles.
ii. It involves movement against the concentration gradient.
iii. It requires the use of energy.
iv. It requires carriers.

Differences between active transport and diffusion.

Active transport.

i. It involves the movement of particles or molecules from a region of high concentration to a region of low concentration.
ii. It involves the movement along the concentration gradient.
iii. It requires the use of energy.
iv. It requires the use of carriers.

Diffusion.

i. It involves the movement of particles or molecules from a region of low concentration to a region of high concentration.
ii. It involves the movement against the concentration gradient.
iii. Does not require the use of energy.
iv. It does not require the use of carriers.

PRACTICAL ACTIVITY 1.

Aim: To demonstrate osmosis using a visking tubing.

Requirements:

1. Visking tubing 8cm long.
2. 500 ml Beaker.
3. 500 ml distilled water.
4. Concentrated salt/ sugar solution.
5. A piece of thread.
6. Glass rod.
7. 500 ml measuring cylinder

Procedure:

1. Put 350 ml of distilled water into the beaker.
2. Dip the visking tubing in water to moisten it. Rub it between the finger top open and tie one end with a thread.
3. Half-fill the visking tubing with salt/ sugar solution and tie the open end of the visking tubing. Ensure that no salt solution spills out of the visking tubing.

4. Immerse the visking tubing into the distilled water and suspend it using the glass rod.
5. Leave the set up for about 30 minutes.
6. Record your observation.
7. Explain the observation.

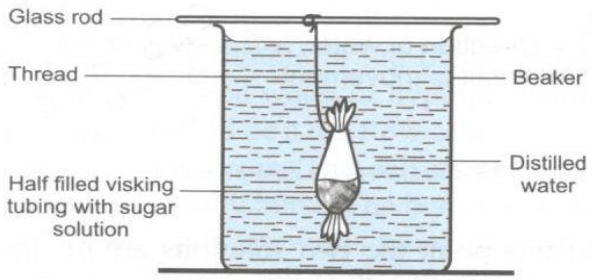
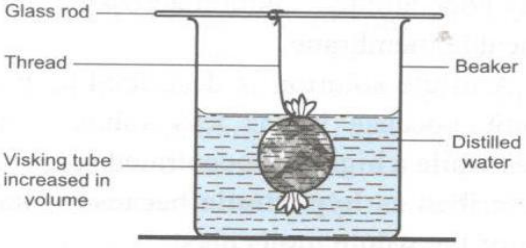


Fig 4.4 (a): At the beginning of experiment



(b): At the end of the experiment

Observation

- The visking tubing swells/ increases in size/ become turgid.

Explanation

* Distilled water in hypotonic to sugar/salt solution OR sugar/salt solution is hypertonic to distilled water.
* Water molecules moved from distilled water in the beaker into the visking tubing through osmosis across the semi-permeable membrane.

PRACTICAL ACTIVITY 2.

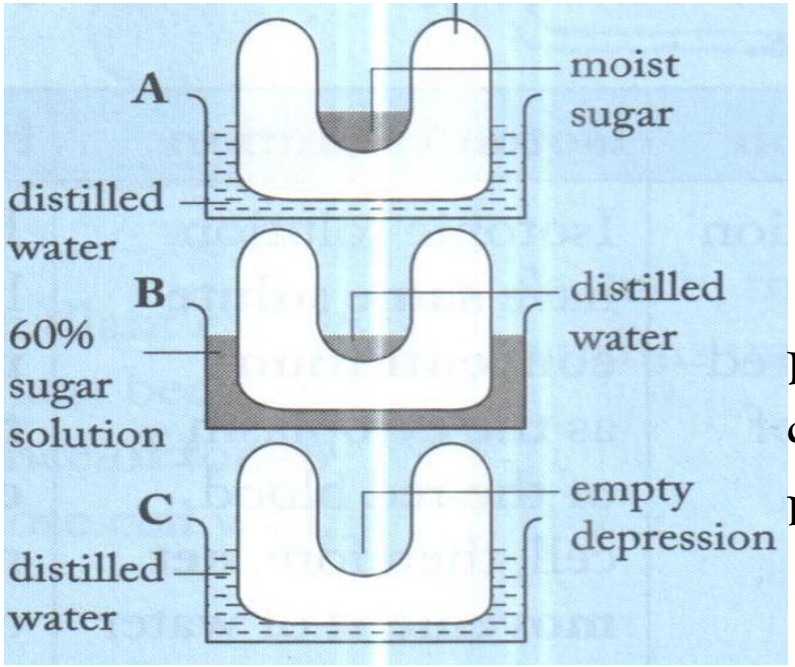
Aim: To investigate osmosis in a potato tissue.

Requirements:

1. Three Irish potatoes.
2. Scalpel.
3. Distilled water.
4. 3 beakers.
5. Sugar solution.

Procedure:

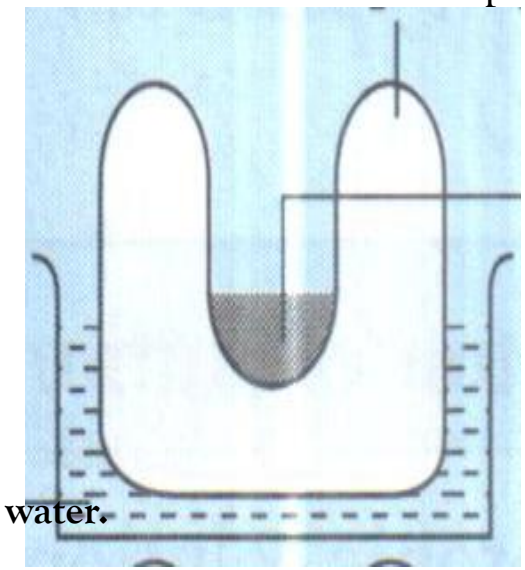
1. Use the scalpel to cut the Irish potatoes into cup shapes then set up apparatus as shown.
2. Leave the set up for 4 hours.



Petri dish

Distilled water.

Boiled potato



Sugar solution

D

1. **State the observation made after the experiment.**

- In Set up A, the depression is filled with sugar solution.
- In B the level of distilled water is reduced in the depression.
- In set up C, no observation is made.

2. **State the observations that would be made if a boiled potato was used in set up D.**

* There would be rise in the level of sugar solution.

3. **Give a reason for your answer in (2) above.**

- Boiling/ high temperature destroys the structure of the membranes hence they are no longer semi-permeable and as such no osmosis takes place.

4. **Explain/account for the observations in 1 above.**

- In set up A, water is more concentrated/hypertonic in the Petri dish than in the cells of the Irish potato. Water moves from the Petri dish to the adjacent cell sap of the Irish potato cells through osmosis.
- This makes the cell sap less concentrated/ hypotonic than the cell sap of adjacent cells.
- Water continuously moves from one cell to another through osmosis until it reaches the sugar solution by resulting into a rise of the volume of the sugar solution in the cup shaped depression of the Irish potato.

- In set up B, water is more concentrated/hypertonic in the cup shaped depression than in the cell sap of the adjacent cells of the Irish potato.
- Water moves from the cup shaped depression to the cell sap of the adjacent cells of the Irish potato through osmosis.
- This makes them hypotonic/ less concentrated than the cell sap of the adjacent cells.
- Water continuously moves from one cell to another through osmosis until it reaches the sugar solution in the petri dish resulting into the drop volume of water in the cup shaped depression of the Irish potato.
- In C, there was no sugar solution hence no concentration gradient existed therefore no osmosis took place.

PRACTICAL ACTIVITY 3.

1. You are provided with Irish potato, 5 ml of distilled water in a beaker labeled R1, 5 ml of 10% sodium chloride solution in a beaker labeled R2, an empty beaker labeled R3 and ruler.
2. Push a cork borer through the Irish potato and remove the cylinder tissue from the borer. Repeat the procedure obtain three cylinders.
3. Chip off one end of each cylinder and starting from the chipped end measure exactly 30 mm and cut the cylinder. Repeat this for the other two cylinders.
4. Place one cylinder in distilled water (R1), another in sodium chloride solution (R2) and the third cylinder in an empty beaker (R3). Leave the set up to stand for 30 minutes.
5. After 30 minutes remove the cylinders from the solutions and gently wipe it with a tissue paper provided.

1. Which physiological process is being investigated? ***Osmosis.***
2. Measure and record new lengths of the cylinders and record your results in the table below.

Cylinder in	Initial length in mm	Final length in mm
R1	30mm	32±1 mm
R2	30mm	28±1 mm
R3	30mm	30mm

3. Feel the textures of the cylinders and record your observations in the table below.

Cylinder in	Observation
R1	Hard/ firm/ turgid/ rigid.
R2	Soft/ flaccid.
R3	Hard/ firm/ turgid/ rigid.

4. Explain/ account for observation made in;

a) R1

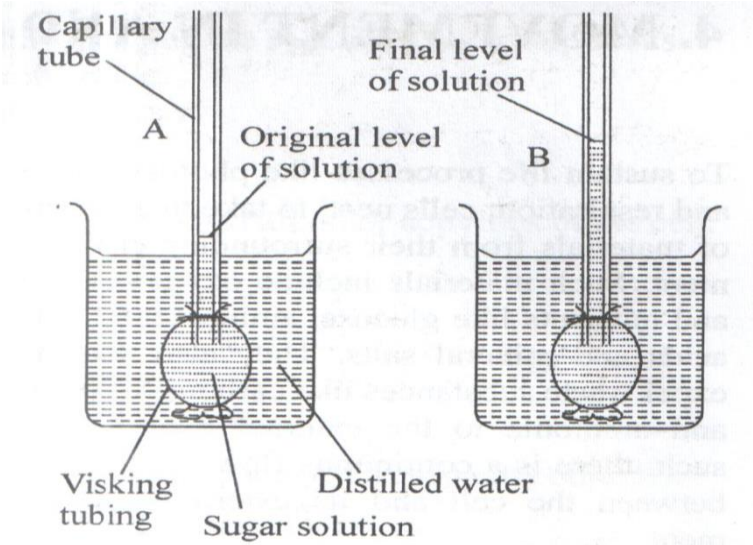
* ***Distilled water was hypotonic/less solute concentrated than cell sap of potato cells. Water moved into potato cell sap of potato cells (from the beaker) through osmosis. This increased turgidity of potato cells which also increased in length.***

b) R2

* ***Sodium chloride solution was hypertonic/highly concentrated than the cell sap of potato cells. Water moved from cell sap of potato cells (into the beaker) through osmosis. This caused the potato cells to be flabby/ flaccid decreasing the length of cells.***

STUDY QUESTIONS

1. The students set up the experiment as shown below.



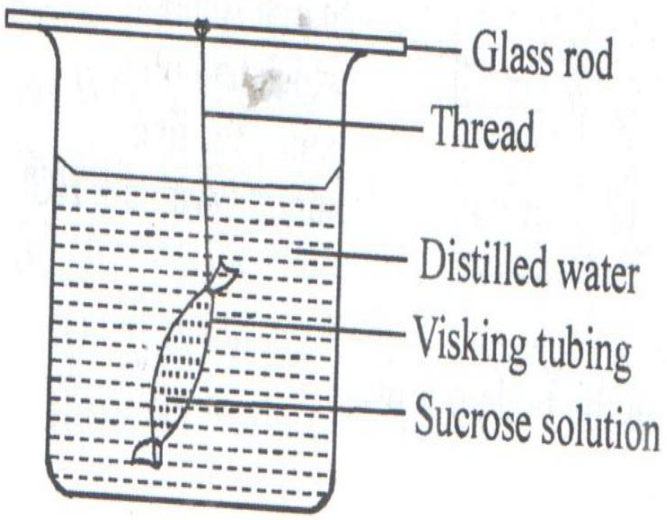
a. **State the reason for the set up.**

To demonstrate osmosis.

b. **Explain the observations made.**

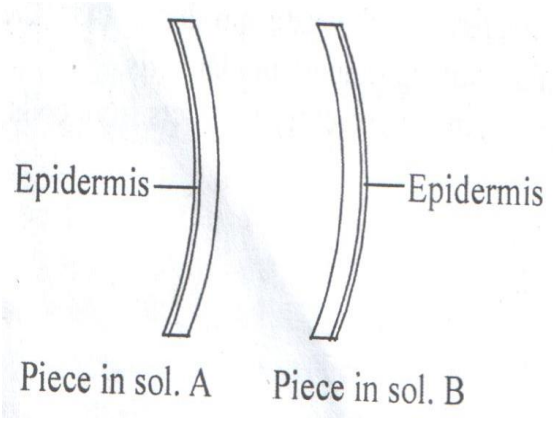
- The level of the solution rises in the capillary tube. This is because water molecules move from the beaker to the visking tubing through osmosis across the semi-permeable membrane.

2. Study the setup below and answer the questions that follow.



1. Name the process that is being investigated.
- ***Osmosis.***
2. State the expected observations after the setup is left for 3 hours.
- ***The visking tubing will become turgid/increase in size.***
3. Explain the answer you have given in (b) above.
- ***Water moves by osmosis from the beaker into the visking tubing across the semi-permeable membrane.***
4. State and explain the expected observation if the experiment is repeated with distilled water in both the visking tubing and the beaker.
- ***There would be no change because a concentration gradient does not exist between the liquids in the beaker and in the visking tubing.***

3. A 4 cm straight piece of stem from a herbaceous plant was split lengthwise into two similar pieces. The pieces were placed in sugar solutions of different concentrations for 30 minutes. Their appearance after 30 minutes is as shown below:



1. Which biological process is being investigated?

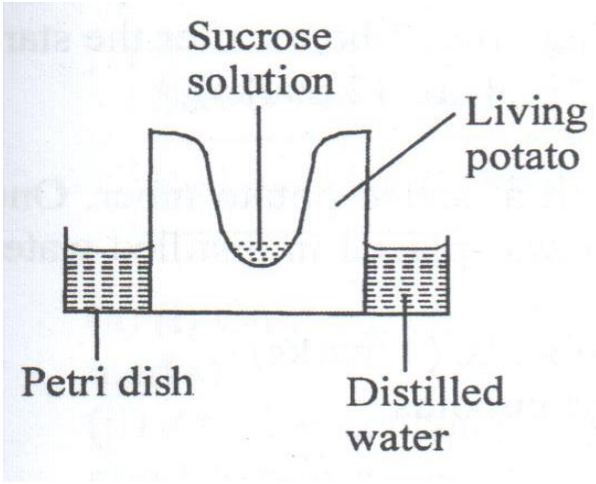
- ***Osmosis.***

2. Account for the appearance of the pieces in solutions A and B.

- ***Piece A was placed in a hypotonic solution. The inner cells gained water by osmosis. They became turgid and increased in size/length.***
- ***Epidermis does not gain water because it is covered by waterproof cuticle. This leads to curvature of the whole piece outwards.***

* ***Piece B was placed in a hypertonic solution. The inner cells lost water by osmosis. They became flaccid and decreased in size/length.***
* ***Epidermis does not gain water because it is covered by waterproof cuticle This leads to curvature in a direction opposite to that of A.***

4. Study the experimental setup below and answer the questions that follow.



a) Name the process that is being investigated.

- ***Osmosis.***

b) State and explain what would be observed if the setup was left for 12 hours.

- ***The level of the liquid in the cavity of the potato will rise while that in the Petri dish will drop because cells adjacent to the sugar solution will lose water into the solution by osmosis. Those cells become hypertonic to the adjacent cells hence draw in water through osmosis. Finally water will be drawn from the Petri dish through osmosis.***

c) State and explain what would be observed if the experiment was repeated:

(i) Using boiled potato instead of living potato.

- ***No change in the level of the liquids. Because boiling destroys the cell membrane.***

(ii) Petri dish contained sugar solution and the cavity in the potato contained distilled water.

- ***The level of the liquid in the cavity of the potato will fall while that of the Petri dish will rise.***
- ***Because cell sap of cells adjacent to the sugar solution will lose water into the solution by osmosis. Those cells become hypertonic to the adjacent cells hence draw in water through osmosis. Finally water will be drawn from the cavity of the potato to the Petri dish through osmosis.***

5. In an experiment, two cuboids of equal size were made out of a peeled potato tuber. One was placed in concentrated salt solution (brine) and the other was placed in distilled water for one hour. State and explain the expected changes in the size of the cuboids.

* ***The cuboid that was immersed in distilled water will be larger because the cells take up water through osmosis hence become turgid and increase in size.***
* ***The cuboid that was immersed in brine (concentrated solution) will be smaller because the cells lost water through osmosis and reduced in size.***

5. NUTRITION IN PLANTS AND ANIMALS.

Definition.

- Nutrition is the process by which organisms **obtain/acquire and utilize nutrients.**

Importance of nutrition.

- It helps organisms to acquire and utilize nutrients for metabolic activities for respiration, growth and repair of worn out tissues.

Types/modes of nutrition.

1. **Autotrophism-** this is the process through which organisms manufacture/make their own food from simple substances e.g. Carbon (IV) oxide, water in the presence of light/ chemical energy.

✓ The organisms that make their own food are called **autotrophs e.g. green plants, algae and some bacteria.**

2. **Heterotrophism-** this is the mode of nutrition where organisms feed on already manufactured food/ complex food materials e.g. carbohydrates, proteins and lipids (fats and oils).

✓ Organisms that feed on already manufactured food are called heterotrophs e.g. animals, protozoa (e.g. amoeba) and some bacteria.

NUTRITION IN PLANTS

✓ Nutrition in plants is called autotrophism.

Types/ modes of autotrophism

1. **Photosynthesis-** this is the process by which green plants manufacture their own food using light energy.

✓ During photosynthesis light energy is converted into chemical energy and stored in food.

2. **Chemosynthesis-** this is the process through which organisms (e.g. bacteria) manufacture their own using chemical energy obtained from chemical reactions.

External parts of a dicot leaf.

1. **Leaf lamina/blade-** it is flat and broad to increase surface area for trapping light energy for photosynthesis. The lamina is green in color and contains the photosynthetic tissue.
2. **Mid rib and veins-** the mid rib is thick and runs in the middle from the petiole to the apex. The veins un into the lamina forming an extensive network of **veins.** The veins have:

i) **Xylem-** which transports water and mineral salts to the photosynthetic cells.

ii) **Phloem-** which transports manufactured food from photosynthetic cells.

3. **Petiole-** Attaches the leaf to the branch or stem.
4. **Margin-** it is either smooth or serrated.
5. **Apex-** It is located at the tip of the blade.

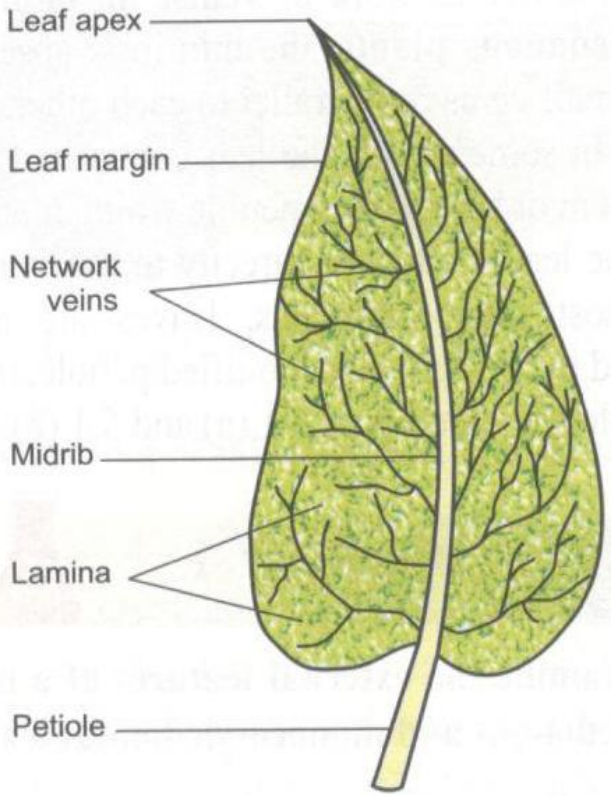


Fig 5.1 (a): External features of a dicotyledonous leaf, e.g., bean.

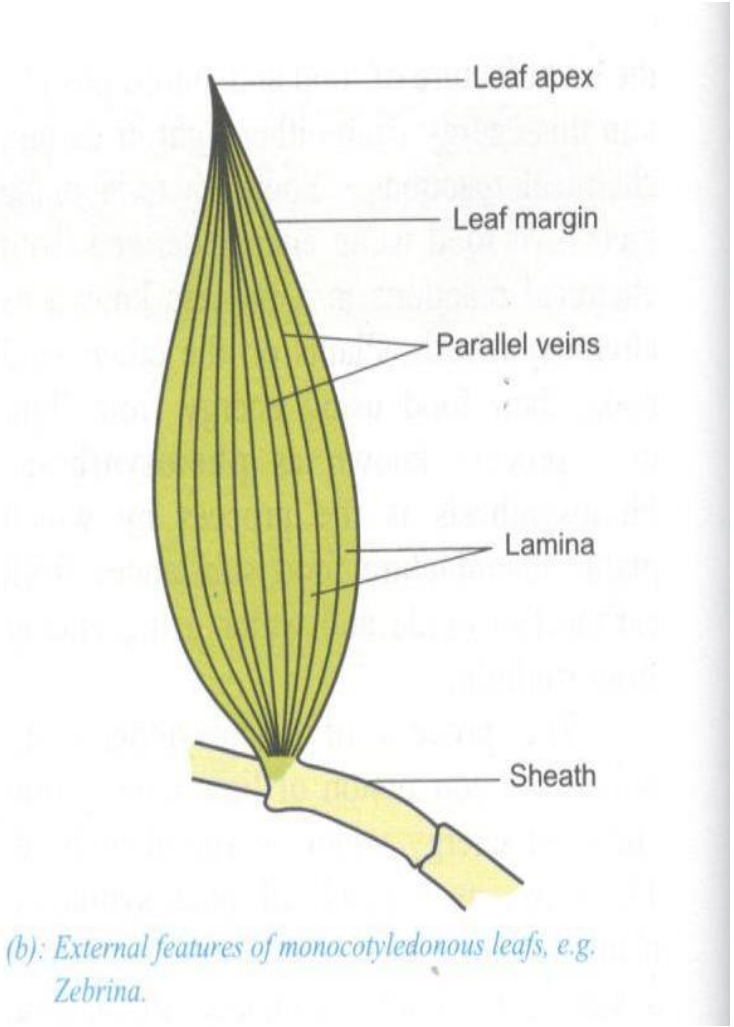
EXTERNAL PARTS OF A MONOCOT LEAF.

1. **Leaf lamina/blade-** it is flat and narrow to trap light energy for photosynthesis. The lamina is green in color and contains the photosynthetic tissue.
2. **Parallel veins-** they run parallel from sheath to apex. The veins have:

i) **Xylem-** which transports water and mineral salts to the photosynthetic cells.

ii) **Phloem-** which transports manufactured food from photosynthetic cells.

3. **Margin-** it is either smooth or serrated.
4. **Apex-** It is located at the tip of the blade.
5. **Leaf sheath-** it attaches the leaf to the stem/ branch.



(b): External features of monocotyledonous leafs, e.g. Zebrina.

Differences between dicot and monocot leaf

Dicot leaf	Monocot leaf
1. Has broad lamina/ blade.	1. Has narrow lamina/ blade.
2. Has leaf petiole.	2. Has leaf sheath.
3. Has midrib.	3. Lacks midrib.
4. Has network veins.	4. Has parallel veins.

INTERNAL STRUCTURE OF A LEAF.

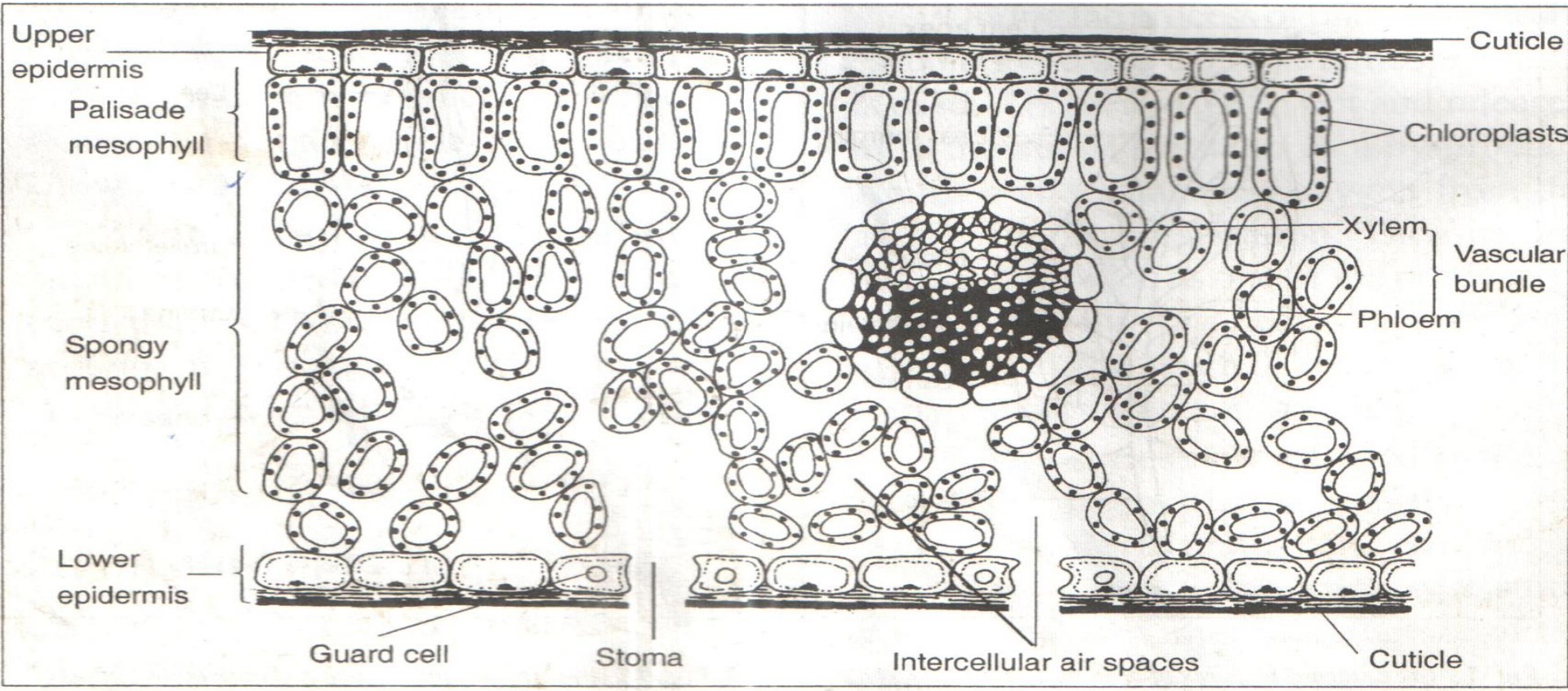


Fig. 5.2: Transverse section of a leaf

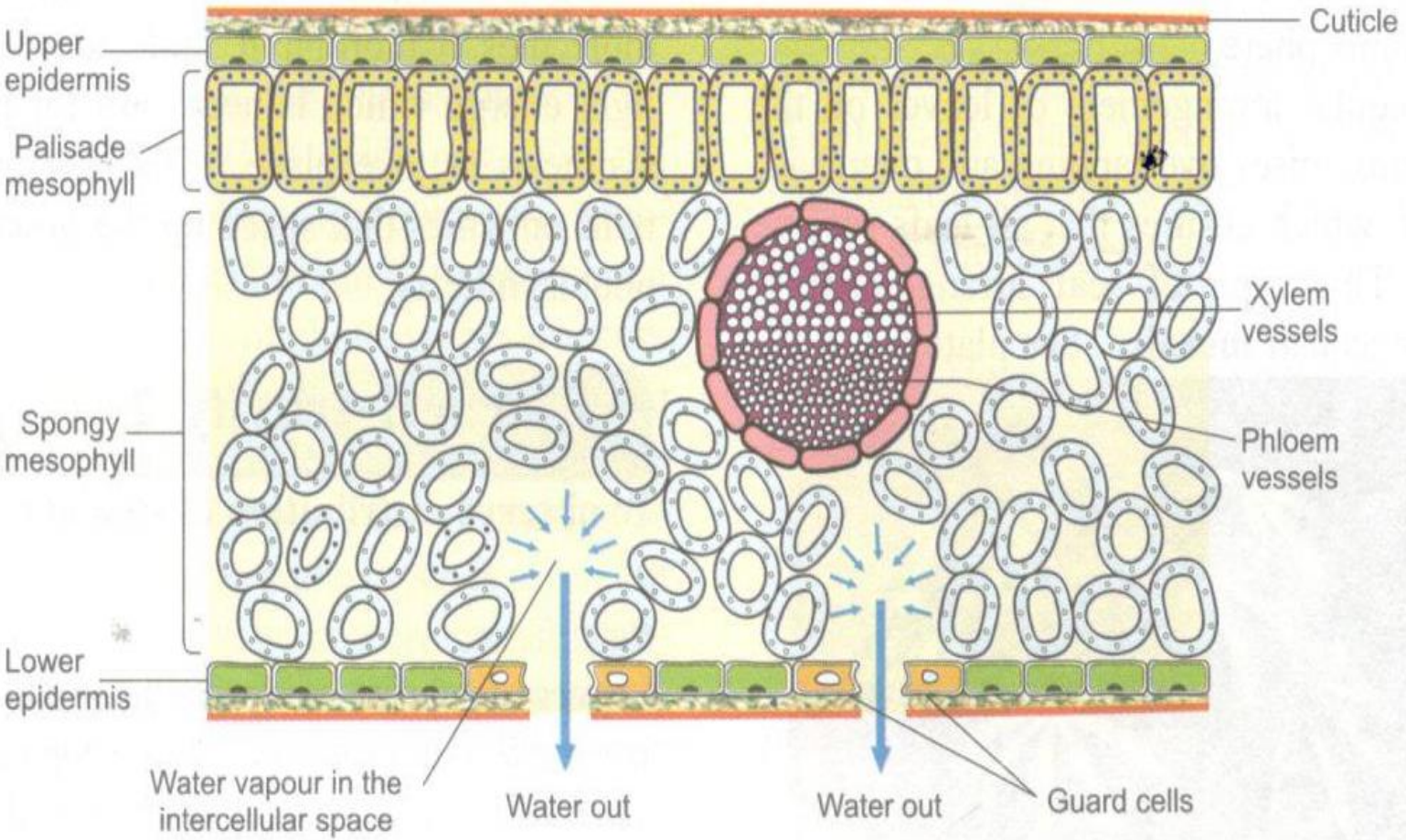


Fig 5.2: Transverse section of a leaf .

Internal parts of a leaf

1. **Cuticle-** This is a thin non-cellular, waxy, waterproof and transparent layer that covers the upper and lower surfaces of the leaf. The cuticle is transparent to allow penetration of light for photosynthesis.

Functions of cuticle

i. It reduces excessive loss of water.

ii. Protects the inner tissues of the leaf from mechanical damage.

iii. Prevents entry of disease-causing microorganisms.

2. **Epidermis-** This is a thin tissue, usually one cell thick, on the upper and lower surfaces of the leaf. The epidermal cells have no chloroplasts ***except the guard cells.*** Chloroplasts are the organelles that contain the photosynthetic material known as **chlorophyll.**

Functions/ adaptations of epidermis.

a) It secretes the cuticle.

b) It is transparent to allow light penetrate to the photosynthetic tissue.

c) It has a single layer of cell (i.e. thin) to reduce the distance over which light penetrates to photosynthetic tissue and carbon (IV) oxide diffuses to photosynthetic cells.

d) It has stomata for gaseous exchange.

e) There are guard cells to control opening and closing of stomata.

f) It is covered with thick, waxy and has waterproof cuticle to prevent excessive water loss and protect the inner parts of the leaf.

3. **Guard cells-** they are specialized epidermal cells used to control opening and closing of stomata.

- Unlike the epidermal cells, the guard cells are bean-shaped while other epidermal cells are blocky shaped. They also contain chloroplasts/ are able to carry out photosynthesis

Structural adaptations of guard cells.

a) They have thicker inner less elastic walls which curve to open the stomata and straighten to close the stoma.

b) They have outer thinner and less elastic walls which bulge outwards.

c) They contain chloroplasts for photosynthesis/ manufacture glucose which is osmotically active.

4. **Palisade layer/ cells-** This is a layer of cells located beneath/below the upper epidermis. It consists of cylindrical shaped cells closely packed together and with the long axis perpendicular to the surface.

Adaptation to function

a) They have numerous chloroplasts containing chlorophyll which is necessary for photosynthesis. Their position and arrangement enables them to receive maximum sunlight.

5. **Spongy mesophyll layer-** this is a layer of cells between the palisade and the lower epidermis. The cells are irregularly shaped and loosely arranged creating large air spaces in between them.

- ✓ The air spaces provide communication pathways through which gases diffuse in between the cells.
- ✓ Unlike the palisade cells, spongy mesophyll cells contain fewer chloroplasts.
- ✓ This explains why the lower surface of the leaf is lighter in colour than the upper surface.

6. **Vascular bundle-** consists of xylem and phloem tissues.

- ✓ The xylem transport water and mineral salts from the roots to the leaf cells.
- ✓ The phloem transports/translocates manufactured food from the leaf cells to the rest of the plant.

Study question

Name three cells in a leaf which contain chloroplasts.

i. **Palisade.**
ii. **Spongy mesophyll.**
iii. **Guard cells.**

ADAPTATIONS OF THE LEAF TO PHOTOSYNTHESIS.

1. It is green in colour/ contain chlorophyll which traps sunlight energy needed for photosynthesis.
2. Has broad and flat lamina which provides a large surface area for the absorption of carbon (IV) oxide trapping sunlight.
3. It has thin lamina to allow light and carbon (IV) oxide to pass through a short distance to reach the photosynthetic cells.
4. It has stomata to ensure efficient diffusion of respiratory gases in and out of the leaf.
5. It contains guard cells which control opening and closing of stomata; and contain chloroplasts/ chlorophyll to trap light energy/ carry out photosynthesis.
6. It has transparent cuticle and epidermis to allow penetration of light to the palisade cells.
7. The palisade cells and mesophyll cells contain large numbers of chloroplasts located next to the upper epidermis enables them to receive maximum sunlight.
8. The mid-rib and veins contain xylem which transports water and mineral salts to photosynthetic cells and phloem; which transports manufactured/ photosynthetic materials from photosynthetic cells
9. Spongy mesophyll cells have large air spaces which allow circulation of air to facilitate gaseous exchange.
10. The regular /mosaic arrangement of leaves on the stem minimizes overlapping and overshadowing so that each leaf receives adequate light
11. Has xylem, parenchyma and sclerenchyma tissues to support the leaf exposing it to sunlight.

Study questions

1. List three adaptations of leaves that maximize efficiency in trapping sunlight for photosynthesis.

i. **Flat broad lamina.**

ii. **Transparent cuticle.**

iii. **Thinness of the leaf.**

2. Explain how aquatic plants are adapted to photosynthesis.

- ***Emergent and floating hydrophytes have broad leaves with numerous stomata*** on the upper surface to increase the surface area for transpiration and for efficient gaseous exchange.
- ***Submerged hydrophytes have highly dissected leaves into thread-like straws*** to increase surface area for absorption of maximum light and CO_2 for photosynthesis and gaseous exchange.
- The leaves of ***Submerged hydrophytes have numerous and sensitive chloroplasts*** that photosynthesize under low light intensities.

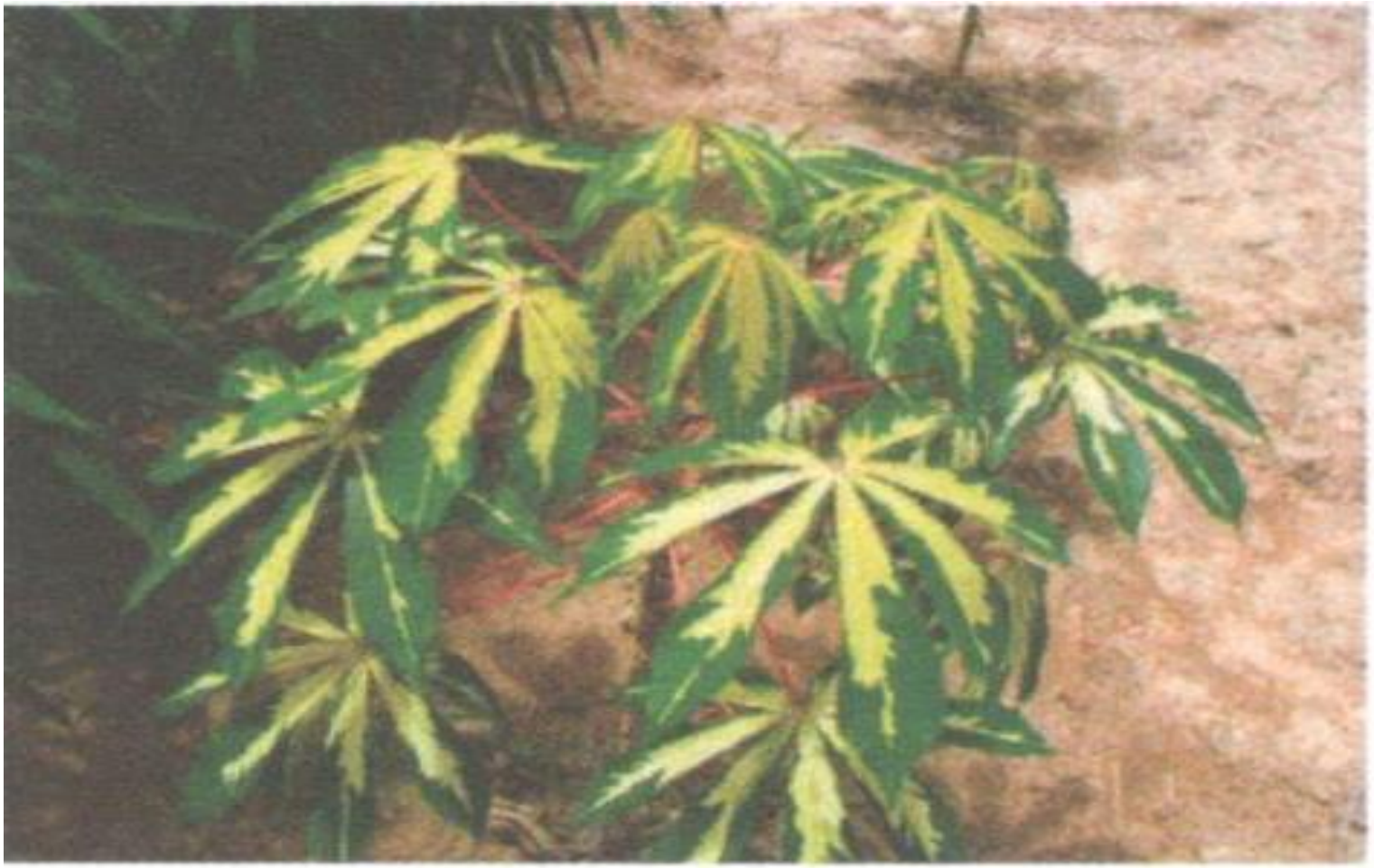


Plate 5.1: Leaf mosaic in cassava

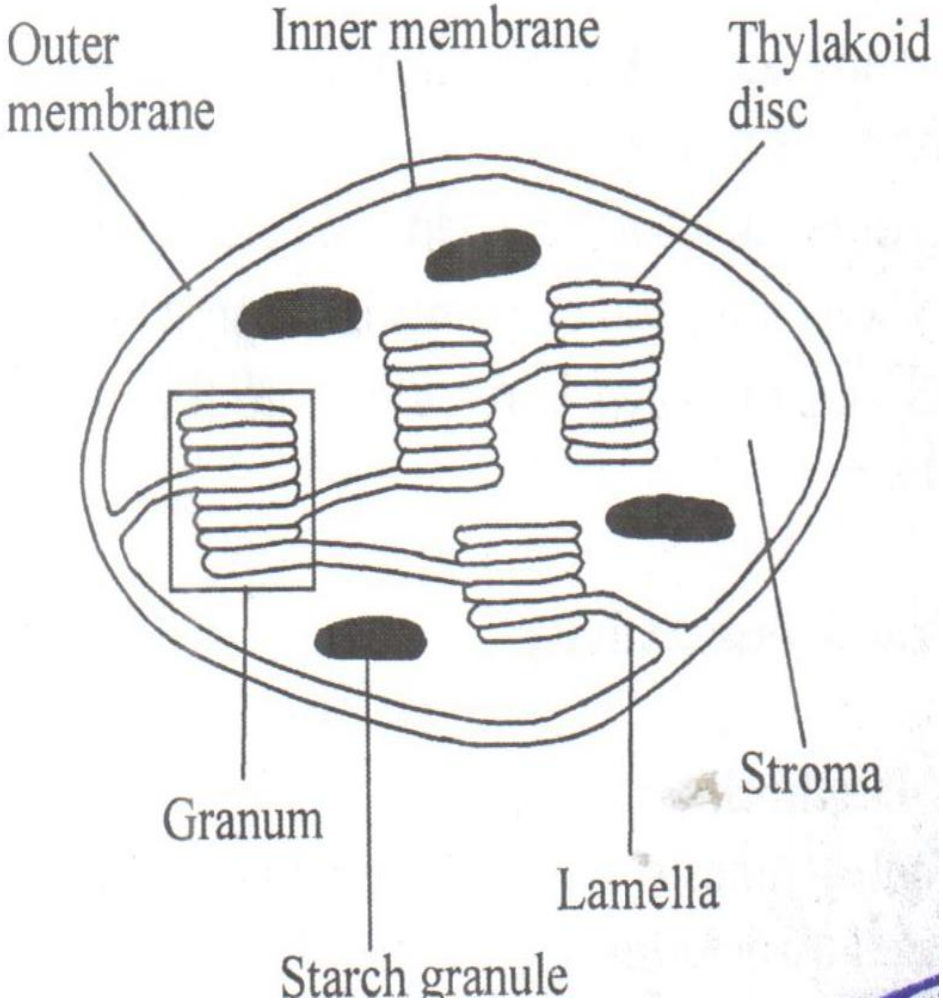
THE CHLOROPLAST.

Parts of chloroplast

1. The outer and inner membranes.
2. Inner membrane is folded to form **lamellae** suspended in an aqueous matrix called **stroma.**
3. The lamellae may at certain intervals form several layers of membranes grouped together to make a **granum** (plural – grana).
4. **Granum** contains **chlorophyll-** which absorb light energy which is necessary for photosynthesis.
5. **Stroma** contains enzymes that speeds up the process of photosynthesis.

Adaptations of chloroplast to its function (photosynthesis).

1. It has lamellae/grana that contains chlorophyll that traps light energy.
2. The grana has a large surface area for accommodation or packing of the chlorophyll.
3. The stroma contains the enzymes that speed up/catalyze the process of photosynthesis.



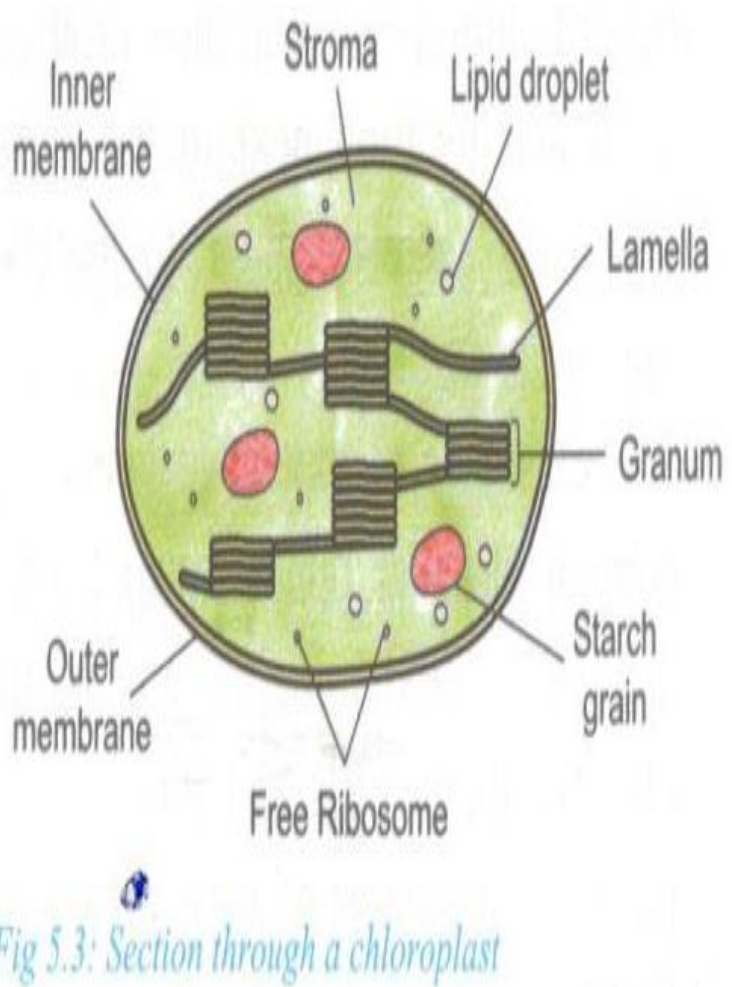


Fig 5.3: Section through a chloroplast

The process of Photosynthesis.

- The raw materials for photosynthesis are:

i. Water

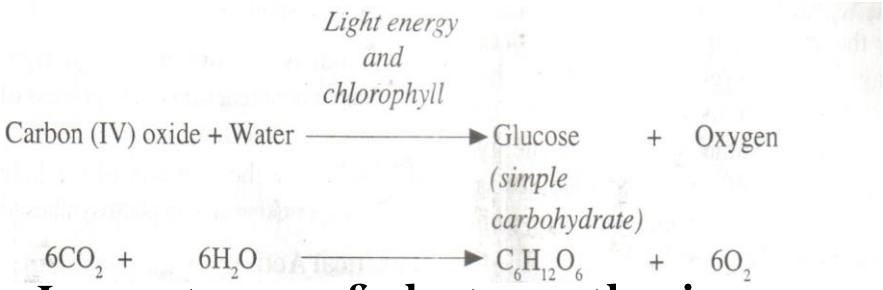
ii. Carbon (IV) oxide gas.

Conditions required for photosynthesis to take place

i. **Light *and***

ii. **Chlorophyll**

- ***Water and carbon (IV) oxide*** molecules undergo several chemical processes in the presence of ***sunlight*** to form ***carbohydrates/glucose, oxygen and energy (ATP)*** are given out as a by-product.



Importance of photosynthesis.

1. Acts as a source of energy.
2. It provides oxygen in the air.
3. It prevents the accumulation of carbon (IV) oxide in the atmosphere.

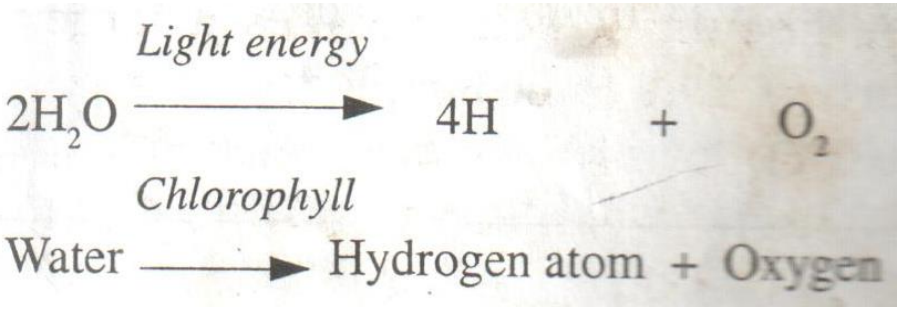
Stages of photosynthesis.

A. Light stage/ light dependent stage.

B. Dark stage/ light independent stage/ Carbon (IV) oxide fixation.

A. Light stage (light dependent stage).

- This is the initial stage in the process of photosynthesis.
- It occurs in the **grana** of the chloroplasts.
- The chlorophyll molecule absorbs/traps light energy which **is used to split water molecules into oxygen and hydrogen atoms.**
- This process is called **photolysis** of water.
- The **hydrogen** atoms that are produced enter the dark stage.



- **Oxygen** is released to the atmosphere or used by the plant for respiration.
- **Adenosine Triphosphate** (ATP) is formed by energy light which is later used in the dark stage.
- This reaction involves conversion of light energy to chemical energy.

Importance of light stage.

- It provides hydrogen atoms and ATP molecules useful during carbon (IV) oxide fixation.

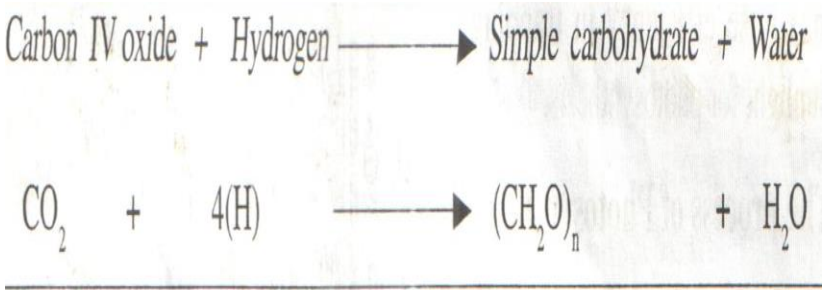
Fate of end products of light stage. (what happens to the end products of light stage?

i) Hydrogen atoms enter the dark stage.

ii) Oxygen atoms are released to the atmosphere as a gas or used for respiration.

B. The Dark Stage/carbon (IV) oxide fixation/ (Light Independent Stage).

- It occurs in the **stroma** in the presence or absence of light.
- It involves the combination of **carbon (IV) oxide** with **hydrogen atoms** to form simple sugar */glucose*, ***fatty acids and amino acids.***
- The energy required for this reaction is provided by ATP from light stage reaction.
- Glucose formed is converted into starch for storage. ***This is important because starch is osmotically inactive (compared to glucose) hence the plant cells do not lose water through osmosis.***
- If the leaf is kept in darkness for 48 hours, starch is converted into glucose. This is called ***destarching.***



What happens to end products of photosynthesis?/ the Fate of end products of photosynthesis.

- ✓ Some glucose is used in respiration.
- ✓ Some glucose is converted into starch for storage.
- ✓ Some glucose is converted into sucrose which is translocated to other parts of the plant.
- ✓ Some glucose is used in making cellulose for the cell wall.
- ✓ Fatty acids and glycerol are combined to form oils and fats (lipids).
- ✓ Amino acids are converted to proteins.
- ✓ Oxygen is used by plants in respiration.
- ✓ Excess oxygen is released into the atmosphere.

Study questions.

1. State four requirements and sources for the process of photosynthesis to occur.

- ✓ ***Water- soil.***
- ✓ ***Carbon (IV) oxide- atmosphere.***
- ✓ ***Chlorophyll- available on the chloroplasts.***
- ✓ ***Light- sunlight***

2. Give the role of each of the following structures in the leaf during photosynthesis.

a) Xylem vessels- ***transports water from the soil to the leaves where photosynthesis takes place.***

b) Chlorophyll- ***traps light energy (used for photolysis).***

c) Guard cells- ***control opening and closing of stomata which allow in carbon (IV) oxide for use during photosynthesis.***

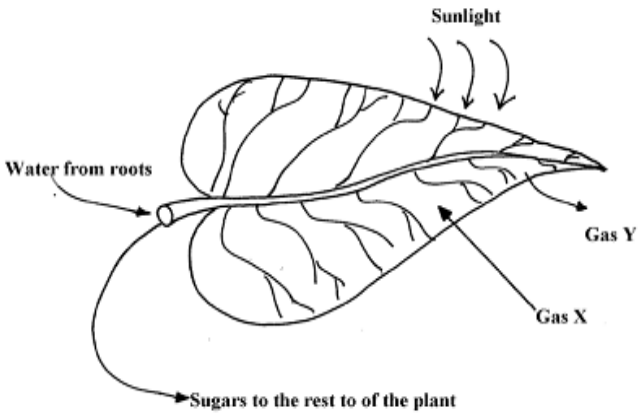
3. Explain why plants will not photosynthesise in the dark.

✓ ***Photosynthesis is the process by which green plants manufacture food in the presence of light hence it does not take place in the absence of light.***

4. Explain why most leaves are thin with broad surface.

✓ ***They are thin and broad to provide a large surface area for absorption of light and carbon (IV) oxide for maximum photosynthesis.***

5. The following diagram of a leaf shows what happens in a plant leaf during photosynthesis.



a) Name the gases labelled **X** and **Y.**

- X – Carbon (IV) Oxide.
- Y – Oxygen.

b) Give **two** ways in which leaves are adapted to absorb light.

- ***Broad and flat to absorb maximum light.***
- ***Have chloroplast with chlorophyll to trap light.***
- ***Transparent cuticle to allow light to pass through.***

c) Name the tissue that transports water into the leaf and sugars out of the leaf.

- ***Xylem – Transports water.***
- ***Phloem – Sugars out of the leaf.***

d) Explain why it's an advantage for the plant to store carbohydrates as starch rather than as sugars.

- ***Starch is insoluble in water, hence osmotically inactive. This reduces effect on absorption of water by cells.***

6. A group of students placed a fresh leaf in warm water. They observed that air bubbles formed on the surface of the leaf.

a) What biological process were they investigating?

Photosynthesis.

b) Name the structures from which the air bubbles were coming from.

Stomata.

c) Explain the distribution of the structures named in (b) above on the leaf surfaces.

They are more on the lower surface and fewer on the upper surface of terrestrial plants to reduce the rate of transpiration.

7. **Explain the formation of starch in green plants.**

- *Green plants manufacture food through the process of photosynthesis; the leaves contain chloroplasts which contain chlorophyll where photosynthesis take place;*
- *Light stage occurs in the granum; where chlorophyll traps light energy; which splits water into hydrogen ions and oxygen atoms/ photolysis; and ATP/ energy used in dark stage;*
- *Dark stage occurs in the stroma; where carbon (IV) oxide from the atmosphere; combines with hydrogen atoms to form simple sugars/ glucose molecules; which are converted into starch for storage;*

8. Other than photosynthesis, explain how carnivorous/ insectivorous plants obtain nutrients.

✓ *They grow in nitrogen deficient soil and obtain nitrogen from insects.*

✓ *Insects are attracted by colour/ scent/ sugary baits and are trapped by plant (nastic responses) and digested by proteases secreted by insects.*

FACTORS AFFECTING THE RATE OF PHOTOSYNTHESIS.

a) Environmental/ external factors

1. Light intensity and quality.
2. Carbon (IV) oxide concentration.
3. Temperature.
4. Water.

b) Internal factors

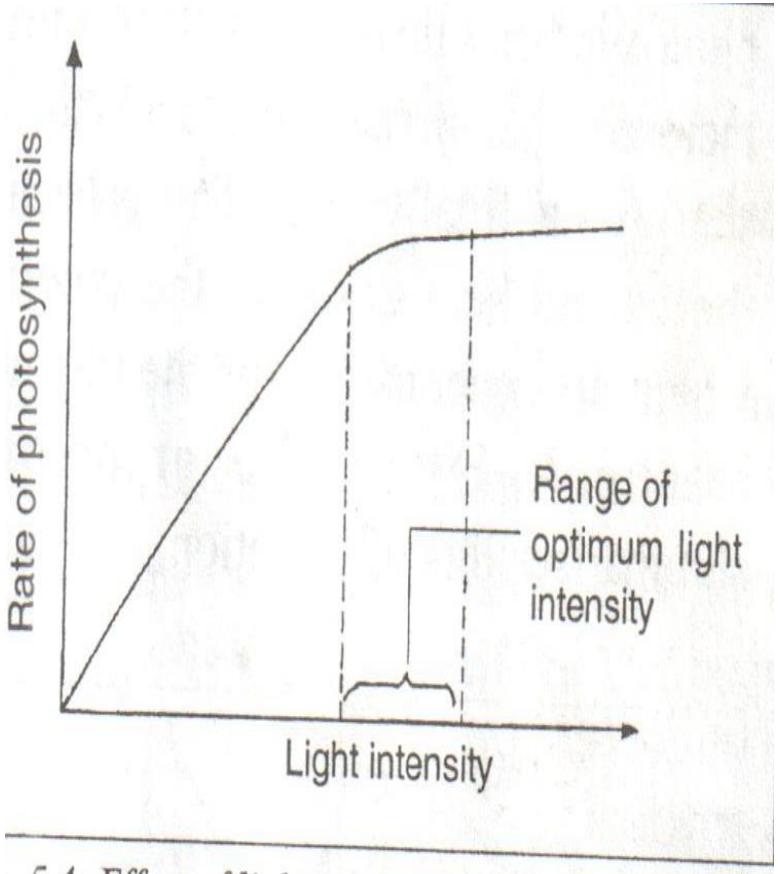
1. Chlorophyll concentration.
2. Enzyme concentration.

1. **LIGHT INTENSITY/ QUALITY OF LIGHT**

- ✓ Light provides the energy required for the process of photosynthesis.
- ✓ Decrease in light intensity decreases the rate of photosynthesis.
- ✓ The rate of photosynthesis increases as light intensity increases up to an optimum level.
- ✓ Beyond the optimum level the rate off photosynthesis remains constant due to other limiting factors.
- ✓ At very high light intensity, chlorophyll is damaged/ bleached and the rate of photosynthesis falls.

Note.

- There is no grass/ vegetation in dense forests because forests form canopies/ shadow which prevents light from reaching grass/ vegetation thus grass/ vegetation die/ fail to flourish due to inactivity to photosynthesize.



. 5.4: Effect of light on the rate of photosynthesis

2. CARBON (IV) OXIDE CONCENTRATION.

- ✓ Carbon (IV) oxide is a raw material for photosynthesis.
- ✓ Decrease in carbon (IV) oxide decreases the rate of photosynthesis.
- ✓ An increase in carbon (IV) oxide (beyond 0.04%) leads to an increase in the rate of photosynthesis up to a given optimum.
- ✓ Beyond optimum, the rate of photosynthesis remains constant due to other limiting factors.

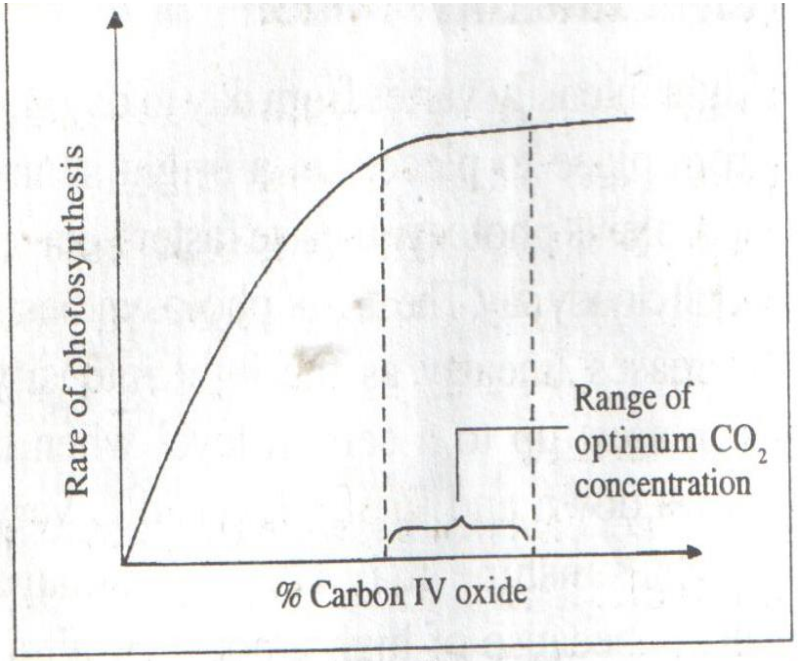
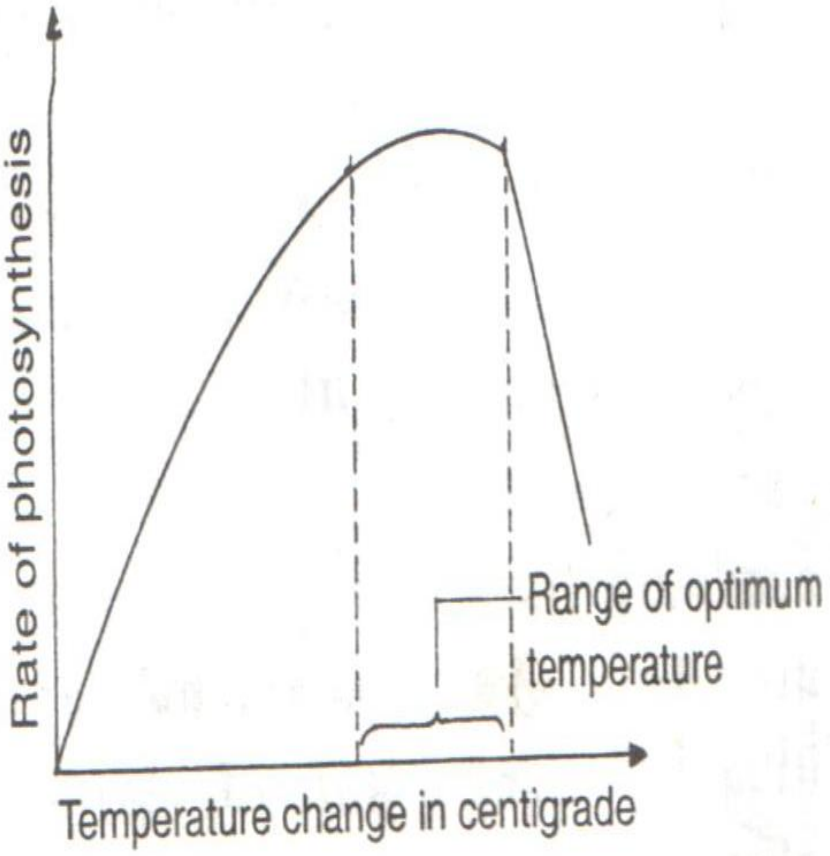


Fig. 5.5: Effect of carbon (IV) oxide on the rate of photosynthesis

3. TEMPERATURE.

- ✓ Photosynthesis reactions are catalyzed/controlled by enzymes.
- ✓ Decrease in temperature decreases the rate of photosynthesis because enzymes are inactivated.
- ✓ Increase in temperature activates enzymes thus increasing the rate of photosynthesis up to optimum.
- ✓ High temperatures above optimum denatures enzymes, thus reducing the rate of photosynthesis.



4. **WATER.**

- ✓ Water is a raw material for photosynthesis.
- ✓ It influences opening and closure of stomata which affects the diffusion of carbon (IV) oxide into the leaf thus further affecting the rate of photosynthesisi.

5. **CHLOROPHYLL CONCENTRATION.**

- ✓ Chlorophyll is the pigment that traps light energy during photosynthesis.
- ✓ The higher the chlorophyll concentration the higher the rate of photosynthesis and vice versa.
- ✓ **A variegated leaf** is one that has some patches that lack chlorophyll. These patches have other colours e.g. yellow.
- ✓ These parts lack chlorophyll hence do not photosynthesize and therefore gives negative results with starch test.
- ✓ The variegated leaf has less starch than a normal leaf **because it has less chlorophyll hence manufactures less food.**

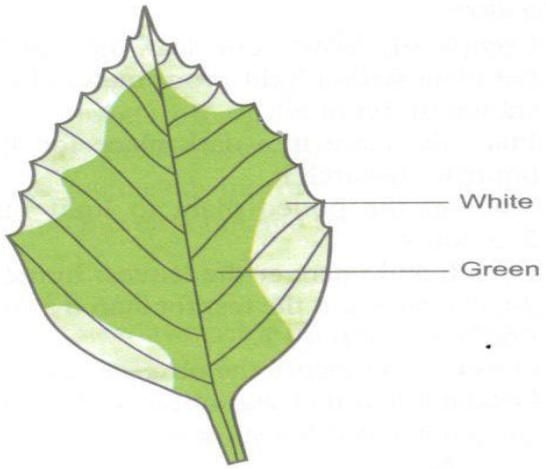


Fig 5.10: A variegated leaf.

6. ENZYME CONCENTRATION

- ✓ Enzymes catalyze the photosynthetic reactions.
- ✓ Increase in enzyme concentration increases the rate of photosynthesis.
- ✓ A decrease in enzyme concentration decreases the rate of photosynthesis.

Study question

1. Variegated plants accumulate less food than non-variegated plants under similar conditions. explain

- ✓ ***Variegated leaves have less chlorophyll compared to non-variegated leaves. They absorb less light hence facilitate less photosynthesis.***

PRACTICAL ACTIVITY 1.

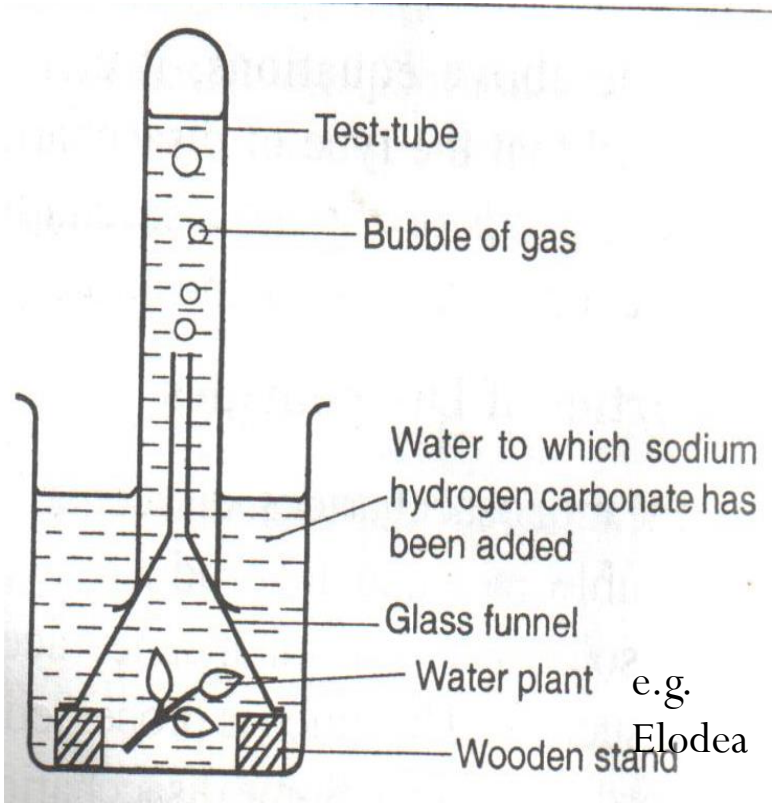
Aim: To investigate the gas produced during photosynthesis.

Requirements:

1. Water plant, e.g. *Elodea* spp., Spirogyra or Nymphea (water lily)
2. Glass funnel.
3. Beaker.
4. Small wooden blocks.
5. Test tube.
6. Wooden splint.
7. Sodium hydrogen carbonate.

Procedure

1. Set-up the experiment as shown below.
2. Place the set-up in the sunlight to allow photosynthesis to take place.
3. Leave the set-up in the sun until sufficient gas has collected in the test-tube.
4. Test the gas collected with a glowing splint.



Questions.

1. What gas is produced during photosynthesis?

- ***Oxygen.***

2. Why was sodium hydrogen carbonate used during the experiment?

- ***To increase the amount of carbon (IV) oxide in water and accelerates the rate of photosynthesis***

3. Explain why only submerged water plants are used instead of terrestrial plants in the experiment.

- ***Submerged plants are adapted to aquatic conditions hence can carry out photosynthesis in water.***

4. Name other factors that can be tested using the set up above.

✓ Temperature.

✓ Light intensity.

✓ Carbon (IV) oxide concentration.

PRACTICAL ACTIVITY 2.

Aim: To test / investigate the presence of starch in a leaf.

Requirements:

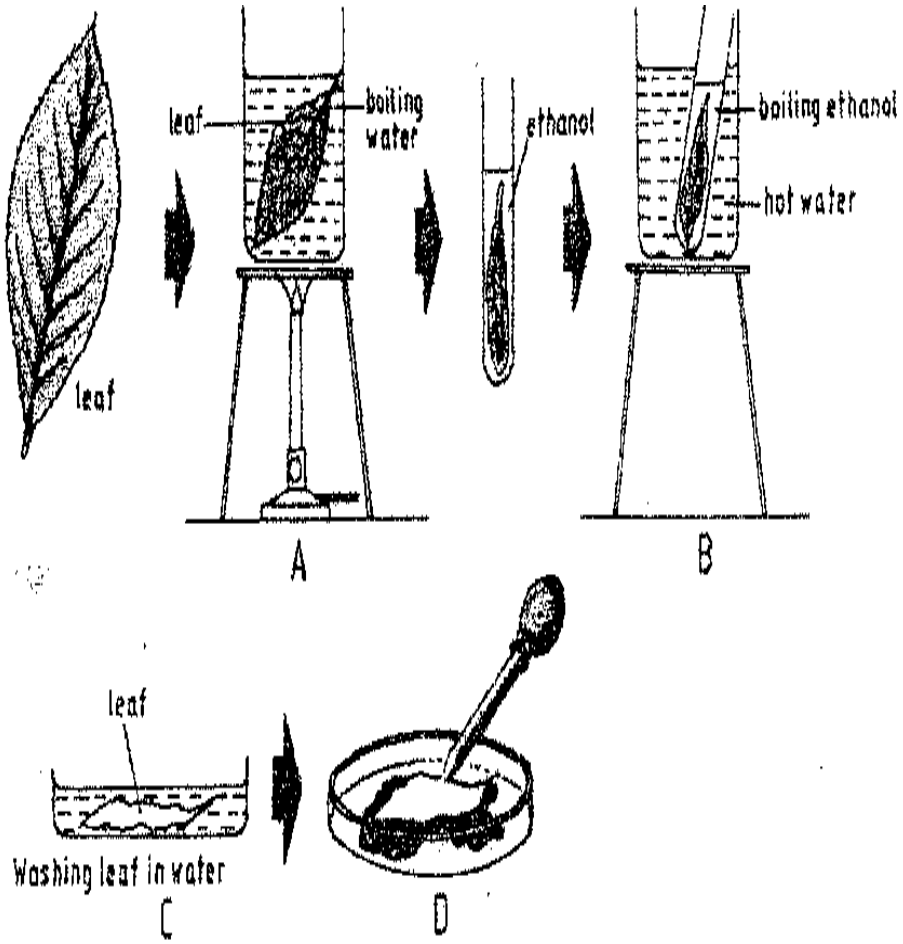
1. Water.
2. Dropper.
3. Beaker.
4. Source of heat.
5. Boiling tube.
6. A normal and variegated leaf.
7. Petri dish.
8. White tile.
9. Iodine solution.
10. Methylated spirit.

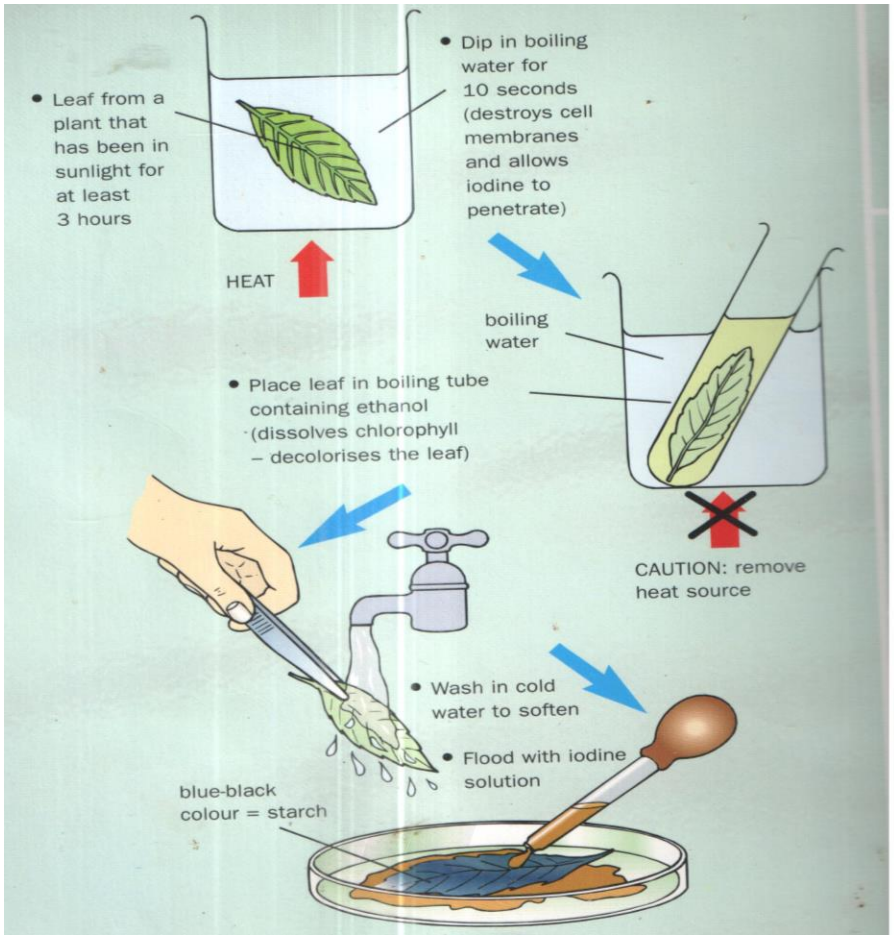
Procedure:

1. Obtain a leaf that has been exposed to light for at least 5 hours.
2. Boil water in a beaker.
3. Dip the leaf in the boiling water for 3 to 4 minutes.
4. Put the leaf in a boiling tube containing methylated spirit and stand the tube in the beaker containing boiling water (water bath) for about 10 minutes **to decolorize the leaf**. Avoid direct heating because spirit is highly flammable.
5. Remove the leaf from the test-tube and wash it in warm water in the beaker **to soften it**.
6. Spread the leaf in a Petri-dish and add drops of dilute iodine solution.
7. Observe and record the colour changes.

Observation.

- The colour changes to blue-black indicating the presence of starch.


leaf
leaf
boiling water
A
ethanol
boiling ethanol
hot water
B
leaf
Washing leaf in water
C
D


Leaf from a plant that has been in sunlight for at least 3 hours
Dip in boiling water for 10 seconds (destroys cell membranes and allows iodine to penetrate)
HEAT
boiling water
Place leaf in boiling tube containing ethanol (dissolves chlorophyll – decolorises the leaf)
CAUTION: remove heat source
Wash in cold water to soften
Flood with iodine solution
blue-black colour = starch

Questions.

1. Why is it important to use the leaf that has been exposed to light for a few hours?

✓ ***To ensure that photosynthesis occurs and starch is formed.***

2. Why is a fresh leaf dipped in boiling water?

✓ ***To kill the protoplasm of the cell/kill the leaf cells/breakdown starch granules/ stop enzymatic activity.***

3. Give a reason why the leaf was dipped in ethanol/ methylated spirit.

✓ ***To remove chlorophyll/ dissolve chlorophyll /decolorize the leaf.***

4. Why was the leaf decolourised?

✓ ***To make the color change in iodine to be seen clearly.***

5. Why is methylated spirit boiled indirectly?

✓ ***It is highly flammable.***

6. Why was the leaf dipped in water?

✓ ***To soften it.***

7. Explain why a leaf cannot be tested for starch by adding iodine solution directly.

✓ ***The leaf must be dipped in water to kill it then boiled in methylated spirit to decolorise it to make color change in iodine to be seen clearly.***

PRACTICAL ACTIVITY 3.

Aim : To investigate whether light is necessary for photosynthesis.

Requirements:

1. Methylated spirit.
2. Iodine solution.
3. Water.
4. White tile.
5. Droppers.
6. Beaker.
7. Source of heat.
8. Boiling tube.
9. Light proof material (e.g. Aluminium foil).
10. Potted plant.
11. Clips.

Procedure.

1. Cover one leaf of a potted plant with a light-proof material as shown below.
2. Place the plant in a dark place for 48 hours **to destarch it/ ensure that all starch has been used up**.
3. Transfer the potted plant to light for 2-3 hours.
4. Detach and uncover the leaves and immediately carry out the test for starch.

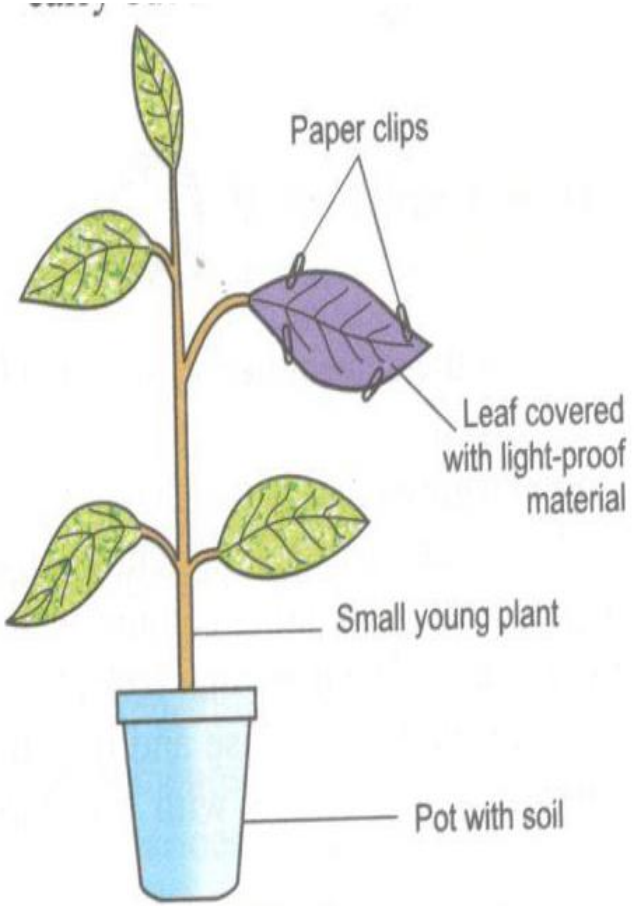


Fig 5.8: Necessity of light in photosynthesis.

Questions

1. Why was the plant kept in the dark for 48 hours?

- ***To destarch it / to ensure that all starch in it is used up.***

2. Why was it necessary to transfer the plant to light?

- ***To allow the plant to photosynthesize and hence manufacture starch.***

3. What was the role of the lightproof paper?

- ***To reflect light so that none is absorbed by the leaves.***

PRACTICAL ACTIVITY 5.

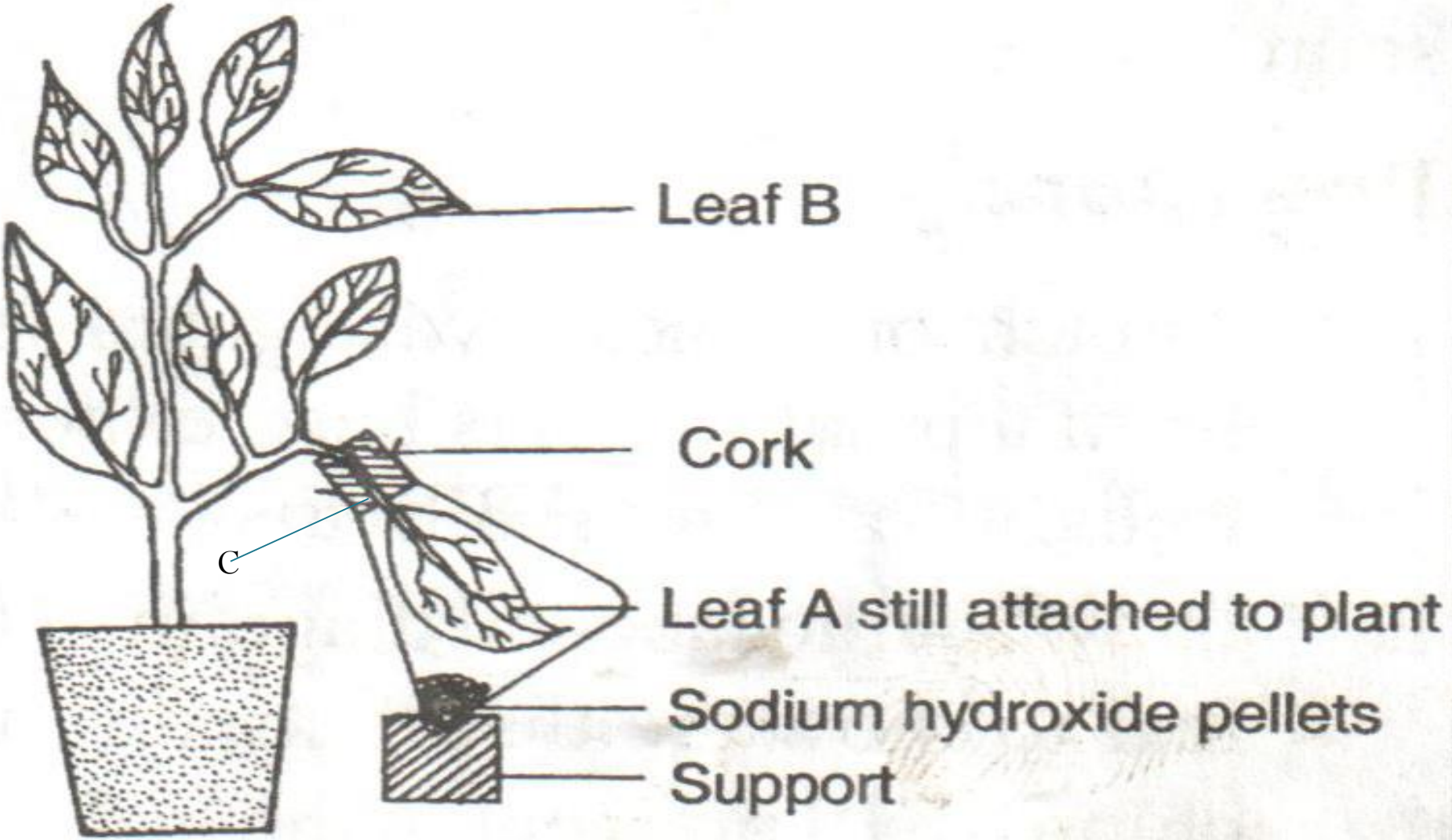
Aim: To investigate whether carbon (IV) oxide is necessary for photosynthesis.

Requirements:

1. Conical flasks/polythene bags.
2. Potted plant.
3. Sodium hydroxide pellets.
4. Cork or plasticine or clay.
5. Cork borers.
6. Scalpel.
7. Petroleum jelly.
8. Iodine solution.
9. Methylated spirit.
10. Water.
11. Beakers.
12. Droppers.
13. White tiles.
14. Boiling tubes.
15. Source of heat.
16. Wooden support.

Procedure.

1. Keep the potted plant in a dark place for 48 hours.
2. Place a few pellets of sodium hydroxide in the flask.
3. Bore a hole in the cork of the same size as the petiole of the leaf being used.
4. Using the scalpel, cut the cork lengthwise.
5. Remove the plant from the dark and immediately fit the petiole of a leaf A in the groove and cork the flask as shown below.
6. Seal the mouth of the conical flask with petroleum jelly to make it airtight.
7. Keep the set up in the light for two to three hours.
8. Detach and test for the presence of starch in both leaves A and B.


Leaf B
Cork
C
Leaf A still attached to plant
Sodium hydroxide pellets
Support

Questions

1. What is the function of the **sodium hydroxide** pellets?

To absorb carbon (IV) oxide.

2. Why was the leaf outside the flask also tested for starch?

- ***It was the control experiment.***

3. Giving a reason explain the expected result after testing for starch on the part labeled C.

- ***Starch absent. This is because of the absence of light and carbon (IV) oxide.***

4. Explain the result obtained after testing for the presence of starch in leaves A and B.

- ***Starch was present in leaf B. This is because it was exposed to sunlight hence carried out photosynthesis forming starch.***
- ***Starch was absent in leaf A. This is because sodium hydroxide pellets absorbed carbon (IV) oxide which is a raw material for photosynthesis.***

5. What is the expected result for starch in leaf A if **sodium hydrogen carbonate** is used instead of **sodium hydroxide?**

- ***Starch was present in leaf A. This is because sodium hydrogen carbonate breaks down to give carbon (IV) oxide which is a raw material for photosynthesis.***

PRACTICAL ACTIVITY 6.

Aim: To investigate whether chlorophyll is necessary for photosynthesis.

Requirements.

1. Variegated leaves.
2. Iodine solution.
3. Methylated spirit.
4. White tile.
5. Water.
6. Boiling tubes.
7. Beaker.
8. Dropper.
9. Source of heat

Procedure

1. Detach a variegated leaf from the plant that has been exposed to light for at least 3 hours.
2. Draw a large labeled diagram of the leaf to show the distribution of the chlorophyll pigment in the leaf as shown.
3. Test for the presence of starch.

Observation and explanation.

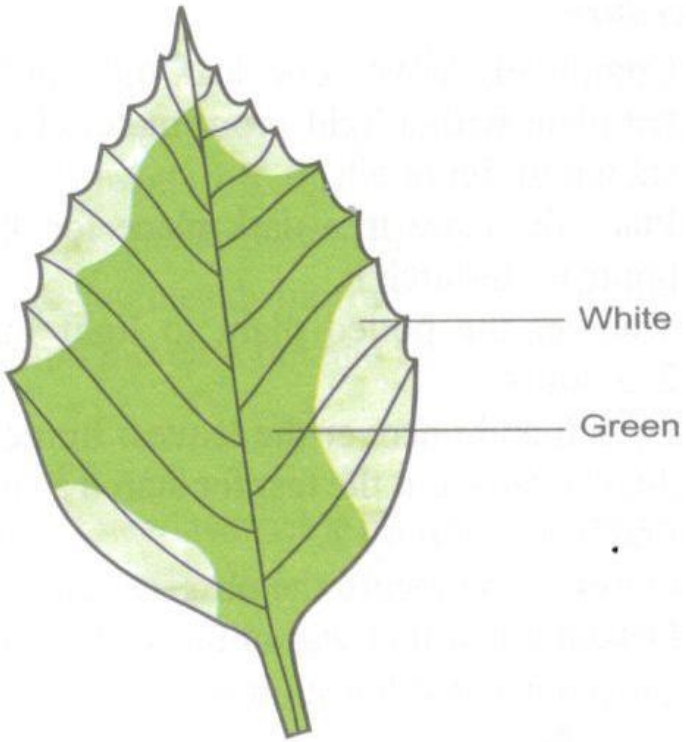


Fig 5.10: A variegated leaf.

- ✓ The green parts/ patches give blue-black color with iodine. This is because they contain chlorophyll hence carry out photosynthesis forming starch.
- ✓ The white parts/ patches retained brown color with iodine. This is because they lack chlorophyll hence did not carry out photosynthesis forming starch.
- ✓ Starch was found on green patches but not on white patches.

CHEMICAL COMPOUNDS WHICH CONSTITUTE LIVING ORGANISMS/ CHEMICALS OF LIFE

- These are compounds found in cells, tissues and organs.
- The study chemical compounds found in living organisms and reactions in which they take place is called **biochemistry.**
- Some of the chemical compounds are organic e.g. carbohydrates, proteins, lipids, nucleic acids and vitamins.
- Other chemical compounds are inorganic compounds e.g. mineral salts, water, acids and bases.

1. CARBOHYDRATES.

- ✓ They are compounds that contain carbon, hydrogen and oxygen in the ratio of 1 carbon : 2 hydrogen : 1 oxygen.
- ✓ The basic formula is (CH_2O) n.
- ✓ The constituents of carbohydrates are joined by a bond called **glycosidic bond.**

Uses/ functions of carbohydrates.

1. They are sources of energy/ are broken down to give energy. Glucose is the main source of energy.
2. They are storage forms of food e.g. plants store food in form of **starch** while animals store food in form of **glycogen.**
3. They are components of structures that provide mechanical support in organisms e.g. cellulose in cell walls, chitin in exoskeleton and lignin in xylem vessels and tracheids.

Classes of carbohydrates.

- ✓ They include:
  - A. Monosaccharides.
  - B. Disaccharides.
  - C. Polysaccharides.

A. MONOSACCHARIDES.

- ✓ They are simple sugars whose general formula is $(CH_2O)n$ where n=6.
- ✓ Therefore the chemical formula of a monosaccharide is $C_6H_{12}O_6$.
- ✓ Examples include:
  i. Glucose.
  ii. Fructose in ripe fruits and honey.
  iii. Galactose in milk.

Functions /uses of monosaccharides.

i. Used in respiration to provide energy.
ii. When condensed they are storage forms of food e.g. plants store food in form of **starch** while animals store food in form of **glycogen.**

Properties of monosaccharides.

i. They easily dissolve in water.
ii. They are **reducing sugars** (when mixed with Benedict's solution they reduce copper (II) ions in the solution into copper (I) ions which are **brown in color**).
iii. They have a sweet taste.
iv. They form crystals/ they are crystallisable.

B. DISACCHARIDES.

- They are formed by combining two monosaccharides in the process called **condensation** releasing water.
- Examples include:

i. Maltose

ii. Sucrose.

iii. Lactose.

Monosaccharide + monosaccharide ⟶ Disaccharide + water

$$C_6H_{12}O_6 + C_6H_{12}O_6 \xrightarrow{\text{(Condensation)}} C_{12}H_{22}O_{12} + H_2O$$

i. **Maltose-** It is found in germinating seed and formed by combining two glucose molecules

Glucose + Glucose $\xrightarrow{\text{(Condensation)}}$ Maltose + Water

✓ Maltose is a reducing sugar.

ii. **Sucrose-** it is found in sugarcane juice formed by combining **glucose and fructose.**

✓ Sucrose is non-reducing sugar.

(Condensation)

Glucose + Fructose ⟶ Sucrose + Water

iii. **Lactose-** It is found in milk and formed by combining galactose and glucose.

✓ Lactose is a reducing sugar.

(Condensation)

Glucose + Galactose ⟶ Lactose + Water

Characteristics/ properties of disaccharides.

i. They are soluble in water.

ii. They have a sweet taste/ form sweet tasting solutions.

iii. Some disaccharides are reducing sugars e.g. maltose and lactose while sucrose is non-reducing sugar.

iv. They can easily be broken down into monosaccharides through **hydrolysis.**

Hydrolysis of disaccharides.

- ✓ It involves disaccharides into monosaccharides/ simple sugars in the presence of water.
- ✓ Hydrolysis is brought about by:

i) Enzymes (in nature/ naturally)

ii) Heating with the acid e.g. Hydrochloric acid (in the laboratory)

Disaccharide + water $\xrightarrow{\text{(Hydrolysis)}}$ Monosaccharide + Monosaccharide.

Examples

i. **Maltose + Water $\xrightarrow{\text{(Hydrolysis)}}$ Glucose + Glucose.**

ii. **Lactose + Water $\xrightarrow{\text{(Hydrolysis)}}$ Glucose + Galactose.**

iii. **Sucrose + Water $\xrightarrow{\text{(Hydrolysis)}}$ Glucose + Fructose.**

C. POLYSACCHARIDES.

- ✓ They are made up of many monosaccharides.
- Examples include:

a) **Starch-** stored in plant tissues. Plants with a lot of **starch** include maize, wheat, potato and rice.

b) **Glycogen-** stored in animal tissues. It is synthesized from excess **glucose**.

c) **Cellulose-** found at cell walls of plant cells giving them definite shape.

d) **Chitin-** it is found on exoskeleton of arthropods and cell wall of fungal hyphae.

e) **Lignin-** it is found in xylem vessels and tracheids and provide mechanical support.

Characteristics / properties of polysaccharides.

i. Are insoluble in water.

ii. They do not have a sweet taste.

iii. They are non-reducing sugars.

iv. They are hydrolyzed into monosaccharides (by heating with acids or by enzymes)

Study question

1. Name the carbohydrate:

a) Present in abundance in germinating seed- **Maltose.**

b) Stored in plant cells- **Starch.**

c) Found on plant cell walls- **Cellulose.**

d) Found in animal tissues/muscles- **Glycogen.**

e) Found in blood- **Glucose.**

PRACTICAL 1.

Aim: Testing for starch.

Requirements:

1. Food substance in solution form.
2. Test tubes.
3. 10 ml measuring cylinder
4. Dropper
5. Iodine solution (Reagent)

Procedure.

1. Into a clean test tube, add 2ml of food substance.
2. Add 3 drops of iodine solution to the food substance and shake.

Observation.

- ✓ The colour turns/ changes (from brown) to **blue-black/ dark blue/ black.**

Conclusion.

- ✓ Starch present.

Note: If brown colour (of iodine) persists / is retained then starch is absent

PRACTICAL ACTIVITY 2.

Aim: To test for the presence of reducing sugar.

- Reducing sugars include glucose, fructose, galactose, maltose and lactose.

Requirements:

1. Food substance in solution form.
2. Benedict's solution (reagent).
3. Test tube.
4. Means of heating/ hot water bath.
5. Test tube holder.
6. 10 ml measuring cylinder.
7. Dropper.

Procedure:

1. Put 2 ml/cm^3 of reducing sugar in a test tube.
2. Add equal amount of Benedict's solution.
3. Heat to boil.

Observations

- The colour changes from **blue to green to yellow and finally orange/ brown.**

Conclusion.

- Reducing sugar present.

N/B.

- If the colour changes to:
  - i. **Green with no further change-** very little amount of reducing sugar is present.
  - ii. **Yellow** –average amount of reducing sugar present.
  - iii. **Orange/ brown-** high amount of reducing sugar present.
  - If the **blue color (of Benedict's solution)** is retained, then reducing sugar is absent.
- Reducing sugar changes copper sulphate in Benedict's solution to copper oxide (which is orange).

PRACTICAL ACTIVITY 3.

Aim: Testing for the presence of non-reducing sugar (e.g. sucrose).

Requirements:

1. Food substance.
2. Benedict's solution.
3. Dilute hydrochloric acid.
4. Sodium hydrogen carbonate.
5. Means of heating/ bunsen burner.
6. Dropper.
7. 10 ml measuring cylinder.

Procedure.

1. Put 2ml of the food substance into a clean test tube.
2. Add 4 drops of dilute hydrochloric acid and shake.
3. Boil the mixture.
4. Cool the mixture in cold water.
5. Add sodium hydrogen carbonate drop wise until fizzing stops.
6. Add equal amount of Benedict's solution to the mixture.
7. Heat the mixture to boil/ boil the mixture.

Observations

- The colour changes from **blue to green to yellow and finally orange/ brown.**

Conclusion.

- Non- reducing sugar present.

Points to note.

- Dilute hydrochloric acid is used/ added to hydrolyze non-reducing sugar to reducing sugar.
- Sodium hydrogen carbonate is used/ added to neutralize the acid.

2. PROTEINS.

- They contain carbon, hydrogen, oxygen and nitrogen (hence they are called **nitrogenous compounds)**.
- Proteins may also contain other compounds e.g. phosphorus, sulphur and iron.
- They are made up of **amino acids** as building blocks i.e. amino acids form proteins.

Structure of amino acid.

- It consists of

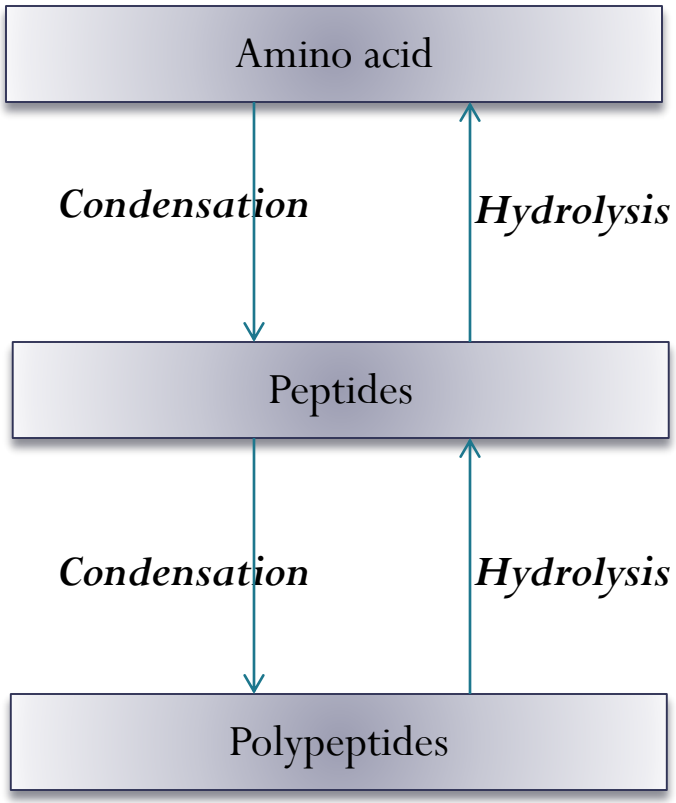
i. Amino group (NH3)- consisting of hydrogen and nitrogen.

ii. Carboxyl group (COOH)- consisting of carbon, oxygen and hydrogen.

- A protein consists of several amino acids joined together by a bond called **peptide bond.**
- Two amino acids combine to form **dipeptide molecule** in the process of **condensation**.
- When 2 amino acids combine they form a **dipeptide** joined by a **peptide bond.**
- A molecule consisting of few amino acids are called **peptides.**
- When peptides combine they form a **polypeptide** which makes up a protein.

- Therefore a protein is made up of one polypeptide or many polypeptides.
- Joining of amino acids to form peptides is called **condensation.**
- Break down of peptides to form amino acids is called **hydrolysis.**
- There are 20 naturally occurring amino acids which can be synthesized by plants.
- Human beings can only synthesize 11 amino acids in their bodies while 9 are supplied from diet.

- The amino acids that can be synthesized in the human bodies are called **non-essential amino acids.**
- Those amino acids that cannot be synthesized but are supplied from diet are called **essential amino acids.**
- Proteins that contain all the essential amino acids are called **1st class proteins e.g. animal proteins.**
- Proteins that lack one or more of the essential amino acids are called **2nd class proteins e.g. plant proteins.**



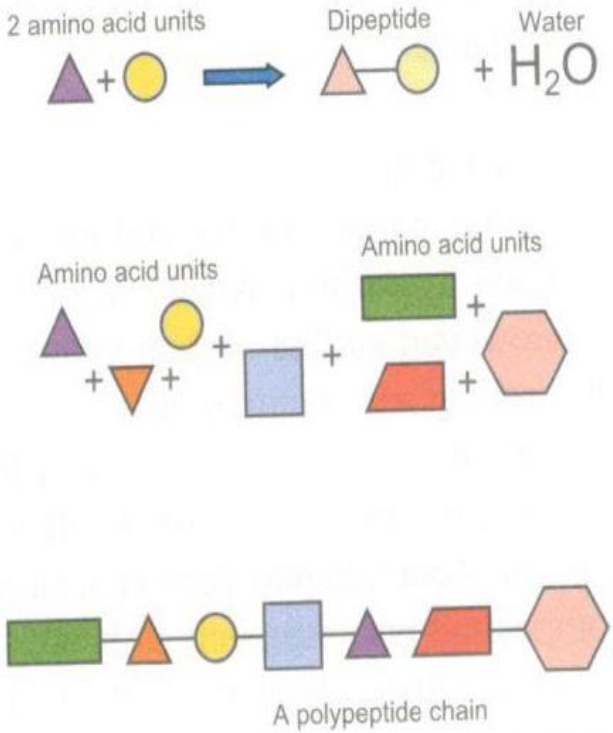


Fig 5.12: Diagrammatic representation of polypeptide formations

Properties of proteins.

1. They dissolve in water forming colloidal suspensions.
2. They are **denatured** by high temperatures above 40 degrees Celsius and extreme pH values. Denaturing changes the structure of protein molecules hence changing physical and chemical properties of protein.
3. Have acidic and basic properties hence described as **amphoteric.**

✓ They therefore react with acids and bases enabling them to form **conjugated proteins (i.e. proteins containing non-protein components).**

✓ Examples of conjugated proteins include:

i) **Mucus** which contains a **carbohydrate.**

ii) **Haemoglobin** which contains **iron.**

Functions of proteins.

1. They are components of structures in living organisms (e.g. plasma/ cell membranes, connective tissue, hair, hooves, nails, muscle fibre, skeletal materials).
2. They are used for making, repair and replacement of worn out tissues in plants and animals.
3. They act as metabolic regulators (e.g. **enzymes** which speed up metabolic reactions, **hormones** which regulate body processes like growth, reproduction, **antibodies** that provide immunity against diseases.
4. They are broken down to give energy during starvation.

PRACTICAL ACTIVITY.

Aim: To test for proteins (biuret test).

Requirements:

1. Food substance in solution form
2. 1% Copper (II) sulphate solution.
3. 10% sodium hydroxide solution
4. Test tube
5. Droppers
6. 10 ml measuring cylinder.

Procedure:

1. Put 2ml of food substance into a test tube.
2. Add equal amount of 10% sodium hydroxide and shake.
3. Into the mixture, add 1% copper (II) sulphate dropwise and shake after every addition.

Observation:

- Colour changes to **purple.**

Conclusion:

- Proteins present.

Note: Sodium hydroxide is used to break the peptide bond.

If blue color is retained / persists then protein is absent.

3. LIPIDS (fats and oils).

- ✓ Fats are found in animals while oils are found in plants.
- ✓ Fats are solid at room temperature while oils are liquid at room temperature.
- ✓ They are like carbohydrates only that they have fewer number of oxygen molecules than carbohydrates.
- ✓ The building blocks of lipids are **fatty acids and glycerol** joined by **ester bond** in the process called **condensation.**
- ✓ The lipids can be broken down to form glycerol and fatty acids through **hydrolysis**.
- ✓ Fatty acids are of different types because they contain different fatty acids e.g. Oils are different in different plants because they have different fatty acids.

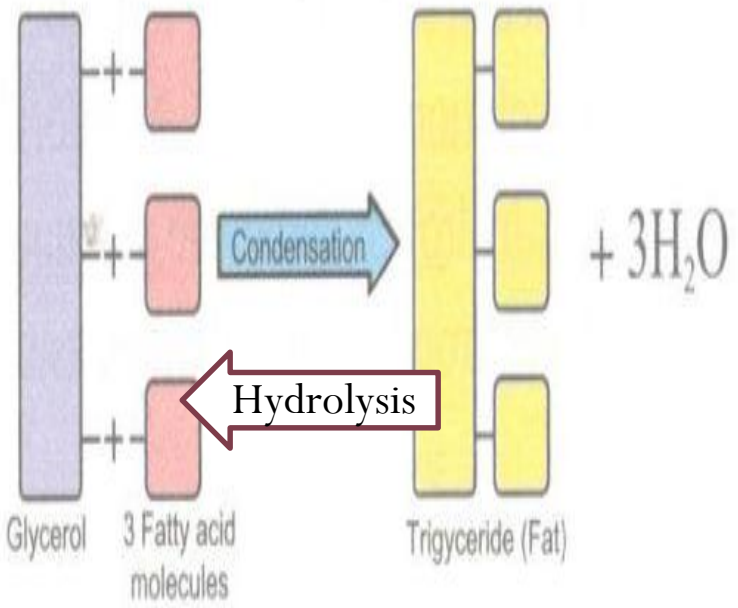


Fig 5.11: Diagrammatic representation of lipid formations.

Properties of lipids/ fats and oils.

1. Fats readily/ easily change into liquid when heated and oils solidify when subjected to low temperature.
2. They are insoluble n water.
3. They dissolve in organic solvents forming emulsions and suspensions.
4. They are inert (hence can be stored in tissues of organisms).

Functions of lipids/ fats and oils.

1. They are broken down/ oxidized to release/ give energy.
2. They are storage forms of food in the body of living organisms e.g. excess can be converted into fats for storage.
3. They are broken down/ oxidized to release metabolic water (to supplement water requirements in the body.
4. Lipids are components of plasma membrane and protoplasm while oils are storage structures in some seeds (e.g. ground nuts, castor seed, maize grains etc).
5. Fats are deposited under the skin as adipose tissue which insulates the body against heat loss/ prevents heat loss.
6. Thick adipose tissue in some aquatic organisms (e.g. whale and hippopotamus) makes them buoyant in water.
7. Fats are deposited around body organs (e.g. kidney, heart and back of eyeball) where it acts as shock absorber.
8. Lipid (wax) found on the cuticles reduce excessive water loss in plants.

PRACTICAL ACTIVITY.

Aim: Testing for the lipids (fats and oils).

A. **The grease spot test.**

Requirements:

1. Food substance.
2. Filter paper.
3. Bunsen burner.

Procedure:

1. Rub a little amount of food substance on a filter paper.
2. Hold the paper above the flame to dry taking care not to burn it.
3. Hold the paper against light.

Observation:

- A permanent translucent spot is formed.

Conclusion:

- Lipids (fats and oils) present.

N/B If the permanent translucent spot is absent, then lipids are absent.

B. Emulsion test.

Requirements:

1. Food substance.
2. Ethanol/alcohol.
3. 2 test tubes.
4. 10ml measuring cylinder.

Procedure:

1. Into a clean test tube, put a little amount of food substance.
2. Add 2 ml of ethanol/alcohol to 2ml of the food substance and shake thoroughly.
3. Transfer the contents of the test tube into another test tube half filled with water.

Observation:

- Formation of a white emulsion.

Conclusion:

- Fats or oils present.

Note:

- Emulsification of fats occurs in the duodenum to increase the surface area for digestion by enzymes.

4. ENZYMES.

- They are organic **biocatalysts i.e. they speed up or slow down the rate of chemical reactions but they are not used up in the process.**
- Enzymes are protein in nature and are produced in living cells.

Types of enzymes

a) **Intracellular enzymes-** they are secreted/ produced and used within the cells that produce them e.g. respiratory enzymes.

b) **Extracellular enzymes-** they are secreted/ produced by cells but used outside the cells that produce them e.g. digestive enzymes.

Naming of enzymes

a) **Trivial naming-** naming of enzymes based on the persons who discovered them. The names of such enzymes end with suffix- **in,** e.g. **Pepsin, Rennin, Trypsin, Ptyalin.**

b) **Use of suffix- ase-** the suffix –ase is added to the type of food/ substrate or reaction the enzymes catalyze e.g.

Food/ substrate	**Enzyme**
Carbohydrate	Carbohydrase
Amylose/ starch	Amylase
Sucrose	Sucrase
Maltose	Maltase
Protein	Protease
Lipids	Lipase
Chemical reaction	**Enzyme**
Hydrolysis	Hydrolase
Oxidation	Oxidase
Reduction	Reductase

Properties of enzymes.

1. They are affected by changes in temperature and pH (because they are protein in nature).
2. They are substrate specific i.e. they act on specific substrate.
3. They are very efficient hence required in small quantities.
4. They are not affected by reactions they catalyze hence they are available for reuse.
5. Most reactions catalyzed by enzymes are reversible.

Importance of enzymes.

- They control and regulate biochemical reactions in the body so that they proceed at a pace suitable for sustaining life.
- This is because the biochemical reactions in body cells are too fast and others too slow. This ensures order in living systems.

N/B

- The speed of enzyme-catalyzed reaction is called **enzymes turnover.**

FACTORS AFFECTING ENZYME CONTROLLED REACTIONS/ ENZYME ACTIVITY.

1. **TEMPERATURE-** enzymes work best within narrow range of temperature (between 35°C- 40°C).

- Increase in temperature increases the rate of enzyme activity up to optimum point. Optimum temperature gives maximum enzyme activity.
- Above the optimum temperature the rate of enzyme activity decreases sharply because **higher temperature denatures / destroys the enzymes** making them non effective.
- When the temperature decrease, the rate of enzyme activity decreases **because enzymes are inactivated.**
- Low temperature does not destroy the enzymes because when temperature is increased again the enzymes become active.

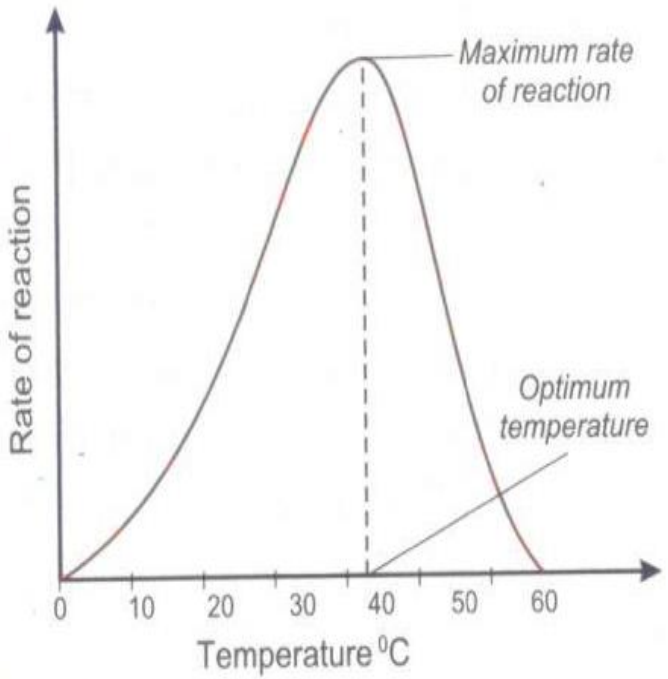


Fig.5.13: Effect of temperature on the rate of enzyme activity

2. **pH-** This is acidity or alkalinity of an substance.

- Most enzymes work best at optimum pH of 7 but others work best in acidic conditions others in basic conditions.
- Change of pH from optimum decreases the rate of enzyme activity.
- Extreme changes of pH range from the optimum denatures the enzymes hence the rate of enzyme activity stops.

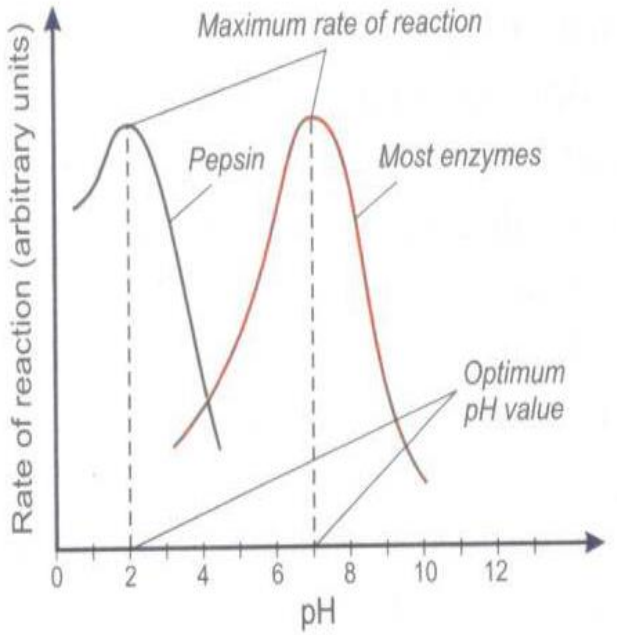


Fig 5.14: Effect of pH on the rate of an enzyme controlled reaction.

3. **SUBSTRATE CONCENTRATION AND ENZYME CONCENTRATION-** when the substrate concentration is increased, the rate of enzymatic reaction also increases up to a certain/ maximum level.

- Further increase in concentration of the substrate does not increase the rate of enzymatic reaction.
- This is because **all active sites of an enzyme are occupied by the substrate**. At this point, the enzyme concentration becomes a limiting factor.
- An increase in amount or concentration of enzyme molecules increases the rate of enzyme reaction. This is because of an **increase in the number** of active sites of enzymes.

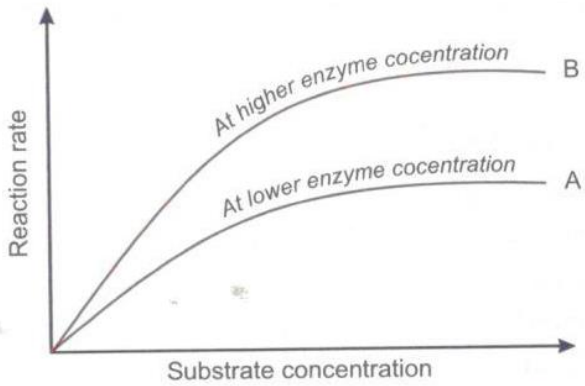


Fig 5.15: Effect of substrate and enzyme concentration on the rate of an enzyme controlled reaction.

Graph A shows the effect of increasing substrate concentration on the rate of an enzyme controlled reaction.
Graph B shows effect of increased enzyme concentration on the rate of an enzyme controlled reaction.

4. **ENZYME INHIBITORS-** they are chemical substances that prevent an enzyme from catalyzing a reaction hence decrease the rate of enzyme activity.

- This is because **they compete for active sites** of enzymes.
- There are two types of inhibitors namely:
  - ✓ Competitive inhibitors.
  - ✓ Non-competitive inhibitors.

a) **Competitive inhibitors-** They have the same shape as that of the substrate and compete for the same active sites of the enzyme. This slows down the rate of enzyme activity.

- The inhibitor stays attached to the active sites of the enzyme preventing the enzyme substrate from binding onto the active sites, hence slowing down the rate of reaction.
- The competitive inhibition can be overcome by:
  - i. Increasing the substrate concentration.
  - ii. Reducing the amount of inhibitor.

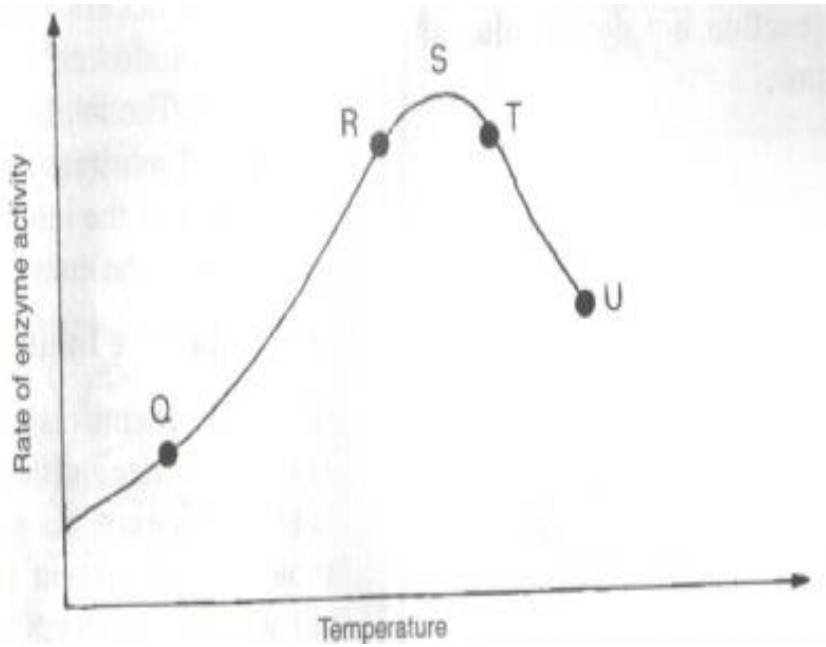
b) **Non-competitive inhibitors-** they attach themselves onto the enzyme molecules changing the shape of the active sites of the enzymes.

- The substrate molecules are not able to bind onto the active sites of the enzymes.
- They do not compete for the active sites of the enzymes with the substrate molecules.
- Examples of non-competitive inhibitors include **cyanide, mercury, silver-arsenic compounds.**

5. **ENZYME CO-FACTORS-** are non-protein substances that activate the enzymes hence increase the rate of enzyme activity.
   - Examples include **metallic ions e.g. magnesium ions, zinc ions, copper, calcium ions, chloride ions, molybdenum ions, manganese ions**
   - They are required in small quantities.
6. **ENZYMES CO-ENZYMES-** are organic co-factors that activate enzymes hence increase the rate of enzyme activity **e.g. vitamins.**
7. **PRODUCT CONCENTRATION-** low product concentration increases the rate of enzyme activity while high product concentration reduces the rate of enzyme activity.
8. **ENZYME SUBSTRATE SPECIFICITY-** enzyme act on specific substrate.

Study question

- The figure below shows the rate of enzyme action in relation to changes in temperature. Study it and answer the questions that follow.



1. Explain giving reasons, the rate of enzyme action :

i. Between Q and R.

✓ **The rate of enzyme activity increases with increase in temperature, because enzymes are activated.**

ii. At S.

✓ **At S there is maximum rate of enzyme reaction because it is the optimum temperature.**

iii. Between T and U.

✓ **There is drastic drop in the rate of reaction of enzymes because very high temperature denatures /destroys the enzymes.**

2. Other the factor being investigated above, state three other factors that affect the rate of enzyme activity.

✓ **pH**
✓ **Substrate concentration.**
✓ **Enzyme concentration.**
✓ **Enzyme co-factors.**
✓ **Enzyme co-enzymes**
✓ **Enzyme inhibitors.**
✓ **Product concentration.**
✓ **Enzyme specificity**

3. State the collective name of the enzymes that work on:

a) Carbohydrates- **carbohydrases.**
b) Proteins- **proteases**
c) Lipids- **lipases**

NUTRITION IN ANIMALS.

- Nutrition in animals is called **heterotrophism.**

Heterotrophism/ heterotrophic mode of nutrition.

- ✓ This is a type of nutrition in which organisms feed on other organisms or feed on already manufactured food.
- ✓ These type of organisms are called **heterotrophs.**

Types of heterotrophs.

They include:

i. **Herbivores-** they feed on plant materials e.g. cows, goats, sheep, grasshoppers.

ii. **Carnivores-** they feed on flesh/meat/other animals e.g. lions, dogs, hyenas, eagles.

iii. **Omnivores-** they feed on both plants and animals/flesh e.g. man and pigs.

iv. **Saprophytes-** they feed on dead decaying matter leading to decomposition e.g. fungi and bacteria.

v. **Parasites-** they live on or in other organisms called hosts and depend on them for nutrients.

Types/modes of heterotrophism

A. Holozoic nutrition.
B. Saprophytic nutrition.
C. Phagocytosis.
D. Parasitic nutrition/parasitism.
E. Symbiosis.

a) **Holozoic nutrition-** this is a type of nutrition where organisms/ animals ingest/take in, digest and assimilate complex food materials. It is common in mammals and birds.

b) **Saprophytism-** this is a type of nutrition where organisms obtain nutrients from dead decaying matter causing decomposition.

✓ They release enzymes that break down decaying matter into simpler soluble substances that are absorbed directly into the body. It is common in bacteria and fungi.

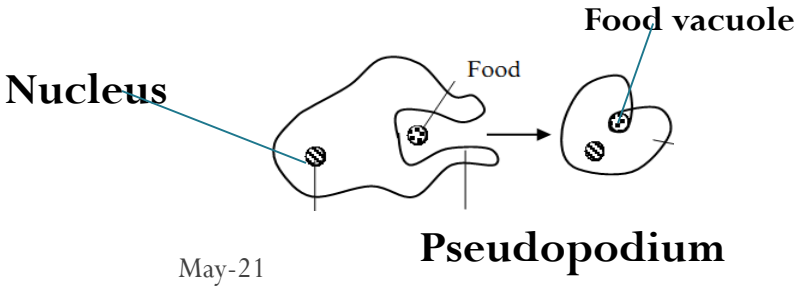
c) **Parasitism-** this is a mode of nutrition where one organism (parasite) feeds on or obtains nutrients from the tissues of another living organism (the host) **e.g. ticks and roundworms.**

d) **Symbiosis-** this is an association where two organisms live together and mutually benefit from each other **e.g. Rhizobium bacteria and leguminous plant.**

e) **Phagocytosis-** This is a type of nutrition where single celled organisms **e.g. amoeba and some white blood cells** feed on solid food materials.

✓ They engulf food material by forming pseudopodia and enclose it in food vacuole.

✓ The enclosed food in digested by enzymes into soluble substances that are absorbed into the cytoplasm



Animal dentition and dental formula.

- **Dentition** refers to the description of the types, arrangement and specialization of teeth in animals.
- **Dentition** is related to the type of food the animal feeds on.

Types of dentition.

i. **Homodont dentition**-in this type, all teeth have similar shape and size e.g. in fish, frogs, crocodiles.

ii. **Heterodont dentition**-in this type, teeth have different shape and size e.g. in mammals.

- **Dental formula** describes the number, type and position of teeth in the jaw of the animal.
- The number usually given is for half of each jaw.
- To get the total number of teeth in an animal, the total number in the formula is multiplied by 2.

Types of teeth.

- There are four types of teeth namely:

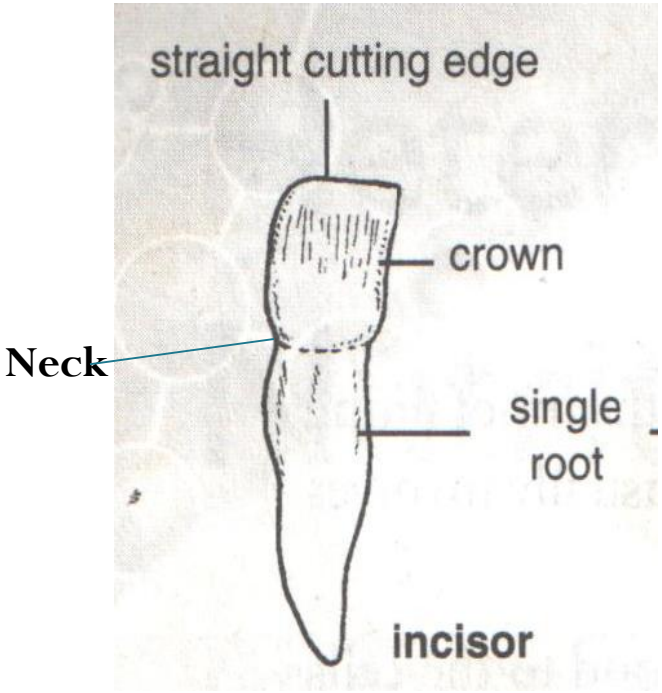
A. Incisors.
B. Canines.
C. Premolars.
D. Molars.

A. INCISORS.

- ✓ Incisors are located at the front of the jaw.

Adaptations of incisor.

1. The crown in chisel-shaped/ flat and sharp for holding, biting and cutting food.
2. Have one root to support them in the jaw.

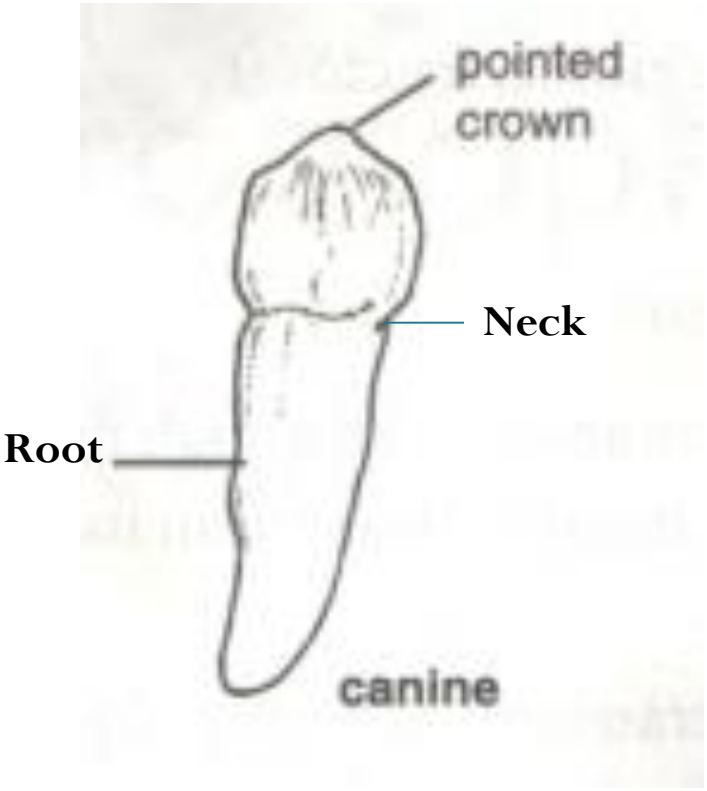


B. CANINES

- They are located next to the incisors.

Adaptations of canine.

1. It has curved and pointed crown for holding/ seizing prey and tearing flesh.
2. Have one pointed root for firm support in the jaw.

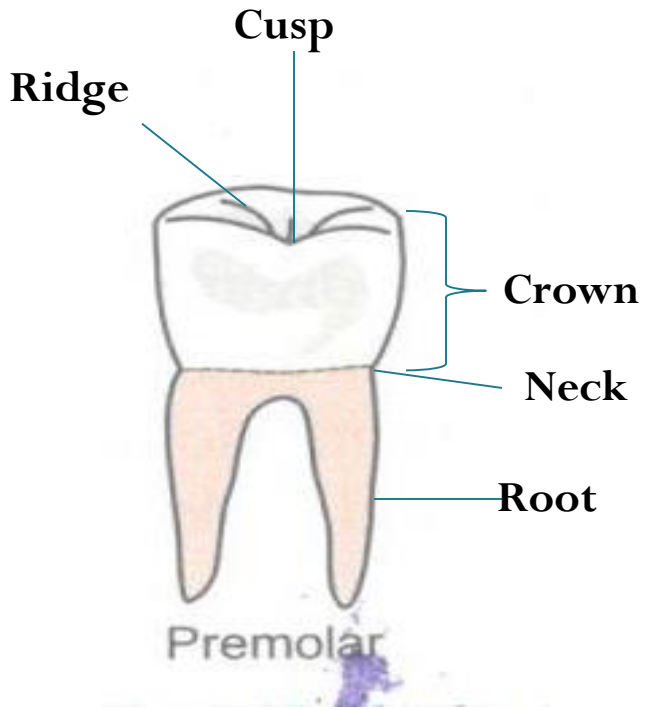


C. PREMOLARS.

- ✓ They are located after the canines towards the back of the jaw.

Adaptations of premolar.

1. The crown is **broad , ridged with cusps** to increase the surface area for crushing and grinding food.
2. It has 2 roots for firm support in the jaw.

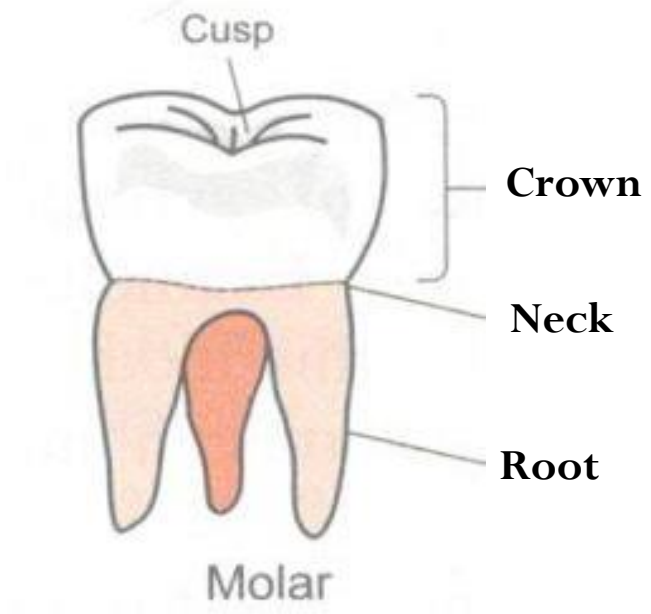


D. MOLARS

- They are located at the back of the jaw

Adaptations of premolar.

1. The crown is **broad , ridged with cusps** to increase the surface area for crushing and grinding food.
2. It has 3 roots for firm support in the jaw.



HERBIVORE DENTITION

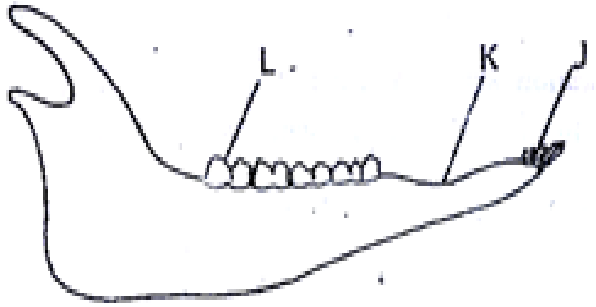
- ✓ Herbivores are animals which feed on vegetation e.g. cow, goat, sheep, donkey, zebra e.t.c.
- ✓ The mode of nutrition is called **herbivorous.**
- ✓ The dental formula is $i\frac{0}{3}\ c\frac{0}{1}\ pm\frac{3}{2}\ m\frac{3}{3} = 30$

Adaptations of herbivore dentition.

1. They lack upper incisors and canines instead they have a rough **horny pad** against which grass/ vegetation is pressed and cut by lower incisors.
2. They have **diastema (a gap in the lower jaw between canines and premolars)** which provides a space for the tongue to manipulate grass/ vegetation/ plant materials (so as to separate the newly cut vegetation from that which is being chewed at the back of the mouth).
3. It lacks canines to facilitate side ways movement.
4. The lower incisors have chisel shaped crown with sharp edge for cutting vegetation.
5. The crown of premolars and molars has broad surface with cusps and ridges to increase surface area for grinding of food/ vegetation.
6. The teeth grow continuously throughout the life of the animal to replace worn out enamel worn out due to continuous grinding.
7. The jaws move side to side to enable premolars and molars to grind vegetation.

Study question.

- The diagram below represents the lower jaw of a mammal



a) Name the mode of nutrition of the mammal whose jaw is shown. (1mk)

- ***Herbivorous.***

b) Give a reason for your answer in a) above. (1mk)

- ***It has diastema.***

c) Name and give the function of the toothless gap labeled K. (2mks)

- ***Diastema- to provide room for manipulation of food to separate ground and unground food.***

d) State one structural and one functional difference between the teeth labelled J and L. (2mks)

Structural

- ***Tooth J is narrow / sharp / chisel like while tooth L is broad / ridged.***
- ***J has one root while L has 3roots.***

Functional

- ***Tooth J is used for cutting food while tooth L is used for crushing food;***

e) Name the substance that is responsible for hardening of teeth. (1mk)

- ***Calcium phosphate / calcium carbonate.***

OMNIVORE DENTITION

- ✓ Omnivores are animals which feed on both vegetation and flesh e.g. man.
- ✓ The mode of nutrition is called **omnivorous.**
- ✓ The dental formula is $i\frac{2}{2}\ c\frac{1}{1}\ pm\frac{2}{2}\ m\frac{3}{3} = 32$

Adaptations of omnivore dentition.

1. The incisors are flat and chisel shaped for cutting and biting food.
2. The canines are small and pointed for tearing of food.
3. Premolars and molars have cusps on the upper surface of the crown to increase the surface area for grinding and crushing of food.

- ✓ There are two sets of teeth in humans:

i. **Milk teeth-** they are first set of teeth and are 20 in number. They are lost between the age of 6-12 years.

ii. **Permanent teeth-** they replace the milk teeth are 28 in number.

iii. **Wisdom teeth-** they are back molars that appear last at the age of 17-25 years. They are 4 in number

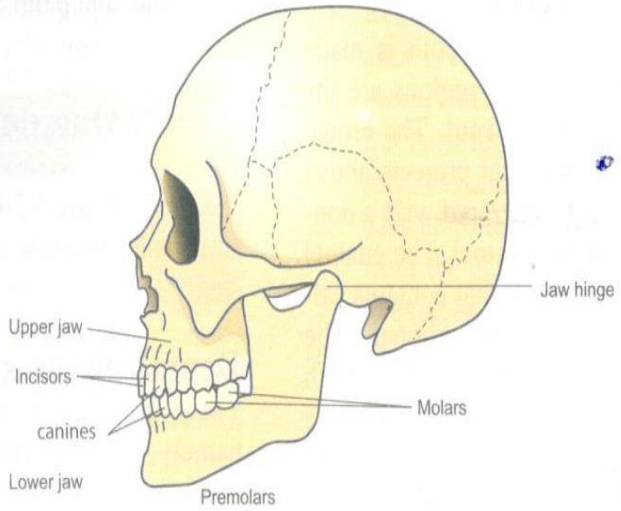
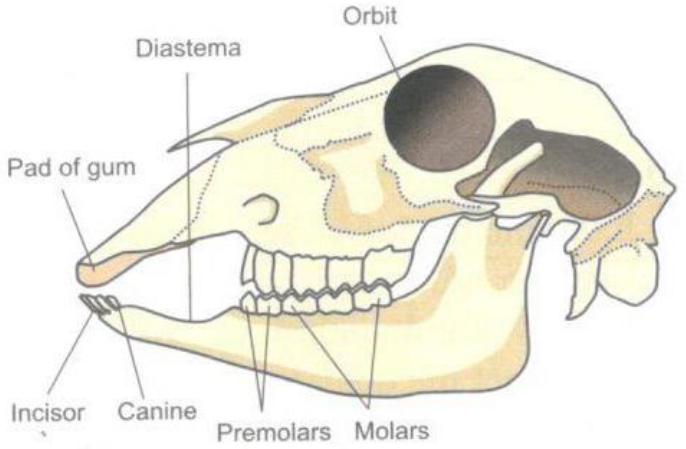


Fig 5.20 (a): A human skull and dentition.



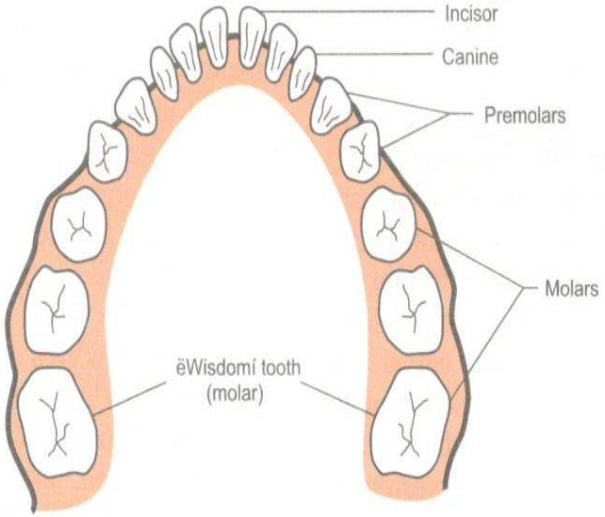
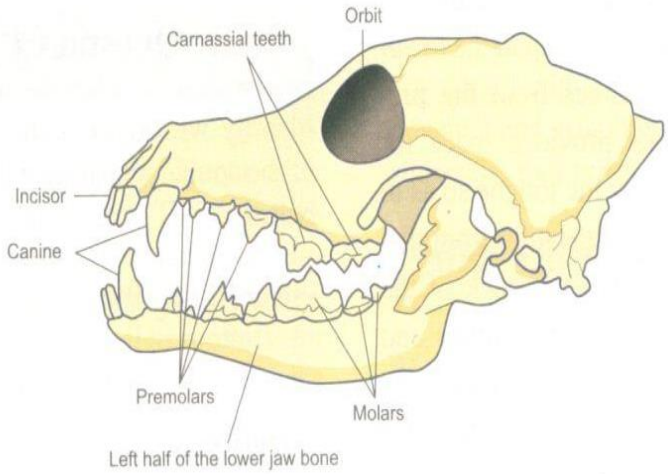


Fig 5.20 (b): Arrangement of different types of teeth in the human jaw.



CARNIVORE DENTITION

- ✓ Carnivores are animals which feed on flesh e.g. lion, dog, cheetah, cat e.t.c.
- ✓ The mode of nutrition is called **carnivorous**
- ✓ The dental formula is $i\frac{3}{3}\ c\frac{1}{1}\ pm\frac{4}{4}\ m\frac{2}{3} = 42$.

Adaptations of carnivore dentition.

1. The incisors are chisel-shaped, small and closely fitted to seize/ hold the prey and stripping flesh from the bone.
2. The canines are long, curved and sharply pointed to hold, kill and tear the prey.
3. The crown of premolars and molars has broad surface with cusps and ridges to increase surface area for grinding flesh.
4. The **carnassial teeth** (modified last premolar in the upper jaw and first molar in the lower jaw) have smooth sides and sharp edges to slice through flesh and crush bones.
5. The jaws are attached to powerful muscles to crash the bones.

STRUCTURE OF A TOOTH

EXTERNAL STRUCTURE.

✓ It consists of:

1. **The crown-** the part that projects above the gum. It is covered by a hard and white non-living layer called **enamel.**

✓ The enamel is hardened by **calcium phosphate and calcium carbonate.**

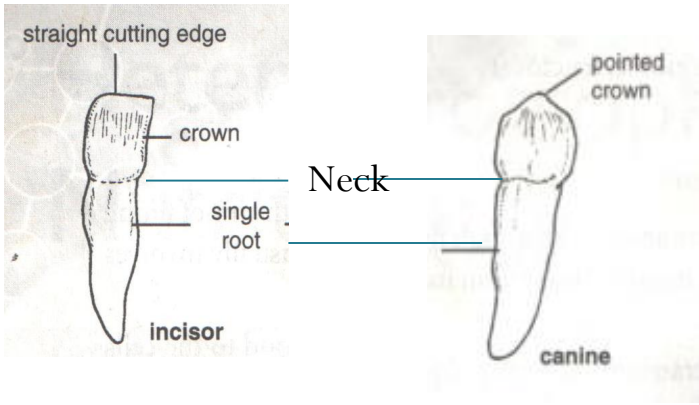
Role/ functions of enamel.

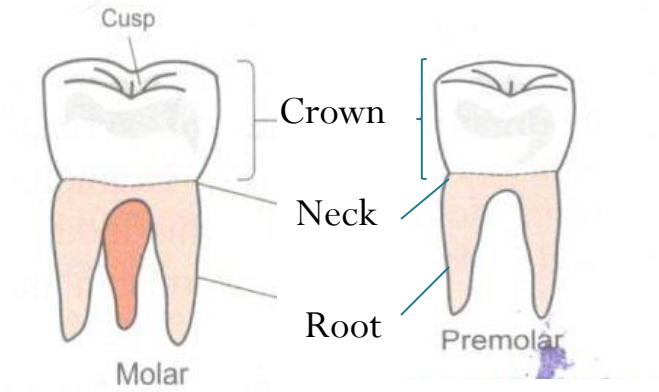
a) It protects internal structures from mechanical/ physical injury.

b) It provides a hard surface for biting and grinding of food.

2. **The neck-** it is a parts between the crown and root. It is covered by gum.

3. **The root-** it is part of the tooth that is firmly fixed into the jaw by cement.





INTERNAL STRUCTURE.

1. **Enamel**- is hardened by **calcium phosphate and calcium carbonate.**

Role/ functions of enamel.

i. It protects internal structures from mechanical/ physical injury.

ii. It provides a hard surface for biting and grinding of food.

2. **Dentine-** it is located below the enamel and extends to the root.

Functions/ role of dentine.

i. It is made up of living cells that give rise to the enamel.

3. **Pulp cavity-** it is located within the dentine.

Functions/ role of pulp cavity.

i. It has blood vessels/capillaries to supply nutrients and oxygen to the cells of the tooth and remove waste products (nitrogenous wastes and carbon (IV) oxide).

ii. Has sensory nerves/ nerve cells that detect heat, cold and pain.

4. **Cement-** It holds the tooth firmly into the jaw bone.

5. **Periodontal membrane-** It is found between the cement and jaw bone.

Functions/ role of periodontal membrane.

i. Contains living cells that secrete the cement.

ii. They act as shock absorbers i.e. allow some slight movement during chewing to avoid breakage.

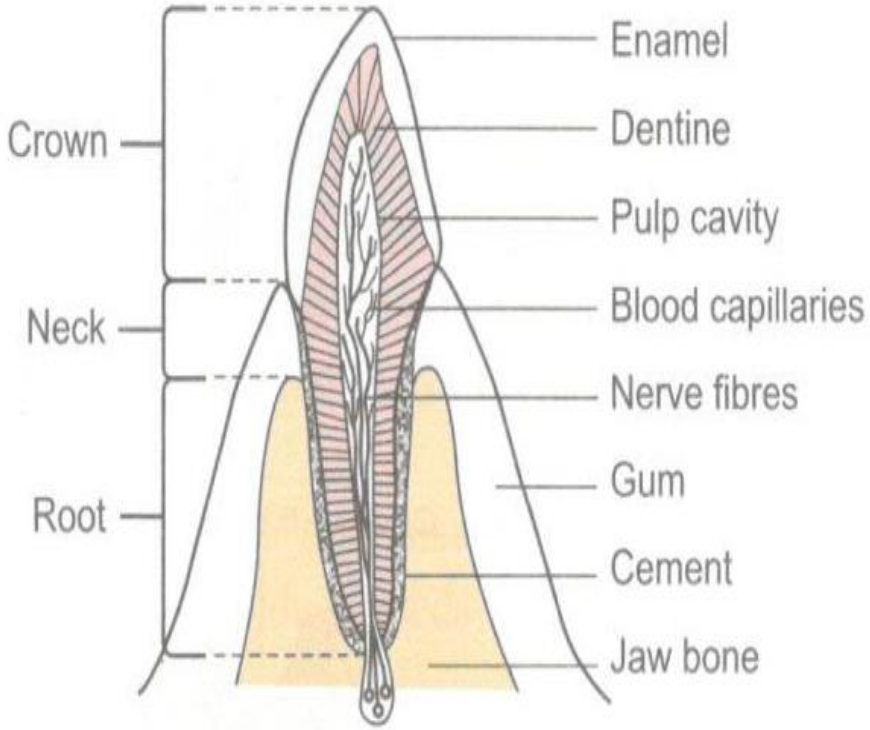
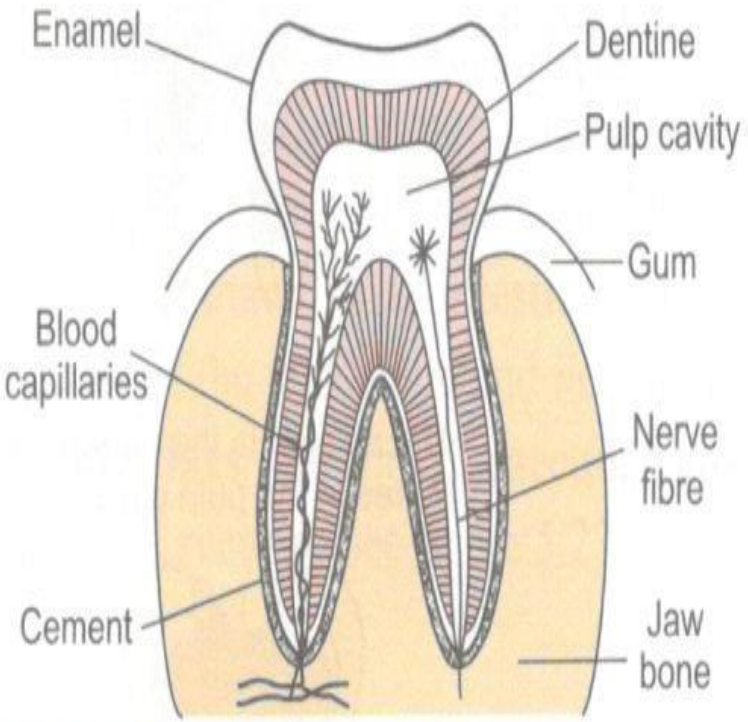


Fig 5.21: (a) Vertical section through an incisor tooth.



(b): Vertical section through a molar tooth.

DENTAL DISEASES

- ✓ Dental diseases include:

A. Dental carriers/ tooth decay.

B. Periodontal disease.

A. **Dental carriers.**

- ✓ It is caused by **plaque** (mixture of sugars, starch and micro-organisms) which accumulates between the tooth.
- ✓ The micro-organisms breakdown sugars in the plaque to form/ produce acids.
- ✓ The acids react with the enamel and dentine causing them to dissolve forming a hollow cavity.
- ✓ When the decaying process continues to the pulp cavity, it affects the nerves leading to pain/tooth ache.
- ✓ In serious cases, the pulp cavity may be destroyed and the infection spread to the gums.

Prevention of dental carriers.

1. Avoiding too much sweet and sugary food.
2. Taking a diet rich in calcium and vitamin D.
3. Eating hard foods.
4. Cleaning the teeth regularly.
5. Filling of cavities to prevent further decay.
6. If the cavities affect the pulp cavity, root canal procedure can be performed by a dentist.
7. Extraction of the tooth by the dentist in serious cases.

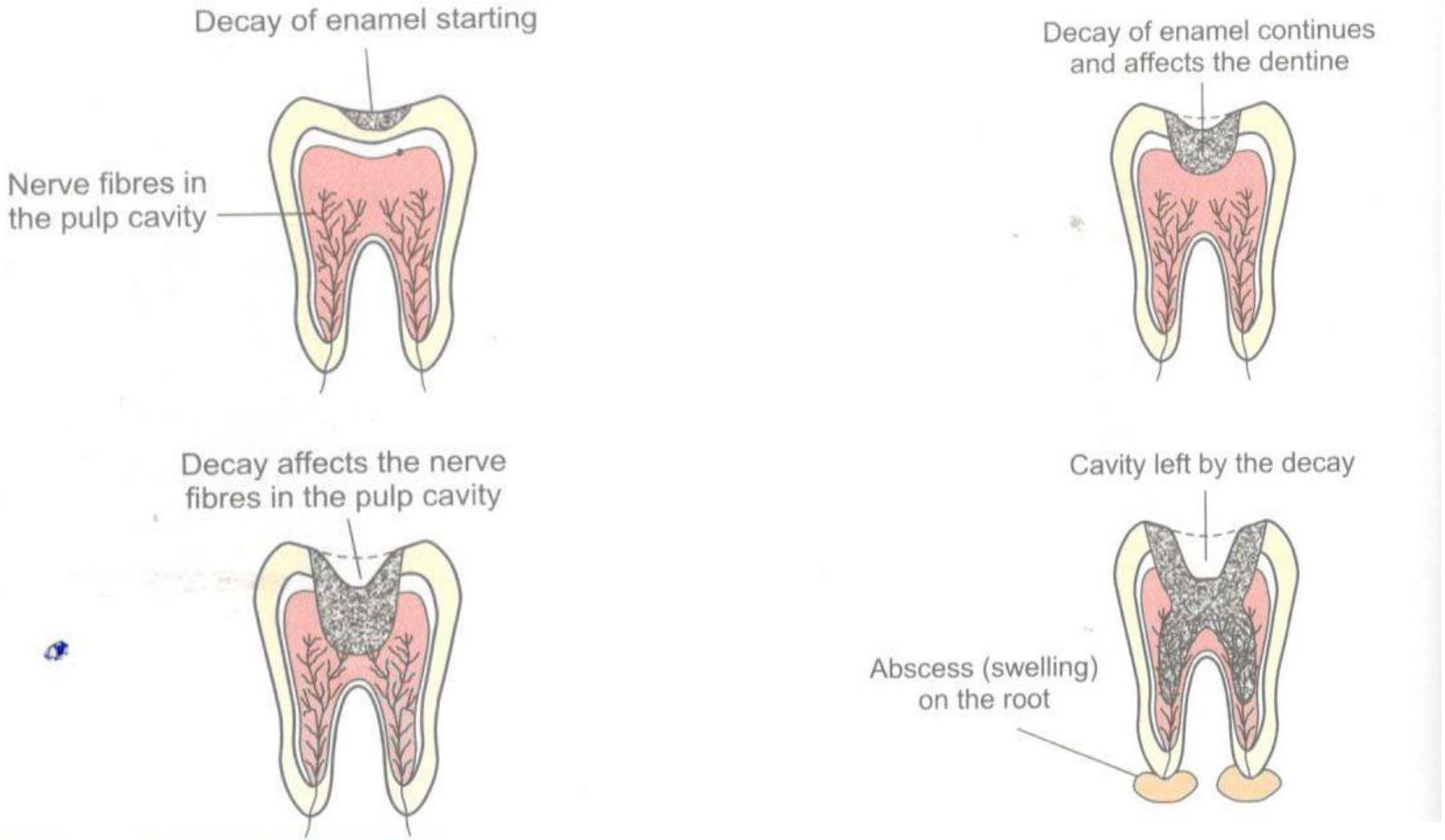


Fig 5.22: Progressive stages in tooth decay.

B. PERIODONTAL DISEASE

- ✓ It affects the gum, caused by bacterial infection.
- ✓ The disease makes the gums to become soft and flabby, so that they do not support the teeth.

Types of periodontal disease.

1. **Gingivitis-** characterized by reddening of gums, bleeding of gums and presence of pus in the gums.
2. **Pyorrhoea-** is a condition where the teeth become loose due to infection and the teeth are finally lost.

Control of periodontal diseases.

1. Eating balanced diet and rich in vitamin A and C.
2. Brushing the teeth regularly (to encourage blood circulation)
3. Dental hygiene

Healthy practices that minimize dental diseases.

1. Regular brushing/ cleaning of teeth after every meal.
2. Avoid too much sugary foods.
3. Eating hard foods e.g. raw carrots, cassava, yams and sugarcane. This helps to exercise the teeth and remove soft materials from gums and teeth.
4. Taking a diet rich in calcium, phosphate, and vitamins A, C and D.
5. Teeth should be used for proper purpose. They should not be used to open beverage bottles or crack hard nuts.
6. Regular dental check up.

DIGESTIVE SYSTEM IN MAN.

- ✓ It is used for **digestion** and **absorption** and consists of:

A. Alimentary canal/ gut/ digestive tract.

B. Associated organs

- ✓ The alimentary canal/ gut/ digestive tract consists of:

i. Mouth.

ii. Oesophagus/gullet.

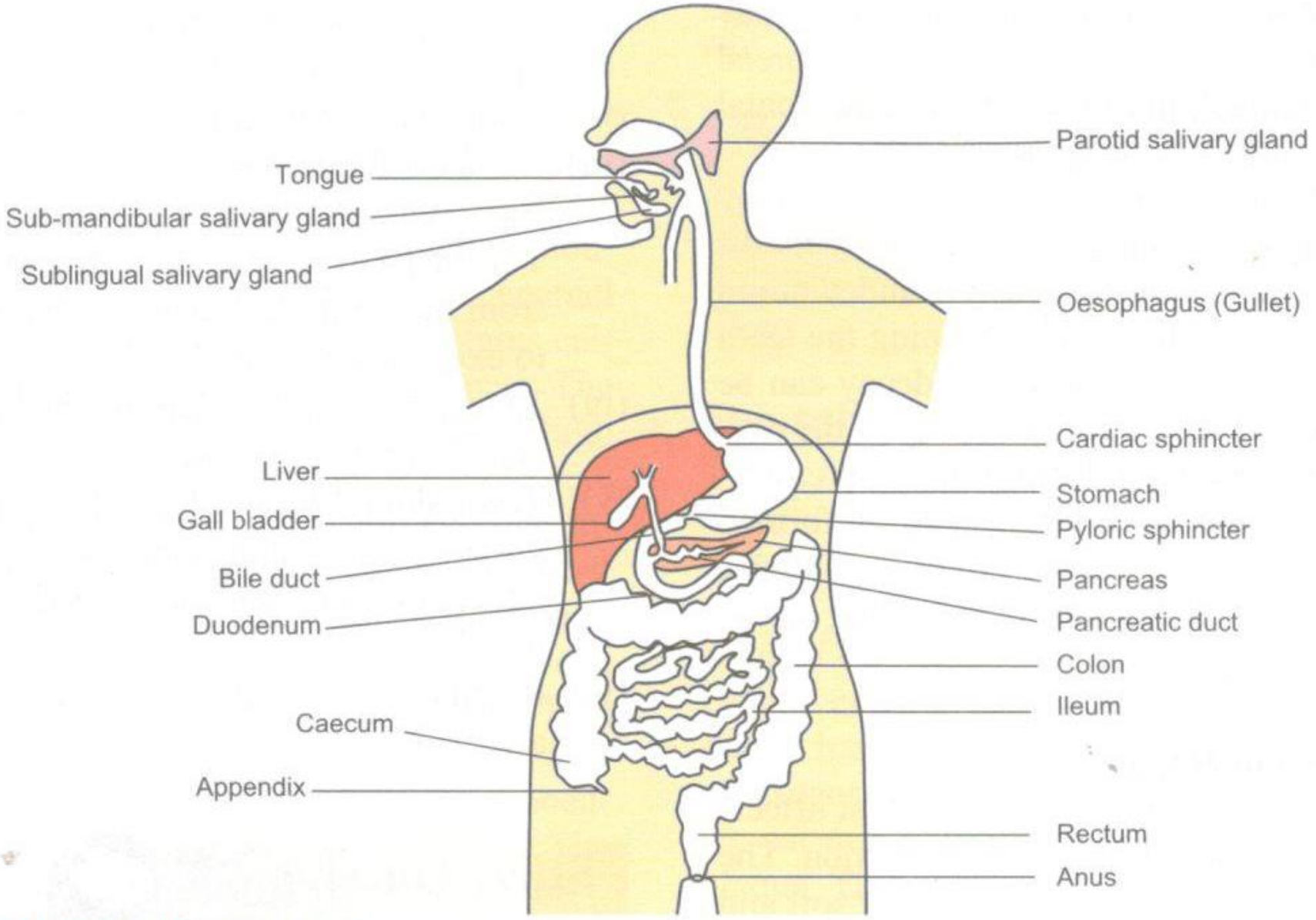
iii. Stomach.

iii. Small intestines (duodenum and ileum).

iv. Large intestines/colon.

v. Rectum.

- Along its length there are associated organs e.g. liver, gall bladder, pancreas, digestive glands.


Parotid salivary gland
Tongue
Sub-mandibular salivary gland
Sublingual salivary gland
Oesophagus (Gullet)
Cardiac sphincter
Liver
Stomach
Gall bladder
Pyloric sphincter
Bile duct
Pancreas
Duodenum
Pancreatic duct
Colon
Caecum
Ileum
Appendix
Rectum
Anus

DIGESTION

- ✓ Digestion refers to mechanical/ physical and chemical breakdown of complex food material into simpler forms that can easily be absorbed into the body.
- ✓ Physical/ mechanical digestion is done by teeth in the **mouth** and by bile salts in the **duodenum**.
- ✓ Chemical digestion is done by the enzymes.
- ✓ When digestion occurs inside the cells it is called **intracellular digestion** e.g. in amoeba and white blood cells.
- ✓ When digestion occurs outside the cells where enzymes are secreted onto food is called **extracellular digestion** e.g. in man.

A. DIGESTION IN THE MOUTH.

- ✓ The ingested food is chewed by teeth into simpler particles. Chewing and grinding of food is called **mastication.**
- ✓ Chewing increases the surface area for action of enzymes on food. The tongue rolls and mixes food with saliva.
- ✓ There are three pairs of salivary glands, namely:

1. **Sub-mandibular glands-** located near the back of the lower jaw which produce enzyme *Amylase*.
2. **Sublingual glands** – located below the tongue which produce mucus.
3. **2 parotid glands-** located on each side of the mouth and below the ear/ on the cheeks which produce enzyme *Amylase*.

✓ Saliva contains the following:

1. **Mucus/mucin-** which lubricates food.
2. **Water-** which softens food, acts as a solvent/ dissolves food and moistens food/mouth.
3. **Enzyme amylase/ptyalin-** which converts starch into maltose/digests starch.

- Saliva is slightly alkaline to provide optimum action of salivary amylase.

✓ Therefore the following are the functions of saliva:

1. Lubricates food.
2. Digestion of starch.
3. Moistens food/mouth.
4. Softens food.
5. Provides alkaline medium for action of enzyme (salivary amylase).
6. Dissolves food.

- ✓ The tongue mixes food with saliva and rolls food into boluses pushes them to the back of the mouth/ pharynx for swallowing into the stomach.
- ✓ During swallowing the soft palate is raised to open the gullet and close nasal cavity while the **epiglottis** closes preventing food from entering into the **trachea/wind pipe.**
- ✓ Food moves down the gullet/ oesophagus through the process called **peristalsis.**
- ✓ **Peristalsis** refers to involuntary movement of food in alimentary canal/ gut.
- ✓ It is brought about by contraction and relaxation of circular and longitudinal (smooth) muscles of the gut/ alimentary canal.

Adaptation of oesophagus/gullet.

1. It is made up of smooth muscles with contract and relax to facilitate peristalsis.
2. Inner lining has goblet cells that secrete mucus to lubricate food hence facilitate smooth movement of food/ boluses.

Study question

- ***How is the mouth adapted/ suited to its function?***

✓ Has teeth for chewing / grinding food to increase surface area for digestion by enzymes.

✓ Has salivary glands which secrete saliva which lubricate, soften, moisten, dissolve food and provide alkaline medium for action of enzymes.

✓ Saliva contains salivary amylase/ ptyalin which digest starch into maltose.

✓ It has muscular tongue to mix food with saliva and roll food into boluses and pushes them to the back of the mouth (for swallowing).

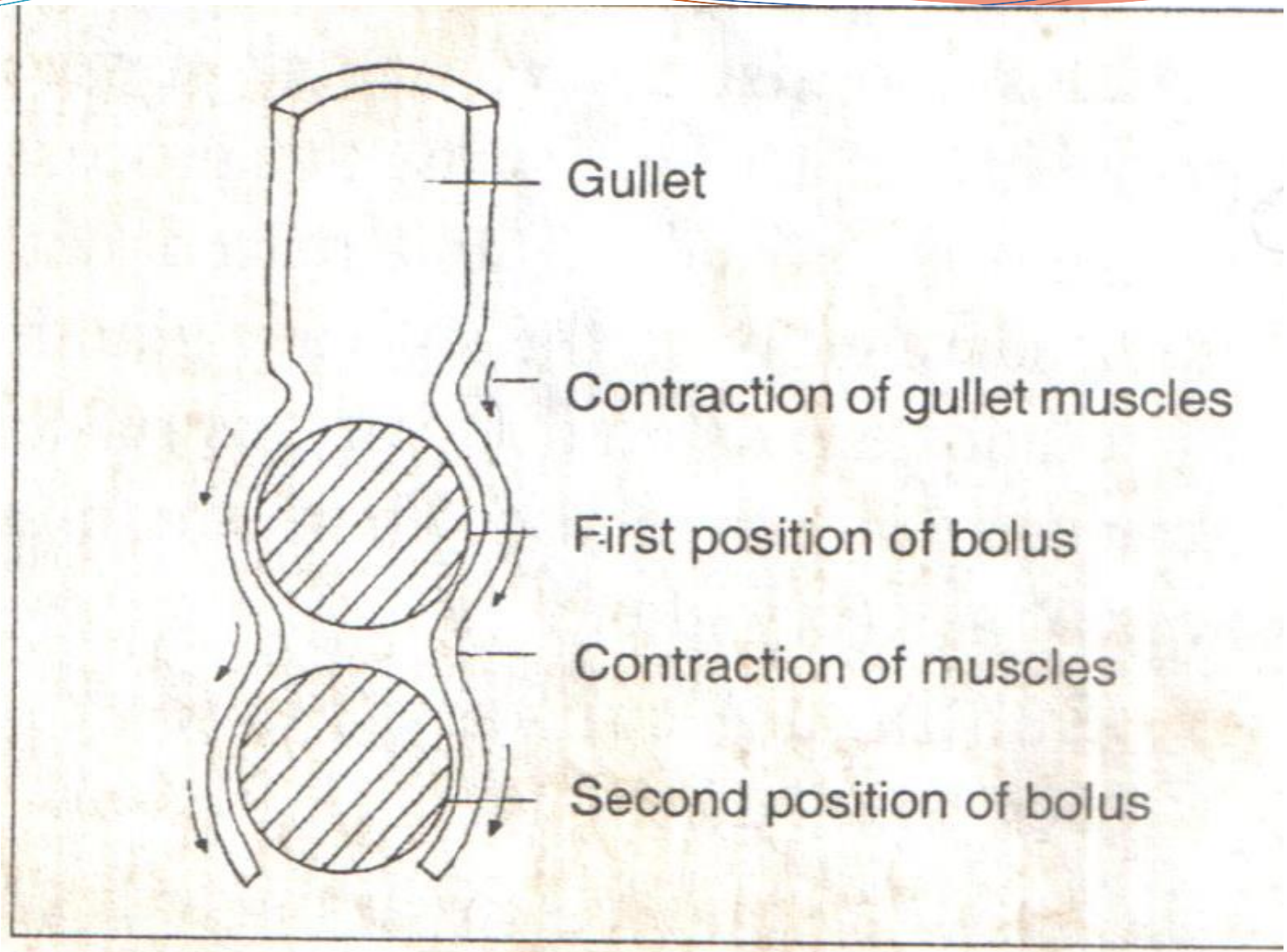


Fig. 5.25: Diagrammatic representation of peristalsis

B. DIGESTION IN THE STOMACH.

- ✓ Food from the oesophagus enters the stomach through the **cardiac sphincter muscle** which closes to prevent the food from moving up the oesophagus.

Role of stomach.

1. Churning of food.
2. Digestion of food/ proteins.
3. Absorption of alcohol, some water, water soluble vitamins (Vitamin B and C) and water soluble salts.

- ✓ The stomach walls have thick muscles (circular and longitudinal) which contract and relax to mix food into **chyme** in the process called **churning.**
- ✓ Churning helps to mix food with digestive enzymes.
- ✓ The presence of food in the stomach/ smell/ taste of food makes the stomach to secrete **gastrin hormone.**
- ✓ This hormone stimulates the **gastric glands** on the stomach walls to secrete **gastric juice.**

- ✓ In the stomach food is mixed with gastric juice which contains:

1. **Pepsin enzyme-** It catalyzes/ speeds up conversion of proteins into peptides/peptones.

- ✓ It is secreted by **peptic cells** in inactive/ precursor form called **pepsinogen** to avoid digesting / auto digestion of the stomach walls/lining (when no food is present in the stomach)**.**
- ✓ **Pepsinogen** is converted into **pepsin** by **hydrochloric acid** present in the stomach.

Study question.

How is the stomach adapted to:

i. **Churning-** The stomach walls have thick muscles which contract and relax.

ii. **Protein digestion-** The stomach walls contain gastric glands which secrete gastric juice containing Pepsin and Rennin.

2. **Rennin enzyme-** It is secreted in inactive/ Precursor form called **prorennin** by gastric glands in young mammals.

- ✓ Rennin which is abundant in young children converts soluble milk protein (caseinogen) into insoluble form (casein)/ curdles milk.
- ✓ Curdling of milk provides enough time for digestion.

3. **Mucus-** secreted by goblet cells to protect the stomach walls against corrosion by hydrochloric acid and auto digestion by enzymes.
4. **Dilute hydrochloric acid-** It is produced by cells of the stomach walls.

i. It provides acidic medium suitable for action of pepsin and rennin enzymes.
ii. It kills any bacteria which may be present in food.
iii. It converts inactive forms of rennin and pepsin into active forms.

Adaptation of stomach

1. It has muscular wall which contract and relax to facilitate churning of food into chyme.
2. The stomach lining has goblet cells that secrete mucus to protect them against auto digestion by enzymes.
3. The inner lining has gastric glands that secrete gastric juice containing pepsin and rennin for digestion of proteins, hydrochloric acid to provide acidic medium for action of enzymes and kill bacteria.
4. It has cardiac sphincter to allow food into the stomach.
5. It has pyloric sphincter to retain food in the stomach for digestion.

C. DIGESTIOIN IN THE DUODENUM.

- ✓ Food/chyme enters the duodenum from the stomach through the **pyloric sphincter.**
- ✓ In the duodenum, food is mixed with bile and pancreatic juice.
- ✓ The presence of food in the duodenum stimulates the duodenal walls to secrete:

a) **Secretin** into blood stream which stimulates the liver to secrete bile which is stored in the gall bladder**.**

b) **Cholescystokinin** into blood which:

i. Stimulates the gall bladder to release the bile and

ii. Stimulates the pancreas to secrete pancreatic juice.

Note; The pancreas secrete hormones and secretes digestive enzymes (hence it has endocrine and digestive roles).

- ✓ Bile contains salts (sodium hydrogen carbonate, sodium glycocholate and sodium taurocholate) which:

i. Neutralize the acidic chyme from the stomach.

ii. Provide suitable alkaline medium for pancreatic enzymes.

iii. Emulsify fats (break down fats into tiny fat droplets) to increase the surface area for digestion by lipases. This is called **emulsification.**

Note: Emulsification is not chemical but physical/mechanical because fats are not broken down to fatty acids and glycerol.

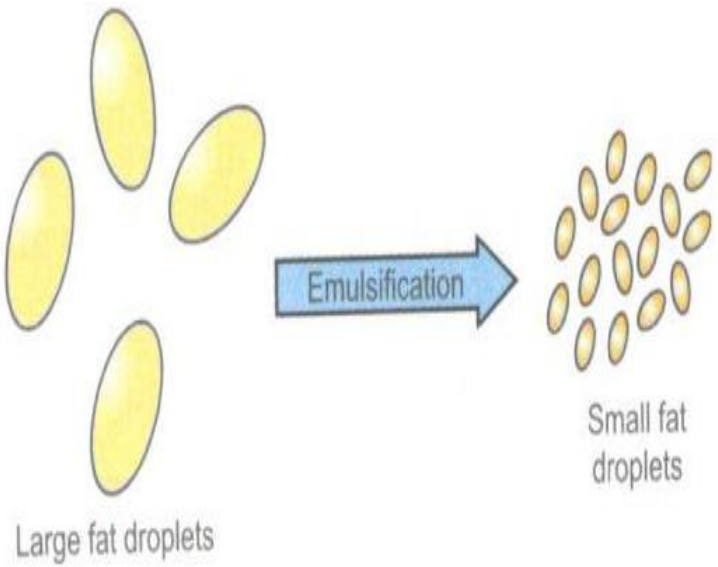


Fig 5.26: Illustration of emulsification.

- ✓ Pancreatic juice contains:

103 1. **Pancreatic lipase (enzyme)-** which converts lipids to **fatty acids and glycerol.**
2. **Pancreatic amylase (enzyme)--** which catalyzes the digestion/ conversion of remaining/ undigested **starch into maltose.**
3. **Sodium hydrogen carbonate (salt)** – which emulsifies fats, neutralizes the acidic chyme and provides alkaline medium suitable for action of pancreatic and intestinal enzymes.
4. **Trypsin (enzyme)--**which digests **proteins into peptides/peptones.**

- ✓ **Trypsin** is secreted in inactive/ precursor form called **trypsinogen** to prevent the digestion of duodenal walls.
- ✓ It is converted into trypsin by an enzyme called **enterokinase.**

(Enterokinase enzyme)

Trypsinogen ⟶ **Trypsin**

Adaptation of duodenum.

1. It has Brunner's gland on its walls to secrete mucus for lubrication of food
2. It has crypts of Liberkuhn whose cells secrete digestive enzymes for digestion of food.
3. It is connected to the pancreas and the liver to supply pancreatic juice and bile respectively bile emulsifies fats/ lipids and neutralizes the acid from the stomach pancreatic juice contains enzymes for digestion of food.

PRACTICAL ACTIVITY.

Aim: To demonstrate emulsification of fats.

Requirements:

1. Sodium hydrogen carbonate solution.
2. Cooking oil.
3. Water.
4. Test tubes.
5. Ruler.
6. Measuring cylinder.

Procedure:

1. Pour 2 cm^3 of cooking oil into the test tubes labelled A and B.
2. Add 2 cm^3 of sodium hydrogen carbonate solution into test tube A. Rinse the measuring cylinder.
3. Add 2 cm^3 of water into test tube B.
4. Shake the contents in both test tubes.
5. Write down your observations.

Observation.

✓ Formation of white emulsion.

D) DIGESTION IN THE ILEUM.

- ✓ In the ileum, food is mixed with mucus and intestinal juice/ *succus entericus*.

Functions of the ileum

i. To complete chemical breakdown of food.

ii. It provide a site for absorption of digested food into the blood.

- ✓ The inner walls of ileum has goblet cells which secrete mucus which;

i. Protects the wall of the intestines from being digested by protein digesting enzymes.

ii. Lubricates food/ allows smooth movement of food along the intestines.

- ✓ The ileum walls also contain secretory/ epithelial cells (Cryts of liberkuhn) which secrete intestinal juice / *succus entericus*.

✓ Intestinal juice contains the following enzymes:

a) **Maltase-** which catalyzes breakdown of maltose into glucose.

b) **Sucrase/ invertase-** which catalyzes breakdown of sucrose into glucose and fructose.

c) **Peptidase-** which catalyzes breakdown of peptides into amino acids.

d) **Polypeptidase-** Which catalyzes the breakdown of polypeptides to amino acids.

e) **Lipase-** which catalyzes breakdown of lipids (fats and oils) into fatty acids and glycerol

f) **Lactase-** which catalyzes breakdown of lactase into glucose and galactose.

Note; Digestion of food is completed at ileum forming chyle. **Chyle** is food ready for absorption.

ADAPTATIONS OF SMALL INTESTINES/ ILEUM.

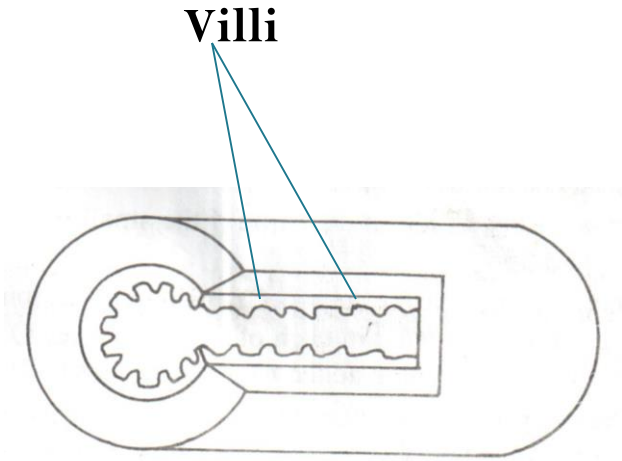
1. The small intestines are **long** to increase the surface area for absorption of food.
2. They are highly **coiled to slow down movement of food** to allow more time for digestion and absorption of digested food substances.
3. Inner lining has **numerous villi and micro-villi** to increase the surface area for absorption of food substances.
4. Their walls **have glands (**crypts of liberkurn) **that secrete intestinal juice which contains enzymes** for digestion of food.
5. Inner lining has **goblet cells** that secrete **mucus** to lubricate food and protect their walls against digestion by enzymes and lubrication of food.
6. It is **narrow/ has narrow lumen** to bring food into contact with intestinal walls/ blood vessels rapid/ faster absorption of food substances.

7. The walls have smooth muscles which contract and relax to facilitate peristalsis.
8. They are highly vascularized/well supplied with blood capillaries to create a steep/high concentration gradient hence faster diffusion of digested food/ for rapid and efficient of removal of absorbed products.
9. They have lacteal vessels for absorption of fatty acids and glycerol.
10. They have thin epithelium to reduce the distance travelled by digested food hence faster absorption.
11. They have numerous mitochondria to provide energy for absorption of food.

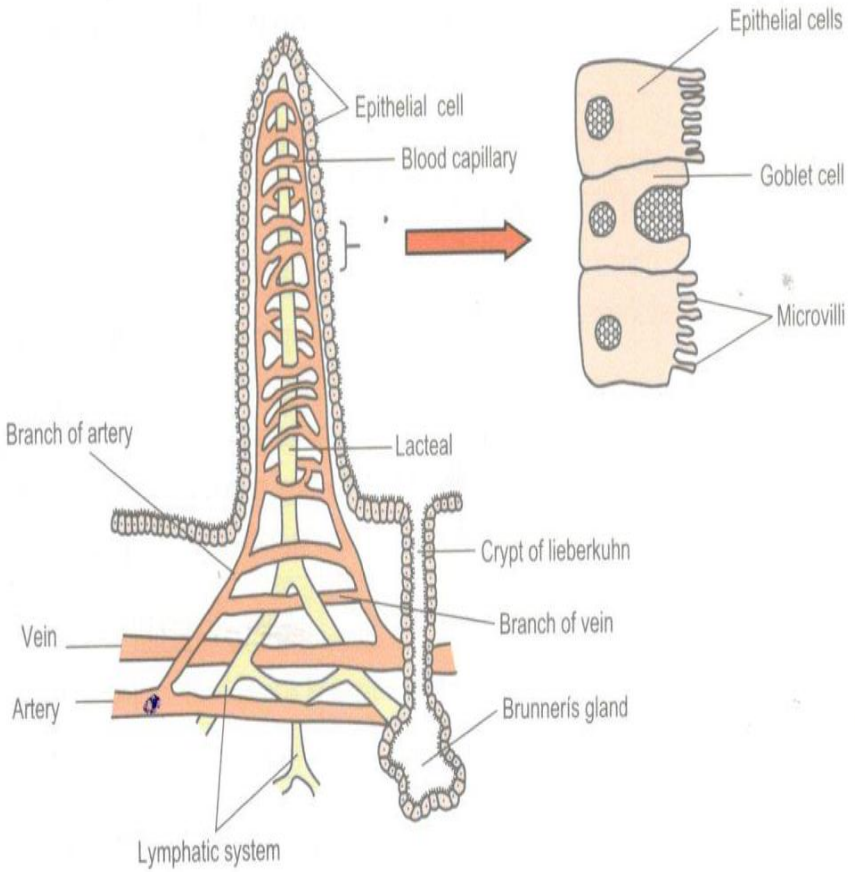
ADAPTATION OF THE VILLUS.

1. The villus has lacteal for absorption and transportation of fatty acids and glycerol.
2. It has a network of capillaries/highly vascularized to transport absorbed food substances.
3. It has thin epithelium to reduce the distance travelled by materials hence faster diffusion of digested food substances.
4. Has microvilli to increase the surface area for absorption of nutrients.
5. Has numerous mitochondria to provide energy for active transport of nutrients.

Structure of small intestine/ ileum



Structure of villus



ABSORPTION OF FOOD.

- ✓ **Absorption** is the process by which soluble products of digestion diffuse into the cellular lining of the villi into blood.
- ✓ **Glucose, fructose, galactose, Amino acids, mineral salts/ions, vitamins, Fatty acids and glycerol** are absorbed into the blood stream/capillaries through the epithelium of the villi by **diffusion and active transport.**

- The capillaries drain into the hepatic portal vein into the liver where amino acids and glucose are regulated before distributed to all body parts.
- ✓ Vitamins, mineral salts and water are absorbed directly without digestion.
- ✓ Water is absorbed through **osmosis**.

- Fatty acids and glycerol are absorbed into lacteals of the villi and combine to form **lipids** that pass into the lymphatic vessels and finally into the blood circulatory system.
- This distributes the fatty acids and glycerol to all parts of the body.
- The lacteals form the lymphatic system.

ASSIMILATION OF FOOD.

- **Assimilation** is the incorporation of absorbed food substances into cell metabolism.
- **Glucose** is oxidized to release energy during respiration and the excess is stored in the body as fats under the skin or in form of glycogen in the liver or muscles.
- **Fatty acids and glycerol** are oxidized to release energy, form new cell membranes and converted into fats and stored under the skin to insulate the body against heat loss and protect delicate internal organs.

- ✓ **Amino acids-** are used to synthesize proteins for body growth, repair of worn out tissues and also oxidized to provide energy during starvation (in the absence of glucose and fats).
- ✓ Excess amino acids are excreted in the process called deamination.

FUNCTIONS OF THE COLON.

i. Absorption of water and mineral salts.

ii. Contain symbiotic bacteria which manufacture/ synthesize vitamin K, B_1, B_2, and B_{12} and amino acids (which are absorbed into the blood stream).

Adaptation of colon.

1. Its walls consists of smooth muscles which contract and relax to facilitate peristalsis.
2. Inner lining has goblet cells which secrete mucus for lubrication.
3. Inner membrane is highly folded to increase surface area for absorption of water, mineral salts and attachment of micro-organisms.

ROLES/ FUNCTIONS OF CAECUM AND APPENDIX.

- ✓ The caecum and appendix in man have no functions but in herbivores they contain numerous symbiotic bacteria which secrete enzyme **cellulase** which digest cellulose into glucose.

ROLE OF ROUGHAGE IN DIGESTION.

- ✓ It is composed of cellulose and plant fibres.
- ✓ It adds bulk to food enabling it to have a grip/hold to the walls of the gut facilitating peristalsis allowing smooth movement of food in the alimentary canal.
- ✓ Lack of roughage in diet leads to constipation characterized by egestion of hard faeces.
- ✓ This is because food stays long in the gut and a lot of water is reabsorbed.

EGESTION

- ✓ This is the removal of undigested and indigestible food substances from the body (through the anus).

ROLE OF WATER IN DIET.

1. Acts as a solvent in which substances dissolve.
2. It acts as a medium for transportation of substances.
3. It acts as a medium in which metabolic reactions occur.
4. It facilitates hydrolysis of food substances.
5. It facilitates osmoregulation and bring about cooling effect in the body.

STUDY QUESTIONS

1. **Describe digestion of fats and oils/lipids in humans**

- ✓ In the duodenum, food is mixed with bile and pancreatic juice.
- ✓ Bile salts emulsify fats hence providing a large surface area for action of lipase enzymes and neutralizes the acidic chyme and provides alkaline medium for action of lipase enzyme.
- ✓ Pancreatic juice contains lipase which converts lipids into fatty acids and glycerol.
- ✓ In the ileum, food is mixed with intestinal juice secreted by intestinal wall. Intestinal juice contains lipase which converts/ breaks down the remaining lipids into fatty acids and glycerol.

2. Describe digestion of proteins in humans.

- ✓ In the mouth, food is broken down mechanically by the teeth to increases the surface area action of enzymes.
- ✓ The tongue rolls food into boluses and swallowed into the stomach.
- ✓ In the stomach, food is mixed with gastric juice which contains Rennin and Pepsinogen.
- ✓ Pepsinogen is activated into Pepsin by Hydrochloric acid.
- ✓ Rennin (which is abundant in young children) converts the milk protein (Caseinogen) into Casein increasing its surface area for digestion by pepsin.
- ✓ Pepsin converts protein into peptides.
- ✓ In the duodenum, food is mixed pancreatic juice which contains Trypsin which digests proteins into peptides.

- ✓ In the ileum food is mixed with intestinal juice *(Succus entericus)* secreted by intestinal walls.
- ✓ Intestinal juice contains peptidase enzyme which converts/ breaks down peptides into amino acids, polypeptidase enzyme which breaks down polypeptides into amino acids.

3. **Describe digestion of carbohydrates in humans.**

- ✓ In the mouth food is chewed/ mechanically broken down to increase the surface area for enzyme activity.
- ✓ Saliva contains salivary amylase/ ptyalin which acts on starch/amylose and converts it into maltose. Saliva mixes with food and provides an alkaline medium for action of amylase.
- ✓ The tongue rolls food into boluses for swallowing into the stomach through peristalsis.
- ✓ In the duodenum, food is mixed with bile and pancreatic juice.

- ✓ Bile salt/sodium hydrogen carbonate provides alkaline medium for activity of duodenal enzymes and neutralizes acidic chyme/ food from the stomach.
- ✓ Pancreatic juice contains pancreatic amylase which converts starch to maltose.
- ✓ In the ileum epithelial cells in the ileum secrete succus entericus/intestinal juice which contains enzymes sucrase/invertase which converts sucrose to fructose and glucose, lactase which converts lactose to galactose and glucose and maltase which converts maltose to glucose.

FACTORS AFFECTING ENERGY REQUIREMENTS IN MAN

1. **Age-** Young children are actively growing/have many actively dividing cells/are physically more active hence require more energy than adults.
2. **Sex-** Males need more energy than females because they are more muscular hence have more cells that respire.

3. **Body size-** A small bodied person requires more energy because they have large surface area to volume ratio thus lose more energy than a person with big body. Some big bodied people may eat a lot of food to maintain energy demands of their large bodies.
4. **Activity/occupation-** A manual worker requires more energy than a sedentary worker.
5. **Lactation and pregnancy-** Pregnant mothers need more energy for foetal development while lactating mothers require more energy for milk production.
6. **Basal metabolic rate (BMR)-** this is the energy required by the body when it is at rest or the minimum amount of energy man requires to keep the body cells alive. The higher the BMR the higher the energy requirement.

ROLE OF VITAMINS IN THE BODY OF MAN/ HUMAN BEINGS.

VITAMIN	SOURCES	USES/ ROLE IN THE BODY	DEFICIENCY SYMPTOMS.
Vitamin A (retinal)	Liver, milk, eggs, carrots, fresh green vegetables,	✓ Night vision. ✓ Protects the skin and cornea from drying and becoming scaly.	✓ Poor night vision. ✓ Sore eyes. ✓ Dry and scaly skin and cornea. ✓ Poor resistance to diseases. ✓ Cold and bronchitis diseases.
Vitamin B1 (Thiamine)	Groundnuts, beans, whole cereals, egg yolk, milk, liver and kidney.	✓ Cell respiration. ✓ Proper growth in children.	✓ General weakness. ✓ Retarded growth in children. ✓ Beriberi disease. <u>Symptoms of beriberi disease</u> ✓ Limb paralysis. ✓ Heart failure. ✓ Swelling of legs (oedema). ✓ Loss of appetite/ diarrhoea/vomiting. ✓ Weight loss/muscle wasting. ✓ Pale skin.
Vitamin B2 (riboflavin)	Groundnuts, beans, whole cereals, egg yolk, milk, liver and kidney.	✓ Proper functioning of skin. ✓ Cell respiration.	✓ Pellagra disease. <u>Symptoms of pellagra disease</u> a) Skin disorders. b) Sores and bleeding in the mouth and gum.

VITAMIN	SOURCES	USES/ ROLE IN THE BODY	DEFICIENCY SYMPTOMS.
Vitamin B5 (Pantothenic acid	Groundnuts, beans, whole cereals, egg yolk, milk, liver and kidney.	✓ Respiration. ✓ Proper functioning of the nervous system and alimentary canal.	✓ Malfunctioning of the nervous and alimentary canal.
Vitamin B12 (Cobalamine)	Liver, beef and kidney.	✓ Formation of blood cells	✓ Anaemia.
Vitamin C (Ascorbic acid)	Fresh fruits, green vegetables.	✓ Enhances absorption of iron. ✓ Promotes healing of wounds. ✓ Prevents infection/provides immunity against diseases. ✓ Helps in synthesis of connective tissues. ✓ Helps in development of healthy gums.	✓ Scurvy characterized by: a) Bleeding of gums. b) Anaemia. c) Swelling on the skin. d) Poor healing of wounds. e) Reduced/ poor resistance of diseases. f) Degeneration of muscles.
Vitamin D (Calciferol)	- It is a fat soluble vitamin manufactured in human body in the skin Sources are: Milk, fish, liver, egg yolk,	✓ Formation and hardening of bones. ✓ Strong teeth formation. ✓ Absorption of calcium and phosphorus.	✓ Rickets characterized by: a) Abnormal bone formation in children. b) Soft and brittle bones in adults.
Vitamin E	Milk, egg yolk, green	✓ Cell metabolism	✓ Infertility in some animals

PRACTICAL ACTIVITY.

Aim- Testing for vitamin C/ Ascorbic acid.

Requirements.

a) Food substance in solution form.

b) 0.1% Dichlorophenol indophenol (DCPIP)

c) Test tube.

d) Dropper.

e) 10 ml measuring cylinder.

Procedure

1. Into a clean test tube put 1ml of DCPIP.
2. Add the food substance drop wise into the DCPIP in the test tube and shake well after each drop.

Observation

✓ DCPIP is decolorized i.e. it becomes colorless.

Conclusion.

✓ Vitamin C/ Ascorbic acid present.

Note- If the **blue** color of DCPIP is retained then vitamin C/ ascorbic acid is absent

ROLE OF MINERAL SALTS / ELEMENTS IN THE HUMAN BODY

ELEMENT	SOURCE	FUNCTIONS IN THE BODY	DISEASE CAUSED BY DEFICIENCY
Nitrogen	Meat, milk, eggs, fish	✓ Protein synthesis. ✓ Formation of cells, tissues, hair and nails.	✓ Kwashiorkor. ✓ Stunted growth.
Phosphorus	Protein foods	✓ Synthesis of proteins. ✓ Formation of bones and teeth. ✓ Formation of ATP.	✓ Rickets (characterized by poorly developed bones)
Calcium	Green vegetables, milk and cheese.	✓ Blood clotting. ✓ Muscle contraction. ✓ Formation of bones and teeth.	✓ Rickets ✓ Muscle cramps
Iodine	Iodinised salts, sea fish, cheese	✓ Formation of the hormone thyroxine	✓ Goitre (characterized by swelling of thyroid glands in the neck region.

ELEMENT	SOURCE	FUNCTIONS IN THE BODY	DISEASE CAUSED BY DEFICIENCY
Potassium	Liver, beef, vegetables, milk, eggs	✓ Transmission of nerve impulses. ✓ Contraction of muscles. ✓ Ionic/ osmotic balance.	✓ Muscular weaknesses ✓ Paralysis ✓ Nausea
Iron	Liver, eggs, green vegetables	✓ Formation of haemoglobin in re d blood cells. ✓ Used in respiration.	✓ Anaemia. ✓ Low resistance to diseases/ low immunity.
Sodium	Table salt, fish, milk, green vegetables	✓ Maintains osmotic balance of body. ✓ Transmission of nerve impulses	✓ Reduced appetite ✓ Muscle cramps
Chlorine	Table salt	✓ Maintains osmotic balance of body. ✓ Transmission of nerve impulses	✓ Reduced appetite ✓ Muscle cramps

ELEMENT	SOURCE	FUNCTIONS IN THE BODY	DISEASE CAUSED BY DEFICIENCY
Sulphur	Protein foods	✓ Protein synthesis ✓ Formation of body tissues	✓ Kwashiorkor. ✓ Stunted growth.
Zinc	Liver, fish	✓ Activates enzymes	
Magesium and calcium	Meat, green vegetables	✓ Activates enzymes. ✓ Teeth and bone formation	✓ Nervous system disturbances
Manganese	Liver, kidney, tea, coffee, nut, vegetables, fruits	✓ Activates enzymes. ✓ Teeth and bone formation	✓ Abnormal bone and cartilage development

Practical activity 1.

Aim: To investigate the effect of temperature on enzyme activities.

Requirements:

- ✓ Six clean test-tubes.
- ✓ White tile.
- ✓ Test-tube holder.
- ✓ A dropper.
- ✓ Distilled water.
- ✓ Benedict's solution.
- ✓ Iodine solution.
- ✓ Water bath maintained at 37°C and 50°C.
- ✓ Source of heat.
- ✓ Thermometer.
- ✓ 10 ml measuring cylinder.
- ✓ 5 Labels.
- ✓ 6 cm^3 of amylase/diastase solution.
- ✓ 10 cm^3 soluble starch powder.

Procedure:

1. Label three test-tubes A, B and C.
2. Into test-tube A, B and C, add 3 cm^3 of starch solution.
3. Into test-tube A, B and C add 2 cm^3 of amylase/diastase solution.
4. Place test-tube C in the water bath maintained at 50°C for 30 minutes.
5. Place the remaining test tubes A and B in the water bath maintained at 38°C for 30 minutes.
6. After the 30 minutes, test for starch and reducing sugars on the contents of each test tube.
7. After the 30 minutes, test for starch and reducing sugars on the contents of each test-tube.

QUESTIONS

1. Which of the test tubes showed presence of starch?

- ***Test tube C.***

2. Which of the test tubes showed presence of reducing sugar?

- ***Test tube A and B.***

3. Explain the results.

- ***In test tube C, the enzyme was denatured by boiling hence starch was not hydrolyzed/broken down.***
- ***In test tube A and B, the enzyme amylase/diastase digested starch into maltose (a complex reducing sugar).***

4. What was the reason for maintaining the test tubes at 38°C?

- ***This is the optimum temperature for enzyme amylase.***

5. What was the reason for maintaining the test tubes at 50°C?

- ***At 50°C, the enzyme is denatured.***

PRACTICAL ACTIVITY 2.

Aim: To investigate the effect of pH on enzyme activity.

Requirements:

- ✓ Water bath kept at 37°C.
- ✓ Egg albumen suspension.
- ✓ 2m of hydrochloric acid.
- ✓ 2m sodium hydroxide,
- ✓ 3 test-tubes.
- ✓ 5 cm^3 of 1% pepsin solution.
- ✓ Means of heating.
- ✓ Measuring cylinder.
- ✓ 5 Labels.

Procedure:

1. Label the test tubes A, B and C
2. Using a measuring cylinder, place 2 cm^3 of the egg albumen suspension into each of the three test-tubes labeled A, B and C.
3. Add 1 cm^3 of the 1 % pepsin solution to each of the three test tubes A, B, C.
4. To the contents of test-tube A, add three drops of the 2M hydrochloric acid, to B add three drops of distilled water and to C add three drops of the 2M sodium hydroxide solution.
5. Incubate the test tubes for 10 minutes in a water bath kept at 37°C.
6. Examine the test-tubes every two minutes, noting the cloudiness of the contents.
7. After the 10 minutes remove the test tubes and place them in a test-tube rack.

Test - tube	Observation of cloudiness					
	0Mins	2Mins	4Mins	6Mins	8Mins	10Mins
A						
B						
C						

Questions

1. Name the tube whose content has different appearance after ten minutes.

- ***Test tube A.***

2. Explain the change.

- ***The acid added provided the optimum pH for the enzyme hence the protein was digested.***

3. Which aspect of the enzyme properties does the experiment investigate?

- ***The optimum pH of the enzyme.***

PRACTICAL ACTIVITY 3.

Aim: To investigate the presence of catalase enzyme in living tissues.

Introduction.

- ✓ Catalase is an enzyme found in living tissues of plants and animals.
- ✓ It breaks down hydrogen peroxide (H_2O_2) produced during cellular metabolism into oxygen and water which are less toxic substances.
- ✓ Hydrogen peroxide is highly toxic hence it should not be allowed to accumulate in the tissues.
- ✓ If it were allowed to accumulate in in the tissues, it would interfere with cellular metabolism.

Requirements:

1. Irish Potato.
2. Fresh piece of liver
3. Hydrogen peroxide.
4. 4 test-tubes.
5. Wooden splints.
6. Means of heating.
7. Scalpel blade.
8. Measuring cylinder (10 cm^3).
9. Labels.
10. Pair of forceps

Procedure:

1. Label four test-tubes A, B, C and D.
2. Measure 2 cm^3 of hydrogen peroxide and put in the test-tubes A, B, C and D.
3. Cut a small piece of the Irish potato, place it in test-tube A and record your observation
4. Immediately, introduce a glowing splint into the mouth of the test tube and record your observation in the table below.
5. Cut a small piece of the fresh liver, place it in test-tube B and record your observation in the table below.
6. Immediately, introduce a glowing splint into the mouth of the test tube B and record your observation in the table below.
7. Cut a small piece of Irish potato and a small piece of liver and boil them for five minutes.
8. Remove a boiled Irish potato from hot water using a pair of forceps and place it in test tube C and record your observation in the table below.
9. Remove a boiled liver from hot water using a pair of forceps and place it in test tube D and record your observation in the table below.

Questions

Test tube	Observation
A	- Bubbling/ effervescence. - Relighting of glowing splint
B	- Bubbling/ effervescence. - Relighting of glowing splint
C	- N o bubbling/ effervescence
D	- No bubbling/ effervescence

1. Account for the observation made in test tubes A and C.

✓ *Test tube A- enzyme catalase present in tissue cells breaks down hydrogen peroxide into water and oxygen hence bubbling and the gas relights a glowing splint.*

✓ *Test-tube B- boiling denatures catalase enzyme hence it did not break down hydrogen peroxide into water and oxygen.*

2. Why were Irish potato and liver used?

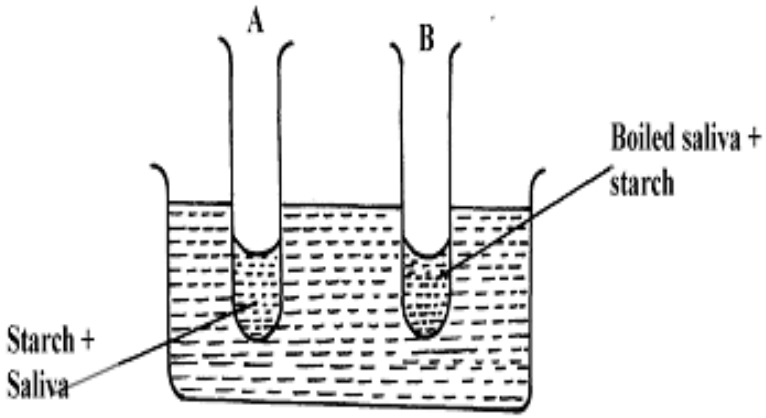
✓ *To show that catalase enzyme is found in both animal and plant tissues.*

3. Which aspect of enzyme property does the experiment investigate?

✓ *Sensitivity to changes in temperature.*

STUDY QUESTION.

- In an experiment to investigate on aspect of digestion, two test tubes A and B were set-up as shown in the diagram below. The test tubes were left in the bath for 30minutes. The content of each test tube was then tested for starch using iodine solution.



(a) What was the aim of the experiment?

✓ ***To investigate the effect of boiled saliva on starch OR to show the effect boiled/denatured enzyme amylase has on starch.***

b) What results were expected in test-tube **A** and **B.**

✓ ***A-brown colour/colour of iodine persists/ no change in colour.***

✓ ***B- blue black colour seen/ colour changed to blue black.***

c) Account of the results you have given in **(b)** above in test tube **A** and **B**.

✓ ***A- Starch has been digested/broken down/ hydrolysed by salivary amylase hence no colour change.***

✓ ***B- Enzymes/Amylase denatured hence starch is not digested/broken down/hydrolysed.***